Question Number	Answer	Mark
1(a)(i)	Use of πr^2 or $\pi d^2/4$ (Use of ρ=m/V (m = 1960 (kg) (1) Reverse argument leading to ρ = 9130 (kg m^{-3}) scores max 2 Example of calculation $V = \pi r^2 \ell = \pi \times \left(0.815\times10^{-3}\,\mathrm{m}\right)^2 \times 105\times10^3\,\mathrm{m} = 0.219\,\mathrm{m}^3$ $m = \rho V = 8960\,\mathrm{kgm}^{-3} \times 0.219\mathrm{m}^3 = 1962\,\mathrm{kg}$	**3**
1(a)(ii)	Use of $\Delta E = mc\Delta T$ (1) ΔE = 8.0 × 10^8 J (1) ΔE = 8.2 × 10^8 J if show that value used Example of calculation $\Delta E = m\,c\,\Delta\theta = 1962\,\mathrm{kg} \times 385\,\mathrm{JK}^{-1}\mathrm{kg}^{-1} \times \left(1085 - 25\right)\mathrm{K} = 8.0\times10^8\,\mathrm{J}$	**2**
1(b)	Idea that whilst copper is being heated to melting point, energy supplied is (mainly) transformed into K.E. of atoms/molecules (1) At melting point: no change in K.E. of atoms/molecules OR energy supplied is transformed into P.E. of atoms/molecules (1)	**2**
	Total for question	**7**

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

Question Number	Answer		Mark
18 (a)(i)	$\mathrm{N}+\ \alpha\rightarrow{}^{17}_{8}\mathrm{O}+{}_{1}\mathrm{p}$ All values correct	(1)	1
18(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
18 (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 $\Delta m = (390.29989 - 233.99404 - 152.64708 - (2\times 1.67493))\times 10^{-27}\,\mathrm{kg}$ $\Delta m = 3.0891\times 10^{-28}\,\mathrm{kg}$ $\Delta E = (3.00\times 10^{8}\,\mathrm{m\,s^{-1}})^2 \times 3.0891\times 10^{-28}\,\mathrm{kg} = 2.780\times 10^{-11}\,\mathrm{J}$ $\Delta E = \frac{2.780\times 10^{-11}\,\mathrm{J}}{1.60\times 10^{-13}\,\mathrm{J\,MeV^{-1}}} = 173.8\,\mathrm{MeV}$	(1) (1) (1) (1)	4
18 (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
18(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 $a = -\left(\frac{60000\times 2\pi}{60\,\mathrm{s}}\right)^2 \times 15\times 10^{-2}\,\mathrm{m} = 5.92\times 10^{6}\,\mathrm{m\,s^{-2}}$	(1) (1)	2
18(c)(iii)	2 Stiff/stiffness Strong/strength Low density	(1) (1) (1)	2
18(d)	Use of ΔE = mcΔθ 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 $\Delta E = 70000\,\mathrm{kg} \times 3990\,\mathrm{J\,kg^{-1}\,K^{-1}} \times 11\mathrm{K} = 3.07\times 10^{9}\,\mathrm{J}$ $\%\,\mathrm{efficiency} = \frac{\text{useful power output}}{\text{total power input}}\times 100 = \frac{2.2\times 10^{9}\ \mathrm{W}}{(2.2+3.1)\times 10^{9}\ \mathrm{W}}\times 100 = 41.5\%$	(1) (1) (1) (1)	4
	Total for question 18		**16**

Question Number	Answer	Mark
4(a)	**Max 4** Assumption: that no energy is transferred to the surroundings OR all energy transferred from washers to water OR energy required to raise temperature of container is negligible OR no water evaporates (1) Measure the mass of the washers and water (using a balance) (1) (Use a thermometer to) measure the temperature of the water before and after the washers are plunged into the water (1) Equate thermal energy lost by steel to the energy gained by water (1) Use a (standard) value for the specific heat capacity of the water OR specific heat capacity of water is known (1)	**Max 4**
4(b)(i)	Infra-red (1)	**1**
4(b)(ii)	Use of $\lambda_{max}T=2.898 \times 10^{-3}$ (1) T = 1450 (K) OR $\lambda_{max} = 1.93 \times 10^{-6}$ (m) (1 Example of calculation $T = \frac{2.898\times10^{-3}\text{ mK}}{2\times10^{-6}\text{ m}} = 1450\text{ K}$	**2**
4(b)(iii)	Use of $L = 4\pi r^2\sigma T^4$ (1) Correct substitution of radius (1) L = 1970 W [2250W if show that value used] (1) Example of calculation $L = 4\pi\times\left(2.5\times10^{-2}\text{ m}\right)^2\times5.67\times10^{-8}\text{ Wm}^{-2}\text{K}^{-4}\left(1450\text{K}\right)^4 = 1970\text{ W}$	**3**
4(b)(iv)	Curve with higher peak (1) Shifted over to left (1)	**2**
	Total for question	**12**

Question Number	Answer	Mark
5	Use of $E_k = \frac{1}{2}mv^2$ **(1)** Use of 25% **(1)** Use of $\Delta E = mc\Delta\theta$ **(1)** $\Delta\theta$ = 39 K [accept 39°C] **(1)** Example of calculation: $E_k = \frac{1}{2}mv^2 = 0.5\times1200\,\mathrm{kg}\times\left(25\,\mathrm{m\,s^{-1}}\right)^2 = 3.75\times10^5\,\mathrm{J}$ $\Delta\theta = \frac{\Delta E}{mc} = \frac{0.25\times3.75\times10^5\,\mathrm{J}}{5.3\,\mathrm{kg}\times450\,\mathrm{J\,kg^{-1}\,K^{-1}}} = 39.3\,\mathrm{K}$	**4**
	Total for Question	**4**

Question Number	Answer	Mark
6(a)	Any two from: Air behaves as an ideal gas (1) Temperature (in the lungs) stays constant (1) Implication of no change in mass of gas (1)	**(max 2)**
6(b)(i)	Use of $\rho = m/V$ 1) Correct answer (1.3×10^{-4} kg s^{-1}) (1) Example of calculation: $\mathrm{m = V.\rho} = 2.5\times10^{-4}\,\mathrm{m^3}\times1.2\,\mathrm{kg\,m^{-3}} = 3\times10^{-4}\,\mathrm{kg}$ $\frac{\Delta \mathrm{m}}{\Delta \mathrm{t}} = 3\times10^{-4}\,\mathrm{kg}\times\frac{25}{60\,\mathrm{s}} = 1.25\times10^{-4}\,\mathrm{kg\,s^{-1}}$	**(2)**
6(b)(ii)	Use of $\Delta E = mc\Delta\theta$ (1) Correct answer (2.2 W) ecf (1) Example of calculation: $\mathrm{P} = 1.25\times10^{-4}\,\mathrm{kg\,s^{-1}}\times1000\,\mathrm{J\,kg^{-1}\,K^{-1}}\times(37.6-20.0)\,\mathrm{K} = 2.2\,\mathrm{W}$	**(2)**
	Total for question	**(6)**