National Unit Specification: general information

UNIT Periodicity, Polarity and Properties (SCQF 6)

CODE FE4H 12

COURSE Chemistry (Higher)

SUMMARY

This Unit develops knowledge and understanding of periodic trends and strengthens the candidate's ability to make reasoned evaluations by recognising underlying patterns and principles. Developing a deeper understanding of the concept of electronegativity allows the two key themes of the Unit to be developed. Firstly, candidates will gain an understanding of the different types of intermolecular force and their role in determining a material's physical properties. Secondly, from the starting point of electronegativity, candidates look at the ability of substances to act as oxidising or reducing agents. The Unit is intended to offer candidates the opportunity to take part in a wide range of stimulating practical activities.

OUTCOMES

1. Demonstrate and apply knowledge and understanding related to *Periodicity, Polarity and Properties*.
2. Demonstrate skills of scientific experimentation and investigation *in the context of Periodicity, Polarity and Properties.*

Administrative Information

Superclass: RD

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Additional copies of this Unit Specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre, telephone 0845 279 1000.

National Unit Specification: general information (cont)

UNIT Periodicity, Polarity and Properties (Higher)

RECOMMENDED ENTRY

Entry for this Unit is at the discretion of the centre. However candidates would normally be expected to have attained the skills and knowledge required by one or more of the following or equivalent:

- Standard Grade Chemistry at Credit level in both Knowledge and Understanding and Problem Solving

or

- the Intermediate 2 Chemistry course at grade B

and

- Standard Grade Mathematics at Credit level or Intermediate 2 Mathematics.

CREDIT VALUE

0.5 credit(s) at Higher (3 SCQF credit points at SCQF level 6).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

UNIT Periodicity, Polarity and Properties (Higher)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

OUTCOME 1

Demonstrate and apply knowledge and understanding related to *Periodicity, Polarity and Properties*.

Performance Criteria

(a) Make accurate statements about *Periodicity, Polarity and Properties* facts, concepts and relationships.
(b) Use knowledge of *Periodicity, Polarity and Properties* to solve problems.
(c) Use knowledge of *Periodicity, Polarity and Properties* to explain observations and phenomena.

OUTCOME 2

Demonstrate skills of scientific experimentation and investigation in the context of *Periodicity, Polarity and Properties.*

Performance Criteria

(a) Use a range of data-handling skills in a scientific context.
(b) Use a range of skills related to the evaluation of scientific evidence.

National Unit Specification: statement of standards (cont)

UNIT Periodicity, Polarity and Properties (Higher)

EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate that candidates have met the requirements of the Outcomes.

For each of the Unit Outcomes, written and/or recorded oral evidence of the appropriate level of achievement is required. This evidence must be produced under closed-book, supervised conditions within a time limit of 45 minutes.

The Instrument of Assessment must sample the content in each of the following areas:

- Trends in the Periodic Table and Bonding
- Intermolecular forces
- Oxidising and reducing agents

An appropriate Instrument of Assessment would be a closed-book, supervised test with a time limit of 45 minutes. Items in the test should cover all of the Performance Criteria associated with both Outcomes 1 and 2, and could be set in familiar or unfamiliar contexts.

Further detail on the breadth and depth of content is provided within in the appendix to the specification.

For Outcome 2, PC(a), candidates are required to demonstrate that they can use a range of data-handling skills. These skills include selecting, processing and presenting information. Information can be presented in a number of formats including: chemical formulae, balanced chemical equations, diagrams depicting laboratory apparatus, line graphs, scatter graphs, bar and pie charts, tables, diagrams and text.

For Outcome 2, PC(b), candidates are required to demonstrate they can use a range of skills associated with the evaluation of scientific evidence. These skills include drawing valid conclusions and making predictions.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

National Unit Specification: support notes

UNIT Periodicity, Polarity and Properties (SCQF 6)

This part of the Unit Specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 20 hours.

