PapaCambridge

Cambridge International AS & A Level

PHYSICS

Paper 4

Topical Past Paper Questions
+ Answer Scheme

2016 - 2021

PapaCambridge

Chapter 4

Thermal properties of materials

51. 9702_m21_qp_42 Q: 3

(a) Using a simple kinetic model of matter, describe the structure of a solid.

....

....

.... [2]

(b) The specific latent heat of vaporisation is much greater than the specific latent heat of fusion for the same substance.
Explain this, in terms of the spacing of molecules.

....

....

.... [1]

(c) A heater supplies energy at a constant rate to 0.045 kg of a substance. The variation with time of the temperature of the substance is shown in Fig. 3.1. The substance is perfectly insulated from its surroundings.

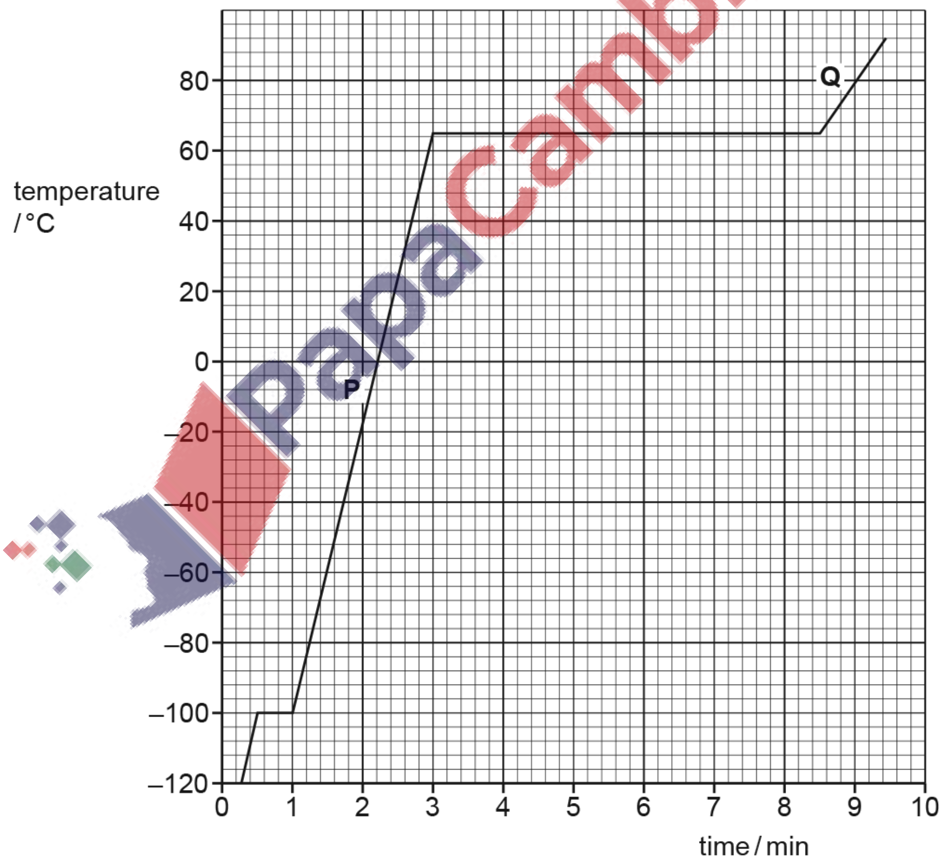

Fig. 3.1

(i) Determine the temperature at which the substance melts.

temperature = ... °C [1]

(ii) The power of the heater is 150 W.
Use data from Fig. 3.1 to calculate, in $kJ\,kg^{-1}$, the specific latent heat of vaporisation L of the substance.

L = ... $kJ\,kg^{-1}$ [3]

(iii) Suggest what can be deduced from the fact that section **Q** on the graph is less steep than section **P**.

....

.... [1]

[Total: 8]

52. 9702_m20_qp_42 Q: 2

A large container of volume 85 m^3 is filled with 110 kg of an ideal gas. The pressure of the gas is 1.0×10^5 Pa at temperature T.

The mass of 1.0 mol of the gas is 32 g.

(a) Show that the temperature T of the gas is approximately 300 K.

[3]

(b) The temperature of the gas is increased to 350 K at constant volume. The specific heat capacity of the gas for this change is 0.66 J kg^{-1} K^{-1}.

Calculate the energy supplied to the gas by heating.

energy = ... J [2]

(c) Explain how movement of the gas molecules causes pressure in the container.

....

....

....

....

....

....

.... [3]

(d) The temperature of a gas depends on the root-mean-square (r.m.s.) speed of its molecules.

Calculate the ratio:

$$\frac{\text{r.m.s. speed of gas molecules at 350 K}}{\text{r.m.s. speed of gas molecules at 300 K}}.$$

ratio = ... [2]

[Total: 10]

---

53. 9702_w19_qp_41 Q: 3

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

....

....

.... [2]

(b) A student determines the specific latent heat of vaporisation of a liquid using the apparatus illustrated in Fig. 3.1.

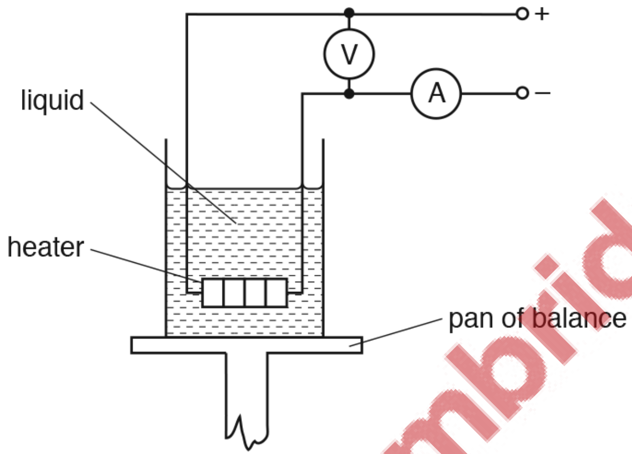

Fig. 3.1

The heater is switched on. When the liquid is boiling at a constant rate, the balance reading is noted at 2.0 minute intervals.

After 10 minutes, the current in the heater is reduced and the balance readings are taken for a further 12 minutes.

The readings of the ammeter and of the voltmeter are given in Fig. 3.2.

	ammeter reading /A	voltmeter reading /V
from time 0 to time 10 minutes after time 10 minutes	1.2 1.0	230 190

Fig. 3.2

The variation with time of the balance reading is shown in Fig. 3.3.

