Energy Production Examples 8.2

The Sun has a surface temperature of 5800 K and a radius of 7.0×10^8 m. Calculate the total energy radiated from the Sun in one hour.

$P = \sigma A T^4$

Surface area of Sun $= 4\pi r^2 = 4 \times 3.14 \times (7 \times 10^8)^2$

$= 6.2 \times 10^{18}$

So power $= 5.7 \times 10^{-8} \times 6.2 \times 10^{18} \times 5800^4$

$= 4.0 \times 10^{26}$ W

In one hour there are 3600 s, so the energy radiated in one hour is 1.4×10^{30} J.

A metal filament used as a pyrometer in a kiln has a length of 0.050 m and a radius of 1.2×10^{-3} m. Determine the temperature of the filament at which it radiates a power of 48 W.

The surface area of the filament is $2\pi rh = (2\pi \times 1.2 \times 10^{-3}) \times 0.050 = 3.8 \times 10^{-4}\ \text{m}^2$

So the power determines the temperature as

$$48 = 5.7 \times 10^{-8} \times 3.8 \times 10^{-4} \times T^4$$

$$T = \sqrt[4]{\frac{48}{5.7 \times 10^{-8} \times 3.8 \times 10^{-4}}} = 1200\ \text{K}.$$

A spherical black body has an absolute temperature T_1 and surface area A.
Its surroundings are kept at a lower temperature T_2.

Determine the net power lost by the body.

The power emitted by the body is; $\sigma A T_1^4$

the power absorbed from the surroundings is $\sigma A T_2^4$.

So the net power lost is $\sigma A(T_1^4 - T_2^4)$.

Note that this is not the same as

$\sigma A(T_1 - T_2)^4$.

Four habitats on the Earth are: forest, grassland (savannah), the sea, an ice cap.

Discuss which of these have the greatest and least albedo.

Surface	Albedo
Ocean	0.06
Fresh snow	0.85
Sea ice	0.60
Ice	0.90
Urban areas	0.15
Desert soils	0.40
Pine forest	0.15
Deciduous forest	0.25

A material with a high albedo reflects the incident visible radiation. Ice is a good reflector and consequently has a high albedo. On the other hand, the sea is a good absorber and has a low albedo.

The data give details of a model of the energy balance of the Earth. Use the data to calculate the albedo of the Earth that is predicted by this model.

Data

Incident intensity from the Sun	$= 340\ \text{W m}^{-2}$
Reflected intensity at surface	$= 100\ \text{W m}^{-2}$
Radiated intensity from surface	$= 240\ \text{W m}^{-2}$
Re-radiated intensity from atmosphere back to surface	$= 2\ \text{W m}^{-2}$

The definition of albedo is clear.

It is $\dfrac{\text{power reflected by a given surface}}{\text{total power incident on the surface}}$

So in this case the value is $\dfrac{100}{340} = 0.29$