Marking Scheme

#1

Question				Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*			**Two × (1) from:** • Molecules [themselves] occupy negligible volume • Molecules exert negligible forces on each other except during collisions or move in straight lines between collisions • There is no preferred direction of molecular velocity or [directions of] motion are random or equivalent • Collisions are elastic [on average] • Collisions take negligible time or equiv, e.g. molecules are hard spheres	2			2		
	(b)	i		$\rho = \frac{2.2 \times 0.0399\ [\text{kg}]}{0.050\ [\text{m}^3]}$ or by implication (1) $c_{rms} = \sqrt{\frac{3p}{\rho}}$ or by implication (e.g. re-arrangement after data inserted). Mark can be given even if ρ is wrong (1) $c_{rms} = 654\ \text{m s}^{-1}$ (1) Slips in $10^x \rightarrow -1$; incorrect $N_A \rightarrow 1_{max}$	1	1 1		3	2	
		ii	I	$\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ used or KE proportional to T or equiv or by imp (1) c_{rms} goes up by [factor of] $\sqrt{2}$. (1) Accept $\sqrt{2} \times 654\ \text{m s}^{-1}$ or $924\ \text{m s}^{-1}$	1	1		2	1	
			II	Yes, c_{rms} depends only on temperature, or equivalent		1		1		
				Question 7 total	**4**	**4**	**0**	**8**	**3**	**0**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		**Indicative comments:** **A: Why the gas exerts a pressure** A1 Molecules collide with walls (or by implication). A2 Collisions exert (outward) forces on walls. A3 Molecules undergo changes in momentum [or in velocity or undergo acceleration] when colliding with walls. A4 Newton's third law applied correctly [even if not named] A5 Collisions distributed randomly over wall area. **Accept** reference to $p = \frac{F}{A}$. A6 Collisions between molecules and walls [on average] elastic **B: Why the pressure increases with temperature** B1 Mean KE of molecules [or rms speed, or mean speed or mean [magnitude] of momentum] increases with temperature. B2 Hence increases pressure [or force] exerted on walls. B3 On average each collision contributes more to pressure [or exerts greater force or has a greater momentum change] if molecules moving faster. B4 There'll also be more collisions per second if molecules are moving faster. **5-6 marks** Comprehensive account of why the gas exerts a pressure along with why pressure increases with temperature typically: Typical example A1 + A2 + A3 + (A4 or A5 or A6) B1 + B2 + (B3 or B4) *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Either comprehensive account of why the gas exerts a pressure or why pressure increases with temperature or account given of why the gas exerts a pressure and why pressure increases with temperature typically: Typical example A1 + A2 + (A3 or A4 or A5) B1 (but no mention of 'mean' needed) + B2 *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Limited account of why the gas exerts a pressure and/or why pressure increases with temperature typically: Typical example A1, A2 B1 (but no mention of 'mean' needed) Any other point from A3, A4, A5, A6, B2 *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** *No attempt made or no response worthy of credit.*	6			6		
	(b)	(i)	$\rho = \frac{0.091}{0.020}$ $[= 4.55\ \text{kg m}^{-3}]$ **or** $Nm = 0.091$ [kg] **or** by implication (1) $c_{\text{rms}} = \sqrt{\frac{3 \times 3.9 \times 10^5 \times 0.020}{0.091}}$ *or* $c_{\text{rms}}{}^2 = \frac{3 \times 3.9 \times 10^5 \times 0.020}{0.091}$ or by implic (1) [transposed and data inserted or vice versa] 510 m s^{-1} (1) Single arithmetical slips, including by a factor of 1 000, attract a 1 mark penalty. An error factor of N_A, (which may arise when $pV = \frac{1}{3}Nmc_{\text{rms}}^2$ is misapplied) loses 2 marks (error of principle).		3		3	3	
		(ii)	$n = \frac{91}{28} = [3.25\ \text{mol}]$ **or** by implication (1) $T = \frac{3.9 \times 10^5 \times 0.020}{3.25 \times 8.31}$ **or** by implication **ecf** on n for this mark only (1) = 290 K **UNIT** (1)		3		3	3	
			Question total	**6**	**6**	**0**	**12**	**6**	**0**

