

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

Unit 2: Particles, atomic structure, ionic bonding and the Periodic Table

Recommended prior knowledge

Basic knowledge of particle theory and the layout of the Periodic Table.

Context

This unit can be taught as a whole or split into two parts: (i) particles, state of matter and atomic structure and (ii) Ionic bonding, Periodic Table and Group 1.

Outline

This unit begins by looking at the particle model of matter and leads onto the structure of the atom. These are fundamental topics, which will be revisited in later units (and in Cambridge IGCSE.Physics). This is then extended to include ions, leading onto ionic bonding (to link up with Group 1). The layout of the Periodic Table can be introduced (opportunity for students, in groups, to research trends within groups or across periods) and the chemistry and properties of the Group 1 metals. This unit is cross-referenced to assessment objectives A1–5, B1–6, C1–4.

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

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
1	Describe the states of matter and explain their interconversion in terms of the kinetic particle theory	<p>Relate the conversions to the motion and arrangement of particles.</p> <p>Use 'particles in boxes' diagrams to represent the three states of matter. Emphasise the change in the arrangement and movement of the particles when a substance changes state.</p> <p>Relate this to the energy input/output.</p> <p>Students can be asked to use the theory to explain properties such as behaviour of gases under pressure and liquid flow (opportunity for a 'circus of experiments' here).</p>	<p>An excellent collection of animations and video clips: Royal Society of Chemistry Particles in Motion, CD ROM, 2006.</p>

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1	Describe and explain diffusion	<p>Simple examples of diffusion include:</p> <ul style="list-style-type: none"> Air freshener , perfume, ether, camphor smells in the lab; Movement of nitrogen dioxide gas or bromine vapour in air; Coloured inks/$\text{CuSO}_4/\text{KMnO}_4$ in water and $\text{Pb}(\text{NO}_3)_2$ in KI <p>Extension – what would influence diffusion rate, for example temperature using tea bags held by a glass rod in beakers of hot and cold water.</p> <p>Students should be able to link their observations to the particulate model.</p>	<p>Use above CD ROM.</p> <p><i>Chemistry Experiments, J. A. Hunt, A. Geoffrey Sykes, J. P. Mason, Longman 1996, Experiments A12–A14.</i></p> <p>www.practicalchemistry.org/experiments/diffusion-in-liquids,185,EX.html</p>
1	Describe evidence for the movement of particles in gases and liquids (a treatment of Brownian motion is not required)	See above examples.	<p>Use above CD ROM.</p> <p>www.practicalchemistry.org/experiments/particles-in-motion,187,EX.html</p>
1(S)	Describe dependence of rate of diffusion on molecular mass (treated qualitatively)	Two cotton wool pads, one soaked with conc. hydrochloric acid and the other with conc. ammonia can be placed at opposite ends of a long glass tube sealed with bungs. A white ‘smoke’ of the precipitated ammonium chloride is seen where the two gases meet.	www.practicalchemistry.org/experiments/diffusion-of-gases-ammonia-and-hydrogen-chloride,184,EX.html
3.1	State the relative charges and approximate relative masses of protons, neutrons and electrons	Opportunity for group work, students can research and present their ideas on the development of the structure of the atom from the Greeks onwards. They can also discuss the limitations of each model using ICT/textbooks.	<p>Summary of atomic structure:</p> <p>www.chemguide.co.uk/atoms/properties/gcse.html</p> <p>Good lesson structure of the history of the atomic structure</p> <p>www.learnnc.org/lp/pages/2892</p>
3.1	Define <i>proton number</i> and <i>nucleon number</i>	Proton number is also the atomic number. Nucleon number is also the mass number – the total number of protons + neutrons.	

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3.1	Use proton number and the simple structure of atoms to explain the basis of the Periodic Table (see section 9), with special reference to the elements of proton number 1 to 20		
3.1	Define <i>isotopes</i>	Illustrate isotopes – by comparing ice cubes in water- D_2O (sinks) and H_2O (floats).	
3.1	State the two types of isotopes as being radioactive and non-radioactive		Information on the two types of isotopes: www.sahra.arizona.edu/programs/isotopes/types/index.html
3.1	State one medical and one industrial use of radioactive isotopes	Possible examples include the location of blockages and leakages in underground pipes and the use of radioactive iodine in tracing thyroid activity.	Modern uses of radioactive isotopes: www.chem.duke.edu/~jds/cruise_chem/nuclear/uses.html I had to copy and paste this one.
6.2	Describe radioactive isotopes, such as ^{235}U , as a source of energy	Possible issues for discussion include <ul style="list-style-type: none"> the long term nature of nuclear energy (sustainable long after coal and oil run out) environmental considerations such as the disposal of radioactive waste 	www.world-nuclear.org/education/uran.htm and this one.
3.1	Describe the build-up of electrons in 'shells' and understand the significance of the noble gas electronic structures and of valency electrons. (The ideas of the distribution of electrons in s and p orbitals and in d block elements are not required.) (Note: a copy of the Periodic Table will be available in Papers 1, 2 and 3)	Use circles to show the shells up to atomic number 20. Students can use mini-whiteboards to draw electron diagrams as a class activity. Extension – to use spectroscopes to illustrate different energy shells.	

