Science standards

Grade 11

Foundation level

Summary of students' performance by the end of Grade 11

Scientific enquiry

Students identify, develop and make predictions related to a clearly focused research question. They control variables, work as a team and use appropriate equipment and materials. They evaluate experimental design, identify weaknesses and develop realistic strategies for improvement. They work in an ethical manner. They understand the historical development of major ideas, through the evolution of competing models, and know that science can generate controversies, which they take part in. They record and process raw data appropriately and draw valid conclusions, allowing for errors and uncertainties. They handle equipment competently with due regard for safety. They follow instructions accurately but are able to adapt to unforeseen circumstances.

Biology

Students describe the structural features of mitochondria and how these relate to the chemical processes of respiration. They understand the mechanisms of diffusion, osmosis and active transport, and relate these processes to the fluid mosaic model of a cell membrane. They know that ATP is the immediate energy source in cellular processes and relate this to respiration. They outline the reaction steps in the glycolysis, Krebs cycle and oxidative phosphorylation stages of respiration. They explain why multicellular animals need a transport system for respiratory gases, water, food and waste, and describe the structure and function of the human circulatory system. They describe the features of the gaseous exchange system and relate these to function. They differentiate between tidal volume and lung capacity. They understand relationships between pulse rate and exercise and the importance of blood pressure. They understand the links between smoking and impairment of the gaseous exchange and cardiovascular systems. They know the nature of asthma, bronchitis, emphysema and lung cancer and how they affect the efficiency of gaseous exchange. They know the nature of homologous chromosomes. They describe mitosis and meiosis and recognise the chromosome configurations in different stages. They understand how mitosis enables a constant number of chromosomes to be passed from cell to cell while meiosis enables a constant number to be passed from generation to generation. They know the difference between genes and alleles and that they are sections of DNA. They understand that a changes in DNA bases cause variation. They know causes of mutation. They understand that a mutation causes a change in DNA and that this can reduce the efficiency or block an enzyme. They know that species are clustered into groups. They know about the hierarchy of classification and the key features of the kingdoms and main phyla of animals and plants. They understand that interactions between organisms can cause changes in the size of populations. They understand that ecosystems are dynamic and subject to change, and that

human activities have an impact on the environment. They recognise the main features of viruses, bacteria and fungi. They know how micro-organisms and cells can be cultured.

Chemistry

Students know the processes for manufacturing ammonia, nitric acid and sulfuric acid, and the chemistry behind the limestone industry. They know the origins of metallic properties and that metals vary in reactivity in a manner linked to their position in the periodic table. They know how useful properties of metals can be designed into alloys. They know that reactions are accompanied by energy changes and that endothermic changes are associated with bond breaking and exothermic ones with bond making. They know and use the concepts of enthalpy of reaction and activation energy. They know that oxidation and reduction reactions are associated with gain or loss of electrons and explain redox reactions in terms of change in oxidation number. They know that transition metals are important redox reagents because they exhibit multiple oxidation states. Students have an understanding of the general chemistry of alkanes, alkenes, halogenoalkanes, alcohols, aldhehydes, ketones, carboxylic acids, esters, acyl chlorides, amines, nitriles, amides and amino acids. They know that the main sources of organic compounds are fossil fuels and living materials. They understand the importance of alkanes as fuels.

Physics

Students state Newton's laws of motion and use them to solve problems of motion in two dimensions. They distinguish between mass and weight, know that momentum is conserved during collisions and apply the knowledge to collisions and explosions in one dimension. They determine the centre of gravity of a lamina and apply the principle of moments to real problems. They define and measure temperature and know how thermal energy moves from place to place. They know that heat is transferred by conduction, convection and radiation and can give examples of each. They know that some substances are better conductors than others, that convection currents are the basis of weather patterns and that some surfaces radiate and absorb heat better than others. They use the concepts of specific heat capacity and specific latent heat to calculate heat transferred to bodies. They know that light travels in straight lines and how it is reflected and refracted; they are aware of some of the applications of these properties. They understand dispersion and recognise some of its natural consequences, and know how the eye receives and focuses light. Students know that an electric current is a stream of charged particles and solve problems related to current and potential difference. They use capacitors in real circuits and use thermistors, diodes, transistors and light-dependent resistors as potential dividers to drive gates in logic circuits. They know how astable and bistable switches can be used in memory circuits.

Assessment weightings for Grade 11

There are three general assessment objectives for the science curriculum:

- knowledge and understanding;
- application of knowledge and understanding, analysis and evaluation of information;
- scientific enquiry skills and procedures.

The science standards for Grade 11, foundation level, are grouped into four strands: three subject content strands – biology, chemistry and physics – and the scientific enquiry skills strand, which addresses the development of scientific practical and intellectual skills across all the content strands. The teaching and the assessment of the scientific enquiry skills strand should be carried out as an integral part of the teaching of the content strands.

For Grade 11, foundation level, each of the three subject content strands – biology, chemistry and physics – carries an equal weighting.

For Grade 11, foundation level, the weightings of the assessment objectives to be applied to each content strand are as follows:

	Knowledge and understanding	**Application, analysis and evaluation**	**Scientific enquiry skills and procedures**
Assessment weighting	45 to 55%	25 to 35%	20 to 25%

Science standards

Grade 11

Foundation level

Scientific enquiry

Key standards

Key standards are shown in shaded rectangles, e.g. 1.3.

