Unit 16: Chemistry for Biology Technicians

Unit code: K/502/5557

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to familiarise learners with some of the basic chemical concepts, on which aspects of biology are based. Concepts such as chemical equilibrium, bonding, rates of reaction and organic molecules will be looked at in detail.

Unit introduction

Biology technicians may perform an enormous range of tasks. They may look after a variety of animals, plants and other organisms or prepare tissue slides in human anatomy and pathology laboratories. Technicians carry out microbiological tests on water or pathology specimens, work in infection control, investigate blood smears, make vaccines, grow cell cultures and carry out biochemical tests and DNA analysis.

Biological knowledge continues to increase exponentially. Thirty to forty years ago, many textbooks would simply describe processes and explain that the underlying mechanisms were not fully understood. This has changed dramatically.

Biological processes work because of the underlying chemical processes. Whatever role in science learners may have or come to have, they will need some understanding of chemistry. If learners understand the units of concentration, they will feel more confident that they are making up a solution or diluting it correctly. If learners understand the nature of chemical bonding, they will understand why certain solvents are used in processing tissue samples. Knowing more about chemical formulae enables learners to identify the correct chemicals to use. Understanding about rates of reaction and equilibrium allows learners to see why standard laboratory protocols may have timed steps.

Biological processes are complex and require a good understanding of chemistry. This unit covers some of the basic chemical concepts to enable learners to begin to understand and explain biological processes.

Learning outcomes

On completion of this unit a learner should:

1 Be able to relate enthalpy changes to the bonding in a range of substances

2 Be able to show how rates of reaction are affected by varying the reaction conditions

3 Be able to interpret key features of equilibrium processes

4 Be able to demonstrate the structure and properties of simple organic molecules.

Unit content

1 Be able to relate enthalpy changes to the bonding in a range of substances

Bonding: ionic; covalent; hydrophilic and hydrophobic; molecules; ions; electronegativity; dipoles; hydrogen bonds; van der Waals forces; intermolecular; intramolecular

Substances: salts; salt solutions; water; organic substances; solids; liquids; gases; emulsions

Influence of bonding on physical propertie:; solubility; melting point; boiling point

Enthalpy and enthalpy changes: system and surroundings; units of enthalpy change; standard enthalpy change, eg sign convention; exothermic and endothermic reactions; reaction profiles; activation energy; enthalpy change associated with making bonds; enthalpy change associated with breaking bonds; principle of Hess's law; enthalpy change in certain reactions and processes, eg boiling, condensation, melting, freezing, dissolution, combustion, respiration, photosynthesis

2 Be able to show how rates of reaction are affected by varying the conditions

Concentration: units of concentration; calculation of concentration on dilution by a known factor

Description of reaction rate: definition of reaction rate in terms of change of concentration with time; units of rate (mol dm^{-3} s^{-1}); rate constant

Factors influencing rates: collision theory, eg number of collisions per unit time; effect of changing concentration; effect of changing particle size; surface area; reaction profiles; activation energy; spread of energies among particles in a sample; temperature; catalysts; enzymes as catalysts

3 Be able to interpret key feature of equilibrium processes

Equilibrium processes: reversible processes; principles of equilibrium, eg rate of forward process = rate of reverse process; equilibrium constants

Examples: concentration on either side of a semi-permeable membrane; acid/base in aqueous solution; redox process

Concentration on either side of a semi-permeable membrane: definition of diffusion in terms of migration of particles from a region of higher concentration to a region of lower concentration; definition of diffusion in terms of movement of water (in the case of a semi-permeable membrane) from a dilute solution to a concentrated solution to attain equilibrium; osmosis.

