BLACKBODY RADIATION
Electromagnetic radiation emitted from hot objects

Blackbody - object which gives the maximum amount of energy radiated from its surface at any temperature and wavelength and the absorbs all the radiation that falls on it.

Model a blackbody - small cavity

The hotter the surface the shorter the wavelength and the greater the quantity of radiation emitted

The Sun behaves as a blackbody with a surface temperature about 5800 K
Wien’s Displacement Law

$$\lambda_{\text{peak}} T = 2.9 \times 10^{-3} \text{ m.K}$$

JWS Rayleigh & James Jeans

Math model described blackbody radiation curves at long wavelengths accurately but not at shorter wavelengths in the UV, radiation from cavity absorbed and emitted with ever smaller and smaller \( \lambda \), energy emitted from cavity becoming infinite – UV catastrophe

Planck’s Hypothesis and Blackbody Radiation

Quantization of energy – particle model of light

Max Planck (19 Oct 1900) - hypothesis – radiation emitted & absorbed by walls of a blackbody cavity – radiation quantized

change in energy \( |E_2 - E_1| = n \ h \ f \) \( n = 1, 2, 3, \ldots \)

His assumption of energy levels quantized enable him to obtain an equation to successfully describe the blackbody radiation curve: Planck radiation law – agreed with experiment.

Each atom behaved as a small antenna (electromagnet oscillator) – energy of an oscillator \( n \ h \ f (n = 0, 1, 2, \ldots) \) - energy of oscillator was quantized. Change in energy of oscillator (emission & absorption) quantized

$$\Delta E = \text{integer} \times h \ f$$

$$\Rightarrow$$
atomic oscillators do not radiate or absorb energy in continuously variable amounts

Birth of Quantum Physics - Planck did not believe that atomic oscillators behaved this way - used his model to simply account for the shape of the blackbody curve
PARTICLE NATURE OF ELECTROMAGNETIC RADIATION

The wave nature of electromagnetic radiation is demonstrated by interference phenomena. However, electromagnetic radiation also has a particle nature. For example, to account for the observations of the radiation emitted from hot objects, it is necessary to use a particle model, where the radiation is considered to be a stream of particles called photons. The energy of a photon, \( E \) is

\[
E = h f
\]

The electromagnetic energy emitted from an object’s surface is called thermal radiation and is due to a decrease in the internal energy of the object. This radiation consists of a continuous spectrum of frequencies extending over a wide range. Objects at room temperature emit mainly infrared and it is not until the temperature reaches about 800 K and above that objects glows visibly.

A blackbody is an object that completely absorbs all electromagnetic radiation falling on its surface at any temperature. It can be thought of as a perfect absorber and emitter of radiation. The power emitted from a blackbody, \( P \) is given by the Stefan-Boltzmann law and it depends only on the surface area of the emitter, \( A \) and its surface temperature, \( T \)

\[
P = A \sigma T^4
\]

**Do problems**  p2.13  p2.33