

4(a)(i)	temperature = $-273.15\text{ }^{\circ}\text{C}$
4(a)(ii)	temperature = 0 K
4(b)(i)	gas is ideal
4(b)(ii)	$pV = NkT$
	$N = 270 / (8.0 \times 10^{-21})$ $= 3.4 \times 10^{22}$
4(b)(iii)	$n = (3.4 \times 10^{22}) / (6.02 \times 10^{23})$ $= 0.056\text{ mol}$
4(c)	$\frac{1}{2} m \langle c^2 \rangle = (3 / 2) kT$
	$\frac{1}{2} \times m \times 1900^2 = 1.5 \times 8.0 \times 10^{-21}$
	$(m = 6.65 \times 10^{-27}\text{ kg})$
	$m = (6.65 \times 10^{-27}) / (1.66 \times 10^{-27})$ $= 4.0\text{ u}$

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 = $-U$:		
	compression	$+W$	$2U - W$
	cooling	0	$-U$

3(a)	(thermal) energy per unit mass (to cause temperature change)
	(thermal) energy per unit change in temperature
3(b)(i)	density = mass / volume
	mass = $2.700 \times 10^3 \times 3.612 \times 10^{-3}$ $= 9.752\text{ kg}$
3(b)(ii)	volume = $3.612 \times 10^{-3} \times (2.700 / 2.620) = 3.722 \times 10^{-3}\text{ m}^3$
	or volume = $9.752 / (2.620 \times 10^3) = 3.722 \times 10^{-3}\text{ m}^3$
3(b)(iii)	$W = p\Delta V$
	$= 1.01 \times 10^5 \times (3.722 - 3.612) \times 10^{-3}$
	$= 11.1\text{ J}$
3(b)(iv)	volume (of block) increases
	work is done against the atmosphere so work done (on block) is negative
3(b)(v)	thermal energy = $(4.38 \times 10^6) + 11.1$
	specific heat capacity = $(4.38 \times 10^6) / (9.75 \times 500)$
	$= 898\text{ J kg}^{-1}\text{ }^{\circ}\text{C}^{-1}$
3(c)	work done is negligible compared with (change in) internal energy so (answer in (b)(v) would be) unchanged

3(a)(i)	(P and Q are at the) same temperature
	no <u>net</u> transfer of thermal energy (between P and Q)
3(a)(ii)	$Q = mc\Delta T$
	$24 \times 10^3 = (0.54 \times 390 \times \Delta T) + (0.37 \times 910 \times \Delta T)$
	$\Delta T = 44\text{ K}$
3(b)(i)	work done = $p\Delta V$
	$= (1.6 \times 10^5) \times (0.18 - 0.32)$
	$= -2.2 \times 10^4\text{ J}$
3(b)(ii)	$pV = NkT$
	$N = (1.6 \times 10^5 \times 0.18) / (1.38 \times 10^{-23} \times 273)$ $= 7.6 \times 10^{24}$
3(b)(iii)	$\frac{1}{2} m \langle c^2 \rangle = (3 / 2) kT$
	r.m.s. speed = $\sqrt{[(3 \times 1.38 \times 10^{-23} \times (210 + 273)) / (4.7 \times 10^{-26})]}$ $= 650\text{ ms}^{-1}$