Acid-base: writing equlibria in terms of acid and conjugate base; acid dissociation constant, K_a; relative concentration of acid and conjugate base in solution in relation to the value of K_a; pH of strong and weak acids and bases; Henderson-Hasselbach equation; calculation of pH from K_a and K_a from pH; structure of amino acids; effect of pH on the ionisation of amino acids

Simple redox reactions: displacement reactions of metal ions by the ions of more reactive metals; half equations for oxidation and reduction; redox equations; writing half equations using equilibrium arrows; standard reduction potentials, $E^{\ominus}$, as a way of expressing the tendency of metal ions to be reduced

4 Be able to demonstrate the structure and properties of simple organic molecules

Functional groups: International Union of Pure and Applied Chemistry (IUPAC) nomenclature; classes of compounds; alkanes; alkenes; alcohols; haloalkanes; carboxylic acids; aldehydes; ketones; esters; amines; amides; recognition of functional groups in complex molecules, eg carbohydrates, fats, amino acids, proteins, nucleic acids

Structure: tetrahedral carbon; planar carbon to carbon double bonds; structural isomerism; chain; positional; functional group; geometric; cis and trans; optical (chiral carbon and its importance in natural systems); linear and cyclic structure of sugars; aldehyde and keto sugars

Properties: similarity of alcohols to water; solubility of alkanes and alcohols; influence of hydrogen bonding on solubility; solubility of sugars; simple reactions of organic compounds (addition reactions for alkenes, oxidation of alcohols to aldehydes and ketones, oxidation of aldehydes to acids, carboxylic acids as acids, esterification, amines as bases, formation of amides)

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 carry out experiments to illustrate the relative magnitudes of the enthalpy changes associated with the formation and breakage of chemical bonds [IE1,2; RL2; EP3]	**M1** explain physical properties of pure substances and solutions in terms of bonding and intermolecular forces	**D1** analyse the influence of electronegativity and molecular size on the bonding and intermolecular forces in pure substances and solutions
P2 carry out experiments to show the effect on the rates of reactions of changes in concentration, particle size, temperature and presence of a catalyst [EP3; RL2]	**M2** explain variation in rates of reaction as a function of concentration, particle size, temperature and presence of a catalyst	**D2** use data to determine orders of reaction, rate constants and rate equations
P3 carry out an experiment on osmosis to demonstrate the drive towards establishment of equilibrium [EP3; RL2]	**M3** use experimental data to calculate Ka	**D3** explain the relationship between the ionisation of amino acids and pH
P4 outline how the acid dissociation constant, Ka, provides information about the extent to which acids and bases dissociate in aqueous solution [CT2; RL2]		
P5 construct half equations and redox equations for simple redox reactions [RL2]		
P6 construct structural formulae for named examples of simple organic compounds, identifying structural, geometric and optical isomers where appropriate [RL2]	**M4** predict the products of reactions of simple organic functional groups, given the reagents and conditions.	**D4** explain, using suitable examples, why understanding the reactions of simple organic molecules is important in living systems.
P7 list typical properties of simple organic compounds. [EP3]		

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 should contain a significant amount of practical work to illustrate the underlying theoretical principles. The learning outcomes may be delivered in an order relevant to the needs of the learners. For example, learning outcome 4 could be studied first where learners need to understand organic chemistry in order to carry out identification of classes of compounds in *Unit 22: Chemical Laboratory Techniques*.

In learning outcome 1, learners measure the enthalpy changes associated with a range of chemical reactions, such as combustion, neutralisation and dissolution of ionic salts. The overall size and magnitude of the enthalpy change is determined by the relative sizes of the enthalpy changes for bond making and bond breaking. Use of reaction profiles is central to understanding this topic. Learners will be introduced to intermolecular forces and merit and distinction learners will extend the notion of bond making and bond breaking for forming new intermolecular forces and overcoming intermolecular forces in relation to understanding physical changes.

In learning outcome 2, learners carry out reactions demonstrating the effects of changes of concentration, particle size, temperature and presence of a catalyst on reaction rates. Learners will explain these effects in terms of collision theory, activation energy and the distribution of energies that molecules in a sample of reacting material possess, merit learners explaining more. Learners should be given the opportunity to use the method of initial rates to determine orders of reaction, rate constants and rate equations from given data.

