Unit 1: Principles and Applications of Science I

Delivery guidance

Approaching the unit

This is an externally assessed unit that gives your learners the knowledge and understanding that underpins progression in the science sector and on to science higher nationals and degrees.

Delivering the topics

For **topic A**, a good starting point would be to give learners a copy of the Periodic Table of the elements and exploring what information can be obtained from it (that is, arrangement of the elements, atomic and mass numbers, relative atomic masses, and the relationship between group and period position to the electronic structure of atoms). You could use demonstrations of elements' properties and reactions to illustrate points (for example, group 1 metals with water, group 7 displacement reactions). You could then give problems to learners to draw simple electron configurations for atoms and then you can discuss with learners the limitations and anomalies of the Bohr model. You can build on this by introducing the concepts of electronic orbitals, the Aufbau principle and s, p and d block elements and s, p, d notation. Learners could then revisit their problems with this new information. Subsequent sessions should move on to include compounds, their bonding (ionic, covalent or metallic) and structure. This would be linked to practical work where learners could investigate the properties of unknown substances (such as conductivity, solubility and relative melting and boiling points), and attempt to classify the type of bonding and structure. Underpinning theoretical work will include drawing dot and cross diagrams and structural cross-sections, explaining the nature of the bonding and its influence upon a substance's physical properties. Factors such as bond strength and length, lattices and molecular shape, and the role of intermolecular forces (van der Waals, dipole-dipole and hydrogen bonding) must also be included in the explanations.

Learners should then move on to look at periodicity of the elements by considering physical and chemical properties. They could research data for physical properties for atoms of elements and explain trends in properties across periods and down groups in terms of atomic and electronic structure. Explanation of changes in macroscopic physical properties, such as conductivity, melting and boiling point, need to be explained in terms of changes in bonding and structure for the elements. You should give learners practical investigations or get them to observe demonstrations for e.g. reactions of elements in periods 2 and 3 with oxygen; metals with oxygen, water and acids; and displacement reactions for metals and halogens. They will need to describe and explain trends in reactivity observed and identify oxidation and reduction. For the reactions, learners must construct chemical equations and name products formed.

You could give learners quantitative practicals such as gravimetric analysis of solids, preparation of standard solutions and titration of acids and alkalis to

determine concentrations, percentage yields, reacting quantities and balance equations.

You can give opportunities throughout the delivery and learning of this topic for learners to present their own research on substances and their applications to the group.

For **topic B**, learners need to complete practical work and assessors will assess and validate this. Centres must ensure they comply with all health and safety guidance and regulations. Learners must be encouraged to risk assess practical work to help ensure they are aware of the safety issues and follow the relevant procedures and guidelines.

Use of simulation and animations of cells and cell organelles using both optical microscopes and electron micrographs could offer stimulus material to aid recall of knowledge from level 2 and allow learners to extend their understanding of the structure and functions of cells. Model making using paper shapes or jelly cells with sweets to simulate cell organelles can be useful to help some learners understand the concept and also to distinguish between plant and animal cells. The production of biological diagrams is essential in terms of understanding the structures and the ability to complete magnification calculations is imperative. You should ensure that learners are able to identify prepared slides showing gram-positive and gram-negative bacteria and understand their use in antibiotic preparation.

In preparation for assessment, learners will need to have had the opportunity to prepare and stain microscope slides for examination. Learners may need to revise handling and use of microscopes. You need to demonstrate good biological drawing technique. You should give learners opportunities for practice prior to assessment using, for instance, purchased prepared microscope slides of material other than that to be assessed. Photomicrographs, simulations from the internet and textbooks should be available, in conjunction with purchased slides showing specialised cell structures. Kinaesthetic learners may benefit from the opportunity to model the sperm and ovum in order to understand fully the size and structure of these specialised cells.

Once again, you will need prepared slides in order to compare the epithelial tissues. Demonstration of an animal pluck will allow the learners to relate the micro to the macro structure of the lungs to understand the hierarchy of cells, tissue and organs. Written lab reports of the practical investigation into the relative strength of arteries and veins should be written and evaluated. You could organise visits to hospitals to see ECG traces and understand how to interpret these. Presentation of personal research into neurotransmitters and naturally occurring brain chemicals to the assessor and other learners will further reinforce the learning. Scientific articles in magazines can reinforce understanding of new developments into the treatment of depression and Parkinson's disease as this is an exciting area of development.

