Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
14	(a)	(i)	An energy resource that can be replenished in a relatively short space of time e.g. human life time or equivalent OR An energy resource that can be used for a long period of time (1)	1			1		
		(ii)	Mass of LHS $4 \times 1.00728\text{u} + 2 \times 0.00055\text{u} = 4.03022$ $\Delta m = 4.03022 - 4.00151 = 0.02871$ [u] (1) $\frac{0.02871}{4.03022} \times 100 = [0.71\,\%]$ (1)		2		2	2	
		(iii)	Use of $E = mc^2$ i.e. $2 \times 10^{30} \times \frac{0.7}{100} \times (3 \times 10^8)^2 = 1.26 \times 10^{45}$ [J] (1) $t = \frac{E}{P} = \frac{1.26 \times 10^{45}}{3.8 \times 10^{26}} = 3.3 \times 10^{18}$ [s] $= 1 \times 10^{11}$ [years] (1)		2		2	2	
	(b)	(i)	θ used as 10° (1) Manipulation $\rightarrow A = \frac{P}{\mu I \cos\theta} = \frac{150}{0.2 \times 600 \times \cos 10°}$ $= 1.27$ [m²] (1)		2		2	2	
		(ii)	**Award (1) mark for calculation and (1) mark for 'suitable' supporting comment** $\frac{3.6 \times 10^4}{1.27} = 28\,000$ cells ∴ roof has large enough area for recommended no. of cells OR $\frac{4 \times 10^6}{150} = 27000$ cells ∴ power output would be large enough with recommended no. of cells OR $\frac{4 \times 10^6}{27\,500} = 145$ W ∴ power output of each cell (150 W) would be large enough with recommended no. of cells. N.B. Accept alternative suitable calculations **Award (1) mark for 'unsuitable' comment referencing power output affected by other factors** e.g. variable cloud cover / daily change in sun's position / seasonal change in sun's position / etc			3	3	1	
	(c)	(i)	Increase concentration of U-235 (relative to U-238) (1) U-235 is fissile whereas U-238 is not [and absorbs neutrons] (1)	2			2		
		(ii)	$\sqrt{\frac{352}{349}} = 1.004$ (1) 0.7 %] $\times 1.004^n = 5$ [%] (1) Taking logs to find n to be 492 or 459 if $\sqrt{\frac{352}{349}}$ used (1) [If $0.7\% + 1.004^n = 5\%$ used to give an answer of 365 or 340 award 2 marks out of 3]		3		3	3	
		(iii)	[Gas] centrifuge Accept alternative e.g. Laser isotope/liquid thermal diffusion	1			1		
	(d)	(i)	Allows only positive H ions through it to the cathode meaning negative electrons must travel along external circuit producing power (1) Waste product: Water (1)	2			2		
		(ii)	Electrolysis of water argument dependent on how electrical energy is produced e.g. gas fired power contributes to CO_2 emissions whereas PV cells do not (1) Reforming fossil fuels releases carbon which could in turn be released into atmosphere as CO_2 or comment regarding carbon capture (1)			2	2		
			Question 14 total	**6**	**9**	**5**	**20**	**10**	**0**

#2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14	*(a)*	(i)		Object totally or partially immersed in a fluid (accept liquid or gas) is buoyed (accept lifted, upward force, upthrust) by a force equal to the weight of the displaced fluid	1			1		
		(ii)	(I)	Volume = $1.5 \times 10^6 \times 2.1 = 3.15 \times 10^6$ km^3 and correct conversion of units seen (e.g 3.15×10^{15} m^3) (1) Mass = $920 \times 3.15 \times 10^{15} = 2.9 \times 10^{18}$ kg seen (1)		2		2	2	