Biological equilibrium processes include osmosis, equilibria between conjugate acids and bases and oxidation/reduction (redox) equilbria. These are the topics covered in learning outcome 3. Learners will carry out an experiment, studying the mass of vegetable pieces in various concentrations of sugar. This should lead learners to determine the concentration of sugar with which the vegetable pieces would be in equilibrium. The explanation of the results of this experiment will involve discussion of diffusion, driven by a concentration gradient.

The notion of equilibrium will be extended to introduce the concept of an equilibrium constant and, in particular, the acid dissociation constant. Learners will be introduced to the concept of acids in equilibrium with conjugate bases. Where possible, learners should have the opportunity to measure the electrical conductivity and pH of several acidic solutions and to relate the magnitude of the acid dissociation to the pH of the solution, the lower the pH. The greater the acid dissociation constant, Ka, the greater the degree of dissociation. Where appropriate, learners should use the Henderson-Hasselbach equation to calculate Ka from appropriate data. This could involve an experiment. Electrophoresis of amino acids depends on the size of the acid and whether the amino acids are negative, positive or neutral in the buffer chosen. The relationship between pH of a buffer solution and degree of dissociation of an amino acid should be explored.

Redox equilibria are important in biology. As an introduction to the concept, learners need to study displacement of one metal by another and the associated oxidation and reduction equations. Having written reduction and oxidation half equations and overall redox equations for reactions that are easily seen, learners should, in subsequent study, be able to understand redox equilibria and the associated standard reduction potentials better. If time permits, learners could be given biological examples.

Initially, one of the most difficult concepts in organic chemistry (learning outcome 4) is recognising the class to which molecules belong and the different way these may be represented. Learners should be acquainted with a range of classes of organic compounds, eg alkanes, alkenes, primary, secondary and tertiary alcohols, aldehydes, ketones, halogenoalkanes, carboxylic acids, ethers, amines and amides. Learners should be able to construct structural formulae, given the names of the compounds. Isomerism needs to be introduced. Learners should carry out some typical reactions of and study some important properties of organic compounds and should be able to list chemical and physical properties of classes of simple organic compounds. Learners could be encouraged to research reactions not studied practically. If *Unit 22: Chemical Laboratory Techniques* is being studied, this will provide background. Some learners will be able to predict the products of reactions, given reagents and conditions. Biological molecules often contain more than one functional group and learners need to be secure in recognising functional groups and be able to explain why the presence of different groups modifies the behaviour of the molecules.

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 and programme of assignments.
Learning outcome 1 – Enthalpy Introduction – could include small experiments showing temperature given out or taken in – explanation of exothermic and endothermic and the shape of an energy profile. Learners tabulate melting and boiling points of alkanes and alcohols of a similar size. Explain melting point and boiling point in terms of intermolecular forces. Carry out practical exercises – eg measuring solubility of anhydrous sodium carbonate and potassium nitrate, measuring enthalpy of combustion of an alcohol, measuring enthalpy of neutralisation, measuring solubility of a range of alcohols in water. Discuss the size and the sign of the enthalpy changes measured and account for this in terms of the relative sizes of the bond making and bond breaking energies. **Assignment 1 – Enthalpy Changes in Chemical and Physical Processes (P1, M1, D1)**
Learning outcome 2 – Rates of reaction Carry out practical work on the effect of concentration on reaction rate – could include dilution of a stock solution; effect of particle size on reaction rate; effect of temperature on reaction rate; effect of a catalyst (could be en enzyme) on reaction rate. Construct appropriate software graphs of the results of practicals. Describe/explain results of practicals. Present learners with data on initial rates of reaction. Relate initial rate and concentration to order of reaction. Calculate rate constant; write rate equations. **Assignment 2 – Rates of Reaction (P2, M2, D2)**

