Mark scheme for Extension Worksheet – Topic 7, Worksheet 1

1 The power generated by burning gas must be $\frac{350}{0.45} = 777.8\ \text{MW}$; and so

$\frac{\Delta m}{\Delta t} \times 58\ \text{MJ kg}^{-1} = 777.8\ \text{MW}$; giving $\frac{\Delta m}{\Delta t} = 13\ \text{kg s}^{-1}$ (watch the units here). [3]

2 Power input to the cell is $IA = 950 \times 3.0 \times 10^{-4} = 0.285\ \text{W} = 285\ \text{mW}$; so efficiency is

$e = \frac{40}{285} = 0.14$ [2]

3 The power needed from the solar panels is $\frac{3.0 \times 10^{3}}{0.25} = 1.2 \times 10^{4}\ \text{W}$; The power provided to the panels from the Sun is $IA = 720 \times A$; and so

$720 \times A = 1.2 \times 10^{4}\ \text{W} \Rightarrow A \approx 17\ \text{m}^{2}$ [3]

4 **a** The falling water must produce a power of $\frac{85 \times 10^{6}}{0.35} = 243 \times 10^{6}\ \text{W}$;

$\frac{\Delta m}{\Delta t} \times gh = 243 \times 10^{6} \Rightarrow \rho \frac{\Delta V}{\Delta t} \times gh = 243 \times 10^{6}$; hence $\frac{\Delta V}{\Delta t} = 428 \approx 430\ \text{m}^{3}\,\text{s}^{-1}$; [3]

(Notice that the question implies that the height of the water above the turbines stays constant.)

b Losses in thermal energy as the water moves down the pipes; frictional losses in the turning turbines [2]

5 See page 427 Physics for the IB Diploma and page 46 of *Physics for the IB Diploma Exam Preparation Guide*. [3]

6 The expression $P = \frac{1}{2}\rho \pi R^{2} v^{3}$ assumes that the air stops moving after it hits the turbines/that the air is incompressible/that no losses are encountered due to turbulence etc. [1]

7 As the wave approaches the OWC, the air above the water and below the valves of the OWC gets pressurised and so moves out through the valves turning a turbine; as the water recedes, the pressure above the OWC is greater than the pressure below and so air now enters the OWC through another valve again turning the turbine; in both cases the turning of the turbines turns a coil in magnetic field that generates electricity. [3]

8 Because the albedo varies over the surface of the Earth. [1]

9 The amount of cloud cover in the atmosphere; the nature of the Earth surface (ice, snow, forest, desert etc.). [2]

10 **a** $I = \frac{P}{4\pi d^{2}} = \frac{3.9 \times 10^{26}}{4\pi (1.5 \times 10^{11})^{2}}$; $I = \frac{P}{4\pi d^{2}} = \frac{3.9 \times 10^{26}}{4\pi (1.5 \times 10^{11})^{2}} = 1379 \approx 1400\ \text{W m}^{-2}$ [2]

b The intensity received at the Earth surface is less than this because some of this intensity is reflected; and this is the un-averaged value during the day not the average during the day and night. [2]

c $\sigma T^4 = 245\ \mathrm{W\,m^{-2}}$; so $T = \sqrt[4]{\dfrac{245}{5.67\times10^{-8}}} = 256\ \mathrm{K}$ [2]

d This calculation ignores the greenhouse effect; some of the radiation radiated by the Earth would be trapped in the atmosphere warming the Earth. [2]

11 The diagrams show rays of light incident on the equator and north or south of the equator. In the case of the rays off the equator the power is spread out over a larger area; and so the intensity is less.

[2]

12 The radiation that can fall on the Earth surface must first pass through a disc of radius equal to the radius of the Earth. This radiation has intensity equal to S. The power going through this disc is $SA = S\pi R^2$; to find the average intensity at any point on the Earth surface we must divide this power by the area of the Earth's surface which is $4\pi R^2$. So the average intensity is $I = \dfrac{S\pi R^2}{4\pi R^2} = \dfrac{S}{4}$; but a fraction α of this intensity is reflected leaving only $(1-\alpha)\dfrac{S}{4}$ going through. [3]

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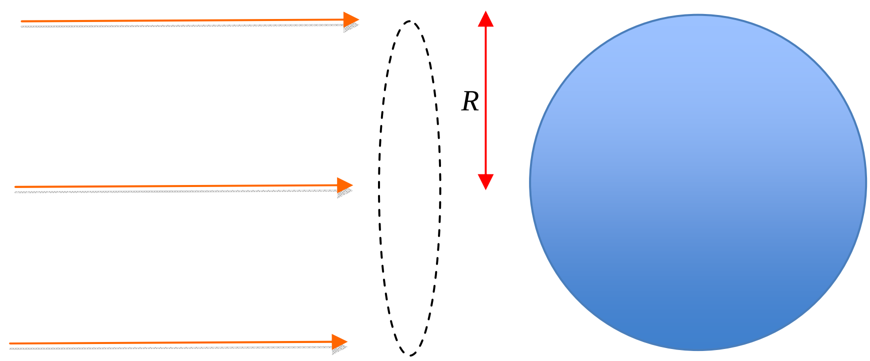

$\sigma T^4 = (1-0.30)\times\dfrac{1400}{4} = 245\ \mathrm{W\,m^{-2}}$; so $T = \sqrt[4]{\dfrac{245}{5.67\times10^{-8}}} = 256\ \mathrm{K}$; assumptions include ignoring the greenhouse effect/treating the Earth surface as a black body/ignoring any exchanges of energy between the surface and the atmosphere etc. [3]

14 **a** σT_1^4 [1]

b $e\sigma T_2^4$ [1]

c $e\sigma T_1^4$ [1]

d $(1-e)\sigma T_1^4$ [1]

15 The intensity out of the black body is σT_1^4 and the intensity in is $e\sigma T_2^4 + (1-e)\sigma T_1^4$; the net intensity out is therefore $\sigma T_1^4 - e\sigma T_2^4 - (1-e)\sigma T_1^4 = e\sigma(T_1^4 - T_2^4)$ and must be zero; so that $T_1 = T_2$. [2]

(The same argument can be applied to the gray body to give the same conclusion.)

16 We know that $\Delta V = \gamma V \Delta\theta$. Then $\Delta V = \gamma(A \times h)\Delta\theta = 2.1 \times 10^{-4} \times A \times 50 \times 1.5 = 0.016$; since $\Delta V = A \times \Delta h \Rightarrow \Delta h = 0.016\ \text{m}$; assumptions include uniform heating down to 50 m/no flooding so all the extra volume is on based on the same area as before/that the temperature stays constant down to 50 m so the same coefficient γ is used. [3]

17 **a** The additional volume of water will be
$\Delta V = A \times h = 4.0 \times 10^8 \times (10^3)^2 \times 6 = 2.4 \times 10^{15}\ \text{m}^3$; so the volume of the ice is

$$V_{ice} = \frac{1000}{900} \times 2.4 \times 10^{15} = 2.7 \times 10^{15}\ \text{m}^3$$ [2]

b A important principle in fluid mechanics known as Archimedes principle states that the upward force experience by a body floating in a liquid is equal to the weight of the displaced liquid; So when ice floats in water, the upward force on the ice equals the weight of the ice. So when the ice melts, its volume will be equal to the volume of the displaced water and so no change in water level will take place. [2]