

PHYSICS



EXAM QUESTION PACK

TOPIC 14: PARTICLE MODEL (PACK 1)

SCORE

/141

PERCENTAGE

%

STEMUP

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Q1.

A student uses the apparatus in Figure 3 to determine the specific heat capacity of water.

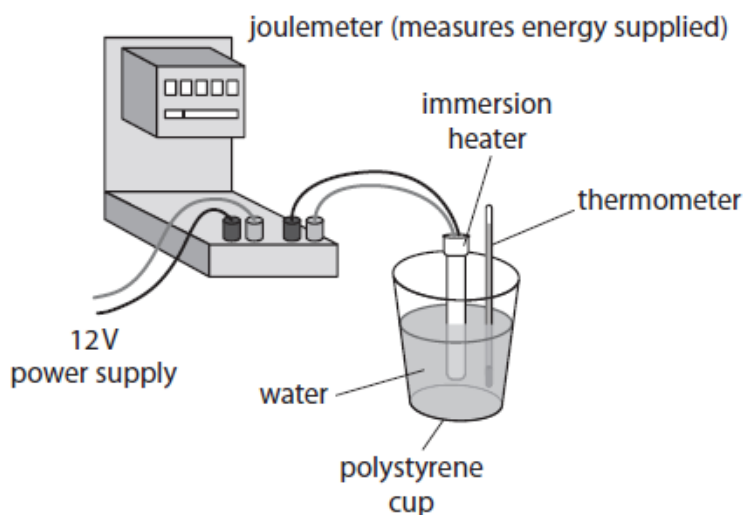


Figure 3

(i) State the measurements needed to calculate the specific heat capacity of water.

(4)

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(ii) State **two** ways that the apparatus could be adapted to improve the procedure.

(2)

1

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2

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(Total for question = 6 marks)

Q2.

A student uses the apparatus in Figure 3 to determine the specific heat capacity of water.

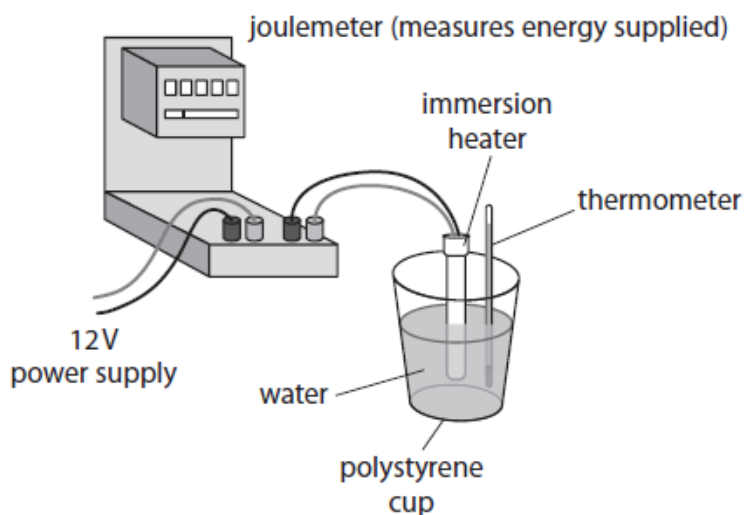


Figure 3

(i) State the measurements needed to calculate the specific heat capacity of water.

(4)

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(ii) State **two** ways that the apparatus could be adapted to improve the procedure.

(2)

1

.....

2

(Total for question = 6 marks)

Q3.

Figure 2 shows a rubber tube that can be used inside a bicycle tyre.

The tube is inflated with a bicycle pump.



Figure 2

(i) The air inside the tube exerts an outward force on the wall of the tube.

State the angle that this outward force makes with the wall of the tube.

(1)

(ii) It takes 4.8 litres of air from the atmosphere to inflate the empty tube to a pressure of 400 000 Pa.

Atmospheric pressure is 100 000 Pa.

Calculate the volume of air inside the tube.

Assume the temperature of the air inside the tube is the same as the temperature of the air outside the tube.

Use an equation selected from the list of equations at the end of this paper.

(3)

volume = ... litres

(iii) When a bicycle pump is used to inflate the tube, the air in the bicycle pump gets warm.

You should ignore any effects of friction in the pump.

Explain why the air in the bicycle pump gets warm.

(2)

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(Total for question = 6 marks)

Q4.

Figure 1 shows air inside a cylinder with a movable piston.

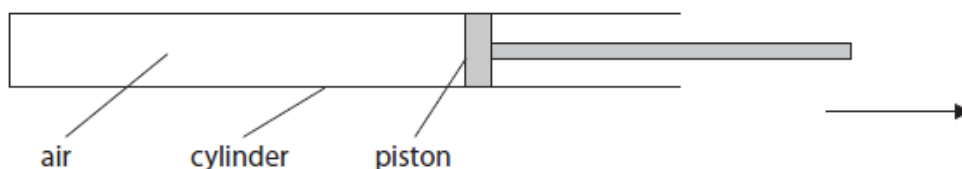


Figure 1

The piston is pulled a little way in the direction of the arrow, but stays inside the cylinder.

Which of these increases?

(1)

- ☐ **A** The mass of the air inside the cylinder.
- ☐ **B** The rate at which air particles collide with the walls of the cylinder.
- ☐ **C** The volume of the air inside the cylinder.
- ☐ **D** The pressure of the air inside the cylinder.

(Total for question = 1 mark)

Q5.

A student wants to determine the specific heat capacity of copper.

Figure 5 shows a piece of copper, with a thread tied around it, in a glass beaker of boiling water.

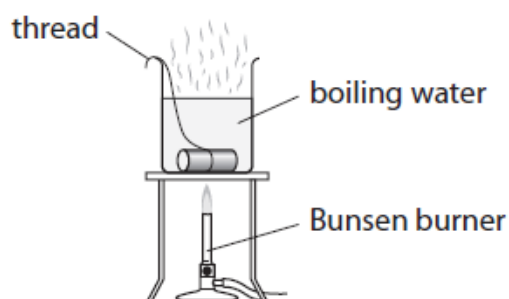


Figure 5

The student leaves the piece of copper in the boiling water so that the copper reaches a temperature of 100 °C.

The student uses the thread to take the piece of copper out of the boiling water.

The student puts the hot piece of copper into a different beaker of cold water at 20 °C.

The apparatus is shown in Figure 6.

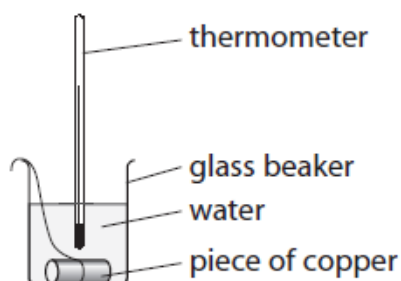


Figure 6

The student assumes that the thermal energy gained by the water equals the thermal energy lost by the piece of copper.

The water and copper both reach a temperature of 22 °C.

The cold water gains 1050 J of energy.

The mass of the piece of copper is 0.058 kg.

(i) Calculate a value for the specific heat capacity of copper, using these results.

Use the equation

change in thermal energy = mass × specific heat capacity × change in temperature

$$\Delta Q = m \times c \times \Delta\theta$$

(2)

specific heat capacity of copper from these results = ... J/kg °C

(ii) The value for the specific heat capacity of copper obtained from the student's results is lower than the correct value.

State **two** ways that the experiment could be improved to give a value that is closer to the correct value.

(2)

- 1
-
- 2
-

(Total for question = 4 marks)

Q6.

A student wants to determine the specific heat capacity of copper.

Figure 2 shows a piece of copper, with a thread tied around it, in a glass beaker of boiling water.

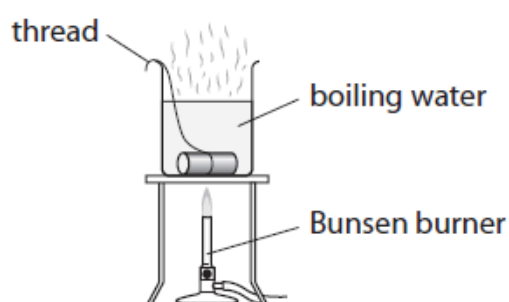


Figure 2

The student leaves the piece of copper in the boiling water so that the copper reaches a temperature of 100 °C.

The student uses the thread to take the piece of copper out of the boiling water.

