Mark Scheme

Q1.

Question Number	Answer	Mark
	B	1

Q2.

Question Number	Answer	Mark
	D	1

Q3.

Question Number	Answer	Mark
	D	1

Q4.

Question Number	Answer	Mark
	B	1

Q5.

Question Number	Answer	Mark
	B	1

Q6.

Question Number	Answer	Mark
	B – 545 ÷ 838 000	**1**
	Incorrect Answers: Correct method: mass = energy transfer ÷ latent heat of vaporisation A – uses energy transfer ÷ latent heat of fusion C – uses latent heat of fusion ÷ energy transfer D – uses latent heat of vaporisation ÷ energy transfer	

Q7.

Question Number	Acceptable answers	Additional guidance	Mark
	• use of $\Delta E = mc\Delta\theta$ **(1)** • use of $P = E/t$ **(1)** • Correct calculation of an appropriate quantity **and** comment consistent with their value. **(1)**	**MP2** Candidates need to calculate either a time, a final temperature, an energy or a power Examples: Yes, because t = 30 s, which is less than one minute **Or** Yes, because it could reach temperature of 408 °C in one minute **Or** Yes, because it would transfer 156 000 J in one minute **Or** Yes, because the power required is 1.3 kW Example of calculation ΔE = 0.89 kg × 450 J kg^{-1} K^{-1} × (215 °C - 18 °C) = 78 900 J t = 78 900 J ÷ 2600 W = 30 s	**3**

Q8.

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

Q9.

Question Number	Answer	Mark
	Use of $E_k = ½mv^2$ **(1)** Use of 25% **(1)** Use of $\Delta E = mc\Delta\theta$ **(1)** $\Delta\theta$ = 39 K [accept 39°C] **(1)** <u>Example of calculation:</u> $E_k = \frac{1}{2}mv^2 = 0.5 \times 1200\,\text{kg} \times (25\,\text{m s}^{-1})^2 = 3.75 \times 10^5\ \text{J}$ $\Delta\theta = \frac{\Delta E}{mc} = \frac{0.25 \times 3.75 \times 10^5\ \text{J}}{5.3\,\text{kg} \times 450\,\text{J kg}^{-1}\,\text{K}^{-1}} = 39.3\text{K}$	4
	Total for Question	**4**

Q10.

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

Q11.

Question Number	Answer		Mark
(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) Example of calculation: $\Delta E = mc\Delta\theta = 175\times10^{-3}\ \text{kg}\times 4200\ \text{J kg}^{-1}\ \text{K}^{-1}\times(85-74)\text{K} = 8090\ \text{J}$	(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 Example of calculation: $\Delta E = mc\Delta\theta$ $8100\ \text{J} = m\times 3900\ \text{J kg}^{-1}\ \text{K}^{-1}\times(74-4.5)\text{K}$ $\therefore \text{m} = \dfrac{8100\ \text{J}}{3900\ \text{J kg}^{-1}\ \text{K}^{-1}\times 69.5\ \text{K}} = 0.0299\ \text{kg}$	(1) (1) (1)	3
	Total for question		7

Q12.

Question Number	Answer		Mark
(a)	The water molecules will have a greater average K.E. **Or** the water will be hotter **Or** less energy transferred to teapot	(1)	1
(b)(i)	Use of $\Delta E = mc\Delta\theta$ $\Delta E = 15\ 000$ J Example of calculation: $\Delta E = mc\Delta\theta = 0.26\ \text{kg}\times 4200\ \text{J kg}^{-1}\ \text{K}^{-1}\times(95-81)\ \text{K} = 15\ 300\ \text{J}$	(1) (1)	2
(b)(ii)	Assumption: no heat is lost to the surroundings **Or** all energy goes to the teapot Use of ΔE value from (i) in $\Delta E = mc\Delta\theta$ c = 600 (J kg^{-1} K^{-1}) Example of calculation: $c = \dfrac{\Delta E}{m\Delta\theta} = \dfrac{15300\ \text{J}}{0.43\ \text{kg}\times(81-22)\ \text{K}} = 603\ \text{J kg}^{-1}\ \text{K}^{-1}$	(1) (1) (1)	3
(b)(iii)	(The calculated value for the specific heat capacity has been overestimated) because energy is transferred to the surroundings (by heating) so the energy gained by the teapot has been overestimated	(1) (1)	2
	Total for question		8

Q13.