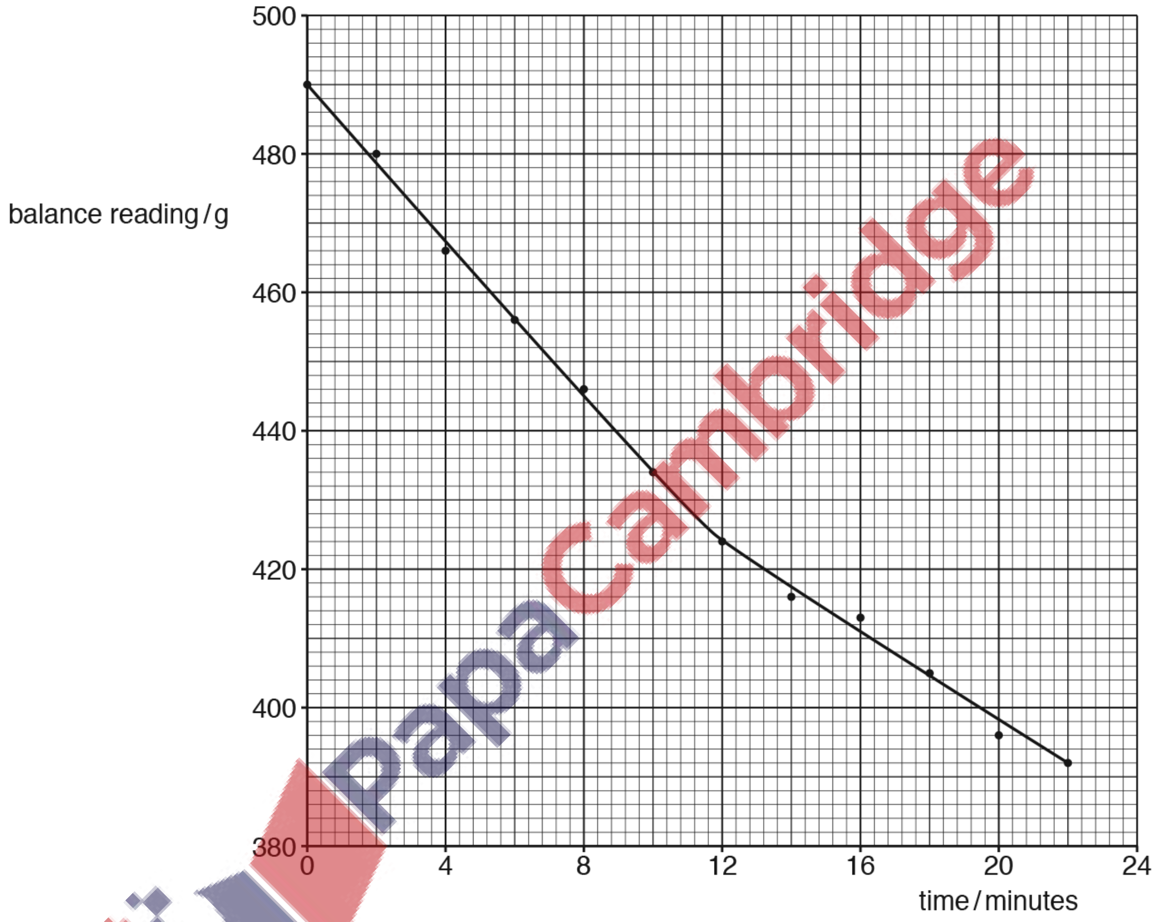

Fig. 3.3

(i) From time 0 to time 10.0 minutes, the mass of liquid evaporated is 56 g.

Use Fig. 3.3 to determine the mass of liquid evaporated from time 12.0 minutes to time 22.0 minutes.

mass = ... g [1]

(ii) Explain why, although the power of the heater is changed, the rate of loss of thermal energy to the surroundings may be assumed to be constant.

....

.... [1]

(iii) Determine a value for the specific latent heat of vaporisation *L* of the liquid.

L = ... $J\,g^{-1}$ [4]

(iv) Calculate the rate at which thermal energy is transferred to the surroundings.

rate = ... W [2]

[Total: 10]

54. 9702_w19_qp_42 Q: 3

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

....

....

.... [2]

(b) A student uses the apparatus illustrated in Fig. 3.1 to determine a value for the specific latent heat of fusion of ice.

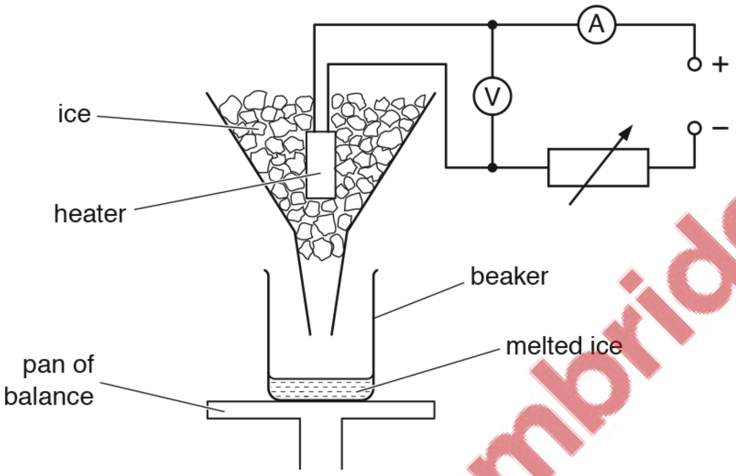

Fig. 3.1

The balance reading measures the mass of the beaker and the melted ice (water) in the beaker.

The heater is switched on and pieces of ice at 0 °C are added continuously to the funnel so that the heater is always surrounded by ice.

When water drips out of the funnel at a constant rate, the balance reading is noted at 2.0 minute intervals. After 10 minutes, the current in the heater is increased and the balance readings are taken for a further 12 minutes.

The variation with time of the balance reading is shown in Fig. 3.2.

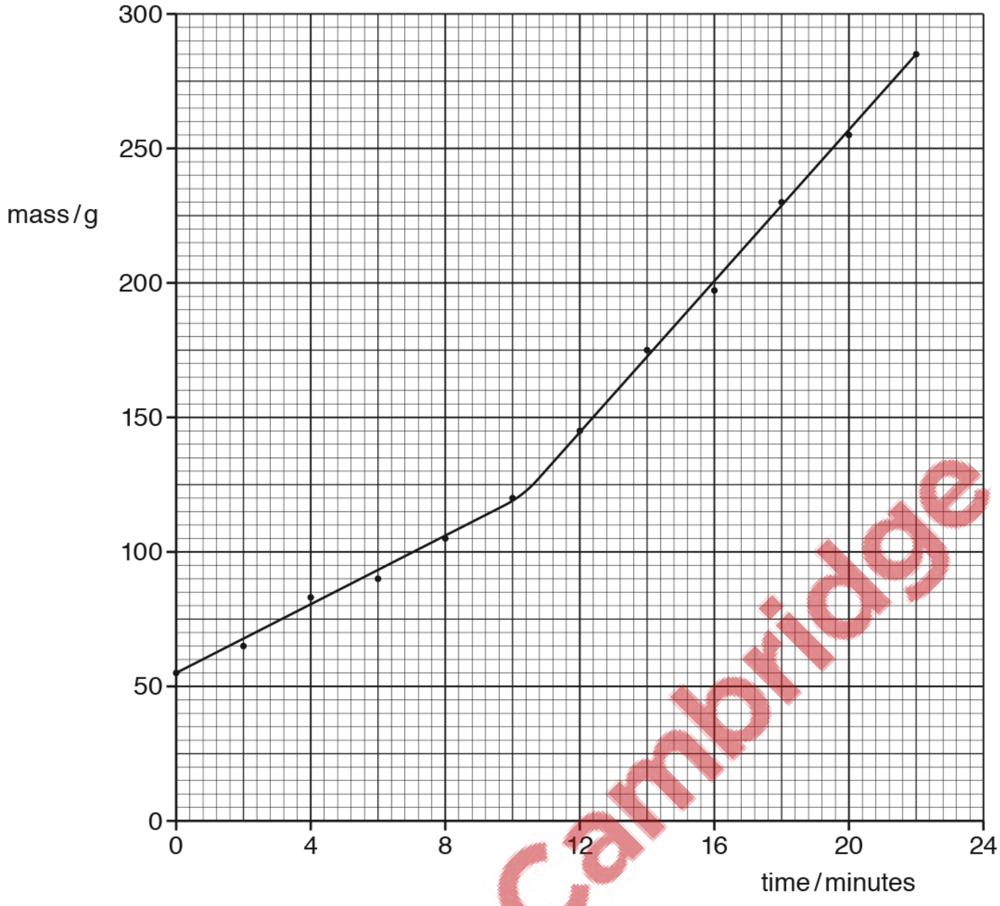

Fig. 3.2

The readings of the ammeter and of the voltmeter are shown in Fig. 3.3.

	ammeter reading / A	voltmeter reading / V
from time 0 to time 10 minutes after time 10 minutes	1.8 3.6	7.3 15.1

Fig. 3.3

(i) From time 0 to time 10.0 minutes, 65 g of ice is melted.

Use Fig. 3.2 to determine the mass of ice melted from time 12.0 minutes to time 22.0 minutes.

mass = ... g [1]

(ii) Explain why, although the power of the heater is changed, the rate at which thermal energy is transferred from the surroundings to the ice is constant.

....

.... [1]

(iii) Determine a value for the specific latent heat of fusion *L* of ice.

L = ... $J\,g^{-1}$ [4]

(iv) Calculate the rate at which thermal energy is transferred from the surroundings to the ice.

rate = ... W [2]

[Total: 10]

55. 9702_w19_qp_43 Q: 3

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

....

....

.... [2]

(b) A student determines the specific latent heat of vaporisation of a liquid using the apparatus illustrated in Fig. 3.1.

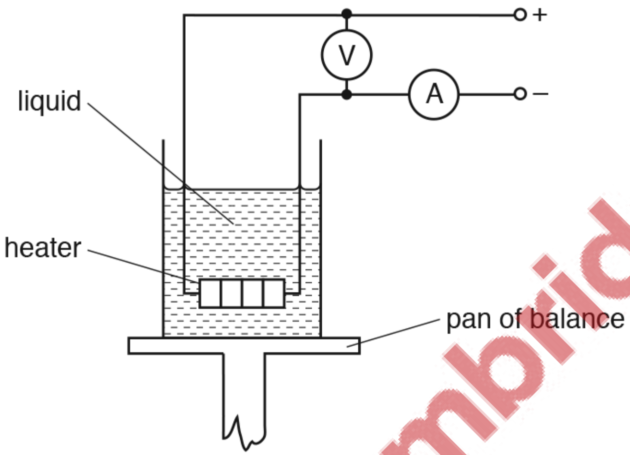

Fig. 3.1

The heater is switched on. When the liquid is boiling at a constant rate, the balance reading is noted at 2.0 minute intervals.

