Green Liberal Democrats Challenge July 2018 Lighting

"I've seen the Light" (or Lights Ancient and Modern) **– Supplement 1**

The main Challenge article gives what the householder needs to know.

This website-only supplement *firstly explains some of the terminology and gives some science background for those who are curious. Then it will move on to wide issues. After Colour temperature will come something on the biological effects of artificial light.*

Colour Temperature

Basic Vocabulary and Background Science

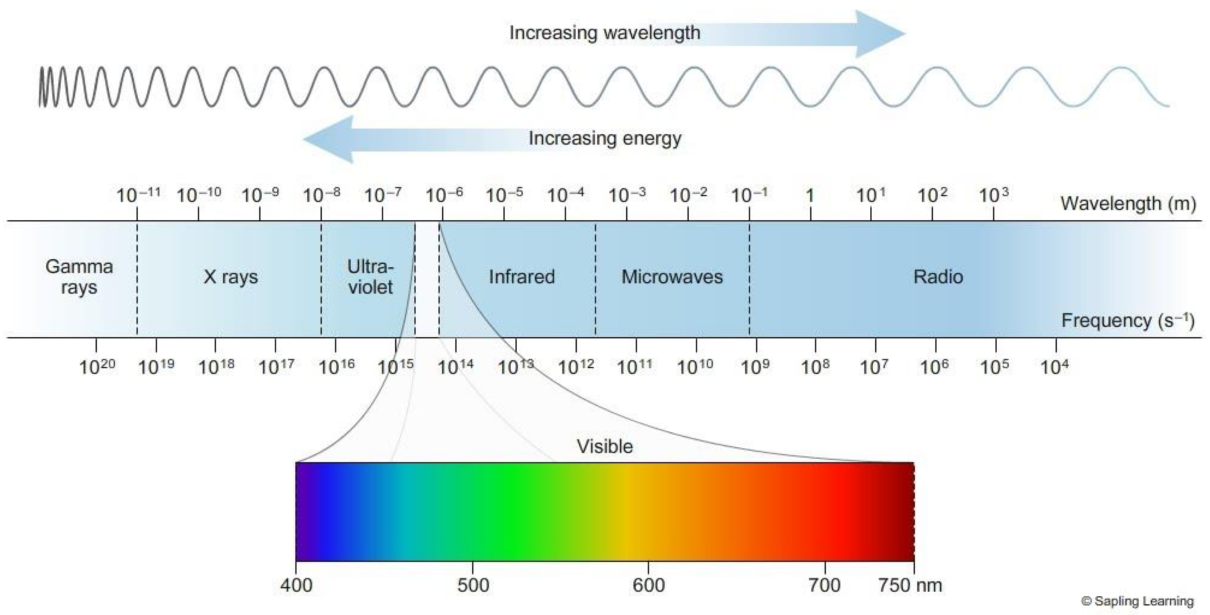
Light is a form of **electromagnetic radiation**. Different parts of the electromagnetic spectrum behave as if waves arriving at different frequencies (unit, cycles/second or hertz)

450 000 000 000 000 electromagnetic wave-peaks arriving per second **-** make us see **red**, whereas 650 000 000 000 000 arriving per second [that is arrival at a **frequency (***f***)** of 650 million million **hertz (**Hz**)**, or 650 **terahertz (**THz**)**] makes us see **blue**.

The higher the frequency the peaks are arriving, the shorter the distance between them as they travel, that is the shorter their **wavelength (**λ**) .**

Thus short $\lambda \equiv$ high f and long $\lambda \equiv$ low f .

For historical reasons we usually refer to the wavelength, rather than the frequency, of light waves, but for other parts of the electromagnetic spectrum, such as radio waves, we now more often use frequency.
On graphs of the electromagnetic spectrum, we normally go in order of increasing wavelength: that is with blue to the left and red to the right. Increasing wavelength is equivalent to reducing frequency.



The blue light in our example has a frequency of 650 THz has a wavelength of 460 nm

= 460 nanometers = 460×10^{-9} m = 4.6×10^{-7} m = 0.000 000 460 m

Any **body**, that is any collections of matter, solid, liquid or gas, gives off electromagnetic radiation to its surroundings, The lower the temperature, the less radiation it produces. The amount falls to zero at the absolute zero of temperature, that is at **minus 273°C** or **zero kelvin (**0 K**).**

Each kelvin is the same size as each degree C, but the **kelvin scale** (named after the Scot, William Thomson, 1st Baron Kelvin) stars at absolute zero, instead of at the freezing point of water.

The intensity or power of the radiation increases rapidly with temperature. The power increases 16 fold if the temperature goes from 100 K to 200 K. Every time the absolute temperature doubles the power goes up 16 fold.