Topic and suggested assignments/activities and/assessment
Learning outcome 3 – Equilibrium
Introduce the concept of equilibrium.
Learners carry out a practical on osmosis eg measurement of the variation of mass of pieces of potato with time for various concentrations of sucrose.
Explain the results in terms of the drive toward equilibrium.
Assignment 3 – Osmosis (P3)
Introduce acid dissociation, eg of ethanoic acid, as an example of an equilibrium process with an equilibrium constant, K_a.
Collate data on K_a for different acids and conjugate bases.
Introduce pH as a measure of the number of H^+ in solution.
Calculate pH of strong acids.
Use Henderson-Hasselbach equation to calculate the pH of weak acid solutions.
Carry out an experiment to measure K_a.
Assignment 4 – Acid Dissociation Constant K_a (P4, M3, D3)
Carry out a practical on displacement reactions of metals.
Explain the results in terms of the reactivity series of metals.
Write oxidation and reduction half equations and redox equations for the displacement reactions.
Introduce E^θ as a measure of the tendency for metal ions to be reduced in solution.
Assignment 5 – Simple Redox Reactions (P5)
Learning outcome 4 – Organic Molecules
Introduce Nomenclature of alkanes and branched alkanes.
Learners name alkanes, branched alkanes and identify chain isomers.
Introduce alkenes.
Learners name alkenes, including cis and trans isomers.
Learners compare reactions of alkanes with alkenes.
Learners name and study reactions of haloalkanes, particularly nuceophilic substitution to give alcohols.
Learners name alcohols, including positional isomers.
Learners study solubility of alcohols and compare the oxidation reactions of primary, secondary and tertiary alcohols with acidified dichromate (VI).
Learners name aldehydes and ketones and compare reactions.
Learners are introduced to the ring and straight chain forms of sugars and keto sugars.
Optical isomerism is introduced. Learners identify chiral carbons in natural molecules.
Learners name and study reactions of acids, including esterification.
Learners name and study basic character of amines.
Learners name and study formation of amides.
Learners list the reactions studied so far.
Learners predict the products of reactions.

Topic and suggested assignments/activities and/assessment
Learners are presented with biological molecules, and are asked to identify functional groups. **Assignment 6 – Formulae of Organic Compounds (P6)** **Assignment 7 – Properties of Organic Compounds (P7, M4, D4)**
Review of unit and assignment programme.

Assessment

To achieve P1, learners should carry out at least three measurements of enthalpy changes for reactions. Learners could write laboratory reports or could complete a worksheet with questions (or another task which fulfils the criterion). Learners should be able to account for negative enthalpy changes in terms of the bond making energy being greater than the bond breaking energy and positive enthalpy changes in terms of the bond making energy being less than the bond breaking energy. Since there is a great deal of content in the unit, it is unfair to expect learners to write reports for every practical activity.

A suggestion for assessing P1 would be for learners to follow at least three given methods to measure enthalpy changes for different processes, eg combustion, neutralisation and dissolution of ionic substances. They may either write laboratory reports or fill in results on the experimental sheet in a clear way which allows other people to follow the calculation method used. Learners must either discuss the relative sizes of bond making and bond breaking enthalpy changes in relation to the measured overall enthalpy changes for the reactions or complete relevant questions.

For M1, learners should explain melting points, boiling points and solubility in terms of the size of the intermolecular forces which exist in the substances.

For D1, learners should be able to explain high melting points/boiling points in terms of strong intermolecular forces resulting from dipole-dipole interactions and hydrogen bonding, due to high electronegativity of one of the atoms in the molecule. Learners should also explain the effect of molecular size on the interaction between molecules. Learners should explain why one specific compound has a higher melting/boiling point than another specific compound. Examples chosen should be ones with which the learner is not familiar.

