Unit-7Dual Nature of Matter and Radiation

1 Free Electron in a Metal:

In metals, the electrons in the outermost shell are loosely bounded. They move freely though out the lattice of the metals called free electronics. However these electrons remain confined in the lattice at ordinary condition. To remove these electrons from lattice we have to do some work, this work done is called work function as.

The minimum amount of energy required to just eject out an electron from metal surface is called work function and it depends upon Nature of metal.

The work function is measured in electron volts

2 Electron Volt:

One electron volt is the amount of kinetic energy gained by an electron when it is accelerated though a potential difference of 1 volt.

$$\text{Energy gain by electron} = \text{work done by electric field} = \text{eV}$$

Or $$\boldsymbol{IeV = 1.6 \times 10^{-19} \times 1V = 1.602 \times 10^{-19} J}$$

- This unit of energy is used in atomic and nuclear physics.
- Work function for platinum is highest ($\emptyset_0 = 5.65\text{eV}$) and minimum for $\text{Cs}(\emptyset_0 = 2.14)$.

Illustration 1: The work function of silver is $5.26 \times 10^{-19} J$. Calculate its threshold wavelength.

Sol: For any metal to eject photo electron the work function of surface is given as $\varphi = \frac{hc}{\lambda_0}$

Threshold wavelength = $\lambda_0 = \frac{hc}{\emptyset} = \frac{6.6\times 10^{-34} \times 3\times 10^8}{5.26\times 10^{-19}} = 3.764 \times 10^{-7}\, m = 3764A°$

Illustration 2: The work function of Na is 2.3 eV. What is the maximum wavelength of light that will cause photo electrons to be emitted from sodium?

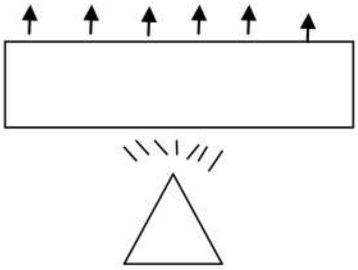
Sol: For any metal to eject photo electron the work function of surface is given as $\varphi = \frac{hc}{\lambda_0}$

The threshold wavelength $\lambda_0 = \frac{hc}{\emptyset}$ =5930 A°

3 Electron Emission:

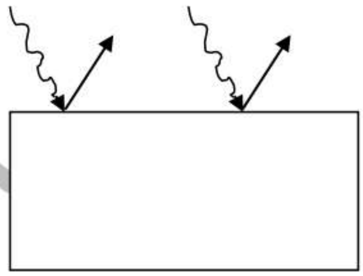
The process of ejection of a electron from a metal surface is called electron emission. It may be of four types.

(i) Thermionic Emission:



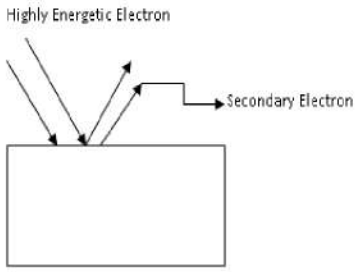
When a metal is heated, then electrons of the metal get acquire sufficient amount of thermal energy and reject out from the metal surface, this phenomenon is called thermionic emission.

(ii) Photoelectric Emission:



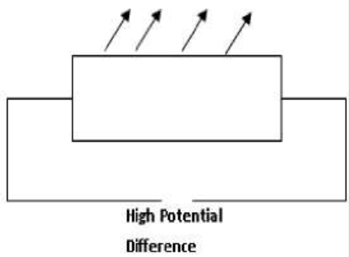
When light of suitable frequency (threshold frequency) is incidental on the metal surface then electron ejects out from metal, this ejected electron is called photo electron and the phenomenon is called photoelectric emission.

(iii) Secondary Emission:



When highly energetic electrons are incidental on the metal surface then free electrons are emitted from the metal surface, this ejected electron is called secondary electron and the phenomenon of emission of electron is called secondary emission.

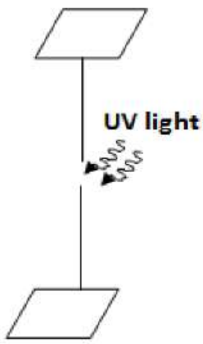
(iv) Field Emission or Cold Emission or Cathode Emission:



When a high electron field is applied across the ends of a metal then free electrons are emitted from the metal surface, this phenomenon of emission of electrons is called filed emission.

