OCR
Oxford Cambridge and RSA

Cambridge **TECHNICALS LEVEL 3**

CAMBRIDGE TECHNICALS

APPLIED SCIENCE

Unit 1 – Science fundamentals
DELIVERY GUIDE

Version 4

ocr.org.uk/science

CONTENTS

INTRODUCTION

This Delivery Guide has been developed to provide practitioners with a variety of creative and practical ideas to support the delivery of this qualification. The Guide is a collection of lesson ideas with associated activities, which you may find helpful as you plan your lessons.

OCR has collaborated with current practitioners to ensure that the ideas put forward in this Delivery Guide are practical, realistic and dynamic. The Guide is structured by learning outcome so you can see how each activity helps you cover the requirements of this unit.

We appreciate that practitioners are knowledgeable in relation to what works for them and their learners. Therefore, the resources we have produced should not restrict or impact on practitioners' creativity to deliver excellent learning opportunities.

Whether you are an experienced practitioner or new to the sector, we hope you find something in this guide which will help you to deliver excellent learning opportunities.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resources.feedback@ocr.org.uk.

OPPORTUNITIES FOR ENGLISH AND MATHS SKILLS DEVELOPMENT AND WORK EXPERIENCE

We believe that being able to make good progress in English and maths is essential to learners in both of these contexts and on a range of learning programmes. To help you enable your learners to progress in these subjects, we have signposted opportunities for English and maths skills practice within this resource. We've also identified any potential work experience opportunities within the activities. These suggestions are for guidance only. They are not designed to replace your own subject knowledge and expertise in deciding what is most appropriate for your learners.

English

Maths


Work

Please note

The activities suggested in this Delivery Guide **MUST NOT** be used for assessment purposes. The timings for the suggested activities in this Delivery Guide **DO NOT** relate to the Guided Learning Hours (GLHs) for each unit.

Assessment guidance can be found within the Unit document available from www.ocr.org.uk. The latest version of this Delivery Guide can be downloaded from the OCR website.

UNIT AIM

A thorough understanding of scientific principles and practices is essential for science technicians. Knowledge learnt in this unit will create a solid foundation in the fundamentals of science that you will be able to build on in your further study through your choice of additional optional units which will provide you with greater depth of knowledge and practice in your chosen specialisms.

Unit 1 Science fundamentals	
LO1	Understand the chemical structures of elements and compounds
LO2	Understand reactions in chemical and biological systems
LO3	Understand cell organisation and structures
LO4	Understand the principles of carbon chemistry
LO5	Understand the importance of inorganic chemistry in living systems
LO6	Understand the structures, properties and uses of materials

To find out more about this qualification, visit the OCR website.

RELATED ACTIVITIES

The Suggested Activities in this Delivery Guide listed below have also been related to other Cambridge Technicals in Applied Science units/Learning Outcomes (LOs). This could help with delivery planning and enable learners to cover multiple parts of units.

This unit (Unit 1)	Title of suggested activity	Other units/LOs	
LO1	Atomic structure	Unit 1 Science fundamentals	LO2 Understand reactions in chemical and biological systems LO3 Understand cell organisations and structures LO5 Understand the importance of inorganic chemistry in living systems
		Unit 2 Laboratory techniques	LO2 Be able to separate, identify and quantify the amount of substances present in a mixture LO4 Be able to examine and record features of biological samples
		Unit 3 Scientific analysis and reporting	LO6 Be able to use modified, extended or combined laboratory techniques in analytical procedures
		Unit 10 Testing consumer products	LO2 Understand how product testing determines the development of consumer products LO3 Be able to use quantitative titration techniques on consumer products
	The periodic table	Unit 1 Science fundamentals	LO2 Understand reactions in chemical and biological systems LO3 Understand cell organisations and structures LO5 Understand the importance of inorganic chemistry in living systems
		Unit 2 Laboratory techniques	LO2 Be able to separate, identify and quantify the amount of substances present in a mixture
		Unit 3 Scientific analysis and reporting	LO6 Be able to use modified, extended or combined laboratory techniques in analytical procedures
	Ionic and covalent bonding	Unit 1 Science fundamentals	LO2 Understand reactions in chemical and biological systems LO3 Understand cell organisations and structures LO5 Understand the importance of inorganic chemistry in living systems
		Unit 3 Scientific analysis and reporting	LO6 Be able to use modified, extended or combined laboratory techniques in analytical procedures
	Orbits and orbitals	Unit 1 Science fundamentals	LO2 Understand reactions in chemical and biological systems LO3 Understand cell organisations and structures LO5 Understand the importance of inorganic chemistry in living systems
		Unit 2 Laboratory techniques	LO3 Be able to determine the concentration of an acid or base using titration
		Unit 3 Scientific analysis and reporting	LO6 Be able to use modified, extended or combined laboratory techniques in analytical procedures
LO2	Rates of chemical reactions in biological and chemical systems	Unit 3 Scientific analysis and reporting	LO1 Be able to use mathematical techniques to analyse data LO2 Be able to use graphical techniques to analyse data LO4 Be able to analyse and evaluate the quality of data

This unit (Unit 1)	Title of suggested activity	Other units/LOs	
LO3	Prokaryotic and eukaryotic cells	Unit 3 Scientific analysis and reporting	LO3 Be able to use keys for analysis
	Cell structure	Unit 2 Laboratory techniques	LO4 Be able to examine and record features of biological samples
		Unit 5 Genetics	LO1 Understand the importance of meiosis
		Unit 8 Cell biology	LO3 Understand the cell cycle and the importance of mitosis
	Cell ultrastructure: electron micrographs	Unit 2 Laboratory techniques	LO4 Be able to examine and record features of biological samples
		Unit 5 Genetics	LO1 Understand the importance of meiosis
		Unit 8 Cell biology	LO3 Understand the cell cycle and the importance of mitosis
	Cell ultrastructure: research project	Unit 1 Science fundamentals	LO4 Understand the principles of carbon chemistry
		Unit 2 Laboratory techniques	LO4 Be able to examine and record features of biological samples
		Unit 5 Genetics	LO1 Understand the importance of meiosis
		Unit 8 Cell biology	LO3 Understand the cell cycle and the importance of mitosis
LO4	The structure of the carbon atom	Unit 6 Control of hazards in the laboratory	LO1 Understand the types of hazard that may be encountered in a laboratory
		Unit 15 Sustainability and renewable energy	LO1 Understand the impacts of energy consumption LO2 Be able to measure energy transfer and calculate energy efficiencies of energy sources LO3 Understand renewable energy technologies
	Alkanes, alkenes and alkynes compounds	Unit 6 Control of hazards in the laboratory	LO1 Understand the types of hazard that may be encountered in a laboratory
	The carbohydrates	Unit 6 Control of hazards in the laboratory	LO1 Understand the types of hazard that may be encountered in a laboratory
	Types of isomer	Unit 6 Control of hazards in the laboratory	LO1 Understand the types of hazard that may be encountered in a laboratory
LO5	What is inorganic chemistry?	Unit 1 Science fundamentals	LO3 Understand cell organisation and structures
	Metals and their ions	Unit 1 Science fundamentals	LO3 Understand cell organisation and structures
	Using the chemical formulae of substances and their oxidation state to predict the result of a reaction	Unit 1 Science fundamentals	LO3 Understand cell organisation and structures
		Unit 3 Scientific analysis and reporting	LO6 Be able to use modified, extended or combined laboratory techniques in analytical procedures
	The role of the magnesium ion in photosynthesis	Unit 1 Science fundamentals	LO3 Understand cell organisation and structures

