Class-XII

Session - 2022-23

Subject - Physics (Theory)

Sample Question Paper - 28

With Solution

BLUE PRINT

Ch. No.	Chapter Name	Per Unit Marks	Section-A MCQs 1 Mark	Section-B SA 2 Marks	Section-C LA-I 3 Marks	Section-D LA-II 5 Marks	Section-E Case Study 4 Marks	Total Marks
1	Electric Charges and Fields	16	1 (Q. 4)	1 (Q. 21)	1 (Q. 28)			6
2	Electrostatic Potential and Capacitance		2 (Q. 1, 7)			1 (Q. 31)		7
3	Current Electricity				1 (Q. 27)			3
4	Moving Charges and Magnetism	17	4 (Q. 2, 3, 5, 6)	1 (Q. 19)				6
5	Magnetism and Matter		1 (Q.15)					1
6	Electromagnetic Induction			1 (Q.23)	1 (Q.26)			5
7	Alternating Current		1 (Q. 16)				1 (Q. 34)	5
8	Electromagnetic Waves	18	1 (Q. 17)	1 (Q. 22)				3
9	Ray optics and Optical Instruments		4 (Q. 8, 11, 14, 18)	1 (Q. 25)				6
10	Wave Optics		2 (Q. 9, 10)	1 (Q. 24)		1 (Q. 33)		9
11	Dual Nature of Radiation and Matter	12				1 (Q. 32)		5
12	Atoms		1 (Q. 12)		1 (Q. 29)			4
13	Nuclei				1 (Q. 30)			3
14	Semiconductor Electronics: Materials, Devices and Simple Circuits	7	1 (Q. 13)	1 (Q. 20)			1 (Q. 35)	7
	Total Marks (Total Questions)		**18 (18)**	**14 (7)**	**15 (5)**	**15 (3)**	**8 (2)**	**70 (35)**

NOTE : The number given inside the bracket denotes question number, ask in the sample paper, while the number given outside the bracket are the number of questions from that particular chapter.

Time Allowed : 3 Hours **Max. Marks : 70**

General Instructions

1. There are 35 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
3. Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
4. There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

SECTION-A

1. Three capacitors each of 4 μF are to be connected in such a way that the effective capacitance is 6μF. This can be done by connecting them :

(a) all in series (b) all in parallel (c) two in parallel and one in series
(d) two in series and one in parallel

2. A charged particle of mass m and charge q travels on a circular path of radius r that is perpendicular to a magnetic field B. The time taken by the particle to complete one revolution is

(a) $\frac{2\pi q^2 B}{m}$ (b) $\frac{2\pi mq}{B}$ (c) $\frac{2\pi m}{qB}$ (d) $\frac{2\pi qB}{m}$

3. Two thin, long, parallel wires, separated by a distance 'd' carry a current of 'i' A in the same direction. They will

(a) repel each other with a force of $\mu_0 i^2/(2\pi d)$ (b) attract each other with a force of $\mu_0 i^2/(2\pi d)$
(c) repel each other with a force of $\mu_0 i^2/(2\pi d^2)$ (d) attract each other with a force of $\mu_0 i^2/(2\pi d^2)$

4. Which statement is true for Gauss law-

(a) All the charges whether inside or outside the gaussian surface contribute to the electric flux.
(b) Electric flux depends upon the geometry of the gaussian surface.
(c) Gauss theorem can be applied to non-uniform electric field.
(d) The electric field over the gaussian surface remains continuous and uniform at every point.

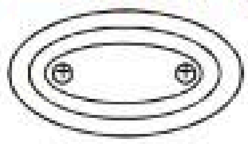
5. The current sensitivity of a galvanometer is defined as

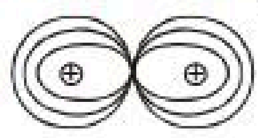
(a) the current flowing through the galvanometer when a unit voltage is applied across its terminals.
(b) current per unit deflection.
(c) deflection per unit current.
(d) dflection per unit current when a unit voltage is applied across its terminals

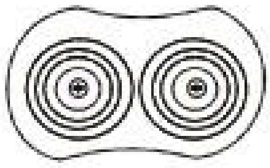
6. A circular coil of wire consisting of 100 turns each of radius 9 cm carries a current of 0.4 A. The magnitude of manetic field at the centre of the coil is

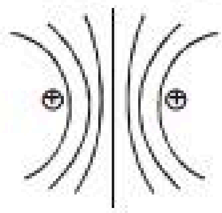
(a) 2.4×10^{-4} T (b) 3.5×10^{-4} T (c) 2.79×10^{-4} T (d) 3×10^{-4} T

7. Which of the following figure shows the correct equipotential surfaces of a system of two positive charges?

(a)


(b)


(c)


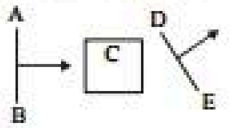
(d)


8. Light travels in two media M_1 and M_2 with speeds 1.5×10^8 ms^{-1} and 2.0×10^8 ms^{-1} respectively. The critical angle between them is:

