Topic 2 · Thermal physics

The kinetic particle model and what it explains: gas pressure, thermal expansion, specific heat capacity, change of state, and the three ways energy moves.

SUGGESTED TIME	TOTAL MARKS	QUESTIONS	MULTIPLE CHOICE
45 minutes	**38**	**10**	**6**

SECTION	**2 · Thermal physics**
IN THE FORMAT OF	Papers 1 and 2 (multiple choice), Papers 3 and 4 (theory), Paper 6 (alternative to practical)
ROUTES	Core only — 6 questions, 13 marks. Core and Supp. — the whole paper, 10 questions, 38 marks. Every question is tagged in the left margin.
DEMAND	**Recall 1 · Routine 4 · Demanding 4 · Discriminating 1**
	Pitched at the board's own level, not above it. Multiple choice is mostly one step, with a couple of two-step items and one that rewards the candidate who does not take the obvious route. Structured questions open on a 1-mark recall and close on an explanation or a suggestion worth two marks — the marks real candidates most often drop.
SYLLABUS POINTS	2.1 · 2.2 · 2.3

INSTRUCTIONS

- Answer all questions in the spaces provided.
- Show your working. Method marks are awarded even where the final answer is wrong.
- Give your answers to a sensible number of significant figures, with a unit.
- The mark scheme for this paper follows the last question.

> *Written by GioPhysics from the published syllabus. These are practice papers in the style of Cambridge IGCSE Physics 0625; they are not Cambridge papers, contain no past-paper questions, and the official syllabus and specimen materials remain the authority.*
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> Cambridge IGCSE Physics 0625 syllabus — https://www.cambridgeinternational.org/Images/697209-2026-2028-syllabus.pdf

THE PAPER

Topic 2 · Thermal physics

Answer all questions. 38 marks in 45 minutes.

1 MULTIPLE CHOICE · RECALL · 2.1 **[1]**

CORE

Which row describes the molecules of a gas?

	separation	arrangement	motion
A	close together	regular	vibrating about fixed positions
B	close together	random	moving past one another
C	far apart	random	moving rapidly in all directions
D	far apart	regular	vibrating about fixed positions

A close together · regular · vibrating about fixed positions

B close together · random · moving past one another

C far apart · random · moving rapidly in all directions

D far apart · regular · vibrating about fixed positions

Answer

2 SUPP.

MULTIPLE CHOICE · ROUTINE · 2.1

[1]

A fixed mass of gas has a volume of 300 cm^3 at a pressure of 1.0×10^5 Pa. The gas is compressed to a volume of 120 cm^3 at constant temperature. What is the new pressure?

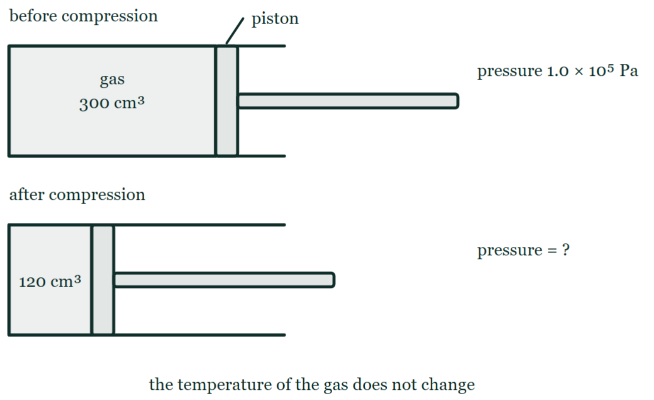

Fig. 2.1 *Two horizontal cylinders are drawn one above the other, each closed at the left-hand end and fitted with a piston on a rod that comes out through the open right-hand end. In the upper cylinder, labelled before compression, the trapped gas fills a column marked 300 cm³ and the pressure beside it is given as 1.0 × 10⁵ Pa. In the lower cylinder, labelled after compression, the piston has been pushed further in so that the gas column is marked 120 cm³, and the pressure beside it is left as a question mark. A note below states that the temperature of the gas does not change.*

A 0.40×10^5 Pa

B 1.2×10^5 Pa

C 2.5×10^5 Pa

D 3.6×10^5 Pa

Answer

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3 CORE

MULTIPLE CHOICE · ROUTINE · 2.2

[1]

The specific heat capacity of water is 4200 J/(kg °C). How much energy is needed to raise the temperature of 2.0 kg of water by 15 °C?