The student puts the hot piece of copper into a different beaker of cold water at 20 °C.

The apparatus is shown in Figure 3.

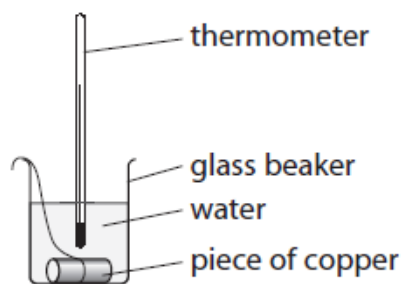


Figure 3

The student assumes that the thermal energy gained by the water equals the thermal energy lost by the piece of copper.

The water and copper both reach a temperature of 22 °C.

The cold water gains 1050 J of energy.

The mass of the piece of copper is 0.058 kg.

(i) Calculate a value for the specific heat capacity of copper, using these results.

Use the equation

change in thermal energy = mass × specific heat capacity × change in temperature

$$\Delta Q = m \times c \times \Delta\theta$$

(2)

specific heat capacity of copper from these results = ...
J/kg°C

(ii) The value for the specific heat capacity of copper obtained from the student's results is lower than the correct value.

State **two** ways that the experiment could be improved to give a value that is closer to the correct value.

(2)

1

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2

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(Total for question = 4 marks)

Q7.

A steel ball has a volume of 3.6 cm^3 and a mass of 28 g.

(i) Calculate the density of steel in kg/m^3 .

(3)

density = ... kg/m^3

(ii) The steel ball is at a room temperature of 20°C .

It is then put in a pan of boiling water maintained at 100°C .

Calculate how much thermal energy the ball gains as its temperature increases from 20°C to 100°C .

Specific heat capacity of steel = $510 \text{ J/kg}^\circ\text{C}$

Use an equation selected from the list of equations at the end of this paper.

(2)

thermal energy gained = ... J

(iii) The steel ball is put into a furnace where it melts.

Compare the motion of particles in the steel when they are in the solid state with their motion when in the molten (liquid) state.

(3)

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(Total for question = 8 marks)

Q8.

A steel ball has a volume of 3.6 cm^3 and a mass of 28 g.

(i) Calculate the density of steel in kg/m^3 .

(3)

density = ... kg/m^3

(ii) The steel ball is at a room temperature of 20°C .

It is then put in a pan of boiling water maintained at 100°C .

Calculate how much thermal energy the ball gains as its temperature increases from 20°C to 100°C .

Specific heat capacity of steel = $510 \text{ J/kg }^\circ\text{C}$

Use an equation selected from the list of equations at the end of this paper.

(2)

thermal energy gained = ... J

(iii) The steel ball is put into a furnace where it melts.

Compare the motion of particles in the steel when they are in the solid state with their motion when in the molten (liquid) state.

(3)

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(Total for question = 8 marks)

Q9.

A beaker contains 0.25 kg of water at room temperature.

The beaker of water is heated until the water reaches boiling point (100°C).

The specific heat capacity of water is $4200 \text{ J/kg }^\circ\text{C}$.

The total amount of thermal energy supplied to the water is 84 000 J.

(i) Calculate the temperature of the water before it was heated.

Use an equation selected from the list of equations at the end of this paper.

(3)

temperature before heating = ... °C

(ii) The heating continues until 0.15 kg of the water has turned into steam.

The thermal energy needed to turn the boiling water into steam is 0.34 MJ.

Calculate the specific latent heat of vapourisation of water.

Use an equation selected from the list of equations at the end of this paper.

(2)

specific latent heat = ... MJ/kg

(iii) The graph in Figure 13 shows how the **volume** of 1 kg of water changes with temperature.

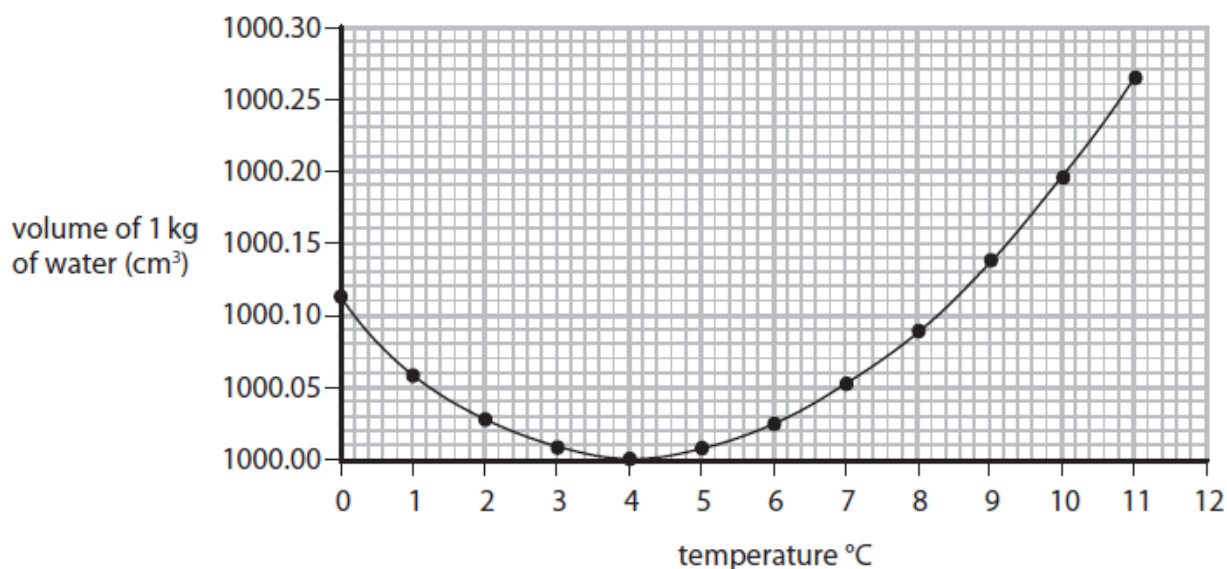


Figure 13

Describe how the **density** of water changes with temperature over the range of temperature shown in Figure 13.

Calculations are not required.

(2)

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Q10.

A beaker contains 0.25 kg of water at room temperature.
The beaker of water is heated until the water reaches boiling point (100 °C).
The specific heat capacity of water is 4200 J/kg °C.
The total amount of thermal energy supplied to the water is 84 000 J.

(i) Calculate the temperature of the water before it was heated.

Use an equation selected from the list of equations from the relevant equation sheet.

(3)

temperature before heating = ... °C

(ii) The heating continues until 0.15 kg of the water has turned into steam.

The thermal energy needed to turn the boiling water into steam is 0.34 MJ.

Calculate the specific latent heat of vapourisation of water.
Use an equation selected from the list of equations from the relevant equation sheet.

(2)

specific latent heat = ... MJ/kg

(iii) The graph in Figure 6 shows how the **volume** of 1 kg of water changes with temperature.

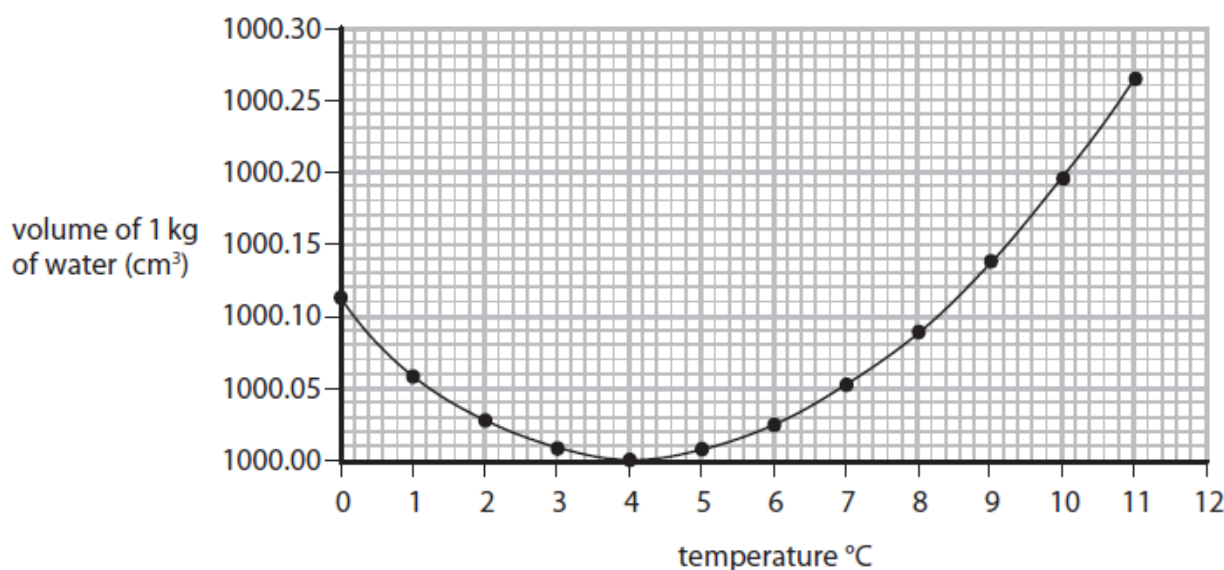


Figure 6

Describe how the **density** of water changes with temperature over the range of temperature shown in Figure 6.