This unit (Unit 1)	Title of suggested activity	Other units/LOs	
LO6	Mechanical properties of materials	Unit 10 Testing consumer products	LO2 Understand how product testing determines the development of consumer products LO5 Be able to test the effectiveness of consumer product tests
		Unit 21 Product testing techniques	LO2 Understand how product testing determines the development of consumer products
	Polymers	Unit 10 Testing consumer products	LO2 Understand how product testing determines the development of consumer products LO5 Be able to test the effectiveness of consumer product tests
		Unit 21 Product testing techniques	LO2 Understand how product testing determines the development of consumer products
	Stress-strain graphs, Hooke's law and Young's modulus	Unit 3 Scientific analysis and reporting	LO7 Be able to record, report on and review scientific analyses
		Unit 10 Testing consumer products	LO2 Understand how product testing determines the development of consumer products LO5 Be able to test the effectiveness of consumer product tests
		Unit 21 Product testing techniques	LO2 Understand how product testing determines the development of consumer products
	Boiling point, melting point and sublimation	Unit 10 Testing consumer products	LO2 Understand how product testing determines the development of consumer products LO5 Be able to test the effectiveness of consumer product tests
		Unit 21 Product testing techniques	LO2 Understand how product testing determines the development of consumer products
	Charge flow, EMF and potential difference	Unit 15 Sustainability and renewable energy	LO3 Understand renewable energy technologies LO4 Be able to recommend sustainable solutions to meet energy demands
	Resistance and current	Unit 15 Sustainability and renewable energy	LO3 Understand renewable energy technologies LO4 Be able to recommend sustainable solutions to meet energy demands
	Electrical energy and power	Unit 15 Sustainability and renewable energy	LO3 Understand renewable energy technologies LO4 Be able to recommend sustainable solutions to meet energy demands

KEY TERMS

Explanations of the key terms used within this unit, in the context of this unit	
Key term	**Explanation**
Alloy	A mixture of a metal with one or more other metals.
Atom	The smallest component of any element which displays the chemical properties of the element. All atoms have a nucleus, which contains neutrons and protons and around the nucleus are electrons in orbit. The neutron has no electric charge. The proton has a positive charge and the electron a negative charge.
Bioinorganic chemistry	The role of non-metals and metals in biological systems. There are two major elements to bioinorganic chemistry: firstly the role of inorganic elements in bio systems, i.e. naturally occurring elements; and secondly how these elements and compounds can be used in drugs, medical probes, or how they contribute to the development and maintenance of botanical and animal organisms.
Boiling point	Boiling point is the temperature at which a liquid boils and turns to vapour.
Brittleness (of a material)	A material is termed 'brittle' if, when subjected to stress, it breaks without significant deformation (strain). Brittle materials absorb relatively little energy prior to fracture, even those of high strength. Breaking is often accompanied by a snapping sound.
Charge and coulomb	The coulomb C is the SI derived unit of electric charge. It is the charge that crosses a section of the circuit in 1 second when a current of 1 ampere flows. $Q = It$, where t is the time (for Q to be in coulombs, I in amperes and t in seconds).
Classification (of materials)	Materials are often classified into groups of materials with like properties. These include metals, ceramics, composites and polymeric materials.
Colloid	When one chemical substance is dispersed through another. The particles that are dispersed are too large to form a solution, but too small to form a suspension, e.g. a mixture of starch dispersed through water.
Covalent bond	Covalent bonding occurs when pairs of electrons are shared by atoms. Atoms bond with other atoms in order to gain stability by achieving a full outermost electron shell. It would be very difficult for elements in the middle or towards the right of the periodic table, bonding with each other, to lose or gain electrons to acquire a full electron shell, so these achieve this by sharing their outer most electrons.
Density (of a material)	A material's density is defined as its mass per unit volume. It is, essentially, a measurement of how tightly matter is crammed together. The principle of density was discovered by the Greek scientist Archimedes. To calculate the density (represented by the Greek letter rho) of an object, take the mass (m) and divide by the volume (v): $\rho = m / v$ The SI unit of density is kilogram per cubic metre (kg/m^3).
Drift current and electron flow in materials	Drift current is the electric current, or movement of charge carriers, which is due to an applied electric field. $I = nAve$, where n is the number of conduction electrons per unit volume, A the cross sectional area of the conductor, v the average drift velocity and e the charge on the electron.
Ductility (of a material)	Ductility is a solid material's ability to deform under tensile stress; this is often characterized by the material's ability to be stretched into a wire.
Elastic deformation of materials	Elastic deformation is deformation that disappears upon removal of the external forces causing the alteration and the stress associated with it.
Electromotive force (emf)	Electromotive force (emf, denoted and measured in volts) is the voltage developed by any source of electrical energy such as a battery or dynamo (i.e. electromagnetic).
Electron flow and current flow	An electric current is a flow of electric charge. In electric circuits this charge is often carried by moving electrons in a wire. By convention, electron flow is in the opposite direction to current flow in a circuit. Current is the rate of flow of charge. The SI derived unit of current is the ampere A.