After 10 minutes, the current in the heater is reduced and the balance readings are taken for a further 12 minutes.

The readings of the ammeter and of the voltmeter are given in Fig. 3.2.

	ammeter reading /A	voltmeter reading /V
from time 0 to time 10 minutes	1.2	230
after time 10 minutes	1.0	190

Fig. 3.2

The variation with time of the balance reading is shown in Fig. 3.3.

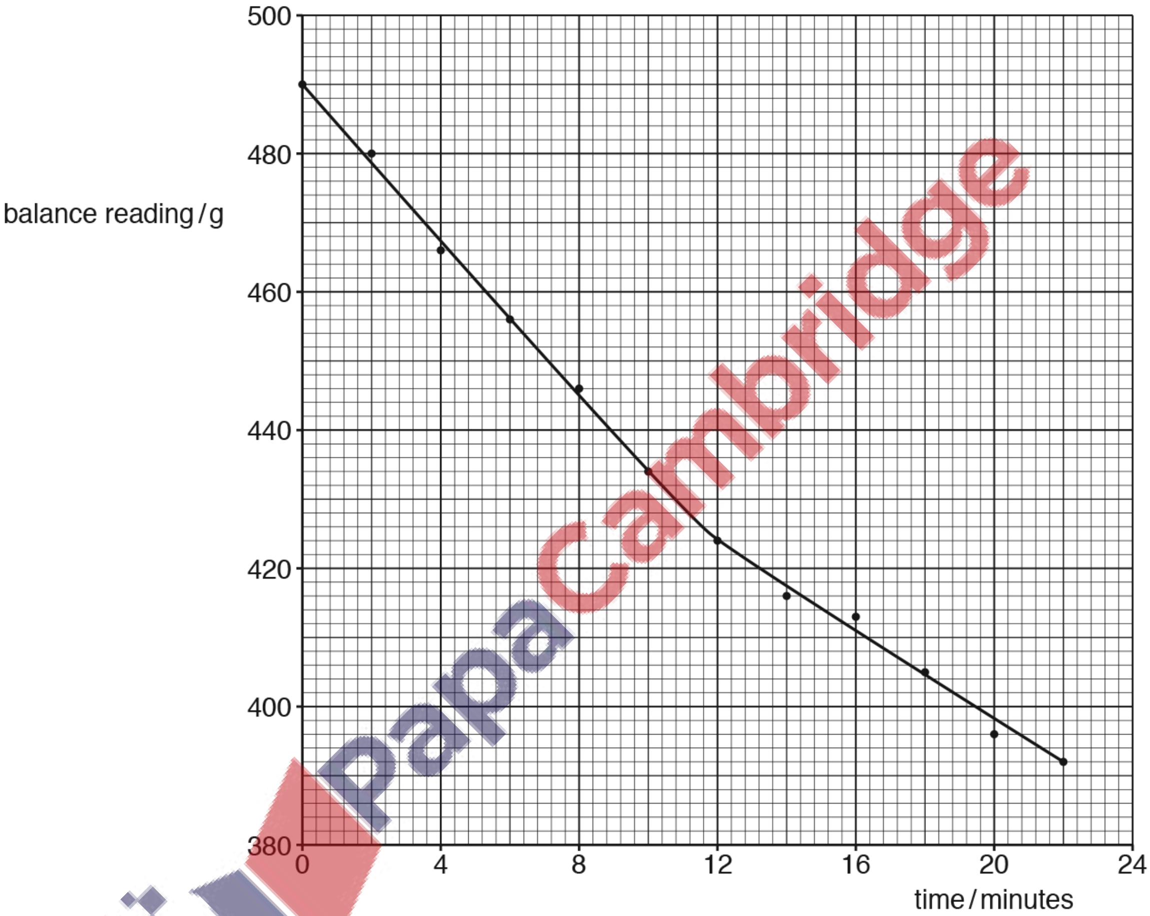

Fig. 3.3

(i) From time 0 to time 10.0 minutes, the mass of liquid evaporated is 56 g.

Use Fig. 3.3 to determine the mass of liquid evaporated from time 12.0 minutes to time 22.0 minutes.

mass = ... g [1]

(ii) Explain why, although the power of the heater is changed, the rate of loss of thermal energy to the surroundings may be assumed to be constant.

....

.... [1]

(iii) Determine a value for the specific latent heat of vaporisation *L* of the liquid.

L = ... $J\,g^{-1}$ [4]

(iv) Calculate the rate at which thermal energy is transferred to the surroundings.

rate = ... W [2]

[Total: 10]

56. 9702_s18_qp_42 Q: 3

(a) During melting, a solid becomes liquid with little or no change in volume.

Use kinetic theory to explain why, during the melting process, thermal energy is required although there is no change in temperature.

....

....

....

....

....[3]

(b) An aluminium can of mass 160 g contains a mass of 330 g of warm water at a temperature of 38 °C, as illustrated in Fig. 3.1.

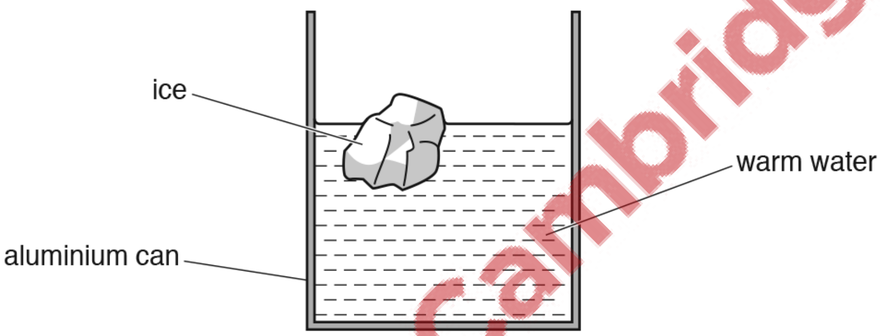

Fig. 3.1

A mass of 48 g of ice at –18 °C is taken from a freezer and put in to the water. The ice melts and the final temperature of the can and its contents is 23 °C.

Data for the specific heat capacity *c* of aluminium, ice and water are given in Fig. 3.2.

	c / J g^{-1} K^{-1}
aluminium	0.910
ice	2.10
water	4.18

Fig. 3.2

Assuming no exchange of thermal energy with the surroundings,

(i) show that the loss in thermal energy of the can and the warm water is 2.3×10^4 J,

[2]

(ii) use the information in **(i)** to calculate a value *L* for the specific latent heat of fusion of ice.

L = ... $J g^{-1}$ [2]

[Total: 7]

57. 9702_w18_qp_42 Q: 3

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

....

....

....[2]

(b) A student sets up the apparatus shown in Fig. 3.1 in order to investigate the melting of ice.

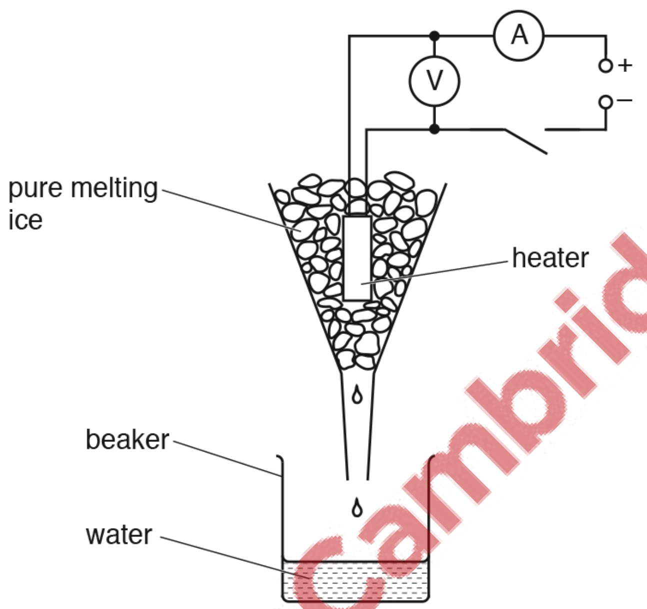

Fig. 3.1

The heater is switched on.
When the pure ice is melting at a constant rate, the data shown in Fig. 3.2 are collected.

voltmeter reading /V	ammeter reading /A	initial mass of beaker plus water/g	final mass of beaker plus water/g	time of collection /minutes
12.8	4.60	121.5	185.0	5.00

Fig. 3.2

The specific latent heat of fusion of ice is $332\,J\,g^{-1}$.

