

UNIT 6 Metals and metal reactivity

Recommended Prior Knowledge Unit 1 and Unit 2. It is suggested that this unit is taught in the middle of the course. If the unit is taught after Unit 7 (Speed of Reaction), the students can use ideas about reaction rate to carry out quantitative experimental work to determine the different speeds of reaction of metal reactions with acids.

Context Students should study this unit before Unit 9, as it covers the extraction of metals using carbon. Unit 9 includes the use of electrolysis to extract aluminium.

Outline The unit covers physical and chemical properties of metals linked to the reactivity series. The unit should be taught using practical experiments wherever possible. It is suggested that Redox reactions are taught in the context of the unit so that more able students learn to analyse metal reactions in terms of electron transfer and oxidation number change. Less able pupils can focus on corrosion as an example of a simpler oxidation reaction. The reactivity series is linked to methods of extraction for metals. There are opportunities for topic based work on recycling.

| | Summary of learning Outcomes (see syllabus for full detail) | Suggested Teaching Activities | Further teacher guidance | Online resources |
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| 2.6 a | Metallic bonding describe metals as a lattice of positive ions in a sea of electrons | Students should be familiar with the 'cations in delocalised mobile electrons' model of metal structure. They should be able to explain metal properties using this model. Students should be careful when drawing the diagram not to have the metal ions touching. | It is important that students can compare metallic structure and properties to ionic and covalent structures e.g. electrical conductivity. They need to be able to identify the type of bonding from a table or list of data such as melting points and conductivity. | www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm Click on 'Structure and Bonding' |
| b | relate properties of metals (malleability & electrical conductivity) to their structure | A suggested activity is for students to use a table or spreadsheet of data about metal physical properties (see 9.1 below) to explain why different metals are used for different purposes. | | www.schoolscience.co.uk Click on: 'Chemistry 14-16' then 'Properties and uses of copper' http://www.btinternet.com/~chemistry.diagrams/molecular_diagrams.htm |
| 9.1 a | Properties of metals describe the physical properties of metals (high melting points, boiling points, malleability, good conductivity of heat and electricity) related to their | The teaching of metal properties should be taught in the context of bonding (above). | This links to early work on Kinetic theory of solids in Unit 1 | http://www.coruseducation.com/VAC/index2.htm |

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| B c,d | <p>structure</p> <p>describe alloys as mixtures of a metal and another element (brass, stainless steel)</p> <p>understand diagrams of the structures of alloys and explain why alloys have different properties to their constituent elements</p> | <p>Students can research the properties of alloys compared to their constituent elements (e.g. solder - see web site experiment 63)</p> <p>They should use diagrams showing the effect of different sized atoms on metal structure and use the diagrams to explain why alloys are typically harder and less malleable than elements.</p> | <p>Paper chromatography can be used to identify the metals present in an alloy such as brass or the coinage metals.</p> | <p>www.chemsoc.org/networks/earnnet/classic_exp.htm Look at experiment 63.</p> <p>Information about gold alloys: www.9carat.co.uk</p> <p>www.cambriangoldfields.co.uk/authentication.htm</p> <p>www.royalmint.com/talk/specifications.asp</p> |
| 9.2 a | <p>Reactivity Series</p> <p>place metals in order of reactivity by considering...</p> <p>reactions with water, steam and dilute hydrochloric acid</p> <p>reduction (if any) of their oxides with carbon and/or hydrogen</p> <p>Metals: calcium, copper, iron, lead, magnesium, potassium, silver, sodium and zinc</p> | <p>Students should carry out experiments test tube reactions of the named metals with water and acids. This is an opportunity for the students to practise making observations and to draw conclusions about relative metal reactivity from their own data. They can compare reactivity by contrasting the speed of evolution of bubbles or by measuring temperature changes.</p> <p>Students should practise making predictions about the reactions of a metal by reference to its position in the reactivity series.</p> <p>A mixture of lead oxide and carbon heated in a crucible will produce a puddle of molten lead.</p> | <p>This is an opportunity to teach the gas test for hydrogen (Syllabus learning outcome 1.3(c))</p> <p>Students may note the exothermic nature of reactions involving acids by using a thermometer to monitor temperature changes during the reaction (Syllabus learning objective 5(a)). These reactions are good examples for the use of datalogging methods using a temperature probe.</p> <p>Students should realise that more reactive metals need more energy to reduce them from their compounds. This idea is an important preparation for Unit 9</p> | <p>www.chemsoc.org/networks/earnnet/classic_exp.htm Look at experiment 31, 62</p> <p>www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm Click on 'Reactivity of Metals'</p> <p>www.s-cool.co.uk/contents.asp click on 'GCSE revision' then 'Chemistry' then choose topic: 'Metals – the Reactivity Series'. Use the 'Quick learn' section.</p> <p>http://www.schoolchem.com/r.htm</p> |