GUIDANCE ON THE CONTENT AND CONTEXT FOR THIS UNIT

The recommended content together with suggestions for possible contexts and activities to support and enrich learning and teaching are detailed in the appendix to this Unit Specification.

This Unit builds knowledge of periodic trends and strengthens candidate's ability to make reasoned evaluations based upon recognising underlying patterns and principles. Developing a deeper understanding of the concept of electronegativity allows the two key themes of the Unit to be developed. Firstly, candidates will gain an understanding of the different types of intermolecular force and their role in determining a material's physical properties. Secondly, from the starting point of electronegativity, candidates look at the ability of substances to act as oxidising or reducing agents.

This Unit offers rich and diverse contexts with ample opportunities for practical work. These are highlighted in the 'Possible contexts and activities' column of the content tables in the Appendix. Opportunities exist for candidates to develop their knowledge and skills as part of a group through practical work undertaken in partnership or in teams.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

General advice on approaches to learning and teaching is contained in the course specification.

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

This Unit provides opportunities to develop Communication, Numeracy, Information and Communication Technology and Problem Solving skills in addition to providing contexts and activities within which the skills associated with Working with Others can be developed.

Outcome 1, PC(b) and (c) develop a candidate's ability to communicate effectively key concepts and to explain clearly chemical phenomena in written media.

Within this Unit candidates will need to extract and process information presented in both tabular and graphical formats developing the core skill of numeracy. Candidates will gain experience in a range of calculations building competence in number.

The appendix to this Unit Specification contains an extensive list of 'Possible Contexts and Activities' which include a large number of web based activities, computer simulations and modelling opportunities which all serve to develop higher levels of competence in the key ICT skill s including; accessing information and providing/creating information.

The Unit appendix contains an extensive range of practical laboratory exercises which provide candidates with the opportunity to working co-operatively with others.

Problem solving skills are central to the sciences and are assessed through Outcome 1, PCs (b) & (c) and also through Outcome 2, PCs (a) & (b).

National Unit Specification: support notes

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GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1 and 2

It is recommended that a holistic approach is taken for assessment of these Outcomes. Outcomes 1 and 2 can be assessed by an integrated end of Unit test with questions covering all the Performance Criteria. Within one question, assessment of knowledge and understanding and skills of experimentation and investigation can occur. Each question can address a number of Performance Criteria from either Outcome 1 or 2.

Appropriate assessment items are available from the National Assessment Bank.

DISABLED CANDIDATES AND/OR THOSE WITH ADDITIONAL SUPPORT NEEDS
The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments for may be required. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements

National Unit Specification: support notes Appendix

UNIT Periodicity, Polarity and Properties (Higher)

The left hand column below details the content in which candidates should develop knowledge and understanding. The middle column contains notes, which give further details of the breadth and depth of content expected. The right-hand column gives possible contexts and activities which could be used to develop knowledge, understanding and skills. Further details on many of the activities mentioned in the final column can be obtained from **National Qualifications Online**, part of the Learning and Teaching Scotland online service. Where such online support exists the 💻 symbol appears in the text.

Content	**Notes**	**Possible Contexts and Activities**
1) Trends in the Periodic Table and Bonding		
(a) The Arrangement of elements in the Periodic Table	Elements are arranged in the Periodic Table in order of increasing atomic number. The Periodic Table allows chemists to make accurate predictions of physical properties and chemical behaviour for any element based on its position. Features of the table are; Groups- vertical columns within the table which will contain elements with similar chemical properties resulting from a common number of electrons in the outer shell, Periods- rows of elements arranged with increasing atomic number demonstrating an increasing number of outer electrons and a move from metallic to non-metallic characteristics. Key groups of elements which can be recognised are metals and non-metals, alkali metals, halogens, noble gases and transition elements. The gaseous elements are generally to be found clustered in the top right corner of the table.	Periodic trends can be illustrated by graphing properties such as first ionisation energy or covalent radius against atomic number. Interactive Periodic Tables, such as that offered by the Royal Society of Chemistry, can be used to generate a large number of plots showing periodically repeating trends. 💻 Element cards can be prepared showing atomic number, element name and symbol, properties and/or electronic arrangements, candidates can lay out the cards on a large table or lab floor and experiment with different arrangements. The story of the development of the modern Periodic Table could be explored.