Explanations of the key terms used within this unit, in the context of this unit	
Key term	**Explanation**
Element	A substance (liquid, gas or solid) which is made up of atoms with the same number of protons: for example, H2 (hydrogen), Hg (mercury) and Au (gold).
Energy (in electrical systems)	Electrical energy is the rate at which energy is transferred (or supplied) over a period of time. It is usually measured as kilowatt-hour (kWh). This is actually a measurement of average power consumption.
Equilibrium separation in materials	Equilibrium separation is the distance between the atoms at which the force on each atom is zero.
Hardness (of a material)	Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied.
Hooke's law	Hooke's law is a law stating that the stress on a solid substance is directly proportional to the strain produced, provided the stress is less than the elastic limit of the substance. It is characterised by the formula F = Ke where F is force in newtons N, K is the spring constant in newtons per metre Nm^{-1} and e is extension in metres. The SI unit for Hooke's law is the newton N. Hooke's law applies to springs and continuous materials (e.g. steel) where it represents the linear region on a force-extension graph.
Inorganic compounds	Those compounds which do not contain one or more carbon atom. There is some overlap but that is the accepted view. Inorganic compounds are used widely: for example, ammonia (NH_3) is used in the production of fertilisers, plastics, nylons and explosives.
Ionic bond	Ionic bonding – an electrostatic force that exists between the oppositely charged positive ions (cations) and negative ions (anions) in ionic compounds. Ionic compounds can be formed by the reaction of metals with non-metals - electrons are transferred from metal atoms to non-metal atoms, forming the constituent ions of the ionic compound.
Malleability (of a material)	Malleability is the quality of something that can be shaped into something else without breaking. It is sometimes also called plasticity.
Mechanical properties of materials	Characteristics that indicate the elastic or inelastic behaviour of a material under pressure or force, such as bending, brittleness, elongation, hardness, tensile strength etc.
Melting point	Melting point is the temperature at which a solid becomes a liquid at a fixed pressure.
Mixture	A combination of two or more chemical substances that are not chemically combined. Hence, they can be separated.
Organelles	The components of a cell: each will have its own function and will have its own membrane which separates it from the cytoplasm of the cell. Examples of organelles are the nucleus, chloroplasts in plant cells which create glucose through photosynthesis.
Periodic table	The most important chemical reference table. Elements arranged from left to right in order of atomic number (periods) and vertically by number of electrons in their outer most s sub-shell.
Plastic deformation of materials	Plastic deformation is a permanent deformation or change in shape of a solid body without fracture under the action of a sustained force.
Polymer	A polymer is a very large, chain-like molecule made up of monomers, which are small molecules.
Potential difference	The potential difference is the difference of electrical potential between two points. V = W/Q where V is the potential difference in volts, W is the work done in joules J and Q is the charge in coulombs C. The SI derived unit of potential difference is the volt V.
Power (in electrical systems)	Electric power is the rate at which electric energy is transferred by an electric circuit. The SI unit of power is the watt W (one joule per second).
Rate of reaction	The speed at which a reaction takes place for a given set of factors. These can include temperature, pressure, catalysts, enzymes and surface area.

Explanations of the key terms used within this unit, in the context of this unit	
Key term	**Explanation**
Reaction	Any action which converts one group of chemical substances into another with different chemical attributes. For example, oxygen and hydrogen, two gases, react to form liquid water. The reactions can take different forms such as oxidation, reduction, addition and substitution.
Relative atomic mass	The average mass of an atom is the combined mass of the naturally occurring isotopes relative to carbon; e.g. chlorine has two naturally occurring isotopes Cl^{35} and Cl^{37} so the average mass will be (35 + 37)/2 = 36. But nature does not have equal amounts of each isotope. For example, for chlorine 75% of the naturally occurring chlorine is made up of Cl^{35} and 25% of Cl^{37}. So we have to change the equation to take account of this, which becomes (35 × 0.75) + (37 × 0.25) = 35.5 which is the relative atomic mass.
Relative charge	This is the difference between the number of protons and electrons in a particular atom. This can be positive or negative dependent upon which is the greater number: protons or neutrons.
Resistivity	Resistivity is a measure of the resisting power of a specified material to the flow of an electric current. The formula relating resistivity (ρ) to resistance (R), cross-sectional area (A) and length (l) is: $\rho = RA/l$. The SI unit of electrical resistivity is the ohm-metre (Ω m).
Stiffness (of a material)	Stiffness is the rigidity of an object – the extent to which it resists deformation in response to an applied force.
Strain	Strain is defined as deformation of a solid due to stress. $\varepsilon = d_l / l_o$ where ε is strain, d_l is change in length in metres and l_o is initial length in metres. As strain is metres divided by metres then it is dimensionless, although strain is sometimes determined as strain rate which has SI units 1/seconds or s^{-1}.
Strength (of a material)	Strength of material relates to how the material behaves when loaded. Strength of material may be compressive strength, tensile strength, shear strength and torsional strength.
Stress	Stress is the load (force) per unit area that tends to deform the body on which it acts. Compressive stress tends to squeeze a body, tensile stress to stretch (extend) it, and shear stress to cut it. $\sigma = Fn / A$ where σ is stress, Fn is force in newtons and A is cross sectional area in m^2 The SI unit of stress is newtons per metre squared Nm^2
Sublimation	Sublimation is the process of a solid turning into a gas without first becoming liquid.
Thermoplastic	A thermoplastic, or thermosoftening plastic, is a plastic material, typically a polymer, that becomes pliable or mouldable above a specific temperature and solidifies upon cooling.
Thermosetting plastic	A thermosetting plastic, also known as a thermoset, is a plastic material that irreversibly cures.
Toughness (of a material)	Toughness is the ability of a material to absorb energy and plastically deform without fracturing.
Young's modulus	Young's modulus is a measure of the stiffness of an elastic material and is a quantity used to characterise materials. It is defined as the ratio of the stress (force per unit area) along an axis to the strain (ratio of deformation over initial length) along that axis in the range of stress in which Hooke's law holds. The defining formula is: $E = FL / A L$ where E is the Young's modulus, F is force in newtons N, L is original length in metres m, A is cross sectional area in m^2 and L is change in length in metres m. The SI unit for Young's modulus is the pascal Pa.

