SECOND MID-TERM TEST

Std. : 12 **PHYSICS**

Marks : 35 Time : 1.30 Hrs

I. Choose the Correct Answer: 10x1=10

1. In a Young's double-slit experiment, the slit separation is doubled. To maintain the same fringe spacing on the screen, the screen-to-slit distance D must be changed to,

(a) 2D (b) $\frac{D}{2}$ (c) $\sqrt{2D}$ (d) $\frac{D}{\sqrt{2}}$

2. Two coherent monochromatic light beams of intensities I and 4I are superposed. The maximum and minimum possible intensities in the resulting beam are.

(a) 5I and I (b) 5I and 3I (c) 9I and I (d) 9I and 3I

3. First diffraction minimum due to a single slit of width 1.0×10^{-5} cm is at 30^o. Then wavelength of light used is,

(a) 400 Å (b) 500 Å (c) 600 Å (d) 700 Å

4. The transverse nature of light is shown in,

(a) interference (b) diffraction (c) scattering (d) polarization

5. If a beam of un-polarized light is incident on a reflecting glass surface at an angle of 57.5^0, then the angle between the reflected and refracted beam will be :

(a) 45^0 (b) 60^0 (c) 90^0 (d) 30^0

6. The wavelength λ_e of an electron and λ_p of a photon of same energy E are related by

(a) $\lambda_p \propto \lambda_e$ (b) $\lambda_p \propto \sqrt{\lambda_e}$ (c)) $\lambda_p \propto \frac{1}{\sqrt{\lambda_e}}$ (d) $\lambda_p \propto \lambda_e^2$

7. The wave associated with a moving particle of mass 3×10^{-6} g has the same wavelength as an electron moving with a velocity 6×10^6 ms^{-1}. The velocity of the particle is

(a) $1\ 82 \times 10^{-18}$ ms^{-1} (b) 9×10^{-2} ms^{-1}

(c) 3×10^{-31} ms^{-1} (d) $1.\ 82 \times 10^{-15}$ ms^{-1}

8. Two radiations with photon energies 0.9 eV and 3.3 eV respectively are falling on a metallic surface successively. If the work function of the metal is 0.6 eV, then the ratio of maximum speeds of emitted electrons in the two cases will be

(a) 1:4 (b) 1:3 (c) 1:1 (d)1:9

9. The threshold wavelength for a metal surface whose photoelectric work function is 3.313 eV is
   (a) 4125Å (b) 3750Å (c) 6000Å (d) 2062.5Å
10. The cutoff wavelength of the X-ray tube with accelerating potential 20,000 V is
   (a) 6.24 Å (b) 6200 Å (c) 0.062 Å (d) 0.62 Å

II. Answer any 3 questions. Question No. 15 is compulsory. 3x2=6

11. State Huygens' Principle.
12. What is myopia? What is its remedy?
13. Define work function of a metal. Give its unit.
14. What is a photo cell? Mention the different types of photocells.
15. Tow light sources of equal amplitudes interfere with each other. Calculate the ratio of maximum and minimum intensities.

III. Answer any 3 questions. Question No. 20 is compulsory. 3x3=9

16. What is Fresnel's distance? Obtain the equation for Fresnel's distance.
17. State and prove Brewster's law.
18. Derive an expression for de Broglie wavelength of electron.
19. List out the laws of photoelectric effect.
20. Calculate the momentum and de Broglie wave length of an
   (i) An electron with Kinetic energy 2 eV
   (ii) A bullet of 50 g fired from riffle with a speed of 200 m/s

IV. Answer the following questions: 2x5=10

21. (a) Obtain the equation for band width in Young's double slit experiment

(OR)

   (b) Explain about compound microscope and obtain the equation for magnification.

22. (a) Describe briefly Davisson – Germer experiment which demonstrated the wave nature of electrons.

(OR)

   (b) Obtain Einstein's photoelectric equation with necessary explanation.

SECOND MID-TERM TEST 2024

Std. : 12 **PHYSICS**

ANSWER KEY

I. Choose the Correct Answer: 10x1=10

1. (a) 2D
2. (c) 9I and I
3. (b) 500 Å
4. (d) polarization
5. (c) 90^0
6. (d) $\lambda_p \propto \lambda_e^2$
7. (d) 1. 82 x 10^{-15} ms^{-1}
8. (b) 1:3
9. (b) 3750Å
10. (d) 0.62 Å

II. Answer any 3 questions. Question No. 15 is compulsory. 3x2=6

11. **Huygens's principle:**

Each point of the wave front is the source of secondary wavelets which **spreading out in all directions with speed of the wave**. The envelope to all this wavelet gives the position and shape of the new wave front at a later time.

