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

Name of the Student:____

Max. Marks : 26 Marks **Time : 26 Minutes**

Mark Schemes

Q1.

(a) Total energy supplied (= Pt) = 12 × 890 = 10 680 (J) ✔$_1$

✔$_1$ Substitution or answer.

Heat energy to evaporate nitrogen at its boiling point (= ml) = 0.05 × 2.0 × 105 = 10 000 (J) ✔$_2$

✔$_2$ Substitution or answer.

(Use of $Q = mc\Delta\theta$)

Attempt to use $c = \left(\frac{Q}{m \times \Delta\theta}\right) = \frac{(10680-10000)}{0.050\times(77-70)}$ ✔$_3$

✔$_3$ Allow any attempt at substitution with (77 – 70) or 7 correct but ΔQ does not have to be correct so can even show an addition.

specific heat capacity of liquid nitrogen =
$c = 1.9 \times 10^3$ ✔$_4$ (allow 1 sig fig due to the small temperature difference)

✔$_4$ Allow 1 sig fig due to the small temperature difference. No ecf – correct answer only.

J kg^{-1} K^{-1} or J kg^{-1} °C^{-1} ✔$_5$ {taken from the answer line but if not present can come from the body of the answer space}

✔$_5$ Correct answer Consistent with 4th mark and only in the form shown ie no double or single solidus/oblique lines.
Only penalise the kelvin unit if it has an obvious loop at the top – allow if simply small.

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(b) (Use of volume = $\frac{m}{\rho}$)

nitrogen gas = $\frac{0.050}{3.8}$ = 0.013 (m^3) ✔$_1$ {if both given both must be correct}

✔$_1$ Substitution or answer and can be seen without label or explanation.

nitrogen liquid = $\frac{0.050}{810}$ = 0.000062 (m^3)
OR
a reference to the volume being negligible ✔$_2$

✔$_2$ Substitution or answer or words.

Work done in expanding (= X = $p\Delta V$)

= $1.0 \times 10^5 \times 0.013 = 1.3 \times 10^3$ (J) ✔$_3$

✔$_3$ Evidence of ΔV or calculation introduced with 'work done =' is required for the mark.

For an ecf the product must be shown in full with the substitution of the ecf being clear.

which is less than 1.0×10^4 J/the energy to change state = Y (ie X < Y) ✔$_4$

✔$_4$ Allow ecf from part (a) for this mark provided the statement is consistent with the figures.

OR

If the ecf comes from the 3rd mark above then the work done in expanding must be clearly labelled for the comparison or have units of J i.e it cannot be compared with a number that just happens to be on the page.

4

[9]

Q2.

(a) Specific latent heat of fusion is the energy (required) to change 1 kg / unit mass of material from the solid state to the liquid state or melt/fuse ✔

Without a change of temperature or at the freezing/melting temperature/point ✔

The direction of energy transfer must be consistent with the direction of the change of state (If energy to change… is given then required or needed is implied)

2nd mark stands alone.

2

(b) (Dividing both sides of the equation $\Delta Q = m\, c\, \Delta\theta$ by Δt gives $\Delta Q/\Delta t = m\, c\, \Delta\theta/\Delta t$ or

$\Delta\theta = (\Delta Q/\Delta t) \times \Delta t/m\, c$ where m = ρV)

$\Delta\theta = 2700 \times (60 \times 60) / (4.5 \times 1000 \times 4200)$ ✔

Full substitution correct ✔

Temperature rise = $\Delta\theta = 0.51$ (K) ✔ (= 0.514 K)

Working must be seen as there is a self-cancelling error with two 1000 factors.

So answer alone gains the 3rd mark only.

First mark can be gained if (60 × 60) is absent even if not re-arranged.

The change of temperature may be written as a difference between 28 °C and an unknown temperature (allow in kelvin written either way round ie with incorrect sign)

*1 sig fig is **not** acceptable.*

Useful numbers:

$4.5 \times 1000 \times 4200 = 1.89 \times 10^7$

$2700/(4500 \times 4200) = 1.4 \times 10^{-4}$

Max 2 if:

Omits (60 × 60) giving 1.43×10^{-4} K

Omits 60 giving 8.57×10^{-3}

3

(c) (When the pump is working at speed) the pump is doing work (on the water) ✔

Work (and heat both) can raise the temperature of a body (as stated in the 1st Law of thermodynamics) (this may be expressed as work is converted to thermal energy) OWTTE

OR

The pump increases the randomness / turbulence of the water/molecules

OR

The mean square speed/*mean* kinetic energy is proportional to the (absolute) temperature ✔ (this may be given in the form on an equation) OWTTE

(Lenient mark – a reference to random motion or more collisions may gain this mark but a simple increase in kinetic energy is not enough).

Do not penalise answers that go nowhere unless they directly contradict a marked answer.

2

[7]

Q3.