A 560 J

B 8400 J

C 63 000 J

D 126 000 J

Answer

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4 CORE

MULTIPLE CHOICE · DEMANDING · 2.2 **[1]**

Which statement about evaporation is correct?

A It happens throughout the liquid, at one fixed temperature.

B It happens only at the surface, at any temperature below the boiling point.

C It raises the temperature of the liquid that is left behind.

D It happens faster when the air above the liquid is still and humid.

Answer

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5 CORE

MULTIPLE CHOICE · ROUTINE · 2.3 **[1]**

An electric heating element is fitted at the bottom of a tank of water. Why is this the best position?

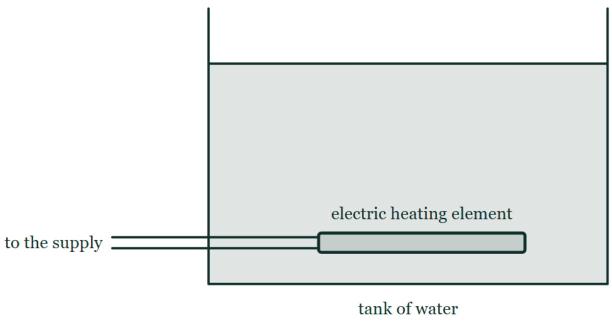

Fig. 5.1 *A rectangular open-topped tank holds water to about four-fifths of its depth. A flat electric heating element lies horizontally inside the tank, well below the water surface and a short distance above the tank floor, spanning about half the width of the tank. Two leads run from the left-hand end of the element out through the side wall of the tank to the electricity supply.*

A Water conducts thermal energy well downwards but not upwards.

B Warm water is less dense, so it rises and a convection current circulates through the tank.

C Thermal radiation travels upwards more easily than downwards.

D The pressure is greatest at the bottom, so energy transfers faster there.

Answer

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6 CORE

MULTIPLE CHOICE · ROUTINE · 2.3 **[1]**

Four identical cans are filled with water at 80 °C and left to cool in the same room. Which can cools fastest?

A a can with a shiny silver surface

B a can with a shiny white surface

C a can with a dull black surface

D all four cool at the same rate

Answer

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7 SUPP.

STRUCTURED · DISCRIMINATING · 2.1 **[8]**

Smoke particles are placed in a small glass cell containing air and viewed through a microscope with a bright light shining from the side. The smoke particles are seen as tiny bright specks.

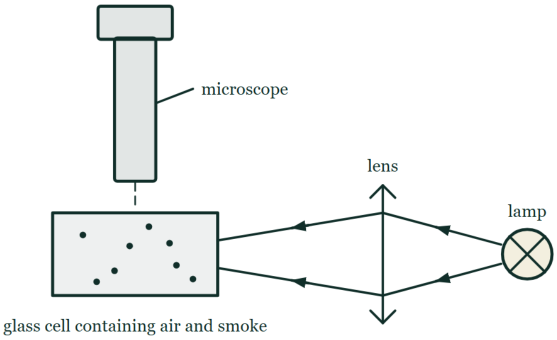

Fig. 7.1 *The apparatus is seen from the side. A small glass cell containing air and a scattering of smoke particles stands in the middle of the drawing. To the right, a lamp shines light through a converging lens, which brings the beam together inside the cell. Directly above the cell stands a microscope, its tube vertical and its lower end pointing straight down into the cell, so that the illuminated particles are viewed from above.*

(a) DESCRIBE **[2]**

Describe what is seen when the smoke particles are observed through the microscope.

(b) EXPLAIN **[3]**

Explain this motion in terms of the molecules of the air.