12. **Myopia:**

A person suffering from **myopia or near-sightedness cannot see distant objects clearly**. It occurs when the eye lens has too short focal length due to thickening of the lens or larger diameter of the eyeball than usual.

Remedy: Using **concave lens this defect can be rectified.**

13. **Work function of a metal and its unit.**

The **minimum energy needed for an electron to escape** from the metal surface is called work function of that metal. It is denoted by ϕ_0. Its unit is **electron volt (eV).**

14. **Photo cell:**

The device which **converts light energy into electrical energy** is called photo electric cell or simply photo cell.
It works on the principle of photo electric cell
Photo cells are classified in to three types.
(1) Photo emissive cell (2) Photo voltaic cell (3) Photo conductive cell

15. Let the amplitude be a, The intensity is, $I \propto 4a^2 \cos^2\left(\frac{\phi}{2}\right)$ (or)

$I = 4 I_0 \cos^2\left(\frac{\phi}{2}\right)$

Resultant intensity is maximum when, $\phi = 0$, $\cos 0 = 1$, $I_{max} \propto 4a^2$

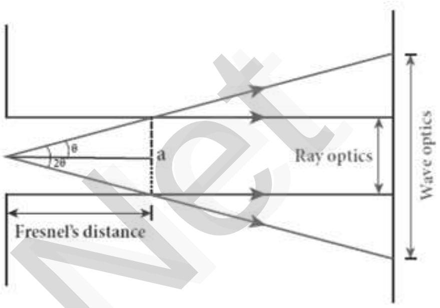
Resultant amplitude is minimum when, $\phi = \pi$, $\cos\left(\frac{\pi}{2}\right) = 0$, $I_{min} = 0$

$\mathbf{I_{max} : I_{min} = 4a^2 : 0}$

III. Answer any 3 questions. Question No. 20 is compulsory. 3x3=9

16. **Fresnel's distance:**

Fresnel's distance is the distance upto which ray optics is obeyed and beyond which ray optics is not obeyed but, wave optics becomes significant.



Let Fresnel distance = Z. From the diffraction equation for first minimum,

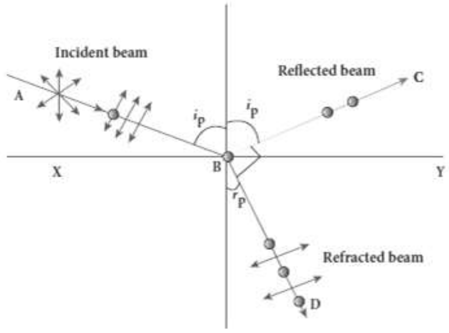
$\sin\theta = \frac{\lambda}{a}$ (or) $\theta = \frac{\lambda}{a}$

From the definition of Fresnel's distance, $\sin 2\theta = \frac{a}{z}$ (or) $2\theta = \frac{a}{z}$

Equating the above two equation, $2\frac{\lambda}{a} = \frac{a}{z}$; $Z = \frac{a^2}{2\lambda}$

17. **Brewster's law:**

The angle of incidence at which a beam of un-polarized light falling on a transparent surface is reflected as a beam of plane polarized light is called **polarizing angle or Brewster's angle** (i_P). Sir David Brewster found that, at polarizing angle, the reflected and transmitted rays are perpendicular to each other. Let, incident polarizing angle = i_P



Angle of refraction = r

From the figure,

$i_p + 90^0 + r_p = 180^0$; $r_P = 90^0 - i_p$ - - - -(1)

From Snell's law $\frac{\sin i_p}{\sin r_p} = n$; $\frac{\sin i_p}{\sin(90^0 - i_p)} = n$

$\frac{\sin i_p}{\cos i_p} = n$; $\mathbf{\tan i_p = n}$

This relation is known as Brewster's law. This law states that, **the tangent of the polarizing angle for a transparent medium is equal to its refractive index.**

18. **De Broglie wavelength of electrons:**

An electron of mass m is accelerated through a potential difference of V volt. The kinetic energy acquired by the electron is given by $\frac{1}{2}mv^2 = ev$

Hence the speed of the electron is , $v^2 = \frac{2\,e\,V}{m}$; $v = \sqrt{\frac{2\,e\,V}{m}}$ ....(1)

