Extension Worksheet – Topic 7, Worksheet 1

1 A natural gas power station has a power output of 350 MW and an efficiency of 45%. Calculate the mass of natural gas that is burned per second given that the energy density of natural gas is 58 MJ kg^{-1}. [3]

2 A solar cell has a collecting area of 3.0 cm^2. When light of intensity 950 W m^{-2} is incident on the cell the power output from the cell is 40 mW. Estimate the efficiency of the solar cell. [2]

3 A house needs 3.0 kW of power in order to provide warm water in the bathrooms. The average solar intensity at the position of the house is 720 W m^{-2} and the efficiency at which the solar panels convert solar energy to thermal energy is 25%. Calculate the area of the solar panel needed. [3]

4 A hydroelectric power station produces 85 MW of electrical power. The overall efficiency of the station is 35%. The average height of the water centre of mass above the turbines is 58 m.

a Calculate the rate at which water flows through the turbines of the power station in m3 s^{-1}. (The density of water is 1.0×10^3 kg m^{-3}.) [3]

b State two reasons why the efficiency of the power station is less than 100%. [2]

5 Show that the maximum energy that can theoretically be extracted from a wind turbine of blade radius R when the wind speed is v is $P = \frac{1}{2}\rho\pi R^2 v^3$ where ρ is the density of air. [3]

6 Explain why the actual power extracted from the wind is less than the expression you just derived in the previous problem. [1]

7 Describe the operation of an oscillating water column (OWC). [3]

8 The average albedo of the Earth is about 0.30. Explain why an average albedo is quoted. [1]

9 State two factors that affect the albedo of the Earth. [2]

10 The power emitted by the Sun is 3.9×10^{26} W and the Sun–Earth distance is 1.5×10^{11} m.

a Calculate the solar intensity at the upper atmosphere. [2]

b Explain why the average intensity of the solar radiation at the Earth's surface is less than your answer to **a**. [2]

c The average intensity incident on the Earth's surface is 245 W m^{-2}. Calculate the average Earth temperature that is consistent with this amount of incident radiation assuming that the Earth surface behaves as a black body. [2]

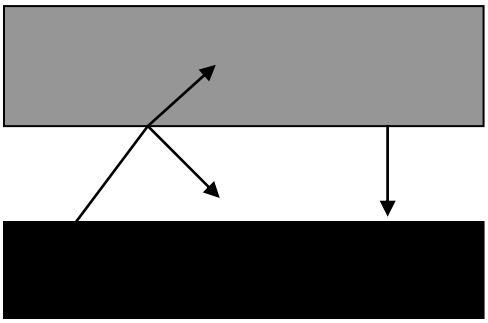
d The actual Earth temperature is higher than the answer to **c**. Suggest a reason for this observation. [2]

11 On a particular day, the intensity of the solar radiation at the Earth's surface on the equator is 850 W m^{-2}. Explain why the intensity in locations north and south of the equator will be less than 850 W m^{-2}. [2]

12 The intensity of the solar radiation at a point in the upper atmosphere facing the Sun is S. The albedo of the Earth is α. Explain why the average solar intensity incident on an arbitrary point on the Earth's surface is $(1-\alpha)\frac{S}{4}$. [3]

13 The average solar intensity on the Earth's surface is $(1-\alpha)\frac{S}{4}$ where the average Earth albedo is $\alpha = 0.30$ and $S = 1400$ W m^{-2}. Assuming the Earth surface to behave like a black body, estimate the Earth surface temperature listing any other assumptions you make. [3]

14 The diagram shows a black body of temperature T_1 emitting radiation towards a gray body of lower temperature T_2 and emissivity e. No radiation gets transmitted through the gray body.



Using all or some of the symbols T_1, T_2, e and σ state expressions for the intensity:

a radiated by the black body. [1]

b radiated by the gray body. [1]

c absorbed by the gray body. [1]

d reflected by the gray body. [1]

15 The black and the gray bodies in question **14** receive as much energy as they lose. Deduce that their temperatures must be the same. [2]

16 The volume expansion coefficient of water is 2.1×10^{-4} K^{-1}. Estimate the increase in sea level for a temperature increase of 1.5 K of sea water. Assume that the depth of water that is heated is 50 m. List any other assumptions you have made to reach your answer. [3]

17 A rise in sea level is an effect of global warming that might come about as a result of land-based ice melting.

a It is estimated that when the West Antarctic ice sheet melts the expected rise in sea level, will be 6 m. Estimate the volume of the West Antarctic ice sheet by assuming that the area of the oceans is 4×10^8 km^2. The density of ice is 900 kg m^{-3} and that of water is 1000 kg m^{-3}. [2]

b Explain why ice floating in water will not result in a rise in sea level. [2]