Calculations are not required.

(2)

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(Total for question = 7 marks)

Q11.

Figure 4 shows a small piece of copper about 3 cm high.



© David J. Green/Alamy Stock Photo

Figure 4

A student wants to determine the density of copper.

The student uses a balance to measure the mass of the piece of copper.

(i) Explain how the student could measure the volume of the piece of copper.

(3)

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(ii) The mass of the piece of copper is 0.058 kg.

The volume of the piece of copper is $6.5 \times 10^{-6} \text{ m}^3$.

Calculate the density of copper.

(2)

density of copper = ... kg/cm³

(Total for question = 5 marks)

Q12.

Figure 1 shows a small piece of copper about 3 cm high.



© David J. Green/Alamy Stock Photo

Figure 1

A student wants to determine the density of copper.

The student uses a balance to measure the mass of the piece of copper.

(i) Explain how the student could measure the volume of the piece of copper.

(3)

.....

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(ii) The mass of the piece of copper is 0.058 kg.

The volume of the piece of copper is $6.5 \times 10^{-6} \text{ m}^3$.

Calculate the density of copper.

(2)

density of copper = ... kg/m^3

(Total for question = 5 marks)

Q13.

Figure 6 shows the dimensions of a solid block of concrete.

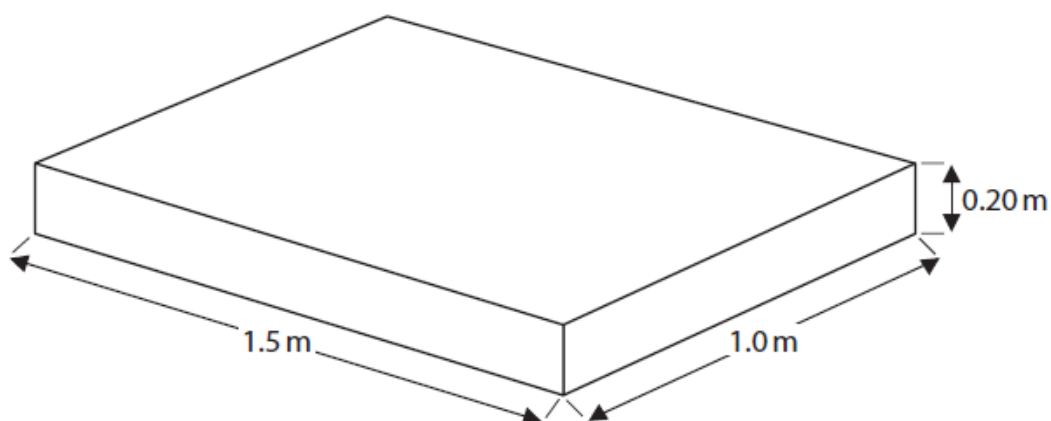


Figure 6

Density of concrete, ρ , = 2100 kg / m^3 .

Calculate the mass of the concrete block.

Use the equation

$$m = \rho \times V$$

(3)

mass of concrete block = ... kg

(Total for question = 3 marks)

Q14.

Figure 3 shows the dimensions of a solid block of concrete.

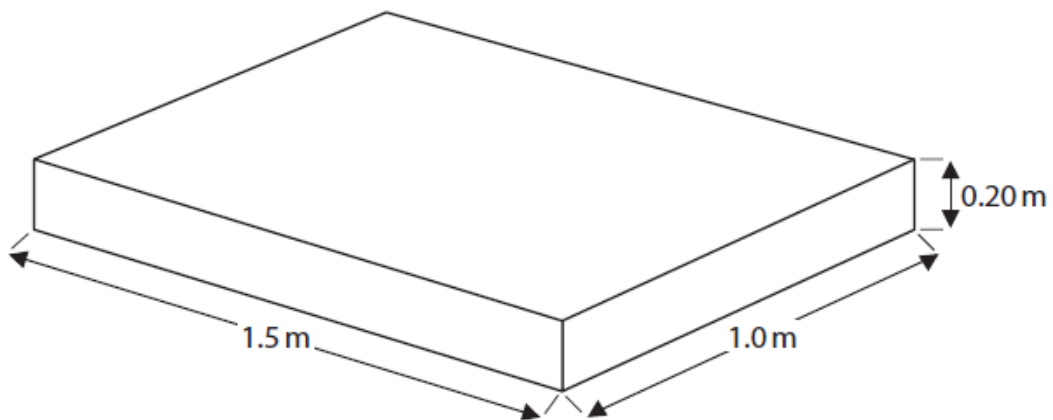


Figure 3

Density of concrete, ρ , = 2100 kg / m³.

Calculate the mass of the concrete block.

Use the equation

$$m = \rho \times V$$

(3)

mass of concrete block = ... kg

(Total for question = 3 marks)

Q15.

Figure 5 shows some water in a measuring cylinder and a lump of iron.

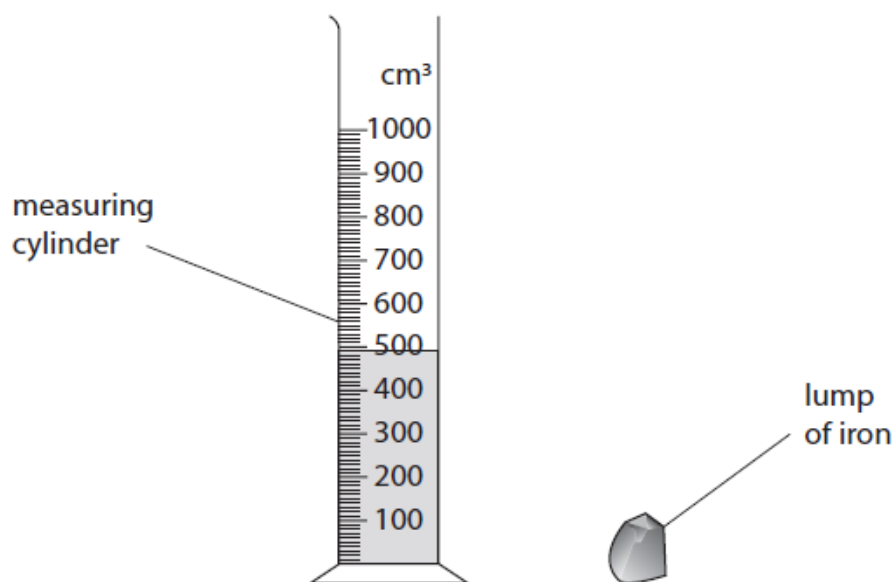


Figure 5

The lump of iron is lowered fully into the water.

The water level in the measuring cylinder rises to 530 cm³.

The density of iron is 7.9 g / cm³.

Calculate the mass of the lump of iron.

Use the equation

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Give your answer to 2 significant figures.

(4)

mass = ... g

(Total for question = 4 marks)

Q16.

Figure 3 shows some water in a measuring cylinder and a lump of iron.