(c) EXPLAIN **[3]**

The air in a sealed metal container is heated. The volume of the container does not change. Explain, in terms of molecules, why the pressure of the air increases.

8 SUPP.

STRUCTURED · DEMANDING · 2.2 **[9]**

A 2.0 kW electric kettle contains 0.50 kg of water at 20 °C. The specific heat capacity of water is 4200 J/(kg °C) and the specific latent heat of vaporisation of water is 2.3×10^6 J/kg.

(a) DEFINE **[2]**

Define specific latent heat of vaporisation.

(b) CALCULATE **[2]**

Calculate the energy needed to raise the water from 20 °C to its boiling point of 100 °C.

(c) CALCULATE **[2]**

Assuming no energy is transferred to the surroundings, calculate the time taken for the water to reach its boiling point.

(d) DETERMINE **[3]**

The kettle is left switched on after the water boils. Determine the mass of water that boils away in the next 60 s.

9 SUPP.

STRUCTURED · DEMANDING · 2.3 **[7]**

A vacuum flask keeps a hot drink warm. It has a double-walled glass container with a vacuum between the walls, both facing surfaces of the glass are silvered, the flask has an insulating plastic stopper, and the glass container rests on soft insulating supports inside an outer case.

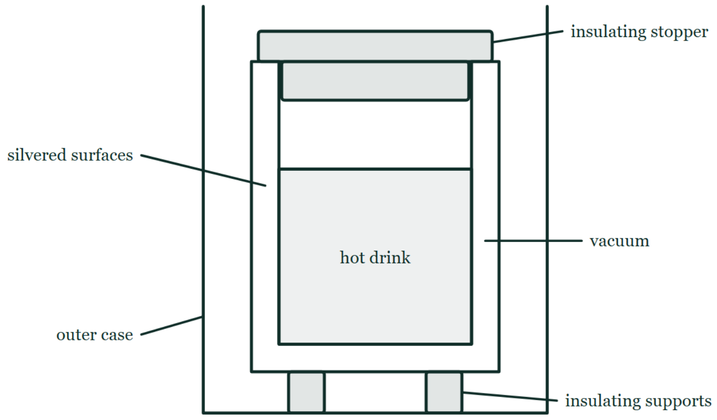

Fig. 9.1 *A cut-away view of a vacuum flask. Inside an outer case stands a double-walled glass container, sealed at the neck, with a narrow gap between the two walls that runs down both sides and under the base; the gap is labelled vacuum and the two facing glass surfaces are labelled silvered. Hot drink fills most of the inner container, an insulating stopper closes the neck at the top, and the glass container rests on small insulating supports standing on the floor of the outer case.*

(a) EXPLAIN **[2]**

Explain how the vacuum between the two walls reduces the transfer of thermal energy.

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(b) EXPLAIN **[2]**

Explain why both facing surfaces of the glass are silvered.

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(c) EXPLAIN **[3]**

Explain, in terms of the particles in a metal, why a metal spoon left in the drink becomes hot along its whole length far more quickly than a plastic one.

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10 CORE

PRACTICAL SKILLS · DEMANDING · 2.2 **[8]**

A student determines the specific heat capacity of aluminium. She uses a 1.0 kg aluminium block with two narrow holes drilled in it, one holding a 48 W electric immersion heater and the other a thermometer. She switches on the heater and records the temperature every 2 minutes.

