Quantum Mechanics-Section4

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1 Particle nature of waves

1.1 Photoelectric Effect: Quantization of Light

1.1.1 Potential difference (V) *vs.* photocurrent (I_{ph}): Frequency (ν) dependence

In figure 1, photocurrent is plotted against the potential differences between electrodes for various incident light frequencies, while the intensity of irradiation is fixed. Three characteristic curves are shown for three different frequencies *i.e.* ν_1, ν_2 and ν_3, respectively, where $\nu_3 > \nu_2 > \nu_1$. At higher potential difference the current I_{ph} reach to its saturation value, which is same for these three cases since the intensity of the incident light is fixed. At lower voltage difference these three curves separate out and at zero potential difference they intersect the y-axis at three points. At negative relative potentials of the anode, the three characteristic curves corresponding to ν_1, ν_2 and ν_3 meet the x-axis at three different co-ordinates indicating the corresponding stopping potentials $-V_S^1$, $-V_S^2$ and $-V_S^3$ respectively where $V_S^3 > V_S^2 > V_S^1$. It is interesting to note that the stopping potential depends on the incident light frequency. In the previous section, we have seen that the stopping potential does not depend on the incident light intensity. This is a very interesting phenomena regarding photoelectric effect.

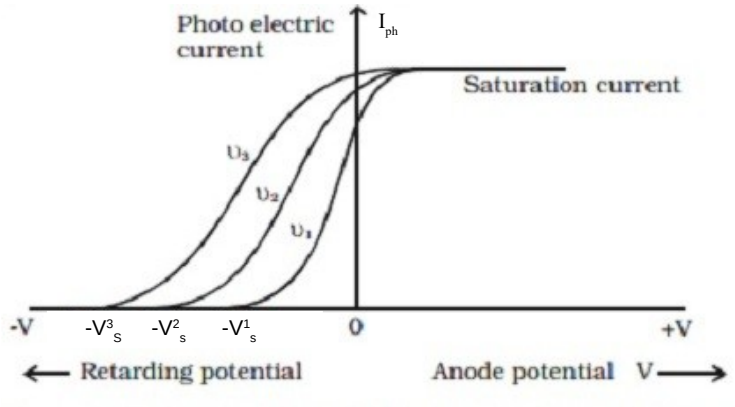

Figure 1: Stopping potential V_S depends on the frequency ν of the incident light.

1.1.2 Stopping potential (V_S) *vs.* frequency (ν): Material dependence

If we plot stopping potentials for various frequencies of the incident light, it shows linear behaviour, as shown in figure 2. In this figure, the behaviours of stopping potential as function of frequency are shown for two different metal A and B respectively. For each metal, there are respective frequencies at which the stopping potential reach down to zero value. This is called *threshold frequency* ν_{th} for that metal. Threshold frequency is significant because below this frequency no photoemission takes place whatever may be the intensity of the irradiation. For metal A and B, value of ν_{th} are different. Evidently, threshold frequency is material specific. Notably, the slopes of the lines for the two cases are same, which indicates that the *proportion* at which stopping potential changes with frequency is independent of material properties.

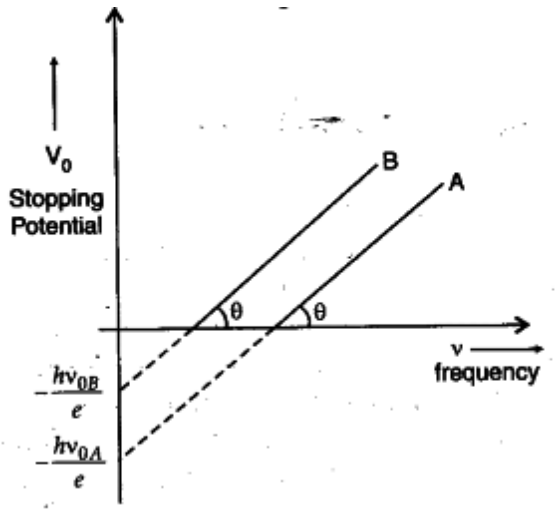

Figure 2: Frequency dependence of the stopping potential.

References

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[1] Figures are collected from online resources.