4 Hertz Observation^{imp}:

The phenomenon of photoelectric effect was discovered by Henrich Hertz in 1887.



He found that when the cathode was illuminated by the ultraviolet light then high voltage sparks produces between the electrodes of the metal, which occurs due to ejection of e^- from the metal surface. Thus e^- are emitted when a light of sufficient high frequency is felled on the metal surface. This is photoelectric effect.

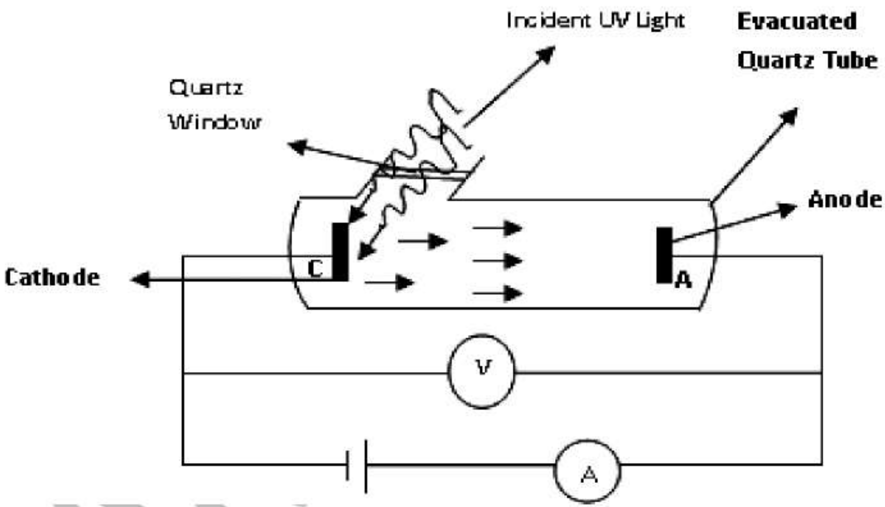
5 Hallwach's and Lenard's Observation imp:

Hallwach observed that when a zinc plate is illuminated with an ultraviolet light then electrons are emitted from the zinc plates. Later Lenard observed that when a metal plate (emitter) in a evacuated glass tube is illuminated with ultraviolet light then current flows between cathode and anodes which remains till the ultraviolet light. They also observed that electrons emits up to a certain frequency (threshold) below which no photo electrons are emitted. Thus Hallwach and Lenard observation supports the phenomenon of photo electric effect,

6 Photoelectric Effect m.imp:

The phenomenon of emission of electrons from a metal surface when electromagnetic waves of sufficient high frequency are incidental on it is called photoelectric effect.

Experimental Study of Photoelectric Effect:

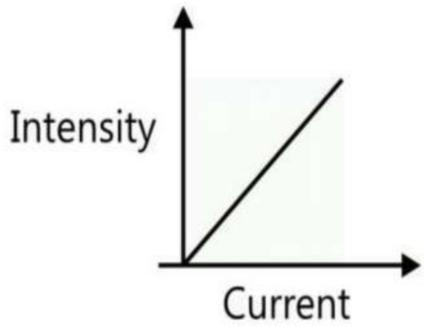


The experimental setup used to study the photoelectric effect is consisting of a vacuum tube having two metallic electrodes A and C.

The electrode C emits photoelectrons when illuminated with UV light and anode collects the electrons. The tube has a side window made of quartz through which the incident light enters into the tube; it allows only passing UV rays through it and preventing visible light. The two electrons are connected to a source of variable potential by which potential of A and C can be sat.

(i) Effect of Intensity of Light on Photoelectric Current:

At constant frequency and potential difference the photoelectric current is directly of proportional to intensity of light. As the number of photoelectrons emitted by cathode is directly proportional to intensity of light.



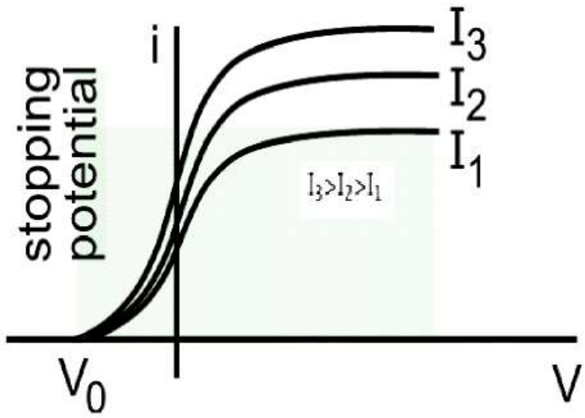
(ii) Effect of Potential on Photoelectric Current:

It is found that at constant intensity, the photo electric current is directly proportional to applied potential difference up to a certain limit after that current becomes constant. This maximum constant current called ***saturation current***.

