Unit 16: Applications of Inorganic Chemistry

Delivery guidance

This unit is made up of four key chemistry topics (patterns of reactivity, solubility and energetics, acid–base (pH) and oxidation and reduction (redox)) that will be useful for learners who indent to study chemistry or biology at a higher level or to progress to industrial laboratory work. All topics include practical work, so learners will have opportunities to become more skilled and personally organised in the laboratory. Throughout, you will be able to lead learners in problem-solving and collaborative discussion.

Approaching the unit

For **learning aim A**, learners must understand what is meant by an acid, a base and a substance which is amphoteric, when investigating the chemical properties of the oxides, hydroxides/oxoacids and chlorides of the period 3 elements. They will undertake practical work involving the reactions of these substances with water, acids and bases and will make predictions regarding the acidity, basicity and amphoteric nature of similar compounds for elements in other periods. Learners must be able to explain the acid–base behaviour of period 3 compounds in terms of structure and bonding, and write balanced equations for all reactions.

Learners are introduced to transition metals and transition metal complex ions; they will be aware from *Unit 2* that these have incomplete d subshells. They should understand that, as a result of this, transition metals can have different oxidation states, form coloured complex (hexaqua) ions in solution and catalyse numerous types of reaction. Learners should also understand that molecules with electron-rich areas (such as lone pairs of electrons) can act as ligands and form dative covalent bonds with the transition metal ion involving the vacant orbitals.

They will undertake practical work to observe the reactions of transition metal ions with sodium hydroxide, ammonia solution, reducing agents etc. Finally, learners should be able to explain the applications of transition metals in biological systems, industry and medicine; some of these applications (e.g. the Haber process, hydrogenation of alkenes etc.) will be familiar to them already.

Some of **learning aim B** builds on the concept of energetics (met in *Unit 6*) and learners must be able to define relevant terms such as ionisation energy, electron affinity, standard molar enthalpies for formation, hydration etc. Learners will undertake practical work which involves measuring enthalpy changes for neutralisation and when substances are added to water to form a solution. They must understand the relationship between hydration enthalpy and lattice energy and predict the effects of ionic radius and polarisability on this relationship and on the thermal stability of ionic compounds. Learners must be able to calculate energy changes involved in the formation of an ionic compound from experimental and/or supplied values, using Born–Haber cycles.

This learning aim also deals with solubility and learners should be able to calculate the solubility of a compound at a given temperature from a graph they have produced from a practical investigation. They will also be introduced to the concept of the solubility product (K_{sp}), for which they must write expressions.

They will also use K_{sp} to calculate maximum concentrations of ions of an ionic compound in a solution. Finally, they will calculate the value of an ionic product of ionic compounds and compare their calculated value with literature K_{sp} values to predict whether precipitation will occur.

Some of **learning aim C** builds on concepts met previously, particularly chemical equilibrium. Learners must understand the differences between strong and weak acids and alkalis, and know the meaning of the acid dissociation constant, K_a. The Brønsted–Lowry definition of acids and bases is a useful model. Learners must understand the relationship between pH and the concentration of hydrogen ions, $[H^+]$, in solution, and be able to calculate pH for solutions of strong acids, strong alkalis, weak acids and buffer solutions. Learners will undertake practical work to find K_a, investigate buffer action, and determine the appropriate indicator to use for a titration. They should be able to explain the shape of pH curves for different combinations of acids and bases in a titration and understand why particular indicators are appropriate for particular titrations. Many industrial laboratories, even relatively small ones, use pH meters routinely; some also use acid–base titration, often with autotitrators. A visit to such an establishment or a guest speaker from one might be beneficial.