(i) State what is observed by the student that shows that the ice is melting at a constant rate.

....

....[1]

(ii) Use the data in Fig. 3.2 to determine the rate at which

1. thermal energy is transferred to the melting ice,

rate = ... W

2. thermal energy is gained from the surroundings.

rate = ... W
[4]

[Total: 7]

58. 9702_s17_qp_42 Q: 2

(a) The pressure p and volume V of an ideal gas are related to the density ρ of the gas by the expression

$$p = \frac{1}{3}\rho\langle c^2\rangle.$$

(i) State what is meant by the symbol $\langle c^2\rangle$.

....

....[1]

(ii) Use the expression to show that the mean kinetic energy E_K of a gas molecule is given by

$$E_K = \frac{3}{2}kT$$

where k is the Boltzmann constant and T is the thermodynamic temperature.

[3]

(b) **(i)** An ideal gas containing 1.0 mol of molecules is heated at constant volume.
Use the expression in **(a)(ii)** to show that the thermal energy required to raise the temperature of the gas by 1.0 K has a value of $\frac{3}{2}R$, where R is the molar gas constant.

[3]

(ii) Nitrogen may be assumed to be an ideal gas. The molar mass of nitrogen gas is 28 g mol^{-1}. Use the answer in **(b)(i)** to calculate a value for the specific heat capacity, in J kg^{-1} K^{-1}, at constant volume for nitrogen.

specific heat capacity = ... J kg^{-1} K^{-1} [2]

[Total: 9]

59. 9702_w17_qp_41 Q: 1

(a) State

(i) what may be deduced from the difference in the temperatures of two objects,

....

.... [1]

(ii) the basic principle by which temperature is measured.

....

.... [1]

(b) By reference to your answer in **(a)(ii)**, explain why two thermometers may not give the same temperature reading for an object.

....

....

.... [2]

(c) A block of aluminium of mass 670 g is heated at a constant rate of 95 W for 6.0 minutes.
The specific heat capacity of aluminium is 910 J kg^{-1} K^{-1}.
The initial temperature of the block is 24 °C.

(i) Assuming that no thermal energy is lost to the surroundings, show that the final temperature of the block is 80 °C.

[3]

(ii) In practice, there are energy losses to the surroundings.
The actual variation with time *t* of the temperature *θ* of the block is shown in Fig. 1.1.

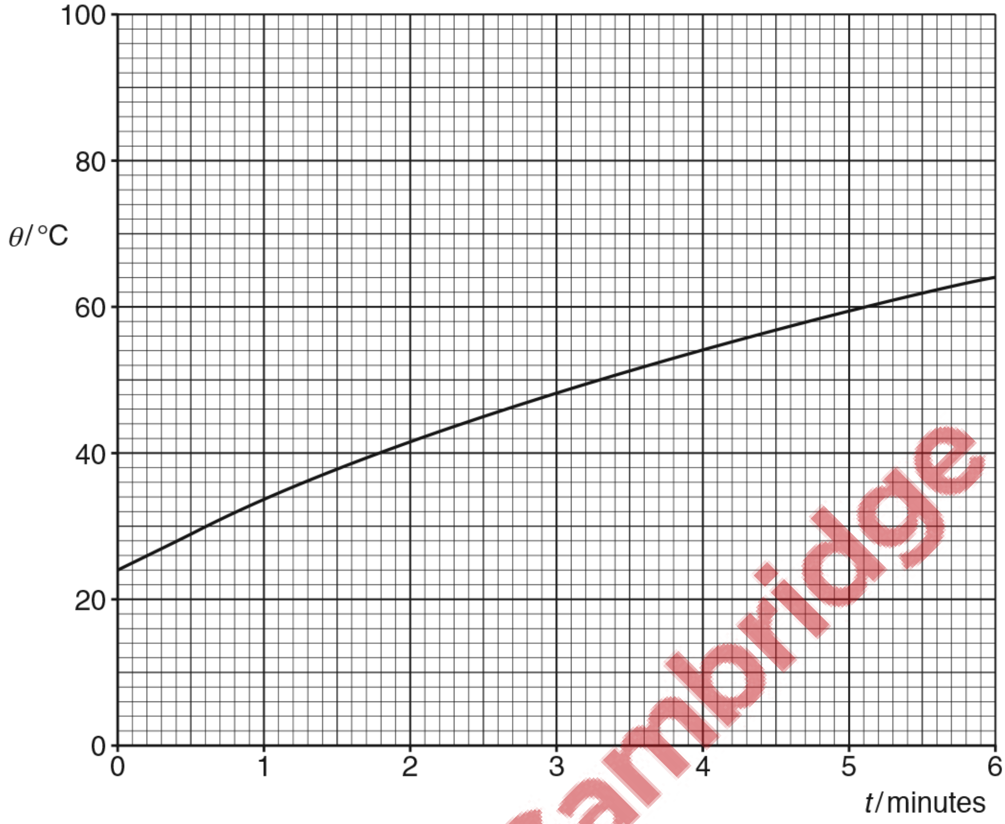

Fig. 1.1

1. Use the information in **(i)** to draw, on Fig. 1.1, a line to represent the temperature of the block, assuming no energy losses to the surroundings. [1]

2. Using Fig. 1.1, calculate the total energy loss to the surroundings during the heating process.

energy loss = ... J [2]

[Total: 10]

60. 9702_w17_qp_43 Q: 1

(a) State

(i) what may be deduced from the difference in the temperatures of two objects,

....

.... [1]

(ii) the basic principle by which temperature is measured.

....

.... [1]

(b) By reference to your answer in **(a)(ii)**, explain why two thermometers may not give the same temperature reading for an object.

....

....

.... [2]

(c) A block of aluminium of mass 670 g is heated at a constant rate of 95 W for 6.0 minutes.
The specific heat capacity of aluminium is 910 J kg^{-1} K^{-1}.
The initial temperature of the block is 24 °C.

(i) Assuming that no thermal energy is lost to the surroundings, show that the final temperature of the block is 80 °C.

[3]

(ii) In practice, there are energy losses to the surroundings.
The actual variation with time t of the temperature θ of the block is shown in Fig. 1.1.

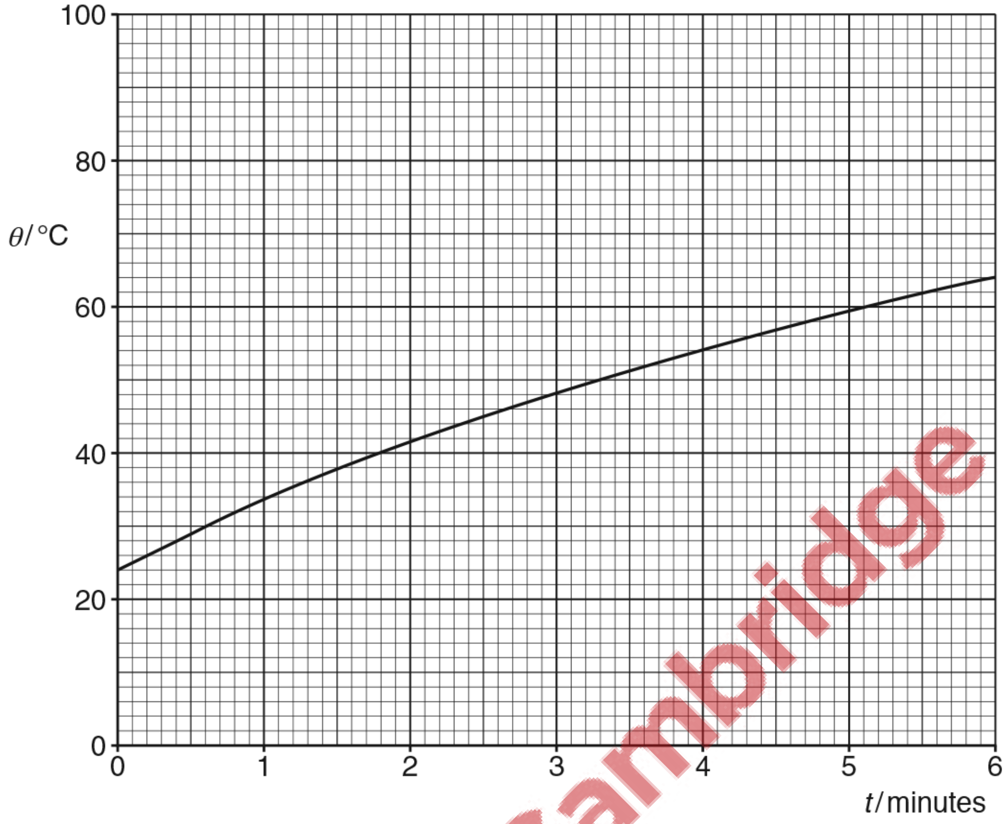

Fig. 1.1

1. Use the information in **(i)** to draw, on Fig. 1.1, a line to represent the temperature of the block, assuming no energy losses to the surroundings. [1]

2. Using Fig. 1.1, calculate the total energy loss to the surroundings during the heating process.

energy loss = ... J [2]

[Total: 10]

61. 9702_s21_qp_41 Q: 2

An ideal gas is contained in a cylinder by means of a movable frictionless piston, as illustrated in Fig. 2.1.

