OXFORD

INTERNATIONAL AQA EXAMINATIONS

Topic Test: OxfordAQA International A level Physics

Thermal Physics

Name: _____

Class: _____

Date: _____

Time: **59 minutes**

Marks: **39 marks**

Comments:

1 (a) The first law of thermodynamics can be written $\Delta Q = \Delta U + \Delta W$

State the usual meaning of each term in the equation.

ΔQ _____

ΔU _____

ΔW _____

(3)

(b) A fixed mass of gas in a cylinder is heated in two stages:

stage 1 at constant volume, when 10.0 kJ of heat is supplied,
stage 2 when it expands isothermally and does 6.0 kJ of work.

Apply the first law of thermodynamics to each of these processes and complete the table to show, for each process, the values of ΔQ, ΔU and ΔW.

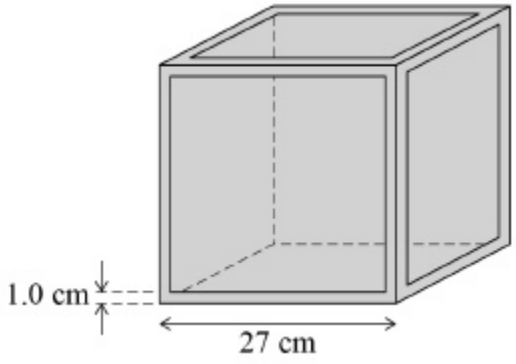
	ΔQ	ΔU	ΔW
stage 1 constant volume	+10.0 kJ		
stage 2 isothermal			+6.0 kJ

(4)

(Total 7 marks)

2 The diagram shows a hollow cube of external dimension 27 cm.

The walls and lid of the cube are made from an insulating material which is 1.0 cm thick.



The cube is filled with 14.3 kg of ice at 0 °C.

The outer surface of the cube is maintained at 25 °C.

It takes 2 days for all the ice to melt.

The specific latent heat of fusion of ice is 334 kJ kg^{-1}

(a) Show that the energy needed to melt the ice is about 5×10^6 J.

energy = _____ J

(1)

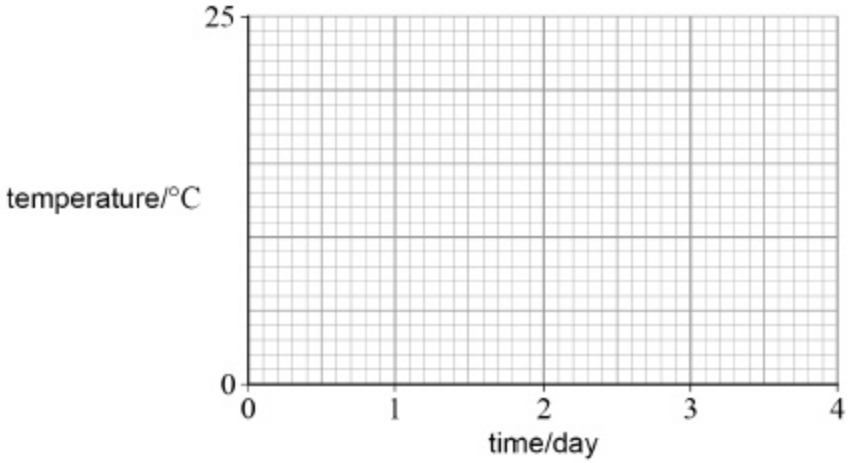
(b) Calculate the thermal conductivity of the insulating material used to make the cube.

thermal conductivity = _____ W m^{-1} K^{-1}

(4)

(c) After the ice has melted, the cube is left in the same conditions for 2 more days.

Sketch a graph to show the variation with time of the temperature of the contents of the cube over the 4-day period.



(2)

(Total 7 marks)

3 A cola drink of mass 0.200 kg at a temperature of 3.0 °C is poured into a glass beaker. The beaker has a mass of 0.250 kg and is initially at a temperature of 30.0 °C.

specific heat capacity of glass = 840 J $kg^{-1}K^{-1}$
specific heat capacity of cola = 4190 J $kg^{-1}K^{-1}$

(i) Show that the final temperature, T_f, of the cola drink is about 8 °C when it reaches thermal equilibrium with the beaker.
Assume no heat is gained from or lost to the surroundings.