In **learning aim D**, learners can build on their learning from *Unit 2* and *Unit 6*. They should be encouraged to build on their knowledge of redox, by writing half equations, assigning oxidation numbers and identifying the oxidising and reducing agents involved. They should apply the techniques developed in *Unit 1* (for volumetric analysis) to carry out redox titrations involving solutions such as potassium permanganate or sodium thiosulphate, as well as using colorimetry. They should also be encouraged to build on their knowledge of the reactivity series and displacement of metal ions in solution by the ions of a more reactive metal. Standard reduction potentials are used to express the tendency of a metal ion to be reduced to the metal in terms of a voltage, measured relative to the zero volts of the standard hydrogen electrode. Standard cell voltage may be easily calculated for combinations of metal/metal ion half-cells, and these principles can be extended to combinations involving half-cells of other types. Finally, learners should be able to explain applications of standard electrode potentials, e.g. batteries, fuel cells, prevention of rusting.

Assessment model

Learning aim	Key content areas	Recommended assessment approach
A Investigate patterns of chemical reactivity in the Periodic Table to understand the chemistry of inorganic compounds	**A1** Acid–base characteristics of inorganic compounds **A2** Characteristics of transition metal compounds and complexes	Report on the common applications of inorganic acids, bases and transition metal compounds. Results table for test tube reactions involving a range of inorganic compounds and transition metal complexes. A PowerPoint presentation analysing and explaining the changing acid–base character across a period and the types of reactions transition metal complexes undergo.
B Investigate the solubility and chemical energetics of ions to understand the properties of inorganic compounds	**B1** Enthalpy changes involving ions **B2** Solubility of ionic compounds	Results of enthalpy change reactions of acids with alkalis and dissolving inorganic compounds. Calculations of theoretical enthalpy changes for hydration of ions and formation of ionic lattices. Results and graphs for solubility of different inorganic compounds. Calculated solubility product values for ionic compounds to predict whether a solution will be saturated. Factors which determine solubility and enthalpy values for ionic compounds are assessed.
C Investigate acid–base equilibria in order to understand acid–base titration procedures and applications of buffer solutions	**C1** Acid–base equilibria **C2** Acid–base titrations and pH curves **C3** Buffer solutions	A report comparing calculated pH values with those experimentally determined for a range of acid/base solutions and concentrations. Results and graphs from four pH titrations, with explanation and justification of suitable indicators for titrations. Results showing how to determine K_a and more complex calculations involving the constant. Results and theory of buffer action. A report evaluating the use of buffer solutions and of acid–base titrations using indicators, pH meters and autotitrators.

Learning aim	Key content areas	Recommended assessment approach
D Investigate reduction and oxidation reactions in order to understand analytical and industrial applications	**D1** Redox reactions **D2** Redox titrations and colorimetry **D3** Electrochemical cells and electrode potentials	Results and calculation for determining the amount of an analyte in different redox titrations and by colorimetry. Comparison of three measured cell voltages with the voltages calculated using standard electrode potentials. Analysis of a range of redox reactions and electrochemical cells using equations and standard cell voltages. An evaluation of the use of and limitations of standard electrode potentials in analytical and large-scale contexts.

Assessment guidance

The unit will be assessed using up to four assignments, one per learning aim. Learners must produce individual evidence that is both original and can be authenticated.

For learning aim A, the assessment criteria require learners to produce a report on the common applications of inorganic acids, bases and transition metal compounds. This should include a results table for investigations whereby learners have individually carried out test tube reactions involving a range of inorganic compounds and transition metal complexes, including reaction with acids and bases. Learners must include equations to explain the acid or base behaviour. They must also produce a PowerPoint presentation, analysing and explaining the changing acid–base character across a period and the types of reaction transition metal complexes undergo. The presentation should be illustrated with appropriate equations or diagrams.

Learning aim B requires learners to produce results of enthalpy change for reactions of acids with alkalis and when dissolving inorganic compounds. They must work independently to complete the relevant practical activities. They must also calculate theoretical enthalpy changes for hydration of ions and formation of ionic lattices. They are required to determine the solubility of two inorganic compounds at a given temperature from a graph they have produced from a practical investigation. They must use calculated solubility product values for ionic compounds to predict whether a solution will be saturated. Finally, they must assess factors which determine solubility and enthalpy values (e.g. ionic radius, magnitude of charge) for ionic compounds.