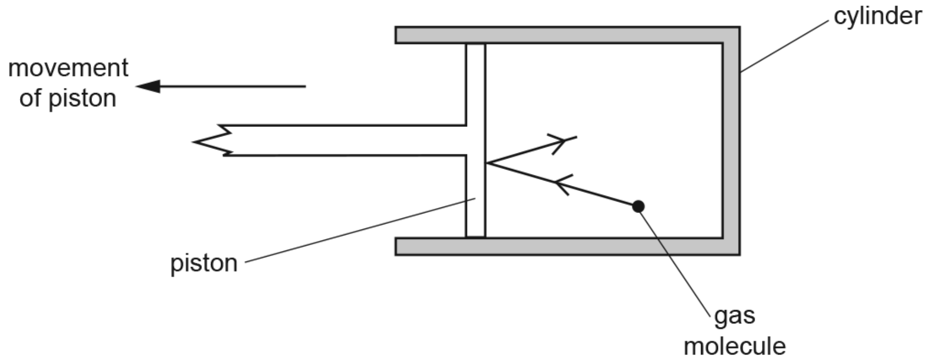

Fig. 2.1

Initially, the gas has a volume of $1.8 \times 10^{-3}\,m^3$ at a pressure of $3.3 \times 10^5\,Pa$ and a temperature of 310 K.

(a) Show that the number of gas molecules in the cylinder is 1.4×10^{23}.

[2]

(b) Use kinetic theory to explain why, when the piston is moved so that the gas expands, this causes a decrease in the temperature of the gas.

....

....

....

.... [3]

(c) The gas expands so that its volume increases to $2.4 \times 10^{-3}\,m^3$ at a pressure of $2.3 \times 10^5\,Pa$ and a temperature of 288 K, as shown in Fig. 2.2.

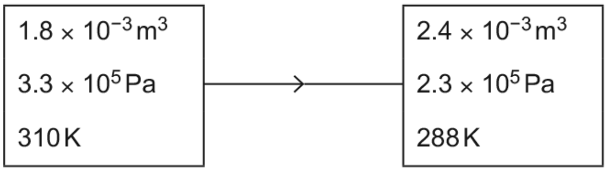

Fig. 2.2

(i) The average translational kinetic energy E_K of a molecule of an ideal gas is given by

$$E_K = \frac{3}{2}kT$$

where k is the Boltzmann constant and T is the thermodynamic temperature.

Calculate the increase in internal energy ΔU of the gas during the expansion.

ΔU = ... J [3]

(ii) The work done by the gas during the expansion is 76 J.

Use your answer in **(i)** to explain whether thermal energy is transferred to or from the gas during the expansion.

....

....

.... [2]

[Total: 10]

62. 9702_s21_qp_42 Q: 2

An ideal gas has a volume of $3.1 \times 10^{-3}\,\text{m}^3$ at a pressure of $8.5 \times 10^5\,\text{Pa}$ and a temperature of 290 K, as shown in Fig. 2.1.

volume $3.1 \times 10^{-3}\,\text{m}^3$ pressure $8.5 \times 10^5\,\text{Pa}$ temperature 290 K	→	volume $6.3 \times 10^{-3}\,\text{m}^3$ pressure $2.7 \times 10^5\,\text{Pa}$ temperature T_F

Fig. 2.1

The gas suddenly expands to a volume of $6.3 \times 10^{-3}\,\text{m}^3$. During the expansion, no thermal energy is transferred. The final pressure of the gas is $2.7 \times 10^5\,\text{Pa}$ at temperature T_F, as shown in Fig. 2.1.

(a) Show that the number of gas molecules is 6.6×10^{23}.

[3]

(b) **(i)** Show that the final temperature T_F of the gas is 190 K.

[1]

(ii) The average translational kinetic energy E_K of a molecule of an ideal gas is given by

$$E_K = \frac{3}{2}kT$$

where T is the thermodynamic temperature and k is the Boltzmann constant.

Calculate the increase in internal energy ΔU of the gas.

ΔU = ... J [3]

(c) Use the first law of thermodynamics to explain why the external work w done on the gas during the expansion is equal to the increase in internal energy in **(b)(ii)**.

....

....

.... [2]

[Total: 9]

63. 9702_s21_qp_43 Q: 2

An ideal gas is contained in a cylinder by means of a movable frictionless piston, as illustrated in Fig. 2.1.

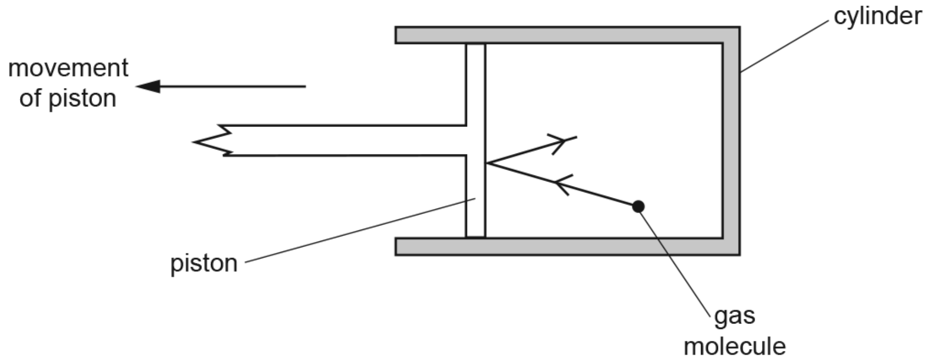

Fig. 2.1

Initially, the gas has a volume of $1.8 \times 10^{-3}\,m^3$ at a pressure of $3.3 \times 10^5\,Pa$ and a temperature of 310 K.

(a) Show that the number of gas molecules in the cylinder is 1.4×10^{23}.

[2]

(b) Use kinetic theory to explain why, when the piston is moved so that the gas expands, this causes a decrease in the temperature of the gas.

....

....

....

.... [3]

(c) The gas expands so that its volume increases to $2.4 \times 10^{-3}\,m^3$ at a pressure of $2.3 \times 10^5\,Pa$ and a temperature of 288 K, as shown in Fig. 2.2.

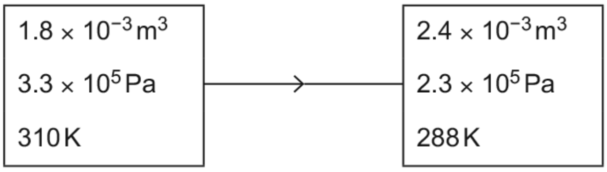

Fig. 2.2

(i) The average translational kinetic energy E_K of a molecule of an ideal gas is given by

$$E_K = \frac{3}{2}kT$$

where k is the Boltzmann constant and T is the thermodynamic temperature.

Calculate the increase in internal energy ΔU of the gas during the expansion.

ΔU = ... J [3]

(ii) The work done by the gas during the expansion is 76 J.

Use your answer in **(i)** to explain whether thermal energy is transferred to or from the gas during the expansion.

....

....

.... [2]

[Total: 10]

64. 9702_w21_qp_41 Q: 3

(a) Define *specific heat capacity*.

....

....

.... [2]

(b) A sealed container of fixed volume V contains N molecules, each of mass m, of an ideal gas at pressure p.

(i) State an expression, in terms of V, N, p and the Boltzmann constant k, for the thermodynamic temperature T of the gas.

.... [1]

(ii) Show that the mean translational kinetic energy E_K of a molecule of the gas is given by

$$E_K = \frac{3}{2}kT.$$

[2]

(iii) Explain why the internal energy of the gas is equal to the total kinetic energy of the molecules.

....

....

