Qatar Science Curriculum

Kindergarten to Grade 12

[revised in 2018]

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FOREWORD
By Ministry of Education and Higher Education

1

INTRODUCTION

Introduction

The State of Qatar recognises that future economic success will increasingly depend on its human capital. Qatari people need to be equipped to thrive in a new international environment that is knowledge-based and extremely competitive. Therefore, the nation's educational goals, as articulated in the Qatar National Vision (QNV) 2030, is to build a modern world-class educational system that provides students with a quality of education comparable to the best in the world, achieving excellence in international benchmarking studies such as TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment).

In its journey towards the QNV 2030, a key initiative, the new Qatar National Curriculum Framework (QNCF) was launched in 2016. This document is aligned with QNV 2030 as well as with other important education sector strategies that promote excellence in an increasingly globalised and competitive context. The QNCF provides a forward-thinking vision for education, ensuring coherent and comprehensive processes in curriculum development.

Thus, the QNCF is used as a main reference against which the review and revision of existing science curriculum standards (first introduced in 2004) were conducted in 2018. The new science curriculum is an inclusive document that caters to all levels from kindergarten to Grade 12. Inclusivity means ensuring all segments of students (grade, track, special needs and individuals) are considered to ensure they are developed holistically, achieve their full potential and embrace lifelong learning.

The new science curriculum (2018) is aligned with the objectives of QNCF to ensure students attain science knowledge and skills and develop attitudes (collectively known as competencies) to achieve the goals and outcomes of the education system. Key changes to the science curriculum include infusion of skills and processes related to Scientific Inquiry into other strands; creation of learning experiences using templates to facilitate teaching and learning processes, and identification of five key competencies in science learning (Inquiry & Research, Communication, Critical & Creative Thinking, Co-operation & Participation and Problem-solving), with competency tagging to learning experiences. The standards were revised, streamlined and organised by theme and topic with the scope and sequence of content standards that are balanced, relevant, integrated and coherent. The new science curriculum necessarily involved an adjustment of curriculum time, and consideration for the development of supporting learning resources with appropriate and continuing professional development for teachers.

While the future is often described as VUCA — volatile, uncertain, complex and ambiguous, the development of a new science curriculum that adopts innovative best practices from high performing countries will support the shift to a new paradigm in science education in the State of Qatar. An engaging, effective and student-centric curriculum, it will lay the foundation to prepare learners to respond positively to the opportunities and challenges of the 21st century and to strive to become successful life-long learners.

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RATIONALE FOR SCIENCE EDUCATION

Rationale for Science Education

Science education has its roots in an agrarian society and has evolved over the centuries to one dominated by and reliant on scientific and technological expertise. Increasingly, we are surrounded by technology and the products of science every day. A student rides to school on a bus, and in that instance alone, there are many examples of technology based on the scientific method. The school bus is a product of many areas of science and technology, including mechanical engineering and innovation. The smartphone in the student's hand is a miracle of modern computer engineering. As students grow up in an increasingly technologically and scientifically advanced world, they need to be scientifically literate to succeed.

Perhaps even more important than specific examples of science in our lives are the ways we use scientific thought, method and inquiry to come to our decisions. This is not necessarily a conscious thing. The human needs to solve problems that can arise from curiosity or from necessity. The process of inquiry is how we find answers and substantiate those answers. In the fields of hard science, the process of inquiry is more direct and finite. A strong science education prepares students to take on careers in science and related sectors and may even open up opportunities in fields not traditionally associated with science like management roles.

In addition, science is a dynamic and collaborative human endeavour with links with other subjects and cross-cutting issues as identified in the QNCF. Often science issues may intersect in one or more subjects or areas within their context. These cross-cutting issues may provide appropriate learning context and deepen the understanding of science and its interconnection with other subject areas. For example, a study of the local environment has the capacity to link Science with Social Studies and Life Skills where learning of science and environment can be applied in real-life situation of solving problems of pollution and waste management issues.

Research has also advocated that science education should begin early, not only does science education teach young learners problem-solving skills that will help them throughout their schooling, it also engages them in science from the start. Whilst there is little disagreement about the necessity for incorporating science into the curriculum, the form and contents of that science education may vary from country to country.

Thus, science is one of the key subjects in school due to its relevance to students' lives and the universally applicable problem-solving and critical thinking skills it uses and develops. These are lifelong skills that allow students to generate ideas, weigh decisions intelligently and even understand the evidence behind public policy-making. Teaching scientific literacy, critical thinking and problem-solving through science education becomes imperative as the country strives to prepare the learners for the 21st Century.

3

AIMS OF SCIENCE CURRICULUM

Aims of Science Curriculum

In line with the development of the new science curriculum and anticipated shift to a new paradigm in science education, the ordering of the aims of science curriculum is imperative to reflect the learning mind-set of inquiry and to raise the motivation for learning science. The aims for the science curriculum begin with developing **A**ttitudes, then acquiring **S**kills and **K**nowledge **(ASK)**. Thus, the aims are to:

Attitudes

- Develop attitudes that are relevant to science such as integrity, objectivity, accuracy and precision, inquiry, initiative and inventiveness
- Develop an interest in learning about scientific issues from different sources including the media
- Stimulate interest in and care for the local and global environment
- Develop an appreciation of and respect for scientific work

Skills

- Develop abilities and skills that are relevant to the study and practice of science; useful in everyday life; encourage efficient and safe practices and encourage effective communication
- Acquire the skills associated with the scientific methods when making key decisions, including the assessment of risks and being prepared to make changes based on a inquiry approach (e.g. decisions relating to moral and health issues)
- Develop student's competency related to numeracy eg computational skills, using mathematical models and graphs;
- Enhance student's ICT skills
- Develop skills in linking scientific knowledge with real life situations; and generation of knowledge and the creation of innovative solutions.

Knowledge

- Acquire understanding and knowledge to be able to take or develop an informed interest in matters of scientific importance
- Recognise the usefulness and limitations of scientific concepts, formulae and the theories that explain the natural phenomena and to appreciate its applicability in other disciplines and in everyday life
- Promote an awareness that the study and practice of science are subjected to social, economic, technological, ethical and cultural influences and limitations

In summary, the aims of the Science curriculum are to provide a worthwhile educational experience for all students, whether or not they go on to study science beyond school, and in particular to enable them to develop positive attitudes and acquire sufficient skills and knowledge. These will enable them to become active, confident and responsible citizens in the global based economy and suitably prepare them to become lifelong learners who are scientifically literate in the 21st Century.

4

TEACHING AND LEARNING IN THE 21ST CENTURY

Teaching and Learning For The 21st Century

In the rapidly changing global economy of the 21st century, there is a significant need to prepare learners for a life in which higher-order thinking skills and creativity have become the main driving factors of economic and societal progress. In addition, learning needs to be structured to provide the learners with not only the highest standards of subject knowledge, but also the competencies (attitudes, skills and knowledge) and values to live successfully in an increasingly diverse and interdependent world.

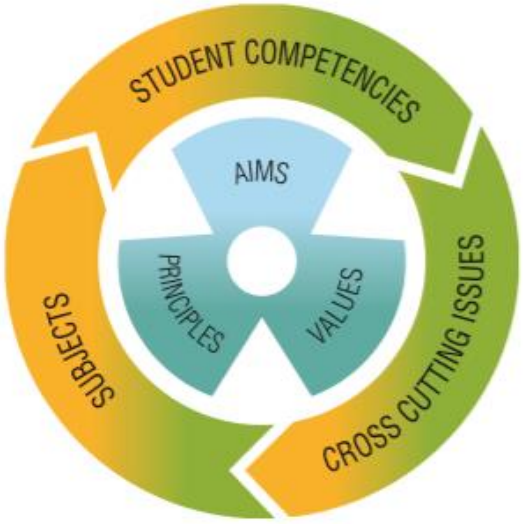

Figure 1 Model of Qatar National Curriculum Framework (QNCF 2016)

Similar to other high performing countries, the development of the QNCF is a critical component of the education system where learning is set out in wider context and links the different elements of education in a structured, cohesive and systematic way as illustrated by the model above. (Figure 1)

The new science curriculum takes its reference from the QNCF where approaches and strategies for the teaching and learning of science will help to:

- Reflect the Qatari values and principles as well as being capable of realising the aims of the curriculum;
- Provide quality learning and quality learning outcomes for students by focussing attention on the competencies that all learners need to develop if they are to successfully respond to the opportunities and challenges of the 21st century;
- Increase alignment of curriculum standards with the needs of the country, manpower and demands of higher education;
- Emphasise active and personalised learning in the classrooms;
- Increase efficiency and effectiveness of student assessment through the implementation of more targeted and focused assessment strategies; and
- Develop and design learning materials including textbooks that will meet the aims of the new curriculum and needs of the learners.

Specifically, in relation to the teaching and learning of science in the 21st century, this section will cover the following components:

- Key Competencies
- Learning Experiences
- Teaching Science
    - Assessment
    - Scientific Inquiry
    - Social Constructivist Theory
    - Integration of ICT
    - Links to other subjects and cross-cutting issues

Key Competencies

The Qatar National Curriculum Framework reflects a competency-based approach, defining several key competencies in the context of science and other subjects. The new science curriculum requires learners at an early stage of their education to develop five key competencies so they can apply them in science and in other subjects and cross-cutting issues, and throughout their life. The five key competencies that are deemed more significant to the learning science are Inquiry and Research, Communication, Creative and Critical Thinking, Co-operation and Participation and Problem Solving. The key competencies will support and enhance students' understanding of science and can be developed in the classroom through the design and execution of science learning experiences as described in the standards.

Figure 2: The components of competency (QNCF 2016)

Competencies are not learned in isolation, but in the context of science and other subjects. There is no direct one-to-one relationship of one key competency to each subject or strand. This means that the knowledge context within science is more consistent with some competencies and more appropriate to be used, developed and acquired.

In the teaching and learning of science, the competencies of literacy and numeracy are fundamental to effective and efficient learning and integrated into the science subjects and lessons. For example, students develop the capacity to apply numeracy, literacy and communication skills to explore natural phenomena. Essentially, the application of mathematical and computational skills will help to develop scientific knowledge. Students may strengthen the usage of mathematical vocabulary and skills in a creative manner in support of problem-solving activities. Language is the key carrier for conveying ideas, formulating conclusions and developing reports. In short, the twin competencies intersect with the other five competencies will help to develop and expand the students' literacy and numeracy competencies and permeate the learning of science.

The five key competencies as emphasised in the science curriculum are described as follows:

Creative and Critical Thinking

Logical thinking implies using concepts and mental operations to draw inferences and to link premises and conclusions. However, developments in today's world clearly emphasise the importance of creativity and critical thinking in addition to logical thinking. It is widely recognised that creative and critical thinking are interwoven, and neither can be separated from the other (Paul & Elder, 2003, 2008). When solving real-life problems, it is customary to move back and forth between creative and critical reflection as we reject less viable options, conjure plausible solutions while considering the consequences of any one solution. Thus, creative and critical thinking can be considered as a single process (Chiam et al., 2014).

Although creative thinking and creativity are conceptually related, they are not identical. Through creativity, issues and problems are approached from new and original perspectives (i.e. out-of-the-box and/or divergent thinking), a process which relies on discovery and problem solving. Critical thinking implies the capacity to reflect on one's own thinking, as well as the thinking of others, to identify the premises or foundations of our reasoning and mental inference and to consider whether the reasoning is correct (i.e. whether conclusions reached are valid and relevant). The competency to think creatively and critically has always been important in the science curriculum but is more important and essential in an era of rapid social, technological and economic changes. The development of this key competency will enable students to analyse, understand and adapt to new and changing circumstances in imaginative ways.

Teachers are the fundamental lever for promoting students' creativity and critical thinking. Teachers need to respect students' thinking and encourage students' self-belief to contribute to their own learning and thinking which would then culminate in the development of creative and critical thinking (Chiam et al., 2014). This key competency can be developed through learning experiences involving:

- Identification and processing information accurately such as through the first step in problem solving.
- Drawing appropriate conclusions following different types of reasoning (i.e. deductive, inductive, probabilistic) such as through conjecturing relationships and making generalisations.
- Using imagination to suggest alternatives such as when discussing real-life applications of science, suggesting alternative solutions to a problem, and creating scientific solutions based on conditions provided.
- Assessing the validity of one's own and others' reasoning through following a line of inquiry, developing an argument or justification, and defending an argument.

Communication

The capacity to communicate effectively is a foundation for developing and sustaining personal relationships, for engaging in formal and informal social interactions, and for being successful in all areas of learning and in all careers. Good communication involves understanding, appreciating and applying a wide range of verbal and non-verbal skills. Research has shown that scientific communication is effective in improving students' conceptual understanding, a reduction in anxiety in learning, and achievement.

Students learn to use language and writing to explain new learning and their ideas which, in turn, help them to construct new ways of scientific thinking and positive emotions towards science. Given its importance for personal and social development, communication is a key competency which is included in almost all modern curricula. Teachers should allocate time in their lessons for students to use scientific communication. This key competency can be developed through learning experiences involving:

- Listening and comprehending oral and written scientific ideas, arguments, thinking and solutions.

- Speaking and writing clearly to communicate scientific ideas, arguments, thinking and solutions coherently, particularly during problem solving.
- Using a range of media, technologies and scientific language effectively.

Co-operation and Participation

The capacity to co-operate with others and to participate in group and community activities is a highly-valued competency in a range of contexts. As members of increasingly complex communities and societies, students must be able to respect the views and personal attributes of others and to contribute positively to the efforts of groups.

Schools rely heavily on students and teachers to be able to work cooperatively and participate actively, including in co-operative group projects, in classrooms and as whole school communities. Group work as a form of active learning, has found to help students to develop a range of critical thinking, analytical and communication skills; effective teamwork; appreciation and respect for other views, techniques and problem solving methods, all of which enhance student learning in science.

The science curriculum is set within a 'social constructivist' theory of learning that sees learners as active participants in their own learning. The learning experiences require students to learn actively in order to make meaning of the learning they are experiencing. This social constructivist theory stems from the work of Vygotsky in the 1930s (published 1978). In the new science curriculum, specific learning experiences are designed for group work or pair work which create opportunities for students to co-operate and learn from one another. Teachers need to prepare or teach students the ways to work cooperatively together, such as respect for self and others, taking responsibilities and giving constructive feedback (Gillies & Boyle, 2010). This key competency can be developed through learning experiences involving:

- Espousing one's scientific thinking confidently.
- Respecting differing views when working together during pair work, group work and projects.
- Working collaboratively towards common goals.
- Being aware of their rights, responsibilities and duties during collaborative work.
- Negotiating, respecting others' rights and responsibilities, and using constructive strategies to resolve disputes and conflicts.
- Developing leadership skills, including skills to assess risks and make informed decisions, to negotiate and to compromise with a view to reaching win-win solutions.

Inquiry and Research

Students should be encouraged to develop the knowledge, skills and attitudes related to inquiry and research, such as being curious about the world around them, to formulate and articulate questions and hypotheses, and to develop systematic approaches to finding and analysing relevant information in science learning. Like in mathematics, scientific inquiry starts with a problem or question with emphasis on practical experimenting (Rocard et al., 2007).

Inquiry in science involves a wide variety of tasks, including articulating or elaborating questions; modelling; exploring; conjecturing; testing, explaining, reasoning, arguing and proving; defining and structuring; connecting, representing and communicating (see PRIMAS, 2012).

While inquiry in science is mostly student-centred and student-driven, teachers must scaffold student learning by modelling and coaching (Calleja, J. 2016). Students' genuine questions, opinions and suggestions should always be appreciated and never be devalued or ridiculed. Mistakes that they might make in this process should be viewed as valuable opportunities to promote deeper understanding. This key competency can be developed through learning experiences involving:

- Scientific investigation, challenging students to look for alternative solutions which helps to develop an interest in inquiry.
- Planning and carrying out problem solving, using information provided and a range of strategies.
- Using the latest technology imaginatively, ethically and responsibly for scientific display, research, and modelling.

Problem-solving

Research has shown that placing problem solving at the centre of science education has been proposed as early as the 1980's. The capacity to solve problems continues to retain its relevance and perhaps has become an even more important competency now as we seek to meet the demands of an increasingly uncertain future. Teaching and learning in science should be characterised by the application of knowledge and skills to a range of problems, both real, authentic and simulated.

Problem solving activities should be promoted in conjunction with other competencies, such as 'creative and critical thinking', 'communication', 'inquiry and research' and 'co-operation and participation'. Consistent with Bloom's taxonomy and similar hierarchies, the ability to understand and solve problems is a competence that is highly regarded in higher education and employment because it illustrates a capacity to apply learning in deeper and more complex ways than simply remembering information. Problem solving is regarded as a higher-order intellectual skill that is essential in the context of today's and tomorrow's world, a world which requires people to adjust to changes of an unprecedented pace while constantly addressing new challenges, situations and opportunities. Teachers should be well-versed in the reasoning and problem-solving skills, incorporating them into their lessons to support students' learning. This key competency can be developed through learning experiences involving:

- Suggesting and developing solutions to problems and thinking of alternative approaches to solve a problem.
- Applying complex ensembles of knowledge, skills and attitudes to solve familiar, new and real-life problems.
- Posing problems that meet given conditions.
- Cooperating and working with others to solve problems.

Learning Experiences

Learning science involves more than the acquisition of content knowledge and scientific skills. It entails cognitive and meta-cognitive process skills such as reasoning, communication and connecting, to create an effective learning process.

Learning experiences, as the term implies, refer to the way students learn science through their own experiences, sometimes referred to as experiential learning and is thus considered student-centric in approach. The underlying goal of learning is to encourage students to take ownership of what they learn. The idea of using learning experiences in education can be attributed to John Dewey (1938) Dewey once said, "Give the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking; learning naturally results." Thus, it is important to complement direct instructions from teachers with active learning for students through learning experiences.

Through learning experiences, students learn to explore, think and reflect on their own. Students further strengthen the key competencies of co-operation and participation and communication when they are provided with the opportunity to collaborate with peers and communicate their thoughts or findings. In the process, students also hone their cognitive and metacognitive process skills and science makes sense through their own efforts.

The learning experiences in the new science curriculum are aligned to the science learning outcomes, however not necessarily in a one-to-one relationship as some of the learning experiences may achieve one or multiple learning outcomes. The learning experiences are intended to provide teachers ideas about the purpose of experiential learning, resources to prepare beforehand and materials required of students. Teachers need to be proactive and encourage a growth mindset among students before the students undertake the task. Experiential learning emphasises the importance of experience to strengthen one's skills and knowledge (Akella 2010). According to Klein (2003) teachers must be facilitators to promote learning, as mere transmission of information does not guarantee that learning has taken place. Thus, it is imperative for facilitators to lay the groundwork for students to become actively involved in the learning process.

Learning experiences may be topical or generic. The following list of learning experiences is by no means exhaustive. Through learning experiences, students are given the opportunity to:

- Conduct fact-finding, make observations and organise information;
- Demonstrate knowledge and understanding in relation to scientific vocabulary, terminology and conventions;
- Explore the rationale of concepts, formulae and equations;
- Manipulate numerical and other data;
- Use information to identify patterns, report trends and draw inferences;
- Present reasoned explanations for phenomena, patterns and relationships;
- Reinforce the learning of concepts using teacher-designed worksheets;
- Apply scientific knowledge in a real-world context and solve problems using a repertoire of thinking skills and problem-solving strategies;
- Make predictions and propose hypotheses;
- Identify anomalous results and suggest improvements to investigations;
- Conduct a fair test during an experiment where only one factor or variable is changed at a time while keeping all other conditions the same;
- Develop skills in using ICT tools; and
- Carry out multi-disciplinary projects where the use of science is integrated with other subjects or cross-cutting issues.

Teaching Science

In line with the QNCF, the approaches to teaching and learning need to shift from teacher-directed towards student-centric instructions and more engaging strategies. This shift needs to occur in classrooms and will have implications for lessons, other learning experiences and learning materials.

In developing students as active learners, teachers need to be more than providers of information. They need to be facilitators of learning, creating learning opportunities and constructing adequate learning experiences. It is expected that whole-school approaches and whole child approaches should be promoted where teachers are involved in communities of practice to work co-operatively towards attaining common goals while sharing effective and successful practices and learning from one another. In order to ensure students' learning is meaningful, information and concepts need to be presented through real-life examples that make sense to students within the context of their experiences. Students when actively engaged in the learning process, will be willing to ask questions, propose ideas and to investigate for themselves and draw their own conclusions.

The remaining section will outline some key and research-based teaching approaches and strategies that could be deployed in the classrooms. These may include but are not limited to scientific inquiry approach, social constructivist theory of learning, integrated use of information and communication technology (ICT) and links to other subjects and cross-cutting issues.

Assessment

Assessment is an integral part of the teaching and learning process. As laid out in the QNCF, assessment needs to address 'of learning' and 'for learning' as well as to assess the breadth of learning.

The aims of the science curriculum are the acquisition of knowledge, understanding and application of the science concepts, the ability to use process skills, and the development of attitudes important to the practice of science. The assessment objectives, aligned to the domains in the QNCF (attitudes, skills and knowledge) will need to measure the extent to which desired standards and competencies (knowledge, skills and attitudes) are attained by students, including higher order thinking skills.

Assessment also provides formative (assessment for learning) and summative (assessment of learning) feedback to teachers, students, schools and parents. Below illustrates the use of assessment information for the different stakeholders:

- For the students, assessment provides feedback to them and allows them to understand their strengths and weaknesses. Through assessment, students can monitor their own performance and achievement of standards and progress. It also points them in the direction they should go to improve further.
- For the teachers, assessment provides feedback to them and enables them to understand the strengths and weaknesses of their students. It provides information about the students' achievement of standards and learning outcomes as well as the effectiveness of their teaching.
- For the school leaders, assessment provides feedback to schools. The information gathered facilitates the placement of students in the appropriate grade or pathway, and the promotion of students from one level to the next. It also allows the schools to review the effectiveness of their science curriculum and its implementation.
- For the parents, assessment provides feedback to them and allows them to monitor their children's progress and achievement through the information obtained.

As assessment serves many purposes, it is important to match the type of assessment to the specific purpose for which it is intended. Before making a judgement about a certain aspect of students' performance, the teacher should ensure that the assessment mode used will generate information that reflect accurately the aspect of performance the teacher intends to assess.

For meaningful assessment, teachers can use real-world situations involving Science in daily life, society and the environment as the starting points for the construction of questions in order to mirror the application of scientific knowledge in real-life contexts. The real-world situations chosen should be significant and engaging for example, the reasons why there is a need to explore renewable energy resources in Qatar or the importance of water conservation and new ways of producing fresh water for the country.

Assessment is more than tests and examinations and can take many forms. In addition to the written tests, teachers can also conduct performance-based assessment using the following modes in the science curriculum:

- Practicals
- Projects
- Teacher observations
- Checklists
- Reflections / Journals
- Model-making
- Posters
- Games and quizzes
- Debates
- Drama / Show and Tell
- Field trips
- Portfolio

The different assessment modes may also provide opportunity for the students to have self-evaluation and reflections by revisiting their own assessment work.

The assessment modes listed above are by no means exhaustive. Adopting a variety of assessment modes enables the teachers to assess different aspects of the teaching and learning of science.

Scientific Inquiry

Scientific inquiry is an essential component of the new science curriculum. Although closely related to science processes, scientific inquiry extends beyond the mere development of process skills such as observing, inferring, classifying, predicting, measuring, questioning, interpreting and analysing data. Scientific inquiry combines the processes with scientific knowledge, scientific reasoning and critical thinking to develop scientific knowledge. Basically, there are five essential features of science as inquiry namely: question, evidence, explanation, connections, and communication.

Scientific inquiry is often viewed as the continuum of levels of instruction of inquiry necessary to engage students in authentic and meaningful scientific experiences. The instruction may involve a more teacher-guided inquiry that provides students with more support to develop and apply concepts and skills to a more open and student-directed inquiry. For a complex inquiry, it may be appropriate to have

more of teacher-guided inquiry approach than student-directed inquiry approach for the beginning inquirer of science.

With the emphasis on the learning of science as inquiry, teachers can incorporate the strategies (listed in the table below) in the planning and delivering of their lessons. The strategies used will help to engage students in meaningful learning experiences and cultivate their interest and curiosity in science. In addition, teachers can incorporate in these strategies; the essential features of Question, Evidence, Explanation, Connections and Communication.
These strategies all support meaningful practical work, which in turn should be delivered by the students carrying out the experiments themselves, or in some cases by students watching a teacher demonstration.
A set of age –related descriptions of the components of scientific enquiry is provided in Appendix 2

A brief description of each of these strategies is given as follows:

Strategy	Description
Brainstorming	Brainstorming is a strategy for generating creative ideas and solutions.
Case Study	The case study approach is a strategy which uses real and hypothetical cases to help students develop critical skills such as analysing, inferring and communicating
Concept Mapping	Concept mapping is a strategy to present meaningful relationships among concepts. Concept maps are useful in organising and linking concepts or ideas
Demonstration	Demonstration is commonly used to scaffold the learning process. This approach is recommended when the learning activity is not safe or too complex for students to set up on their own.
Field Trip	A field trip is any learning activity outside the school. It provides opportunities for students to explore, discover and experience science in everyday life.
Games	Games engage students in play or simulations for the learning of concepts or skills. This is useful in helping students to visualise or illustrate objects or processes in the real world.
Investigation	In scientific investigation, students engage in activities that mirror how scientists think and what they do in a decision-making process, such as asking or posing questions and planning or designing investigations.
Model Building	Model building is an activity in which students design and construct a representation of a concept or object.
Practical work	Students carry out practical investigations themselves. These may range from simple activities lasting minutes, to experiments requiring complex apparatus which may take an entire lesson

Problem Solving	Problem solving engages students in finding solutions to problems by applying scientific knowledge and skills.
Projects	Projects are learning activities that require students to find out about an object, event, process or phenomenon over a few weeks or even months.
Questioning	Questions are useful tools in the scientific inquiry process. Both teachers and students should engage in cycles of questions-answers-questions throughout the learning process.
Role Play, Drama and Movement	Role play, drama, and movement allow students to express their understanding of scientific concepts and processes in a creative way. They can also be a valuable way for students to explore some of the ethical issues linked to some areas of science.
Stories	Stories of science in everyday life and of scientists can capture students' interest and engage them in talking about science. Either the teacher or students can be the story creator or teller.

The list of strategies for conducting inquiry-based learning and teaching is not exhaustive. The following illustrate how some strategies are incorporated into the learning experiences across strands and grade levels in the new science curriculum.

In Kindergarten, students during their Biology lesson, will listen to stories about animals and plants while in Grade 1 Chemistry lessons, students will work in pairs to use an App or online games to explore and classify objects based on the material from which they are made. At Grade 3, students during a Chemistry lesson, will work in small groups to create a project booklet showing the uses of different building materials. In Grade 7 Chemistry lessons, the teacher organises a field trip for students to study the origins of the Qatar gas field and in Grade 7 Biology lessons, students use microscopes to observe and draw a range of different plant and animal cells. In Grade12A Physics lessons, students work in small groups to conduct a fair test to investigate the relationship between the centripetal force on an object and the speed of an object in uniform circular motion.

The benefits of an inquiry-oriented teaching approach in the science curriculum are students:

- Take ownership of the learning;
- Experience the scientific method and acquire an appreciation and understanding for scientific achievement;
- Become interested in ongoing and future scientific achievements as it relates to current events;
- Experience the successes and failures of scientific research;
- Learn to collaborate to obtain successful results;
- Develop critical thinking and problem-solving skills; and
- Retain the learned concepts better.

The teacher would need to take on the role of facilitator of scientific inquiry in the teaching and learning of science in the science laboratory, the classroom as well as the outdoors. Teachers should strive for a mix of inquiry levels appropriate to the abilities of their students. To this end, it is essential for the teacher to create a conducive and positive learning environment that will provide ample equal opportunities for all students to be encouraged to develop their science inquiry skills as an inquirer of science. With experience, students will be able to achieve the required levels and methods of scientific inquiry in their journey to becoming scientifically literate.

Social Constructivist Theory

Vygotsky's theory of sociocultural learning in the 1930s highlights the role played by social and cultural interactions in the learning process. His work has been built on over the years by researchers and theorists such as Bruner (1966) and more recently by Gardner (1999), Craft (2008) and Goswami (2008). Vygotsky's theory states that knowledge is co-constructed and that individuals learn from one another. It is called a social constructivist theory because in Vygotsky's opinion the learner must be engaged in the learning process. Learning happens with the assistance of other people, thus contributing the social aspect of the theory. A fundamental aspect of Vygotsky's theory is the Zone of Proximal Development. This is a "range of tasks that are too difficult for an individual to master alone, but can be mastered with the assistance or guidance of adults or more-skilled peers" (Vygotsky, 1962). Another part of this theory is the idea of "scaffolding", which is giving the learner the right amount of assistance at the right time. If the learner can perform a task with some assistance, then he or she is closer to mastering it. This theory is relevant to teaching and learning of science because if students work in pairs, they are interacting with people and therefore can learn different ideas from one another. This theory shows that when students learn from each other, they can assist one another and co-construct knowledge in science.

This theory can be applied in the classroom in several ways. The students can be grouped such that the students who understand the content work with the students who do not. For example, if a student did not understand the concept of "acceleration" in Physical Processes, a teacher could have another student explain the concept to him or her. The more knowledgeable peer might use different language than a teacher. The student's phrasing might make more sense to the other student. The more knowledgeable student would also learn something, perhaps a deeper understanding of the content or a way to explain the concept that they had not thought of before. Students of different readiness levels will work together in groups when they do discovery activities, such as problem-based learning activities. The groups would consist of at least three students and they would be given a problem that would challenge them all, and as a group they would have to solve the problem. The activity could be designed such that it allows for everyone to contribute some ideas as to how to solve the problem before any method is attempted. Thus, the development of science-related competencies like problem-solving, communication and co-operation and participation could be further enhanced.

The constructivist view of learning can point towards a number of different teaching practices; this usually means encouraging students to use active techniques (investigations, field trips, science competitions and fairs) to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing. With a structured approach, the students learn "how to learn" and learn science in a spiral approach; when they continuously reflect on their experiences and increasingly develop strong abilities to integrate new information.

With the advance of technology, students may also interact with the wider community beyond the classroom and nation, through online platforms and inter-institutional collaborative projects.

Integration of ICT

Several studies and reports have highlighted the opportunities and the potential benefits of ICT for improving the quality of education. While ICT is taught as a separate subject in the Qatari curriculum, ICT is also expected to be integrated into subjects like Science.

According to Hennessy (2003) and Denby and Campbell (2005), ICT use in science learning can:

- Make learning active, constructive, contextual, cooperative, self-regulated, reflective and cumulative. Thus, it engages students in tackling the topic to be learnt and they can create meaningful knowledge.

- Increase interest, motivation and engagement in activities;
- Provide access to resources (web-pages, text, databases, videos, demonstrations, applets) that are of high quality and relevant to science learning;
- Help students focus attention on over-arching issues, increasing understanding of abstract concepts;
- Enable visualisation and manipulation of complex models, three-dimensional images and movement to enhance understanding of scientific ideas;
- Supporting exploration and experimentation by providing immediate, visual feedback
- Help students to strengthen their digital competencies (use of computers to retrieve, present and exchange information via the Internet),
- Expedite and enhance work production and offer release from routine laborious manual processes, affording more time for thinking, discussion and interpretation; and
- Increase currency and scope of relevant phenomena by linking science to contemporary science and providing access to experiences not otherwise feasible.

The internet and the advent of mobile computing have escalated the use of ICT in education to a greater height; learning goes beyond the confines of the classroom to become borderless and available 24/7. Suggestions on the use of ICT can be found in learning experiences which are tagged to learning outcomes and competencies. However, teachers are expected to use ICT whenever, in their judgement, it enhances learning or provides a more efficient means of delivering an outcome.

ICT use in science education may be classified into tool applications and ICT use in learning, and the latter may be classified into three categories of directly supported learning, computer-assisted learning and computer-assisted inquiry (McFarlane & Sakellariou (2002). Below are some examples of the varied ICT use in the science education:

- Science education software for young learners where they learn basic terminology to explore science concepts;
- Use of word processing, spreadsheets, graphing and modelling tools including concept mapping in science activities;
- Electronic mail, newsgroups, chatrooms, blogs and video-conferencing may be used to collect information and data to support inquiry and distance learning approaches;
- Learning Management System e.g. Moodle or Blackboard may provide a platform to mount self-directed courses on science topics with accompanying notes, projects and resources
- Simulation and virtual experiments can be conducted in the absence of actual resources and help students to problem solve. Additional digital equipment connected to computer to make digital recording that are effective and efficient for science learning e.g. a microscope connected to a computer to made images of cells available to the whole class or use of sensor or data loggers to monitor the rate of chemical reaction more accurately.
- Science Websites that offer a wide range of web applications and information on science e.g. applets to enhance the explanation and interpretation of processes in nature or technological world; and
- Mobile computing has given rise to a wide range of hand-held personal digital assistants (PDAs) like tablets, smartphones. These have impacted the way of teaching and learning, where students may discuss and exchange ideas interactively on voice and transmit data and multimedia displays from device to device over the internet. In addition, numerous apps are available for downloads and use in science learning.

The rich digital world has strong implications for science education. The roles of teachers and students need to shift from traditional to one that can harness the power of ICT to support and facilitate the teaching and learning of science. When students are provided with the best possible learning

opportunities through the integrated use of ICT in science, they will progress towards becoming active learners equipped with the required competencies and skills for life-long learning.

Links to Other Subjects and Cross-cutting Issues

The new science curriculum recognises that learning of science is not done in isolation but has linkages with other subjects and cross-cutting issues identified in the QNCF. For example, mathematics develop the students' capacity to enhance the numeracy competency through the application of mathematical formulae and equations and computational skills to develop scientific knowledge; in the Arts: the subject provides the tool for expressing scientific concepts and imagining scientific models; in Social studies, the learning of science and natural phenomena is further reinforced through the study of environment-related topics and sustainability and in Physical Education, science plays a role in promoting healthy life styles and in analysing the mechanisms of the body in order to identify appropriate ways for exercising in relation to different sports.

There are also strong links between the sciences, which teachers can highlight and use to support learning and conceptual development in their students. Examples include the study of light and sound in physics, and the biology of the senses, including the eye and the ear; the chemistry of reaction rates and the biology of enzyme action; and the chemistry of the atom and the physics of radioactivity.

Thus, facilitating students to make connection with other subjects and cross-cutting issues is an important aspect of teaching science. In addition, through projects related to everyday life or other subject areas, information from external resources and use of ICT, students learn to see a wide range of connections between science and the world at large.

The QNCF has stated six cross-cutting issues which are an important component of the national curriculum as listed as follows:

- The Environment and Sustainability
- Life Skills
- Safety and Security
- Health Education
- Values Education
- Family Education

Cross-cutting issues are deemed key issues that young people should learn about, which do not fall entirely within certain subject or knowledge areas, but they intersect in one or more subject or area within their context. Like the student competencies, there is no strict one-to-one relationship, and it is important that teachers of science understand and include the relevant cross-cutting issues in their lesson. Through exposure to these cross-cutting issues during science lessons, students are provided appropriate learning contexts and deepen their understanding of science. For example, through Materials lesson, students are involved in conservation projects and appreciate the value of renewable energy resources to protect the environment and ensure sustainability of resources.

Future Directions

The 21st century brings both opportunities and challenges for implementation of the curriculum and teaching and learning of science. Content and approaches related to science curriculum should not be static and must respond to global challenges and changing national priorities.

For example, it may be at some time necessary to develop new subjects in response to changing technologies or to develop specific electives in response to changing economic and employment trends

in Qatar. Thus, the Qatar Education System (Figure 3) has introduced three different pathways at Grade 11A and 12A in 2018 to address the learning needs of students and eventually different career aspirations. What is important throughout the process of adaptation and change is that the content and approach must be consistent with the philosophy of the QNCF and contribute to the achievement of its aims. Science must continue to reflect the principles of QNCF and contribute in its own way to the development of key competencies and to an understanding of cross-cutting issues both in Qatar and across the world.

Increasingly employers place great value on the capacity of their employees to show initiative, to communicate effectively, to work in teams and to be creative thinkers and problem-solvers. The universities also value students who are familiar with inquiry and research, can communicate their thoughts and ideas and can manage their own learning. As such, the curriculum needs to focus more intensely on the development of competencies that will ensure "college-readiness" and "work-readiness" ensuring that learners will be prepared for new frontiers of learning in science and be future-ready.

5

THE SCIENCE CURRICULUM: KINDERGARTEN to GRADE 12

The Science Curriculum: Kindergarten to Grade 12

About the Science Curriculum

The new science curriculum for Kindergarten to Grade 12 is designed in alignment to the QNCF and QNV 2030 together with its implementation, adopting learner-centric teaching and learning practices. The key features of the new science curriculum are described in the following sections.

Subject Architecture

The content of the science subjects is arranged in a hierarchy as shown below. The strand is at the highest level where the content is organised into themes and topics. The achievement of the related standards will eventually be met via the learning outcomes and learning experience at the lowest level.

- Strand
- Theme
- Topic
- Standard
- Learning Outcome
- Learning Experience

The science subject is divided into three strands, namely Biology, Chemistry and Physics. The strands can be taught in an integrated way, with an increasing focus on the separate strands in the higher grades. Thus, the science subjects of Physics, Chemistry and Biology are taught separately at Grade 10 to 12A with a focus on acquiring higher levels of knowledge and skills.

Unpacking of Standards

There is a tendency for standards documents to identify more content than can actually be taught. In addition, standards documents are written in a way that demand constant thought and discussion to carefully interpret its meaning as the practical meaning of a standard may not be self-evident. In order to make the standard document more useful to classroom teachers, the new science curriculum addresses this challenge by unpacking the standards with the articulation of the expected learning outcomes which is further enhanced with the design of learning experiences. The associated learning outcomes aim to provide greater clarity and strengthen the acquisition of the required skills and knowledge as outlined in the science curriculum and enhances classroom instruction and assessment. Some of the learning experiences are compulsory, ensuring that all students have a rich experience of active learning. Others are additional – if time allows, teachers may use them to reinforce competencies, extend more able students or support weaker students.

Streamlining of Standards

As part of the curriculum review and revision processes, standards were streamlined. This involved:

- Removal of repeated standards from different grades in the previous curriculum while maintaining the spiral approach of the science curriculum. For example, in the strand of Materials and Chemistry, the standard 19.7 at Grade 10 was removed as it was repeated in Grade 12A topic “Properties of Transition Elements and their Compounds”. Within the theme, Patterns in Chemical Reactivity, the content at Grade 10 on the periodicity in the properties of element will be built on as students transit to Grade 12A and learn specifically on the properties of Transition Elements. In the Earth & Space strand, the standards 13.1,13.2 and 13.6 were

removed in Grade 6 as the content at Grade 6, related to movement of the Earth and Moon will spiral to the standards related to the Solar System. Likewise in the Physics strand at Grade 10, standards related to properties are removed to focus on the study of wave front as there is a progression of knowledge from basic properties of waves at Grade 9 to Wave fronts at Grade 10 and advanced properties of waves at Grade 11A.

- Deletion and or merging of standards to reduce content; Addition of standards to address gaps in content and to ensure that new advances in science are introduced. .This particularly relates to the environment and the world we live today, and topics such as genetic modification.

Bloom's Taxonomy

The old Standards can be somewhat opaque, and they often vary in clarity, complexity and specificity. Concerted efforts were taken to rephrase or revise the standards and related learning outcomes and learning experiences using Bloom's Taxonomy of action verbs. This will help to reflect progression of learning across the grades and development of higher-order thinking skills, in alignment with the new science curriculum and QNCF. Bloom's Taxonomy of action verbs is given in **Appendix 3.**

Learning Experiences

Learning experiences are designed across all grades for all three strands of the new science curriculum in a coherent and consistent approach and comprise the keys to realising the aims for science education. The learning experiences provide opportunities to actively engage learners to deepen their understanding of core concepts as well as the platform for teachers to enhance their teaching to achieve the expected learning outcomes and standards of the science curriculum. They vary from short oral exercises to relatively complex practical work

Competency Tagging

Five competencies of Inquiry and Research, Critical and Creative Thinking, Co-operation and Participation, Communication and Problem-solving were highlighted to be of greater significance in the learning of science across grades, and across the wider curriculum. Thus, most learning experiences are explicitly tagged to one or more competencies. This give teachers guidance on the skills which are most relevant in a particular Learning Experience and helps them ensure the development of the full spectrum of desired competencies among the learners over the years. These competencies are summarised below.

Creative and Critical Thinking

This key competency can be developed through learning experiences involving:

- Identification and processing information accurately such as through the first step in problem solving.
- Drawing appropriate conclusions following different types of reasoning (i.e. deductive, inductive, probabilistic) such as through conjecturing relationships and making generalisations.
- Using imagination to suggest alternatives such as when discussing real-life applications of science, suggesting alternative solutions to a problem, and creating scientific solutions based on conditions provided.
- Assessing the validity of one's own and others' reasoning through following a line of inquiry, developing an argument or justification, and defending an argument.

Communication

This key competency can be developed through learning experiences involving:

- Listening and comprehending oral and written scientific ideas, arguments, thinking and solutions.
- Speaking and writing clearly to communicate scientific ideas, arguments, thinking and solutions coherently, particularly during problem solving.
- Using a range of media, technologies and scientific language effectively.

Co-operation and Participation

This key competency can be developed through learning experiences involving:

- Espousing one's scientific thinking confidently.
- Respecting differing views when working together during pair work, group work and projects.
- Working collaboratively towards common goals.
- Being aware of their rights, responsibilities and duties during collaborative work.
- Negotiating, respecting others' rights and responsibilities, and using constructive strategies to resolve disputes and conflicts.
- Developing leadership skills, including skills to assess risks and make informed decisions, to negotiate and to compromise with a view to reaching win-win solutions.

Inquiry and Research

This key competency can be developed through learning experiences involving:

- Scientific investigation, challenging students to look for alternative solutions which help to develop an interest in inquiry.
- Planning and carrying out problem solving, using information provided and a range of strategies.
- Using the latest technology imaginatively, ethically and responsibly for scientific display, research, and modelling.

Problem-solving

This key competency can be developed through learning experiences involving:

- Suggesting and developing solutions to problems and thinking of alternative approaches to solve a problem.
- Applying complex ensembles of knowledge, skills and attitudes to solve familiar, new and real-life problems.
- Posing problems that meet given conditions.
- Cooperating and working with others to solve problems.

Scientific Inquiry Standards

In the new science curriculum, the four standards related to the scientific inquiry strand are integrated into the other three strands of Biology, Chemistry, and Physics. The standards are:

- Standard 1 - Use methods of scientific investigation
- Standard 2 - Know how scientists work
- Standard 3 - Process and communicate information
- Standard 4 - Handle equipment and make measurements

The Scientific inquiry standards are reflected in the learning experiences for students to better acquire the related skills and processes. Examples include the design of numerous investigations and experiments across the strands and grades to use the scientific methods and understand how scientists work to formulate hypothesis, collect evidence and draw conclusions. Often students need to perform experiments involving the use of science apparatus and take measurements of volume, mass and time; followed up with recording data gathered, and presenting the information in tables or graphs, and at

times making oral reports. Thus, learning science in context will help students achieve the standards expected in scientific inquiry.
Students develop their scientific enquiry skills over time as they develop as learners. For example, the measurements made in the early years of learning will be very different from the precise measurements of a student at grade 11A or 12A, but they are part of the same continuum of skills.

Appendix 2 – **The Learning Experience and Scientific Enquiry -** describes in much more detail both what teachers should endeavour to develop and the skills students could achieve.

Recommended Curriculum Time

The new science curriculum assumed that the approximate time needed to deliver the content in a school year of 165 school days is as follows:

Grade	Subject	Weight	Number of periods per week	Recommended curriculum time# (to the nearest hour) per year
K	Science	9%	2 periods	22 hours
1 to 6	Science	9%	3 periods	75 hours
7 to 9	Science	11%	4 periods	99 hours
10	Biology	9%	3 periods	75 hours
	Chemistry	9%	3 periods	75 hours
	Physics	9%	3 periods	75 hours
11A to 12A (Scientific Track)	Biology	12%	4 periods	99 hours
	Chemistry	12%	4 periods	99 hours
	Physics	12%	4 periods	99 hours
	Elective (Geology/Ecology)	6%	2 periods	50 hours
11A to 12A (Humanities Track)	General Science	9%	3 periods	75 hours
11A to 12A (Technology Track)	Physics	12%	4 periods	99 hours
	Elective (Chemistry)	6%	2 periods	50 hours

(Note: #The recommended curriculum time has been calculated based on 45 minutes per period with 33 weeks per year of curriculum time)

Guidelines for the Implementation of Science Curriculum

The new science curriculum adopts a spiral approach with the standards that build upon the previous related content as the learners progress from one grade to the next higher grade. The curriculum design strives to keep the teaching professionals and all stakeholders focussed on the expected learning outcomes and to provide guidance for the teachers specifically on what to teach. The expected learning outcomes related to the standards constitutes the minimum requirement for learners to achieve for each grade over the course of their learning.

The translation of the standards and learning outcomes involved different teaching professionals and stakeholders with different roles as illustrated below:

- Principal and senior managers may use the standards to guide their planning of resources, monitoring and evaluation of the science curriculum and to strengthen the development of school policies related to teaching and learning.
- Subject coordinators and team of teachers may use the standards to develop schemes of work or programmes of study, teaching and assessment resources for each grade level.
- Team of teachers from one or more schools may also collaborate using the relevant standards to design an integrated programme for the selected grade.
- Individual teachers may use the standards in their lesson planning using the newly designed template to reflect learning outcomes and learning experiences which are tagged to desired competencies. Hence, the monitoring and assessment of the learners' progress are more targeted with meaningful reporting for stakeholders like parents.
- Stakeholders involved in the education sectors like school inspectors may evaluate the school effectiveness by taking into account of the extent to which standards are successfully implemented to achieve the aims of the curriculum framework. Similarly, the curriculum and assessment officers may use standards as a fundamental reference for continuing curriculum review, revision, implementation, monitoring and evaluation that will keep the curriculum and assessment in line with the goals of education system. The developers for learning resources (including textbooks) will need to use standards to ensure they are consistent with the aims, values and principles of the curriculum and promote key competencies.
- Other stakeholders, specifically parents may use the standards to support their children's exploration of science concepts and practices. As science is a process of asking and answering questions parents can build on children's curiosity through looking for answers together as they work towards becoming more science literate. In fact, all global evidence points to education being most effective when parents are fully involving in the learning process.

As teachers study, understand and apply the standards, they need to exercise flexibility and creativity during the lesson planning as they incorporate appropriate teaching experiences and pedagogies in the classrooms and beyond. To this end, besides the normal classroom learning activities, the teachers may leverage on extra-curricular activities like community service (recycling projects involving plastic during materials lesson at Grade 7), Science competitions, performances, and sporting activities to develop students' interest, competencies, knowledge and skills related to the cross-cutting issues. These learning opportunities related to science will helped to strengthen the achievement of relevant standards and develop students to be active and responsible citizens.

Where necessary, teachers may customise their instructions for different segments of learners; from high achieving students to move them forward and providing greater support for low progress students who may encounter challenges with basic science concepts. Teachers are key to ensure the standards are translated effectively and meaningful for learners. This has implications on the assessment of standards. The range of assessment strategies need to measure the intended aims of the standards and can include peer and group activity-based, oral questioning (e.g. poster presentation of the stages of

human life cycle in a Biology lesson), performance analysis and assessment in authentic settings (e.g. at Grade 7 Chemistry students could move outdoors to examine different type of rocks and effects of weathering). With a student-centric focus, the new science curriculum and related standards will facilitate the development of learners to maximise their potential with attributes for life-long learning.

The use of standards in the new science curriculum will also guide the revisions of science-related curriculum, instruction, assessment, and professional development for educators in the cycle of improvements for teaching and learning process.

Mathematical Requirements of the Science Standard

The development of scientific knowledge is not independent of mathematics. When working with mathematical ideas, language and procedures in science lessons, there is a need for students to transfer their mathematical skills and understanding effectively to their science learning. While there are important mathematical techniques and procedures to be learned, the way that mathematics is used in science is a matter of judgement influenced by context and circumstances, and not of applying hard-and-fast rules.

The mathematics required by the science standards is introduced in the same grade or in a lower grade in the mathematics standards. This implies that science teachers are strongly encouraged to work closely with their colleagues teaching mathematics to ensure continuity.

A number of the scientific inquiry skills are specifically mathematical. These relate mainly to the expression of data in appropriate graphical formats and the interpretation of graphs and to some extent measurements of physical quantities. The related mathematics topic is covered either in the same or earlier grades of mathematics curriculum in all cases.

Some mathematical requirements may be applicable across all strands like estimating or approximating values for observed quantities during an experiment. Students need to understand uncertainty and error in measuring physical quantities and express results in the appropriate number of significant figures. In the learning of science, students should also be able to interpret graphical behaviour, measure graphical quantities (e.g. gradient, area under curve, intercepts) and determine physical values from them.

In some cases, the mathematical requirement may be more relevant in some strands than the others. Below illustrate three examples where specific mathematical requirements for the study of Grades 10 to 12A science:

- In Biology Grade 10, the topic of Mendelian genetics requires the use of diagram to solve genetic problems and calculate the ratio of genotypes and phenotypes in the progeny (Punnet square). In another instance, students will have to use probability or statistics to predict the gender of the foetus.
- In Physics Grade 11A, the topic of Advanced Properties of Waves involving the Young's double slit experiment. The important mathematical manipulation in science involves the use of composite functions to rewrite complex equations and perform calculations using the equations $\lambda = ax/D$ and $d\sin\theta = n\lambda$.
- In Chemistry Grade 12A, the topic of Reaction Kinetics could require the manipulation of equation, $\ln A = -kt + \ln A_o$ to calculate the half life of first order reactions and demonstrate that the reaction is concentration independent.

6

CONTENT STRANDS OF THE SCIENCE CURRICULUM

Content Strands

In tandem with the review and revision of the science curriculum, the content has been organised into three strands, namely Biology, Chemistry, and Physics. At Grades 10 to 12A there is a focus on the separate subjects within Science, so that Physics, Chemistry and Biology are taught separately. In Grades 7-9 the three science subjects may be taught separately or an integrated approach may be used if desired.

The skills and processes related to Scientific Inquiry (SI) strand have been integrated into the three strands mentioned above. This approach will help to nurture the students as an inquirer in the learning of science and help the students to comprehend that Science is not about just knowing facts, and to take charge of their own learning and apply knowledge to develop explanations for other event, phenomena or new situations.

Each content strand of the new science curriculum is designed around themes that learners can relate to in their everyday experiences and on commonly observed phenomena in nature. The tables below summarise the themes to be implemented at the appropriate grades from Kindergarten to Grade 12A (as indicated by the black boxes).

THE FOUR CURRICULUM MAPS

Primary science					
Biology					
Grade	**Structure and function of organisms**	**Growth, development, reproduction and inheritance**	**Organisms & their environment**	**Health and disease**	**Diversity and variation in living things**
K	- Tissues, organs and systems		- Interdependence of organisms	- Healthy lifestyles	- Classification
1	- Requirements for life			- Healthy lifestyles	- Classification
2	- Requirements for life		- Interdependence of organisms	- Healthy lifestyles	
3	- Tissues, organs and systems			- Healthy lifestyles	- Classification
4			- Interdependence of organisms	- Healthy lifestyles	
5		- Growth and development	- Interdependence of organisms	- Healthy lifestyles	
6	- Tissues, organs and systems: Human body systems	- Growth and development in plants - Human growth and development			- Classification
Chemistry					
Grade	**Materials & their Properties**	**Structure & Bonding of Matter**	**Patterns in Chemical Reactivity**	**Reaction Kinetics & Energetics**	**Chemistry in Our World**
K					
1	- Physical properties of common materials				
2					
3	- Physical uses and properties of materials				- Rocks and their everyday uses
4	- Physical properties and different states of matter				
5	- Physical properties and three states of water				
6	- Physical and chemical changes				
Physics					
Grade	**Waves, light and Sound**	**Forces, motion and scale**	**Electricity and magnetism**	**Matter and energy**	**Earth and space**

K	- Using senses to observe the world				
1		- Movements and what causes them			
2	- Transmission of light through objects		- Simple electrical devices		
3		- Magnetic forces and uses of magnets			
4	- Sound - Heat and temperature				
5		- Friction and resistance	- Simple electrical circuits - Electric charges		
6		- The effects of forces			- Our solar system

Biology					
Grade	**Structure and function of organisms**	**Growth, development, reproduction and inheritance**	**Organisms & their environment**	**Health and disease**	**Diversity and variation in living things**
7	- Cell structure and function - Tissues, organs and systems: plants - Photosynthesis		- Interdependence of organisms - Environment interactions and processes		- Adaptation
8	- Tissues, organs and systems: Digestive system - Tissues, organs and systems: Respiratory system - Tissues, organs and systems: Circulatory system		- Interdependence of organisms	- Healthy lifestyles	
9	- Tissues, organs and systems: Control and coordination - Tissues, organs and systems: The skeletal system - Biochemistry: anaerobic respiration	- Cell division and asexual reproduction - Reproduction in plants - Reproduction in humans		- Communicable disease	
10	- Cell structure and function	- Growth and development - Reproduction - Inheritance and the genome	- Interdependence of organisms - Environment interactions and processes	- Healthy lifestyles	- Classification - Adaptation
11	- Biochemistry: Biological molecules - Biochemistry: Cellular respiration - Biochemistry: Photosynthesis - Cell structure and function: Membranes and transport - Cell structure and function: Enzymes	- Inheritance and the genome - Reproduction in plants	- Microbiology	- Communicable disease	- Variation and natural selection
12	- Tissues, organs and systems: Circulatory system - Tissues, organs and systems: Muscles and movement - Tissues, organs and systems: Control systems in humans - Homeostasis	- Inheritance and the genome		-Communicable disease: body defence systems	

	- Tissues, organs and systems: Transport in plants - Tissues, organs and systems: Control systems in plants				

Chemistry					
Grade	**Materials & their Properties**	**Structure & Bonding of Matter**	**Patterns in Chemical Reactivity**	**Reaction Kinetics & Energetics**	**Chemistry in Our World**
7		-The Particulate Nature of Matter including a model of matter. -Chemical composition of substances in terms of elements, compounds and mixtures			-Physical Properties and uses of metals -Different methods of separation and purification -The origins and properties of rocks
8	-Chemical Changes occurring in substances	-Atoms, Molecules, Elements and Compounds	-Characteristics and chemical reaction of acids and alkalis		-Air and sources of chemical pollution of the environment
9		-Atomic Structure -Chemical Formulae and Chemical Bonding (Ionic, Covalent, Metallic)			-What is a pure substance? -Introduction to Life Cycle Analysis -Reactivity series of metals including extraction of metals.
10		-The Mole Concept and Stoichiometry	-Periodicity in the Properties of Elements -Characteristic Properties of acids and bases. -Organic Chemistry	-Fundamentals of reaction kinetics using collision theory -Types of energy changes, construction of energy profile diagrams	
11		-Structure and -Properties in terms of Chemical Bonding -The Mole concept and Stoichiometry	- Redox reactions Organic chemistry		-Economic, Social and Environmental Issues -Chemistry of Synthetic and Natural polymers and their uses
12			-Periodic Trends in the Properties of Elements	-Concepts of reactions kinetics relating to order of	-Modern Analytical Techniques

			-Properties of Transition elements and their compounds -Organic Chemistry	reactions and factors involved -Concepts of equilibria in chemical reactions and ionic equilibria in aqueous solution -Calculations on Enthalpy changes using Hess's Law -Entropy and Free Energy	

Physics					
Grade	**Waves, light and Sound**	**Forces, motion and scale**	**Electricity and magnetism**	**Matter and energy**	**Earth and space**
7		- Centre of mass and stability - Simple machines - Density and its applications	- Static electricity - Flow of charges in circuits		
8	- Interaction of light with plane mirrors - Interaction between light and the interface of two media		- Household electricity and dangers	- Energy transfers by conduction, convection and radiation	- About the solar system
9	- Basic properties of waves - Interaction of light with curved mirrors	- Pressure and its applications	- Magnetic fields		Evolution of the visible universe
10	- Interaction between light and the interface of two media: refractive index - Interaction between light and lenses	- Physical quantities and uncertainties in experimental results - Kinematics	- The fundamentals of current electricity - Principles of electrostatics, magnetism and electromagnetism	- Nature of matter	
11	- Advanced properties of waves	- The relationship between forces and motion - The relationship between work, energy and power	- Electronic devices in practical control circuits - Electromagnetic induction	- Modern atomic and nuclear physics	
12	- Oscillations and advanced properties of waves	- Gravity and circular motion	- Electric fields and potential	- Fluid behaviour - Fundamentals of thermodynamics - Quantum physics	

7

SCIENTIFIC INQUIRY

Scientific Inquiry

Scientific inquiry denotes the activities and processes which scientists and students engage in to pose questions about the natural and physical world, investigate phenomena and acquire scientific knowledge (Chiappetta, Koballa, & Collette; Crawford, 2007; National Research Council, 2000). As such, teaching science as inquiry would involve students having to plan, conduct investigations, apply the science inquiry skills, think critically about the phenomena, and develop values and attitudes that are important to the practice of science as an inquiry.

Teachers need to demonstrate how the products of scientific investigations are obtained by scientists and provide opportunities for students to ask scientifically oriented questions about knowledge and issues related to the society, their everyday life, and the environment; actively collect and interpret data or evidence; formulate, communicate and justify explanations based on scientific knowledge.

Basically, there are five essential features of science as inquiry namely Question, Evidence, Explanation, Connections and Communication. This also involves the extent of student's ownership of being responsible for their inquiry-based learning as well as that of teacher-guided inquiry as shown in the table. A more teacher-guided inquiry lesson provides students with more support to develop and apply concepts and skills than in a more open and student-directed inquiry. For complex inquiry, it may be appropriate to have more of teacher-guided inquiry approach than student-directed inquiry approach for the beginning inquirer of science.

Essential Features of science as inquiry	**Less Amount of Student Self-Direction ----→ More Amount of Guidance from Teacher ----→**			
1. Student engages in scientifically oriented questions	Student poses a question	Student selects among questions, poses new questions	Student sharpens or clarifies question provided by teacher, materials, or other source	Student engages in question provided by teacher, materials, or other source
2. Student gives priority to evidence in responding to questions	Student determines what constitutes evidence and collects it	Student directed to collect certain data	Student given data and asked to analyse	Student given data and told how to analyse
3. Student formulates explanations from evidence	Student formulates explanations after summarizing evidence	Student guided in process of formulating explanations from evidence	Student given possible ways to use evidence to formulate explanation	Student provided with evidence
4. Student connects explanations to scientific knowledge	Student independently examines other resources and forms the links to explanations	Student directed toward areas and sources of scientific knowledge	Student given possible connections	Student provided with connections
5. Student communicates and justifies explanations	Student forms reasonable and logical argument to communicate explanations	Student coached in development of communication	Student provided broad guidelines to sharpen communication	Student given steps and procedures for communication

Adapted from Inquiry and the National Science Education Standards: A Guide for Teaching and Learning, National Research Council (2000).

In other words, students should be provided with varied meaningful experiences across a range of relevant activities from guided to open inquiry in which the students can pose and respond to questions, design investigations, collect evidence, construct and evaluate their explanations, and communicate their findings. This would help to nurture the students as an inquirer in the learning of science. This would also help the students to comprehend that Science is not about just knowing facts, and to take charge of their own learning and apply knowledge to develop explanations for other event, phenomena or new situations.

The teacher would need to take on the role of facilitator of science inquiry in the teaching and learning of science in the science laboratory, the classroom as well as the outdoors. Besides, 'teacher questioning' is useful in scaffolding instruction and learning, for example, using questioning strategies to elicit what students think, encourage them to elaborate on their thinking, and help them construct conceptual knowledge. This will also help the students to think of new ideas or acquire new way of thinking. Thus, it is vital for the teacher to create a conducive and positive learning environment that will provide ample equal opportunities for all students to be encouraged to develop their science inquiry skills as an inquirer of science.

