Subject- Physics (Theory)

Time- 3 Hours **Session- (2024-25)** **Maximum Mark- 70**

General Instructions

(1) There are 33 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.
(3) All the sections are compulsory.
(4) **Section A** contains **sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each**, **Section B** contains **five questions of two marks each**, **Section C** contains seven questions of three marks each, **Section D** contains **two case study-based questions of four marks each** and **Section E** contains **three long answer questions of five marks each**.
(5) There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants where ever necessary
i. $c = 3 \times 10^8$ m/s
ii. Mass of electron = 9.1×10^{-31} kg
iii. Mass of Proton = 1.7×10^{-27} kg
iv. $e = 1.6 \times 10^{-19}$ C
v. $\mu_0 = 4\pi \times 10^{-7}$ T m $\boldsymbol{A^{-1}}$
vi. $h = 6.63 \times 10^{-34}$ J s
vii. $\varepsilon_0 = 8.854 \times 10^{-12}$ $\boldsymbol{C^2N^{-1}m^{-2}}$
viii. Avogadro's number = 6.023 X $\mathbf{10^{23}}$ per gram mole.

SECTION- A

Q1. What will be the nature of equipotential surfaces due to a point charge, situated at infinity?
a) Plane surface b) Spherical c) Elliptical d) Cylindrical

Q2. If the force acting on a point charge kept on the axis of an electric dipole is F, what will be the amount of force if the distance of the point charge is doubled from the dipole?
a) 2F b) F/8 c) F/2 d) F/4

Q3. During Einstein's Photoelectric Experiment, what changes are observed when the frequency of the incident radiation is increased?
a) The value of saturation current increases b) No effect
c) The value of stopping potential increases d) The value of stopping potential decreases

Q4. What is the order of the radius of an electron orbit in a hydrogen atom?

a) 10^{-8} m b) 10^{-9} m c) 10^{-11} m d) 10^{-13} m

Q5. What is the force exerted by a stationary charge when it is placed in a magnetic field?

a) Zero b) Maximum c) Minimum d) Depends on the strength of the magnetic field

Q6. If a material is ferromagnetic, what shall be the value of χ?

a) Negative b) Small and positive c) Large and Positive d) Insufficient information

Q7. Pick out the expression for galvanometer constant from the following?

a) G = kNAB b) G = k × NAB c) G = NABk d) 1G=kNAB

Q8. The magnetization is defined by the ratio of

a) Magnetic moment to area b) Magnetic moment to volume

c) Magnetic flux density to area d) Magnetic flux density to volume

Q9. What is the function of a transformer?

a) Transformer is used to step down or up the AC voltages and currents

b) Transformer is used to step down or up the DC voltages and currents

c) Transformer converts DC to AC voltages

d) Transformer converts AC to DC voltages

Q10. What is the velocity of electromagnetic wave in free space?

a) $c = \sqrt{\mu_0\varepsilon_0}$ b) $c = 1/\sqrt{\mu_0\varepsilon_0}$ c) $c = 1/\mu_0\varepsilon_0$ d) $c = \mu_0\varepsilon_0$

Q11. What happens to the current in a coil while accelerating a magnet inside it?

a) Increases b) Decreases c) Remains constant d) Reverses

Q12. What will be the longest wavelength in the Balmer series of hydrogen spectrum?

a) 6557×10^{-10} m b) 5557×10^{-10} m c) 9557×10^{-10} m d) 1557×10^{-10} m

For Questions 13 to 16, two statements are given –one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

A. If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true but Reason is false.

D. If both Assertion and Reason are false.

Q13. **Assertion**: Though light of a single frequency (monochromatic) is incident on a metal, the energies of emitted photoelectrons are different.

Reason: The energy of electrons emitted from inside the metal surface, is lost in collision with the other atoms in the metal

Q14. **Assertion**: If the temperature of a semiconductor is increased then its resistance decreases.

Reason: The energy gap between conduction band and valence band is very small.

Q15. **Assertion**: According to classical theory the proposed path of an electron in Rutherford atom model will be parabolic.

Reason: According to electromagnetic theory an accelerated particle continuously emits radiation.