Examples of learning exercises

The examples of active learning exercises shown in italics are intended to be illustrative and do not represent the full range of possible exercises.

By the end of Grade 11, students identify, develop and make predictions related to a clearly focused research question. They control variables, work as a team and use appropriate equipment and materials. They evaluate experimental design, identify weaknesses and develop realistic strategies for improvement. They work in an ethical manner. They understand the historical development of major ideas, through the evolution of competing models, and know that science can generate controversies, which they take part in. They record and process raw data appropriately and draw valid conclusions, allowing for errors and uncertainties. They handle equipment competently with due regard for safety. They follow instructions accurately but are able to adapt to unforeseen circumstances.

Students should:

1 Use methods of scientific investigation

1.1 Identify and develop a clearly focused research question.

Research to determine if there is a link between heart rate and body size.

Compare the tar content of different brands of cigarette.

Investigate whether the number of chromosomes an organism has is linked to characteristics such as body size or sensitivity.

Determine the percentage of sodium bicarbonate in a sample of baking powder.

Investigate the effect of different concentrations of sulfur dioxide on growing plants.

Design an experiment to show that the time taken by a object to drop is independent of its mass under conditions of negligible air resistance.

Design experiments to measure the power output of a muscle under varying conditions.

Compare the insulating properties of different roof materials and structures.

Demonstrate that infrared radiation is reflected and refracted in the same way as light.

1.2 Make predictions directly related to a research question.

Predict relationships between lung capacity and body size.

Predict whether heat will be reflected and refracted in the same way as light.

Predict the output a given logic circuit.

1.3 Identify and control variables.

Investigate the effect of exercise on the heart rates of people of different size.

Investigate the effect of different concentrations of sulfur dioxide on growing plants.

Design experiments to measure the power output of a muscle under varying conditions.

1.4 Work constructively and adaptively with others as a team on a scientific investigation.

Form teams to carry out a field study of seashore plants.

Work as a class to compare the power output of muscles.

1.5 Evaluate experimental design, identify weaknesses and develop realistic strategies for improvement.

Devise a way of determining the impact of humans on a selected habitat.

Develop an effective way of making soap by traditional methods.

Devise an effective way to compare fairly the insulating properties of different materials.

1.6 Work in an ethical manner with regard to acknowledging data sources and authenticity of results.

Interview people about their smoking habitats and present the data in a newspaper article.

Obtain information on fertiliser use over time from the Internet.

1.7 Work in an ethical manner with regard to living things and the environment.

Develop ethical guidelines to be followed when doing biological fieldwork.

1.8 Identify, and make critical use of, secondary information.

Consult reports to compare the levels of lung cancer in Qatar and neighbouring countries.

Obtain information on fertiliser use over time from the Internet.

Study material related to the Chernobyl explosion.

2 Know how scientists work

2.1 Understand the historical development of the major scientific ideas.

Find out how we have come to our present understanding of the human blood system.

Study the development of the understanding of mutations.

Study the quest for an artificial nitrogenous fertiliser in agriculture.

Study the development of our understanding of the phenomenon of radioactivity.

Study the development of our understanding of the nature of the electron.

2.2 Know that many scientific topics are controversial, causing debates both between scientists and also among the general public, and be able to take part in such debates in an informed manner.

Research and debate different explanations for the increased numbers of people with asthma.

Present evidence related to the possible effects of passive smoking.

Debate the use of renewable versus fossil fuels.

Debate the desirability of increasing our use of nuclear energy.

2.3 Know that scientists work by building conceptual models that can be tested by experiment, and realise the value of controversy around competing models.

Find out why the Krebs cycle is so named.

Study the development of competing models of atomic structure and chemical bonding.

Study the development of our understanding of the nature of the electron, from a wave to a particle to wave–particle duality.

3 Process and communicate information

3.1 Record raw data appropriately in a manner that allows easy interpretation.

Prepare charts to illustrate differences in tidal volume and lung capacity and whether this differs with chest size.

Use graphical extrapolation to show absolute zero.

Use multiflash photography to illustrate the acceleration of a falling ball.

3.2 Process raw data by the most appropriate means.

Use graphs to depict changes in heart rate over time.

Draw conclusions on the half-life of radioisotopes using a graphical method.

3.3 Draw valid conclusions, allowing for errors and uncertainties.

Understand the importance of multiple readings of radioactive disintegrations to arrive at a statistical average.

3.4 Use an appropriate range of methods to communicate scientific information.

Write a magazine article aimed at alerting young people to the health risks of smoking.

Use models to show organic molecular structures.

Use flow charts to show industrial processes.

4 Handle equipment and make measurements

4.1 Select and use correctly and competently the appropriate equipment and materials for an investigation, with due regard for the safety of self and others.

Use a spirometer to measure lung capacity and tidal volume.

Use an oscilloscope to study alternating current and induced voltages.

Carry out work with radioactive materials safely.

