Marking scheme of Physics | Class 12

SECTION - A (Q1 to Q21 One Mark Each)

1. b) C/3
2. c) energy
3. b) 1:1
4. a) c
5. b) Al
6. a) doubled
7. b) Violet
8. c) 1:1
9. d) 2.25 × 108 m/s
10. d) Total Internal Reflection
11. c) Energy
12. d) Red
13. c) 6
14. b) 0
15. a) circular
16. Reverse biased
17. Scalar quantity
18. Angular momentum
19. Electric Potential (or Electromotive Force / Potential Difference)
20. Conductivity
21. Intrinsic

SECTION - B (2 Marks Each)

22. a) Electric Dipole Moment: 1 + 1
    - Definition: The electric dipole moment (p) of an electric dipole is defined as a vector quantity whose magnitude is equal to the product of the magnitude of one of the charges (q) and the separation distance (2a) between them.
    - SI Unit: Coulomb-meter (C · m).

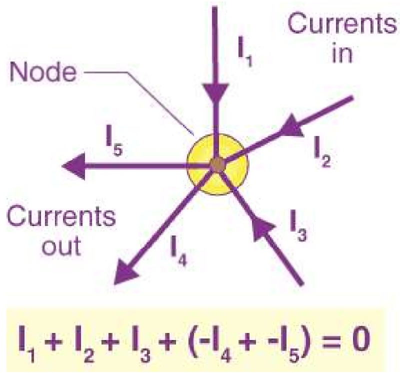
OR

22. b) Gauss's Law: 1 + 1
    - Statement: Gauss's law states that the total electric flux passing through any closed hypothetical surface (called a Gaussian surface) is equal to $1/\varepsilon_0$ times the net total charge enclosed within that surface.
    - Mathematical Form:

$\phi = 1/\varepsilon_0 (Q)$

23. Kirchhoff's First Law (Junction Rule): 1 + 1

- Explanation: It states that the algebraic sum of currents meeting at any lectrical junction in a circuit is always zero



24. Self-Inductance: 1 + 1

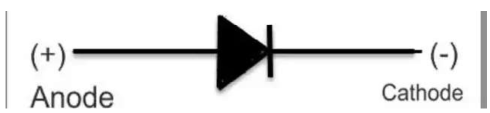
- Definition: Self-inductance (L) is defined as the property of an electric circuit (or a coil) by virtue of which it opposes any change in the strength of current flowing through it by inducing an electromotive force (emf) within itself. Quantitatively, it equals the magnetic flux linkage per unit current.
- SI Unit: Henry (H).

25. Properties of Electromagnetic Waves (Any Two) : 1 + 1

1. Transverse Nature: Electromagnetic waves are transverse in nature, meaning the electric field vector (E) and magnetic field vector (B) oscillate perpendicular to each other and also perpendicular to the direction of wave propagation.
2. Speed in Vacuum: They do not require any material medium to travel and propagate through a vacuum at a constant speed of $c = 3 \times 10^8$ m/s.

26. p-n Junction Diode: 1 + 1

- Definition: A p-n junction diode is a two-terminal semiconductor device formed by placing a p-type semiconductor material in intimate atomic contact with an n-type semiconductor material, creating a depletion barrier across the interface that allows current to flow easily in only one direction.
- Symbolic Diagram:



27. Differentiation between Intrinsic and Extrinsic Semiconductors: 1 + 1
(Any two difference)

28. Biot-Savart Law in Vector Form: 1 + 1

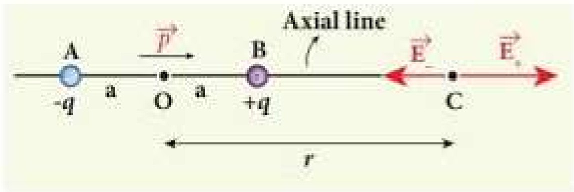
The magnetic field element dB produced at a position vector r by a small current element I dl is given by:

$\overrightarrow{dB} = (\mu_0 / 4\pi)\ (I\ \overrightarrow{dl} \times \vec{r})\ /\ r^3)$

(Where μ_0 is the permeability of free space, I is current, and dl is the length vector of the filament).

