Practice Question Set For A-Level
Subject : Physics
Paper-2 Topic: Thermal Physics

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Name of the Student:____
Max. Marks : 24 Marks **Time : 24 Minutes**

Mark Schemes

Q1.

(a) 28 (°C) ✔

1

(b) The energy transferred reduces the number of nearest atomic neighbours

First alternative must not imply total loss of intermolecular forces or neighbours.

A reference to 'breaking the bonds' implies all the bonds and does not gain the mark.

No mark for saying bonds weaken.

However these errors in discussing the bonds does not prevent a mark coming from another point

OR
allows atoms to move their centre of vibration

Last alternative might be expressed as 'atoms change from fixed positions to them being able to slide around each other'.

Ignore any references to changes in separation.

OR
breaks some of the (atomic) bonds

OR
crystalline to amorphous ✔ (owtte)

An explanation that involves increasing the kinetic energy will lose the mark.

So will any description that implies it becomes a gas.

1

(c) The (total or mean) kinetic energy remains constant. ✔
The (total or mean) potential energy increases. ✔

2

(d) The mean speed/mean kinetic energy increases ✔

Ignore references to larger separation (because it's not always true): collisions (as it is not a gas) or measures of randomness (which are usually too vague).

Condone use of average for mean.

Don't allow velocity instead of speed.

During this time interval the atoms are all in the liquid form so no credit for references that indicate a change of state.

1

(e) Using both $\Delta Q = mc\Delta\theta$ **and** $\Delta Q = P\Delta t$ ✔

$$\left(c = \frac{P\Delta t}{m\Delta\theta} = \frac{35 \times (14.8 - 11.2) \times 60}{0.25 \times (110 - 28)} = 369\right)$$

c = 370 ✔ (allow 365–375)

J kg^{-1} K^{-1} ✔ (or J kg^{-1} C^{-1})

First mark can be given by seeing the substitution which may have some errors for example not using exactly 28. These will be penalised in the second mark.

Correct answer gains first two marks NB 400 J kg^{-1} K^{-1} shows candidate has wrongly made calculations for the solid. No mark for the unit if a solidus is used because of the uncertainty of whether the K is on the top or bottom line. (which is correct J / kg / K or J / kg K ?) However allow a prefix if kilojoules are used for example.

3

(f) (Using both $\Delta Q = ml$ and $\Delta Q = P\Delta t$)

$$l\left(=\frac{P\Delta t}{m}\right) = \frac{35 \times ((11.2 - 1.8) \times 60)}{0.25} = 79 \text{ kJ kg}^{-1}$$ ✓

hence M = gallium ✔ (condone an ecf consistent with the calculation provided a comment is made if the value falls outside the range of the table)

The calculation yields1.3 kJ kg^{-1} if the 60 seconds is omitted.

Interim stage heat supplied = 19.7 kJ

A valid calculation must be shown to gain this second mark.

2

[10]

Q2.

(a) It is the sum/total of the (kinetic and potential) energies of the particles/atoms/molecules (that move at random in the gas) ✔$_1$

✔$_1$ Cannot be an average or a rms energy. Nor a vague reference to an energy of or in the gas.

For reference to kinetic energy of the gas or molecules ✔$_2$

✔$_2$ This is independent of the first mark provided energy of the gas is given in some form. So here an average kinetic energy would be acceptable.

2

(b) (Using) the gas laws it is the temperature at which the volume/pressure of a gas extrapolates to zero

OR

(Using $pV = nRT$ or $pV = NRT$) it is the temperature when pV or V or p is zero

OR

Plotting data of volume (or pressure) against temperature the plot extrapolates and crosses the temperature axis at absolute zero OWTTE ✔$_1$

✔$_{1\ first}$ Condone 'becomes/is zero' or phrases like 'said to be zero' or

‘thought to be zero’.

✔$_{1\ second}$ *Just quoting Charles’ law or the Pressure law is not enough.*

✔$_{1\ third}$ *Allow the information in the form of a sketch.*

(whereas) using the kinetic energy it is the temperature at which the (random) motion stops or can be extrapolated to stop or the kinetic energy (of the particles) is zero. ✔$_2$

✔$_2$ *The zero must be very explicit e.g. not just very very small. Allow reference to zero point energy/residual kinetic energy at 0 K/uncertainty at 0 K*

2

(c) Mass of argon atom = $\frac{\text{molar mass}}{N_A}$

$= \frac{4.0 \times 10^{-2}}{N_A} = \frac{4.0 \times 10^{-2}}{6.02 \times 10^{23}}$ = 6.6(4) × 10^{-26} (kg) ✔$_1$

✔$_1$ *Substitution of the molar mass or the answer gains the mark. Also the numbers may be seen in the equation of the second mark.*

$$c_{rms} = \left(\frac{3kT}{m}\right)^{1/2}$$

$$= \left(\frac{3 \times 1.38 \times 10^{-23} \times 310}{6.64 \times 10^{-26}}\right)^{1/2}$$ ✔$_2$ {k can be in form of a symbol}

✔$_2$ *Give a mark for this rearrangement and substitution even if the mass is incorrect.*

c_{rms} must be the only unknown in the equation, data and constants to be shown.