For learning aim C, learners are required to produce a report comparing calculated pH values with those they have determined experimentally for a range of acid/base solutions and concentrations. This should include the results and graphs from four pH titrations, with explanation and justification of suitable indicators for the titrations. Learners must use their results to show how to determine K_a and carry out more complex calculations involving the constant. They will explain the action of buffers and make an acidic buffer solution, calculating its pH and comparing that pH with the measured pH. Their report should include an evaluation of the use of buffer solutions and of acid–base titrations using indicators, pH meters and autotitrators.

Learning aim D requires learners to produce results and calculations to determine the amount of an analyte in different redox titrations and by colorimetry. This will include the Fe^{2+}/MnO_4^- titration to determine the concentration of a solution of Fe^{2+} ions with given standardised potassium permanganate solution, and use of sodium thiosulfate solution, standardised with potassium iodate (KIO_3), to determine the concentration of at least two analytes in solution. (Colorimetry should be used to determine the concentration of at least one of the analytes.) Learners must compare three measured cell voltages with the voltages calculated using standard electrode potentials and analyse a range of redox reactions and electrochemical cells using equations and standard cell voltages. Finally, they must evaluate the use and limitations of standard electrode potentials in analytical and large-scale contexts.

Getting started

This gives you a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 16: Applications of Inorganic Chemistry

Introduction

This unit gives learners the opportunity to develop their knowledge, skills and understanding in the basic principles of chemistry, beyond that which was dealt with in *Unit 2* and *Unit 6*. The unit will be useful for learners who intend to study chemistry or biology at a higher level and for those who progress to industrial laboratory work. All topics include practical work, so learners will have opportunities to become more skilled and personally organised in the laboratory. Throughout the unit, you will be able to lead learners in problem solving and collaborative discussion. At the start of each learning aim, test learners' prior knowledge and understanding using activities such as quizzes and/or question and answer sessions. It will also be useful to identify appropriate videos and websites. It may be beneficial to visit an organisation that is involved with topics from this unit (particularly the transition metals) or to invite a guest speaker from such an organisation.

Learning aim A: Investigate patterns of chemical reactivity in the Periodic Table to understand the chemistry of inorganic compounds

- The teaching for learning aim A focuses on two main areas: the period 3 elements and the transition metals. It is likely that, for *Unit 2*, learners will have drawn structures that show the bonding in oxides and chlorides of the elements in this row; it will be helpful to recap this learning before moving on to new topics. Similarly, learners will have written electronic configurations for the transition elements and should be aware that they have partially filled d subshells. You could use a quiz or similar activity to gauge learners' understanding of the properties of the transition elements. You could also show a video about the reactions of the period 3 elements and compounds, as an introduction to this learning aim.
- Although acids and bases will be covered in more detail later, learners should be able to define acids and bases and realise that some substances are capable of acting as both. You could use an activity such as a crossword, in which the clues relate to the chemical and physical properties of the period 3 elements and their compounds (oxides and chlorides).
- Learners will need to complete practical activities which involve investigation of the oxides, metal hydroxides, oxoacids and chlorides of period 3 elements. This will include looking at reactions with water, acids and bases. If any reactions cannot be investigated practically (e.g. for safety reasons), ask learners to research them independently or in groups.
- Learners must be able to write balanced full and ionic equations for the reactions, showing the appropriate state symbols.
- Learners should understand how bonding and structure can explain the acid–base behaviour of oxides, hydroxides and chlorides and predict how similar compounds for elements in other periods would react. Learners should be aware that, as you move down to the next period, some of the influences on bonding and structure may become more or less pronounced (e.g. bond length, bond polarity etc.).
- Show a video on the applications of the inorganic compounds listed in the unit content.

Then ask learners to carry out independent research into this.