With increase in potential, K.E. of photo electrons increases. The maximum K.E. of photo electrons must be equal to eV_0,

i.e. $\frac{1}{2}mv_{max}^2 = eV_0$

Or $\frac{1}{2}mv_{max}^2 \propto V_0$



- Thus maximum K.E. of photoelectrons depends upon the potential difference between the plates.

If anode is connected to $-ve$ terminal of the battery then current decreases and at a certain $-ve$ potential of plate A, the current becomes zero.

This potential at which current becomes zero is called ***cut off potential***.

- Also we can see that maximum photo electric current depends upon the intensity of incident radiations however the cut off potential is independent on intensity of light.
- Cut of potential depends on frequency of light.

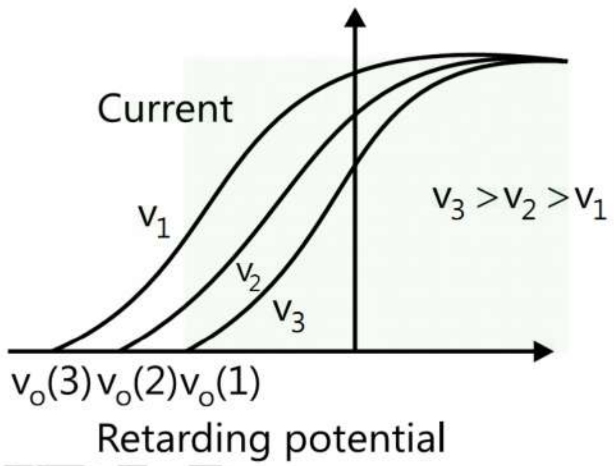
Illustration 3: Calculate the value of the stopping potential if one photon has 25 eV energy and the work function of material is 7 eV.

Sol: The stopping potential required to stop the photoelectrons to reach cathode is

$$V_0 = \frac{E-\varphi_0}{e} = \frac{(25-7)eV}{e} = 18V$$

(iii) Effect of Frequency on Photoelectric Current:

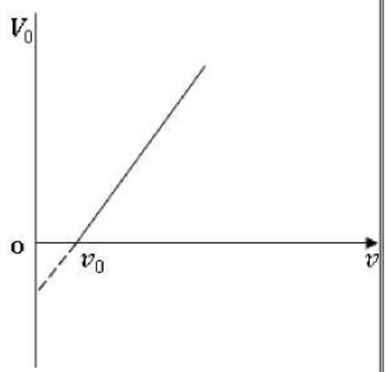
- It is found that at constant intensity when frequency is changed then in each case saturation current remains constant i.e *value of saturation current is independent on frequency of light.*



- But for larger value of frequency the stopping potential shifts toward more $-ve$ anode.

  I.e with rise in frequency the K.E. of photo electrons increases due to which we require more potential to make current zero hence stopping potential increase with increase in frequency.

- When a graph is plotted between stopping potential and frequency of incident radiation then it is a straight line not passing through origin. This indicates a *minimum value of frequency at which stopping potential becomes zero i.e. no electron ejects out from metal surface. This minimum frequency at which stopping potential becomes zero is called* ***threshold frequency***.



7 Laws of Photoelectric Emission[m.imp]:

On the basis of experimental study the following laws of photoelectric emission are given:

- For a given material, there is a minimum frequency below which no photoelectric emission takes places called threshold frequency.
- The number of photo electrons emitted from cathode is directly proportional to the intensity of light provide frequency is greater than threshold frequency.
- The maximum kinetic energy of photoelectrons depends upon the frequency of light and is independent on intensity of light.
- The photoelectric effect is instantaneous process.

8 Failure of Classical Wave Theory:

- As according to wave theory of light greater is intensity of light greater is the amplitude of light wave so more should be the K.E. of electrons but is found that depends upon frequency of incident ray.
- According to wave theory the electron must be ejected due to intensity of light, it could not explain the concept of threshold frequency.
- It could not explain the spontaneous nature of photoelectric light.