(a) The volume / size of the gas molecules is negligible / point mass or point molecule

Or molecules are point masses

Or small compared to the volume / size occupied by of the gas ✔ owtte

No mark for all the same size or spherical.

Without the comparison the word used must suggest extremely small.

Zero volume is wrong.

1

(b) (using $N = PV/kT$)

$N = (1.0 \times 10^5 \times 0.70 \times 10^{-3}/(1.38 \times 10^{-23} \times 300)$ ✔ (first mark is for converting the temperature to kelvin and using it in a valid equation)

$N = 1.7 \times 10^{22}$ molecules ✔ (1.69×10^{22} molecules)

Alternatively (using $n = PV/RT$)

$n = (1.0 \times 10^5 \times 0.70 \times 10^{-3} / 8.31 \times 300) = 0.028$ mol ✔ (first mark is for converting the temperature to kelvin and using it in a valid equation)

N (= $n\ N_A = 0.028 \times 6.02 \times 10^{23}$) = 1.7×10^{22} molecules ✔ (1.69×10^{22} molecules)

Correct answer scores both marks

Power of 10 issue = AE

Temperature conversion = PE

2

(c) (using $T_B = T_A\ V_B / V_A$)
$T_B = 300 \times 0.50 / 0.70 = 214$ (K) ✔
Change in temperature (= 214 – 300) = (–) 86 (K)✔
Or

T_B (= PV/Nk) = $1.0 \times 10^5 \times 0.50 \times 10^{-3}/(1.38 \times 10^{-23} \times 1.69 \times 10^{22})$ = 214 (K) ✔
Change in temperature (= 214 – 300) = (–) 86 (K)✔ (± 1 K)
Or
T_B = (PV/nR) = $1.0 \times 10^5 \times 0.50 \times 10^{-3}/(0.028 \times 8.31)$
= 215 (K) ✔
Change in temperature (= 215 – 300) = (–) 85 (K)✔

Correct answer scores both marks

Let the last mark stand alone provided an attempt at calculating T_B is made.

Also allow working in Celsius for this last stand-alone mark.

2

(d) An appropriate calculation might be:

(If the temperature remained constant $P_C = P_B V_B / V_C$)

$P_C = 1.0 \times 10^5 \times 0.50 \times 10^{-3} / 0.30 \times 10^{-3} = 1.7 \times 10^5$ (Pa) ✔

(but the pressure at C is higher than this so) the temperature at C is different / higher / not constant ✔

Or

(If the temperature remained constant $P_C V_C$ would equal $P_B V_B$)

$P_B V_B = 1.0 \times 10^5 \times 0.50 \times 10^{-3} = 50$

$P_C V_C = 2.05 \times 10^5 \times 0.30 \times 10^{-3} = 61$ ✔

($P V$ is not equal) the temperature at C is different / higher / not constant ✔

Or a full calculation can be given using $P V / T$ = constant.

$P_B V_B / T_B = 1.0 \times 10^5 \times 0.5 \times 10^{-3} / 214 = (0.234 \text{ J K}^{-1})$

$T_C = P_C V_C$ / constant = $2.05 \times 10^5 \times 0.30 \times 10^{-3} / 0.234$

$T_C = 263$ K ✔

the temperature at C is different / higher / not constant ✔

On its own higher temperature scores 0. ***Additionally there must be a reference to a correct calculation to obtain the last mark.***

The question only requires the candidate to spot a change. The two marks are for each side of a comparison.

Complete figures are not always required. For example in the last alternative the common factor 10^5 could be missing.

2nd alternative may come from a ratio.

Depending on the sig figs used in the substitution of data the temperature has a range 256 – 270 K

PV = NkT may be used as another alternative.

On a few occasions the full paper may be required to view.

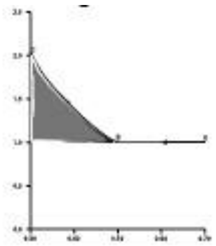
2

(e) work done on gas from **A** to **B** (using $W = P\Delta V$ or W = area under the graph = $1.0 \times (0.70 - 0.50) \times 10^{-3}$) = 20 (J) ✔

giving a reference to the work done being the area under the graph ✔

The third mark can be obtained in the following ways:

calculating the area indicated corresponds to the <u>additional work</u> done on the gas from **B** to **C**



(166 mm^2 where 1 mm^2 = 0.05 J) = 8.3 J √
(allow 8.0 – 10.0 J)

Or

The total work done (566 mm^2 where 1 mm^2 = 0.05 J) = 28.3(J) ✔

(allow 28.0 – 30.0 J)

This second mark can be obtained from an attempt at an area calculation that involves the curved section of the graph.

NB '<u>additional</u> work' must be quoted to give mark for 8 – 10 J.

This 3rd mark is for a correct evaluation and not for details of the process.

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[10]