Essentially exhibiting science inquiry skills in the science inquiry process include:
Pre-engaging in the science inquiry process

- Recognise scientifically oriented question or define the scientific problem
- Pose questions about the event, phenomena or problem
- Formulate hypotheses
- Plan investigations, select techniques, apparatus and materials

Engaging in the investigation during the science inquiry process

- Conduct investigations
- Follow safety rules
- Observe the phenomena
- Collect and represent the data or evidence or observations

Making sense of the information acquired from the science inquiry process

- Analyse and interpret data, evidence or observations
- Construct and evaluate explanations
- Evaluate the method of investigation
- Make decisions or predictions, infer conclusions
- Communicate scientific findings, information, and justify the explanations

8

SCOPE AND SEQUENCE

Scope and sequence

Curriculum content

The content of the Science Curriculum for each grade is defined as follows:-

- **Strand** – Biology/Chemistry/Physics
- **Theme** – The 5 over-arching sub-divisions of each subject eg Tissues, organs and systems, Materials and their properties or Waves, light and sound
- **Topic** – The particular subject area being considered within a theme eg Growth and development, Characteristics and chemical reactions of acids and alkalis or Household electricity and dangers
- **Standard** – What the student should know and understand to be considered competent in that Topic or part of Topic **eg**

B0809 Explain how blockage of the coronary arteries causes coronary artery disease and evaluate known risk factors

C0803 Explain how the structure of the atom (protons, neutrons and electrons) leads to different elements

P0804 Understand how light refracts at the interface between two media

- **Learning Outcome** – What the student should be able to do to demonstrate mastery of a specific standard eg

B0809.1 Describe coronary artery disease in terms of the blockage of coronary arteries

B0809.2 List possible causes of coronary heart disease such as diet, stress and smoking

B0809.3 Analyse data and evaluate the effect of smoking and other risk factors on the incidence of coronary heart disease

C0803.1 Recognise that the smallest particle of an element is an atom and that atoms of one element are of one kind and are different from atoms of every other element

C0803.2 Describe the simple (Dalton) atomic model and outline how the atomic model changed over time

C0803.3 Describe an atom as made up of a positively charged nucleus that contains positively charged protons and neutrons (no charge) with negatively charged electrons moving round the nucleus

C0803.4 Recognise that the atoms of an element have a distinctive number of protons and the mass of the atom is approximately that of the mass of the nucleus

C0803.5 Recognise that elements can be represented by chemical symbols

P0804.1 Draw ray diagrams showing refraction of light between two media of different optical density

P0804.2 Label the angles of incidence and refraction, as well as the normal to the interface between the two media

P0804.3 Use ray diagrams to investigate the path of light rays refracted through the interface between two media

- **Learning Experiences** – these provide compulsory activities for students which enable them to deliver the Learning outcomes, and to develop cross-cutting skills (see p42). The compulsory Learning experiences are shown in **bold.** There are also additional Learning experiences which teachers can use to support learning, stretch able students and practice competencies beyond the compulsory LEs. These are shown in *italics.* It should be noted that a Learning Experience does NOT equate to a lesson. Some Learning Experiences may take several lessons to fulfil. Others may be short activities which will only take a few minutes.

- **Competencies** – cross-cutting skills that the study of Science can develop.

Learning experiences

The Learning Experiences (LEs) are designed to promote active learning by the students. In many cases they should be preceded by teacher exposition and class questioning.

Wherever possible students should carry out experiments themselves, bearing in mind local Health and Safety, organisational, and resource considerations.

When students cannot carry out an experiment, it is preferable for a teacher to demonstrate the experiment rather than the students watch it on video. The internet is also a rich source of material about, for instance, industrial processes and a wide range of ecosystems, but it should be used sparingly so it retains impact and usefulness., not as an easy alternative to hands-on experiences for the students.

When there is an experiment that students should not do on Health and Safety grounds (for example, adding sodium to water) it is preferable for a teacher to demonstrate the experiment, rather than watching it on a video.

Local conditions will determine how practical and other work is organised, with students working singly, in pairs, or, in some cases, where there is a need to achieve a group consensus, in larger groups as appropriate. Guidance is offered when it is of particular value to work in pairs or groups.

Students need to recognise that science is based on data. The LEs refer to data and this includes data which results from investigations carried out by the students, data provided by the teacher and data extracted from a paper data book or an electronic database or from the internet. If data is pertinent to the LE this is specified. The use of electronic means of representation, for example to avoid laboriously drawing graphs, should be encouraged.

The LEs also refer to modelling. In Chemistry this could be using molecular models in the classroom or electronically on a screen. In Biology it could include modelling ecosystems. Simulations of experiments can be used to enhance learning but this should not be at the expense of students carrying the experiment out themselves or watching a teacher demonstration.

- Some LEs are **compulsory**: these are shown in **BOLD and all students must have the opportunity to do them.**

- Some LEs are additional or optional and these are shown in *italics*. *These support the teacher by providing extra opportunities to practice specific competencies, give extension work or support weaker students.*

Competencies

Some Learning Experiences are particularly relevant in developing the cross-cutting skills of

- **Communication (C)**
- **Cooperation & Participation (CP)**
- **Creative & Critical Thinking (CT)**
- **Inquiry and Research (IR)**
- **Problem Solving (PS).**

Most Learning Experiences will involve aspects of several of these competencies, but each will have a particular focus on one or two of them. Guidance is provided on the particular competency or competencies which can be demonstrated in a specific Learning Experience, annotated with the appropriate codes listed above.

Possible teaching orders

The Curriculum Standards are NOT designed to be a teaching order. They are arranged to demonstrate the spread of content in each grade and progression in different themes through the grades.

Each teacher can develop their own scheme of work, delivering the content of a grade in whichever order will most benefit their students. Here we provide one possible order of teaching which, if adopted, will enable students to build up their conceptual understanding of the science strands through each year of study. This possible teaching order will be positioned after each set of Grade standards

Please note other orders are possible and acceptable.

9

CONTENT STANDARDS BY GRADE

Content standards by grade

Science Standards Grades K-6

Grade K

Biology Grade K	
Diversity and variation in living things	
Classification	
Standards **B0K01** Identify some common animals and plants in the local environment.	
Learning Outcomes **Students should be able to:** **B0K01.1** Name some plants found in the local environment and describe in simple terms their size, flower and/or leaf shape and colour. **B0K01.2** Name some animals found in the local environment and describe them using simple adjectives.	
LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0K01.1	**a)** Explore the environment around the classroom, photographing, picking (where safe and appropriate to do so) and/or drawing pictures of plants found to help identify them. IR
B0K01.1	**b) Handle and observe a variety of local plants, discussing and comparing their physical features. IR; C**
B0K01.2	**c) Create a display in the classroom of animals found in Qatar using photographs, drawings and labels from descriptions that children have suggested. C; CT**
B0K01.2	**d)** *Give children sets of photographs of locally found animals, and flash cards with simple adjectives which could apply to more than one of them. Ask the children to sort the animals by which ones could be described using one of the adjective flash cards.* **C; CT**
Organisms and their environment	
Interdependence of organisms	
Standards **B0K02** Name and describe some micro-habitats found in the local environment. **B0K03** Identify the different features of a variety of habitats**.**	

Learning Outcomes
Students should be able to:

B0K02.1 Name some types of microhabitat and describe their features in simple terms.

B0K02.2 Predict, observe and record the different types of living things that exist in a local microhabitat.

B0K03.1 Name a variety of different types of habitat and describe them in simple terms.

B0K03.2 Suggest living things which live in a particular habitat.

LO references	Learning Experience **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0K02.1	**a) Look at examples of microhabitats within the school grounds (under logs, in trees, ponds), a local park, or photographs if this is not possible. Discuss the features found there and compare them with one another. IR; C**
B0K02.1	**b)** *Create a microhabitat in the classroom using boxes or trays. Encourage the children to add features to mirror those found in a given microhabitat.* **CT; IR**
B0K02.2	**c) Make drawings, take photographs and collect specimens (where appropriate to do so) of living things in a variety of local microhabitats. Study and compare these in the classroom to identify them. IR**
B0K03.1	**d) Make a collage using both natural and classroom materials (leaves, sand, paint, tissue paper, etc.) to show different habitats. CT**
B0K03.2	**e) Cut out pictures of different animals and stick them on a background showing their correct habitat. IR**
B0K03.2	**f)** *Make a matching game using pictures of animals and their habitats.* **CT**

Structure and function of organisms

Tissues, organs and systems

Standards

B0K04 Identify and name the functions of some external parts of the human body.

Learning Outcomes
Students should be able to:

B0K04.1 Identify the hands, feet, arms, legs, fingers and toes and explain what they can help us to do.

B0K04.2 Name the head and its parts (eyes, ears, mouth, nose) and relate each part to its relevant sense.

B0K04.3 Name the five senses and describe different ways that they are used.

LO references	Learning Experiences

	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0K04.1 **B0K04.1** **B0K04.2** **B0K04.3** **B0K04.3**	**a) Sing songs using the names of the body parts and what they are for. C; CP** **b) Draw and label the parts of the head with their names and the senses they relate to. IR; CT** *c) Create and play games to quickly match the sense to its organ*. **C; CT** **d) Access a variety of different objects (foods, musical instruments, classroom tools etc) and discuss which senses can be used to interact with them. IR; CT** ***e)*** *Discuss preferences for each of the different senses- pleasant and unpleasant sounds, textures etc.* **C; CP**
Health and disease	
Healthy lifestyles	
Standards **B0K05** Discuss why regular washing is an important way to help keep us clean and healthy. **B0K06** Recognise that teeth are important for eating and chewing, and we must clean our teeth regularly.	
Learning Outcomes **Students should be able to:** **B0K05.1** Explain how to wash properly and describe a good washing routine. **B0K05.2** Describe the potential consequences of not keeping a regular washing routine. **B0K05.3** Explain why we must always wash our hands after using the toilet. **B0K06.1** Explain the function of teeth in eating and chewing. **B0K06.2** Describe a good teeth-cleaning routine, including how often it should be done. **B0K06.3** Describe the consequences of not cleaning teeth regularly.	
LO references	**Learning Experience** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0K05.1	**a) Using dolls, demonstrate good washing routines in groups. CP; C**

B0K05.2	**b) Brainstorm and hold a class discussion about what can happen if we don't wash regularly. C; CT**
B0K05.3	**c) Draw pictures to show when hands should be washed. C; IR**
B0K06.1	**d) Compare how many times different foods need to be chewed and discuss reasons for this. IR; CT**
B0K06.2	**e) Hold a class tooth brushing session, asking children to observe and critique their own and one another's tooth brushing techniques. CP; C**
B0K06.2	**f)** *Use plaque disclosing tablets to highlight areas that need attention when brushing teeth.* **CP**
B0K06.3	**g) Watch videos about cleaning teeth and why it is important, and discuss what has been learned C; IR**
B0K06.3	**h)** *Listen to a talk from a dentist about why it is important to clean teeth regularly.* **CP; C**

Physics

Waves, Light and Sound

Using senses to observe the world

Standards

P0K01 Use the senses to make observations about the world around us.

P0K02 Name some common sources of light, sound and heat.

P0K03 Make observations using all our senses and describe how we can use inventions to assist us.

Learning Outcomes

Students should be able to:

P0K01.1 Distinguish between how an object looks and feels and use adjectives to describe the appearance and feel of objects.

P0K01.2 Name and describe some commonly heard sounds in the local environment.

P0K01.3 Begin to show an understanding that the volume of a sound can indicate the distance and location of its source.

P0K02.1 Name some common sources of light, including both man-made and natural sources.

P0K02.2 Recognise that some light sources can be more intense than others, and that the Sun should never be directly looked into.

P0K02.3 Name some common sources of sound, including living things.

P0K02.4 Name some common sources of heat, including both man-made and natural sources.

P0K02.5 Recognise that many heat sources can be dangerous to touch and should be approached with caution. **P0K03.1** Use more than one sense to describe an object. **P0K03.2** Match some inventions to the sense that they can assist. **P0K03.3** Use different inventions to make observations of the world around us.	
LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0K01.1	**a) Touch and observe a wide range of objects with a variety of textures. Write labels for these objects on two different colours of card- one for touch, one for sight. C; IR**
P0K01.1	**b)** *Feel unseen objects in bags and use this information to describe how they may look.* **IR; CT**
P0K01.2	**c) Sit quietly outside and listen carefully, writing down any sounds heard. Make a list of all of the sounds and their sources. IR; CT**
P0K01.3	**d) Play a game where one child makes a sound using an instrument from anywhere in the room. The other children, with their eyes closed, must point to the location of the sound's source. CP; C**
P0K02.1-2	**e) Using pictures and other stimuli, discuss different light sources and compare their brightness. C; CT**
P0K02.3	**f) Identify as many things as possible in the classroom which make sounds. Make lists using words and pictures and categorise them by whether they are living or man-made. CT; IR**
P0K02.4-5	**g) Look at images showing examples of heat sources. In groups, suggest the function of each item and how it is used. Discuss which ones pose a danger to humans if not treated cautiously. CT; CP**
P0K03.1	**h) Investigate objects which can stimulate several senses, such as a flower. Fill in a concept map with adjectives to describe each applicable sense. CT; C**
P0K03.2	**i) Investigate a variety of different tools which enhance the senses, such as stethoscopes and magnifying glasses. Link them to the appropriate sense and suggest what they can help us to do. CT; IR**

Possible teaching order

Please note other orders are possible and acceptable.

Science			
	Biology	**Chemistry**	**Physics**
Grade K	**1** Tissues, organs and systems **3** Classification **4** Healthy lifestyles **5** Interdependence of organisms		**2** Using senses to observe the world

Grade 1

Biology Grade 1

Diversity and variation in living things

Classification

Standards

B0101 Distinguish between living and non-living things.

B0102 Observe and describe how the appearance of organisms changes over their lifetime.

Learning Outcomes

Students should be able to:

B0101.1 Identify some characteristics of living things.

B0101.2 Use known characteristics to distinguish between given living and non-living things.

B0102.1 Make oral and written observations about the life cycle of a variety of different living things.

B0102.2 Make comparisons between the life stages of two or more living things, noting basic similarities and differences.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0101.1	**a) Look at photographs of living things. Discuss their common features in groups, with teacher input as needed. C; CT**
B0101.2	**b) Sort pictures into two groups; living and non-living. Choose key words to describe each group. C; IR**
B0102.1	**c) Create a life cycle display with photographs, drawings, key words and sentences showing a variety of different life stages. CT; C**
B0102.2	**d) Watch videos showing the life cycles of a variety of living things. Compare, in groups, similarities and differences. C; CP**
B0102.2	**e)** *Visit a local farm or animal park. Observe the living things there and discuss their life cycles, making notes and drawings.* IR; C

Structure and function of organisms

Requirements for life

Standards

B0103 Describe the needs of all living things.

B0104 Identify that living things grow, reproduce and release waste.

B0105 List ways in which living things should be treated with care.

Learning Outcomes
Students should be able to:

B0103.1 List air, food and water as the needs of all living things.

B0103.2 Demonstrate an understanding that plants are also living things with the same needs as others.

B0104.1 Explain, using examples, that living things are able to grow, reproduce and release waste.

B0104.2 Measure and make drawings of the growth of a plant from seed.

B0104.3 Compare growth in plants and animals to show that all things grow, but rates of growth are relative.

B0105.1 Understand that humans can damage living things if they are not treated with care.

B0105.2 List some precautions which should be taken when handling or moving around living things.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0103.1	**a) Compare the needs of a variety of different animals, showing that whilst diets can differ, they all need the same things to live. C; CT**
B0103.2	**b) Compare plants that are not watered or fed with those that are. Describe the changes and compare them to other living things. IR**
B0104.1	**c) Watch videos of a variety of animals with their young. Discuss the physical appearance of the young compared to adults. IR; C**
B0104.1	**d)** *Sort photographs of a variety of young by whether they are born live or hatched from eggs.* **IR; CT**
B0104.2	**e) Make daily observations of a plant growing from seed, making notes and sketches, as well as predictions. IR**

B0104.3	**f) Compare animals that grow to different sizes in adulthood to their young, showing that all things grow, but not indefinitely. CT; C**
B0104.3	**g)** *Grow a variety of plants from seed, observing the different rates of growth in each.* **IR; CT**
B0105.1-2	**h) Draw pictures to show different ways in which humans can purposely and accidentally damage the wildlife around them and discuss ways to prevent this. C; CP**

Health and disease

Healthy lifestyles

Standards

B0106 Recognise that fresh fruits and vegetables have a shelf-life, after which they become mouldy.

B0107 Describe some ways to prevent food becoming mouldy, and explain what can happen if rotten fruit or vegetables are eaten.

Learning Outcomes

Students should be able to:

B0106.1 Distinguish between fresh and preserved foods, and describe which ones need to be refrigerated.

B0106.2 Observe and describe what happens when fresh food becomes mouldy.

B0106.3 Investigate how many days are required for a banana, orange, date or any other fruit to rot and become mouldy and unfit to eat.

B0107.1 Draw and describe some simple methods, such as refrigeration and prompt consumption, which can delay food from becoming mouldy.

B0107.2 Explain the potential health consequences of eating mouldy food.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0106.1	**a) Group a variety of foods by whether they are fresh or preserved and understand some of the ways in which food is preserved. IR; CT**
B0106.2-3	**b) Observe, over a period of days, how the appearance of food changes when it becomes mouldy, making notes and drawings. IR; C**
B0107.1	**c) Investigate ways that food can be prevented from becoming mouldy too quickly. Make a poster showing the ways investigated. IR; C**

B0107.2	**d) Discuss what can happen if mouldy food is eaten, and how this can be avoided. C; CP**

Chemistry Grade 1

Materials and their properties

Physical properties of common materials

Standards

C0101 Name a number of common materials.

C0102 Describe some physical characteristics of common materials.

C0103 Classify objects according to the material from which they are made.

Learning Outcomes

Students should be able to:

C0101.1 Recognise and name some common materials such as glass, wood, clay, fabrics, paper, metal, plastic and rubber.

C0101.2 Distinguish between an object and the material it is made from.

C0102.1 Use the senses (sight and touch) to investigate the physical properties of common materials.

C0102.2 Describe materials using simple adjectives.

C0103.1 Sort materials into two groups based on their use.

C0103.2 Classify common objects based on the material from which they are made.

C0103.3 Find groups of objects which are made from the same material.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0101.1	**a) Match labels to samples of material, discussing how they feel and look. IR; C**
C0101.2	**b) Look at a variety of everyday objects. Discuss in small groups what the object is, and what material/s it is made from. CP; IR**
C0102.1	**c) Feel materials in bags and use their feel to predict the material they are made from. PS; CT**
C0102.2	**d) Create a display using adjective labels to describe a variety of materials. C**

C0103.1	**e) Choose a property and sort a variety of objects based on whether they have this property. CT; C**
C0103.2-3	**f) Select a variety of everyday objects and group them by a common material. IR**

Physics Grade 1

Forces, motion and scale

Movements and what causes them

Standards

P0101 Make observations about different objects which move.

P0102 Compare and describe different movements.

P0103 Demonstrate that forces can start and stop objects moving.

P0104 Explain that some moving objects can be dangerous.

Learning Outcomes

Students should be able to:

P0101.1 Make lists and drawings of different things in the local environment which move.

P0101.2 Identify things that move on their own, and things which are helped to move.

P0101.3 List things which can move by themselves.

P0102.1 Match appropriate verbs to movements.

P0102.2 List things which move in a similar way.

P0102.3 Describe similarities in objects which move in the same way.

P0103.1 Show how pushes and pulls can be used to make objects move.

P0103.2 Link the force behind a push or pull with the speed an object moves at.

P0103.3 Link the direction of a force with the direction an object moves in.

P0103.4 Observe that an object slows down before stopping naturally, and that force can be used to stop an object which is moving.

P0104.1 Link the mass and speed of an object with the amount of danger it can pose.

P0104.2 Describe some scenarios where moving objects can be dangerous, and how to stay safe around them.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***

P0101.1-3	**a) Select verbs from lists that best match a wide variety of movements. C; CT**
P0101.1-3	**b) Observe the world around the school, drawing pictures of things which can move on their own. Discuss any misconceptions, such as cars, as a class. IR; C**
P0101.1-3	c) *Make lists of things which are helped to move, by a human force, engine etc. around the classroom and in everyday life.* **IR; C**
P0102.1-3	d) *Create poems and songs about different types of movement.* **C; CT**
P0103.1-4	**e) Experiment, using a variety of different toys, with how the force and direction of pushes and pulls affects the movement of the object the force is exerted upon. Make observations about which types of toys move best at speed. CT; IR**
P0103.1-4	f) *Use the same toys on different types of surface, noting the difference in speed of object when roughly the same level of force is applied, beginning to make suggestions as to why.* **CT; IR**
P0104.1-2	**g) Discuss some types of object, including living things, which can be dangerous when moving- such as cars or camels. Compare the objects mentioned, finding commonality in physical features. C; CP**
P0104.1-2	**h) Make posters about staying safe around roads or large animals. C**

Possible teaching order

Please note other orders are possible and acceptable.

Science			
	Biology	**Chemistry**	**Physics**
Grade 1	**1** Requirements for life **2** Classification **4** Healthy lifestyles	**3** Physical properties of common materials	**5** Movements and what causes them

Grade 2

Biology Grade 2

Organisms and their environment

Interdependence of organisms

Standards

B0201 Explain some simple ways in which plants and animals are suited to their habitats.

B0202 Describe how the habitats of animals and plants can be respected and cared for.

Learning Outcomes

Students should be able to:

B0201.1 Match animals to their habitats based on observations of their characteristics.

B0201.2 Make connections between characteristics of animals and simple factors such as climate.

B0201.3 Match types of plant to a variety of different habitats based on observations of their characteristics.

B0202.1 Identify some ways that human activity can directly impact on the habitats of living things.

B0202.2 Explain why it is important to respect and care for different habitats.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0201.1-2	**a) Use books and other research materials to match animals with their habitats. Draw and label the animals in their environments, labelling the features which make them well suited to living there. IR; C**
B0201.1-2	**b)** *Look at video clips of animals interacting with their habitats. Discuss some of the ways in which their physical features are useful to the environment in which they live.* **C; CT**
B0201.3	**c) Look at some pictures or real-life examples of plants which live in a variety of habitats. Discuss their physical similarities and differences, and how they are well-suited to where they live. Make and label drawings showing some of these features. IR; C**
B0202.1	**d) Examine the school site, finding examples of situations where humans could have impacted on wildlife. Discuss a set of rules that**

	the class should follow when in the local environment to minimise damage. C; CT; CP
B0202.2	**e)** *Research some animals in Qatar and across the world which have become endangered. With teacher guidance, discuss the possible causes of population decline, including habitat loss, and what can be done to help this on an individual level.* **CT; C**

Structure and function of organisms

Requirements for life

Standards

B0203 Identify and label the parts of a flowering plant (leaves, stem, roots, flower and seed).

B0204 Identify the requirements of a plant for life.

B0205 Discuss the functions of each part of a plant.

B0206 Describe how, given the right conditions, the seeds of flowering plants can sprout and grow into new plants.

Learning Outcomes

Students should be able to:

B0203.1 Identify and label the parts of a variety of flowering plants using pictures, diagrams and real-life examples.

B0204.1 List light, water, air and nutrients as the requirements of a plant for life.

B0204.2 Investigate the effects on a plant of not receiving different requirements for life.

B0205.1 Demonstrate a basic understanding of the role of flowers in attracting pollinators for reproduction.

B0205.2 Match each part of a flowering plant to its corresponding requirements for life and describe in simple terms how they function.

B0206.1 List the factors required for a seed to grow.

B0206.2 Make observations and drawings of the stages of seed growth.

B0206.3 Show an understanding that many plants, including trees and crops, grow from seeds.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0203.1	**a) Create a model of a flowering plant, including leaves, flower, roots and stem, using a variety of materials. IR; CT**

B0203.1	**b)** *Make life-sized drawings of the structures of a variety of different size and shaped flowering plants, such as sunflowers, Shafallah and daisies. IR*
B0204.1-2	**c)** *Plant seeds in different environments, where they are missing one of the conditions needed for life. Make notes and take pictures to record what happens. IR*
B0205.1	**d) Compare photographs or specimens of different flowers, observing their similarities and differences. Discuss in groups how flowers attract insects, and why they do this. C; CT; CP**
B0205.2	**e) Place the roots of a plant with white or light-coloured petals (such as a chrysanthemum white carnation) into a container of water coloured with red ink. Observe the movement of the ink through the plant and into the petals and discuss the function of the parts which transported it. IR; CT**
B0206.1-3	**f) Place seeds of plants such as cress, peas, beans, oats or sunflowers on damp paper or cotton wool in glass containers and observe their germination and growth over time. IR**
B0206.1-3	**g)** *Sow seeds of colourful flowers in a garden plot and water them regularly. Observe and take photographs, and keep a diary as they germinate, grow, flower and develop seeds.* **IR**

Health and disease

Healthy lifestyles

Standards

B0207 Describe a healthy eating routine, and explain simply why this is essential to good health.

Learning Outcomes

Students should be able to:

B0207.1 Describe a healthy eating routine as comprising a variety of foods including fresh fruits and vegetables.

B0207.2 Identify some foods which are high in sugar, fat and/or salt and should therefore be eaten in moderation.

B0207.3 Explain in basic terms how healthy eating habits contribute to good overall health.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0207.1	**a) Create a drawing of a healthy plate, showing the quantity and types of foods which make up a healthy meal. CT, C**
B0207.1	**b)** *Keep a food diary for a school week, to show all foods eaten. Review at the end of the week and suggest ways to improve.* **C; IR**

B0207.2	**c) Look at the nutritional information on different foods' labels, comparing sugar, salt and fat. IR**
B0207.2	**d)** *Create a healthy eating display in the classroom, showing which foods should be eaten as a treat.* **C**
B0207.3	**e) Discuss how healthy eating habits do not change one's health overnight but should be a routine to lead a healthy life. Talk about the benefits of good diet and exercise, and what can happen if too much unhealthy food is eaten, or not enough exercise is taken. C; CP**

Physics Grade 2

Electricity and magnetism

Simple electrical devices

Standards

P0201 Name some common devices that use electricity.

P0202 Explain the different ways that electrical devices can help us in daily life.

P0203 Understand that batteries have a finite period of charge, whereas mains electricity can be used continuously.

P0204 Become aware that the chemicals inside batteries can be harmful and that batteries should be recycled when possible.

P0205 Become aware of the dangers of mains electricity.

Learning Outcomes

Students should be able to:

P0201.1 Sort objects by whether or not they are electrical.

P0201.2 Sort electrical devices by whether they plug into the wall (and describe this as mains electricity) and those which run on batteries.

P0202.1 List electrical devices in the classroom and home environment and explain their function.

P0202.2 Explain the ways that electrical devices can help us and make our lives easier.

P0203.1 Understand that a battery will run out after some time of usage, but some types of battery can be recharged.

P0203.2 Explain that a battery-operated device will not work if it does not have a battery in it or when the battery is discharged.

P0204.1 Explain the harmful effects that the chemicals inside batteries can have on living things, including humans.

P0204.2 Understand that batteries should be recycled rather than thrown away, and what happens to them in each case.

P0205.1 Discuss ways in which mains electricity can be dangerous, and how to use it safely.

LO references	Learning Experience **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0201.1	**a) List and draw a variety of different everyday objects, categorising them by whether they are electrical or not. IR; CT**
P0201.2	**b) Look at a wide variety of pictures of everyday appliances and classify them by whether they are battery or mains electricity. IR; CT**
P0202.1	**c) Sort the photographs of mains and battery appliances again, this time by whether they produce light, heat or sound. Discuss any examples which produce more than one of these. CT; C**
P0202.2	**d) Match a variety of devices to their purpose, and explain how our lives may be more difficult without them. CT; CP**
P0203.1-2	**e) Use fully powered, partially discharged, fully discharged and no cells to power the same electrical toy. Predict the effect that each will have, then compare how its functionality changes. IR; CT**
P0204.1-2	**f) Watch video clips showing the dangers of batteries, and how they should be safely handled and recycled. Discuss what should happen to used batteries from classroom devices. CP; C**
P0205.1	**g) Watch appropriate video clips about the dangers of mains electricity, and how electrical items can be safely handled. IR**

Waves, light and sound

Transmission of light through objects

Standards

P0206 Classify and name some everyday examples of opaque, translucent and transparent objects.

P0207 Investigate how opaque objects cast a shadow, and how the shadow appears.

P0208 Investigate how shadows change when the distance of a light source is altered.

P0209 Investigate how shadows change at various times of the day.

P0210 Differentiate between reflectors and light sources.

Learning Outcomes

Students should be able to:

P0206.1 Define the terms opaque, translucent and transparent.

P0206.2 Using a torch, explore a range of different objects and materials to decide whether they are opaque, translucent or transparent.

P0206.3 Classify objects based on whether they are opaque, translucent or transparent, and suggest further examples for each.

P0207.1 Use a torch to cast a shadow behind opaque objects, investigating how changing the position of the torch changes the appearance of the shadow.

P0207.2 Observe and make drawings showing the relationship between the shape of an object and its shadow.

P0208.1 conduct a fair-test experiment to investigate how shadow size varies with varying object distances from a light source.

P0208.2 Create a written record of the investigation, including drawings to show the experiment and the resulting shadows.

P0209.1 Conduct a fair-test experiment to investigate how shadow size varies with different times of the day.

P0309.1 Explain why the position of shadows move across different times of day, and how this was used in the past to tell the time.

P0210.1 Define an object which makes its own light as a light source, and give examples.

P0210.2 Name some objects which can appear to give off light, but are actually reflectors.

LO references	**Learning Experience** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0206.1-3	**a) Sort a variety of materials by whether they are opaque, translucent or transparent. IR; CT**
P0206.1-3	**b) Identify materials used in everyday objects as being opaque, translucent or transparent, and suggest reasons for material choices based on this property. IR; CT**
P0207.1-2	**c) Using a torch, make drawings of the shadows cast by an object, the source object, and the direction of the light. CT; IR**
P0208.1-2	**d) Plan, conduct and make notes and drawings on a fair-test experiment, showing how the size and shape of a shadow varies according to its distance from a light source. IR; C**

P0209.1-2	**e) Have learners trace one another's shadows from the same points at different times of day. Use the observations from this to discuss the movement of shadows, why this appears to happen, and what is actually happening as the Sun appears to move across the sky. IR; C**
P0210.1-2	**f) Using photographs, sort objects into light sources and reflectors. Have a class discussion of common misconceptions such as the Moon being a light source. C; IR**

Possible teaching order

Please note other orders are possible and acceptable.

Science			
	Biology	**Chemistry**	**Physics**
Grade 2	**1** Requirements for life **2** Interdependence of organisms **3** Healthy lifestyles		**4** Transmission of light through objects **5** Simple electrical devices

Grade 3

Biology Grade 3

Diversity and variation in living things

Classification

Standards

B0301 Classify plants and animals based on observable features.

B0302 Identify the characteristics of different classes of animal, and sort living things according to these groups.

B0303 Use simple branching tree keys to identify organisms.

Learning Outcomes

Students should be able to:

B0301.1 Classify living things according to self-selected observable features.

B0301.2 Classify living things based on a variety of features, such as appearance and habitat.

B0302.1 Name some characteristics of mammals, reptiles, amphibians, birds and fish.

B0302.2 Give examples of animals within each class and sort given animals based on observation and prior knowledge.

B0303.1 Define an organism as the scientific name for a living thing.

B0303.2 Give examples of species which can have both similar and distinct physical characteristics (e.g. cats, roses).

B0303.3 Use simple branching tree keys featuring different species to correctly identify an organism.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0301.1	**a) Classify images of a wide variety of living things based on observable features. Explain, verbally and in writing, how groupings were chosen. Discuss a number of ways that they can be classified, based on learners' choices, and how these are all valid classifications. C; IR**
B0301.2	**b) Create a list of ten different living things, from a variety of classes and habitats. In small groups, research the habitat, diet and physical features of one or more creatures. Rotate around groups to share information, then choose a variety of ways to classify the ten living things. CP; CT**

B0301.2	**c)** *Children classify themselves and their classmates by a variety of non-observable features, such as favourite lesson at school or how many siblings they have. Discuss how there are many different ways to classify the same things.* **C; CP**
B0302.1	**d) Create a concept map with a section for each class of vertebrate, showing the features of each. Use this to compare similarities and differences. IR; C**
B0302.2	**e) Classify photographs of vertebrates by class using observation and prior knowledge. Suggest others which could belong in each group and justify these. CT; C**
B0303.2	**f) Compare photographs of living things with noticeable physical differences, such as breeds of cat or rose, or humans with different coloured hair or eyes. Discuss their similarities and differences. C; IR**
B0303.1 **B0303.3**	**g) Play a game in partners using photographs and branching keys. One partner chooses a photograph of an organism without showing the other. The other asks the questions on the branching key, then follows it according to the given answers. Swap when the correct organism has been identified. C; CP**
B0303.3	**h) Give children a branching key featuring a selection of living things found in Qatar (such as insects or birds) and a photograph. Have them follow the branching key using observable features to identify the organism correctly. IR**

Structure and function of organisms

Tissues, organs and systems

Standards

B0304 Describe the structure and function of teeth (molar, premolar, canine and incisor).

B0305 Recognise that living things have structures with specialised functions.

B0306 Locate some muscles and bones in the human body and identify their roles in movement.

Learning Outcomes

Students should be able to:

L0304.1 Describe the appearance of human molar, premolar, canine and incisor teeth and locate them in the mouth.

L0304.2 Explain the function of different types of teeth in the human mouth.

L0304.3 Recognise that many animals have the some of the same types of teeth as humans, and that they are often roughly the same shape.

L0305.1 Label some of the major organs of the human body (heart, lungs, intestines, stomach, kidneys).

L0305.2 Explain, in simple terms, the function of major organs.

B0306.1 Label a human skeleton with some of its major bones (e.g. Skull, ribs, knee caps, pelvis).

B0306.2 Observe the relaxing and contracting of muscles within the human body.

B0306.3 Explain the role of bones in protecting, moving and supporting the body.

B0306.4 Observe how the contracting and relaxing of muscles moves the arm and relate this to the function of muscles.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0304.1-2 **B0304.3** **B0305.1-2** **B0306.1** **B0306.3** **B0306.2** **B0306.4**	**a) In groups, look at models or images of the human mouth. Match each type of tooth to its function and make suggestions about how its shape suits its purpose. IR; CT** **b) Compare images of animals' teeth to those of humans. Discuss the similarities in each type of tooth and suggest reasons for any differences seen. IR; CT** **c) Create a collage or model of the human body, labelling its major organs and giving a description of its function. C; IR** **d) Label an image of the human skeleton with its major bones, recalling where each is found in the body, and what it protects. C** **e) In groups, observe as other learners contract and relax different muscles. Compare the different movements these result in. IR; CP**

Health and disease

Healthy lifestyles

Standards
B0307 Understand that germs can pass on some illnesses.

Learning Outcomes
Students should be able to:
B0307.1 Describe germs as being too small to see with our eyes.

B0307.2 Describe how an object or body part can have germs on them, even if they do not appear to be dirty.

B0307.3 Explain that germs can enter our bodies and make us unwell, giving examples of methods of transmission.

B0307.4 List some ways of minimising contact with germs.

B0307.5 Understand that some types of illness, such as diabetes or injuries leading to wheelchair use, are not spread by germs so cannot be passed on.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0307.1-2	**a) Ask children to dip their hands in a bag of flour or cornflour. Have them shake hands with their friends and pick up and pass a selection of objects to demonstrate how germs can be passed from person to person, or person to object. IR; CP**
B0307.1-2	**b)** *Research what germs look like when magnified, and how small they are compared to humans. IR*
B0307.3	**c) Watch and discuss video clips about how germs are spread, and the effect they can have. Discuss illnesses that learners have had that may have been spread by germs. C; CP**
B0307.4	**d) Create a poster for display in school about how germs are spread, and what can be done to prevent this from happening. C; CT**
B0307.5	**e) Compare photographs of different people, including some who use mobility aids. Discuss the difference between communicable and non-communicable diseases, and how the people in the pictures cannot pass on their medical conditions. Talk how only the same basic hygiene routines is needed when being around people with non-communicable conditions, and how they should be treated no differently. Name some non-communicable diseases and speak in basic terms about their effects. C; CP**

Chemistry Grade 3

Materials and their properties

Physical uses and properties of materials

Standards

C0301 Investigate various ways of classifying a range of common materials using their physical properties.

C0302 Investigate a range common uses of a range of materials.

C0303 Discuss some of the ways in which materials can be changed.

Learning Outcomes

Students should be able to:

C0301.1 Make predictions, based on observation and prior knowledge, about the properties of materials.

C0301.2 Identify physical properties of common materials through investigation.

C0301.3 Plan investigations to classify common materials according different properties.

C0302.1 Give explanations for the choices of different materials in the making of objects.

C0302.2 Select materials for a given task based on their properties.

C0303.1 Investigate whether materials can be changed by squashing, twisting, bending or squeezing.

C0303.2 Discuss circumstances in which the ability to change materials can be an advantage or a disadvantage.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0301.1-3	**a) Plan and conduct investigations to explore the different properties of materials, such as waterproofing or flexibility. Make predictions before they are conducted, and compare the outcomes to them, using the results to classify the materials. IR; CT**
C0302.1	**b) Examine different everyday objects to ascertain which materials they are made from. Using knowledge of material properties, explain why those materials were chosen, and why others may not allow the object to function correctly. CT; IR**
C0302.2	**c) Design an object for a given task, such as a piece of play equipment. Explain, in writing, why materials have been chosen for each part of it. CT; PS**
C0303.1-2	**d) Identify common objects which must be able to flex and name the material they are made from. Discuss why this material is the one best suited to its task. C; CT**

Chemistry in our world

Rocks and their everyday uses

Standards

C0304 Investigate the physical characteristics and properties of different rocks.

C0305 Perform tests to make simple comparisons between different rock types, such as hardness and porosity.

C0306 Link the properties of rocks to their common uses.

C0307 Recognise that rock forms the Earth's surface, including soil.

Learning Outcomes
Students should be able to:

C0304.1 Describe some variations in the appearance and feel of different rocks.

C0304.2 Compare and classify rocks according to readily observable characteristics.

C0305.1 Discuss ways in which rocks could be fairly tested for different properties.

C0305.2 Carry out simple tests to compare properties of rocks, recording results and comparing found data.

C0306.1 List some common uses of rocks and explain why rocks are suited to this purpose.

C0306.2 Explain why certain types of rocks are used for specific tasks.

C0307.1 Show an understanding that rock exists under all of Earth's surfaces, including the ocean.

C0307.2 Recognise that soil is partly formed from rocks by the process of weathering.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0304.1-2	**a) Handle and observe a variety of different types of rocks, comparing and classifying them by what can be noticed about them. IR; CT**
C0304.1-2	**b)** *Take a field trip to a coastal area to collect rock samples. Compare them to each other, as well as rocks found in other locations.* **IR**
C0305.1-2	**c) Devise and carry out experiments to test rocks for a variety of different properties. Use the results of these experiments to suggest the types of jobs each rock may be more suited for. IR; CT; CP**
C0306.1-2	**d) Research different uses for rocks and discuss the best types of rock for each use, giving reasons based on earlier investigations. IR; CT**

C0307.1-2	**e) Create diagrams showing where rock is found within the Earth, and what the soil on the Earth's surface is made up of. C; CT**

Physics Grade 3

Electricity and magnetism

Magnetic forces and uses of magnets

Standards

P0301 Explore the effects of magnetic poles.

P0302 Investigate and identify the interaction of a magnet with an iron nail.

P0303 Investigate the interaction of a magnet with various materials.

P0304 Identify some common uses of magnets in everyday life.

Learning Outcomes

Students should be able to:

P0301.1 Identify the north and south poles on a magnet.

P0301.2 Investigate the interaction between same and opposite poles on two magnets.

P0301.3 Explain the effect of the same and opposite poles using the terms 'attract' and 'repel'.

P0302.1 Investigate what happens when an iron nail is brought close to the two poles of a magnet.

P0302.2 Describe the push or pull effect of an iron nail on a magnet.

P0303.1 Investigate the effect of the two poles of a magnet on a variety of materials (metals and non-metals).

P0303.2 Identify attraction and distinguish between when a material is repelled and not attracted.

P0303.3 Classify materials as being magnetic or non-magnetic according to investigation.

P0304.1 Give examples of some common uses of magnets in everyday life.

P0304.2 Show an awareness of the potential dangers of magnets, especially strong ones.

LO references	Learning Experiences
	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0301.1-3	**a) In groups, investigate how magnets behave when opposite and same poles are placed next to one another. Use this information to draw conclusions about which pole is which on a magnet. IR; CP**

P0302.1-2	**b) Work in small groups to place a magnet on a flat table. Place a short iron nail at various distances away from one pole of the magnet. Observe what happens and describe the result as magnetic attraction. IR; CP**
P0303.1-3	**c) Work in small groups to place various objects made of different materials near one pole of the magnet and observe what happens to each object. Classify the objects into two groups. After the classification, identify the material that each object is made of. IR; CT**
P0304.1	**d) Examine a range of object that use magnets and discuss how the magnet in them functions. C; CP**
P0304.2	**e) Watch video clips showing the dangers associated with magnets and create a poster to warn others about using magnets safely. C; CT**

Possible teaching order

Please note other orders are possible and acceptable.

Science			
	Biology	**Chemistry**	**Physics**
Grade 3	**1** Tissues, organs and systems **2** Classification **6** Healthy lifestyles	**4** Physical uses and properties of materials **5** Rocks and their everyday uses	**3** Magnetic forces and uses of magnets

Grade 4

Biology Grade 4

Organisms and their environment

Interdependence of organisms

Standards

B0401 Describe the features of terrestrial, marine and freshwater habitats.

B0402 Understand the impact of humans on our planet.

B0403 Outline the life cycles of insects, fish, amphibians, reptiles, birds and mammals.

B0404 Become aware of how water quality and availability affect human life processes.

B0405 Describe how changes in body temperature can affect human health.

Learning Outcomes

Students should be able to:

B0401.1 Describe, using examples, different types of terrestrial, marine and freshwater habitats and their features.

B0401.2 Identify some living things which are native to each type of habitat, including some which spend time in different habitats.

B0401.3 Explain how some living things have specialised features for the habitats they live in.

B0402.1 Discuss, using a global case study example, a habitat that has been negatively affected by humans, and the consequences of this.

B0402.2 Discuss, using a global case study example, a habitat that has been positively affected by humans, and the consequences of this.

B0402.3 Explain the aims and work of a Qatari environmental initiative.

B0403.1 Draw and label the different stages in the life cycles of insects, fish, amphibians, reptiles, birds and mammals.

B0403.2 Compare and contrast the life cycles of insects, fish, amphibians, reptiles, birds and mammals.

B0404.1 Explain why humans need water to survive, and what happens if they do not get enough water.

B0404.2 List some of the reasons that humans need clean water and describe the effects of dirty water on human health.

B0405.1 Recognise that human body temperature remains relatively constant, and that changes to body temperature can affect human health.

B0405.2 Investigate factors that can affect human body temperature, including illness and environment.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0401.1	**a) Make labelled drawings of a variety of different habitats, showing their conditions and features. IR; C**
B0401.2	**b) Match a variety of different living things to their habitat, making justifications for each choice. Where an animal lives in more than one habitat, suggest how and why they travel between them. IR; CT**
B0401.3	**c) Research examples of different specialised features, such as skin, fur, feathers or fat, and some animals which use them in different ways. IR; CP**
B0401.3	**d)** *Looking at a specific habitat, suggest some types of features which might benefit a creature living there, giving examples. C*
B0402.1	**e) Research and discuss a globally significant habitat loss or damaging, such as the overfishing of cod, the Great Pacific Garbage Patch or deforestation in the Amazon rainforest. Think about why this has happened, the negative effects it has already had and could have in the future, and what could be done to help solve the problem. Create a poster using this information. C; IR**
B0402.2-3	**f) Research and discuss examples of humans trying to conserve habitats and wildlife, such as the Al Wabra Wildlife Preserve or the World Wildlife Fund. Investigate the types of projects and work they do and suggest ways this work could be supported in school. C; CT**
B0403.1-2	**g) Watch videos and look at photographs showing the life cycles of a variety of living things, using the information to create annotated diagrams. C; IR**
B0404.1-2	**h) Research how much water humans should drink every day, the health effects of not doing so, and what could happen if the water drunk is not clean. IR**
B0405.1-2	**i) In groups, measure learners' temperatures before and immediately after exercise. Record data found and examine the lack of variation in results. Discuss the effects on human health if body temperatures become too low or high. IR; CT**

B0405.1-2	**j)** *Compare the average body temperature of a baby, child and adult to see if it changes over a human's life time. IR*

Health and disease

Healthy lifestyles

Standards

B0405 Examine how exercise affects heart rate.

B0406 Explain why regular exercise and a proper diet are important for health.

Learning Outcomes

Students should be able to:

B0405.1 Make predictions about the effect of different levels on heart rate.

B0405.2 Conduct an investigation into the effect of exercise on heart rates.

B0405.3 Link increased heart rate with increased blood flow and give reasons for this.

B0406.1 List the benefits of regular exercise on health and explain the effects of insufficient exercise.

B0406.2 Contrast the effect of healthy and unhealthy diets on the human body.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0405.1-2	**a) Plan and perform an experiment by measuring heart rate before, during and after different types of exercise. Compare predictions made before the test to outcomes and use these to draw conclusions about how exercise affects heart rate. IR; CT; CP**
B0405.3	**b) Watch videos showing how heart rate affects blood flow, and the effect this has on the body. Discuss how this feels and appears during exercise. CT; C**
B0406.1-2	**c) Discuss the long-term effects of healthy and unhealthy lifestyles on the body. Make a poster reflecting the main points. C; CP**

Chemistry Grade 4

Materials and their properties

Physical Properties and Different States of Matter

Standards

C0401 Define the terms mass, volume and shape.

C0402 Define solids, liquids and gases as states of matter, and give examples for each.

C0403 Classify matter as solids, liquids or gases based on their observable characteristics.

Learning Outcomes
Students should be able to:

C0401.1 Understand that the term mass relates to how much matter something is made of.

C0401.2 Understand volume as meaning how much space something takes up.

C0401.3 Understand shape as meaning the form that matter takes.

C0401.4 Investigate the mass, volume and shape of different solids.

C0402.1 Explain a solid as having a fixed shape, mass and volume.

C0402.2 Explain that a liquid has a constant volume and mass but does not take a fixed shape.

C0402.3 Explain that gases do not have a fixed shape or volume and can be compressed.

C0403.1 Give everyday examples of solids, liquids and gases.

C0403.2 Classify different items as solids, liquids or gases based on observable characteristics and prior knowledge.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0401.1-4	**a) Watch videos demonstrating the difference between mass and volume, discussing circumstances where volume would be measured rather than mass, and vice versa. CP; C**
C0401.1-4	**b) Measure the volume of liquids in millilitres, and the mass of a range of objects in grams. Investigate how the volume of a solid can be measured by displacing a known quantity of water. IR**
C0402.1-3	**c) Create a concept map showing the properties of solids, liquids and gases. C; IR**
C0403.1-2	**d) Classify a range of everyday objects as solids, liquids and gases based on observation. IR; CT**

Physics Grade 4

Waves, light and sound

Sound

Standards

P0401 Describe how sounds are made.

P0402 Explain how sound travels to our ears.

P0403 Describe how living things are able to hear sounds.

P0404 Demonstrate and explain that sounds can travel through liquids and solids as well as through the air.

P0405 Investigate the effectiveness of different materials on muffling sound.

Learning Outcomes
Students should be able to:

P0401.1 Define sound as being the result of vibration.

P0401.2 Link the strength of a vibration with the volume of a sound.

P0401.3 Make observations about the volume of a sound and its origin.

P0401.4 Conduct an investigation into the effects of distance on how a sound is heard.

P0402.1 Create a diagram to show how sound can travel directly to our ears.

P0402.2 Create a diagram to show how sound can bounce off an obstacle (e.g. a wall) to our ears.

P0402.3 Describe the phenomenon of an echo and explain how they occur.

P0403.1 Recognise that sound travels in all directions from a source.

P0403.2 Explain how having two ears, and their respective positions, help us to locate the source of sounds.

P0403.3 Label a diagram with explanations, in basic terms, of how the human ear works.

P0403.4 Explain how and why loud sounds can damage the ear.

P0404.1 Recognise that sounds need a medium to travel.

P0404.2 Conduct an experiment into how sound can travel through liquids, solids and air.

P0405.1 Conduct an investigation into which materials muffle sound.

P0405.2 Use the results of the investigation to draw conclusions about the types of materials which muffle sound.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0401.1-2	**a) Investigate the vibrations that create sound using a tuning fork. Link the strength of vibration with the volume by experimenting**

	with how hard the fork is struck, and the resulting strength of vibration. IR
P0401.3	**b) Using a variety of musical instruments, experiment with the way and volume varies when the instruments are manipulated in different ways. IR; CP**
P0401.4	**c) Conduct an experiment into how the distance from a sound affects how it is heard. Discuss and agree on conclusions based on the information gathered. IR; CT**
P0402.1	**d) Tour the school and listen for all the different sounds. Discuss how the sound travels to the ear. C; CP**
P0402.2-3	**e) Locate a place in the school where echoes can be heard. Draw diagrams to represent how the sound in each case travel to our ears. Use a diagram to show how sound travels to the ear. CT; IR**
P0403.1	**f) Investigate how well we can detect where sound is coming from using one ear, with the other ear covered. Draw a diagram to show why having two ears helps in locating the position of the source of the sound better. IR; CT**
P0403.3	**g) Watch video clips showing the inside of the human ear and how it functions. C; IR**
P0403.4	**h) Look at images of personnel who need to wear ear protection. Discuss the circumstances, and why hearing protection should be worn in certain situations. C; CP**
P0404.1-2	**i) Listen to the sound of a clock held in the air and then put it on a table. Press your ear against the table and listen again. Place the clock in a sealed plastic bag and then place it in a pail of water. Check whether the clock ticking can be heard. IR; CP**
P0405.1-2	**j) Plan, conduct and write up an investigation into how materials can muffle sound. Use the conclusions of this experiment to list materials best used for sound insulation. IR; CP**
P0405.1-2	**k)** *Research how sound is muffled in professional environment such as halls and recording studios. IR*

Matter and energy

Heat and temperature

Standards

P0406 Estimate and measure temperature in different contexts.

P0407 Investigate the changes in temperature of a hot and a cold object in a room.

P0408 Investigate the heat conducting and insulating properties of different materials.

Learning Outcomes
Students should be able to:

P0406.1 Estimate the temperature of different objects and locations.

P0406.2 Measure the temperature of different objects using a thermometer and a datalogger.

P0407.1 Investigate how the temperature of hot water changes when left in an ambient room.

P0407.2 Investigate how the temperature of cold water changes when left in an ambient room.

P0408.1 Investigate the heat conducting properties of different materials.

P0408.2 Investigate the heat insulating properties of different materials.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0406.1-2	**a) Study charts showing average temperatures across the year in Qatar, human body temperature and the temperature inside fridges, freezers and at the North and South Poles. Compare and discuss these temperatures. IR; C**
P0407.1-2	**b) Plan and conduct experiments to measure the changing temperature of hot and cold water. Record data, draw diagrams and discuss outcomes in groups. IR; CT**
P0408.1-2	**c) Research how different objects are designed to conduct and insulate heat, and what this makes them useful for. Use this information to create a fact file on heat insulators and conductors. IR; C**

Possible teaching order

Please note other orders are possible and acceptable.

Science			
	Biology	**Chemistry**	**Physics**
Grade 4	**1** Interdependence of organisms **4** Healthy lifestyles	**2** Physical properties and different states of matter	**3** Heat and temperature **5** Sound

Grade 5

Biology Grade 5

Organisms and their environment

Interdependence of organisms

Standards

B0501 Recognise the feeding relationships among herbivores, carnivores and omnivores.

B0502 Draw and label food chains to recognise the feeding relationships.

B0503 Relate the physical characteristics of an animal to its feeding role.

B0504 Identify the roles in the natural world of scavengers and decomposers.

Learning Outcomes

Students should be able to:

B0501.1 Define the terms herbivore, carnivore and omnivore.

B0501.2 List a variety of animals as herbivores, carnivores and omnivores, and match given animals to their descriptors.

B0501.3 Make observations about feeding relationships between herbivores, carnivores and omnivores by studying food chains.

B0502.1 Define the terms producer, predator and prey, understanding a producer as making its own nutrition.

B0502.2 Label food chains with the terms producer, predator, prey, herbivore, carnivore and omnivore.

B0502.3 Create and label food chains with three or more steps.

B0503.1 Make comparisons between the beaks and teeth of different herbivores, carnivores and omnivores.

B0503.2 Make suggestions as to the benefits of different types of teeth and beaks for the animal they belong to.

B0503.3 Explain the purpose of different physical features, such as claws and eye placement, in animals with different feeding roles.

B0504.1 Define the terms scavenger and decomposer and list some examples for each.

B0504.2 Explain the roles that scavengers and decomposers fill, and what might happen if they were removed from a food chain.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0501.1-2	**a) Group photographs of a variety of living things as herbivores, omnivores or carnivores, discussing the diet of each in groups. C; CP**
B0501.3 **B0502.1-2**	**b) Create food chains using images of a variety of animals and plants. Label each animal as being a carnivore, omnivore or herbivore, and all as being producer, predator or prey. Compare a variety of such food chains and discuss similarities and differences. C; IR**
B0501.3 **B0502.1-2**	**c)** *Watch videos showing the eating habits of a variety of living things, noting how their food is available in the environment around them.* **IR**
B0502.3	**d) Choose from a wide variety of living things to create a food chain with several steps. Note which type of diet appears more than once in a longer food chain. IR; C**
B0503.1-3	**e) Watch videos and look at photographs showing the different physical features, including beaks, teeth and claws, of a variety of creatures. Discuss in groups how these features help the creature to feed and label a picture to summarise the discussion. C; CP; IR**
B0504.1-2	**f) Use research to discover some scavengers and decomposers, and what they do. Use this information to create a fact file, also explaining what could happen if they did not exist. IR; CT**

Growth, development, reproduction and inheritance

Growth and development

Standards

B0505 Describe the human life cycle as involving the stages of birth, childhood, adolescence, adulthood and old age.

Learning Outcomes

Students should be able to:

B0505.1 Discuss the approximate ages at which each stage of the human life cycle begins.

B0505.2 Identify some ways in which people change physically during each stage.

B0505.3 Discuss some of the significant milestones for the different stages of the human life cycle.

B0505.4 Draw a diagram showing the different stages of the human life cycle.

LO references	Learning Experiences

	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0501.1-3 **B0505.3** **B0505.4**	**a) Have a class discussion about each stage of the human life cycle; agree on ages where each phase roughly begins. Discuss how human's appearances change physically and use this information to make sketches with accompanying notes for each stage. CP; C** **b)** *Create a table, with a row for each of the life stages. Give two further columns, one to be headed 'natural' and one 'legal'. Fill in the table to show the ages at which natural milestones are reached, such as walking, and legal ones, such as driving. Fill these in in groups.* **C; CP** **c) Use the information learnt to create an illustrated diagram of the human life cycle, annotated with notes about each stage. C**

Health and disease

Healthy lifestyles

Standards

B0506 Explain the nutritional benefits of the different food groups.

Learning Outcomes

Students should be able to:

B0506.1 Give examples of different foods that could be found in the following food groups: vegetables, fruits, cereals and starchy vegetables, legumes, milk and dairy, fish and meat including poultry.

B0506.2 Explain the function of these food groups as part of a balanced diet.

B0506.3 Identify the food groups which should make up the majority of a healthy diet, and those which should be eaten in more limited quantities.

B0506.4 Explain some of the potential consequences of eating a diet high in sugar, salt or fat.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0506.1 **B0506.2** **B0506.2**	**a) In groups, brainstorm as many foods as possible, and record each one in the correct group. C; CP** **b) Create a poster to be displayed in school, explaining to other learners how each food group contributes to our diet. C; CT** **c)** *Compare the nutritional values in a range of everyday foods to discover which foods are the best sources of each type of nutrient, and link this to the job it does in the body.* **IR**

B0506.3	**d) Create a menu showing a healthy and balanced day's food, including healthy snacks and drinks. C; CT; PS**
B0506.3	**e)** *Decide which combinations of foods could form a balanced diet. Make up diets for different people (e.g. office workers, builders, athletes) to illustrate how different lifestyles require a different balance of carbohydrate, protein and fat.* **IR**
B0506.4	**f) Create a video or short performance encouraging others to eat a healthy diet, explaining what can happen if too much sugar, salt or fat is eaten, and how foods high in these should be eaten as occasional treats. C; CP; CT**

Chemistry Grade 5

Materials and their properties

Physical properties and three states of water

Standards

C0501 Investigate how water changes from one state to another, relating it to heat gain or loss.

C0502 Describe the concepts of the boiling point of water, the freezing point of water, and the melting point of ice at room temperature.

C0503 Describe the water cycle, relating it to evaporation and condensation.

C0504 Recognise that liquids can change into gases through evaporation without boiling and investigate the factors that affect the rate of evaporation.

C0505 Recognise water conservation is a global issue, which has importance in Qatar.

Learning Outcomes

Students should be able to:

C0501.1 Define the terms heating, cooling, freezing, melting, evaporation and condensation.

C0501.2 Conduct an experiment to melt ice in different conditions, relating it to heat gain and melting.

C0501.3 Conduct an experiment to cool and freeze water in different conditions, relating it to heat loss and freezing.

C0501.4 Observe how water changes into steam, relating it to evaporation, boiling and condensation.

C0502.1 Understand that water will begin to behave in a certain way at a specific temperature.

C0502.2 State the temperature, in degrees Celsius, for boiling point of water, freezing point of water and melting point of ice.

C0503.1 Identify the different stages of the water cycle, and where these occur.

C0503.2 Draw and label a diagram of the water cycle, including the terms precipitation, evaporation and condensation.

C0503.3 Define the term precipitation and give examples of different types.

C0503.4 Discuss the need for the building of reservoirs for fresh water supply in Qatar, relating it to the water cycle.

C0504.1 Plan and conduct an investigation to explore the factors that affect the rate of evaporation.

C0504.2 Use the concept of evaporation to explain the results of the investigation.

C0504.3 Give examples of evaporation in everyday life, recognising that this is a constant occurrence.

C0505.1 Understand that water is a finite resource, and the potential consequences of not conserving water.

C0505.2 Identify domestic processes which use large amounts of water and describe measures that can be taken in the home to conserve water.

C0505.3 Discuss nations which have inadequate personal access to water, and initiatives which help them.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0501.1	**a) Create a glossary of the terms heating, cooling, freezing, melting, evaporation and condensation, adding examples to each. C; IR**
C0501.2-3	**b) Devise a set of fair tests to observe how water changes state. Agree on variables and controls in groups, make lists of equipment to be used, and consider a method to conduct the experiment. Record the findings and use this to present conclusions. IR; C; CP**
C0501.4	**c) Watch and discuss a teacher-led experiment showing the change from water to steam. IR**
C0502.1-2	**d) Create a poster showing the temperatures at which water boils and freezes, and where ice melts. C**
C0503.1	**e) Watch videos showing how the water cycle creates rain and discuss what takes place at each stage in groups. C**

C0503.2	**f) Use research to discover images of the water cycle and use these to create a labelled diagram. IR**
C0503.3-4	**g) Investigate countries that experience different types of precipitation; compare how much and how often with that of Qatar. Discuss the effect this has on Qatar's water supply compared with other countries. IR**
C0504.1-3	**h) Devise and undertake an experiment into the rate of evaporation using different areas in the school. Use the results to draw conclusions about the factors involved in evaporation. IR; CP**
C0505.1-2	**i) Research the average amount of water used by people in Qatar and around the world. Find ways to reduce water consumption and create a poster explaining these methods. IR; C**
C0505.1-2	**j)** *Compare the use of water in Qatar with a country in a temperate climate and one in a cold climate. Suggest reasons for the differences.* **IR;C**
C0505.3	**k) Research charities which help to provide water in developing nations. Find out the problems with accessing water that local people have, and how they can be helped to access enough water. IR**

Physics Grade 5

Forces motion and scale

Friction and resistance

Standards

P0501 Investigate and explain the effect of friction on the movement of an object.

P0502 Observe, describe and compare the effect of water and air resistance on the movement of objects.

P0503 Investigate how the shape of an object affects the action of air and water resistance.

Learning Outcomes

Students should be able to:

P0501.1 Describe friction as a resisting force acting on an object.

P0501.2 Make predictions about the amount of friction in different circumstances, and the effect this will have on the movement of an object.

P0501.3 Design and perform an experiment to identify the amount of friction acting on different materials.

P0502.1 Describe the effects of air resistance on moving objects.

P0502.2 Describe the effects of water resistance on objects.

P0503.1 Investigate, using real life examples, how the shape of an object affects its movement in water due to water resistance.

P0503.2 Observe the design of aircraft and discuss how they are designed to minimise air resistance.