9 Einstein's Theory of Photoelectric Effect[m.imp]:

Einstein's explained the phenomenon of photo electric effect on the bases of Planck's hypothesis. According to Einstein light is consist of photons of energy $h\nu$, When it falls on metal surface, then some energy is used to eject out the photoelectron from the metal surface and remaining energy provides the sufficient K.E to electrons

As $$h\nu = \emptyset_0 + \frac{1}{2}mv_{max}^2 \qquad \text{Here } \emptyset_0 = h\nu_0 = work\ function$$

$\Rightarrow$ $$h\nu = h\nu_0 + \frac{1}{2}mv_{max}^2$$

Or $$\frac{1}{2}mv_{max}^2 = h\nu - h\nu_0$$

Or $$\frac{1}{2}mv_{max}^2 = h(\nu - \nu_0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

The above eq. is called Einstein's photo electric equation.

Explanations of Law of Photoelectric effects:

- As from above eq. larger the frequency of incident radiation larger is the K.E of photo electrons.
- If $\nu < \nu_0$ then $K.E = -ve$ which is not possible, hence no photo electric emission takes place below threshold frequency.
- As electron absorb energy in from of certain packet so no delay in emission so process is spontaneous.
- As larger the intensity of light more will be the number of photons falling on metal surface so more electrons will emit from metal surface. Hence number of photo electrons emitted per second is proportional to intensity of light.

Illustration 4: A light beam of wavelength 4000 Å is directed on a metal whose work function is 2 eV. Calculate the maximum possible kinetic energy of the photoelectrons.

Sol: According to photoelectric equation the maximum kinetic energy of photoelectron after being ejected from metal is $KE = h\nu - \varphi$ Energy of the incident photon $= \frac{hc}{\lambda}$

. Energy of the incident photon in $eV = \frac{19.8 \times 10^{-19}}{4 \times 1.6 \times 10^{-19}} = 3.09\ eV$;

Kinetic energy of the emitted electron K E = hv −ϕ = 3.09 – 2.00 = 1.09 eV

10 Particle Nature of Light- The Photon:

As in case of photoelectric effect, the lights behave as a particle. Hence we may say that *light is consisting of discrete packets of energy called quanta or quantum. Each quantum having definite energy and momentum is called photon.*

Properties:

- A photon travel's with a speed of light i.e $3 \times 10^8 \text{m/sec}$.
- A photon has zero rest mass i.e $m_0 = 0$. It means a photon cannot be in rest, it will move with a speed v as $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$ $\Rightarrow$ $m_0 = m\sqrt{1 - \frac{v^2}{c^2}}$
- If λ is the wavelength of photon or light and c is velocity of light then energy possessed by photon is $E = \frac{hc}{\lambda}$ The energy of photon is measured in ev.
- Photon travel in straight line.
- The velocity of photon is different in different mediums.
- Photons have no any charge so it is neutral.
- Photon may show diffraction under certain conditions.
- It does not deviate in electric and magnetic fields.
- The linear momentum of a photon is $P = mc = \frac{h\nu}{c} = \frac{h}{\lambda}$
- In a photon particle collision both K.E and linear momentum remains conserved.

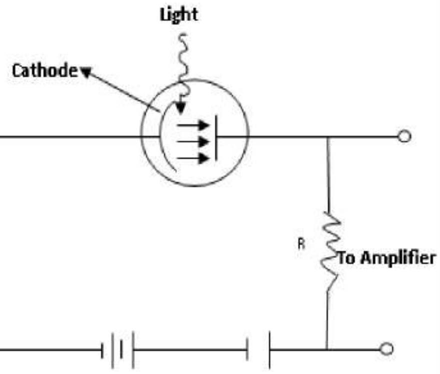
Illustration 5: Determine the momentum of a photon of frequency 10^9 Hz.

Sol: The momentum of photon is $p = \frac{h\nu}{c} = \frac{6.62 \times 10^{-34} \times 10^9}{3 \times 10^8} = 2.2 \times 10^{-33} kg\ m/s$

11 Photo cell or photoelectric cell imp:

A device which converts light energy into electrical energy is called photo cell or photoelectric cell.

