Thermal Properties of Materials

Question paper 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Thermal Properties of Materials
Sub Topic	
Paper Type	Theory
Booklet	Question paper 3

Time Allowed: 57 minutes

Score: /47

Percentage: /100

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 (a) State what is meant by the *internal energy* of a gas.

....

....

.... [2]

(b) The first law of thermodynamics may be represented by the equation

$$\Delta U = q + w.$$

State what is meant by each of the following symbols.

+ΔU ....

+q ....

+w ....
                                                                                                                     [3]

(c) An amount of 0.18 mol of an ideal gas is held in an insulated cylinder fitted with a piston, as shown in Fig. 2.1.
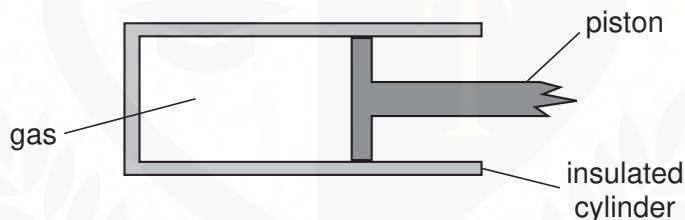

Fig. 2.1

Atmospheric pressure is 1.0×10^5 Pa.

The volume of the gas is suddenly increased from 1.8×10^3 cm^3 to 2.1×10^3 cm^3.

For the expansion of the gas,

(i) calculate the work done by the gas and hence show that the internal energy changes by 30 J,

                                                                                                                     [3]

(ii) determine the temperature change of the gas and state whether the change is an increase or a decrease.

change = ... K

....

[3]

2 When a liquid is boiling, thermal energy must be supplied in order to maintain a constant temperature.

(a) State two processes for which thermal energy is required during boiling.

1. ....

....

2. ....

....
[2]

(b) A student carries out an experiment to determine the specific latent heat of vaporisation of a liquid.
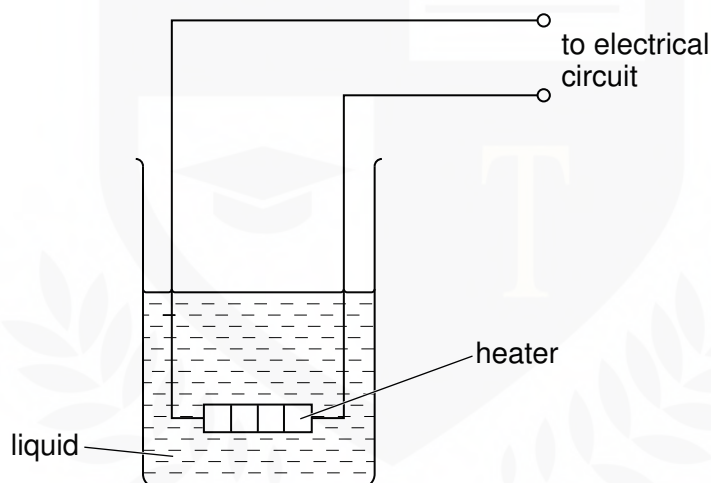Some liquid in a beaker is heated electrically as shown in Fig. 3.1.

Fig. 3.1

Energy is supplied at a constant rate to the heater. When the liquid is boiling at a constant rate, the mass of liquid evaporated in 5.0 minutes is measured.
The power of the heater is then changed and the procedure is repeated.
Data for the two power ratings are given in Fig. 3.2.

power of heater /W	mass evaporated in 5.0 minutes /g
50.0	6.5
70.0	13.6

Fig. 3.2

(i) Suggest

    1. how it may be checked that the liquid is boiling at a constant rate,

    ....

    .... [1]

    2. why the rate of evaporation is determined for two different power ratings.

    ....

    .... [1]

(ii) Calculate the specific latent heat of vaporisation of the liquid.

specific latent heat of vaporisation = ... $J g^{-1}$ [3]

3 **(a)** Define *specific latent heat of fusion*.

....

....

.... [2]

(b) Some crushed ice at $0\,°C$ is placed in a funnel together with an electric heater, as shown in Fig. 2.1.
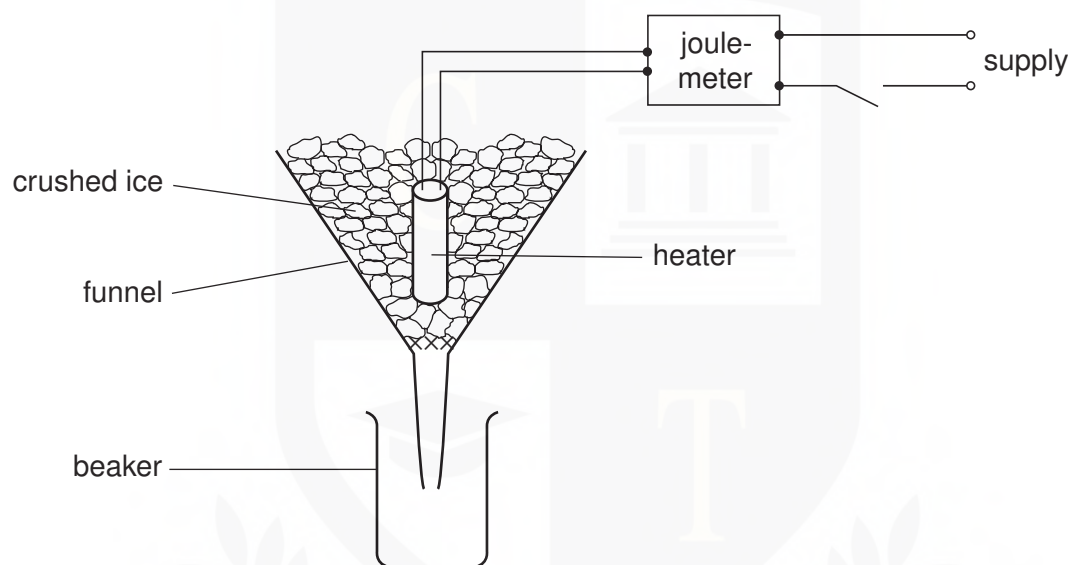

