A2 Physics UNIT 2 Thermal Physics

Recommended Prior Knowledge. Students need to be familiar with energy concepts (AS Unit 2). The Unit builds on the study of Matter in AS Unit 4. There are also references to AS Unit 3 as regards electrical components and electrical heating.

Context. In this Unit, aspects of ideal gases and thermodynamics are studied. The studies contribute towards a rounded education for those students who will not study further any physics and provide an introduction to the topic of thermodynamics for later studies.

Outline. The mole is introduced as the unit of the base quantity 'amount of matter'. The ideal gas equation and the kinetic theory of gases are studied. Finally, there is an introduction to thermal physics and the first law of thermodynamics.

	Learning Outcomes **Candidates should be able to:**	**Suggested Teaching Activities**	**Other resources**
			Reference should be made to the list of textbooks printed in the Syllabus document. Note that some texts are more suitable as library reference texts whilst others are more suitable as students' texts and, in particular, the 'endorsed'textbook. All examples of examination questions are taken from 9702 papers.
1(h)	show an understanding of that the Avogadro constant is the number of atoms in 0.012 kg of carbon-12.		
1(b)	recall the base quantity amount of substance (mol).		
1(i)	Use molar quantities where one mole of any substance is the amount containing a number of particles equal to the Avogadro constant.	The difference between mass and amount of substance should be stressed. One mol of any element is contained *A* g of the element, where *A* is the nucleon number of the element.	

	Learning Outcomes Candidates should be able to:	Suggested Teaching Activities	Other resources
11(a)	recall and solve problems using the equation of state for an ideal gas expressed as $pV = nRT$ (n = number of moles).	One or more of the gas laws (Boyle's law, Charles' law, the law of pressures) may be investigated experimentally. Charles' law and the law of pressures enable a value (in °C) to be found for the absolute zero. The mathematical combination of the individual gas laws to give the equation of state is not required.	May 2010, Paper 41, q.1(c) Oct 2009, Paper 41, q.2 Oct 2007, Paper 4, q.2(a) May 2002, Paper 4, 3(b)
11(b)	infer from a Brownian motion experiment the evidence for the movement of molecules.	This may be revised from AS Unit 4. It may be extended to consider the likely affects on the observed motion of change in temperature and change of particle size.	
11(c)	state the basic assumptions of the kinetic theory of gases.	It should be stressed that mean kinetic energy proportional to thermodynamic temperature is not an assumption.	Oct 2009, Paper 41, q.2
11(d)	explain how molecular movement causes the pressure exerted by a gas and hence deduce the relationship, p = 🗎 $\frac{Nm}{V}\langle c^2\rangle$. ($N$ = number of molecules) [A rigorous derivation is not required].	A derivation based on a molecule moving between opposite faces of a square box is sufficient. The quantity $\frac{Nm}{V}$ is the density of the gas. Thus, a value for $\langle c^2\rangle$ may be determined for air at atmospheric pressure. The r.m.s. speed is found to be of the same order of magnitude as the speed of sound in the gas.	May 2008, Paper 4, q.2
11(e)	compare pV = 🗎$Nm\langle c^2\rangle$ with $pV = NkT$ and hence deduce that the average translational kinetic energy of a molecule is proportional to T.	Students should realise that, for 1 mol of gas, $N = N_A$, $n = 1$ and $R = N_A k$.	May 2010, Paper 41, q.1(b)(c) May 2002, Paper 4, q.3(a)
12(a)	show an appreciation that thermal energy is transferred from a region of higher temperature to a region of lower temperature.	Students should appreciate that no external work is done for such a transfer.	

	Learning Outcomes Candidates should be able to:	Suggested Teaching Activities	Other resources
12(b)	show an understanding that regions of equal temperature are in thermal equilibrium.		
12(c)	show an understanding that a physical property that varies with temperature may be used for the measurement of temperature and state examples of such properties.	Candidates will be familiar with the thermistor (AS Unit 3). Other examples should include liquid-in-glass, thermocouple. Although not required for the syllabus, it is instructive to determine the temperature of a Bunsen flame using a thermocouple that requires calibration.	May 2010, Paper 42, q.3(a)
12(d)	compare the relative advantages and disadvantages of resistance and thermocouple thermometers as previously calibrated instruments.	Range, thermal capacity, physical size, response time, remote reading and possible storage of data should be considered.	
12(e)	show an understanding that there is an absolute scale of temperature which does not depend on the property of any particular substance (i.e. the thermodynamic scale and the concept of absolute zero).	Students need to appreciate that most temperature scales require fixed points {see experiment in 12(c)}	May 2002, Paper 4, q. 3(a)
12(f)	convert temperatures measured in kelvin to degrees Celsius and recall that T / K = T / °C + 273.15.		May 2010, Paper 41, q.1(a)
13(b)	define and use the concept of specific heat capacity, and identify the main principles of its determination by electrical methods.	Students should be familiar with the determination for a metal in the form of a cylindrical block and for a liquid. Electrical heating (AS Unit 3) may need to be revised.	May 2010, Paper 42, q.3(b) Nov 2002, Paper 4, q.1(a)(b)

	Learning Outcomes Candidates should be able to:	Suggested Teaching Activities	Other resources
13(c)	define and use the concept of specific latent heat, and identify the main principles of its determination by electrical methods.	The heating of melting ice in a funnel and the rate of loss of mass of a kettle containing boiling water provide adequate methods.	May 2009, Paper 4, q.3(b)
13(a)	explain using a simple model for matter why • melting and boiling take place without a change in temperature, • the specific latent heat of vaporisation is higher than the specific latent heat of fusion for the same substance, • a cooling effect accompanies evaporation.	This should build on studies from AS Unit 4. Students should consider the bonding between molecules, changes in potential energy and in kinetic energy of molecules.	May 2009, Paper 4, q.3(a) May 2002, Paper 4, q. 2(a)
13(e)	show an understanding that internal energy is determined by the state of the system and that it can be expressed as the sum of a random distribution of kinetic and potential energies associated with the molecules of a system.	The distinction between 'ordered' and 'random' kinetic energy can be illustrated by reference to temperatures at the top and bottom of a waterfall. It is important to stress the direction of each change. Examples may well use the formula $W = p\mathrm{d}V$ (AS Unit 2) and could include latent heat of vaporisation and simple pressure-volume changes for a gas.	
13(d)	relate a rise in temperature of a body to an increase in its internal energy.		May 2002, Paper 4, q. 2(a)(b)
13(f)	recall and use the first law of thermodynamics expressed in terms of the increase in internal energy, the heating of the system and the work done on the system.		Oct 2009. Paper 42, q.2