

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

Unit 6: Metals and the Reactivity Series

Recommended prior knowledge

Knowledge on particle theory and atomic structure and the reaction of metals with oxygen and acids is preferable. Again, not sure why particle theory and atomic structure are here.

Context

This unit builds on ideas from Units 2, 3 and 4. The concepts of this unit will be revisited in Unit 11.

Outline

This unit begins by looking at the general properties of metals and the benefits of forming alloys. The reactivity series is introduced and there is a considerable range of practicals that can be used to illustrate the reactivity of different elements. This is related to the method of extraction of different metals. There is an opportunity for discussion about the economic and environmental factors in relation to the location of a manufacturing plant and the benefits of recycling. This unit is cross-referenced to assessment objectives A1–5, B1–6, C1–4 and Units 2, 3 and 4.

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

| Syllabus ref | Learning objectives | Suggested teaching activities | Learning resources |
|--------------|---|---|--|
| 10.1 | Describe the general physical and chemical properties of metals | Physical properties could include appearance, melting/boiling point, conduction of heat and electricity, malleability and ductility. Chemical properties: could include reactions with water, steam and dilute mineral acids [link with Unit 4]. | www.practicalchemistry.org/experiments/exothermic-metal-acid-reactions%2C101%2Cex.html |

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| 10.1 | Explain why metals are often used in the form of alloys | <p>Relate to improvement in corrosion resistance and mechanical properties such as strength. This can be illustrated using a simple particle diagram (particles can not slide over each other as easily- different sized particles)</p> <p>Students, in groups, can research different alloys and their uses. There results could be presented in class or on a poster.</p> <p>Link to production of steel and brass.</p> | <p>Background information on some common alloys: www.bbc.co.uk/schools/gcsebitesize/design/resistmaterials/materialsmaterialsrev3.shtml</p> |
| 3.2(d) (S) | Describe metallic bonding as a lattice of positive ions in a 'sea of electrons' and use this to describe the electrical conductivity and malleability of metals | <p>Emphasise that the 'free' electrons can move (delocalised electrons) in the metallic structure.</p> <p>Modelling a metallic structure using a shallow dish of water with detergent.</p> | <p>Notes on metallic bonding: www.docbrown.info/page04/4_72bond5.htm <i>Chemistry for IGCSE, R. Norris & R. Stanbridge, Nelson Thornes, 2009, ISBN 9781408500187, p40 Fig 3.6.2.</i></p> |
| 10.2 | <p>Place in order of reactivity: potassium, sodium, calcium, magnesium, zinc, iron, (hydrogen) and copper, by reference to the reactions, if any, of the metals with:</p> <ul style="list-style-type: none"> • water or steam • dilute hydrochloric acid and • the reduction of their oxides with carbon | <p>Experiments possible include:</p> <p>Potassium, sodium with water (as demonstration only) – [link to Unit 2]. Calcium, magnesium with water Magnesium, zinc with steam Magnesium, zinc, iron with dilute hydrochloric acid.</p> <p>For advanced candidates this could be extended to (aluminium), lead, nickel, tin and silver to provide a longer list of reactivity. (note: that aluminium is less reactive than expected in test tube experiments)</p> | <p>www.practicalchemistry.org/experiments/the-position-of-iron-in-the-reactivity-series%2C173%2CEX.html</p> |

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| 10.2(S) | <p>Describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with</p> <ul style="list-style-type: none"> the aqueous ions the oxides of the other listed metals | <p>Experiments could include:</p> <p>Reaction of the metals magnesium, zinc, iron and copper with aqueous solution of their ions. This could be extended to introduce redox reactions [link to Unit 11].</p> <p>(Again (aluminium), lead, nickel, tin and silver could be added to the list to expand the experiment.)</p> <p>Aluminium and iron(III) oxide (Thermite reaction) as a demonstration of the reactions of metals and oxides.</p> | <p>www.creative-chemistry.org.uk/gcse/documents/Module5/N-m05-03.pdf</p> <p>www.practicalchemistry.org/experiments/the-thermite-reaction,172.EX.html</p> |
| 10.2(S) | <p>Account for the apparent unreactivity of aluminium in terms of the oxide layer which adheres to the metal</p> | <p>Do not confuse with rusting of iron.</p> | |
| 10.3 | <p>Name the uses of aluminium:</p> <ul style="list-style-type: none"> in the manufacture of aircraft because of its strength and low density in food containers because of its resistance to corrosion | <p>Relate to the uses of aluminium e.g. aluminium is toxic, but oxide layer enables its use for drinks cans.</p> | |
| 10.2 | <p>Deduce an order of reactivity from a given set of experimental results</p> | <p>Reactions of metals with water, steam and dilute hydrochloric or sulfuric acid (for advanced candidates also with other aqueous metal ions).</p> <p>Students, in groups, can be given three/four elements on cards and asked them to put in order of reactivity and present their reasoning to the class.</p> | |

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| 10.3(a) | Describe the ease in obtaining metals from their ores by relating the elements to the reactivity series | <p>Electrolysis, carbon + metal oxide (reduction using carbon) and mining of native metal as the different methods.</p> <p>Demonstration of the reduction of lead(IV)oxide and charcoal blocks with a blowpipe.</p> <p>Emphasise that metals above carbon in the reactivity series are extracted by electrolysis. Metals below carbon are usually extracted by heating their corresponding metal oxide with carbon.</p> <p>Relate these three methods to the position of the metal in the reactivity series.</p> <p>Possible issues to discuss include:</p> <ul style="list-style-type: none"> • the economic and environmental cost of the high energy required in metal extraction processes • the large input of non renewable fossil fuel resources into electrolysis and carbon reduction • the importance of recycling metals | <p>Video clips on the various methods of extraction: www.rsc.org/Education/Teachers/Resources/Alchemy/</p> <p>Notes of extraction of metals: www.chemguide.co.uk/inorganic/extractionmenu.html</p> |