Fig. 2.1

The mass of water collected in the beaker in a measured interval of time is determined with the heater switched off. The mass is then found with the heater switched on. The energy supplied to the heater is also measured.

For both measurements of the mass, water is not collected until melting occurs at a constant rate.

The data shown in Fig. 2.2 are obtained.

	mass of water / g	energy supplied to heater / J	time interval / min
heater switched off heater switched on	16.6 64.7	0 18000	10.0 5.0

Fig. 2.2

(i) State why the mass of water is determined with the heater switched off.

....

[1]

(ii) Suggest how it can be determined that the ice is melting at a constant rate.

....

....[1]

(iii) Calculate a value for the specific latent heat of fusion of ice.

latent heat = ... kJ kg^{-1} [3]

4 **(a)** Write down an equation to represent the first law of thermodynamics in terms of the heating *q* of a system, the work *w* done on the system and the increase ΔU in the internal energy.

....[1]

(b) The pressure of an ideal gas is decreased at constant temperature.
Explain what change, if any, occurs in the internal energy of the gas.

....

....

....

....[3]
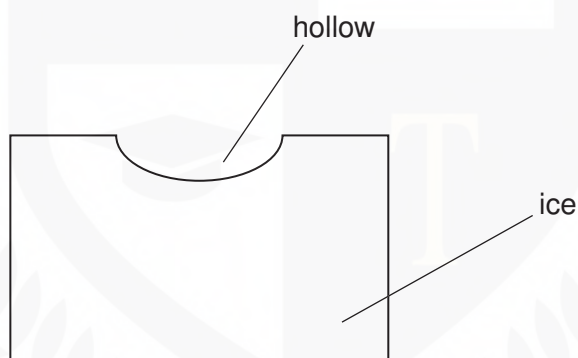
5 **(a)** Use the kinetic theory of matter to explain why melting requires energy but there is no change in temperature.

....

....

....

.... [3]

(b) Define *specific latent heat of fusion*.

....

....

.... [2]

(c) A block of ice at 0 °C has a hollow in its top surface, as illustrated in Fig. 2.1.

hollow

ice

Fig. 2.1

A mass of 160 g of water at 100 °C is poured into the hollow. The water has specific heat capacity $4.20 \, \text{kJ} \, \text{kg}^{-1} \, \text{K}^{-1}$. Some of the ice melts and the final mass of water in the hollow is 365 g.

(i) Assuming no heat gain from the atmosphere, calculate a value, in $\text{kJ} \, \text{kg}^{-1}$, for the specific latent heat of fusion of ice.

specific latent heat = ... $\text{kJ} \, \text{kg}^{-1}$ [3]

(ii) In practice, heat is gained from the atmosphere during the experiment. This means that your answer to **(i)** is not the correct value for the specific latent heat.
State and explain whether your value in **(i)** is greater or smaller than the correct value.

....

....

.... [2]

6 A mercury-in-glass thermometer is to be used to measure the temperature of some oil.

The oil has mass 32.0 g and specific heat capacity 1.40 J g^{-1} K^{-1}. The actual temperature of the oil is 54.0 °C.

The bulb of the thermometer has mass 12.0 g and an average specific heat capacity of 0.180 J g^{-1} K^{-1}. Before immersing the bulb in the oil, the thermometer reads 19.0 °C.

The thermometer bulb is placed in the oil and the steady reading on the thermometer is taken.

(a) Determine

    (i) the steady temperature recorded on the thermometer,

temperature = ………………………… °C [3]

(ii) the ratio

$$\frac{\text{change in temperature of oil}}{\text{initial temperature of oil}} \, .$$

ratio = ………………………… [1]

(b) Suggest, with an explanation, a type of thermometer that would be likely to give a smaller value for the ratio calculated in **(a)(ii)**.

....

....

.... [2]

(c) The mercury-in-glass thermometer is used to measure the boiling point of a liquid. Suggest why the measured value of the boiling point will **not** be affected by the thermal energy absorbed by the thermometer bulb.

....

....

....

.... [2]