(a) $\tan^{-1}\left(\frac{3}{\sqrt{7}}\right)$ (b) $\tan^{-1}\left(\frac{2}{3}\right)$ (c) $\cos^{-1}\left(\frac{3}{4}\right)$ (d) $\sin^{-1}\left(\frac{2}{3}\right)$

9. The phenomenon of diffraction can be treated as interference phenomenon if the number of coherent sources is
(a) one (b) two (c) zero (d) infinity

10. A wavefront AB passing through a system C emerges as DE. The system C could be
(a) a slit
(b) a biprism
(c) a prism
(d) a glass slab



11. A double convex lens of focal length 6 cm is made of glass of refractive index 1.5. The radius of curvature of one surface is double that of other surface. The value of small radius of curvature is
(a) 6 cm (b) 4.5 cm (c) 9 cm (d) 4 cm

12. Which of the following series in the spectrum of hydrogen atom lies in the visible region of the electromagnetic spectrum?
(a) Paschen series (b) Balmer series (c) Lyman series (d) Brackett series

13. For a p-type semiconductor, which of the following statements is true?
(a) Electrons are the majority carriers and trivalent atoms are the dopants.
(b) Holes are the majority carriers and trivalent atoms are the dopants.
(c) Holes are the majority carriers and pentavalent atoms are the dopants.
(d) Electrons are the majority carriers and pentavalent atoms are the dopants.

14. If the focal length of objective lens is increased then magnifying power of :
(a) microscope will increase but that of telescope decrease.
(b) microscope and telescope both will increase.
(c) microscope and telescope both will decrease
(d) microscope will decrease but that of telescope increase.

15. Magnetic permeability is maximum for
(a) diamagnetic substance (b) paramagnetic substance
(c) ferromagnetic substance (d) All of the above

For question numbers 16, 17 and 18, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

16. **Assertion (A) :** The alternating current lags behind the e.m.f by a phase angle of $\pi/2$, when current flows through an inductor.
Reason (R) : The inductive reactance increases as the frequency of ac source decreases.

17. **Assertion (A) :** The basic difference between various types of electromagnetic waves lies in their wavelength or frequencies.
Reason (R) : Electromagnetic waves travel through vacuum with the same speed.

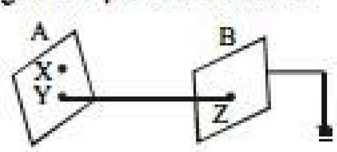
18. **Assertion (A) :** If P_1 and P_2 be the powers of two thin lenses located coaxially in a medium of refractive index μ at a distance d, then the power P of the combination is
$P = P_1 + P_2 - P_1P_2d/\mu$
Reason (R) : Because for above given system equivalent focal length is given by $F = \dfrac{f_1f_2}{f_1 + f_2 - d/\mu}$ and $P = \dfrac{1}{F}$.

SECTION-B

19. A coil of 200 turns has a cross-sectional area 900 mm^2. It carries a current of 2A. The plane of the coil is perpendicular to a uniform magnetic field of 0.5 T. Calculate (i) the magnetic moment of the coil and (ii) the torque acting on the coil.

20. Distinguish between 'intrinsic' and 'extrinsic' semiconductors.

21. Two identical plane metallic surfaces A and B are kept parallel to each other in air, separated by a distance of 1 cm as shown in the figure. A is given a positive potential of 10 V and the outer surface of B is earthed.
(i) What is the magnitude and direction of the uniform electric field between Y and Z?
(ii) What is the workdone in moving a charge of 20 μC from X to Y?



22. Give two characteristics of electromagnetic waves. Write the expression for velocity of electromagnetic waves in terms of permittivity and permeability of the medium.

OR

Identify the part of the electromagnetic spectrum which is
(i) suitable for radar systems used in air craft navigation.
(ii) adjacent to low frequency end of the electromagnetic spectrum.
(iii) produced in nuclear reactions.
(iv) produced by bombarding a metal target by high speed electrons.

23. State Lenz's law.
A metallic rod held horizontally along east-west direction, is allowed to fall under gravity. Will there be an emf induced at its ends? Justify your answer.

OR

Current in a circuit falls steadily from 2.0 A to 0.0 A in 10 ms. If an average emf of 200 V is induced, calculate the self-inductance of the circuit.

24. Answer the following questions :
(a) In a double slit experiment using light of wavelength 600 nm, the angular width of the fringe formed on a distant screen is 0.1°. Find the spacing between the two slits.
(b) Light of wavelength 5000 Å propagating in air gets partly reflected from the surface of water. How will the wavelengths and frequencies of the reflected and refracted light be affected?

25. A prism of refractive index $\sqrt{2}$ has a refracting angle of 60°. At what angle a ray must be incident on it so that it suffers minimum deviation.

SECTION-C

26. Two concentric circular coils, one of small radius r and the other of large radius R, such that R >> r, are placed coaxially with centres coinciding. Obtain the mutual inductance of the arrangement.

OR

Derive the formula for the self inductance of a long solenoid.