SECTION - C (3 Marks Each)

29. a) Expression for Electric Field due to an Electric Dipole at an Axial Point: 1



- Consider an electric dipole consisting of two charges -q and +q separated by a distance 2a. Let P be a point on the axial line at a distance r from the center O of the dipole. The electric field at point P due to charge +q (at point B) is directed away from the dipole:

$E + q = \frac{1}{4\pi\varepsilon_0}\ \frac{q}{(r-a)^2}$ (along BP) ½

The electric field at point P due to charge -q (at point A) is directed toward the dipole :

$E - q = (\frac{1}{4\pi\varepsilon_0})\ \frac{q}{(r+a)^2}$ (along BP) ½

The net axial electric field

$$E = E_{+q} - E_{-q} = \frac{1}{4\pi\varepsilon_0}\ \frac{q}{(r-a)^2} - \frac{1}{4\pi\varepsilon_0}\ \frac{q}{(r+a)^2}$$

$$= \frac{1}{4\pi\varepsilon_0}\ \frac{2pr}{(r^2-a^2)^2}$$ 1

OR

29. b) Electric Field due to an Electric Dipole at the Mid-Point:

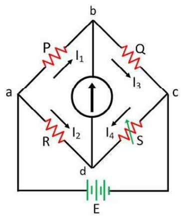
- Consider an electric dipole with charges -q at A and +q at B, separated by a distance 2a. Let O be the mid-point on the axis between them. The distance from each charge to the mid-point O is exactly a.E

$$E + q = \frac{1}{4\pi\varepsilon_0} \frac{q}{(a)^2}$$ 1

$$E - q = \frac{1}{4\pi\varepsilon_0} \frac{q}{(a)^2}$$ 1

$$\text{Total } E = E_{+q} + E_{-q} = \frac{1}{4\pi\varepsilon_0} \frac{2q}{(a)^2}$$ 1

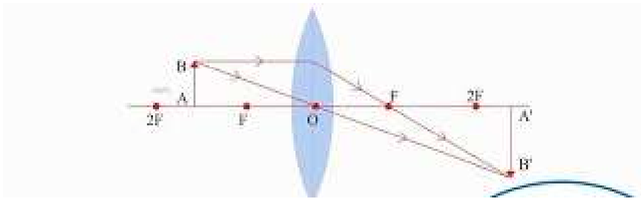
30. Balanced Condition in a Wheatstone Bridge using Kirchhoff's Laws:



1

* Derivation (Using Kirchhoff's) 2

31. a) Ray Diagram for Convex Lens (Object between F and 2F):



2

Uses of Convex Lens (Any Two): ½ + ½

1. Used in optical instruments like magnifying glasses, microscopes, and telescopes.
2. Used in corrective eyeglasses to treat hypermetropia (farsightedness).

OR

31. b) Three Differences between Interference and Diffraction (any three)

1+1+1

32. Total Internal Reflection (TIR): 2

- Total Internal Reflection is an optical phenomenon that occurs when a ray of light traveling inside an optically denser medium strikes the boundary of an optically rarer medium at an angle of incidence greater than the critical angle for those two media. Instead of refracting, the light ray is entirely reflected back into the denser medium.
- Two Conditions for TIR: ½ + ½
  1. The light ray must travel from an optically denser medium toward an optically rarer medium.

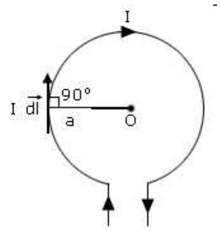
2. The angle of incidence in the denser medium must be greater than the critical angle for the given pair of media.

33. Photoelectric Definitions: 1½ + 1½

- Work Function : The work function of a photosensitive material is defined as the minimum amount of thermodynamic energy required to liberate a single electron from the surface of the metal against its internal electrostatic barriers. It depends directly on the surface properties of the chosen metal and is expressed in electron-volts (eV).
- Threshold Frequency : The threshold frequency is defined as the absolute minimum frequency of incident light radiation below which no photoelectric emission can take place from a metal surface, regardless of how intense or long the light shines.

SECTION - D (5 Marks Each)

34. a) Magnetic Field at the Centre of a Current Carrying Circular Loop: 1



Derivation: Let us consider a circular loop of radius r carrying a steady current I. We wish to determine the net magnetic field B at its center O. According to the Biot-Savart Law, the small magnetic field dB due to a current element Idl is:

$\vec{dB} = (\mu_0 / 4\pi)\ (I\ \vec{dl} \times \vec{r})\ /\ r^3)$ 1

The angle between the length element dl along the tangent and the radius vector r is always 90°.