- Use an appropriate activity – for example, a quiz or a question and answer session – to confirm understanding and learning, or ask learners to produce a short video or presentation to summarise their learning so far.
- Give a presentation to explain that, because transition metal ions have an incomplete d subshell, some have variable oxidation states, some produce coloured solutions, and some can participate in catalysis and the formation of complexes.
- Give learners a list of the oxidation states and ask them to write the electronic configurations for the ions. They should be aware that colour production in some ions is due to electron transitions between lower and higher energy orbitals and the consequent emission of visible light at a particular wavelength.
- Learners should understand that empty and/or partially filled orbitals can accept electrons from other molecules, which gives transition metals the ability to catalyse certain reactions and accept ligands to form metal complexes.
- Explain that a metal ion in solution is surrounded by water molecules which act as ligands by donating their lone pair of electrons to the metal ion, forming dative or coordinate bonds, e.g. as in $[Fe(H_2O)_6]^{3+}(aq)$.
- Ask learners to draw some of these hexaqua complexes, illustrating the octahedral 3D conformation. Then move on to consider tetrahedral, square planar and linear complexes, and complexes which involve bidentate and multidentate ligands.
- Allow learners to complete practical activities which involve observing reactions with sodium hydroxide, ammonia solution, sodium carbonate and reducing agents such as iodide. Encourage them to note the colour changes, whether or not a precipitate is formed and whether the precipitate redissolves. They should also write ionic equations for the reactions.
- Show a video on the biological, medical and industrial applications of the transition metals (as listed in the unit content) and ask learners to carry out their own independent research into this.
- Use a quiz or other appropriate activity to confirm understanding.

Learning aim B: Investigate the solubility and chemical energetics of ions to understand the properties of inorganic compounds

- For learning aim B, teaching and learning will focus on two main areas, which build on concepts encountered in *Unit 6*: enthalpy changes involving ions and the solubility of ionic compounds. These topics bring in aspects of energetics and chemical equilibrium, so it will be useful to recap relevant definitions, measurement and calculation of enthalpy changes, equilibrium constants, expressions for K_c and calculations to determine K_c and unknown concentrations of reactants and products. It would also be worthwhile to briefly revisit ionic bonding, properties of ionic compounds and trends in atomic and ionic radii. Activities could include quizzes, question and answer sessions and class/group discussions.
- Encourage learners to participate in practical work which involves measuring enthalpy changes for neutralisation and when ionic compounds are dissolved in water. These investigations will involve basically the same techniques as in *Unit 6* and learners will perform calculations to determine enthalpy changes using the equation $Q = mc_p\Delta T$. They should be able to extend relevant definitions to include a wider range of enthalpy changes, considering formation, atomisation, ionisation energy, electron affinity and lattice energy.

- Explain how to use these values to construct an energy cycle (Born–Haber), which can be used to determine a particular enthalpy value for an ionic compound, e.g. the standard molar enthalpy of formation, which can be difficult to determine experimentally. This will build on their knowledge and understanding of Hess's law (covered in *Unit 6*).
- Supply relevant values and ask learners to work out a particular enthalpy change for different ionic compounds.
- If possible, arrange a visit to a relevant organisation – for example, one involved in water treatment/purification or desalination – or invite a guest speaker from such an organisation.
- Explain how to equate lattice energy with the enthalpy of hydration and apply the formula $\Delta H^{o}_{soln} = -\Delta H^{o}_{lat} + \Delta H^{o}_{hyd}$ to calculate enthalpies of solutions for ionic compounds. Give learners a set of questions to gauge their learning and understanding of enthalpy changes involving ions.
- Explore the degree of solubility of ionic compounds. Ask learners to define solubility, explain what constitutes a saturated solution and calculate the solubility of substances from solubility curves.
- Allow learners to participate in practical activities in which they investigate the solubility of compounds such as sodium chloride and potassium chloride. This will involve adding known volumes of water from a burette to a known mass of the compound, heating and stirring until the compound dissolves, then cooling and recording the temperature at which the first sign of precipitation appears.
- Learners must be able to process the results. They must calculate the solubility for each run in grams of solute per 100 grams of water and plot this against the temperature at which it precipitated to obtain a solubility curve. They can then use these curves to work out the solubility of a substance at a given temperature and how much of the substance would dissolve at a given temperature.
- Build on learners' knowledge of equilibrium and K_c to introduce the concept of the solubility product, K_{sp}.
- Learners should be able to write expressions for K_{sp} for ionic dissociation, showing the correct powers regarding the concentrations of the ions (e.g. for $Ca(OH)_2$, $K_{sp} = [Ca^{2+}][OH^-]^2$ etc.).
- Give learners a list of ionic compounds and ask them to write the expression for K_{sp} for each one. Then give them K_{sp} values and ask them to use the expression and values to calculate the maximum concentration of ions of the ionic compound in solution.
- Learners should understand that precipitation of ionic compounds will occur when solutions of ions are mixed and K_{sp} is exceeded. Give learners a list of ionic compounds with given concentrations for the ions and ask them to calculate the ionic product and compare this with literature values for K_{sp}.
- Learners should be able to predict whether or not precipitation will occur. Give them a set of questions to gauge their learning and understanding of the solubility of ionic compounds.

