# Unit 1: Fundamentals of Science

**Unit code:** R/502/5536

**QCF Level 3:** BTEC National

**Credit value:** 10

**Guided learning hours:** 60

## Aim and purpose

The aim of this unit is to enable learners to develop the practical techniques necessary to pursue a career as a laboratory technician. Learners will investigate the quantities necessary in chemical reactions, the structure and functions of cells, the calorific value of different fuels and develop skills in communicating scientific information.

## Unit introduction

Learners wishing to pursue a career in science will need a general understanding of all the main sciences, including basic practical techniques. This unit introduces learners to a number of fundamental scientific concepts in chemistry, biology and physics.

Learners will develop vocational practical skills and knowledge of techniques through carrying out practical investigations. These include general skills such as handling and setting up laboratory apparatus; carrying out risk analysis; safely following laboratory procedures and processes; recording and analysing data; and communication skills in recording and using information. Equipment and apparatus for more specific uses will include volumetric equipment, microscopes and simple calorimeters.

The unit also concentrates on the important aspect of communicating scientific information using the correct terminology. Learners will have the opportunity to present their own information using a variety of formats and to consider the way that information is presented within a professional journal.

Successful completion of this unit should develop learners underlying skills in simulating work carried out by science technicians in order to enable them to work effectively in industry and in analytical services.

## Learning outcomes

**On completion of this unit a learner should:**

1 Be able to use the necessary skills to measure quantities for chemical reactions

2 Be able to use the correct equipment to identify structures and functions in different types of cells

3 Be able to investigate different types of energy and their transfers

4 Be able to communicate scientific information.

# Unit content

## 1 Be able to use the necessary skills to measure quantities for chemical reactions

*The periodic table*: organisation of elements; periodicity; groups (physical and chemical properties); relative atomic mass; atomic number

*Electronic structure of atoms*: Bohr's theory

*Bonding of elements*: ionic bonding; covalent bonding; tetrahedral basis of organic chemistry

*Quantities in chemical reactions*: formulae; balanced equations; relative molecular mass; moles; molar masses; molarities; preparation of standard solutions and titrations

## 2 Be able to use the correct equipment to identify structures and functions in different types of cells

*Microscopic structures of cells*: prokaryote (bacteria); eukaryote (plants, animals)

*Cell organelle structure and function*: cell membrane; cell wall; nucleus; nucleolus; cytoplasm; mitochondria; ribosome; endoplasmic reticulum (smooth and rough); Golgi body; lysosome; vesicles

*Tissues and their functions*: epithelial; connective; nerve; muscular

## 3 Be able to investigate different types of energy and their transfer

*Types of energy*: mechanical (kinetic and potential); chemical; thermal; electrical

*Examples of energy transfer*: metabolism, potential to kinetic, generation of electrical energy; thermal energy from fuels; nuclear energy to electrical energy

*Measurement of energy*: units; use of the calorimeter, efficiencies of energy transfer

## 4 Be able to communicate scientific information

*Methods of communication*: scientific report; scientific posters; presentations; audience; terminology

*Scientific report writing*: title; abstract; introduction; method; results; accuracy; discussion; conclusions; references; bibliography

# Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

| Assessment and grading criteria | | |
|---|---|---|
| **To achieve a pass grade the evidence must show that the learner is able to:** | **To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:** | **To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:** |
| **P1** outline the key features of the periodic table, atomic structure and chemical bonding [IE1, SM2,3] | **M1** relate the key features of the periodic table to the conclusions drawn from the practical activities | **D1** explain how standard solutions and titrations are prepared in industry |
| **P2** demonstrate practically the ability to prepare chemical solutions and test their accuracy [IE2, EP3] | | |
| **P3** record accurately observations of different types of tissues from a light microscope [IE6, SM2,3] | **M2** explain how the relative presence of different cell components influences the function of tissues | **D2** compare different tissues with similar functions in terms of their structure and functions |
| **P4** interpret electron micrographs of different types of tissues [IE6] | | |
| **P5** describe the key structures and functions of a eukaryotic and prokaryotic cell [IE1; SM2,3] | | |
| **P6** describe different types of energy transfer [IE1] | | |
| **P7** carry out a practical investigation into the calorific value of different fuels [IE2; SM2,3; EP3] | **M3** carry out a practical demonstration of a range of energy interconversions with appropriate explanations of the systems investigated | **D3** evaluate the efficiencies of energy conversion systems |
| **P8** outline the methods by which scientific information is communicated [IE1] | **M4** produce a detailed, correctly structured report which demonstrates a high level of presentation. | **D4** compare and contrast the report with a similar report from a professional journal. |

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| **P9** report on a scientific investigation that has been carried out. [IE6, RL6, SM1] | | |

**PLTS**: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

| **Key** | IE – independent enquirers | RL – reflective learners | SM – self-managers |
|---|---|---|---|
| | CT – creative thinkers | TW – team workers | EP – effective participators |

# Essential guidance for tutors

## Delivery

This unit is delivered through the introduction of scientific concepts followed by a series of practical exercises. These should be set in the context of realistic vocational scenarios where possible.