			(II)	Volume of water produced = $\frac{2.9 \times 10^{18}}{10^3}$ (= 2.9×10^{15} m^3) (1) (accept 3.0×10^{15} m^3 if value given used) Sea level rise = $\frac{2.9 \times 10^{15}}{3.6 \times 10^{14}}$ = 8.05 (m) (seen) (or 8.3 if 3.0×10^{18} kg used) (1)			2	2	2	
	(b)	(i)		Mass of air (per second) = $\rho A u$ (1) Convincing substitution into ½ mu^2 (1)	2			2		
		(ii)		Doubling blade length will increase power by a factor of 4 (accept 2^2) (1) Doubling speed will increase power by a factor 8 (accept 2^3) (1)		2		2		
		(iii)		Either Correct substitution and power calculated for either input or output power: i.e. input P = 0.87 MW, Output P = 0.21 MW Or $P_{IN} = \frac{1}{2}\pi \times 30^2 \times 1.2 \times (8^3 - 5^3)$ (1) P_{IN} calculated (0.87 – 0.21 = 0.66) (1) (ecf for either or both powers]. % efficiency = ($\frac{0.66}{0.87}$) × 100 = 75.9% [accept 76%, 0.759 or 0.76](1)		3		3	2	
		(iv)		Friction between moving parts (in the turbine). Don't accept 'heat', 'sound'.			1	1		
	(c)	(i)		All units correctly identified: $\frac{\Delta Q}{\Delta t}$: J s^{-1}; A: m^2 ; $\frac{\Delta\theta}{\Delta x}$: K m^{-1} (1) Correct substitution and convincing algebra (1)	2			2		
		(ii)		Understanding shown that heat flow through both materials is the same (even if substitution below incorrect) (1) **Either** $\frac{0.06 \times A \times (18 - \theta_B)}{8} = \frac{0.9 \times A \times (\theta_B - 8)}{120}$ (1) Convincing algebra to show θ_B = 13 °C (1) **Or** With 13 °C: Carpet heat flow/m^2 = 37.5 W m^{-2} or Concrete heat flow / m^2 = 37.5 W m^{-2} (1) Other heat flow shown to be the same, thus confirming (1)	1	1 1		3	2	
		(iii)		Either carpet: $\frac{\Delta Q}{\Delta t} = \frac{0.06 \times 48 \times 5}{0.008}$ [or 48 × 37.5] or concrete: $\frac{\Delta Q}{\Delta t} = \frac{0.9 \times 48 \times 5}{0.12}$ [or 48 × 37.5] (1) = 1.8 kW = 50% ∴ claim verified (1)			2	2	2	
				Question 14 total	6	9	5	20	10	0

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	$I = \frac{P}{A} = \frac{3.8\times10^{26}}{4\pi(1.5\times10^{11})^2}$ = 1 344 [W m^{-2}] (1) Solar constant (1)	1	1		2	1	
		(ii)	Use of $P = \sigma A T^4$ (1) Manip and sub to give $T = \sqrt[4]{\frac{P}{\sigma A}} = \sqrt[4]{\frac{1.2\times10^{17}}{5.67\times10^{-8}\times4\pi\times(6.4\times10^{6})^2}}$ (1) 253 [K] (answer seen) (1)		3		3	3	
		(iii)	Atmosphere and the greenhouse effect (1) Burning fossils fuels/increased livestock farming increase CO_2/methane (1) More IR absorbed (1)		3		3		
	(b)	(i)	High enough temperatures to overcome coulomb repulsion (1) High enough particle density to allow high enough collision rate (1) Long enough confinement time [for more output/reactions] (1)	3			3		
		(ii)	$3.5\times10^{28} = \frac{2.4\times10^{22}}{70}\times T\times0.9$ (1) $T = 1.13\times10^{8}$ [K] (1)		2		2	2	
	(c)	(i)	[Rate of flow of heat is] 0.030 J s^{-1} (or W) through an area of 1 m^2 (1) when the temperature gradient is 1 K m^{-1}(1) **Alternative:** (Rate of heat flow is) 0.030 J s^{-1} (or W) per unit cross-sectional area (1) per unit temperature gradient (1)	2			2		