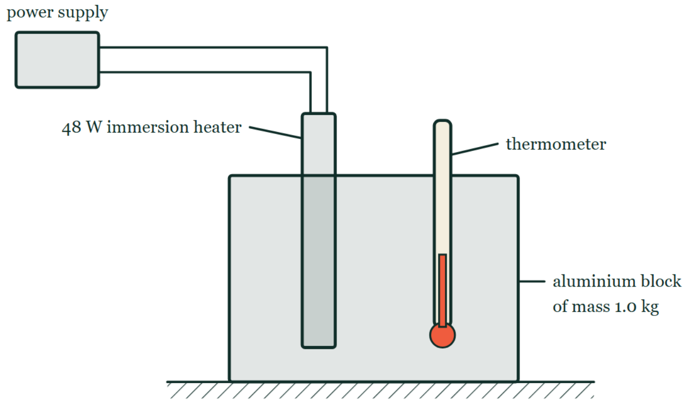

Fig. 10.1 *The apparatus is seen from the side. A rectangular aluminium block of mass 1.0 kg stands on the bench. A 48 W electric immersion heater is pushed down into a narrow hole drilled near one side of the block, and a thermometer is pushed down into a second narrow hole near the other side, its bulb reaching well inside the block. Two leads run from the top of the heater across to a power supply standing beside the apparatus.*

The student's results

time / minutes	**0**	**2**	**4**	**6**	**8**
temperature / °C	19.0	24.5	30.0	35.5	41.0

(a) DETERMINE **[4]**

Determine the temperature rise over the 8 minutes, and hence determine a value for the specific heat capacity of aluminium.

(b) SUGGEST **[2]**

The accepted value for the specific heat capacity of aluminium is 900 J/(kg °C). Suggest why the student's value is higher than this.

(c) SUGGEST **[2]**

Suggest two improvements to the student's method that would give a more accurate value.

MARK SCHEME

Topic 2 · Thermal physics — mark scheme

One line per mark, as an examiner would award them. A note under a part is the error that part is set to catch.

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1 CORE

MULTIPLE CHOICE · RECALL · 2.1 **[1]**

Which row describes the molecules of a gas?

KEY **C** **far apart · random · moving rapidly in all directions**

A is a solid — close together, regular, vibrating in place. B is a liquid: close together but disordered and able to move past one another. D is the trap, pairing a gas separation with solid motion, and it catches candidates who have learned that gas molecules are far apart without learning what they then do.

AO1

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2 SUPP.

MULTIPLE CHOICE · ROUTINE · 2.1 **[1]**

A fixed mass of gas has a volume of 300 cm^3 at a pressure of 1.0×10^5 Pa. The gas is compressed to a volume of 120 cm^3 at constant temperature. What is the new pressure?

KEY **C** **2.5×10^5 Pa**

A applies the ratio the wrong way round — the answer must be larger, because squeezing a gas raises its pressure. D multiplies the volumes instead of taking their ratio.

AO2

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3 CORE

MULTIPLE CHOICE · ROUTINE · 2.2 **[1]**

The specific heat capacity of water is 4200 J/(kg °C). How much energy is needed to raise the temperature of 2.0 kg of water by 15 °C?

KEY **D** **126 000 J**

C forgets the mass. B forgets the temperature rise. A divides where the candidate should multiply.

AO2

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4 CORE

MULTIPLE CHOICE · DEMANDING · 2.2 **[1]**

Which statement about evaporation is correct?

KEY **B** **It happens only at the surface, at any temperature below the boiling point.**

A describes boiling, which is the distinction the item is set on. C reverses the cooling effect — the fastest molecules leave, so the mean energy of those remaining falls. D reverses the effect of a draught.

AO1

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5 CORE

MULTIPLE CHOICE · ROUTINE · 2.3 **[1]**

An electric heating element is fitted at the bottom of a tank of water. Why is this the best position?

KEY **B** **Warm water is less dense, so it rises and a convection current circulates through the tank.**

A is wrong twice over — water is a poor conductor and conduction has no preferred direction. D confuses pressure with energy transfer.

AO1

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6 CORE

MULTIPLE CHOICE · ROUTINE · 2.3 **[1]**

Four identical cans are filled with water at 80 °C and left to cool in the same room. Which can cools fastest?

KEY **C** **a can with a dull black surface**

D tempts candidates who remember that the water and temperature are identical but forget that the surface controls the rate of emission. A dull black surface is the best emitter as well as the best absorber.

AO2

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7 SUPP.

STRUCTURED · DISCRIMINATING · 2.1 **[8]**

Smoke particles are placed in a small glass cell containing air and viewed through a microscope with a bright light shining from the side. The smoke particles are seen as tiny bright specks.

