12th STD.

PUBLIC EXAM - MAY - 2022

Part III - PHYSICS

(With Answers)

Time Allowed : 3.00 Hours] [Maximum Marks : 70

Instructions : (1) Check the question paper for fairness of printing. If there is any lack of fairness, inform the Hall Supervisor immediately.

(2) Use **Blue** or **Black** ink to write and underline and pencil to draw diagrams.

PART - I

Note : (i) Answer **all** the questions.

(ii) Choose the most appropriate answer from the given **four** alternatives and write the option code and the corresponding answer. **(15 × 1 = 15)**

1. Which one of the following is the natural nanomaterial?
   (a) Grain of sand (b) Peacock feather
   (c) Skin of the whale (d) Peacock beak

2. In an electron microscope, the electrons are accelerated by a voltage of 14 kV. If the voltage is changed to 224 kV, then the de-Broglie wavelength associated with the electrons would:
   (a) decrease by 4 times
   (b) increase by 2 times
   (c) increase by 4 times
   (d) decrease by 2 times

3. The variation of frequency of carrier wave with respect to the instantaneous amplitude of the modulating signal is called:
   (a) Phase modulation
   (b) Amplitude modulation
   (c) Pulse width modulation
   (d) Frequency modulation

4. Q factor is equal to ______.
   (a) $\frac{\omega_r L}{R}$ (b) $\frac{1}{R}\sqrt{\frac{L}{C}}$
   (c) $\frac{X_L}{R}$ (d) All the above

5. Two metallic spheres of radii 1 cm and 3 cm are given charges of -1×10^{-2} C and 5×10^{-2}C respectively. If these are connected by a conducting wire, the final charge on the bigger sphere is:
   (a) 1×10^{-2} C (b) 3×10^{-2} C
   (c) 2×10^{-2} C (d) 4×10^{-2} C

6. Which of the following is an electromagnetic wave?
   (a) β - rays (b) γ- rays
   (c) α- rays (d) All of the above

7. An air bubble in glass slab of refractive index 1.5 (near normal incidence) is 5 cm deep when viewed from one surface and 3 cm deep when viewed from the opposite face. The thickness of the slab is:
   (a) 12 cm (b) 8 cm
   (c) 16 cm (d) 10 cm

8. In India electricity is supplied for domestic use at 220 V. It is supplied at 110 V in USA. If the resistance of a 60W bulb for use in India is R, the resistance of a 60W bulb for use in USA will be :
   (a) R / 4 (b) R
   (c) R / 2 (d) 2 R

9. A wire of length l carrying a current I along the Y direction is kept in a magnetic field given by $\vec{B} = \frac{\beta}{\sqrt{3}}\left(\hat{i}+\hat{j}+\hat{k}\right)$T. The magnitude of Lorentz force acting on the wire is :
   (a) $\sqrt{2}\beta I l$ (b) $\sqrt{\frac{2}{3}}\beta I l$
   (c) $\sqrt{\frac{1}{2}}\beta I l$ (d) $\sqrt{\frac{1}{3}}\beta I l$

10. Emission of electrons by the absorption of heat energy is called _____ emission.
(a) Thermionic (b) Photoelectric
(c) Secondary (d) Field

11. If a current of 7.5 A is maintained in a wire for 45 seconds then the charge flowing through the wire is:
(a) 6 C (b) 365.5 C
(c) 3 C (d) 337.5 C

12. The charge of cathode ray is :
(a) neutral (b) positive
(c) not defined (d) negative

13. A step-down transformer reduces the supply voltage from 220 V to 11 V and increases the current from 6 A to 100 A. Then its efficiency is:
(a) 0.12 (b) 1.2
(c) 0.9 (d) 0.83

14. The electric potential of an electron is given by $V = V_0 \ln\left(\frac{r}{r_0}\right)$, where r_0 is a constant. If Bohr atom model is valid, then variation of radius of n^{th} orbit r_n with the principal quantum number n is :
(a) $r_n \propto \frac{1}{n^2}$ (b) $r_n \propto \frac{1}{n}$
(c) $r_n \propto n^2$ (d) $r_n \propto n$

15. Transverse nature of light is shown in :
(a) scattering (b) interference
(c) polarisation (d) diffraction

PART - II

Note: Answer **any six** questions. Question number **24** is **compulsory.** **(6 × 2 = 12)**

16. What is corona discharge?
17. How will you increase the current sensitivity of a galvanometer?
18. Define work function of a metal. Mention its unit.
19. Calculate the radius of $^{197}_{79}Au$ nucleus.
20. State Fleming's right hand rule.
21. What do you mean by Doping?
22. What is displacement current?
23. Define electrical resistivity.
24. The angle of minimum deviation for the equilateral prism is 40°. Find the refractive index of the material of the prism.

PART - III

Note: Answer **any six** questions. Question number **33** is **compulsory.** **(6 × 3 = 18)**

25. Derive the relation between f and R for a spherical mirror.
26. Obtain a relation between current and drift velocity.
27. List out the laws of photo electric effect.
28. Draw the circuit diagram of NPN transistor in Common Emitter Configuration.
29. Give the uses of Polaroids.
30. Derive the expression for resultant capacitance, when capacitors are connected in series.
31. Find the :
(i) Angular momentum
(ii) Velocity of the electron revolving in the 5th orbit of hydrogen atom. ($h = 6.6 \times 10^{-34}$ Js; $m = 9.1 \times 10^{-31}$ kg)
32. List out salient features of magnetic Lorentz force.
33. Find the impedance of a series RLC circuit, if the inductive reactance, capacitive reactance and resistance are 184 Ω, 144 Ω and 30 Ω respectively. Also calculate the phase angle between voltage and current.