Learning aim C: Investigate acid–base equilibria in order to understand acid–base titration procedures and applications of buffer solutions

- Learning aim C is largely concerned with acids and bases and builds on the concept of chemical equilibrium (introduced in *Unit 6*). Learners may have encountered acids and bases in previous learning, and they have been covered in learning aim A. Many laboratories use pH meters routinely and some use buffers and carry out acid–base titrations. A visit to such an establishment or a guest speaker might be beneficial.
- Learners must be able to define acids and bases and understand the differences between strong and weak acids and alkalis. Recap previous learning using activities such as quizzes, question and answer activities and general class or group discussions.
- The Brønsted–Lowry definition is a useful model for understanding the concept of conjugate acids and bases when they dissociate in solution respectively (e.g. hydrochloric acid as an acid and Cl^- as the conjugate base). However, you could refer briefly to other acid–base theories such as Lewis and Arrhenius.
- Ask learners to work in pairs or groups to research a particular acid–base theory and present their findings to the class, highlighting the advantages and disadvantages of the theory.
- Explore in detail what learners understand by ‘pH’ and ‘the pH scale’, and how pH can be used to identify strong acids and alkalis, weak acids and alkalis and solutions which are neutral. They could use a calibrated pH meter to measure the pH of household compounds over the full range. They must understand that pH is derived from the hydrogen ion concentration in solution, i.e. the ‘power of hydrogen’ and can be calculated from $pH = -\log[H^+]$.
- Give learners sets of values and ask them to calculate $[H^+]$ from $[H^+] = 10^{-pH}$.
- Apply the concept of equilibrium (developed in *Unit 6*) to the acid–base situation and ask learners to write an expression for a general acid dissociation constant, K_a (e.g. for an acid HA, $K_a = ([H^+][A^-])/[HA]$).
- Prompt learners to identify strong and weak acids from their K_a value. Ensure they understand the notation $pK_a = -\log K_a$ and introduce the equation $[H^+] = K_a \times [HA]$ for calculating $[H^+]$ of a weak acid.
- Give learners opportunities to calculate the pH of weak acid solutions, given K_a and the acid concentration, and also to calculate K_a and [HA].
- Explain the ionic product for water, $K_w = [H^+][OH^-]$, which allows learners to calculate $[H^+]$ for a strong alkali ($[H^+] = 1 \times 10^{-14}/[OH^-]$). (Emphasise that learners should enter 10^{-14} into their calculators as 1×10^{-14} using the scientific notation function.) Allow learners to work through calculations of the pH of strong alkali solutions of various concentrations and to work out the $[OH^-]$, given the pH.
- Give learners opportunities to carry out pH titrations for a strong acid/strong alkali, a weak acid/strong alkali and a strong acid/weak alkali (adding, say 0.5 cm^3 at a time) and establishing the pH range of the jump. They should be able to describe the shapes of the titration curves plotted for pH/volume and explain that, for an indicator to be suitable, it must change colour within the pH range of the jump.
- Ask learners to research the pH ranges of indicators, find a suitable indicator, and confirm that it gives the correct equivalence-point by carrying out an indicator titration. This will prepare learners to find indicators for all the titration combinations indicated in the unit content. It should also facilitate an explanation of how autotitrators work.