P0503.3 Compare the shapes of man-made objects and living things which move through air and water.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0501.1-2	**a) Make predictions about how a wide variety of different materials will be affected by friction and justify these predictions by comparing the materials. C; IR**
P0501.3	**b) Using the objects that they have already made predictions about, learners devise and conduct an experiment to test effects of friction. Use the results to draw conclusions and compare these to earlier predictions. IR; C**
P0502.1-2 **P0503.1**	**c) Watch videos and perform simple tests to observe how differently shaped objects move through water and air. IR**
P0503.2	**d) Compare photographs of different types of aircraft. Use their designs to create a paper model, and test how far each learner's model can travel. Compare the ones which travel furthest to draw conclusions about the least air-resistant shapes. IR; C**
P0503.3	**e) Look at photographs of air and sea creatures. Compare for each their features, noting common structures and comparing these to air and sea craft. IR; CT**
P0503.3	**f)** *Visit a local aquarium or aquatic animal sanctuary. Observe and sketch the creatures there, noting the variety of shapes and how these creatures move.* **IR; CT**

Electricity and magnetism

Simple electrical circuits

Standards

P0504 Construct simple electrical circuits, using bulbs, switches, wires and batteries.

P0505 Draw circuit diagrams using universally recognised symbols.

Learning Outcomes

Students should be able to:

P0504.1 Describe the function of bulbs, switches, wires and batteries in circuits, connecting these to real-life uses.

P0504.2 Construct a variety of functioning circuits using different combinations of components.

P0505.1 Recognise the universal symbols for different electrical components.

P0505.2 Draw circuit diagrams for created circuits.

P0505.3 Create a circuit from a given diagram.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0504.1 **P0504.2** **P0505.1-2** **P0505.3** **P0505.3**	**a) Brainstorm a variety of electrical devices which use switches and/or bulbs. Explain the function of these components and why they are useful. CT; CP** **b) In groups, use the available components to try a variety of different circuit combinations. Discuss any which do not work, or have different results from others, and suggest reasons for this. CT; PS** **c) Recreate a selection of the functioning circuits made in groups as diagrams, using the universal symbols for components. CT; IR** **d) Create a working circuit from a given diagram, using the correct number and configuration of components. IR; C** **e)** *Work in pairs - one to create a circuit diagram, and the other to build the circuit shown. Once built, check that the circuit is correct and functions as it should.* **IR; CP**

Electric charges

Standards

P0506 Describe the single directional flow of electric current around a circuit.

P0507 Investigate the effects of increasing the numbers of bulbs or cells in a circuit.

P0508 Identify which types of materials make good conductors, and which do not.

Learning Outcomes

Students should be able to:

P0506.1 Identify a cell as having a positive and negative terminal.

P0506.2 Recognise that a complete circuit, connected to both the positive and negative terminals of a cell, is needed for electric current to flow.

P0506.3 Label a diagram to show electric current flowing from the positive terminal to the negative one in a complete circuit.

P0507.1 Make predictions about the effect of adding bulbs and cells to a simple series circuit.

P0507.2 Perform an experiment to show the effects of adding bulbs and cells to a simple series circuit.

P0508.1 Define the term conductor and make predictions about which types of materials will be good conductors.

P0508.2 Conduct an experiment to test a variety of materials to determine whether they are good or bad electrical conductors.

P0508.3 Use the results of the experiment to draw conclusions about which types of materials (e.g. metals) make for good electrical conductors.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0506.1-3	**a) On diagrams and circuits, identify the positive and negative terminals on a cell, and mark the direction of flow of electric current as being in a single direction. C; IR**
P0506.1-3	**b)** *Investigate what happens if a cell is placed the wrong way into a circuit and suggest reasons for this.* **IR; PS**
P0507.1	**c) Look at circuit diagrams featuring more than one bulb or cell. Make predictions about how adding additional bulbs or cells will affect the circuit and suggest reasons for this. C**
P0507.2	**d) Build the circuits from the previously seen diagrams, comparing the results to predictions and discussing the reasons for the observed effects. IR; C**
P0508.1	**e) In groups, categorise a variety of everyday materials by making predictions about whether they would be good conductors. CP; C; CT**
P0508.2	**f) Plan and safely conduct an experiment to investigate which materials make good conductors. Record the results and use them to draw conclusions about which types of materials make better conductors. CT; IR**

Possible teaching order

Please note other orders are possible and acceptable

Science			
	Biology	**Chemistry**	**Physics**
Grade 5	**1** Interdependence of organisms **2** Healthy lifestyles **5** Growth and development	**6** Physical properties and three states of water	**3** Simple electrical circuits **4** Electric charges **7** Friction and resistance

Grade 6

Biology Grade 6

Structure and function of organisms

Tissues, organs and systems: Human body systems

Standards

B0601 Label and describe the function of some of the structures in the circulatory system.

B0602 Label and describe the function of some of the structures in the respiratory system.

B0603 Label and describe the function of some of the structures in the digestive system.

B0604 Label and describe the function of some of the structures in the urinary system.

B0605 Label and describe the function of the brain and sense organs.

Learning Outcomes

Students should be able to:

B0601.1 Describe the circulatory system as comprising the heart, arteries and veins, giving descriptions of each.

B0601.2 Draw and label a diagram to show blood flow around the body, including oxygenation of blood in the lungs.

B0601.3 Describe the function of blood in transporting oxygen and nutrients for use around the body.

B0602.1 Identify the lungs, trachea, diaphragm and rib cage on a diagram of the human body.

B0602.2 Identify that humans, like many living things, have two lungs which are used in breathing.

B0603.1 Identify the oesophagus, stomach, large intestine, small intestine and liver on a diagram of the human body.

B0603.2 Explain the role of the teeth, saliva and the oesophagus in the digestive system.

B0603.3 Describe the transit of food from the mouth to the anus, and the role of the main organs it passes through.

B0604.1 Identify the bladder and kidneys on a diagram of the human body.

B0604.2 Describe the kidneys as the organs that filter and clean the blood and remove excess water and waste products, and the bladder as the organ which collects and stores urine.

B0605.1 Describe the brain as the control centre of the human body, which allows us to think and make sense of the world around us.

B0605.2 Identify the organs linked to sense, including the role of skin in touch, and understand that they relay information to the brain.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0601-6	**a)** *As each new body system is investigated, add representations (models, drawings) to a display of the human body.*
B0601.1-3	**b) In groups create a diagram, using a variety of media, to show the circulatory system and how blood moves around the body. Use this to give a presentation about how the circulatory system, and what it carries around the body. CP**
B0602.1-2	**c) Make a model of the respiratory system using balloons and a plastic bottle. IR**
B0603.1-3	**d) Use the internet to look up how to make a working model of the digestive system and create one in groups. IR; CP**
B0604.1	**e)** *Make a poster explaining the functions of the kidneys and bladder using drawings and text.* **C**
B0604.2	**f) Create a simple representation of the kidneys using oil, water, insoluble materials/foodstuffs and a sieve to show how kidneys filter waste products, blood and plasma. IR**
B0605.1	**g) Make notes on how many senses are used in different everyday situations, such as eating or sitting outdoors, and what messages the sense organs send about each situation. IR; CT**

Growth, development, reproduction and inheritance

Growth and development in plants

Standards

B0606 Describe the functions of the parts of a flower.

B0607 Draw, label and describe the main stages in the life cycle of a flowering plant.

B0608 Recognise the ways in which plants can be pollinated.

B0609 Compare different methods of seed dispersal.

Learning Outcomes

Students should be able to:

B0606.1 Draw a diagram showing the structure of a flower, including the stamen, carpel, petals and sepals.

B0606.2 Explain the role of the stamen, carpel, petals and sepals in the reproduction of a flower.

B0607.1 Define the purpose of germination, growth, development, reproduction and seed dispersal in flowering plants.

B0607.2 Draw and label a diagram to show the life cycle of a flowering plant.

B0608.1 Understand that living things and the wind can assist in the pollination of plants.

B0608.2 Compare the physical appearance of plants which pollinate by wind with animal-pollinated plants.

B0609.1 Explain how plants use animal dispersal, wind dispersal, water dispersal and mechanical dispersal to move their seeds, and compare the distance each method can move a seed.

B0609.2 Compare the structures of seeds dispersed by different methods and suggest reasons why they are well suited to their function.

LO references	**Learning Experience** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0606.1-2 **B607.1-2** **B0608.1-2** **B0609.1-2** **B0609.1-2**	**a) Dissect a flower, stick an example of each part onto a sheet of paper, then label each part and explain its function. IR; C** **b) Draw a detailed diagram of each part of a plant's life cycle, adding a description of the process and function of each stage. C** **c) Use the internet to research some plants which use living things as pollinators. Compare their appearance to those which are wind pollinated and discuss how each type of plant is well suited to its method of pollination. CT; IR** **d) Compare photographs of seeds with different dispersal mechanisms. Note the features of each, and how this supports their dispersal method. CT** **e)** *Create paper models of different air-dispersed seeds, make predictions about how effective each will be, and conduct an investigation into which model travels furthest.* **CT; IR**

Human growth and development

Standards

B0610 Label and describe the function of some of the structures in the reproductive system.

B0611 Describe the process of puberty, including how physical appearance changes.

Learning Outcomes
Students should be able to:

B0610.1 Understand that males and females have different reproductive organs, which serve different purposes.

B0610.2 Describe the testes as producing sperm, the ovaries as releasing eggs, and how both are needed in reproduction.

B0611.1 Understand puberty as part of the physical process of becoming an adult.

B0611.2 Understand that puberty affects the sexes differently.

B0611.3 Describe some of the physical changes that happen during puberty, including the development of secondary sexual characteristics.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0610.1-2	**a) Create a table comparing the functions of ovaries and testes, showing the similarities and differences of the jobs that they do. IR;CT**
B0611.1-3	**b) Have an appropriate, teacher-led discussion about how puberty affects all people, focusing on its existence as a natural process and discussing any likely misconceptions children may have. C; CP**
B0611.1-3	**c)** *Give children an opportunity to anonymously write any questions they have about puberty, which can be addressed in a following lesson. C*
B0611.2-3	**d) In groups, create a poster aimed at other children, dealing with some of the changes that take place in puberty, correcting some of the misconceptions around the process and its outcomes. C; CP**

Diversity and variation in living things

Classification

Standards

B0612 Compare a wide variety of plants according to different criteria.

B0613 Compare the characteristics of vertebrates and invertebrates.

Learning Outcomes
Students should be able to:

B0612.1 Understand that some plants are non-flowering, giving examples.

B0612.2 Explain the differences between deciduous and evergreen trees, giving examples.

B0612.3 Recognise and name a wide variety of food plants, comparing their appearance.

B0613.1 Identify a wide range of vertebrates from a range of classes, studying their skeletons and physical appearance.

B0613.2 Study the physical characteristics of a wide variety of invertebrates, including insects and molluscs, comparing their structural support systems to those of vertebrates**.**

B0613.3 Classify a variety of given living things as invertebrates or vertebrates.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0612.1	**a) Use research and/or fieldwork to find some examples of non-flowering plants. IR**
B0612.1	**b)** *Conduct research to explain how non-flowering plants reproduce.* **IR;C**
B0612.2	**c) Draw and label an example of a deciduous and evergreen tree. C**
B0612.3	**d) Compare, using photographs or specimens, foods where the roots, leaves, stems, seeds and fruits are eaten. IR; CT**
B0612.3	**e)** *Create a list of as many different foods as possible, and then classify these by which ones come from plant sources, which contain some plant sources, and those with no plant source. Use the internet to check that they are all correct.* **IR**
B0613.1	**f) Study the structures of the skeletons of two or more vertebrates, comparing their similarities and differences. Create a table to show the comparison. IR; CT**
B0613.2	**g) Make observations from photographs and diagrams about the support structures of a range of invertebrates. Discuss how each creature's structure is useful to it. IR; C**
B0613.3	**h) Create a branching key, using suitable questions, to classify some vertebrates and invertebrates that are found in Qatar. PS, IR**

Chemistry Grade 6

Materials and their properties

Physical and chemical changes

Standards

C0601 Distinguish between physical and chemical changes.

C0602 Observe how substances can change physically or chemically through heating.

C0603 Identify a variety of soluble and insoluble substances.

C0604 Describe how a solute can be recovered by evaporation and condensation.

C0605 Investigate the separation of insoluble solids from a liquid by filtration.

Learning Outcomes
Students should be able to:

C0601.1 Show an understanding that physical changes may affect the appearance of an object, but the object is still made of the same elements.

C0601.2 Show an understanding that chemical changes result in a new substance being formed, which often cannot be changed back.

C0601.3 Give some everyday examples of chemical and physical changes.

C0602.1 Observe and make notes on the effects of heating on different substances.

C0602.2 Identify the changes observed as either physical or chemical changes.

C0602.3 Distinguish between heating and burning and recognise that these can have different effects on a substance.

C0603.1 Define the terms soluble and insoluble.

C0603.2 Perform an experiment to distinguish between soluble and insoluble materials.

C0603.3 Suggest which types of substance are more likely to be soluble, based on the findings of the performed experiment.

C0604.1 Define the terms solute, solvent and solution.

C0604.2 Observe evaporation and condensation being used to separate a solute from a solution.

C0604.3 Draw a diagram to show the process of evaporation and condensation in recovering a solute.

C0605.1 Observe and discuss the process of filtration to remove an insoluble solid from a liquid.

C0605.2 List examples of filtration in daily life.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0601.1	**a) Conduct an experiment in groups, undertaking some physical changes. C; CP**

C0601.2	**b) Observe a teacher-led experiment showing some chemical changes, discussing how the makeup of the substance has been altered C; CP; IR**
C0601.3 C0602.1-2	**c) In groups, investigate physical and chemical changes in familiar foods when they are cooked (e.g. melting butter, dissolving sugar or salt in water, boiling potatoes, bread dough baking, toasting bread, frying eggs). IR; CP; CT**
C0601.3 C0602.1-2	**d)** *Work in pairs to heating a variety of substances with a flame, including some common chemicals (e.g. copper sulfate, copper carbonate, sodium chloride) and some everyday materials (e.g. sugar, flour, egg, paper, wood, ice, various metals) and relate to physical changes and chemical changes.* **IR; CP; PS**
C0602.3	**e) Watch videos showing heating and burning of different substances and discuss the differences in outcomes. C; CP**
C0603.1-3, C0604.1	**f) Design a fair test to ascertain whether a material is soluble and insoluble and perform this test in small groups. Record the results and present the findings appropriately. Use the information gathered to devise a set of criteria for a material more likely to be soluble. CT; C; IR**
C0604.2-3	**g) Observe a teacher-led experiment showing evaporation and condensation of water, creating a labelled diagram of the experiment to show what has occurred. C; CP**
C0605.1	**h) In groups, conduct an experiment to filter dirty water. Examine what has been left behind in the filtration process and the water that has been filtered. Compare this to a sample of the unfiltered water and discuss what has happened. CP; IR; C**
C0605.2	**i) Research examples of filtration, record some examples and explain how useful the process of filtration can be. C; IR**

Physics Grade 6

Earth and space

Our solar system

Standards

P0601 Name and describe the planets in our solar system.

P0602 Describe the Earth's rotation on its axis as being the reason for our day and night cycle.

P0603 Describe how the Moon revolves around the Earth once every 28 days and explain how this causes the phases of the Moon.

P0604 Describe the Earth's path of orbit around the Sun.

Learning Outcomes

Students should be able to:

P0601.1 Name, in order, the planets in our solar system.

P0601.2 Understand that the Sun is a star, not a planet.

P0601.3 Describe our Moon as a satellite, and recognise that other planets have moons.

P0601.4 Describe the planets, as well as the Sun and our Moon, as being roughly spherical.

P0601.5 Recognise that the planets vary greatly in size and climate, but only Earth is known to be able to sustain life.

P0601.6 Compare the sizes of the Sun, Earth and Moon.

P0602.1 Understand that the Earth spins on its axis, the top and bottom of which are the North and South Poles.

P0602.2 Explain that the Earth makes one full rotation on its axis every 24 hours, defining the length of a day.

P0602.3 Draw a diagram to show why one side of the Earth is in darkness and the other in light at any one time.

P0602.4 Use knowledge of the Earth's rotation to explain why the Sun appears to move through the sky during the day.

P0603.1 Recognise that the Moon orbits around the Earth once every 28 days.

P0603.2 Relate the orbit of the Moon to the phases of the Moon.

P0604.1 Recognise that the Earth orbits the Sun once every 365.25 days, and how this relates to the yearly calendar.

P0604.2 Relate the Earth's path of orbit to the four seasons using diagrams.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0601.1 **P0601.1-6** **P0601.1-6**	**a) Create a rhyme, poem, song or mnemonic to remember the names and order of the planets in our solar system. CT** **b) Create a diagram or model of our solar system, including the planets, Sun and our Moon. CT; C** **c)** *Research the relative sizes of the planets, Moon and Sun, and use everyday objects to create a scale model.* **CT; PS**

P0601.1-6	**d)** *Research the climates of the different planets and use this information to suggest why life is only known to exist on Earth.* **CT; C; IR**
P0602.1-3	**e) Draw diagrams to show the rotation of the Earth on its axis and how this causes the day and night cycle. C**
P0602.3-4	**f) Use a torch and spherical object in groups to show the movement of the Earth around the Sun, its rotation on its axis and how this leaves one half of the Earth in darkness. IR; CT**
P0602.3-4	**g)** *Perform an experiment over the course of a school day to mark the apparent movement of the Sun across the sky. Use this information to prove where the Sun rises and sets in relation to both the position of the school and on a compass.* **IR; CT**
P0603.1-2	**h) Create a 'Moon map' for the month ahead, using internet research to help. IR**
P0604.1-2	**i) Draw and label a diagram showing the position of Qatar as the Earth orbits the Sun. Annotate this with the season shown in each position, and how long the full orbit takes. C; IR**

Forces, motion and scale

The effects of forces

Standards

P0605 Distinguish between forces that act at a distance and contact forces.

P0606 Distinguish between mass and weight.

P0607 Explain the action of gravity on objects.

P0608 Recognise that objects are always being acted on by different forces, and that there must be disequilibrium for an object to move.

Learning Outcomes

Students should be able to:

P0605.1 Understand that, in some cases, two objects do not need to touch in order for one to exert force on the other.

P0605.2 Give some common examples of at-a-distance forces.

P0606.1 Explain the concepts of mass and weight, and how they differ.

P0606.2 Use knowledge of other planets to demonstrate the differences in mass and weight.

P0607.1 Explain, in simple terms, the action of gravity on an object.

P0607.2 Investigate the effects of gravity on different objects.

P0607.3 Understand that the surfaces of different planets have different levels of gravitational pull and explain the effects of dropping the same object on different planets.

P0608.1 Draw and label a diagram to show the equal but opposite forces acting on an object at rest. **P0608.2** Draw and label a diagram to show the forces acting on a moving object, noting which forces are greater, causing disequilibrium.	
LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0605.1-2	**a) Work in small groups and recall all the forces encountered so far (e.g. push, pull, friction, air resistance, water resistance, gravity, magnetic force, electrostatic force) Classify these forces into those that require contact and those that act at a distance. IR; CP**
P0606.1	**b) Use scales and Newton meters to measure the mass and weight of different everyday objects. Present the findings as a table and a graph, in order to study the relationship between the two measures. IR; C**
P0606.2	**c) Use the internet to research the difference in weight of different objects on Earth and other planets. Present your findings as a poster. C; IR**
P0607.1-3	**d) Perform a simple investigation in groups by dropping a range of objects from the same height. Discuss why the objects behave in the way that they do. C; CP**
P0607.1-3	**e)** *Use the internet to watch videos of astronauts on the ISS. Investigate the idea of weightlessness to explain why objects behave differently in space. IR*
P0608.1-2	**f) In groups, observe an object at rest, and discuss the forces at work in keeping the object still. Exert a force on the object and discuss what forces are now at work on that object. Draw diagrams to represent this. IR; C; CP**

Possible teaching order

Please note other orders are possible and acceptable

Science			
	Biology	**Chemistry**	**Physics**
Grade 6	**1** Tissues, organs and systems: Human body systems **2** Human growth and development **3** Growth and development in plants **5** Classification	**7** Physical and chemical changes	**4** Our solar system **6** The effect of forces

Science Standards Grades 7-9

Grade 7

Biology Grade 7

Structure and function of organisms

Cell structure and function

Standards

B0701 Recognise the main structures in plant and animal cells (nucleus, cell membrane, mitochondria, cytoplasm, cell walls, cell vacuoles and chloroplasts) and describe their functions.

B0702 Describe the relationships between structure and function in specialised cells (plant root hair cell, xylem vessel, nerve cell and red blood cell).

B0703 Describe diffusion and osmosis and explain how they act as mechanisms for the movement of water in and out of cells.

Learning Outcomes

Students should be able to:

B0701.1 Use a light microscope.

B0701.2 Observe, draw and label the functions of the cell structures and organelles in animal cells (cell membrane, cytoplasm, nucleus).

B701.3 Describe the functions of the cell structures and organelles in animal cells (cell membrane, cytoplasm, nucleus and mitochondria).

B0701.4 Observe, draw and label the cell structures and organelles in plant cells (cell membrane, cytoplasm, nucleus, cell wall, cell vacuole, chloroplasts)

B0701.5 Describe the functions of the cell structures and organelles in plant cells (cell membrane, cytoplasm, nucleus, cell wall, cell vacuole, chloroplasts and mitochondria).

B0701.6 Compare and contrast plant and animal cells.

B0702.1 Describe the structures of specialised animal cells including nerve cells and red blood cells.

B0702.2 Explain how the structures of specialised animal cells including nerve cells and red blood cells are related to their functions.

B0702.3 Describe the structures of specialised plant cells including root hair cells and xylem cells.

B0702.4 Explain how the structures of specialised plant cells including root hair cells and xylem cells are related to their functions

B0703.1 Describe the process of diffusion in terms of particles moving down a concentration gradient and explain its importance in the movement of substances in and out of cells.

B0703.2 Describe the process of osmosis in terms of water moving down a concentration gradient through a partially permeable membrane.

B0703.3 Explain the role of diffusion and osmosis in the movement of water in and out of cells.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0701.1	**a) Students work in pairs or small groups to practice using a light microscope, looking at graph paper, a human hair and a prepared slide of familiar tissue such as a plant leaf or skin to familiarise them with using the microscope and the different lenses and to help them understand magnification CP**
B0701.1	**b)** *Students produce a set of instructions for using a light microscope which could be used to help other students when they use a microscope for the first time.* **C**
B0701.1 **B0701.5-6**	**c) Students work in pairs or small groups to prepare a slide of cheek cells, stained with methylene blue. They observe the cells under x4 and x10 objective lenses. Students make pencil drawings of the cells as seen under the microscope and label the cell boundary, the nucleus and the cytoplasm. CP**
B0701.1 **B0702.1-4**	**d) i) Students work in pairs or small groups and make a slide of plant cells, some using a water weed such as *Elodea* and others using onion epidermis. Students observe the cells under the light microscope and make pencil drawings of the cells, labelling the cell wall, the nucleus, the cytoplasm, and the vacuole and chloroplasts if present and visible. CP** **ii)** *Students look at prepared slides of plant material and compare these with the slides they made from fresh specimens* **CT**
B0702.1-4	**e)** *Students work in small groups to discuss the problems of making slides with fresh plant leaves (eg Elodea) and suggest ways in which these can be overcome. Each group shares their conclusions with the whole class.* **PS ; C**
B0702.1 **B0702.3**	**f) Students work around a series of light microscope or projection microscope to observe prepared slides of specialised animal cells including nerve cells and red blood cells and specialised plant cells including root hair cells and xylem cells. Students are given a set amount of time at each microscope station in which to make labelled pencil drawings indicating the specialised features from their direct observations. CP**

B0703.1	**g)** *Students work individually or in pairs to investigate more examples of specialised cells eg in animals: fat cells, muscle cells, sperm or egg cells; in plants; phloem cells, palisade mesophyll cells. Use books or the internet for research. Draw diagrams of the cells and annotate the structures related to particular specialised functions.* **IR**
B0703.2	**h)** *Students make a model of a specialised cell of their choice, using a variety of materials.* **CT**
B0703.2-3	**i) Teacher demonstrates simple diffusion in liquids using either a crystal of potassium manganate (VII) in a beaker of water or a drop of food colouring or ink in a beaker of water, and in gases using a spray of perfume in one corner of the class.**
B0703.2-3	**j) Students observe a teacher demonstration of osmosis using partially permeable membrane bags acting as model cells. Students observe the apparatus at the beginning of a lesson, discuss possible outcomes, make further observations after 30 minutes and offer explanations for these observations based on osmosis.** **CT**
B0703.2-3	**k) Students work in pairs and cut carrots or potatoes in ten equal length sticks, and place half in distilled water and the other half in strong salt or sugar solution. Record the length and the texture of the plant tissue. Leave them for a minimum of 30 minutes, remove and repeat the observations. Put the class data together and produce graphs to show the effect on length of the sticks. Students explain their observations in terms of the effect of osmosis on plant cells** **PS**
B0703.1-3	**l)** *Students work in small groups to investigate osmosis using partially permeable membrane bags acting as model cells. They use their results to discuss the effect of diffusion and osmosis on the movement of water in and out of cells.* **CP**

Photosynthesis

Standards

B0704 Describe the process of photosynthesis and investigate the requirement for light for photosynthesis to take place.

Learning Outcomes

Students should be able to:

B0704.1 State the equation for photosynthesis in words.

B0704.2 Know how iodine solution can be used to indicate the presence of starch in the leaves of a plant which has been exposed to light.

B0704.3 Investigate the requirement of a plant for light to carry out photosynthesis, using iodine solution to indicate the presence or absence of starch in a land plant and a data logger to detect changes in oxygen concentration in a water plant.

LO reference	Learning Experiences

	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0704.2	**a) Teacher demonstrates the use of iodine solution to test a leaf for starch, explaining the purpose of each step:(leaf is boiled in ethanol in a water bath, rinsed in hot water, spread onto a white tile and iodine solution added. (In demonstration, use a leaf from a plant exposed to light for 24 hours)**
B0704.1 **B0704.3**	**b) Students work in groups to investigate the need for light for photosynthesis in a land plant, using the iodine test from Compulsory LE a). Some groups test leaves from a plant exposed to light for 24 hours and other groups test leaves from a plant kept in darkness for 24 hours for starch. [ALTERNATIVE: *Students cover some leaves on a plant with dark paper or foil. The plant is then left in bright light for a minimum of 24 hours. Some groups test leaves exposed to light for starch and other groups test covered leaves for starch]*. Students combine their results to draw their conclusions. CP; C**
B0704.3	**c) Students work in groups investigate the need for light for photosynthesis in a water plant, using data loggers to show the increase in dissolved oxygen in the water in the presence of light, and the fall in oxygen concentration in the dark. CP**
Tissues, organs and systems	
Standards **B0705** Describe the position of and functions of plant transport tissues, in relation to the movement of water in a plant. **B0706** Explain the relationship between the structures and functions of the cells and tissues of a dicotyledonous leaf.	
Learning Outcomes **Students should be able to:** **B0705.1** Identify the position of xylem and phloem tissue in the leaf, stem and root of a plant **B0705.2** Explain how the position of the xylem and phloem tissue in the leaf, stem and root of a plant relates to the functions of these tissues. **B0705.3** Describe how water and nutrients enter a root hair cell and move up through a plant. **B0706.1** Observe and describe the structure of a dicotyledonous leaf, including a palisade cell, chloroplasts, gas exchange mesophyll, vascular bundles and stomata. **B0706.2** Explain how the cells and tissues of a dicotyledonous leaf relate to their roles in photosynthesis, gaseous exchange and water movements in the plant.	
LO reference	**Learning Experiences**

	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0705.1-2 **B0706.1-2**	**a) Students use light microscopes or a projection microscope with prepared slides of TS root, stem and leaf of a young dicotyledonous plant to observe the position of the xylem and phloem tissues in the different areas of a plant. Students draw and label the position of the xylem and phloem in the root, stem and leaves. C**
B0705.3	**b)** *Students use light microscopes or a projection microscope and prepared slides to observe, draw and label root hair cells. Annotate the drawings to relate the structure of the cell to water movement in the plant* **C**
B0705.1-2	**c) Students investigate the transport of water through the xylem vessels in the stem of a plant using long-stalked white flowers (eg roses, chrysanthemums or carnations) and water containing red food dye. Annotate the drawings to relate the structure of the cell to water movement in the plant. CP**
B0705.1-2	**d)** *Students investigate the movement of water up the xylem tissue in the stem of a plant using celery stalks with leaves and red and blue food dye and use this to explain the role of the xylem in water movements in the plant.* **CP**
B0706.1-2	**e) Students use light microscopes or a projection microscope with prepared slides of TS leaf of a young dicotyledonous plant to observe the position of the vascular bundle containing the xylem and phloem, the stomata, the air spaces for gas exchange in the gas exchange mesophyll cells and the palisade mesophyll cells with many chloroplasts where photosynthesis takes place. Students draw and label a plan of the leaf structure showing the positions of the main types of tissue WITHOUT individual cell details and discuss how the tissues are related to their functions of photosynthesis, gas exchange and water movements C**

Organisms and their environment

Interdependence of organisms

Standards

B0707 Explain the relationships between trophic levels in an ecosystem.

B0708 Evaluate different ways of modelling relationships in an ecosystem.

Learning Outcomes

Students should be able to:

B0707.1 Construct food chains and food webs to explain the terms producer, consumer and trophic levels.

B0707.2 Explain, with examples, how biomass is lost between trophic levels along a food chain and discuss why there are never more than 5 trophic levels in a food chain.

B0707.3 Discuss the effect of biomass loss along a food chain on the efficiency of food production.

B0708.1 Interpret pyramids of numbers and pyramids of biomass representing the organisms linked in a food chain.

B0708.2 Explain the advantages and disadvantages of using pyramids of biomass rather than pyramids of numbers to represent the organisms in a food chain

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0707.1	**a) Students produce a poster to illustrate trophic levels along food chains and food webs, illustrating the general principles by using examples they know or find by research. C; (IR)**
B0707.1	**b)** *Students select examples of predator-prey relationships from video clips.* **CP**
B0707.1	**c)** *Students work in pairs and use a spreadsheet to model the changes in numbers of organisms in a food chain as a consequence of increasing or decreasing the numbers of primary consumers. This can be developed to consider the effect of changes in numbers of primary consumers on a food web.* **CT**
B0707.2	**d) Students discuss the limits on the length of food chains and why 5 levels are the maximum. They then use the internet to find food chains with as many trophic levels as possible. Students share findings with the class to find the food chain with the highest number of trophic levels. IR; C**
B0707.3	**e) Students investigate the rearing of goats for humans to eat. Students should discover or estimate the biomass lost at each level of this process and work in small groups to suggest ways of making this process more efficient. PS**
B0708.1	**f) Students use provided numerical data on plant and animal populations in various habitats to draw pyramids of numbers and pyramids of biomass for each habitat. PS**
B0708.2	**g)** ***Follow-up from f): Students work in groups to produce lists of the advantages and disadvantages of pyramids of numbers and pyramids of biomass as ways of modelling the organisms in a food chain*** **CT**

B0708.2	**h)** *Students are provided with a number of pyramids of number and pyramids of biomass for different food chains. Students interpret what they can about the different food chains and then discuss which model gives the most information.* **CT**

Environmental interactions and processes

Standards

B0709 Explain how toxins can increase in concentration along a food chain.

B0710 Explain how human action can cause environmental change, alter food webs and affect biodiversity.

Learning Outcomes

Students should be able to:

B0709.1 Describe how toxins can increase in concentration along a food chain (bioaccumulation) eg DDT.

B0709.2 Explain why top predators are most commonly affected by the increase in concentration of toxins along a food chain.

B0710.1 Define biodiversity and explain its importance.

B0710.2 Carry out a simple field investigation into the distribution and abundance of organisms in an ecosystem and explain how to determine their numbers in a given area.

B0710.3 Give examples of how human actions can cause both positive and negative environmental change, and explain how they can affect food webs and biodiversity.

B0710.4 Recognise why conservation of the environment is important and suggest some methods of environmental conservation.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0709.1-2	**a) Students use the internet to investigate the impact of DDT on food chains, producing a wall chart showing the organisms affected, the feeding relationships between the organisms and the increase in pesticide concentration per unit of body mass along the chain.** **IR-**
B0709.1-2	**b)** *Using data provided, students calculate the percentage increase in concentration of pesticide per unit body mass in the organisms in an affected food chain.* **PS**
B0710.2	**c)** *Students work in small groups. Each group is given the name of a country eg Qatar, Costa Rica, Antarctica, the UK, and they investigate the levels of biodiversity in that country – for example the number of species of animals or plants in a country, the most common species of*

		bird, mammal, insect or plant and the rarest species in the country. Each group reports back to the whole class. **IR; C**
B0710.3	**d)**	**Students work in pairs to carry out a simple field investigation into a local ecosystem. Using quadrats they should investigate the distribution and abundance of plants or slow moving animals in their chosen ecosystem and determine the numbers in a given area.** *[Students may use data loggers to record abiotic features of the ecosystem such as soil pH or water oxygen levels]* **CP**
B0710.3	**e)**	*Discuss data on the organisms living in an area before and after development or environmental change and list how the changes have affected local food webs and/or biodiversity* **CP**
B0710.3	**f)**	**Students take part in a class exercise including brainstorming to identify human actions which have caused positive and negative environmental change both locally and globally. Students then split into groups to research specific examples of both positive and negative human actions and the impact they have had on specific food webs and/or biodiversity. Each group reports back in a plenary session**. **CT; IR; C**
B0710.4	**g)**	*Interview adults about their memories of the plants and animals that were found in different places in their youth and compare this with what is found today* **C**
B0710.4	**h)**	**Students work in pairs to produce a poster to explain to the population of Qatar why conservation of the environment is important, and to give some methods of environmental conservation which may be local to Qatar or may be international examples. CP; C**
B0710.4	**i)**	*Visit a conservation project in Qatar and write up a report of the visit* **C**

Diversity and variation in living things

Adaptation

Standards

B0711 Describe some adaptations of animals for feeding at different trophic levels, and some adaptations of plants to protect themselves from herbivores.

Learning Outcomes

Students should be able to:

B0711.1 Describe some of the adaptations of herbivores and carnivores for their biological niche, using local and international examples.

B0711.2 Describe some plant adaptations which protect them from herbivores, using local and international examples.

LO reference	Learning Experiences

	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0711.1	**a) Students observe skulls of a carnivore and an herbivore. Make annotated drawings to show how the skulls are adapted for the biological niche of the animal, including the eye position, the teeth and the jaws. IR**
B0711.1	**b)** *Students watch videos showing a variety of carnivores and herbivores and make a table to summarise common adaptations seen in each type of animal, and specific adaptations in particular species*. **C**
B0711.2	**c) Examine a number of local plants which demonstrate protective adaptations against herbivores. Draw each plant and annotate the protective adaptations. C**
B0711.2	**d)** *Students use the internet to investigate international examples of protective plant adaptations against herbivores*. **IR**

Chemistry Grade 7

Structure and Bonding of Matter

The Particulate Nature of Matter including a model of matter

Standards

C0701 Develop an understanding of the particulate nature of matter

C0702 Understand diffusion in terms of the movement of particles

Learning Outcomes

Students should be able to:

C0701.1 Recognise that matter is made up of tiny particles that are in constant and random motion based on the particulate nature of matter

C0701.2 Develop a model of matter for solids, liquids and gases in terms of the arrangement and movement of particles

C0701.3 Compare the physical properties of solids, liquids and gases (shape, volume, density, compressibility) in terms of a model of matter

C0702.1 Describe, and explain evidence for the movement of particles in liquids and gases (Brownian motion is not required) and explain examples of diffusion occurring in daily life in terms of particles

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold. *Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.*** **a)** *Work in pairs. Students perform a circus of experiments such as* *– comparing the masses of identically-sized blocks of two or three different materials such as wood, glass and metal* *– putting one small coloured crystal into a beaker of cold water and one into a beaker of hot water* *– trying to fit a metal bar into a gauge before and after strong heating* *– opening a perfume bottle at arm's length* *– heating one end of a metal rod that has paperclips attached by petroleum jelly* *– trying to depress the plungers of three sealed syringes, one containing a solid, one a liquid and one a gas* *– adding small weights, one at a time, to a thin wire suspended from a clamp until it snaps* *to exemplify the different behaviours of solids, liquids and gases and then discuss their observations in small groups to try to explain what happened. The teacher guides a discussion to explain the behaviours in terms of the random motion of particles.* **CP**
C0701.1-4	
C0701.1-4	**b)** *Work in pairs. Students perform further experimentss such as*

	– placing coloured crystals on agar gel and observing the diffusion of colour *– placing distinct layers of water and ink in plastic syringes and observing the mixing of colour over a short period of time* *– observing dust particles in a beam of light* *to reinforce their ideas about the properties of solids, liquids and gases and the arrangement, spacing and movement of particles.* **CP**
C0701.1-4	**c) Students make annotated drawings to describe the arrangement and movement of particles and how they explain the properties of solids, liquids and gases.** **C**
C0701.1-4	**d)** *Teacher demonstrates the ammonia and hydrogen chloride, hydrogen and air and potassium manganate(VII) and water diffusions. Students observe, record and explain what happens. Cooking smells, perfume etc may be used to give relevance.* *C*
Chemical composition of substances in terms of elements, compounds and mixtures	
Standards **C0703** Understand that substances can be classified as elements, compounds and mixtures	
Learning Outcomes **Students should be able to:** **C0703.1** Recognise that all matter (living and non-living) is made from elements and that elements can be classified based on their properties **C0703.2** Identify that substances can be classified as elements, compounds and mixtures, and distinguish between them **C0703.3** Investigate that the properties of compounds are different from the properties of their constituent elements **C0703.4** Explain what mixtures are and investigate the properties of a solution and a suspension to recognise different types of mixtures	
LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0703.1	**a)** *Students are asked to name samples from a collection of elements, living things, plastics and rock samples. The teacher keeps the elements separate and explains why by showing a collection of building blocks of the same type joined together and breaking them up. The teacher does the same for blocks of a different colour.* **C**
C0703.1	**b)** *Students attempt a basic classification of elements such as 'are they shiny, bendy etc?* **C**

C0703.2	**c)** *Students use bricks or model kits to model elements, compounds and mixtures; they then explain what each one is.* C
C0703.3	**d)** **Students heat magnesium, zinc and copper in air and observe the differences between reactants and products. Teacher demonstrates the reactions between hydrogen and oxygen, sodium and chlorine and carbon and oxygen to emphasise the differences.** C
C0703.4	**e)** *Students attempt to filter a solution and a suspension and observe the difference. They draw particle models to explain their observations.* CT

Chemistry in our World

Physical Properties and uses of metals

Standards

C0704 Describe the properties of metals to include being malleable, ductile and good conductors of heat and electricity, and that these physical properties vary from metal to metal

Learning Outcomes

Students should be able to:

C0704.1 Describe metals as ductile, malleable and good conductors of heat and electricity, and that these physical properties vary from metal to metal

C0704.2 Relate the properties and uses of some well-known metals, such as gold, silver, copper, iron and aluminium

C0704.3 Compare and contrast the physical properties of metallic and non-metallic elements

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0704.1	**a)** **Students work in pairs to test samples of various elements (metals and non-metals) for ductility, malleability, conduction of electricity (and possibly heat) and work in pairs to classify them based on their observations.** CP
C0704.2	**b)** *Students work in groups to research and present their results on the properties and uses of some well-known metals.* CP
C0704.3	**c)** *Using provided data students work in pairs to produce a list of the generalised properties of metals and non-metals.* CP

Different methods of separation and purification

Standards

C0705 Appreciate the concept of a pure substance

C0706 Explain the principles of methods of separation and purification including filtration, evaporation, distillation and chromatography

Learning Outcomes

Students should be able to:

C0705.1 Define the meaning of a 'pure substance'

C0705.2 Deduce from given data on boiling point and melting point the identities of substances including their purity

C0705.3 Explain the importance of the measurement of purity in substances in daily life

C0706.1 Investigate and discuss the principles of separation in the different methods of separation and purification -filtration, evaporation, distillation and chromatography

C0706.2 Perform chromatographic separations and explain why chromatography is widely used as a method for analysing mixtures

C0706.3 Discuss examples of the applications of the different methods of separation in daily life and industries with reference to water purification and the oil and gas industries

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0705.1	**a) Students draw up lists entitled 'pure' and 'impure/mixture'. They attempt to define the terms and complete their lists with appropriate words and phrases. In a plenary the meaning of pure substance is defined. C**
C0705.2	**b) Students are provided with data on melting points and boiling points and the values for some 'unknowns' selected by the teacher, which they identify. IR** *Extension. Students research the melting points of metals and alloys and generalise that those with a large melting point range are impure (mixtures). Teacher demonstrates the melting of pure and impure substances (ice and ice from salt water) using a datalogger to produce a temperature v time graph.*
C0705.3	**c)** *The teacher gives groups of students areas of everyday life to investigate such as medicines, foodstuffs, water supply, materials for the electronics industry Each group reports to the class why purity is important in the area they investigated.* **CT**
C0706.1	**d) Students are provided with dirty salt water and have to remove the dirt by filtration. Students are then set the problem to get salt and water back from salt water, using the particle model to explain their ideas. They carry out evaporation and the teacher demonstrates distillation. Finally, the teacher introduces paper chromatography. IR**

C0706.2	**e) Students plan and carry out paper chromatography on water soluble black inks. IR; CP** *Extension. The teacher provides students with prepared chromatograms and information about the contexts in which these might be needed, eg in forensic science, in identifying traces of substances in urine or medical preparations and ask them to draw conclusions from the chromatograms and explain why chromatography is widely used.*
C0706.3	**f) Students work in groups to research the applications of filtration, evaporation, and distillation to water purification and the oil and gas industries in Qatar and prepare a case study. CT**

The origins and properties of rocks

Standards

C0708 Recognise the main features of the internal structure of the Earth

C0709 Understand the rock cycle and the main types of rocks in the Earth's crust

Learning Outcomes

Students should be able to:

C0708.1 Describe the main features of the internal structure of the Earth

C0709.1 Understand the rock cycle and the formation of igneous, sedimentary and metamorphic rocks

C0709.2 Use the distinctive features of igneous, sedimentary and metamorphic rocks to distinguish among them

C0709.3 Describe that rocks are made up of pure compounds called minerals that are important for industry

C0907.4 Relate the uses of some rocks to their properties

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0708.1	**a) Students research the internal structure of the Earth and explain how we know about somewhere no one has been. IR**
C0709.1	**b) Students grow crystals of eg copper(II) sulfate or sodium chloride to gain an idea of how igneous rocks are formed. They research the causes of weathering and the formation of sedimentary rocks, and then the formation of metamorphic rocks. Students construct a labelled rock cycle. PS**

C0709.2	**c)** *Students use a collection of rocks local to the area to identify which are igneous, which are sedimentary and which are metamorphic.* **C**
C0709.3	**d)** *Students research what minerals are, where various minerals of industrial importance are found, and attempt to find out the time scale for their depletion and possible consequences of this.* **IR**
C0709.4	**e)** *Students are given rocks which are ideally used for specific purposes in the local area and data on their properties. They identify the property that is important for that use.* **IR**

Physics Grade 7

Forces, motion and scale

Centre of mass & stability

Standards

P0701 Understand the effects of forces acting on an object, including determining the centre of mass

Learning Outcomes

Students should be able to:

P0701.1 Recall that forces acting on an object may cause disequilibrium

P0701.2 Determine the centre of mass of a regular and irregular object

P0701.3 Investigate the stability of an object with respect to the location of its centre of mass

LO reference	Learning Experiences All students should be provided with the learning opportunities stated in bold.
P0701.1	**a)** *Working in small groups, students identify a number of objects, in the classroom and/or schoolgrounds, that are in equilibrium* **CP**
P0701.1 **P0701.2**	**b)** *Working in small groups, students demonstrate and draw a diagram to show how a ruler is balanced at its geometrical centre. Ask students to identify the forces acting on the ruler. Ask learners what will happen if a small weight is added on one side of the ruler. Introduce the term disequilibrium* **C**
P0701.2	**c)** *Working in small groups, students draw some regular objects and locate their geometrical centre to identify the centre of mass* **CP**
P0701.2	**d) Working in small groups, students conduct an experiment to determine the centre of mass of an irregular lamina. They then relate the centre of gravity with the point where the weight will act PS**
P0701.3	**e) In small groups students investigate the stability of rectangular blocks and cylindrical objects when placed on a flat table in different positions. They identify the position of the centre of mass in each case by tilting the object until it topples over. A useful plenary problem could be to predict which fruit juice cardboad container topples over first: a full one, an empty one or a half-full one IR; PS**
P0701.3	**f)** *Students use a range of resources to research everyday situations and devices where the position of the centre of mass affects their performance, e.g. boats, double decker buses* **IR**

Simple machines

Standards

P0702 Recognise that there are different types of simple machines (including levers, inclined planes, wheel and axel, wedge and pulleys)

Learning Outcomes

Students should be able to:

P0702.1 Identify different types of simple machines (levers, inclined planes, wheel and axel, wedge and pulleys) and give everyday examples of their use

P0702.2 Investigate the benefits of levers and classify them according to their three classes, giving everyday examples.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0702.1	**a)** *In small groups, students identify and group examples of simple machines (devices that make work 'easier'). Learners could also be shown examples of different simple machines brought into the classroom and add them to their groupings. Then, they describe the features of each machine to the rest of the class* **CP; C**
P0702.1	**b) In pairs, students balance a long stick on their forefinger. Introduce the idea of a supporting point called fulcrum and two arms for the load and effort to be applied. Introduce the different possible position of the fulcrum with respect to the load and effort and hence the three classes of levers CT**
P0702.1	**c) Teacher cuts a wooden spoon in two parts at its centre of mass before the lesson and re-joins the two sides with a small nail (so the sides are detachable). Balance the joined spoon on your finger and detach the two bits to show the mass of the handle to the students on a digital mass scale, then ask the students to predict the mass of the other side CT; PS**
P0702.1 **P0702.2**	**d) Working in small groups, students are shown different classes of levers and are asked to describe benefits of using them. Then, they investigate each with appropriate equipment, e.g. turning a nut with a long spanner by adding masses at different distances from the nut IR**

Density and its applications

Standards

P0703 Explain density in relation with sinking and floating objects

P0704 Understand the relationship between upthrust and the weight of an object

Learning Outcomes

Students should be able to:

P0703.1 Identify the most appropriate method to measure the mass and the volume of regular and irregular objects.

P0703.2 Calculate the density of solids with regular and irregular shapes using the equation: Density (kg/m^3) = Mass (kg)/Volume (m^3)

P0703.3 Investigate floating and sinking of objects in fluids in terms of their density

P0704.1 Investigate floating and sinking objects to measure the upthrust experienced by them

P0704.2 Describe the relationship between upthrust and the weight of an object

LO Reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0703.1 **P0703.2**	**a) In pairs or small groups, students determine and compare the densities of regular solids made from various materials C**
P0703.1 **P0703.2** **P0703.3**	**b) In pairs or small groups, students determine and compare (1) the density of irregular solids using the water displacement method, and (2) the the density of a liquid PS**
P0703.3	**c) Learners work in small groups to investigate the density of different liquids and build a density tower CT**
P0703.2 **P0703.3**	**d) Learners conduct an experiment to investigate whether the various objects in (a) will float or sink in water CT; PS**
P0704.1	**e)** *In small groups students use data loggers to investigate how the pressure of water in a tank changes with the depth of the water* **CT; CP**
0704.1 **0704.2**	**f) In pairs or small groups, learners lower objects hanging from a spring balance into water and measure the change in weight, as well as the volume of water displaced. Introduce the concept of upthrust as the weight of the volume of water displaced and represent the forces involved with an appropriate diagram PS; CT**

Electricity and magnetism

Static Electricity

Standards

P0705 Describe how matter can be charged and how charge can be detected

P0706 Explain how a potential difference (p.d.) is generated between two charged objects and how this p.d. can become large enough to cause a spark (including lightning as an example of discharge)

P0707 Describe how electric charges concentrate at points/tips in a conductor

Learning Outcomes
Students should be able to:

P0705.1 Investigate the three ways in which matter can be charged - by friction, by induction and by contact

P0705.2 Explain the movements of the gold leaf of an electroscope when it is used to detect charge

P0705.3 Use an electroscope to investigate the magnitude and type of charges on matter

P0706.1 Explain that when charges are moved from one object to another they become charged with opposite charges and a potential difference (p.d.) is generated between the two objects.

P0706.2 Explain that when the p.d. between two electrically charged objects becomes large enough an electrical discharge (spark) can cause the charges to jump from the negatively charged object to the positively charged object through air molecules

P0706.3 Explain how lightning is an electrical discharge caused by static charges that result from friction between droplets of rain/water and how it can be dangerous

P0707.1 Describe how electric charges concentrate at points/tips in a conductor and build a large electric potential there, so they also discharge most easily at a point

P0707.2 Describe some applications of conducting tips, such as pointed lightning conductors, and discuss other applications of static electricity in everyday life, e.g. earthing the nozzle of a petrol pump

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0705.1-3 **P0706.1**	**a)** *In pairs or small groups, students use a range of resources to research and discuss how matter can be charged by (1) friction, (2) induction, and (3) contact/conduction. Then, they draw diagrams to illustrate each process clearly* **CP; C**
P0705.1	**b) Learners investigate the effects of charging glass and ebonite (or acetate and polythene) rods with a woollen cloth and identify the charges generated in each situation PS**
P0705.2-3	**c)** *In small groups, students construct a simple electroscope and use it to detect charges and compare magnitudes, as well as to distinguish between positive and negative charge. With the aid of appropriate diagrams, they explain the movement of the gold leaf when an electroscope is used to detect charge* **IR; CT**
P0706.1-3	**d) Teacher demonstrates electrical discharge using a range of demonstrations with a Van de Graaff generator C**

P0706.3 **P0707.1-2**	**e)** *Using a range of resources, learners research how lightning is caused and how pointed conductors are used of to keep houses safe from lightning strikes* **IR; C**
P0707.2	**f)** Using a range of resources, students discuss some applications of static electricity in everyday life **IR; CP**

Flow of charges in circuits

Standards

P0708 Understand the concepts of potential difference (p.d.), electrical current and resistance in electric circuits

P0709 Explain how current and p.d. changes in series and parallel circuits

P0710 Describe the effect of adding electrical cells in series and parallel

Learning Outcomes

Students should be able to:

P0708.1 Explain the concepts of potential difference (p.d.), electric current and resistance in an electric circuit and describe qualitatively the relationship between them

P0708.2 Recall the units of p.d., resistance and electric current

P0709.1 Compare the current through components in series and parallel circuits and explain the observed outcomes

P0709.2 Compare the potential difference across components in series and parallel circuits and explain the observed outcomes

P0710.1 Demonstrate that batteries are cells connected in series

P0710.2 Explain why adding cells in series will increase the current flowing in a circuit

P0710.3 Explain that adding cells in parallel will not increase the current through a circuit, but will allow the current to flow for a longer time before the cells run down

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0708.1-2	**a) Teacher introduces the concepts of current, potential difference and resistance using the rope model (search "IOP supporting physics teaching" for more information). Teacher also introduces the function of ammeters and voltmeters and how they should be connected in a circuit C; CT**

P0708.1-2 **P0709.1-2**	**b) In pairs or small groups, students investigate how the current through and the p.d. across components in a circuit change, as more components are added in series and parallel CP; CT**
P0708.1-2 **P0709.1-2**	**c)** *Working in pairs, students use a simulation for constructing simple circuits to research and discuss a range of parallel and series circuits* CT; C
P0708.1-2 **P0709.1-2**	**d)** *Students observe which set of bulbs are brighter and explain their findings in relation to the current through and voltage across each bulb. Then, they discuss and explain which circuits are used in houses and buildings* CT; C
P0710.1-3	**e) Working in pairs students add cells in series and parallel to each of the circuit and discuss their observations CT; PS**

Possible teaching order

Students can learn the sciences in any order – they have been listed alphabetically.

These suggestions give a strong teaching order for the topics within each science strand.

Please note other orders are possible and acceptable

Science			
	Biology	**Chemistry**	**Physics**
Grade 7	**1** Cell structure and function **2** Tissues, organs and systems **3** Photosynthesis **4** Interdependence of organisms **5** Environmental interactions and processes **6** Adaptation	**1** The Particulate Nature of Matter including a model of matter. **2** Chemical composition of substances in terms of elements, compounds and mixtures **3** Different methods of separation and purification **4** The origins and properties of rocks **5** Physical Properties and uses of metals	**1** Centre of mass and stability **2** Simple machines **3** Density and its applications **4** Static electricity **5** Flow of charges in circuits

Grade 8

Biology

Structure and function of organisms

Tissues, organs and systems: Digestive system

Standards

B0801 Explain the need for organ systems such as digestive systems, respiratory systems and transport systems in terms of surface area to volume ratios.

B0802 Identify the sources and describe the functions of nutrients in a diet (carbohydrates, protein, lipid, vitamins, minerals, water and fibre).

B0803 Describe the structure of the human digestive system, explain how the structures are adapted for their functions and explain the importance of a healthy digestive system.

B0804 Understand the role of enzymes, gastric acid and bile in controlling digestion.

Learning Outcomes

Students should be able to:

B0801.1 Describe and calculate the relationship between surface area and volume.

B0801.2 Explain why simple unicellular organisms can rely on simple diffusion while multicellular organisms need digestive, respiratory and transport systems in terms of the surface area to volume ratio.

B0802.1 Describe some sources and explain the importance of carbohydrates, proteins and lipids in the human diet.

B0802.2 Describe some sources of and explain the importance of vitamins, minerals, water and fibre in the human diet.

B0803.1 Identify and label the general structure of the human digestive system (mouth, oesophagus, stomach, small intestine, large intestine, rectum and anus).

B0803.2 Identify the accessory organs of the digestive system (salivary glands, pancreas, liver and gall bladder).

B0803.3 Explain how the structure of the human digestive system and the accessory organs are adapted to their functions.

B0803.4 Describe the structure of a villus in a small intestine and explain the role of capillaries and lacteals for absorption of digested materials.

B0803.5 Describe peristalsis as the rhythmic wave-like contractions of the muscles to mix and move the contents in the digestive system.

B0803.6 Discuss ways of keeping the digestive system healthy, including a varied diet rich in minerals and vitamins, drinking plenty of fluids and eating fibre-rich foods, and explain why this is so important.

B0804.1 Explain digestion in terms of the breakdown of large insoluble food molecules into smaller soluble molecules that can be absorbed into the blood stream for transport round the body.

B0804.2 Identify the digestive enzymes amylase, protease, maltase and lipase with their substrates and final products.

B0804.3 Explain how secretions of enzymes, gastric acid and bile control digestive processes.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0801.1	**a) In pairs/small groups, calculate the surface area to volume ratio of a large potato compared to the surface area to volume ratio of several small potatoes of approximately the same mass (and therefore approximately the same volume). Peel the potatoes and use graph paper to estimate the area of the peel removed from the single large potato and the several smaller potatoes of the same mass. Compare the surface area of the potatoes and find the surface area:volume ratio of the large potato compared to the smaller potatoes. PS**
B0801.1-2	**b)** *Students make large and small model cubes from paper, card or modelling clay and calculate the surface area to volume ratio of the large and small cubes, comparing the two. Relate this to the size of organisms and why larger organisms need digestive, respiratory and transport systems to meet the needs of their cells.* **PS**
B0802.1	**c)** *Work together as a class to make a list of favourite foods. Working in groups, discover the main nutrient groups in each of these foods* **IR**
B0802.1	**d) In pairs/small groups, use food tests to identify starch (iodine test), glucose (Benedict's test), soluble protein (Biuret test) and fat (smear test) in samples provided CP**
B0803.1-2	**e) Draw a large, labelled diagram of the human digestive system including the accessory organs**
B0803.1-3	**f) Test the levels of vitamin C in fruit juice and other drinks and foods using DCPIP CP**
B0802.2 **B0803.6**	**g) Produce a table to show the source, use and symptoms caused by the deficiency of of three vitamins and three minerals in the diet. *IR***

B0803.4	**h)** *Use light microscopes or projection microscope to investigate the structure of villi, particularly observing the large surface area. Model the effect of the villi using a straight and folded piece of string.* **CT**
B0803.5	**i)** *Teacher demonstrates peristalsis using model, or using animation from the internet.* **CT**
B0802.2 **B0803.6**	**j) Investigate the importance of fibre and water for a healthy digestive system. Produce a leaflet or a poster to encourage people of all ages to look after their digestive systems and avoid digestive diseases. CT; C**
B0804.1	**k)** *In pairs/small groups make a model to show how large food molecules cannot pass through the lining of the intestines into the blood, but the small molecules produced by digestion can pass through.* **CT**
B0804.1-3	**l) In pairs/small groups investigate the effect of amylase enzyme on starch suspension, using a water bath and data loggers to maintain the starch/ enzyme mixture at body temperature and iodine solution to indicate the presence or absence of starch in samples of the mixture. Relate the results to the role of amylase produced by the salivary glands and the pancreas [***Additional exercise: investigate the effect of different temperatures or different pH on the activity of amylase, using data loggers to record the different variables***.]** **CP**
B0804.3	**m)** *Work in pairs. Draw a sequence of diagrams showing the importance of bile from the gall bladder in the digestion of lipids in the digestive system.* **C**

Tissues, organs and systems: Respiratory system

Standards

B0805 Understand the structure and function of the human respiratory tract including adaptations for ventilation and gas exchange and explain the importance of a healthy respiratory system.

Learning Outcomes

Students should be able to:

B0805.1 Identify the structures of the upper and the lower respiratory tracts.

B0805.2 Explain the roles of the main structures in the respiratory system in gas exchange.

B0805.3 Describe the mechanism of breathing (inhalation and exhalation).

B0805.4 Describe the structure of an alveolus and explain how it is adapted to its function in gas exchange, including large surface area:volume ratio, good blood supply and ventilation to maintain concentration gradients.

B0805.5 Discuss factors that improve the health of your respiratory system, including taking exercise and breathing clean air and explain why this is so important.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.**

	Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.
B0805.1-2	**a)** *Watch an animation of the processes of breathing and gas exchange, demonstrating the structure and function of the respiratory system*
B0805.1-2	**b) Draw a large labelled diagram of the human respiratory system and annotate each structure to give its function CT**
B0805.2	**c)** *Measure lung capacity using a spirometer, balloon or displacement of water and find the class range* **CP; IR**
B0805.2	**d) Working in pairs/small groups, demonstrate that exhaled air contains a raised level of carbon dioxide using limewater and a straw.** *Data loggers can also be used to demonstrate the rise in carbon dioxide concentration in the air in the classroom during the lesson, if the doors and windows are kept closed and air conditioning turned off.* **CP**
B0805.3	**e) Using themselves as a subject, students investigate the movements of the ribs in inhalation, normal exhalation and forced exhalation CP**
B0805.3	**f)** *Teacher demonstrates the role of the diaphragm in breathing using a bell jar, vacuum and balloon model*
B0805.4	**g)** *Use light microscopes or a projection microscope to observe, draw and label the microscopic appearance of alveoli and relate the appearance of the alveoli to their adaptations for gas exchange* **C**
B0805.5	**h) Work in pairs/small groups to measure the breathing rate in different conditions (e.g. at rest and after a short period of exercise). Combine data from the whole class, calculate the mean class breathing rate and discuss factors which affect a healthy respiratory system PS; C**
B0805.5	**i) Research the most effective exercise to improve lung capacity. Plan and carry out a regular exercise routine, as a class or individually. After several weeks, repeat LE f) and record any change in individual breathing rates and the class mean CP; CC**

Tissues, organs and systems: Circulatory system

Standards

B0806 Understand the structure and function of the human circulatory system including the heart, blood vessels and the blood, and explain the importance of having a healthy circulatory system.

Learning Outcomes

Students should be able to:

B0806.1 Describe the structure and function of the components of the circulatory system.

B0806.2 Describe the structure of the heart (right and left atria, right and left ventricles, and septum) and identify the main blood vessels entering and leaving the heart from the body and the lungs.

B0806.3 Describe the structures of arteries, veins and capillaries and explain how they are adapted to their functions.

B0806.4 Describe the components of blood (red blood cells, white blood cells, plasma and platelets) and explain how they are adapted to their functions.

B0806.5 Discuss factors that improve the health of your heart (including exercise), of your blood (including a healthy diet containing plenty of iron), and your blood vessels (including exercise and a relatively low-fat diet).

