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Scheme of work – Cambridge IGCSE® Physics (0625)

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Unit 7: Thermal physics

Recommended prior knowledge
Many physics teachers do not like the term *heat*, preferring to refer to *heating* as a process rather than to *heat* as a form of energy. The Cambridge IGCSE Physics syllabus takes a more inclusive view. The terms *thermal energy* and *internal energy* are used most directly in the syllabus. It would be clumsy, however, to avoid the historical terms *latent heat* and *specific heat capacity* both of which appear in the syllabus.

Although heat is in many ways as intangible and abstract as electricity, it is one that most students are more comfortable with. The idea of temperature is one that students ought to have encountered by the time they embark on this course although they might well use it interchangeably with the term heat. Likewise, liquid-in-glass thermometers should be familiar as well as digital thermometers of various sorts. Not all students will realise that heat is a form of energy and the historically separate unit *the calorie* only re-emphasises this perceived distinction. It is better not to mention *the calorie* at all; it is unfortunate that nutritional information is so often given in this unit. Similarly, it is important to use the temperature unit *the degree Celsius* rather than *the degree centigrade*. Students should have encountered the term *molecule* and should be aware of the microscopic structure of matter. This unit does include *evaporation* from section 2.1 of the syllabus.

Context
Although the concept of energy is hard to grasp, students seem much more comfortable with the specific example of *thermal energy* and *heating*. Consequently, this unit or at least most of it can comfortably be taught towards the beginning of the course. This might well be because of the student's familiarity with heating. This acquaintance will have been developed from using domestic heating systems, cooking with oil or water and simple things like adjusting the temperature of the water in a bath or from a shower. It shows the importance of practical experience in general and the pedagogic importance of practical lessons in this subject.

Outline
This unit contains ideas that are very familiar to many students but their understanding is unlikely to be thorough. The relationship between macroscopic phenomena and molecular behaviour will probably be new to many but it is one of the foundations of all physics and the topics from this unit are excellent vehicles for introducing this relationship.

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

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
2.1 (a)	State the distinguishing properties of solids, liquids and gases	Simple experiments can show that liquids flow, are incompressible and so on.	
2.1(b)	Describe qualitatively the molecular structure of solids, liquids and gases Interpret the temperature of a gas in terms of the motion of its molecules Describe qualitatively the pressure of a gas in terms of the motion of its molecules Describe qualitatively the effect of a change of temperature on the pressure of a gas at constant volume Show an understanding of the random motion of particles in a suspension as evidence for the kinetic molecular model of matter Describe this motion (sometimes known as Brownian motion) in terms of random molecular bombardment	Use examples of phenomena that are explained by the particle theory to build up understanding e.g. diffusion in liquids, diffusion of gases (bromine in air – fume cupboard required), crystal structure etc. Students should observe Brownian motion e.g. using the 'smoke cell' experiment. Get the pupils to explain randomness in both speed and direction of motion but without using the word random. Models using large spheres (e.g. table tennis balls) should be used to illustrate as much as possible (e.g. crystal model).	www.video.google.com/videoplay?docid=-5242394503257451479 Brownian motion is well illustrated on this website: www.phys.virginia.edu/classes/109N/more_stuff/Applets/ Click on Einstein's Explanation of Brownian Motion. IGCSE Physics Coursebook CD-ROM Activity Sheet 9.3 Unit 7: Past Paper Question Core 3 Unit 7: Past Paper Question Extension 2
2.1(b) (S)	**Relate the properties of solids, liquids and gases to the forces and distances between molecules and to the motion of the molecules** **Show an appreciation that massive particles may be moved by light, fast-moving molecules**	**The ordinary experiments may be explained using a more exact approach and by talking about how the force between the molecules act at different distances.**	

