1. Details of unit revision and its structure

Subject Name	Physics
Course Name	Physics 04 (Physics Part-2, Class XII)
Title	Revision Unit-07_Study Guide
Pre-requisites	eContent of Unit 07: Dual Nature of Radiation and Matter
Objectives	After going through this study guide, the learners will be able to: • How to consolidate the unit? • How to prepare notes?
Keywords	Photoelectric effect, Einstein Photo-electric equation, Davisson-Germer experiment and Photovoltaic cell

2. Development Team

Role	Name	Affiliation
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STUDY GUIDE

UNIT 7 Physics 04

Dual nature of radiation and matter

Dual Nature of Radiation and matter

Dual nature of radiation, photoelectric effect, Hertz and Lenard's observations. Einstein's photoelectric equation, particle nature of light

Matter waves, wave particle duality, nature of particles de Broglie relation, Davisson - Germer experiment (experimental details should be omitted only conclusion should be explained

This unit is very interesting. Make sure you study each section carefully

Take care to understand the concept of wave particle duality and its application to explain the phenomenon linked with it.

Make your list to ensure coverage of the syllabus

- **Dual nature of radiation,**
- **Photoelectric effect,**
- **Hertz and Lenard's observations.**
- **Einstein's photoelectric equation,**
- **particle nature of light**
- **Matter waves,**
- **wave particle duality,**
- **nature of particles de Broglie relation,**
- **Davisson -Germer experiment (experimental details should be omitted only conclusion**

Write the definitions for each

- **Electron volt**
- **Work function**
- **Thermionic emission**
- **Field emission**
- **Photo emission**
- **Threshold frequency**
- **Photon**
- **Photon energy**
- **Planck's constant**
- **Photocell**

- **De Broglie wavelength**
- **Matter waves**

FOR FOLLOWING GRAPHS

- **Explain each**
- **How to plot the graphs**
- **Write the inference from each**
- **Any special feature**

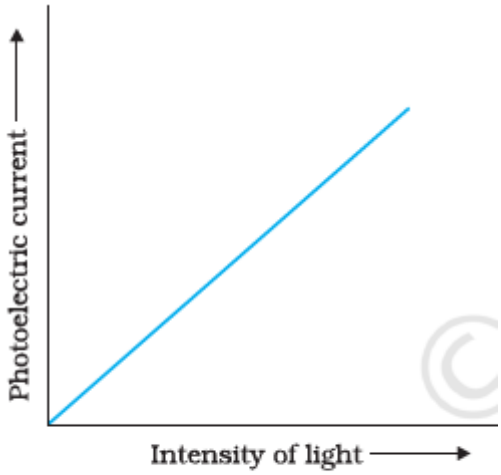

FIGURE 11.2 Variation of Photoelectric current with intensity of light.

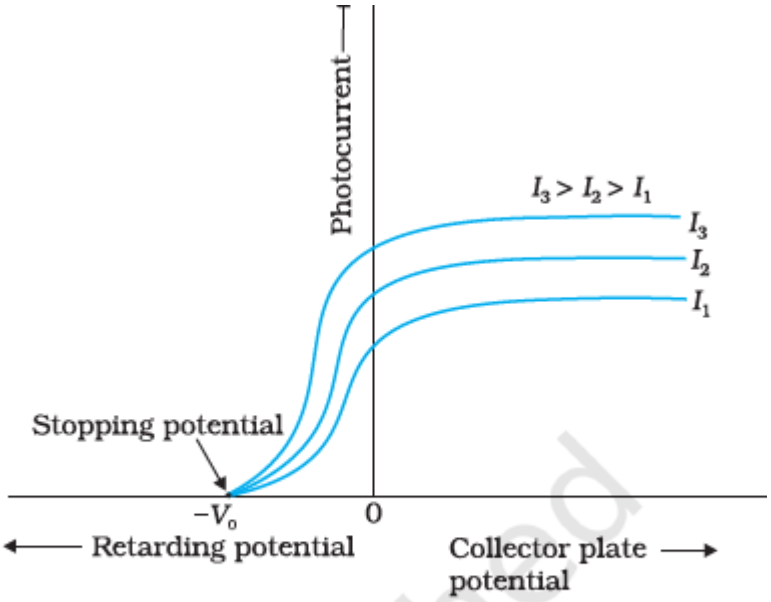

FIGURE 11.3 Variation of photocurrent with collector plate potential for different intensity of incident radiation.