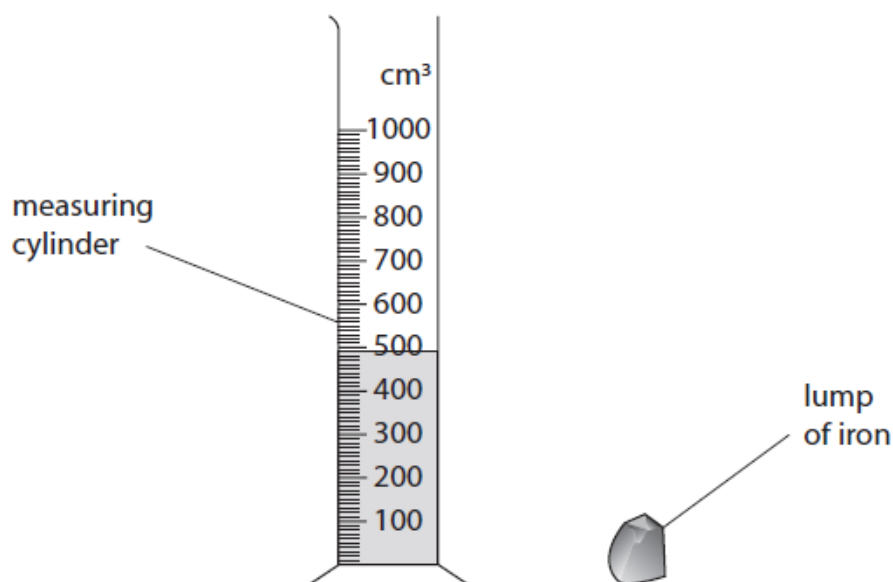


Figure 3

The lump of iron is lowered fully into the water.

The water level in the measuring cylinder rises to 530 cm³.

The density of iron is 7.9 g / cm³.

Calculate the mass of the lump of iron.

Use the equation

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Give your answer to 2 significant figures.

(4)

mass = ... g

(Total for question = 4 marks)

Q17.

Figure 1 shows some gas in a container.

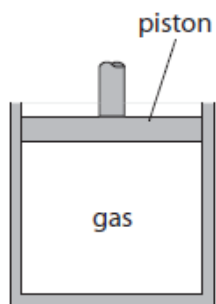


Figure 1

The pressure of gas in Figure 1 is 103 kPa, and the volume of gas is 0.010 m^3 .

Calculate the pressure of the gas in Figure 2 if the volume is now 0.0070 m^3 .

Use an equation selected from the list of equations at the end of this paper.

(3)

pressure = ... kPa

(Total for question = 3 marks)

Q18.

On a very cold day, the temperature of the air is $-4 \text{ }^\circ\text{C}$.

Calculate the value of this temperature on the kelvin scale.

(1)

temperature = ... K

(Total for question = 1 mark)

Q19.

Figure 24 shows a submarine underwater.

air

water

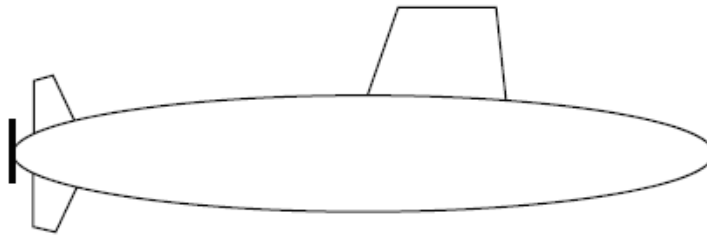


Figure 24

A bubble of gas escapes from the submarine.

The volume of the bubble is 23.0 cm^3 .

The pressure of the gas inside the bubble is 297 kPa .

The bubble rises to the surface without changing temperature.

Calculate the volume of the bubble when it reaches the surface.

Atmospheric pressure = 101 kPa

Use an equation from the formula sheet.

(3)

volume = ... cm^3

(Total for question = 3 marks)

Q20.

An electric kettle contains 1.41 kg of water at 25°C .

The kettle is switched on.

After a while, the water reaches boiling point at 100°C .

The specific heat capacity of water is $4200 \text{ J / kg }^\circ\text{C}$.

- (i) Calculate the amount of thermal energy supplied to the water by the kettle.
Give your answer to the appropriate number of significant figures.

Use an equation selected from the list of equations at the end of the paper.

(3)

energy supplied = ... J

(ii) The kettle is kept switched on and the water continues to boil.

After a while, the mass of the water in the kettle has decreased to 1.21 kg.

The thermal energy supplied to the water during this time was 450 000 J.

Calculate the specific latent heat of vaporisation of water.

Use an equation selected from the list of equations at the end of the paper.

(3)

specific latent heat of vaporisation = ... J / kg

(Total for question = 6 marks)

Q21.

An electric kettle contains 1.41 kg of water at 25 °C.

The kettle is switched on.

After a while, the water reaches boiling point at 100 °C.

The specific heat capacity of water is 4200 J / kg °C.

(i) Calculate the amount of thermal energy supplied to the water by the kettle.
Give your answer to the appropriate number of significant figures.

Use an equation selected from the list of equations at the end of the paper.

(3)

energy supplied = ... J

(ii) The kettle is kept switched on and the water continues to boil.

After a while, the mass of the water in the kettle has decreased to 1.21 kg.

The thermal energy supplied to the water during this time was 450 000 J.

Calculate the specific latent heat of vaporisation of water.

Use an equation selected from the list of equations at the end of the paper.

(3)

specific latent heat of vaporisation = ... J/kg

(Total for question = 6 marks)

Q22.

Another student decides to melt some ice.

The student melts 380 g of ice at 0 °C.

The specific latent heat of fusion of ice is 3.34×10^5 J/kg.

Calculate the thermal energy needed to melt the ice.

Select an equation from the list of equations at the end of this paper.

(2)

thermal energy needed = ... J

(Total for question = 2 marks)

Q23.

Another student decides to melt some ice.

The student melts 380 g of ice at 0 °C.

The specific latent heat of fusion of ice is 3.34×10^5 J/kg.

Calculate the thermal energy needed to melt the ice.

Select an equation from the list of equations at the end of this paper.

(2)

thermal energy needed = ... J

Q24.

The espresso machine shown in Figure 27 is an electrical appliance.



(Source: © tanawaty/123RF)

Figure 27

The espresso machine has an electrical heater connected to a 440 V mains supply.

The power of the electrical heater is 3.5 kW.

(i) The rating of a fuse is the current above which it melts.

Which of these is the most suitable fuse for the espresso machine circuit?

(1)

- ☐ **A** 1 A
- ☐ **B** 5 A
- ☐ **C** 10 A
- ☐ **D** 13 A

(ii) Before the espresso machine can be used, its heater must raise the temperature of some cold water.

The specific heat capacity of water is 4200 J/kg K.

Show that it takes the heater about 90 s to raise the temperature of 1 kg of water from 18°C to

95°C.

Use an equation from the formula sheet.

(3)

(Total for question = 4 marks)

Q25.

The espresso machine shown in Figure 27 is an electrical appliance.



(Source: © tanawaty/123RF)

Figure 27

The espresso machine has a steam pipe that can be used to heat milk in a jug, as shown in Figure 28.



(Source: © Wavebreak Media Ltd/123RF)

Figure 28

Steam from the pipe enters the milk, where steam condenses to water.

The steam and hot water heat the milk.

(i) Describe, in terms of energy, how the arrangement and movement of particles in the steam changes as the steam enters the milk, condenses and cools.

(2)

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(ii) The specific heat capacity of milk is 3840 J/kg K .

The specific heat capacity of water is 4200 J/kg K .

The specific latent heat of condensation of steam is 2260 kJ/kg .

The temperature of the steam is 100°C

The mass of steam that condenses is 25 g .

The temperature of the milk rises from 5°C to 65°C .

By considering the transfer of energy from the steam to the milk, calculate the mass of milk that is heated by the steam and hot water.

Use equations from the formula sheet.

(4)

mass of milk = ... kg

(iii) Give **two** reasons why the actual mass of steam needed to heat the milk from 5°C to 65°C is greater than 25 g.

(2)

- 1
-
- 2
-

(Total for question = 8 marks)

Q26.

On a very cold day, the temperature of the air is -4°C .

Calculate the value of this temperature on the kelvin scale.

(1)

temperature = ... K

(Total for question = 1 mark)

Q27.

Figure 17 shows information about the pressures in the ocean and in the atmosphere of a distant planet.

Graph A shows the variation of pressure as the depth in the ocean increases.

Graph B shows the variation of pressure as the height in the atmosphere increases.



Figure 17

(i) Use information from Graph A to obtain a value for the density of the ocean water.

Use an equation selected from the list of equations at the end of this paper.

(4)

density = ... kg/m³

* (ii) Explain the similarities and differences in the pressure variations shown in graphs A and B.