Substituting this value into the magnitude equation yields :

$dB = (\mu_0 / 4\pi) \dfrac{Idl}{(r)^2}$ 1

$B = (\mu_0 / 4\pi) \dfrac{I}{(r)^2} \oint dl$ 1

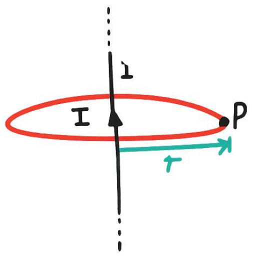
$B = (\mu_0\, I / 2r)$ 1

OR

34. b) Ampere's Circuital Law : 2

Statement: Ampere's circuital law states that the line integral of the magnetic field vector B along any closed loop (called an Amperian loop) in free space is equal to μ_0 times the total net current threading through the surface bounded by that loop.

Derivation for Infinitely Long Straight Wire: Consider an infinitely long, straight wire carrying a steady current I. To find the magnetic field at a perpendicular distance r from the wire, draw a circular Amperian loop of radius r centered on the wire.



1

$\oint \vec{B}\vec{dl} = \oint Bdl \ \cos(0°) = B\oint dl$ 1

Since the total length of the circular loop is its circumference,

dl = $2\pi r$:

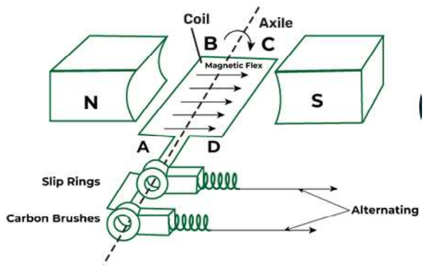
$B\oint dl = B\,(2\pi r)$

Applying Ampere's Circuital Law (? B · dl = μ0I):

$B\,(2\pi r) = \mu_0 I$ 1

$B = \mu_0 I / 2\pi r$

35. a) AC Generator:



2

Construction: An AC Generator consists of four primary components: 1

1. Armature: A rectangular loop or coil (ABCD) consisting of many turns of insulated copper wire wound over a soft iron core.
2. Field Magnets: Strong permanent magnets or electromagnets that provide a uniform magnetic field across the armature region.
3. Slip Rings: Two coaxial metallic rings (R1 and R2) connected to the ends of the armature coil that rotate alongside it.
4. Brushes: Two stationary carbon blocks (B1 and B2) held against the slip rings to maintain electrical contact with the external load.

Working Principle: When the armature coil is rotated mechanically by an external prime mover inside the uniform magnetic field, the magnetic flux (FB) passing through the coil changes continuously over time. According to Faraday's Law of Induction, this changing flux induces an alternating electromotive force (emf) within the circuit, driving an alternating current through the load. 1

Derivation of Induced EMF:

Let the coil have N turns, area A, and rotate with a constant angular velocity ? in a magnetic field B. The magnetic flux F at any time t is:

$\phi = NBA \cos(\theta)$

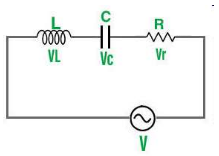
According to Faraday's Law, the induced emf (e) is given by the negative time rate of change of flux:

$e = -d\phi/dt = -d/dt\,[NBA \cos(\omega t)] = -NBA\,\omega\,(-\sin(\omega t))$ 1

$e = NBA\,\omega \sin(\omega t)$

OR

35. b) Series LCR Circuit:



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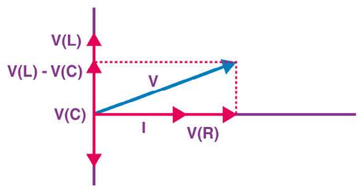
Derivation for Impedance: Consider a resistor R, an inductor L, and a capacitor C connected in series with an alternating voltage source V = V0 sin(ωt). Let the resulting alternating current in the series loop be I.

Phasor Diagram:



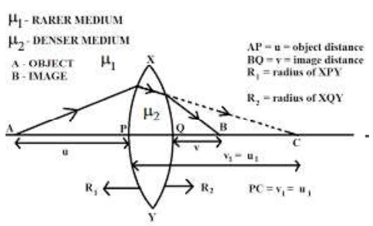
1

The total effective opposition to alternating current in an LCR circuit is called its impedance (Z = V / I):

$$Z = \sqrt{R^2 + \left(X_L - X_C\right)^2}$$ 2

Resonance Condition: Electrical resonance occurs when the inductive reactance equals the capacitive reactance ($X_L = X_C$). 1

36. a) Lens Maker's Formula for a Thin Convex Lens:



2

Derivation: Consider a thin lens of a material with refractive index n2 placed in a medium of refractive index n_1. Let R_1 and R_2 be the radii of curvature of its two spherical surfaces. Let a point object be placed on the principal axis in front of the first surface.

