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

Name of the Student:____

Max. Marks : 25 Marks **Time : 25 Minutes**

Mark Schemes

Q1.

(a) The mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC).

High Level − Good to Excellent
An experiment with results and interpretation must be given leading to the measurement of absolute zero. The student refers to 5 or 6 points given below. However each individual point must stand alone and be clear. *The information presented as a whole should be well organised using appropriate specialist vocabulary. There should only be one or two spelling or grammatical errors for this mark.*

6 clear points = 6 marks

5 clear points = 5 marks

5-6

Intermediate Level − Modest to Adequate
An experiment must be given and appropriate measurements must be suggested. For 3 marks the type of results expected must be given. 4 marks can only be obtained if the method of obtaining absolute zero is given. *The grammar and spelling may have a few shortcomings but the ideas must be clear.*

4 clear points = 4 marks

3 clear points = 3 marks

3-4

Low Level − Poor to Limited
One mark may be given for any of the six points given below. For 2 marks an experiment must be chosen and some appropriate results suggested even if the details are vague. Any 2 of the six points can be given to get the marks.
There may be many grammatical and spelling errors and the information may be poorly organised.

2 clear points = 2 marks

Any one point = 1 mark

1-2

The description expected in a competent answer should include:
1. Constant mass of gas (may come from the experiment if it is clear that the gas is trapped) <u>and</u> constant volume (or constant pressure).

For (point 1) amount / quantity / moles of gas is acceptable.

2. Record pressure (or volume) for a range of temperatures.(the experiment must involve changing the temperature with pressure or volume being the dependent variable).

For (point 2) no specific details of the apparatus are needed. Also the temperature recording may not be explicitly stated eg. record the pressure at different temperatures is condoned.

3. How the temperature is maintained / changed / controlled. (The gas must be heated uniformly by a temperature bath or oven − so not an electric fire or lamp).

4. Describe or show a graph of pressure against temperature (or volume against temperature) that is linear. The linear relationship may come from a diagram / graph or a reference to the Pressure Law or Charles' Law line of best fit is continued on implies a linear graph).

5. Use the results in a graph of pressure against temperature (or volume against temperature) which can be extrapolated to lower temperatures which has zero pressure (or volume) at absolute zero, which is at 0 K or −273 °C (a reference to crossing the temperature axis implies zero pressure or volume).

For (points 4 and 5) the graphs referred to can use a different variable to pressure or volume but its relationship to V or P must be explicit.

In (point 5) the graph can be described or drawn.

6. Absolute zero is obtained using any gas (provided it is ideal or not at high pressures or close to liquification)
Or Absolute temperature is the temperature at which the volume (or pressure or mean kinetic energy of molecules) is zero / or when the particles are not moving.

Discount any points that are vague or unclear

(Second part of point 6) must be stated not just implied from a graph.

(b) (i)
- The motion of molecules is random.
- Collisions between molecules (or molecules and the wall of the container) are elastic.
- The time taken for a collision is negligible (compared to the time between collisions).
- Newtonian mechanics apply (or the motion is non-relativistic).
- The effect of gravity is ignored or molecules move in straight lines (at constant speed) between collisions.

✓✓ any two

If more than 2 answers are given each wrong statement cancels a correct mark.

2

(ii) **Escalate if the numbers used are 4000, 5000 and 6000 giving 25666666 or similar.**

mean square speed
(= $(2000^2 + 3000^2 + 7000^2) / 3$ =
20.7×10^6)
= 2.1×10^7 ($m^2\ s^{-2}$)

Common correct answers

20.7×10^6

21×10^6

2.07×10^7

2.1×10^7

20 700 000

21 000 000.

***Possible escalation**.*

1

(c) **Escalate if the question and answer line requires a volume instead of a temperature.**

(using meanKE = $3RT / 2N_A$)
$T = 2N_A \times$ meanKE / $3R$
$=2 \times 6.02 \times 10^{23} \times 6.6 \times 10^{-21} / 3 \times 8.31$ ✓
= 320 (K) ✓ (318.8 K)
Or
(meanKE = $3kT / 2$)
$T = 2 \times$ meanKE / $3k$
$=2 \times 6.6 \times 10^{-21} / 3 \times 1.38 \times 10^{-23}$ ✓
= 320 (K) ✓ (318.8 K)

First mark for substitution into an equation.
Second mark for answer
***Possible escalation**.*
Answer only can gain 2 marks.