PART - IV

Note: Answer **all** the questions **(5 × 5 = 25)**

34. (a) Explain the construction and working of full wave rectifier.
OR
(b) Explain the construction and working of transformer.

35. (a) Derive an expression for electrostatic potential due to an electric dipole.
OR
(b) Obtain the equation for bandwidth in Young's Double Slit Experiment.

36. (a) Using Biot-Savart Law deduce the relation for the magnetic field at a point due to an infinitely long straight conductor carrying current.

OR

(b) Discuss the spectral series of hydrogen atom.

37. (a) (i) How do we obtain characteristic X-ray spectra?

(ii) Calculate the cut-off wavelength and cut-off frequency of X-rays from an X-ray tube of accelerating potential 20,000 V.

OR

(b) What is spectrum? Explain the types of emission spectrum.

38. (a) Obtain Lens maker's formula.

OR

(b) Explain the determination of the internal resistance of cell using voltmeter.

★ ★ ★

ANSWERS

Part - I

1. (b) Peacock feather
2. (a) decrease by 4 times
3. (d) Frequency modulation
4. (d) All the above
5. (b) 3×10^{-2} C
6. (b) γ- rays
7. (a) 12 cm
8. (a) R / 4
9. (b) $\sqrt{\frac{2}{3}}\beta I l$
10. (a) Thermionic
11. (d) 337.5 C
12. (d) negative
13. (d) 0.83
14. (d) $r_n \propto n$
15. (c) polarisation

Part - II

16. (i) The electric field near the edge is very high and it ionizes the surrounding air.

(ii) The positive ions are repelled at the sharp edge and negative ions are attracted towards the sharper edge.

(iii) This reduces the total charge of the conductor near the sharp edge. This is called action of points or corona discharge.

17. The current sensitivity of a galvanometer can be increased by

(i) increasing the number of turns, N

(ii) increasing the magnetic induction, B

(iii) increasing the area of the coil, A

(iv) decreasing the couple per unit twist of the suspension wire, K.

18. (i) The minimum energy needed for an electron to escape from the metal surface is called work function of that metal.

(ii) It is denoted by ϕ_0 and is measured in electron volt (eV).

19. ***Solution :***

Radius of the nucleus $R = R_0 A^{\frac{1}{3}}$

$$R = 1.2 \times 10^{-15} \times (197)^{\frac{1}{3}} = 6.97 \times 10^{-15} \text{ m}$$

$$R = 1.2 \times 5.819 \times 10^{-15}$$

$$R = 6.98 \times 10^{-15} \text{ m.}$$

20. Fleming's right hand rule states that if the index finger points the direction of the magnetic field and the thumb indicates the direction of motion of the conductor, then the middle finger will indicate the direction of the induced current.

21. (i) The Process of adding impurities to the intrinsic semiconductor is called doping.

(ii) The impurity atoms are called dopants in 100 ppm

22. The displacement current can be defined as the current which comes into play in the region in which the electric field in changing with time.

23. Electrical resistivity of a material is defined as the resistance offered to current flow by a conductor of unit length having unit area of cross section.

$\rho = \frac{RA}{L}$. Unit : ohm-metre (Ω m)

24. **Solution:**

Given, A = 60° ; D = 40°

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Substituting the values,

$$n = \frac{\sin\left(\frac{60^\circ+40^\circ}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)} = \frac{\sin(50^\circ)}{\sin(30^\circ)}$$

$$= \frac{0.766}{0.50}$$

$$= 1.532$$

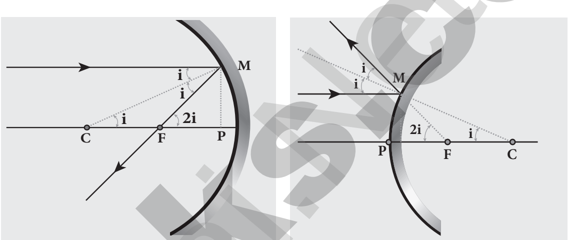
$$\mu = 1.53$$

Part - III

25. (i) C - centre of curvature of the mirror.

F - principal focus

(ii) A parallel ray of light is incident at M and after reflection passes through F angle an incidence i will be same to the angle of reflection.



(a) Concave mirror (b) Convex Mirror

(iii) MP perpendicular from M

(iv) $\angle MCP = i$ and $\angle MFP = 2i$

(v) From ΔMCP and ΔMFP,

$$\tan i = \frac{PM}{PC} \text{ and } \tan 2i = \frac{PM}{PF}$$

(vi) Angles are small,

$$\therefore \tan i \approx i \text{ and } \tan 2i \approx 2i$$

$$i = \frac{PM}{PC} \text{ and } 2i = \frac{PM}{PF}$$

(vii) $2\frac{PM}{PC} = \frac{PM}{PF}$; 2PF = PC.

PF - focal length 'f'

PC - Radius of curvature R.

$$\therefore \boxed{2f = R} \text{ or } \boxed{f = \frac{R}{2}}$$

26. The drift velocity of the electrons = v_d

If the electrons move through a distance dx within a small interval of dt, then

$$v_d = \frac{dx}{dt}; \quad dx = v_d\, dt \qquad ...(1)$$

Since A is the area of cross section of the conductor, the electrons available in the volume of length dx is = volume × number of electrons per unit volume

$$= A dx \times n \qquad ...(2)$$

Substituting for dx from equation (1) in (2)

$$= (A\, v_d\, dt)\, n$$

Total charge in the volume element dQ = (charge) × (number of electrons in the volume element)

$$dQ = (e)(A\, v_d\, dt)\, n$$

Hence the current $I = \frac{dQ}{dt}$

$$I = ne A\, v_d \qquad ...(3)$$

27. (i) For a given metallic 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**.

