BB radiation and PEE

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Black body radiation spectrum

- Black-body radiation is the thermal electromagnetic radiation within or surrounding a body in thermodynamic equilibrium with its environment that is emitted by a black body (an idealized opaque, non-reflective body). It has a specific continuous spectrum of wavelengths which is inversely related to the intensity of a black body that depend only on the body's temperature and the spectrum is assumed, for the sake of calculations and theory, to be uniform and constant.
- The thermal radiation spontaneously emitted by many ordinary objects can be approximated as black-body radiation.

Black body radiation spectrum

A black body at room temperature [23°C (296K)] radiates mostly in the infrared spectrum which cannot be perceived by the human eye. But can be sensed by some reptiles. As the object increases in temperature to about 500 °C (773 K), the emission spectrum gets stronger and extends into the human visual range and the object appears dull red. As its temperature increases further, it emits more and more orange, yellow, green, and blue light (and ultimately beyond violet, ultraviolet).

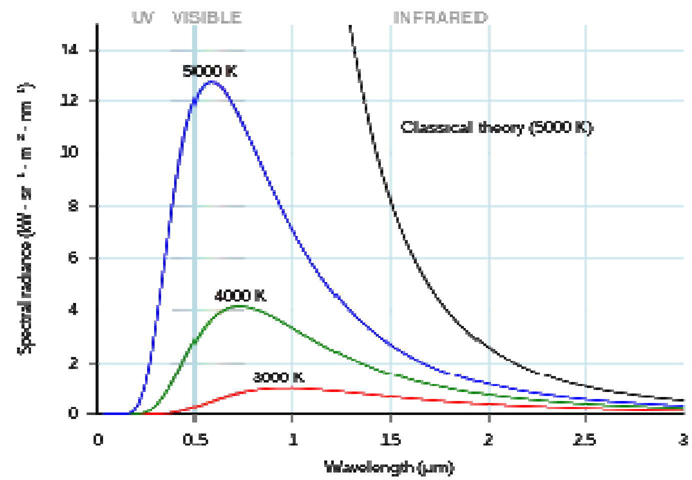

Fig .1: BB radiation spectrum

Black body radiation spectrum

- As the temperature of a black body decreases, its intensity also decreases and its peak moves to longer wavelengths. The UV region can be explained by the classical Rayleigh-Jeans law.
- The wavelength at which the radiation is strongest is given by Wien's

displacement law($\lambda_{\max} = \frac{b}{T}$) and the overall power emitted per unit area is given by the Stefan-Boltzmann law. The formula is given by $E = \sigma T^4$, where E is the radiant heat emitted from a unit of area per unit time, T is the absolute temperature and σ = 5.670367×10^{-8} W·m^{-2}·K^{-4} is the Stefan-Boltzmann constant. Thus the visible region is explained by Wien's displacement law and infrared region along with vigible region can be explained by Stefan-Boltzmann law.

Planck's law

In physics, **Planck's law** describes the spectral density of electromagnetic radiation emitted by a black body in thermal equilibrium at a given temperature *T*, when there is no net flow of matter or energy between the body and its environment.

According to this, the spectral radiance of a body for frequency *ν* at absolute temperature *T* is given by

$$B(\nu, T) = \frac{2h\nu^3}{c^2} \frac{1}{\frac{hv}{ek_BT} - 1}$$

$$\left(e^{\frac{h\nu}{k_BT}}\right)$$

Where h= Planck constant

k_B= Boltzmann constant

c = speed of light in the medium

Thus Planck's law applies quantum theory to explain the entire spectrum of black body radiation.

Photoelectric effect

The photoelectric effect is the emission of electrons when electromagnetic radiation, such as light, hits a material. Electrons emitted in this manner are called photoelectrons. And the current due to these photoelectrons is called photoelectric current.

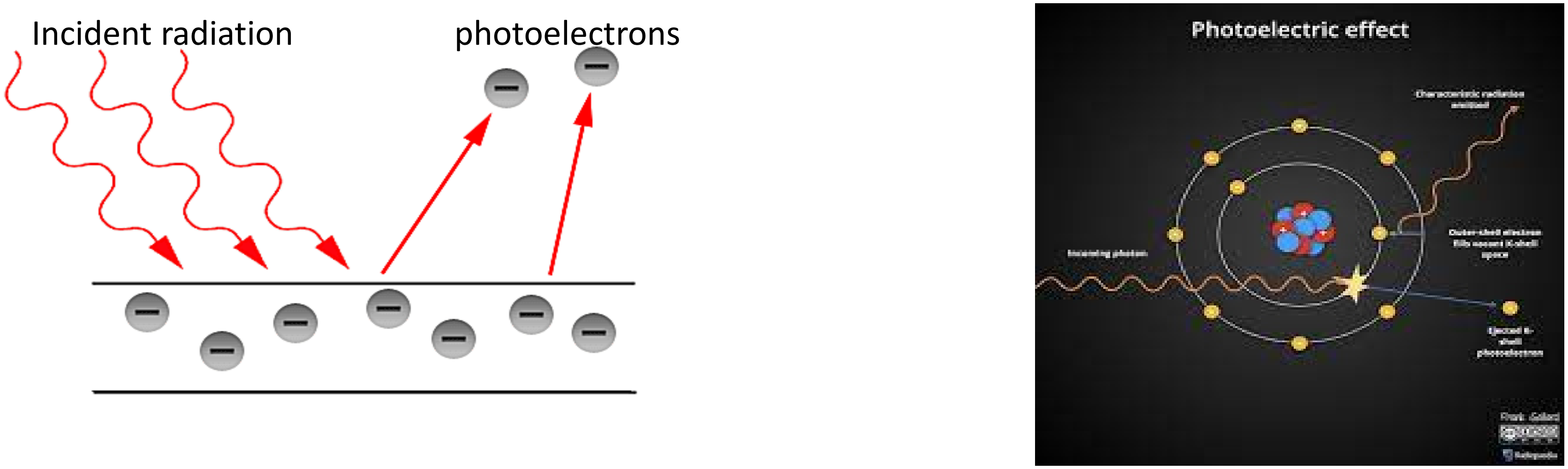

Fig.2: photoelectric effect

Einstein's photoelectric equation

Let 'm' be the mass of electron and v_{max} be the maximum velocity of photo-electron by which it will be ejected. Then the maximum KE gained by the photoelectron will be

$$\therefore \frac{1}{2} m v^2_{max} = h\nu - \phi_o$$

$$\therefore h\nu = \phi_o + \frac{1}{2} m v^2_{max}$$

But $\phi_o = h\nu_o$

Where ν_o = Threshold frequency.

$$\therefore h\nu = h\nu_o + \frac{1}{2} m v^2_{max}$$

$$\therefore \frac{1}{2} m v^2_{max} = h\nu - h\nu_o$$

$$\therefore \boxed{\frac{1}{2} m v^2_{max} = h(\nu - \nu_o)} \rightarrow \text{Einstein's PE equation}$$

Thank You