Thermodynamics MS2

Question Number	Answer		Mark
1(a)	Use of electrical power equation e.g. $P = \frac{V^2}{R}$ R = 8.8 Ω [Use of V=IR and P=VI gains mp1] <u>Example of calculation</u> $R = \frac{(230V)^2}{6000W} = 8.82\Omega$	(1) (1)	**2**
1(b)	See 30 K [30 ^{o}C] **Or** 6000 J s^{-1} Use of ΔE = mcΔθ [Do not penalise wrong temperature conversions, but Δθ must be a temperature difference] $\frac{\Delta m}{\Delta t} = 0.048\,\text{kg}\,\text{s}^{-1}$ [accept 0.048 litre s^{-1} and other volume flow rates with correct units] <u>Example of calculation</u> Δθ = (37.5 – 7.5) ^{o}C = 30 ^{o}C $\frac{\Delta m}{\Delta t} = \frac{6000\,\text{W}}{4200\,\text{J}\,\text{kg}^{-1}\,\text{K}^{-1} \times 30\,\text{K}} = 0.0476\,\text{kg}\,\text{s}^{-1}$	(1) (1) (1)	**3**
	Total for question 1		**5**

Question Number	Answer		Mark
2(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**
2(b)	Use of $\rho = \frac{m}{V}$ Use of $\Delta E = mc\Delta\theta$ [$\Delta\theta$ must be a temperature difference] ΔE = 1.3(5) × 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**
2(c)(i)	Use of $pV = NkT$ [temperature in either K or °C] p = 9.24 × 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**
(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**
2(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 2		**12**

Question Number	Answer		Mark
3 (a)	Use of $\Delta E_k = m\,g\,\Delta h$	**(1)**	
	$\Delta E_k = 1.42$ J	**(1)**	
	Or use of $v^2 = u^2 + 2as$ **and** $E_k = \frac{1}{2}mv^2$	**(1)**	
	$\Delta E_k = 1.42$ J– 1.44J	**(1)**	**2**
	<u>Example of calculation</u> $\Delta E_k = m\,g\,\Delta h = 57.0 \times 10^{-3}\text{ kg} \times 9.81\text{ N kg}^{-1} \times 2.54\text{ m} = 1.42\text{ J}$		
(b)(i)	**QWC – Work must be clear and organised in a logical manner using technical wording where appropriate**		
	Max 4		
	(Average) kinetic energy of molecules is greater **Or** molecules move faster	**(1)**	
	Volume available decreases	**(1)**	
	(So) collision rate with walls of container is greater	**(1)**	
	There is a greater rate of change of momentum	**(1)**	
	Therefore a greater force on the container walls (dependent on MP4)	**(1)**	**4**
(b)(ii)	Use of $pV = NkT$ with T in K or °C	**(1)**	
	$T_2 = 299$ K or 26 °C	**(1)**	**2**
	<u>Example of calculation</u> $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$ $T_2 = \frac{197 \times 10^3\text{ Pa} \times 101 \times 10^{-6}\text{ m}^3}{182 \times 10^3\text{ Pa} \times 107 \times 10^{-6}\text{ m}^3} \times 293\text{K} = 299.4\text{ K}$		

(b)(iii)	Use of $pV = NkT$	(1)	
	$N = 4.8 \times 10^{21}$	(1)	
	Using $E_k = \frac{3}{2}kT$ with 2 temperatures	(1)	
	Use of $E = N E_k$ using their value for N or show that value	(1)	4
	Example of calculation $N = \frac{p.V}{kT} = \frac{182 \times 10^3\,\text{Pa} \times 107 \times 10^{-6}\,\text{m}^3}{1.38 \times 10^{-23}\,\text{JK}^{-1} \times (273+20)\text{K}} = 4.82 \times 10^{21}$ $\Delta E_k = \frac{3}{2}k\Delta T$ $\Delta E_{k,total} = 4.82 \times 10^{21} \times 1.5 \times 1.38 \times 10^{-23}\,\text{J K}^{-1} \times (299-293)\text{K} = 0.599\text{J}$		
(b)(iv)	Less kinetic energy after bounce, **so** bounce height less (than release height)	(1)	
	Energy is dissipated during bounce (Idea that not all thermal energy will return to kinetic energy of the ball)	(1)	2
	Total for Question 17		**14**