(ii) 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.

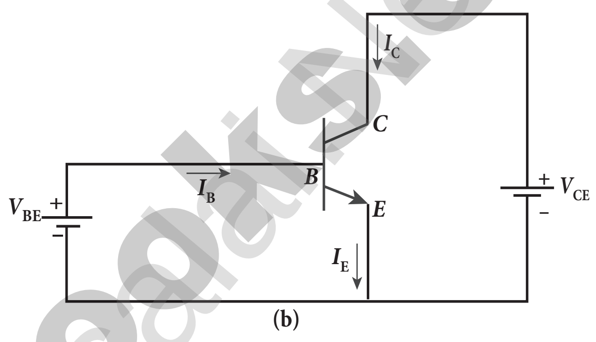
(iii) Maximum kinetic energy of the photo electrons is independent of intensity of the incident light.

(iv) Maximum kinetic energy of the photo electrons from a given metal is directly proportional to the frequency of incident light.

(v) For a given metallic 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**.

(vi) There is no time lag between incidence of light and ejection of photoelectrons.

28.



NPN transistor in common emitter configuration

29. (i) Polaroids are used in goggles and cameras to avoid glare of light.

(ii) Polaroids are used to take 3D pictures i.e., holography.

(iii) Polaroids are used to improve contrast in old oil paintings.

(iv) Polaroids are used in optical stress analysis.

(v) Polaroids are used as window glasses to control the intensity of incoming light.

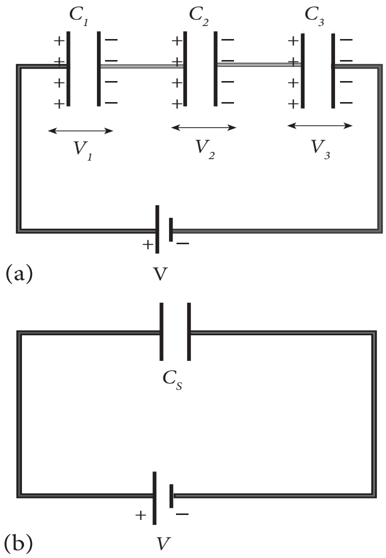
(vi) Polarised laser beam acts as needle to read/write in compact discs (CDs).

(vii) Polarised light is used in liquid crystal display (LCD).

30. **Capacitors in series :**

(i) Consider three capacitors of capacitance C_1, C_2 and C_3 connected in series with a battery of voltage V as shown in the Figure.

(ii) As soon as the battery is connected to the capacitors in series, the electrons of charge



(a) Capacitors connected in series
(b) Equivalent capacitors C_s

(iii) –Q are transferred from negative terminal to the right plate of C_3 which pushes the electrons of same amount –Q from left plate of C_3 to the right plate of C_2 due to electrostatic induction. At the same time, electrons of charge –Q are transferred from left plate of C_1 to positive terminal of the battery.

(iv) The capacitances of the capacitors are in general different, so that the voltage across each capacitor is also different and are denoted as V_1, V_2 and V_3 respectively. The sum of the voltages across the capacitor must be equal to the voltage of the battery.

$$V = V_1 + V_2 + V_3 \quad \text{...... (1)}$$

Since $Q = CV$; $V = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$

$$= Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right) \quad \text{...... (2)}$$

(v) If three capacitors in series are considered to form an equivalent single capacitor C_s shown in Figure (b), then we have $V = \frac{Q}{C_s}$ Substituting this expression into equation (2), we get

$$\frac{Q}{C_S} = Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

$$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \quad \text{...... (3)}$$

This equivalent capacitance C_S is always less than the smallest individual capacitance in the series.

31. (i) Angular momentum is given by

$$l = n\hbar = \frac{nh}{2\pi}$$

$$= \frac{5 \times 6.6 \times 10^{-34}}{2 \times 3.14}$$

$$= 5.25 \times 10^{-34} \text{ kgm}^2\text{s}^{-1}$$

(ii) Velocity is given by

$$\text{Velocity } v = \frac{l}{mr}$$

$$= \frac{(5.25 \times 10^{-34} \cancel{\text{kg}}\, \text{m}\cancel{^2} \text{s}^{-1})}{(9.1 \times 10^{-31} \cancel{\text{kg}})(13.25 \times 10^{-10} \cancel{\text{m}})}$$

$$\Rightarrow v = 4.4 \times 10^5 \text{ ms}^{-1}$$

32. **Features of Magnetic Lorentz force :**

(i) $\vec{F}_m$ is directly proportional to the magnetic field $\vec{B}$

(ii) $\vec{F}_m$ is directly proportional to the velocity $\vec{v}$ of the moving charge

(iii) $\vec{F}_m$ is directly proportional to sine of the angle between the velocity and magnetic field

(iv) $\vec{F}_m$ is directly proportional to the magnitude of the charge q

(v) The direction of $\vec{F}_m$ is always perpendicular to $\vec{v}$ and $\vec{B}$ as $\vec{F}_m$ is the cross product of $\vec{v}$ and $\vec{B}$

