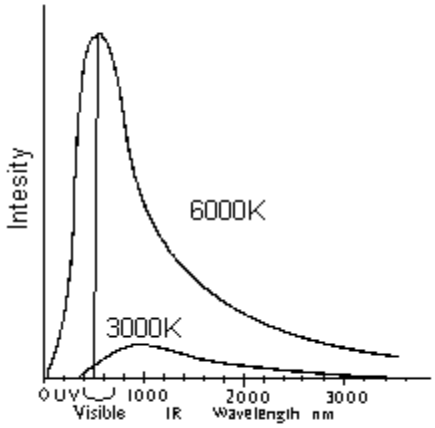
1.8 Wien's Displacement law

Video: Wien's Law

Demo: Bunsen and spectroscopes, compare blue and yellow flames

The spectrum of radiation emitted by an object has a peak radiation, the position of which varies depending on the temperature of the body.



The colour of the body corresponds to the colour of the peak wavelength. It is found that the wavelength at the peak of the spectrum , λ_p, is related to the Kelvin temperature by

$$\lambda_p = \frac{2.898 \times 10^{-3}}{T}$$

This is known as Wien's displacement law.

Note: Kelvin = °C + 273

Example The Sun has a peak radiation corresponding to 500 nm. Calculate the surface temperature of the Sun.

Solution

$$500 \times 10^{-9} = \frac{2.898 \times 10^{-3}}{T}$$

$$T = \frac{2.898 \times 10^{-3}}{500 \times 10^{-9}}$$

$$T = 5796 \text{ K}$$

1.9 Stefan-Boltzmann Equation

Video: Stephan-Boltzmann's Law

The rate at which an object emits radiation depends on a number of factors:

- Surface area.
- Temperature.
- Surface colour and texture.

An objects effectiveness at emitting energy is called its emissivity (e). Ludwig Boltzmann and Joseph Stefan researched the laws that govern radiation. They found that the rate at which an object radiates energy (the power) is related to the temperature^4, $P \propto T^4$.
The Stefan-Boltzmann equation incorporates all the variables.

$$P = e\,\sigma\,A\,(T^4 - T_s^4)$$

Where T = temperature of the object in Kelvin
T_s = temperature of the surroundings in Kelvin
A = surface area in metres squared
σ = the Stefan-Boltzmann constant $5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$
e = the emissivity of the surface

Example A galvanized water tank (e = 0.28) holds 1000L of hot water at 90°C. The tank is a cube of 1m length on each side. Estimate the rate of heat loss from the tank, assuming the surroundings are at 20°C

e = 0.28 A = 6 × 1 × 1 = 6 T = 90 + 273 = 363 $T_s = 20 + 273 = 293$
$\sigma = 5.67 \times 10^{-8}$

$$P = e\,\sigma\,A\,(T^4 - T_s^4)$$

$$P = 0.28 \times 5.67 \times 10^{-8} \times 6 \times (363^4 - 293^4)$$

$$P = 951.89\ W$$

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