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0806.1-2	**a) Draw a large, labelled diagram of the heart including the major blood vessels entering and leaving the heart, the semi-lunar and the atrio-ventricular valves, the difference in thickness of the atrial and ventricular walls and the difference in thickness between the walls of the right and left ventricles. CT**
B0806.1-2	**b) Work in small groups examine the structure of the heart an animal heart obtained from a butcher (or use a 3-D model or find a model of the heart on the internet) and identify as many features as possible. IR**
B0806.1-2	**c)** Watch an animation of the heart beating on the internet or a video **IR**
B0806.3	**d)** *Work in pairs to search online for micrographs showing the structure of an artery, a vein and a capillary. Discuss and then make a table to show the differences in the size and structure of the different types of vessel.* **IR;C**
B0806.3	**e) Work in pairs. Using the veins of the hand, investigate how the valves prevent the back-flow of blood CP**
B0806.2-3	**f) Work in pairs. Find the pulse in the artery in your wrist. Count and record the number of beats in one minute to find your heart rate at rest. Repeat three times to find the mean. Combine class results and find the mean. Carry out 2 minutes vigorous exercise and repeat the heart rate recording. Calculate the class mean for the heart rate after exercise. Compare the readings at rest and after exercise and discuss reasons for any changes observed. CT; C**
B0806.1-3	**g)** *Investigate the history of our understanding of the heart and circulatory system including the work of Ibn al-Nafis and William Harvey* **IR**
B0806.4	**h) Use light microscopes or a projection microscope to observe, draw and label the microscopic appearance of red blood cells and white**

	blood cells and annotate your drawings to relate the structures to their functions C
B0806.5	**i)** *Compare your heart rate with your family members. Suggest factors that might affect any differences eg age, gender, fitness* **CT**
B0806.5	**j) Work in three groups. One group carries out research, plans and gives a presentation to the rest of the class on factors that improve heart health, another does the same on factors that improve the health of the blood and the third group presents on factors that improve the health of your blood vessels CP; IR; C**

Health and disease

Healthy lifestyles

Standards

B0807 Describe the link between an unbalanced diet, obesity and diseases such as diabetes.

B0808 Describe and evaluate the effects of tobacco smoke and its toxic components on health.

B0809 Explain how blockage of the coronary arteries causes coronary artery disease and evaluate known risk factors.

Learning Outcomes

Students should be able to:

B0807.1 Describe how an unbalanced diet may lead to obesity and diabetes.

B0807.2 Describe the link between obesity and diabetes.

B0808.1 List nicotine, tar and carbon monoxide as components of tobacco smoke.

B0808.2 Describe the effects of nicotine on the body.

B0808.3 Describe the effects of tar from cigarette smoke on the lungs and analyse data to evaluate the effect of smoking on the incidence of lung cancer.

B0808.4 Describe the effects of carbon monoxide on the oxygen-carrying capacity of the blood and analyse data to evaluate the effects of this carbon monoxide on human health, including the health of pregnant women and their babies.

B0809.1 Describe coronary artery disease in terms of the blockage of coronary arteries.

B0809.2 List possible causes of coronary heart disease such as diet, stress and smoking.

B0809.3 Analyse data and evaluate the effect of smoking and other risk factors on the incidence of coronary heart disease.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***

B0807.1-2	**a)** *Teacher presents class with data on standard calorie requirements for individuals of different age and gender, and with information on the average calorie intake in Qatar, and obesity levels in Qatar. Teacher then leads class discussion on the causes of obesity and why this is a problem in Qatar [if used, this activity should be used before (b)].* **C**
B0807.2	**b) Work in pairs/small groups. Find statistics on the frequency of diabetes and obesity in Qatar and compare this with other countries. Produce a bar chart to compare both the rates of obesity and the rate of diabetes in a minimum of five countries. IR; C**
B0808.1-3	**c) Using a smoking machine, collect and observe the tar and other residues produced by cigarette smoke. Use a data logger to measure the levels of carbon monoxide in cigarette smoke. Analyse graphs provided by the teacher showing the link between cigarette smoking and death from lung cancer. Discuss, based on your observations of the chemicals collected from the cigarette smoke and the data on the graphs, why cigarette smoking is so damaging to the lungs IR; C**
B0808.4	**d)** *Work in pairs. Use the internet and other resources to find graphical data showing the increased risk of low birthweight, still birth and neonatal death of babies of mothers who smoke. Produce a poster explaining why it is so important that both parents give up smoking if they are expecting a baby, including details of the impact of the carbon monoxide from tobacco smoke on the oxygen-carrying capacity of the blood of the mother and so on the development of the baby.* **CT**
B0809.1-3	**e) Work in groups. A number of factors increase the risk of coronary artery disease These include high levels of sugar in the diet, a high fat or cholesterol rich diet, stress, lack of exercise and smoking. Each group takes one factor, looks for evidence on the internet and present their findings to the rest of the class. IR; C**
B0809.2-3	**f)** *Discuss ways in which the incidence of coronary artery disease could be reduced in Qatar* **PS**

Organisms and their environment

Interdependence of organisms

Standards

B0810 Explain how carbon and water cycle through the abiotic and biotic components of an ecosystem.

B0811 Explain how environmental change, including global warming, can affect biodiversity.

Learning Outcomes

Students should be able to:

B0810.1 Describe the abiotic and biotic elements of an ecosystem.

B0810.2 Explain the importance of the carbon cycle and the water cycle to living organisms.

B0811.1 Explain how human action can bring about environmental change, including global warming and climate change. **B0811.2** Discuss the effect of environmental change on food webs and biodiversity. **B0811.3** Explain why the conservation of the environment is important.	
LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B8010.1	**a)** *In a class brainstorming session, list the main abiotic and biotic factors that would affect organisms in a) Qatar b) the Serengeti in Africa c) the Arctic circle* **CT**
B8010.2	**b) The teacher divides the class in half. Students work in small groups. One half of the class make posters or models to explain the carbon cycle and the other half make posters or models about the water cycle. Groups from the two halves of the class then share their posters/models to explain the process they have studied C**
B8011.1	**c) Work in pairs/small groups. List everything you know about how human action can bring about environmental change. Carry out 15 minutes research using the internet and other resources about this subject. In the same groups, add everything new you have discovered to your lists. CT**
B8011.2	**d) Draw a local food chain or food web, and another from a completely different environment. Annotate each drawing to show where and how different types of climate change might affect the organisms in the feeding relationships you have drawn CT**
B8011.2	**e)** *Following on from the work in LEs (c) and (d, have a class discussion titled 'Biodiversity – why is it so important?'* **C**
B8011.3	**f) Work in pairs/small groups. Investigate a conservation project in Qatar or another country of your choice. Produce a presentation explaining why conservation is important, illustrated by the example you have chosen. CP; C**

Chemistry Grade 8

Materials & their Properties

Chemical Changes occurring in substances

Standards

C0801 Understand how chemical reactions occur by the rearrangement of atoms

C0802 Write word equations for simple reactions

Learning Outcomes

Students should be able to:

C0801.1 Identify a change which leads to the formation of new product(s) as a chemical change

C0801.2 Recognise compounds can react chemically with each other to form new compounds

C0801.3 Identify combustion, thermal decomposition, oxidation and neutralisation as different types of chemical reactions

C0801.4 Recognise chemical reactions as involving rearrangement of atoms, which are neither created nor destroyed

C0802.1 Use word equations to represent simple chemical reactions

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0801.1	***a)*** *The teacher shows students some reactions between elements that they have previously seen, eg hydrogen and oxygen, sodium and chlorine, carbon and oxygen, copper and sulfur. The students record their observations.* *Students heat magnesium ribbon in air. Students summarise how the products are different to the starting materials and are led to the definition of a chemical change. CT*
C0801.2	**b) Students work in pairs to carry out simple test tube reactions between compounds. They observe closely and record what happens as an important component of scientific enquiry. Reactions should be selected to give colour changes, precipitates, and gaseous products. They could include:** - **mixing sodium carbonate solution and iron (II) chloride solution** - **adding dilute hydrochloric acid to solid magnesium carbonate** - **adding dilute ammonia solution to copper sulphate solution**

	- **heating sucrose. CP**
C0801.3	**c)** *Students work in small groups to carry out combustion (eg burning a splint), thermal decomposition (eg heating Cu(II) sulfate, oxidation (eg heating copper) and neutralisation (eg hydrochloric acid and sodium hydroxide) reactions and, in a plenary, they summarise the essential characteristics of each in terms of how they are similar and how they are different. CT*
C0801.4	**d) The teacher summarises the work on atoms, elements, compounds and chemical reactions and asks students to produce a concept map. The teacher sets students a problem – to determine whether an unknown green powder (copper(II) carbonate) is an element or a compound? Students propose a plan, check it with the teacher for safety and viability, carry it out, record what they did and observed, and draw any conclusions. PS**
C0802.1	**e) Teacher explains the chemist's shorthand and structure of word equations. (Scaffolding may be required for this activity depending on the ability of the students.) Students initially identify reactants and products from provided exemplars, then supply missing reactants or products to complete a word equation and finally write complete word equations. C**

Structure & Bonding of Matter

Atoms, Molecules, Elements and Compounds

Standards

C0803 Explain how the structure of the atom (protons, neutrons and electrons) leads to different elements

C0804 Understand that atoms can combine to form molecules of constant composition

Learning Outcomes

Students should be able to:

C0803.1 Recognise that the smallest particle of an element is an atom and that atoms of one element are of one kind and are different from atoms of every other element

C0803.2 Describe the simple (Dalton) atomic model and outline how the atomic model changed over time

C0803.3 Describe an atom as made up of a positively charged nucleus that contains positively charged protons and neutrons (no charge) with negatively charged electrons moving round the nucleus

C0803.4 Recognise that the atoms of an element have a distinctive number of protons and the mass of the atom is approximately that of the mass of the nucleus

C0803.5 Recognise that elements can be represented by chemical symbols **C0804.1** Recognise that elements join together chemically to form compounds and that the smallest particle of a compound is a molecule **C0804.2** Recognise that all molecules of a compound are made up of the same fixed number of atoms of the constituent elements	
LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0803.1 **C0803.2** **C0803.3** **C0803.4** **C0803.5** **C0804.1**	**a) The teacher reviews the idea of particles and questions the class on cutting up a sample of eg copper into smaller and smaller pieces until it cannot be cut anymore. This leads to the idea of an atom (as in the simple (Dalton) model and that atoms of one kind are different from atoms of every other element and there are approximately 100 different elements. Students can look at a list of all the elements and note which ones they have heard of. C** **b) There is an opportunity here to discuss the nature of scientific enquiry in a historical context through the different models of the structure of the atom. Students define an atom and can research how the atomic model has changed over time. The teacher gives the currently accepted model for students at this level. CT** **c) The teacher introduces the idea of atomic number as representing the number of protons in the atoms of a particular element and that, as an electron weighs 1/1840 of the mass of a proton or neutron, that the mass of the atom is approximately that of the mass of the nucleus.** *Students attempt to write down the symbols from a list of element names. The teacher then reveals a complete list and explains why an internationally agreed list of symbols is required. C* **The teacher shows some examples of symbols of elements with atomic number attached.** **d) The teacher gets the class to brainstorm information about some chemicals they have heard of and what elements they might be made of. Teacher selects some that exemplify compound formation and uses the argument of cutting a sample into smaller and smaller bits to the smallest particle – a molecule. Students examine some space filling models of elements and compounds such as carbon, hydrogen, oxygen, carbon dioxide, water and methane to identify which are which and postulate what a mixture would look like. PS**

	Extension – Teacher shows other more complicated models such as ball and stick or skeletal models that chemists use to explain things they cannot see.
C0804.2	**e) The teacher questions class as to how eg water molecules from Antarctica differ from water molecules from Qatar and similarly for other common elements and compounds from around the world. Students should be guided to reach a consensus that all molecules of a compound are made up of the same fixed number of atoms of the constituent elements, wherever they come from. CT**

Patterns in Chemical Reactivity

Characteristics and chemical reactions of acids and alkalis

Standards
C0805 Understand the basis of acidity and alkalinity and how they are measured

Learning Outcomes
Students should be able to:
C0805.1 Investigate the characteristics of common acids and alkalis

C0805.2 Recognise that some acids and alkalis can be corrosive and hazardous, and identify the use of hazard symbols to describe this

C0805.3 Investigate the use of indicators (litmus paper, litmus solution, Universal Indicator and natural indicators from plants) to classify whether the solution is acidic, alkaline or neutral

C0805.4 Describe the pH scale as measure of the acidity and alkalinity of an aqueous solution and that the pH of a solution can be determined by Universal Indicator colour changes or by a pH meter

C0805.5 Identify strong and weak acids, strong and weak alkalis, and pure water on the pH scale

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0805.1	**a) The teacher introduces the topic by asking students to name common acids and alkalis and explains their scientific names all contain the words 'acid' and 'hydroxide'. Students are asked if they have seen any acids in the kitchen and could be shown samples (including vinegar) and fruit such as lemons. The foodstuffs may be tasted if appropriate precautions are taken.** **Students investigate other physical properties of acids and alkalis such as texture and smell.**

	Students then investigate the chemical properties of acids by reacting acids with magnesium ribbon, with metal oxides eg copper(II) oxide, with metal carbonates eg zinc carbonate, and with metal hydroxide solutions eg calcium hydroxide. **Students also react sodium hydroxide with copper(II) sulfate solution.** **Students are finally asked to summarise the physical and chemical properties of acids and alkalis. C**
C0805.2	**b) The teacher has samples of acids and alkalis with hazard symbols on. Other hazard symbols are introduced and the teacher demonstrates the action of concentrated sulfuric acid on sugar. It is important to draw attention to the effect of alkalis on the eye and reinforce the importance of safety glasses. Mention hazard symbols used when chemicals are transported by road. C**
C0805.3	**c) Working in pairs the students test dilute solutions of acids and alkalis with various indicators, indicators from plant sources and Universal Indicator to classify whether the solutions are acidic, alkaline or neutral. CP**
C0805.4 **C0805.5**	**d) The teacher introduces the pH scale, the numbering system used and the colours of Universal Indicator paper. Students work in pairs to test a range of solutions to identify and record their pH using a pH probe and datalogger. The students compare their values using Universal Indicator paper with those from the datalogger to initiate a discussion on accuracy. CP**

Chemistry in Our World

Air and sources of chemical pollution of the environment

Standards

C0806 Understand how it is thought the atmosphere evolved to its current composition

C0807 Understand the effects of human beings on the atmosphere and the steps taken for the remediation of these effects.

Learning Outcomes

Students should be able to:

C0806.1 Outline the evolution of the Earth's atmosphere. Describe how it is thought an oxygen-rich atmosphere developed over time.

C0806.2 Describe the current composition of the atmosphere

C0807.1 State the sources of some common atmospheric pollutants eg carbon monoxide, sulfur dioxide, nitrogen oxides and their effects on health and the environment eg formation of acid rain

C0807.2 Identify the sources of greenhouse gases that may contribute to global warming eg carbon dioxide and methane and discuss possible impacts on the environment if global warming increases **C0807.3** Suggest some solutions that can reduce the main sources of atmospheric pollution	
LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0806.1 **C0806.2** **C0807.1** **C0807.2** **C0807.3**	**a)** *Students research the theory of the evolution of the Earth's early atmosphere and how algae and plants caused the concentration of oxygen to increase.* **IR** **b)** *Students research the current composition of the Earth's atmosphere and represent it pictorially in a manner of their choosing.* **IR** **c) The teacher explains the problems caused by incomplete combustion of hydrocarbons, how sulfur dioxide and nitrogen oxides are produced in some combustion reactions and help to cause acid rain. Students annotate a diagram of the water cycle to show how air pollution leads to ground and water pollution** **Students use atmospheric pollution sensors (if available) to monitor and log pollution levels.** **Students work in small groups to research how neutralisation can be used to reduce pollution from fossil fuel combustion in power stations and how vehicle catalytic converters work (to reduce pollution from fossil fuel combustion).** **CT** **d) Students research and report on sources of greenhouse gases that may contribute to global warming e.g carbon dioxide and methane and discuss possible impacts on the environment if global warming increases.** **CT** **e) Students work in small groups to produce a report on solutions to reduce the main sources of atmospheric pollution with one example described in detail.** **CT**

Physics Grade 8

Matter and energy

Energy transfers by conduction, convection and radiation

Standards

P0801 Explain the concept of energy

P0802 Explain energy transfers by conduction, convection and radiation

Learning Outcomes

Students should be able to:

P0801.1 Explain that energy is a mathematical value associated to a system (or situation) and that it can be stored in different ways, e.g. gravitational potential, elastic potential, chemical, thermal.

P0801.2 Explain that energy is always stored within a system and that it can be transferred between different systems through different pathways, e.g. by radiation, mechanical and/or electrical working, or by movement of particles

P0801.3 State the principle of conservation of energy

P0801.4 Explain that during energy transfers some energy is always dissipated (wasted) in less useful stores. This dissipated energy eventually causes the temperature of the surroundings to increase

P0802.1 Describe how thermal energy can be transferred by conduction, convection and radiation and that some materials are better conductors than others, giving everyday examples, such as the thermos flask, polystyrene cups for hot drinks…

P0802.2 Compare and contrast the ability to conduct thermal energy between metals and non-metals and state some applications, e.g. metal pans

P0802.3 Explain that convection currents can be formed by the movement of hotter and cooler fluids (like air and water) and the mechanism of these movements of particles. Describe the formation of convection currents in different natural environments, e.g. the Gulf Current, water heating in a pan…

P0802.4 Recall that thermal energy can be transferred via infrared radiation and that this can travel through a vacuum. Describe how infrared radiation from the Sun reaches the Earth to warm our planet

P0802.5 Explain that all bodies emit and absorb infrared radiation and investigate how the properties of different surfaces affect the amount of infrared radiation absorbed and/or emitted by them

LO references	Learning Experiences
	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***

P0801.1-4	**a)** *Teacher demonstrates how energy can be stored and transferred between different parts of a system using different examples and illustrations. For example, a beaker full of water could represent the energy stored gravitationally when a ball is on top of a table. That water can be then poured partly into a beaker representing the energy stored kinetically and a smaller quantity into a beaker representing the energy dissipated to the surroundings thermally, when the ball is just about to hit the floor* **CT; C**
P0801.1-4	**b) Students work in pairs to describe other examples of energy transfers using illustrations similar to the one introduced in point (a) CP; C**
P0802.1-5	**c)** *Students brainstorm ideas about everyday objects and devices, and group them on a Venn Diagram with three intersecting sets: Energy transferred by… conduction, convection, radiation (consider objects such as a refrigerator, a cooker, a fire, a water boiler, a car radiator)* **IR; CP**
P0802.1-2	**d)** *Working in small groups, students will conduct a fair test to investigate the thermal conductivity of rods made of different materials* **CT**
P0802.1-5	**e) In small groups, students will design and construct models to compare the effectiveness of different roof structures and materials in keeping buildings thermally insulated IR; PS**
P0802.3	**f)** *By mixing water dyed with food colouring and of different temperature, the teacher demonstrates how convection currents occur* **C; CP**
P0802.3	**g)** *Students draw a diagram of a domestic water system, showing how it depends on convection to operate correctly* **C; CP**
P0802.3	**h)** *Using a range of resource students explain, with diagrams and prose, why onshore and offshore winds are common at different times of the day* **IR; C**
P0802.4-5	**i) In small groups, students design an investigation to measure the infrared radiation emitted by different surfaces at the same temperature. Then, they discuss how infrared radiation from the Sun reaches the Earth CT; PS**

Waves, Light and Sound

Interaction of light with plane mirrors

Standards

P0803 Explore the interaction of light with plane mirrors

Learning Outcomes

Students should be able to:

P0803.1 Investigate the path of light rays reflected by a plane mirror to derive the laws of reflection

P0803.2 Use the laws of reflection to construct a periscope and explain how it works

P0803.3 Determine the nature and position of an image in a plane mirror	
LO Reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0803.1	**a)** *In pairs or small groups, students use a ray box or optical pins to trace the path of a ray of light reflected in a mirror and label their diagram* **CP**
P0803.1 **P0803.3**	**b)** *Students determine the nature and position of an image in a plane mirror and derive the laws of reflection* **CT; PS**
P0803.1 **P0803.3**	**c)** *Students work in small groups and design a board game using plane mirrors to show the path to escape a maze with a light ray* **PS; CP**
P0803.2	**d) Students design and construct a (i) forward-looking periscope that enables them to see objects in front of them and (ii) backward-looking periscope that will enable them to see objects behind of them** **IR; CT**
Interaction between light and the interface of two media	
Standards **P0804** Understand how light refracts at the interface between two media	
Learning Outcomes **Students should be able to:** **P0804.1** Draw ray diagrams showing refraction of light between two media of different optical density **P0804.2** Label the angles of incidence and refraction, as well as the normal to the interface between the two media **P0804.3** Use ray diagrams to investigate the path of light rays refracted through the interface between two media	
LO Reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0804.1-3	**a) Working in pairs, students trace the path of a ray of light travelling through a glass block** **C; CP**
P0804.1-2	**b)** *Students complete a worksheet to guide them in the use of terminologies related to refraction and to make appropriate observations on patterns at the interfaces* **IR; C**

P0804.1-3	**c) Using a Perspex tank filled with water and a few drops of milk, the teacher demonstrates refraction of light using a laser pointer CT**
P0804.1 **P0804.3**	**d)** *Students take photos or a video of a coin at the bottom of a mug that becomes visible only when water is poured in the mug and reaches a certain level. They explain this phenomenon using their knowledge of refraction* **PS; C**

Electricity and magnetism

Household electricity and dangers

Standards

P0805 Understand the need for household electricity and the health and safety issues linked to it, and distinguish between alternating current (AC) and direct current (DC)

P0806 Explain how electricity is generated in Qatar

P0807 Understand the concept of power in the context of electrical appliances

Learning Outcomes
Students should be able to:

P0805.1 Explain why electricity is useful in everyday life

P0805.2 Distinguish alternating current (AC) from direct current (DC) and explain why household electricity is AC and not DC

P0805.3 Recognise and discuss the hazards of mains electricity

P0805.4 Describe the purpose and operation of safety devices such as fuses, circuit breakers and the earth wire

P0806.1 Explain how electricity in Qatar is generated using gas turbines

P0806.2 Explain that much of the wasted energy from the turbines is used to produce fresh water from seawater

P0807.1 Explain the concept of power as the rate of energy transferred, i.e. Power (W) = Energy Transferred (J) / Time taken (s)

P0807.2 Describe how transducers such as radios and light bulbs transfer less energy over a given time via electrical working than appliances such as heaters and cookers

P0807.3 State the unit of household electrical energy transferred as the kilowatt-hour and calculate the cost of running different appliances from their power rating, using the equation: Cost of energy transferred = electrical power (kW) x time (h) x cost per kW-h

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0805.1-2 **P0806.1-2**	**a) In pairs or small groups, students use a range of resource to research how household electricity is produced. They also explain why household electricity is AC and not DC IR; CP**
P0805.1-2 **P0806.1-2** **P0807.1**	**b)** *Organise a field trip to visit Qatar's electrical power plant to study why and how gas turbines are used to generate electricity. Students can then produce a presentation about their visit* **IR; CT**
P0805.3-4 **P0807.1-2**	**c)** *Working in small groups, learners will collect the manuals of electrical appliances like radio, water heater, toaster and cooker from their homes. They will identify and compare the wattage specification for each appliance. They will then relate this wattage specification to the energy usage over a fixed time and the higher wattage specification to the lower electrical resistance of the appliance* **IR; CP**
P0805.3	**d) Students brainstorm and discuss the dangers of household electricity CT; C**
P0807.3	**e) Students make a list of the appliances they use in a typical day, their power rating and the time they use them for. Then, use this information to estimate the kW-h of energy transferred and the cost to run these appliances IR; PS**

Earth and space

About the solar system

Standards

P0808 Recognise the main features of the solar system

P0809 Explain the functions of natural and artificial satellites

P0810 Describe the Islamic calendar and its origins

Learning Outcomes
Students should be able to:

P0808.1 Describe the relative positions of the planets, and their conditions compared with conditions on Earth

P0808.2 Identify some planets in the night sky and explain that we can see them and the Moon because they reflect light from the Sun

P0808.3 Recognise that the Sun is a star and that, like all stars, it radiates visible light and infrared radiation

P0809.1 Describe the difference between natural satellites (like the Moon) and artificial satellites (like the Herschel Space Telescope)

P0809.2 Explain eclipses in terms of the movement and relative sizes of the Sun, Earth and Moon

P0809.3 Give examples of uses for artificial satellites, like GPS positioning and communications

P0810.1 Discuss the reasons for the differences between the Islamic calendar and the Gregorian calendar

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0808.1-3	**a)** *In small groups, students build a scaled model of the Solar System to include the Earth and planets (different scales need to be used for distance from the Sun and planet diameter). Collect data on size, composition, density, day and year length, and on special features, such as moons, rings and atmospheric phenomena* **IR; CP**
P0808.1-3 **P0809.1**	**b)** *In pairs, students design a presentation to display photographs of planets taken by various spacecrafts* **IR; C**
P0808.1 **P0808.3**	**c)** *With the class organised into two (or more) groups, students debate why life seems to exist on only one planet – the Earth* **C; CP**
P0808.1-2	**d)** *Students research what planets are visible in the night sky for the time of year they are studying this topic and record their observations about their relative position on the night sky* **IR; CT**
P0809.1-2	**e) Students research how of solar and lunar eclipses occur. Then, they draw and explain diagrams to show the positions of the Sun, Earth and Moon for partial and total lunar and solar eclipses** **IR; PS**
P0809.1 **P0809.3**	**f)** *Students complete a worksheet to identify, describe and explain different artificial satellites orbits and their uses* **C**
P0809.1 **P0809.3**	**g)** *In pairs or small groups, students carry out an activity to find the position of a GPS receiver device (e.g. a smartphone) by knowing the position and distance of four GPS satellites at any time from a receiver. This illustrates trilateration and can be done on a map, or on a large area* **PS; CT**
P0810.1	**h) Students use a range of resources to tabulate the differences between the Islamic and Gregorian calendars and to account for these differences** **IR; CT**

Possible teaching order

Students can learn the sciences in any order – they have been listed alphabetically.

These suggestions simply give a strong teaching order for the topics within each science strand.

Please note other orders are possible and acceptable

Science			
	Biology	**Chemistry**	**Physics**
Grade 8	**1** Tissues, organs and systems: Digestive system **2** Tissues, organs and systems: Respiratory system **3** Tissues, organs and systems: Circulatory system **4** Healthy lifestyles **5** Interdependence of organisms	**1** Atoms, Molecules, Elements and Compounds **2** Chemical Changes occurring in substances **3** Characteristics and chemical reaction of acids and alkalis **4** Air and sources of chemical pollution of the environment	**1** Energy transfers by conduction, convection and radiation **2** Household electricity and dangers **3** Interaction of light with plane mirrors **4** Interaction between light and interface of two media **5** About the solar system

Grade 9

Biology

Structure and function of organisms

Tissues, organs and systems: Control and coordination

Standards

B0901 Explain the role of nervous coordination and control in multicellular animals.

B0902 Recognise the main human sense organs (eyes, ears, skin, nose, tongue) and describe their roles in the body.

B0903 Describe the structure of the human eye and ear and explain how the structures are related to their function.

B0904 Explain the importance of hormonal coordination and control in multicellular animals

Learning Outcomes

Students should be able to:

B0901.1 State the importance of coordination and control in multicellular animals.

B0901.2 Describe the main structures of the nervous system including sensory receptors, motor and sensory neurones and the central nervous system.

B0901.3 Explain how the structure of a reflex arc is related to its function.

B0902.1 Identify the main human sense organs (eyes, ears, skin, nose, tongue).

B0902.2 Describe the roles of the main human sense organs.

B0903.1 Describe the main structures of the human eye.

B0903.2 Explain how the structures of the human eye are related to their functions in vision.

B0903.3 Describe the main structures of the human ear.

B0903.4 Explain how the structures of the human ear are related to their functions in hearing and balance.

B0904.1 Describe the principles of hormonal control.

B0904.2 Identify the main human endocrine glands.

B0904.3 Compare nervous and hormonal control.

LO reference	Learning Experiences All students should be provided with the learning opportunities stated in bold.

	Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.
B0901.1-2	**a)** *Work in pairs. Investigate the density of the touch receptors on the skin of the back of the hand and the fingertips. Explain your observations in terms of the nervous system* **CP**
B0901.2	**b) Work in pairs. Investigate reaction times by dropping and catching a ruler. Consider factors that might affect reaction times and investigate at least one of them practically PS**
B0901.3	**c)** *Teacher demonstrates a reflex action eg blinking to protect the eyes knee jerk reaction used by doctors.*
B0902.1-2	**d)** *Make a poster to show the main sense organs with text and images to illustrate what the sense organs detect* **C**
B0903.1-2	**e) Examine a 3-D model of the human eye and use it to relate the structures to their functions in vision. Draw a large, annotated diagram of the human eye, linking each structure to its function IR; C**
B0903.2	**f) Work in pairs/small groups. Investigate and plot the human field of vision, and research on-line the field of vision of a large herbivore eg a horse. Write a report, comparing the human field of vision with the herbivore, and explain the advantages and disadvantages of different eye positions in the head IR; C**
B0903.2	**g)** *Investigate on-line how to make a diagram which you can use to demonstrate to a non-scientist the existence of the blind spot, based on two drawings a measured distance apart.* **CC**
B0903.3-4	**h) Examine a 3-D model of the human ear and use it to relate the structures to their functions in hearing and balance. Draw a large, annotated diagram of the human ear, linking each structure to its function IR; C**
B0903.4	**i)** *In a brain storming exercise, compare the sizes and positions of the external ears of different animals. List some adaptive advantages of these different types of ears* **CT**
B0904.1-2	**j) Work in small groups. Each group uses books and the internet to investigate one of the main human endocrine glands. Each group makes a short presentation to the rest of the class IR; C**
B0904.3	**k)** *Make a table comparing nervous and hormonal control in the human body*
Tissues, organs and systems: The skeletal system	
Standards **B0905** Describe the structure of the human skeleton and explain its adaptations for function.	

B0906 Understand the role of antagonistic muscle pairs and synovial joints in the movement of the skeleton.

Learning Outcomes
Students should be able to:

B0905.1 Identify the main bones of the human skeleton and describe how it provides support and protection for body tissues and organs.

B0905.2 Explain how the skeleton serves as a reservoir of calcium and potassium, and know that its bone marrow produces all blood cells.

B0906.1 Describe a synovial joint and explain the importance of these joints in the movements of the arms and the legs.

B0906.2 Explain how the contracting and relaxing of antagonistic pairs of muscles results in the movement of the bones of the limbs.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0905.1-2	**a) Using a model skeleton, identify the main bones in the skeleton and discuss the function of the skull, the ribs, the bones of the legs and arms and the pelvis for their functions in the body. (if no alternative, use a 3-D skeleton from the internet) CP**
B0905.2	**b)** *Teacher demonstrates the inside of a large bone from a sheep, goat or cow to identify the bone marrow, the spongy bone and the compact bone so students can relate structure to function* **PS**
B0905.2	**c)** *Work in pairs/small groups. Compare the strength of model bones made from solid rolls of paper and from cylinders of paper and use this to help you explain the structure of the bones of the skeleton.* **CT**
B0906.1	**d) Investigate the range of movement of the synovial joint at your knee and at your shoulder. Represent these movements diagrammatically and explain the importance of the synovial fluid in these joints. C IR**
B0906.2	**e)** *As a class identify as many pairs of antagonistic muscles in the human body as you can by thinking about the ways the different parts of the body can move. Use the internet or other resources to discover if the pairs you have suggested are correct, and to find more examples* **CP ; CT**

Biochemistry

Standards
B0907 Understand the principles of anaerobic cellular respiration

Learning Outcomes
Students should be able to:

B0907.1: Define anaerobic respiration in the cell as the partial breakdown of organic molecules in the absence of oxygen.

B0907.2: Explain the different end products of anaerobic respiration in mammals and bacteria (lactic acid) and microorganisms such as yeast (ethanol).

B0907.3 State the formula for both types of anaerobic respiration in words.

B0907.4 Describe how micro-organisms are used in making food such as bread, cheese and yoghurt.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0907.1-3	**a) Students all begin a repetitive motion eg lifting a book from the desk to their shoulder and down again OR stepping onto a step and off again, at the same time. Each student notes how long it takes for their arm or legs to ache so they cannot carry on (when anaerobic respiration has caused lactic acid to build up in the muscle. Record the class results and display as a barchart. Students suggest reasons for the differing results. Write a report of the investigation, and include word equations for both aerobic and anaerobic respiration in your write-up CT CP**
B0907.4	**b) Work in pairs. Research the way microorganisms are used to make bread, cheese and yoghurt using the internet and make a short powerpoint presentation to explain the different processes, including word equations for both types of anaerobic respiration C IR**
B0907.2-3	**c)** *Work in groups. Use data loggers to investigate the difference in pH between milk and yoghurt, which contains lactic acid from the anaerobic respiration of bacteria* **CP**
B0907.4	**d)** *Work in pairs. Plan how to use a live yoghurt culture containing different types of bacteria to make yoghurt from milk in anaerobic conditions. If time, students can continue and make yoghurt, using data loggers to show the change in pH as lactic acid produced by anaerobic respiration of bacteria* **CT; PS**

Growth, development, reproduction and inheritance

Cell division and asexual reproduction

Standards

B0908 Describe the importance of mitotic cell division in growth and repair.

B0909 Explain the role of meiosis in the production of haploid sex cells.

B0910 Describe the differences between asexual and sexual reproduction.

Learning Outcomes

Students should be able to:

B0908.1 Define the term diploid.

B908.2 Describe mitotic cell division producing two identical diploid cells and explain the role of this process in growth and repair. *Stages of mitosis **NOT** required.*

B0908.3 Recognise that unicellular organisms including yeast and bacteria reproduce by means of simple cell division.

B0909.1 Define the term haploid.

B0909.2 Explain the role of meiotic cell division in halving the chromosome number to form sex cells. *Stages of meiosis **NOT** required*.

B0910.1 Describe asexual reproduction as a process that produces offspring that are genetically identical to the parent organism and sexual reproduction as a process that involves the fusion of nuclei to create a zygote that is genetically different from its parents.

B0910.2 Explain why the male and female sex cells differ in size, number and motility.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0908.1 **B0909.1**	**a) Make a model of a diploid cell and a haploid cell in an organism which has 8 chromosomes in a diploid cell CT**
B0908.2	**b)** *Watch the process of mitosis on a video or the internet to observe the movements of the chromosomes and the production of two identical daughter cells* **IR**
B0908.2	**c)** *Work in pairs. Use a projection microscope to observe mitotic cell division taking place in prepared slides showing the meristem cells of an onion root tip. Teacher explains what is happening as the chromosomes replicate and divide between the two new cells.* **CP**
B0908.3	**d) Work in pairs/small groups. Set up a culture of yeast with sugar and warm water and after an hour observe a sample of the mixture using a light microscope. Draw and label examples of yeast cells budding and estimate what percentage of the yeast cells are dividing. CP PS**
B0909.1-2	**e)** *Watch the process of meiosis on a video or the internet to observe the movements of the chromosomes and the production of four non-identical haploid cells* **IR**
B0908.2 **B0909.2** **B0910.1-2**	**f) Make a poster to compare the processes asexual and sexual reproduction at the cellular level, including the differences between mitosis and meiosis C**

B0910.2	**g) Work in pairs/small groups. Use a light microscope or projection microscope to observe sperm and ova (egg cells) of the same species of animal. Draw them to scale and estimate the diameter of an ovum and a sperm and compare the two. Make a table to compare the size, number and motility of the male and female sex cells CP; PS**
B0910.1-2	**h) Make a wall poster showing sexual reproduction at cellular level, with a sperm and an egg cell, explaining the fusion of the two gametes to form a zygote. Draw the sperm, egg and zygote roughly to scale and show the number of chromosomes in each nucleus CT; C**

Reproduction in plants

Standards

B0911 Describe the processes of asexual reproduction in plants.

B0912 Describe the processes of sexual reproduction in plants and explain the advantages and disadvantages of each type of reproduction.

Learning Outcomes

Students should be able to:

B0911.1 Describe asexual reproduction in plants including runners, suckers and bulb formation.

B09011.2 Identify examples of asexual reproduction in plants.

B0912.1 Define flowers as the organs of sexual reproduction in plants. Identify and state the functions of sepals, petals, stamen (anther and filament), carpel (stigma, style and ovary) and pollen grains of a flower.

B0912.2 Describe the process of pollination and compare an insect-pollinated and wind-pollinated flower.

B0912.3 Describe the process of fertilisation including the growth of the pollen tube and the movement of the pollen nucleus into the ovule.

B0912.4 Understand that fertilisation leads to seed and fruit formation and describe the role of fruits in the dispersal of seeds.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0911.1-2	**a) Observe, draw and label a plant undergoing asexual reproduction to show the adult plant and the identical plantlets eg strawberry plant, spider plant, plant which grows from a bulb etc C**
B0911.1-2	**b)** *Use the internet to find examples of plants undergoing different types of asexual reproduction including runners, suckers, stolons, bulbs and corms* **IR**

B0912.1-2	**c) Work in pairs. Observe, draw and label a whole insect-pollinated flower, then dissect the flower and identify the main parts – sepal, petal, stamen (anther and filament) and carpel (stigma, style and ovary). Draw and label all of these parts, then cut open the ovary to see the ovules and the anther to see the pollen grains. Observe these using a hand lens, draw and label them.** ***If different groups of students examine different flowers, they can give presentations on what they have seen*** **CP C**
B0912.1-2	**d)** *Use the internet to observe different types of flowering plants and different arrangements of flower parts* **IR**
B0912.1-2	**e) Work in pairs. Observe, draw and label the parts of a wind-pollinated flower, using a hand lens if necessary. Compare the drawings to those made of an insect pollinated flower completed in d). CP**
B0911.1-2 **B0912.1-2**	**f)** *Teacher led or individual trip to Botanical gardens or any area with a variety of plant life to observe, draw and photograph asexual reproduction in plants along with insect and wind pollinated flowering plants. Students produce a poster or booklet to illustrate the different types of reproduction in plants* **CP CT**
B0912.2	**g)** *Use the internet to investigate some of the amazing adaptations seen in flowers to increase the chances of successful pollination: include Ophrys scolopax (the bee orchid), Rafflesia and the giant Amazonian water lily* **. CP; PS**
B0912.3	**h)** *Work in pairs. Using a light microscope or projection microscope, observe the growth of pollen tubes from pollen grains in real time. Make a series of drawings of the pollen tubes growing, and add a brief report to your drawings about the purpose of the pollen tubes and how quickly they grow.* **CP**
B0912.3	**i) Use the internet to find videos showing the growth of pollen tubes from pollen grains and then write a brief report explaining the growth of pollen tubes, how quickly they grow and why they are necessary IR**
B0912.4	**j) Work in pairs. Students investigate and dissect a range of fruits from different plants. Draw and label their observations and annotate the adaptations of the fruit to help in seed dispersal C**

Reproduction in humans

Standards

B0913 Describe the process of human reproduction

Learning Outcomes

Students should be able to:

B0913.1 Identify the general structure of the human female and male reproductive systems.

B0913.2 Explain the functions of the main structures of the human female and male reproductive systems.

B0913.3 Describe the menstrual cycle in terms of menstruation and ovulation, cycle length, fertile and infertile phases.

B0913.4 Describe simply the development of the human fetus during pregnancy, the process of birth and the care of the infant.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0913.1-2	**a) Work in pairs. Make a table to compare the male and female reproductive systems including the main secondary sexual characteristics, and the features of the sex organs and the sex cells. CT**
B0913.3	**b) Watch a video describing the sequence of events of the menstrual cycle including menstruation and ovulation, cycle length, fertile and infertile phases IR**
B0913.3	**c)** *Listen to a nurse talking about menstruation, how the menstrual cycle relates to fertility and how problems with the menstrual cycle can be overcome. Make notes on what has been said.* **PS**
B0913.4	**d) Watch a video showing the growth of a baby over the duration of a pregnancy and produce a poster showing a growing fetus with the placenta and membranes and add notes to the poster explaining the roles of the different structures in providing food and removing waste from the fetus and protecting it from damage. C; CP**
B0913.4	**e)** *Listen to a nurse talking about baby care and make a leaflet explaining how to look after a young infant to make sure it remains healthy, grows well and is happy and contented.* **CT; C**

Health and disease

Communicable diseases

Standards

B0914 Describe the spread of communicable diseases caused by viruses, bacteria and fungi in humans, and explain ways in which this spread can be prevented, including active and passive immunity.

Learning Outcomes

Students should be able to:

B0914.1: Describe how communicable diseases caused by viruses, bacteria and fungi can be spread in humans.

B0914.2: Describe different ways in which the spread of communicable diseases can be prevented including personal hygiene and public health measures. **B0914.3**: Describe simply the differences between natural and artificial immunity, and between active and passive immunity. **B0914.4:** Evaluate the effectiveness of vaccines in preventing disease.	
LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B0914.1	**a) Produce a poster to be used in school warning of the ways that common communicable diseases can be spread from one person to another C**
B0914.2	**b)** *Work in groups. Students role play a number of scenarios giving good advice to friends and family, explaining why measures such as cleaning the teeth, good personal hygiene, washing the hands after using the toilet or preparing food, and not coughing and sneezing over others are important ways of preventing the spread of disease.* **CT; C**
B0914.2	**c) Work in groups. Students list important public health measures in Qatar including effective sewage treatment, food hygiene in restaurants and the food industry, and vaccination programmes for babies and children, and explain how these programmes prevent the spread of communicable disease CP; PS**
B0914.3	**d) Work in pairs to make a table comparing natural active immunity, natural passive immunity, artificial active immunity and artificial passive immunity CP**
B0914.4	**e) Use data provided by the teacher and found on the internet to evaluate the effect of the main childhood vaccination programmes in Qatar on the incidence of childhood and adult disease. Use this information to produce a poster encouraging all parents to get their babies fully vaccinated. PS; CT; C**

Chemistry Grade 9

Structure & Bonding of Matter

Atomic Structure

Standards

C0901 Understand that the atomic structure of elements leads to the construction of the Periodic Table

Learning Outcomes

Students should be able to:

C0901.1 Recall the structure of an atom as having a nucleus that contains protons and neutrons (nucleons) and electrons arranged in shells

C0901.2 Define proton number (Z), mass number(A). Deduce the number of protons, neutrons and electrons in an atom or ion from the proton number and mass number

C0901.3 Establish that in the Periodic Table elements are arranged in increasing proton number and hence increasing number of electrons.

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0901.1	**a)** *Students write down what they know about the structure of the atom and attempt to draw a model. The teacher and class synthesise a model from their ideas including the idea that the electrons may be arranged in shells.* **CT**
C0901.2	**b) The teacher displays the nuclide notation $^{A}_{Z}M$ for some simple atoms and defines the proton number and mass number. Students deduce the number of protons, neutrons and electrons in some atoms from the proton number and mass number. They research what an ion is and deduce the number of protons, neutrons and electrons for some ions.** **CT**
C0901.3	**c)** *Students examine a modern Periodic Table to note increasing atomic number and by questioning the teacher attempts to draw out that it might be the electrons that determine chemical properties, and they might not be arranged in one shell.* **C**

Chemical Formulae and Chemical Bonding (Ionic, Covalent, Metallic)

Standards

C0902 Use ideas about atomic structure to construct and explain models of ionic, covalent and metallic bonding

C0903 Relate the physical properties of substances to the bonding in them

Learning Outcomes
Students should be able to:

C0902.1 Deduce the combining power of an element from its electron configuration and explain how to use this in determining the formulae of its compounds

C0902.2 Describe the formation of ions as involving electron gain or loss to attain a noble gas electronic configuration

C0902.3 Illustrate using 'dot-and-cross' diagrams, the formation of ionic bonds between metals and non-metals and describe the structure of an ionic compound as a giant lattice of ions held by electrostatic attraction

C0902.4 Describe the formation of a covalent bond by the sharing of a pair of electrons to attain a noble gas electronic configuration

C0902.5 Illustrate, using 'dot-and-cross' diagrams, the formation of covalent bonds between non-metallic elements

C0902.6 State the number of bonds formed by the elements hydrogen, oxygen, carbon and nitrogen in covalent compounds and be able to represent compounds of these elements diagrammatically

C0902.7 Describe metals as a lattice of positive ions in a 'sea of electrons' and use this to explain why they are good conductors of heat and electricity

C0903.1 Explain the difference in the physical properties of ionic compounds, covalent substances and metals by relating them to the ionic lattice structure, the covalent structure and the mobility of the electrons in the structure

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.*** ***(Access to a variety of chemical models would be advantageous)***
C0902.1 **C0902.2**	**a)** *The teacher explains that the electrons are arranged in shells, the inner shell can contain 2 electrons and the next shell 8 electrons. When atoms combine the result is often a noble gas configuration, which means the shell is full or empty. Students are asked to suggest how this can happen for a number of possible outer shells and the implications for bonding. Some guidance may be required.* C

C0902.3	**b) Students construct dot and cross diagrams for a range of ionic substances and draw how the ions formed can make a giant lattice. C**
C0902.4 **C0902.5** **C0902.6**	**c) Students construct dot and cross diagrams for a range of covalent substances using electron sharing. They generalise the number of bonds formed by hydrogen, oxygen, carbon and nitrogen and attempt to represent compounds of these elements diagrammatically. C** *Extension. Students may realise some electron pairs are not used for bonding and can be questioned on the implications for structure to minimise interactions between the bonds.* **C**
C0902.7	**d) The teacher asks the students if the dot and cross model would work for metals and asks them to draw possible structures. The students research the lattice of positive ions in a 'sea of electrons'. The students are asked to postulate how this model could be used to explain the conduction of heat and electricity by metals. IR; PS**
C0903.1	**e) Students work in pairs to produce generalised summaries of the physical properties of ionic compounds, covalent substances and metals and to relate these general properties to their structure. C**

Chemistry in Our World

What is a pure substance?

Standards

C0904 Understand the importance of obtaining both pure substances, in good yield and with high atom economy, and accurate formulations of mixtures for life today

Learning Outcomes

Students should be able to:

C0904.1 Explain what is meant by the purity of a substance, distinguishing between the scientific and everyday use of the term 'pure'. Differentiate between the yield and atom economy of a chemical reaction.

C0904.2 Explain that many useful materials are formulations of mixtures

C0904.3 Suggest the most suitable purification technique given information about the physical properties of the substances involved.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0904.1	**a) The teacher explains the difference between the use of 'pure' in chemistry compared with its everyday use.** *Pairs of students could either:*

	• *use a sample set of data to work out how the purity of gold affects its melting point, or,* • *carry this out as a research-based activity by asking them to find the melting point for different types of gold.* *Students suggest why chemically pure substances are required.* **Teacher defines yield and atom economy of a reaction and provides students with data to calculate yield and atom economy for some reactions of industrial importance, such as production of calcium oxide, sulfur dioxide, ammonia etc. Exemplars can also be given where there are two ways to produce a product. PS**
C0904.2	**b)** *Pairs of students choose an everyday product from a range provided by the teacher and investigate its formulation, including why words like 'aqua' are used.* **CT**
C0904.3	**c) Students describe an appropriate experimental technique to separate an unknown mixture, having been given the physical properties of the components of the mixture. PS**

Introduction to Life Cycle Analysis

Standards

C0905 Understand the world has finite resources and reduction of use, reusing materials and recycling will become more and more important

Learning Outcomes

Students should be able to:

C0905.1 Describe the basic principles in carrying out a life-cycle assessment of a material or product

C0905.2 Describe a process where a material or product is recycled for a different use, and explain why this is viable.

C0905.3 Describe examples of both reduction of use and reusing materials either in a process or in an everyday situation.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0905.1	**a)** *The teacher discusses with students what the environmental impact of products used in everyday life are. This can be assessed with a Life Cycle Assessment. Students are asked to brainstorm individually what a Life Cycle Assessment (LCA) might be for an everyday item, and then work in small groups to refine their ideas. One group presents initially*

	and others add to the overall idea. **The teacher draws together the stages that need to be considered to result in a description of a LCA:** • **extracting and processing raw materials,** • **manufacturing and packaging,** • **use and operation during its lifetime,** • **disposal at the end of its useful life,** **including transport and distribution at each stage. PS** *Extension. Students discuss which of the above are difficult to quantify.*
C0905.2	**b)** *Students can choose a class of substance such a glass, metals, plastics and research how it is recycled for a different use and whether this is viable.* **IR**
C0905.3	**c)** *Students choose to investigate either a manufacturing process or a part of everyday life and produce a report including examples of both reduction of use and reusing materials.* **IR**

Reactivity series of metals including extraction of metals.

Standards

C0906 Understand the reactivity series and its importance in extracting metals

C09007 Explain how corrosion of metals can be prevented

Learning Outcomes

Students should be able to:

C0906.1 Deduce an order of reactivity of metals based on experimental results

C0906.2 Explain, using the position of both carbon and metals in the reactivity series, the principles of industrial processes used to extract metals.

C09007.1 List a number of alloys, including the common forms of steel, how they prevent corrosion and their uses

C0907.2 Describe the rusting of iron in the presence of air and water, and that it can be protected from rusting by oiling, painting, galvanising, coating with plastic, electroplating and chromium plating

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C0906.1	**a) The teacher provides pairs of students with small samples of metals, eg magnesium, iron, copper, zinc, and solutions of metal salts, eg zinc sulfate, iron (II) sulfate, copper sulfate, silver nitrate. Students are asked to plan tests of combinations of metal and metal salt to find out if there is a reaction, recording their results in a table.**

	Students are asked to find a pattern in their results and, if possible, to reorder their table to show the results more clearly. PS *Extension. Provide students with results of a similar series of reactions with less common metals and ask them to predict another reactivity series.*
C0906.2	**b)** *The teacher demonstrates the thermite reaction between iron (III) oxide and aluminium to show that displacement reactions can be useful.*
C0906.2	**c)** *Small groups of students research when and how various metals were first extracted and use this information to suggest where carbon comes in the reactivity series.* **IR**
C0906.2	**d) Students work in pairs to carry out experiments to extract metals from four metal oxides(copper(II) oxide, lead(II) oxide, magnesium oxide etc, by heating with carbon (powdered charcoal).Students then suggest what methods are used for metals below carbon in the reactivity series. CP; IR**
C0906.2	**e) The teacher demonstrates the electrolysis of molten zinc chloride. Students observe and record what happens. C**
C09007.1	**f)** *Students work in small groups to investigate the composition of various alloys and, using diagram and noting the atoms are different sizes, suggest the difference in the arrangement of atoms between metals and their alloys and how this may change their properties including preventing corrosion.* **IR**
C09007.2	**g)** *Pairs of students carry out, describe and interpret the results of experiments (eg iron nails in test tubes) to show that both air and water are necessary for rusting.* *Students work in small groups to investigate suitable examples of corrosion being prevented using barriers, and research other methods of prevention (such as sacrificial barriers).* **IR**

Physics Grade 9

Waves, light and sound

Basic properties of waves

Standards

P0901 Describe the main properties of waves

P0902 Describe and apply the properties of sound waves

P0903 Understand the importance of the electromagnetic spectrum and its applications

Learning Outcomes

Students should be able to:

P0901.1 Describe the concept of waves and the difference between longitudinal and transverse waves

P0901.2 Recall that waves carry energy between different systems (e.g. infrared waves from the sun to the earth) and compare and contrast mechanical and electromagnetic waves as pathways for energy transfer

P0901.3 Define and use wave terms: crest, trough, compression, rarefaction, displacement, amplitude, period, frequency, wavelength and wave speed

P0901.4 Investigate the relationship between wave speed, frequency and wavelength and perform calculations using the relationship: wave speed (m/s) = wavelength (m) x frequency (Hz)

P0902.1 Explain how sound waves are transmitted as compressions and rarefactions of the particles of a medium and that the particles of the medium are only displaced locally

P0902.2 Describe how the structure of the human ear enables us to detect sound waves of frequencies ranging from 20 to 20,000 Hz

P0902.3 Relate pitch to the frequency and amplitude to the loudness of a sound

P0902.4 Describe what is meant by an echo and discuss its applications in everyday life

P0903.1 Display and describe the electromagnetic spectrum with respect to frequency and wavelength

P0903.2 State that the velocity of all electromagnetic radiation in a vacuum is the same

P0903.3 Describe the properties and applications of different parts of the electromagnetic spectrum, including that EM waves are transversal waves that can travel through a vacuum

LO References	Learning Experiences All students should be provided with the learning opportunities stated in bold.

	Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.
P0901.1-4 **P0902.1**	**a)** *Teacher demonstrates that when water in a ripple tank is displaced with constant frequency, a train of waves is formed. Teacher demonstrates that if a small object is floating on the water, the object will only move up and down a not in the direction of the waves. The wave speed equation can be introduced and students could perform calculations by measuring the frequency and wavelength of the waves in the ripple tank. Wave reflection and refraction can also be demonstrated with the ripple tank* **C; PS**
P0901.1-3	**b) In small groups, students will use a slinky spring to demonstrate longitudinal and transverse waves. Illustrate with appropriate diagrams or animations the difference between energy transmission through mechanical and electromagnetic waves CP; CT**
P0901.3	**c) Students identify and label different properties of waves (e.g. amplitude, period, wavelength…) using diagrams and/or simulations demonstrated by the teacher C; IR**
P0901.4	**d)** *Students measure the distance from a pupil holding cymbals (or similar loud instrument – at least 300m). When they see the pupil hitting the instruments they start a stopwatch and stop it when they hear the sound of the instruments. They then use their measurements to calculate the speed of sound in air and perform other calculations on the wave equation given by the teacher* **CP; PS**
P0902.1-3	**e)** *In small groups and using oscilloscopes/dataloggers, learners investigate the differences between pure sounds from a tuning fork or a signal generator and mixtures of sounds, such as those produced by musical instruments and the human voice* **IR; CT**
P0902.1-3	**f)** *Teacher demonstrates how the amplitude of sound waves can be increased by compressing more air particles, e.g. a music box on top of a table. Then, students work in small groups to design and build simple musical instruments using recycled materials and explaining how their instruments increase the amplitude and can change the frequency of sound waves produced* **CT; PS**
P0902.4	**g) Students describe, with the aid of appropriate diagram, how echoes occur and give everyday examples of how they are used, e.g. ultrasound scans IR; C**
P0903.1-3	**h) Students use a range of resources to research the EM spectrum and make a diagram or display showing the frequency and wavelength range of different parts of the electromagnetic spectrum. They also discuss the properties and applications of different regions of the electromagnetic spectrum IR; C**
Interaction of light with curved mirrors	

Standards
P0904 Understand how images are formed with curved mirrors

Learning Outcomes
Students should be able to:

P0904.1 Describe the main terms associated with a curved mirror (principal axis, focal point, focal length, radius of curvature)

P0904.2 Investigate properties of images formed by convex and concave mirrors

P0904.3 Recall and describe some everyday applications of plane, convex and concave mirrors, e.g. reflective telescopes

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0904.1-2	**a) Students investigate the properties of convex and concave mirrors using light boxes with triple slits and compare them with plane mirrors. CT**
P0904.1-2	**b)** *Students work on teacher designed worksheets to complete ray diagrams to locate images formed by convex and concave lenses, leading to definitions of 'principal axis', 'focal point', 'focal length' and 'radius of curvature'.* **PS**
P0904.3	**c) Using a range of resources, students research and discuss the uses of curved mirrors in everyday applications (e.g., car headlights, makeup mirrors, and reflective telescopes). IR; C**

Forces, motion and scale

Pressure and its applications

Standards
P0905 Explain the concept of pressure exerted by a force.

P0906 Understand the effects of pressure in fluids.

Learning Outcomes
Students should be able to:

P0905.1 Calculate the pressure exerted by a force knowing the area over which it acts, using the equation: Pressure (Pa) = Force (N) / Area (m^2). Describe some everyday applications of pressure.

P0906.1 Investigate how the pressure in a fluid depends on the depth and density of the fluid and show that the pressure at any point in it is the same in all directions

P0906.2 Calculate the pressure in fluids using the equation: $p = \rho gh$; where p is pressure in Pa, ρ is the fluid's density in kg/m^3, $g = 9.8 m/s^2$ and h is the depth in m

P0906.3 Explain upthrust in fluids as a result of pressure at different depths

P0906.4 Describe how fluids can be put under external pressure and describe some applications of this according to Pascal Principle, e.g. hydraulic brakes in cars

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0905.1	**a) In small groups, students calculate the pressure exerted by a uniform brick when placed face, edge and end downwards on a surface. They then show how the pressure exerted is related to the depth of compression formed when the brick is placed face, edge and end downwards on a flat bed of plasticine CP; PS**
P0905.1	**b)** *Students brainstorm and group devices designed to exert low pressure (e.g. wide car tyres, camel's feet) and high pressure (e.g. pin, knife blade). Then, they explain how their design features achieve low and high pressures* **CT; IR**
P0906.1-3	**c)** *In pairs or small groups, students download a pressure app on their smartphones and use it to show how atmospheric pressure decreases the higher the smartphone. Then, they use their observations to explain how upthrust forces are generated in fluids* **CT; PS**
P0906.1-3	**d) In small groups, students design an investigation to observe how pressure in a fluid is affected by the depth and by the density of the fluid. They will discuss examples of calculations which make use of the formula p = ρgh. PS; CP**
P0906.4	**e)** *Students discuss how a syringe works, draw a model of a car braking system, state Pascal's principle and demonstrate a hydraulic jack lifting a heavy weight using a small force* **IR; C**

Electricity and magnetism

Magnetic fields

Standards

P0907 Recognise the patterns generated by magnetic field lines from magnets

P0808 Describe the magnetic effects of electric currents

Learning Outcomes
Students should be able to:

P0907.1 Investigate the magnetic field lines of a single magnet and of two magnets near each other using iron filings and compasses

P0907.2 Describe and draw the Earth's magnetic field lines on diagrams

P0908.1 Demonstrate that a current-carrying wire generates a magnetic field around it and draw the patterns of its magnetic field lines

P0908.2 Demonstrate that a coil of wire carrying a current produces a magnetic field similar to a bar magnet and describe the factors affecting the strength of an electromagnet

P0908.3 Describe the function of electromagnets in some everyday examples, e.g. the electric bell

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0907.1	**a) In pairs, students map the magnetic field lines generated by single and combinations of pairs of bar magnets using iron filings and small compasses. Then, they describe the properties of the magnetic field generated by these configurations CT; C**
P0907.2	**b)** *Students research the patterns of the earth's magnetic field and compare and contrast this with their observations of the magnetic field generated by bar magnets* **IR; CT**
P0907.2	**c) The teacher demonstrates how the earth's magnetic field lines are distributed around it by surrounding a bar magnet with a ball made of plasticine and using a magnetic probe to show the direction of the field lines in different places near the plasticine sphere C; CT**
P0908.1-2	**d)** *The teacher demonstrates how the magnetic field lines of a current-currying wire and of a coil form using iron filings and a visualiser. Students sketch diagrams to describe these patterns and compare these phenomena with magnetic fields from bar magnets* **CT; IR**
P0908.2-3	**e) Students brainstorm different applications of electromagnets in everyday life. Then, using mainly recycled materials, design and build a useful device using electromagnets, e.g. a door bell, a magnetic door catch/lock, a speaker… PS; CP**

Earth and space

Evolution of the visible universe

Standards

P0909 Describe the structure of galaxies and the size of the known universe

P0910 Understand the life-cycle of stars

P0911 Explain how our solar system is believed to have formed

Learning Outcomes
Students should be able to:

P0909.1 Recall the size and number of stars and galaxies, the distances between them, and the size of the visible Universe expressed in light-years

P0909.2 Explain that stars are grouped by gravitational attraction in galaxies, and that our Sun is a star in the Milky Way galaxy

P0910.1 Describe the life-cycle of stars and that they are made mainly from the element hydrogen. Explain the process of element formation in stars and how the energy of a star is generated by nuclear fusion

P0911.1 Describe how planets are believed to form when the remains of an exploded star gather by gravitational attraction

P0911.2 Evaluate the evidence for our modern understanding of the Solar System, including how this understanding has changed over time

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P0909.1-2	**a)** *In pairs, students research pictures of galaxies from a range of resources and study their characteristics. Find out what is meant by galaxy, details of the Milky Way galaxy and how stars are grouped together* **IR; C**
P0909.1	**b)** *In pairs, students research information about the size and number of stars and galaxies, the distances between them and the size of the Universe, including the meaning of light-year as a measure of distance* **IR; C**
P0910.1	**c) In small groups, students design and produce a display, or presentation, to explain the current theory of the life-cycle of a star, including the formation of elements from stars** **IR; CP**
P0911.2	**d)** *Working in pairs, make a chart to display and describe the evolution of the Universe* **CT; C**
P0911.1	**e)** *Working in pairs, students use a range of resources to describe how planets are formed* **IR; C**

Possible teaching order

Students can learn the sciences in any order – they have been listed alphabetically.