Your answer should refer to both the particle model (kinetic theory) and to density.

(6)

This image shows a full page of white paper with horizontal dashed lines, typical of primary school writing paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

(Total for question = 10 marks)

Q28.

Describe, in terms of particles, **two** differences between a solid and a liquid of the same substance.

(2)

1

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2

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(Total for question = 2 marks)

Q29.

* This question is about determining the specific heat capacity of aluminium.
An aluminium block is placed in boiling water as shown in Figure 21.

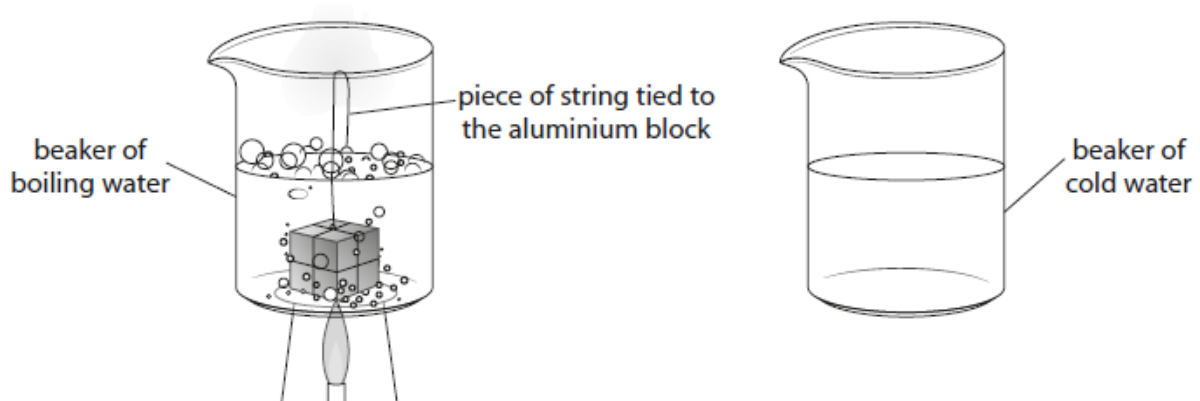


Figure 21

The piece of string is tied to the aluminium block so the block can be transferred from the boiling water to the cold water.

Describe how a student could use this apparatus, and any additional items needed, to determine the specific heat capacity of aluminium.

Your answer should include how the student would

- obtain the necessary measurements
- use the measurements to calculate the specific heat capacity of aluminium.

(6)

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(Total for question = 6 marks)

* This question is about determining the specific heat capacity of aluminium. An aluminium block is placed in boiling water as shown in Figure 10.

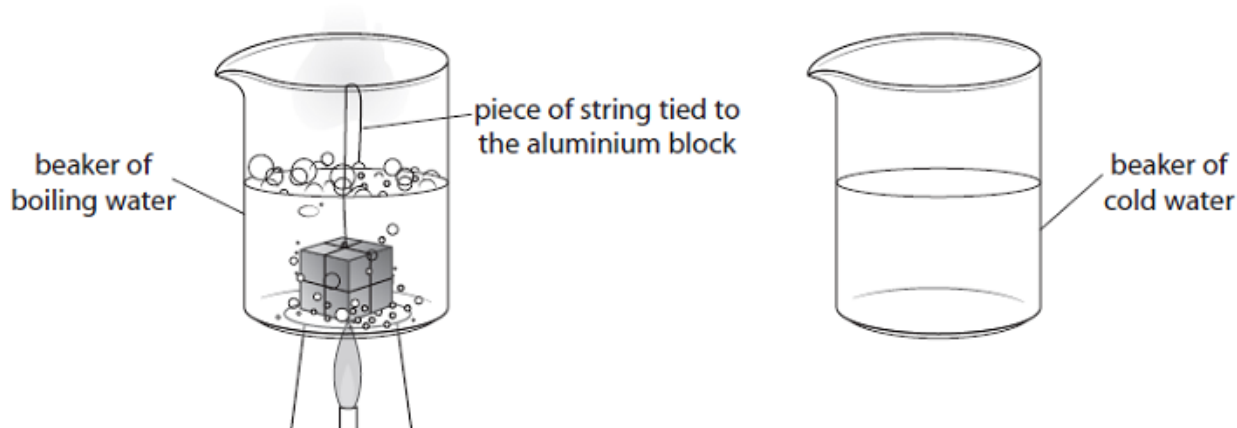


Figure 10

The piece of string is tied to the aluminium block so the block can be transferred from the boiling water to the cold water.

Describe how a student could use this apparatus, and any additional items needed, to determine the specific heat capacity of aluminium.

Your answer should include how the student would

- obtain the necessary measurements
- use the measurements to calculate the specific heat capacity of aluminium.

(6)

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(Total for question = 6 marks)

Mark Scheme

Q1.

Question Number:	Answer	Additional Guidance	Mark
(i)	a description to include:		(4) AO 1 2
	(measurement of) the mass of water (1)	accept volume / weight of water ignore amount	
	(measurement of) the temperature (rise/change) (1)	accept (take) thermometer reading	
	(measurement of) the energy supplied / from heater (1)	accept (take) reading of the joulemeter ignore 'change in thermal energy' (from equation)	
	detail of any of the above (1)	e.g. measure temp at the start and end or measure mass of empty cup or start and end readings on the meter	

Question Number:	Answer	Additional Guidance	Mark
(ii)	any two improvements from: add lid /cover (1) add lagging / insulation (1) add a stirrer (1) use a more sensitive thermometer (1) ensure heater fully submerged (1)	both marks can be scored in one answer space ignore repeating readings ignore increase voltage / power / energy ignore use of clamp to hold thermometer / heater accept use better insulator or better insulated / thicker cup accept use calorimeter ignore use glass beaker unless cup is inside it ignore different type of cup accept use digital / electric thermometer / data logger	(2) AO 3 3b

Q2.

Question Number:	Answer	Additional Guidance	Mark
(i)	a description to include: (measurement of) the mass of water (1) (measurement of) the temperature (rise/change) (1) (measurement of) the energy supplied / from heater (1) detail of any of the above (1)	accept volume / weight of water ignore amount accept (take) thermometer reading accept (take) reading of the joulemeter ignore 'change in thermal energy' (from equation) e.g. measure temp at the start and end or measure mass of empty cup or start and end readings on the meter	(4) AO 1 2

Question Number:	Answer	Additional Guidance	Mark
(ii)	any two improvements from: add lid /cover (1) add lagging / insulation (1) add a stirrer (1) use a more sensitive thermometer (1) ensure heater fully submerged (1)	both marks can be scored in one answer space ignore repeating readings ignore increase voltage / power / energy ignore use of clamp to hold thermometer / heater accept use better insulator or better insulated / thicker cup accept use calorimeter ignore use glass beaker unless cup is inside it ignore different type of cup accept use digital / electric thermometer / data logger	(2) AO 3 3b

Q3.

Question Number:	Answer	Additional Guidance	Mark
(i)	at right angles / 90°	perpendicular / normal to the tube wall	(1) AO 1 1

Question Number:	Answer	Additional Guidance	Mark
(ii)	select and substitute into $P_1 \times V_1 = P_2 \times V_2$ (1) $400\,000 \times V_1 = 100\,000 \times 4.8$ rearrangement (1) $V_1 = \frac{100\,000 \times 4.8}{400\,000}$ evaluation (1) ($V_1 =$) 1.2 (litres)	substitution and rearrangement in either order award full marks for the correct answer without working POT error 2 marks	(3) AO 2 1

Question Number:	Answer	Additional Guidance	Mark
(iii)	an explanation linking: work is done (in compressing the air) (1) increases the kinetic energy of the (air) particles / thermal energy (of the system) (1)	heat for thermal accept answer in terms of p ΔV $W = F \times d$ $= p \times (A \times d)$ $= p \Delta V$	(2) AO 1 1

Q4.

Question Number	Answer	Mark
	C The volume of the air inside the cylinder. The only correct answer is C <i>A is not correct because the mass remains unchanged</i> <i>B is not correct because the rate of collision decreases</i> <i>D is not correct because the pressure decreases</i>	(1) AO 1 1

Q5.