- Lead a class discussion about which titrations are most accurate: pH titrations, indicator titrations or autotitrator titrations. Encourage learners to be specific and to give examples.
- Give a presentation exploring buffers. Learners should be able to define a buffer solutions as one which resists changes in pH when small quantities of acid or alkali are added to it. They should understand that an acid buffer solution consists of a weak acid and the salt of a weak acid (e.g. ethanoic acid/sodium ethanoate) and an alkali buffer consists of a weak base and the salt of a weak base (e.g. ammonia/ammonium chloride).
- Ask learners to investigate what happens to the pH when small amounts of acid and alkali are added to buffer solutions and to explain the observations using equations and making reference to equilibrium (i.e. le Chatelier's principle).
- Give a presentation to introduce the Henderson–Hasselbalch equation, which can be used to estimate the pH of a buffer solution. Ask learners to use known values for K_a to calculate the pH for given concentrations of the acid HA and the salt MA, of its conjugate base (e.g. ethanoic acid/sodium ethanoate).
- Ask learners to work in pairs or groups to research the action of buffers practically and then share their findings with the class through a presentation. This should include buffer action in blood, acidity regulators in food and citric acid/citrate in shampoo.

Learning aim D: Investigate reduction and oxidation reactions in order to understand analytical and industrial applications

- Learning aim D is primarily concerned with reduction and oxidation (redox) and builds on concepts from *Unit 2*. There are three main areas: redox reactions, redox titrations and electrochemistry. Learners will have dealt with aspects of redox in learning aim A when they investigated the chemistry of the transition metals. Many different sectors use redox titrations, including the food industry, organisations involved in metallurgy, water testing industries etc. A visit to such an establishment or a guest speaker might be beneficial.
- Begin with a recap exercise to gauge learners' knowledge and understanding of the relevant terms, identifying oxidising and reducing agents and assigning oxidation numbers. Activities such as quizzes, question and answer sessions and class or group discussions will be useful here.
- Introduce redox reactions by dropping some shiny, silvery, granulated zinc into copper(II) sulfate solution in a beaker and asking learners to comment on what is happening. Guide learners to describe this reaction as a word equation and then as a symbol equation. Explain why this is, in fact, an oxidation/reduction (redox) reaction and write the half equations.
- Give learners opportunities to carry out a few displacement reactions (involving metals and halogens). For each reaction, they should write half equations for oxidation and reduction and a complete, balanced redox equation, based on the reactivity series.
- Revisit the concept of oxidation numbers and the rules for assigning them. Ask learners to complete worked examples to identify the oxidation number of elements such as N, S, P. Cl etc. in a range of compounds and compound ions. They should be able to recognise redox equations, by working out the oxidation numbers of the atoms on the left- and right-hand sides of the equations.
- Explain that oxidising and reducing agents are useful for volumetric analysis and can be used to determine the concentration of substances through their redox reactions.
- Explain how potassium permanganate solution can be used to determine the concentration of iron(II) and sodium thiosulphate for the concentration of iodine.