27. What is the emf of a cell ? State the factors on which its value depends. Derive a relation between emf E, contact potential V, internal resistance r of a cell and external resistance R. Proove that emf is more than potential difference.

28. An electric dipole consists of the two particles, having the opposite charges $+2 \times 10^{-6}$ C and -2×10^{-6} C and separated by a distance of 10^{-2} m. What is the electric dipole moment of the dipole? Calculate the electric field at a point P on the axis of dipole at a distance of 1 m from it's mid point. Also, calculate the electric field at a point P on the equator of dipole at a distance of 1 m from its mid point.

29. In a Geiger-Marsden experiment, calculate the distance of closest approach to the nucleus of Z = 80, when an α-particle of 8 MeV energy impinges on it before it comes to momentarily rest and reverses its direction.
How will the distance of closest approach be affected when the kinetic energy of the α-particle is doubled?

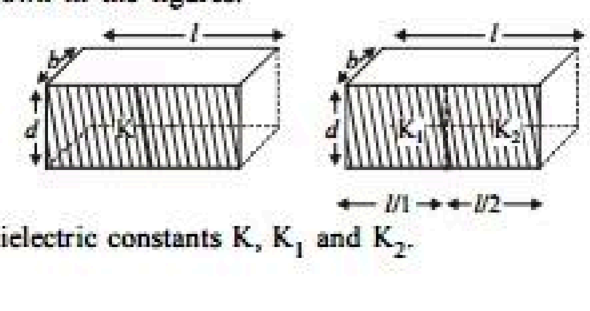
OR

Show that the electron revolving around the nucleus in a radius '*r*' with orbital speed '*v*' has magnetic moment *evr*/2. Hence, using Bohr's postulate of the quantization of angular momentum obtain the expression for the magnetic moment of hydrogen atom in its ground state.

30. Assuming that p^+ and n^0 have equal masses, calculate how many times nuclear matter is denser than water. Take m(nucleon) $= 1.67 \times 10^{-27}$ kg and $R_0 = 1.2 \times 10^{-15}$m.

SECTION-D

31. (a) Obtain the expression for the potential due to an electric dipole of dipole moment *p* at a point '*x*' on the axial line.
(b) Two identical capacitors of plate dimensions : *l* × *b* and plate separation *d* have dielectric slabs filled in between the space of the plates as shown in the figures.



Obtain the relation between the dielectric constants K, K_1 and K_2.

OR

A parallel plate capacitor with air as dielectric is charged by a d.c. source to a potential V. Without disconnecting the capacitor from the source, air is replaced by another dielectric medium of dielectric constant 10. State with reason, how does

(i) electric field between the plates and

(ii) energy stored in the capacitor change.

32. (a) Why photoelectric effect cannot be explain on the basis of wave nature of light? Give reasons.

(b) Write the basic features of photon picture of electromagnetic radiation on which Einstein's photoelectric equation is based.

OR

Write Einstein's photoelectric equation and mention which important features in photoelectric effect can be explained with the help of this equation.

The maximum kinetic energy of the photoelectrons gets doubled when the wavelength of light incident on the surface changes from λ_1 to λ_2. Derive the expressions for the threshold wavelength λ_0 and work function for the metal surface.

33. (a) Write the necessary conditions to obtain sustained interference fringes.

(b) In Young's double slit experiment, plot a graph showing the variation of fringe width versus the distance of the screen from the plane of the slits keeping other parameters same. What information can one obtain from the slope of the curve?

(c) What is the effect on the fringe width if the distance between the slits is reduced keeping other parameters same?

OR

(a) Write two characteristics features distinguishing the diffraction pattern from the interference fringes obtained in Young's double slit experiment.

(b) Two wavelengths of sodium light 590 nm and 596 nm are used, in turn, to study the diffraction taking place due to a single slit of aperture 1×10^{-4} m. The distance between the slit and the screen is 1.8 m. Calculate the separation between the position of the first maxima of the diffraction pattern obtained in the two cases.

SECTION-E

34. Case Study: Series LCR Circuit and Resonance

Read the following paragraph and answer the questions.

In a series LCR circuit with an ideal ac source of peak voltage $E_0 = 50V$, frequency $v = \frac{50}{\pi}$ Hz and $R = 300\Omega$. The average electric field energy stored in the capacitor and average magnetic energy stored in the coil are 25 mJ and 5 mJ respectively. The value of RMS current in the circuit is 0.1 A. Then find :

(i) Find the capacitance (C) of the capacitor.

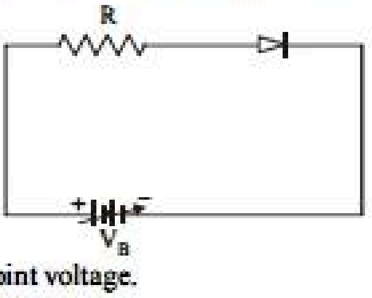
(ii) Find the inductance (L) of inductor.

(iii) Find the sum of rms potential difference across each of the three elements.

OR

(iii) In a series combination of R, L and C to an A.C. source at resonance, if R = 20 ohm, then find the impedance Z of the combination.