4.2 Follow instructions accurately but be able to adapt to unforeseen circumstances.

Biology

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gaseous exchange system and relate these to function. They differentiate between tidal volume and lung capacity. They understand relationships between pulse rate and exercise and the importance of blood pressure. They understand the links between smoking and impairment of the gaseous exchange and cardiovascular systems. They know the nature of asthma, bronchitis, emphysema and lung cancer and how they affect the efficiency of gaseous exchange. They know the nature of homologous chromosomes. They describe mitosis and meiosis and recognise the chromosome configurations in different stages. They understand how mitosis enables a constant number of chromosomes to be passed from cell to cell while meiosis enables a constant number to be passed from generation to generation. They know the difference between genes and alleles and that they are sections of DNA. They understand that a changes in DNA bases cause variation. They know causes of mutation. They understand that a mutation causes a change in DNA and that this can reduce the efficiency or block an enzyme. They know that species are clustered into groups. They know about the hierarchy of classification and the key features of the kingdoms and main phyla of animals and plants. They understand that interactions between organisms can cause changes in the size of populations. They understand that ecosystems are dynamic and subject to change, and that human activities have an impact on the environment. They recognise the main features of viruses, bacteria and fungi. They know how micro-organisms and cells can be cultured.

Students should:

5 Link biological structures to their functions

5.1 Describe the structure of mitochondria and relate this to the biochemical reactions of respiration.

Study electron microscope pictures of cell structures.

Make a model of a mitochondrian.

5.2 Explain the structure and functioning of the fluid mosaic model of the cell membrane in relation to the properties of phospholipids and the mechanisms of diffusion, osmosis and active transport.

Study diagrammatic and physical models.

Use visking tubing to model the osmosis of water through a semi-permeable membrane.

6 Know the stages in the biochemistry of aerobic respiration

6.1. Describe the role of ATP as the universal energy currency in all living organisms and relate this to respiration.

6.2. Describe the reaction steps in the three stages of aerobic respiration (glycolysis, Krebs cycle and oxidative phosphorylation), including the roles of oxygen and ATP.

Make a wall chart to illustrate the reactions in aerobic respiration.

Use the library and the Internet to find out about the work of Hans Krebs.

ICT opportunity

Use the Internet to gather information.

7 Know about the human blood system as an example of a transport system in a multicellular animal

7.1 Explain why large animals need transport systems for respiratory gases, water, food and waste in terms of their surface to volume ratio.

Construct cubes of different sizes and calculate their surface to volume ratios.

Investigate the time taken for a drop of coloured dye to diffuse completely in different volumes of water.

7.2 Describe the external and internal structure of the heart. Relate features to functions in pumping blood round the body and maintaining separation of oxygenated and deoxygenated blood.

Dissect a heart or study a model.

Find out about artificial heart valves.

Watch and discuss a video of heart action.

ICT opportunity

Use video for illustration.

7.3 Know how the heartbeat is initiated and maintained, and describe the cardiac cycle.

Measure heart rate.

Study charts of heart rate.

Use the library and the Internet to find out how a heart pacemaker works.

ICT opportunity

Use the Internet to gather information.

7.4 Know that the human blood system is a double closed system and know the names, locations and roles of the major blood vessels.

Study charts of the human blood system.

Play a card game in which the names of blood vessels have to be matched with the organs they are attached to.

Use the library and the Internet to investigate claims for the first description of the human blood system.

ICT opportunity

Use the Internet to gather information.

7.5 Differentiate between arteries, veins and capillaries in terms of wall thickness and valves, and relate their structure to their function.

Use a microscope to observe and draw cross-sections through arteries, veins and capillaries.

7.6 Know that red blood cells carry oxygen.

Use a microscope to observe and draw red blood cells.

Determine the number of red cells in various volumes of blood.

Use a video clip to observe the changes in colour of oxygenated and deoxygenated blood.

ICT opportunity

Use video for illustration.

8 Understand the importance of an efficient gaseous exchange system

8.1 Explain the structure, anatomy and function of the human lungs and related structures for gaseous exchange and the muscle and skeletal systems that enable breathing.

Examine lungs obtained from a butchery.

Study a model of the human torso and lungs.

Make a simple model of the chest and lungs to show how the lungs inflate and deflate.

8.2 Differentiate between tidal volume and vital capacity of the lungs.

Measure tidal volume and lung capacity.

Calculate the volume of air exchanged in an hour.

8.3 Describe the effects of tar and carcinogens in tobacco smoke on the gaseous exchange system and the cardiovascular system.

Use a smoking machine to illustrate the tar content of cigarettes.

8.4 Describe the symptoms of chronic bronchitis, emphysema, asthma and lung cancer and their effects of on the gaseous exchange system.

Collect and display pictures and diagrams of healthy and diseased lungs.

Find out the incidence of lung cancer in Qatar and other countries.

9 Understand the importance of blood pressure and pulse rate as indicators of health

9.1 Explain blood pressure and factors that affect it.

Ask a nurse or a doctor to demonstrate how blood pressure is measured and recorded.

9.2 Explain pulse rate and the effect of exercise on the pulse rate of fit and unfit individuals.

Measure resting pulse rate and the time taken for it to be re-established following exercise.

10 Understand mitotic and meiotic cell division

10.1 Explain the significance of organisms having a set of homologous chromosomes

Use drawings or photographs of chromosomes to match homologous pairs.