.... [2]

(c) The gas in **(b)** is supplied with thermal energy Q.

(i) Explain, with reference to the first law of thermodynamics, why the increase in internal energy of the gas is Q.

....

....

.... [2]

(ii) Use the expression in **(b)(ii)** and the information in **(c)(i)** to show that the specific heat capacity c of the gas is given by

$$c = \frac{3k}{2m}.$$

[2]

(d) The container in **(b)** is now replaced with one that does not have a fixed volume. Instead, the gas is able to expand, so that the pressure of the gas remains constant as thermal energy is supplied.

Suggest, with a reason, how the specific heat capacity of the gas would now compare with the value in **(c)(ii)**.

....

....

....

.... [2]

[Total: 13]

65. 9702_w21_qp_43 Q: 3

(a) Define *specific heat capacity*.

....

....

.... [2]

(b) A sealed container of fixed volume V contains N molecules, each of mass m, of an ideal gas at pressure p.

(i) State an expression, in terms of V, N, p and the Boltzmann constant k, for the thermodynamic temperature T of the gas.

.... [1]

(ii) Show that the mean translational kinetic energy E_K of a molecule of the gas is given by

$$E_K = \frac{3}{2}kT.$$

[2]

(iii) Explain why the internal energy of the gas is equal to the total kinetic energy of the molecules.

....

....

.... [2]

(c) The gas in **(b)** is supplied with thermal energy Q.

(i) Explain, with reference to the first law of thermodynamics, why the increase in internal energy of the gas is Q.

....

....

.... [2]

(ii) Use the expression in **(b)(ii)** and the information in **(c)(i)** to show that the specific heat capacity c of the gas is given by

$$c = \frac{3k}{2m}.$$

[2]

(d) The container in **(b)** is now replaced with one that does not have a fixed volume. Instead, the gas is able to expand, so that the pressure of the gas remains constant as thermal energy is supplied.

Suggest, with a reason, how the specific heat capacity of the gas would now compare with the value in **(c)(ii)**.

....

....

....

.... [2]

[Total: 13]

66. 9702_s20_qp_41 Q: 2

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

....

....

....

.... [2]

(b) By reference to intermolecular forces, explain why the change in internal energy of an ideal gas is equal to the change in total kinetic energy of its molecules.

....

....

.... [2]

(c) State and explain the change, if any, in the internal energy of a solid metal ball as it falls under gravity in a vacuum.

....

....

....

.... [3]

[Total: 7]

67. 9702_s20_qp_42 Q: 3

By reference to the first law of thermodynamics, state and explain the change, if any, in the internal energy of:

(a) a lump of solid lead as it melts at constant temperature

....

....

....

....

.... [3]

(b) some gas in a toy balloon when the balloon bursts and no thermal energy enters or leaves the gas.

....

....

....

....

.... [3]

[Total: 6]

68. 9702_s20_qp_43 Q: 2

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

....

....

....

.... [2]

(b) By reference to intermolecular forces, explain why the change in internal energy of an ideal gas is equal to the change in total kinetic energy of its molecules.

....

....

.... [2]

(c) State and explain the change, if any, in the internal energy of a solid metal ball as it falls under gravity in a vacuum.

....

....

....

.... [3]

[Total: 7]

69. 9702_s19_qp_41 Q: 2

A fixed mass of an ideal gas has volume 210 cm^3 at pressure 3.0×10^5 Pa and temperature 270 K.

The volume of the gas is reduced at constant pressure to 140 cm^3, as shown in Fig. 2.1.

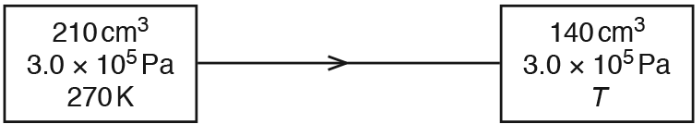

Fig. 2.1

The final temperature of the gas is *T*.

(a) Determine:

(i) the amount of gas

amount = ... mol [3]

(ii) the final temperature *T* of the gas

T = ...K [2]

(iii) the external work done on the gas.

work done = ... J [2]

(b) For this change in volume and temperature of the gas, the thermal energy transferred is 53 J.

Determine ΔU, the change in internal energy of the gas.

ΔU = ... J [3]

[Total: 10]

---

70. 9702_s19_qp_42 Q: 2

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

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

(i) State, for a system, what is meant by:

1. $+q$

....

....

2. $+w$.

....

....
[2]

(ii) State what is represented by a negative value of ΔU.

....

....[1]

(b) An ideal gas, sealed in a container, undergoes the cycle of changes shown in Fig. 2.1.

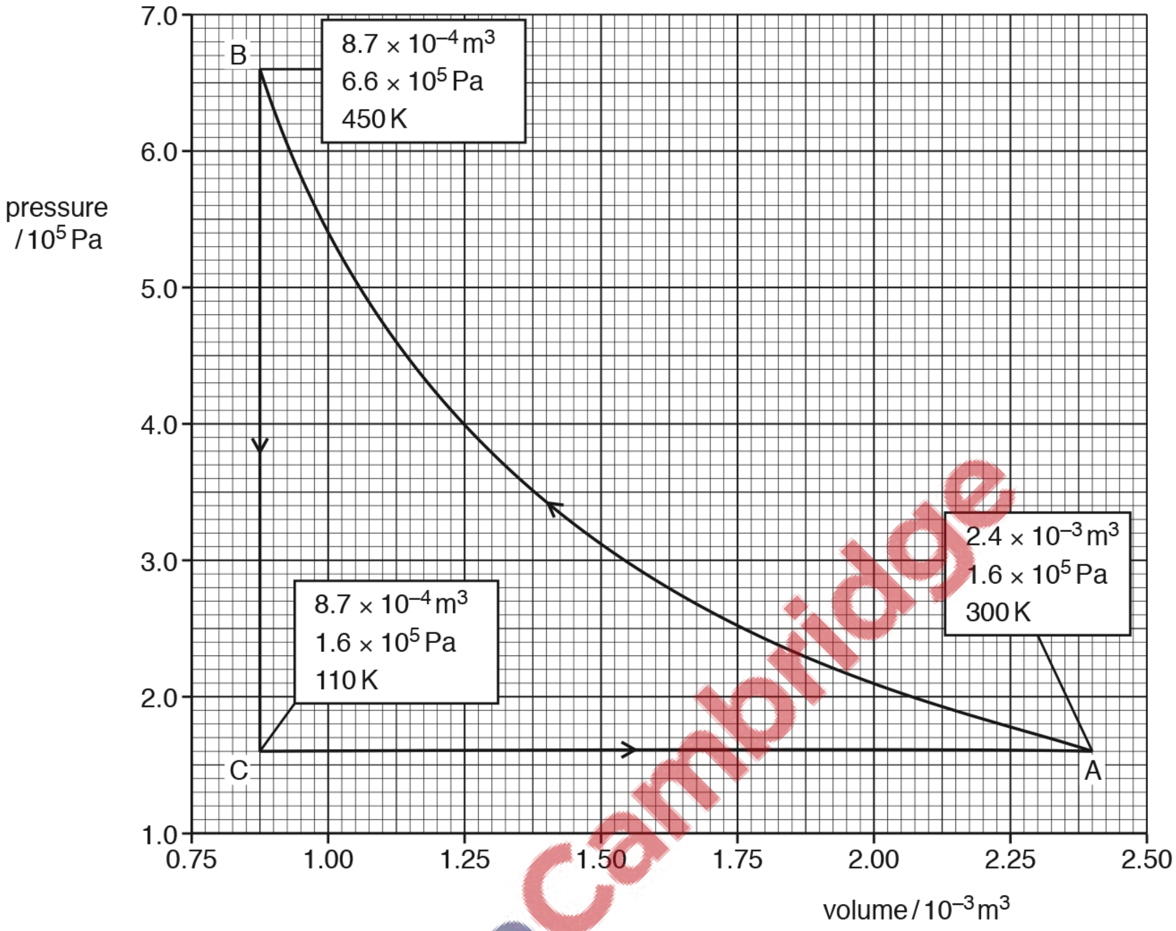

Fig. 2.1

At point A, the gas has volume 2.4×10^{-3} m^3, pressure 1.6×10^5 Pa and temperature 300 K.

The gas is compressed suddenly so that no thermal energy enters or leaves the gas during the compression. The amount of work done is 480 J so that, at point B, the gas has volume 8.7×10^{-4} m^3, pressure 6.6×10^5 Pa and temperature 450 K.

The gas is now cooled at constant volume so that, between points B and C, 1100 J of thermal energy is transferred. At point C, the gas has pressure 1.6×10^5 Pa and temperature 110 K.