MISCONCEPTIONS

Some common misconceptions and guidance on how they could be overcome		
What is the misconception?	**How can this be overcome?**	**Resources which could help**
The application and meaning of the term 'acid' within chemistry and biochemistry	The Royal Society of Chemistry has produced a comprehensive range of downloadable information and revision questions on this topic. It is important that learners explore their own ideas of what the term means and then have this challenged through the worksheets and experimentation.	http://www.rsc.org/learn-chemistry This location takes you to the front page of a very wide range of books, learning materials, etc. There are a range of drop down menus which allow you to identify whether the resources are for teachers or learners, the age ranges (from primary to undergraduate), and the resource types: from websites to books and handouts. Select browse the resources which suit your teaching style and the knowledge and ability level of your learners. For example, http://www.rsc.org/learn-chemistry/resource/res00002202/beyond-appearances takes you to an 84-page resource covering misconceptions including acid but also a range of other chemical misconceptions such as bonding. However, do not miss the opportunity to look at this site where you can click and purchase books as well as download support material for free.
Differentiating between 'chemical' and 'physical' changes in chemistry	The Royal Society of Chemistry has produced a comprehensive range of downloadable information and revision questions on this topic. It is important that learners explore their own ideas of what the terms mean and then have this challenged through the worksheets and experimentation (see above).	https://edu.rsc.org/resources/changes-in-chemistry/1085.article This book can be used to find strategies for use with common misconceptions around this topic.
Alloys are mixtures of metals	Reinforce definition and provide examples. Emphasise that the most widely used alloy, steel, contains carbon.	https://www.youtube.com/watch?v=KgUmNQD6m5Q This video details how alloys are formed.
Large biological molecules form solutions	Distinguish between the three primary types of mixture, i.e. solutions, colloids and suspensions.	The UC Davis ChemWiki gives a concise introduction to colloids: https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/Solutions_and_Mixtures/Colloid#Properties_of_Colloids
Heat 'kills' enzymes	Heat does modify and thus deactivate enzymes but as they are proteins, they are not alive and thus cannot be killed. Examples of proteins and enzymes followed by a discussion of what they are and their role in chemical reactions would be useful.	
The optimum operating temperature for all enzymes is 37°C (98°F), that is to say, the temperature of the human body	Enzymes are found in a range of organisms which have different internal temperature ranges.	https://www.rsb.org.uk/images/07_Enzymes.pdf This sheet explains how temperature affects enzyme activity; it also has a link to a quiz.

Some common misconceptions and guidance on how they could be overcome		
What is the misconception?	**How can this be overcome?**	**Resources which could help**
Enzymes cause reactions	Enzymes do not cause reactions; they do increase the rate at which the reaction takes place.	http://www.rsc.org/learn-chemistry/resource/res00000425/testing-for-enzymes?cmpid=CMP00005921 This is an experiment on enzyme reactions which can aid the discussion of how enzymes work. It is one of a wide range of practical experiments created by the Nuffield Trust and the RSC to promote practical science.
All biological catalysts are proteins	Some ribonucleic acid (RNA) molecules can also carry out the function of catalysts.	
Bone is made up of dead tissue	No, bone is made up of bone tissue which has cells, nerves, pain receptors, blood vessels. It would be helpful to discuss the role of RNA in replication. It would be helpful to review the structure of bone using diagrams; consider how broken bones mend and bones in young mammals grow.	
Understanding atomic structure	Learners often find the understanding of atomic structure difficult. Teachers could use examples of the atomic structure of different materials or elements – showing the structure of protons, electrons and neutrons for each.	http://www.chemicalelements.com/groups/transition.html This website has all the transition metals. Students can click on each metal and find its atomic structure and other basic information.
Understanding atomic bonding	Learners often find it difficult to understand how atoms are bound together, and the different types of bonding (e.g. metallic, ionic and covalent bonding). Resources showing different examples may be useful.	http://www.chem4kids.com/files/atom_bonds.html This website can be used with students for a basic recap of atomic bonding. https://www.bbc.co.uk/bitesize/guides/zqmrsrd/revision/1 This BBC Bitesize revision section looks at bonding in more detail, and again can be used for a recap of knowledge.
Interpretation of a force-extension graph	The understanding and interpretation of force-extension graphs might be reinforced if it is possible to perform tensile testing of materials. Alternatively real data could be used or web-based videos showing tensile testing. Learners could plot force-extension graphs for different materials, identifying key characteristics from the graph.	http://www.youtube.com/watch?v=D8U4G5kcpcM This video goes through a real-world example of tensile testing and the graph produced from it https://www.youtube.com/watch?v=eWgKh9fVGHs This video looks at different force-extension graphs and goes through how to interpret the graphs
Definition of stress and strain	It may be possible to demonstrate both stress and strain using practical experiments. Internet videos showing stress and strain measurement might also prove useful.	http://www.youtube.com/watch?v=0s5kBrk0d80 This video goes through definitions and examples of stress and strain

Some common misconceptions and guidance on how they could be overcome		
What is the misconception?	**How can this be overcome?**	**Resources which could help**
Application of Kirchhoff's laws	Kirchhoff's laws could be explained using practical resistor circuits in which voltage and current are measured.	
Difference between power and energy	Reference might be made to domestic appliances e.g. a hairdryer that consumes 2000 watts; this is the power consumed by the hairdryer. If the hairdryer is used for 1 hour, then it consumes 2000 watt/hour or 2 kWh of energy. This could be related to domestic energy costs (tariff costs).	http://www.energylens.com/articles/kw-and-kwh This webpage goes through the difference between energy and power, using kW and kWh.