- Guide learners to recall how they used volumetric analysis in *Unit 2* and to apply this technique to redox titrations. Allow them to carry out the Fe^{2+}/MnO_4^- titration to determine the concentration of a solution of Fe^{2+} ions (from iron tablets or steel wool) with given standardised potassium permanganate solution.
- Give learners an opportunity to use sodium thiosulphate solution, standardised with potassium iodate (KIO_3), to determine the concentration of at least two analytes in solution (iodine, hypochlorite, Cu^{2+}, peroxide).
- Ensure learners can write balanced stoichiometric equations and use the results from titrations to calculate concentrations.
- The assessment guidance requires learners to use colorimetry to determine the concentration of at least one of the analytes, so introduce the principles behind this (chromatography) technique. It will be useful for learners to experience the practical aspects of colorimetry before their assessment, so give them opportunities to practise calibrating the colorimeter, measuring and using absorbance, applying the Beer–Lambert law to determine concentration etc.
- Encourage learners to compare the accuracy of the concentration of the analyte determined by redox titration and by colorimetry.
- Ask learners to investigate other applications of redox titrations, practically and through independent research. This should include those applications listed in the unit content and could involve a visit to an establishment that uses them or a visiting speaker.
- Give a presentation explaining that an electrochemical cell can be used to generate electrical energy from chemical reactions, or use electrical energy to carry out a chemical reaction.
- If possible, set up an electrochemical cell using two half cells (e.g. the Daniell cell) so learners can observe the changes at the electrodes as zinc displaces copper from a solution of copper sulphate. Ask learners to write the half-equations for the oxidation of zinc and the reduction of copper and then use standard cell notation, e.g. $Zn(s)\,|\,Zn^{2+}(aq)$ ¦¦ $Cu^{2+}(aq)\,|\,Cu(s)$.
- Give learners a list of electrochemical reactions and ask them to write half-equations and standard cell notation.
- Give a presentation to explain that the standard hydrogen electrode is a redox electrode which forms the basis of the thermodynamic scale of oxidation–reduction potentials, being based on $2H^+(aq) = 2e^- + H_2(g)$.
- Explain how a table of standard reduction potentials would be constructed from combinations of half-cells with the standard hydrogen electrode.
- Encourage learners to use this table to predict the reaction that will take place from various metal/metal ion half-cells, construct the oxidation, reduction and redox reactions, and calculate the cell voltage under standard conditions. Ask learners to compare calculated values with those determined experimentally and to assess the limitations of prediction.
- Show learners how to assemble such cells and measure the voltage. (They will have to do this independently as part of the assessment.)
- Give learners the opportunity to further investigate the applications of standard electrode potentials, practically and through independent research. This should include those applications listed in the unit content and could involve a visit to an establishment that uses them or a visiting speaker.

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

This unit links to:

- Unit 2: Principles and Applications of Chemistry I
- Unit 6: Principles and Applications of Chemistry II
- Unit 16: Applications of Inorganic Chemistry
- Unit 21: Applications of Organic Chemistry.

The experience of using pH meters and carrying out acid–base titrations in *Unit 2* will allow learners to be more effective in their practical work for learning aim A.

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 International Level 3 Applied Science . Check the Pearson website (http://qualifications.pearson.com/endorsed-resources) for more information as titles achieve endorsement.

Textbooks

- Chapman, B. and Jarvis, A., *Organic Chemistry, Energetics, Kinetics and Equilibrium*, revised edition, Nelson Thornes, 2003, ISBN 978-0-748-77656-6 – Sets out the basics of energy change and equilibrium.
- Clark, J., *Calculations in AS/A Level Chemistry*, Longman, 2000, ISBN 978-0-582-41127-2 – Contains many relevant calculations and worked examples.
- Hill, G., Holman, J. and Gardom Hulme, P., *Chemistry in Context for Cambridge International AS & A Level*, 7th edition, OUP, 2017, ISBN 978-0-198-39618-5 – Detailed and accessible general A level textbook.
- Ramsden, E., *Calculations for A-Level Chemistry*, 4th edition, Nelson Thornes, 2001, ISBN 978-0-748-75839-5 – Contains many relevant calculations and worked examples.
- Ramsden, E., *A-level Chemistry*, 4th edition, OUP, 2000, ISBN 978-0-748-75299-7 – An in-depth look at energy changes, organic and inorganic chemistry.

Journals

The following technical journals require high-level reading skills and an ability to use and understand technical terms. They contain the latest news and research into related topics.

- *Chemistry World*
- *Education in Chemistry*
- *Scientific American*

Videos

Search YouTube for 'Redox reactions' – a series of videos by Bozeman Science which give verbal explanations of redox reactions and other topics and may be useful for revision or to consolidate understanding.

Websites

- chemguide – Although this website is aimed at AS level and A level learners, it contains explanations of the topics that are broader than required for particular syllabi and thus targets the BTEC content effectively.
- Royal Society of Chemistry – This website has links to resources relevant to the topics in this unit.
- Preparatory Chemistry – This website provides links *to* eBook chapters on acids and bases and on oxidation and reduction.