

4(a)(i)	thermodynamic temperature
4(a)(ii)	molar gas constant
4(b)(i)	m : mass of one molecule (of the gas) $\langle c^2 \rangle$: mean-square speed (of molecules)
4(b)(ii)	$NBT/A = \frac{1}{3} Nm\langle c^2 \rangle$ clear use of $E_K = \frac{1}{2} m\langle c^2 \rangle$ leading to $E_K = 3BT/2A$
4(c)	line with positive gradient passing through the origin smooth curve with decreasing positive gradient

3(a)	(gas that obeys) $pV \propto T$ (at all values of p , V and T) where T is thermodynamic temperature
3(b)(i)	$pV = \frac{1}{3} Nm\langle c^2 \rangle$ and $Nm/V = \rho$ ($p = \frac{1}{3} \rho \langle c^2 \rangle$) r.m.s. speed = $\sqrt{\langle c^2 \rangle}$ $1.6 \times 10^5 = \frac{1}{3} \times 1.9 \times \langle c^2 \rangle$ leading to r.m.s. speed = 500 m s^{-1} or r.m.s. speed = $\sqrt{(3 \times 1.6 \times 10^5 / 1.9)} = 500 \text{ m s}^{-1}$
3(b)(ii)	$(pV =) \frac{1}{3} Nm\langle c^2 \rangle = NkT$ (so) $\frac{1}{2} m\langle c^2 \rangle = (3/2) kT$ $\frac{1}{2} \times 4.7 \times 10^{-26} \times 503^2 = (3/2) \times 1.38 \times 10^{-23} \times T$ $T = 290 \text{ K}$ or $pV = NkT$ and $Nm/V = \rho$ (so) $T = pm / \rho k$ $T = 1.6 \times 10^5 \times 4.7 \times 10^{-26} / (1.9 \times 1.38 \times 10^{-23})$ $= 290 \text{ K}$
3(c)	potential energy (of molecules) is zero $U = N \times \frac{1}{2} m\langle c^2 \rangle = 6.0 \times 6.02 \times 10^{23} \times \frac{1}{2} \times 4.7 \times 10^{-26} \times 503^2$ or $U = N \times (3/2) kT = 6.0 \times 6.02 \times 10^{23} \times (3/2) \times 1.38 \times 10^{-23} \times 287$ or $U = n \times (3/2) RT = 6.0 \times (3/2) \times 8.31 \times 287$ $U = 21000 \text{ J}$

4(a)	- particles are in (continuous) random motion - particles have negligible volume (compared with the gas) - negligible forces between particles (except during collisions) (all) collisions (perfectly) elastic - time of collision negligible (in comparison with time between collisions) Any two points, 1 mark each																
4(b)(i)	(general starting equation) $pV = nRT$ $T = (2pV / nR)$ where R is the (molar) gas constant																
4(b)(ii)	sketch: straight vertical line XY from $(V, 2p)$ to (V, p) straight horizontal line YZ from (V, p) to $(2V, p)$ curve with gradient increasing from Z to X from $(2V, p)$ to $(V, 2p)$																
4(b)(iii)	XY work done on gas correct (= 0) ZX increase in internal energy correct (= 0) YZ work done on gas correct (= $-pV$) XY increase in internal energy such that the increase in internal energy column adds up to zero all three thermal energies transferred such that $\Delta U = q + w$ in each row (completely correct answer: <table><tr><td>change</td><td>ΔU</td><td>Q</td><td>w</td></tr><tr><td>X to Y</td><td>$-U$</td><td>$-U$</td><td>0</td></tr><tr><td>Y to Z</td><td>[$+U$]</td><td>$U + pV$</td><td>$-pV$</td></tr><tr><td>Z to X</td><td>0</td><td>$-W$</td><td>[$+W$]</td></tr></table>)	change	ΔU	Q	w	X to Y	$-U$	$-U$	0	Y to Z	[$+U$]	$U + pV$	$-pV$	Z to X	0	$-W$	[$+W$]
change	ΔU	Q	w														
X to Y	$-U$	$-U$	0														
Y to Z	[$+U$]	$U + pV$	$-pV$														
Z to X	0	$-W$	[$+W$]														