SUGGESTED ACTIVITIES

LO No:	1		
LO Title:	**Understand the chemical structures of elements and compounds**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Atomic structure	All natural sciences are governed by the activities of molecules which form elements and compounds. The characteristics of each one are dependent upon the underlying structure of its atoms. This should include the nucleus, protons, neutrons and electrons. From this learners should understand the different forces which act upon the atom and their relative strengths. Tutors may use a range of resources, including those from the Royal Society of Chemistry, which include video clips from the Christmas Lectures, tutorial notes and quizzes and games. There are also resources, available through the web, which provide animations which can help to bring the theory to life. Details of resources for this task are provided in the Resource Links. For example, tutors could use the Grid Locks game to help learners identify the number of protons, neutrons and electrons for a particular isotope or the subatomic particles of the atom, bonding. This helps to develop knowledge and understanding of these areas or interactive simulations to build atoms. Practical activities such as determining the relative atomic mass of magnesium are also provided which support the development of understanding of both the theory of atomic mass and practical activities which provide proof. Learn Chemistry Learning Resources for Students: http://www.rsc.org/learn-chemistry/resource/listing?searchtext=&reference=students&filter=all&fAudience=AUD00000002&fLevel=LEV00000005&fAudience,Audience=AUD00000002 Institute of Physics (Atoms and nuclei): https://spark.iop.org/collections/atoms-and-nuclei-guidance-notes#gref *It should be noted that these links point to many different resources e.g. worksheets, experiments and videos and are aimed at different concepts and levels of ability or attainment. Tutors should consider their learners' specific needs and select appropriate resources from the libraries at these links.*  \\ Useful resource: Chemical Bonds - Covalent vs Ionic http://www.youtube.com/watch?v=7DjsD7Hcd9U	2.5 hours	Unit 1 LO2, LO3, LO5 Unit 2 LO2 Unit 3 LO6 Unit 10 LO2, LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
The periodic table	The periodic table is the important reference source for chemistry. It contains all known elements and can be used to predict those to be discovered, although these are now normally highly radioactive and often short lived. It enables scientists to extract, from one source, useful information on any elements. However, in order to make the most of this table, it is important that the learner understands the organisation of the table and how this reflects the attributes of the individual elements. Tutors could use the very useful interactive version of the periodic table available through the Royal Society of Chemistry's website (see below). Learners could be given a range of problems to solve, such as which elements have a particular atomic number, atomic mass or atomic radius or which are metallic and which are inorganic elements, etc, which of the elements are gases, liquids or solids at a particular temperature or which elements are noble gases or where the valence electrons are located. These could be undertaken as group activities with each group having to justify their decisions. Periodic Table http://www.rsc.org/periodic-table	1.5 hours	Unit 1 LO2, LO3, LO5 Unit 2 LO2 Unit 3 LO6
Ionic and covalent bonding	Although atoms and elements are very important, the molecules which they create by bonding to themselves or to other elements are equally important, not only in the natural world but also in areas such as manufacturing and engineering. In order to create these molecules, it is important that the learner understands how the atoms interact to form molecules. Learners need to understand the difference between ionic and covalent bonding. Tutors could provide learners with a range of liquids, gases and solids and ask the learners, in small groups, to observe the outcomes from a range of experiments: e.g. melting the solids, boiling liquids, measuring conductivity of elements dissolved in water. The selection of the compounds should enable the learners to observe a range of outcomes: for example, melting points at room temperature and at high temperature, no electrical conductivity to strong levels of conductivity. The precise range will be dependent upon the availability of resources. However, the observations could be discussed to identify how different compounds react dependent upon their constituent atoms e.g. Why do some compounds dissolve in water and others do not? Why do some compounds melt at room temperature and others do not?  Chemical bonds https://www.youtube.com/watch?v=7DjsD7Hcd9U Christmas Lectures 2012: The Modern Alchemist https://www.rigb.org/christmas-lectures/watch/2012/the-modern-alchemist	2 hours	Unit 1 LO2, LO3, LO5 Unit 3 LO6

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Orbits and orbitals 	It is important that learners understand that electrons do not orbit the nucleus like planets around the Sun. Heisenberg's uncertainty principle, which states that 'the position and momentum of an electron at the same time cannot be precisely stated', makes this clear. Tutors could explain that we cannot follow the path of the electron, that is to say its precise orbit. The concept of 'snapshots' of the location of the electron at any moment will produce a shape around the nucleus corresponding to the space in which the electron exists: this is the orbital. From the consideration of the hydrogen atom, the simplest atom, the spherical space is identified as s for spherical and 1 for being the orbital nearest to the nucleus. From this, the energy of the electrons and the different orbitals can be identified and explained. Atomic Orbitals http://www.chemguide.co.uk/atoms/properties/atomorbs.html#top	30 minutes	Unit 1 LO2, LO3, LO5 Unit 2 LO2 Unit 3 LO6

SUGGESTED ACTIVITIES

LO No:	2		
LO Title:	**Understand reactions in chemical and biological systems**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Types of chemical interactions: alloys	Tutors could begin this session with a discussion of how chemical substances can interact with each other. One way is to form a mixture. This could first be defined chemically, i.e. two or more substances in combination that can be separated by physical means. Learners will be familiar with alloys, and the definition could be reinforced, i.e. a mixture of a metal with one or more other elements. A key feature of alloys is that they will combine beneficial properties of both elements. The specification lists amalgams (mercury alloys), solder, bronze and titanium alloys. The composition of these could be discussed along with their properties. The remainder of this activity would be a good research activity. Learners could research wider applications of alloys, including medical ones. The benefits could be discussed, e.g. in surgical instruments: titanium has a higher strength to mass ratio than competing steels. Titanium alloys are suitable for implants, also, because they are inert and do not initiate an immune response. See: http://www.azom.com/article.aspx?ArticleID=1794. This activity also provides the opportunity to discuss some contemporary applications, for instance in shape memory alloys in medical applications. See: http://www.azom.com/article.aspx?ArticleID=134. Learners could discuss the controversy in recent years concerning the use of dental amalgams, and the implication of the toxicity of mercury. For example, see: http://www.theguardian.com/lifeandstyle/2013/mar/25/should-amalgam-fillings-be-removed.	2.5 hours	

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Types of chemical interactions: colloids	A type of mixture important in biological systems is a colloid. It is likely that learners will have previously have regarded some colloidal mixtures they have used as 'solutions', e.g. referring to a colloidal mixture of starch in water, for instance, as a 'starch solution'. Solutions, colloids and suspensions could be defined. A colloid is the intermediate mixture, where particles are dispersed rather than being dissolved or suspended. For a good introduction, see: http://chemwiki.ucdavis.edu/Physical_Chemistry/Physical_Properties_of_Matter/Solutions_and_Mixtures/Colloid#Properties_of_Colloids. The components of a colloid will be particles ranging from 1 – 1000 nm in size. Learners do not need to know the terms disperse phase and dispersion medium. The Tyndall effect with a colloid could be demonstrated to learners as a means of distinguishing a colloid from a solution. Common examples of colloids in biology could be introduced to learners, e.g. blood, gelatine, milk, etc. This could lead to an introduction to the macromolecules in biological systems and the interactions between them. The antimicrobial properties of colloidal silver could be discussed. Discussion could then lead to a consideration of some of the wider applications of colloids, along with defining some of the types, e.g. aerosol, emulsion, foam, gel, sol, and learners could research some examples of these. They could consider whether the alloys considered in the previous activity could be classified as a colloid.	2.5 hours	
Types of chemical reaction: nomenclature	The nomenclature of different types of chemical reaction varies between different sources and at different levels. This nomenclature could be established before learners do any independent research. The six types of chemical reaction that learners need to know are: • Oxidation and reduction • Addition • Substitution • Polymerisation • Radical reactions • Displacement. Give a short overview of these initially. There is an opportunity for some practical work in redox reactions (metal extraction), addition (a halogen to an unsaturated compound), substitution (an alkane with a halogen), polymerisation (of glucose-1-phosphate), displacement (metal in a salt solution). Learners could be given the opportunity to recognise each type of reaction and appreciate the roles of these in chemical synthesis and also, where appropriate, in biological systems.	1 hour	

