Photoelectric Effect

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Outline

What is Photoelectric Effect ?

Emission of electrons (photoelectrons) when light (of a certain wavelength/frequency) falls on a metallic surface.

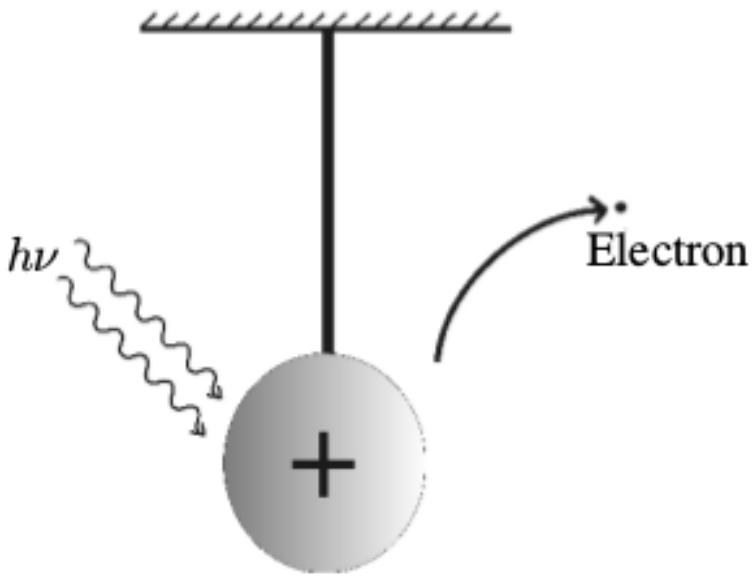

Figure 1: Sphere tied with an insulating string. Electron emission occurs and sphere gains a positive charge which can be verified by bringing a charged object near to it. Here h is Planck's constant and ν is frequency of light.

Experimental Setup and Observations

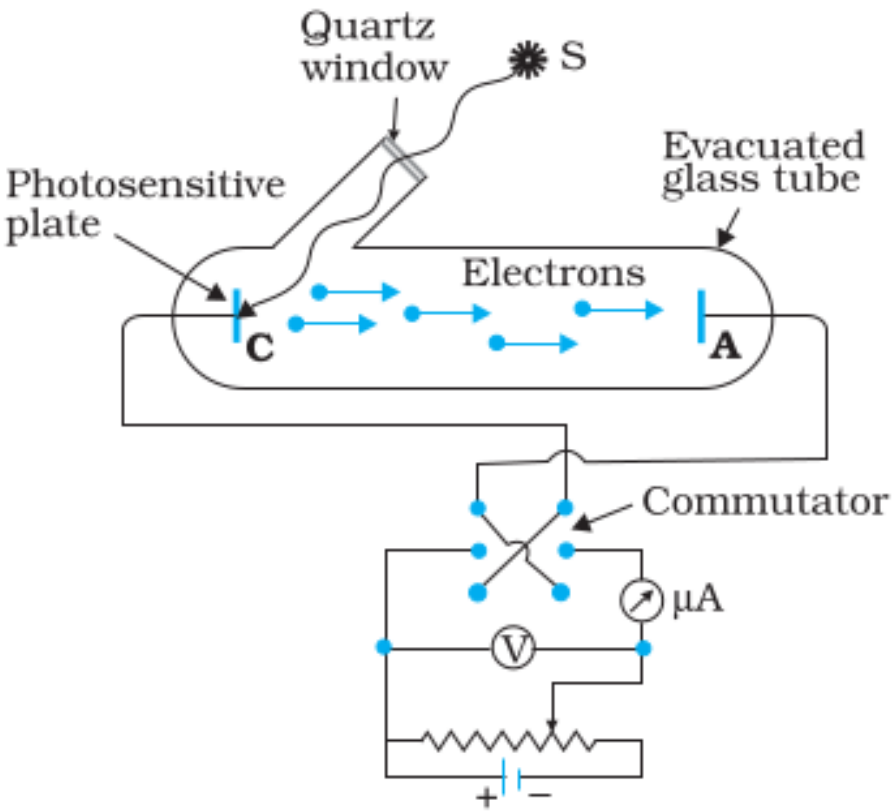

Figure 2: Basic experimental setup for studying photoelectric effect. (Fig. source-NCERT)