(2)

(ii) The cola drink and beaker are cooled from T_f to a temperature of 3.0 °C by adding ice at a temperature of 0 °C.
Calculate the mass of ice added.
Assume no heat is gained from or lost to the surroundings.

specific heat capacity of water = 4190 J kg^{-1} K^{-1}
specific latent heat of fusion of ice = 3.34 × 10^5 J kg^{-1}

mass _____ kg

(3)

(Total 5 marks)

4 **Figure 1** shows a *p*–*V* graph that you are to use to illustrate the process of a gas undergoing two changes.
In its initial state, the gas has a pressure of 50 kPa and a volume of 1.5 m^3; this is plotted on the graph.
First, the gas undergoes an isothermal change from an initial volume of 1.5 m^3 to 0.85 m^3 followed by a compression at constant pressure to a volume of 0.35 m^3.

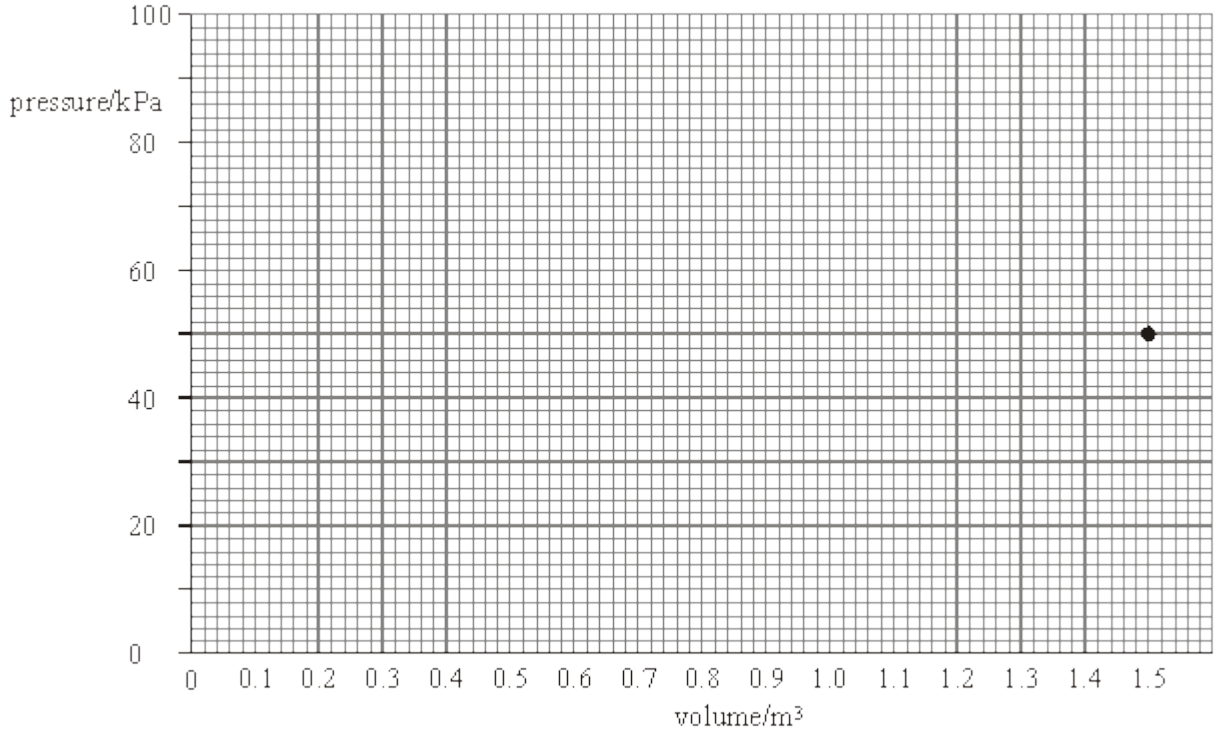


Figure 1

(a) Show that the final pressure of the gas is about 90 kPa.

(2)

(b) Complete the graph in **Figure 1** to show both changes.

(2)

(c) (i) Use your graph to estimate the work done during the whole process.

(3)

(ii) State and explain whether the work in part (c)(i) is done *on* or *by* the gas.

_____

_____

(1)

(Total 8 marks)

5 (a) Define the Avogadro constant.

_____

_____

_____

(1)

(b) (i) Calculate the mean kinetic energy of krypton atoms in a sample of gas at a temperature of 22 °C.

mean kinetic energy _____ J

(1)

(ii) Calculate the mean-square speed, $(c_{rms})^2$, of krypton atoms in a sample of gas at a temperature of 22 °C.
State an appropriate unit for your answer.

mass of 1 mole of krypton = 0.084 kg

mean-square speed_____ unit _____

(3)

(c) A sample of gas consists of a mixture of krypton and argon atoms.
The mass of a krypton atom is greater than that of an argon atom.
State and explain how the mean-square speed of krypton atoms in the gas compares with that of the argon atoms at the same temperature.