	Answer		Mark
4 (a)	Use of $\Delta E = mc\Delta T$	(1)	
	$\Delta E = 5.4 \times 10^8$ J	(1)	
	Assumption: No energy transferred to surroundings **Or** all energy from heater used to heat water	(1)	3
	Example of calculation $\Delta E = mc\Delta T = 1.6 \times 10^4\,\text{kg} \times 4200\,\text{J kg}^{-1}\,\text{K}^{-1} \times (20-12)\text{K} = 5.38 \times 10^8\,\text{J}$		
(b)	Use of $W = VIt$ **Or** Use of $P = \frac{\Delta E}{\Delta t}$ **and** $P = VI$ **Or** Use of $V = \frac{W}{Q}$ **and** $I = \frac{Q}{t}$	(1)	
	Converts hours to seconds	(1)	
	$I = 22$ A	(1)	3
	Example of calculation $P = \frac{\Delta E}{\Delta t} = \frac{0.55 \times 10^9\,\text{J}}{(30 \times 60 \times 60)\text{s}} = 5.09 \times 10^3\,\text{W}$ $I = \frac{P}{V} = \frac{5.09 \times 10^3\,\text{W}}{230\,\text{V}} = 22.1\,\text{A}$		
	Total for Question 13		**6**

Question Number	Answer		Mark
5 (a)	Idea that internal energy is the sum of (Total) kinetic energy and potential energy of molecules/atoms	 **(1)** **(1)**	**2**
(b)(i)	Use of $\Delta E = mc\Delta\theta$ $\Delta E = 8100$ (J) <u>Example of calculation:</u> $\Delta E = mc\Delta\theta = 175\times10^{-3}\ \mathrm{kg}\times4200\ \mathrm{J\ kg^{-1}\ K^{-1}}\times(85-74)\mathrm{K} = 8090\ \mathrm{J}$	**(1)** **(1)**	**2**
(b)(ii)	Use of ΔE value from (i) in $\Delta E = mc\Delta\theta$ $m = 0.030$ kg No energy transferred to surroundings **Or** all energy transferred from tea used to heat milk <u>Example of calculation:</u> $\Delta E = mc\Delta\theta$ $8100\ \mathrm{J} = m\times3900\ \mathrm{J\ kg^{-1}\ K^{-1}}\times(74-4.5)\mathrm{K}$ $\therefore \mathrm{m} = \dfrac{8100\ \mathrm{J}}{3900\ \mathrm{J\ kg^{-1}\ K^{-1}}\times69.5\ \mathrm{K}} = 0.0299\ \mathrm{kg}$	**(1)** **(1)** **(1)**	**3**
	Total for question 13		**7**

Question Number	Answer		Mark
6 (a)	Use of $pV = NkT$ Pressure difference **Or** temperature conversion $\Delta N = 5.0 \times 10^{21}$ <u>Example of calculation:</u> $\Delta N = \frac{\Delta p.V}{kT} = \frac{(6.5\times10^{5} - 5.8\times10^{5})\text{Pa}\times 2.9\times10^{-4}\,\text{m}^{3}}{1.38\times10^{-23}\,\text{JK}^{-1}\times(273+20)\text{K}} = 5.0\times10^{21}$	**(1)** **(1)** **(1)**	**3**
(b)	Use of $pV = NkT$ T_2 = 307 (K) stated or implied **Or** 293(K) subtracted ΔT = 14 K <u>Example of calculation:</u> $\frac{p_1}{T_1} = \frac{p_2}{T_2}$ $T_2 = \frac{6.8\times10^{5}\,\text{Pa}}{6.5\times10^{5}\,\text{Pa}}\times 293\text{K} = 307\text{K}$ ΔT = (307 – 293) K = 14 K	**(1)** **(1)** **(1)**	**3**
(c)	**Max 3** (Average) <u>kinetic</u> energy of molecules/atoms is greater **Or** molecules/atoms move faster Collision rate with walls of container is greater There is more momentum (exchanged) per collision **Or** the rate of change of momentum is greater Therefore a greater force on the container walls (dependent upon mp2 or mp3)	**(1)** **(1)** **(1)** **(1)**	**3**
	Total for question 14		**9**