10.2 Recognise and describe the behaviour of chromosomes during mitosis and explain how this enables a constant number of chromosomes to be passed from cell to cell.

View a video of mitosis.

Arrange photographs of stages of mitosis into sequence.

ICT opportunity

Use video for illustration.

10.3 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.

View a video of meiosis.

Arrange photographs of stages of meiosis into sequence.

ICT opportunity

Use video for illustration.

11 Understand genetic inheritance

11.1 Know that a base sequence in a location on DNA forms a gene and that different functional base sequences at that location form alleles of that gene; know that differences in the base sequences of DNA of the individuals of a species result in variation.

Make a model of DNA with base sequences.

11.2 Know some causes of mutation and that a mutation is a change in the base sequence of DNA that can lead to changes in protein structure, which in turn can reduce the efficiency of or block an enzyme action.

Given a series of triplet DNA base codes, use a chart of base codes for amino acids and determine which triplets code for amino acids and which are nonsense codes.

12 Understand how organisms are classified and know the key features of the major groups

12.1 Understand the term *species*, know that species can be placed in groups with shared features, and that the groupings of kingdom, phylum, class, order, genus and species form a hierarchy of classification.

Use keys to classify organisms.

12.2 Know the distinguishing features of the five kingdoms: Prokaryotae, Fungi, Protoctista, Plantae and Animalia.

Use specimens, models, photographs and drawings to illustrate examples of organisms from each of the kingdoms.

Make a wall display to illustrate the different kingdoms.

12.3 Use knowledge of the key features of the major phyla of animals and plants to recognise a typical member.

Use specimens, models, photographs and drawings to classify organisms.

Make a photographic record of local members of selected phyla.

13 Understand ecological relationships and population dynamics

13.1 Explain examples of a predator–prey relationship and the possible effects on the population size of both the predator and the prey.

Analyse and interpret population curves of predator and prey.

Use a computer simulation to investigate how changes in predator numbers affect the population of their prey and consequently the predator population itself.

ICT opportunity

Use a computer simulation to investigate a dynamic relationship.

13.2 Explain examples of inter- and intra-specific competition for food and space and the effects on the distribution and size of the populations of organisms.

Use video to study how animals defend their territory against members of their species.

ICT opportunity

Use video for illustration.

Analyse records of the increase in numbers of invading species of plants (e.g. water weed) and animals (e.g. crown of thorns).

13.3 Explain how disease affects the size of population of organisms and the significance of limiting factors in determining the ultimate size of a population.

Examine case studies of population data, discuss possible causes for population changes and compare interpretations with those of the scientists who investigated the populations.

13.4 Explain how the diversity and numbers of organisms and the environmental factors in an ecosystem form a dynamic relationship that is open to disruption.

Analyse and interpret population curves of a predator and its prey.

Use a computer simulation to investigate how changes in predator numbers affect the population of its prey and consequently the predator population itself.

ICT opportunity

Use a computer simulation to investigate a dynamic relationship.

13.5 Explain examples of short- and long-term human impact on a variety of environments.

Study pictures of a range of environments taken at different times and determine the human impact.

14 Understand the form and culture of micro-organisms

14.1 Know the basic distinguishing features of viruses and types of bacteria and microbial fungi.

Study microscope slides or photographs of different forms of bacteria.

Use electron microscope photographs to study the morphology of viruses.

14.2 Know methods for the laboratory and bulk culture of micro-organisms and cell lines.

Use the Internet to determine how micro-organisms are grown in bulk.

Grow colonies of micro-organisms on agar slopes and Petri plates.

ICT opportunity

Use the Internet to gather information.

Chemistry

By the end of Grade 11, students know the processes for manufacturing ammonia, nitric acid and sulfuric acid, and the chemistry behind the limestone industry. They know the origins of metallic properties and that metals vary in reactivity in a manner linked to their position in the periodic table. They know how useful properties of metals can be designed into alloys. They know that reactions are accompanied by energy changes and that endothermic changes are associated with bond breaking and exothermic ones with bond making. They know and use the concepts of enthalpy of reaction and activation energy. They know that oxidation and reduction reactions are associated with gain or loss of electrons and explain redox reactions in terms of change in oxidation number. They know that transition metals are important redox reagents because they exhibit multiple oxidation states. Students have an understanding of the general chemistry of alkanes, alkenes, halogenoalkanes, alcohols, aldhehydes, ketones, carboxylic acids, esters, acyl chlorides, amines, nitriles, amides and amino acids. They know that the main sources of organic compounds are fossil fuels and living materials. They understand the importance of alkanes as fuels.

Students should:

15 Understand the principles behind some of the industrial processes that we use to obtain pure chemicals

15.1 Know the essential details of the Haber process for making ammonia from nitrogen.

Study the history of the development of the Haber process using images from the Internet.

ICT opportunity

Obtain information from the Internet.

15.2 Know the essential details of the commercial oxidation of ammonia to nitric acid and of the main commercial uses of nitric acid.

Draw a flow chart showing the essential reactions of the Haber process and the subsequent oxidation of ammonia to nitric acid. Illustrate with images from the Internet.

ICT opportunity

Obtain information from the Internet.

