Thermodynamics MS1

Question Number	Answer		Mark
1(a)	Any two from: Air behaves as an ideal gas Temperature (in the lungs) stays constant Implication of no change in mass of gas	 (1) (1) (1)	**(max 2)**
1(b)(i)	Use of $\rho = m/V$ Correct answer (1.3×10^{-4} kg s^{-1}) Example of calculation: $m = V.\rho = 2.5 \times 10^{-4}\ \text{m}^3 \times 1.2\ \text{kg m}^{-3} = 3 \times 10^{-4}\ \text{kg}$ $\frac{\Delta m}{\Delta t} = 3 \times 10^{-4}\ \text{kg} \times \frac{25}{60\,\text{s}} = 1.25 \times 10^{-4}\ \text{kg s}^{-1}$	(1) (1)	**(2)**
1(b)(ii)	Use of $\Delta E = mc\Delta\theta$ Correct answer (2.2 W) ecf Example of calculation: $P = 1.25 \times 10^{-4}\ \text{kg s}^{-1} \times 1000\ \text{J kg}^{-1}\ \text{K}^{-1} \times (37.6 - 20.0)\text{K} = 2.2\ \text{W}$	(1) (1)	**(2)**
	Total for question 1		**(6)**

Question Number	Answer	Mark
2(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> $T=\frac{pV}{Nk}=\frac{12\times1.0\times10^5\ \text{Nm}^{-2}\times3.00\times10^{-4}\,\text{m}^3}{3\times10^{22}\times1.38\times10^{-23}\,\text{JK}^{-1}}=869.6\ \text{K}$ OR $p=\frac{NkT}{V}=\frac{3\times10^{22}\times1.38\times10^{-23}\ \text{JK}^{-1}\times900\ \text{K}}{3\times10^{-4}\ \text{m}^3}$ $\therefore\ p=1.24\times10^6\,\text{Pa}=\frac{1.24\times10^6\,\text{Pa}}{3\times10^{-4}\,\text{Pa}}=12.4$	**2**
2(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 2	**5**

Question Number	Answer		Mark
3(a)	Use of $P=IV$ $I = 9.1$ A <u>Example of calculation</u> $I = \frac{P}{V} = \frac{2100\ \text{W}}{230\ \text{V}} = 9.13\ \text{A}$	**(1)** **(1)**	**2**
3(b)(i)	Use of $\Delta E = mc\Delta\theta$ (for t =1s) $\theta = 51^{\circ}$C or 324 K <u>Example of calculation</u> $\Delta\theta = \frac{\Delta E}{mc} = \frac{2100\ \text{J}}{0.068\ \text{kg} \times 1010\ \text{J kg}^{-1}\ {}^{\circ}\text{C}^{-1}} = 30.6\ {}^{\circ}\text{C}$ $\theta = 30.6 + 20 = 50.6\ {}^{\circ}\text{C}$	**(1)** **(1)**	**2**
3(b)(ii)	Thermal energy (is transferred) to <u>air</u> (molecules) Kinetic energy [E_k] of (air) molecules is increased	**(1)** **(1)**	**2**
	Total for question 3		**6**

Question Number	Answer		Mark
4(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**
4(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**
4(b)	Use of $V=4\pi r^{3}/3$ Use of $pV = NkT$ $N = 1.5 \times 10^{22}$ <u>Example of calculation</u> $V = \frac{4\pi r^3}{3} = \frac{4\pi\left(\frac{0.225\ \text{m}}{2}\right)^3}{3} = 5.96 \times 10^{-3}\ \text{m}^3$ $N = \frac{pV}{kT} \therefore \Delta N = \frac{V(p_2 - p_1)}{kT}$ $\Delta N = \frac{5.96 \times 10^{-3}\text{m}^3 (1.76 \times 10^{5} - 1.65 \times 10^{5})\ \text{Pa}}{1.38 \times 10^{-23}\ \text{J K}^{-1} \times 313\ \text{K}}$ $\Delta N = 1.52 \times 10^{22}$	**(1)** **(1)** **(1)**	**3**
	Total for question 4		**6**

Question Number	Answer		Mark
5(a)	Use of $\Delta E = mc\Delta\theta$ Energy = 780 J <u>Example of calculation</u> $\Delta E = 34 \times 10^{-3}\ \text{kg} \times 490\ \text{J kg}^{-1}\text{K}^{-1} \times (100 - 53)\text{K} = 783\ \text{J}$	**(1)** **(1)**	**2**
5(b)	Heat / thermal energy is transferred from the sphere to the wax Idea that the lead sphere has insufficient energy for melting the wax (e.g. The lead sphere transfers less heat / thermal energy (than the steel sphere). Credit a supporting calculation)	**(1)** **(1)**	**2**
	Total for question 5		**4**

Question Number	Answer		Mark
6(a)	Use of $pV = NkT$ Number of molecules = 2.2×10^{23} (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> $N = \dfrac{1.1 \times 10^5\ \text{Pa} \times 8.2 \times 10^{-3}\ \text{m}^3}{1.38 \times 10^{-23}\ \text{J K}^{-1} \times 295\ \text{K}} = 2.2 \times 10^{23}$	**(1)** **(1)**	**2**
6(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 • In (an ideal) gas the molecules have only kinetic energy **Or** the molecules do not have potential energy. • $E_k = 3kT/2$ **Or** $E_k \propto T$ **Or** (above 0 K) the air molecules are in (continual) random motion • 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)** **(1)** **(1)** **(1)**	**4**
	Total for question 6		**6**