Ideal Gases

Mark Scheme 4

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Ideal Gases
Sub Topic	
Paper Type	Theory
Booklet	Mark Scheme 4

Time Allowed: **71 minutes**

Score: **/59**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a** atoms / molecules / particles behave as elastic (identical) spheres (1)
volume of atoms / molecules negligible compared to volume of containing vessel (1)
time of collision negligible to time between collisions (1)
no forces of attraction or repulsion between atoms / molecules (1)
atoms / molecules / particles are in (continuous) random motion (1)
(*any four, 1 each*) B [4]

(b) $pV = \frac{1}{3}Nm\langle c^2\rangle$ and $pV = nRT$ *or* $pV = NkT$ B1
$\frac{1}{3}Nm\langle c^2\rangle = nRT$ or $= NkT$ and $\langle E_K\rangle = \frac{1}{2}m\langle c^2\rangle$ B1
$n = N/N_A$ *or* $k = R/N_A$ B1
$\langle E_K\rangle = \frac{3}{2} \times R/N_A \times T$ A0 [3]

(c) **(i)** reaction represents *either* build-up of nucleus from light nuclei
or build-up of heavy nucleus from nuclei M1
so fusion reaction A1 [2]

(ii) proton and deuterium nucleus will have equal kinetic energies B1
$1.2 \times 10^{-14} = \frac{3}{2} \times 8.31 / (6.02 \times 10^{23}) \times T$ C1
$T = 5.8 \times 10^8$ K A [3]
(*use of $E = 2.4 \times 10^{-14}$ giving 1.16×10^9 K scores 1 mark*)

(iii) *either* inter-molecular / atomic / nuclear forces exist
or proton and deuterium nucleus are positively charged / repel B1 [1]

2 **(a)** *either* $pV = NkT$ *or* $pV = nRT$ <u>*and*</u> $n = N / N_A$ C1
clear correct substitution e.g.
$2.5 \times 10^5 \times 4.5 \times 10^3 \times 10^{-6} = N \times 1.38 \times 10^{-23} \times 290$ M1
$N = 2.8 \times 10^{23}$ ..... A0 [2]
(*allow 1 mark for calculation of n = 0.467 mol*)

(b) volume $= (1.2 \times 10^{-10})^3 \times 2.8 \times 10^{23}$ *or* $\frac{4}{3}\pi r^3 \times 2.8 \times 10^{23}$ C1
$= 4.8 \times 10^{-7}$ m^3 2.53×10^{-7} m^3 ..... A1 [2]

(ii) *either* 4.5×10^3 cm^3 >> 0.48 cm^3 *or* ratio of volumes is about 10^{-4} B1
justified because volume of molecules is negligible ..... B1 [2]

[Total: 6]

3 **(a)** *either* the half-life of the source is <u>very</u> long
or decay constant is <u>very</u> small
or half-life >> 40 days
or decay constant << 0.02 day^{-1} B1 [1]

(b) number of helium atoms = $3.5 \times 10^6 \times 40 \times 24 \times 3600$ C1
= 1.21×10^{13}
either $pV = NkT$ *or* $pV = nRT$ <u>*and*</u> $n = N / N_A$ C1
$1.5 \times 10^5 \times V = 1.21 \times 10^{13} \times 1.38 \times 10^{-23} \times 290$
$V = 3.2 \times 10^{-13}\ m^3$ A1 [3]
(if uses T/°C or n = 1 or n = 4, then 1 mark max for calculation of number of atoms)

4 **(a** molecule(s) rebound from wall of vessel / hits walls B1
change in momentum gives rise to impulse / force B1
either (many impulses) averaged to give constant force / pressure
or the molecules are in random motion B1 [3]

(b) **(i)** $p = \frac{1}{3}\rho\langle c^2\rangle$ C

$1.02 \times 10^5 = \frac{1}{3} \times 0.900 \times \langle c^2\rangle$

$\langle c^2\rangle = 3.4 \times 10^5$ C1
$c_{RMS} = 580\ m\ s^{-1}$ A1 [3]

(ii) *either* $\langle c^2\rangle \propto T$ *or* $\langle c^2\rangle = 2 \times 3.4 \times 10^5$ C1
$c_{RMS} = 830\ m\ s^{-1}$ (allow 820) A1 [2]

(c) c_{RMS} depends on temperature (alone) B1
so no effect B1 [2]

5 **(a** **(i)** $pV = nRT$

$V = (8.31 \times 300)/(1.02 \times 10^5)$ C1

$= 0.0244\ m^3$ (if uses Celsius, then 0/2) ..... A1 [2]

(ii) volume occupied by one atom = $0.0244 / (6.02 \times 10^{23}) = 4.06 \times 10^{-26}\ m^3$ M1

separation $\approx \sqrt[3]{(4.06 \times 10^{-26})}$ A1

$= 3.44 \times 10^{-9}$ m ..... A0 [2]

(b) **(i)** $F = GMm / r^2$ C1

$= (6.67 \times 10^{-11} \times \{4 \times 1.66 \times 10^{-27}\}^2) / (3.44 \times 10^{-9})^2$ C1

$= 2.49 \times 10^{-46}$ N ..... A1 [3]

(ii) ratio = $(4 \times 1.66 \times 10^{-27} \times 9.8) / 2.49 \times 10^{-46}$ C1

$= 2.6 \times 10^{20}$ ..... A1 [2]

(c) assumption that forces between atoms are negligible B1

comment e.g. ratio shows gravitational force to be very small

e.g. force is very much less than weig

e.g. if there are forces, they are not gravitational ..... B1 [2]

6 **(a** obeys the law pV = constant $\times T$ …….…….. M1

at all values of p, V and T ……. A1 **[2]**

(b) $n = (2.9 \times 10^5 \times 3.1 \times 10^{-2}) / (8.31 \times 290)$ …...…….……...

= 3.73 mol ……. A1 **[2]**

(c) at new pressure, $n_n = 3.73 \times \frac{3.4}{2.9} \times \frac{290}{300}$

= 4.23 mol ……. C1

change = 0.50 mol …….… C1

number of strokes = 0.50 / 0.012 = 42 (must round up for mark) ……. A1 **[3]**

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7	**(a)**	obeys the law pV/T = constant <u>or</u> any <u>two</u> named gas laws	**M1**	
		at all values of p, V and T	**A1**	[2]
		<u>or</u> two correct assumptions of kinetic theory of ideal gas **(B1)**		
		third correct assumption **(B1)**		
	(b) (	mean square speed	**B1**	**[1]**
	(ii)	mean kinetic energy = $\frac{1}{2}m\langle c^2\rangle$	**M1**	
		$\rho = Nm/V$ and algebra leading to [do not allow if takes N = 1]	**M1**	
		$\frac{1}{2}m\langle c^2\rangle = 3/2\ kT$	**A0**	**[2]**
	(c)	$\frac{1}{2} \times 6.6 \times 10^{-27} \times (1.1 \times 10^4)^2 = 3/2 \times 1.38 \times 10^{-23} \times T$	**C1**	
		$T = 1.9 \times 10^4$ K	**A1**	[2]
	(ii)	Not all atoms have same speed/kinetic energy	**B1**	**[1]**

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