Finally, the gas is returned to point A.

(i) State and explain the total change in internal energy of the gas for one complete cycle ABCA.

....

....

....[2]

(ii) Calculate the external work done on the gas during the expansion from point C to point A.

work done = ... J [2]

(iii) Complete Fig. 2.2 for the changes from:

1. point A to point B

2. point B to point C

3. point C to point A.

change	$+q$/J	$+w$/J	ΔU/J
A → B	....	....	....
B → C	....	....	....
C → A	....	....	....

Fig. 2.2

[4]

[Total: 11]

71. 9702_s19_qp_43 Q: 2

A fixed mass of an ideal gas has volume 210 cm^3 at pressure 3.0×10^5 Pa and temperature 270 K.

The volume of the gas is reduced at constant pressure to 140 cm^3, as shown in Fig. 2.1.

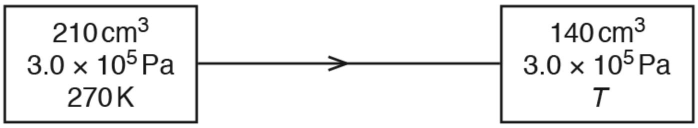

Fig. 2.1

The final temperature of the gas is T.

(a) Determine:

(i) the amount of gas

amount = ... mol [3]

(ii) the final temperature T of the gas

T = ...K [2]

(iii) the external work done on the gas.

work done = ... J [2]

(b) For this change in volume and temperature of the gas, the thermal energy transferred is 53 J.

Determine ΔU, the change in internal energy of the gas.

ΔU = ... J [3]

[Total: 10]

72. 9702_w19_qp_42 Q: 2

(a) Smoke particles are suspended in still air. Brownian motion of the smoke particles is seen through a microscope.

Describe:

(i) what is seen through the microscope

....

.... [1]

(ii) how Brownian motion provides evidence for the nature of the movement of gas molecules.

....

....

.... [2]

(b) A fixed mass of an ideal gas has volume $2.40 \times 10^3\,cm^3$ at pressure $3.51 \times 10^5\,Pa$ and temperature 290 K. The gas is heated at constant volume until the temperature is 310 K at pressure $3.75 \times 10^5\,Pa$, as illustrated in Fig. 2.1.

Fig. 2.1

The quantity of thermal energy required to raise the temperature of 1.00 mol of the gas by 1.00 K at constant volume is 12.5 J.

Calculate, to three significant figures:

(i) the amount, in mol, of the gas

amount = ... mol [3]

(ii) the thermal energy transfer during the change.

energy transfer = ... J [2]

(c) For the change in the gas in **(b)**, state:

(i) the quantity of external work done on the gas

work done = ... J [1]

(ii) the change in internal energy, with the direction of this change.

change = ... J

direction ....

[2]

[Total: 11]

73. 9702_m18_qp_42 Q: 2

A cylinder contains 5.12 mol of an ideal gas at pressure of 5.60×10^5 Pa and volume 3.80×10^4 cm^3.

(a) Determine the temperature of the gas.

temperature = ... K [2]

(b) The average kinetic energy E_K of a molecule of the gas is given by the expression

$$E_K = \frac{3}{2} kT$$

where k is the Boltzmann constant and T is the thermodynamic temperature.

The gas is heated at constant pressure so that its temperature rises by 125 K.

(i) Use your answer in **(a)** to determine the new volume of the gas.

volume = ... cm^3 [2]

(ii) Calculate the increase in internal energy of the gas. Explain your working.

increase in internal energy = ... J [3]

(c) **(i)** Use your answer in **(b)(i)** to determine the external work done during the expansion of the gas.

work done = ... J [2]

(ii) Calculate the total thermal energy required to heat the gas in **(b)**.

energy = ... J [1]

[Total: 10]

74. 9702_s18_qp_41 Q: 3

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

....

....

....

....[2]

(ii) Explain why, for an ideal gas, the change in internal energy is directly proportional to the change in thermodynamic temperature of the gas.

....

....

....

....

....[3]

(b) A cylinder of volume $1.8 \times 10^4\,\text{cm}^3$ contains helium gas at pressure $6.4 \times 10^6\,\text{Pa}$ and temperature 25 °C.
Helium gas may be considered to be an ideal gas consisting of single atoms.

Calculate the number of helium atoms in the cylinder.

number = ...[3]

[Total: 8]

75. 9702_s18_qp_43 Q: 3

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

....

....

....

....[2]

(ii) Explain why, for an ideal gas, the change in internal energy is directly proportional to the change in thermodynamic temperature of the gas.

....

....

....

....

....[3]

(b) A cylinder of volume $1.8 \times 10^4 \text{cm}^3$ contains helium gas at pressure $6.4 \times 10^6 \text{Pa}$ and temperature 25 °C.
Helium gas may be considered to be an ideal gas consisting of single atoms.

Calculate the number of helium atoms in the cylinder.

number = ...[3]

[Total: 8]

76. 9702_w18_qp_43 Q: 2

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

....

....

....

....[2]

(b) An ideal gas undergoes a cycle of changes as shown in Fig. 2.1.

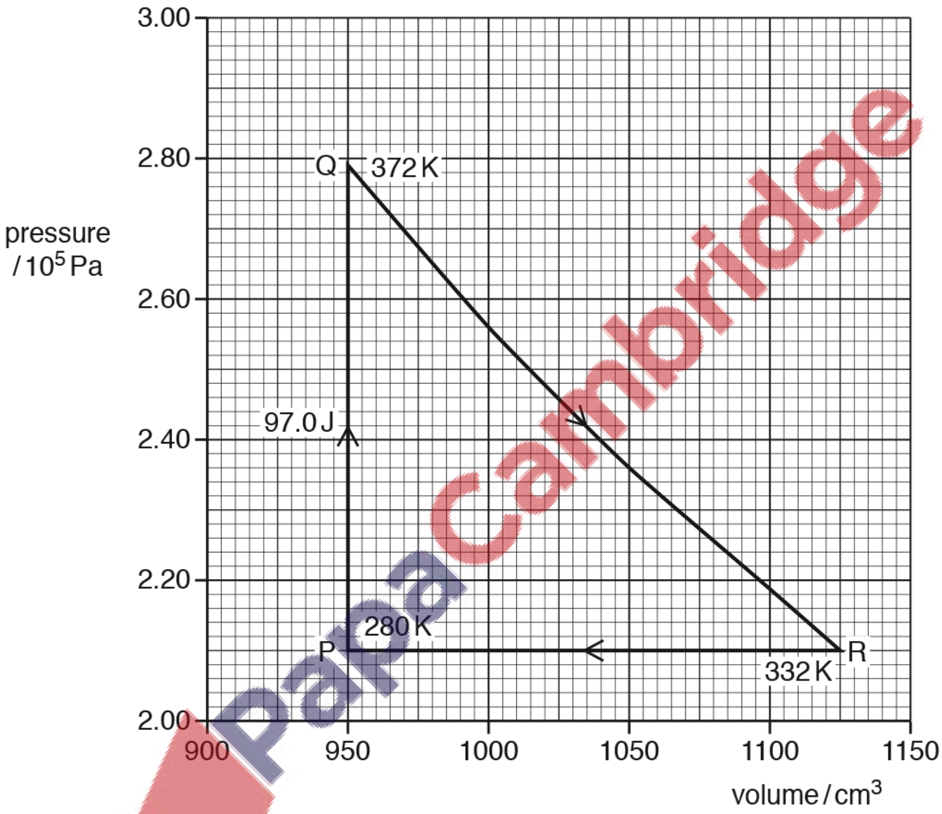

Fig. 2.1

At point P, the gas has volume 950 cm^3, pressure 2.10×10^5 Pa and temperature 280 K.

The gas is heated at constant volume and 97.0 J of thermal energy is transferred to the gas. Its pressure and temperature change so that the gas is at point Q on Fig. 2.1.

The gas then undergoes the change from point Q to point R and then from point R back to point P, as shown on Fig. 2.1.

Some energy changes that take place during the cycle PQRP are shown in Fig. 2.2.

	change P → Q	change Q → R	change R → P
thermal energy transferred to gas / J	+97.0	0	....
work done on gas / J	....	−42.5	+37.0
increase in internal energy of gas / J	....	....	....

Fig. 2.2

(i) State the total change in internal energy of the gas during the complete cycle PQRP. Explain your answer.

....

....

....[2]

(ii) On Fig. 2.2, complete the energy changes for the gas during

1. the change P → Q,

2. the change Q → R,

3. the change R → P.