35. Case Study: P-N Junction Diode and its Characteristics



Read the following paragraph and answer the questions.

A Si diode (p-n junction) is connected to a resistor and a biasing battery of variable voltage V_B. Assume that the diode requires a minimum current of 1 mA to be above the knee point 0.7 V of its V-I characteristic curve. Also assume that the voltage V across the diode is independent of current above the knee (cut-off) point

(i) If $V_B = 5V$, then find the maximum value of R so that the voltage V is above the knee point voltage.

(ii) If $V_B = 5V$, then find the value of R in order to establish a current of 5 mA in the circuit.

(iii) If $V_B = 6V$ and 5mA current flows through the circuit, then calculate the power dissipated in R.

OR

(iii) A semiconductor device is connected in a series circuit with a battery and a resistance. A current is found to pass through the circuit. If the polarity of the battery is reversed, the current drops to almost zero. Name the device.

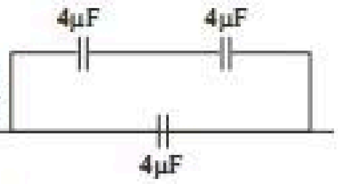
Solutions

SAMPLE PAPER-6

1. (d) To get effective capacitance of 6 μF two capacitors of 4 μF each connected in series and one of 4 μF capacitor in parallel with them.

Two capacitors in series

$\therefore \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$



1 capacitor in parallel

$\therefore C_{eq} = C_3 + C = 4 + 2 = 6\,\mu F$ (1 mark)

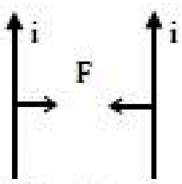
2. (c) Equating magnetic force to centripetal force,

$\frac{mv^2}{r} = qvB \sin 90°$

Time to complete one revolution,

$T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}$ (1 mark)

3. (b) $\frac{F}{\ell} = \frac{\mu_0 i_1 i_2}{2\pi d} = \frac{\mu_0 i^2}{2\pi d}$



(1 mark)

(attractive as current is in the same direction)

4. (d) All other statements except (iv) are incorrect. The electric field over the Gaussian surface remains continuous and uniform at every point. (1 mark)

5. (c) Current sensitivity of a galvanometer = deflection per unit current. (1 mark)

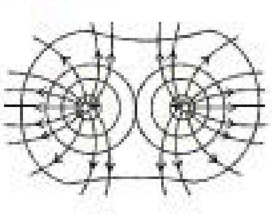
6. (c) Here, $N = 100$
$R = 9$ cm $= 9 \times 10^{-2}$ m, and $I = 0.4$ A

Now, $B = \frac{\mu_0 NI}{2R} = \frac{2\pi \times 10^{-7} \times 100 \times 0.4}{9 \times 10^{-2}}$

$= \frac{2 \times 3.14 \times 0.4}{9} \times 10^{-3}$

$= 0.279 \times 10^{-3}$ T $= 2.79 \times 10^{-4}$ T (1 mark)

7. (c) Equipotential surfaces arenormal to the electric field lines. The following figure shows the equipotential surfaces along with electric field lines for a system of two positive charges.



(1 mark)

8. (a) $n_d \sin i_c = n_r \sin 90°$ ($\because$ From Snell's law)

$\sin i_c = \frac{n_r}{n_d} = \frac{v_d}{v_r}$ $\left(\therefore v = \frac{c}{n}\right)$

$\sin i_c = \frac{1.5 \times 10^8}{2 \times 10^8} = \frac{1.5}{2}$

$\sin i_c = \frac{3}{4}$ $\tan i_c = \frac{3}{\sqrt{4^2 - 3^2}} \Rightarrow \frac{3}{\sqrt{7}}$

The critical angle between them, $i_c = \tan^{-1}\left(\frac{3}{\sqrt{7}}\right)$

(1 mark)

9. (d) Diffraction on a single slit is equivalent to interference of light from infinite number of coherent sources contained in the slit. (1 mark)

10. (c) A slit would give divergent; a biprism would give double; a glass slab would give a parallel wavefront. Edge is downward. (1 mark)

11. (b) If $R_1 = R, R_2 = -2R$

$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{6} = (1.5 - 1)\left(\frac{1}{R} + \frac{1}{2R}\right) = \frac{0.5 \times 3}{2R}$

$R = 4.5$ cm (1 mark)

12. (b) Transition from higher states to n = 2 lead to emission of radiation with wavelengths 656.3 nm and 365.0 nm. These wavelengths fall in the visible region and constitute the Balmer series. (1 mark)

13. (b) In p-type semiconductor, trivalent impurities are added to intrinsic semiconductor, which creates holes which are majority charge carriers. (1 mark)

14. (d) $M_{microscope} \Rightarrow$ decrease
$M_{telescope} \Rightarrow$ increase (1 mark)

15. (c) μ_{ferro} is maximum (1 mark)

16. (c) $X_L \propto V$ (1 mark)

17. (a) Different types of electromagnetic waves have different frequencies. Also, they travel through vacuum with same speed. (1 mark)

18. (b) (1 mark)

19. Here, $n = 200, A = 900 mm^2 = 900 \times 10^{-6}\, m^2, I = 2A, B = 0.5\,T$

(i) Magnetic moment of the coil $M = nIA$
$= 200 \times 2 \times 900 \times 10^{-6} = 36 \times 10^{-2}\, Am^2$ (1 mark)

(ii) Torque acting on the coil $\tau = MB \sin\theta$
$= 36 \times 10^{-2} \times 0.5 \times 0 = 0$ $[\theta = 0°]$ (1 mark)

20.