These suggestions simply give a strong teaching order for the topics within each science strand.

Please note other orders are possible and acceptable

Science			
	Biology	**Chemistry**	**Physics**
Grade 9	**1** Tissues, organs and systems: The skeletal system **2** Tissues, organs and systems: Coordination and control **3** Biochemistry (anaerobic respiration) **4** Communicable diseases **5** Cell division and asexual reproduction **6** Reproduction in plants **7** Reproduction in humans	**1** Atomic Structure **2** Chemical Formulae and Chemical Bonding (Ionic, Covalent, Metallic) **3** Reactivity series of metals including extraction of metals. **4** What is a pure substance? **5** Introduction to Life Cycle Analysis	**1** Basic properties of waves **2** Interaction of light with curved mirrors **3** Pressure and its applications **4** Magnetic fields **5** Evolution of the visible universe

Science Standards Grades 10-12

Grade 10

Biology Grade 10

Structure and function of organisms

Cell structure and function

Standards

B1001 Describe cell theory and explain the difference between eukaryotic and prokaryotic cells.

B1002 Explain the impact of microscopy on our knowledge and understanding of cell structure and ultrastructure.

B1003 Describe the ultrastructure of cells and relate the structure of organelles to their function.

Learning Outcomes

Students should be able to:

B1001.1 Define cell theory: that all living organisms are composed of cells.

B1001.2 Explain the significance of compartmentalization in eukaryotic cells.

B1001.3 Differentiate between prokaryotic and eukaryotic cells.

B1002.1 Explain how light microscopes have contributed to our knowledge of cell structure.

B1002.2 Define resolution and calculate the magnification power for light microscopes.

B1002.3 Explain how electron microscopes have contributed to our knowledge of cell ultrastructure.

B1003.1 Describe the ultra-structure of eukaryotic cells including nucleus, cytoplasm, cell membrane, cell wall, cytoskeleton, Golgi apparatus, mitochondria, chloroplasts, centrioles, lysosome, endoplasmic reticulum and ribosomes.

B1003.2 Recall the principles of the surface area to volume ratio and calculate the surface area to volume ratio of model cells and organisms.

B1003.3 Relate the structure of cell organelles to their function, including reference to surface area to volume ratios as appropriate.

LO reference	Learning Experiences
	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***

B1001.1-2	**a) Use prepared slides of eukaryotic tissues to learn to use the high-power, oil immersion objective lens on the microscope and use this to observe, identify, draw and label eukaryotic cell structures at higher magnification IR**
B1001.3	**b)** *Work in pairs/small groups. Discuss and develop the most effective way to help other students differentiate between prokaryotic and eukaryotic cells – for example a poster, a model, a web page or a table* **C**
B1002.2	**c) Work in pairs. Use a light microscope and a graticule, measure a number of specimens and calculate the actual size based on the magnification used. PS**
B1002.2	**d)** *Make a visit to see an electron microscope and/or an ultracentrifuge in the University of Qatar* **CT**
B1002.1 **B1002.3**	**e) Use the internet to develop a timeline to show how light microscopes and electron microscopes have contributed to our knowledge of cell structure over the years IR; C**
B1003.1	**f) Use electron micrographs provided or from the internet to recognise, identify and draw the ultrastructure of a eukaryotic cell including the nucleus, cytoplasm, cell membrane, cell wall, cytoskeleton, Golgi apparatus, mitochondria, chloroplasts, centrioles, lysosome, endoplasmic reticulum, ribosomes and vacuoles (where present) IR; C**
B1003.2 **B1003.3**	**g)** *Work in groups to make a model of an organelle of a eukaryotic cell as seen under the electron micrograph eg mitochondrion, chloroplast, nucleus. It must be possible to see inside the organelle. Add labels to the model, emphasising areas which increase the surface to volume ratio.* **CT; CP**

Growth, development, reproduction and inheritance

Growth and development

Standards

B1004 Describe the stages of the cell cycle and explain its importance to organisms.

B1005 Recognise and describe the behaviour of chromosomes during mitosis and explain how this results in the formation of genetically identical daughter cells.

B1006 Explain tumour formation in terms of uncontrolled cell division.

Learning Outcomes

Students should be able to:

B1004.1 State the main stages of the cell cycle - interphase, when growth and replication of organelles and DNA take place, mitosis and cytokinesis, when the cell divides.

B1004.2 Explain the importance of mitosis and the production of genetically identical daughter cells to organisms in terms of asexual reproduction, growth and repair.

B1004.3 Explain how the rate of cell division is controlled at checkpoints in the cell cycle (details of the process are NOT required).

B1005.1 Describe somatic (body) cells as diploid and sex cells as haploid, and explain how DNA is folded into chromosomes, including the difference between chromatin and chromosomes.

B1005.2 Describe chromatids, centromere and telomeres.

B1005.3 Explain the significance of homologous chromosomes.

B1005.4 Describe the main stages of mitosis (prophase, metaphase, anaphase and telophase).

B1006.1 Describe how uncontrolled cell division can result in the formation of a tumour.

B1006.2 Explain the difference between non-malignant tumours and malignant tumours (cancer).

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1004.1-3	**a) Produce a diagram that matches the stages of a simple cell cycle diagram to the appearance of the cells at the different stages CT**
B1004.1 **B1004.3**	**b)** *Search the internet for a clear animation of the stages of the cell cycle and the checkpoints that control the rate of mitotic cell division* **IR**
B1005.1-2	**c) Work in small groups. Using a range of materials, make 2 models – one to show DNA wound around histones to form the chromatin of the chromosomes, and the other to show the structure of a pair of chromatids held together by the centromeres (including the telomeres) CP; C**
B1005.1	**d)** *Use a light microscope and prepared slides to observe, draw and label the giant chromosomes in the salivary glands of Drosophila* **CP**
B1005.3-4	**e) Work in pairs. Investigate mitosis in the root tip of an allium such as garlic or onion. Students prepare the root tip squash and stain the cells with aceto-orcein. In a good slide, a number of stages of mitosis will be seen. Use prepared slides if the fresh ones fail. Draw and label only the stages of mitosis that can be seen. CP; CT**
B1005.4 **B1006.1**	**f) Using root tip squashes or a prepared slide, students calculate the mitotic index of different areas of a root tip. PS**

B1005.4 **B1006.1**	**g) Watch the movements of the chromosomes during mitosis and cytokinesis on the internet and relate these observations to the stages of mitosis you have studied IR**
B1006.1	**h)** *As a class, discuss the changes expected in the mitotic index of the cells of a tumour compared to the surrounding healthy tissue and how this might be used both in diagnosis and to monitor treatment **CT***
B1006.2	**i) Produce a Health Education leaflet or poster explaining to ordinary people what goes wrong when a tumour forms, and the differences between a non-malignant tumour and a malignant tumour C**

Reproduction

Standards

B1007 Recognise and describe the behaviour of chromosomes during meiosis and explain how this enables a constant number of chromosomes to be passed from generation to generation.

Learning Outcomes

Students should be able to:

B1007.1 Recognise and describe the behaviour of chromosomes during the main stages of meiosis.

B1007.2 Explain how meiosis enables a constant number of chromosomes to be passed from generation to generation.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1007.1	**a) Examine prepared slides of locust testes using a light microscope. Identify, draw and label as many stages as possible. CT**
B1007.1	**b) Watch the movements of the chromosomes during meiosis on the internet IR**
B1007.2	**c)** *Work in pairs. Make a simple model to show how the chromosomes duplicate and then separate during meiosis to give four non-identical haploid daughter cells* **CP; C**
B1007.2	**d) Draw a series of diagrams showing how meiosis maintains the chromosome number through the generations, showing the parental cells and the sex cells CT**

Inheritance and the genome

Standards

B1008 Explain the principles of Mendelian genetics and use genetic diagrams to solve genetic problems involving monohybrid crosses.

B1009 Explain sex determination in humans and the inheritance of X-linked characteristics

Learning Outcomes

Students should be able to:

B1008.1 Describe the basic principles of Mendelian genetics.

B1008.2 Define the terms; recessive, dominant, phenotype, genotype, complete dominance, co-dominance and multiple alleles.

B1008.3 Use genetic diagrams (Punnett squares) to solve genetic problems involving monohybrid crosses and calculate the ratio of genotypes and phenotypes in the progeny.

B1009.1 Describe how X and Y chromosomes determine sex in humans and explain why it is the father who determine the sex of a child.

B1009.2 Recognise the inheritance patterns of X-linked characteristics and solve genetic problems relating to X-linked characteristics using Punnett squares.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1008.1	**a) Research the life and work of Gregor Mendel and write a report on how he discovered the science of genetics and the problems he had in getting his ideas accepted. IR; C**
B1008.1	**b) Use coloured beads to represent dominant and recessive alleles in parental genes and to illustrate how these alleles pass to gametes and on to progeny PS**
B1008.2	**c)** *Make an illustrated glossary of terms to use when studying genetics* **CT**
B1008.3	**d) Work in pairs. Practice using Punnett squares to predict the progeny of genetic crosses. Then think up two different genetic crosses. Exchange problems and work them out PS ; CT**
B1008.2-3	**e) Make a poster to demonstrate the possible inheritance patterns of the different human blood groups A, B, AB and O. C**
B1008.1 **B1008.3**	**f)** *Use Punnett squares to work out genetics problems involving the inheritance of human blood groups.* **PS**
B1009.1	**g)** *Observe human karyotypes on the internet and identify them as male or female using the sex chromosomes.* **CT**
B1009.1-2	**h) Make model chromosomes for male and female parents and use these to demonstrate the segregation of sex chromosomes into gametes, the formation of male and female offspring and the problems of sex-linked diseases as a result of the structure of the X and Y chromosomes. CT**

B1009.2	**i)** *Investigate 2 different sex-linked characteristics on the internet and use Punnet squares to demonstrate how they are inherited* **IR**

Organisms and their environment

Interdependence of organisms

Standards

B1010 Describe all levels of organisation in the living world from atom to biosphere.

B1011 Recognise a variety of ecological relationships including mutualism, parasitism and commensalism.

Learning Outcomes

Students should be able to:

B1010.1 Describe the various levels of the natural world, from atoms to the biosphere.

B1010.2 Define the terms species, population, community, ecosystem, habitat and niche.

B1011.1 Define an ecological relationship.

B1011.2 Define a mutualistic, parasitic and commensal relationship and describe a minimum of two examples of each.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1010.1-2 **B1011.2**	**a) Make a dictionary of terms used in ecology (including biosphere species, population, community, ecosystem, habitat and niche) and give a local example and an international example to illustrate each term. Add to this dictionary as you continue your studies in ecology.** **CT; C**
B1010.2 **B1011.1**	**b)** *Work in small groups. Each group researches a different type of habitat or ecosystem using the internet, including the main abiotic factors and some of the important ecological relationships found there. Each group gives a short presentation to the rest of the class.* **IR; C**
B1010.2 **B1011.1-2**	**c) Work in pairs/small groups. Carry out a short field study of a local habitat (eg a tree, a flower bed, a pond, an area of leaf litter). Survey the most common types of plant and animal life, observe, draw and identify as many species as possible, measure abundance where possible and investigate feeding relationships between the organisms when you return. [If appropriate, students may use data loggers to record abiotic aspects of the habitat eg temperature, soil pH, oxygen levels etc]** **CP**

B1011.2	**d)** *Investigate one example each of a mutualistic, parasitic and commensal relationship which you have NOT covered in your textbooks or lesson.* **IR**
B1010.1-2 **B1011.1-2**	**e)** *Watch nature documentaries to find out more about the range of ecosystems and interacting species in the world eg Life on Earth, Life on Earth II, Blue Planet etc by Sir David Attenborough* **IR**

Environmental interactions and processes

Standards

B1012 Discuss some human impacts on the environment and describe ways in which a sustainable ecosystem can be maintained, including anthropogenic climate change and the use of pesticides.

Learning Outcomes

Students should be able to:

B1012.1 Describe the use of chemical pesticides in the production of human food crops and explain the ecological problems which this can cause (including loss of pollinators).

B1012.2 Explain ways in which sustainable ecosystems can be maintained including the use of biological pest control.

B1012.3 Define anthropogenic climate change and evaluate some of the evidence for its effect on biodiversity including rising temperatures and extreme weather events.

B1012.4 Describe ways in which humans can maintain sustainable ecosystems including the role of Qatar and other countries in reducing carbon dioxide emissions through international agreements, developing alternative energy strategies and building environmentally friendly buildings.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1012.1	**a) Work in groups. Each group investigates one aspect of the use of chemical pesticides in human food production: the need for food; crop loss to insect and fungal pests; the benefits of pesticide use to crop yield; ecological problems linked to pesticide use; the impact of pesticides on pollinators. Each group reports back, followed by a class debate on the future use of chemical pesticides.** **IR**; **C**
B1012.2	**b)** *Produce a poster on the benefits and risks of biological pest control* **CT**
B1012.3	**c) Analyse some of the evidence for anthropogenic climate change including ice core evidence, Mauna Loa atmospheric carbon dioxide concentration graphs and peat cores and summarise the problem.** **PS**
B1012.3	**d)** *Work in pairs/small groups. Investigate* either *the frequency of extreme weather events globally* OR *the effect of rising global temperatures on the polar ice caps* **IR**

B1012.3	**e) Each student uses the internet and other media to investigate one example of the effect of anthropogenic climate change on biodiversity, either in Qatar or internationally, and writes a brief report. All the reports are put on display to give a sense of the size of the problem. CT**
B1012.4	**f) Work in pairs/small groups. Produce a poster to highlight current work in Qatar towards maintaining sustainable ecosystems including reducing carbon dioxide emissions, developing alternative energy strategies and environmentally friendly buildings. IR; CT**
B1012.4	**g)** *Research international efforts to reduce anthropogenic climate change including reducing carbon dioxide emissions and developing alternative energy strategies and environmentally friendly buildings, and take part in a class discussion on ways to maintain sustainable ecosystems for the future* **IR; PS**

Health and disease

Healthy lifestyles

Standards

B1013 Explain the importance of a balanced diet for human health.

B1014 Describe and evaluate the impact of bad eating habits on body mass index and health and discuss ways of maintaining a healthy lifestyle.

Learning Outcomes

Students should be able to:

B1013.1 Analyse the constituents of human nutrition and balanced diet.

B1013.2 Distinguish between essential and non-essential nutrients in the diet.

B1013.3 Identify the roles of major dietary minerals, vitamins, fibres, and antioxidants in promoting human health.

B1014.1 Describe how to use a calorimeter to calculate calories in different kinds of food and compare the amount of energy generated from the oxidation of proteins, carbohydrates and fats.

B1014.2 Explain, with reference to data analysis, the causes of and health problems associated with obesity, including diabetes, hypertension and coronary heart disease.

B1014.3 Describe anorexia and explain some of the related health problems.

B1014.4 Explain how exercise and good choices of balanced diet can help achieve weight loss and maintain a healthy life style, using BMI as an indicator.

B1014.5 Discuss current research into appetite control and the causes of obesity, including the role of the hormones leptin and ghrelin in appetite control

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1013.1	**a) Draw a pie chart to show the ideal proportion of food groups in a balanced diet C**
B1013.1-2	**b)** *Search the internet for the New Food Pyramid proposed by the Department of Health, USA and the USDA Food Plate. Discover the basic differences between the old food pyramid and the new food pyramid and discuss how misconceptions about what makes up a healthy diet come about* **IR; CT**
B1013.1-2	**c)** *Make a collection of food labels. Draw up tables to show the amounts of carbohydrate, protein and fat contained in different foods. Indicate which foods contain vitamins and minerals* **C**
B1013.3	**d) Make a poster to show the main constituents of a healthy balanced diet and health problems linked to the diet eg vitamin deficiencies, obesity, type 2 diabetes, coronary heart disease, bowel cancer CT**
B1014.1	**e) Using tables of energy values of different foods, students estimate their daily energy intake and compare this with recommended levels. CT**
B1013.1-2 **B1014.1**	**f) Work in pairs/small groups. Decide which combinations of foods are needed to provide a balanced diet for people of different ages and different lifestyles, including office workers, builders, athletes, a pregnant woman, a young person going through puberty and an old man. Compare and discuss the decisions of the different groups. CP; PS**
B1014.2-3	**g) Work in small groups. Each group investigates the trends in the national statistics for one of the following diet-related health problems in Qatar: anorexia, obesity, hypertension (high blood pressure), coronary heart disease and diabetes. The group produces graphs or bar charts to demonstrate the trends and then shares the information with the rest of the class to make a wall display of major diet-related health problems in Qatar. IR; C**
B1014.2	**h)** *Work in pairs/small groups. Use the information on the frequency of diabetes and obesity in Qatar from LE g) and compare this with statistics on the same conditions for other countries, using the internet or other media for your research. Suggest reasons for any differences you may find.* **IR; CT**

B1014.2	**i)** *Use the internet to produce a timeline showing some of the scientists and major breakthroughs in our understanding of diabetes (type 1 and type 2) and how they can be treated* **IR**
B1014.3	**j) Work in groups. Practice calculating BMI and discuss its value and limitations as an indicator for recommended healthy body mass. CP**
B1014.4	**k)** *Research alternatives to BMI for predicting future health problems such as type 2 diabetes, hypertension (high blood pressure) and coronary heart disease, including waist to hip ratios and neck circumference.* **IR**
B1014.4	**l) Work in pairs. Produce a plan to help someone lose weight and get fitter using a combination of diet and exercise and explain how they can monitor their progress CP; PS**
B1014.5	**m)** *Use the internet to research recent advances in our understanding of the roles of the hormones leptin and ghrelin in appetite control* **IR**

Diversity and variation in living things

Classification

Standards

B1015 Explain the principles of modern classification systems.

Learning Outcomes

Students should be able to:

B1015.1 Define the term species as a group of organisms which can reproduce successfully to produce fertile offspring and explain some of the problems with this definition.

B1015.2 Recall the taxonomic hierarchy of domain, kingdom, phylum, class, order, family, genus and species.

B1015.3 Summarise the characteristics of three domains of life (Archaea, Bacteria and Eukaryota).

B1015.4 Outline the characteristic features of the 6 kingdoms Archaea, Prokaryota (Bacteria), Protista, Fungi, Plantae and Animalia.

B1015.5 Explain why viruses are not included in the six kingdoms classification.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1015.1	**a)** *List several different species definitions and discuss the advantages and limitations of each* **C**

B1015.2 **B1015.4**	**b) Working individually, choose an example of an animal and a plant, either from Qatar or elsewhere. Either see and draw local specimens, or take a photographic record, or find organisms that interest you online or in books. Identify the animal and plant you have chosen according to the taxonomic hierarchy of domain, kingdom, phylum, class, order, family, genus and species. You may use the internet and identification books to help you. IR; C**
B1015.3-4	**c)** *Write a summary of how the model of a three domain, 6 kingdom classification system has been developed, using the internet to help with your research* **IR; C**
B1015.4	**d) Work in groups of three. The number of kingdoms in the classification hierarchy is still debated by scientists. One group member researches the five kingdom model, another the six kingdom model and the third researches the seven kingdom model. Evaluate the strengths and weakness of all three models and explain why the 3 domain, 6 kingdom model is the most widely used. CP**
B1015.4	**e) Work in pairs/small groups. Make a wall display to illustrate the main features of the 6 different kingdoms and share with the class CP; C**
B1015.5	**f)** *Use the internet to research the classification of viruses and make a table comparing it to the classification of eukaryotes and prokaryotes.* **IR**

Adaptation

B1016 Explain how some plants and animals are adapted to succeed in desert and marine ecosystems.

Learning Outcomes
Students should be able to:

B1016.1 Describe the challenges of a desert ecosystem for plants and animals.

B1016.2 Describe and explain a range of adaptations for survival seen in desert animals and plants.

B1016.3 Describe the challenges of an aquatic habitat for plants and animals.

B1016.4 Describe and explain a range of adaptations for survival seen in aquatic animals and plants.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1016.1	**a) Using Qatar as an example, list the challenges of a desert ecosystem for a) plants and b) animals CT**

B1016.1-2	**b) Work in small groups. List as many plants and animals that are adapted to life in the desert as possible. Then list as many adaptations to desert life as you can. Each group member then researches the adaptations of specific animals or plants to desert conditions. Combine the work of the whole class in a plenary session and develop a wall display of adaptations of animals and plants for survival in desert ecosystems. CP; C**
B1016.3	**c) List the challenges of an aquatic ecosystem for a) plants and b) animals CT**
B1016.3-4	**d) Work in small groups. List as many plants and animals that are adapted to aquatic life as possible. Then list as many adaptations to aquatic life as you can. Each group member then researches the adaptations of specific animals or plants to aquatic life. Combine the work of the whole class in a plenary session and develop a wall display of adaptations of animals and plants for survival in aquatic ecosystems. CP; C**
B1016.1-4	**e)** *Watch nature documentaries to find out more about the amazing adaptations of some animals and plants to both desert and aquatic ecosystems eg Life on Earth, Life on Earth II, Blue planet etc by Sir David Attenborough* **IR**
B1016.1-4	**f)** *Design an animal or plant for survival in either an aquatic or a desert ecosystem. Draw your organism and annotate the adaptations. Then search on the internet and see if a similar organism exists.* **PS**
B1016.1-4	**g)** *Investigate the adaptations of animals or plants for another, different type of ecosystem eg a marine ecosystem, a very cold ecosystem, or a hot, wet ecosystem* **IR**

Possible teaching order

Please note other orders are possible and acceptable

Biology	
Grade 10	**1** Cell structure and function **2** Growth and development **3** Reproduction **4** Inheritance and the genome **5** Classification **6** Adaptation **7** Interdependence of organisms **8** Environmental interactions and processes **9** Healthy lifestyles

Chemistry Grade 10

Structure & Bonding of Matter

The Mole Concept and Stoichiometry

Standards

C1001 Be able to carry out calculations on reacting quantities of solids, liquids, gases and solutions

Learning Outcomes

Students should be able to:

C1001.1 Construct balanced chemical equations with state symbols (s,l,g and aq) including ionic equations

C1001.2 Define relative atomic mass, A_r, relative molecular mass, M_r, and calculate relative molecular mass and relative formula mass as the sum of relative atomic masses. Calculate, given relevant data, the percentage mass of an element in a compound

C1001.3 Define the terms relative isotopic mass based on the ^{12}C scale and calculate the relative atomic mass of an element given the relative abundances of its isotopes

C1001.4 Recall and use the definitions of the Avogadro constant (in standard form) and of the mole

C1001.5 Explain how the mass of a given substance is related to the amount of the substance in moles and vice versa.

C1001.6 Solve problems in stoichiometry involving reacting masses and volumes of gases (one mole of gas occupies 22.4 dm^3 at standard temperature and pressure).

C1001.7 Explain how the mass of a solute and the volume of the solution is related to the concentration of the solution

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.*** .
C1001.1	**a)** *The teacher demonstrates the reaction of lead(II) nitrate and potassium iodide solutions on a digital balance to show there is no change in mass but an obvious chemical change. This gives a practical demonstration for the law of conservation of mass and a rationale for constructing and balancing equations.* **Students first of all balance provided equations of increasing complexity and then construct equations of increasing complexity. Students examine equations split into ions and identify ions that do not participate (spectator ions). CT**

C1001.2	**b) The teacher defines relative atomic mass, A_r and relative molecular mass, M_r. Students calculate relative molecular mass and relative formula mass as the sum of relative atomic masses for a number of compounds they have met. CT** **Students calculate, given relevant data, the percentage mass of an element in a compound. PS**
C1001.3	**c) Teacher defines relative isotopic mass. Students calculate the relative atomic masses of a variety of elements from the percentage abundance of their isotopes, including some that give non-integer results such as chlorine and copper. CT**
C1001.4	**d)** *Teachers introduce the idea of the mole by analogy (eg counting coins or other everyday similar objects) or by definition. It should be reinforced by measuring out and comparing 1 mole of elements like iron, sulfur, magnesium, copper, aluminium and 1 mole of common compounds like water, sodium chloride, calcium carbonate. This reinforces the idea of the same number of atoms or molecular entities and leads into a definition of the Avogadro constant as a fundamental constant.* **C** **The teacher defines the mole and the Avogadro constant (the latter as a pure number).** *Students work in small groups to research information about Amadeo Avogadro and produce posters showing his discoveries.* **IR; C** *Extension. Very able students research proposals to redefine the kilogram in terms of a fundamental constant and the implications for the definition of the mole.* **PS**
C1001.5	**e) Students use the relative formula mass of a substance to calculate the number of moles in a given mass of that substance and vice versa. Substances can include atoms, ions, molecules etc.** *They then carry out more sophisticated calculations eg to balance an equation given the masses of reactants and products.* **PS**
C1001.6	**f) Students carry out calculations as in (e) but using volumes of gases. PS**
C1001.6	**g)** *Students try to explain, in terms of particle theory, why 1 mole of any gas occupies 22.4dm^3 at standard temperature and pressure* **CT**
C1001.7	**h)** *The teacher explains that many chemical reactions occur in solution and thus it is important to be able to calculate masses from volumes of solution.* **Students calculate the concentration of solutions from the mass of solute and the volume of solution and vice versa. PS**

	Students make up a standard solution of a chemical compound using volumetric apparatus **CP**

Patterns in Chemical Reactivity

Periodicity in the Properties of Elements

Standards

C1002 Understand the strengths and weaknesses of Mendeleev's Periodic Table, how it has been adapted , and that physical and chemical properties are periodic

Learning Outcomes

Students should be able to:

C1002.1 Carry out an activity to simulate the derivation of Mendeleev's Periodic Table using information on the elements known in 1869

C1002.2 Recognise Mendeleev's Periodic Table as a means of classifying elements according to their properties. Identify where the more reactive and the less reactive metals occur on the Periodic Table and where the metals and the non-metals occur

C1002.3 Deduce that elements with similar properties are arranged in columns in the Periodic Table and that the properties of elements change gradually along the rows

C1002.4 Relate the modern periodic classification to the electronic structure of the elements and explain in terms of isotopes how this changes the arrangement proposed by Mendeleev and has led to the discovery of the trans-uranic elements

C1002.5 Describe trends in the physical and chemical properties of the elements and their simple compounds within Groups I, II, VII and VIII and account for these trends in terms of atomic structure. Physical properties should include atomic radius, ionic radius, melting point and electrical conductivity

C1002.6 Predict possible reactions and probable reactivity of elements from their positions in the Periodic Table

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1002.1	**a) Pairs of students use cards or an electronic simulation carry out a sorting activity to attempt the derivation of Mendeleev's Periodic Table using information on the elements known in 1869. They should be guided to the conclusion that Mendeleev left gaps for elements not yet discovered and predicted the possible properties of these elements. Students predict the properties of germanium (in the same group as carbon).** **CP; PS**

C1002.2 **C1002.3**	**b) Students indicate where the more reactive and the less reactive metals occur and where the metals and the non-metals occur. They research how the properties of elements change along the rows. CP**
C1002.4	**c) The teacher describes the salient features of a modern Periodic Table in terms of electron configuration** *and asks the class to identify which elements are anomalous based on Mendeleev's way of arranging the elements.* **CT** *Extension. Students examine the isotopic composition of these elements to explain the anomalies.***CT**
C1002.4	**d)** *Students may research the discovery of the trans-uranic elements and why 2019 is 'The Year of the Periodic Table'.* **IR**
C1002.5	**e) Students work in small groups and use a database to describe trends in the physical l properties of the elements within Groups I, II, VII and VIII and account for these trends in terms of proton number and atomic structure. Physical properties should include atomic radius, ionic radius, melting point and electrical conductivity** **Students describe the chemical properties of the elements and their simple compounds within Groups I, II, VII and VIII such as:** • **watching the teacher demonstrate the reactions of the first three alkali metals with oxygen, chlorine and water,** • **researching the nature of the compounds formed when chlorine, bromine and iodine react with metals and non-metals,** • **working in pairs to carry out displacement reactions of the halogens from halides to deduce the trend in reactivity of the halogens. C**
C1002.6	**f) Students predict possible reactions and probable reactivity of elements from their positions in the Periodic Table exemplified by rubidium, caesium , fluorine, astatine etc. PS** *They could be shown video to confirm or deny their predictions.*

Characteristic properties of acids and bases.

Standards

C1003 Generalise the properties of acids and bases to produce a salt plus water

Learning Outcomes

Students should be able to:

C1003.1 Recognise the characteristic properties of acids and bases in aqueous solution. Define acid and base using the Arrhenius theory and the Bronsted-Lowry theory

C1003.2 Explain qualitatively the differences in behaviour between strong and weak acids and alkalis in terms of the extent of dissociation and relate this to the pH scale

C1003.3 Explain the changes in pH during neutralisation and recognise that neutralisation can be generalised to the reaction of hydrogen ions with hydroxide ions to form water.

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1003.1	**a) Students work in pairs to investigate the reactions of metals such as magnesium, iron and zinc with sulfuric acid. They also investigate the following reactions: acids + soluble metal hydroxide, acid + insoluble metal hydroxide, acids + metal carbonates.** **Students write word and symbol equations for the reactions and draw generalisations as to acid behaviour.** **The teacher explains the difference between an alkali and a base and then defines acid and base using the Arrhenius theory and the Bronsted-Lowry theory, ensuring that students are aware the latter is a development of the former.** **Students carry out the reaction between hydrogen chloride and ammonia gas. CP**
C1003.2	**b) Students work in pairs to measure the pH of a variety of the following solutions: acidic, alkaline, and neutral using Universal Indicator or a pH meter or probe and use their results to suggest which solutions are strong, which weak, which concentrated and which dilute. PS** The teacher explains these terms using the extent of dissociation in the solution.
C1003.3	**c)** *The teacher demonstrates an experiment to measure the pH change when a strong acid neutralises a strong alkali. This is best done using a data logger and pH probe or digital pH meter. The students identify the end point from the graph.* **Students write equations for a variety of acid/alkali reactions and attempt to generalise them. PS**
Organic Chemistry	
Standards **C1004** Understand the basis of organic chemistry in terms of the bonding of carbon **C1005** Recognise the importance of the alkanes to the petrochemical industry.	
Learning Outcomes **Students should be able to:** **C1004.1** Recall that carbon can form four covalent bonds **C1004.2** Explain that the vast array of natural and synthetic organic compounds are the result of the ability of carbon to form families of similar compounds, chains and rings **C1005.1** Interpret and use the nomenclature and molecular and structural formulae of alkanes	

C1005.2 State that the main use of alkanes is as fuels and that the size of the molecule determines what kind of fuel it is and how it is used

C1005.3 Describe the important processes of fractionation and catalytic cracking to produce more useful organic products

C1005.4 Explain how modern life is crucially dependent on hydrocarbons and recognise that crude oil is a finite resource

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1004.1 **C1004.2**	**a)** *Students use the electronic configuration of carbon to draw dot and cross diagrams with any other elements (including carbon) and these can be collated as displayed formulae. The teacher summarises that carbon can form four covalent bonds (including bonds to itself) and the students either draw or use molecular models to create other molecules.* **C**
C1004.1 **C1004.2**	**b)** *Students attempt to research how many carbon-containing molecules there are.* **IR**
C1005.1	**c) Pairs of students use modelling kits or draw as many molecules as they can with up to 6 carbon atoms with no rings. The teacher defines molecular and structural formula and the students attempt to write structural formulae for their molecules and generalise the results. They list the nomenclature of the first ten straight chain alkanes.** **IR**
C1005.2	**d)** *Students work in small groups to research the main use of alkanes as fuels focusing on the size of the molecule determining what kind of fuel it is and how it is used.* **IR**
C1005.3	**e) Students describe the process of fractional distillation and explain it in terms of evaporation and condensation either by carrying out a practical or by watching an animation. They compare the petroleum oil with the products. They produce a diagram summarising the industrial process of fractionation.** **IR; CT**
C1005.3	**f) Students carry out an experiment to show the cracking of paraffin over porous clay pot or observe a teacher demonstration of the process. Students should then describe and explain the industrial process of cracking. They write balanced symbol equations for the cracking of alkanes and make a wall chart explaining the process and its applications.** **C** *There may be opportunity to use local industries and carry out fieldwork.*

C1005.4	**g) Students produce a report focused on the explanation of how modern life is crucially dependent on hydrocarbons and recognising that crude oil is a finite resource. Students could suggest the impact on fuels, feedstocks and petrochemicals of the depleting stocks of crude oil. They could describe a life without oil or oil derived products. They could look at the cultural and environmental impact of the oil industry both in Qatar and around the world. IR; C**

Reaction Kinetics & Energetics

Fundamentals of reaction kinetics using collision theory

Standards
C1006 Understand the factors that affect rates of reaction

Learning Outcomes
Students should be able to:

C1006.1 Recognise that reaction rates vary considerably and be able to produce, and analyse graphically, data from rate experiments

C1006.2 Explain a bimolecular reaction in terms of particle collisions and recognise that the chance of reaction depends on correct orientation and energy of the particles

C1006.3 Determine the effect on reaction rates of concentration, temperature, particle size, and catalysts and explain the effect in terms of a kinetic particle model

C1006.4 Distinguish between heterogeneous and homogeneous catalysts and give examples of both

C1006.5 Establish that many reactions occur in multiple steps and that only the slowest (the rate determining step) determines the reaction rate

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1006.1	**a) Students work in pairs to investigate how changes in concentration affect the rates of reaction by a method involving either measuring the volume of a gas produced or a method involving change in colour or turbidity using data loggers or otherwise. IR**
C1006.2	**b) Students research and describe collision theory and activation energy for a bimolecular reaction, using simple animations and graphs. C**
C1006.3	**c) Pairs of students carry out further experiments to investigate how some of temperature, particle size, or the presence of a catalyst affect rates of reaction using data loggers where possible. They explain these effects in terms of a kinetic particle model. CP**

C1006.4	**d) The teacher defines heterogeneous and homogeneous catalysts and students research examples of each. C** **If catalysis is not investigated in (c) students work in pairs to investigate the effect of the addition of various metal salts on the decomposition of hydrogen peroxide using a data logger or otherwise. CP**
C1006.5	**e) The teacher establishes that it is highly unlikely for a reaction involving more than two particles to occur by a three or more particle collision and thus the reaction must occur in steps. Students suggest what may control the rate of such a reaction and the teacher defines rate determining step. CT**

Types of energy changes, construction of energy profile diagrams

Standards

C1007 Understand that chemical reactions are accompanied by energy changes brought about by bond breaking and bond making

Learning Outcomes

Students should be able to:

C1007.1 Recognise that chemical reactions are accompanied by energy changes, usually in the form of heat energy, and that the energy changes can be exothermic or endothermic

C1007.2 Recognise that bond breaking is associated with endothermic changes and bond formation is associated with exothermic changes

C1007.3 Represent endothermic and exothermic reactions and activation energy on an energy profile diagram

C1007.4 Describe how a catalyst can provide an alternative energy profile with a lower activation energy

LO References	Learning Experiences
	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1007.1	**a) Students work in pairs to investigate the variables that affect temperature changes in reacting solutions eg acids plus metals, or acids plus carbonates, or acid/base neutralisations or displacement of metals using a data logger or otherwise. CP** **They then investigate some endothermic reactions such as dissolving ammonium nitrate in water or mixing solid ammonium chloride with solid sodium nitrite. CP**
C1007.2	**b) Students are asked to justify whether bond-breaking is exothermic or endothermic in simple terms relating to energy input. CT**

C1007.3 **C1007.4**	**c) Students draw energy profile diagrams for exothermic, endothermic and catalysed reactions to show the alternative catalysed profile with a lower activation energy. C**
C1007.4	**d)** *Use the internet to investigate the use of catalysts – for example, in the chemical industry, in the food industry and in cars. Make a table to show at least 6 different examples of catalysts in use in industrial or technological applications.* **IR; C**

Possible teaching order

Please note other orders are possible and acceptable

Chemistry	
Grade 10	**1** Periodicity in the Properties of Elements **2** Characteristic Properties of acids and bases. **3** Fundamentals of reaction kinetics using collision theory **4** Types of energy changes, construction of energy profile diagrams **5** Organic Chemistry **6** The Mole Concept and Stoichiometry

Physics Grade 10

Forces, motion and scale

Physical quantities and uncertainty in experimental results

Standards

P1001 Understand the importance of the SI units and how to process them.

P1002 Evaluate the validity of experimental results.

Learning Outcomes

Students should be able to:

P1001.1 Distinguish between fundamental and derived SI units using appropriate prefixes.

P1001.2 Manipulate ranges of magnitude and express quantities correctly in standard form in SI units.

P1002.1 Explain how to obtain precise and accurate measurements in practical tasks.

P1002.2 Calculate the absolute and percentage uncertainty in experimental results using a range of methods, including maximum and minimum gradient of a graph.

P1002.3 Make valid and simplified assumptions in solving problems.

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1001.1-2	**a)** *In small groups, students tabulate objects of differing sizes from a proton to the Milky Way galaxy and indicate the size using the appropriate SI unit of measurement. Convert measurements from one unit to another, expressing the result in standard form* **IR; PS**
P1001.1-2	**b)** *In small groups, students view a video on "Why the metric system matters". Learners will discuss how NASA accidentally crashed a US$125 million orbiter into Mars in 1999 is related to the use of metric system* **C; CP**
P1002.1-3	**c) Students will use a micrometer screw gauge and a Vernier calliper to measure length, and an electronic timer to measure time intervals precisely to a known margin of error. Repeat the measurements and take a mean to ensure accuracy, calculate the absolute and percentage error on the mean values obtained** **CT; PS**
P1002.1	**d)** *Students describe precision and accuracy using the analogy of an archer's target* **CT; C**

P1002.3	**e) In small groups, students identify sources of uncertainty that may be ignored in problem solving, such as air resistance in projectile motion, energy loss through heating in thermal physics and cell internal resistance in electricity CT; PS**

Kinematics

Standards

P1003 Analyse and explain the motion of objects through graphical representations.

P1004 Analyse and explain the motion of objects which are uniformly accelerated along a straight line.

Learning Outcomes

Students should be able to:

P1003.1 Explain the difference between scalar and vector quantities to resolve vectors and calculate the resultant in real situations.

P1003.2 Describe the meaning of the concepts of distance and displacement, speed and velocity, and acceleration.

P1003.3 Represent distance, displacement, speed and velocity graphically and interpret graphs that represent them, including finding the displacement as the area under a velocity - time graph.

P1004.1 Derive mathematically and graphically from the definitions of velocity and acceleration, equations that represent uniformly accelerated motion in a straight line and use them to solve problems relating to the motion of objects under uniform acceleration.

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1003.1	**a)** *Students work on teacher designed worksheets comprising examples on:* • *the addition and subtraction of vectors;* • *the representation of vectors by lines;* • *the resolution of vectors into perpendicular components and their addition by the method of components* C, PS
P1003.1	**b) Students tie a string to a door handle and a newton meter. Then, pull the door open at different angles from the handle and calculate the parallel and perpendicular component of the force to the door. They use their calculations to explain how the angle affected their ability to open the door CT; PS**
P1003.2-3	**c) Students interpret motion graphs given to them to identify a range of properties of moving objects, including calculating velocity and acceleration from the gradient of D-T and V-T graphs and the displacement as the area under a V-T graph CT; PS**

P1003.3	**d)** *Students move in front of a motion sensor to match the graphs that are provided to them* **CT; PS**
P1003.1-2	**e)** *In small groups, students discuss the difference between distance and displacement (e.g., use an example of a runner who has just completed one lap of a 400 m track)* **CT; CP**
P1003.2-3	**f)** *In small groups, students investigate and make calculations of velocity and acceleration using equipment such as an air track and interval timers or trolleys and ticker-timers* IR, CP
P1003.3	**g)** *Students watch appropriate movie clips on Olympics track events to plot distance-time and speed-time graphs, and compute speed and acceleration* **IR; PS**
P1004.1	**h)** *Students work on teacher designed worksheets to derive mathematically and graphically the equations of motion and to solve problems using these equations* **PS**
P1004.1	**i)** *Students calculate the gravitational field strength g using appropriate measurements of a falling object (e.g. a ball)* PS

Matter and energy

Nature of matter

Standards

P1005 Explain the kinetic particle model in relation to the properties of solids, liquids and gases

P1006 Understand the difference between temperature and energy stored thermally

P1007 Use the concepts of specific heat capacity and specific latent heat capacity

Learning Outcomes

Students should be able to:

P1005.1 Describe the kinetic particle model for solids, liquids and gases, and relate the difference in their structures and densities to the spacing, ordering and motion of particles

P1005.2 Use the kinetic particle model to explain fluid pressure, freezing, melting, boiling, evaporation, crystallisation and Brownian motion

P1005.3 Use the kinetic particle model to explain the thermal expansion of solids and liquids and give some applications, e.g. the gap between railway tracks

P1005.4 Explain how the anomalous expansion of water results in ice forming on the surface of water and not at the bottom, and recognise the importance of this to the survival of aquatic living things

P1006.1 Recall that the temperature of a substance is a measure of the average kinetic energy of its molecules due to their random movement

P1006.2 Explain how a temperature scale is constructed and how different temperature scales can be converted

P1006.3 Describe the energy stored thermally by a body as the total energy of its molecules due to their random movement

P1006.4 Recognise that energy is transferred from a region of higher temperature to a region of lower temperature and that regions of equal temperature are in thermal equilibrium

P1007.1 Define and explain the concepts of specific heat capacity and specific latent heat in terms of the kinetic particle model

P1007.2 Investigate the specific heat capacity of a substance using suitable apparatus and the equation: $Q = mc\Delta T$ and perform calculations using this equation

P1007.3 Investigate the specific latent heat of a substance using suitable apparatus and the equation: $Q = mL$ and perform calculations using this equation

P1007.4 Describe the importance of the unusually large value of the specific latent heat and the specific heat capacity of water, in terms of temperature regulation in the body and petrochemical industry; and the impact of the oceans on climate

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1005.1	**a)** *Using coloured sticky dots, students represent particles in solids, liquids and gases and write a description of their behaviour in each state* **CT; C**
P1005.1	**b)** *Students take part in a whole class role play to model molecules in solid, liquid, and gases* **C; CP**
P1005.2-3	**c)** *Students work on teacher designed worksheets to explain fluid pressure in terms of kinetic particle model and explain the changes of state in terms of kinetic particle model with reference to melting, boiling, evaporation, freezing, condensation and sublimation* **CT; C**
P1005.2	**d)** *In small groups, students use a microscope to study Brownian motion in a smoke cell and identify two characteristics of Brownian motion* **CT; IR**
P1005.1-3	**e) In small groups, students will use round cereals, or marbles/ball bearings, to create a stop motion animation with their smartphones to show the changes that occur as a solid is gradually heated and changes state up to a gaseous state** **CT; C**

P1005.3	**f)**	*In pairs or small groups, students make and test a model thermostat from a bimetallic strip* **IR; CP**
P1005.4	**g)**	*Students watch a video on "anomalous expansion of water" and use round cereals (or LEGO® bricks) to demonstrate the anomalous expansion of water (e.g., what happen if water is cooled from 4°C to 0°C?)* **IR; C**
P1006.1-3	**h)**	**In small groups, students use small capillary tubes and sulphuric acid (or an oil "plug") to determine empirically absolute zero (0 K) by extrapolating the "length of air bubble" vs "temperature" graph (carry out a thorough risk assessment before this practical task). Students also convert temperatures measured in kelvin to degrees Celsius from given examples: T/K = T/°C + 273.15 IR; PS**
P1007.1-2 P1007.4	**i)**	**In small groups, students conduct practical tasks to determine the specific heat capacity of solids and liquids by a variety of methods and to solve related problems CP; PS**
P1007.1 P1007.3-4	**j)**	*In small groups, students conduct practical tasks to determine the specific latent heats of melting and vaporization and to solve related problems* **CP; PS**
P1006.4 P1007.4	**k)**	*Students watch videos on "global warming" and "high specific heat capacity of water" and then discuss whether ponds and lakes would be more or less likely to freeze in winter if water had a lower specific heat capacity* **IR; CT**
P1007.1-2 P1007.4	**l)**	*Students estimate the thermal energy that can be stored in the top metre of the Pacific Ocean per degree rise in its temperature* **IR; PS**

Waves, light and sound

Interaction between light and interface of two media: refractive index

Standards

P1008 Represent wavefronts to show how waves propagate through a medium

P1009 Use the refractive index between optical media to study the properties of light

Learning Outcomes

Students should be able to:

P1008.1 Contrast and compare wave pulses and continuous travelling waves, giving examples of both

P1008.2 Explain how waves propagate through a medium using the concept of wavefronts and represent and explain the reflection of sound and light in terms of wavefronts

P1009.1 Investigate the relationship between $\sin(\theta_i)$ and $\sin(\theta_r)$, and state and discuss the laws of refraction

P1009.2 Define, demonstrate and calculate refractive index as: (1) ratio of $\sin(\theta_i)$ to $\sin(\theta_r)$, (2) ratio of real depth to apparent depth and (3) ratio of speed of light in vacuum and speed of light in medium

P1009.3 Investigate total internal reflection (TIR) and the critical angle (θ_c) for different materials, and explain applications of TIR; e.g. optical fibres

P1009.4 Derive the equation $\sin(\theta_c) = n_r/n_i$ from Snell's law

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1008.1-2	**a)** *Teacher demonstrates how pulses and continuous waves can be generated using a ripple tank. Students make observations about the nature and behaviour of wavefronts in the tank* **C; CT**
P1009.1-2	**b) In pairs or small groups, students investigate the relationship between the angle of incidence and the angle of refraction of light from air to glass by using a glass block, drawing board, and pins PS; CP**
P1009.1-2	**c)** *Students research and discuss Ibn Sahl's contributions to our understanding of the laws of refraction and other optical phenomena* **IR; C**
P1009.1-2	**d) Teacher demonstrates the refraction of light using common optical equipment and asks students to calculate the refractive index of selected media as the ratio of sin (angle of incidence) to sin (angle of refraction) CT; PS**
P1009.2	**e) Learners view examples of real and apparent depth (e.g. the 'bent stick' in water) and calculate the refractive index of water as a ratio of real depth to apparent depth. Learners will deduce a condition for this definition of refractive index CP; PS**
P1009.1-2	**f)** *Students research the refractive indices of a variety of materials and use them to calculate the velocity of light in each medium* **IR; PS**
P1009.3-4	**g) Teacher demonstrates total internal reflection of a laser beam using a transparent tank filled with water and a few drops of milk. Then, students find the critical angle of glass/Perspex by using a semi-circular glass block and a light box. Students derive the equation $\sin(\theta_c) = n_r/n_i$ from Snell's law and use the critical angle measured to confirm the refractive index of glass/Perspex CT; PS**
P1009.3	**h)** *Students research and explain everyday applications of total internal reflection (e.g. optical fibres, periscope, and endoscope)* **IR; C**

Interaction between light and lenses	
Standards **P1010** Explain how refraction of light can be applied to different types of lenses	
Learning Outcomes **Students should be able to:** **P1010.1** Show and explain refraction of light and describe the main terms associated with a lens (principal axis, focal point, focal length, radius of curvature) **P1010.2** Investigate the properties of images formed by a convex lens. Recall the lens' formula 1/f = 1/u + 1/v and use it for computations in convex lens **P1010.3** Investigate the properties of images formed by a concave lens **P1010.4** Discuss the uses of lenses in everyday applications (magnifying glass, camera, telescope, microscope) **P1010.5** Explain the causes of short and long sightedness, and use knowledge and understanding of lenses to suggest ways to correct them	
LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1010.1-4	**a)** *In pairs, students identify the differences between a concave lens (e.g. spectacles) and a convex lens (e.g. a magnifying glass) provided* **CT; C**
P1010.1-4	**b) Students work on teacher designed worksheets to complete ray diagrams to locate images formed by convex and concave lenses, leading to definitions of 'principal axis', 'focal point', 'focal length' and 'radius of curvature'. Students also determine by ray tracing the location of the image of a real object located inside or outside the focal point of a convex lens, and state whether the image is upright or inverted, real or virtual PS**
P1010.1-3	**c) In small groups, students will study image formation by convex and concave lenses experimentally, and verify the focal length and image location of a convex lens by using the thin lens equation 1/f = 1/u + 1/v CP; PS**
P1010.3	**d)** *Students determine by ray tracing the location of the image of a real object located inside or outside the focal point of a concave lens, and state whether the resulting image is upright or inverted, real or virtual* **IR; CT**

P1010.4	**e)** *In pairs or small groups, students research and discusses the uses of thin lenses in everyday applications (magnifying glass, camera, telescope, microscope)* **IR; C**
P1010.4-5	**f)** **Students draw a diagram to illustrate how the eye receives and focuses light onto the retina. Then, they draw diagrams to illustrate how short and long sight can be corrected by a thin lens C; PS**

Electricity and magnetism

The fundamentals of current electricity

Standards

P1011 Explore the relationship between potential difference (p.d.), current and resistance

P1012 Explain and use the properties of components to build and draw useful and more complex circuits

Learning Outcomes

Students should be able to:

P1011.1 Define electric current, as the charge passing through a point in a second and use the equation I = Q/t to solve problems

P1011.2 Define the p.d. across two points in a circuit as the work done when a coulomb of charge passes between the points and use the equation V = W/Q to solve problems

P1011.3 Define resistance and investigate the relationship between voltage and current for ohmic and non-ohmic components, including graphical analysis

P1011.4 Use the relationship V = IR to calculate V, I and R

P1012.1 Identify factors that affect the resistance of a wire, use R = ρl/A in computations and explain why the mains circuits that supply the sockets have thicker wires and have higher rated circuit breakers than lighting circuits

P1012.2 Determine the equivalent resistance for complex resistor circuits

P1012.3 Describe the difference between electromotive force and p.d. and determine the internal resistance of a cell using the equation E=I(R+r)

P1012.4 Use the relationships P = E/t; P = VI; P = I^2R and P = V^2/R to solve problems

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1011.1	**a)** *Teacher demonstrates that electric current is the flow of charged particles using a Van de Graaff generator supplying charge through a*

	sensitive galvanometer to two plates with a conducting ball suspended between them. Students work on teacher designed worksheets to define electric current and identify its unit **CT; C**
P1011.2	**b)** *In small groups, students work on worksheets to define potential difference and solve problems using the equation $V = W/Q$* **PS**
P1011.3-4	**c) In pairs of small groups, students investigate the I-V characteristic graphs for an ohmic and non-ohmic conductors (including an ohmic resistor, a filament lamp and a diode) CP; PS**
P1012.1	**d) Students use the equation $R = \rho l/A$ and appropriate equipment to determine the resistivity of wires of different metals empirically. Then, they estimate the uncertainty of their results and compare their values with accepted values of resistivity for those metals IR; PS**
P1012.1	**e)** *Students use the equation $R = \rho l/A$ and appropriate equipment to estimate the resistivity of graphite from a thick line of graphite drawn by a pencil. Students could also investigate how the resistance of electrolycra changes as they stretch a piece of electrolycra fabric* **CT; PS**
P1012.1	**f)** *Working in same small groups, learners will work on teacher designed worksheets to use the equation $R = \rho l/A$ to solve problems and explain why the mains circuits have thicker wires and higher rated circuit breakers than lighting circuits* **IR; PS**
P1012.2	**g)** *By working in small groups, learners will conduct experiments to investigate the use of potatoes and lemons (with copper and zinc nails) to light up LEDs that are connected in series or parallel by using $R = R_1 + R_2 + \ldots$ for series circuits, and $1/R = 1/R_1 + 1/R_2 + \ldots$ for parallel circuits* **CT; CP**
P1012.3	**h)** *By measuring the potential difference (p.d.) of a battery, students explain that the electromotive force of the battery is the energy transferred when a coulomb of change (unit of charge) passes through it. They compare their measurements with the potential difference (p.d.) measured across the components in the circuit and explain that this is the work done per unit charge when charge passes through an electrical component* **CT; IR**
P1012.3	**i) Students calculate the internal resistance of a cell in a circuit by measuring the current and electromotive force of the battery, as well as the resistance of an external variable resistor CT; PS**
P1012.3	**j)** *In small groups, students discuss and explain why the car headlights dim when the starter motor is used* **IR; C**
P1012.4	**k)** *Students work on worksheets to derive and solve problems using the relationships $P = E/t$, $P = VI$, $P = I^2R$ and $P = V^2/R$* **PS**

P1012.4	**l)** *By working in small groups, learners will compare charging rates of a smartphone using a power adaptor and a laptop. Learners will estimate the electric current through the USB port of the laptop during charging by using an appropriate formula* **IR; PS**

Principles of electrostatics, magnetism and electromagnetism

Standards

P1013 Describe and represent the magnetic fields in permanent magnets and electromagnets

P1014 Explain the interaction of magnetic fields with current-currying conductors

Learning Outcomes

Students should be able to:

P1013.1 Describe and represent electric fields by means of field lines and define electric field strength

P1013.2 Identify the pattern of the magnetic field lines due to a single current-carrying wire, a coil and a solenoid and describe the factors affecting the magnetic field generated by them

P1013.3 Define the magnetic flux density (B) of a magnetic field

P1013.4 Calculate the magnetic field of current-carrying wires using the equation: $B = m_0 l/(2pr)$

P1014.1 Demonstrate and explain how the magnetic field around a current-carrying conductor can interact with a fixed magnetic field in which it is placed

P1014.2 Describe the motor effect on a current-carrying wire perpendicular to a magnetic field and calculate the force on the wire using the equation: F=BIL

P1014.3 Describe and explain the function of an electric motor

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1013.1	**a)** *Teacher demonstrates electric fields by using a Van de Graaff generator. Students work on worksheets to describe an electric field and define electric field strength* **CT; C**
P1013.1	**b)** *After watching a video on "electric field of parallel plates" that demonstrates the principle of gel electrophoresis, students work on worksheets to represent electric field by means of electric field lines* **IR; PS**
P1013.2-4	**c)** ***In small groups, learners will use a magnetic compass to deduce and sketch the magnetic field lines due to a single current-carrying wire, a***

	coil and a solenoid. Then, the calculate the magnetic field generated by the wire **CT; CP**
P1013.2-4	**d)** *In pairs or small groups, students demonstrate the effect of varying parameters like core material, current and number of coils in a solenoid on the magnetic field induced* **CT; CP**
P1013.2-4	**e)** *In small groups, students use a smartphone as a magnetic field detector (the PhyPox and Sci Journal apps are useful to take measurements from smartphone sensors) to measure the magnetic fields of a long, straight current-carrying wire and compare with the magnetic field calculated using an appropriate formula* **CT; PS**
P1014.1-2	**f)** *Students and/or teacher set up a thick strip of aluminium foil between two clamps and connect the two ends to a signal generator. With a large horse shoe magnet across the foil the foil will vibrate producing a sound* **CT; C**
P1014.1-2	**g) In small groups, students investigate the force on a current-carrying aluminium bar in a magnetic field using a sensitive top-pan balance and varying the current through the bar. Then, they use their findings to confirm the relationship F = BIl and explain the interaction of a constant magnetic field with the current-carrying conductor** **CT; PS**
P1014.3	**h)** *In pairs or small groups, students make and test a simple DC electric motor and explain its function* **IR; C**
P1014.3	**i) In pairs, students research and discuss the advantages and implications of using Tesla's electric motors in future cars** **IR; CP**

Possible teaching order

Please note other orders are possible and acceptable

Physics	
Grade 10	**1** Physical quantities and uncertainty in experimental results **2** Kinematics **3** Interaction between light and interface of two media: refractive index **4** Interaction between light and lenses **5** The fundamentals of current electricity **6** Principles of electrostatics, magnetism and electromagnetism **7** Nature of matter

Grade 11A

Biology Grade 11A

Structure and function of organisms

Biochemistry: Biological molecules

Standards

B1101 Relate the properties of water to its roles in living organism.

B1102 Describe the structure and explain the properties of carbohydrates.

B1103 Describe the structure and explain the properties of lipids.

B1104 Describe the structure and explain the properties of proteins

Learning Outcomes

Students should be able to:

B1101.1 Describe the chemistry of water and explain how this affects its properties.

B1101.2 Relate the properties of water to its roles in living organisms.

B1102.1 Define the terms monomer, polymer and macromolecule and define and recognise condensation and hydrolysis reactions.

B1102.2 Recognise the structure and properties of the glucose in carbohydrates.

B1102.3 Describe the formation and breakage of the glycosidic bond in carbohydrates.

B1103.1 Recognise the structure and properties of glycerol and fatty acids in lipids.

B1103.2 Describe the formation and breakage of the ester bond in lipids including the formation of saturated and unsaturated lipids.

B1104.1 Recognise the structure and properties of amino acids in proteins.

B1104.2 Describe the formation and breakage of the peptide bond in proteins.

B1104.3 Explain the primary, secondary and tertiary, quaternary structure of proteins.

B1104.4 Describe the types of bonds that hold protein molecules in shape (hydrogen, ioniC; disulphide bonds and hydrophobic interactions).

LO reference	Learning Experiences
	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***

B1101.1-2	**a)** *Collect some statistics about the importance of water to living organisms, including the percentage of water in the bodies of different organisms, including humans, and the percentage of life on earth that lives in water.* **IR**
B1102.1-2 **B1103.1-2** **B1104.1-2**	**b) Make a wall poster to show the basic monomer and polymer structures of carbohydrates, proteins and lipids** **C**
B1104.1-4	**c)** *Make simple models of the primary, secondary, tertiary and quaternary structure of proteins* **CT**
B1102.1-2 **B1103.1-2** **B1104.1-4**	**d) Work in pairs/small groups. Research good web resources showing aspects of the biochemistry of carbohydrates, lipids and proteins, including the formation and breaking of the different types of bond. Share the urls around the class and evaluate a minimum of six resources. Decide as a class which are the most useful** **CP; PS**

Biochemistry: Cellular respiration

Standards

B1105 Describe the structure and function of ATP as the universal energy currency in all living organisms and relate this to respiration and photosynthesis.

B1106 Relate the structure of mitochondria to their origins and to the reactions of aerobic respiration.

B1107 Describe the stages of aerobic respiration (glycolysis and Krebs cycle), and oxidative phosphorylation in the electron transport chain, including the roles of oxygen and ATP.

B1108 Explain how the products and energy release in anaerobic respiration differ from those of aerobic respiration, and how anaerobic respiration in muscles builds up an oxygen debt that must be repaid after exercise ends.

Learning Outcomes

Students should be able to:

B1105.1 Describe the structure and function of ATP as the universal energy currency in all living organisms.

B1105.2 Explain the importance of ATP in respiration and photosynthesis.

B1106.1 Describe the structure of mitochondria and relate this to the reactions of aerobic respiration.

B1106.2 Compare the structural similarities between mitochondria and bacteria and introduce the theory of endosymbiosis.

B1107.1 Describe the reactions of glycolysis as taking place in the cytoplasm of the cell (Only phosphorylation of hexose molecules by ATP, breakdown to glycerate-3-phosphate, and production of reduced NADH and ATP - details of other intermediate compounds **NOT REQUIRED**).

B1107.2 Describe the reactions of Krebs cycle taking place in the mitochondrial matrix as the complete oxidation of pyruvate resulting in the removal of carbon atoms to form carbon dioxide, the production of reduced NADH and the production of ATP- details of other intermediate compounds beyond 6C; 5C; 4C etc **NOT REQUIRED**).

B1107.3 Describe the role of the electron transport chain on the inner mitochondrial membrane in the formation of ATP by oxidative phosphorylation, including the role of oxygen as the final electron acceptor.

B1108.1 Explain how the products and energy release in anaerobic respiration differ from those of aerobic respiration.

B1108.2 Describe oxygen debt as the build-up of lactic acid in muscles during anaerobic respiration and explain why the lactic acid must be removed once exercise is over.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1105.1-2	**a)** *Make a model of ATP which allows you to remove and add the final phosphate group* **CT**
B1106.1	**b)** *Using information from electron micrographs and other sources, make a 3-D model of a mitochondrion with annotations to show where different parts of the respiratory pathways take place* **IR; CT**
B1107.1-2	**c) Work in pairs. Make a wall chart to illustrate the reactions of aerobic respiration, indicating where the different stages of the process take place in the cell and approximately how much ATP is produced CP; C; CT**
B1107.3	**d)** *Make a flow diagram summarising the reactions of the electron transport chain* **C**
B1107.1-3	**e) Prepare revision cards that depict the reactants and reactions of glycolysis the Krebs cycle and the electron transport chain and arrange these in sequence PS; C**
B1108.1	**f)** *Work in small groups. Set up experiments using germinating seeds, yeast and/or small invertebrates such as maggots to investigate the products of aerobic and anaerobic respiration under different conditions, using data loggers to monitor factors such as the uptake of oxygen, output of waste gases, and temperature increases* **CP**
B1108.2	**g) Interpret a graph showing the build-up of an oxygen debt during exercise and the time taken to remove the lactic acid and pay back the oxygen debt. CT**

B1107.1-3 **B1108.1-2**	**h) Work in small groups. Make a concept map to illustrate the differences and similarities between aerobic respiration and anaerobic respiration CT**

Biochemistry: Photosynthesis

Standards

B1109 Describe the structure of chloroplasts and relate this to the biochemical and photochemical reactions of photosynthesis, and to their origins.