Learners need to review and develop their understanding of the periodic table, atomic structure and chemical bonding. This can be done through a series of worksheets or using one of the many computer programmes available. Some learners may need substantial teacher input. Practical work should provide learners with the opportunity to learn the techniques needed to prepare standard solutions and carry out titrations by using volumetric glassware appropriately. Calculation of quantities used in chemical reactions should be introduced through the use of balanced equations and learners should have the opportunity to develop their understanding of the terms and use of relative molecular mass, moles and molarities.

Although learners may have used microscopes previously, time should be allowed for maximising the effective use of the varying components of the instrument and stains. Learners need to develop correct techniques for drawing images seen with the microscope. This is fundamental to future use of the microscope in other units. The study of cell organelle structure and function can usefully be carried out using a combination of light microscope work, observation of electron micrographs and learner research. Groups of learners could make models of different cell types and make presentations to other groups. Learners need to consider all organelles and tissue types listed in the *Unit content*.

For learning outcome 3, a review of the different types of energy will be needed. This may be through class discussion, group presentations, teacher input or individual completion of worksheets. An understanding of types of energy is essential before learners investigate examples of energy transfers. The energy transfers investigated should be a development from Key Stage 4 work and therefore more complex. Formal teaching may be necessary for learners to be able to appreciate the varying efficiencies of conversion systems. Simple calorimeters will be needed for investigating different fuels.

The importance of effectively communicating scientific information is often overlooked. Learning outcome 4 enables learners to develop a coherent approach to writing scientific reports and to consider other important ways of presenting information. A visit to a scientific museum or display could be a useful and informative activity for this learning outcome. Planned activities should include the research and preparation of material for learners to present in a variety of formats. Learners should develop a standard format for reporting results of scientific investigations using the headings listed in the *Unit content*.

## Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

| Topic and suggested assignments/activities and/assessment |
|---|
| Introduction to unit – concept of looking at theory and then related practical work. Health and safety implications. |
| Tutor introduction to a review of the periodic table, atomic structure and bonding using computer software or worksheets. |
| The mole in chemistry, calculating quantities. Formal teaching followed by practice exercises. |
| Theoretical input on use of volumetric equipment. Practise preparing standard solutions and carrying out titrations. |
| **Assignment 1 – Volumetric Analysis Made Easy (P1, P2, M1, D1)**<br>Individual learning time plus laboratory practical work. |
| Correct use of microscope using prepared slides. Practise how to draw and label from slides which show cell structure. |
| Use of electron micrographs to observe cell structures. Discussion of differences in observations using light and electron microscopes.<br>Identification of cell organelles, individual research on function of organelles. Cells – tissues – organs – systems. |
| **Assignment 2 – Training for Work (P3, P4, P5, M2, D2)**<br>Individual learning time plus laboratory practical work. |
| Review of energy types and identification of units used in measurement of each type. |
| Practical demonstrations of energy conversions. Learners research applications of energy transfers, consideration of efficiency. |
| Practise use of calorimeter. |
| **Assignment 3 – Energy for All (P6, P7, M3, D3)**<br>Individual learning time plus laboratory practical work. |
| Tutor introduction to the topic. Learner research into methods of communication. Class discussion on suitability of different methods. |
| Preparation of material to produce a scientific poster and carry out a presentation of scientific information – topic to be chosen by learners. Consideration of different purposes and types of audience. |
| 'What goes where' – class or group discussion of the component parts of a scientific report. |
| **Assignment 4 – Communicating Scientific Information (P8, P9, M4, D4)**<br>Individual learning time. |
| Review of unit and assessment. |

## Assessment

For P1, learners must outline the periodic table, the electronic structure of atoms and the bonding of atoms. For P2, learners must demonstrate practically the ability to prepare standard solutions and test their accuracy by titration. Learners must write balanced chemical equations from the results they generate. The quantities in chemical reactions must also be calculated accurately. Lengthy descriptions of the quantities in which chemical systems react are not required for P2. Tutors should complete observation forms as evidence of learners demonstrating required practical skills.

For P3, learners must use a light microscope in accordance with good practice to draw and label samples of tissue types. For P4, learners should use electron micrographs and identify and draw the cell organelles listed in the *Unit content*. For P5, learners must produce a short description of the structures and functions of cell components.