The de Broglie wavelength of electron is $\lambda = \frac{h}{mv} = \frac{h}{m\sqrt{\frac{2\,e\,V}{m}}}$

$\lambda = \frac{h}{\sqrt{2\,m\,e\,V}}$ ....(2)

Where, h = 6.626 x 10^{-34} Js. **e = 1.6 x 10^{-19} C. m = 9.11 x 10^{-31} kg**

$\therefore\ \lambda = \frac{12.27 \times 10^{-10}}{\sqrt{V}} = \frac{12.27}{\sqrt{V}}$ Å

19. **Laws of photo electric effect:**

1. For a given frequency of incident light, the number of photoelectrons emitted is **directly proportional to the intensity of the incident light**. The saturation current is also directly proportional to the intensity of incident light.
2. **Maximum kinetic energy of the photo electrons is independent of intensity of the incident light.**
3. **Maximum kinetic energy** of the photo electrons from a given metal is **directly proportional to the frequency of incident light.** For a given surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than a certain minimum frequency called the threshold frequency.
4. **There is no time lag between incidence of light and ejection of photoelectrons.**

20. i) Momentum of the electron is

p = $\sqrt{2mK} = \sqrt{2 \times 9.1 \times 10^{-31} \times 2 \times 1.6 \times 10^{-19}}$; $\sqrt{58.24 \times 10^{-50}}$

p = 7.63 x 10^{-25} kg ms^{-1}

Its de Broglie wavelength is $= \frac{h}{p} = \frac{6.634 \times 10^{-34}}{7.63 \times 10^{-25}}$; = 0.868 x 10^{-9} m

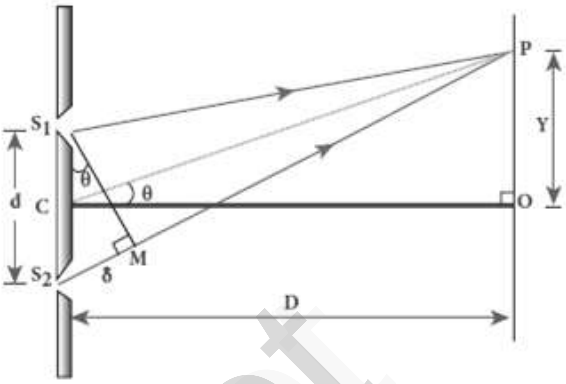
$\lambda = 8.68$ Å

ii) Momentum of the bullet is p = mv = 0.050 x 200 = 10 $kgms^{-1}$

Its de Broglie wavelength is $\lambda = \frac{h}{p} = \frac{6.634 \times 10^{-34}}{10}$; = 6.626 x 10^{-33} m

IV. Answer the following questions: 2x5=10

21. (a) **Path difference (δ) :**



Let distance between S_1 and S_2 $=d$,
Distance of the screen from double slit = D,
Wavelength of coherent light wave = λ

Hence path difference between the light waves from S_1 and S_2 to the point 'P' is

$\delta = S_2P - S_1P = s_2P - MP = S_2M$

From the figure,

$\angle OCP = \angle S_2S_1M = \theta$

In ΔS_2S_1M , $\text{Sin}\,\theta = \frac{S_2M}{S_1S_2} = \frac{\delta}{d}$;

$\therefore \delta = \text{Sin}\,\theta . d$

Here θ is small. Hence, $\text{Sin}\,\theta \approx \tan\theta \approx \theta$

$\delta = \theta . d$ .... (1)

Also. in ΔOCP, $\theta \approx \tan\theta = \frac{OP}{OC} = \frac{y}{D}$

Put this in equation (1) $\delta = \frac{y}{D} d$ ------------- (2)

Point 'P' may be appear either bright or dark depending on the path difference.