B1110 Know there are a number of photosynthetic pigments that reflect green light and absorb red and/or blue light and understand the importance of these photosynthetic pigments to plants.

B1111 Outline the reactions of the light-dependent and the light-independent stages of photosynthesis.

Learning Outcomes

Students should be able to:

B1109.1 Describe the structure of chloroplasts and relate this to the biochemical and photochemical reactions of photosynthesis.

B1109.2 Briefly compare the structural similarities between chloroplasts, mitochondria and bacteria and include chloroplasts in the theory of endosymbiosis.

B1110.1 Know there are a number of photosynthetic pigments (including chlorophyll a and chlorophyll b) that reflect green light and absorb the red and blue light of the spectrum.

B1110.2 Demonstrate that the photosynthetic pigments can be separated by chromatography.

B1110.3 Explain the importance of the mixture of photosynthetic pigments to plants.

B1111.1 Describe the role of the thylakoid membranes in the light-dependant stage of photosynthesis.

B1111.2 Describe the process of cyclic photophosphorylation including the role of photosystem I and the production of ATP.

B1111.3 Describe the process of non-cyclic photophosphorylation including the roles of photosystems I and II in photolysis and the production of ATP, reduced NADP and oxygen.

B1111.4 Describe the light-independent stage of photosynthesis including the role of the stroma and how carbon dioxide is fixed by combination with 5C ribulose bisphosphate (RuBP) to form gylcerate-3-phosphate (GP) by the enzyme ribulose bisphosphate carboxylase (RUBISCO).

B1111.5 Explain how reduced NADP and ATP from the light-dependent stage are used in the light-independent stage to synthesise glyceraldehyde phosphate (GALP) from GP as an end product, and to regenerate 5C ribulose bisphosphate in the Calvin cycle (details of intermediate compounds are **NOT REQUIRED**).

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1109.1	**a)** *Using information from electron micrographs and other sources, make a 3-D model of a chloroplast with annotations to show where different parts of the photosynthetic pathways take place* **IR; CT**
B1109.2	**b)** *Work in pairs. Use the internet to research the endosymbiosis theory for the origins of chloroplasts and mitochondria from bacteria and discuss the ideas presented* **IR; CT**
B1110.1-2	**c) Work in pairs. Separate the photosynthetic pigments from the leaves of a plant using simple or thin layer chromatography and calculate the R_f values of the pigments that result. CP; PS**
B1110.3	**d) Work in pairs/small groups. Investigate the effect of different coloured light on the rate of photosynthesis of a water plant such as *Elodea* or *Cabomba* by counting the bubbles produced in a given time interval. CP**
B1110.3	**e)** *An oxygen probe and meter can be used to measure the oxygen produced by a plant in a day, which is a proxy measurement for the amount of photosynthesis taking place. Using this information, work in pairs to plan and carry out an investigation to discover if the photosynthetic pigments of a plant absorb different wavelengths (colours) of light.* **CT**
B1110.1/ B1110.3	**f)** *Not all leaves are green. Use the internet to find out how different coloured leaves carry out photosynthesis* **IR**
B1111.1-3	**g) Work in pairs. Make a wall chart to illustrate the reactions of photosynthesis including cyclic and non-cyclic photophosphorylation and the Calvin cycle, indicating where the light dependant and light independent stages of the process take place in the chloroplast CP; C; CT**
B1111.1-5	**h) Prepare revision cards that depict the reactants and reactions of cyclic photophosphorylation, non-cyclic photophosphorylation and the Calvin cycle and arrange these in sequence, indicating the light dependant and the light independent stages of the process PS; C**
B1111.1-B1111.5	**i)** *(Extension) Work in small groups and investigate other biochemical pathways used by plants to make food including the C4 pathway and CAM plants. Suggest ways in which these plants may help us overcome some of the problems of sustainable food production in the world.* **IR**
Cell structure and function: Membranes and transport	
Standards	

B1112 Describe the fluid mosaic model of the cell membrane and explain the roles of the constituent biomolecules (including phospholipids, cholesterol, glycolipids, proteins and glycoproteins).

B1113 Explain how and why different substances move across membranes through simple diffusion, osmosis, active transport, endocytosis and exocytosis.

B1114 Explain the movement of water between cells and solutions with different water potentials and the different effects of osmosis on plant and animal cells.

Learning Outcomes
Students should be able to:

B1112.1 Describe the fluid mosaic model of the cell membrane and identify the constituent biomolecules including phospholipids, cholesterol, glycolipids, proteins and glycoproteins.

B1112.2 Explain the roles of the constituent biomolecules in a cell membrane, including phospholipids, cholesterol, glycolipids, proteins and glycoproteins.

B1112.3 Outline the function of membranes at the surface of cells and within the cell.

B1113.1 Describe the processes of simple diffusion, osmosis, active transport, endocytosis and exocytosis across the cell membrane.

B1113.2 Discuss the factors that affect the movement of different substances across the cell membrane.

B1114.1 Investigate the movement of water between model cells and solutions with different water potentials and explain your observations in terms of osmosis.

B1114.2 Explain the different effects of osmosis in animal and plant cells.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1112.1-2	**a)** *Examine a number of electron micrographs of cells and cell membranes and identify as many features as you can.* **IR**
B1113.1	**b) Demonstrate diffusion by spraying perfume in a corner of the classroom to see the pattern of spread and how rapidly all students can smell it. CP**
B1113.2	**c) Investigate the effect of temperature and/or solvents on the permeability of the cell membrane using red beet tissue and a colorimeter CP; CT**
B1114.1	**d) Investigate osmosis using partially permeable Visking tubing models of a cell with solutions of different water potentials inside and outside the cell CP; PS**

B1114.1	**e)** *Investigate osmosis using cylinders or thin sections of potato or yam, different concentrations of salt or sugar solution, and distilled water to show the movement of water by osmosis across a partially permeable membrane* **CT**
B1114.1-2	**f) Work in pairs. Use a light microscope or projection microscope to observe the effect of osmosis on plant cells (eg red onion epidermis) when flooded with hypotonic, isotonic and hypertonic solutions** **CP**
B1114.2	**g)** *Work in pairs. Use the internet to find videos showing the effect of solutions with different water potentials on animal cells* **IR**
B1113.2 **B1114.1-2**	**h)** *Work in small groups and produce a concept map to show the factors affecting the movement of water and substances across the cell membrane. Include the terms water potential, plant cells, animal cells, temperature, isotonic, hypotonic and hypertonic***. CT;C**

Cell structure and function: Enzymes

Standards

B1115 Explain the mode of action of enzymes in terms of an active site, enzyme-substrate complex, lowering of activation energy and enzyme specificity using the lock-and-key and induced-fit hypotheses.

B1116 Discuss cofactors, coenzymes and enzyme inhibition.

Learning Outcomes

Students should be able to:

B1115.1 Define enzymes as globular proteins that act as biological catalysts.

B1115.2 Explain the mode of action of enzymes in terms of an active site, enzyme-substrate complex, lowering of activation energy and enzyme specificity using the lock-and-key and induced-fit hypotheses.

B1115.3 Investigate the effects of temperature, pH and substrate concentration on the rate of enzyme action and explain these effects.

B1116.1 Describe the roles of cofactors (including chloride ions in amylase) and coenzymes (including vitamins B3 in NAD and B5 in Coenzyme A) in enzyme reactions.

B1116.2 Differentiate between competitive and non-competitive inhibition of enzyme action.

B1116.3 Explain the importance of competitive inhibition of enzyme action in biochemical pathways including rate control of glycolysis by competitive inhibition of phosphofructokinase.

B1116.4 Describe how cyanide acts as a non-competitive inhibitor of cytochrome oxidase in the electron transport chain and so causes death.

LO reference	**Learning Experiences**

	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1115.1-2	**a)** *Use internet resources to look for videos and animations showing the substrate-enzyme complex, lock and key models and the induced-fit hypothesis* **IR**
B1115.2	**b)** *Make a simple 3-D model of an enzyme with an active site and substrate that will fit into it* **CT**
B1115.3	**c) Work in pairs/small groups. Investigate the effect of temperature on the rate of enzyme activity using amylase and starch with iodine solution as an indicator. Use data loggers to record the temperature changes. Record results and display the data as a graph. Combine the whole class data and compare it to your individual results. CP; C**
B1115.3	**d) Work in pairs/small groups. Investigate the effect of pH changes on the rate of enzyme activity using amylase and starch with using buffers for different pHs, data loggers to recorde the pH and iodine solution as an indicator Record your results and display the data as a graph. Combine the whole class data and compare it to your individual results. CP; C**
B1115.3	**e) Work in pairs/small groups. Investigate the effect of substrate concentration on enzyme activity using catalse from pureed raw potato, different concentrations of hydrogen peroxide solution and the rate of oxygen gas production to measure the rate of the reaction, using data loggers as appropriate. Record results and display the data as a graph. Combine the whole class data and compare it to your individual results. CP; C**
B1116.2	**f)** *Use children's modelling clay to make simple models of enzymes and inhibitors to demonstrate the difference between competitive and non-competitive inhibition of enzyme action* **CT**

Growth, development, reproduction and inheritance

Inheritance and the genome

Standards

B1117 Describe the basic structure of DNA as deoxyribose, a phosphate group and one of four nitrogenous bases.

B1118 Describe the process of DNA replication and explain how the arrangement of the bases determines the structure of the double helix.

B1119 Explain how the base sequence of the DNA forms the genetic code and describe the structure and the roles of DNA, RNA (tRNA, rRNA and mRNA) and ribosomes in the process of protein synthesis.

B1120 Define the term gene mutation, and explain how substitution, addition and deletion of bases can change the amino acid sequence.

B1121 Define the term chromosomal mutation, and explain numerical mutations including trisomy 21 and structural mutations including translocation, duplication, inversion and deletion.

Learning Outcomes
Students should be able to:

B1117.1 Describe the basic structure of DNA as deoxyribose, a phosphate group and one of four nitrogenous bases adenine (A), thymine (T), cytosine (C) and guanine (G).

B1118.1 Describe the pairing of the bases A-T and C-G, including the role of hydrogen bonds, and recognise the importance of this pairing in the structure of the DNA double helix.

B1118.2 Describe the process of DNA replication including the role of DNA helicase, DNA polymerase and DNA ligase.

B1119.1 Explain how the base sequence of the DNA forms the genetic code, which is passed on from generation to generation.

B1119.2 Describe the basic structure of RNA as ribose, a phosphate group and one of four nitrogenous bases adenine (A), uracil (U), cytosine (C) and guanine (G).

B1119.3 Identify the structure of tRNA, mRNA and rRNA.

B1119.4 Describe the roles of DNA, tRNA, mRNA, rRNA and the ribosomes in the process of protein synthesis.

B1120.1 Define the term gene mutation.

B1120.2 Explain how DNA substitution, addition and deletion can change the amino acid sequence eg in sickle cell disease.

B1121.1 Define the term chromosomal mutation.

B1121.2 Explain what happens in numerical mutations of the chromosomes when the sex cells form during meiosis and how this can lead to numerical aberrations eg trisomy 21 causing Down syndrome.

B1121.3 Describe what happens in structural mutations of the chromosomes including translocation, duplication, inversion and deletion and explain how this can have an effect on the individual.

LO reference	Learning Experiences
	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***

B1117.1 **B1118.1**	**a) Work in pairs. Make a 3-D model of a DNA molecule including the paired base sequences using instructions provided or from instructions found on the internet CP; CT**
B1117.1 **B1118.1**	**b)** *Research the story of the discovery of the structure of DNA by Watson and Crick, including the contributions of Franklin and Wilkins* **IR**
B1118.2	**c) Work in pairs. Extract DNA from plant material (eg strawberries) using a standard protocol CP**
B1119.1-2	**d)** *Watch a video of DNA replication and discuss the way the process was first demonstrated by Meselson and Stahl* **C**
B1119.3-4	**e) Work in pairs. Use a chart of DNA base codons and the amino acids they code for and use them to make a similar table demonstrating which RNA triplets code for which amino acids and which ones are nonsense codes PS**
B1119.4	**f)** *Watch a video or animation of protein synthesis and discuss how useful it is at making the process clearer* **C**
B1119.4	**g) Work in pairs. Produce a wall chart showing the stages of protein synthesis annotated clearly CP; C**
B1120.1-2	**h)** *Using beads or modelling clay, make models which demonstrate DNA substitution, addition or deletion* **CT**
B1119.4 **B1120.2**	**i) Work in pairs or small groups. Choose one of the following genetic diseases: sickle cell disease, thalassemia or cystic fibrosis. Using the internet and any other available resources, investigate the genetic causes of these diseases. Make a leaflet explaining how the symptoms arise from the genetic mutation and how it is passed on, to be used with families affected by the disease. IR; C**
B1120.2 **B1121.1-3**	**j)** *Make a table summarising the main forms of mutations – single gene or point mutations, numerical chromosomal mutations and structural chromosomal mutations* **C**
B1120.1-2 **B1121.1-3**	**k)** *Work in small groups. Research some of the ways in which scientists are identifying the mutations found in different types of cancers and using these to help develop new and more effective forms of treatment. Each group presents one breakthrough in treatment to the rest of the class.* **IR; C**

Reproduction in plants

Standards

B1122 Describe some of the different methods of vegetative propagation (grafting, cutting, layering and air layering).

B1123 Describe the totipotent meristems in plants (root, stem and leaves) and explain how this tissue can be used in micro-propagation for agricultural applications.

Learning Outcomes
Students should be able to:
B1122.1 Review natural methods of vegetative (asexual) reproduction from grade 9.

B1122.2 Observe and describe some of the different methods of vegetative propagation (grafting, cutting, layering and air layering).

B1123.1 Identify and describe the totipotent meristems in the root and stems of plants.

B1123.2 Explain and demonstrate how meristematic tissue can be used in micro-propagation to produce large numbers of identical plants for agriculture.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1122.1-2	**a)** *Research different methods of artificial vegetative propagation and look for examples in the surrounding location* **IR**
B1123.1	**b) Work in pairs. Use a light microscope or projection microscope to examine totipotent stem cells in the meristems or a plant root or shoot. Observe and draw a plan of the main areas of the meristem under low magnification, with no cells shown and then identify, draw and label the stem cells.** **CP**; **C**
B1123.2	**c)** *Visit a plant propagation institution in Qatar and discover how this new technology is used to produce large numbers of identical plants* **CP**
B1123.2	**d)** *Work in pairs/small group. Carry out micropropagation of plants in using sterile techniques and grow them until small new plants are visible* **CP**

Health and disease

Communicable disease

Standards
B1124 Identify the basic distinguishing features of viruses, some common types of bacteria and microbial fungi and explain how they cause communicable diseases.

B1125 Summarise the action of some common antibiotics used to treat communicable diseases on prokaryotic cells and explain why they do not damage eukaryotic cells or viruses.

Learning Outcomes
Students should be able to:
B1124.1 Describe the basic identifying features of viruses and explain how viral reproduction causes communicable diseases.

B1124.2 Describe the basic identifying features of different types of bacteria, including cocci, bacilli and spirilla and Gram positive and negative bacteria and explain how bacteria cause disease by damaging cells or by the toxins they produce.

B1124.3 Describe the basic identifying features of microbial fungi and explain how they cause communicable diseases.

B1125.1 Compare ways in which different types of antibiotics destroy or damage prokaryotic cells, including antimetabolites, protein synthesis inhibitors, cell wall agents and cell membrane agents and explain how this makes them effective treatments for a wide range of communicable diseases.

B1125.2 Explain why antibiotics which will destroy or damage prokaryotic cells do not affect eukaryotic cells or viruses.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1124.1-3	**a) Make a wall poster to compare the basic identifying features of viruses, bacteria and fungi C**
B1124.2	**b)** *Work in pairs. Use a light microscope or projection microscope to observe Gram positive and Gram negative bacteria* **CP**
B1125.1	**c) Work in pairs. Using aseptic techniques, and following a clear protocol, seed agar plates with a bacterial culture. Using antibiotic-impregnated discs, investigate the effectiveness of the different antibiotics or different concentrations of the same antibiotic. Never open the plates – they should be sterilised and thrown away. [*If necessary this could be a teacher demonstration*] CP; PS**
B1125.1 **B1125.2**	**d)** *Research some of the possible sources of new antibiotics and discuss why it is so important to find effective new medicines* **IR**

Organisms and their environment

Microbiology

Standards

B1126 Describe the role of microorganisms in biodegradation.

B1127 Describe the role of microorganisms in biofuel production and explain some of the advantages and disadvantages of biofuels.

Learning Outcomes

Students should be able to:

B1126.1 Describe the role of microorganisms in biodegradation.

B1126.2 Recognise the effect of environmental conditions on the rate of biodegradation.

B1127.1 Describe how microorganisms are used in the production of biofuel.

B1127.2 Discuss the advantages and disadvantages of biofuels (including carbon neutral as an advantage and the problems of using land that could grow food to grow plants for biofuel as a disadvantage).

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1126.1-2	**a) Work in pairs/small groups. Design and set up an investigation into the effect of environmental conditions on the rate of biodegradation of fruit or vegetables PS**
B1126.2	**b)** *Research, using the internet, the time it takes for biological material to degrade in countries with different conditions of temperature and humidity. Make a table to show your findings and write a brief report explaining the differences you can see.* **IR; C**
B1127.1	**c)** *Make a large labelled diagram of a reactor used to produce biofuel using microorganisms. Annotate all the main features, explaining why they are needed.* **CT**
B1127.2	**d)** *Analyse data from the internet and produce a bar chart or graph to compare the production of biofuels in different countries* **CT**
B1127.2	**e) Work in groups. Using the internet, research some advantages and disadvantages of biofuels. Use this information as the basis for a class discussion on whether biofuels offer a realistic way of reducing carbon dioxide levels in the atmosphere in the future. IR; C**
B1127.1/ B1127.2	**f)** *Visit a research centre into biofuel production in the University of Qatar and write up an account of the visit to highlight the most recent findings.* **CP; C**

Diversity and variation in living things

Variation and natural selection

Standards

B1128 Identify environmental and genetic causes of variation.

B1129 Distinguish between continuous and discontinuous variation within a population and understand that the phenotypes of polygenic characteristics tend to show continuous variation.

B1130 Describe the process of natural selection and explain how, over a long period of time, natural selection has resulted in a great diversity of forms among living organisms.

Learning Outcomes
Students should be able to:

B1128.1 Describe genetic causes of variation including mutation, random assortment and crossing over during meiosis and random fertilisation during sexual reproduction.

B1128.2 Describe environmental causes of variation including both abiotic and biotic factors.

B1129.1 Differentiate between continuous and discontinuous variation within a population and give examples of both.

B1129.2 Define polygenic characteristics.

B1129.3 Explain why the phenotypes of polygenic characteristics, and characteristics which are strongly affected by environmental variation, tend to show continuous variation.

B1130.1 Describe the process of natural selection.

B1130.2 Explain how, over a long period of time, natural selection has resulted in a great diversity of forms among living organisms with examples including the modern horse, antibiotic resistance and sickle cell anaemia.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1128.1-2	**a) Work in small groups. Investigate the height of seedlings (eg corn, peas, barley or beans) grown under a range of conditions of light, temperature and water availability measured using data loggers. Take measurements at regular intervals, present your data in graphical form and give scientific explanations for any variation you see. CP; CT**
B1128.1-2 **B1129.1**	**b)** *Research evidence from twin studies carried out in different parts of the world. Discuss the findings and give examples of characteristics that appear to be mainly genetic, those which appear to be mainly the result of the environment, and those which are a combination of both.* **IR; C**
B1129.1-3	**c) Collect data on several different variables for the class – for example, heights, hand span, shoe size and whether the thumb is straight or curved- and display the data in graphical form. Make sure at least one feature showing discontinuous variation (eg thumb curves, ear lobes) is used. Discuss which features show continuous variation, including polygenic inheritance and which show discontinuous variation. PS**
B1130.1-2	**d)** *Research the work of Darwin and Wallace on natural selection and evolution. Produce a poster about one of them, highlighting their most important work* **IR; C**

B1130.1-2	**e)** *Find out and explain why the Galapagos Islands are of interest to those studying natural selection and evolution* **IR; C**
B1130.1-2	**f) Work in pairs/small groups. Investigate examples of how natural selection has driven evolution in the past, and examples of natural selection in action today using the internet and documentaries such as Life on Earth II and The Blue Planet by Sir David Attenborough to help you. IR**

Possible teaching order

Please note other orders are possible and acceptable

Biology	
Grade 11A	**1** Biological molecules **2** Cell structure and function: Membranes and transport **3** Cell structure and function: Enzymes **4** Biochemistry: cellular respiration **5** Biochemistry: Photosynthesis **6** Inheritance and the genome **7** Reproduction in plants **8** Variation and natural selection **9** Communicable disease **10** Microbiology

Chemistry Grade 11A
Structure & Bonding of Matter
Structure and Properties in terms of Chemical Bonding
Standards **C1101** Use atomic orbitals to predict the intramolecular bonding in, and shapes of, molecules **C1102** Explain how the strengths of intermolecular forces explain the physical properties of substances
Learning Outcomes **Students should be able to:** **C1101.1** Describe and explain that all chemical bonds are electrostatic in nature. Use Lewis 'dot-and-cross' diagrams for ionic bonding, covalent bonding and co-ordinate (dative covalent) bonding **C1101.2** Describe the number and relative energies of the s, p, d and f orbitals for the principal quantum numbers 1, 2, 3 and for 4s and 4p orbitals. Recognise the crossover of 3d and 4s levels.

C1101.3 State the electronic configuration of atoms and ions given the proton number (and charge) based on spdf notation, using the electron configuration rules.

C1101.4 Describe the shape of the s and p orbitals and their hybrids in atoms such as carbon and oxygen and relate this to bond angles.

C1101.5 Describe covalent bonding in terms of orbital overlap, giving σ (sigma) and π (pi) bonds; recognise bond shape and angles in ethane, ethene and benzene in terms of σ and π bonds. Recognise the cause of delocalisation of electrons in benzene.

C1101.6 Explain the shapes and bond angles in molecules using the Valence Shell Electron Pair Repulsion Theory

C1101.7 Deduce bond polarity using the concept of electronegativity (qualitative aspect only)

C1102.1 Describe intermolecular forces/ Van der Waals' forces as electrostatic forces of attraction based on permanent and induced dipoles respectively and explain its effect on physical properties of substances (e.g. $CHCl_3$(l), Br_2(l) and the liquid noble gases)

C1102.2 Describe hydrogen bonding as electrostatic force of attraction, using ammonia and water as examples of molecules containing -NH and -OH groups

C1102.3 Outline the importance of hydrogen bonding to the physical properties of substances, including ice, water and DNA.

C1102.4 Describe, in simple terms, the differences between the lattice structures of crystalline solids which are: ionic, as in sodium chloride; simple molecular, as in iodine; giant molecular, as in graphite, diamond or silicon(IV) oxide; hydrogen bonded, as in ice; metallic, as in copper

C1102.5 Describe what is meant by allotropy, for example in carbon, including fullerenes and graphene, relating molecular structure to physical properties

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1101.1	**a) The teacher reviews representations of bonding and introduces dative covalent bonds.** **By drawing Lewis dot and cross diagrams students categorise a range of compounds in terms of ionic, covalent and dative covalent bonds. Examples could be sodium chloride, magnesium oxide, hydrogen, nitrogen, oxygen, chlorine, hydrogen chloride, carbon**

	dioxide, methane, ethane, the ammonium ion, aluminium chloride dimer and carbon monoxide. The teacher introduces the concept of lone pairs. C
C1101.2	**b) Students research and compare the shapes of s p, d, and f orbitals , if possible using a 3-D electronic representation. C**
C1101.3	**c) The teacher introduces the rules governing electron configuration. Students work in pairs to then use an energy level diagram to work out the electron configuration for a range of atoms and ions.PS**
C1101.4	**d) Students research the bond angles in methane and compare them to the bond angles in the s and p orbitals as an introduction to hybridisation. CT**
C1101.5	**e) Students look at visualisations of sp^3, sp^2 and sp hybrid orbitals and thus deduce the molecular shape and bond angles in methane, ethane, and ethyne using σ and π bonds. PS** **Students then extend this idea to the bonding in benzene. PS**
C1101.6	**f) Students use Valence Shell Electron Pair Repulsion (VSEPR) theory to determine the shapes of and bond angles in a variety of molecules such as BF_3, CO_2, NH_3, H_2O, SF_6. PS**
C1101.7	**g) Students use the concept of electronegativity to qualitatively predict the bond polarity of a variety of molecules. PS**
C1102.1	**h) Students are asked to explain why helium which is a symmetrical atom that forms no bonds and has no permanent dipole eventually freezes to a solid at very low temperatures. Teacher introduces the idea of induced dipoles that lead to weak forces of attraction -Van der Waals forces. The students then predict what might happen in molecules with permanent dipoles which leads to a consideration of dipole –dipole interactions. CT**
C1102.2	**i) Students use a charged plastic rod to deflect a stream of water to indicate the polarity of water. Using diagrams, they predict how water molecules interact with each other. They then plot either the boiling points of the four hydrides HF, HCl, HBr and HI or H_2O, H_2S, H_2Se and H_2Te against the period number in the Periodic Table to provide evidence for hydrogen bonding. PS**
C1102.3	**j) Students research the importance of hydrogen bonding to the properties of ice and water, and to DNA. CT**
C1102.4	**k)** *Students work in small groups to produce an agreed summary, in simple terms, using eg a concept map, the differences between the lattice structures of crystalline solids which are: ionic, as in sodium chloride; simple molecular, as in iodine; giant molecular, as in*

	graphite, diamond or silicon(IV) oxide; hydrogen bonded, as in ice; metallic, as in copper. **C**
C1102.5	**l)** *Students work together in groups of their choosing to prepare a presentation on the allotropes of carbon, including a brief description of the discovery of fullerenes and graphene.* **IR**

The Mole Concept and Stoichiometry

Standards
C1103 Calculate empirical and molecular formulae and use the mole concept in calculations

Learning Outcomes
Students should be able to:
C1103.1 Calculate empirical and molecular formulae using combustion data or composition by mass

C1103.2 Define a mole of a substance in terms of the Avogadro constant and construct balanced chemical equations with state symbols and solve stoichiometry problems involving reacting masses and volumes of gases

C1103.3 Solve stoichiometry problems to determine concentrations of reactants in solutions through acid–base titrations with appropriate indicators

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1103 .1	**a) After the teacher defines empirical formula students are provided with the results of combustion analysis of an organic compound containing carbon, hydrogen and nitrogen only and use this information to calculate the empirical formula of the compound. Students carry out a similar calculation on a sample with known composition by mass.** **PS**
C1103 .2	**b) Students revisit the definition of a mole and their ability to construct balanced chemical equations, before solving stoichiometry problems involving reacting masses and volumes of gases.** **PS**
C1103 .3	**c) Students work in pairs to carry out a simple acid/base titration to identify the concentration of solutions of unknown concentration using either indicators or a pH probe and data logger.** **PS** Extension. Students solve more complex problems such as the percentage of sodium hydrogen carbonate in baking powder.

Patterns in Chemical Reactivity

Redox reactions	
Standards **C1104** Understand the electrolysis of molten metals, molten ionic substances and aqueous solutions in terms of electron transfer **C1105** Use electrode potentials to predict cell potentials and calculate the quantity of a substance liberated during electrolysis	
Learning Outcomes **Students should be able to:** **C1104 .1** Explain oxidation and reduction in terms of gain or loss of oxygen and in terms of electron transfer **C1104 .2** Explain redox reactions in terms of change in oxidation number **C1104 .3** Investigate the electrolysis of molten ionic compounds and ionic compounds dissolved in water and observe the decomposition of the electrolyte **C1104 .4** Construct, given relevant data, balanced half equations with state symbols for the chemical reactions occurring at the electrodes **C1104 .5** Describe, including the electrode reactions, industrial electrolytic processes such as: the extraction of aluminium from molten aluminium oxide in cryolite; and describe the electroplating of metals and its use **C1105.1** Measure cell potentials and relate them to the relative position of the metals in the reactivity series; describe the chemical changes in a cell in terms of half equations **C1105.2** Define standard electrode potentials relative to the standard hydrogen electrode and describe methods used to measure the standard electrode potentials of metals or non-metals in contact with their ions in aqueous solution **C1105.3** Calculate a standard cell potential by combining two standard electrode potentials **C1105.4** Apply the equation F = Le, where F is the Faraday constant, L the Avogadro constant and e the charge on the electron to calculate the quantity of charge passed and hence to calculate the mass and/or volume of substance liberated during electrolysis **C1105.5** Recognise half-cell reactions of cells used in daily life and describe the function of the hydrogen–oxygen cell as a fuel cell **C1105.6** Discuss electronic waste (e-waste) and the need to recycle rechargeable consumed batteries, such as those in computers and cellular telephones	
LO References	**Learning Experiences**

	All students should be provided with the learning opportunities stated in bold. ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1104 .1 **C1104 .2**	**a) Students categorise reactions as oxidation or reduction in terms of gain or loss of oxygen, in terms of electron transfer and in terms of change in oxidation number.** **They define oxidation number and use the rules to determine oxidation numbers in a variety of compounds. They then categorise some reactions in terms of change in oxidation number. C; PS**
C1104 .3 **C1104 .4**	**b) The teacher demonstrates electrolysis of molten zinc chloride and of aqueous copper(II) chromate(VI). The students explain the results in terms of the mobility of ions using simulations or animations. IR; C**
C1104 .3 **C1104 .4**	**c) Students work in pairs to carry out the electrolysis of various aqueous solutions such as acidified water, copper(II) sulfate solution and observe the products. Students then construct balanced half equations for the reactions occurring at the electrodes. PS; CP**
C1104 .5	**d)** *Students research the chemistry (in particular the electrode reactions) behind industrial electrolytic processes including the extraction of aluminium and titanium, and electroplating. Students carry out an electroplating experiment.* **IR; CP**
C1105.1	**e) Students work in pairs to investigate the relationship between the initial emf of a variety of combinations of half cells such as Zn/Zn^{2+}, Cu/Cu^{2+}, and Fe^{3+}/Fe^{2+} and the reactivity series of metals. They construct half equations to describe the chemical changes in the cell and distinguish between galvanic and electronic electrochemical cells. CP**
C1105.2	**f) Students research information about standard electrode potentials and the standard electrode series. C**
C1105.3	**g) Students calculate a variety of standard cell potentials by combining standard electrode potentials and relate the size of the potential to the spontaneity of reaction. PS**
C1105.4	**h) Students apply the equation F = Le to calculate the quantity of charge passed and hence to calculate the mass and/or volume of substance liberated during electrolysis. PS**
C1105.5	**i)** *Students work in small groups to acquire information about different types of fuel cells and produce a presentation comparing them.* **C**

C1105.6	**j)** *Students work in small groups to research and present information on electronic waste (e-waste) and the need to recycle rechargeable consumed batteries, such as those in computers and cellular telephones. CP*

Organic Chemistry

Standards

C1106 Understand that organic chemistry is based on the chemistry of functional groups and recall examples of these.

Learning Outcomes

Students should be able to:

C1106 .1 Interpret and use the nomenclature and molecular and structural formulae of the following classes of compound:

- alkanes and alkenes;
- halogenoalkanes;
- alcohols;
- aldehydes and ketones;
- carboxylic acids, esters and acyl chlorides.

C1106.2 Describe the chemistry of alkanes as exemplified by their combustion, by substitution of hydrogen by halogens, and by their general unreactivity towards electrophiles and nucleophiles

C1106.3 Describe the chemistry of alkenes as the chemistry of the double bond, exemplified by addition and polymerisation

C1106.4 Describe the chemistry of halogenoalkanes as exemplified by substitution reactions and the elimination of hydrogen halides to form an alkene

C1106.5 Classify alcohols according to number of hydroxyl groups and distinguish between primary, secondary and tertiary alcohols

C1106.6 Describe the chemistry of alcohols as exemplified by ethanol, including combustion, substitution reactions, reaction with sodium, oxidation to carbonyl compounds and acids, dehydration, and ester formation

C1106.7 Describe the formation of aldehydes and ketones by oxidation of the corresponding alcohol by acidified dichromate(VII)

C1106.8 Describe the chemistry of the carbonyl group as exemplified by aldehydes and ketones

C1106.9 Describe the formation of carboxylic acids and their reactions to form esters and salts

C1106.10 Describe the characteristic structure of esters, their uses and their hydrolysis to alcohol and acid

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1106 .1	**a) Students interpret and use the nomenclature and molecular and structural formulae of the following classes of compound:** **• alkanes and alkenes;** **• halogenoalkanes;** **• alcohols;** **• aldehydes and ketones;** **• carboxylic acids, esters and acyl chlorides. C**
C1106 .2	**b) Students carry out an experiment to investigate the properties of alkanes. PS**
C1106 .3	**c) Students carry out an experiment to investigate the properties of alkenes (eg cyclohexene). PS**
C1106 .4	**d) Students carry out an experiment to investigate the properties of halogenoalkanes (eg 2-chloro-2methylpropane) PS**
C1106 .5 **C1106 .6**	**e) Students carry out an experiment to investigate the properties of alcohols, including distinguishing between primary, secondary and tertiary alcohols. PS**
C1106 .7	**f) Students carry out an experiment to produce aldehydes and ketones from alcohols. PS**
C1106 .8	**g) Students carry out an experiment to investigate the properties of aldehydes and ketones. PS**
C1106 .9	**h) Students carry out an experiment to investigate the properties of carboxylic acids (eg ethanoic acid). PS**
C1106 .10	**i) Students carry out an experiment to investigate the properties of esters. PS**
Chemistry in Our World	
Economic, Social and Environmental issues	
Standards **C1107** Understand that chemistry has brought about many benefits to life today but also concomitant problems. Recognise some of the problems such as climate change and the availability of enough potable water and some of the solutions such as moving towards sustainable development	
Learning Outcomes **Students should be able to:**	

C1107.1 Discuss the broad issues relating to social benefits and environmental costs associated with the organic chemical industry including that feedstocks are a finite resource

C1107.2 Evaluate evidence for the additional anthropogenic causes of climate change including the correlation between change in atmospheric carbon dioxide concentration and the consumption of fossil fuels, and describe the uncertainties in the evidence base

C1107.3 Describe the potential effects of increased levels of carbon dioxide and methane on the Earth's climate and how these effects can be mitigated, including a consideration of scaling, risk and environmental implications

C1107.4 Describe the principal methods for increasing the availability of potable water in terms of the separation techniques used, including ease of treatment of waste, ground and salt water

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
	Teachers and students should endeavour to use up to date but authoritative information when studying material relevant to this section.
C1107.1	**a) Students brainstorm a cost/benefit analysis of the organic chemical industry. The teacher guides them to concentrate on the broad issues relating to the production and use of the materials that enhance modern life. These could include process control, minimising waste, storage and transfer of raw materials, energy and water consumption, atmospheric emissions and regulation initiatives such as the Gulf Cooperation Council. They should also consider the implications for sustainable development. They then work in small groups to produce a brief report. CT**
C1107.2	**b) The teacher introduces this topic by explaining that greenhouse gases in the atmosphere maintain temperatures on Earth high enough to sustain life and that temperatures have varied over thousands of years leading to droughts and ice ages. The importance of peer- reviewed evidence is stressed.** **Students work in pairs to evaluate evidence in a report about global climate change, focusing on the correlation between change in atmospheric carbon dioxide concentration and the consumption of fossil fuels, which they display graphically. They describe the uncertainties in the evidence base and the consequences that arise from this in terms of simplified models, speculations and opinions presented in the media. CT**
C1107.3	**c) Students work in small groups to research and describe four potential effects of global climate change, and their possible consequences in Qatar. They then describe how individuals may**

	reduce their carbon footprint and compare this with the effects from international agreements and from natural events such as the release or trapping of carbon dioxide in the deep oceans. Make a wall chart to summarise these findings. CT
C1107.3	**d)** *Produce a leaflet to be delivered to every home in Qatar, giving people ideas for how to reduce their carbon footprint.* **C**
C1107.4	**e) Students research and explain the difference between pure water and potable water, and the principles of how waste and ground water can be made potable, including the need for sedimentation, filtration and methods of sterilisation using chlorine, ozone or ultra-violet light. They then describe the methods and energy costs of how sea water is made potable in Qatar. CT**

Chemistry of Synthetic and Natural Polymers and their uses.

Standards
C1108 Understand the chemistry of polymers and where synthetic polymers come from

Learning Outcomes
Students should be able to:

C1108.1 State that a polymer is a macromolecule containing repeating units joined together by covalent bonds and recognise the difference between condensation and addition polymers

C1108.2 Give examples of natural and synthetic polymers and describe how the use that we make of a polymer is related to the characteristic features of its molecular structure

C1108.3 Recognise that oil and natural gas are the raw materials from which synthetic polymers (plastics and synthetic fibres) are commonly made and that many are made in Qatar

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1108.1	**a) Students research and differentiate between the structures of addition and condensation polymers.** **Students individually make a molecular model of a monomer for an addition polymer and then they collectively join them to form a long chain. They repeat for a condensation polymer and describe the differences between them. CT**
C1108.1	**b) The teacher demonstrates the polymerisation of phenylethene (only if a fume hood is available).** **Students draw any of the structure of the monomer, the repeating unit of the polymer and a section of the polymer given one of the others (for addition polymerisation)** **Working in pairs students carry out the 'nylon rope trick'.**

	Students draw the structure of the repeating units in polyesters and polyamides given the monomer and vice versa. CP
C1108.2	**c)** *Students work in small groups to tabulate information on some natural and synthetic polymers that are in common use and relate use to features of the molecular structure.* **CP**
C1108.3	**d)** *Students work in small groups to source local information relating to the production of plastics and synthetic fibres in terms of their types and efforts recycle, reduce waste and energy use.* **CP**
C1108.3	**e)** *Students make a site visit to see an industrial plant producing polymers in Qatar* **CP; C**
C1108.3	**f)** *Students research the concept of 'green' polymers to minimise waste.* **IR; C**

Possible teaching order

Please note other orders are possible and acceptable

Chemistry	
Grade 11A	**1** Structure and Properties in terms of Chemical Bonding **2** Redox reactions **3** The Mole concept and Stoichiometry **4** Organic chemistry **5** Chemistry of Synthetic and Natural polymers and their uses **6** Economic, Social and Environmental Issues

Physics Grade 11A

Forces, motion and scale

The relationships between Forces, motion and scale

Standards

P1101 Apply vector properties and free body diagrams to the forces acting on bodies

P1102 Describe and calculate frictional forces

P1103 Describe and apply Newton's laws of motion

P1104 Explain the concept of linear momentum and apply the principle of conservation of momentum

P1105 Explain and apply the concept of moment of a force

Learning Outcomes

Students should be able to:

P1101.1 Resolve forces into components and use the vector triangle to represent forces in equilibrium

P1101.2 Identify forces acting on a body using free-body diagrams and determine the resultant force

P1102.1 Describe frictional and viscous forces qualitatively, including air and water resistance, and compare and contrast static and dynamic friction

P1102.2 Identify factors affecting friction and use the concepts of static and dynamic coefficients of friction in computations

P1103.1 State Newton's laws of motion and apply them to real situations

P1103.2 Define the gravitational field constant near the surface of the earth as g = 9.82 N/kg and explain that it will vary for different planets due to their gravitational field

P1103.3 Describe the difference between mass and weight and perform calculations of weight on different planets

P1104.1 Define linear momentum of a body as the product of its mass and velocity using the equation $p = mv$

P1104.2 Determine the resultant force on an object as the rate of change of its momentum using the equation $F = \Delta p/\Delta t$ and explain that this is equivalent to Newton's second law

P1104.3 Define the principle of conservation of momentum and apply it to elastic and inelastic collisions and explosions involving two bodies in one dimension

P1105.1 Apply the moment of a force, the moment of a couple, and the principle of moments to a system in equilibrium, including associated calculations

P1105.2 Explain some applications of the principle of moments to engineering systems and to the muscles of the human body

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1101.1-2	**a)** *Students work on worksheets to identify forces acting on a body using free-body diagrams* **PS**
P1101.1-2	**b) Students will study the forces (including their direction) acting on an object suspended by two threads and demonstrate that the vector sum of the tension of the two strings is equal and opposite to the weight of the object. Students also explain why the sum of the tensions and the weight of the object are not an example of Newton's 3rd law CT; PS**
P1101.1-2 **P1102.2**	**c)** *In pairs or small groups, students investigate the static friction force on a block of wood at rest on a ramp by resolving the weight of the block into its perpendicular components. Then, estimate the angle at which the block will start sliding down the ramp.* **CP; PS**
P1102.1-2	**d)** *Students measure the static and dynamic frictional force required to move a variety of objects across a variety of surfaces. Then, they determine the coefficient of static friction for two surfaces in contact by measuring the friction angle and apply the concepts of static and dynamic coefficients of friction in computations* **CT; PS**
P1102.1-2	**e)** *After watching a video on "the future tires", learners will discuss the frictional forces and implications of future spherical tires* **C; CP**
P1103.1 **P1104.1-3**	**f)** *In pairs or small groups, students relate Newton's three laws of motion to traffic accidents. For example, the third law can be related to two vehicles in a head-on collision and learners will discuss why people in lighter vehicles tend to have more serious injuries* **CT; C**
P1103.3	**g) Students explain the effect of using a top-pan balance and a beam balance for measuring *mass* in different gravitational fields CT; PS**
P1104.2	**h)** *Students use $F = \Delta p/\Delta t$ to calculate the force needed to maintain the speed of a conveyor belt when grains of sand are dropping on it at a constant rate* **CT; PS**
P1104.1-3	**i) Using ticker-timers and/or motion sensors, students study elastic and inelastic collisions between two trolleys of different mass.**

		They also make predictions based on calculations and the principle of conservation of momentum PS; CP
P1105.1-2	**j)**	*By taking appropriate measurements, learners will work on teacher designed worksheets to calculate the torque of a moment and torque of a couple in real situations (e.g. turning a six-sided nut using a spanner)* **IR; PS**
P1105.2	**k)**	*Students research and explain everyday applications of the principle of moments to engineering systems such as buildings and bridges* **IR; C**
P1105.2	**l)**	*Working in small groups, learners will make a model arm showing the two lever mechanisms by using elastic bands as muscles* **IR; PS**
P1105.2	**m)**	**Working in small groups, learners will take appropriate measurements and calculate the force exerted by an arm muscle lifting a known mass. By applying the principle of moments and taking appropriate measurements, learners will calculate the force acting on the Achilles tendon when they stand on their tip-toes CT; PS**

The relationship between work, energy and power

Standards

P1106 Define and apply the concepts of energy and work done

P1107 Use energy calculations to solve problems

P1108 Describe and apply the concept of power and efficiency

Learning Outcomes

Students should be able to:

P1106.1 Define the work done by a force as the product of the force and the displacement in the direction of the force: W = Fd

P1106.2 Describe how energy can be stored in different ways/parts of a system, e.g. energy stored thermally, gravitationally, etc.

P1106.3 Recall the principle of conservation of energy and apply it to simple examples

P1107.1 Derive and apply the formulae $E_k = ½ mv^2$, $E_p = mgh$ and use the principle of conservation of mechanical energy in problem solving

P1108.1 Define power as the rate of doing work or the rate of energy transferred and solve problems using P = W/t = E/t

P1108.2 Explain that power is associated to the transfer of energy between different parts of a system and it is measured in watts (W)

P1108.3 Explain that in all energy transfers some energy is dissipated (wasted) and can no longer be stored usefully

P1108.4 Calculate the efficiency of a system as: Efficiency = Energy transferred usefully / Total input energy

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1106.1	**a)** *Students use a range of examples to calculate the work done by a constant force (e.g. lifting a bag)* **PS**
P1106.1	**b)** *Students use force–displacement graphs to determine the work done on a body when the force on it is not constant* **CT; PS**
P1106.2-3	**c)** *Using Sankey diagrams students describe the energy transferred per second by different machines and explain that energy is conserved, although some will be dissipated* **IR; CT**
P1107.1	**d)** ***In small groups, students study falling objects in air or a fluid using a video camera and calculate the velocity just before impact. Compare the gain in kinetic energy with the loss in potential energy and account for any difference*** **CT; PS**
P1108.1-2	**e)** *In pairs or small groups, students will take appropriate measurements to calculate the power output of a muscle system (e.g. a leg or an arm). Compare maximum output with maximum sustained output* **CT; C**
P1108.3-4	**f)** **In pairs or small groups, students investigate the efficiency of different balls (e.g. tennis ball, golf ball, squash ball at different temperatures…) by measuring the heights after each bounce after being dropped from a known height** **CT; PS**
P1108.3-4	**g)** *Students research ways in which dissipated energy (by heating) is minimised, used, or dispersed, in Qatar industrial plants such as power stations* **IR; C**

Electricity and magnetism

Electronic devices in practical control circuits

Standards

P1109 Understand and apply the properties of capacitors in electric circuits

P1110 Describe how semiconductors work

P1111 Use electronic devices to affect the output p.d. in circuits

Learning Outcomes
Students should be able to:

P1109.1 Describe how capacitors can be built and investigate their properties in electrical circuits

P1109.2 Define capacitance and solve problems using C = Q/V. Derive and use the formula to calculate the energy stored by a capacitor: U = ½ QV

P1109.3 Investigate the charge and discharge of a capacitor and use the time constant $\tau = RC$ in calculations

P1109.4 Derive and use formulae for the capacitance of capacitors in series and in parallel

P1110.1 Compare and contrast conductors, semiconductors and insulators with reference to moving electrons or ions

P1110.2 Describe how the properties of semiconductors can be influenced by the presence of small quantities of impurities

P1111.1 Derive equations for potential divider circuits and describe how the potential output of a potential divider can be varied

P1111.2 Draw and assemble potential divider circuits to investigate the properties of components like potentiometers, diodes, light dependent resistors, transistors and thermistors

P1111.3 Use logic gates in practical circuits (NOT, AND, OR, NAND, NOR) and determine truth tables for the gates, individually and in combination

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1109.1	**a)** *Teacher demonstrates how capacitors work by building a super capacitor with two large sheets of aluminium foil separated by a thick black bin bag. The teacher increases the p.d. across the plates until sparks begin to form between the plates and holes (this demonstration uses really high p.d., so it is essential you carry out a thorough risk assessment before the lesson)* **CT; C**
P1109.2	**b) In pairs or small groups, students investigate the relationship between charge stored in a capacitor and potential difference applied using different capacitors. Then, they use their graphs of**

	Q vs V to calculate the energy stored in the capacitor for different p.d. PS, CP
P1109.3	**c) In pairs or small groups, students investigate the exponential change and discharge of capacitors and perform calculations PS, CP**
P1109.4	**d)** *Students derive formulae for capacitors in series and in parallel by using the formula C = Q/V, conservation of charge and the addition of potential differences* **CT; PS**
P1109.4	**e) Students verify the formulae for capacitors connected in series and in parallel empirically and solve problems related to these configurations CT; PS**
P1110.1-2	**f)** *Students define conductivity and compare the conductivities of different conductors, semiconductors and insulators* **CT; IR**
P1110.1-2	**g)** *Working in pairs, students watch a video on "Transistors, how do they work?" and discuss the changes in conductivity of semiconductors doped with certain impurities and explain how these can be exploited through pn and npn junctions* **CT; CP**
P1111.1-2	**h) In pairs or small groups, students use a potential divider circuit to investigate how the changes in the external conditions surrounding devices like thermistors, LDRs, etc… vary the output p.d. and explain how these circuits can be used in electronic devices CT; PS**
P1111.3	**i)** *After watching videos on "logic gates" and "transistors", students research and discuss everyday applications of logic gates in practical electronic control circuits* **IR; C**
P1111.3	**j)** *Students work on worksheets, or by assembling electronic circuits using logic gates, to determine truth tables for logic gates (NOT, AND, OR, NAND, NOR), individually and in combination* **CT; PS**

Electromagnetic induction

Standards

P1112 Explain how electromagnetic induction occurs and the factors affecting it

P1113 Describe how electromagnetic induction is used to generate AC currents and in transmission of electricity

Learning Outcomes
Students should be able to:

P1112.1 Compare and contrast the concepts of magnetic flux and flux density and use numerical problems to relate them

P1112.2 Describe the induction of e.m.f. by the relative motion between a conductor and a magnetic field and state the factors that influence its magnitude and direction

P1112.3 Use Faraday's and Lenz's laws to solve numerical problems related to electromagnetic induction, including when flux density is not perpendicular to the conductor cutting through the flux lines

P1112.4 Describe qualitatively how eddy currents form and state some of the applications of eddy currents

P1113.1 Identify that an alternating current is induced in a coil rotating in a uniform magnetic field and explain the operation of a simple AC generator

P1113.2 Describe the concepts of root mean square current and voltage, period, frequency and peak value for alternating current; and solve numerical problems related to them

P1113.3 Describe the action of a transformer and explain its importance in the long-distance transmission of electricity

P1113.4 Solve numerical problems related to power transmission

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1112.1	**a)** *In small groups, students work on worksheets to differentiate the concepts of magnetic flux (φ) and magnetic flux density (B). Learners will solve numerical problems that relate the concepts of magnetic flux and magnetic flux density (e.g., contactless charging of smartphones)* **IR; CT**
P1112.1-3	**b)** *Teacher forms a very large loop of wire using a 50m (or longer) extension lead and connects the pins of the plug to a large galvanometer. Students hold the cable at different points along the loop and move it up and down. A current is induced by the interaction of the earth's magnetic field with the moving cable* **C; CP**
P1112.1-3	**c) In small groups, students demonstrate, using an oscilloscope, an induced e.m.f. in a single coil moving in a magnetic field** **CT; C**
P1112.1-3	**d) In small groups, students demonstrate, using an oscilloscope, an induced e.m.f. in a solenoid when a magnet oscillates in and out of it and identify the factors that influence the induced e.m.f.** **C; CP**
P1112.3	**e)** *Students work on worksheets to solve numerical problems related to electromagnetic induction* **CT; PS**

P1112.4	**f)** *Teacher demonstrates the formation of eddy currents in a freely suspended aluminium sheet between the poles of an AC electromagnet. Demonstrate how an aluminium grid similarly suspended will fail to move* **CT; C**
P1112.4	**g)** *In pairs, students watch videos on electromagnetic braking and eddy currents. Then, they research and discuss everyday applications of eddy currents* **IR; CP**
P1113.1-2	**h) Students make and test a simple AC generator IR; PS**
P1113.1-2	**i)** *Students work on worksheets to solve numerical problems related to the use of alternating current* **CT; PS**
P1113.3-4	**j) In pairs or small groups, students use a demountable transformer to demonstrate the structure and uses of transformers, as well as the relationship between number of turns and p.d. in the primary and secondary coils CT; PS**
P1113.3-4	**k)** Students research and discuss the importance of AC transformers (as opposed to "direct current") in the long-distance transmission of electricity **IR; CP**

Matter and energy

Modern atomic and nuclear physics

Standards

P1114 Describe the model of the atom

P1115 Explain the effects of radioactive decay from unstable isotopes

P1116 Relate nuclear reactions to the generation of energy

Learning Outcomes
Students should be able to:

P1114.1 Interpret the results of Rutherford's scattering experiment and describe how it led to modern models of the structure of the atom

P1115.1 Describe the spontaneous and random nature of nuclear decay and the properties of α, β and λ radiation

P1115.2 Write nuclear interaction equations taking conservation of mass, charge and energy into account

P1115.3 Discuss some common uses of radioisotopes and the sources of background radiation

P1115.4 Explain the significance of half-life of a radioisotope and calculate the activity and number of undecayed nuclei using the equations: $A = A_0e^{-\delta t}$ and $N = N_0e^{-\delta t}$

P1116.1 Explain the processes of nuclear fission and nuclear fusion, and describe how heavier elements are formed in older stars by nuclear fusion

P1116.2 Describe the equivalence of matter and energy, and use the equation $E = mc^2$ in calculations

P1116.3 Discuss the significant social, political and environmental issues around the use of nuclear fission

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1114.1	**a) Students research the historical models for explaining the structure of matter and create a timeline of the evolution of the model of the atom, explaining at each stage the reasons why earlier models have been superseded by subsequent ones IR; CT**
P1115.1-2	**b) Students work on worksheets to write equations representing nuclear transformations using the common notations for representing nuclides CT; PS**
P1115.1	**c)** *Teacher demonstrates the main properties of radiation emitted by unstable sources using radioactive isotopes* **C**
P1115.4	**d) In pairs, students model the spontaneous and random nature of nuclear decay by repeatedly dropping a large number of drawing pins and removing all those that drop on their backs at each stage. They use their results to draw graphs and estimate the half-life of the pins CT; CP**
P1115.4	**e)** *Students complete worksheets to determine the half-life of different radioactive isotopes and calculate their decay constant* **PS**
P1115.3 **P1116.3**	**f) In pairs students research the Chernobyl explosion and the Fukushima nuclear disaster, then design a presentation on the dangers of radioactive decay to life and health IR; C**
P1115.3	**g)** *In small groups, students research and describe the uses of radioisotopes in industry, in scientific research, in medicine, and in the home.* **IR; CP**

P1116.1-2	**h)** *Students explain the difference between nuclear fission and nuclear fusion by drawing simple diagrams and using equations representing nuclear transformations* **CT; C**
P1116.2	**i)** *In pairs or small groups, students research and debate two interpretations of $E = mc^2$ ("the interconversion of matter and energy" versus "the complete equivalence of mass and energy")* **IR; CT**
P1116.2	**j)** *Students work on worksheets to use the equation $E = mc^2$ in computations* **PS**
P1116.3	**k)** *Students research and discuss topical issues related to nuclear fission (e.g. the advantages and disadvantages of nuclear power generation)* **IR; CP**

Waves, light and sound

Advanced properties of waves

Standards

P1117 Describe the effects of superposition of waves

P1118 Explain the wave-like properties of electromagnetic radiation through coherent sources of light

P1119 Explain coherence and polarisation of electromagnetic waves

P1120 Explain how standing waves are formed and the conditions for resonance to occur

Learning Outcomes

Students should be able to:

P1117.1 Describe, with the aid of appropriate diagrams, the principle of superposition of waves and use it to explain interference

P1117.2 Discuss the conditions for observable interference and relate constructive and destructive interference to phase difference

P1118.1 Demonstrate how Young's double-slit experiment shows wave-like behaviour of light and perform calculations using the equations $\lambda = ax/D$

P1118.2 Derive the diffraction grating equation $d\sin\theta = n\lambda$ and use it to investigate diffraction gratings and laser wavelengths

P1119.1 Explain the phenomena of coherence and polarisation of transverse waves and describe applications of both

P1119.2 Explain electromagnetic radiation in terms of oscillating electric and magnetic fields and recognise that all electromagnetic waves travel with the same velocity in free space

P1120.1 Distinguish between a standing and a travelling wave and describe the meaning of the terms node and antinode

P1120.2 Describe how harmonics are produced and how the frequency and sound of the harmonics relate to the fundamental

P1120.3 Illustrate the phenomenon of resonance with particular reference to vibrating stretched strings and air columns

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1117.1	**a)** *Students complete worksheets to describe, with the aid of appropriate diagrams, the principle of superposition* **CT**
P1117.1-2	**b)** *Teacher demonstrates diffraction and interference of waves using a ripple tank* **C**
P1117.1-2	**c) Demonstrate the superposition and interference of coherent sound waves from two identical loudspeakers as students move around the classroom to notice the effects of interference CT; CP**
P1117.1-2	**d)** *In pairs students demonstrate the link between constructive and destructive interference and the path difference from two sources of coherent waves using waveforms printed on strips of acetate films* **CT; PS**
P1118.1	**e)** *Teacher demonstrates diffraction and interference of light using a laser and two slits, and of microwaves using a microwave generator, slits and detector* **C**
P1118.2	**f) Using known diffraction gratings and a laser, students use the diffraction equation and appropriate measurements to calculate the wavelength of the laser used. Then, they use the same apparatus to calculate the slits per mm of an unknown grating and finally use the same technique to find the separation between the barbs of a feather CP; PS**
P1119.1-2	**g)** *In small groups, students study the effect of crossed Polaroid sheets on the transmission of light by using a lux meter (or a smartphone)* **CT; CP**
P1119.1-2	**h)** *Students research and discuss the mechanism behind a liquid crystal display* **IR; C**

P1119.2	**i)** *Students make a display showing the wavelength and frequency range of different parts of the electromagnetic spectrum and the uses we make of each part* **C; IR**
P1119.2	**j)** *Students make a table of calculations showing how long light takes to get to us from different light sources (e.g. a television set, a distant streetlight, the Moon, the Sun, a nearby star, the Andromeda galaxy – our nearest neighbour galaxy)* **CT; PS**
P1120.1-3	**k) Students generate standing waves using a rubber string attached to a vibrating plate and investigate the speed of the waves as the wavelength increases** **CT; PS**
P1120.1-3	**l)** *Demonstrate nodes and antinodes in a vibrating string using a strobe light* **CT; C**
P1120.3	**m)** *Demonstrate resonance and the relationship between the fundamental and harmonics using a violin or guitar string. Demonstrate resonance of an air column using a column of varying length and a tuning fork* **C**

Possible teaching order

Please note other orders are possible and acceptable

Physics	
Grade 11A	**1** The relationships between forces and motion **2** The relationship between work, energy and power **3** Electronic devices in practical control circuits **4** Electromagnetic induction **5** Modern atomic and nuclear physics **6** Advanced properties of waves

Grade 12A

Biology Grade 12A

Structure and function of organisms

Tissues, organs and systems: Circulatory system

Standards

B1201 Explain how the components of the blood are related to their functions in the transport of gases.

B1202 List the events which occur after a blood vessel is injured including the clotting cascade and explain its role in the body.

B1203 Describe the formation of tissue fluid from the blood and of lymph from tissue fluid.

B1204 describe the events of the cardiac cycle, explain how the heartbeat is initiated and maintained and relate an ECG to the cardiac cycle.

B1205 Explain blood pressure and factors that affecting it.

B1206 Describe cardiovascular disease (CVD) and explain how to reduce the risk of CVD, including reducing obesity, controlling blood pressure, stopping smoking/not smoking and taking exercise

Learning Outcomes

Students should be able to:

B1201.1 List the main components of human blood.

B1201.2 Explain how red blood cells are adapted for the carriage of oxygen from the lungs to the tissues.

B1201.3 Describe how carbon dioxide is transported in the blood from the tissues to the lungs, including the role of carbonic anhydrase.

B1201.4 Explain and evaluate the effect of carbon dioxide concentration on the uptake and release of oxygen from the haemoglobin of the red blood cells, including the Bohr shift.

B1202.1 List the events which occur after blood vessel injury including vascular spasm, platelet plug formation and clot formation.

B1202.2 Describe the events of the clotting cascade and explain the protective roles of blood clotting.

B1203.1 Distinguish between tissue fluid and lymph.

B1203.2 Describe the formation of tissue fluid from the blood, and of lymph from tissue fluid.

B1204.1 Describe the events of the cardiac cycle including diastole and systole.

B1204.2 Explain the roles of the sinoatrial node, the atrio-ventricular node, the bundle of His and Purkinje tissue in the initiation and maintenance of the heartbeat.

B1204.3 Define an electrocardiogram (ECG) as a test used to check the rhythm and electrical activity of the heart, made by attaching sensors to the skin and recording the electrical activity of the heart as it beats.

B1204.4 Relate the events of the cardiac cycle to a normal ECG trace.

B1205.1 Explain blood pressure and describe how it is measured.

B1205.2 List some factors that affect the blood pressure and explain how each has its effect.

B1206.1 Describe cardiovascular disease, including the process of atherosclerosis and the increased risk that results from raised blood pressure.

B1206.2 Know that the risk of developing cardiovascular disease is partly genetic and partly due to lifestyle choices.

