1. The nature of light

Dual nature of light

Light behaves both as particles and wave

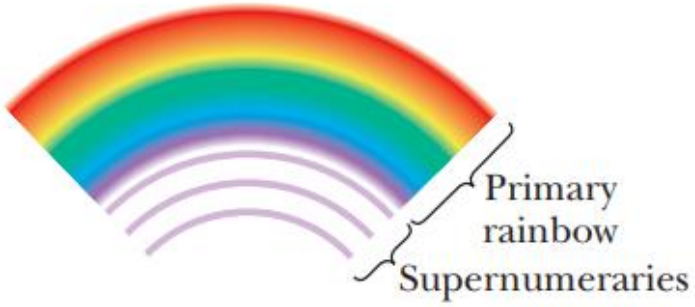
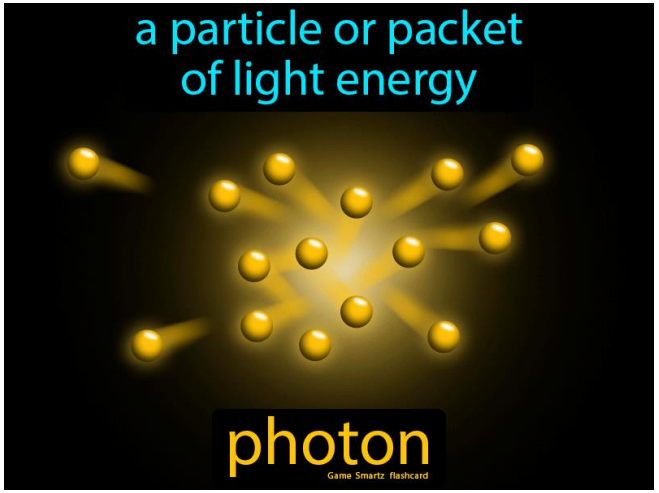


Figure 35-5 A primary rainbow and the faint supernumeraries below it are due to optical interference.



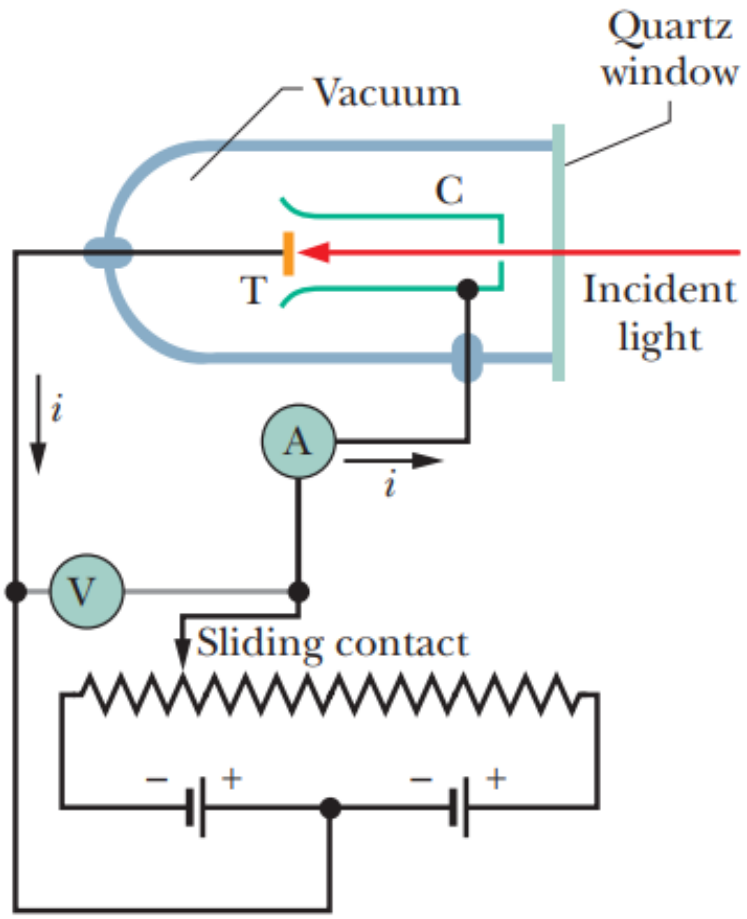
$$E = hf \quad \text{(photon energy)}.$$

***h* is the Planck constant**

$$h = 6.63 \times 10^{-34}\ \text{J} \cdot \text{s} = 4.14 \times 10^{-15}\ \text{eV} \cdot \text{s}.$$

Photoelectric effect (particle nature)

First experiment



The incident light shines on target T, ejecting electrons, collected by collector cup C → an electric current through circuit

- Adjusting the potential difference *V* to slow down the ejected electron.
- We then vary *V* until it reaches a certain value, called the stopping potential V_{stop}, at which point the reading of meter A has just dropped to zero
- The kinetic energy of these most energetic electrons

$$K_{max} = eV_{stop}$$

K_{max} does not depend on the intensity of the light source!?