33. **Solution :**

$X_L = 184\ \Omega$; $X_C = 144\ \Omega$; $R = 30\ \Omega$

(i) The impedance is

$$z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$= \sqrt{30^2 + (184-144)^2}$$

$$= \sqrt{900+1600} = \sqrt{2500}\ \Omega$$

$$z = 50\ \Omega$$

(ii) Phase angle ϕ between voltage and current is

$$\tan\phi = \frac{X_L - X_C}{R}$$

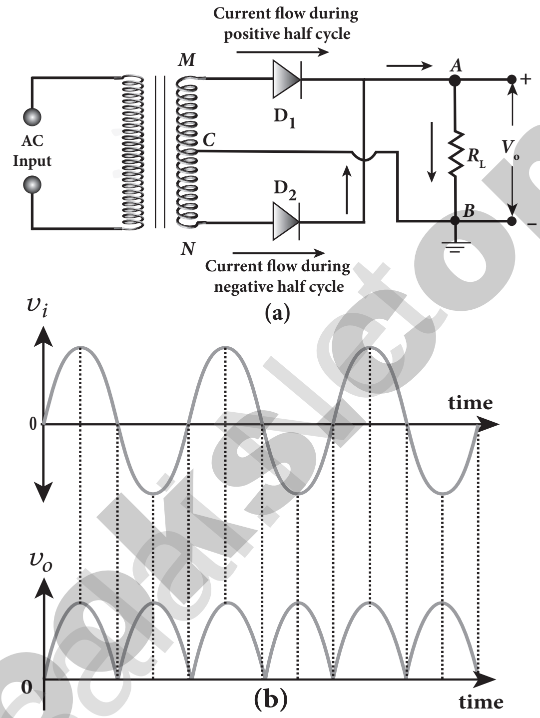
$$= \frac{184-144}{30} = 1.33$$

$$\phi = 53.1°$$

Since the phase angle is positive, voltage leads current by 53.1° for this inductive circuit.

Part - IV

34.(a)



(a) Fulal wave rectifier circuit
(b) Input and output waveforms

Full wave rectifier

(i) The positive and negative half cycles of the AC input signal are rectified in this circuit and hence it is called the full wave rectifier

(ii) The circuit is shown in Figure. It consists of two *p-n* junction diodes, a centre tap transformer and a load resistor R_L.

(iii) The centre is usually taken as the ground or zero voltage reference point.

(iv) With the help of the centre tap transformer, each diode rectifies one half of the total secondary voltage.

During positive half cycle

(i) When the positive half cycle of the AC input signal passes through the circuit, terminal M is positive, C is at zero potential and N is at negative potential.

(ii) This forward biases diode D_1 and reverse biases diode D_2. Hence, being forward biased, diode D_1 conducts and current flows along the path MD_1ABC.

During negative half cycle

(i) When the negative half cycle of the AC input signal passes through the circuit, terminal N becomes positive, C is at zero potential and M is at negative potential.

(ii) This forward biases diode D_2 and reverse biases diode D_1. Hence, being forward biased, diode D_2 conducts and current flows along the path ND_2ABC.

(iii) During both postive and negative half cycles of the input signal, the current flows through the load in the same direction. The output signal corresponding to the input signal is shown in Figure.

(iv) Though both half cycles of AC input are rectified, the output is still pulsating in nature.

(v) The efficiency (η) of full wave rectifier is twice that of a half wave rectifier and is found to be 81.2%. It is because of power losses in the winding, the diode and the load resistance.

(OR)

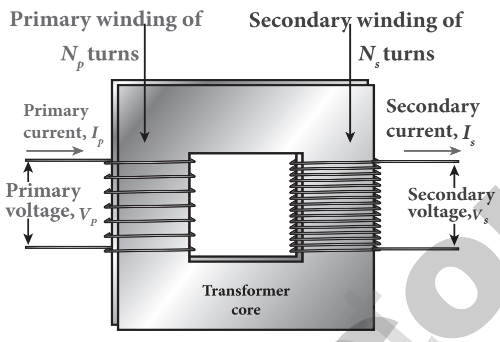
(b) **Principle :**

The principle of transformer is the mutual induction between two coils. That is, when an electric current passing through a coil changes with time, an emf is induced in the neighbouring coil.

Construction :

(i) In the simple construction of transformers, there are two coils of high mutual inductance wound over the same transformer core.

(ii) The core is generally laminated and is made up of a good magnetic material like silicon steel. Coils are electrically insulated but magnetically linked via transformer core .



Construction of Transformer

(iii) The coil across which alternating voltage is applied is called primary coil P and the coil from which output power is drawn out is called secondary coil S.

(iv) The assembled core and coils are kept in a container which is filled with suitable medium for better insulation and cooling purpose.

Working :

(i) If the primary coil is connected to a source of alternating voltage, an alternating magnetic flux is set up in the laminated core.

(ii) If there is no magnetic flux leakage, then whole of magnetic flux linked with primary coil is also linked with secondary coil.

(iii) The emf induced in the primary coil or back emf ε_p is given by

$$\varepsilon_p = -N_p \frac{d\phi_B}{dt}$$

(iv) But the voltage applied v_p across the primary is equal to the back emf. Then

$$V_p = -N_p \frac{d\phi_B}{dt} \quad \text{--- (1)}$$

The emf induced in the secondary coil ε_s is given by

$$\varepsilon_s = -N_s \frac{d\phi_B}{dt}$$

where N_p and N_s are the number of turns in the primary and secondary coil respectively. If the secondary circuit is open, then $\varepsilon_s = v_s$ where v_s is the voltage across secondary coil.

$$V_s = -N_s \frac{d\phi_B}{dt} \quad \text{--- (2)}$$

From equations (1) and (2),

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = K \quad \text{---- (3)}$$

This constant K is known as voltage transformation ratio. For an ideal transformer,