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Types of chemical reaction: learner research	Oxidation and reduction (redox): • Oxidation and reduction reactions are often referred to as redox reactions. Learners could understand oxidation as being the addition of oxygen, removal of hydrogen, or the removal of electrons, and reduction being the reverse of these. For example, extraction of metals from their oxides with carbon; reduction of nitrogen to ammonia; reactions of respiration (oxidation of respiratory substrate) – removal of hydrogen by coenzymes, iron and copper in the electron transport chain; reactions of photosynthesis (reduction of carbon dioxide). The following website gives a helpful overview: http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch9/redox.php Addition reactions: • Two or more molecules combine to form a larger one. For example, addition of hydrogen or other molecules to alkenes or unsaturated fatty acids, which contain double bonds. There is no need, at this level, to consider π and σ bonds. The following website gives a helpful overview: https://www.bbc.co.uk/bitesize/guides/zw4tw6f/revision/7 Substitution: • An atom or functional group is replaced by another. For example, in ultraviolet radiation, methane reacts with bromine or chlorine. The following website gives a helpful overview: http://www.chemguide.co.uk/organicprops/alkanes/halogenation.html Polymerisation: • When small molecules, or monomers, join together to produce larger ones (polymers). Learners could distinguish between addition polymers and condensation polymers, where a small molecule is released, usually water. For example, addition polymerisation of alkenes and derivatives; condensation polymerisation of amino acids into peptides, polypeptides and proteins; monosaccharides into polysaccharides; nucleotides into DNA and RNA. The following website gives an introduction to both types of polymerisation: http://www.s-cool.co.uk/a-level/chemistry/aromatic-and-plastics/revise-it/polymerisation	3 hours (timing of individual components will depend on any practical work being carried out)	

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Types of chemical reaction: learner research (continued) See Lesson Element: Understanding chemical reactions	Radical reactions: • Involve free radicals, chemical species with one or more unpaired electrons. They are formed thermally or photochemically. For example, can be illustrated by free radical polymerisation of ethene. A good, non-synthetic example is with ozone and chlorofluorocarbons (CFCs). The following website gives an overview, though some of this is at a level above that required: http://chemwiki.ucdavis.edu/Organic_Chemistry/Organic_Chemistry_With_a_Biological_Emphasis/Chapter_17:_Radical_reactions/Section_17.2:_Radical_chain_reactions Displacement: • A more reactive element displaces another from its compound. The following website gives a basic overview: http://amrita.olabs.co.in/?sub=73&brch=3&sim=81&cnt=1		
Rates of chemical reactions in biological and chemical systems See Lesson Element: Understanding chemical reactions	Rates of reaction are important in chemical synthesis and in biological systems. Learners could draw up a list of factors that affect the rates of chemical reactions, to cover the eight factors listed in the specification. The following web page provides a starting point: http://www.docbrown.info/page03/3_31rates.htm. The activity/activities carried out could then provide learners with an opportunity to determine the rate of a chemical reaction, which could be chemical or biochemical in nature, and how this is affected by a factor. Rates of reaction can be calculated as how much product is formed per minute, an inverse relationship of the time taken for its completion or from the (initial) gradient of a graph. For more detail, see: http://www.docbrown.info/page03/3_31rates1.htm. Note that The Royal Society of Chemistry website lists 92 activities based on reaction rates. The reaction could be inorganic or an enzyme-controlled biochemical reaction. Learners could make comparisons between reactions taking place in the lab and those in industry. The Internet has a range of data on industrial syntheses, and ideally, learners could be given the opportunity of working through some of these tasks, e.g.: http://www.rsc.org/learn-chemistry/resource/res00000017/ammonia#!cmpid=CMP00001812 Learners could be given the opportunity to present and discuss their findings, ideally from a combination of the same and different chemical reactions.	6 hours	Unit 3 LO1, LO2, LO4