#3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)	(i)		ρ correctly calculated ignoring sig figs, units, factors of 10^n [1] $\rho = 8.9 \times 10^3$ [kg m^{-3}] Accept $\rho = 8.87 \times 10^3$ [kg m^{-3}] [1] Percentage (or fractional) unc =0.07[2] (or 7[.2]%)] **or by implic** [1] $\rho = (8.9 \pm 0.6$ [or 0.7]$) \times 10^3$ [kg m^{-3}] **accept** $\rho = (8.87 \pm 0.64) \times 10^3$ [kg m^{-3}] [1]	1	 1 1 1		4	2	4
		(ii)		Division of density by atomic mass even if error in units [1] 8.4×10^{28} [m^{-3}] ecf on ρ, no sig fig penalty [1]		2		2	1	2
	(b)	(i)	I	Correct transpos'n at any stage of $pV = nRT$ or $pV = NkT$ [1] Correct insertion of data, including $T = 288$ K in $pV = NkT$ or in $pV = nRT$ giving $n = 42[.2]$ [mol] or by implic from N [1] $N = 2.5[4] \times 10^{25}$ [m^{-3}] [1]		3		3	2	
			II	Gas mainly empty space (between molecules) [but atoms packed/bonded together in solid] [1] Gas molecules are moving about at high speeds [so could be said to take up more space than vibrating atoms in solid] **or** molecules themselves are of comparable size [1]	1		1	2		
		(ii)	I	Correct use of $\frac{1}{2}mc^2_{rms} = \frac{3}{2}kT$ or equivalent [1] Convincing algebra [1]	1	1		2		
			II	$\frac{c_{rms} \text{ for nitrogen}}{c_{rms} \text{ for oxygen}} = 1.07$ **or equiv or by implic** [1] 7 % [1]			2	2	1	
				Question 6 total	3	9	3	15	6	6

#4

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)		Mean KE $= \frac{3}{2} \times 1.38 \times 10^{-23} \times 1500$ [J] **or by impl** [1] $= 3.11 \times 10^{-20}$ [J] [1]	1	1		2	1	
		(ii)		$c^2{}_{rms} = \frac{3.11 \times 10^{-20}}{\frac{1}{2} \times 3.82 \times 10^{-26}}$ [i.e. transposed] **or by impl** [1] $c_{rms} = 1275 \text{ m s}^{-1}$ [1]		2		2	2	
	(b)	(i)		Any statement that shows knowledge of gas molecules [at a given temp] having a range of speeds [1] 6.40 km s^{-1} is a few [5] times greater than rms speed [1] Molecule could have acquired this speed through a succession of 'lucky' collisions [1]		3		3		
		(ii)		$m \times 6.40 + 0 = m \times 4.39 + m \times v$ **or equiv or by impl** [1] $v = 2.01$ km s^{-1} **to the East** [1]		2		2	2	
		(iii)		KE before = 7.82×10^{-19} [J] [1] KE after = 3.68×10^{-19} J + 0.77×10^{-19} J [1] [= 4.45×10^{-19} J] or equivalent (no need to include the $\frac{1}{2}m$ or 10^3] Inelastic as KE [= 3.37×10^{-19} J] has been lost [1] **Alternative** Considering relative velocities of approach and separation [1] $6.40 \times 10^3 > 4.39 \times 10^3 - 2.01 \times 10^3$ **or equiv** [1] Therefore KE lost **or** inelastic [1]		3		3	2	
		(iv)		The molecules exert equal and opp forces on each other	1			1		
		(v)		Photon momentum $= \frac{6.63 \times 10^{-34} \text{ J s}}{589 \times 10^{-9} \text{ m}}$ or by implication [1] $= 1.1 \times 10^{-27}$ **N s UNIT mark** [1] << either molecule's momentum, so insignificant effect [1]			3	3	1	
				Question total	2	11	3	16	8	0