15.3 Understand the industrial importance of ammonia and nitrogen compounds derived from ammonia and nitric acid.

Represent graphically, using statistics from the Internet or elsewhere, the growth in worldwide production and use of nitrogenous fertilisers since the Haber process was invented.

Summarise, using a flow chart, the industrial uses of ammonia and nitric acid.

15.4 Know that the Qatar natural gas field is also a source of sulfur and that this has consequences for the processes that exploit the gas.

Obtain statistics on the sulfur content of Qatar gas as part of an industrial visit and find out what is done with the sulfur extracted.

15.5 Know the essential details of the contact process for manufacturing sulfuric acid and understand the industrial importance of sulfuric acid.

Demonstrate the production of sulfur trioxide (solid) in the laboratory.

Prepare an illustrated flow chart showing the production and use of sulfuric acid using information and graphics from the Internet or elsewhere.

ICT opportunity

Obtain information from the Internet.

15.6 Know that limestone is a source of many important agricultural and industrial chemicals and describe the conversion of limestone into quicklime and slaked lime.

Make and test quicklime and slaked lime in the laboratory. Make limewater with the slaked lime made and test it.

Show the many uses for limestone and its derivatives in a flow chart or an HTML presentation.

ICT opportunity

Download information and images from the Internet; use HTML.

15.7 Describe the manufacture of cement and know how changes at the molecular level that take place during the setting of concrete give it its strength and durability.

Make a variety of concrete bricks using identical moulds, using different mixes and setting conditions. Devise investigations for testing the blocks for tensile strength, hardness, etc.

16 Know the important properties of metals and how these can be modified by the formation of alloys

16.1 Know that metals can be arranged in order of reactivity according to their reaction with agents such as air, water and acids, and that this order is related to their position in the periodic table.

Selectively revisit work done on metal reactions and the reactivity series in earlier grades. Investigate additional characteristics (e.g. the thermal stability of carbonates and nitrates) Predict the properties of a less common metal (e.g. nickel) from its position in the series and carry out investigations to test the predictions.

Account for the anomalous unreactivity of aluminium, given its position in the reactivity series.

16.2 List a number of alloys, including the common forms of steel, and their uses, and compare their properties with those of the metals from which they are made.

Tabulate the properties and uses of some common alloys with the help of information from sites on the Internet. Note specifically the importance of alloys of aluminium.

ICT opportunity

Use the Internet as an information source.

16.3 Explain, in terms of particle theory, why alloys are often much harder and more rigid than the pure metal from which they are predominantly made.

Download and study applets showing how the presence of foreign atoms in a metal lattice can affect its physical properties.

ICT opportunity

Use applets to illustrate a concept.

17 Understand reaction energetics

17.1 Know 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.

Investigate exothermic and endothermic reactions. Suitable exothermic reactions are neutralisations and suitable endothermic reactions are those that involve the production of gases (e.g. the reaction between potassium carbonate or bicarbonate and hydrochloric acid).

17.2 Construct reaction energy profiles showing enthalpy changes in the reaction and activation energy.

Show similar examples where the heat produced by the reaction is sufficient to sustain it (e.g. the combustion of magnesium) and those where it is not (e.g. the oxidation of copper).

17.3 Know that a catalyst can provide an alternative energy profile with a lower activation energy.

Demonstrate and discuss the energy profile of a reaction such as the combustion of hydrogen with and without the presence of a platinum catalyst or the decomposition of hydrogen peroxide in the presence of manganese dioxide or dust as a catalyst

Safety

Take appropriate care over the use of hydrogen and hydrogen peroxide solution.

17.4 Explain and use the concept of standard enthalpy change (ΔH), with particular reference to combustion, formation, solution and neutralisation, and calculate enthalpy changes from experimental results.

Measure experimentally some standard enthalpy changes (e.g. combustion and neutralisation).

Use the relationship $\Delta H = (mc_p\Delta T)/n$, where $(mc_p\Delta T)$ represents the heat produced from the reactions and absorbed by an appropriate medium, such as water, of specific heat capacity c_p.

Compare the heat energy released during the burning of different fuels; calculate the molar enthalpies of the reactions.

17.5 Recognise that bond breaking is associated with endothermic changes and bond formation is associated with exothermic changes.

18 Understand redox reactions

18.1 Explain oxidation and reduction in terms of gain or loss of oxygen and in terms of electron transfer.

Investigate a number of common redox reactions, identifying starting materials and products. Show the electron transfer process for each reaction.

18.2 Explain redox reactions in terms of change in oxidation number.

Further analyse the reactions in Standard 18.1 to show changes in oxidation number.

18.3 Know that variable oxidation number is an important feature of transition metal chemistry and explain it in terms of the elements' electronic structures.

Carry out redox reactions involving transition metal compounds (e.g. iron salts, potassium manganate(VII)). Deduce the changes in oxidation number from the equations.

18.4 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-cell reactions.

Measure the initial e.m.f. of cells made from a variety of half-cells and deduce an order of half-cell potential.

Write ionic equations for the half-cell reactions.

18.5 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. Calculate a standard cell potential by combining two standard electrode potentials.

Demonstrate the action of a standard hydrogen electrode.

