Ideal Gases

Mark Scheme 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Ideal Gases
Sub Topic	
Paper Type	Theory
Booklet	Mark Scheme 3

Time Allowed: **72 minutes**

Score: **/60**

Percentage: **/100**

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

1 **(a) (i) 1.** $pV = nRT$

$1.80 \times 10^{-3} \times 2.60 \times 105 = n \times 8.31 \times 297$ C1

$n = 0.19$ mol A1 [2]

2. $\Delta q = mc\Delta T$

$95.0 = 0.190 \times 12.5 \times \Delta T$ B1

$\Delta T = 40$ K A1 [2]

(allow 2 marks for correct answer with clear logic shown)

(ii) p/T = constant

$(2.6 \times 10^5) / 297 = p / (297 + 40)$ M1

$p = 2.95 \times 10^5$ Pa A0 [1]

(b) change in internal energy is 120 J / 25 J B1

internal energy decreases / $\underline{\Delta}U$ is negative / kinetic energy of molecules decreases M1

so temperature lower A1 [3]

2 **(a) (i)** number of molecules B1 [1]

(ii) mean square speed B1 [1]

(b) (1. $pV = nRT$ C1
$n = (6.1 \times 10^5 \times 2.1 \times 10^4 \times 10^{-6}) / (8.31 \times 285)$ C1
$n = 5.4\,\text{mol}$ [3]

2. *either* $N = nN_A$
$= 5.4 \times 6.02 \times 10^{23}$ C1
$= 3.26 \times 10^{24}$ A1
or
$pV = NkT$
$N = (6.1 \times 10^5 \times 2.1 \times 10^4 \times 10^{-6}) / (1.38 \times 10^{-23} \times 285)$ (C1)
$N = 3.26 \times 10^{24}$ (A1) [2]

(ii) *either* $6.1 \times 10^5 \times 2.1 \times 10^{-2} = {}^1/_3 \times 3.25 \times 10^{24} \times 4 \times 1.66 \times 10^{-27} \times \langle c^2 \rangle$ C1
$\langle c^2 \rangle = 1.78 \times 10^6$ C1
$c_{RMS} = 1.33 \times 10^3\,\text{m s}^{-1}$ A1
or
${}^1/_2 \times 4 \times 1.66 \times 10^{-27} \times \langle c^2 \rangle = {}^3/_2 \times 1.38 \times 10^{-23} \times 285$ (C1)
$\langle c^2 \rangle = 1.78 \times 10^6$ (C1)
$c_{RMS} = 1.33 \times 10^3\,\text{m s}^{-1}$ (A1) [3]

3 **(a) (i)** *either* random motion
or constant velocity until hits wall/other molecule B1 [1]

(ii) (total) volume of molecules is negligible M1
compared to volume of containing vessel A1
or
radius/diameter of a molecule is negligible (M1)
compared to the average intermolecular distance (A1) [2]

(b) *either* molecule has component of velocity in three directions
or $c^2 = c_X^2 + c_Y^2 + c_Z^2$ M1
random motion and averaging, so $\langle c_X^2 \rangle = \langle c_Y^2 \rangle = \langle c_Z^2 \rangle$ M
$\langle c^2 \rangle = 3\langle c_X^2 \rangle$ A1
so, $pV = \frac{1}{3}Nm\langle c^2 \rangle$ A0 [3]

(c) $\langle c^2 \rangle \propto T$ or $c_{rms} \propto \sqrt{T}$ C1
temperatures are 300 K and 373 K C1
$c_{rms} = 580\,\text{m s}^{-1}$ A1 [3]
(Do not allow any marks for use of temperature in units of ºC instead of K)

4 **(a)** e.g. moving in random (rapid) motion of molecules/atoms/particles
no intermolecular forces of attraction/repulsion
volume of molecules/atoms/particles negligible compared to volume of container
time of collision negligible to time between collisions
(1 each, max 2) B2 [2]

(b) (i) 1. number of (gas) molecules B1 [1]

2. mean square speed/velocity (of gas molecules) B1 [1]

(ii) either $pV = NkT$ *or* $pV = nRT$ and links n and k
and $\langle E_K \rangle = \frac{1}{2}m\langle c^2 \rangle$ M

clear algebra leading to $\langle E_K \rangle = \frac{3}{2}kT$ A1 [2]

(c) (i) sum of potential energy and kinetic energy of molecules/atoms/particles M1
reference to random (distribution) A1 [2]

(ii) no intermolecular forces so no potential energy B1
(change in) internal energy is (change in) kinetic energy and this is proportional to (change in) T B1 [2]

5 **(a)** number of atoms of carbon-12 M1
in 0.012 kg of carbon-12 A1 [2]

(b) $pV = NkT$ or $pV = nRT$ C1
substitutes temperature as 298 K C1
either $1.1 \times 10^5 \times 6.5 \times 10^{-2} = N \times 1.38 \times 10^{-23} \times 298$
or $1.1 \times 10^5 \times 6.5 \times 10^{-2} = n \times 8.31 \times 298$ and $n = N / 6.02 \times 10^{23}$ C1
$N = 1.7 \times 10^{24}$ A1 [4]

6 **(a)** amount of substance M1
containing same number of particles as in 0.012kg of carbon-12 A1 [2]

(b) $pV = nRT$ C1
amount= $(2.3 \times 10^5 \times 3.1 \times 10^{-3}) / (8.31 \times 290)$
+ $(2.3 \times 10^5 \times 4.6 \times 10^{-3}) / (8.31 \times 303)$ C1
= 0.296 + 0.420 C1
= 0.716mol A1 [4]
(give full credit for starting equation $pV = NkT$ and $N = nN_A$)

7 **(a) (i)** no forces (of attraction or repulsion) between atoms / molecules / particles B1 [1]

(ii) sum of kinetic and potential energy of atoms / molecules M1
due to random motion A1 [2]

(iii) (random) kinetic energy increases with temperature M1
no potential energy
(so increase in temperature increases internal energy) A1 [2]

(b) (i) zero A1 [1]

(ii) work done = $p\Delta V$ C1
$= 4.0 \times 10^5 \times 6 \times 10^{-4}$
= 240 J (*ignore any sign)* A1 [2]

(iii)

change	work done / J	heating / J	increase in internal energy / J
P → Q	**+24**	–60	**–36**
Q → R	0	+72	**+72**
R → P	**–84**	+48	**–36**

(*correct signs essential*)
(*each horizontal line correct, 1 mark – max 3*) B [3]