Thermal Properties of Materials

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Thermal Properties of Materials
Sub Topic	
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: **59 minutes**

Score: **/49**

Percentage: **/100**

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

1 The volume of 1.00 kg of water in the liquid state at 100 °C is $1.00 \times 10^{-3}\,m^3$. The volume of 1.00 kg of water vapour at 100 °C and atmospheric pressure $1.01 \times 10^5\,Pa$ is $1.69\,m^3$.

(a) Show that the work done against the atmosphere when 1.00 kg of liquid water becomes water vapour is $1.71 \times 10^5\,J$.

[2]

(b) **(i)** The first law of thermodynamics may be given by the expression

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

where ΔU is the increase in internal energy of the system.

State what is meant by

1. $+ q$,

..... [1]

2. $+ w$.

..... [1]

(ii) The specific latent heat of vaporisation of water at 100 °C is $2.26 \times 10^6\,J\,kg^{-1}$.

A mass of 1.00 kg of liquid water becomes water vapour at 100 °C.

Determine, using your answer in **(a)**, the increase in internal energy of this mass of water during vaporisation.

increase in internal energy = ... J [2]

2 A microwave cooker uses electromagnetic waves of frequency 2450 MHz.
The microwaves warm the food in the cooker by causing water molecules in the food to oscillate with a large amplitude at the frequency of the microwaves.

(a) State the name given to this phenomenon.

..... [1]

(b) The effective microwave power of the cooker is 750 W.
The temperature of a mass of 280 g of water rises from 25 °C to 98 °C in a time of 2.0 minutes.

Calculate a value for the specific heat capacity of the water.

specific heat capacity = ... $J\,kg^{-1}\,K^{-1}$ [3]

(c) The value of the specific heat capacity determined from the data in **(b)** is greater than the accepted value.
A student gives as the reason for this difference: 'heat lost to the surroundings'.

Suggest, in more detail than that given by the student, a possible reason for the difference.

.....

..... [1]

3 (a) (i) State what is meant by the ***internal energy*** of a system.

.....

.....

.....[2]

(ii) Explain why, for an ideal gas, the internal energy is equal to the total kinetic energy of the molecules of the gas.

.....

.....

.....[2]

(b) The mean kinetic energy $<\boldsymbol{E}_K>$ of a molecule of an ideal gas is given by the expression

$$<\boldsymbol{E}_K> = \tfrac{3}{2}\boldsymbol{kT}$$

where ***k*** is the Boltzmann constant and ***T*** is the thermodynamic temperature of the gas.

A cylinder contains 1.0 mol of an ideal gas. The gas is heated so that its temperature changes from 280 K to 460 K.

(i) Calculate the change in total kinetic energy of the gas molecules.

change in energy = ... J [2]

(ii) During the heating, the gas expands, doing 1.5×10^3 J of work.
State the first law of thermodynamics. Use the law and your answer in **(i)** to determine the total energy supplied to the gas.

.....

.....

total energy = ... J [3]

4 A student suggests that, when an ideal gas is heated from 100 °C to 200 °C, the internal energy of the gas is doubled.

(a) (i) State what is meant by ***internal energy***.

.....

.....

.....[2]

(ii) By reference to one of the assumptions of the kinetic theory of gases and your answer in **(i)**, deduce what is meant by the internal energy of an ideal gas.

.....

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.....

.....[3]

(b) State and explain whether the student's suggestion is correct.

.....

.....

.....[2]

5 **(a)** Define ***specific latent heat***.

.....

.....

..... [2]

(b) The heater in an electric kettle has a power of 2.40 kW.
When the water in the kettle is boiling at a steady rate, the mass of water evaporated in 2.0 minutes is 106 g.
The specific latent heat of vaporisation of water is 2260 J g^{-1}.

Calculate the rate of loss of thermal energy to the surroundings of the kettle during the boiling process.

rate of loss = ... W [3]

6 **(a)** State what is meant by the ***internal energy*** of a system.

.....

.....

.....[2]

(b) State and explain qualitatively the change, if any, in the internal energy of the following systems:

(i) a lump of ice at 0 °C melts to form liquid water at 0 °C,

.....

.....

.....

.....[3]

(ii) a cylinder containing gas at constant volume is in sunlight so that its temperature rises from 25 °C to 35 °C.

.....

.....

.....

.....[3]

7 **(a)** The first law of thermodynamics may be expressed in the form

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

Explain the symbols in this expression.

+ ΔU .....

+ ***q*** .....

+ ***w*** .....

[3]

(b) **(i)** State what is meant by ***specific latent heat***.

.....

.....

.....

..... [3]

(ii) Use the first law of thermodynamics to explain why the specific latent heat of vaporisation is greater than the specific latent heat of fusion for a particular substance.

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..... [3]