B1206.3 Explain ways of reducing the risk of CVD including a healthy diet, reducing obesity, controlling blood pressure, stopping smoking/not smoking and taking exercise.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1201.1-2	**a)** *Use a light microscope to examine prepared slides of blood at high magnification. Draw and label the cells that you see.* **C**
B1201.1	**b)** *Construct a pie chart to illustrate the percentage composition of human blood* **C**
B1201.2 **B1204.2**	**c) Using free apps on tablets, measure the heart rate and blood oxygenation levels of all class members. Present the data graphically, comment on the range of measurements in the class and suggest reasons for this. CP; C**
B1201.2-4	**d)** *Investigate and plan a presentation on the adaptations of the blood and cardiovascular system of diving mammals* **IR; C**
B1201.2-4	**e) Work in pairs. Make a wall chart comparing the carriage of oxygen and carbon dioxide by the blood and explaining how levels of carbon dioxide affect oxygen uptake and release, including the Bohr shift. CP; C**
B1202.1-2	**f) Make a poster, storyboard or simple animation showing the blood clotting cascade C**

B1203.1-2	**g) Produce a diagram or flow chart to show the relationship between blood, tissue fluid and lymph**
B1204.1-4	**h)** *Work in pairs. Examine normal and abnormal electrocardiograms and relate the changes seen to the relevant events in the cardiac cycle***.** **CP; CT**
B1205.1-2	**i) Search the internet to find out how blood pressure is measured, and the healthy range for normal blood pressure. Investigate the proportion of the Qatar population with healthy and unhealthy blood pressure and suggest reasons for your findings. If possible, take blood pressure readings for the class and present your data graphically. CT**
B1206.2	**j) Make a poster to show how atherosclerosis forms and explain risk factors for cardiovascular disease C**
B1206.1-2	**k)** *Analyse data from Qatar showing the proportion of the population with lifestyle factors associated with increased risk of cardiovascular disease and discuss why heart disease is such a problem in the country* **IR**
B1206.3	**l) Make a booklet or a web page planning a lifestyle regime for a healthy heart C; PS**

Tissues, organs and systems: Muscles and movement

Standards

B1207 Explain how the ultrastructure of skeletal muscles is related to its functions in antagonistic muscle pairs.

Learning Outcomes

Students should be able to:

B1207.1 Explain how the contraction and relaxation of antagonistic muscle pairs enables locomotion.

B1207.2 State that a muscle fibre contains many myofibrils and that each myofibril is made up of contractile sarcomeres.

B1207.3 Explain how contraction of skeletal muscle is attained by the sliding of actin and myosin filaments, involving ATP hydrolysis and cross bridge formations

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***

B1207.1	**a) Work in pairs to demonstrate how the biceps and triceps muscles of the upper arm move the lower arm and the hand up and down. Investigate where the muscles and tendons are attached and explain how the force is applied to move the bones CT**
B1207.2	**b) Work in pairs and use a light microscope to look at prepared slides of striated muscles. Observe, draw and label the main features of striated muscle. CP; C**
B1207.3	**c)** *Make a poster or a model to illustrate the sliding of the actin and myosin filaments in the contraction of the skeletal muscles* **CT**

Tissues, organs and systems: Control systems in humans

Standards

B1208 Describe the structure of central nervous system and peripheral nervous system and explain the importance of the different types of neurone in a simple reflex arc.

B1209 Explain the resting potential and the propagation of the action potential along an axon in terms of membrane properties and the movements of sodium and potassium ions.

B1210 Describe the structure of chemical synapses in the nervous system and explain how they determine the direction of nerve impulse transmission and allow interconnections of nerve pathways.

B1211 State examples of neurotransmitters and discuss the effects of some drugs on synapses including nicotine, caffeine, curare, and ecstasy, linking this to the problems of drug abuse.

B1212 Identify the main structures of human brain and explain how the hypothalamus acts as the link between the nervous system and the endocrine system.

B1213 Identify the main endocrine glands of humans, the function of the main hormones they produce and explain the modes of action of steroid and peptide hormones.

Learning Outcomes

Students should be able to:

B1208.1 Describe the structure of central nervous system and peripheral nervous system.

B1208.2 Describe the structure of motor, sensory and intermediate neurones.

B1208.3 Compare and contrast the function of motor, sensory and intermediate neurones in a simple reflex arc.

B1209.1 Explain how the resting potential results from the properties of the axon membrane and the movement of sodium and potassium ions across that membrane, including the sodium/potassium pump.

B1209.2 Explain how the action potential results from changes in the permeability of the axon membrane, and how it is propagated along the axon, including membrane depolarisation, the role of ion channels, voltage gated channels and the sodium/potassium pump.

B1209.3 Interpret graphs showing the events of an action potential.

B1209.4 Describe the refractory period and explain how it limits both the speed and direction of impulses.

B1210.1 Describe the structure of a synapse and how it functions to transmit impulses from one neurone to another.

B1210.2 Explain how synapses determine the direction of nerve impulse transmission.

B1210.3 Explain how synapses allow interconnections between nerve pathways, including multiple synapses and excitatory and inhibitory post-synaptic potentials.

B1211.1 List examples of a number of different neurotransmitters including acetylcholine, noradrenaline and serotonin.

B1211.2 Describe the effects of a number of legal and illegal drugs on synapses including nicotine, caffeine, curare, and ecstasy, and link this to the problems of drug abuse.

B1212.1 Identify the position and main functions of the medulla oblongata, the cerebellum, the cerebrum (cerebral hemispheres), hypothalamus and pituitary gland in the human brain.

B1212.2 Explain how the hypothalamus acts as the link between the nervous system and the endocrine system.

B1213.1 Identify the names and locations of the main endocrine glands in humans and describe the functions of the hormones they produce.

B1213.2 Know that there are two main classes of hormones, steroid hormones and peptide hormones, and give examples of each.

B1213.3 Explain the modes of action of steroid hormones with direct entry to the cell, and peptide hormones which bind to receptors on the cell membrane and involve a second messenger.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1208.1-2	**a)** *Make a poster showing the overall structure of the human nervous system along with detailed diagrams of the three main types of neurones* C
B1208.2-3	**b) Use a light microscope or projection microscope to examine prepared slides of neurones. Draw, label and annotate your observations, relating the structures you see to their functions** C

B1208.3	**c) Work in pairs/small groups. Plan how to investigate at least one spinal reflex and one brain reflex using different stimuli. Carry out your investigations and report back to the class. CP; CT**
B1209.1-4	**d)** *Watch a video/internet animation of the transmission of a nerve impulse and the ion movements across the membrane of a neurone. Use this to annotate a graph showing the ion movements during an action potential.* **C**
B1210.3	**e) Work in pairs/small groups. Investigate habituation using the withdrawal and re-emergence of the tentacles of a giant African land snail in response to a gentle stimulus CP; PS**
B1210.1-3 **B1211.2**	**f) Work in pairs. Produce a wall chart to show the structure of a synapse, with annotations to show the potential sites of action of medical and illegal drugs CT**
B1212.1	**g)** *Study a model of the brain and locate the main structures. Make a chart of the brain structures and their functions. Use this to explain why damage to the brain can have very specific effects.* **CT**
B1212.1	**h)** *Use the internet to research the story of Phineas Gage and write a report explaining the difficulty of investigating the human brain and the role of modern technologies such as fMRI scans in improving our understanding of the functions of the different areas of the brain.* **IR; C**
B1213.1-2	**i) Work in small groups. Draw a concept map showing the names, locations and functions of the main endocrine glands of humans, the type of hormone (steroid or peptide), the target organs and the hormone actions. CP; C**
B1213.3	**j)** *Produce a wall chart comparing the modes of action of peptide and steroid hormones* **C**

Homeostasis

Standards

B1214 Explain the importance of homeostasis in mammals and recognise the roles of receptors, effectors, negative feedback and positive feedback in the process.

B1215 Explain the role of hypothalamus and skin in thermoregulation and how some physiological and behavioural responses of mammals to hot and cold conditions enable them to thermoregulate effectively.

B1216 Explain how insulin and glucagon control the blood glucose level and how failure of the system results in diabetes.

B1217 Describe the gross and microscopic structure of the kidney.

B1218 Describe the function of the kidney in osmoregulation and in controlling metabolic wastes, explaining the role of the pituitary gland, ADH and aldosterone.

Learning Outcomes
Students should be able to:

B1214.1 Define homeostasis and explain the importance of homeostasis in mammals.

B1214.2 Describe the roles of receptors, effectors and negative feedback and positive feedback in homeostasis.

B1215.1 Define endotherms as animals that regulate their body temperature through metabolic processes, behavioural and physiological responses and state that mammals are endotherms.

B1215.2 Explain the role of the hypothalamus and the skin in thermoregulation in humans and other mammals.

B1215.3 Describe some physiological and behavioural responses of mammals to hot and cold conditions and explain how these responses enable them to thermoregulate effectively.

B1216.1 Recognise why it is important to keep blood glucose levels between narrow limits.

B1216.2 Describe the roles of the hormones insulin and glucagon in controlling blood sugar levels and explain the importance of negative feedback in the system.

B1216.3 Explain how failures in the system can cause both type 1 and type 2 diabetes.

B1217.1 Investigate, identify and label the gross external and internal structures of a kidney.

B1217.2 Identify and label the detailed structure of a nephron and its associated blood vessels.

B1218.1 Define the term osmoregulation and explain why maintaining the concentration of the body fluids is such an important part of homeostasis.

B1218.2 Describe the function of the kidney in osmoregulation and in removing metabolic wastes.

B1218.3 Explain the roles of the pituitary gland, ADH and aldosterone in osmoregulation.

B1218.4 Recognise that the failure of osmoregulation and salt regulation can lead to malfunction and failure of the kidney, and that this is life-threatening.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1214.1-2	**a)** *Divide into four groups. Discuss the importance of negative feedback in the regulation of homeostasis and each group lists as many*

	examples as possible. In a plenary session compare examples and consider why positive feedback is rarely involved in homeostasis. **CP; C**
B1215.1-2	**b)** *Draw a flow chart to illustrate the feedback systems involved in thermoregulation* **C**
B1215.2-3	**c)** *Work in pairs. Produce a role play showing someone suffering from the symptoms of heat stroke, and the actions needed to help them recover* **CT**
B1215.3	**d) Using the internet and the wildlife documentaries of Sir David Attenborough, research how three different mammals maintain homeostasis in very hot environments and three in very cold environments. Produce a report on homeostasis in extreme environments IR; C**
B1215.1-3	**e) Produce a tourist guide to heatstroke – the causes, the symptoms and how to avoid it PS; C**
B1216.1-3	**f) Make a wall poster explaining diabetes, including a diagram to illustrate the control of blood sugar levels showing where feedback systems are involved, how different types of diabetes can be treated and how to reduce the risk of type 2 diabetes CT; C**
B1217.1	**g) Work in small groups. Draw and label the external features of a kidney obtained from a butcher. Then dissect the kidney and locate, draw and label the main gross structures (*student practical OR teacher demonstration)* C**
B1217.2 **B1218.2**	**h) Make an annotated diagram showing the external structure of a kidney, the gross internal structure of the kidney and the detailed structure of a nephron, relating the structure of the kidney to its functions in osmoregulation and removing metabolic wastes C**
B1218.4	**i) Research ways of overcoming kidney failure, including dialysis and kidney transplants. Write a full report, explaining the problems caused by kidney failure and evaluating the advantages and disadvantages of both dialysis and transplants IR; C**
B1214-B1218	**j) Work in pairs/small groups. Draw a concept map summarising the role of the hypothalamus and pituitary gland in the body, including the hormones it produces, their functions, and their roles in homeostatic responses CT; C**

Tissues, organs and systems: Transport in plants

Standards

B1219 Describe the processes of transpiration and the movement of dissolved minerals in the xylem.

B1220 Explain the translocation of photosynthetic products in the phloem, including the role of the companion cells.

Learning Outcomes
Students should be able to:

B1219.1 Identify xylem and phloem tissue (vascular bundles in plant stems, roots and leaves) and describe the main features of both.

B1219.2 Describe the movement of water in plants in the transpiration stream.

B1219.3 Describe the movement of dissolved minerals in the xylem.

B1219.4 Investigate factors that affect the rate of transpiration in plants.

B1220.1 Describe translocation of photosynthetic products in the phloem.

B1220.2 Explain the role of the companion cells in translocation

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1219.1	**a) Work in pairs. Use light microscope or projection microscope to observe xylem and phloem tissue in vascular bundles of stems, roots and leaves of dicot plants. Sketch plans to show the position of the tissue and draw labelled diagrams of sample cells under high magnification. CP; C**
B1219.2	**b)** *Work in pairs. Investigate the stomata on the surface of a leaf using clear nail polish or water based varnish to make a film which can be viewed using a light microscope*. **PS.**
B1219.2 **B1219.4**	**c) Work in small groups. Use a potometer to investigate factors affecting the rate of water uptake by a plant with each group investigating a different factor. Display data graphically and exchange results and draw conclusions in a plenary session. CP; CT**
B1220.1-2	**d)** *Use the internet to research how scientists discovered that translocation is an active process and transpiration is passive* **IR**

Tissues, organs and systems: Control systems in plants

Standards
B1221 Describe the responses of plants to light and gravity and explain the role of plant hormones in these responses.

Learning Outcomes

Students should be able to:

B1221.1 Investigate and describe how plant shoots and roots respond to light and gravity (phototropisms and geotropisms).

B1221.2 Explain how plant hormones (auxins) bring about the phototrophic responses of plant shoots and roots to unilateral light

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1221.1	**a) Work in pairs/small groups. Carry out a practical investigation into the effect of light on seedlings, using freshly germinated seedlings and a box with a hole to admit unilateral light CP**
B1221.1	**b) Work in pairs/small groups. Plan and carry out an investigation into the effect of different coloured light on seedlings, using freshly germinated seedlings, a box with a hole in it to admit unilateral light, and coloured filters CP; CT**
B1221.1	**c) Work in pairs/small groups. Carry out a practical investigation into the effect of gravity on newly germinated seedlings, using petri dishes stuck to the wall. CP; CT**
B1221.1	**d)** *Use the internet to investigate the use of clinostats to investigate geotropisms (gravitropisms)* **IR**
B1221.1-2	**e)** *Use the internet to research the classic experiments demonstrating the presence of plant hormones and their role in phototropisms and produce a timeline showing how our understanding of plant hormones and phototropisms has developed since the time of Charles and Francis Darwin* **IR; C**

Growth, development, reproduction and inheritance

Inheritance and the genome

Standards

B1222 Recognise the importance of the process of PCR in sequencing the genome.

B1223 Describe the principles of gel electrophoresis and DNA sequencing and explain some of the ways in which this information is being used.

B1224 Explain the principles of gene modification using the modification of bacteria to produce human insulin as an example, including the roles of restriction enzymes, plasmids and bacteriophages and the formation of recombinant DNA molecules.

B1225 Discuss recent advances in the use of genetically modified animals, plants and bacteria (GMOs) and in gene therapy, with reference to examples such as cystic fibrosis, thalassaemia

and macular degeneration and recognise some of the possible benefits and risks associated with this new technology.

Learning Outcomes

Students should be able to:

B1222.1 Define the genome as all of the DNA of an organism, both in the nucleus and in mitochondria and chloroplasts.

B1222.2 Describe the process and importance of the polymerase chain reaction (PCR).

B1223.1 Describe the process and principles of gel electrophoresis.

B1223.2 Describe the process and principles of DNA sequencing based on the traditional Sanger method, recognising that the technology is now much faster, cheaper and more efficient.

B1223.3 Discuss some of the ways in which our new understanding of the genome is being used, to include DNA fingerprinting, identification of heritable diseases, identification of genes for genetic modification identifying drug resistance in pathogens such as bacteria and malarial protozoa, and new ways of treating cancer.

B1224.1 Explain the principle of the genetic modification of organisms.

B1224.2 Describe the original process of genetic modification including the roles of restriction enzymes, plasmids and bacteriophages and the formation of recombinant DNA molecules, using the modification of bacteria to produce human insulin as an example.

B1225.1 Describe some of the recent advances in genetically modified plants and bacteria (GMOs), including plants that can withstand extremes of drought or have nutritional enhancement, and plants and bacteria that can make human medicines.

B1225.2 Describe the principles of gene therapy, with reference to examples such as cystic fibrosis, thalassemia and macular degeneration.

B1225.3 Identify some of the possible benefits and risks associated with the use of GMOs and gene therapy.

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1222.2	**(a) Using textbooks and the internet, research the polymerase chain reaction and write a short article explaining its importance in genomics and forensic science IR; C**
B1223.1	**(b)** *Work in small groups. Watch several internet videos on the process of gel electrophoresis and decide which is the clearest and most informative, giving the reasons.* **CP; CT**

B1223.2	**(c)** *Use the internet to write a report on the impact of new DNA sequencing technologies on our understanding of the genome, referencing the original Human Genome Project, later international genome projects and current research.* **IR**
B1223.3	**(d) Work in pairs. Produce a presentation on the use of DNA sequencing in the accurate diagnosis of various genetic diseases, in identifying and treating infectious diseases and in cancer treatment. Use the internet for your research, using only reliable sources. IR; C**
B1223.3	**(e)** *Study the DNA fingerprints of 'suspects' and decide which set best matches the evidence collected at a 'crime scene'* **PS**
B1223.3	**(f)** *Write an account of the work of Sir Alex Jeffry, who is credited with the development of genetic fingerprinting techniques, and tell the story of the first use of DNA fingerprinting to prove innocence and guilt in a murder investigation* **IR; CT**
B1224.2	**(g) Produce a wall chart to show the process of genetic engineering C**
B1225.1	**(h)** *Work in pairs. One person researches the original way in which insulin was produced for people with diabetes. The other researches the use of genetically modified bacteria to produce human insulin. Make a table comparing the two methods and evaluate them.* **CT**
B1225.1 **B1225.3**	**(i) Use the internet to investigate the production of genetically modified plants in agriculture, including examples which give increased nutritional benefits, examples which contain pesticides and other benefits to growers and sellers. Have a class debate on the use of genetically modified plants in world agriculture. IR; C**
B1225.2-3	**(j)** *Work in small groups. Produce a wall chart summarising the current state of gene therapy, including successes and failures and perceived potential benefits and risks. Use the internet for extra information if needed.* **CT; C**

Health and disease

Communicable disease: Body defence systems

Standards

B1226 Describe the different types of white blood cells and summarise their roles in the non-specific and specific responses to infection.

B1227 Describe the unique structure of cell surface antigens and explain the role of surface receptors in identifying self and non-self cells.

B1228 Describe the non-specific immune response to infection including the release of histamines, fevers and phagocytosis and explain how histamines can cause allergic responses.

B1229 Describe the specific immune response in humans, including the actions of B lymphocytes and T lymphocytes, and explain the action of antibodies against antigens.

B1230 Distinguish between natural and artificial, and active and passive immunity and explain the role of vaccination and herd immunity in combating disease.

B1231 Explain how different types of stem cells, including iPSCs, may be used in medical treatments now and in the future, and some of the moral and ethical issues raised by their use.

Learning Outcomes
Students should be able to:

B1226.1 Identify the main types of white blood cells, including monocytes, basophils, neutrophils, eosinophils and lymphocytes.

B1226.2 Recognise which types of white blood cell are involved in the non-specific response of the body to infection and which are involved in the specific immune response.

B1227.1 Describe the unique structure of cell surface antigens on the surface of the cells of every organism.

B1227.2 Explain the interaction of cell surface receptors with antigens, and the role of these receptors in identifying self and non-self cells.

B1228.1 Describe the non-specific immune response to infection including the release of histamines by mast cells and basophils, fevers and phagocytosis by neutrophils and macrophages.

B1228.2 Explain how histamines released by white blood cells may cause allergic reactions such as asthma.

B1229.1 Describe the mode of action of T and B lymphocytes in the immune response.

B1229.2 Describe the humoral immune response.

B1229.3 Describe the cell-mediated immune response.

B1229.4 Explain the action of antibodies against antigens in the human immune system.

B1230.1 Describe, compare and contrast active and passive immunity.

B1230.2 Describe artificial active immunity (vaccination).

B1230.3 Explain the role of vaccination in combating disease, including the importance of herd immunity.

B1231.1 Describe the main types of stem cells (including induced pluripotent stem cells, iPSCs) and their properties.

B1231.2 Explain how stem cells are used in medicine now and how they may be used in the future.

B1231.3 Discuss some of the moral and ethical issues raised by the use of some types of stem cells in medicine.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
B1226.1-2	**a) Work in pairs. Use a light microscope or projection microscope to observe prepared slides of human blood. Find several different types of white blood cells, identify, draw and label them, giving an indication of their size. CP; C**
B1226.1-2	**b)** *Make a table summarising the main types of human white blood cells and their roles in the body* **CT**
B1227.1-2	**c)** *Make paper or clay models to illustrate antibody–antigen reactions* **PS**
B1227.2	**d)** *Work in groups. Discuss the impact of the antigen/antibody response on blood transfusions and organ transplants, research ways in which these problems can be overcome and write an article explaining these problems to non-scientists, to help understanding of the need to act as blood donors and potential organ donors.* **IR; CT**
B1228.1-2	**e) Carry out a survey among class members on allergies suffered, symptoms caused by the allergies and how they are treated. Display the collected data graphically CP; C**
B1229.1-3	**f)** *Produce a series of revision cards, each with a single step of the specific immune response on it. Challenge other students to put the cards in order to show the whole specific immune response.* **PS**
B1229.1-4	**g) Work in small groups. Discuss how the body reacts to invasion by a pathogen including the nonspecific response and the specific immune response. Develop a concept map or flow chart showing the coordinated responses of the body CP; C**
B1230.1	**h) Produce a brief summary of the history of vaccination and how the process works, using the internet for research IR**
B1230.2	**i)** *Investigate the compulsory vaccination programme for new-borns in Qatar. Suggest reasons a) why childhood vaccination programmes around the world are often very similar and b) why childhood vaccination programmes around the world can differ.* **IR; CT**

B1231.1-2	**j)** *Work in pairs/small groups. Investigate the current use of stem cells in medicine. Present two wall charts, one highlighting the successes and future potential of these treatments, the other highlighting some of the moral, ethical and safety concerns that have been expressed about this area of research.* **CP; CT; C**

Possible teaching order

Please note other orders are possible and acceptable

Biology	
Grade 12A	**1** Tissues, organs and systems: Circulatory system **2** Tissues, organs and systems: Transport in plants **3** Tissues, organs and systems: Muscles and movement **4** Tissues, organs and systems: Control systems in humans **5** Homeostasis **6** Tissues, organs and systems: Control systems in plants **7** Communicable disease: Body defence systems **8** Inheritance and the genome

Chemistry Grade 12A

Patterns in Chemical Reactivity

Periodic Trends in the Properties of Elements

Standards

C1201 Understand and explain the concept of periodicity in terms of the physical and chemical properties of the elements

Learning Outcomes

Students should be able to:

C1201.1 Explain the factors influencing the ionisation energies of elements and the trends in ionisation energies across a period and down a group of the Periodic Table

C1201.2 Explain the periodic trends in electron affinity and electronegativity

C1201.3 Outline and explain trends in the following properties down group IV: melting point and electrical conductivity of the elements; acid–base nature and thermal stability of the oxides

C1201.4 Outline and explain trends in the following properties down group VII:

- Physical properties
- The reactivity of the elements as oxidising agents
- The thermal stability of the halides
- The reaction of the halide ions with silver nitrate followed by aqueous ammonia

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1201.1	**a) Students produce or are given graphical formats of the changes in first ionisation energy across Period 3 and down Groups II and VII of the Periodic Table. They explain trends across the Period in terms of shielding and increasing nuclear charge and explain trends down the Groups in terms of the increasing number of electron shells and nuclear charge. C; PS**
C1201.1	**b) Given successive ionisation energies for an element (graphically or otherwise), students deduce its electronic configuration. PS**
C1201.2	**c) Students are provided with data on trends in electron affinity down a Group and explain them. They distinguish between electron affinity and electronegativity and explain the trend in electronegativity values down Group VII. PS**
C1201.3	**d) Students work in pairs to research, outline and explain trends in the following properties down group IV: melting point and electrical**

	conductivity of the elements; acid–base nature and thermal stability of the oxides. PS
C1201.4	**e) Students work in pairs to research, outline, and explain trends in the following properties down group VII:** **• physical properties;** **• the reactivity of the elements as oxidising agents;** **• the thermal stability of the hydrides;** **• the reaction of the halide ions with silver nitrate followed by aqueous ammonia.PS** *Extension. Students carry out appropriate test tube reactions to confirm their research.*

Properties of Transition elements and their compounds

Standards
C1202 Understand the chemistry of the transition elements

Learning Outcomes
Students should be able to:

C1202.1 Relate the electronic configurations to the typical properties of the first- row transition elements.

C1202.2 Recognise that transition elements typically form more than one stable ion and that the metals have generally similar physical and chemical properties

C1202.3 Explain how the variable oxidation states can result in transition metal ions acting as oxidising and reducing agents. Give examples of transition metal redox systems

C1202.4 State some common uses of some transition elements, including examples of catalysis by transition metals, and relate these uses to their properties.

C1202.5 Illustrate that transition elements combine with both mono- and bi-dentate ligands through dative bonding to form complexes and that these are often coloured. Give examples of ligand exchange reactions

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1202.1	**a) Students propose the electronic configurations of the first row of the transition elements and relate them to their typical properties. The teacher draws attention to the actual configurations of chromium and copper and discusses this. C**
C1202.2	**b) Students are given the definition of a transition element as d block elements forming more than one stable ion with partially filled d**

	subshells and are asked to discuss in pairs whether scandium and zinc are transition elements. CT
C1202.3	**c) Students look at some samples of transition metals and their compounds, including vanadium, chromium, manganese and iron, They also look at data on the physical properties of these chemicals and summarise their properties. They tabulate their oxidation states and the colour of their common compounds. IR**
C1202.3	**d) Students work in pairs to carry out simple test tube reactions on iron compounds. CP**
C1202.3	**e) Using electronic configurations students postulate the possible oxidation states of the first row transition metals. CT**
C1202.3	**f) Students work in pairs to carry out an experiment on the redox reactions of eg vanadium and identify the various redox systems present. CP**
C1202.4	**g) Students research some common uses of some transition elements, including examples of catalysis by transition metals in industrial processes carried out in Qatar, and relate these uses to their properties. IR**
C1202.5	**h) Students work in pairs to carry out an experiment on eg Cu(II) complexes with mono- bi-dentate ligands. They explain the bonding in terms of dative bonding. Students then carry out substitution reactions of metal aqua complexes with mono-dentate ligands (from ammonia and concentrated hydrochloric acid) to consider whether there is a change in co-ordination number and whether all the water ligands are substituted. CP**

Organic Chemistry

Standards

C1203 Understand how organic reaction mechanisms explain the chemistry of functional groups

C1204 Understand the chemistry of arenes

Learning Outcomes

Students should be able to:

C1203.1 Describe the shape of organic compounds in terms of orbital overlap and electron-pair repulsion. Estimate bond angles.

C1203.2 Describe structural isomerism, E-Z isomerism in alkenes, and how chiral centres give rise to optical isomerism

C1203.3 Describe the mechanisms of electrophilic addition in alkenes and nucleophilic substitution in compounds such as halogenoalkanes

C1203.4 Describe the chemistry of the carbonyl group in terms of a nucleophilic substitution mechanism and show how its reactivity depends on the electronegativity of the group or groups attached to it

C1203.5 Illustrate the hydrolysis of acyl chlorides (exemplified by ethanoyl chloride) and recall that they are useful agents for acylating alcohols, phenols

C1204.1 Interpret and use the nomenclature and structural formulae of the following classes of aromatic compounds:
• arenes;
• halogenoarenes;
• phenols;
• aromatic aldehydes and ketones;
• aromatic carboxylic acids, esters and acyl chlorides

C1204.2 Describe the chemistry of arenes (such as benzene and methylbenzene), as exemplified by substitution reactions with electrophiles eg nitration and oxidation of the side chain
C1204.3 Examine the mechanism of electrophilic substitution in arenes and the effect of the delocalisation of electrons in arenes in such reactions

C1204.4 Describe the chemistry of phenol, as exemplified by its reactions with bases and sodium and by electrophilic substitution in the aromatic ring

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1203.1	**a) Students use molecular models or simple animations to describe the shape of organic compounds in terms of orbital overlap and electron-pair repulsion. They estimate bond angles in given molecules. PS**
C1203.2	**b) The students define structural isomerism, E-Z isomerism in alkenes, and optical isomerism and construct molecular models and formulae with displayed bonds to show the various isomers. They identify chiral centres in eg sugars and cholesteryl benzoate (liquid crystals). PS**
C1203.3	**c) Students consider the reaction of ethene, bromine and sodium chloride solution to form 1,2-dibromoethane and 1-bromo-2-chloroethane to explain the mechanism of electrophilic addition. They then draw the mechanisms of other electrophilic additions to ethene. CT**

C1203.3	**d)** *Students research evidence for the mechanism of nucleophilic substitution in halogenoalkanes.* **IR**
C1203.4	**e) Students draw diagrams to represent the dipole due to the C=O bond and predict which substituent groups would enhance the dipole and which types of compound would react with it. They summarise the reaction mechanism as nucleophilic substitution. CT**
C1203.5	**f) The teacher demonstrates some reactions of an acyl chloride and an acid anhydride, which the students summarise. C**
C1204.1	**g) The students interpret and use the nomenclature and structural formulae of the following classes of aromatic compounds:** **• arenes;** **• halogenoarenes;** **• phenols;** **• aromatic aldehydes and ketones;** **• aromatic carboxylic acids, esters and acyl chloride. C**
C1204.2	**h) The students work in pairs to carry out and summarise an experiment to determine the reactions of the arenes using methylbenzene. CP**
C1204.3	**i) Students work in the same pairs to carry out a comparative experiment with methoxybenzene to show its enhanced reactivity. They consider the products of the reaction of methoxybenzene with iodine monochloride to postulate an electrophilic substitution reaction mechanism. CP**
C1204.4	j) **Students work in pairs to carry out and summarise an experiment to determine the reactions of phenol as an arene and as an acid. CP**

Reaction Kinetics & Energetics

Concepts of reaction kinetics relating to order of reactions and the factors involved

Standards

C1205 Explain reaction rates in terms of the Boltzmann distribution

C1206 Carry out quantitative calculations on reaction rates

Learning Outcomes

Students should be able to:

C1205.1 Recognise that different reactions proceed at different rates and explain reaction rate in terms of particle collisions and particle energy

C1205.2 Outline the Boltzmann distribution and demonstrate its importance in reaction kinetics, with particular reference to activation energy

C1206.1 Derive and use rate expressions of the form rate = $k[A]^m[B]^n$ from data and draw and analyse graphical representations for zero, first- and second-order reactions in a specified reactant

C1206.2 Calculate the half-life of first-order reactions and show an understanding of why it is concentration independent

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1205.1 **C1205.2** **C1206.1** **C1206.2**	**a) Students summarise the factors that affect reaction rate. CT** **b) Using a simulation or otherwise of the Boltzmann distribution students recognise qualitatively the statistical distribution of the energy of molecules and how it changes with temperature. They relate this to activation energy. IR** **c) Students work in pairs to carry out kinetic experiments such as between iodine and propanone in acid solution, between calcium carbonate and hydrochloric acid or between iodine and sodium thiosulphate solution using a data logger or otherwise. They use the results and those from provided data to derive and use rate expressions of the form rate = $k[A]^m[B]^n$ from data and draw and analyse graphical representations for zero, first- and second-order reactions in a specified reactant. CP** **d) Students calculate the half-life of first-order reactions. They then calculate subsequent half-lives to show an understanding of why the half-life is concentration independent.PS** *Extension. Students can use a mathematical method to obtain this result.*

Concepts of equilibria in chemical reactions and ionic equilibria in aqueous solution

Standards

C1207 Understand chemical equilibrium and be able to apply the concept to equilibrium calculations

C1208 Apply equilibrium ideas to acid-base reactions including the application to buffer solutions.

Learning Outcomes

Students should be able to:

C1207.1 Discuss, in terms of rates of the forward and reverse reactions, what is meant by a reversible reaction and dynamic equilibrium

C1207.2 Apply Le Chatelier's principle and deduce qualitatively the effect of temperature, concentration or pressure on a system at equilibrium

C1207.3 Deduce expressions for forward and backward rate constants for a simple bimolecular reaction and hence deduce expressions for equilibrium constants in terms of concentrations (K_c) and partial pressures

C1207.4 Calculate the values of equilibrium constants in terms of concentrations or partial pressures from appropriate data, and calculate the quantities present at equilibrium, given appropriate data

C1207.5 Discuss and use the term position of equilibrium as applied to a reversible reaction

C1207.6 Recognise that the size of the equilibrium constant is an indication of the extent to which a reaction nears completion

C1208.1 Describe the Brønsted–Lowry theory of acidity. Recognise the terms pH, K_a, pK_a and K_w, and use these concepts in calculations such as of the pH of solutions of weak acids and bases

C1208.2 Recognise that indicators are weak acids and explain the choice of suitable indicators in acid–base titrations, in terms of the dissociation constant of the indicator

C1208.3 Describe how buffer solutions control pH (including the role of HCO_3^- in controlling blood pH) and calculate the pH of buffer solutions, given appropriate data

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1207.1 **C1207.2** **C1207.3** **C1207.4**	**a) The teacher demonstrates some examples of reversible reactions such as the blue bottle experiment and students carry out eg the reaction of dichromate(VII) ions with varying pH. Students discuss the results and summarise the characteristics of the equilibrium state. CT** **b) Students are provided with a formal definition of Le Chatelier's principle and are asked to produce guidelines in favour of more product for endothermic and exothermic reactions and for when there are fewer product molecules than reactant molecules, and vice versa.** **Students deduce qualitatively the effect of temperature, concentration or pressure on a number of provided systems at equilibrium. PS** **c) Students are asked to suggest how to measure equilibrium given the rate of forward and backward reactions. The teacher defines K_c and K_c. Students calculate the values of equilibrium constants in terms of concentrations or partial pressures from appropriate data, and**

	calculate the quantities present at equilibrium, given appropriate data. PS
C1207.5 **C1207.6**	**d) Students consider values of equilibrium constants to suggest reactions which have gone nearly to completion, have barely gone at all or have reached a position of equilibrium. PS**
C1208.1	**e) Students revisit the Bronsted-Lowry theory and students use pH, K_a, pK_a and K_w, in calculations such as the determination of the pH of solutions of weak acids and bases. PS**
C1208.2	**f)** *Students use the dissociation constant of an indicator to explain the choice of a suitable indicator in an acid–base titrations.* **PS**
C1208.3	**g)** *Students use equilibrium ideas to describe how buffer solutions control pH (including the role of HCO_3^- in controlling blood pH). They calculate the pH of buffer solutions, given appropriate data.* **CT**
Calculations on Enthalpy changes using Hess's Law	
Standards **C1209** Use energy cycles to calculate thermodynamic quantities	
Learning Outcomes **Students should be able to:** **C1209.1** Explain and use the concept of standard enthalpy change (ΔH), with particular reference to combustion, formation, solution and neutralisation. Calculate enthalpy changes from experimental results **C1209.2** Use Hess's law to construct simple energy cycles and determine enthalpy changes that cannot be found by direct experiment, such as enthalpies of formation and of ionisation and lattice energies	
LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1209.1	**a) Students work in pairs to carry out an experiment to determine a standard enthalpy change for a reaction eg for the reaction between copper(II) sulfate and zinc, or citric acid and sodium hydrogen carbonate, or magnesium and dilute hydrochloric acid, or in burning a fuel. They use a data logger or another method. Hess's Law is introduced as a way of calculating enthalpy changes that cannot be measured directly. CP**
C1209.2	**b) Students use Hess's law to construct simple energy cycles and determine enthalpy changes such as enthalpies of formation and of ionisation and lattice energies.PS**
Entropy and Free Energy	

Standards
C1210 Understand how free energy drives the direction of chemical change

Learning Outcomes
Students should be able to:

C1210.1 Discuss how the natural tendencies in the Universe towards minimum potential energy and maximum disorder are reconciled in the second law of thermodynamics, and describe how these tendencies are applied to chemical systems

C1210.2 State and explain the factors that lead to an increase in the entropy (disorder) of a chemical system

C1210.3 Calculate the standard entropy change for a reaction using absolute entropy values and recognise and explain the impact of changes of state on this value

C1210.4 Calculate standard free energy changes for reactions from enthalpy and entropy changes and use this to predict the spontaneity of a reaction at a particular temperature

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1210.1	**a)** *Students are given some everyday examples where it is obvious they become disordered and do not spontaneously rearrange to an ordered state and they move to a state of lower energy. The teacher formalises this as the second law of thermodynamics.* **CT**
C1210.2	**b)** *Students brainstorm factors that lead to an increase in entropy of chemical systems and agree their results.* **CP**
C1210.3	**c) Students calculate the standard entropy change for a series of reactions using absolute entropy values and summarise the impact of changes of state on these values.** **PS**
C1210.4	**d) Students are introduced to Gibbs Free Energy and us this to calculate standard free energy changes for reactions. They use these values to predict the spontaneity of a reaction at a particular temperature.** **PS**

Chemistry in Our World

Modern Analytical Techniques

Standards
C1211 Understand the importance of modern analytical techniques in analysis and structure determination

Learning Outcomes
Students should be able to:

C1211.1 Mass spectrometry - use precise atomic masses and the precise molecular mass to determine the molecular formula of a compound

C1211.2 Infrared spectroscopy -use infrared spectra and provided data on absorption to identify particular bonds, and hence functional groups

C1211.3 Understand that separation in chromatography depends on the balance between solubility in the moving phase and retention by the stationary phase.

C1211.4 Calculate retardation factor (R_f) values from a chromatogram and compare retention times and R_f values with standards to identify different substances.

C1211.5 Appreciate that scientists use a range of analytical techniques to enable the structures of new compounds to be confirmed.

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
C1211.1	**a) Students are introduced to the basic idea of mass spectrometry and then use precise atomic masses and the precise molecular mass to determine the molecular formula of a compound. C**
C1211.2	**b) Students are introduced to the basic idea of infra-red spectroscopy and then use infra red spectra and provided data on absorption to identify particular bonds, and hence functional groups. C**
C1211.3 **C1211.4**	**c) Students identify the stationary phase and the moving phase in chromatography and are given the definition of retardation factor. They calculate retardation factor(R_f) values from a chromatogram and compare retention times and R_f values with standards to identify different substances. C**
C1211.3 **C1211.4**	**d) Working in pairs, students carry out at least one type of chromatography on common substances such as food dyes or black ink. They calculate R_f values for the pigments revealed in their own chromatograms. CP;PS**
C1211.3 **C1211.4**	**e)** *Students are provided with several chromatograms and the data they need to identify different compounds based on R_f measurements* **CT**

C1211.5	**f) Students are provided with data on mass spectrometry, infra-red spectroscopy and chromatography to enable them to determine the structure of an unknown substance. They are then provided with a number of unknown examples which they have to identify from the information they have been given. PS**

Possible teaching order

Please note other orders are possible and acceptable

Chemistry	
Grade 12A	**1** Periodic Trends in the Properties of Elements **2** Properties of Transition elements and their compounds **3** Organic Chemistry **4** Concepts of reactions kinetics relating to order of reactions and factors involved **5** Calculations on Enthalpy changes using Hess's Law **6** Concepts of equilibria in chemical reactions and ionic equilibria in aqueous solution **7** Entropy and Free Energy **8** Modern Analytical Techniques

Physics Grade 12A

Forces, motion and scale

Gravity and circular motion

Standards

P1201 Explain the conditions to maintain uniform circular motion

P1202 Explain how gravitational forces and fields affect the relative movement of heavenly bodies

Learning Outcomes

Students should be able to:

P1201.1 Express angular displacement in radian and describe, qualitatively and quantitatively, motion in a circular path due to a perpendicular force causing a centripetal acceleration

P1201.2 Use the concept of angular velocity and the formulae $v = r\omega$, $a = r\omega^2$ and $a = v^2/r$ to solve problems in various situations

P1202.1 Recall and use Newton's law of universal gravitation in the form $F = G(m_1m_2)/r^2$

P1202.2 Define the concept of gravitational field strength generated by a distribution of mass as force per unit mass

P1202.3 Define the gravitational potential at a point of a gravitational field generated by a spherical distribution of mass as $V = -GM/r$ and use it in calculations

P1202.4 Relate gravitational force to the centripetal acceleration it causes, with particular reference to Earth satellite orbits

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1201.1-2	**a)** *Students use the arms of a clock to express the time in radian (e.g. 3 o'clock could be expressed as $\pi/2$: 2π), then work on worksheets to express other examples of angular displacement in radian and make calculations of tangential and angular velocity, as well as the radius, e.g the radius of a bicycle wheel, the drum of a washing machine, a spot on a long-playing (LP) turntable…* **CT; PS**

P1201.1-2	**b) In small groups, students push a tennis/golf ball inside the ring of a hoola-hoop, so that the ball follows a circular path. Then, they lift the hoop and observe what happens to the ball. They take videos to explain the motion of the ball and the forces involved C; CT**
P1201.1-2	**c) In pairs or small groups, students use an accelerometer on their smartphones or data loggers (the PhyPhox app is a useful tool for this) to investigate the centripetal acceleration on the sensor when placed at different distances from the centre on a ruler rotating on the turntable of an LP (a roundabout in a children's play area would also work well) CT; PS**
P1202.1	**d)** *Students work on worksheets to calculate the mass of the Sun, the Moon and the planets using Newton's law of universal gravitation* **PS**
P1202.1-2	**e) In small groups, students conduct a practical task to determine *g* on the Earth's surface using a free-fall method and compare it with the *g* measured by a gravimeter (or a smartphone) CP, PS**
P1201.1-2 **P1202. 4**	**f)** *In small groups, students work on teacher designed worksheets to calculate the orbital radius of a satellite knowing its velocity, and calculate the orbital radius and velocity of geostationary satellites* **PS**
P1202.3-4	**g)** *By using a worksheet, students are guided to derive expressions relating the kinetic energy, potential energy, and total energy of an orbiting satellite* **CT; PS**

Waves, light and sound

Oscillations and advanced properties of waves

Standards

P1203 Explain the properties of a body moving with simple harmonic motion (SHM)

P1204 Evaluate systems in resonance and subjected to forced oscillations

Learning Outcomes

Students should be able to:

P1203.1 Describe examples of free oscillations and define the terms amplitude, period, frequency, angular frequency and phase difference

P1203.2 Use equations expressing the displacement, period, velocity and acceleration of SHM and represent them graphically

P1203.3 Describe the transfers of energy in a system in SHM graphically and using the principle of conservation of energy

P1204.1 Describe practical examples of forced oscillations and resonance and show how the amplitude of a forced oscillation changes with frequency near to the natural frequency of the system

P1204.2 Describe and explain practical examples of different types of damped oscillations **P1204.3** Describe circumstances in which resonance is desirable and others when it should be avoided	
LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1203.1	**a)** *Students work on worksheets to describe examples of free oscillations and define the terms amplitude, period, frequency, angular frequency, and phase difference* **CT; C**
P1203.1-2	**b) In pairs or small groups, students conduct a practical task to determine g using a simple pendulum (or use a smartphone as a pendulum) IR; PS**
P1203.1-2 **P1204.1-2**	**c) In small groups, students design experiments to investigate simple harmonic motion using mechanical methods (e.g., an oscillating paper funnel full of sand) and electronic methods (e.g., a pendulum suspended from the shaft of a potentiometer, a magnet on a spring oscillating in and out of a coil) CT; PS**
P1203.2-3	**d)** *In small groups, students will calculate the potential energy of a spring when it is stretched using a known force. Students will also calculate the kinetic energy by measuring the velocity of the spring as it passes its equilibrium position* **CP; PS**
P1204.2-3	**e)** *Students investigate the damping effects on the oscillation of an object on a spring by allowing it to oscillate in air and different concentrations of Karo syrup. Then, students describe real examples of damping (e.g. a car's suspensions)* **C; CP**
P1204.2-3	**f) Working in pairs students watch a video on the collapse of Tacoma Narrows bridge in 1940. They will initially explain the collapse in terms of frequency and resonant frequency, then they also research and discuss why some physics teachers explain that the bridge collapse "was not a case of resonance" CT; C; IR**
P1204.2-3	**g)** *In small groups, students discuss circumstances in which resonance is desirable and others when it should be avoided. They also research and discuss why only some buildings collapsed (in terms of resonant frequencies) during Mexico earthquake in 1985* **CT; IR**
Electricity and magnetism	
Electric fields and potential	
Standards	

P1205 Explain the properties of uniform electric fields and their interactions with charged particles

P1206 Describe and calculate the effects of charged particles on the space surrounding them

Learning Outcomes
Students should be able to:

P1205.1 Recall and use E=V/d to calculate the field strength of a uniform electric field between charged parallel plates, calculate the forces on charges in uniform electric field, and describe the effect of uniform electric field on the motion of charged particles

P1205.2 Define the electron-volt as the work done on an electron in accelerating it through a p.d. of 1 volt and recall that: $1eV = 1.6 \times 10^{-19}$ J

P1205.3 Solve problems involving electrical potential energy and potential difference

P1206.1 Define and apply coulomb's law relating the force(s) between two or more charged particles in air as $F = kq_1q_2/r^2$

P1206.2 Define the electric field strength due to charged particles as the electrostatic force per unit charge and use the equation: $E = kQ/r^2$

P1206.3 Define electrical potential at a point due to a charged particle as $V = kQ/r^2$

P1206.4 Compare and contrast electric and gravitational fields

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1205.1-3	**a)** *Teacher demonstrates electrostatic electric field lines using seeds in glycerol placed under a high voltage (or let students view a related video). A piezoelectric gas lighter can be used as a safe source of the voltage. Learners will use E = V/d to calculate the field strength of a uniform field between charged parallel plates in the worksheet* **CT; C**
P1205.1-3	**b) In pairs or small groups, students investigate the electric field between two plates by using a charged strip of foil CP, PS**
P1205.2-3	**c)** *Students work on worksheets to solve problems related to a particle accelerator (involving electrical potential energy and potential difference) and use the term electron-volt* **CT; PS**
P1206.1	**d)** *Students demonstrate Coulomb's law experimentally by measuring the separation of two conducting spheres charged to a known potential. Then, students work on worksheets to define the electric field strength*

	of a charged particle and calculate the electric field strength due to charged particles **CT; PS**
P1206.1-3	**e)** *Students work on worksheets to define electrical potential at a point in an electric field and relate electric field strength to potential gradient* **CT; PS**
P1206.4	**f)** *In pairs, students tabulate the similarities and differences between electric and gravitational fields* **CT; C**

Matter and energy

Fluid behaviour

Standards

P1207 Describe how fluids flow

P1208 Explain how effectively the kinetic particle model predicts the behaviour of ideal gases

Learning Outcomes
Students should be able to:

P1207.1 Discuss how the continuity equation and Bernoulli's principle are applicable to fluid flow and give practical examples

P1208.1 Derive and use the gas laws and the ideal gas equation PV = nRT

P1208.2 Show empirically how the ideal gas equation leads to a concept of absolute zero of temperature

P1208.3 Apply the kinetic particle model to an ideal gas and explain, in terms of molecular size and intermolecular forces, how the behaviour of real gases deviates from the ideal model at high pressures and low temperatures

P1208.4 Show that a theoretical treatment of molecular movement and gas pressure leads to the relationship $PV = \frac{1}{3}Nm(\overline{c})^2$ and by combining with the gas equation recognise that the average kinetic energy of a particle due to its motion is proportional to its absolute temperature

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1207.1	**a)** *Students discuss the continuity equation Av = constant that is applicable for the flow of an ideal, incompressible fluid* **CT; C**

P1207.1	**b)** *Students discuss the Bernoulli principle in form $p_1 + ½\rho v_1^2 = p_2 + ½\rho v_2^2$ for a horizontal tube of flow that is incompressible and non-viscous* **CT; CP**
P1207.1	**c)** *Students explain practical examples of Bernoulli effect in everyday applications (e.g., filter pump, Venturi meter, atomisers and the flow of air over an aerofoil)* **CT; C**
P1208.1	**d)** *Students work on worksheets to deduce the meaning of Boyle's (pressure-volume) law, Charles' (volume-temperature) law, and Gay-Lussac's (pressure-temperature) law* **CT; PS**
P1208.1 **P1208.3**	**e) Using a pressure sensor (the PhyPhox app is useful here) students measure the atmospheric pressure near the floor and the ceiling of a room. Then, they watch a video on "The effects of underwater pressure on the body" and discuss problems relating to the changes in temperature, pressure and volume of a gas in both theoretical and real situations (e.g., bubble size in deep water, the volume of gas in a weather balloon)** **CT; IR**
P1208.1	**f)** *Students work on worksheets to derive the ideal gas equation $PV = nRT$. They also show how an extrapolation of Charles's law leads to the theoretical concept of absolute zero of temperature* **CT; PS**
P1208.3	**g) Students research and apply the kinetic particle model to an ideal gas and explain, in terms of molecular size and intermolecular forces, how the behaviour of real gases deviates from the ideal model at high pressures and low temperatures** **CT; IR**
P1208.4	**h)** *Students work on worksheets to show that a theoretical treatment of molecular movement and gas pressure leads to the relationship $PV = ⅓Nm(\bar{c})^2$. They also show that the average kinetic energy of a particle is proportional to its absolute temperature by combining the relationship $PV = ⅓Nm(\bar{c})^2$ with the ideal gas equation* **PS, C**

Fundamentals of thermodynamics

Standards

P1209 Describe the properties of thermodynamic systems

P1210 Explain how the laws of thermodynamics affect thermodynamic systems

Learning Outcomes

Students should be able to:

P1209.1 Explain what is meant by a thermodynamic system and describe the concepts of heat, work and internal energy in the case of an ideal gas

P1209.2 State that the internal energy of a real gas is determined by the state of the system and that it can be expressed as the sum of the kinetic and potential energies associated with the molecules of a system

P1210.1 Use the first law of thermodynamics expressed in terms of the change in internal energy, heating of the system and the work done on the system and use the equation $\Delta U = W + Q$

P1210.2 Explain why the first law of thermodynamics is a statement of the principle of conservation of energy and describe the second law of thermodynamics in terms of entropy change

P1210.3 Calculate work done by a gas expanding against a constant external pressure using $W = -p\Delta V$

P1210.4 State the Kelvin–Planck formulation of the second law of thermodynamics and show how it leads to the imposition of limits to the efficiency of any heat engine that are related to the temperatures of the heat sources and heat sinks

LO References	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1209.1	**a)** *Students work on worksheets to explain what is meant by a thermodynamic system and describe the concepts of heat, work and internal energy in the case of an ideal gas* **C; CP**
P1209.2	**b)** *Students work on worksheets to describe the internal energy of a gas as a state function that is independent of path and recognise that work (or heat) is a path function that is independent of state* **C; CT**
P1209.2 **P1210.1-2**	**c) Students use creative writing to express the internal energy of the real gas as the sum of the kinetic and potential energies associated with the molecules of a system. They can do this by writing, for example, a poem or a play, but the science needs to be consistent with their piece of writing** **CT; C**
P1210.1	**d)** *Demonstrate that pumping a bicycle pump to compress a gas is an (almost) adiabatic process that raises the internal energy of the gas that is compressed, which causes the pump to become warm (IR images of the tube of the pump before and after pumping could be shown). Students work on worksheets to relate heating of a system, Q, to the internal energy of the system, ΔU, and the work done on the system, W.* **CT; PS**
P1210.1-3	**e)** *Students work on worksheets to calculate work done by a gas expanding against a constant external pressure using $W = -p\Delta V$. They recognise that the work done by a gas can be represented by $W = p\Delta V$ if the first law of thermodynamics is expressed as $\Delta U = Q - W$* **CT; PS**

P1210.2	**f)** *Students research and discuss everyday examples of energy changes in terms of changes of entropy. They also discuss how the second law of thermodynamics gives a natural direction to our everyday experiences and cite examples of processes that only happen naturally in one direction (e.g. the decrease heights in the bouncing of a ball, the scattering of a box of matches)* **C; IR**
P1210.4	**g)** *In pairs, students watch a video on the "second law of thermodynamics" and discuss the Kelvin–Planck formulation of the second law of thermodynamics. They should recognise that the Kelvin–Planck formulation is equivalent to Clausius statement of the second law of thermodynamics* **CT; CP**
P1210.4	**h) Students conduct a short research task and design a presentation to show how the maximum theoretical efficiency of a power station is related to the difference between the temperature of the heat source and the temperature of the waste gases emerging from the power station. Similarly, students show how the maximum theoretical efficiency of a car engine can be calculated knowing the temperature of the explosion in the cylinder and the ambient temperature of the cylinder block (the heat sink) IR; PS**

Quantum physics

Standards

P1211 Understand the concept of photons to describe the nature of electromagnetic waves

P1212 Explain that at very small scales physical quantities are quantised

P1213 Explain the significance of the wave-particle duality of matter

Learning Outcomes

Students should be able to:

P1211.1 Describe the particulate nature of electromagnetic radiation; and use the formula E = hf in computations

P1211.2 Explain the photoelectric effect in terms of the particulate nature of electromagnetic radiation and use the equation $hf = E_{k(max)} + \Phi$

P1212.1 Explain atomic spectra and permitted electron orbitals in terms of the quantisation of angular momentum and Bohr model

P1212.2 Describe how emission and absorption spectra are formed (including energy levelλ calculations) and how these can provide information on the elements present in stellar objects

P1212.3 Explain the quantisation of electronic charge as demonstrated, for example, by Millikan's experiment

P1212.4 Describe the production of X-rays, explain its spectrum and discuss its application in medical physics

P1213.1 Describe the wave–particle duality of electrons and how the operation of the cathode-ray tube and the television tube make use of them

P1213.2 Perform calculations using De Broglie's equation for particles and photons: $\lambda = h/p = \lambda /(mv)$

LO References	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
P1211.1	**a)** *Students research the historical development of our understanding of the nature of light and draw a timeline of the main ideas* **IR; C**
P1211.2	**b) In small groups, students design and perform a role play to model Einstein's explanation of the photoelectric effect in terms of the quantisation of light and in terms of threshold frequency and photon energy CT; CP**
P1211.2	**c)** *Students work on worksheets to explain the photoelectric effect in terms of particulate nature of electromagnetic radiation and perform calculations using the photoelectric effect equation* **CT; PS**
P1212.1-2	**d)** Students observe the emission spectra from different lamps (e.g. sodium, magnesium, hydrogen lamps) and explain them in terms of the quantisation of radiation and that the existence of the spectra provides important evidence to support Bohr's model **CT; C**
P1212.2	**e)** *In small groups, students determine the wavelengths of the emission spectra of mercury and iodine using vapour lamps* **CT; PS**
P1212.3	**f) In small groups, students determine the charge to mass ratio of an electron using a fine beam tube (or use a simulation website) CT; PS**
P1212.3	**g)** *In small groups, students will carry out internet research on Millikan's oil drop experiment and discuss (or debate) whether Millikan manipulated his experimental data* **IR; CT**
P1213.1	**h)** *Students watch a video on "wave-particle duality" and discuss whether an electron is both a particle and a wave (or electrons have wave properties and particle properties)* **CT; CP**

P1213.1	**i)** *In pairs, learners will research and discuss the discoveries of Sir Joseph John Thomson (on particle properties of electrons) and his son, Sir George Paget Thomson (on wave properties of electrons)* **IR; CT**
P1213.1	**j)** *Students research and discuss the operation of the cathode-ray tube and explain how the television tube makes use of the cathode-ray tube technology with three electron guns (red, green, and blue) that fire electrons toward a phosphorescent screen* **IR; CT**
P1212.4	**k)** *In pairs, students research how X-rays are produced and describe the production of X-ray spectra including methods of controlling the beam intensity and photon energy in a worksheet. They also work on worksheets to describe the X-ray emission spectrum including the minimum wavelength, and the production of line and background spectra* **IR; PS**
P1212.4	**l)** **Students research the medical uses of X-rays and produce a medical pamphlet to explain the use of high energy X-rays in the treatment of patients (therapy) and low energy X-rays in diagnosis** **IR; C**
P1212.4	**m)** *Students work on worksheets to explain interactions of X-rays with matter (or absorptions) in terms of the photoelectric and Compton effects* **CT; PS**

Possible teaching order

Please note other orders are possible and acceptable

Physics	
Grade 12A	**1** Gravity and circular motion **2** Oscillations and advanced properties of waves **3** Electric fields and potential **4** Fluid behaviour **5** Fundamentals of thermodynamics **6** Quantum physics

10

GENERAL SCIENCE

10

GENERAL SCIENCE

General Science for Grades 11 and 12

This course helps to broaden the curriculum for arts/ humanities students and allows them to reflect on their previous science studies in a wider context. It develops students' scientific literacy and critical thinking skills when reading, writing and talking about science. The strong emphasis on problem-based learning and the consideration of relevant issues makes this a course that allows students to consider aspects of science that may be relevant to their life after formal education ceases. The prime intention of this course is to develop an understanding of the nature of science in Humanities students. It should provide them with a level of scientific literacy – the knowledge and skills that learners need to make sense of the issues related to science and technology that they meet now and will meet in future in their working and adult life.

Many of the learning experiences in this course involve researching information from the internet and students are expected to develop the skills needed to recognise information from an unbiased trustworthy source, to interpret and draw conclusions from data and to recognise uncertainty in results.

Course structure

In **Grade 11** there are two themes: **Medicine** and **Our Fragile Earth.** Each theme has two units of biology, chemistry and physics.

In **Grade 12** there are also two themes: **Sport Science** and **Future Challenges**. Again, each theme has two units each of biology, chemistry and physics.

The overall structure can be summarised as follows:

Grade 11	**Medicine**	**Our fragile earth**
Biology	• Lifestyle and health • Antibiotic resistance and the fight against infectious disease	• Biodiversity and the changing climate • Food sustainability in a changing world
Chemistry	• Drug development • Analysis	• Carbon cycle, greenhouse effect and global warming • Reversing ozone hole and unleaded petrol
Physics	• Waves in diagnosis and treatment • Strength of materials	• Energy resources and energy generation • Natural disasters

Grade 12	Sport science	Future challenges
Biology	• Muscles and genetics • The impact of sport on the body	• Using DNA sequencing and genomics • Biotechnology and GMOs
Chemistry	• Spectroscopy and analysis – the race between cheats and testers • Materials in sports technology	• Biofuels, biomass and carbon sequestering. • The plastic problem
Physics	• Measuring and timing • Forces in different sports	• Nuclear fusion: the future of energy generation? • The next generation of quantum technologies

When they have studied this course, students will be able to:

- recognise the ways in which scientific methods and theories develop over time
- use a variety of concepts and models to develop scientific explanations and understanding
- appreciate the power and limitations of science and considering ethical issues which may arise
- explain every-day and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments
- evaluate risks in the wider societal context, and develop an understanding of the importance of the perception of risk
- recognise the importance of peer review of results and of communication of results to a range of audiences
- present data using appropriate methods
- translate data from one form to another
- carry out and represent mathematical and statistical analysis
- representing distributions of results and making estimations of uncertainty
- interpret data, including identifying patterns and trends, making inferences and drawing conclusions
- present reasoned explanations, including relating data to hypotheses
- be objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error
- communicate the scientific rationale for investigations, including the methods used, the findings and reasoned conclusions, using paper-based and electronic reports and presentations.

- communicate complex scientific ideas to a range of audiences, including a non-scientific audience.

Whilst there are opportunities for experimentation, such activities are not the major focus of these courses, nor is acquiring the knowledge and understanding of the science behind the context. The focus is on understanding the application of the science to the context, and how this may affect life in the world today.

The topics in each area of the General Science curriculum can be taught in the order they appear.