[5]

[Total: 9]

77. 9702_m17_qp_42 Q: 2

(a) The first law of thermodynamics can be represented by the expression

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

State what is meant by the symbols in the expression.

$+\Delta U$ ....

$+q$ ....

$+w$ ....

[2]

(b) A fixed mass of an ideal gas undergoes a cycle ABCA of changes, as shown in Fig. 2.1.

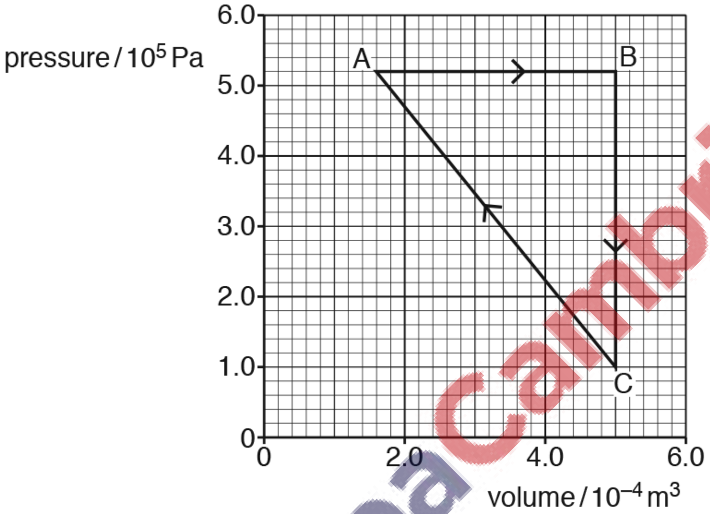

Fig. 2.1

(i) During the change from A to B, the energy supplied to the gas by heating is 442 J.

Use the first law of thermodynamics to show that the internal energy of the gas increases by 265 J.

[2]

(ii) During the change from B to C, the internal energy of the gas decreases by 313 J.

By considering molecular energy, state and explain qualitatively the change, if any, in the temperature of the gas.

....

....

....

....

....[3]

(iii) For the change from C to A, use the data in **(b)(i)** and **(b)(ii)** to calculate the change in internal energy.

change in internal energy = ... J [1]

(iv) The temperature of the gas at point A is 227 °C. Calculate the number of molecules in the fixed mass of the gas.

number = ... [2]

[Total: 10]

78. 9702_w17_qp_42 Q: 2

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

....

....

....[2]

(b) A beaker of boiling water is placed on the pan of a balance, as illustrated in Fig. 2.1.

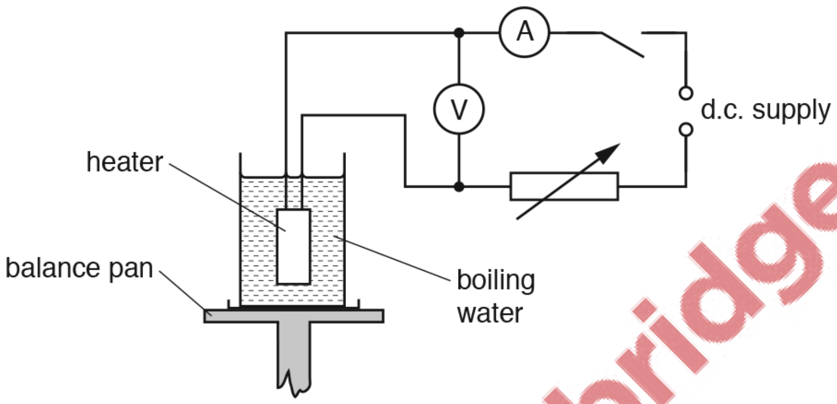

Fig. 2.1

The water is maintained at its boiling point by means of a heater.
The change M in the balance reading in 300 s is determined for two different input powers to the heater.
The results are shown in Fig. 2.2.

voltmeter reading / V	ammeter reading / A	M / g
11.5 14.2	5.2 6.4	5.0 9.1

Fig. 2.2

(i) Energy is supplied continuously by the heater.
State where, in this experiment,

1. external work is done,

....

....

2. internal energy increases. Explain your answer.

....

....

....

[3]

(ii) Use data in Fig. 2.2 to determine the specific latent heat of vaporisation of water.

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

[Total: 8]

79. 9702_m16_qp_42 Q: 2

(a) State

(i) what is meant by *internal energy*,

....

....

....[2]

(ii) the basic assumption of the kinetic theory of gases that leads to the conclusion that there is zero potential energy between the molecules of an ideal gas.

....

....[1]

(b) The pressure p and volume V of an ideal gas are related by

$$pV = \frac{1}{3} Nm\langle c^2 \rangle$$

where N is the number of molecules, m is the mass of a molecule and $\langle c^2 \rangle$ is the mean-square speed of the molecules.

Use this equation to show that the mean kinetic energy $\langle E_K \rangle$ of a molecule is given by

$$\langle E_K \rangle = \frac{3}{2} kT$$

where k is the Boltzmann constant and T is the thermodynamic temperature.

[3]

(c) A cylinder contains 17 g of oxygen gas at a temperature of 12 °C. The mass of 1.0 mol of oxygen gas is 32 g. It may be assumed that the oxygen behaves as an ideal gas.

Calculate, for the oxygen gas in the cylinder,

(i) the mean kinetic energy of a molecule,

mean kinetic energy = ...J [2]

(ii) the number of molecules,

number = ...[2]

(iii) the total internal energy.

internal energy = ...J [1]

[Total: 11]

80. 9702_w16_qp_41 Q: 2

An ideal gas initially has pressure 1.0×10^5 Pa, volume 4.0×10^{-4} m^3 and temperature 300 K, as illustrated in Fig. 2.1.

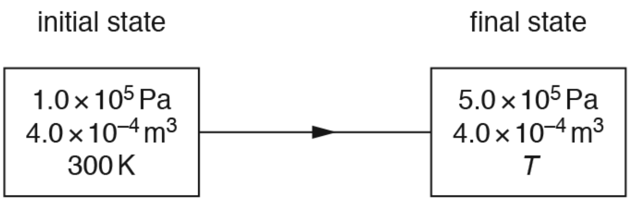

Fig. 2.1

A change in energy of the gas of 240 J results in an increase of pressure to a final value of 5.0×10^5 Pa at constant volume.
The thermodynamic temperature becomes T.

(a) Calculate

(i) the temperature T,

T = ... K [2]

(ii) the amount of gas.

amount = ... mol [2]

(b) The increase in internal energy ΔU of a system may be represented by the expression

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

(i) State what is meant by the symbol

1. $+q$,

....

2. $+w$.

....
[2]

(ii) State, for the gas in **(a)**, the value of

1. ΔU,

ΔU = ... J

2. $+q$,

$+q$ = ... J

3. $+w$.

$+w$ = ... J
[3]

[Total: 9]

81. 9702_w16_qp_42 Q: 3

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

....

....

....[2]

(b) Explain, by reference to work done and heating, whether the internal energy of the following increases, decreases or remains constant:

(i) the gas in a toy balloon when the balloon bursts suddenly,

....

....

....

....[3]

(ii) ice melting at constant temperature and at atmospheric pressure to form water that is more dense than the ice.

....

....

....

....[3]

[Total: 8]

82. 9702_w16_qp_43 Q: 2

An ideal gas initially has pressure 1.0×10^5 Pa, volume 4.0×10^{-4} m^3 and temperature 300 K, as illustrated in Fig. 2.1.

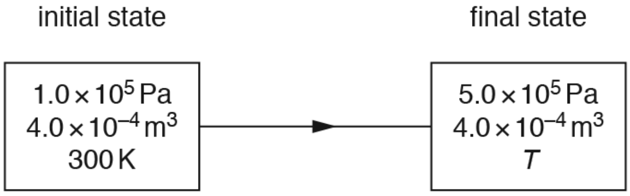

Fig. 2.1

A change in energy of the gas of 240 J results in an increase of pressure to a final value of 5.0×10^5 Pa at constant volume.
The thermodynamic temperature becomes T.

(a) Calculate

(i) the temperature T,

T = ... K [2]

(ii) the amount of gas.

amount = ... mol [2]

(b) The increase in internal energy ΔU of a system may be represented by the expression

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

(i) State what is meant by the symbol

1. $+q$,

....

2. $+w$.

....
[2]

(ii) State, for the gas in **(a)**, the value of

1. ΔU,

ΔU = ... J

2. $+q$,

$+q$ = ... J

3. $+w$.

$+w$ = ... J
[3]

[Total: 9]