18.6 Know the half-cell reactions of everyday cells, such as the dry cell and the accumulator.

Make and test a model accumulator.

18.7 Describe the function of a fuel cell with particular reference to the hydrogen–oxygen cell.

Find information on the current state of fuel-cell research and application and discuss the future of the fuel cell.

18.8 Be aware of the need to recycle modern rechargeable batteries, such as those in computers and cellular telephones, because of the poisonous heavy metals they contain (e.g. mercury and cadmium).

Set up a used-battery collection point in school.

18.9 Know and use the concept of the faraday (96 500 coulombs) as a mole of electrons.

Determine the magnitude of a faraday by the electrolysis of molten lead bromide.

Calculate the quantity of charge passed during electrolysis and the mass, or volume, of substance liberated during electrolysis in reactions such as the electrolysis of water, (with a small quantity of dilute sulfuric acid added to make it conducting) and copper sulfate solution at copper electrodes.

19 Understand basic aliphatic organic chemistry

19.1 Know, interpret and use the nomenclature and molecular and structural formulae of the following classes of compound:

- alkanes and alkenes;
- halogenoalkanes;
- alcohols;
- aldhehydes and ketones;
- carboxylic acids, esters and acyl chlorides;
- amines, nitriles, amides and amino acids.

19.2 Describe the chemistry of alkanes as exemplified by their combustion, by substitution by chlorine and by bromine, and by their general unreactivity towards electrophiles and nucleophiles.

Compare the combustion characteristics of a variety of liquid and gaseous alkanes.

Show that alkanes do not react with electrophilic reagents mentioned in the examples given with Standard 19.4.

Safety

All practical organic chemistry involves a fire risk; appropriate precautions should be taken.

19.3 Know 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.

Tabulate the different categories of fuels together with their main uses, their approximate boiling range and their main constituents.

Note the trends in the physical properties of alkanes.

Debate the use of renewable versus fossil fuels.

19.4 Describe the chemistry of alkenes as the chemistry of the double bond, exemplified by addition and polymerisation.

Show addition of hydrogen, steam, hydrogen halides and halogens, and oxidation by cold, dilute manganate(VII) ions to form the diol.

(Advanced) Show that all the reactions of alkenes follow the same pattern of electrophilic addition.

19.5 Illustrate structural and geometric isomerism in alkanes and alkenes.

Draw diagrams or make models (preferably space-filling) of geometric and structural isomers.

19.6 Describe the stereochemistry of alkanes and alkenes and related molecules.

Use molecular models to illustrate molecular shapes.

19.7 Know that petroleum and natural gas are sources of organic compounds and describe the processes of catalytic cracking and gas-to-liquid refining.

Develop a flow chart of the gas-to-liquid process used in Qatar.

19.8 Know that many organic compounds are made from plant and animal material.

List some examples (e.g. the manufacture of ethanol from sugar, the use of plant material as the raw material for drugs in the pharmaceutical industry).

19.9 Describe the chemistry of halogenoalkanes as exemplified by substitution reactions and the elimination of hydrogen halide to form an alkene.

Investigate the reactions of bromoethane: hydrolysis; formation of nitriles; formation of primary amines by reaction with ammonia.

(Advanced) Show that these reactions fall into two general categories of nucleophilic substitution and elimination.

19.10 Know some of the important applications of halogenoalkanes.

Discuss the importance of halogenoalkanes as important reactive intermediate compounds in the synthesis of more complex compounds.

Note some specific uses of halogenoalkanes (e.g. in dry cleaning, in refrigerants, the use of chloroform as an anaesthetic). Note also the environmental issues raised by the use of some halogenoalkanes by referring to Grade 10 standards relating to the ozone layer.

19.11 Describe the chemistry of alcohols as exemplified by ethanol, including combustion, substitution reactions, reaction with sodium, oxidation to carbonyl compounds and acids, dehydration, ester formation and its commercial production.

Discuss the commercial importance of alcohol and its preparation from petroleum and from sugars by the action of yeasts. Compare the economics and the sustainability of these two methods.

Investigate the reaction of ethanol with sodium, sodium dichromate and ethanoic acid.

Prepare bromoethane from ethanol.

19.12 Classify alcohols as primary, secondary and tertiary, and describe the formation of aldehydes and ketones by oxidation of the corresponding alcohol by acidified dichromate.

Note the trends in the physical properties of primary, secondary and tertiary alcohols.

Prepare typical aldehydes and ketones by the oxidation of the appropriate alcohol with acidified dichromate with distillation and characterisation of the product.

19.13 Describe the chemistry of the carbonyl group, as exemplified by aldehydes and ketones.

Distinguish between aldehydes and ketones by their reactions with oxidising agents such as Tollens' reagent.

Show nucleophilic addition to the carbonyl bond (e.g. the reaction with sodium hydrogensulfite).

Show halogenation of the alkyl groups by reactions such as the iodoform reaction.

Show condensation reactions to the carbonyl group (e.g. the reaction with 2,4-dinitophenylhydrazine).

19.14 Describe the formation of carboxylic acids and their reactions to form esters and salts.

Make ethanoic acid by the oxidation of ethanol.

Make the sodium salt of ethanoic acid by neutralisation of the acid with sodium hydroxide.