Question number	Answer	Additional guidance	Mark
(i)	Rearrangement (and substitution) (1) (c) $= \frac{1050}{0.058 \times 78}$ evaluation (1) 230 (J/kg °C)	$c = \frac{\Delta Q}{m \times \Delta \theta}$ award 1 mark if 78 seen accept 232(J/kg °C) award full marks for correct answer without working.	(2)

Question number	Answer	Additional guidance	Mark
(ii)	any two of the following reduce heat loss from water/insulate beaker/add cover (1) make the temperature rise larger/use a larger piece of copper/ use a smaller amount of water (1) (use) a stirrer (1) account for heat gained by glass beaker (1) transfer the hot copper faster (1) use a different heating method (1) measure the temperature of the boiling water (1)	ignore more accurate measurements e.g. thermometer, balance etc. ignore taking repeats start with colder water	(2)

Q6.

Question number	Answer	Additional guidance	Mark
(i)	Rearrangement (and substitution) (1) (c) $= \frac{1050}{0.058 \times 78}$ evaluation (1) 230 (J/kg °C)	$c = \frac{\Delta Q}{m \times \Delta \theta}$ award 1 mark if 78 seen accept 232(J/kg °C) award full marks for correct answer without working.	(2)

Question number	Answer	Additional guidance	Mark
(ii)	any two of the following reduce heat loss from water/insulate beaker/add cover (1) make the temperature rise larger/use a larger piece of copper/ use a smaller amount of water (1) (use) a stirrer (1) account for heat gained by glass beaker (1) transfer the hot copper faster (1) use a different heating method (1) measure the temperature of the boiling water (1)	ignore more accurate measurements e.g. thermometer, balance etc. ignore taking repeats start with colder water	(2)

Q7.

Question number	Answer	Additional guidance	Mark
(i)	Substitution: Density = mass/ volume (1) = $28 \times 10^{-3} / 3.6 \times 10^{-6}$ (1) Evaluation = 7777 kg / m^3 (1)	(recalled / used) ignore any power of ten (pot) error here do not penalise any sf errors (7.77 etc. would get 2 marks: losing the pot mark in the evaluation)	(3)

Question number	Answer	Additional guidance	Mark
(ii)	(Use $\Delta Q = m \times c \times \Delta\theta$) substitution thermal energy gained = $0.028 \times 510 \times 80$ (1) evaluation = 1100 (J) (1)	ignore any pot error here 1142 (J)	(2)

Question number	Answer	Mark
(iii)	An explanation that combines identification – knowledge (2 marks) and reasoning / justification (1 mark) Solid state → particles vibrate (1) → about fixed positions (1) Liquid state → particles move randomly / freely (1)	(3)

Q8.

Question number	Answer	Additional guidance	Mark
(i)	Substitution: Density = mass/ volume (1) = $28 \times 10^{-3} / 3.6 \times 10^{-6}$ (1) Evaluation = 7777 kg / m³ (1)	(recalled / used) ignore any power of ten (pot) error here do not penalise any sf errors (7.77 etc. would get 2 marks: losing the pot mark in the evaluation)	(3)

Question number	Answer	Additional guidance	Mark
(ii)	(Use $\Delta Q = m \times c \times \Delta \theta$) substitution thermal energy gained = $0.028 \times 510 \times 80$ (1) evaluation = 1100 (J) (1)	ignore any pot error here 1142 (J)	(2)

Question number	Answer	Mark
(iii)	An explanation that combines identification – knowledge (2 marks) and reasoning / justification (1 mark) Solid state → particles vibrate (1) → about fixed positions (1) Liquid state → particles move randomly / freely (1)	(3)

Q9.

Question Number	Answer	Additional guidance	Mark
(i)	substitution into $\Delta Q = m \times c \times \Delta\theta$ (1) $84\,000 = 0.25 \times 4200 \times \Delta\theta$ rearrangement $\frac{\Delta Q}{m \times c}$ (1) $(\Delta\theta =) \frac{84\,000}{0.25 \times 4200}$ (= 80) evaluation (1) (temperature before heating =) 20 (°C)	accept substitution and rearrangement in either order answer of 80 (°C) scores 2 marks award full marks for the correct answer without working	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	substitution into $Q = m \times L$ (1) $0.34 = 0.15 \times L$ re-arrangement and evaluation (1) $(L = \frac{0.34}{0.15} =)$ 2.3 (MJ/kg)	allow values that round to 2.3 (MJ/kg) allow 1 mark for POT error award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(iii)	A description that makes reference to any two of the following (density) increases between 0°C and 4 °C (1) reaches a maximum at 4 °C (1) (density) decreases above 4 °C (1)	increases initially / at first / up to 4 °C then decreases if no other marks scored then credit reference to large volume means low density (OWTTE) for 1 mark only	(2)

Q10.

Question Number	Answer	Additional guidance	Mark
(i)	substitution into $\Delta Q = m \times c \times \Delta\theta$ (1) $84\,000 = 0.25 \times 4200 \times \Delta\theta$ rearrangement $\frac{\Delta Q}{m \times c}$ (1) $(\Delta\theta =) \frac{84\,000}{0.25 \times 4200}$ (= 80) evaluation (1) (temperature before heating =) 20 (°C)	accept substitution and rearrangement in either order answer of 80 (°C) scores 2 marks award full marks for the correct answer without working	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	substitution into $Q = m \times L$ (1) $0.34 = 0.15 \times L$ re-arrangement and evaluation (1) $(L = \frac{0.34}{0.15})$ 2.3 (MJ/kg)	allow values that round to 2.3 (MJ/kg) allow 1 mark for POT error award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(iii)	A description that makes reference to any two of the following (density) increases between 0°C and 4 °C (1) reaches a maximum at 4 °C (1) (density) decreases above 4 °C (1)	increases initially / at first / up to 4 °C then decreases if no other marks scored then credit reference to large volume means low density (OWTTE) for 1 mark only	(2)

Q11.

Question number	Answer	Additional guidance	Mark
(i)	an explanation linking any three of the following : use a measuring cylinder/beaker or use a eureka can /displacement can/container with spout (1) (partly)fill measuring cylinder/beaker (with water) note the reading or fill (eureka) can to spout (1) immerse piece of copper (in water) (1) note difference in readings of water level (in measuring cylinder /beaker) or collect water from spout in a measuring cylinder /beaker (1)	give credit for other acceptable methods If no other marks scored then allow 1 mark for attempt to measure volume directly: e.g. fill copper tube with water, tip out and measure volume or measure dimension(s) of copper tube	(3)

Question number	Answer	Additional guidance	Mark
(ii)	recall and substitution (1) density = $\frac{m}{V}$ (density =) $\frac{0.058}{6.5 \times 10^{-6}}$ evaluation (1) $8.9 \times 10^3 \text{ (kg/m}^3\text{)}$	accept values that round to 8900 e.g. 8923(kg/m³) or 9000 8.9 to any other power of ten gains 1 mark award full marks for correct answer without working.	(2)

Q12.

Question number	Answer	Additional guidance	Mark
(i)	an explanation linking any three of the following : use a measuring cylinder / beaker or use a eureka can /displacement can/container with spout (1) (partly) fill measuring cylinder / beaker (with water) note the reading or fill (eureka) can to spout (1) immerse piece of copper (in water) (1) note difference in readings of water level (in measuring cylinder / beaker) or collect water from spout in a measuring cylinder / beaker (1)	give credit for other acceptable methods If no other marks scored then allow 1 mark for attempt to measure volume directly: e.g. fill copper tube with water, tip out and measure volume or measure dimension(s) of copper tube	(3)

Question number	Answer	Additional guidance	Mark
(ii)	recall and substitution (1) density= $\frac{m}{V}$ (density=) $\frac{0.058}{6.5 \times 10^{-6}}$ evaluation (1) $8.9 \times 10^3 \text{ (kg/m}^3\text{)}$	accept values that round to 8900 e.g. 8923(kg/m³) or 9000 8.9 to any other power of ten gains 1 mark award full marks for correct answer without working.	(2)

Q13.

Question number	Answer	Additional guidance	Mark
	volume substitution (1) $1.5 \times 1.0 \times 0.2(0) (= 0.3)$ substitution in equation (1) $\text{mass} = 2100 \times (0.3(0))$ evaluation (1) $= 630 \text{ (kg)}$	ecf from calculated value of volume for this mark only award 2 marks for $6.3 \times$ any other power of 10 5670 gains 1 mark from use of $1.5+1.0+0.2=2.7$ award full marks for correct answer without working	(3) AO2

Q14.