For **topic C**, learners must develop an understanding of the theory of both transverse and longitudinal waves and be able to use this theory to understand and explain the importance of waves in a variety of applications. Learners need to see superposition effects to understand this concept. You can best do this through practical demonstrations or the use of online resources. Learners should have the opportunity to use diffraction gratings to produce spectra and be able to take measurements from vibrating strings and air columns to study the characteristics of notes produced by musical instruments. Refraction of light and the measurement of critical angles is another practical activity that learners can carry out. You can then apply these concepts to optical fibres and their uses in medicine and communication. Learners also need to appreciate the difference between analogue and digital signals, and the importance of the regions of the

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electromagnetic spectrum in producing the high-quality signals needed for modern day communication systems.

As concepts in physics are expressed mathematically, this topic requires that learners need to be able to use the relevant equations and are able to apply mathematical skills to problems in physics. Learners need to be able to transform equations, use standard form and trigonometric functions. They must also be familiar with the accepted symbols that are used for quantities given in equations, give units in standard form and know the standard prefixes to indicate multiples or fractions of a unit. Throughout the course, you should stress accurate use of symbols and units as well as always showing the working for calculations. Prior to the examination learners should be given a suitable time for revision, which the assessor will lead. This should include a discussion of examination technique, review of the examination command words as well as completion of exemplar material.

Assessment guidance

This unit will be assessed through a 90-minute written exam worth 90 marks. The paper is split into three sections, and each section (biology, chemistry and physics) is worth 30 marks. The exam will be set and marked by Pearson.

The paper will include a range of question types. These include:

- multiple choice
- calculations
- short answer
- open response.

These question types are intended to assess learners' discrete knowledge and understanding of the content in this unit.

Sample assessment materials will be available to help centres prepare learners. You should also give learners the table of command words found in the specification and talk through the words.

Getting started

This gives you a starting place for one way of delivering the unit. Activities are supplied in preparation for the external assessment.

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Topic A – Periodicity and properties of elements

A1 Structure and bonding in applications in science

A2 Production and uses of substances in relation to properties

- Learners can discuss what they already know about the periodic table of elements, its value to chemists and information that they can take from it, as a means to get everyone to the same starting point. Tutor input can then fill gaps in knowledge and extend understanding of the atomic model further into orbitals and s, p and d notation.
- Theoretical sessions should be regularly interspersed with practical activity sessions such as the decomposition of a group 2 carbonate, the preparation of a standard solution, and acid-base and redox titrations. You can link this to the use of the Periodic Table to undertake mass, volume and molar calculations, and the writing of balanced equations.
- Learners can move on to compounds and use the periodic table to solve problems involving the deduction of formulae and drawing diagrams to represent the bonding between atoms. The theory can again be interspersed with practical investigations so that learners can determine the differences in properties between metals, ionic and covalent compounds, such as solubility, electrical conductivity and melting points.
- You can give a project to learners to look at different substances and their everyday use or application. Learners can then present their findings back to the group, giving explanations of the substance's properties and justification of its use rather than alternative substances.
- Learners will then look at trends in physical properties across periods and down groups by being set a research-based task to find data relating to first ionisation energy, electron affinity, electronegativity and atomic and ionic radius. Learners could tabulate the data or present it in graphical form, and supplement it with an explanation.
- Practical work or tutor demonstrations should form the basis of the learners' understanding of the chemical properties of the elements. Practical activities should include period 2 and 3 elements burning in oxygen, the reaction of metals with water and acids, and displacement/redox reactions, so that learners can observe relative reactivity down groups and across periods. You should give them the opportunity to explain their observations, write equations and carry out quantitative calculations.

Topic B – Structure and function of cells and tissues

B1 Cell structure and function

- Learners should carry out practical work to practise preparation of microscope slides and use microscopes. Your input about good drawing technique and opportunity to practise skills will be required.

