<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>

<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)(i)	gas for which $pV \propto T$
	where T is thermodynamic temperature
3(a)(ii)	no intermolecular forces
	(so) potential energy is zero
3(b)(i)	$pV = NkT$
	$N = (2.0 \times 10^5 \times 0.26) / (1.38 \times 10^{-23} \times 290)$ $= 1.3 \times 10^{25}$
3(b)(ii)	$E_K = (3/2)\, kT$
	$E_K = (3/2) \times 1.38 \times 10^{-23} \times 290$ $= 6.0 \times 10^{-21}$ J
3(b)(iii)	internal energy = total KE + PE of molecules **or** PE = 0 so internal energy = total KE of molecules
	internal energy = $1.3 \times 10^{25} \times 6.0 \times 10^{-21}$ $= 7.8 \times 10^4$ J
3(c)	straight line with positive gradient
	line passing through the origin