For P6, learners must understand different types of energy and their interconversions. The tutor should teach all the listed types of energy, their associated units of measurement and the interconversions listed in the *Unit content*. Learners should explain the different types of energy and understand their interconversions by completing appropriate practical investigations, under tutor supervision, or worksheets provided by the tutor. For P7, learners must carry out a practical investigation into the calorific value of fuels. Some centres may have limited practical apparatus but simple calorimetry is an essential practical requirement. As an example, the investigation could cover the calorific value of different types of alcohol.

For P8, learners should outline the different methods used to communicate information. For P9, learners need to produce a report using a standard format indicated by the headings given in the *Unit content*. The report should be an accurate account of how the investigation was carried out and should include correctly labelled diagrams, graphs, tables etc.

For M1, learners must draw conclusions for the practical work completed on preparing standard solutions and titrating as appropriate and relate the key features outlined in P1 to these conclusions. Learners must ensure the calculations for the quantities in which chemicals react are accurate. The need for a safe working environment and risk assessments should be reinforced by the tutor. The conclusions given by learners must be accurate and account for anomalous results.

For M2, learners must briefly explain cell differentiation and its importance in the formation of tissue types. Learners should be able to identify different types of tissues from their observations of electron micrographs and explain how the presence of certain numbers of cell components influences the function of tissues. For example, consideration of the effect a large number of mitochondria in a tissue may have on its function. Different tissue types should be considered.

For M3, learners must use appropriate practical methods, as provided by the tutor, to show energy interconversions. Tutors delivering this unit can select appropriate practical methods to enable learners to demonstrate and explain energy conversion systems. Learners should be encouraged to take responsibility for safety and doing risk assessments. Tutors should record practicals carried out by learners on observation forms as evidence of the required work being completed.

For M4, the report produced by the learners must be correctly structured with the appropriate information provided under the correct headings. The abstract, for example, should be concise and stand on its own and the introduction should set the scene for the investigation. The work should be detailed and well presented with a clear record of what was measured and how, with accurate recording, manipulation and interpretation of data and conclusions which accurately reflect observations.

Distinction criteria will develop learners' knowledge, skills and understanding further. Tutors should ensure that calculations are well presented, and there is correct use of scientific terminology. Learners must work with a greater level of independence to achieve the distinction criteria.

For D1, learners must relate their practical work in the laboratory to industrial applications and comment on how procedures and equipment may differ in industry.

For D2, learners must compare different tissues, in terms of their structure, that have similar functions. For example, learners could compare cardiac and skeletal muscle, or endocrine and exocrine glands, or two sense organs/receptors, clearly describing the differences between the tissues and explaining how both tissue types perform similar functions. This grading criterion requires a detailed review of the information learners have given for M2 so that the cellular components of the different tissue types can be identified and explained in terms of the functions of the tissue types. Illustrations learners have provided for M2 would be useful in developing greater understanding of cellular components of tissues and the relationship to the function of the tissue types.

For D3, learners must use the practical investigations completed for M3 to write evaluations on the efficiencies of the energy conversion systems. Each energy conversion system investigated should be individually evaluated with appropriate vocational examples of their applications in industry.

For D4, learners should find a report from a professional journal which reflects the investigation they have carried out. Learners must then compare and contrast the report with their own.

### Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, M1, D1 | Volumetric Analysis Made Easy | You are working as a scientist for 'Edvisprog' – a company producing visual aids for education. | Portfolio of scientific information to be passed to the graphic designer for preparation of a web-based programme to help the teaching and understanding of the use of titrations. |
| P3, P4, P5, M2, D2 | Training for Work | You are newly employed in a cytology department within the NHS. | 'Test sheet' following a training programme. |
| P6, P7, M3, D3 | Energy for All | You are working for an energy company and asked to investigate different types of energy and their conversions. | A portfolio which records the results of research carried out and practical investigations. |
| P8, P9, M4, D4 | Communicating Scientific Information | You have applied for a job as a Scientific Information Officer for a company and asked to provide information which demonstrates understanding and ability to carry out the job. | Presentation to outline the various methods used to communicate scientific information. Production of a report of a scientific investigation and comparison with a professional journal. |

## Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC in Applied Science sector suite. This unit is linked with all the units in the Applied Science suite of qualifications as it underpins the knowledge and understanding of core scientific principles.