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

6 Which is the correct unit for U-value?

A $J\ m^{-2}\ K^{-1}$ ⬭

B $J\ K^{-1}$ ⬭

C $W\ m^{-2}\ K^{-1}$ ⬭

D $W^2\ K^{-1}$ ⬭

(Total 1 mark)

7 Which process would cause the internal energy of a gas to change by – 40 J?

A The gas is cooled losing 120 J of energy and expands doing 80 J of work. ⬭

B The gas is cooled losing 120 J of energy and 80 J of work is done on the gas by compressing it. ⬭

C The gas is heated gaining 120 J of energy and expands doing 80 J of work. ⬭

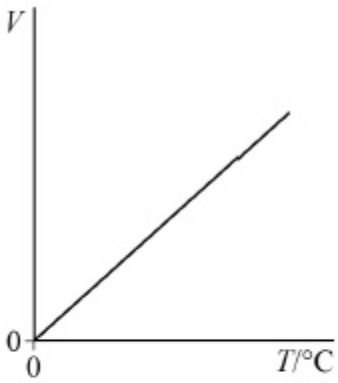
D The gas is heated gaining 120 J of energy and 80 J of work is done on the gas by compressing it. ⬭

(Total 1 mark)

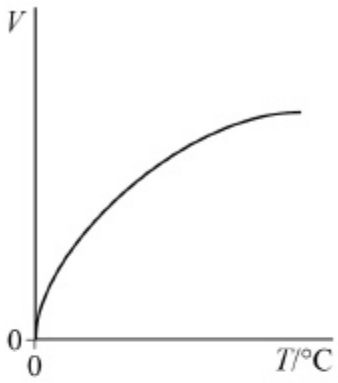
8 A fixed mass of an ideal gas is at a constant pressure.

Which graph shows the variation of volume with temperature in °C?

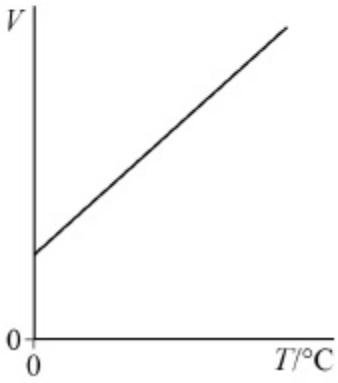
A



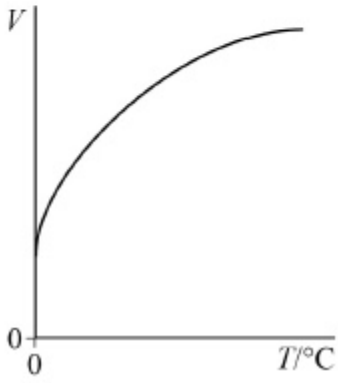
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

9 A fixed mass of an ideal gas initially has a volume V and an absolute temperature T. Its initial pressure could be doubled by changing its volume and temperature to

A $V/2$ and $4T$

B $V/4$ and $T/2$

C $2V$ and $T/4$

D $4V$ and $2T$

(Total 1 mark)

10 Which assumption is made about the particles when using the kinetic theory model of a gas?

A They have negligible mass. ⬭

B They have negligible volume. ⬭

C They have the same speed. ⬭

D They travel in the same direction. ⬭

(Total 1 mark)

1

(a) ΔQ: (heat) energy supplied to the gas **(1)**
ΔU: increase in internal energy of the gas **(1)**
ΔW : (mechanical) work done by the gas **(1)**

3

(b)

	ΔQ	ΔU	ΔW
constant volume		+10.0 (kJ) **(1)**	0 **(1)**
isothermal	+6.0 (kJ) **(1)**	0 **(1)**	

4

[7]

2

(a) Q (= ml = 14.3 × 334000) = 4.7(8) × 10^6 J ✓
Answer to 2 or more sf

1

(b) Calculation of surface area A = 6 × 0.25 × 0.25 = 0.375 m^2 ✓
Condone use of 0.26 or 0.27 in calculating area

Rate of energy transfer = $\frac{4776200}{2 \times 24 \times 60 \times 60}$ = 27.64 W ✓
Condone a recognisable attempt at time e.g. 24 × 60 × 60 or 2 × 24 × 60 for second mark

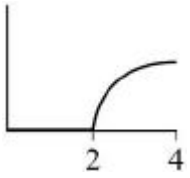
Use of Rate of energy transfer = $\frac{kA\Delta\theta}{L}$ ✓
ecf their rate and their area for third mark

k = 0.025 − 0.030 W m^{-1} K^{-1} ✓
no ecf for final mark

4

(c) Temperature = 0 °C for 2 days ✓

Curve with decreasing gradient from 2−4 days ✓



2

[7]