It is also known as electric eye. A photo cell works on the phenomenon of photoelectric effect. There are of three types of photo cells:



(i) Photo Emissive Cell:

It is consist of an evacuated glass bulb fitted with a photosensitive metal cathode of cylindrical shape and an anode. When light fall on cathode then electrons emits from it and move toward anode due to high potential difference and constituent electric current.

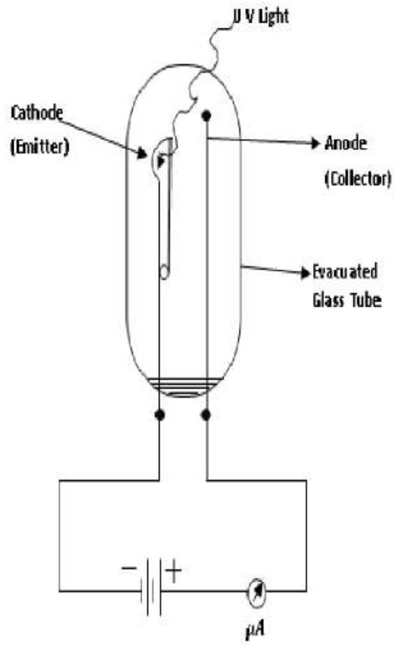
(ii) Photo Conductive Cell:

It is based on the principle that conductivity of a semiconductor increases with increase in the intensity of light. It is made of selenium.

(iii) Photo Voltaic Cell:

It works on the principle that photo electric emission can develop potential difference between suitable substances.

It consists of a glass tube or quartz tube fitted with two electrodes made up of photosensitive materials and is connected with high tension battery and a micro ammeter. When a light is incidental on the cathode then electrons emits from it, which moves toward the anode and constant electric current. As shown in fig.



Application of Photo Cells:

(i) It is used in automatic fire alarm: As in case of fire light falls on cell due to which current flow in circuit connected to a alarm.

(ii) Automatic Burglar Alarm: In this case a photo cell is illuminated with a ultraviolet light (invisible), When a burglar crosses the beam the emission of photo electrons stops and alarm starts ringing.

(iii) **Scanners:** In scanners photo cells are used.

(iv) In cinema it is used reproduction of sounds.

(v) To control the thickness of a paper, a photo cell is used in paper industry.

(vi) To locate a hole in the finished good photo cell may be used.

(vii) In astronomy to analyze the intensities and temperature of style and heavy bodies photo cells may be used.

(viii) It may also be used street lightning, photometry etc.

12 Wave Nature of Particle and De-Broglie Waves [m.imp]:

According to De-Broglie, a moving particle may be supposed to associate with a wave called De Broglie wave or matter waves.

Expression for De Broglie Wave:

As according to Planck's quantum theory, the energy of photon of frequency v can be given

As $E = hv$ ……………………(i)

And from Einstein's mass energy relationship, the energy of photon of light of mass m is given

by $E = mc^2$ ………………..(ii)

From eq. (i) and (ii) we get $hv = mc^2$

Or $\frac{hc}{\lambda} = mc^2$ $\left(\because v = \frac{c}{\lambda}\right)$

Or $\lambda = \frac{h}{mc}$

For a material particle we may write $\lambda = \frac{h}{mv} = \frac{h}{P}$

The above eq. is called De Broglie wave equation for a material particle.

- *The wave length of material particle is inversely proportional to its momentum.*
- *If $v = o$ then $\lambda = \infty$ i.e waves only associated with particle when it is in motion.*
- *These waves are not electromagnetic waves but are matter waves.*
- *This concept is application on only microscopic objects and fails on macroscopic objects.*

13 De Broglie Wavelength of an Electron[m.imp] :

Suppose a potential difference v applied to a beam of electrons moving with kinetic energy is given

by $\frac{1}{2}mv^2 = eV \quad \Rightarrow \quad mv^2 = 2eV$

Or $m^2v^2 = 2eVm$

Or $mv = \sqrt{2meV}$

Now from De Broglie relationship $\lambda = \frac{h}{mv}$ Or $\lambda = \frac{h}{\sqrt{2meV}}$

Here $h = 6.625 \times 10^{-34} J_s$, $m = 9.1 \times 10^{-31} Kg$,$e = 1.6 \times 10^{-19} c$

$$\Rightarrow \quad \lambda = \frac{6.625\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times1.6\times10^{-19}}} = \frac{12.27\times10^{-10}}{\sqrt{V}} m$$