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
	<u>Example of calculation:</u> $m = \rho V = 1.20\,\text{kg m}^{-3} \times 7.4 \times 10^4\,\text{m}^3 = 8.88 \times 10^4\,\text{kg}$ $\Delta E = mc\Delta\theta = 8.88 \times 10^4\,\text{kg} \times 1010\,\text{J kg}^{-1}\,\text{K}^{-1}(35-20)\text{K} = 1.345 \times 10^9\,\text{J}$		
(c)(i)	Use of $pV = NkT$ [temperature in either K or °C]	(1)	
	$p = 9.24 \times 10^4$ Pa	(1)	2
	<u>Example of calculation:</u> $\frac{p_2}{p_1} = \frac{T_2}{T_1}$ $p_2 = (1.01 \times 10^5)\text{Pa} \times \frac{(273-5)\text{K}}{(273+20)\text{K}} = 9.238 \times 10^4\,\text{Pa}$		
(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**

Q14.

Question Number	Answer		Mark
(a)(i)	$N + \alpha \rightarrow {}^{17}_{8}O + {}_{1}p$ All values correct	(1)	1
(a)(ii)	In nuclear fission a chain reaction can be set up **Or** in a chain reaction the (total) energy released can be very large **Or** heavier/larger nuclei release much more energy **Or** a very high reaction rate releases much more energy	(1)	1
(b)	Attempt at mass deficit calculation Use of $\Delta E = c^2 \Delta m$ (Allow use of 1 u = 1.66 x 10^{-27} kg) Use of 1 MeV = 1.6 × 10^{-13} J (Allow use of 1u = 931.5 MeV/c^2) ΔE = 174 MeV Example of calculation $\Delta m = (390.29989 - 233.99404 - 152.64708 - (2 \times 1.67493)) \times 10^{-27}\,\text{kg}$ $\Delta m = 3.0891 \times 10^{-28}\,\text{kg}$ $\Delta E = (3.00 \times 10^8\,\text{m s}^{-1})^2 \times 3.0891 \times 10^{-28}\,\text{kg} = 2.780 \times 10^{-11}\,\text{J}$ $\Delta E = \dfrac{2.780 \times 10^{-11}\,\text{J}}{1.60 \times 10^{-13}\,\text{J MeV}^{-1}} = 173.8\,\text{MeV}$	(1) (1) (1) (1)	4
(c)(i)	Same number of protons [do not accept atomic/proton number], Different numbers of neutrons [do not accept mass/nucleon/neutron number]	(1) (1)	2
(c)(ii)	Correct calculation for ω [see 6283 or 2000π or $\frac{60\,000 \times 2\pi}{60}$] a = (-) 5.9 × 10^6 m s^{-2} Example of calculation $a = -\left(\dfrac{60000 \times 2\pi}{60\,\text{s}}\right)^2 \times 15 \times 10^{-2}\,\text{m} = 5.92 \times 10^6\,\text{m s}^{-2}$	(1) (1)	2
(c)(iii)	**Max 2** Stiff/stiffness Strong/strength Low density	(1) (1) (1)	2
(d)	Use of $\Delta E = mc\Delta\theta$ Rate at which energy is removed = 3.1 × 10^9 (W) Use of the efficiency equation [must have 2.2 × 10^9 (W) on top line] Efficiency = 42% [accept 0.42] Example of calculation $\Delta E = 70000\,\text{kg} \times 3990\,\text{J kg}^{-1}\,\text{K}^{-1} \times 11\,\text{K} = 3.07 \times 10^9\,\text{J}$ $\%\,\text{efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100 = \dfrac{2.2 \times 10^9\,\text{W}}{(2.2 + 3.1) \times 10^9\,\text{W}} \times 100 = 41.5\%$	(1) (1) (1) (1)	4