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| 10.3(a) | Describe the essential reactions in the extraction of iron from hematite | <p>Emphasise the use of a blast furnace and the raw materials: hematite (iron ore), coke and hot air.</p> <p>Stress limestone is added to removed acidic impurities like SiO_2 in the ore and forms a useful by-product called calcium silicate (slag).</p> <p>Iron from the blast furnace is 95% pure and is very brittle, called cast iron.</p> <p>Possible issues to discuss include:</p> <ul style="list-style-type: none"> • local environmental effect of large scale mining of haematite • the economic and environmental cost of the high energy demand of blast furnace. • the large input of non-renewable fossil fuel resources into carbon reduction. • the need to collect waste toxic carbon monoxide, which can be used as a fuel to reduce energy cost of plant • the need to recycle iron | <p>Iron and steel manufacture: www.chemguide.co.uk/inorganic/extraction/iron.html</p> <p>Use of the above video clip.</p> |
| 10.3(a) | Describe the conversion of iron into steel using basic oxides and oxygen | <p>The impurities in cast iron are removed to form pure iron. Pure iron is very soft and rusts easily. So it is converted into various types of steel by adding calculated amounts of carbon/ other metals. Link to 10.3(b) below.</p> <p>Use of Basic Oxygen Process (O2 lance) limited to the removal of carbon (good example of redox chemistry to illustrate syllabus section 7.3).</p> | <p>www.resources.schoolscience.co.uk/Corus/14-16/steel/index.html</p> |

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| 10.3(b) | Describe the idea of changing the properties of iron by the controlled use of additives to form steel alloys | <p>Use of other elements (often transition elements) and changing carbon content to alter properties such as strength and hardness.</p> <p>Illustrate the above structure changes using a particle model. Emphasising the different sized atoms stop the layers sliding over one another easily.</p> <p>Opportunity for data analysis activities to link steel specifications to use.</p> | <i>R. Norris & R. Stanbridge. Chemistry for IGCSE, Nelson Thornes, 2009, ISBN 9781408500187, p176 Fig 14.4.1.</i> |
| 10.3(b) | Name the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery) | Relate to greater resistance to chemical attack on stainless steel. | |
| 10.3(a) (S) | Describe in outline, the extraction of zinc from zinc blende Should be bold | <p>Raw materials zinc blende, coke and air:</p> <ul style="list-style-type: none"> roast the zinc sulfide in air to form ZnO and SO₂; then it is a similar process to iron manufacture- the zinc oxide is heated with coke (carbon) reduced to form Zn and carbon monoxide (except there is no limestone and zinc vaporizes and condenses in pans high in the furnace). <p>Students, in groups, could produce a flowchart or a poster of the process.</p> <p>Possible issues to discuss:</p> <ul style="list-style-type: none"> high energy demand of process and input of non-renewable fossil fuel polluting effects of waste sulfur dioxide the need to recycle zinc | <p>www.iza.com/production.html</p> <p>www.newton.dep.anl.gov/askasci/chem03/chem03435.htm</p> |
| 10.3(b) (S) | Name the uses of zinc for galvanizing and for making brass | Can be expanded to include coinage and musical instruments. | |

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| 10.3(b) (S) | Name the uses of copper related to its properties (electrical wiring and in cooking utensils) | <p>Properties such as electrical conductivity, melting point and general low chemical reactivity.</p> <p>Uses can be expanded to include coinage.</p> <p>Link to Unit 11 regarding the purification of copper.</p> <p>Issues of the need and economic difficulties of recycling of metals could be discussed here.</p> | |
| 9.3 | Describe the transition elements as a collection of metals having high densities, high melting points and forming coloured compounds, and which, as elements and compounds, often act as catalysts | <p>Relevant elements for colours include iron (valency of 2 and 3), manganese (in potassium manganate(VII)), chromium (in potassium dichromate(VI)) and copper(II).</p> <p>Students can be introduced to different coloured ions and asked to predict the colours of some compounds.</p> <p>Catalysts to include nickel for hydrogenation of alkenes/fats, platinum/rhodium/palladium in car catalytic converters and iron in the Haber process (also vanadium(V) oxide in the Contact process).</p> <p>Possible issues to discuss include the importance of catalysts in lowering the energy demand of industrial processes and hence conserving fossil fuel and increasing profitability.</p> | www.bbc.co.uk/schools/gcsebitesize/science/edexcel/patterns/transitionmetalsrev1.shtml |

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| 10.2(S) | Describe the action of heat on the hydroxides and nitrates of the listed metals | <p>Emphasise that this type of reaction is called thermal decomposition.</p> <p>Describe the action of heat on the hydroxides and nitrates of calcium, copper(II), iron(II), iron(III), magnesium, potassium, sodium and zinc.</p> <p>Most metal hydroxides decompose to the corresponding metal oxide and water when heated.</p> <p>Most metal nitrates decompose to nitrites and oxygen or to oxides, nitrogen dioxide and oxygen when heated.</p> <p>The more reactive the metal, the more stable the hydroxide/nitrate.</p> | <p><i>Chemistry for IGCSE, R. Norris & R. Stanbridge, Nelson Thornes, 2009, ISBN 9781408500187, p167 Fig 3.6.2.</i></p> |