Q16. **Assertion**: The critical angle is the minimum angle of incidence at which total internal reflection occurs.

Reason: Total internal reflection occurs when light travels from a denser medium to a rarer medium at an angle greater than the critical angle.

SECTION-B

Q17. What is the result of doping germanium metal with a little quantity of indium? What are the majority charge carriers in n-type and p-type semiconductors.

Q18. Write Einstein's photoelectric equation and point out any two characteristic properties of photons on which this equation is based.

Q19. The objective of a telescope is of larger focal length and of larger aperture compared to the eyepiece. Give reasons?

OR

Write the advantages of reflecting type telescope over Refractive type telescope.

Q20. Plot a graph showing the variation of resistivity with temperature for (i) Copper and (ii) Nichrome.

Q21. The radii of curvature of the faces of a double convex lens are 10cm and 15cm. If the focal length of the lens is 12cm, find the refractive index of the material of the lens?

SECTION-C

Q22. Suppose, we think of fission of a $^{56}_{26}Fe$ nucleus into two equal fragments, $^{28}_{13}Al$. Is the fission energetically possible? Mass of $^{56}_{26}Fe$ = 55.934939u, mass of $^{28}_{13}Al$=26.98153 u.

Q23. Two Point charges +q and +9q are separated by a distance of 10 a. Find the point on the line joining the two changes where electric field is zero?

Q24. Find the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its a) second permitted energy level to the first level and b) The highest permitted energy level to the first permitted level.

Q25. What is drift velocity? Derive expression for drift velocity of electrons in a good conductor in terms of relaxation time of electrons?

Q26. What is radial magnetic field? How it is obtained in moving coil galvanometer?

Q27. Name the part of the electromagnetic spectrum, which is suitable for (i) Radar system used in aircraft navigation (ii) Treatment of cancer tumours (iii) Produced in nuclear reaction (iv) Produced by bombarding a metal target by high speed electrons.

Q28. Define the term self-inductance. Write its SI unit. Give 2 factors on which self-inductance of air core coil depends.

SECTION-D
CASE STUDY BASED QUESTIONS

Q29. Power (P) of a lens is given as the reciprocal of focal length (P=1/f) where f should be in meter and P is in Diopter. For convex power is positive and concave power is –ve. When two or more lenses are kept in contact then power of the combined lens is given as P= P1 + P2+P3 ……. Desired power of lens may be obtained by suitable combination of lenses. When a glass lens is immersed in a liquid its focal length and power are changed according to the relative refractive index of the liquid.

i) A convex lens of focal length 30cm is placed coaxially in contact with a concave lens of focal length 20cm the system will be-

(a) converging in nature (b) diverging in nature
(c) can be converging or diverging (d) None of the above.

ii) The two lenses of power +1.5D and +1.0D are placed in contact then the effective focal length of the combination will be-

(a) 20 cm (b) 30 cm (c) 40 cm (d) 50 cm

iii)Two thin lenses are in contact and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, the focal length of the other would be-

(a) -26.7 cm (b) 60 cm (c) 80 cm (d) -20 cm

iv) A lens has a power of +4D in air. What will be the power of the lens if it is completely immersed in water? Given, $\mu_g = 3/2$ and $\mu_w = 4/3$

a) 2 D b) 3 D c) 1 D d) 4 D

OR

Two thin lenses of focal length +10cm and -5cm are kept in contact, the power of the combination is?

a) -10D b) -20D c) 10D d) 15

Q30. A prism is a portion of a transparent medium bounded by two planes face inclined to each other at a suitable angle. A ray of light suffers two refractions on passing through a prism and hence deviates through a certain angle from its original path. The angle of deviation of a prism is d = (μ-1) A, through which a ray deviates on passing through a thin prism of small refracting angle A. If μ is the refractive index of the material of the prism is given by

$$\mu = \frac{\sin(A + dm/2)}{\sin(A/2)}$$

i) The angle of the prism is equal to the angle of minimum deviation for a prism of refractive index 1.5. What is the value of the angle of the prism? (Use $\cos 41^0 = 0.75$)

a) 41^0 b) 82^0 c) 62^0 d) 31^0

ii) For which colour, angle of deviation is minimum –

a) Red b) Yellow c) Violet d) Blue

iii) When white light passes through the achromatic combination of prism, then what is observed-

a) Dispersion b) Deviation

c) Dispersion and deviation d) None of the above

iv) A prism (μ=1.5) has a refracting angle of 30^0. The deviation of a monochromatic ray incident normally on its one surface will be

a) 18^0 36’ b) 20^0 30’ c) 18^0 d) 19^0 30’