(b) Bonding and structure in the first twenty elements.	The first 20 elements in the Periodic Table can be categorised according to bonding and structure: • metallic (Li, Be, Na, Mg, Al, K, Ca) • covalent molecular (H_2, N_2, O_2, F_2, Cl_2, P_4, S_8 and fullerenes (eg C_{60})) • covalent network (B, C (diamond, graphite), Si) • monatomic (noble gases)	Elements can be extracted from their compounds. Silicon (an interesting example as it is a covalent network and 'looks' metallic) can be extracted from sand using magnesium. Details of this experiment are available in 'Classic Chemistry Demonstrations', Lister T. The Royal Society of Chemistry (1995) pp. 127-129 💻. The experiment is also available as a video download from 💻 The molecular nature of sulfur can be discussed during an exploration of the allotropes of sulfur. Details of an experimental method are also to be found in 'Classic Chemistry Demonstrations', Lister T. The Royal Society of Chemistry (1995) pp. 191-195 💻 Molecular models can also be constructed or viewed. Entertaining video portraits of all of the elements in the Periodic Table can also be viewed online.💻
(c) Periodic trends in ionisation energies and covalent radii	The covalent radius is a measure of the size of an atom. The trends in covalent radius across periods and down groups can be explained in terms of the number of occupied shells, and the nuclear charge. The first ionisation energy is the energy required to remove one mole of electrons from one mole of gaseous atoms. The second and subsequent ionisation energies refer to the energies required to remove further moles of electrons. The trends in ionisation energies across periods and down groups can be explained in terms of the atomic size, nuclear charge and the screening effect due to inner shell electrons.	Interactive Periodic Tables, such as that offered by the Royal Society of Chemistry, can be used to generate a large number of plots showing periodically repeating trends. 💻 Striking 'landscapes' have been created by producing three dimensional plots of ionisation energy and covalent radii for the entire Periodic Table. These are available as both still images and in the form of animated 'fly through' across the periodic landscape. 💻

(d) Periodic trends in electronegativity	Atoms of different elements have different attractions for bonding electrons. Electronegativity is a measure of the attraction an atom involved in a bond has for the electrons of the bond. Electronegativity values increase across a period and decrease down a group. Electronegativity trends can be rationalised in terms of nuclear charge, covalent radius and the presence of ‘screening’ inner electrons.	A bonding simulation can be used in which you can adjust the electronegativity of each atom, and view the effect of the resulting electron cloud. 💻 The story of Linus Pauling, after whom the most commonly used electronegativity scale is named, is available from the RSC 💻 The RSC interactive Periodic Table can be very useful for showing trends 💻
(e) Polar covalent bonds	In a covalent bond atoms share pairs of electrons. The covalent bond is a result of two positive nuclei being held together by their common attraction for the shared pair of electrons. Polar covalent bonds are formed when the attraction of the atoms for the pair of bonding electrons is different. Delta positive and delta negative notation can be used to indicate the partial charges on atoms, which give rise to a dipole.	It is likely that candidates will have encountered a variety of molecular compounds in their earlier studies of Chemistry. Candidates can often tend to regard the predictive rule-of-thumb, ‘covalent compounds are formed from non-metals only’ as an absolute law. At Higher level, where candidates will be exposed to the concept of a ‘bonding continuum’, it is possible to illustrate the limitations of such convenient rules-of-thumb by allowing the candidates to encounter covalent molecular compounds which contain a metal. Tin(IV) iodide can be formed by gently heating tin and iodine in toluene in a small conical flask. When the mixture is allowed to cool, yellow-brown crystals form which can be collected by filtration. Melting point of SnI_4 c. 143 ^{o}C. Tin has an electronegativity of 1.8 and iodine has an electronegativity of 2.6 so this molecule contains polar covalent bonds. 💻