Condition for bright fringe (maxima):

For constructive interference, the path difference will be,

$\delta = n\lambda \quad [n = 0, 1, 2, \ldots]$

$\frac{y}{D} d = n\lambda$

Thus the distance of the n^{th} bright fringe from "O" is

$y_n = \frac{D}{d} n\lambda$ -------------- (3)

Condition for dark fringe (minima):

For destructive interference, the path difference will be,

$\delta = (2n-1)\frac{\lambda}{2} \quad [n = 1, 2, \ldots]$

$\frac{y}{D} d = (2n-1)\frac{\lambda}{2}$

Thus the distance of the n^{th} dark fringe from "O" is $y_n = \frac{D}{d}(2n-1)\frac{\lambda}{2}$ ------ (4)

Band width (β) :

The band width is defined as **the distance between any two consecutive bright or dark fringes.** The distance between $(n+1)^{th}$ and nth consecutive bright fringes from 'O' is $\beta = y_{n+1} - y_n$

$$\beta = \frac{D}{d}(n+1)\lambda - \frac{D}{d}n\lambda \ ; \beta = \frac{D}{d}\lambda \text{ ---------- (5)}$$

Similarly the distance between $(n+1)^{th}$ and n^{th} Consecutive dark fringes from 'O' is $\beta = y_{n+1} - y_n$

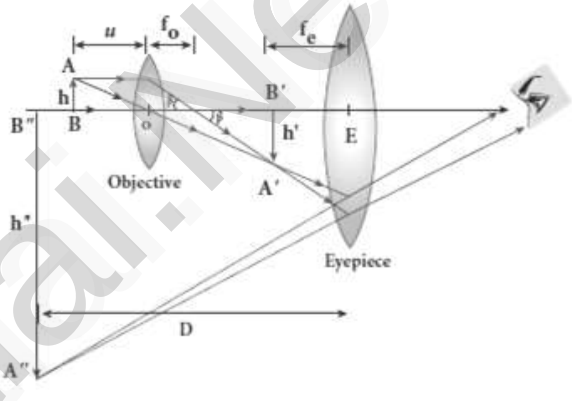
$$\beta = \frac{D}{d}[2(n+1)-1]\frac{\lambda}{2} - \frac{D}{d}(2n-1)\frac{\lambda}{2}$$

$$\boldsymbol{\beta = \frac{D}{d}\lambda} \text{ ---------- (6)}$$

Equation (5) and (6) shows that the bright and dark fringes are of same width equally spaced on either side of central bright fringe.

(OR)

(b) **Compound microscope:**



The lens near the object is called the objective, forms a real, inverted, magnified image of the object. This serves as the object for the second lens which is the eyepiece. Eye piece serves as a simple microscope that produces finally an enlarged and virtual image.

The first inverted image formed by the objective is to be adjusted close to, but within the focal plane of the eyepiece, so that the final image is formed nearly at infinity or at the near point.

The final image is inverted with respect to the original object.

Magnification (m) :

From the ray diagram, the linear magnification due to the objective is,

$$m_0 = \frac{h'}{h} = \frac{L}{f_0} \text{ .... (1)}$$

Here 'L' is the distance between the first focal point of the eye piece to the second focal point of the objective. This is called the tube length.

The magnification of the eyepiece, $m_e = 1 + \frac{D}{f_e}$ .... (2)

The total magnification 'm' in near point focusing,

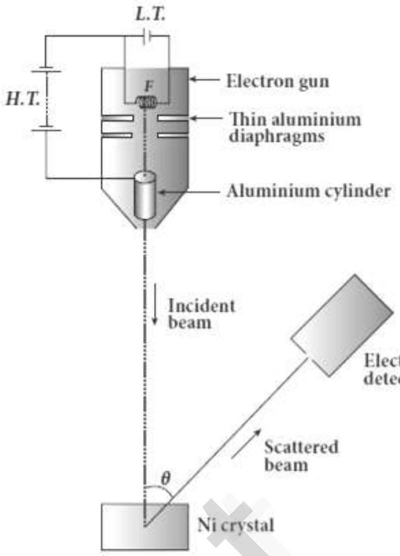
$$m = m_0 m_e = \left[\frac{L}{f_0}\right]\left[1 + \frac{D}{f_e}\right]$$

If the final image is formed at infinity (normal focusing), the magnification if eye piece is, $m_e = \frac{D}{f_e}$ .... (3)

The total magnification 'm' in normal focusing is,

$$m = m_0 m_e = \left[\frac{L}{f_0}\right]\left[\frac{D}{f_e}\right]$$

22. (a) **Davisson - Germer experiment:**



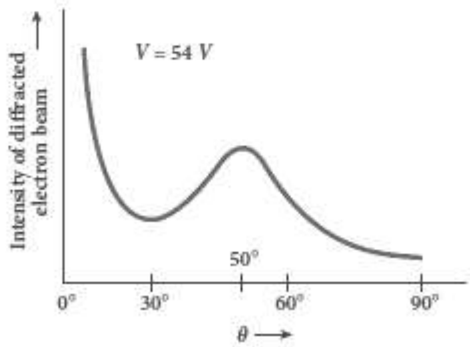
De Broglie hypothesis of matter waves was experimentally confirmed by Clinton Davisson and Lester **Germer in 1927**. They demonstrated that **electron beams are diffracted when they fall on crystalline solids**. Since crystal can act as a three-dimensional diffraction grating for matter waves, the electron waves incident on crystals are diffracted off in certain specific directions.