Input power $V_p i_p$ = Output power $V_s i_s$

where i_p and i_s are the currents in the primary and secondary coil respectively. Therefore,

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{i_p}{i_s} \quad \text{--- (4)}$$

Equation (4) is written in terms of amplitude of corresponding quantities,

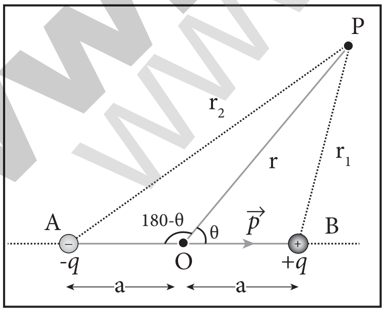
$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{i_p}{i_s} = K$$

i) If $N_s > N_p$ (K>1), then $V_s > V_p$ and $I_s < I_p$.

This is the case of step-up transformer in which voltage is increased and the corresponding current is decreased.

ii) If $N_s < N_p$ (K<1), then and $V_s < V_p$ and $I_s > I_p$. This is step-down transformer where voltage is decreased and the current is increased.

35. (a)(i) Consider two equal and opposite charges separated by a small distance 2a. The point P is located at a distance r from the midpoint of the dipole. Let θ be the angle between the line OP and dipole axis AB.



Potential due to electric dipole

(ii) Let r_1 be the distance of point P from $+q$ and r_2 be the distance of point P from $-q$.

Potential at P due to change $+q = \frac{1}{4\pi\varepsilon_0}\frac{q}{r_1}$

Potential at P due to change $-q = -\frac{1}{4\pi\varepsilon_0}\frac{q}{r_2}$

Total potential at at the point P,

$$V = \frac{1}{4\pi\varepsilon_0} q\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \quad \text{...(1)}$$

(iii) By the cosine law for triangle BOP,

$$r_1^2 = r^2 + a^2 - 2ra\cos\theta$$

$$r_1^2 = r^2\left(1 + \frac{a^2}{r^2} - \frac{2a}{r}\cos\theta\right)$$

Since $r >> a$, Neglecting $\frac{a^2}{r^2}$

$$r_1^2 = r^2\left(1 - 2a\frac{\cos\theta}{r}\right)$$

$$\text{(or) } r_1 = r\left(1 - \frac{2a}{r}\cos\theta\right)^{\frac{1}{2}}$$

$$\frac{1}{r_1} = \frac{1}{r}\left(1 - \frac{2a}{r}\cos\theta\right)^{\frac{1}{2}}$$

(iv) Using binomial theorem, we get,

$$\frac{1}{r_1} = \frac{1}{r}\left(1 + \frac{a}{r}\cos\theta\right) \quad \text{...(2)}$$

Similarly applying the cosine law for triangle AOP,

$$r_2^2 = r^2 + a^2 - 2ra\cos(180-\theta)$$

Since cos(180 – θ) = –cos θ we get

$$r_2^2 = r^2 + a^2 + 2ra\cos\theta$$

Neglecting $\frac{a^2}{r^2}$ (because $r >> a$)

$$r_2^2 = r^2\left(1 + \frac{2a\cos\theta}{r}\right)$$

$$r_2 = r\left(1 + \frac{2a\cos\theta}{r}\right)^{\frac{1}{2}}$$

Using Binomial theorem, we get

$$\frac{1}{r_2} = \frac{1}{r}\left(1 - a\frac{\cos\theta}{r}\right) \quad \text{...(3)}$$

Substituting equation (3) and (2) in equation (1),

$$V=\frac{1}{4\pi\varepsilon_0}q\left(\frac{1}{r}\left(1+a\frac{\cos\theta}{r}\right)-\frac{1}{r}\left(1-a\frac{\cos\theta}{r}\right)\right)$$

$$V=\frac{1}{4\pi\varepsilon_0}\frac{2aq}{r^2}\cos\theta$$

(v) $p = 2qa$,

$$V=\frac{1}{4\pi\varepsilon_0}\left(\frac{p\cos\theta}{r^2}\right)$$

Special cases

Case (i) If the point P lies on the axial line of $+q$ side, then $\theta = 0$, then

$$V=\frac{1}{4\pi\varepsilon_0}\frac{p}{r^2} \quad ...(4)$$

Case (ii) If the point P lies on $-q$ side then $\theta = 180°$, then

$$V=-\frac{1}{4\pi\varepsilon_0}\frac{p}{r^2} \quad ...(5)$$

Case (iii) If the point P lies on the equatorial line, then $\theta = 90°$. Hence

$$V = 0 \quad ...(6)$$

(OR)

(b) **Condition for bright fringe (or) maxima :**

(i) The condition for the point P to have a constructive interference (or) be a bright fringe is, Path difference, $\delta = n\lambda$
where, $n = 0, 1, 2, \ldots$

$$\therefore \frac{dy}{D} = n\lambda.$$

$$y = n\frac{\lambda D}{d} \text{ (or) } y_n = n\frac{\lambda D}{d}$$

(ii) This is the condition for the point P to have a bright fringe. The distance y_n is the distance of the n^{th} bright fringe from the point O.

Condition for dark fringe (or) minima :

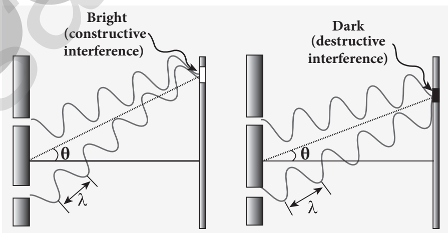
(i) The condition for the destructive interference or the point P to be have a dark fringe is,
Path difference, $\delta = (2n-1)\frac{\lambda}{2}$
where, $n = 1, 2, 3, \ldots$

$$\therefore \frac{dy}{D} = (2n-1)\frac{\lambda}{2}$$

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

(ii) This is the condition for the point P to have a dark fringe. The distance y_n is the distance of the n^{th} dark fringe from the point O.