(f) Bonding continuum	Pure covalent bonding and ionic bonding can be considered as being at opposite ends of a bonding continuum with polar covalent bonding lying between these two extremes. The larger the difference in electronegativities between bonded atoms is, the more polar the bond will be. If the difference is large then the movement of bonding electrons from the element of lower electronegativity to the element of higher electronegativity is complete resulting in the formation of ions. Compounds formed between metals and non-metals are often, but not always ionic. The properties of the compound should be used to deduce the type of bonding and structure rather than the type of elements present in the formula.	An Ionic bonding simulations can be used. 💻 A creative problem solving exercise of the ‘four white powders’ type could be used where candidates have white powders and must devise their own experimental method to tell them apart experimentally. The powders are; silicon dioxide, glucose, sodium chloride and calcium carbonate. Please also see the activity relating to ‘Polar Covalent Bonds’ above, for an example of a compound formed from a metal and non-metal where a molecular compound containing polar covalent bonds is formed between a metal and a non-metal.
2) Intermolecular forces		
(a) Van der Waals’ forces	All molecular elements and compounds and monatomic elements will condense and freeze at sufficiently low temperatures. For this to occur, some attractive forces must exist between the molecules or discrete atoms. Any ‘intermolecular’ forces acting between molecules are known as van der Waals’ forces. There are several different types of van der Waals’ forces such as London dispersion forces and permanent dipole-permanent dipole interactions which includes hydrogen bonding.	Common misunderstandings arise when candidates focus upon covalent and ionic bonding and fail to appreciate other types of interaction at play. The two activities ‘Interactions’ and ‘Spot the Bonding’ allow consolidation and discussion of intramolecular and intermolecular interactions. It was published in ‘Chemical misconceptions : prevention, diagnosis and cure (Volume 2)’, Keith Taber, Royal Society of Chemistry 2002 which is available in both word and pdf format free of charge. 💻

(b) London dispersion forces	London dispersion forces are forces of attraction which can operate between all atoms and molecules. These forces are much weaker than all other types of bonding. They are formed as a result of electrostatic attraction between temporary dipoles and induced dipoles caused by movement of electrons in atoms and molecules. The strength of London dispersion forces is related to the number of electrons within an atom or molecule. London dispersion forces are a type of van der Waals' force.	London forces are named after Fritz Wolfgang London (1900–1954) a German-born American theoretical physicist. The relationship between the strength of London forces and the number of electrons can be shown by plotting the melting or boiling points for the noble gases or for the halogens 💻
(c) Permanent dipole-permanent dipole interactions	A molecule is described as polar if it has a permanent dipole. The spatial arrangement of polar covalent bonds can result in a molecule being polar. Permanent dipole-permanent dipole interactions are additional electrostatic forces of attraction between polar molecules. Permanent dipole-permanent dipole interactions are stronger than London dispersion forces for molecules with similar numbers of electrons. Permanent dipole-permanent dipole interactions are a type of a van der Waals' force.	A practical demonstration of the polarity of molecules is provided by experiments in which liquids are deflected by a static charge. Classic experiments would include allowing candidates to experiment with the use of charged rods to deflect a stream of polar liquid flowing from a burette, but there are also more unusual variations such as the deflection of syrup by a charged balloon. The effect of the polarity of a molecule on the strength of intermolecular forces can be illustrated by comparing molecules with similar numbers of electrons but differing polarity, for example bromine and iodine monochoride. (Br_2, 70 electrons, non-polar, mp -7 ^{o}C) (ICl, 70 electrons, polar, mp +27 ^{o}C)

