Name of the Student:_____
Max. Marks : 29 Marks **Time : 29 Minutes**

Mark Schemes

Q1.

Question Number	Acceptable answers	Additional guidance	Mark
	• Equate $pV = NkT$ and $pV = \frac{1}{3}Nm < c^2 >$ • Suitable algebra		2

Q2.

Question Number	Answer		Mark
(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] Example of calculation $R = \frac{(230V)^2}{6000W} = 8.82\Omega$	(1) (1)	2

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(b)	See 30 K [30 °C] **Or** 6000 J s^{-1} (1) Use of $\Delta E = mc\Delta\theta$ [Do not penalise wrong temperature conversions, but $\Delta\theta$ must be a temperature difference] (1) $\frac{\Delta m}{\Delta t} = 0.048\,\text{kg s}^{-1}$ [accept 0.048 litre s^{-1} and other volume flow rates with correct units] (1) Example of calculation $\Delta\theta = (37.5 - 7.5)\,^{\circ}\text{C} = 30\,^{\circ}\text{C}$ $\frac{\Delta m}{\Delta t} = \frac{6000\,\text{W}}{4200\,\text{J kg}^{-1}\,\text{K}^{-1} \times 30\,\text{K}} = 0.0476\,\text{kg s}^{-1}$	**3**
	Total for question	**5**

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Use of $E_K = \frac{1}{2}mv^2$ **(1)** • Use of $\Delta E = mc\Delta\theta$ **(1)** • Use of 8000 **Or** use of (energy required) / (energy per slap) **(1)** • Use of 65% with input energy **(1)** • Energy from 8000 slaps would be 1.78×10^5 J which is less than the energy required to raise the temperature to 165 °C (2.20×10^5 J) **Or** final temperature would be 138 °C, so not enough **Or** 9900 slaps would be needed, so not enough **Or** temperature rise from 8000 slaps is 115 K which is less than required temperature rise of 142 K **(1)**	Example of calculation $E_K = \frac{1}{2} \times 1.75\,\text{kg} \times (6.25\,\text{m s}^{-1})^2 = 34.2\,\text{J}$ $\Delta E = 0.65 \times 8000 \times 34.2\,\text{J} = 1.78 \times 10^5\,\text{J}$ $\Delta E = 0.875\,\text{kg} \times 1770\,\text{J kg}^{-1}\text{K}^{-1} \times (165 - 23)\text{K}$ $\therefore \Delta E = 2.20 \times 10^5\,\text{J}$ $E_K = \frac{1}{2} \times 1.75\,\text{kg} \times (6.25\,\text{m s}^{-1})^2 = 34.2\,\text{J}$ $\Delta E = 0.65 \times 34.2\,\text{J} = 22.2\,\text{J}$ $\Delta E = 0.875\,\text{kg} \times 1770\,\text{J kg}^{-1}\text{K}^{-1} \times (165 - 23)\text{K}$ $\therefore \Delta E = 2.20 \times 10^5\,\text{J}$ Number of slaps $= \frac{2.20 \times 10^5\,\text{J}}{22.2\,\text{J}} = 9910$ $E_K = \frac{1}{2} \times 1.75\,\text{kg} \times (6.25\,\text{m s}^{-1})^2 = 34.2\,\text{J}$ $\Delta E = 0.65 \times 8000 \times 34.2\,\text{J} = 1.78 \times 10^5\,\text{J}$ $1.78 \times 10^5\text{J} = 0.875\,\text{kg} \times 1770\,\text{J kg}^{-1}\text{K}^{-1} \times (T_f - 296)\text{K}$ $\therefore T_f = \frac{1.78 \times 10^5\,\text{J}}{1.55 \times 10^3\,\text{J K}^{-1}} + 296\,\text{K} = 411\,\text{K}$ $\therefore \theta_f = (411 - 273)\,\text{K} = 138\,^{\circ}\text{C}$ MP5: must see a correct value as part of the conclusion	**5**

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Q4.

Question Number	Answer		Mark
	The star cools, so temperature T reduces	(1)	
	The star contracts (under gravitational forces), so area A reduces	(1)	
	$L = \sigma A T^4$ hence L is reduced (mark dependent upon either mp1 or mp2)	(1)	3

Q5.

Question Number	Answer	Mark
	B	1

Q6.

Question Number	Answer		Mark
(a)	Pressure (of gas)	(1)	
	Amount of gas **Or** mass of gas **Or** number of moles / molecules / atoms	(1)	2
(b)	Extending/extrapolating the line backwards	(1)	
	The volume occupied by a gas will be zero at a particular temperature	(1)	
	Or		
	The graphs for different gases	(1)	
	All cut the x axis at the same temp	(1)	2

Q7.

Question Number	Answer		Mark
(a)	(When the air is heated) the density (of air in) the balloon decreases	(1)	
	So the upthrust is greater than the weight of the balloon (plus occupants)	(1)	2
(b)	Use of $\rho = \frac{m}{V}$	(1)	
	Use of $\Delta E = mc\Delta\theta$ [$\Delta\theta$ must be a temperature difference]	(1)	
	$\Delta E = 1.3(5) \times 10^9$ J	(1)	3
	Example of calculation: $m = \rho V = 1.20\,\text{kg m}^{-3} \times 7.4 \times 10^4\,\text{m}^3 = 8.88 \times 10^4\,\text{kg}$ $\Delta E = mc\Delta\theta = 8.88 \times 10^4\,\text{kg} \times 1010\,\text{J kg}^{-1}\,\text{K}^{-1}(35-20)\text{K} = 1.345 \times 10^9\,\text{J}$		

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(c)(i)	Use of $pV = NkT$ [temperature in either K or °C]	(1)	
	$p = 9.24 \times 10^4$ Pa	(1)	2
	Example of calculation: $\frac{p_2}{p_1} = \frac{T_2}{T_1}$ $p_2 = (1.01 \times 10^5)\text{Pa} \times \frac{(273-5)\text{K}}{(273+20)\text{K}} = 9.238 \times 10^4$ Pa		
(c)(ii)	**Max 2** Hydrogen/gas behaves as an ideal gas	(1)	
	Mass of hydrogen/gas in balloon stays constant [Accept amount of hydrogen/gas]	(1)	
	Or number of molecules/atoms/particles of hydrogen/gas in balloon stays constant	(1)	2
	Temperature of hydrogen/gas is the same as the temperature of the surroundings		
(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	(1)	
	Molecules travel slower (on average) **Or** rate of collisions with walls is less	(1)	
	So rate of change of momentum (during collisions) with walls is less	(1)	3
	Total for question		**12**

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