Intrinsic Semiconductor	Extrinsic Semiconductor
1. It is pure semiconducting material and no impurity atoms are added to it.	1. It is prepared by doping a small quantity of impurity atoms to the pure semiconducting material.
Examples are crystalline forms of pure silicon and germanium.	Examples are silicon and germanium crystals with impurity atoms of arsenic, antimony, phosphorous etc. or indium, boron, aluminium etc.
2. The number of free electrons in conduction band and the number of holes in valence band is exactly equal and very small indeed.	2. The number of free electrons and holes is never equal. There is excess of electrons in n-type semiconductors and excess of holes in p-type semiconductors.
3. Its electrical conductivity is low.	3. Its electrical conductivity is high.
4. Its electrical conductivity is a function of temperature alone.	4. Its electrical conductivity depends upon the temperature as well as on the quantity of impurity atoms doped in the structure.

(½ × 4 = 2 marks)

21. Potential difference between the plates

$\Delta V = 10 - 0 = 10$ V (B is grounded so its potential is zero)

(i) $E = \dfrac{\Delta V}{d} = \dfrac{10}{10^{-2}} = 10^3$ V/m (1 mark)

(ii) Plate A is an equipotential surface.

Hence work done in moving a charge of 10 μC from X to Y is zero. (1 mark)

22. Characteristics of electromagnetic waves:

(i) They travel in free space with the same speed equal to $c = 3 \times 10^8$ m/s

(ii) Electromagnetic waves are transverse in nature. Velocity of electromagnetic waves in any medium is given by

$v = \dfrac{1}{\sqrt{\mu\varepsilon}}$,

where μ is the permeability and ε is the permittivity of the medium (2 × 1 = 2 marks)

OR

(i) Microwaves

(ii) Radio waves

(iii) Gamma rays

(iv) X-rays. (½ × 4 = 2 marks)

23. (i) **Lenz's law :** Whenever the magnetic flux linked with a circuit changes, an induced emf is produced and the direction of the induced current is such that it opposes the cause which produces it. (1 mark)

(ii) Yes, emf will be induced in the metallic rod because there will be a change of magnetic flux. The metallic rod will cut the magnetic lines of the earth's magnetic field. (1 mark)

OR

As $\Delta I = -2$ A

$\Delta t = 10 \times 10^{-3}$ s

$V = 200$ V

As we know, $e = -L\dfrac{\Delta I}{\Delta t}$

$\therefore\ 200 = -L\left(\dfrac{-2}{10 \times 10^{-3}}\right)$

$200 = L \times 2 \times 10^2$

L = 1H

(2 × 1 = 2 marks)

24. (a) Angular width, $\Delta\theta = \dfrac{\beta}{D} = \dfrac{(\lambda D/d)}{D} = \dfrac{\lambda}{d}$

$\therefore\ d = \dfrac{\lambda}{\Delta\theta} = \dfrac{6000 \times 10^{-10}(m)}{1° \times \pi/180(rad)}$

$= 3.44 \times 10^{-5}$m = 0.0344 mm (1 mark)

(b) The frequency and wavelength of reflected wave will not change.

The refracted wave will have same frequency.

The velocity of light in water is given by,

$v = \lambda f$ (1 mark)

where, v = velocity of light

λ = wavelength of light

f = frequency of light

If velocity will decrease, wavelength (λ) will also decrease.

25. Here, $\mu = \sqrt{2}$, $A = 60°$

As, $r_1 + r_2 = A$ for minimum deviation

$r_1 = r_2 = \dfrac{A}{2} = \dfrac{60°}{2} = 30°$ (1 mark)

As, $\mu = \dfrac{\sin_1}{\sin_1} = \sqrt{2} \times \sin 30° = \sqrt{2} \times \dfrac{1}{2} = \dfrac{1}{\sqrt{2}}$

$\sin i_1 = \sin 45°\ \ \therefore i = 45°$ (1 mark)

26. Let a current I flows through the outer coil of radius R. The magnet field at the centre of the coil is

$B = \dfrac{\mu_0 I}{2R}$ (1 mark)

As r << R, hence B may be considered to be constant over the centre cross-sectional area of inner coil of radius r. Hence, magnetic flux linked with the smaller coil will be

$\phi_1 = BA_1 = \dfrac{\mu_0 I}{2R}\pi r^2$ (1 mark)

As we know, $\phi_1 = M_{12}I_2$

Now mutual inductance $M_{12} = \frac{\phi_1}{I_2} = \frac{\mu_0 r^2}{2R}$

But, $M_{12} = M_{21}$ = suppose, M

$\therefore \quad M = \frac{\mu_0 \pi r^2}{2R}$ (1 mark)

OR

Magnetic field at a point inside the solenoid is $B = \frac{\mu_0 NI}{\ell}$

Where N is the total number of turns of the solenoid and l is its length. B is constant throughout the length of the solenoid.