SUGGESTED ACTIVITIES

LO No:	3		
LO Title:	**Understand cell organisation and structures**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Prokaryotic and eukaryotic cells	Many learners will be familiar with the structure of eukaryotic cells, but few with prokaryotic. Organisms with prokaryotic cells could first be defined, i.e. bacteria (including 'eubacteria' and 'blue-green algae') and archaeans. There is little to be achieved in terms of cell structure by looking at prokaryotic cells with a light microscope, but both types could be examined – a plant and animal cell, and cells on a bacterial smear (or hanging drop) – so that learners gain a true impression of comparative size. Bacteria for a smear could be stained with Gram stain. Learners could then research the similarities and differences between the two types of cell, restricted to: • Similarities: both types have a plasma membrane, cytoplasm and genetic material as DNA • Differences: – size – the eukaryotic cell has a nucleus; in prokaryotic cells, the DNA is free in the cytoplasm. A number of websites cover these comparisons, including this one below: http://www.life.umd.edu/classroom/bsci424/BSCI223WebSiteFiles/ProkaryoticvsEukaryotic.htm Learners could identify prokaryotic and eukaryotic cells from micrographs, drawings and photographs.	4 hours	Unit 3 LO3
Cell structure	Learners could be given the opportunity to examine a number of types of plant and animal cells, initially, either from prepared slides or slides made from living tissue. This links with Unit 2; learners could also gain an appreciation of scale of cells by making measurements. With the light microscope, learners could be given the opportunity to become familiar with the plasma membrane, cytoplasm and the nucleus with its contained chromatin material. Chromosomes can be observed in root tip and testis squashes. Mitochondria and chloroplasts are also visible with the light microscope.	2 hours	Unit 2 LO4 Unit 5 LO1 Unit 8 LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Cell ultrastructure: electron micrographs	Learners could then be provided with a range of electron micrographs showing the plasma membrane, mitochondria, Golgi apparatus, lysosomes, rough and smooth endoplasmic reticulum, the nucleus (including the nuclear membrane, nucleolus and chromatin). Electron micrographs of plant cells will reveal, in addition, the cell wall and chloroplasts. Learners could be given the opportunity to recognise these organelles and appreciate that the appearance of these can vary depending on the cell type. Mitochondria, for instance, vary in size and shape, from sausage-shaped to spherical, and in the number and density of cristae. Sets of instructive electron micrographs are available from the scientific suppliers, but these are also freely available on the Internet. A series of labelled micrographs, albeit small, can be found at: http://www.ouhsc.edu/histology/Text%20Sections/Electron%20Micrographs.html.	2 hours	Unit 2 LO4 Unit 5 LO1 Unit 8 LO3
Cell ultrastructure: research project	The work on the roles of cell organelles can be undertaken independently as research projects. The structure of DNA links with Learning Outcome 4. Learners could be given the opportunity to examine and/or construct models of DNA. A good starting point here is the TV production, Life Story (US title:The Race for the Double Helix), which provides a good introduction to the topic being a film dramatisation of the discovery of the structure of DNA in 1953. Learners could be able to describe DNA as a macromolecule made up of nucleotide monomers. A nucleotide comprises a sugar (deoxyribose), one of four bases (adenine [A], thymine [T], cytosine [C] and guanine [G]) and a phosphate. Strands of nucleotide polymers are linked by hydrogen bonds to form a double helix. Learners could produce a model, which they could photograph, or display materials to illustrate the structure of DNA. DNA replication could be described using a series of diagrams or in an animation.	2 hours	Unit 1 LO4 Unit 2 LO4 Unit 5 LO1 Unit 8 LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Tissues	Learners could be given an introduction as to how cells are grouped into tissues that fulfil a specific role. There are numerous websites with light micrographs of cells and tissues. Particularly helpful for the investigation of mammalian cells and tissues is the Blue Histology website (http://lecannabiculteur.free.fr/SITES/UNIV%20W.AUSTRALIA/mb140/Lectures.htm) with a range of mammalian tissues at different magnifications made using different staining techniques. Learners could be given the opportunity to examine and record (by diagrams or digitally) and to describe different types of tissue by examining prepared slides of epithelia, connective tissue, muscle (striated, smooth and cardiac), bone, reproductive tissue (ovary and testis) and nervous tissue. They could research and understand how the structure of each tissue is related to its function. Learners could also appreciate how the cells work so that a tissue works as an integrated whole.	3 hours	

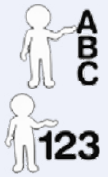
SUGGESTED ACTIVITIES

LO No:	4		
LO Title:	**Understand the principles of carbon chemistry**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
The structure of the carbon atom	The tutor could provide learners with a general discussion of the structure of the carbon atom and its potential to form huge numbers of compounds (estimated as many millions), by bonding with itself and other elements, eg nitrogen, oxygen, phosphorus, sulfur and halogens. In addition to this, it can also form single, double and triple bonds with itself. Periodic Table http://www.rsc.org/periodic-table Chemical bonds https://www.youtube.com/watch?v=7DjsD7Hcd9U Build an atom simulation http://www.rsc.org/learn-chemistry/resources/phet/build-an-atom_en.html	2 hours	Unit 6 LO1 Unit 15 LO1, LO2, LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Alkanes, alkenes and alkynes compounds	Tutors could discuss the structure of alkanes, alkenes and alkynes and use these to discuss the type of bonds which carbon atoms can form. The pictorial and formula representations could also be explained using these types of compound. Learners could then go on to identify alkanes, alkenes and alkynes from formulae or draw the pictorial representation from the name either individually or in groups. Learn Chemistry Learning Resources for Students: http://www.rsc.org/learn-chemistry/resource/listing?searchtext=&reference=students&filter=all&fAudience=AUD00000002&fLevel=LEV00000005&fAudience%2cAudience=AUD00000002 *It should be noted that these links point to many different resources e.g. worksheets, experiments and videos and are aimed at different concepts and levels of ability or attainment. Tutors should consider their learners' specific needs and select appropriate resources from the libraries at these links.* Useful resource: Organic Chemistry (1/3) - Alkanes, Alkenes & Alkynes https://www.youtube.com/watch?v=Z495_i16b8g	1 hour	Unit 6 LO1

Title of suggested activity	Suggested activities	Suggested timings	Also related to
The carbohydrates See Lesson Element: The role of carbohydrates in respiration	Tutors could explain the basic structure of simple sugars and their general formula and then build a picture of the increasing complexity of sugars as they relate to biological systems; for example, glucose is the means by which energy is available to cells and tissue. Learners could then be asked to investigate specific types of reaction within biological systems such as aerobic and anaerobic respiration and present their findings. Learn Chemistry Learning Resources for Students: http://www.rsc.org/learn-chemistry/resource/listing?searchtext=&reference=students&filter=all&fAudience=AUD00000002&fLevel=LEV00000005&fAudience%2cAudience=AUD00000002 *It should be noted that these links point to many different resources e.g. worksheets, experiments and videos and are aimed at different concepts and levels of ability or attainment. Tutors should consider their learners' specific needs and select appropriate resources from the libraries at these links.* Useful resources: Christmas Lectures 2012: The Modern Alchemist https://www.rigb.org/christmas-lectures/watch/2012/the-modern-alchemist Carbohydrates https://www.rsb.org.uk/images/04_Carbohydrates.pdf	1.5 hours	Unit 6 LO1
Types of isomer	Tutors could provide models of isomers and use these to differentiate between structural, geometric and optical isomers. The learners could also carry out experiments such as the extraction of the limonene enantiomer (see resources below). Properties of stereoisomers http://www.rsc.org/learn-chemistry/resource/res00000544/properties-of-stereoisomers Three isomeric alcohols http://www.rsc.org/learn-chemistry/resource/res00000588/three-isomeric-alcohols	2 hours	Unit 6 LO1