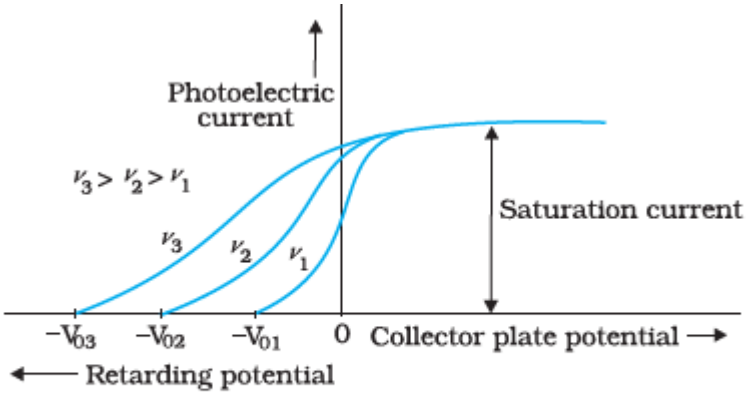

FIGURE 11.4 Variation of photoelectric current with collector plate potential for different frequencies of incident radiation.

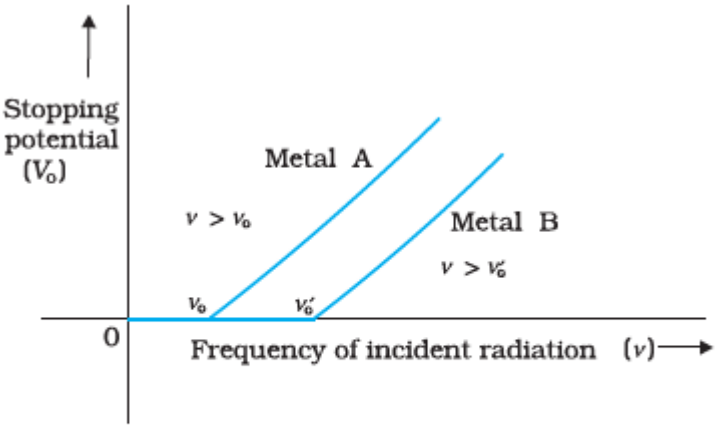

FIGURE 11.5 Variation of stopping potential V_0 with frequency ν of incident radiation for a given photosensitive material.

Collect the expressions and explain each term for each

$$K_{max} = eV_0$$

$$K_{max} = h\nu - \emptyset_0$$

$$eV_0 = h\nu - \emptyset_0$$

For $\nu \geq \nu_0$

Or

$$V_0 = \left(\frac{h}{e}\right)\nu - \frac{\emptyset_0}{e}$$

$$\lambda = \frac{h}{P} = \frac{h}{mv}$$

$$K = eV$$

Now, $k = \frac{1}{2}mv^2 = \frac{p^2}{2m}, so\ that$

$$p = \sqrt{2mk} = \sqrt{2meV}$$

The de-Broglie wavelength λ of the electron is then

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mk}} = \frac{h}{\sqrt{2meV}}$$

Substituting the numerical values of h, m, e

We get

$$\lambda = \frac{1.227}{\sqrt{V}} nm$$

$$\Delta \boldsymbol{x} \Delta \boldsymbol{p} \approx \hbar$$

Analyse these

- Free electrons in a metal are free in the sense that they move inside the metal in a constant potential (This is only an approximation). They are not free to move out of the metal. They need additional energy to get out of the metal.

- Free electrons in a metal do not all have the same energy. Like molecules in a gas jar, the electrons have a certain energy distribution at a given temperature. This distribution is different from the usual Maxwell's distribution that you have learnt in the study of kinetic theory of gases. You will learn about it in later courses, but the difference has to do with the fact that electrons obey Pauli's exclusion principle.

- Because of the energy distribution of free electrons in a metal, the energy required by an electron to come out of the metal is different for different electrons. Electrons with higher energy require less additional energy to come out of the metal than those with lower energies. Work function is the least energy required by an electron to come out of the metal.

- Observations on photoelectric effect imply that in the event of matter light interaction, *absorption of energy takes place in discrete units of hν*. This is not quite the same as saying that light consists of particles, each of energy *hν*.

- Observations on the stopping potential (its independence of intensity and dependence on frequency) are the crucial discriminator between the wave-picture and photon-picture of photoelectric effect.

- The wavelength of a matter wave given by

$$\lambda = \frac{h}{p}$$

has physical significance; its phase velocity has no physical significance. However, the group velocity of the matter wave is physically meaningful and equals the velocity of the particle.

Write the inferences from

- **Hertz and Lenard's observations.**
- **Davisson -Germer experiment**
- **Experiments with photo cell**

Read the unit from NCERT