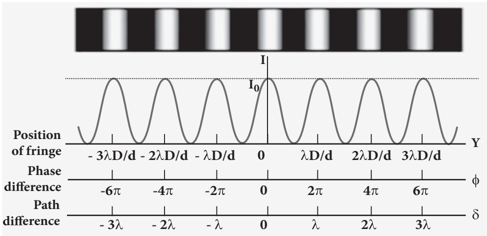
(iii) The formation of bright and dark fringes is shown in Figure.



Formation of bright and dark fringes

(iv) This shows that on the screen, alternate bright and dark fringes are seen on either side of the central bright fringe.

(v) The central bright is referred as 0^{th} bright followed by 1^{st} dark and 1^{st} bright and then 2^{nd} dark and 2^{nd} bright and so on, on either side of O successively as shown in Figure.



Interference fringe pattern (need to make it vertical)

Equation for bandwidth :

(i) The bandwidth (β) is defined as the distance between any two consecutive bright or dark fringes.

(ii) The distance between $(n+1)^{th}$ and n^{th} consecutive bright fringes from O is given by

$$\beta = y_{(n+1)} - y_n = \left((n+1)\frac{\lambda D}{d}\right) - \left(n\frac{\lambda D}{d}\right)$$

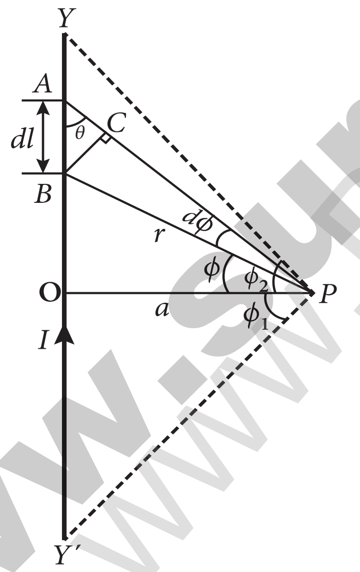
$$\beta = \frac{\lambda D}{d}$$

(iii) Similarly, the distance between $(n+1)^{th}$ and n^{th} consecutive dark fringes from O is given by,

$$\beta = y_{(n+1)} - y_n = \left(\frac{(2(n+1)-1)}{2}\frac{\lambda D}{d}\right) - \left(\frac{(2n-1)}{2}\frac{\lambda D}{d}\right)$$

$$\beta = \frac{\lambda D}{d}$$

36. (a)



Magnetic field due to a long straight current carrying conductor

Let YY' be an infinitely long straight conductor and I be the steady current through the conductor. In order to calculate magnetic field at a point P which is at a distance a from the wire, let us consider a small line element dl (segment AB).

The magnetic field at a point P due to current element Idl can be calculated form Biot-Savart's law, which is

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}\hat{n}$$

Where $\hat{n}$ is the unit vector which points into the page at P, θ is the angle between current element Idl and line joining dl and the point P. Let r be the distance between line element at A to the point P.

To apply trigonometry, draw a perpendicular AC to the line BP.

In triangle ΔABC, $\sin\theta = \frac{AC}{AB}$

$$\Rightarrow AC = AB\sin\theta$$

But $AB = dl \Rightarrow AC = dl\sin\theta$

Let $d\phi$ be the angle subtended between AP and BP

i.e., $\angle APB = \angle BPC = d\phi$

In a triangle ΔAPC, $\sin(d\phi) = \frac{AC}{AP}$

Since, $d\phi$ is very small, $\sin(d\phi) \simeq d\phi$

But $AP = r \Rightarrow AC = rd\phi$

$$\therefore AC = dl\sin\theta = rd\phi$$

$$\therefore d\vec{B} = \frac{\mu_0}{4\pi}\frac{I}{r^2}(rd\phi)\hat{n} = \frac{\mu_0}{4\pi}\frac{Id\phi}{r}\hat{n}$$

Let ϕ be the angle between BP and OP

In a ΔOPA, $\cos\phi = \frac{OP}{BP} = \frac{a}{r}$

$$\Rightarrow r = \frac{a}{\cos\phi}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I}{a/\cos\phi}d\phi\hat{n}$$

$$\Rightarrow d\vec{B} = \frac{\mu_0 I}{4\pi a}\cos\phi\, d\phi\hat{n}$$

The total magnetic field at P due to the conductor YY' is

$$\vec{B} = \int_{-\phi_1}^{\phi_2} d\vec{B} = \int_{-\phi_1}^{\phi_2} \frac{\mu_0 I}{4\pi a} \cos\phi d\phi \hat{n}$$

$$= \frac{\mu_0 I}{4\pi a} [\sin\phi]_{-\phi_1}^{\phi_2} \hat{n}$$

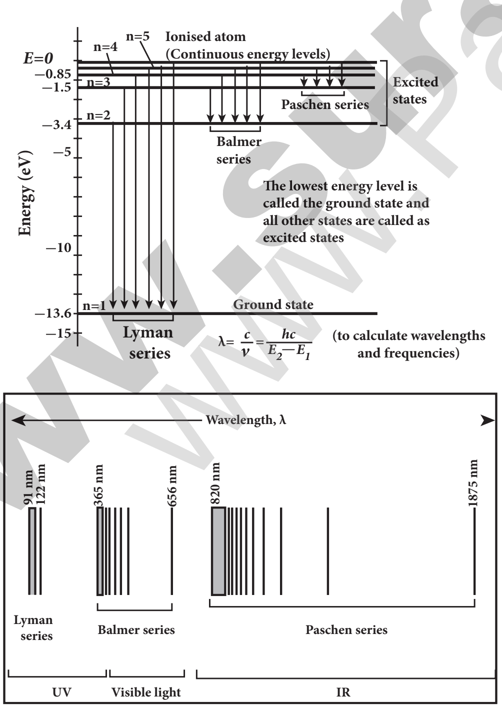
$$= \vec{B} = \frac{\mu_0 I}{4\pi a} (\sin\phi_1 + \sin\phi_2) \hat{n}$$