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- Use optical microscopes to observe slides of various types of bacterial cells to distinguish prokaryotes and compare these to electron micrographs of subcellular structures.
- Calculate the size of cells using 'I AM' calculations from direct viewing using an optical microscope or images from electron micrographs.
- Ask learners to label subcellular structures using electron micrographs in prokaryotic and eukaryotic cells.
- Make jelly cells to illustrate subcellular structures of eukaryotic cells using sweets as organelles for both plant and animal cells to distinguish specific structures.
- Arrange an assessor-led discussion showing three-dimensional views of cells to enable further understanding of these structures.
- Individual research into one subcellular structure to be presented to the class.
- Ask learners to carry out a research task into Hans Christian Gram to discover the difference between the staining of gram-positive and gram-negative bacteria. This task could also be extended to look at the uses of these bacteria in everything from medical treatment to Swiss cheese manufacture.

B2 Cell specialisation

- Optical microscopy will enable learners to look at specialised cells and drawing of biological structures in order to understand their complexity and structure function relationship.
- Model sex cells using modelling clay, paper and string to show size and major structures.
- Preparation and viewing of root hair cells from cress seeds works particularly well.
- View prepared blood smears to distinguish the various components of the blood.
- Production of cartoon strip on the action of the different white blood cells when encountering foreign pathogens.

B3 Tissue structure and function

- Allow learners to observe squamous and columnar epithelial tissue under optical microscopes and drawing of biological diagrams to reflect the differences and similarities.
- Demonstrate a pluck to illustrate the macro structure of the lungs including inflation of the lung to show the action of ventilation.
- Ask learners to carry out an investigation into the strength of arteries and veins to understand the differences between the different vessels.
- Learners should undertake research into respiratory and cardiovascular diseases due to smoking tobacco. Learners should research and present their findings back to the class in five-minute presentations.
- Assessor-led discussion about sliding filament theory with animation of the action of fast and slow twitch muscle fibres.
- Interpretation of graphical displays of a nerve impulse and electrocardiogram (ECG) recordings.
- Compare graphs of myelinated and non-myelinated neurones, comparing size and speed of action.
- Learners should research the action of neurotransmitters at the synapse.
- Use NASA's 'the brain in space' learning activity II to model axons.

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- Learners could carry out a research task for feedback to groups into the action of dopamine and serotonin on the brain.

Topic C – Waves in communication

This topic will give learners the opportunity to study different types of waves and appreciate the importance of waves to many aspects of their lives. Most of the theory delivered is supported by practical experiments that encourage critical thinking, problem solving and team working. Learners will also learn to apply mathematical relationships to wave forms and develop communication skills by giving their own presentations. This, with time dedicated to revision, will give a good basis for success in the examination.

C1 Working with waves

- You should define the features of both longitudinal and transverse waves, carrying out experiments and demonstrations to support the understanding of wave motion.
- Light waves are applied to diffraction gratings and sound waves to musical instruments. Learners research further applications, select relevant information and make short presentations. The equations are given and verified by experiment. This tests problem solving, critical thinking and develops mathematical understanding.

C2 Waves in communication

- Learners need to understand the transmission of light through fibre optic cables and the uses of fibre optics in medicine and communication. Learners should carry out experimental work to show refraction and total internal reflection, and from the results they can calculate values of refractive index. This requires learners to work accurately, as they can compare their results with known values of refractive index.

C3 Use of electromagnetic waves in communication

- Learners will study the waves of the electromagnetic spectrum as a whole and the mathematical link between intensity and distance from the source of a wave should be established through experiment and then applied to the equation. Applications of various waves in the electromagnetic spectrum to modern day communication can then be researched and a short presentation given.
- Preparation of a revision timetable, time management of revision and tutor-led revision exercises will help prepare learners to attempt the sample examination material. This then gives a basis for tutor-led discussion and more focused revision prior to learners taking the examination.

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Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

This unit, alongside *Unit 5: Principles and Applications of Science II*, covers some of the fundamental core science concepts in biology, chemistry and physics.

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC Nationals in Applied Science. Check the Pearson website (http://qualifications.pearson.com/en/support/published-resources.html) for more information as titles achieve endorsement.

Textbooks

Annets, F., *Applied Science L3 BTEC National*, Pearson Education, 2010 (ISBN: 978-1846906800).
The chapter on cells and tissue structure supports the unit content and has activities suitable for learners to access practice skills and acquire knowledge and understanding prior to assessment. Chapter 1 supports understanding of atomic structure, bonding and quantitative chemistry and Chapters 4 and 22 support an understanding of practical and analytical skills needed.

