

## UNIT 4: Matter

**Recommended Prior Knowledge** Students should be able to describe matter in terms of atoms, with a qualitative understanding of their behaviour. They should be able to model an atom as electrons orbiting a positively charged nucleus.

**Context** An understanding of the qualitative behaviour of atoms in matter is aid to further more advanced studies in the A2 course. For those students who elect not to study beyond AS level, the topic is important in the understanding of the world around us.

**Outline** Students will study how the spacing, ordering and motion of atoms determines the state and structure of matter. A particular study is made of the deformation of solids. On a sub-atomic scale, the structure of the atom is considered together with the nature of nuclear decay.

Learning Outcomes		Suggested Teaching Activities	Resources
	Candidates should be able to		
9.(b)	relate the difference in structures and densities of solids liquids and gases to simple ideas of the spacing, ordering and motion of molecules.	Revision of density from Unit 2. Discussion: solids - fixed volume and shape liquids - fixed volume, no fixed shape, about same density as solid gases - no fixed volume or shape.	Reference should be made to the list of textbooks printed in the Syllabus document. Note that some of these texts are more suitable as reference texts for the teacher whilst others are more suitable as student texts. Some Internet sites are shown within certain topics. The list of sites is by no means comprehensive but provides examples of what is available. Material may provide a link with O-level and IGCSE studies, thus providing background experience, as well as reinforcing AS studies. All examples of examination questions are taken from Physics 8702 and 9702 Papers  Marbles on tray. Model crystals, 'springy' model of crystal structure

		<p>density about 1/1000 solid or liquid</p> <p>Relate volume/shape to rigid/non-rigid/no force between atoms/molecules</p> <p>Relate spacing to density.</p>	
9.(c)	describe a simple kinetic model for solids, liquids and gases.	<p>Discussion: thermal energy supplied to matter seen as increase in potential and kinetic energy of molecules.</p> <p>Situation in solid – vibrational, fixed lattice</p> <p>Liquid – clusters moving randomly within body of liquid</p> <p>Gas – individual molecules moving randomly</p>	<p>See also Specimen Paper 1, question 22 May/June 2001, Paper 1, question 22 May/June 2001, Paper 2, question 4</p>
9.(d)	describe an experiment which demonstrates Brownian motion and appreciate the evidence for the movement of molecules provided by such an experiment.	<p>Expt: Observation of Brownian motion</p> <p>Discussion: how observations explained by random motion of molecules of gas</p>	<p>Smoke cells, low power microscopes</p> <p>See also Oct/Nov 2001, Paper 1, question 21</p>
9.(f)	define the term pressure and use the kinetic model to explain the pressure exerted by gases.	<p>Revision: what is pressure (Unit 2)</p> <p>Discussion: random motion of atoms in a gas</p> <ul style="list-style-type: none"> <li>- collisions with walls of vessel</li> <li>- associated momentum change (Unit 2) and averaging over many collisions leads to idea of gas pressure</li> </ul>	<p>Kinetic theory model (if available)</p> <p><a href="http://plabpc.csustan.edu/">http://plabpc.csustan.edu/</a></p>
9.(i)	distinguish between the processes of melting, boiling and evaporation.	<p>Discussion: what is melting, boiling and evaporation</p> <p>nature of forces between atoms in solids, liquids and gases leading to an explanation of the changes of state in molecular terms.</p>	<p>Kinetic theory model (if available)</p> <p><a href="http://www.bamaed.ua.edu/sciteach/EnergytoMeltIce.html">http://www.bamaed.ua.edu/sciteach/EnergytoMeltIce.html</a></p> <p>See also Specimen Paper 2, question 6 May/June 2001, Paper 1, question 21 May/June 2002, Paper 1, question 20</p>

9.(e)	distinguish between the structure of crystalline and non-crystalline solids with particular reference to metals, polymers and amorphous materials.	Discussion: what is meant by a (i) crystalline solid (ii) non-crystalline solid Structure of metals, polymers, amorphous materials. Examples of each named	Examples of crystalline and non-crystalline solids, metals, polymers, amorphous materials Examples handout including Oct/Nov 2001, Paper 2, question 5(a)
10.(a)	appreciate that deformation is caused by a force and that, in one dimension, the deformation can be tensile or compressive.	Discussion of terms load and extension Note that support provides a force on spring as well as load.	Elastic bands, helical springs
10.(b)	describe the behaviour of springs in terms of load, extension, elastic limit, Hooke's law and the spring constant (i.e. force per unit extension).	Expt: dependence of extension on load  Definitions: elastic limit Hooke's law and spring constant Expt: spring constant for springs in series and parallel  Worked examples	Helical spring, weight carrier and weights, thread, metre rule, set square, stands, bosses and clamps.  Several similar helical springs, weight carrier and weights, thread, metre rule, set square, stands, bosses and clamps. Examples sheet including Specimen Paper 2, question 7(a) May/June 2001, Paper 1, question 24
10.(c)	define and use the terms stress, strain and the Young modulus.	Discussion: stress defined as $F/A$ strain defined as $\Delta L/L$	
10.(d)	describe an experiment to determine the Young modulus of a metal in the form of a wire.	Expt: Stress-strain graph for a metal wire  Discussion: Young modulus as <i>stress/strain</i> Worked examples	Copper wire, pulley, protractor also weights, micrometer screw gauge, metre rule. NOTE: length of wire is NOT the wire's length but the distance from the support to the marker Examples sheet including Oct/Nov 2001, Paper 1, question 23, 24 and 25 May/June 2001, Paper 2, question 5 May/June 2002, Paper 1, question 22, 23