Question number	Answer	Additional guidance	Mark
	volume substitution (1) $1.5 \times 1.0 \times 0.2(0) (= 0.3)$ substitution in equation (1) $\text{mass} = 2100 \times (0.3(0))$ evaluation (1) $= 630 \text{ (kg)}$	ecf from calculated value of volume for this mark only award 2 marks for $6.3 \times$ any other power of 10 5670 gains 1 mark from use of $1.5+1.0+0.2=2.7$ award full marks for correct answer without working	(3) AO2

Q15.

Question number	Answer	Additional guidance	Mark
	calculation of change in volume (1) $(530 \text{ cm}^3 - 490 \text{ cm}^3) = 40 \text{ (cm}^3\text{)}$ substitution (1) $7.9 = \frac{\text{mass}}{40}$ rearrangement and evaluation (1) (mass = 7.9×40) (mass =) 316 (g) evaluation to 2 sig fig (1) 320 (g)	measurement mark – using scale allow use of incorrect volume answers without working 316 (g) scores 3 marks 0.316 kg scores 3 marks 316 to any other power of 10 scores 2 marks 4187 or 3871 scores 2 marks (incorrect volume) any answer written to 2sf independent mark answers without working 320 scores 4 marks 320 to any other power of ten scores 3 marks 4200 scores 3 marks 3900 scores 3 mark	(4) A02.2

Q16.

Question number	Answer	Additional guidance	Mark
	calculation of change in volume (1) $(530 \text{ cm}^3 - 490 \text{ cm}^3) = 40 \text{ (cm}^3\text{)}$ substitution (1) $7.9 = \frac{\text{mass}}{40}$ rearrangement and evaluation (1) $(\text{mass} = 7.9 \times 40)$ $(\text{mass} =) 316 \text{ (g)}$ evaluation to 2 sig fig (1) 320 (g)	measurement mark – using scale allow use of incorrect volume answers without working 316 (g) scores 3 marks 0.316 kg scores 3 marks 316 to any other power of 10 scores 2 marks 4187 or 3871 scores 2 marks (incorrect volume) any answer written to 2sf independent mark answers without working 320 scores 4 marks 320 to any other power of ten scores 3 marks 4200 scores 3 marks 3900 scores 3 mark	(4) AO2.2

Q17.

Question number	Answer	Additional guidance	Mark
	Rearrangement (1) $P_2 = \frac{P_1 V_1}{V_2}$ substitution (1) $P_2 = \frac{103 \times 0.010}{0.0070}$ evaluation to 2 sf (1) = 150 (kPa)	147 (kPa) 1.5×10^2 kPa or 1.5×10^5 Pa rearrangement and substitution in either order award full marks for correct answer without working	(3)

Q18.

Question number	Answer	Additional guidance	Mark
	269 (K)	allow use of 273.14? 269.14 (K)	(1) AO2

Q19.

Question number	Answer	Additional guidance	Mark
	Rearrangement (1) $V_2 = (p_1 \times V_1) \div p_2$ Substitution (1) $V_2 = (297 \times 10^3 \times 23.0) \div (101 \times 10^3)$ Evaluation (1) $V_2 = 67.6 \text{ (cm}^3\text{)}$	67.633	(3)

Q20.

Question number	Answer	Additional guidance	Mark
i	substitution into $\Delta Q = m \times s \times \Delta T$ (1) $(\Delta Q) = 1.41 \times 4200 \times (100-25)$		(3) AO2
	evaluation (1) (energy =) 444,150 (J) answer to 2 sf (1) 440,000 (J)	ignore POT error for this mark independent mark allow 3 sf 444,000 award full marks for the correct answer without working award 1 mark for answers with values 148,050 or 592,200 (incorrect temp and sf) award 2 marks for answers with values 150,000 or 148,000 or 590,000 or 592,000 (incorrect temp but allowed sf)	

Question number	Answer	Additional guidance	Mark
ii	substitution into $\Delta Q = m \times L$ $450,000 = (1.41 - 1.21) \times L$ (1) rearrangement $L = \frac{450,000}{0.2}$ (1) evaluation $(L) = 2\,200\,000 \text{ (J/kg)}$ (1)	allow substitution and rearrangement in either order accept 2 250 000 award full marks for the correct answer without working award 1 mark for answers that round to 330,000 or 370,000 (incorrect mass used)	(3) AO2

Q21.

Question number	Answer	Additional guidance	Mark
(i)	substitution into $\Delta Q = m \times s \times \Delta T$ (1) $(\Delta Q) = 1.41 \times 4200 \times (100-25)$ evaluation (1) (energy =) 444,150 (J) answer to 2 sf (1) 440,000 (J)	 ignore POT error for this mark independent mark allow 3 sf 444,000 award full marks for the correct answer without working award 1 mark for answers with values 148,050 or 592,200 (incorrect temp and sf) award 2 marks for answers with values 150,000 or 148,000 or 590,000 or 592,000 (incorrect temp but allowed sf)	(3) AO2

Question number	Answer	Additional guidance	Mark
(ii)	substitution into $\Delta Q = m \times L$ $450,000 = (1.41 - 1.21) \times L$ (1) rearrangement $L = \frac{450,000}{0.2}$ (1) evaluation $(L) = 2\,200\,000 \text{ (J/kg)}$ (1)	allow substitution and rearrangement in either order accept 2 250 000 award full marks for the correct answer without working award 1 mark for answers that round to 330,000 or 370,000 (incorrect mass used)	(3) AO2

Q22.

Question Number:	Answer	Additional Guidance	Mark
	substitution (1) $(Q =) \frac{380 \times 3.34 (\times 10^5)}{(1000)}$ evaluation (1) $1.27 \times 10^5 \text{ (J)}$	127 kJ 126920 (J) accept answers that round to 1.27×10^5 e.g. 1.2692×10^5 accept 130 kJ or $1.3 \times 10^5 \text{ (J)}$ POT error max. 1 mark award full marks for correct answer without working	(2) AO 2 1

Q23.

Question Number:	Answer	Additional Guidance	Mark
	substitution (1) $(Q =) \frac{380 \times 3.34 (\times 10^5)}{(1000)}$ evaluation (1) $1.27 \times 10^5 \text{ (J)}$	127 kJ 126920 (J) accept answers that round to 1.27×10^5 e.g. 1.2692×10^5 accept 130 kJ or $1.3 \times 10^5 \text{ (J)}$ POT error max. 1 mark award full marks for correct answer without working	(2) AO 2 1

Q24.

Question number	Answer	Mark
(i)	C	(1)

Question number	Answer	Additional guidance	Mark
(ii)	Equating the same variable in both equations (1) $\Delta Q = m \times c \times \Delta\theta = P \times t$ Rearrangement (1) $t = \frac{(m \times c \times \Delta\theta)}{P}$ Substitution and evaluation (1) $t = \frac{(1 \times 4200 \times 77)}{3500}$ $= 92 \text{ s}$	allow $\Delta\theta$ seen as 95 – 18 92.4 evaluation must be seen to at least 2 s.f. at some point in the working	(3)

Q25.

Question number	Answer	Mark
(i)	An answer that combines the following points of understanding to provide a logical description: - when steam condenses, its molecules move closer together, so the internal energy decreases (1) - when the water from the condensed steam cools, its molecules move more slowly, therefore storing less kinetic energy (1)	allow as water cools, the distance between the particles decreases which increases the intermolecular forces (2)

Question number	Answer	Additional guidance	Mark
(ii)	equating the variables in the three equations/principle of conservation of energy (1) $(m_w \times l_w) + (m_w \times c_w \times \Delta\theta_w) = (m_m \times c_m \times \Delta\theta_m)$ rearrangement (1) $m_m = \frac{(m_w \times l_w) + (m_w \times c_w \times \Delta\theta_w)}{(c_m \times \Delta\theta_m)}$ substitution of correctly calculated quantities (1) $= \frac{\left(\left(\frac{25}{1000} \right) \times 2260000 \right) + \left(\left(\frac{25}{1000} \right) \times 4200 \times 35 \right)}{3840 \times 60}$ evaluation (1) 0.26 (kg)	allow in words or with suitable alternative subscripts temperature changes and l_w must be correct allow maximum of 3 marks for calculations that omit the energy from cooling of water	(4)

Question number	Answer	Mark
(iii)	Any two of the following reasons: • more steam must condense and transfer the energy that is dissipated to the jug during the process (1) • more steam must condense and transfer the energy that is dissipated to the surroundings during the process (1) • more steam must condense and transfer the energy needed to cause the milk to froth (1) • more steam must condense to replace any steam that might leave the milk without condensing (1)	(2)

Q26.