		(ii)	Gradients calculated: A = [-]0.25 and B = [-]0.5 [°C/mm] (1) Heat flow per unit area same through both materials so temperature gradient $\alpha \frac{1}{K}$ or K × temp gradient = constant (1) Material A has 2× thermal conductivity of material B ∴ suggestion is incorrect (1) Use of B's gradient to find $\frac{P}{A} = 0.030\times0.5\times10^3 = 15$ W m^{-2} and $U = \frac{P}{A\Delta\theta} = \frac{15}{17}$ or use of thermal resistance (1) = 0.88 W m^{-2} K^{-1} ∴ suggestion is correct or too high as there is no consideration of stationary air layers (1)			5	5	4	
			Question total	**6**	**9**	**5**	**20**	**10**	**0**

#4

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
(a)	(i)		Use of Wien' law or correct substitution [$\lambda = \frac{0.0029}{288}$] (1) λ = 10.1 μ[m] and confirmation statement (1)			2	2	1	
	(ii)		**Any 3 ×(1) from:** • All gases absorb in IR region (or between 1 μm at 20 μm) • Methane absorbs strongly at 3 μm and 8 μm / has two peaks • CO_2 - Isolated peaks at 2 / 2.5 / 4 and 15 μm • CO_2 - Complete 'blockout' between 5 and 8 μm • H_2O - Numerous peaks between 1 and 10 μm **General comparison with no numerical data award max of 1 mark**			3	3		
	(iii)		**Any 2 ×(1) from:** CO_2 – Burning fossil fuels or deforestation (answer must imply increase as consequence of human activity e.g. more cars etc) CH_4 – Increased agriculture or melting permafrost H_2O – Melting ice caps (or global warming – more evaporation)	2			2		
(b)	(i)		Correct attempt (without efficiency) at $mg\Delta h = 120 \times 10^6$ (1) Correct use of efficiency e.g. $m = \frac{120 \times 10^6}{0.85 \times 9.81 \times 420}$ (1) $m = 3.4 \times 10^4$ [kg s^{-1}] (1)	1	1 1		3	3	
	(ii)		$t = \frac{E}{P}$ i.e. $\frac{240 \times 10^9}{365 \times 120 \times 10^6}$ or t = 2 000 hrs /yr seen (1) t = 5.5 hrs per day (1)	1	1		2	1	
	(iii)		Limited by amount of water available in upper lake / time taken to pump water up	1			1		
(c)	(i)		$\frac{Q}{t} = 1.6 \times (16.12 - 4) \times 8 + 154$ (1) $\frac{Q}{t}$ = 309.14 [W] (1)		2		2	2	
	(ii)	I	$154 = \frac{(0.8 \times 4 \times \Delta\theta)}{6 \times 10^{-3}}$ (1) $\Delta\theta$ = 0.29 [°C] seen (1)		2		2	2	
		II	Inside air/glass boundary temp calculated to be = 16.15 °C **or** outside glass/air boundary temp to be 15.85 °C **or** $\Delta\theta$ for air = 3.85 °C (1) Correct use of thermal conduction equation to show thickness of air = 2.6 [mm] e.g. $154 = \frac{(4 \times 0.026 \times (20 - 16.5))}{x}$ (1) **Alternative:** $\Delta\theta$ across total air layers = (20 – 8 – 0.3) °C [= 7.7 °C] (1) Correct use of thermal conduction equation e.g. $154 = \frac{(4 \times 0.026 \times 7.7)}{2x}$ (1)		2		2	1	
		III	Rate of heat loss would increase due to removal of insulating (air) layer(s) (or $\Delta\theta$ for glass greater without air layers / greater temperature gradient). Accept appropriate calculation.	1			1		
			Question total	**6**	**9**	**5**	**20**	**10**	**0**