Magnetic flux through each turn = B × area of each turn.

$\therefore \quad \phi_1 = \mu_0 \frac{N}{\ell} I \times A$ (1 mark)

where A is the area of each turn.

$\therefore$ Total magnetic flux linked with the solenoid = ϕ

$= \mu_0 \frac{N}{\ell} IA \times N$ (1 mark)

But from the definition of self inductance (L), $\phi = LI$.

$\therefore \quad LI = \mu_0 \frac{N}{\ell} IA \times N \Rightarrow L = \frac{\mu_0 N^2 A}{\ell}$ (1 mark)

27. E.m.f of a cell is defined as the maximum potential difference between the two electrodes of the cell when no current is drawn from the cell (ie, in open circuit). (1 mark)

The e.m.f of a cell depends upon the nature of electrodes, concentration and nature of electrolyte and its temperature. (1 mark)

Consider a cell of emf E, internal resistance r connected to an external resistor R. Total resistance of the circuit = R + r ....(1)

$\therefore$ Current flowing in the circuit

$I = \frac{E}{R+r}$ ....(2)

Potential difference across internal resistance r = Ir ....(3)

$\therefore$ Terminal potential difference

V = E – Ir ....(4)

or, $V = \frac{E}{R+r} R$ (Since V = IR) ....(5)

(1 mark)

From (4) we can see that emf is more than potential difference.

28. The electric dipole moment of dipole has the magnitude

$p = ql = 2 \times 10^{-6} \times 10^{-2} = 2 \times 10^{-8}$ C-m (1 mark)

The electric field at the point P on the axis of dipole has the magnitude

$$E = \left(\frac{1}{4\pi\varepsilon_0}\right)\left(\frac{2p}{r^3}\right) = (9\times10^9)\left(\frac{2\times2\times10^{-8}}{1^3}\right)$$

= 360 N/C (1 mark)

The electric field at the point P on the equator of dipole has the magnitude

$$E = \left(\frac{1}{4\pi\varepsilon_0}\right)\left(\frac{p}{r^3}\right) = (9\times10^9)\left(\frac{2\times10^{-8}}{1^3}\right) = 180 \text{ N/C}$$

(1 mark)

29. Here, Z = 80, KE = K = 8 MeV

$= 8 \times 10^6 \times 1.6 \times 10^{-19}$ J

$\because$ Energy conservation law,

$K = \frac{(Ze)(2e)}{4\pi\varepsilon_0 r_0}$ (1 mark)

where r_0 = distance of closest appreach.

$r_0 = \frac{2Ze^2}{4\pi\varepsilon_0(K)}$

$= \frac{(9\times10^9 \times 2\times80\times0.6\times10^{-19})^2}{8\times10^6\times1.6\times10^{-19}}$

$r_0 = 2.88 \times 10^{-19}$ m $= \frac{1}{K}$ (1 mark)

If KE gets doubled, distance of closest approach reduces to half. (1 mark)

OR

Let there be an electron revolving in an orbit of radius 'r' with velocity v. The orbit is equivalent to a magnetic shell of magnetic moment

M = IA ... (i)

(1 mark)

Where I is the current and A is the area of the orbit.

Now, I is given by

$I = \frac{e}{T} = \frac{ev}{2\pi r}$ ... (ii)

From eqs.(i) and (ii)

$M = \frac{ev}{2\pi r} \times \pi r^2 = \frac{evr}{2}$ ...(iii)

(1 mark)

According to Bohr's theory angular momentum

$mvr = \frac{nh}{2\pi}$ or $vr = \frac{nh}{2\pi m}$ ... (iv)

From equations (iii) and (iv),

$M = \frac{neh}{4\pi m}$ ... (v)

For the ground state n = 1

Therefore magnetic moment, $M = \frac{eh}{4\pi m}$ (1 mark)

30. Density of water $= 10^3$ kg/m$^3 = \rho_w$

Density of a nucleon $= \frac{\text{mass}}{\text{valume}} = \rho_n$

$$\rho_n = \frac{m}{\frac{4}{3}\pi R_0^3} = \frac{1.67\times10^{-27}}{\frac{4}{3}\times3.14\times(1.2\times10^{-15})^3}$$

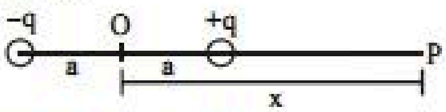
(1 mark)

$$= \frac{1.67\times10^{-27}}{4.185\times1.2\times1.2\times1.2\times10^{-45}}$$

$= \frac{1.67}{7.23} \times 10^{18} = 0.23 \times 10^{18} = 23 \times 10^{16}$ (1 mark)

Ratio $\frac{\rho_n}{\rho_w} = \frac{23 \times 10^{16}}{10^3} = 23 \times 10^{13} = 2.3 \times 10^{14}$. (1 mark)

31. (a) Let there be an electric dipole of length 2a and having charges +q and −q. We have to find potential on the axial line at point P at a distance OP = x from the centre O of the dipole.