The photoelectric equation

$$hf = K_{\max} + \Phi \quad \text{(photoelectric equation).}$$

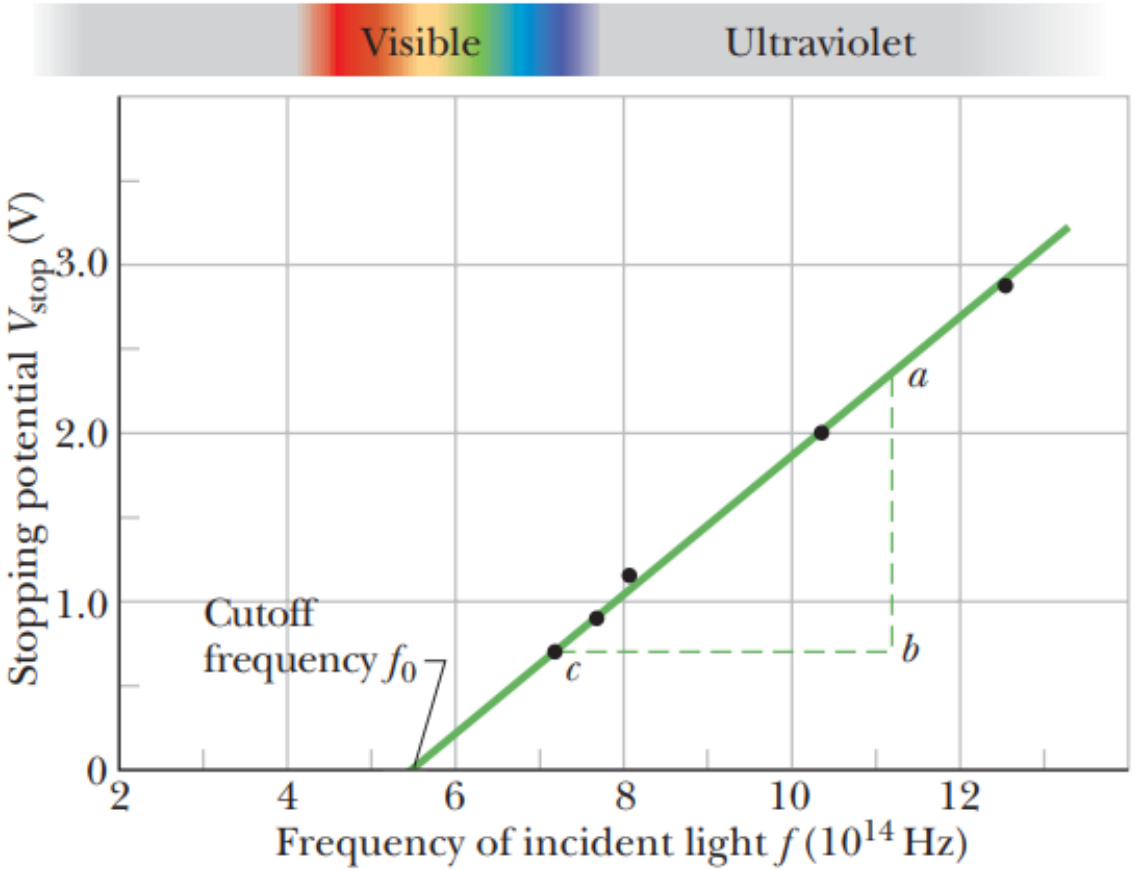
- Energy equal to the photon's energy hf is **transferred** to a single electron in the material of the target.
- If the electron is to escape from the target, it must pick up energy at least equal to the work function Φ (materials property).
- Any additional energy (hf - Φ) acquired from the photon is **kinetic energy *K* of the electron**.
- In the most favorable circumstance, the electron can escape through the surface **without losing** any of this kinetic energy in the process → outside the target, electrons have the maximum possible kinetic energy $\boldsymbol{K_{max}}$.
- We can also get

$$V_{\text{stop}} = \left(\frac{h}{e}\right) f - \frac{\Phi}{e}.$$

Second experiment

Electrons can escape only if the light frequency exceeds a certain value.

The escaping electron's kinetic energy is greater for a greater light frequency.



The photoelectric effect does not occur if the frequency is below a certain cutoff frequency f_0, ***no matter how intense the incident light is.***

cutoff wavelength $\lambda_0 = c/f_0$