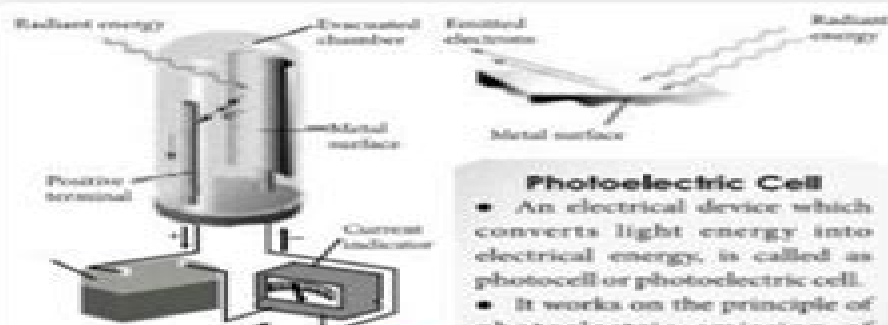


QUANTUM THEORY OF LIGHT

**BRAIN
MAP**
CLASS XII



Photoelectric Cell

- An electrical device which converts light energy into electrical energy, is called as photocell or photoelectric cell.
- It works on the principle of photo-electric emission of electrons.

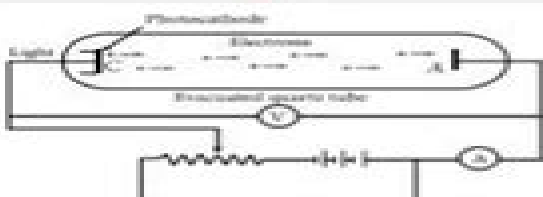
Photo-electric Effect

- The phenomenon of emission of electrons from a metal surface when an electromagnetic wave of suitable frequency is incident on it is called photoelectric effect.



Photoelectric Equation

- $E = K_{\max} + \phi_0$
where ϕ_0 = work function of metal,
 E = energy of incident light,
 K_{\max} = maximum kinetic energy of electrons
- $\frac{1}{2}mv_{\max}^2 = h\nu - \phi_0 = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$
where, $\lambda_0 = \frac{hc}{\phi_0}$ = threshold wavelength



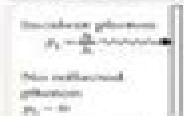
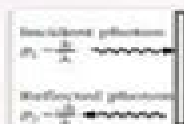
PARTICLE NATURE OF RADIATION

Basic Quantum Theory of Light

- According to Planck, the energy of a photon, $E = h\nu$;
$$E = h\nu = \frac{hc}{\lambda} = \frac{1240}{\lambda(\text{in nm})} \text{ eV}$$
- Momentum of photon, $p = \frac{E}{c} = \frac{h\nu}{c} = \frac{h}{\lambda}$
- If source is 100% efficient, then the number of photons emitted per second by the source can be given by
$$n = \frac{\text{Power of source}}{\text{Energy of photon}} = \frac{P}{E} = \frac{P}{h\nu} = \frac{PA}{hc}$$
- The energy crossing per unit area per unit time perpendicular to the direction of propagation is called the intensity of a wave.
 $I = E/At = P/A$
- Force exerted on perfectly reflecting surface
$$F = \frac{\Delta p}{t} = \frac{2Nh}{t\lambda} = n\left(\frac{2h}{\lambda}\right) = \frac{2P}{c}$$

$$\text{Pressure} = \frac{F}{A} = \frac{2P}{cA} = \frac{2I}{c}$$
- Force exerted on perfectly absorbing surface
$$F = \frac{\Delta p}{t} = \frac{Nh}{t\lambda} = n\left(\frac{h}{\lambda}\right) = \frac{P}{c}$$

$$\text{Pressure} = \frac{F}{A} = \frac{P}{cA} = \frac{I}{c}$$



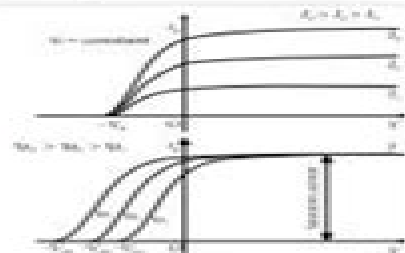
- When a beam of light is incident at an angle θ on perfectly reflector surface then force exerted on the surface,
$$F = \frac{2P}{c} \cos \theta = \frac{2IA \cos \theta}{c}$$

$$\text{Pressure} = \frac{2I \cos \theta}{c}$$

Conclusions of Experimental Study of Photoelectric Effect

- Photo-current is directly proportional to the intensity of incident light, i.e., $i_p \propto I$.
(At constant frequency ν and potential V)
- At constant frequency and intensity, the minimum negative potential at which the photocurrent becomes zero is called stopping potential (V_0).
- At stopping potential V_0 , $K_{\max} = eV_0$.
- For a given frequency of the incident radiation, the stopping potential is independent of its intensity.
- The stopping potential varies linearly with the frequency of incident radiation but saturation current value remains constant for a fixed intensity of incident radiation.

- Quantum efficiency = $\frac{n_e}{n_{ph}}$
 n_e = number of electron emitted per second
 n_{ph} = total number of photon incident per second



Study Guide Quantum Theory

Jean Dorricott



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Table of Contents Study Guide Quantum Theory

1. Understanding the eBook Study Guide Quantum Theory
 - The Rise of Digital Reading Study Guide Quantum Theory
 - Advantages of eBooks Over Traditional Books
2. Identifying Study Guide Quantum Theory
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Study Guide Quantum Theory
 - User-Friendly Interface
4. Exploring eBook Recommendations from Study Guide Quantum Theory
 - Personalized Recommendations
 - Study Guide Quantum Theory User Reviews and Ratings
 - Study Guide Quantum Theory and Bestseller Lists
5. Accessing Study Guide Quantum Theory Free and Paid eBooks
 - Study Guide Quantum Theory Public Domain eBooks
 - Study Guide Quantum Theory eBook Subscription Services
 - Study Guide Quantum Theory Budget-Friendly Options
6. Navigating Study Guide Quantum Theory eBook Formats

- ePub, PDF, MOBI, and More
- Study Guide Quantum Theory Compatibility with Devices
- Study Guide Quantum Theory Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Study Guide Quantum Theory
 - Highlighting and Note-Taking Study Guide Quantum Theory
 - Interactive Elements Study Guide Quantum Theory
- 8. Staying Engaged with Study Guide Quantum Theory
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Study Guide Quantum Theory
- 9. Balancing eBooks and Physical Books Study Guide Quantum Theory
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Study Guide Quantum Theory
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Study Guide Quantum Theory
 - Setting Reading Goals Study Guide Quantum Theory
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Study Guide Quantum Theory
 - Fact-Checking eBook Content of Study Guide Quantum Theory
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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