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3.2	Describe the differences between elements, mixtures and compounds, and between metals and non-metals	Link to Unit 5 – Periodic Table. The reaction between iron, sulfur and iron(II) sulphide can be carried out by students to illustrate the varying properties of the elements, the mixture and the compound.	Video animation of Fe & S: www.bbc.co.uk/schools/ks3bitesize/science/chemical_material_behaviour/compounds_mixtures/activity.shtml
3.2	Describe an alloy, such as brass, as a mixture of a metal with other elements	Awareness of the importance of alloys to meet industrial specifications for metals. Link to Section 2.2(a) Unit 1 and Section 10.3(a) Unit 6	www.practicalchemistry.org/experiments/intermediate/metals/making-an-alloy-solder,131,EX.html
10.1	Identify representations of alloys from diagrams of structure	Construct models of an alloy using plasticine.	www.practicalchemistry.org/experiments/intermediate/metals/modelling-alloys-with-plasticine,135,EX.html
3.2(a)	Describe the formation of ions by electron loss or gain	Emphasise formation of a full shell/noble gas configuration. Students should be shown dot and cross diagrams for simple ionic substances e.g. NaCl, KF, MgO. Then challenged to draw diagrams for more complicated examples like CaCl ₂ , MgBr ₂ , AlF ₃ . Students can use mini-whiteboards to draw electron diagrams as a class activity. This can also be done using cut out electrons and shells so students can move electrons into place. Link this to Unit 11.	www.chemguide.co.uk/atoms/bonding/ionic.html
3.2(a)	Describe the formation of ionic bonds between elements from Groups I and VII	Concentrate on the attraction of + and – charges and the full outer shells obtained by electron transfer. Use above examples.	

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
3,2(a) (S)	Describe the formation of ionic bonds between metallic and non-metallic elements	Students can explore the properties of ionic compounds experimentally and link them to the model of ionic bonding – solubility in water, conductivity when solid, in solution and molten (do as a demo with PbBr_2) and melting point. Extension – students could be introduced to writing ionic formulae (Unit 9) and electrolysis (Unit 11).	
3,2(a) (S)	Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions	Ball and spoke models will be useful here.	Good website to illustrate this: www.chm.bris.ac.uk/pt/harvey/gcse/ionic.html
6.1	Describe the meaning of <i>exothermic</i> and <i>endothermic</i> reactions	This can be seen as a rise or fall in temperature of many chemical reactions used in the syllabus. This concept can be taught across the syllabus, rather than as a discrete lesson. Suggested experiments: <ul style="list-style-type: none"> • neutralisation reactions of acids and alkalis (see Unit 4) • metal displacement reactions (see Unit 6) • dissolving salts, including ammonium salts (see Unit 4) • if data loggers are available, temperature probes could be used 	

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
9	Describe the Periodic Table as a method of classifying elements and its use to predict properties of elements	<p>Elements to be classified as metals and non-metals. Their states should be mentioned.</p> <p>Properties limited to qualitative idea of melting/boiling point.</p> <p>Suggested activities:</p> <ul style="list-style-type: none"> Students make observations from photocopied version of the Periodic table. A database of properties and states for element of periods 1, 2 and 3 could be set up. Students, in groups, could be asked to design a flowchart to find the metals, non metal, solids and liquids and enter the results on a blank copy of the periodic table. 	<p>Excellent suite of video clips on various elements of the Periodic Table: www.periodicvideos.com/</p> <p>Interactive Periodic Tables: www.webelements.com/ www.rsc.org/chemsoc/visualelements/index.htm www.ptable.com/ www.chemicool.com/ Copy and paste again</p>
9.1	Describe the change from metallic to non-metallic character across a period	Emphasise the metal/non metal boundary.	
9.1(S)	Describe the relationship between Group number, number of valency electrons and metallic/non-metallic character	Emphasise number of valency electrons = group number.	
4	Use the symbols of the elements and write the formulae of simple compounds	<p>Students can calculate the formula by using the 'valencies' or 'combining powers' of the elements.</p> <p>Students can use mini-whiteboards to write formulae or bingo activity for working out the total number of atoms in a formula.</p>	<i>R. Norris & R. Stanbridge. Chemistry for IGCSE, Nelson Thornes, 2009, ISBN 9781408500187, p44–45.</i>
4	Deduce the formula of a simple compound from the relative numbers of atoms present	<p>As above.</p> <p>This should be linked with organic molecules and with inorganic substances such as P_4O_{10}.</p>	

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9.2	Describe lithium, sodium and potassium in Group I as a collection of relatively soft metals showing a trend in melting point, density and reaction with water	<p>Group 1 metals are called the alkali metals.</p> <p>Demonstration with very small amounts of the metals behind a safety screen <i>or video</i> only of reactions with water due to highly exothermic nature.</p> <p>Focus on the observations here and link to theory and relative reactivity:</p> <ul style="list-style-type: none"> metal floats, so less dense than water fizzing indicates a gas is given off molten ball (not Li) indicates highly exothermic reaction lilac flame (K) indicates very exothermic reaction because the hydrogen gas given off ignites 	<p>Excellent video of the reaction of all the alkali metals with water: www.open2.net/sciencetechnologynature/worldarouндus/akalimetals.html</p> <p>www.practicalchemistry.org/experiments/alkali-metals,155,EX.html</p>
9.2	Predict the properties of other elements in Group I, given data, where appropriate	<p>Include reactions of Rb and Cs and physical properties such as melting and boiling points. Trends can be obtained from suitable databases. Sometimes you refer to elements by their symbols.</p> <p>You can demonstrate the low melting point of caesium by holding a sealed glass vial in your hand. The metal quickly melts inside the vial.</p>	<p>Useful background data on Rb, Cs and Fr: www.chemtopics.com/elements/alkali/alkali.htm</p>