The **filament F is heated by a low tension (L.T)** battery so that electrons are emitted from the **hot filament by thermionic emission**. They are then accelerated due to the potential difference between the filament and the anode aluminium cylinder by a high tension (H.T.) battery.

Electron beam is collimated by using two thin aluminium diaphragms and is allowed to strike a single crystal of Nickel. The electrons scattered by **Ni atoms in different directions are received by the electron detector which measures the intensity of scattered electron beam.**

The detector is rotatable in the plane of the paper so that the angle θ between the incident beam and the scattered beam can be changed at our will. **The intensity of the scattered electron beam is measured as a function of the angle θ.**

The graph shows the variation of intensity of the scattered electrons with the angle θ for the **accelerating voltage of 54V.** For a given accelerating voltage V, the scattered wave shows a peak or **maximum at an angle of 50°** to the incident electron beam. This peak in intensity is attributed to the constructive interference of electrons diffracted from various atomic layers of the target material.



From the known value of inter planar spacing of Nickel, the wavelength of the electron wave has been experimentally calculated as **1.65Å. The wavelength can also be calculated from de Broglie relation for V = 54 V as** $\lambda = \frac{12.27}{\sqrt{V}}Å = \frac{12.27}{\sqrt{54}}Å$

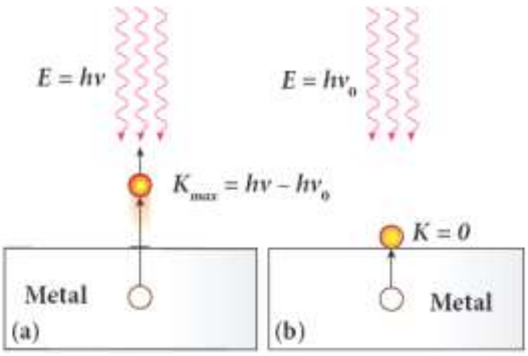
λ = 1.67 Å

This **value agrees well with the experimentally observed wavelength of 1.65Å.** Thus this experiment directly verifies de Broglie's hypothesis of the wave nature of moving particles.

(OR)

(b) **Einstein's explanation of photoelectric equation:**

When a photon of energy 'hv' is incident on a metal surface, it is completely absorbed by a single electron and the electron is ejected.



In this process, the energy of incident photon is utilized in two ways.

(1) Part of the photon energy is used for the ejection of the electrons from the metal surface and it is called work function (ϕ_0)

(2) Remaining energy as the kinetic energy (K) of the ejected electron.

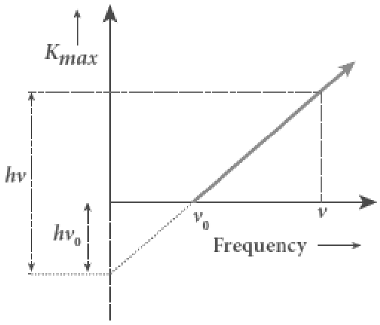
From the **law of conservation of energy**, $hv = \phi_0 + K$ (or)

$$hv = \phi_0 + \frac{1}{2}mv^2 \text{ .... (1)}$$

Where m → mass of the electron and v → velocity

At threshold frequency, the kinetic energy of ejected electrons will be zero. (i.e.) when $v = v_0$ then K = 0 Thus equation (1) becomes

$hv_0 = \phi_0$ ....(2)



Put equation (2) in (1) $hv = hv_0 + \frac{1}{2}mv^2$........... (3)

The equation (3) is known as **Einstein's photoelectric equation.**

If the electron does not lose energy by internal collisions, then it is emitted with maximum kinetic energy K_{max}. Then $hv = hv_0 + \left[\frac{1}{2}mv^2\right]_{max}$

(or) $\frac{1}{2}mv_{max}^2 = hv - hv_0$ (or) $K_{max} = hv - \phi_0$.................... (4)

A graph between maximum kinetic energy K_{max} of the photoelectron and frequency v of the incident light is a straight line.