The radiation is spread across the whole electromagnetic spectrum. On a hot summer day the temperature is about 27 °C or 300 K.. The radiation from a 300 K black body is almost all at is low frequency (or long wavelength) **infrared (IR).** At 5000 K the peak radiation is in the visible region, but there is also a large amounts of infrared and some ultraviolet.

The laws describing the relationships between temperature, power and peak wavelength are more complex expressed using °C, which is why when we usually work in kelvin .

All bodies also absorb radiation from their surroundings. For any colour, a good absorber is also a good emitter.

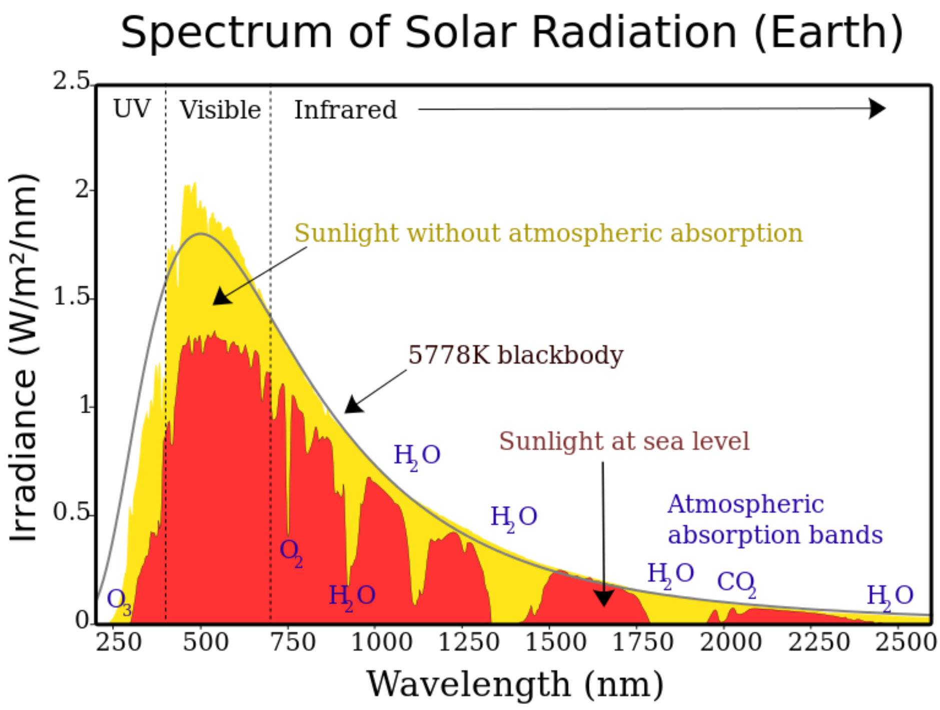
A lump of charcoal, or any other black body, appears black because it absorbs all light falling on it. When heated (provided they do not change chemically) all black bodies glow with a colour which depends only on their temperature.

However being a visually black does not mean a body is a perfect absorber/emitter for all the non-visible wavelengths too. However we can visualise, and contrive, a "**perfect black body"** that is. The spectra of thermal radiation from the sun and other real bodies approximate quite closely to (perfect) **black body radiation** spectra.

The Sun

The surface of the Sun is at about 4400 kelvin, but much of its radiation comes from deeper layers up to 6400 K. Various constituent of the outer layers absorb some of the radiation from further inside; making the spectrum of solar radiation heading towards Earth, (shown in yellow on the diagram). a jagged approximation to, that of a black body at 5778 K.

Further absorption in the Earth's atmosphere make the spectrum of solar radiation reaching the surface even more jagged (shown in orange). The part in the visible region is more like that of a 5000K black body.



By Nick84 - http://commons.wikimedia.org *Note the absorption by CO_2 and H_2O – but that is another topic*