Or $\lambda = \frac{12.27}{\sqrt{V}} A^\circ$

14 De Broglie Wavelength in Term of Temperature:

As we know the average K.E of electron or a particle may be given by $\frac{1}{2}mv^2 = \frac{3}{2}KT$

$$\Rightarrow \quad mv^2 = 3KT$$

Or $m^2v^2 = 3KTm$ Or $mv = \sqrt{3mKT} \ldots\ldots\ldots\ldots\ldots (i)$

Now from De Broglie wave relation $\lambda = \frac{h}{mv}$ Using eq. (i) we get $\lambda = \frac{h}{\sqrt{3mKT}}$

i.e $\lambda \ \alpha \ \frac{1}{\sqrt{T}}$

Thus larger is the temperature smaller will be the De Broglie wavelength.

Illustration 6: A body of 10 gm is moving with velocity 2×10^3 m/s. Determine the value of its associated de-Broglie wavelength.

Sol: The de-Broglie wavelength associated with particle moving with speed v is calculated as

$\lambda = \frac{h}{mv} = \frac{6.62\times10^{-34}}{10\times10^{-3}\times2\times10^{3}} = 3.3 \times 10^{-35}$ m So $\lambda \propto \frac{1}{p}$ or $\lambda \propto \frac{1}{\sqrt{E}}$

Illustration 7: Determine the associated de-Broglie wavelength if the energy of a thermal neutron is 0.02 eV,

Sol: For neutron having kinetic energy K, the associated de-Broglie wavelength is found to be

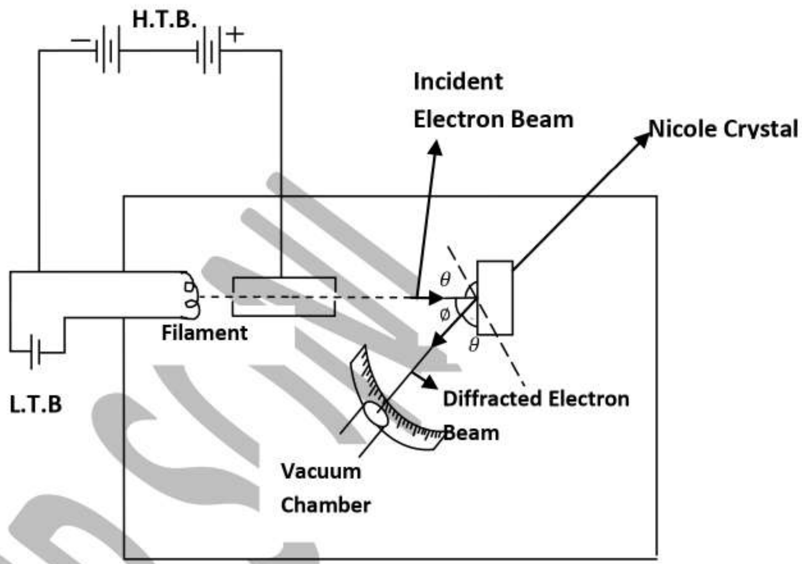
$\lambda = \frac{h}{\sqrt{2mK}} = \frac{6.6\times10^{-34}}{2\times1.6\times10^{-27}\times0.02\times1.6\times10^{-19}} = 2 \times 10^{-10}\, m = 2Å$

15 Davison and Germer Experiment(Experimental Verification of De Broglie Wave) m.imp:

Use: *Davison and Germer Experiment is used to perform the verification of De Broglie concept.*

Construction and Working:

A beam of electron is emitted by electron gun is made to fall on a nickel crystal cut along a particular angle. The scattered beam of electron is received by the detector which can be positioned at any angle by rotating it about the point of incidence. The energy of the incident beam can also be changed by applying a voltage to the electron gun.



Theory:

Davison and Germer found that intensity of scattered beam of electrons was different at different angle of scattering.