Potential at point P

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{x-a} + \frac{1}{4\pi\varepsilon_0}\frac{-q}{x+a}$$ (1 mark)

or $$V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{x-a} - \frac{1}{x+a}\right)$$

$$= \frac{q}{4\pi\varepsilon_0}\left(\frac{2a}{x^2-a^2}\right)$$

$$V = \frac{p}{4\pi\varepsilon_0(x^2-a^2)} \quad (\because p = q \times 2a)$$ (1 mark)

(b) When there is no dielectric, then capacitance

$$C = \frac{\varepsilon_0 lb}{d}$$

For the first capacitor, capacitance

$$C' = \frac{K\varepsilon_0 lb}{d} = KC \quad \text{...(i)}$$

(1 mark)

In second case two capacitors connected in parallel

$$C_1 = \frac{K_1\varepsilon_0 lb}{2d} \text{ and } C_2 = \frac{K_2\varepsilon_0 lb}{2d}$$

$$\therefore \quad C'' = C_1 + C_2 = \frac{K_1\varepsilon_0 lb}{2d} + \frac{K_2\varepsilon_0 lb}{2d}$$

or $$C'' = C\frac{(K_1+K_2)}{2} \quad \text{....(ii)}$$

(1 mark)

If the capacitance in each case be same, then from equ.(i) and (ii)

$$K = \left(\frac{K_1+K_2}{2}\right)$$ (1 mark)

OR

This work is stored as P.E. of the capacitor.

$$C_0 = \frac{\varepsilon_0 A}{d},\ C = \frac{k\,\varepsilon_0\,A}{d} \text{ and } Q = C_0V$$

Here, $C = 10\,C_0 \quad (\because k = 10)$

$\therefore \quad Q' = CV = 10Q$ (2 marks)

(i) $E = \frac{V}{d}$, as potential (V) and distance between the plates (d) is not changed, E also does not change. (1 mark)

(ii) $E_{initial} = \frac{1}{2}C_0V^2$

$$E_{final} = \frac{1}{2}(10C_0)V^2 = 10 \times \frac{1}{2}C_0V^2$$

$= 10E_{initial}$ (2 marks)

32. (a) When light wave is incident on photoelectric material, the photoelectrons should be emitted (after a long time) if work function is large. But no photoelectron is emitted by incident radiations if the frequency is less than the threshold frequency. The energy of the ejected electrons also has no relevance with the intensity of incident light, although according to the wave nature, it should be there. If the light is incident for a longer interval of light, the energy should also have increased. That is why photoelectric effect is not explained on the basis of wave nature of light. (2 marks)

(b) Basic features of photon picture :

(i) A photon of frequency ν is a packet of energy E = hν, where h is a planck's constant.

(ii) While interacting with matter photons behave as if they are all particles.

(iii) All photons travel in vacuum with the same velocity. However, their velocity in different media is different.

(iv) There is no charge on a photon. They are not deflected by electric and magnetic fields.

(v) The energy of a photon does not depend upon the intensity of radiation.

(vi) When it interacts with a photoelectric material, it is completely absorbed and loses its identity.

(vii) Its collisions with the electron in the photoelectric material is elastic i.e., total energy and momentum are conserved during the collision. (3 marks)

OR

Einstein's photoelectric equation

$$h\nu = h\nu_0 + \frac{1}{2}mv^2$$

$h\nu = h\nu_0 + eV_s$, (1 mark)

where v is the velocity of the ejected electrons and V_s is the stopping potential.

This equation is based on the following properties of photons:

(i) A photon is a packet of energy. It frequency and h plank's constant.

(ii) When a photon is incident on a photoelectric material, it is completely absorbed by the electron. The energy of the photon is used in ejecting electron and the balance if any is used up in imparting kinetic energy to the electron.

(½ × 2 = 1 mark)

Two important observation which can be explained by the equation :

(i) The photoelectric emission takes place only if the incident light has a frequency greater than the threshold frequency v_0. If $v < v_0$, then $\frac{1}{2}mv^2$ will be –ve, which is not possible. Hence, electron will not be emitted.(1 mark)

(ii) When the frequency of the incident light increases, then $\frac{1}{2}mv^2$ i.e., kinetic energy of electron increases because work function = hv_0 is fixed. With increase in frequency more and more energy is available to the electron ejected and hence stopping potential also increases.