(Advanced) Show how ethanoic acid can also be formed from acid hydrolysis of ethanenitrile and by oxidation of ethanal.

Make ethyl ethanoate by the reaction between ethanoic acid and ethanol.

19.15 Describe the characteristic structure of esters and know that they can be hydrolysed to the alcohol and acid.

Hydrolyse ethyl ethanoate.

19.16 Know the main commercial uses of esters in perfumes and flavourings.

Physics

By the end of Grade 11, students state Newton's laws of motion and use them to solve problems of motion in two dimensions. They distinguish between mass and weight, know that momentum is conserved during collisions and apply the knowledge to collisions and explosions in one dimension. They determine the centre of gravity of a lamina and apply the principle of moments to real problems. They define and measure temperature and know how thermal energy moves from place to place. They know that heat is transferred by conduction, convection and radiation and can give examples of each. They know that some substances are better conductors than others, that convection currents are the basis of weather patterns and that some surfaces radiate and absorb heat better than others. They use the concepts of specific heat capacity and specific latent heat to calculate heat transferred to bodies. They know that light travels in straight lines and how it is reflected and refracted; they are aware of some of the applications of these properties. They understand dispersion and recognise some of its natural consequences, and know how the eye receives and focuses light. Students know that an electric current is a stream of charged particles and solve problems related to current and potential difference. They use capacitors in real circuits and use thermistors, diodes, transistors and light-dependent resistors as potential dividers to drive gates in logic circuits. They know how astable and bistable switches can be used in memory circuits.

Students should:

20 Understand the relationships between forces and movement

20.1 State Newton's laws of motion and apply them to real situations.

Illustrate Newton's laws of motion with real situations. The first two laws can be illustrated by examples such as the speeding up and slowing down of a car, traffic collisions, the movement of a ball during a game of soccer or tennis. The third law can be illustrated by examples such as two vehicles involved in a traffic accident.

20.2 Know that linear momentum is the product of mass and velocity, and that a momentum change on a body is equal to the force causing it. Understand and use the relationship $F = ma$.

Measure, using a ticker-timer, the acceleration of a trolley pulled with a constant force on a friction-compensated runway. Vary the mass of the trolley and the force used. Measure the acceleration of a falling object in a similar way.

20.3 Distinguish between inertial and gravitational mass.

Demonstrate inertia using simple experiments (e.g. pulling a piece of paper from underneath an object, such as a large coin, without moving the object).

Discuss the distinction between gravitational mass and inertial mass as different concepts yielding the same value.

Investigate the force needed to stop objects of different masses moving with the same velocity. Find the mass of someone by (a) weighing them on bathroom scales and (b) measuring the force needed to stop them moving in a rotating chair, in comparison with the force needed to stop a known mass from moving at the same angular velocity.

20.4 Distinguish between mass and weight.

Discuss the use of a top-pan balance and a beam balance for measuring mass in different gravitational fields.

20.5 Know the principle of conservation of momentum and apply it to elastic and inelastic collisions and explosions involving two bodies in one dimension.

Use ticker-timers or similar equipment to study elastic collisions and explosions between two trolleys of different mass.

20.6 Know that the weight of a body may be taken as acting at a single point known as its centre of gravity.

Find the centre of gravity of an irregular lamina.

Discuss the effect of a vehicle's centre of gravity on its road-holding ability.

20.7 Describe and apply the moment of a force and the torque of a couple, and apply the principle of moments to a system in equilibrium.

Take appropriate measurements to calculate the torque of a couple in real situations (e.g. turning a six-sided nut using a spanner).

20.8 List and explain applications of the principle of moments to engineering systems and to the muscles of the human body.

Make a model arm showing the two lever mechanisms, using elastic bands as muscles.

Take appropriate measurements and calculate the force exerted by an arm muscle lifting a known mass.

Take appropriate measurements and calculate the force on your Achilles tendon when you stand on the ball of your foot.

21 Understand thermal physics

21.1 Define temperature and explain how a temperature scale is constructed. Know how different types of thermometer work and list their advantages and disadvantages.

Calibrate an alcohol-in-glass thermometer.

Compare the use of different types of thermometer (e.g. digital, alcohol in glass, thermocouple) to measure temperature changes in water as it is heated.

21.2 Recognise that thermal 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.

21.3 Know that heat is transferred by conduction, convection and radiation; explain conduction and convection in terms of particle movement.

Recall and expand learning activities from Grade 8, section 17, to demonstrate heat transfer.

21.4 Know the causes of convection currents in air and water and understand how these can affect climate and weather.

Show convection currents in a water using a crystal of potassium manganate (VII).

Draw a diagram of a domestic water system showing how it depends on convection to operate correctly. Make a model domestic water system and show convection currents with a colourant.

Study the influence of the sea on climate, both global and local. Note the effects of apparently small changes in sea temperature such as those that cause 'El Niño' events.

See Standard 21.7

21.5 Know that heat can be radiated through a vacuum and that this is how the heat from the Sun reaches Earth.

Use a pair of parabolic reflectors with a heat source at the focus of one and a match head at the focus of the other to show that radiant heat can be reflected like light.