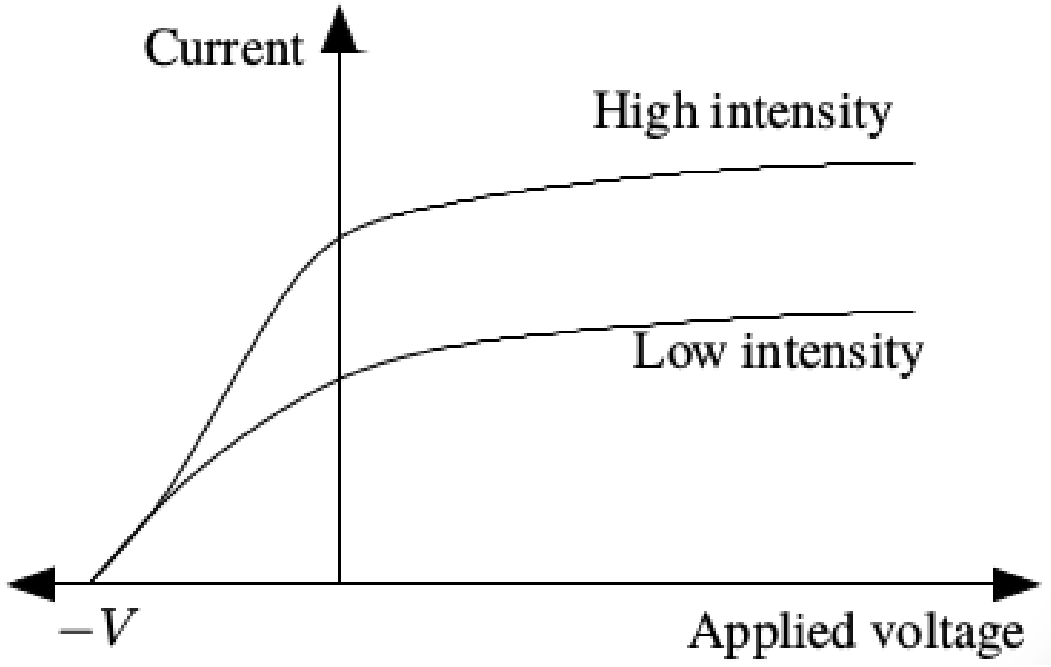

Figure 3: Observations. Photocurrent depends on the intensity of light.

Einstein's Photoelectric Equation and Its Implications

An anology to obtain Einstein's photoelectric equation

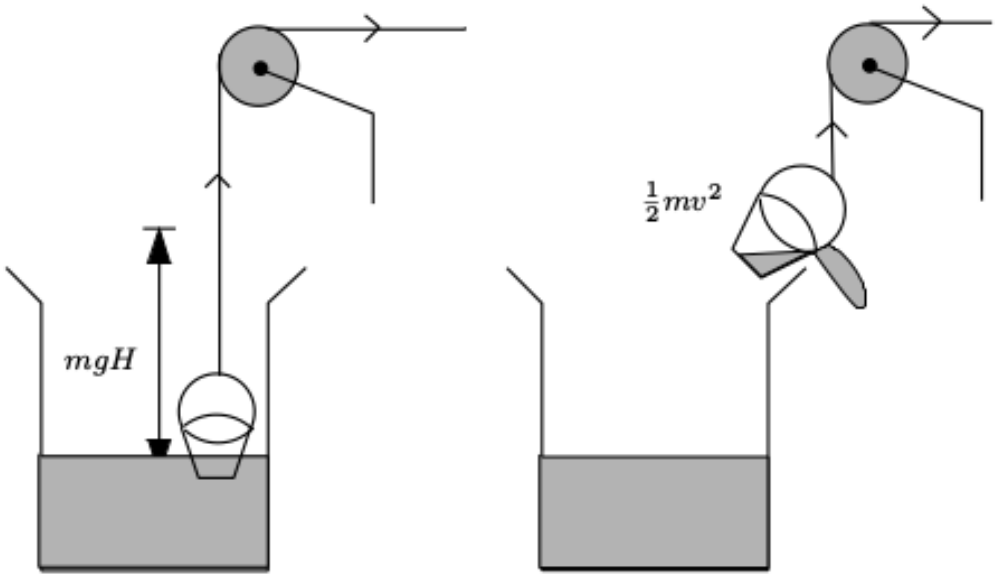

Figure 4: Illustrates total energy required to pull a bucketful of water from a well of depth H and throwing it to nearby land with speed v. Here m represents mass. Total energy required in this process is $E = mgH + \frac{1}{2}mv^2$.

