

Scheme of work – Cambridge IGCSE[®] Chemistry (US) 0439

Unit 3: Air and water

Recommended prior knowledge

Knowledge on atomic structure and the basic layout of the Periodic Table is preferable.

Context

This unit builds on ideas from Units 1 and 2. The concepts of this unit will be revisited in Units 6 and 11.

Outline

This unit begins by looking at the way in which we can test for water and its treatment. Students could compare methods of treatment in their country and the UK. Discussion why some governments recommend boiling tap water or to drink bottle water together with the environmental consequences. The composition of the air and the common pollutants. Students can research how they are being monitored and managed in their own country. This unit is cross-referenced to assessment objectives A1–5, B1–5, C1–3 and Unit 2.

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

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
11	Describe chemical tests for water using cobalt(II) chloride and copper(II) sulfate	Use either anhydrous cobalt(II) chloride (blue cobalt chloride paper) or anhydrous copper(II) sulfate (solid) Students could be introduced to 'reversible reactions' [link to Unit 12]. Extension – practical/demonstration of burning a fuel (candle) and illustrating that water is one of the combustion products [link to Unit 8].	<i>Chemistry Experiments, J. A. Hunt, A. Geoffrey Sykes, J. P. Mason, Longman 1996, Experiment B5.</i>

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
11	Describe, in outline, the treatment of the water supply in terms of filtration and chlorination	<p>Emphasis on filtration [link to Unit 1] and chlorination stages.</p> <p>Opportunity to introduce the properties of chlorine/Group VII elements as poisonous, safe only in very dilute solution.</p> <p>Can discuss role of chlorine in eradicating waterborne diseases in many countries.</p> <p>Possible school visit to a water treatment plant.</p>	<p>Notes on water purification: www.docbrown.info/page01/AqueousChem/AqueousChem.htm</p>
11	Name some of the uses of water in industry and in the home	<p>Water is used as a solvent and a coolant in industry, as well as used for drinking and washing in the home.</p> <p>Possible activities include writing a 24 hour 'water use' diary and presenting data as bar or pie charts, perhaps using a spread sheet.</p>	
11	Describe the composition of clean air as being approximately 79 % nitrogen, 20 % oxygen and the remainder as being a mixture of noble gases, water vapour and carbon dioxide	<p>Experiment to derive the % oxygen in the air using the oxidation of heated copper metal.</p> <p>Alternatives could be:</p> <ul style="list-style-type: none"> • Iron wool with air • Phosphorus with air (demonstration only- using a fume cupboard) 	<p>Video clip on gases from the air: www.rsc.org/Education/Teachers/Resources/Alchemy/index2.htm</p> <p><i>R. Norris & R. Stanbridge. Chemistry for IGCSE, Nelson Thornes, 2009, ISBN 9781408500187, p182.</i></p> <p>Class practical sheet using iron wool: www.chemlabs.uoregon.edu/Classes/Exton/CH228/PercentOxygen.pdf</p>
11(S)	Describe the separation of oxygen and nitrogen from liquid air by fractional distillation	<p>Link to Unit 1- Experimental techniques.</p> <p>Link this to boiling points and the fractional distillation of petroleum and ethanol [Unit 8 and 10].</p>	<p>Good summary of the process: www.bbc.co.uk/schools/gcsebitesize/science/edexcel/oneearth/usefulproductsrev2.shtml</p>
9.4	Describe the noble gases as being unreactive	<p>Opportunity to reinforce ideas of full outer shells leading to lack of reactivity [link to Unit 2].</p>	<p>Good video clip about the noble gases: www.open2.net/sciencetechnologynature/worldarounds/noblegases.html</p>

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
9.4	Describe the uses of the noble gases in providing an inert atmosphere, i.e. argon in lamps, helium for filling balloons	Students can produce posters, or in groups do a short-presentation/poster illustrating the uses of the different noble gases.	www.drbateman.net/gcse2003/gcse/sums/chemsums/noble_gases/noble_gases.htm
6.2	Describe the production of heat energy by burning fuels	<p>Emphasise combustion is an exothermic process.</p> <p>Relevant examples should include Bunsen burner, fuels for heating the home and fossil fuel burning power stations.</p> <p>Students can research/do an investigation into what makes a good fuel?</p> <p>Opportunities for experiments to compare energy evolved on heating fuels using spirit burner and metal can.</p> <p>Awareness of the importance of energy output of hydrocarbon fossil fuels to transport and manufacturing industry.</p>	<p>What makes a good fuel?: <i>Chemistry Experiments, J. A. Hunt, A. Geoffrey Sykes, J. P. Mason, Longman 1996, Experiment K4.</i></p> <p><i>R. Norris & R. Stanbridge. Chemistry for IGCSE, Nelson Thornes, 2009, ISBN 9781408500187, p 88 Fig 7.2.1.</i></p>
11	<p>Describe the formation of carbon dioxide:</p> <ul style="list-style-type: none"> as a product of complete combustion of carbon containing substances as a product of respiration as a product of the reaction between an acid and a carbonate from the thermal decomposition of a carbonate 	<p>Opportunity for demonstration or students to perform a variety of experiments to prepare carbon dioxide.</p> <p>Students can be introduced to the limestone cycle (link to Unit 4) and this can be extended to make temporary hard water (calcium hydrogencarbonate solution).</p> <p>Comparison of oxygen and carbon dioxide content in air before and after respiration and combustion.</p> <p>Possible issues to raise include the role of carbon dioxide from combustion of fossil fuels contributing to global warming. (note that the present concentration of CO₂ in the atmosphere is 0.038%)</p>	<i>Chemistry Experiments, J. A. Hunt, A. Geoffrey Sykes, J. P. Mason, Longman 1996, Experiments B6 & D5.</i>

