Ideal Gases

Mark Scheme 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Ideal Gases
Sub Topic	
Paper Type	Theory
Booklet	Mark Scheme 2

Time Allowed: **58 minutes**

Score: **/48**

Percentage: **/100**

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

1 **(a)** obeys the equation pV/T = constant B1 [1]
(accept $pV = nRT$)

(b) **(** $pV = nRT$ C1
$5.0 \times 10^7 \times 3.0 \times 10^{-4} = n \times 8.31 \times 296$ giving $n = 6.1$ mol [2]

(ii) pressure $\propto$ amount of substance
loss $= 0.40/100 \times 6.1$ mol $= 0.0244$ mol
$= 0.0244 \times 6.02 \times 10^{23}$ (atoms) C1
$= 1.47 \times 10^{22}$ atoms C1

rate $= (1.47 \times 10^{22})/(35 \times 24 \times 60 \times 60)$
$= 4.9 \times 10^{15}\ s^{-1}$ A1 [4]

2 **(a)** initially, $pV/T = (2.40 \times 10^5 \times 5.00 \times 10^{-4})/288 = 0.417$ M1
finally, $pV/T = (2.40 \times 10^5 \times 14.5 \times 10^{-4})/835 = 0.417$ M1
ideal gas because pV/T is constant A1 [3]
(*allow 2 marks for two determinations of V/T and then 1 mark for V/T and p constant, so ideal*)

(b) **(** work done $= p\Delta V$
$= 2.40 \times 10^5 \times (14.5 - 5.00) \times 10^{-4}$ C1
$= 228$ J (*ignore sign, not 2 s.f.*) A [2]

(ii) $\Delta U = q + w = 569 - 228$
$= 341$ J M
increase A1 [2]

3 **(a)** the number of atoms — M1
in 12 g of carbon-12 — A1 [2]

(b) **(** amount = 3.2/40
= 0.080 mol — A1 [1]

(ii) $pV = nRT$
$p \times 210 \times 10^{-6} = 0.080 \times 8.31 \times 310$ — C1
$p = 9.8 \times 10^{5}$ Pa — A1 [2]
(do not credit if T in °C not K)

(iii) *either* $pV = 1/3 \times Nm <c^2>$
$N = 0.080 \times 6.02 \times 10^{23}$ (= 4.82×10^{22})
and $m = 40 \times 1.66 \times 10^{-27}$ (= 6.64×10^{-26}) — C1
$9.8 \times 10^{5} \times 210 \times 10^{-6} = 1/3 \times 4.82 \times 10^{22} \times 6.64 \times 10^{-26} \times <c^2>$ — C
$<c^2> = 1.93 \times 10^{5}$
$c_{RMS} = 440$ m s^{-1} — A1 [3]

or $= 3.2 \times 10^{-3}$ — (C1)
$9.8 \times 10^{5} \times 210 \times 10^{-6} = 1/3 \times 3.2 \times 10^{-3} \times <c^2>$ — (C1)
$<c^2> = 1.93 \times 10^{5}$
$c_{RMS} = 440$ m s^{-1} — (A1)

or $1/2\, m<c^2> = 3/2\, kT$ — (C1)
$1/2 \times 40 \times 1.66 \times 10^{-27} <c^2> = 3/2 \times 1.38 \times 10^{-23} \times 310$ — (C1)
$<c^2> = 1.93 \times 10^{5}$
$c_{RMS} = 440$ m s^{-1} — (A1)

(*if T in °C not K award max 1/3, unless already penalised in* ***(b)(ii)***)

4	**(a**	use of kelvin temperatures	B1	
		both values of (V/T) correct (11.87), V/T is constant so pressure is constant	M1	[2]
		(*allow use of n =1. Do not allow other values of n.)*		
	(b)	**(i)** work done $= p\Delta V$		
		$= 4.2 \times 10^5 \times (3.87 – 3.49) \times 10^3 \times 10^{–6}$	C1	
		$= 160$ J	A1	[2]
		(do not allow use of V instead of ΔV)		
		(ii) increase/change in internal energy = heating of system		
		+ work done on system	C1	
		= 565 – 160		
		= 405 J	A	[2]
	(c)	internal energy = sum of kinetic energy and potential energy / $E_K + E_P$	B1	
		no intermolecular forces	M1	
		no potential energy (so $\Delta U = \Delta E_K$)	A	[3]
5	**(a**	**(i)** N: (total) number of <u>molecules</u>	B1	[1]
		(ii) $<c^2>$: mean square speed/velocity	B1	[1]
	(b)	$pV = ⅓Nm<c^2> = NkT$		
		(mean) kinetic energy = $½\ m<c^2>$	C1	
		algebra clear leading to $½\ m<c^2> = (3/2)kT$	A1	[2]
	(c)	**(** *either* energy required = $(3/2) \times 1.38 \times 10^{–23} \times 1.0 \times 6.02 \times 10^{23}$	C1	
		= 12.5 J (*12J if 2 s.f.*)	A	[2]
		or energy = $(3/2) \times 8.31 \times 1.0$	(C1)	
		= 12.5 J	(A1)	
		(ii) energy is needed to push back atmosphere/do work against atmosphere		
		so total energy required is greater	A1	[2]

6 **(a**	obeys the equation pV = constant × T or $pV = nRT$	M1	
	p, V and T explained	A1	
	at all values of p, V and T/fixed mass/n is constant	A1	[3]
(b) **(**	$3.4 \times 10^5 \times 2.5 \times 10^3 \times 10^{-6} = n \times 8.31 \times 300$	M1	
	n = 0.34 mol		[1]
(ii)	for total mass/amount of gas		
	$3.9 \times 10^5 \times (2.5 + 1.6) \times 10^3 \times 10^{-6} = (0.34 + 0.20) \times 8.31 \times T$	C1	
	T = 360 K	A	[2]
(c)	when tap opened		
	gas passed (from cylinder B) to cylinder A	B1	
	work done <u>on</u> gas in cylinder A (and no heating)	M1	
	so internal energy and hence temperature increase	A1	[3]