(a) DESCRIBE · AO1 **[2]**

Describe what is seen when the smoke particles are observed through the microscope.

1. the bright specks move continuously
2. in random directions / on jerky, unpredictable paths

(b) EXPLAIN · AO1 **[3]**

Explain this motion in terms of the molecules of the air.

1. the air molecules are in constant random motion and collide with the smoke particle
2. the molecules are much smaller than the smoke particle but move much faster, so each collision transfers a noticeable momentum
3. at any instant the collisions on one side outnumber those on the other, so the resultant force on the particle changes direction randomly

The mark most often lost is the second: candidates say the molecules "hit" the particle without saying why an object too small to see can move something visible.

(c) EXPLAIN · AO2 **[3]**

The air in a sealed metal container is heated. The volume of the container does not change. Explain, in terms of molecules, why the pressure of the air increases.

1. heating increases the average kinetic energy, so the molecules move faster on average
2. so they strike the walls more often
3. and each collision produces a greater change of momentum, so the average force on unit area of the wall increases

Both reasons are needed. "They hit the walls harder" on its own is one mark; a candidate who also mentions frequency of collisions earns the second.

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8 SUPP. STRUCTURED · DEMANDING · 2.2 **[9]**

A 2.0 kW electric kettle contains 0.50 kg of water at 20 °C. The specific heat capacity of water is 4200 J/(kg °C) and the specific latent heat of vaporisation of water is 2.3×10^6 J/kg.

(a) DEFINE · AO1 **[2]**

Define specific latent heat of vaporisation.

1 the energy required to change unit mass of a substance from liquid to gas

2 without a change in temperature

The second half is the mark: no temperature change is what distinguishes latent from specific heat capacity.

(b) CALCULATE · AO2 **[2]**

Calculate the energy needed to raise the water from 20 °C to its boiling point of 100 °C.

1 $E = mc\Delta\theta = 0.50 \times 4200 \times 80$

2 $E = 168\,000$ J $= 1.7 \times 10^5$ J

(c) CALCULATE · AO2 **[2]**

Assuming no energy is transferred to the surroundings, calculate the time taken for the water to reach its boiling point.

1 $t = E / P = 168\,000 / 2000$

2 $t = 84$ s

(d) DETERMINE · AO2 **[3]**

The kettle is left switched on after the water boils. Determine the mass of water that boils away in the next 60 s.

1 energy supplied = $2000 \times 60 = 120\,000$ J

2 $m = E / L = 120\,000 / 2.3 \times 10^6$

3 $m = 0.052$ kg (52 g)

Candidates who add an $mc\Delta\theta$ term here have not noticed that the water is already at 100 °C and stays there. That is the discrimination the part is built on.

9 SUPP.

STRUCTURED · DEMANDING · 2.3 **[7]**

A vacuum flask keeps a hot drink warm. It has a double-walled glass container with a vacuum between the walls, both facing surfaces of the glass are silvered, the flask has an insulating plastic stopper, and the glass container rests on soft insulating supports inside an outer case.

(a) EXPLAIN · AO1 **[2]**

Explain how the vacuum between the two walls reduces the transfer of thermal energy.

1. there are (almost) no molecules between the walls
2. so energy cannot be transferred by conduction or convection, both of which need a medium

(b) EXPLAIN · AO1 **[2]**

Explain why both facing surfaces of the glass are silvered.

1. a shiny silvered surface is a poor emitter of infrared radiation, so the inner wall radiates less energy away
2. and a shiny surface is a good reflector, so radiation crossing the gap is reflected back rather than absorbed

(c) EXPLAIN · AO1 **[3]**

Explain, in terms of the particles in a metal, why a metal spoon left in the drink becomes hot along its whole length far more quickly than a plastic one.

1. in both, particles at the hot end vibrate more and pass energy on by colliding with neighbouring particles
2. a metal also contains free (delocalised) electrons
3. these gain kinetic energy at the hot end, move rapidly through the metal, and transfer energy by collision far along the spoon, so conduction is much faster

   The Supplement mark is the free-electron mechanism. A candidate who describes only vibrating particles has described the process that happens in plastic too, and has not answered the question asked.