The intensity of electron beam is maximum at 50° and 54V potential i.e. $\theta + 50° + \theta = 180°$

Or $2\theta + 50 = 130$ $\Rightarrow$ $2\theta = 130°$ Or $\theta = 65°$

It means when a beam of electron is incident on nickel crystal at a glancing angle $\theta = 65°$, the sharp maximum is obtained at an angle $50°$

Now from Broglie diffraction we get $d sin\theta = \lambda$

Where d is inter -atomic spacing between atoms of nickel i.e. $d = 0.91A°$

$$\Rightarrow \quad d\ \lambda = 0.91 \times sin65° = 1.65A°$$

And from Broglie hypothesis $\lambda = \frac{12.27}{\sqrt{V}} = \frac{2.27}{\sqrt{54}} = 1.67A°$

Since *both the results are close to each other thus Davison and Germer experiment verify the concept of De Broglie is wave particle dualistic.*

Illustration 8: Determine the potential to be applied to accelerate an electron such that its de-Broglie wavelength becomes 0.4 Å.

Sol: The de-Broglie wavelength of an electron in terms of accelerating potential difference is $\lambda = \frac{12.27}{\sqrt{V}}$

Here V is the applied potential on electron to accelerate it. $0.4 == \frac{12.27}{\sqrt{V}}$

Squaring on both the sides we get $0.16 = \frac{(12.27)^2}{V} \Rightarrow V = \frac{12.27 \times 12.27}{16 \times 10^{-2}} \Rightarrow V = 941.0V$

***Example* 5: Find the de Broglie wavelength for an electron beam of kinetic energy 100 eV.**

Solution: Kinetic energy of electrons: $(E)_K = \frac{1}{2}mv^2$

$\Rightarrow$ Velocity of electrons: $v = \sqrt{\frac{2(E)_K}{m}} = \sqrt{\frac{2 \times 100 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}} = 5.9 \times 10^6$ m/s

Momentum: $p = mv = 9.1 \times 10^{-31} \times 5.9 \times 10^6 = 5.37 \times 10^{-24}$ kg m/s

$\Rightarrow$ De Broglie wavelength: $\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{5.37 \times 10^{-24}} = 1.23 \times 10^{-10}$ m = 123 pm

-: **SOME IMPORTANT MCQ:-**

1. The idea of matter waves was given by

(a) Davisson and Germer **(b) de-Broglie•** (c) Einstein (d) Planck

2. Wave is associated with matter

(a) When it is stationary (b) When it is in motion with the velocity of light only

(c) When it is in motion with any velocity• (d) none of the above

3. If the de-Broglie wavelengths for a proton and for a α Particle are equal, then the ratio of their velocities will be

(a) 4 : 1• (b) 2 : 1 (c) 1 : 2 (d) 1 : 4

4. If particles are moving with same velocity, then maximum de-Broglie wavelength will be for

(a) Neutron (b) Proton **(c) β-particle•** (d) α-particle

5. The kinetic energy of an electron with de-Broglie wavelength of 0.3 nanometer is

(a) 0.168 eV **(b) 16.8 eV•** (c) 1.68 eV (d) 2.5 eV

6. Davisson and Germer experiment proved

(a) Wave nature of light (b) Particle nature of light (c) Both (a) and (b) **(d) • Neither (a) nor (b)**

7. The wavelength of the matter wave is independent of

(a) Mass (b) Velocity (c) Momentum **(d) Charge•**

8. The energy of a photon of wavelength λ is given by

(a) λh (b) λch (c) λ / hc **(d) hc / λ •**

9. The momentum of a photon of energy hν will be

(a) $h\nu$ **(b) hν / c•** (c) c h ν (d) h/ ν

10. The momentum of the photon of wavelength 5000Å will be

(a) 1.3×10^{-27}kgm/sec• (b) 1.3×10^{-28}kgm/sec (c) 4×10^{29}kgm/sec (d) 4×10^{-18}kgm/sec

11. Einstein got Nobel Prize on which of the following works

(a) Mass-energy relation (b) Special theory of relativity **(c) Photoelectric equation •** (d) (a) and (b) both

12. When light falls on a metal surface, the maximum kinetic energy of the emitted photo-electrons depends upon

(a) The time for which light falls on the metal **(b) Frequency of the incident light•**

(c) Intensity of the incident light (d) Velocity of the incident light

13. Electron are emitted in the photoelectric effect from a metal surface

(a) Only if the frequency of the incident radiation is above a certain threshold value•

(b) Only if the temperature of the surface is high

(c) At a rate that is independent of the nature of the metal

(d) With a maximum velocity proportional to the frequency of the incident radiation