Now we write Einstein's photoelectric equation

$$h\nu = \phi + \frac{1}{2}mv_{max}^2$$

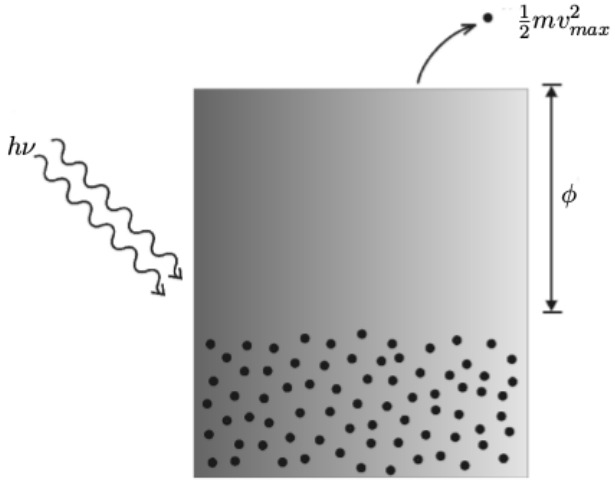

Figure 5: Ejection of electrons from metal surface. Here ϕ is the work function of the metal. It is the minimum amount of energy required to eject an electron from the metal surface. Equation shows that maximum kinetic energy of photoelectrons depends on the frequency of light falling on the metal surface.*Photoelectric effect confirms the particle nature of light.*

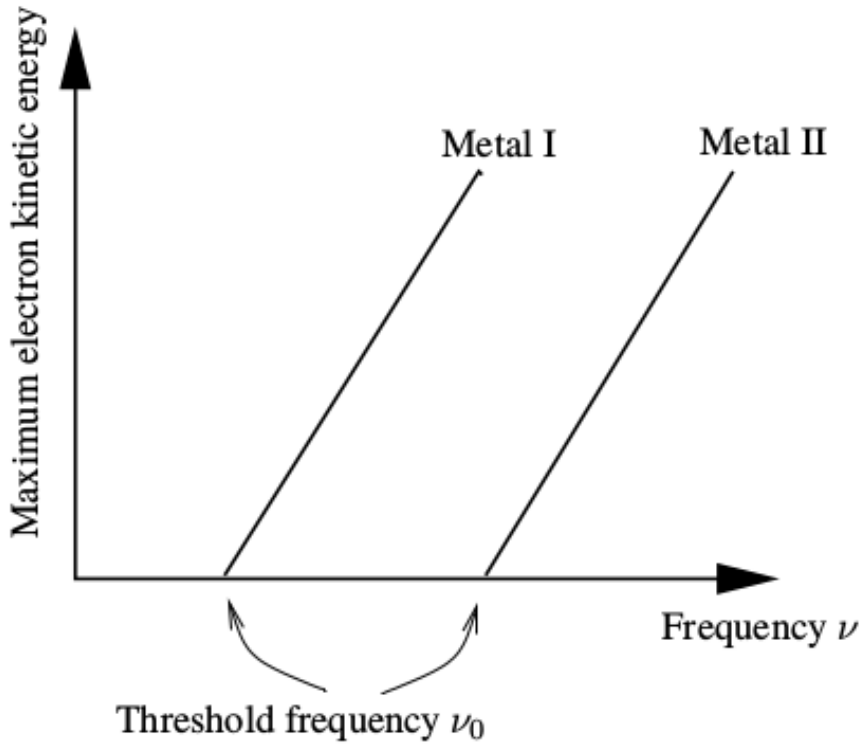

Figure 6: Sketch of dependence of the maximum kinetic energy of the photoelectrons on the frequency of the incident light. For setup see Figure 2. The threshold frequency ν_0, which is the minimum frequency of light required to eject an electron from metal surface, is different for different materials. Kinetic energy increases linearly with frequency of light. One can obtain the work function of a metal from the intercept on the vertical energy axis.

Applications: Photoelectric cells (alarms), solar power satellites, etc.

References

- On a heuristic point of view concerning production and transformation of light, Annalen der Physik **17** (1905) 132148. (Photoelectric effect).
- A Revolution in Physics: Einsteins Papers of 1905 Made Simple, TIFR, Mumbai (2005).