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
2.1 (c)	Describe evaporation in terms of the escape of more-energetic molecules from the surface of a liquid Relate evaporation and the consequent cooling	This is how a refrigerator works. Students should experience the cooling effect of evaporation using a non-toxic volatile substance.	
2.1 (c) (S)	**Demonstrate an understanding of how temperature, surface area and draught over a surface influence evaporation**	**Leave water in different vessels overnight and observe the rate at which evaporation occurs.**	
2.1 (d)	Relate the change in volume of a gas to change in pressure applied to the gas at constant temperature	A direct measuring Boyle's Law apparatus can be used here. Useful graph plotting and interpretation skills are included. Place a partially inflated balloon in a bell-jar and reduce the pressure in the jar.	Extend this work by using the practical experiment suggested on this site about the temperature and pressure of a gas: www.school.discovery.com/lessonplans/ Click on Physical Science, then Temperature and Pressure IGCSE Physics Coursebook CD-ROM Activity Sheet 9.4
2.1 (d) (S)	**Recall and use the equation** **pV = constant** **at constant temperature**	**Values from the graph can be used to illustrate the constancy of the product pV. Also use phrases like doubling the pressure halves the volume.**	This website may provide an interesting interactive experience for a more able student to explore the ideas around the gas laws: www.jersey.uoregon.edu/vlab/Piston/index.html
2.2 (a)	Describe qualitatively the thermal expansion of solids, liquids and gases Identify and explain some of the everyday applications and consequences of thermal expansion Describe qualitatively the effect of a change of temperature on the volume of a gas at constant pressure	Experiments to show expansion of a metal rod and the 'bar breaker' demonstration. A large round bottom flask filled with (coloured) water and fitted with a long glass tube shows expansion of the water when heated gently. The 'fountain' experiment shows the expansion of air and brings in good discussion of the effect of pressure difference to stretch the more able students.	www.youtube.com/watch?v=AX5eVxxQgPc

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
2.2 (a) (S)	**Show an appreciation of the relative order of magnitude of the expansion of solids, liquids and gases**	**Take a flask full of coloured water connected to a tube and immerse in hot water. The initial decrease in level of the water shows the expansion of the glass; the subsequent expansion of the liquid is greater and the water rises up the tube.**	
2.2 (b)	Appreciate how a physical property which varies with temperature may be used for the measurement of temperature and state examples of such properties Recognise the need for and identify fixed points Describe the structure and action of liquid-in-glass thermometers	Different types of thermometer can be used e.g. resistance thermometer, thermocouple pressure of a copper sphere of gas. Calibrate an unmarked thermometer (mark 0°C and 100°C with rubber bands using an ice bath and a steam bath)) and use it to measure an unknown temperature.	IGCSE Physics Coursebook CD-ROM Activity Sheet 10.1
2.2 (b) (S)	**Demonstrate understanding of sensitivity, range and linearity** **Describe the structure of a thermocouple and show understanding of its use for measuring high temperatures and those which vary rapidly**	**Sensitivity for a liquid-in-glass thermometer is measured in mm/°C. This makes it clear that it does not mean the speed of response or anything similar. A simple thermocouple can be constructed and used. State the advantages of a thermocouple thermometer over a liquid-in-glass thermometer.**	IGCSE Physics Coursebook CD-ROM Activity Sheet 10.2 Unit 7: Past Paper Question Alternative to Practical 1 Unit 7: Past Paper Question Extension 1
2.2 (c)	Relate a rise in temperature of a body to an increase in internal energy Show an understanding of the term thermal capacity	Metal blocks of different metals and of different masses can be heated with identical immersion heaters to show their different thermal capacities. Many texts use the term *heat capacity*, and students should be made familiar with this term also. The syllabus uses the term *thermal energy* for energy transferred by heating. This energy will cause an increase in the internal energy of the blocks. This is a good point to remind students of the difference between internal energy and temperature.	Unit 7: Past Paper Question Core 1
2.2 (c) (S)	**Describe an experiment to measure the specific heat capacity of a substance**	**This can be extended to a quantitative determination of specific heat capacity. The word *specific* often means *per kilogram*.**	

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
2.2 (d)	Describe melting and boiling in terms of energy input without a change in temperature State the meaning of melting point and boiling point Describe condensation and solidification	Heating and cooling curves can be plotted from experimental readings (e.g. timed temperature readings when heating ice until the water boils and during the solidification of stearic acid). Show that ice and water can only co-exist at the melting point, steam and water only at the boiling point.	An interesting animated mystery for students to solve: www.teams.lacoe.edu/documentation/classrooms/gary/heat/activities/mystery/Mystery.html
2.2 (d) (S)	**Distinguish between boiling and evaporation** **Use the term latent heat and give a molecular interpretation of latent heat** **Describe an experiment to measure specific latent heats for steam and for ice**	**Simple and direct experiments to determine specific latent heat (e.g. using a low voltage immersion heater).**	More for teachers than students: www.pkwy.k12.mo.us/west/teachers/anderson/pack7/boil/boil.html Unit 7: Past Paper Question Core 2 Unit 7: Past Paper Question Extension 3