

Scheme of work – Cambridge IGCSE[®] Chemistry (0620)

Unit 11: Redox, electrochemistry and Group VII

Recommended prior knowledge

Students should have good understanding of the Periodic Table, ionic bonding and writing equations.

Context

This unit builds on ideas from Units 2 and 6, and lays the foundations for Unit 12.

Outline

This unit begins with the introduction of redox reactions and their importance to the electrochemical industry and the world economy. These industrial processes allow important chemicals to be isolated, such as aluminium and others to be prepared, such as hydrogen, chlorine and sodium hydroxide. This unit gives students opportunities to investigate new types of electrochemical cells and the importance to world energy production. This unit is cross-referenced to assessment objectives A1–5, B1–6, C1–3 and Units 2 and 6.

(Please note: **(S)** in **bold** denotes material in the Supplement (Extended syllabus) only)

| Syllabus ref | Learning objectives | Suggested teaching activities | Learning resources |
|--------------|---|---|--|
| 7.3 | Define <i>oxidation</i> and <i>reduction</i> in terms of oxygen loss/gain (Oxidation state limited to its use to name ions, e.g. iron(II), iron(III), copper(II), manganate(VII), dichromate(VI)) | <p>Stress that oxidation and reduction reactions always occur together in a redox reaction.</p> <p>Redox changes can often be observed as significant colour changes e.g. rusting/corrosion of iron or iron + copper(II) sulphate ==> iron(II) sulphate + .copper.</p> <p>Link to ideas of the role of redox reactions in the production of energy from fuels and the extraction of metals. The reactions in car catalytic converters can also be studied here [link to Unit 3 – Air and Water].</p> <p>Link to the reactions of metals and halogens.</p> <p>Experiments possible include the reaction of metals/non-metals with oxygen and the reaction of metal oxides with carbon.</p> | <p>www.chemguide.co.uk/inorganic/redox/definitions.html</p> <p><i>R. Norris & R. Stanbridge. Chemistry for IGCSE, Nelson Thornes, 2009, ISBN 9781408500187, p114 [Fig. 9.3.1], p117 [Fig [9.4.1]</i></p> |
| 7.3(S) | Define redox in terms of electron transfer | <p>Use the mnemonic OILRIG (oxidation is loss of electrons, reduction is gain of electrons).</p> <p>Practice ionic equations and identify the substance oxidised and reduced in a given reaction.</p> <p>Link this to the reactivity series and reactions of metals and metal salt solutions in Unit 6, the Halogens and electrolysis later in this unit.</p> | |
| 4(S) | Construct ionic equations with state symbols | <p>Students can use flash cards [formulae of ions and simple molecules] as an activity to construct ionic equations.</p> <p>Spectator ions can be introduced here.</p> | <p>www.chemguide.co.uk/inorganic/redox/equations.html</p> |

| Syllabus ref | Learning objectives | Suggested teaching activities | Learning resources |
|--------------|--|--|--|
| 7.3(S) | <p>Identify redox reactions by changes in oxidation state and by the colour changes involved when using acidified potassium manganate(VII), and potassium iodide. (Recall of equations involving KMnO_4 is not required.)</p> | <p>Demonstrations can include the:</p> <ul style="list-style-type: none"> • Reaction of ethanol and acidified KMnO_4 to yield ethanoic acid [link to Unit 8]; • Preparation of chlorine by reaction of conc. HCl and KMnO_4 solid and the reaction of potassium iodide solution with either chlorine or bromine (link to Group VII later in this unit). • Other reactions which could be demonstrated include zinc + copper(II) sulphate and iodide ions + hydrogen peroxide. | |
| 7.1(S) | <p>Describe the use of silver salts in photography as a process of reduction of silver ions to silver; and photosynthesis as the reaction between carbon dioxide and water in the presence of chlorophyll and sunlight (energy) to produce glucose and oxygen</p> | <p>Experiments on how light affects photosynthesis and darkening of slow photographic film in various light intensities.</p> <p>A simple experiment can be to make silver chloride, bromide and iodide by precipitation [link to Unit 4 – Acids, Bases and Salts] and watch them change colour under strong light.</p> <p>Photosynthesis is an endothermic process.</p> | <p>How light affects photosynthesis and a photo-sensitive reaction <i>R. Norris & R. Stanbridge. Chemistry for IGCSE, Nelson Thornes, 2009, ISBN 9781408500187, p106-107</i>, Fig 8.6.1 & 8.6.2].</p> <p>Role of silver salts in photography: www.eurochlor.org/silver%20chloride</p> |
| 5 | <p>Describe the electrode products in the electrolysis of:</p> <ul style="list-style-type: none"> • molten lead(II) bromide • concentrated hydrochloric acid • concentrated aqueous sodium chloride between inert electrodes (platinum or carbon) | <p>These are demonstrations only and link with the production of halogens later in this unit.</p> <p>Students can safely carry out the electrolysis of small quantities of aqueous sodium chloride.</p> <p>Tests from Unit 4 – Acids, bases and salts, can be used to identify all three products.</p> <p>Link this to the industrial electrolysis of brine later in this unit.</p> <p>Students can practice writing electron half equations and link this to ideas of redox from earlier in this unit.</p> | <p>Useful notes on electrochemistry: www.docbrown.info/page01/ExIndChem/ExtraElectrochem.htm</p> <p>www.open2.net/science/roughscience/diy/electrolysis.htm</p> |