10 PRACTICAL SKILLS · DEMANDING · 2.2 **[8]**

CORE

A student determines the specific heat capacity of aluminium. She uses a 1.0 kg aluminium block with two narrow holes drilled in it, one holding a 48 W electric immersion heater and the other a thermometer. She switches on the heater and records the temperature every 2 minutes.

(a) DETERMINE · AO2 **[4]**

Determine the temperature rise over the 8 minutes, and hence determine a value for the specific heat capacity of aluminium.

1. $\Delta\theta = 41.0 - 19.0 = 22.0$ °C
2. energy supplied $E = Pt = 48 \times 480 = 23\,040$ J
3. $c = E / (m\Delta\theta) = 23\,040 / (1.0 \times 22.0)$
4. $c = 1050$ J/(kg °C) (accept 1000–1100)

Converting 8 minutes to 480 s is worth a mark on its own in the real mark scheme, and is the commonest single reason a candidate's answer is out by a factor of 60.

(b) SUGGEST · AO3 **[2]**

The accepted value for the specific heat capacity of aluminium is 900 J/(kg °C). Suggest why the student's value is higher than this.

1. thermal energy is transferred from the block to the surroundings, so not all of the 23 040 J raises the temperature of the block
2. the measured $\Delta\theta$ is therefore smaller than it should be for that energy, making the calculated c too large

Two marks, and the second is the reasoning. Saying "heat was lost" identifies the cause but does not explain the direction of the error, which is what is being marked.

(c) SUGGEST · AO3 **[2]**

Suggest two improvements to the student's method that would give a more accurate value.

1. lag the block with insulation / place it in an insulated container
2. any one of: put oil in the holes to improve thermal contact; start below and finish above room temperature; take readings more frequently and plot a graph; use a datalogger

THE CHEAPEST MARKS ON ANY PAPER

What the command words are asking for

Every board publishes these and marks to them. A candidate who explains where the question said state has spent four minutes earning one mark; one who states where it said explain has earned none.

Calculate	Work out from given facts, figures or information.
Define	Give the precise meaning.
Describe	State the points of a topic; give characteristics and main features.
Determine	Establish an answer using the information available.
Estimate	Suggest an approximate value.
Explain	Set out purposes or reasons; make relationships evident; give why and/or how.
Give	Produce an answer from a given source or recall.
Identify	Name, select or recognise.
Show (that)	Provide structured evidence that leads to a given result.
State	Express in clear terms.
Suggest	Apply knowledge and understanding to situations where there is a range of valid responses in order to make proposals.

WHAT IS BEING TESTED

IGCSE assessment objectives

Every candidate sits two theory papers and one practical-skills paper. Core takes Papers 1 and 3 and is capped at grade C; Extended takes Papers 2 and 4 and reaches A*. Both then take either Paper 5 (practical test) or Paper 6 (alternative to practical), which carries 20% either way. Theory papers give you no formula sheet.

AO1
17 MARKS · 45%
QUALIFICATION 50%

Knowledge with understanding

Recall, describe, explain and use physics ideas, terminology, instruments and conventions.

AO2
17 MARKS · 45%
QUALIFICATION 30%

Handling information and problem-solving

Locate and interpret information, translate between forms, calculate, reason, and apply physics to unfamiliar situations.

AO3
4 MARKS · 11%
QUALIFICATION 20%

Experimental skills and investigations

Plan, use apparatus, record and present observations, analyse, evaluate, and suggest improvements.

> *Written by GioPhysics from the published syllabus. These are practice papers in the style of Cambridge IGCSE Physics 0625; they are not Cambridge papers, contain no past-paper questions, and the official syllabus and specimen materials remain the authority.*
>
> Cambridge IGCSE Physics 0625 syllabus — https://www.cambridgeinternational.org/Images/697209-2026-2028-syllabus.pdf