10.(e)	distinguish between elastic and plastic deformation of a material.	Expt: extending a copper wire Discussion: elastic and plastic deformation	copper wire, pulley, protractor, weights, metre rule See also Specimen Paper 2, question 7(c)
10.(f)	deduce the strain energy in a deformed material from the area under the force-extension graph.	Revision of <i>work done</i> (Unit 2) leading to idea of area under force/extension graph representing energy Concept of strain energy Worked examples	Examples sheet including Specimen Paper 1, question 24, 25 Specimen Paper 2, question 7(b) May/June 2001, Paper 1, question 25 May/June 2002, Paper 1, question 24
6.(f)	distinguish between gravitational potential energy, electric potential energy and elastic potential energy.	Revision of gravitational (Unit 2) and of electric (Unit 3) potential energy in the context of strain energy	See also May/June 2002, Paper 2, question 5
10.(g)	demonstrate knowledge of the force-extension graphs for typical ductile, brittle and polymeric materials, including an understanding of ultimate tensile stress.	Discussion: different shapes of force/extension graphs ultimate tensile stress categorisation of materials as ductile, brittle and polymeric	Named specimens of ductile, brittle and polymeric materials. Examples sheet including Specimen Paper 1, question 23 Oct/Nov 2001, Paper 2, question 5(b)
27.(b)	describe a simple model for the nuclear atom to include protons, neutrons and orbital electrons.	Discussion: simple Bohr model of the atom - nucleus, orbital electrons - protons and neutrons - relative size of masses and charges	

27.(a)	infer from the results of the $\alpha$ -particle scattering experiment the existence and small size of the nucleus.	Discussion: how to provide evidence for relative size of nucleus <i>Brief description of the <math>\alpha</math>-particle scattering experiment</i> Discussion of observations of scattering linked to size of nucleus	air table, magnetic pucks or $\alpha$ -particle scattering model  See also Specimen Paper 2, question 11 May/June 2001, Paper 1, question 39 Oct/Nov 2001, Paper 2, question 8(b) and 8(c)
27.(c)	distinguish between nucleon number (mass number) and proton number (atomic number).	Discussion: distinction between nucleus, nuclide and nucleon nucleon number proton number	
27.(e)	use the usual notation for the representation of nuclides.	Discussion: nuclide notation	
27.(d)	show an understanding that an element can exist in various isotopic forms each with a different number of neutrons.	Discussion based on Neon-20 and Neon-22 Idea of isotopes Calculation of percentage composition	Examples sheet including May/June 2001, Paper 1, question 40 Oct/Nov 2001, Paper 1, question 40 May/June 2001, Paper 2, question 8(a) Oct/Nov 2001, Paper 2, question 8(a) May/June 2002, Paper 1, question 39
27.(f)	appreciate that nucleon number, proton number, and energy and mass are all conserved in nuclear processes.	Discussion: nuclear reactions - conservation of charge / proton number - conservation of nucleon number -	
27.(g)	represent simple nuclear reactions by nuclear equations of the form ${}^{14}_7\text{N} + {}^4_2\text{He} \rightarrow {}^{17}_8\text{O} + {}^1_1\text{H}$	example ${}^{14}_7\text{N} + {}^4_2\text{He} \rightarrow {}^{17}_8\text{O} + {}^1_1\text{H}$ Discussion: mass-energy considerations	Examples sheet including Specimen Paper 1, question 40 May/June 2001, Paper 2, question 8(b)

27.(h)	show an appreciation of the spontaneous and random nature of nuclear decay.	Discussions: meaning of spontaneity meaning of randomness Expt: demonstration of randomness	G.M. tube and counter (audible if available) radioactive source ( $\beta$ - or $\gamma$ -emitter), suitable shielding, source-handling tool
21.(j)	infer the random nature of radioactive decay from the fluctuations in count rate.	Discussion: background count rate correct procedure for obtaining a count rate distinction between count rate and activity	
27.(i)	show an understanding of the nature of $\alpha$ -, $\beta$ - and $\gamma$ -radiations.	Comparison between $\alpha$ -, $\beta$ - and $\gamma$ - emissions with respect to (i) nature of particle / photon (ii) mass of particles (iii) charge on particle / photon (iv) energies of particles / photons (v) speeds of particles / photons (vi) degree of ionisation (v) ranges in various materials	Handout giving table that compares nature and properties of $\alpha$ -, $\beta$ - and $\gamma$ -emissions  <a href="http://www.accessexcellence.org/AE/AEC/CC/historical_background.html">http://www.accessexcellence.org/AE/AEC/CC/historical_background.html</a>  Examples sheet including Specimen Paper 1, question 39 Oct/Nov 2001, Paper 1, question 39 May/June 2002, Paper 1, question 38 and 40 May/June 2002, Paper 2, question 9