Question Number	Answer	Mark
1(a)	Use of $pV = NkT$ **(1)** Number of molecules = 2.2×10^{23} **(1)** (Use of the number of molecules to get a pressure of 0.99×10^{5} Pa can score both marks. Allow use of pV = nRT leading to correct answer for 2 marks, but no credit for a substitution of incorrect values into this equation) <u>Example of calculation</u> $N = \frac{1.1\times10^{5}\ \text{Pa}\times8.2\times10^{-3}\ \text{m}^{3}}{1.38\times10^{-23}\ \text{J K}^{-1}\times295\,\text{K}} = 2.2\times10^{23}$	**2**
1(b)	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate **(For this question accept answers in terms of atoms, molecules or particles)** • Internal energy is (sum of) molecular kinetic and potential energies **(1)** • In (an ideal) gas the molecules have only kinetic energy **Or** the molecules do not have potential energy. **(1)** • $E_k = 3kT/2$ **Or** $E_k \propto T$ **Or** (above 0 K) the air molecules are in (continual) random motion **(1)** • If the gas reached absolute zero, then the K.E. of the molecules would be zero and so the statement is correct **Or** If air is identified as not being ideal, then allow idea that molecules would still have potential energy at 0 K, and so statement is incorrect **(1)**	**4**
	Total for question	**6**

Question Number	Answer		Mark
2(a)(i)	Use of p/T= a constant $p = 1.8 \times 10^5$ (Pa) (no ue) <u>Example of calculation</u> $\frac{p_2}{T_2} = \frac{p_1}{T_1}$ $\therefore p_2 = \frac{(273+40)\text{ K} \times 1.65 \times 10^5 \text{ Pa}}{(273+20)\text{ K}} = 1.76 \times 10^5 \text{ Pa}$	**(1)** **(1)**	**2**
2(a)(ii)	Air behaves as an ideal gas / mass of air remains constant / number of molecules remains constant/same amount of air/number of moles remains constant/no air escapes	**(1)**	**1**
2(b)	Use of $V=4\pi r^3/3$ Use of $pV = N\text{k}T$ $N = 1.5 \times 10^{22}$ <u>Example of calculation</u> $V = \frac{4\pi r^3}{3} = \frac{4\pi(\frac{0.225\text{ m}}{2})^3}{3} = 5.96 \times 10^{-3}\text{ m}^3$ $N = \frac{pV}{\text{k}T} \therefore \Delta N = \frac{V(p_2 - p_1)}{\text{k}T}$ $\Delta N = \frac{5.96 \times 10^{-3}\text{m}^3 (1.76 \times 10^5 - 1.65 \times 10^5)\text{ Pa}}{1.38 \times 10^{-23}\text{J K}^{-1} \times 313\text{ K}}$ $\Delta N = 1.52 \times 10^{22}$	**(1)** **(1)** **(1)**	**3**
	Total for question		**6**

Question Number	Answer	Mark
3(a)	Use of $pV=NkT$ (1) $T =$ 870 (K) OR p = 12.4 (atmospheres) (1) If final pressure is given as 1.24×10^6 Pa, then just "use of" mark <u>Example of calculation</u>: $T = \frac{pV}{Nk} = \frac{12 \times 1.0 \times 10^5 \text{ Nm}^{-2} \times 3.00 \times 10^{-4} \text{ m}^3}{3 \times 10^{22} \times 1.38 \times 10^{-23} \text{ JK}^{-1}} = 869.6 \text{ K}$ OR $p = \frac{NkT}{V} = \frac{3 \times 10^{22} \times 1.38 \times 10^{-23} \text{ JK}^{-1} \times 900 \text{ K}}{3 \times 10^{-4} \text{ m}^3}$ $\therefore p = 1.24 \times 10^6 \text{ Pa} = \frac{1.24 \times 10^6 \text{ Pa}}{3 \times 10^{-4} \text{ Pa}} = 12.4$	**2**
3(b)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) <u>Atoms/molecules</u> would gain energy (1) <u>Atoms/molecules</u> would escape from the liquid OR liquid propellant would vaporise / turn into gas OR the amount of gas in can would increase (1) Pressure would increase due to **both** temperature/energy increase **and** increase in amount of gas OR pressure would increase more for the same temperature increase OR pressure would be greater than 12 atmospheres before 900 K (1) Can would explode before 900 K reached (1)	**Max 3**
	Total for question	**5**

Question Number	Answer		Mark
4(a)	(When the air is heated) the density (of air in) the balloon decreases So the upthrust is greater than the weight of the balloon (plus occupants)	**(1)** **(1)**	**2**
4(b	Use of $\rho = \frac{m}{V}$ Use of $\Delta E = mc\Delta\theta$ [$\Delta\theta$ must be a temperature difference] $\Delta E = 1.3(5) \times 10^9$ J <u>Example of calculation:</u> $m = \rho V = 1.20\,\text{kg m}^{-3} \times 7.4 \times 10^4\,\text{m}^3 = 8.88 \times 10^4\,\text{kg}$ $\Delta E = mc\Delta\theta = 8.88 \times 10^4\,\text{kg} \times 1010\,\text{J kg}^{-1}\,\text{K}^{-1}(35-20)\text{K} = 1.345 \times 10^9\,\text{J}$	**(1)** **(1)** **(1)**	**3**
4(c)(i)	Use of $pV = NkT$ [temperature in either K or °C] $p = 9.24 \times 10^4$ Pa <u>Example of calculation:</u> $\frac{p_2}{p_1} = \frac{T_2}{T_1}$ $p_2 = (1.01 \times 10^5)\text{Pa} \times \frac{(273-5)\text{K}}{(273+20)\text{K}} = 9.238 \times 10^4\,\text{Pa}$	**(1)** **(1)**	**2**
4(c)(ii)	**Max 2** Hydrogen/gas behaves as an ideal gas Mass of hydrogen/gas in balloon stays constant [Accept amount of hydrogen/gas] **Or** number of molecules/atoms/particles of hydrogen/gas in balloon stays constant Temperature of hydrogen/gas is the same as the temperature of the surroundings	**(1)** **(1)** **(1)**	**2**
4(c)(iii)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) The average/mean kinetic energy of the molecules decreases Molecules travel slower (on average) **Or** rate of collisions with walls is less So rate of change of momentum (during collisions) with walls is less	 **(1)** **(1)** **(1)**	**3**
	Total for question		**12**