11

GENERAL SCIENCE CONTENT STANDARDS BY GRADE

Grade 11

General science grade 11	
Medicine	
Biology	
Lifestyle and health	
Standards **GB1101:** Explain how lifestyle choices can impact on health and well-being, including obesity, diabetes and heart health **GB1102** Understand the impact of smoking and air pollution on lung health, including lung cancer, Chronic Obstructive Pulmonary Disease (COPD) and asthma	
Learning Outcomes **Students should be able to:** **GB1101.1** Describe the link between diet and obesity and recognise global patterns in obesity, including the high levels of obesity in Qatar **GB1101.2** Discuss the evidence for the relationship between obesity, exercise levels and type 2 diabetes and relate this to ways of reducing levels of type 2 diabetes in Qatar **GB1101.3** Explain the links between obesity, exercise levels and heart disease, including hypertension and atherosclerosis and relate this to ways of reducing levels of heart disease in Qatar **GB1102.1** Understand the effect of smoking and air pollution on lung health, including lung cancer, COPD and asthma. **GB1102.2** Explain ways of improving lung health in Qatar, recognising that smoking is an individual choice but levels of air pollution are a national and international problem	
LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.**

	Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.
GB1101.1	**a)** *Work in pairs. Research information about the link between diet and obesity including the average daily calories needed for an adult man and an adult woman and the use of BMI as a measure of healthy body mass. Make a poster titled 'Obesity: a modern epidemic'.* **CP; C**
GB1101.1	**b) Recall what the term BMI means and discuss briefly the benefits and limitations of using BMI as a measure of obesity (to include ease of use and general application versus misleading measure in some cases for example in very muscular individuals such as athletes. CP**
GB1101.1	**c) Work in pairs or small groups. Research global patterns in obesity using data from your text books, data supplied by your teacher and data from the internet to plan a short news report on the problem of global obesity, and the linked problems of type 2 diabetes and heart disease, with a particular focus on Qatar. As part of this report, produce charts showing the relationship between the obesity levels of a country and the incidence of these diseases. *If time is available students can film their news reports and share them with the class* [https://www.qatarbiobank.org.qa/home]. IR; CP; C**
GB1101.2 **GB1101.3**	**d)** *Work in pairs. Prepare a talk to give to students in Grade 10 on the links between obesity, exercise, type 2 diabetes and heart disease. Produce a slideshow to make your talk as interesting as possible. Use graphs or other data from the internet to provide evidence for the ideas you put forward. Give your talk to another pair of students, or to the whole class.* **CP; C**
GB1101.3	**e) Work in small groups. Half of the group research evidence to show that losing weight and taking exercise reduce the levels of type 2 diabetes in a population and the other half of the group research evidence to show that losing weight and taking exercise reduce the level of heart disease in a population. Use the internet to investigate the level of obesity, type 2 diabetes and heart disease in Qatar and to find out about the organisations working to reduce these levels eg the Qatar National Diabetes Association, the Qatar National Obesity Treatment Centre, Hamad Medical Corporation etc. The groups share data and each individual produces a leaflet or wall poster on how weight loss and exercise can be used to reduce the risk of type 2 diabetes and heart disease in Qatar. *This could include developing healthy dietary plans to accompany the poster*. IR; C**
GB1101.1-3	**f)** *Teacher leads brainstorming session on ways to lose weight and why people often find it very hard to lose weight even when they know obesity is bad for their health. Students produce a concept map to show as many of the ideas expressed as possible.* **CT**

GB1102.1	**g)** *Students discuss the events in an asthma attack with their teacher and research the way the most common asthma treatments (relievers and preventatives) work. Students then produce a flow diagram to show the sequence of events in an untreated asthma attack, after using a reliever and with regular use of a preventative drug.* **C**
GN1102.1	**h)** *Work in pairs. Carry out research into the links between smoking and lung cancer and between smoking and Chronic Obstructive Pulmonary Disease (COPD). As part of this research, look at graphical data showing the links between smoking and these two diseases. Use this information to make an anti-smoking poster to use in your school, including at least one graph on your poster.* **C**
GB1102.1 **GB1102.2**	**i) Work in small groups. Each group investigates one of the following aspects of lung health** • **The symptoms of asthma and how they can be relieved or prevented** • **The main triggers for asthma, focusing particularly on different types of air pollution** • **The links between cigarette smoking and diseases such as lung cancer and COPD.** • **The main symptoms of lung cancer and COPD** • **The incidence of asthma, COPD and lung cancer in Qatar with international comparisons** • **The incidence of smoking and levels of air pollution in Qatar with international comparisons** **Each group reports back to the whole class, using slideshows or other IT to show graphs etc if required. The teacher organises a class discussion on ways of improving lung health in Qatar. Each student then produces a brief report on the problems of lung health in Qatar, showing awareness of the difference between smoking related diseases, where there is personal choice, and problems linked to national and international issues such as air pollution, and suggesting possible ways of reducing the problems CP; C; IR**

Antibiotic resistance and the fight against infectious disease

Standards

GB1103: Describe the development of antibiotic resistance in bacteria and explain the impact of this on human health

GB1104 Explain measures which can reduce the development of antibiotic resistance and discuss some of the problems in developing new antibiotics

Learning Outcomes

Students should be able to:

GB1103.1 Describe antibiotics as important medicines used against bacterial diseases because they destroy bacteria or stop them growing without affecting human cells

GB1103.2 Describe the impact of antibiotics on deaths from infectious diseases since they were first discovered

GB1103.3 Describe how antibiotic resistance develops in bacteria and explain why this is a matter for serious concern globally

GB1104.1 Explain measures which can reduce the development of antibiotic resistance

GB1104.2 Understand some of the problems in developing new antibiotics, both in terms of the scientific challenges and the economic constraints

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GB1103.1	**a) Discuss and make a table to summarise the similarities and differences between disinfectants, antiseptics and antibiotics CT**
GB1103.2	**b)** *Students research the story of the discovery and eventual widespread use of penicillin, the first antibiotic* **IR**
GB1103.2	**c) Work in pairs. Research the impact of antibiotic use on deaths from infectious diseases over time. Discuss the patterns that you see and work as a class to suggest reasons for your observations CP; PS**
GB1103.3	**d) Produce a series of diagrams explaining how antibiotic resistance develops in bacteria with notes on why this process is such a matter for concern C**
GB1103.3	**e)** *Students research World Health Organisation statements about the development of antibiotic resistance and discuss why this is a matter of global concern* **IR**
GB1103.3 **GB1104.1**	**f) Work in pairs. Produce EITHER a short advert OR a poster telling people why antibiotic resistance threatens everyone, explaining what can be done to reduce the development of antibiotic resistance and how individuals can help CP; CT**
GB1104.2	**g)** *Work in pairs. One researches some of the scientific problems in finding and developing new antibiotics. The other researches the economic problems with finding and developing new antibiotics. Students share the information found and write a brief report.* **CP; IR**

Our fragile earth

Biology

Biodiversity and the changing climate

Standards

GB1105 Understand that the climate of the Earth has changed over time and that this affects biodiversity

GB1106 Discuss the evidence for the impact of current anthropogenic climate change on biodiversity [*NB Students will discover causes of and evidence for anthropogenic climate change in Chemistry]*

Learning Outcomes

Students should be able to:

GB1105.1 Describe the evidence for climate-linked changes in biodiversity over time, including peat cores and fossil evidence

GB1106.1 Explain the impact of climate change on abiotic factors in ecosystems including melting sea ice, reduced rainfall, excess rainfall, increasing temperatures

GB1106.2 Explain how changing ecosystems affect biodiversity and evaluate evidence for changing ranges of animals and plants, changing migration patterns and extinction rates

GB1106.3 Discuss the impact of climate change on feeding relationships and explain how this can affect biodiversity

GB1106.4 Suggest ways people can act to reduce climate change and so conserve biodiversity

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GB1105.1	**a) Work in pairs. Produce a poster to show evidence for climate-linked changes in biodiversity over time including i) peat cores which yield pollen from plants that only survive in different types of climate, and ii) fossil records which show remains of organisms which lived in very cold and very hot environments in the same part of the world at different times. Students should show the sources of their information on the posters. IR; C**
GB1106.1	**b)** *Brainstorm the factors which make the scientific evidence in a report on climate change reliable and valid. Work in small groups to Investigate different sources for evidence of climate change. Consider carefully where the evidence in the different reports comes from and have a class discussion about the need to think carefully about sources, using examples from your research as evidence.* **PS**
GB1106.2 **GB1106.3**	**c) Work in small groups. Each group investigates one example of how climate change can affect biodiversity eg changing ranges for animals and plants; changing migration patterns; rising extinction rates; impact of changing populations on feeding relationships etc. Each group produces a short video report, containing as much evidence and as many examples as possible both from Qatar and internationally. Each video is shared with the whole class. CT; CP; C**
GB1106.3	**d)** *Produce diagrams of three food chains from the natural world and annotate each one to show how climate change might impact on the feeding relationships and so affect biodiversity* **CT**
GB1106.4	**e) Use one of the Carbon Footprint Calculators on the net to calculate the carbon emissions produced by the student himself. CP**

GB1106.4	**f) The students investigate and evaluate the measurements taken by the gas and petroleum industries in Qatar to minimize air, water and land pollution. The teacher sets up a class discussion on why biodiversity is important. and how people can act to reduce climate change and so conserve biodiversity. Students then work in pairs to produce leaflets explaining to members of the public the importance of taking action to reduce climate change and maintain biodiversity, including what is already being done in Qatar CP; CT**
GB1106.4	**g)** *Students work in groups to study the main environmental risks to the plants and animals of Qatar and produce a news report to alert the rest of the population to the risks and what can be done.* **CP**

Food sustainability in a changing world

Standards

GB1107 Explain some of the problems in providing food for a growing global population

GB1108 Discuss some of the ways of producing a sustainable food supply

Learning Outcomes

Students should be able to:

GB1107.1 Explain the increasing problems in the global food supply, including the growing human population, the loss of rainforests for raising cattle and growing oil palms, reduced yields due to climate change and extreme weather events, and overfishing

GB1108.1 Describe the benefits and problems caused by the use of artificial fertilisers and pesticides to increase crop yields and reduce losses by pests

GB1108.2 Explain the potential benefits of using biological pest control on global food production

GB1108.3 Define genetic modification and discuss the potential of this technique in a sustainable food supply for the future. [*NB Students will learn more about the techniques and application of genetic modification in Grade 12 so details of the process are NOT required here]*

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GB1107.1	**a) Work in groups. Each group investigates one of the following causes of problems in the global food supply:** • **Growing human population** • **Loss of rainforests for growing beef cattle or oil palms and its impact on global climate** • **Reduced crop yields due to climate change and extreme weather events** • **Overfishing** **Each group reports back to the class on what they have discovered, referencing their source material, leading to a class discussion on these and any other problems in providing a sustainable food supply and the importance of reliable data for making judgements. CP; PS**

GB1108.1	**b) Work in pairs. Use secondary sources – for example the internet – to help in your investigations. One student investigates the benefits of using artificial fertilisers and pesticides to increase crop yields. The other investigates the problems caused by the use of artificial fertilisers and pesticides. The whole class creates a table with different individuals filling in each point. Discuss whether the overall benefits outweigh the problems. Have a class vote to decide whether you would recommend their use or not. PS**
GB1108.2	**c) Brainstorm what students know about biological pest control. Students use secondary sources including the internet to investigate one example of successful biological pest control (for example the use of the moth *Cactoblastis cactorum* to control the cactus *Opunti stricta* (prickly pear cactus) in Australia; the use of the vedalia beetle to control cottony cushion scale (*Icerya purchase)* on citrus plants in California; possible use of bacteria to control leaf spot diseases of the date palm) and one example which has caused problems (for example the use of cane toads to control greyback cane beetles on sugar cane in Australia. Make a poster comparing the benefits and risks of biological pest control with conventional pesticide use as a method of producing a sustainable food supply for the future. IR**
GB1108.3	**d)** *Students use definition of genetic modification as 'Adding, removing or changing one or more of the genes in the genome of an organism to give new, desirable characteristics' and suggest ways in this might be used to provide a sustainable food supply for the future.* **CT**

General science grade 11

Medicine

Chemistry

Drug development

Standards

GC1101 Understand that some drugs can be extracted from natural sources but the pharmaceutical industry needs to synthesise and process a great number of compounds to begin the development process.

GC1102 Consider some of the ethical issues involved in testing and trialling drugs.

Learning Outcomes

Students should be able to:

GC1101.1 List some drugs originally from natural sources and explain the benefits of synthesising them chemically.

GC1101.2 Understand the use of combinatorial chemistry in producing libraries of precursors for the drug development process.

GC1102.1 Explain the ethical issues involved in trialling and testing drugs.

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GC1101.1	**a) The teacher shows an extraction process of a medicine from a plant using video or a virtual laboratory or by demonstration. Students work in groups to research and list a variety of drugs that were originally extracted from natural sources and produce an overarching list as a poster. CP**
GC1101.1	**b) Students, working in pairs, choose a drug and research the main problems in obtaining enough of it in a pure form from natural sources to meet demand.IR**
GC1101.1	**c) The class brainstorms the benefits of synthesising drugs chemically as well as the problems that could be met. C**
GC1101.2	**d) Students estimate the number of compounds required for the initial stage of the drug discovery process, and how these might be produced.IR**
GC1101.2	**e) The teacher introduces the topic of Combinatorial Chemistry as a group of techniques for synthesising large arrays of related**

	chemicals using robot syringes controlled by computers to carry out repetitive processes. These arrays of chemicals called 'libraries' are then screened for potential drug activity. Students watch a video on the technique and then answer a pre-prepared worksheet on Combinatorial Chemistry that is based on the video they have seen. C
GC1102.1	**f) Students are guided by the teacher to debate the ethical issues of using animals in the trials of new medicines and humans in clinical trials. CT**

Analysis

Standards

GC1103 Understand the need for accurate analysis of samples in a wide range of contexts ranging from food safety, manufacturing, to forensic science.

GC1104 Recognise that one technique may not be sufficient to identify and quantify a substance.

Learning Outcomes

Students should be able to:

GC1103.1 Explain why it is important to analyse samples of foodstuffs and materials on a production line quickly and cheaply for quality control.

GC1103.2 Recognise the importance of forensic science in a wide range of contexts.

GC1103.3 Explain the problems of analysing a sample in a forensic context.

GC1104.1 List the main separative and instrumental techniques used in analysis and indicate in simple (laymans) terms the information they provide individually.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GC1103.1	**a) Students research examples in the media, either locally or internationally, of contaminated products and produce a news report. They are then posed the question 'How can these problems be prevented? PS**
GC1103.1	**b) They research the types of analyses required by local requirements for food standards and produce a flow chart/poster showing where checks take place for a product of their choice. C**
GC1103.2	**c) Students work in groups to research where forensic science is used across a range of examples: in civil cases, criminal cases, food and drink industries, medicines, pesticides, drinking water, automobile emissions, chemical and nuclear weapons monitoring etc. C**

GC1103.3	**d) Students consider the types of materials that are analysed in a forensic context after removal from a crime scene using an appropriate protocol and are asked to consider what problems there could be in establishing evidence. CT** *Students attend an awareness lecture from the Forensic Medicine Centre at the Ministry of the Interior or the Faculty of Law, University of Qatar.*
GC1104.1	**e)** *The teacher organises a field trip to the Forensic Laboratory in the Criminal Investigation Department and the students write a field trip report. C*
GC1104.1	**f) Students research the main chromatographic and instrumental techniques (gas chromatography and mass spectrometry) used in analysis and summarise what it is they tell the analyst in laymans terms.IR**
GC1104.1	**g)** *Students work in pairs to carry out simple chromatographic separations and flame tests. CP*

Our fragile earth

Chemistry

Carbon cycle, greenhouse effect and global warming

Standards

GC1105 Understand why human activity can change the climate, interpret given information and make predictions.

GC1106 Understand and make valued judgements on the responses to climate change.

Learning Outcomes

Students should be able to:

GC1105.1 Describe how gases in the air contribute to the greenhouse effect and the feedback processes that arise from them.

GC1105.2 Identify anthropogenic sources of greenhouse gases.

GC1105.3 Use a variety of types of climate record to draw conclusions and make predictions

GC1106.1 Realise the limitations of the models used to both simulate and predict climate change. Suggest reasons why someone might dispute the existence of anthropogenic influences on climate.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GC1105.1	**a) The teacher leads a class discussion to identify what students know about greenhouses gases, what these gases are and their effects and summarises this.**

	The students then represent the flows between the reservoirs of the carbon cycle pictorially. CT
GC1105.1	**b) Students work in pairs to consider the following feedback processes that climate scientists have to consider:** **- temperature and water vapour** **- radiation and clouds** **- ocean circulation** **- ice** **and explain the possible effects of each one in terms of positive and/or negative feedback. C**
GC1105.2	**c) Students identify the greenhouse gases that are added to the air as a direct result of human activity and estimate how potent they are relative to carbon dioxide using a chart by percentage.PS**
GC1105.3	**d) Students are presented with sets of data sourced both locally and internationally. For each one they are asked to draw conclusions and make predictions based on extrapolation of the data sets. CT**
GC1105.3	**e)** *Students work in small groups to produce suggestions for the actions the Qatari government should take to reduce the effects of greenhouse gases.* **PS**
GC1106.1	**f) The teacher introduces the idea that models can be used to simulate and predict climate change by showing an appropriate video or multi-media resource.**
GC1106.1	**g) Students research and consider the limitations of the models used both to simulate climate in the past and predict climate in the future. They should concentrate on the uncertainties and reproducibility of the models and summarise these factors.** **They are asked to prepare an argument as the basis for a script for a television programme to dispute the existence of anthropogenic influences on climate. CP**

Reversing the ozone hole and unleaded petrol

Standards

GC1107 Understand the role of ozone in the atmosphere, the causes of ozone depletion (both natural and anthropogenic), and the regeneration of the ozone hole.

GC1108 Recognise that the beneficial effects of using lead in the automotive industry was followed by the harmful effects of lead pollution in the atmosphere. Recognise how technological changes allowed this to be reversed.

Learning Outcomes

Students should be able to:

GC1107.1 Recognise the role of ozone as a pollutant in the troposphere and as a protection in the stratosphere.

GC1107.2 Describe the ways the ozone layer was depleted both anthropogenically (by CFCs) and naturally (eg by volcanic eruptions).

GC1107.3 Recognise the perceived benefits of chlorofluorocarbons (CFCs) and halons in consumer goods and industry.
GC1107.4 Recognise the need for international agreements to solve the world's problems (eg The Montreal Protocol) and describe how the ozone layer is regenerating as a consequence.
GC1108.1 Describe why tetraethyllead was added to petrol.
GC1108.2 Describe the consequences of this both for humans and for technologies to reduce pollution such as catalytic converters.
GC1108.3 Interpret data on lead levels in the atmosphere as a consequence of the move to unleaded petrol.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GC1107.1	**a) Students research the contrasting roles of ozone contributing to the greenhouse effect in the troposphere and preventing damaging radiation reaching the Earth in the stratosphere and present this as a poster. IR**
GC1107.2	**b) The teacher shows a video of the effect of natural disasters, such as volcanic emissions, which can release substances into the atmosphere to interact with and destroy ozone. The students either summarise these effects or answer a pre-prepared worksheet on this. C**
GC1107.3	**c) Students work in groups using a range of external resources to find out the range of chlorofluorocarbons that used to be used as solvents, as the coolant liquids in refrigerators and in aerosol cans in the second half of the twentieth century. They describe the common features of their chemical structures. IR**
GC1107.3	**d)** *Students work in small groups to describe the work of Mario Molina, including the scientific controversy it provoked, and how CFCs depleted the ozone layer.* **CP**
GC1107.4	**e) Students suggest and debate why Governments, multi-national industries and environmental pressure groups have differing opinions about the need for an agreement such as the Montreal protocol. They report on the evidence for its effect. CT**
GC1108.1	**f) Students watch a video or animation and then describe the basic principle of the internal combustion engine and why tetraethyllead was added to petrol. C**
GC1108.2	**g) Students describe the consequences of adding tetraethyllead to petrol both for humans and for technologies to reduce pollution such as catalytic converters. C**

GC1108.3	**h) Using provided data students describe the effect of the ban on leaded petrol on lead levels in the atmosphere. They research the causes of lead in the atmosphere today.PS**

General science grade 11

Medicine

Physics

Waves in diagnosis and treatment

Standards

GP1101 Understand how different parts of the electromagnetic spectrum are used in medical diagnosis and treatment

GP1102 Explain how mechanical waves (like ultrasounds) are used in medical diagnosis and treatment

Learning Outcomes

Students should be able to:

GP1101.1 List the different regions of the electromagnetic spectrum and explain that as the wavelength decreases the frequency (hence their energy) increases

GP1101.2 Describe the health and safety issues linked with exposure of humans to different electromagnetic waves

GP1101.3 Describe a range of uses of electromagnetic waves for medical diagnosis, including x-rays photography and X-ray sources inside the body. Discuss the benefits and risks of using these diagnostic techniques

GP1101.4 Describe a range of uses of electromagnetic waves for medical treatment, including laser eye surgery, ultraviolet treatment of severe acne and X-ray treatment of cancer. Discuss the benefits and risks of using these treatments

GP1102.1 Explain that ultrasound scans analyse the echoes of ultrasound waves emitted by a transmitter and received by a receiver to form an image of organs and tissues inside the human body

GP1102.2 Describe the use of ultrasounds in the treatment of kidney stones

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GP1101.1	**a)** *Teacher demonstrates how energy increases for EM waves of increasing frequency by drawing lines on a fluorescent sheet using LEDs of different colours* **C**
GP1101.1-4	**b) In small groups, students research the different regions of the EM spectrum and prepare a pamphlet or display on their uses in medicine and associated risks IR; C**

GP1101.3	**c)** *In pairs or small groups, students design a simulation of X-rays to diagnose broken bones using a range of materials, e.g. UV discharge tube and fluorescent tube, graphite crayons and cut out shapes…* **CT; CP**
GP1102.1	**d)** *Students analyse simple oscilloscope traces to calculate the distance between two obstacles inside a body, knowing the time delay between emitted and received signals.* **PS**
GP1102.1	**e) Using a box, wooden skewers and shapes inside the box, students work in small group to build a model of how the known distance travelled by the ultrasound signal echoing inside the womb can be used to form an image of a baby on a screen. PS; CT**
GP1102.2	**f)** *Students write a short account of how ultrasound waves of the right frequency cause kidney stones to resonate until they disintegrate.* **IR; C**

Strength of materials

Standards

GP1103 Explain the relevance of Young modulus in determining the strength of different materials

GP1104 Explain why artificial materials replacing human bones are not as effective as real bones

Learning Outcomes

Students should be able to:

GP1103.1 Define the concept of tensile stress and tensile strain applied to different materials

GP1103.2 Determine the Young modulus of different materials experimentally and through calculations, using E = Stress/Strain

GP1103.3 Explain that the Young modulus of a material is related to its strength as it measures how easily a material can be deformed (i.e. its stiffness)

GP1104.1 Compare the Young modulus of different materials with that of human bones

GP1104.2 Describe the structure of human bones and the importance of calcium in maintaining their strength

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GP1103.1-3	**a)** *Students complete worksheets to calculate the tensile stress and strain, as well as the Young modulus of different materials.* **PS**

GP1103.2-3	**b) In small groups, students complete practical tasks to determine and compare the Young modulus of wires of different materials. CP**
GP1104.1-2	**c) In small groups, students investigate the Young modulus of chicken bones (or other animals) and compare it with other materials studied. Then, completely immerse the chicken bones in vinegar for a week to see and investigate the effects of removing calcium from the bones. CT; PS**
GP1104.1-2	**d)** *In pairs, students research the structure and Young modulus of human bones and compare it with other materials to suggest the most suitable material for bone replacement in humans.* **IR; C**

Our fragile earth

Physics

Energy resources and energy generation

Standards

GP1105 Understand the importance of energy resources for generating the energy needed by the world's population

GP1106 Describe the difference between renewable and non-renewable energy resources and explain their advantages and disadvantages

GP1107 Define the relationship between energy and power as Power (W) = Energy (J)/time (s) and use it to calculate the power and energy output for different power stations

Learning Outcomes

Students should be able to:

GP1105.1 Recall different types of energy resources and explain that all the energy supplied to our planet ultimately comes from the sun

GP1105.2 Describe the process of energy generation in different power stations, e.g. burning fossil fuels to produce steam which spins a turbine coupled to a generator

GP1106.1 Describe the difference between renewable and non-renewable energy resources

GP1106.2 Explain the advantages and disadvantages of the main energy resources, including: solar, wind and geothermal power, as well as, fossil and nuclear fuels

GP1107.1 Describe the power output of a range of power stations and perform calculations to compare costs and benefits of each

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GP1105.1 **GP1106.1-2**	**a) In small groups, students research different types of energy resources (one type for each group) and produce a news report to present their energy resource to the rest of the class. Then, they evaluate each other's presentations by assessing the validity of the sources used by different groups to present their reports. IR; C**

GP1105.2	**b) In small groups, students design and build a simple model power station, e.g. a wind turbine, using simple equipment and recycled materials. CT; CP**
GP1106.1-2 **GP1107.1**	**c)** *Students complete worksheets to answer questions about renewable and non-renewable energy resources, including power calculations to compare costs and benefits of different power stations.* PS
Natural disasters	
Standards **GP1108** Understand how convection currents can lead to the formation of hurricanes and tornadoes **GP1109** Explain how seismic waves are formed and the dangers associated with them	
Learning Outcomes **Students should be able to:** **GP1108.1** Explain how convection currents are formed in fluids by the movement of hotter and cooler regions within the fluid **GP1108.2** Describe how sea currents (like the Gulf Current) are formed by convection and how the rising of the oceans' temperature could threaten their balance **GP1108.3** Explain how hurricanes and tornadoes are formed as a result of strong convection currents in the atmosphere **GP1109.1** Explain that the movement of tectonic plates can form seismic waves that could cause catastrophic earthquakes **GP1109.2** Describe how the detection of primary and secondary seismic waves from different stations around the earth has enabled scientists to understand the internal structure of the earth **GP1109.3** Describe the formation of tsunamis from the displacement of water in the ocean caused by tectonic plates movement	
LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GP1108.1	**a)** *By mixing water dyed with food colouring and of different temperature, the teacher demonstrates how convection currents occur.* **C; CP**
GP1108.2	**b)** *Using a range of resource students explain, with diagrams and prose, why onshore and offshore winds are common at different times of the day.* **IR; C**
GP1108.2	**c) In pairs or small groups, students research sea currents and how they form. Then, they simulate these currents with food colouring (or other substances like potassium permanganate) and a heat source like a Bunsen Burner, including simulating the effects of the rise of ocean temperatures. CT; CP**

GP1108.3	**d)** *The teacher demonstrates how tornado-like flames can be generated by a flame spinning inside a metal bin mesh. Then, students research the causes of hurricanes and tornadoes and produce a fact sheet to explain the dangers and precautions needed in affected areas.* **IR; C**
GP1109.1	**e) In pairs students produce a short, narrated video showing the effects of primary and secondary seismic waves on model buildings they built out of wooden coffee stirrers. The models could be placed on a vibrating plate to simulate Primary and Secondary waves. C; CP**
GP1109.2	**f)** *Students complete worksheets to describe the structure of the earth by considering seismic waves received by different seismic stations around the world.* **PS; CT**
GP1109.3	**g)** *Students research the causes of tsunamis and produce a presentation on their formation and dangers to people and their economy.* **IR; C**

Grade 12

General science grade 12

Sport science

Biology

Muscles and genetics

Standards

GB1201 Understand the principles of muscle contraction, including actin and myosin and the build- up of lactic acid during anaerobic respiration

GB1202 Describe the difference in slow and fast twitch muscle fibres, their heritability and explain the impact this has on sporting abilities

Learning Outcomes

Students should be able to:

GB1201.1 Describe the action of antagonistic pairs of muscles in moving the bones of the legs and arms

GB1201.2 Describe simply the interactions of actin, myosin, ATP and calcium ions in bringing about muscle contraction

GB1201.3 Explain the process of anaerobic respiration in muscles and describe its effect on muscle performance

GB1202.1 Describe slow and fast twitch muscle fibres and explain the impact of the balance of these fibres on innate sporting ability

GB1202.2 Describe a simple Mendelian model of how characteristics such as the proportions of slow and fast twitch muscle fibres are inherited

GB1202.3 Discuss the role of nature (genetics) and nurture (environmental factors such as diet and training) on sporting achievement

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GB1201.1 **GB1201.2**	**a)** *Make a series of annotated diagrams to show how the biceps and triceps (antagonistic muscles) move the bones of the lower arm up and down.* **C** **b) Make a simple model or an animation to demonstrate how actin and myosin interact with ATP and calcium ions to bring about muscle contraction** **CT**

GB1201.3	**c)** *Interpret a graph showing the build-up of lactic acid in a muscle during exercise and the oxygen debt required to remove it from the system, and annotate the graph to identify what is happening at each stage* **PS**
GB1202.1	**d) Students work in pairs using the internet to investigate the characteristics of fast and slow twitch muscle fibres and film a short report on how the distribution of these fibres can affect sporting ability, using examples of well-known sporting figures from Qatar and internationally. CP; CT**
GB1202.1-2	**e) Work in pairs to produce a simple model to explain how a feature such as the proportion of fast and slow twitch fibres can be inherited. Students use their model repeatedly to show the way different children from the same family may have different combinations of slow and fast twitch muscle fibres. (Students may want to research the inheritance of the ACTN3 gene to help with their ideas). CP; PS**
GB1202.3	**f)** *Set up a class debate titled 'Great athletes are born, not made' in which students discuss the relative importance of nature and nurture on sporting achievement.* **CT; C**

The impact of sport on the body

Standards

GB1203 Explain the effect of sport training on the lungs, the blood and the heart, and evaluate the benefits of training at altitude and the potential problems caused by the use of erythropoietin (EPO).

GB1204 Understand the potential benefits and long-term damage of sport training on the skeletal system

Learning Outcomes

Students should be able to:

GB1203.1 Explain, with reference to reliable evidence, the effect of training on the lungs (increased capacity and surface area, increased number of capillaries), the blood (increased number of red blood cells and increased haemoglobin levels) and the heart (larger capacity, stronger pumping, reduced resting heart rate and blood pressure)

GB1203.2 Evaluate the benefits of training at altitude on the lungs, blood and heart, with reference to populations born at altitude

GB1203.3 Describe the effect of the illegal use of erythropoietin (EPO) in athletes, why it is difficult to detect and the potential benefits to the athlete and the health risks

GB1204.1 Describe the long-term benefits to the skeletal system of sporting activities such as running, football and gymnastics in terms of bone and muscle strength

GB1204.2 Explain the changes in a synovial joint as it becomes arthritic as a result of overtraining, excess road running etc, and recognise these same changes can occur through age, long-term obesity etc

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.**

	Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.
GB1203.1	**a) Work in pairs. Produce a leaflet to summarise the main impact and benefits of sports training at any level on the lungs, the blood and the heart. C**
GB1203.2/ GB1203.3	**b) Work in groups. Some groups research why elite athletes in many sports, from football to athletics, train at altitude [consider as a minimum: lung and heart capacity, blood supply to lungs, natural erythropoietin (EPO) levels and red blood cell count; reference populations born at altitude] Other groups research the use of EPO as an illegal drug in athletes, how it affects red blood cell count, how it can mimic altitude training, why it is difficult to detect and potential risks to the athlete (especially too many red blood cells and thickened blood). Groups get together to discuss their findings and make a news report considering why altitude training is legal for elite athletes and the use of EPO is not. CP; CT; C**
GB1204.1	**c) Research on the internet for evidence on the impact of sporting activities such as running, football and gymnastics on bone and muscle strength and make a table to show which types of sporting activities give the most benefits to the skeletal system. Discuss what makes a reliable site with information you can trust. IR**
GB1204.2	**d) Produce a poster titled 'Healthy joints for life' showing a normal synovial joint and an arthritic joint, along with warnings about the dangers of excessive training, road running and obesity and ways to protect your joints when exercising. IR; C**
GB1203 1-3 GB1204.1-2	**e)** *Organize a visit to Aspire Academy laboratories specializing in biomechanics, physiology, haematology and biochemistry which uses world-class sports science equipment. Write a report about the level of support they give to the coaches and student athletes.* **CP**

Future challenges

Biology

Using DNA sequencing and genomics

Standards

GB1205 Understand how our ability to sequence DNA and read genomes has changed over time and continues to change (*Details of DNA sequencing techniques are NOT required*)

GB1206 Discuss some of the ways information from DNA sequencing and genomics can be used including understanding of genetic causes of diseases, improved cancer treatment and stem cell therapies

Learning Outcomes

Students should be able to:

GB1205.1 Recognise how DNA sequencing has developed over time and is becoming faster, cheaper and more available all the time

GB1206.1 Explain how DNA sequencing has revolutionised our understanding of both single gene diseases such as thalassemia, and problems such as heart disease which has many genetic risk factors

GB1206.2 Describe how DNA sequencing of tumours is revolutionising cancer treatments

GB1206.3 Describe different types of stem cell therapies and discuss some of the ethical issues involved.

GB1206.4 Explain the importance of using DNA sequencing to help us understand the genetic switches which produce specialised cells for the future success of stem cell therapies

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GB1205.1	**a) Research and produce a timeline highlighting the main developments in DNA sequencing highlighting the increasing speed and reducing cost of sequencing and the major international genome projects IR; C**
GB1206.1	**b) Work in small groups. Research the Qatar Genome Programme and plan a video to explain this exciting project to other students in the school. They should explain what the project involves and how the knowledge gained will be used to improve health and wellbeing in Qatar in the future, using diagrams and models where appropriate. Students can use the web site** http://qatargenome.org.qa **to help in their research. CP; IR; C**
GB1206.1	**c)** *Work in pairs. Make a table comparing the Qatar Genome Programme with the original Human Genome Project* **IR**
GB1206.2	**d)** *Produce a flow diagram to explain how genome sequencing of tumours throughout different treatments could potentially improve the success rate in treating cancers.* **CT**
GB1206.3 **GB1206.4**	**e) Work in small groups to research different types of stem cell therapies and the practical and ethical issues involved in these new technologies. Each group researches one aspect of stem cell therapy and produces a poster on their own aspect of stem cell biology, resulting in a class display highlighting many of the potential benefits and perceived potential problems of stem cell research and medicine. Areas for research include:** • **What is a stem cell?** • **Traditional use of stem cells in medicine – bone marrow transplants** • **The advantages and disadvantages of using pluripotent stem cells in therapies** • **The advantages and disadvantages of using adult stem cells in therapies** • **The production of iPSCs (induced pluripotent stem cells) and their potential benefits in medicine**

	• **Ethical issues for and against research into the use of different types of stem cells in medicine.** • **The potential importance of using DNA sequencing to identify genetic switches in stem cell research and medicine CP; IR; C**
GB1206.3 **Gb1206.4**	**f)** *Students may use online access to Virginia cord-blood bank in Qatar to discuss possible advances in stem cell use.* **IR**
Biotechnology and GMOs	
Standards **GB1207** Describe the basic process of genetic modification and recognise the development of new technologies **GB1208** Explain some of the ways in which genetically modified organisms (GMOs) are being used including the production of medicines, food production and bioremediation and evaluate some of the perceived benefits and risks	
Learning Outcomes **Students should be able to:** **GB1207.1** Describe simply the basic process of genetic modification and recognise that newer, more accurate and cheaper ways of genetic modification are being developed all the time. **GB1208.1** Discuss the benefits of using genetically modified microorganisms in the production of human medicines such as insulin and clotting factors for haemophiliacs **GB1208.2** Describe some of the ways genetically modified plants are being used including the role of transgenic plants in reducing the need for agrichemicals such as pesticides, in producing high yields of food crops in changing environmental conditions (eg drought resistance, flood resistance) and in the bioremediation of contaminated land **GB1208.3** Discuss some of the potential benefits and perceived risks of using GMOs and evaluate some of the evidence	
LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GB1207.1 **GB1208.1**	**a) Make a model to demonstrate a simple model of the process of genetic engineering to insert a gene for the manufacture of human insulin into the DNA of a bacterium. Use materials such as paper, modelling clay, scissors etc. CT** **b) Write an illustrated report on the use of genetically modified organisms in the production of large quantities of human medicines including insulin, and clotting factors for haemophiliacs and growth hormone. Include an explanation of the advantages of these techniques in their report. C**

GB1208.2	**c) The class works in three groups. Each group carries out research and produces a poster or short video to explain the use of genetically modified (transgenic) plants in one of three ways:** • **the use of genetically modified (transgenic) plants in reducing the need for agrichemicals such as pesticides** • **the development of transgenic plants adapted to produce high yields in difficult conditions such as droughts and floods** • **the use of transgenic plants in bioremediation, removing heavy metal and other contamination from the soil** **Each group presents their findings to the rest of the class. CP; CT; C**
GB1208.2 **GB1208.3**	**d)** *Scientists have developed some transgenic crops which contain extra nutrients. Students investigate the development of golden rice and write a short article arguing for* OR *against the use of such GM crops* **C**
GB1208.3	**e) Students each prepare a two-minute speech either for OR against the use of GMOs, giving evidence to support their argument where possible. Equal numbers of students speak on both sides of the debate before the teacher opens up a class discussion, ending with a vote to show whether students feel the benefits outweigh the risks or not. IR; C**
GB1207.1 **GB1208.1-3**	**f)** *Use modelling or card games which are available online to simulate genetic modification.* **CT**

General science grade 12

Sport science

Chemistry

Spectroscopy and analysis – the race between cheats and testers

Standards

GC1201 Recognise the different types of performance enhancing drugs (stimulants, narcotic analgesics, anabolic agents, diuretics, peptide hormones (EPO), blood doping and beta blockers) and describe their effects.

GC1202 Appreciate the importance of both testing for very small amounts of unnatural substances and determining what are normal levels for both natural substances and approved medications in the body and the need for international standards.

Learning Outcomes

Students should be able to:

GC1201.1 List the different types of performance enhancing drugs (PED).

GC1201.2 Describe the different effects on performance of each type of PED and any negative impacts they may have.

GC1202.1 Describe the ways testing is carried out and how a synthetic chemical can be distinguished from one naturally produced in the body.

GC1202.2 Recognise that international rules are needed with reference to The World Anti-Doping Agency (WADA).

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning***
GC1201.1 **GC1201.2**	**a) The teacher introduces the topic in an open discussion about the enhancement of performance in sport and the ways it can be achieved. Students work in pairs to research and list the different types and give examples of performance enhancing drugs (PEDs) – stimulants, narcotic analgesics, anabolic agents, diuretics, peptide hormones (EPO), blood doping and beta blockers. Students should realise there are non-anabolic steroids that may be prescribed to athletes.** C **b) In the same pairs they then match the PED to the positive effect it has on the body for an athlete.** *Students could use the media to identify athletes found guilty of taking each category of PED and report back to the class.* **In the same pairs they should identify any negative**

	impacts on the body of the category of PED they are studying and report back to the class.PS
GC1202.1	**c) Students research and produce a leaflet aimed at athletes of the drug test procedure from collection of the sample to analysis for both urine and blood. Students then describe how urine is tested using gas chromatography and mass spectrometry. (Immunoassay is not required).C**
GC1202.1	**d)** *The teacher organises a field trip to the Aspetar Hospital (the first specialised Orthopaedic and Sports Medicine Hospital in the Gulf region) to show students the procedures used, and students write a report on their visit.* **CP; C**
GC1202.1	**e)** *Students can work in pairs to carry out an experiment to simulate this kind of testing using paper chromatography of a mixture of complex chemicals such as chlorophyll, xanthophylls, anthocyan and carotene.IR*
GC1202.2	**f) Students consider how to test for doping by naturally occurring chemicals and work in small groups to produce case studies on eg blood doping, the use of testosterone, the use of EPO etc. CP**
GC1202.2	**g) Students consider the reasons why international doping rules are needed and the ethical concerns of state sponsored doping.IR**

Materials in sports technology

Standards

GC1203 Understand how improvements in a wide range of materials enhance performance in sport for both elite sportspeople and recreational participants.

GC1204 Recognise the importance of composite materials with a focus on sport.

Learning Outcomes

Students should be able to:

GC1203.1 Research the applications of new materials in a range of sports and identify the main factor that contributes to their use.

GC1204.1 Understand the reasons for using composite materials eg Kevlar and carbon fibre in sport and describe the features of their structures that make them suitable for the particular use.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning***
GC1203.1	**a) Students work in pairs to identify the sports where new materials are in use, what the material is, and the advantages that are gained. The class then pool their results into types of materials and see if there is any commonality in the advantages gained. CP**
GC1203.1	**b) Students research the reasons for using composite materials in terms of the enhancement of the properties of their components. C**

GC1203.1	**c)** *Students can make a simple composite using flour, water and fabric strips.* **CP**
GC1203.1	**d) Students work in pairs to explain what composite materials are and how they are formed. They use an animation or video to describe how thermoset resins crosslink and explain why they cannot be converted back to their original liquid form and that a variety of fibres can be embedded in them.PS**
GC1204.1	**e) Students use either Kevlar or carbon fibre as an exemplar to research where they are used in a particular sport, what advantages over the materials previously used this gives in participating in the sport, and what features of the structure are most important for this purpose. They present their results as an advertisement for the product.IR**

Future challenges

Chemistry

Biofuels, biomass and carbon sequestering

Standards

GC1205 Understand how biofuels and biomass as a feedstock may be partial solutions to the world's reliance on fossil fuels and that there may be cleaner fossil fuels awaiting economic viability

GC1206 Understand that limiting carbon dioxide production is not a solution to increasing levels in the atmosphere, but efforts must be made to remove it.

Learning Outcomes

Students should be able to:

GC1205.1 Identify the main kinds of biomass feedstocks and explain the factors mitigating against their use.

GC1205.2 Compare and contrast ethanol use and biodiesel use in terms of sources of raw materials and amount of carbon dioxide produced.

GC1205.3 Consider the advantages and disadvantages of using methane hydrates as a fuel.

GC1206.1 Recognise the three main carbon dioxide storage reservoirs (the oceans, geologic, and mineral carbonation)

GC1206.2 Evaluate the pros and cons of each method.

LO reference	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning***
GC1205.1	**a) Students use a video or animation to research and define biomass and consider factors such as location, available area, destruction of**

	habitats in an evaluation of their use. They then consider biomass use in Qatar and debate whether it should be expanded. CT
GC1205.2	**b) Students consider two biofuels produced from biomass and compare and contrast ethanol use and biodiesel use in terms of sources of raw materials and amount of carbon dioxide produced. They explain how their comparison of amount of carbon dioxide produced is a fair one. PS**
GC1205.3	**c) Students research what methane hydrates are, what their structure is and the conditions under which they can exist. They consider the advantages of using them as a fuel particularly in terms of the hydrogen to carbon ratio and the amount of carbon dioxide produced relative to other hydrocarbon fuels. They then consider the disadvantages of methane hydrates.IR**
GC1206.1	**d) Students work in small groups to research one of the three main carbon dioxide storage reservoirs (the oceans, geologic, and mineral carbonation) in terms of their ability to be used in carbon capture and sequestration from sources such as power plants and other industrial facilities. CP**
GC1206.2	**e) In the same groups they evaluate the potential of the chosen method to mitigate climate change and the costs associated with the technique and report back to the class using a presentation technique of their choice. CP**
GC1206.2	**f)** *Students work in pairs to carry out the mentos/lemonade or similar experiment to model the effect of the deep oceans releasing vast amounts of carbon dioxide. The students take a bottle of a carbonated drink such as lemonade and add to it a material with lots of nucleation sites (mentos mints, salt, sand etc). There will be a violent eruption of carbon dioxide and liquid so care needs to be taken to carry this out in an appropriate area such as outside.* **CP**

The plastic problem

Standards

GC1207 Understand the problems associated with our use of disposable plastic articles particularly in the oceans and the need to replace them with reusable, recyclable and biodegradable materials.

GC1208 Consider other viable solutions to the use of plastics.

Learning Outcomes

Students should be able to:

GC1207.1 Understand that many plastics can be recycled, or the chemicals recovered or energy recovered by being burnt.

GC1207.2 Describe the particular problems associated with plastics accumulating in the ocean.

GC1207.3 Understand why some plastics are biodegradable.

GC1208.1 Suggest alternatives to the use of plastics.

LO reference	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning***
GC1207.1	**a) The teacher introduces the idea of Life Cycle Assessment and draws students' attention to appropriate resources on this. Students then work in pairs to consider the Life Cycle Assessment from the cradle to the graves of a synthetic polymer with a focus on the possible graves (recycling, recovering the chemicals, recovering the energy and landfill). They research the problems associated with each of recycling, recovering the chemicals, recovering the energy and landfill and produce a presentation showing these problems. IR**
GC1207.2	**b) In the same pairs students research the particular problems of plastic waste ending up in the oceans either deliberately or accidentally in terms of the sizes of the waste, where it ends up, and the effect on marine life. They present their results as a poster or leaflet aimed at the general public. CP**
GC1207.2	**c)** *The teacher organises a field trip to an appropriate environmental organisation such as Friends of the Environment Centre, Environment Science Centre in the University of Qatar or invites a speaker to lecture on these issues.* **CP**
GC1207.3	**d) Students research the types of biodegradable plastics, what breaks them down and the conditions required for this. They then consider whether the conditions found in the oceans would make biodegradable plastics break down. PS**
GC1208.1	**e) Students are given an open-ended brief to suggest criteria for alternatives to the use of plastics such as cost, ease of recycling, biodegradability etc. In a plenary they produce a definitive list of criteria by consensus. CT**

General science grade 12

Sport science

Physics

Measuring and timing

Standards

GP1201 Understand how to measure distances and time intervals accurately and precisely

GP1202 Describe and represent how the motion of athletes changes during sporting activities

Learning Outcomes

Students should be able to:

GP1201.1 Recall that the average reaction time of a person is 0.6 s and describe ways to measure the reaction time of different athletes

GP1201.2 Explain why electronic systems to measure time are needed to record accurate and precise times in sporting events

GP1201.3 Describe different methods to measure distances in different sports

GP1202.1 Use the equation Average Speed (m/s) = Distance travelled (m) / Time taken (s) to calculate the average speed of athletes in different sport disciplines

GP1202.2 Interpret and plot distance-time and speed-time graphs from given data to describe the motion of athletes in different sporting events

LO references	Learning Experiences **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GP1201.1-2	**a) In pairs, students investigate their reaction times using a range of methods and online resources. Then, they compare different methods to assess their validity and explain why humans' reaction time is not reliable enough for timing sporting events. C; PS**
GP1201.1-3 GP1202.1	**b)** *In small groups, students use the most appropriate method to measure distance travelled and time to calculate the average speed in different sports, e.g. a student running 100m, a football kicked across a field…* **PS; CP**
GP1202.1	**c)** *Students complete worksheets to perform calculations of speed, time and distance travelled in different sports situations.* **PS**
GP1202.2	**d)** *In pairs students act D-T and V-T graphs given to them by moving in the way described by the graphs.* **CT; CP**

GP1202.2	**e) Students research data on various races (e.g. 100m race) to plot distance-time graphs for different athletes. Then, they describe the graph as the story (or commentary) of the race for these athletes. CT; IR**

Forces in different sports

Standards

GP1203 Understand how Newton's laws of motion are applied in different sports

GP1204 Understand how frictional forces affect positively and negatively the performance of athletes in different sports

Learning Outcomes

Students should be able to:

GP1203.1 State Newton's three laws of motion

GP1203.2 Apply Newton's laws of motion to a range of actions and objects involved in sport, e.g. a tennis ball flying over a net

GP1204.1 Describe the negative effects of frictional forces in various sports, e.g. air resistance in cycling, and suggest ways to reduce them to maximise performance

GP1204.2 Describe sporting equipment and situations where increased friction is desirable and suggest ways to improve it, e.g. the surface of a goalkeeper's gloves

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GP1203.1-2	**a) In small groups, students choose a sporting activity to research and analyse in order to produce a presentation showing how Newton's laws apply, e.g. drawing free body diagrams on different stages of an athlete performing a long jump. IR; CT**
GP1204.1-2	**b) In small groups, students choose a sporting activity to research and analyse. Then, design clothing and/or equipment features to reduce friction where it is unwanted (e.g. a cyclist's helmet) and to improve friction where it is desirable (shoes for a runner). PS; CP**

Future challenges

Physics

Nuclear fusion: the future of energy generation

Standards

GP1205 Explain the difference between nuclear fission and fusion

GP1206 Understand the benefits and risks in developing sustainable nuclear fusion

Learning Outcomes
Students should be able to:

GP1205.1 Describe the process of nuclear fission as the splitting of a heavy nucleus into two smaller nuclei and the release of two-three neutrons and energy

GP1205.2 Explain that the further fission of nuclei caused by the absorption of fission neutrons can initiate a chain reaction and the need to control this chain reaction in nuclear fission power stations

GP1205.3 Describe the process of nuclear fusion as the merging (fusion) of two light nuclei to form a heavier nucleus and the release of large amounts of energy

GP1206.1 Describe the study of nuclear fusion at experimental facilities like the Joint European Torus (JET) in Oxford and discuss the challenges in developing fully functioning fusion power stations

GP1206.2 Explain the advantages and disadvantages of developing nuclear fusion power stations in the future

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GP1205.1-3	**a) In small groups, students develop a role play that could be used with younger pupils to describe the process of nuclear fission (including chain reactions) and nuclear fusion. Different groups enact each other's role plays to assess their accuracy as a teaching model. CT; CP**
GP1206.1-2	**b) Students research current development in nuclear fusion research and produce a short documentary on nuclear fusion. In their research students need to demonstrate they have considered a range of sources of information and how they assessed their validity. IR; CT**

The next generation of quantum technologies

Standards

GP1207 Describe the process of 'laser cooling' to harness the quantum properties of matter in quantum sensors

GP1208 Explain the importance of accurate and very precise time keeping in GPS satellites

GP1209 Describe the importance of developing quantum encryption protocols to keep data secure

Learning Outcomes
Students should be able to:

GP1207.1 Describe the wave-particle duality of light and define the photon as a packet (or particle) of electromagnetic radiation

GP1207.2 Describe qualitatively the process of 'laser cooling' as the slowing down of atoms through the transfer of the momentum of laser photons to the atoms from a minimum of 4 perpendicular directions

GP1207.3 Explain that slowing atoms so that they are almost still is important in quantum sensors to be able to detect the quantum behaviour of atoms, hence take very accurate and precise measurements

GP1208.1 Recall that current GPS positioning achieves accuracies of roughly 10 m radius and that new generation atomic clocks on GPS satellites will enable accuracies of about 30 cm radius

GP1208.2 Explain and model how GPS satellites enable a GPS receiver to find its position on the earth through the process of trilateration

GP1209.1 Describe qualitatively the threat posed by the development of quantum computers to traditional encryption protocols, like the RSA public key distribution

GP1209.2 Describe qualitatively how quantum key distribution enables secure communications to be established between a sender and a receiver

LO references	**Learning Experiences** **All students should be provided with the learning opportunities stated in bold.** ***Statements in italics provide additional opportunities which may be used to develop competencies, provide extension and support learning.***
GP1207.1	**a)** *Students research and discuss the quantum properties of light, such as its wave-particle duality.* **IR; CP**
GP1207.2-3	**b) In pairs, students produce a short comic strip to describe qualitatively the process of 'laser cooling' in quantum sensors. CT; C**
GP1208.1-2	**c) Students research GPS positioning and develop a role play, or a worksheet to simulate how four GPS satellites communicate with a receiver to enable it to find its position. IR; PS**
GP1209.1-2	**d)** *Students research qualitatively new developments in quantum computers and quantum key distribution. Then, write a short story where quantum key distribution is used to prevent a national threat.* **IR; C**

12
ANNEXES

Annex 1

SI units in science

The International System of Units (Système International d'Unités), which is abbreviated SI, is a coherent system of seven base units, two supplementary units, and an unlimited number of derived units (eighteen of which have special names).

Base units

These units and their associated quantities are dimensionally independent.

metre
Unit symbol: **m**
kilogram
Unit symbol: **kg**
second
Unit symbol: **s**
ampere
Unit symbol: **A**
kelvin
Unit symbol: **K**
mole
Unit symbol: **mol**
candela
Unit symbol: **cd**

Supplementary units

radian
Unit symbol: **rad**
steradian
Unit symbol: **sr**

Some derived units with special names

Frequency hertz Hz
Force newton N
Energy joule J
Power watt W
Pressure pascal Pa
Electric charge coulomb C
Electric potential difference volt V
Electric resistance ohm Ω
Activity (of a radioactive source; nuclear transformations per unit time) Becquerel Bq
Absorbed dose (of ionizing radiation) gray Gy
Dose equivalent (of ionizing radiation) sievert SV

Annex 2

The Learning Experiences and Scientific Enquiry

Teachers will need to make decisions on the amount of guidance they provide to their students when they are engaged in a scientific enquiry.
The level of their understanding and application of the ideas of scientific enquiry will depend on their age and ability. Through their teaching of the subject content teachers should endeavour to develop and progress the scientific attitudes listed as 1 to 4 below.
1.At the beginning of their study of Science students should start to develop scientific attitudes by

- asking simple questions and recognising that they can be answered in different ways
- observing closely, using simple equipment
- performing simple tests
- identifying and classifying
- using their observations and ideas to suggest answers to questions
- gathering and recording data to help in answering questions.

2.As they progress this develops into

- asking relevant questions and using different types of scientific enquiries to answer them
- setting up simple practical enquiries, comparative and fair tests
- making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers
- gathering, recording, classifying and presenting data in a variety of ways to help in answering questions
- recording findings using simple scientific language, drawings, labelled diagrams, keys, bar charts, and tables
- reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions
- using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions
- identifying differences, similarities or changes related to simple scientific ideas and processes
- using straightforward scientific evidence to answer questions or to support their findings.

These methods, processes and skills develop through

- planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary
- taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate
- recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs

- using test results to make predictions to set up further comparative and fair tests
- reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and a degree of trust in results, in oral and written forms such as displays and other presentations
- identifying scientific evidence that has been used to support or refute ideas or arguments

3.As they develop and move on into secondary education students should be taught to further develop their scientific attitudes by

- paying attention to objectivity and concern for accuracy, precision, repeatability and reproducibility
- understanding that scientific methods and theories develop as earlier explanations are modified to take account of new evidence and ideas, together with the importance of publishing results and peer review
- evaluating risks.

They should also be taught to acquire the following experimental skills when carrying out an investigation. They should

- ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
- make predictions using scientific knowledge and understanding
- select, plan and carry out the most appropriate types of scientific enquiries to test predictions, including identifying independent, dependent and control variables
- use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety
- make and record observations and measurements using a range of methods for different investigations; and evaluate the reliability of methods and suggest possible improvements
- apply sampling techniques.

When making measurements they should

- understand and use SI units and IUPAC (International Union of Pure and Applied Chemistry) chemical nomenclature
- use and derive simple equations and carry out appropriate calculations
- undertake basic data analysis including simple statistical techniques.

They should be taught the following skills of analysis and evaluation

- applying mathematical concepts and calculate results
- presenting observations and data using appropriate methods, including tables and graphs
- interpreting observations and data, including identifying patterns and using observations, measurements and data to draw conclusions
- presenting reasoned explanations, including explaining data in relation to predictions and hypotheses
- evaluating data, showing awareness of potential sources of random and systematic error
- identifying further questions arising from their results.

4.Towards the end of their scientific education students should have developed understanding and first-hand experience of:

1. The development of scientific thinking

- the ways in which scientific methods and theories develop over time
- using a variety of concepts and models to develop scientific explanations and understanding
- appreciating the power and limitations of science and considering ethical issues which may arise
- explaining every day and technological applications of science; evaluating associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments
- evaluating risks both in practical science and the wider societal context, including perception of risk
- recognising the importance of peer review of results and of communication of results to a range of audiences

2. Experimental skills and strategies

- using scientific theories and explanations to develop hypotheses
- planning experiments to make observations, test hypotheses or explore phenomena
- applying a knowledge of a range of techniques, apparatus, and materials to select those appropriate both for fieldwork and for experiments
- carrying out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations
- recognising when to apply a knowledge of sampling techniques to ensure any samples collected are representative
- making and recording observations and measurements using a range of apparatus and methods
- evaluating methods and suggesting possible improvements and further investigations

3. Analysis and evaluation

- applying the cycle of collecting, presenting and analysing data, including:
  - presenting observations and other data using appropriate methods
  - translating data from one form to another
  - carrying out and representing mathematical and statistical analysis
  - representing distributions of results and making estimations of uncertainty
  - interpreting observations and other data, including identifying patterns and trends, making inferences and drawing conclusions
  - presenting reasoned explanations, including relating data to hypotheses
  - being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error

- communicating the scientific rationale for investigations, including the methods used, the findings and reasoned conclusions, using paper-based and electronic reports and presentations

4. Vocabulary, units, symbols and nomenclature

- developing their use of scientific vocabulary and nomenclature
- recognising the importance of scientific quantities and understanding how they are determined
- using SI units and IUPAC chemical nomenclature unless inappropriate
- using prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano)
- interconverting units
- using an appropriate number of significant figures in calculations

Annex 3
Glossary of Bloom's Action Verbs

Account	Describe using words.
Analyze	Identify the parts of objects, information or processes, and the patterns and relationships between these parts.
Apply	Use an idea, equation, principle, theory or law in relation to a given problem or issue.
Appreciate	Recognise the value of a concept or situation.
Assess	Weigh and give consideration.
Become aware	Recognise or realise of the facts or knowledge.
Calculate	Compute or work out mathematically a numerical answer.
Classify	Group objects or events based on common characteristics.
Compare and contrast	Identify the similarities and differences between two or more objects, concepts or processes.
Construct	Make something by putting a set of components together, based on a given plan
Deduce	Reach a conclusion from the information given.
Define	Give the precise meaning of a word, phrase, concept or physical quantity.
Demonstrate	Make clear by reasoning or evidence, illustrating with examples or practical application. Perform a simple activity to illustrate a concept, idea or object.
Derive	Manipulate a mathematical relationship to give a new equation or relationship.
Describe	State in words (using diagrams where appropriate) the main points of a topic
Design a fair-test experiment/investigation	Plan an experiment or investigation identifying the independent (manipulated), dependent (responding) and controlled variables.
Determine	Obtain by calculation or find out by performing an experiment or investigation.
Develop	Build up the meaning or idea or concept.
Devise	Produce a plan, simulation or model.

Differentiate	Identify the differences between objects, concepts or processes
Discuss	Reflect on and explore a topic in speech or writing.
Distinguish	Identify and understand the differences between objects, concepts and processes.
Draw	Represent by means of a labelled, accurate diagram or graph, using a pencil.
Establish	Make known the facts or knowledge.
Estimate	Make an approximation.
Evaluate	Assess the reasonableness, accuracy and quality of information, processes or ideas, and the quality and feasibility of objects.
Examine	Make a study of the situation or context or conditions; investigate situation or context or conditions by doing an experiment.
Explain	Give a detailed account including reasons or causes
Explore	Make an initial study or investigation of the possibilities.
Express	State the meaning, equation or formula.
Generate	Give other examples or possibilities.
Give examples	Provide or identify examples of organisms, materials, and processes that possess certain specified characteristics; and clarify statements of facts or concepts with appropriate examples.
Identify	Select and/or name the object, event, concept or process.
Illustrate	Show by using a diagram or a demonstration.
Induce	Make conclusion based on experimental or investigation data or many similar events.
Infer	Draw a conclusion based on observations.
Interpret	Use knowledge of science concepts to give meaning to relevant textual, tabular, pictorial, and graphical information.
Introduce	Give the term, language used, meaning, equation or formula.
Investigate	Find out by carrying out experiments.
Know	Comprehend the term, language used, meaning, equation or formula; translate information from one form to another, explain information and apply information

Label	Add descriptive information to a diagram.
List	Give a number of points or items without elaboration.
Make	Use the equation or formula; construct a model, object or meaning.
Manipulate	Control an object in order to explore and discover its behaviour
Measure	Obtain a reading from a suitable measuring instrument.
Name	List out the characteristics, examples, applications, or identities.
Observe	Obtain information through the use of the senses.
Outline	Give a brief description of the main points.
Perform	Conduct or carry out a demonstration or experiment.
Plot	Mark the position of points on a diagram.
Predict	Make an educated guess.
Realise	Recall and become aware the facts, knowledge or meaning.
Recall	Remember facts, characteristics or concepts that are critical to the understanding of a situation, event, process or phenomenon.
Recognise	Identify facts, characteristics or concepts that are critical to the understanding of a situation, event, process or phenomenon.
Recount	Describe by remembering the fact, knowledge or details.
Relate	Identify and explain the relationships between objects, concepts or processes.
Represent	Show using descriptive words, diagram, equation, formula, flowchart, table of data or graph.
Resolve	Break down into components or details.
Show an awareness	Have a superficial knowledge of the concepts or processes.
Show an understanding	Recall information (facts, concepts, models, data), translate information from one form to another, explain information and apply information.
Sketch	Draw a simple, freehand diagram.
Solve	Obtain the answer(s) using algebraic and/or numerical and/or graphical methods
State	Give a specific name, value or other brief answer without explanation or calculation.

Study	Examine the situation, context, solution or meaning; can carry out an experiment to examine.
Suggest	Apply their general knowledge to provide responses.
Test	Find out by carrying out a demonstration or experiment to verify.
Trace	Follow and draw a path.
Understand	Recall information (facts, concepts, models, data), translate information from one form to another, explain information and apply information
Use	Use a diagram or other model to demonstrate knowledge of science concepts, to illustrate a process cycle relationship, or system, or equations or formulae to find solutions to science problems.

Annex 4
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