A-Level Physics: **w25 41**

4(a)(i)	temperature = –273.15 °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)	$n = (3.4 \times 10^{22}) / (6.02 \times 10^{23})$ $= 0.056$ mol
4(c)	$½\, m<c^2> = (3 / 2)\, kT$
	$½ \times m \times 1900^2 = 1.5 \times 8.0 \times 10^{-21}$ ($m = 6.65 \times 10^{-27}$ kg)
	$m = (6.65 \times 10^{-27}) / (1.66 \times 10^{-27})$
	$= 4.0$ u

A-Level Physics: **s25 41**

<table>
<tr><td>4(a)(i)</td><td>sum of potential energy and kinetic energy</td></tr>
<tr><td></td><td>(total) energy of random motion of particles</td></tr>
<tr><td>4(a)(ii)</td><td>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)</td></tr>
<tr><td></td><td>kinetic energy of molecules is proportional to (thermodynamic) temperature (so internal energy is proportional to (thermodynamic) temperature))</td></tr>
<tr><td>4(b)</td><td>cooling work done = 0</td></tr>
<tr><td></td><td>compression increase in internal energy = $+2U$</td></tr>
<tr><td></td><td>cooling change in internal energy = $–U$</td></tr>
<tr><td></td><td>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>
)</td></tr>
</table>

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 $= 2.700 \times 10^3 \times 3.612 \times 10^{-3}$ $= 9.752$ kg
3(b)(ii)	volume $= 3.612 \times 10^{-3} \times (2.700 / 2.620) = 3.722 \times 10^{-3}$ m^3 **or** volume $= 9.752 / (2.620 \times 10^3) = 3.722 \times 10^{-3}$ m^3
3(b)(iii)	$W = p\Delta V$
	$= 1.01 \times 10^5 \times (3.722 - 3.612) \times 10^{-3}$ $= 11.1$ 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 $= (4.38 \times 10^6) / (9.75 \times 500)$
	$= 898$ J kg^{-1} °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)	$Q = mc\Delta T$
	$24 \times 10^3 = (0.54 \times 390 \times \Delta T) + (0.37 \times 910 \times \Delta T)$
	$\Delta T = 44$ K
3(b)(i)	work done $= p\Delta V$
	$= (1.6 \times 10^5) \times (0.18 - 0.32)$
	$= -2.2 \times 10^4$ 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 $= \sqrt{[(3 \times 1.38 \times 10^{-23} \times (210 + 273) / (4.7 \times 10^{-26})]}$ $= 650$ m s^{-1}