2

[11]

Q2.

(a) (i) Appreciates pV should be constant for isothermal change (by working or statement) $W = p\Delta V$ is TO

Allow only products seen where are approximately 150 for 1 mark
Penalise J as unit here

M1

Demonstrates pV = constant using 2 points (on the line) set equal to each other or conclusion made or **shows** that for V doubling that p halves (worth 2 marks)
need to see values for p and V

Products should equal 150 to 2 sf
Accept statement that products are slightly different so not quite isothermal

A1

Demonstrates pV = constant using 3 points (on the line) <u>with conclusion</u>
Need to see values for p and V

Products should equal 150 to 2 sf
Accept statement that products are slightly different so not quite isothermal

A1
3

(ii) Adiabatic <u>therefore</u> no heat transfer **or**
Adiabatic <u>therefore</u> $Q = 0$

B1

Work is done <u>by</u> gas <u>therefore</u> W is <u>negative</u> **or**
Work is done <u>by</u> gas <u>therefore</u> energy is removed from the system

B1

$\underline{\Delta U}$ is negative <u>therefore</u> internal energy of gas decreases **or** energy is removed from the system <u>therefore</u> internal energy of gas decreases or work done by the gas <u>so</u> internal energy decreases

Allow

$-\Delta U = -W \text{ or } \Delta U = -W$

B1
3

(iii) Uses pV / T = *constant or uses* $pV=nRT$ *or uses* $pV=NkT$

e.g. makes T subject or substitutes into an equation with p_A and V_A or p_C and V_C (condone use of n = 1) or their $\frac{(pV)_A}{(pV)_C}$

V_a read off range
= 2.5 to 2.6 (× 10^{-4})
p_A = 600 × 10^3
V_C read off range
= 8.5 to 8.6 (× 10^{-4})
p_C = 140 × 10^3

C1

Correct substitution of coordinates (inside range) into $\frac{(pV)_A}{(pV)_C}$
With consistent use of powers of 10

$(pV)_A$ range is 150 to 156 and $(pV)_C$ range is 119 to 120.4

C1

1.2(5) Allow range from 1.2 to 1.3

Accept decimal fraction : 1

A1
3

(b) Energy per large square = 10(J) **or** <u>states</u> that work done is equal to area under curve (between A and B)
or energy per small square = 0.4(J)
or square counting seen on correct area

Must be clear that area represents energy either by subject of formula or use of units on 10 or 0.4

Alternative:
W = area of a trapezium
(with working)
or *W =* $P_{mean} \times \Delta V$ ***or***
W = 450 × 10^3 × 2.5 × 10^{-4}
or *W = area of a rectangle + area of a triangle (with working)*

B1

Number of large squares = 10.5 to 11.5 seen <u>and</u> (W) = *number of*

squares × area of one square (using numbers)
Range = 105 to 115 (J)
Or

Number of small squares = 263 to 287 seen <u>and</u> (W) = *number of squares × area of one square (using numbers)*
Range = 105 to 115 (J)

States that actual work done would be lower because of curvature of line

B1
2

(c) (Total energy removed per s =) 4560 (J)
or number of cycles per s = 40
or (Mass per second =) 114 ÷ 68400 in rearranged form
or their energy ÷ (c ΔT) **or** their energy ÷ 68400

C1

0.067 (kg) seen Allow 0.066 (kg) here
or allow V / t = 1.67 × 10^{-3} ÷ 1100
or ($\frac{V}{t}$) = $\frac{E}{\rho c\,\Delta\theta}$ and correct **substitution** seen

Condone E = 114 (J) **or** temperature = 291(K)

C1

= 0.061 × 10^{-3} or 6.06 × 10^{-5} (m^3)

A1
3

[14]