

4(a)(i)	sum of potential energy and kinetic energy								
	(total) energy of random motion of particles								
4(a)(ii)	potential energy (of molecules) (in an ideal gas) is zero, so the internal energy of the gas is equal to the total kinetic energy (of molecules)								
	kinetic energy of molecules is proportional to (thermodynamic) temperature (so internal energy is proportional to (thermodynamic) temperature))								
4(b)	cooling work done = 0								
	compression increase in internal energy = $+2U$								
	cooling change in internal energy = $-U$								
	both rows: thermal energy adds to work to give increase in internal energy in terms of U and/or W								
	(if fully correct, thermal energy for compression = $2U - W$ and thermal energy for cooling = $-U$:								
	<table><tr><td>compression</td><td>$+W$</td><td>$2U - W$</td><td>$+2U$</td></tr><tr><td>cooling</td><td>0</td><td>$-U$</td><td>$-U$</td></tr></table>	compression	$+W$	$2U - W$	$+2U$	cooling	0	$-U$	$-U$
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3(a)(i)	N : number of molecules (of the gas)
	m : mass of one molecule (of the gas)
	$\langle c^2 \rangle$: mean square speed (of molecules)
3(a)(ii)	$pV = NkT$
	$NkT = \frac{1}{2}Nm\langle c^2 \rangle$ and $E_K = \frac{1}{2}m\langle c^2 \rangle$ leading to $E_K = (3/2) kT$
3(b)	$\frac{1}{2} \times 3.34 \times 10^{-27} \times 9300^2 = (3/2) \times 1.38 \times 10^{-23} \times T$
	$T = 6980 \text{ K}$
3(c)(i)	$L = F \times 4\pi d^2$
	$L = 2.52 \times 10^{-8} \times 4\pi \times (4.16 \times 10^{16})^2$
	$= 5.48 \times 10^{26} \text{ W}$
3(c)(ii)	$L = 4\pi\sigma r^2 T^4$
	$5.48 \times 10^{26} = 4\pi \times 5.67 \times 10^{-8} \times r^2 \times 6980^4$
	$r = 5.69 \times 10^8 \text{ m}$
3(d)	(very high pressure so) molecules are (very) close together (<i>not just 'nearer'</i>)
	forces between molecules are not negligible or volume of molecules not negligible compared with gas volume

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	$-W$	[$+W$]
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