

Ideal Gases

Mark Scheme 5

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Ideal Gases
Sub Topic	
Paper Type	Theory
Booklet	Mark Scheme 5

Time Allowed: 63 minutes

Score: /52

Percentage: /100

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

1	(a)	<u>mean (value of the) square</u> of the speeds (velocities) of the atoms/particles/molecules	M1 A1 [2]
	(b) (i)	$p = \frac{1}{3} \rho \langle c^2 \rangle$ $\langle c^2 \rangle = 3 \times 2 \times 10^5 / 2.4 = 2.5 \times 10^5$ r.m.s speed = 500 ms^{-1}	C1 C1 A1 [3]
	(ii)	new $\langle c^2 \rangle = 1.0 \times 10^6$ or $\langle c^2 \rangle$ increases by factor of 4 $\langle c^2 \rangle \propto T$ or $3/2 kT = 1/2 m \langle c^2 \rangle$ $T = \{(1.0 \times 10^6) / (2.5 \times 10^5)\} \times 300$ $= 1200 \text{ K}$	C1 C1 A1 [3]
			Total [8]
2	(a)	(sum of) potential energy and kinetic energy of molecules/atoms/particles mention of random motion/distribution	M1 A1 [2]
	(b) (i)	$pV = nRT$ either at A, $1.2 \times 10^5 \times 4.0 \times 10^{-3} = n \times 8.31 \times 290$ or at B, $3.6 \times 10^5 \times 4.0 \times 10^{-3} = n \times 8.31 \times 870$ $n = 0.20 \text{ mol}$	C1 [2]
	(ii)	$1.2 \times 10^5 \times 7.75 \times 10^{-3} = 0.20 \times 8.31 \times T$ or $T = (7.75 / 4.0) \times 290$ $T = 560 \text{ K}$ (Allow tolerance from graph: $7.7 - 7.8 \times 10^{-3} \text{ m}^3$)	C1 A1 [2]
	(c)	temperature changes/decreases so internal energy changes/decreases volume changes (at constant pressure) so work is done	B1 B1 [2]

3	(a) (i) weight = GMm/r^2 = $(6.67 \times 10^{-11} \times 6.42 \times 10^{23} \times 1.40)/(1/2 \times 6.79 \times 10^6)^2$ = 5.20 N	C1 C1 A1 [3]
	(ii) potential energy = $-GMm/r$ = $-(6.67 \times 10^{-11} \times 6.42 \times 10^{23} \times 1.40)/(1/2 \times 6.79 \times 10^6)$ = $-1.77 \times 10^7 \text{ J}$	C1 M1 A0 [2]
	(b) either $\frac{1}{2}mv^2 = 1.77 \times 10^7$ $v^2 = (1.77 \times 10^7 \times 2)/1.40$ $v = 5.03 \times 10^3 \text{ ms}^{-1}$ or $\frac{1}{2}mv^2 = GMm/r$ $v^2 = (2 \times 6.67 \times 10^{-11} \times 6.42 \times 10^{23})/(6.79 \times 10^6/2)$ $v = 5.02 \times 10^3 \text{ ms}^{-1}$	C1 C1 A1 (C1) (C1) (A1) [3]
	(c) (i) $\frac{1}{2} \times 2 \times 1.66 \times 10^{-27} \times (5.03 \times 10^3)^2 = \frac{3}{2} \times 1.38 \times 10^{-23} \times T$ $T = 2030 \text{ K}$	C1 A1 [2]
	(ii) either because there is a range of speeds some molecules have a higher speed or some escape from point above planet surface so initial potential energy is higher	M1 A1 (M1) (A1) [2]
4	(a) (i) $27.2 + 273.15$ or $27.2 + 273.2$ 300.4 K	C1 A1 [2]
	(ii) 11.6 K	A1 [1]
	(b) (i) ($\langle c^2 \rangle$) is the mean / average square speed	B1 [1]
	(ii) $\rho = Nm/V$ with <u>N explained</u> so, $pV = 1/3 Nm\langle c^2 \rangle$ and $pV = NkT$ with <u>k explained</u> so mean kinetic energy / $\langle E_K \rangle = \frac{1}{2}m\langle c^2 \rangle = 3/2 kT$	B1 B1 B1 B1 [4]
	(c) (i) $pV = nRT$ $2.1 \times 10^7 \times 7.8 \times 10^{-3} = n \times 8.3 \times 290$ $n = 68 \text{ mol}$	C1 A1 [2]
	(ii) mean kinetic energy = $3/2 kT$ = $3/2 \times 1.38 \times 10^{-23} \times 290$ = $6.0 \times 10^{-21} \text{ J}$	C1 A1 [2]
	(iii) realisation that total internal energy is the total kinetic energy energy = $6.0 \times 10^{-21} \times 68 \times 6.02 \times 10^{23}$ = $2.46 \times 10^5 \text{ J}$	C1 C1 A1 [3]

- 5 (a) $pV/T = \text{constant}$ C1
 $T = (6.5 \times 10^6 \times 30 \times 300)/(1.1 \times 10^5 \times 540)$ C1
 $= 985 \text{ K}$ A1 [3]
(if uses °C, allow 1/3 marks for clear formula)

(b) (i) $\Delta U = q + w$
symbols identified correctly M1
directions correct A1 [2]

(ii) q is zero B1
 w is positive OR $\Delta U = w$ and U increases B1
 ΔU is rise in kinetic energy of atoms M1
and mean kinetic energy $\propto T$ A1 [4]
(allow one of the last two marks if states 'U increases so T rises')