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
11	State that carbon dioxide and methane are greenhouse gases and may contribute to climate change	<p>Emphasise that a greenhouse gas absorbs heat energy and stops heat escaping into space and warms the atmosphere, which causes an increase in global warming.</p> <p>Methane is formed as a result of digestion in cows and from rice paddy fields.</p>	www.timesonline.co.uk/tol/news/science/earth-environment/article6895907.ece
11	Name the common pollutants in the air as being carbon monoxide, sulfur dioxide, oxides of nitrogen and lead compounds	<p>Emphasise that CO is a poisonous gas and both sulfur dioxide and oxides of nitrogen can lead to breathing difficulties and the formation of acid rain.</p> <p>Extension – students can produce a flowchart to show how acid rain is formed.</p> <p>Opportunity for group work – data analysis of tables of air quality data.</p>	<p>Overview on air pollution and update readings for nitrogen oxides in London: www.londonair.org.uk/london/asp/information.asp Fact sheet on SO₂ pollution: www.environment-agency.gov.uk/business/topics/pollution/433.aspx</p>
11	<p>State the source of each of these pollutants:</p> <ul style="list-style-type: none"> carbon monoxide from the incomplete combustion of carbon-containing substances sulfur dioxide from the combustion of fossil fuels which contain sulfur compounds (leading to 'acid rain') oxides of nitrogen from car exhausts 	<p>Emphasise the source of gas:</p> <ul style="list-style-type: none"> CO from incomplete combustion of a carbon-based fuel; SO₂ from the combustion of fossil fuels containing sulfur; Nitrogen oxides from the reaction of nitrogen and oxygen <u>inside</u> a car engine at high temperature or by their reaction during a lightning strike. <p>Possible issues for discussion include</p> <ul style="list-style-type: none"> Reliance on fossil fuels (petrol, power stations) as a major contributory factor to air pollution; Use of lead compounds in petrol and their gradual reduction in use over the last decade. 	

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
11(S)	<p>Describe and explain the presence of oxides of nitrogen in car exhausts and their catalytic removal</p>	<p>Emphasis the purpose of a catalytic converter to change the poisonous gases, carbon monoxide and oxides of nitrogen, into non-toxic nitrogen and carbon dioxide.</p> <p>Links to other units include the opportunity for treatment of converter reactions in terms of redox [section 7.3, Unit 11].</p> <p>Reinforcement of catalytic chemistry [section 7.1, Unit 5] and transition metal use [section 10.3(b), Unit 6].</p>	

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
11	State the adverse effect of common pollutants on buildings and on health	<p>Emphasis on limestone decay, rusting of iron and tarnishing of copper.</p> <p>This provides an opportunity for students to carry out group research, perhaps presenting their findings to the rest of the class using overhead projection foils or posters.</p> <p>Each group can research the effects of a different pollutant gas in terms of how it is produced, its adverse effects and methods for solving the problem. Issues include:</p> <ul style="list-style-type: none"> • Effects of acid rain on vegetation, aquatic life, limestone buildings. • Oxides of nitrogen and sulfur dioxide as respiratory irritants. • Dangers of CO poisoning from cars and poorly maintained domestic heaters. • Reasons for high concentration of pollutants in cities and subsequent effects on health. <p>The role of chemistry in a 'search for solutions' can also be discussed, for example:</p> <ul style="list-style-type: none"> • attempts to control the effects of sulfur emissions (scrubbers) • liming of lakes and soil to neutralise some of the effects of acid rain • development of alternative fuels, catalysts to lower energy use in industry and catalytic converters for cars 	

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
11	Describe methods of rust prevention, specifically paint and other coatings to exclude oxygen	<p>Experiment involving the investigation of rusting of iron nails using these methods.</p> <p>A simple investigation or experiment to demonstrate methods of prevention can be:</p> <ul style="list-style-type: none"> • apply coating to a nail- colourless nail varnish, liquid removal (Tippex), cling film, grease or oil, oil-based paint • sacrificial protection – wrap a small piece of Mg ribbon around a nail 	<p><i>R. Norris & R. Stanbridge. Chemistry for IGCSE, Nelson Thornes, 2009, ISBN 9781408500187, p 192 Fig 15.7.1.</i></p> <p>Rust prevention demonstration: www.practicalchemistry.org/experiments/preventing-rusting%2C251%2CEX.html</p>
11(S)	Describe sacrificial protection in terms of the reactivity series of metals and galvanising as a method of rust prevention	<p>Opportunity to reinforce reactivity series [section 10.2 Unit 6].</p> <p>This could be emphasised in the above experiment, where two or three metals of different reactivity could be investigated – Mg, Sn, Cu.</p>	<p>Extension- mechanism of sacrificial protection: www.dynamicscience.com.au/tester/solutions/chemistry/corrosion/rustpreventionsacanode.htm</p>