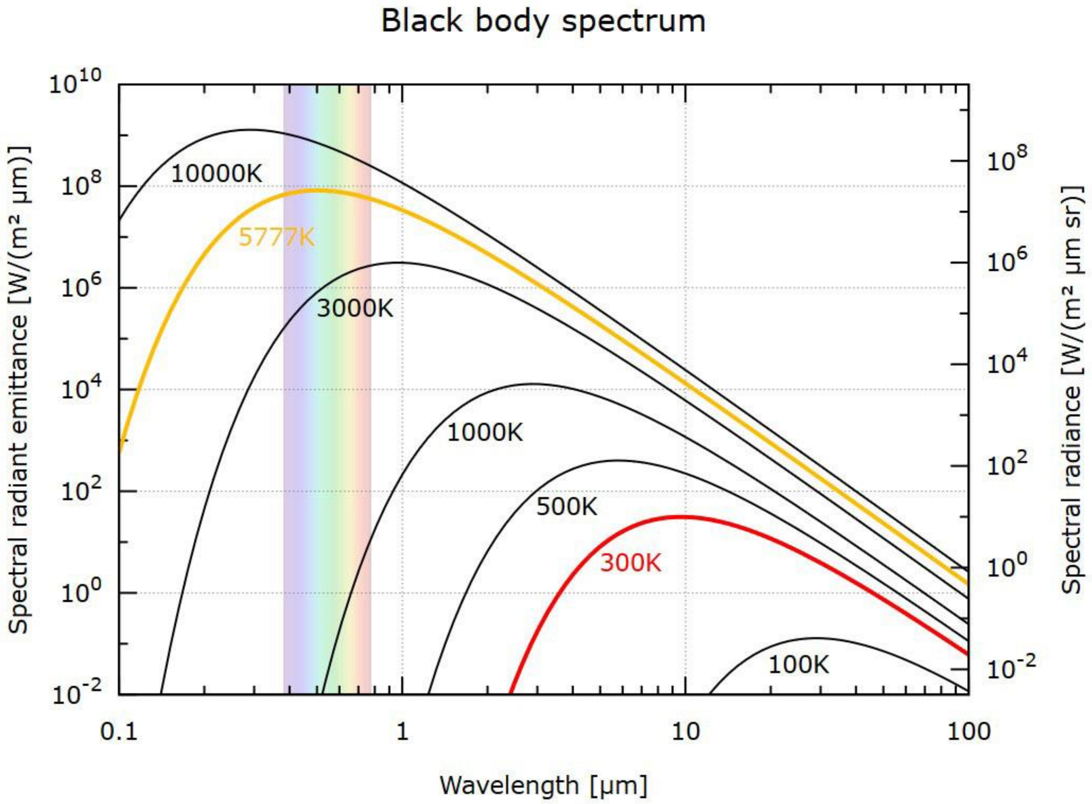
Colour Temperature

As the sunlight reaching the earth approximates to that of a black body at 5000 kelvin, we say **sunlight has a colour temperature of 5000 K.**

[Let's hope the Brexit mob do not require as to translate to the value on ancient scale of German/Polish/Dutch Herr Doctor Fahrenheit's scale. (7659 °F). **]**

The spectrum from an incandescent light is even closer to a black body spectrum, because short distance between the filament lamp and the beholder means there is virtually no atmospheric absorption.

However we cannot heat an electric light filament to 5000 K. The tungsten it is made of melts at 3700 K, and even before that there is a significant rate of evaporation (or more correctly sublimation) from its surface,



*The above chart of spectr**a** has logarithmic scales to enable the display of the spectra of black bodies at six very different temperatures. Each major line on the axes represents multiplication by 10. Logarithmic scales cannot go down to zero.*

The graphs show that for the 10 fold increase in temperature from 100K to 1 000K , the peak spectral emittance is 100 000 times higher and wavelength for the peak becomes 10 times ***smaller****.*

300 K = 27℃ (which is often used as a round number approximation to room temperature) .

A domestic radiator is at about 315 K. A radiant electric fire is at about 1000K

In a standard **domestic filament lamp**, filament is heated to about **2700 K**.

The 2700 K black body spectrum has more infrared and less visible radiation than sunlight. The light also has more red and less blue, making it look yellowy. The colour is felt to be warm (possibly by association with the yellowy flames of wood and coal fires), but the downside is that much more electrical energy is converted into invisible IR than into light, making its efficiency as a light source low.

We say the colour temperature of this **"warm white"** light is **2700 K**.

Lamps run at 2400K, give extra warm light. The lower temperature increases the filament life, but makes the bulb even more inefficient.

If a filament is encased in a small **quartz** pod of a **halogen** gas (inside the glass bulb) net evaporation is reduced and the filament temperature can be taken up to about **3000 K**, giving a whiter light.

To achieve a colour temperature over 3200 K with a filament lamp (without making the life very short) a blue (or "steel" colour) filter is used to absorb some of the red and yellow.

However, as described in the main article, we can achieve close approximations to the visible part black body radiation spectra, from very warm colour temperature of 2500 K to a daylight colour temperature of 5000 K or more, using LEDs with various blends of phosphors. With LEDs very little energy is converted into invisible infrared, making them much more efficient than filament lamps.

There are some claims that near infrared has health benefits and too much blue is harmful. These will be addressed in the next addition to this supplement.

Steve Bolter. Member Green Liberal Democrats Exec July 2018