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| <p>b</p> <p>c</p> | <p>describe the reactivity series relation to the readiness of a metal to form its positive ion – particularly with reference to reactions with...</p> <p>aqueous ions of other metals oxides of other metals</p> <p>deduce order of reactivity from experimental results</p> | <p>Students can carry out test-tube scale reactions of copper, iron, lead, magnesium and zinc with aqueous solutions of their salts. They can produce tabulated observations and use their findings to deduce an order of reactivity.</p> <p>For reinforcing these ideas, students can use two piles of cards; one of metal names, one of names of aqueous salts or metal oxides. They choose a card from each pile and say whether or not a reaction will happen. More able students should predict observations and write equations for their predicted reactions.</p> | <p>Students should be able to represent displacement reactions using ionic equations (Syllabus learning objective 3(d)).</p> <p>Metal reactions also need to be discussed in terms of electron transfer and oxidation state change (see 6.2 below). This is a further opportunity to reinforce ideas about exothermic reactions. The Thermit reaction is an interesting context to illustrate these ideas.</p> | <p>www.chemsoc.org/networks/learnnet/classic_exp.htm Look at experiment 97</p> <p>Use Google image search to search for 'Thermit process' or 'Thermite process' to see images of welding railway lines.</p> |
| <p>d</p> | <p>describe the action of heat and the thermal stability of metal carbonates related to the reactivity series</p> | <p>Students can heat metal carbonates in test tubes attached to a delivery tube. The gas evolved can be bubbled through a second test tube containing lime water. Students can time how long it takes for the lime water to go cloudy and so rank the carbonates in order of stability.</p> <p>As an extension, more able students may consider the size and charge on the cation as a factor in determining stability.</p> | <p>This is an opportunity to teach the gas test for carbon dioxide (Syllabus learning outcome 1.3(c))</p> <p>More able pupils should be aware that these reactions require energy and are therefore endothermic.</p> <p>All students should write equations for the reactions.</p> | <p>www.chemsoc.org/networks/learnnet/classic_exp.htm Look at experiment 66.</p> |
| <p>6.2</p> <p>a</p> <p>b,c</p> | <p>Redox</p> <p>define oxidation and reduction in terms of...</p> <p>oxygen/hydrogen loss/gain electron gain/loss changes in oxidation state</p> | <p>These ideas should be taught where they occur across the syllabus.</p> <p>NB. Use of the mnemonic 'OILRIG'</p> <p>The students can work to a set of rules for determining oxidation numbers. They can use metal displacement reactions as a context to learn to identify the oxidiser and</p> | <p>.</p> <p>This is an opportunity to teach the gas test for sulphur dioxide (Syllabus learning outcome 1.3(c))</p> <p>This is also an opportunity to revise and compare displacement reactions of</p> | <p>www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm Click on 'Reactivity of Metals'</p> |