14. The number of photo-electrons emitted per second from a metal surface increases when

(a) The energy of incident photons increases (b) The frequency of incident light increases

(c) The wavelength of the incident light increases **(d) the intensity of the incident light increases•**

15. Photoelectric effect was successfully explained first by

(a) Planck (b) Hallwash (c) Hertz **(d) Einstein•**

16. The minimum energy required to remove an electron is called

(a) Stopping potential (b) Kinetic energy **(c) Work function•** (d) None of these

17. as the intensity of incident light increases

(a) Photoelectric current increases• (b) Photoelectric current decreases

(c) Kinetic energy of emitted photoelectrons increases (d) Kinetic energy of emitted photoelectrons decreases

18. Which of the following is dependent on the intensity of incident radiation in a photoelectric experiment?

(a) Work function of the surface **(b) Amount of photoelectric current •**

(c) Stopping potential will be reduced (d) Maximum kinetic energy of photoelectrons

19. In photoelectric effect if the intensity of light is doubled then maximum kinetic energy of photoelectrons will become

(a) Double (b) Half (c) Four time **(d) No change•**

20. When wavelength of incident photon is decreased then

(a) Velocity of emitted photo-electron decreases **(b) Velocity of emitted photoelectron increases•**

(c) Velocity of photoelectron do not charge (d) Photo electric current increases

21. Quantum nature of light is explained by which of the following phenomenon

(a) Huygens wave theory **(b) Photoelectric effect •**

(c) Maxwell electromagnetic theory (d) de-Broglie theory

22. Which of the following shown particle nature of light

(a) Refraction (b) Interference (c) Polarization **(d) Photoelectric effect•**

23. Photo-electric effect can be explained by

(a) Corpuscular theory of light (b) Wave nature of light (c) Bohr's theory **(d) Quantum theory of light•**

24. in photoelectric effect, the K.E. of electrons emitted from the metal surface depends upon

(a) Intensity of light **(b) Frequency of incident light •**

(c) Velocity of incident light (d) both intensity and velocity of light

25. X-rays are in nature similar to

(a) Beta rays **(b) Gamma rays•** (c) de-Broglie waves (d) Cathode rays

26. Planck constant has the same dimensions as

(a) Force × time (b) force × distance (c) force × speed **(d) force × distance × time•**

27. Two photons having

(a) Equal wavelengths have equal linear momenta (b) equal energies have equal linear momenta

(c) Equal frequencies have equal linear momenta **(d) equal linear momenta have equal wavelengths.•**

28. Let p and E denote the linear momentum and energy of a photon. If the wavelength is decreased,

(a) Both p and E increase• (b) p increases and E decreases

(c) p decreases and E increases (d) both p and E decrease.

29. The equation E = pc is valid

(a) For an electron as well as for a photon (b) for an electron but not for a photon

(c) For a photon but not for an electron• (d) neither for an electron nor for a photon.

30. If the frequency of light in a photoelectric experiment is doubled, the stopping potential will

(a) Be doubled (b) be halved **(c) become more than double•** (d) become less than double.

31. The frequency and intensity of a light source are both doubled. Consider the following statements.

(A) The saturation photocurrent remains almost the same.

(B) The maximum kinetic energy of the photoelectrons is doubled.•

(a) Both A and B are true. (b) A is true but B is false.

(c) A is false but B is true. (d) Both A and B are false.

32. A point source of light is used in a photoelectric effect. If the source is removed farther from the emitting metal, the stopping potential

(a) Will increase (b) will decrease **(c) will remain constant•** (d) will either increase or decrease.

33. When the intensity of a light source is increased, (more than one corrects)

(a) The number of photons emitted by the source in unit time increases•

(b) The total energy of the photons emitted per unit time increases•

(c) More energetic photons are emitted (d) Faster photons are emitted.

34. Photoelectric effect supports quantum nature of light because

(a) There is a minimum frequency below which no photoelectrons are emitted•

(b) The maximum kinetic energy of photoelectrons depends only on the frequency of light and not on its intensity•

(c) Even when the metal surface is faintly illuminated the photoelectrons leave the surface immediately•

(d) Electric charge of the photoelectrons is quantized.

35. If the wavelength of light in an experiment on photoelectric effect is doubled,

(a) The photoelectric emission will not take place

(b) The photoelectric emission may or may not take place•

(c) The stopping potential will increase

(d) The stopping potential will decrease.•