Refraction at the First Surface (Radius R_1):

$$n_2/v_1 - n_1/u = (n_2 - n_1)/R_1 \text{ — (1)}$$

Refraction at the Second Surface (Radius R2): Since light travels from medium n_2 back to n_1:

$$n_1/v - n_2/v_1 = (n_1 - n_2)/R_2 = -(n_2 - n_1)/R_2 \text{ — (2)}$$

Adding Eq 1 and Eq 2 eliminates the intermediate image

$$(n_1/v - n_2/v_1) + (n_2/v_1 - n_1/u) = (n_2 - n_1)/R_1 - (n_2 - n_1)/R_2$$

$$n_1/v - n_1/u = (n_2 - n_1)(1/R_1 - 1/R_2)$$

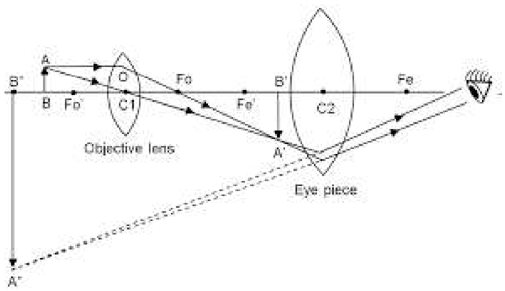
Dividing both sides by n_1:

$$1/v - 1/u = (n_2/n_1 - 1)(1/R_1 - 1/R_2)$$

$$1/F = (n_2/n_1 - 1)(1/R_1 - 1/R_2)$$

OR

36. b) Compound Microscope: 2



Derivation for Magnifying Power (M) at Least Distance of Distinct Vision (D):

The total angular magnification M of a compound microscope is equal to the product of the linear magnification of the objective lens (mo) and the angular magnification of the eyepiece lens (me):

$$M = m_o \times m_e \qquad 1$$

For the objective lens, the linear magnification is given by the ratio of image distance to object distance: $m_o = v_o / u_o$. 1

For the eyepiece acting as a simple magnifier, when the final image is formed at the near point (ve = -D), its magnification is given by: me = $1 + D / f_e$.

Substituting these components into the total magnification equation yields:

$$M = (v_o / u_o)(1 + D / f_e) \qquad 1$$

Applying sign conventions for a typical arrangement ($u_o = -f_o$ and $v_o =$

L, where L is the length of the microscope tube):

$$M = -(L / f_o)(1 + D / f_e)$$

37. a) Bohr's Postulates and Radius of nth Orbit: 3

Bohr's Three Postulates:

1. An electron in an atom rotates around a heavy, positively charged central nucleus in specific circular paths called stationary orbits. While in these orbits, the electron does not radiate any electromagnetic energy.
2. Angular Momentum Quantization: An electron can only orbit in paths where its total orbital angular momentum ($L = mvr$) is equal to an integral multiple of $h/2\pi$:

$$mvr = nh / 2\pi \quad (n = 1, 2, 3, ...)$$

3. Electromagnetic radiation is emitted or absorbed only when an electron jumps from one permitted non-radiating orbit to another.

   Derivation for Radius of nth Orbit (any method) 2

$$r = \frac{n^2h^2\varepsilon_o}{\pi mZe^2}$$

OR

37. b) Mass Defect 1

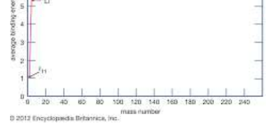
The mass defect is defined as the difference between the sum of the individual rest masses of all the constituent nucleons (protons and neutrons) that make up a nucleus and the actual measured rest mass of the assembled nucleus itself.

$\Delta m = [Z\, m_p + (A - Z)\, m_n]$ - Mass of nucleus 1

Binding Energy

The binding energy of a nucleus is defined as the total equivalent energy liberated during the assembly of the nucleus from its constituent nucleons, or the minimum external energy required to completely break apart a nucleus into its individual protons and neutrons.

Binding Energy per Nucleon Curve:



1

Significance of the Curve (Any Two): 2

1. Maximum Stability:

   The curve reaches a broad maximum of approximately 8.8 MeV near mass number A = 56 (Iron, 56Fe), showing that intermediate-mass nuclei are the most tightly bound and stable elements in nature.

2. Energy Release Mechanisms:

   Nuclear Fusion :

   For very light nuclei ($A < 20$), binding energy per nucleon is low. They can fuse together to form heavier, more stable nuclei, releasing large amounts of energy.

   Nuclear Fission:

   For very heavy nuclei ($A > 200$), the binding energy per nucleon drops. They can split into lighter, more stable fragments when triggered, releasing significant nuclear energy.