SUGGESTED ACTIVITIES

LO No:	5		
LO Title:	**Understand the importance of inorganic chemistry in living systems**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
What is inorganic chemistry? 	Tutors could use the interactive periodic table on the Royal Society of Chemistry website in order to identify the different metals and their properties. Bioinorganic chemistry http://www.adichemistry.com/inorganic/bioinorganic/bioinorganic-chemistry.html Bio inorganic compounds flashcards https://quizlet.com/13805183/bio-inorganic-compounds-flash-cards/ Periodic Table http://www.rsc.org/periodic-table	1 hour	Unit 1 LO3
Metals and their ions 	Tutors could discuss the charges of alkali, alkaline and transitional metal ions and demonstrate how metal ions can be identified by the colour of the flame they produce. Learners could be asked to observe the flame tests and record the findings. Further, unidentified substances could be tested and the learners required to identify the metal ions. This could be delivered jointly with elements of Learning Outcome 2. Metal alloys http://metals.about.com/od/specification1/a/Metal-Alloys.htm	1 hour	Unit 1 LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Using the chemical formulae of substances and their oxidation state to predict the result of a reaction 	Tutors could explain, using examples, how to use the knowledge of the chemical formulae of the original substances and their oxidation state to identify the outcomes of a reaction. This could lead to a discussion of reduction and oxidation (redox) reactions. Learners could then be given a handout with a number of original substances and be asked to identify the outcomes and identify the reduction and oxidation elements of the reaction. Writing Ionic Equations For Redox Reactions http://www.chemguide.co.uk/inorganic/redox/equations.html	1.5 hours	Unit 1 LO3 Unit 3 LO6
The role of the magnesium ion in photosynthesis 	Tutors could discuss the process of photosynthesis and the two different types of chlorophyll and their structures and use this to explain the role of magnesium as the coordinating ion. Photosynthesis https://www.rsb.org.uk/images/15_Photosynthesis.pdf	1 hour	Unit 1 LO3

SUGGESTED ACTIVITIES

LO No:	6		
LO Title:	**Understand the structures, properties and uses of materials**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Mechanical properties of materials	Tutors could begin this Learning Outcome with a brief introduction to the classification of materials (see http://www.nde-ed.org/EducationResources/CommunityCollege/Materials/Introduction/classifications.htm) and how atomic structure and atomic bonding affects the properties of materials (see http://www.nde-ed.org/EducationResources/CommunityCollege/Materials/Structure/bonds.htm). This could also include how crystal structure affects material properties, such as that of metals (see http://www.chemguide.co.uk/atoms/structures/metals.html). Learners could investigate the mechanical properties of materials including strength, stiffness, malleability, ductility, brittleness, hardness and density. Web-based resources such as the following could prove a useful starting point: Material properties http://www.technologystudent.com/joints/matprop1.htm Ductility of metals http://www.youtube.com/watch?v=OkuDM3hYutI	2 hours	Unit 10 LO2, LO5 Unit 21 LO2
Polymers	Tutors could begin by explaining what is meant by 'polymerisation', including molecular arrangement. The following web-based resource includes comprehensive tutor resources: http://bpes.bp.com/secondary-resources/science/ages-14-to-16/chemical-and-material-behaviour/polymerisation/. They could also explain the applications and types of plastics – including thermosets and thermoplastics (see http://www.plasticseurope.org/what-is-plastic/types-of-plastics-11148.aspx). Learners could perform practical experiments in order to make polymers. The following web page includes a series of experiments: https://edu.rsc.org/searchresults?qkeyword=polymers%20and%20polymerisation&PageSize=10&parametrics=&cmd=AddPm&val=WVSECTIONCODE%7C2046	2 hours	Unit 10 LO2, LO5 Unit 21 LO2

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Stress-strain graphs, Hooke's law and Young's modulus See Lesson Element: Force-extension graphs	Tutors could begin by explaining the terms 'stress' and 'strain' (see http://physicsnet.co.uk/a-level-physics-as-a2/materials/stress-strain/) and how the properties of materials can be determined through force-elongation graphs. This could include an explanation of Hooke's law and Young's modulus (see http://www.youtube.com/watch?v=KxxTTf7kUTM). Learners could perform practical experiments to produce force-elongation graphs for different materials, including determining the elastic region, plastic region and yield point. These experiments could be related back to Hooke's law and Young's modulus. Alternatively, web-based videos illustrating how materials' properties are determined through testing could prove useful (see http://www.youtube.com/watch?v=D8U4G5kcpcM).	2 hours	Unit 3 LO7 Unit 10 LO2, LO5 Unit 21 LO2
Boiling point, melting point and sublimation	Learners could independently investigate the terms boiling point, melting point and sublimation. They could relate boiling and melting points to the position of elements in the periodic table and also examine boiling and melting points for common materials including how this affects their application (see http://www.engineeringtoolbox.com/melting-boiling-temperatures-d_390.html). Learners could perform practical experiments to explore boiling and melting points, and also observe the process of sublimation (see http://www.youtube.com/watch?v=6YYrcHLckMw).	2 hours	Unit 10 LO2, LO5 Unit 21 LO2
Charge flow, EMF and potential difference	Tutors could explain the process of charge flow, and how this differs in conductors, insulators and semiconductors (see http://www.physicsclassroom.com/class/estatics/Lesson-1/Conductors-and-Insulators). They could relate this to the drift velocity of electrons and its relationship to current (see http://resources.schoolscience.co.uk/CDA/16plus/copelech2pg3.html). The concepts of electromotive force (emf) and potential difference could also be explained (see http://www.physicsclassroom.com/class/circuits/Lesson-1/Electric-Potential-Difference). Learners could perform practical experiments to measure electromotive force and potential differences in simple electric circuits.	2 hours	Unit 15 LO3, LO4

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Resistance and current	Tutors could consolidate existing knowledge of charge flow, electromotive force and potential difference to introduce resistance and resistivity. The relationship between these could be explained, and Ohm's law introduced (see http://www.allaboutcircuits.com/vol_1/chpt_2/1.html). Tutors could explain that electrical cells have their own internal resistance (see https://www.bbc.co.uk/bitesize/guides/zxx66sg/revision/1) and that circuits present external resistances that can be in series, parallel or in combination. Tutors could develop problems for learners to solve involving internal resistances, series resistors, parallel resistors, resistors in combination and the application of Ohm's law. Tutors could explain with suitable examples Kirchhoff's laws i.e. the voltage law and the current law (see http://www.electronics-tutorials.ws/dccircuits/dcp_4.html).	3 hours	Unit 15 LO3, LO4
Electrical energy and power	Tutors could conclude this Learning Outcome by introducing learners to power and energy in electric circuits (see http://www.physicsclassroom.com/Class/circuits/u9l2d.cfm). They could explain the difference between power and energy with examples – such as the power consumed by household appliances and how this relates to energy charges and tariffs. Tutors could develop power and energy problems for learners to solve which involve voltage, current, resistance and time. Learners could perform simple experiments to determine, for example, power dissipated in a resistor or energy consumed by a circuit over a set time period.	1 hour	Unit 15 LO3, LO4

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