(d) Hydrogen Bonding	Bonds consisting of a hydrogen atom bonded to an atom of a strongly electronegative element such as fluorine, oxygen or nitrogen are highly polar. Hydrogen bonds are electrostatic forces of attraction between molecules which contain these highly polar bonds. A hydrogen bond is stronger than other forms of permanent dipole-permanent dipole interaction but weaker than a covalent bond. Hydrogen bonds are a type of van der Waals' force.	Computer animations showing the formation of a hydrogen bond are available. 💻 Water can be placed into sealed glass bottles and frozen, demonstrating the formation of the hydrogen bonded lattice structure which causes the anomalously large volume for frozen water. Hydrogen bonding is also responsible for the surface tension of water can be demonstrated using classic experiments such as the floating needle on the surface of a glass of water, or adding coins to a wine glass full of water to demonstrate the level rising above the rim of the glass. Hydrogen bonding is at the heart of 'hydrogels' materials. A range of experiments illustrating these materials is available in 'Inspirational Chemistry', Vicky Wong, Royal Society of Chemistry 2006 pp. 115 — 120 💻. Activities include 'Plant Water Storage Crystals', 'Disposable Nappies', 'Hair Gel' in addition to a practical problem- 'Hydrogels and Sugar'. 'Instant snow' is a slightly modified form of hydrogel which expands dramatically when hydrated. Teachers may wish to outline the role of hydrogen-bonding in maintaining the shape of DNA molecules. An excellent flash presentation on hydrogen bonds including their role in DNA structure. 💻

(e) Relating properties to intermolecular forces	Melting points, boiling points and viscosity can all be rationalised in terms of the nature and strength of the intermolecular forces which exist between molecules. By considering the polarity and number of electrons present in molecules, it is possible to make qualitative predictions of the strength of the intermolecular forces. The melting and boiling points of polar substances are higher than the melting and boiling points of non-polar substances with similar numbers of electrons. The anomalous boiling points of ammonia, water and hydrogen fluoride are a result of hydrogen bonding. Boiling points, melting points, viscosity and solubility/miscibility in water are properties of substances which are affected by hydrogen bonding. Hydrogen bonding between molecules in ice results in an expanded structure which causes the density of ice to be less than that of water at low temperatures.	The anomalous density of ice can be demonstrated by showing that wax beads sink when dropped into molten wax in contrast to ice which floats on water. An alternative experiment from the RSC involves placing ice cubes into vegetable oil. The ice cube floats, but on melting the liquid water descends through the oil to form a layer at the bottom of the vessel. 💻 In an investigative variation, a glass containing a layer of oil on water is placed in the freezer to see what happens. 'Bubble tubes' are sealed glass tubes containing a liquid and a small volume of air. When the tube is inverted the air rises as a bubble through the liquid. If different liquids are used, the time taken for the bubble to rise to the top end of the tube is inversely related to viscosity. These tubes allow the relationship between polarity and viscosity to be explored. Details can be found in 'Classic Chemistry Experiments', Kevin Hutchings 2000 pp. 4,5 💻 The effect of the number of O-H bonds in a molecule on the strength of the intermolecular forces can be explored using propan-1-ol, propane-1,2-diol and propane-1,2,3-triol. Three test-tubes are set-up, one containing propan-1-ol, one containing propane-1,2-diol and one containing propane-1,2,3-triol. A small ball is dropped into each test-tube simultaneously and the rate with which they sink to the bottom of the tubes compared. 💻

