1	Expected answers	Mark	Additional guidance
(a)(i)	A collision with no change / loss of kinetic energy.	B1	**Allow** coeff't of restitution = 1
(a)(ii)	Any 3 from Volume of particles negligible compared to volume of vessel OR molecules much smaller than distance between them No intermolecular forces acting (other than during collisions) OR molecules only have kinetic energy (and no PE) Particles travel in straight lines/at uniform velocity between collisions OR force of gravity on molecules is negligible time of collisions much smaller than time between collisions gas consists of a large number of molecules moving randomly (both needed for the mark)	 B1 B1 B1	 do not allow a bare "negligible volume of molecules " Do not allow "collisions between molecules are elastic" because this is given in the question. do not allow a bare "negligible time of collisions" Do not allow a bare "rapid random motion"
(b)(i)	$\Delta p = mv - mu$ $= 4.8 \times 10^{-26} [500 - (-500)] = 4.8 \times 10^{-23}$ kg m s^{-1}	C1 A1	2.4×10^{-23} scores zero
(b)(ii)	(time between collisions = 0.4 /500 s) . Number of collisions/sec. = 500/0.4 = 1250	A1	Correct answer only
(b)(iii)	(Mean) force = $\Delta p/t$ OR Force = rate of change of momentum OR Impulse = change in momentum Force = $1250 \times 4.8 \times 10^{-23} / 1 = 6.0 \times 10^{-20}$ N	C1 A1	**Allow** ecf from (b)(i) and (b)(ii) e.g. if 2500 is used from (b)(i $F = 2500 \times 4.8 \times 10^{-23} = 1.2 \times 10^{-19}$ N and this scores 2 marks
(b)(iv)	Same value as candidate's (b)(iii) due to Newton's third law OR this force acts in opposite direction	B1	 OR –ve sign shown
(c)(i)	$3 \times 6 \times 10^{23} = 1.8 \times 10^{24}$	B1	1.806×10^{24} if 6.02 is used
(c)(ii)	(very) large number of particles that are moving randomly means that at any instant the number of collisions on each face will be the same (WTTE)	B1	Allow no gravitational forces and hence uniform density
(c)(iii)	(mean) KE/speed of molecules increases Increased rate of collisions with wall OR 'harder' collisions with wall	B1 B1	Also **allow** greater change of momentum per collision (WTTE) Not just "more collisions".
	Total	**14**	

2	Expected answers	Mark	Additional guidance
(a)(i)	Straight line (judged by eye)with positive slope AND passing through the origin	B1	correct answer only
(a)(ii)	8.31 (J mol^{-1} K^{-1})	B1	Allow *R* and molar gas constant, but do not allow *pV*/*T* OR *nR*
(b)(i)	-40 ^{o}C = 233 K, AND 250 ^{o}C = 523 K Use of $V_1/T_1 = V_2/T_2$ 2.4 x 10^{-2} / 233 = V_2 / 523 V_2 = 0.053(8) (m^3)	M1 C1 A1	No marks scored if 40^{o} C and/or 250^{o}C are used Accept other correct versions.
(b)(ii)	Use of $p = nRT/V$ = 1.5 x 8.31 x 233 / 2.4 x 10^{-2} = 1.21 x 10^5 (Pa)	C1 A1	Allow *T*= 523 and *V*= 0.053 hence *p* = 1.2 x10^5 Allow ecf from (b)(i)
	Total	**7**	

Question	Expected Answers	Marks	Additional guidance
3(a)	The magnitude of the impulse on each object is the same Total energy is conserved	B1 B1	For 3 or 4 ticks mark and deduct 1 mark for each error.
(b)	Correct use of ½ mv^2 Loss of KE = 0.03(144-81) = **1.9** (or 1.89) **J**	C1 A1	0.27 J scores 1st mark Do not allow 1.8
(b) (	Change in momentum = (0.06x12)+(0.06x9) = 1.26 (Ns) Average force=rate of change of momentum = 1.26/0.15 = **8.4** (or 8) **N**	C1 A1	Award 1 mark for 1.2 N ignore minus signs
(b) (i	**8.4 N** (or - 8.4)	B1	Allow ecf from (ii)
(c)	ANY 3 of the following particles move with rapid, random motion (WTTE) elastic collisions negligible (or zero) volume of atoms (compared with volume of container) no intermolecular forces (except during collisions)/all internal energy is KE collision time negligible (compared to time between collision).	 B1 B1 B1	Allow " gravitational force on molecules is negligible" Do not allow a bare "large number of particles".
(c) (	molecules make collisions with walls/surface (WTTE) (hence) exerts a force on the wall (or each collision has a change of momentum) Pressure = force/area	B1 B1 B1	Do not allow a bare "molecules collide with each other"
	Total	13	

Question	Expected Answers	Marks	Additional guidance
4 (a) (i)	**Brownian** (motion) (QWC mark)	B1	QWC Brownian spelled correctly
(a) (	ANY two from the following three: air molecules are moving in different directions/randomly with different speeds mass/size of air molecules is smaller than smoke particles	 B1 B1	Answers that refer to smoke particles only cannot score the marks.
(b)	vol = (4/3) $\pi r^3 = 5.58 \times 10^{-3}$ correct sub into pV = nRT i.e. with T as 290K n = $(2.6 \times 10^5 \times 5.58 \times 10^{-3})/8.31 \times 290 = 0.602$ moles mass = n x 0.028 = **0.0169** kg (0.016856)	C1 C1 A1 A1	Allow ecf for wrong volume Allow use of pV = NkT and $n = N/N_A$ Allow ecf for cand's value for n If 17^o C used allow maximum of 2 marks for n = 10.3 moles and m = 0.29 kg
(b) (ii	no net heat flow between objects (WTTE)	B1	Allow "they are at the same temp."
(b) (ii	correct use of P/T = constant: e.g. P = (273/290) x 2.6 x 10^5 P = **2.45×10^5** (or 2.4×10^5 or 2.5×10^5)Pa	C1 A1	Allow correct use of pV=nRT
	Total	10	