A suggestion for assessing M1 and D1 would be to extend the article written for the chemical processes of P1 to include physical processes. Learners could be given data or compile data on physical properties of substances, such as solubility, melting point and boiling point. The size of melting points and boiling points should be related to the strength of intermolecular forces which in turn should be related to the atoms in the molecules, eg presence of electronegative oxygen introducing a separation of charge. To give the article focus, learners could be given some specific comparisons of values to account for, eg the relative differences in the boiling point of methane and water and ethanol and propane. This could be related to the biological importance of water being a liquid over a huge range of temperature.

For P2, learners should follow given methods to investigate the effect of concentration, particle size, temperature and presence of a catalyst (could be an enzyme) on the rates of reaction. (The choice of reactions will depend on what learners have previously experienced and the resources of the centre.) Learners should not only compile data on the effects on reaction rate of changing conditions but also account for the effects measured in terms of collision theory, activation energy and the number of molecules with a particular energy. More detailed explanations of these effects showing clear understanding of collision theory are required for M2.

For D2, it is unlikely that learners would generate enough experimental data to fulfil the criteria. Learners should be presented with data for the initial rate of reaction as a function of initial concentration for at least two reactions involving two or three reactants. Learners should then deduce the order of reaction with respect to the reagents, use the data to determine rate constant and write a rate equation for the reaction in terms of the product of the concentration of reactants, raised to the appropriate power and the rate constant.

A suggestion for an assignment would be to relate the importance of rate of reaction to understanding drug metabolism. The learner could be put in the position of a pharmacology technician, trying to explain basic concepts to a trainee. Learners could follow given methods to investigate the effects of change in concentration, particle size, temperature and presence of a catalyst on reaction rate. A portfolio of experimental data should be generated for P1. Learners should account for this in terms of collision theory, distribution of energy in molecules at a given temperature and activation energy. For M1, learners could be asked to present summary data for each investigation in the form of a PowerPoint with an explanation of the reasons for the observations. To achieve D2, learners could be presented with data on initial rate of reaction for reactions involving two or more reactants. Learners would deduce the order of reaction with respect to concentrations of reactants and the rate equation. Using the scenario of the pharmacology technician, training a more junior technician, the learner could be asked to provide worked examples to problems on initial rates of reaction so that the trainee may better understand the concepts of reaction order, rate constant and rate equations. This scenario could be contextualised to drug metabolism.

For P3, learners should collect data from an osmosis experiment involving loss/gain of mass of pieces of vegetable in sucrose solutions of different concentration, following given instructions. In addition, learners should make conclusions about the drive toward equilibrium being determined by the presence of a concentration gradient. The learner may make independent conclusions or may answer questions/respond to prompts.

Achievement of P4 requires learners to obtain data about the acid dissociation constant, Ka, of at least five substances. Learners should write the equilibrium expressions for the dissociation of the acid in question into its conjugate base. Learners should show that they understand that if Ka is large, the substance will be fully dissociated and that the smaller Ka, the less the substance will dissociate into ions.

For M3, learners could carry out an experiment to find Ka following a given method and calculate results. Alternatively, they could calculate Ka from given experimental data.

For D3, learners should explain that the form of an amino acid, whether positively charged, negatively charged or neutral, depends on the pH of the solution and also on the Ka of the acid group and the amino group. This should be done in relation to at least two specific examples. This may be related to the conditions used in electrophoresis experiments, if appropriate.

Learners will achieve P5 by carrying out simple metal/ion of less reactive metal displacement reactions (at least three) and writing reduction, oxidation and redox equations for the reactions.

To achieve P6, learners will be presented with names of a range of simple organic functional group molecules, representing at least six different classes of compounds. They will construct structural formulae for these compounds and for any isomers (structural, geometric, optical) of the compounds.

To achieve P7, learners should present evidence of knowing the main reactions and important physical properties of at least six classes of organic compounds – alkenes, alcohols, aldehydes, ketones, acids and amines. This may be in any suitable format, eg a list, PowerPoint, poster, synthesis map.

For M4, learners should correctly predict the products of at least six organic reactions of different functional groups, given the starting material and conditions.