(f) Predicting solubility from solute and solvent polarities	Ionic compounds and polar molecular compounds tend to be soluble in polar solvents such as water and insoluble in non-polar solvents. Non-polar molecular substances tend to be soluble in non-polar solvents and insoluble in polar solvents. Key features to be considered are: the presence in molecules of O-H or N-H bonds, which would imply hydrogen bonding; the spatial arrangement of polar covalent bonds which could result in a molecule possessing a permanent dipole.	Experimental investigation of the solubility of molecular compounds chosen to include examples with O-H or N-H bonds, and shapes which would result in permanent dipoles.
3) Oxidising and reducing agents		
(a) Elements as oxidising or reducing agents	An oxidising agent is a substance which accepts electrons; a reducing agent is a substance which donates electrons. Oxidising and reducing agents can be identified in redox reactions. The elements with low electronegativities (metals) tend to form ions by losing electrons (oxidation) and so can act as reducing agents; the elements with high electronegativities (non-metals) tend to form ions by gaining electrons (reduction) and so can act as oxidising agents. The strongest reducing agents are found in Group 1 whilst the strongest oxidising agents come from Group 7. The electrochemical series indicates the effectiveness of oxidising and reducing agents.	Displacement reactions are a classic way to compare the relative strength of oxidising and reducing agents. To compare the strength of elements as oxidising agents experiments with halogen displacement can be used. Experiments suitable for candidate use are available in Classic Chemistry Experiments, K Hutchings, Royal Society of Chemistry 2000- halogen displacement pp. 46-48 💻Videos showing halogen displacement are also available. 💻 The relative strengths of other non-metals as oxidising agents can also be compared. Oxygen gas can be bubbled through solutions of potassium sulfide, chloride, bromide and iodide to establish which non-metallic elements are displaced from their compounds by oxygen. Then chlorine water is added to the same solutions to establish which elements are displaced by chlorine. 💻 To compare the strength of elements acting as reducing agents, metal displacement reactions can be used. A typical candidate experiment is described in Classic Chemistry Experiments, K Hutchings, Royal Society of Chemistry 2000- halogen displacement pp. 249-252 💻

		Demonstration metal displacement experiments include the well known 'snow tree' experiment, in which copper foil cut in the shape of a pine tree is lowered into silver nitrate solution causing 'snow' crystals to form on the branches, and the thermit reaction. Classic Chemistry Demonstrations, Ted Lister, Royal Society of Chemistry 1995 contains details of two methods for carrying out this dramatic experiment. 💻 The thermit reaction is also available on video.
(b) Molecules and group ions can act as oxidising and reducing agents	Compounds can also act as oxidising or reducing agents. Electrochemical series contain a number of ions and molecules. The dichromate and permanganate ions are strong oxidising agents in acidic solutions whilst hydrogen peroxide is an example of a molecule which is a strong oxidising agent. Carbon monoxide is an example of a gas that can be used as a reducing agent. Oxidising and reducing agents can be selected using an electrochemical series from a databook or can be identified in the equation showing a redox reaction.	The 'elephant's toothpaste' experiment provides an illustration of hydrogen peroxide's ability to act as an oxidising agent. 💻 An adaptation of the blue bottle experiment allows candidates to see dextrose acting as a reducing agent, and oxygen acting as an oxidising agent. Every time a bottle containing an alkaline solution of methylene blue and dextrose is shaken, the methylene blue is reduced by the dextrose turning the solution colourless, but then reacts with atmospheric oxygen to return to its blue colour. A version for candidates to try for themselves is described in Classic Chemistry Experiments, Kevin Hutchings, 2000 Royal Society of Chemistry. 💻 A startling and unusual demonstration of hydrogen peroxide's ability to act as an oxidising agent is demonstrated by the 'Luminescent Tea' experiment. Ethyl ethanoate and 35% hydrogen peroxide are measured into a beaker in a 5:1 ratio. A small pinch of oxalic acid-bis-(2,3-dinitrophylester) is added along with a peppermint tea bag. The hydrogen peroxide oxidises the oxalic ester producing carbon dioxide in an excited state. The carbon dioxide transfers energy to the chlorophyll in the peppermint tea causing red light to be emitted. If the room is completely darkened, every time the beaker is moved a red glow