According to the photoelectric equation.

$$K_{max} = \frac{1}{2}mv^2_{max} = hv - \phi_0$$

$$K_{max} = \frac{hc}{\lambda_1} - \phi_0 \text{ .... (i)}$$

Let the maximum kinetic energy for the wavelength of the incident λ_2 be K_{max}

$$K_{max} = \frac{hc}{\lambda_2} - \phi_0 \text{ ......(ii)}$$ (1 mark)

From equations (i) and (ii) we have

$$\frac{hc}{\lambda_2} - \phi_0 = 2\left(\frac{hc}{\lambda_1} - \phi_0\right)$$

$$\Rightarrow \phi_0 = hc\left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right) \Rightarrow hv_0 = hc\left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right)$$

$$\Rightarrow \frac{c}{\lambda_0} = c\left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right) \Rightarrow \frac{1}{\lambda_0} = \left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right)$$

$$\Rightarrow \lambda_0 = \frac{\lambda_1\lambda_2}{2\lambda_2 - \lambda_1}$$ (1 mark)

33. (a) The necessary conditions to obtain sustained interference fringes are:

(i) The two sources of light must be coherent.

(ii) The two sources should preferably be monochromatic.

(iii) The coherent sources must be very close to each other. (1 mark)

(b) The fringe width in Young's double slit experiment is given by

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

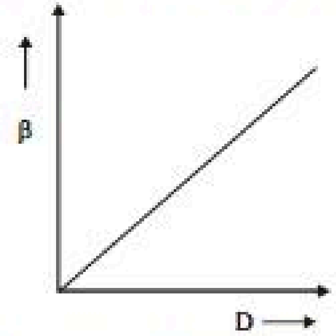
where λ = wavelength of source

D = distance between the slits and screen

d = distance between the slits

$\Rightarrow \beta \propto D$ (1 mark)

The variation of fringe width with distance of screen from the slits is given by the graph shown below:



(1 mark)

It is a linear graph with slope equal to λ/d , So. for the fringe width to vary linearly with distance of screen from the slits, the ratio of wavelength to distance between the slits should remain constant. Therefore, it is advised to take wavelengths of incident light nearly equal to the width of the slit. (1 mark)

(c) Fringe width is given by

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

Hence, if the distance between the slits is reduced then the width of the fringes increases. (1 mark)

OR

(a)

	Diffraction		Interference
1	The diffraction pattern has a central bright maximum which is twice as wide as other maxima.	1	The interference has a number of equally spaced bright and dark bands
2	The diffraction pattern is a superposition of waves originating from each point on a single slit.	2	The interference pattern is due to the superposition of waves emanating from the two narrow slits.

(2 × 1 = 2 marks)

(b) Given : $a = 1 \times 10^{-4}$ m, D = 1.8 m,

$\lambda_1 = 590 \text{ nm} = 590 \times 10^{-9}$ m,

$\lambda_2 = 596 \text{ nm} = 596 \times 10^{-9}$ m

To obtain first maxima, phase difference,

$$a\sin\theta = (2n+1)\frac{\lambda}{2}$$ (1 mark)

for $n = 1$ $a\sin\theta = 3\frac{\lambda}{2}$

or $a.\frac{y}{D} = 3\frac{\lambda}{2} \Rightarrow y = \frac{3}{2}\lambda\frac{D}{a}$ (1 mark)

Separation between the positions of the first maxima

$= y_2 - y_1 = \frac{3}{2}\frac{D}{a}\lambda_2 - \frac{3}{2}\frac{D}{a}\lambda_1 \qquad = \frac{3}{2}\frac{D}{a}(\lambda_2 - \lambda_1)$

$= \frac{3}{2} \times \frac{1.8}{1 \times 10^{-4}} \times (596 - 590) \times 10^{-9}$

$= 16.2 \times 10^{-5}$ m (1 mark)

34. (i) Av. electric field energy (1 mark)

$= \left(\frac{1}{2}CV_{rms}^2\right) = 25 \times 10^{-3}$ J

$\therefore \quad \frac{1}{2}C \times (I_{rms} X_C)$

$\therefore \quad \frac{1}{2} \times C.I^2_{rms} \times \frac{1}{4\pi^2 v^2 c^2} = 25 \times 10^{-3}$ J

$\therefore \quad C = 20\mu F$ (1 mark)

(ii) Av. magnetic energy $\left(\frac{1}{2}LI_{rms}^2\right)$

$\therefore \quad L = \frac{2 \times 5 \times 10^{-3}}{(.10)^2} \Rightarrow L = 1$ henry (1 mark)

(iii) The sum for rms voltage across C, rms voltage across R and rms voltage across L is not equal to rms voltage across ideal ac source. (1 mark)

OR

(iii) At resonance inpedence Z = R

35. (i) $V_B = I(R_D + R)$ (1 mark)

$\Rightarrow 5 = 1 \times 10^{-3}\left(\frac{0.7}{10^{-3}} + R\right)$

$\Rightarrow R = 4.3\ k\Omega$

(ii) $V_B = I(R_D + R)$ (1 mark)

$\Rightarrow 5 = 5 \times 10^{-3}\left(\frac{0.7}{5mA} + R\right)$

$\Rightarrow 1\ k\Omega = 180\Omega + R$

$\Rightarrow R = 860\Omega$ (1 mark)

(iii) Power = VI = $(6 - 0.7) \times 5 \times 10^{-3}$ W

= 26.4mW (1 mark)

OR

(iii) p-n junction diode