The unit may provide links with the National Occupational Standards (NOS) in Laboratory and Technical Activities at Level 3 and the NOS in Laboratory Science at Level 3 (see *Annexe E* for mapping)

## Essential resources

Learners require access to an appropriate laboratory. The following equipment is essential for learners to provide suitable assessment evidence:

- basic laboratory glassware and general laboratory equipment
- volumetric glassware including flasks, pipettes and burettes
- light microscopes
- prepared microscope slides of prokaryotic and eukaryotic cells
- photomicrographs showing cell organelles
- calorimeter.

## Employer engagement and vocational contexts

Where possible, learners should visit industrial laboratories to see how the science they are studying in this unit is used practically within the workplace. Where visits are not possible the use of visiting speakers is encouraged.

It would be beneficial for centres to visit the STEMNET website **www.stemnet.org.uk** or Future Morph **www.futuremorph.org** for more ideas about vocational contexts.

## Indicative reading for learners

### Textbooks

Foale S, Hocking S, Llewellyn R, Musa I, Patrick E, Rhodes P and Sorensen J – *BTEC Level 3 in Applied Science Student Book* (Pearson, 2010) ISBN 9781846906800

Adams S and Allday J – *Advanced Physics* (Oxford University Press, 2000) ISBN 9780199146802

Ciccotti F and Kelly D – *Physics AS* (Collins Educational, 2000) ISBN 9780003277555

Fullick A and Fullick P – *Chemistry: Evaluation Pack* (Heinemann Educational Secondary Division, 2000) ISBN 9780435570965

Fullick A – *Heinemann Advanced Science: Biology* (Heinemann Educational Secondary Division, 2000) ISBN 9780435570958

Fullick P – *Heinemann Advanced Science: Physics* (Heinemann Educational Secondary Division, 2000) ISBN 9780435570972

Thompson A, Lainchbury A and Stephens J – *Advanced Practical Chemistry, 2nd Edition (Independent Learning Project for Advanced Chemistry)* (Hodder Murray, 1997) ISBN 9780719575075

**Journals**

*Chemical Reviews*

*Journal of Applied Physics*

*Nature*

*Scientific American*

*Science*

**Websites**

| | |
|---|---|
| www.akzonobel.com | Akzonobel (formally the ICI Company) |
| www.bbc.co.uk/learning | BBC learning |
| www.cellsalive.com | CELLS alive |
| www.nln.ac.uk | National Learning Network resources |
| www.rsc.org | The Royal Society of Chemistry |

## Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

| Skill | When learners are ... |
|---|---|
| **Independent enquirers** | [IE1,2] carrying out research and reviewing information<br>[IE6] using evidence to support conclusions raised from practical investigations |
| **Reflective learners** | [RL6] communicate learning in a relevant way for different audiences |
| **Self-managers** | [SM2,3] completing practical and work within timescale |
| **Effective participators** | [EP3] proposing practical ways forward when carrying out practical investigations. |

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

| Skill | When learners are ... |
|---|---|
| **Independent enquirers** | [IE4] undertaking independent research, judging the relevance of information |
| **Creative thinkers** | [CT5] preparing presentation material |
| **Team workers** | [TW1] working together in teams with clear responsibilities and roles |
| **Self-managers** | [SM3] action planning for completion of assignments and production of evidence<br>[SM7] seeking help and support from tutor or mentor when necessary |
| **Effective participators** | [EP5,6] contributing to group discussion. |

## Functional Skills – Level 2

| Skill | When learners are ... |
|---|---|
| **ICT – Use ICT systems** | |
| Select, interact with and use ICT systems independently for a complex task to meet a variety of needs | making appropriate choices of software programs to facilitate research, storage and development of information |
| Manage information storage to enable efficient retrieval | correctly using folders etc to store researched information about a number of different topics in an efficient manner |
| **ICT – Find and select information** | |
| Select and use a variety of sources of information independently for a complex task | researching information using a variety of websites to create reports or presentations |
| **ICT – Develop, present and communicate information** | |
| Enter, develop and format information independently to suit its meaning and purpose including:<br>• text and tables<br>• images<br>• numbers<br>• records | producing a well-structured scientific report |
| Bring together information to suit content and purpose | preparing presentation material |
| Present information in ways that are fit for purpose and audience | making presentations |
| **Mathematics** | |
| Identify the situation or problem and the mathematical methods needed to tackle it | identifying the mathematical techniques required during practical investigations |
| Select and apply a range of skills to find solutions | manipulating data gathered |
| Use appropriate checking procedures and evaluate their effectiveness at each stage | ensuring accuracy of calculations |
| **English** | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | presenting their findings to the class<br>listening to tutors and visiting speakers<br>listening to peer presentations<br>taking part in group discussions |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | reading information from a variety of sources, selecting the relevant information to fulfil purpose |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | writing reports, articles and producing presentations following their own research. |