		can be seen. Ethyl ethanoate acts as the solvent in this experiment. (Spectacular Chemistry Experiments, HW Roesky, Wiley-VCH 2007 pp. 49-50) To illustrate the oxidising nature of permanganate ions, glycerol is poured onto potassium permanganate crystals. After a short lag time, the permanganate ions oxidise the glycerol causing steam to be given off.
		An illustration of the chlorate(V) ions ability to act as oxidising agents is provided in a spectacular demonstration using chlorate(V) salts to oxidise granulated sugar. The potassium ions present result in spectacular pink flames being produced 💻 Instructions on how to carry this experiment safely are given in Contemporary Chemistry for Schools and Colleges, Vanessa Kind, Royal Society of Chemistry 2004 pp. 11-12 💻 The potassium ions present result in spectacular pink flames being produced 💻 Instructions on how to carry this experiment safely are given in Contemporary Chemistry for Schools and Colleges, Vanessa Kind, Royal Society of Chemistry 2004 pp. 11-12 💻 Experiments which show the ability of molecules to act as reducing agents include the reduction of copper(II) oxide using methane or hydrogen. 💻 A version of this experiment adapted for use by pairs of candidates is also available. 💻

(c) Everyday uses for strong oxidising agents	Oxidising agents are widely employed because of the effectiveness with which they can kill fungi and bacteria, and can inactivate viruses. The oxidation process is also an effective means of breaking down coloured compounds making oxidising agents ideal for use as 'bleach' for clothes and hair.	Potassium permanganate, $KMnO_4$, is a chemical oxidising agent that will react with any organic matter in a pond including algae, bacteria, fish, particulate and dissolved organic matter, and organic bottom sediments. It has been used in fish ponds to treat common fish pathogens such as gill parasites and external bacterial and fungal infections. Bleaching reactions can be carried out using sulfur dioxide- red roses rapidly decolourise in a gas jar of SO_2. When chorine gas, generated by adding 6M HCl to $KMnO_4$ is bubbled through tomato juice, the red colour quickly disappears. (Details from 'Spectacular Chemistry Experiments', H.W. Roesky Wiley-VCH 2007 pp. 87-88.) Another demonstration which works well uses a household bleach containing sodium hypochlorite. 4 drops of yellow food colouring (E102) and 4 drops of blue food colouring (E 124) are dissolved in 40 cm^3 of water. A solution containing 4 drops of household bleach in 20 cm^3 of water is added to the solution and the mixture stirred. The hypochlorite oxidises the colourings taking the solution through a number of colour changes. This experiment will work with both thick and thin bleaches. Thicker bleaches tend to give more gradual colour changes which are easier for candidates to observe. (Details from 'Spectacular Chemistry Experiments', H.W. Roesky Wiley-VCH 2007 pp. 77-78.)

(d) Ion-electron and redox equations	Oxidation and reduction reactions can be represented by ion-electron equations. When molecules or group ions are involved, if the reactant and product species are known, a balanced ion-electron equation can be written by adding appropriate numbers of water molecules, hydrogen ions and electrons. (Candidates would not be expected to complete and balance ion-electron equations for reactions occurring in alkaline solutions.) Ion-electron equations can be combined to produce redox equations.	Redox titrations could be used to illustrate quantitatively, the relevance of balanced redox equations. Possible titrations could include; determination of vitamin C in vitamin tablets by titration with acidified permanganate💻, determination of the concentration of a hydrogen peroxide solution by titration with acidified potassium permanganate. There are a number of methods that allow the concentration of household bleaches to be investigated. Excess hydrogen peroxide can be added to household bleach and the volume of oxygen produced measured. The concentration of sodium hypochlorite in the bleach can be calculated. 💻A version of this experiment adapted for use by candidates is also available. 💻 Alternatively, candidates can measure the bleach content of a variety of bleaches, and calculate their cost effectiveness, by reacting the chlorine in the bleach with iodide to form iodine and then titrating the iodine solution against sodium thiosulfate. 💻