3 (i) (heat supplied by glass = heat gained by cola)
(use of $m_g\, c_g\, \Delta T_g = m_c\, c_c\, \Delta T_c$)

1st mark for RHS or LHS of substituted equation

$0.250 \times 840 \times (30.0 - T_f) = 0.200 \times 4190 \times (T_f - 3.0)$ ✓

2nd mark for 8.4°C

$(210 \times 30 - 210\, t_f = 838\, T_f - 838 \times 3)$

$T_f = 8.4(1)$ (°C) ✓

Alternatives:

8°C is substituted into equation (on either side shown will get mark) ✓

resulting in 4620J~4190J ✓

or

8°C substituted into LHS ✓ *(produces ΔT = 5.5°C and hence)*

= 8.5°C ~ 8°C ✓

8°C substituted into RHS ✓

(produces ΔT = 20°C and hence)

= 10°C ~ 8°C ✓

2

(ii) (heat gained by ice = heat lost by glass + heat lost by cola)

NB correct answer does not necessarily get full marks

(heat gained by ice = $mc\Delta T + ml$)
heat gained by ice = $m \times 4190 \times 3.0 + m \times 3.34 \times 10^5$ ✓
(heat gained by ice = $m \times 346600$)

3rd mark is only given if the previous 2 marks are awarded

heat lost by glass + heat lost by cola
$= 0.250 \times 840 \times (8.41 - 3.0) + 0.200 \times 4190 \times (8.41 - 3.0)$ ✓
(= 5670 J)

(especially look for m × 4190 × 3.0)

the first two marks are given for the formation of the substituted equation not the calculated values

m (=5670 / 346600) = 0.016 (kg) ✓

if 8°C is used the final answer is 0.015 kg

or (using cola returning to its original temperature)
(heat supplied by glass = heat gained by ice)
(heat gained by glass = 0.250 × 840 × (30.0 – 3.0))
heat gained by glass = 5670 (J) ✓
(heat used by ice = $mc\Delta T + ml$)
heat used by ice = $m(4190 \times 3.0 + 3.34 \times 10^5)$ ✓ (= m(346600))

m (=5670 / 346600) = 0.016 (kg) ✓

3

[5]

4 (a) pV = *constant* seen

C1

p = 88 kPa

A1

2

(b) completes correct shape curve to (0.85,88 000 **or** 90000),

B1

then horizontal to 0.35 m^3

B1

2

(c) attempts to measure area [graph evidence or words]

C1

correct use of graph scale

C1

answer in range (80 – 91) Kj

A1

3

(d) done **on** gas because it is compressed

B1

1

[8]

5 (a) the number of atoms in 12g of carbon-12
or the number of particles / atoms / molecules in one mole of substance ✓

not – N_A quoted as a number

1

(b) (i) mean kinetic energy (= 3 / 2 *kT*) = 3 / 2 × 1.38 × 10^{-23} × (273 + 22)
= 6.1 × 10^{-21} (J) ✓

6 × 10^{-21} J is not given mark

1

(ii) mass of krypton atom
= 0.084 / 6.02 × 10^{+23} ✓
(= 1.4 × 10^{-25} kg)
$\overline{c^2}$ (= 2 × mean kinetic energy / mass

= 2 × 6.1 × 10^{-21} / 1.4 × 10^{-25})
= 8.7 - 8.8 × 10^4 ✓
$m^2\ s^{-2}$ or J kg^{-1} ✓

1st mark is for the substitution which will normally be seen within a larger calculation.
allow CE from (i)
working must be shown for a CE otherwise full marks can be given for correct answer only
no calculation marks if mass has a physics error i.e. no division by N_A note for CE
answer = (i) × 1.43 × 10^{25}

3

(c) (at the same temperature) the mean kinetic energy is the same
or

gases have equal $\frac{1}{2}mc_{rms}^2$
or
mass is inversely proportional to mean square speed / m ∝ 1 $\overline{c^2}$ ✓

$\overline{c^2}$ or mean square speed of krypton is less ✓

1st mark requires the word <u>mean / average</u> or equivalent in an algebraic term

2nd mark 'It' will be taken to mean krypton. So, 'It is less' can gain a mark
allow 'heavier' to mean more massive'
allow vague statements like speed is less for 2nd mark but not in the first mark

2

[7]

6 C

[1]

7 B

[1]

8 C

[1]

9 B

[1]

10 B

[1]