Question number	Answer	Additional guidance	Mark
	269 (K)	allow use of 273.14? 269.14 (K)	(1) AO2

Q27.

Question number	Answer	Additional guidance	Mark
(i)	rearrange $p = \rho g h$ to give $\rho = p / (g h)$ (1) substitution using any point from graph (1) e.g. depth = 50km and pressure = 1.5 GPa $\rho = p / (g h)$ $= 1.5 \times 10^9 / (10 \times 50 \times 10^3)$ Evaluation (2) $= 3000 \text{ (kg/m}^3\text{)}$	rearrangement and substitution in any order allow any combination from the graph and ignore 'pot' error here 'pot' error scores 2 marks maximum	(4)

Question number	Indicative content	Mark
(ii)	Answers will be credited according to the candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all of the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. A02 (3 marks) A03 (3 marks) A03 Interpretation and evaluation from the graph Similarities: • both show increasing pressure with depth • both show a range of pressures over kilometre depths / heights Differences: • ocean water shows a linear relationship (straight line) but atmosphere gives a non-linear (curved) relationship • density of ocean water not changing with depth but density of atmosphere changes as you go higher • The pressures in the ocean recorded are much bigger (GPa compared with kPa) The depth of the ocean shown is up to 100km whereas the height of the atmosphere involved is only up to 10km A02 Link between graph shapes and underlying physics Similarities: • pressure is due to (increasing) weight of fluid (liquid / gas) above • more molecules above Differences: • atmosphere becomes thinner the higher you go molecules in the ocean stay (on average) the same distance apart but in the atmosphere they get further apart (on average) as you go higher up	(6)

Level	Mark	Descriptor
	0	No awardable content
Level 1	1–2	- Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3) - The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3–4	- Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3) - The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5–6	- Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3) - The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Q28.

Question number	Answer	Additional guidance	Mark
	descriptions to include any two of particles / atoms in solid close(r) together (1) particles / atoms in solid (vibrate) in fixed positions but particles in liquid move (freely) (1) particles in a solid in regular arrangement but particles in liquid are randomly arranged (1) particles in a liquid have more (kinetic) energy (than in a solid) (1)	reverse argument difference asked for so must compare for subsequent marking points allow answers in terms of forces between particles	(2) AO1

Q29.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Procedure • Measure the temperature of the boiling water • Allow sufficient time for block to reach temperature of boiling water • Measure temperature of cold water in beaker • Using a thermometer • Transfer (hot) aluminium block to cold water in the beaker. • Work quickly to avoid thermal energy loss during transfer • Measure temperature of water • Stir to ensure even distribution • Measure maximum temperature reached by water • Calculate temp rise of water by subtracting initial from final temperature. • Calculate temp drop of aluminium by subtracting final temperature from 100. • Find mass of beaker and water and aluminium • Use a balance • Empty water from beaker and dry beaker and block • Weigh beaker and block alone • Find mass of water by subtraction. • Allow plausible method of finding mass of water before putting block in.	(6) AO2 and AO3

	Process results • Calculate thermal energy gained water using $\Delta Q = m \times c \times \Delta\theta$ • Thermal energy gained by water = thermal energy lost by aluminium • Specific heat capacity of aluminium = $\frac{\text{thermal energy transferred}}{\text{mass of Al} \times \text{temp drop of Al}}$	
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Level	Mark	Descriptor
	0	No awardable content
Level 1	1–2	- The plan attempts to link and apply knowledge and understanding of scientific enquiry, techniques and procedures, flawed or simplistic connections made between elements in the context of the question. (AO2) - Analyses the scientific information but understanding and connections are flawed. An incomplete plan that provides limited synthesis of understanding. (AO3)
Level 2	3–4	- The plan is mostly supported through linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, some logical connections made between elements in the context of the question. (AO2) - Analyses the scientific information and provides some logical connections between scientific enquiry, techniques and procedures. A partially completed plan that synthesises mostly relevant understanding, but not entirely coherently. (AO3)
Level 3	5–6	- The plan is supported throughout by linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, logical connections made between elements in the context of the question. (AO2) - Analyses the scientific information and provide logical connections between scientific concepts throughout. A well-developed plan that synthesises relevant understanding coherently. (AO3)

Summary for guidance

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> Partially complete description of a suitable procedure with at least one measurement	<u>Possible candidate responses</u> Heat up the block in the boiling water. Then put the block into the cold water. Measure the temperature reached by the water.
Level 2	3–4	<u>Additional guidance</u> Mostly complete description of a suitable procedure with at least two measurements and some description of processing the results.	<u>Possible candidate responses</u> As above with Measure mass of water. Use $\Delta Q = m \times c \times \Delta\theta$ to find thermal energy transferred
Level 3	5–6	<u>Additional guidance</u> Detailed description of a suitable procedure with most of the necessary measurements and a clear description of processing the results.	<u>Possible candidate responses</u> As above with Calculate temperature changes by subtraction. Calculate thermal energy lost by Al as being equal to thermal energy gained by water. Specific heat capacity of Al = $\frac{\text{thermal energy transferred}}{\text{mass of Al} \times \text{temp drop of Al}}$

Q30.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Procedure • Measure the temperature of the boiling water • Allow sufficient time for block to reach temperature of boiling water • Measure temperature of cold water in beaker • Using a thermometer • Transfer (hot) aluminium block to cold water in the beaker. • Work quickly to avoid thermal energy loss during transfer • Measure temperature of water • Stir to ensure even distribution • Measure maximum temperature reached by water • Calculate temp rise of water by subtracting initial from final temperature. • Calculate temp drop of aluminium by subtracting final temperature from 100. • Find mass of beaker and water and aluminium • Use a balance • Empty water from beaker and dry beaker and block • Weigh beaker and block alone • Find mass of water by subtraction. • Allow plausible method of finding mass of water before putting block in.	(6) AO2 and AO3

	Process results • Calculate thermal energy gained water using $\Delta Q = m \times c \times \Delta\theta$ • Thermal energy gained by water = thermal energy lost by aluminium • Specific heat capacity of aluminium = $\frac{\text{thermal energy transferred}}{\text{mass of Al} \times \text{temp drop of Al}}$	
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Level	Mark	Descriptor
	0	No awardable content
Level 1	1–2	- The plan attempts to link and apply knowledge and understanding of scientific enquiry, techniques and procedures, flawed or simplistic connections made between elements in the context of the question. (AO2) - Analyses the scientific information but understanding and connections are flawed. An incomplete plan that provides limited synthesis of understanding. (AO3)
Level 2	3–4	- The plan is mostly supported through linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, some logical connections made between elements in the context of the question. (AO2) - Analyses the scientific information and provides some logical connections between scientific enquiry, techniques and procedures. A partially completed plan that synthesises mostly relevant understanding, but not entirely coherently. (AO3)
Level 3	5–6	- The plan is supported throughout by linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, logical connections made between elements in the context of the question. (AO2) - Analyses the scientific information and provide logical connections between scientific concepts throughout. A well-developed plan that synthesises relevant understanding coherently. (AO3)

Summary for guidance			
Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> Partially complete description of a suitable procedure with at least one measurement	<u>Possible candidate responses</u> Heat up the block in the boiling water. Then put the block into the cold water. Measure the temperature reached by the water.
Level 2	3–4	<u>Additional guidance</u> Mostly complete description of a suitable procedure with at least two measurements and some description of processing the results.	<u>Possible candidate responses</u> As above with Measure mass of water. Use $\Delta Q = m \times c \times \Delta\theta$ to find thermal energy transferred
Level 3	5–6	<u>Additional guidance</u> Detailed description of a suitable procedure with most of the necessary measurements and a clear description of processing the results.	<u>Possible candidate responses</u> As above with Calculate temperature changes by subtraction. Calculate thermal energy lost by Al as being equal to thermal energy gained by water. Specific heat capacity of Al = $\frac{\text{thermal energy transferred}}{\text{mass of Al} \times \text{temp drop of Al}}$