21.6 Define, explain in terms of the kinetic particle model and use the concepts of specific heat capacity and specific latent heat. Offer explanations for the relative magnitudes of these quantities and for differences between materials.

Plot cooling curves of liquids solidifying and explain their shape.

Determine the specific heat capacity of solids and liquids by a variety of methods.

Determine the specific latent heats of melting and boiling of ice and water.

Safety

The solid traditionally used in for plotting cooling curves, naphthalene, is carcinogenic. Use alternatives.

21.7 Show an understanding of the importance of the unusually large value of the specific latent heat and the specific heat capacity of water, in terms of heat regulation in the body and the impact of the oceans on climate.

Compare the heat capacities and specific latent heats of various liquids.

Estimate the heat that can be stored in the top metre of the Pacific Ocean per degree rise in its temperature.

22 Understand light and optics

22.1 Know that light travels in straight lines and can be reflected by plane surfaces, and explain how images are formed in plane mirrors. Explain common applications of this phenomenon.

Show reflection of light and the formation of images using common optical equipment.

Study the path of light through devices such as a periscope.

22.2 Know that light is refracted as it passes from one medium to another. Explain the geometry of refraction, calculate the refractive index of a medium and interpret it in terms of change in the velocity of light.

Show reflection of light using common optical equipment and calculate experimentally, refractive index for several different media.

22.3 Show how images are formed by converging and diverging lenses and understand the concept of focal length. Explain common applications of these phenomena.

Study image formation by converging and diverging lenses, and determine the focal point and focal length of a converging lens.

Study the path of a light through devices such as a magnifying glass, a camera, a telescope and a microscope.

(Advanced) Develop ray diagrams experimentally to locate images formed by converging and diverging lenses, leading to a definition of the terms 'principal axis', 'focal point', 'focal length' and 'linear magnification'.

22.4 Know and explain some common uses of curved mirrors.

Study the use of mirrors in applications such as car headlights and reflecting telescopes.

22.5 Explain total internal reflection and its application in fibre optics.

Study total internal reflection in a glass block.

Demonstrate the transmission of light through an optical fibre and discuss its applications in, for example, telecommunications, medicine and engineering.

(Advanced) Demonstrate and develop the concept of critical angle.

22.6 Show and explain the dispersion of light.

Show the formation of an optical spectrum (using light from the Sun and a water prism made from a mirror immersed at an angle in a bowl of water).

(Advanced) Show how dispersion can be a problem in optical instruments such as a camera or binoculars and explain how it is overcome by the use of achromatic compound lenses.

22.7 Explain, in terms of refraction and dispersion, natural phenomena such as rainbows, mirages, the colour of the sky, the colour of sunsets and the difference between real and apparent depth of water.

Carry out the 'appearing coin' experiment and demonstrate other common consequences of refraction.

Demonstrate the path of light that causes natural phenomena such as mirages and rainbows.

22.8 Know how the eye receives and focuses light and how short and long sight can be corrected.

Determine the near and far points of the unaided eye and the of same eye with spectacles.

23 Understand the fundamentals of current electricity

23.1 Know that electric current is the rate of flow of charged particles, define charge and the coulomb, and solve problems using the relationship $Q = It$.

Demonstrate that 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.

23.2 Define potential difference and the volt. Solve problems using the relationships $V = W/Q$, $P = VI$, $P = I^2R$.

Measure and compare the power consumption of a variety of electrical devices.

Measure electrical power consumption of an electric motor raising a load and compare that with the mechanical power output.

23.3 Define resistance and solve problems using the relationships $V = IR$ and $R = \rho l/A$ for multiple resistances connected in series and in parallel.

Investigate the relationship between current and voltage for ohmic and non-ohmic conductors.

Investigate the dependence of resistance on heat and light in thermistors and light-dependent resistors.

Use different resistors as potential dividers.

23.4 Distinguish between electromotive force and potential difference and understand the concept of internal cell resistance.

Calculate internal cell resistance in a circuit by measuring the current in a circuit and the voltage across an external variable resistance as the resistance changes.

Explain why car headlights dim when the starter motor is used.

24 Use electronic devices in practical control circuits

24.1 Demonstrate an understanding of the construction of capacitors and their use in electrical circuits.

Discharge capacitors through a microammeter, an LED or a small motor.

Show full wave rectification using a diode circuit and an oscilloscope, and show the smoothing effect of a capacitor.

Design and make simple delayed-action switching circuits.

24.2 Explain the variation in resistance shown by devices such as the potentiometer, the diode, the light-dependent resistor, the transistor and the thermistor; use these resistors as potential dividers in practical circuits.

Construct practical circuits using different kinds of resistors and switches (e.g. a reed switch) in potential dividers to control a transistor, which in turn controls other transducers through a relay.

24.3 Use logic gates in practical circuits (AND, OR, NAND, NOR) and determine truth tables for the gates, individually and in combination.

Use logic gates in practical electronic control circuits.

Devise and build practical control circuits (e.g. a vehicle courtesy light circuit, an automatic curtain closer circuit, an intruder alarm).

24.4 Understand and use bistable and astable switches and know how these can constitute memory circuits.

Set up arrays of switches to count events.

(Advanced) Use simple integrated circuit devices (e.g. op-amps and timers) in control circuits.