For infinitely long conductor $\phi_1 = \phi_2 = 90°$

$$\therefore \vec{B} = \frac{\mu_0 I}{4\pi a} \times 2\hat{n} \Rightarrow \vec{B} = \frac{\mu_0 I}{2\pi a} \hat{n}$$

(OR)

(b) (i) In each series, the distance of separation between the consecutive wavelengths decreases from higher wavelength to the lower wavelength, and also wavelength in each series approach a limiting value known as the series limit.



Spectral series – Lyman, Balmer, Paschen series

(ii) The wavelengths of these spectral lines perfectly agree with the wavelengths calculate using equation derived from Bohr atom model.

$$\frac{1}{\lambda} = R\left[\frac{1}{n^2} - \frac{1}{m^2}\right] = \bar{\nu} \quad ...(1)$$

(iii) where $\bar{\nu}$ is known as wave number which is inverse of wavelength, R is known as Rydberg constant whose value is 1.09737×10^7 m^{-1} and m and n are positive integers such that $m > n$. The various spectral series are discussed below:

(a) Lyman series

For $n = 1$ and $m = 2,3,4.......$ in equation, the wave numbers or wavelength of spectral lines of Lyman series which lies in ultra-violet region,

$$\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{m^2}\right]$$

(b) Balmer series

For $n = 2$ and $m = 3,4,5.......$ in equation, the wave numbers or wavelength of spectral lines of Balmer series which lies in visible region,

$$\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{m^2}\right]$$

(c) Paschen series

Put $n = 3$ and $m = 4,5,6.......$ in equation (1). The wave number or wavelength of spectral lines of Paschen series which lies in infra-red region (near IR) is

$$\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{m^2}\right]$$

(d) Brackett series

For $n = 4$ and $m = 5,6,7......$ in equation(1), the wave numbers or wavelength of spectral lines of Brackett series which lies in infra-red region (middle IR),

$$\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{m^2}\right]$$

(e) Pfund series

For $n = 5$ and $m = 6,7,8$........ in equation(1), the wave numbers or wavelength of spectral lines of P fund series which lies in infra-red region (far IR),

$$\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{5^2} - \frac{1}{m^2}\right]$$

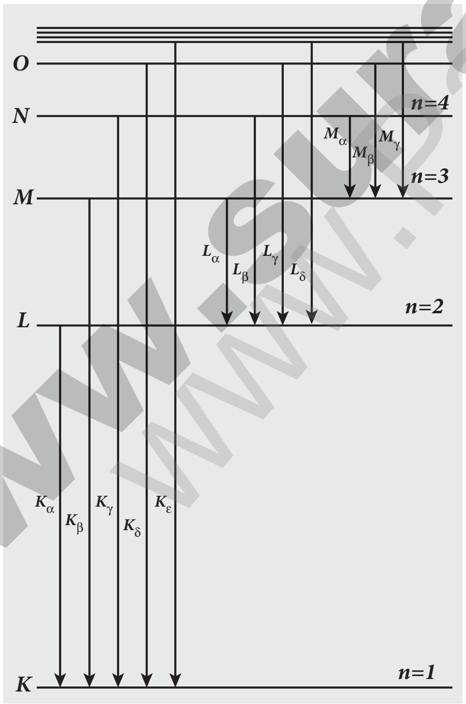
37. (a) (i)

(i) X – ray spectra show some narrow peaks at some well – defined wavelengths when the target is hit by fast electrons.

(ii) The line spectrum showing these peaks is called characteristic x – ray spectrum. This x – ray spectrum is due to the electronic transitions within the atoms.

(iii) When an energetic electron penetrates into the target atom and it can remove some of the K-shell electrons.

(iv) Then the electrons from outer orbits jump to fill up the vacancy so created in the K-shell.



Origin of characteristic x-ray spectra

(v) During the downward transition, the energy difference between the levels is given out in the form of x– ray photon of definite wavelength.

(vi) Such wavelengths, characteristic of the target, constitute the line spectrum.

(vii) K-series of lines in the x-ray spectrum of an element arises due to the electronic transitions from L, M, N, . . levels to the K-level.

(viii) Similarly, the longer wavelength L-series originates when an L-electron is knocked out of the atom and the corresponding vacancy is filled by the electronic transitions from M, N, O level to the L-level and so on.

(ix) The K_α and K_β of the K-series of molybdenum are shown by the two peaks in its x-ray spectrum.

(ii) The cut-off wavelength of the characteristic X-rays is

[Speed of light $C = 3 \times 10^8\ ms^{-1}$]

$$\lambda_0 = \frac{12400}{V}\ Å = \frac{12400}{20000}\ Å = 0.62\ Å$$

The corresponding frequency is

$$\nu_0 = \frac{c}{\lambda_0} = \frac{3\times10^8}{0.62\times10^{-10}} = 4.84 \times 10^{18}\ Hz$$

(OR)

(b) A beam of white light to pass through the prism. It is split into its seven constituent colours which can be viewed on the screen as continuous spectrum. This phenomenon is known as dispersion of light and the definite pattern of colours obtained on the screen after dispersion is called as spectrum.