| Syllabus ref | Learning objectives | Suggested teaching activities | Learning resources |
|--------------|---|---|--|
| 5 | State the general principle that metals or hydrogen are formed at the negative electrode (cathode), and that non-metals (other than hydrogen) are formed at the positive electrode (anode) | A demonstration of the electrolysis of molten lead bromide can be used to 'set the scheme'. This should be carried out in a fume cupboard. Students can electrolyse a range of aqueous solutions of salts and collect and test electrode products to confirm this. | <i>R. Norris & R. Stanbridge. Chemistry for IGCSE, Nelson Thornes, 2009, ISBN 9781408500187, p70, Figs 6.1.2.</i> |
| 5 | Predict the products of the electrolysis of a specified binary compound in the molten state | This should involve metal halides or metal oxides only. Emphasise that the product at the cathode is the corresponding metal and at the anode, a non-metal molecule [O ₂ or Group VII molecule]. | |
| 10.3(S) | Name the main ore of aluminium as bauxite (see section 5) | | |
| 5(S) | Describe, in outline, the manufacture of <ul style="list-style-type: none"> aluminium from pure aluminium oxide in molten cryolite chlorine and sodium hydroxide from concentrated aqueous sodium chloride (Starting materials and essential conditions should be given but not technical details or diagrams.) | Link the production of aluminium back to the production of other metals from their ores [Unit 6]. Link to methods of extraction linked to metal reactivity Unit 6. Awareness of the economic and environmental implications of the very high energy demand for electrolysis (link to need for recycling of aluminium and hydroelectric power). | Video clips on the aluminium extraction: www.rsc.org/Education/Teachers/Resources/Alchemy/ |
| 5 | Describe the reasons for the use of copper and (steel-cored) aluminium in cables, and why plastics and ceramics are used as insulators | The steel core provides additional strength. Aluminium is lightweight and a good conductor. Ceramics are found on pylons carrying high tension (voltage) cables. | |

| Syllabus ref | Learning objectives | Suggested teaching activities | Learning resources |
|--------------|--|---|--|
| 5(S) | Describe electrolysis in terms of the ions present and reactions at the electrodes in the examples given | This links with writing ionic equations [Unit 9]. | www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/ions/electrolysisrev3.shtml |
| 5(S) | Predict the products of electrolysis of a specified halide in dilute or concentrated aqueous solution | <p>Demonstrations of the electrolysis of dilute and concentrated brine can show this.</p> <p>Potential for group work as students can produce a model to illustrate each process.</p> <p>Emphasise the difference in products at the anode, oxygen (dilute solution) and the corresponding halogen (concentrated solution).</p> <p>In addition, stress that the concentration of the halide in solution increases in the electrolysis of the dilute solution, but in a concentrated halide solution it decreases.</p> | www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/ions/electrolysisrev4.shtml |
| 5(S) | <p>Describe, in outline, the manufacture of</p> <ul style="list-style-type: none"> chlorine and sodium hydroxide from concentrated aqueous sodium chloride <p>(Starting materials and essential conditions should be given but not technical details or diagrams.)</p> | Awareness of the importance of the products of the processes in terms of their uses e.g. hydrogen for making ammonia, chlorine for water treatment, NaOH for making soap. | Video clips on the electrolysis of NaCl: www.rsc.org/Education/Teachers/Resources/Alchemy/ |

