A Level · OCR · Physics

49 mins 5 questions

Structured Questions

Thermal Properties of Materials

Thermal Equilibrium / Measurement of Temperature / Solids, Liquids & Gases / Brownian Motion / Internal Energy / Specific Heat Capacity / Specific Latent Heat

Easy (1 question)	/5
Medium (2 questions)	/19
Hard (2 questions)	/25
Total Marks	**/49**

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Easy Questions

1 (a) Define the *internal energy* of a substance.

[1]

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(1 mark)

(b) A block of paraffin wax is melting at a constant temperature of 52 °C. Use the behaviour of paraffin molecules to describe and explain the changes to the internal energy of the molecules of the paraffin wax as it melts.

[4]

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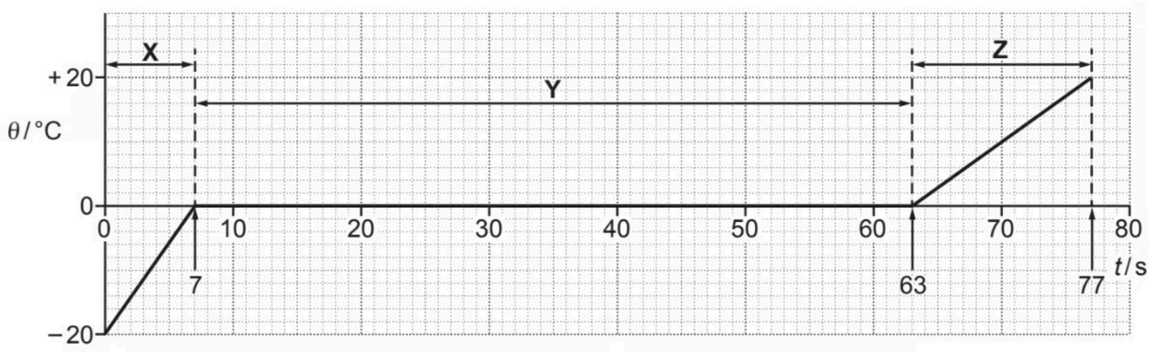
(4 marks)

Medium Questions

1 (a) A 150 W heater is used to heat 25 g of ice in a sealed and well-insulated container. The initial temperature of the ice is –20°C. The graph shows the variation of temperature θ with time t as the ice is heated.



There are three distinct regions of the graph, **X**, **Y** and **Z**.

i) Use the graph to determine the specific heat capacity c of the ice.

c = ... J $kg^{-1}K^{-1}$ **[3]**

ii)

Use the graph to determine the specific latent heat of fusion of ice L_f

L_f = ... J kg^{-1} **[2]**

iii)

Use the graph to compare the specific heat capacities of ice and water. Explain your answer.

[2]

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(7 marks)

(b) i) Describe the motions of the molecules in region **X** and in region **Z**.

[2]

ii) The internal energy of the ice increases from t = 0 to t = 77 s. Complete the table below using the following key for the physical quantities:

- K = kinetic energy of molecules
- P = potential energy of molecules.

Region	**Physical quantity, or quantities, that increases as time increases**	**Physical quantity, or quantities, that remain constant as time increases**
X		
Y		
Z		

[3]

iii) State the temperature of the ice at which its molecules have zero kinetic energy.

[1]

(6 marks)

2 (a) A plastic kettle is filled with 0.60 kg of water at a temperature of 20 °C. A 2.2 kW electric heater is used to heat the water for a time of 4.0 minutes.

Calculate the total energy supplied by the heater during the time of 4.0 minutes.

energy = ... J **[2]**

(2 marks)

(b) The specific heat capacity of water is 4200 J kg^{-1} K^{-1} and the specific latent heat of vaporization of water is 2.3×10^6 J kg^{-1}. The boiling point of water is 100 °C.

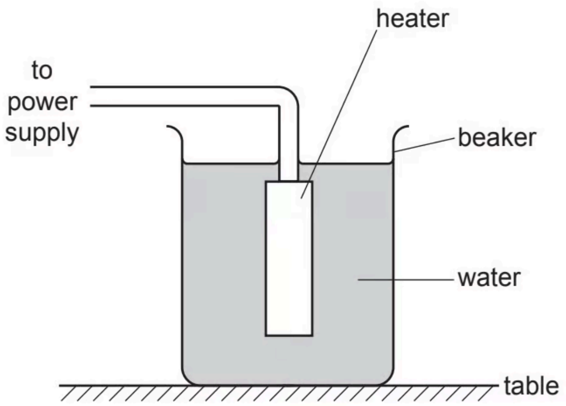
Calculate the mass of water **remaining** in the kettle after 4.0 minutes. Assume that all the thermal energy from the heater is transferred to the water.

mass of water remaining = ... kg **[4]**

(4 marks)

Hard Questions

1 (a) A heater is used to heat water in a beaker.



i) Before switching on, the metal heater and the water are both at room temperature.

Describe the motion of the atoms of the metal heater and of the water molecules.

[3]

ii) The heater is now switched on.

The power of the heater is 200 W. The mass of the water in the beaker is 500 g. It takes 10.0 minutes to increase the temperature of the water in the beaker from 20 °C to 60 °C.

Calculate the energy transferred from the water to the **beaker and the surroundings**.

- specific heat capacity of water = 4200 J kg^{-1} K^{-1}

energy transferred = ... J **[3]**

(6 marks)

(b) A student is carrying out an experiment to determine the specific latent heat of fusion L_f of ice. The student has two sets of apparatus next to each other on the laboratory bench, as shown in **Fig. 17.1** and **Fig. 17.2**.