For D4, to set the study of functional groups in context, learners should choose at least three different types of biological molecule having at least two functional groups and argue the case for a study of simple molecules being relevant to the study of larger, biological molecules.

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, M1, D1	Enthalpy Changes in Chemical and Physical Processes	As a respected molecular biology technician, you have been asked to write an article for a school science magazine, explaining how enthalpy changes arise in biologically important chemical and physical processes.	Measure enthalpy changes for three chemical processes and relate these to the chemical bonds made and broken. Present data, relating physical properties of substances to the bonding in and interactions between molecules/ions, relating this to electonegativity and size of molecules.
P2, M2, D2	Rates of Reaction	You are a pharmacology technician researching the rate of metabolism of drugs in the body. You have been asked to prepare information for a trainee to enable them to understand the basic factors affecting rates of reaction.	Data from rate experiments could be collated as a portfolio. Explanations of the trends could be presented as a Power-Point presentation. Work on rate equations could be presented as worked examples for a trainee. All this could be contextualised.
P3	Osmosis	You are a technician working for a company that makes medicinal isotonic drinks.	Carry out an osmosis practical. Use the results of a practical osmosis to prepare a guide for new employees on how concentration gradient drives the establishment of equilibrium.
P4, M3, D3	Acid Dissociation Constant, K_a	You are a technician in a biochemistry laboratory which carries out electrophoresis.	You have been asked to write notes about acid dissociation constant, including its measurement, for trainee technicians. This should include the effect of pH on ionisation of amino acids.
P5	Simple Redox Reactions	You work for an organisation which is helping athletes improve their fitness.	Redox principles are central to understanding metabolism but the concept is difficult to understand in terms of the complicated molecules involved. You prepare a guide for staff based on simple metal displacement reactions.

Criteria covered	Assignment title	Scenario	Assessment method
P6	Formulae of Organic Molecules	Technicians at the sports fitness centre have been reading about metabolism of molecules from food. The material involves lots of names of organic compounds which sound similar.	Construct a card activity or a domino activity to help the technicians name compounds correctly.
P7, M4, D4	Properties of Organic Compounds	As a scientific journalist, you have been asked to write an article for a biology journal, explaining why studying organic chemistry is relevant to biology.	Demonstrate what you know about a range of chemical reactions. Show how large biological molecules may contain several functional groups.

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 has particular links with units in this qualification:

Level 3
Biochemistry and Biochemical Techniques
Chemical Laboratory Techniques
Industrial Chemical Reactions
Industrial Applications of Organic Chemistry

Essential resources

Learners require access to a well-equipped laboratory which allows them to carry out practical work with organic compounds safely. Consequently, there must be at least one fume cupboard available. There should be access to computers.

Employer engagement and vocational contexts

There are clear links between chemistry and biochemistry/molecular biology and pharmacology. There are links between this unit and physiology and genetics. Where possible, learners should visit clinical chemistry departments, oncology departments and university physiology, biochemistry, genetics, pharmacology departments where the work of the biology technician depends on his/her understanding of chemistry. Many recent biology journal articles also contain chemistry. A bank of suitable articles should be collected to demonstrate the importance of chemistry to biology.

Indicative reading for learners

Textbooks

Chapman C – *Basic Chemistry for Biology* (William C Brown, 1998) ISBN 9780697360878

Fry M and Page E – *Catch Up Chemistry: For the Life and Medical Sciences* (Scion Publishing, 2005) ISBN 9781904842101

Rockett B and Sutton R – *Chemistry for Biologists at Advanced Level* (John Murray, 1996) ISBN 9780719571466

Sackheim G I – *An Introduction to Chemistry for Biology Students* (Benjamin Cummings, 2007) ISBN 9780805395716

Journals

Chemistry Review

Chemical Science (RSC)

Chemistry World (RSC)

Journal of Chemical Education

Websites

www.chemguide.co.uk	Guide to chemistry
www.chemsoc.org/networks/learnnet/cfb/index.htm	Chemistry for biologists

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 experiments to show the effect on the rates of reactions of changes in concentration, particle size, temperature and presence of a catalyst
Creative thinkers	[CT2] outlining how the acid dissociation constant, K_a, provides information about the extent to which acids and bases dissociate in aqueous solution
Reflective learners	[RL2] setting goals with success criteria when carrying out experiments
Effective participators	[EP3] proposing practical ways forward when carrying out experiments.