| Syllabus ref | Learning objectives | Suggested teaching activities | Learning resources |
|---------------|--|---|--|
| 9.2 | Describe chlorine, bromine and iodine in Group VII as a collection of diatomic non-metals showing a trend in colour, and state their reaction with other halide ions | <p>Demonstration of preparation of chlorine (from concentrated hydrochloric acid and potassium manganate(VII)) and physical state and colour of bromine/iodine carried out in fume cupboard. [Link to Unit 2].</p> <p>Students can predict the trend in reactivity and oxidising nature (giving reasons) and, as a result, predict the effect of adding aqueous halogen to a halide salt. They can then carry out test tube scale displacement reactions to see if their predictions are true.</p> <p>Opportunity to practice writing half equations.</p> <p>Possible extension could be to demonstrate the reaction of iron with the halogens.</p> | <p>www.americanchemistry.com/chlorine/</p> <p><i>R. Norris & R. Stanbridge. Chemistry for IGCSE, Nelson Thornes, 2009, ISBN 9781408500187, p151, Fig 12.3.2</i></p> <p>www.practicalchemistry.org/experiments/halogen-reactions-with-iron%2C44%2CEX.html</p> |
| 9.2 | Predict the properties of other elements in Group VII, given data where appropriate | <p>This extends the list of halogens to include fluorine and astatine in theory only.</p> <p>In groups, students could predict the reactivity, colour/physical state, melting/boiling point of fluorine and astatine.</p> | |
| 9.2(S) | Identify trends in other Groups, given information about the elements concerned | <p>Information could include melting and boiling points, density and chemical reactivity.</p> <p>Students could do a group activity and present their findings to other members of the class.</p> <p>Include examples from <u>any</u> group in the Periodic Table.</p> | |
| 5 | Describe the electroplating of metals | <p>Students can electroplate zinc strips with copper.</p> <p>An initial can be painted onto the strip with clear nail varnish, to give a silver initial on a copper background.</p> | <p><i>R. Norris & R. Stanbridge. Chemistry for IGCSE, Nelson Thornes, 2009, ISBN 9781408500187, p78, Figs 6.5.1 & 6.5.2</i></p> |

| Syllabus ref | Learning objectives | Suggested teaching activities | Learning resources |
|--------------|--|--|--|
| 5 | Name the uses of electroplating | To protect metals from corrosion and improve the appearance of metals, e.g. plating cutlery with silver and jewellery with gold or silver. | |
| 5(S) | Relate the products of electrolysis to the electrolyte and electrodes used, exemplified by the specific examples in the Core together with aqueous copper(II) sulfate using carbon electrodes and using copper electrodes (as used in the refining of copper) | Awareness of the need for very pure copper for electrical wiring (pupils can cut open samples of wire to find copper) due to the interruption of current flow by impurities, as compared to copper needed for water pipes [link to Unit 6]. | Video clip on copper refining: www.rsc.org/Education/Teachers/Resources/Alchemy/ |
| 6.2(S) | Describe the production of electrical energy from simple cells, i.e. two electrodes in an electrolyte. (This should be linked with the reactivity series in section 10.2 and redox in section 7.3.) | Students can make simple cells using a potato or any citrus fruit with metal electrodes. Opportunity for group work – students could investigate the best substance for making a simple cell. | www.miniscience.com/projects/PotatoElectricity/ |
| 6.2(S) | Describe the use of hydrogen as a potential fuel reacting with oxygen to generate electricity in a fuel cell (details of the construction and operation of a fuel cell are not required) | Possible issues to discuss include: <ul style="list-style-type: none"> • toxicity of heavy metals used in batteries and subsequent hazards of their disposal • usefulness of re-chargeable batteries including their use for storage of energy from alternative energy sources such as domestic solar panels and wind powered generators (and in cars) | Useful background information: www.greenspec.co.uk/html/energy/fuel_cells.html |