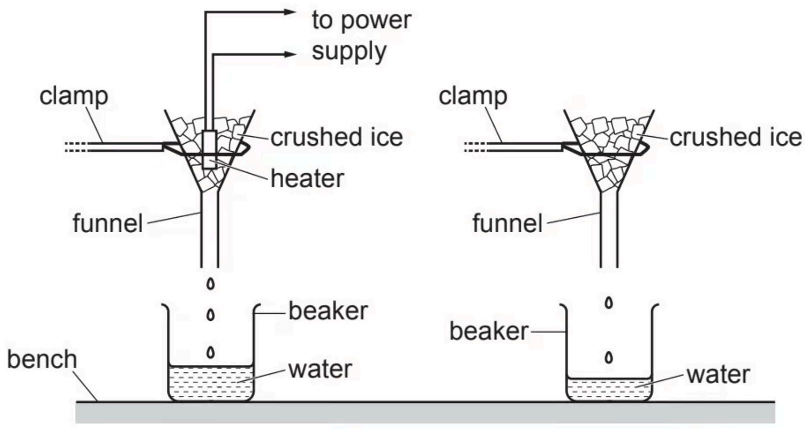


Fig. 17.1 | **Fig. 17.2**

Both funnels are identical and have the same mass of crushed ice at 0 °C.

The current in the heater is 5.0 A and the potential difference across it is 12 V.

Fig. 17.3 shows the variation of mass of water m collected in each beaker with time t.

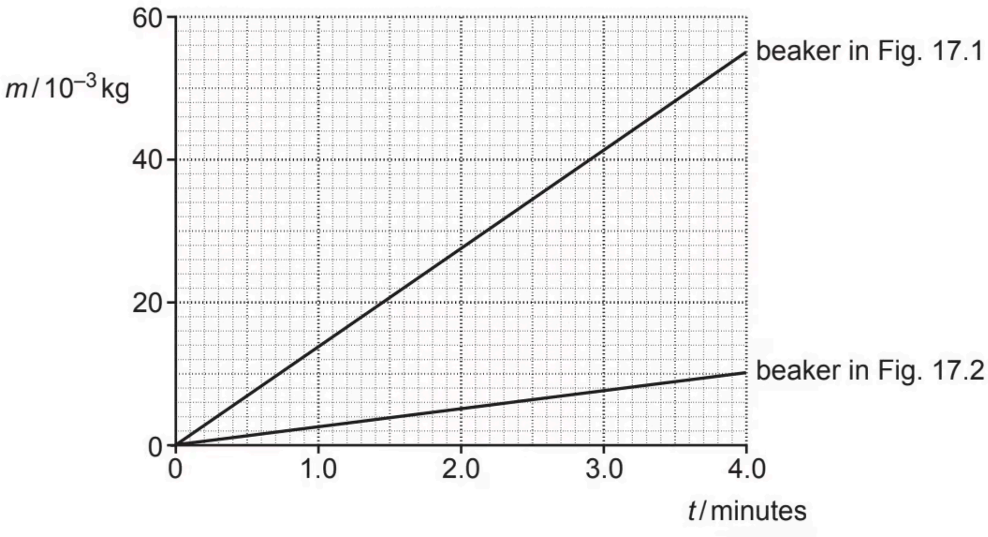


Fig. 17.3

Describe and explain the shape of the two graphs in **Fig. 17.3** and use them to determine the specific latent heat of fusion L_f of ice.

[6]

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(6 marks)

2 (a) A substance can exist as a crystalline solid, a liquid or a gas. A solid sample of the substance is placed in a sealed container and heated at a constant rate until it changes into a gas.

Fig. 21 shows the variation with time t of the temperature θ for the substance.

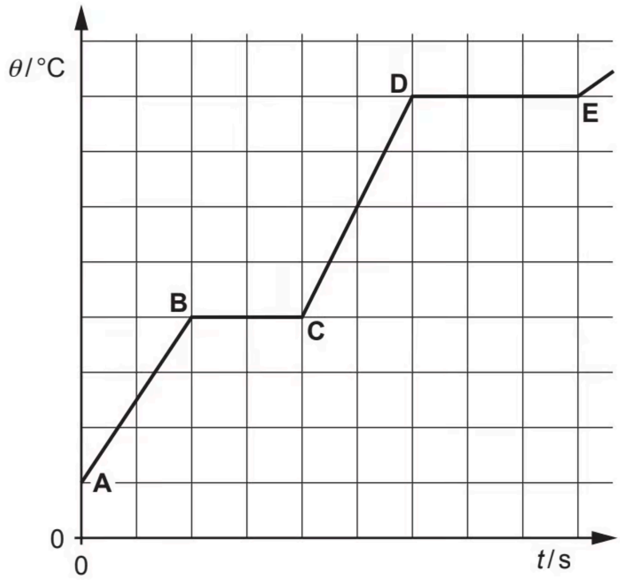

Fig. 21

Use the kinetic theory of matter to describe the solid phase (section **AB**) and the liquid phase (section **CD**) in terms of the motion and arrangement of the molecules of the substance.

Section **AB**:

Section **CD**:

[4]

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(4 marks)

(b) Use Fig. 21 to explain how the specific heat capacity of the liquid compares with the specific heat capacity of the solid.

[2]

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(2 marks)

(c) State what is meant by the **internal energy** of the substance.

[1]

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(1 mark)

(d) Beyond the point **E** in Fig. 21, the substance behaves as an ideal gas.

i) The mass of a gas molecule is 4.8×10^{-26} kg. Calculate the root mean square speed of the gas molecules at a temperature of 250°C.

root mean square speed = ... ms^{-1} **[3]**

ii) Calculate the internal energy of 1.3 moles of the gas at 250°C.

internal energy = ... J **[3]**

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(6 marks)