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	[IE2,4,6] researching values for acid dissociation constant; finding examples of biological molecules with more than one functional group; finding specific information on the ionisation of amino acids in solutions of different pH; carrying out investigations into the effect of varying concentration, particle size, temperature and effect of a catalyst
Creative thinkers	[CT1,2,6] explaining the physical properties of pure substances and solutions; analysing the effects of electronegativity and molecular size on bonding
Reflective learners	[RL3] addressing the constraints of the scenario for an assessment
Team workers	[TW1,4,6] sharing and comparing experimental data from rate of reaction experiments
Effective participators	[EP4,5] taking part in discussions and question and answer sessions; carrying out any sort of practical work.

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	carrying out internet searches and recording the outcomes in a suitable format
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	constructing diaries and planning documentation which include the scope for reflection
Manage information storage to enable efficient retrieval	saving information from internet searches and from books in suitable files and suitable folders
Follow and understand the need for safety and security practices	keeping food and drink away from computers not using someone else's login explaining how safety is addressed in the context of the tasks. explaining why the IT usage policy forbids certain actions
Troubleshoot	carrying out checks to identify the source of a problem encountered, eg missing file of work
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	saving and bookmarking appropriate sites consulting textbooks collating experimental data. Highlighting key information in sources
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	saving and bookmarking appropriate sites highlighting key information in sources explaining how the information meets the purpose
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	writing about practical work entering numerical information from practical work into suitable tables. collating other data, such as acid dissociation constant in tables saving suitable images like reaction profiles and distribution curves for the energy that molecules have int a sample
Bring together information to suit content and purpose	constructing documents which contain all of the above sorts of information, edited to fit the required purpose plotting suitable graphs in relation to work on rate of reaction
Present information in ways that are fit for purpose and audience	following suggested presentational methods given in the scenarios for the assignments improving the layout of data presented
Evaluate the selection and use of ICT tools and facilities used to present information	writing about why their selection and manipulation of data has been effective

Skill	When learners are ...
Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists	emailing tutors and other learners' data from experiments, including file attachments saving messages appropriately being observed sending emails to people on a list of contacts
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	recognising where mathematical processes need to be applied in the course of practical work on enthalpy change measurement, rate of reaction measurement and studying osmosis
Identify the situation or problem and the mathematical methods needed to tackle it	identifying the ways calculations should be carried out in relation to specific problems
Select and apply a range of skills to find solutions	calculating using calculators and spreadsheets plotting graphs
Use appropriate checking procedures and evaluate their effectiveness at each stage	calculating enthalpy changes and working back from the enthalpy changes to the temperature changes and commenting on this checking process. reading the equilibrium concentration of sucrose from the graph for the osmosis experiment and checking whether the vegetable piece in the solution closest to this concentration did, in fact, lose/gain little mass
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	writing suitable reports or preparing other documents in line with the assignment briefs
Draw conclusions and provide mathematical justifications	drawing conclusions about the effects of concentration, particle size and temperature in relation to the trends where two experiments have involved the same reagents, showing that the results obtained under similar conditions are similar
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	taking part in discussions about the effects on rate of varying concentration, particle size and temperature presenting the results of experiments carried out to peers and to tutors presenting the information in a way that suits the scenario of the assignment brief
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading about the effects on molecular masses of molecular size and the presence of electronegative atoms in molecules
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing lab reports, leaflets and guides according to the suggestions in the assignment brief explaining why studying displacement reactions as examples of redox reactions is relevant to biology.