= 440 (m s^{-1}) ✔$_3$

✔$_3$ *Only allow a correct answer so no ecf from the second mark.*

A correct answer gains all three marks

Alternative 1

$$\frac{m(c_{rms})^2}{2} \text{ or } (E_k)_{average} = \left(\frac{3kT}{2}\right) = \frac{3RT}{2N_A}$$ ✔$_{1Alt1}$

✔$_{1Alt1}$ *The Mark is for introducing R/N_A in the mean energy equation.*

$$c_{rms} = \left(\frac{3RT}{mN_A}\right)^{1/2} = \left(\frac{3 \times 8.31 \times 310}{4.0 \times 10^{-2}}\right)^{1/2}$$ ✔$_{2Alt1}$ {R can be in form of a symbol}

✔$_{2Alt1}$ *The mark is for the use of the molar mass.*

c_{rms} must be the only unknown in the equation, data and constants to be shown.

= 440 (m s^{-1}) ✔$_{3Alt1}$

✔$_{3Alt1}$ *Only allow a correct answer so no ecf from the second mark.*

A correct answer gains all three marks

{On most occasions answer 5.7 × 10^{-10} m s^{-1} yields 2 marks as the wrong mass has been used}

Alternative 2

$(E_k)_{average}$ = $\frac{3kT}{2} = \frac{3 \times 1.38 \times 10^{-23} \times 310}{2}$ = 6.42 × 10^{-21} (J)

OR

$(E_k)_{total} = (E_k)_{average} \times N_A$ = 6.42 × 10^{-21} × 6.02 × 10^{23}

$(E_k)_{total}$ =3.86 × 10^3 (J) ✔$_{1Alt2}$

✔$_{1Alt2}$ The mark can be given for evaluating either the average or the total kinetic energy.

$$c_{rms} = \left(\frac{2 \times (their\ energy)}{\text{molar mass}}\right)^{1/2} = \left(\frac{2 \times (E_k)_{total}}{\text{molar mass}}\right)^{1/2}$$

✔$_{2Alt2}$ Give a mark for this rearrangement and substitution even if the energy is incorrect.

c_{rms} must be the only unknown in the equation, data and constants to be shown.

$$\left(\frac{2 \times 3.86 \times 10^3}{4.0 \times 10^{-2}}\right)^{1/2}$$ ✔$_{2Alt2}$

= 439 (m s^{-1}) ✔$_{3Alt2}$

✔$_{3Alt2}$ Only allow a correct answer so no ecf from the second mark.

A correct answer gains all three marks

{On most occasions answer 5.7 × 10^{-10} m s^{-1} yields 2 marks as the wrong mass has been used}

Note the slightly different answers for the third mark which depends on the route taken.

2

(d) (In equilibrium at the same temperature) both gases have the same mean or average kinetic energy ✔

Allow 'they are the same' as a bold statement. However if this is not an opening statement following the question then 'mean or average' must be used.

2

(e) Particles/atoms/molecules collide with the piston/walls and change momentum ✔$_1$

✔$_1$ Ignore any reference to particles colliding with each other.

(The piston provides the) force = rate of change of momentum or impulse(*Ft*) = change in momentum ✔$_2$

(The particles give a force on the piston producing a pressure)

A relevant reference to pressure = force divided by/over area or F/A ✔$_3$

✔$_3$ Relevant = reference to Piston or arising from the particles. (ie where or what)

If no mark is scored give a mark for P = F/A alone

3

(f) **change**

the volume could be increased

explanation

which increases the time between collisions OR results in less frequent collisions (with the piston/wall so reducing the rate of change of momentum)

OR

which increases the area of the piston/wall (and so reduces the pressure)

change

the temperature could be reduced

explanation

which reduces the momentum (change at the wall)

OR

(and) increases the time between collisions or reduces the frequency of collisions (reducing the rate of change of momentum)

✔ ✔ ✔

An explanation in terms of the gas laws is not acceptable.

3 marks

for 2 changes and 2 explanations

2 marks

for 2 changes and 1 explanation

1 mark

for 1 change with corresponding explanation

OR

2 changes with no adequate explanation

If a wrong change is given, eg. reduce the mass, then only one mark is available for one change with corresponding explanation.

3

[14]