When the spectrum of self luminous source is taken, we get emission spectrum. Each source has its own characteristic emission spectrum.

(a) Continuous emission spectrum (or continuous spectrum)

continuous emission spectra

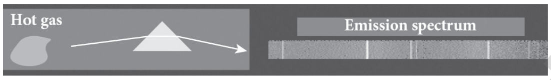
(i) If the light from incandescent lamp is allowed to pass through prism.

(ii) It splits into seven colours.

(iii) It consists of all wavelengths from violet to red.

(v) Examples: Spectrum obtained from carbon arc and incandescent solids.

(b) Line emission spectrum (or line spectrum):



line emission spectra

(i) Light from hot gas is allowed to pass through prism, line spectrum is obtained.

(ii) Spectra consists of sharp lines of definite wavelengths or frequencies.

(iii) Examples: spectra of atomic hydrogen, helium, etc.

(c) Band emission spectrum (or band spectrum)

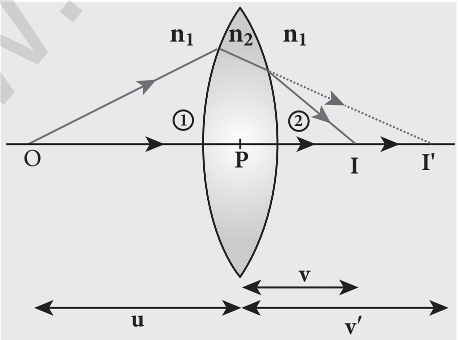
(i) Consists of several number of very closely spaced lines overlapped together forming bands separated by dark spaces.

(ii) A sharp edge at one end and fades out at the other end.

(iii) Examples, spectra of ammonia gas in the discharge tube etc.

38. (a) (i) Consider a thin lens made up of a medium of refractive index n_2 is placed in a medium of refractive index n_1.

(ii) Let R_1 and R_2 be the radii of curvature of two spherical surfaces (1) and (2) respectively and P be the pole as shown in figure.



Refraction through thin lens

(iii) Consider a point object O on the principal axis. A paraxial ray from O which falls very close to P, after refraction at the surface (1) forms image at I'. Before it does so, it is again refracted by the surface (2).

(iv) Therefore the final image is formed at I. The general equation for the refraction at a single spherical surface is given by the equation is

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R_1}$$

For the refracting surface (1), the light goes from n_1 to n_2.

$$\frac{n_2}{v'} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R_1} \quad ...(1)$$

For the refracting surface (2), the light goes from medium n_2 to n_1.

$$\frac{n_1}{v} - \frac{n_2}{v'} = \frac{(n_1 - n_2)}{R_2} \quad ...(2)$$

For surface (2) I' acts as virtual object

Adding the above two equations (1) and (2)

$$\frac{n_1}{v} - \frac{n_1}{u} = (n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

On Further simplifying and rearranging,

$$\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ...(3)$$

(v) If the object is at infinity, the image is formed at the focus of the lens. Thus, for $u = \infty$, $v = f$. Then the equation becomes.

$$\frac{1}{f} - \frac{1}{\infty} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ...(4)$$

(vi) If the refractive index of the lens is n_2 and it is placed in air, then $n_2 = n$ and $n_1 = 1$. So the equation (4) becomes,

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ...(5)$$

(vii) The above equation is called the lens maker's formula, because it tells the lens manufactures what curvature is needed to make a lens of desired focal length with a material of particular refractive index.

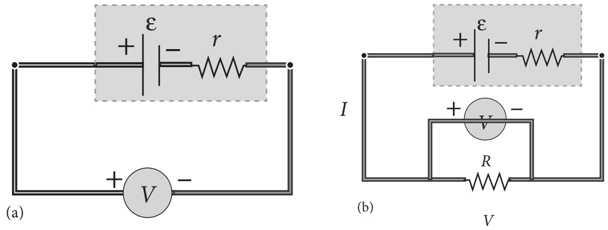
(viii) This formula holds good also for a concave lens. By comparing the equations (3) and (4) we can write,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad ...(6)$$

(ix) This equation is known as **lens equation** which relates the object distance u and image distance v with the focal length f of the lens. This formula holds good for any type of lens.

(OR)

(b) (i) The emf of cell ε is measured by connecting a high resistance voltmeter across it without connecting the external resistance.



Voltmeter   Internal resistance of the cell

(ii) Since the voltmeter draws very little current for deflection, the circuit may be considered as open. Hence the voltmeter reading gives the emf of the cell.

(iii) Then, external resistance R is included in the circuit and current I is established in the circuit.

(iv) The potential difference across R is equal to the potential difference across the cell (V) as shown in Figure (b).

The potential drop across the resistor R is

$$V = IR \quad ....(1)$$

(v) Due to internal resistance *r* of the cell, the voltmeter reads a value V, which is less than the emf of cell ε. Then

$$V = \varepsilon - Ir$$

$$Ir = \varepsilon - V \quad ...(2)$$

Dividing equation (2) by equation (1), we get

$$\frac{Ir}{IR} = \frac{\varepsilon - V}{V}$$

$$r = \left[\frac{(\varepsilon - V)}{V}\right]R$$

(vi) Since ε, V and R are known, internal resistance *r* can be determined.

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