Chapman, B., Beavon, R. and Jarvis, A., *Structure, Bonding and Main Group Chemistry*, Nelson Thornes, 2003 (ISBN: 978-0748776559).
Good overview of the main features of the periodic table, groups, bonding and structure.

Clark, J., *Calculations in AS/A Level Chemistry*, Longman, 2000 (ISBN: 978-0582411270).
This book has many relevant calculations and worked examples.

Duncan, T., *Advanced Physics*, 5th edition, John Murray, 2000 (ISBN: 978-0719576690).
Has clear references to standard experimental activities and challenging problems.

Fullick, A. and McDuell, B., *Edexcel AS Chemistry Students' Book*, 1st edition, Longman, 2008 (ISBN: 978-1405896351).
Various chapters support understanding of periodicity, group 1 and 7 properties and reactivity.

Ramsden, E.N., *A-level Chemistry*, 4thedition, Nelson Thornes, 2000 (ISBN: 978-0748752997).
In-depth look at atomic theory, bonding and periodicity.

Ramsden, E., *Calculations for A-Level Chemistry*, Nelson Thornes, 2001 (ISBN: 978-0748758399).
This book has many relevant calculations and worked examples.

Journals

Chemistry World
www.rsc.org/chemistryworld

Education in Chemistry
www.rsc.org/Education/EiC

Guardian Science
www.guardian.co.uk/science

Nature
www.nature.com

New Scientist
www.newscientist.com

Scientific American
http://www.scientificamerican.com

Technical journals requiring high-level reading skills and ability to use and understand technical terms. They contain articles and latest news and research into related topics.

Videos

https://www.youtube.com/watch?v=gFuEo2ccTPA
An introduction to cells (2.55 mins).

https://www.youtube.com/watch?v=4OpBylwH9DU
History of cell theory TED ED.

Websites

www.cellsalive.com
This gives an overview of both prokaryotic and Eukaryotic cells and specialised cells including interactive cells and videos on microscopy.

http://chemistry.about.com
About Chemistry website – engaging chemistry practical demonstrations and videos.

www.cleapss.org.uk
Health and safety information when handling chemicals and performing experiments.

www.ibiblio.org/virtualcell
This shows a virtual cell and is an online textbook on cell structure.

www.mananatomy.com
A useful website for research into tissues and organs.

www.nasa.gov
Activities on the brain in space to model the axons.

www.nationalstemcentre.org.uk
National STEM (Science Technology Engineering and Mathematics) Centre website – resources for supporting delivery and learning, links with employers and industry.

www.nuffieldfoundation.org/practical-chemistry
Nuffield Foundation website – a good range of practical chemistry experiments.

www.physicsclassroom.com/gallery/waves
Photos of different types of waves.

www.rsc.org
Royal Society of Chemistry website – resources and videos to support the delivery of chemistry.

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www.schoolscience.co.uk
Association of Science Education website – links to resources, activities, events and research.

http://spiff.rit.edu/classes/phys312/workshops/w10b/spectra/mystery_spectra.html
Using diffraction gratings to produce line spectra of elements.

www.youtube.com/watch?v=0MwMkBET_5I
Fibre optic cables.

www.youtube.com/watch?v=8VZHym6HqVU
TRI for semi-circular glass block.

www.youtube.com/watch?v=9LkLj8TS9VI
Different types of waves.

www.youtube.com/watch?v=BE827gwnnk4
Resonance in a wine glass.

www.youtube.com/watch?v=eAXVa__XWZ8
Millennium bridge.

www.youtube.com/watch?v=egRFqSKFmWQ
Diffraction single and double slit MIT.

www.youtube.com/watch?v=HPcAWNIVI-8
NASA tour of the electromagnetic spectrum.

www.youtube.com/watch?v=j-zczJXSxnw
Tacoma Narrows bridge.

www.youtube.com/watch?v=NpEevfOU4Z8
Standing water waves.

www.youtube.com/watch?v=RIx8jdhtngs
Resonance tube, pipe closed at one end (closed pipe).

www.youtube.com/watch?v=VE520z_ugcU
Wave machine demonstration.

www.youtube.com/watch?v=w2s2fZr8sqQ
Different types of waves.