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| d | describe tests for oxidising and reducing agents (using aqueous potassium iodide, acidified potassium manganate(VII) and acidified potassium dichromate (VI)) | <p>reducer from full and ionic equations. They need to be able to do this both in terms of electron transfer and oxidation number.</p> <p>The common reactions and colour changes of oxidising and reducing agents can be demonstrated. These are covered again in other syllabus areas (e.g. amount of substance).</p> | halogens from Unit 2 and analyse them using ideas about redox in terms of electron transfer. | |
| 9.3 a b,c | <p>Extraction of metals</p> <p>relate the ease of obtaining metals from their ores to the position of the metal in the reactivity series</p> <p>discuss the social, economic and environmental advantages and disadvantages of recycling metals (e.g. aluminium and copper)</p> | <p>One approach is to ask different groups of students to research the extraction of different metals e.g.</p> <ul style="list-style-type: none"> • name of metal • occurrence in nature (element or compound?) • how it is extracted from its ore (heating with carbon or electricity?) • cost per tonne (this can be found using an internet search engine for latest metal prices) • uses of the metal • whether or not the metal is usually recycled. <p>This data can be displayed on fact cards or put into a table on board, spreadsheet or database.</p> <p>The metals can then be considered in order of reactivity to link trends in reactivity with the method and energy of extraction. It is important that students recognise that the energy demand of extraction determines the price of the metal, and that the use of large amounts of energy has implications for recycling and the need to save fuel resources.</p> | Percentage purity calculations (Syllabus learning outcome 3(k)) can be taught here. Students can work out the percentage of metal compounds in various ores. | <p>www.chemsoc.org/networks/learnnet/classic_exp.htm Look at experiments 33, 74, 94.</p> <p>www.s-cool.co.uk/contents.asp click on 'GCSE revision' then 'Chemistry' then choose topic: 'Extraction of Metals'. Use the 'Quick learn' section.</p> <p>www.schoolscience.co.uk Click on: 'Chemistry 14-16' then 'Copper mining' and 'Properties and uses of copper'</p> <p>http://www.schoolchem.com/ex.htm</p> <p>www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm Click on 'Extraction of Metals'</p> |

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| 9.4 a | Iron describe the extraction of iron in the blast furnace | Students need to be familiar with an outline schematic diagram of the blast furnace. They need to know the raw materials, waste outputs (slag, carbon monoxide and dioxide) and equations for the oxidation of carbon, reduction of iron oxide and formation of slag. | The equations for the reactions in the Blast furnace should be discussed in terms of redox (oxidation state and oxygen transfer). | www.chemsoc.org/networks/learnnet/classic_exp.htm Look at experiment 35. www.bbc.co.uk/history/games/blast/blast.shtml http://www.btinternet.com/~cchemistry.diagrams/blastfurnace.htm http://www.coruseducation.com/galleryironmaking.asp |
| b | describe the composition, properties and uses of some examples of steel – particularly mild steel (car bodies, machinery) and stainless steel (chemical plant, cutlery, surgical instruments). | Students can carry out a 'steel survey' using a magnet to identify where iron and steel are used in the materials around them. Examples include food and drinks cans, vehicles, paper clips. For each use students should be able to outline which properties of steel are most important in its choice. | This is an opportunity to reinforce ideas about alloys. Students can research to find out which elements are added to make different types of steel e.g. mild steel, stainless steel, high tensile steel. | www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm Click on 'Extra Industrial Chemistry' http://www.coruseducation.com/wordsearch/index2.html For a list of online resources relating to the steel industry go to http://www.coruseducation.com/internet.asp |

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| | | | | www.schoolscience.co.uk Click on: 'Steel for many purposes' Or click 'Chemistry 14-16' then 'The chemistry of steelmaking' |
| d,e | describe how iron rusts and methods of rust prevention, including sacrificial protection | <p>Test tube reactions using nails can be set up to show that air and water are needed for rusting to take place. Students can investigate different methods of rust prevention e.g. coating the nails with oil, grease or paint, using copper or zinc foil, investigating the effect of acid and salt on rate of rusting.</p> <p>Another activity is to bring a bicycle into the classroom. Students look to find out how the different parts of the bicycle are protected from rusting. They can consider why different methods of rust prevention are used for different areas.</p> | <p>Contrast the rusting of iron to the formation of a protective oxide layer on aluminium (Syllabus learning objective 9.5 (b))</p> <p>Students should recognise rusting as an oxidation reaction.</p> <p>Contexts to use for discussion include the use of zinc and magnesium blocks to protect oil rigs and ships and the sealing of car undercarriages with plastic sealants.</p> | www.chemsoc.org/networks/learnnet/classic_exp.htm Look at experiments 50, 55, 69. http://www.coruseducation.com/RailWebRun/index1.html |