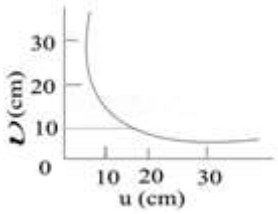
OR

The refractive angle of a prism for a monochromatic light is 60^0 and refractive index is √2. For minimum deviation, the angle of incidence will be-

a) 60^0 b) 45^0 c) 30^0 d) 75^0

SECTION-E

Q31. A lens forms a real image of an object. The distance of the object. From the lens is U cm and the distance of the image from the lens is v cm. The given graph shows the variation of v and U



(a) What is the nature of the lens?

(b) Using the graph find the focal length of the lens?

(c) Draw a ray diagram to show the formation of image of same size as that of object in case of converging lens hence derive lens equation?

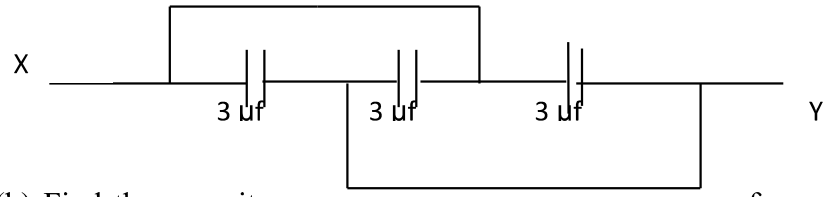
OR

A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double-slit experiment.

(a) Find the distance of the third bright fringe on the screen from the central maximum for wavelength 650 nm.

(b) What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincide?

Q32. a) Find the equivalence capacitance between X and Y.



(b) Find the capacitance of a system of three parallel plates each of area A m^2 separated by d_1 and d_2 m respectively. The space between them is filled with dielectrics of dielectric constant K_1 and K_2.

OR

(a) What happens to the capacitance of a capacitor when a copper plate of thickness one third of the separation between the plates is introduced in the capacitor?

(b) A 800 pF capacitor is charged by a 100V battery. After some time the battery is disconnected. The capacitor is then connected to another 800 pF capacitor. What is the electrostatic energy stored?

Q33. A series LCR circuit is connected to an ac source. Using the phasor diagram, derive the expression for the impedance of the circuit. Plot a graph to show the variation of current with frequency of the source, explaining the nature of its variation.

OR

A device X is connected across an ac source of voltage $v = v_m sin\omega t$. The current through X is given as $i = i_m \sin(\omega t + \frac{\pi}{2})$.

(a) Identify the device X and write the expression for its reactance.

(b) Draw graphs showing variation of voltage and current with time over one cycle of a.c. for X.

(c) How does the reactance of the device X vary with the frequency of the a.c. ? Show the variation graphically.

(d) Draw the phasor diagram for the device X.

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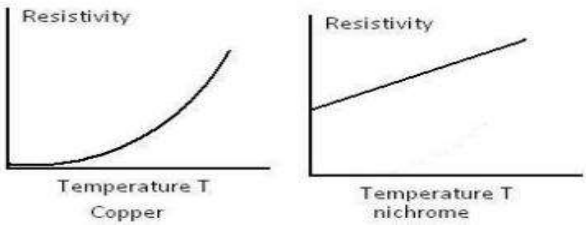
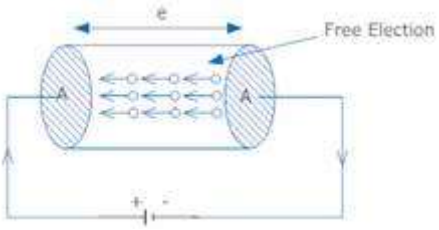
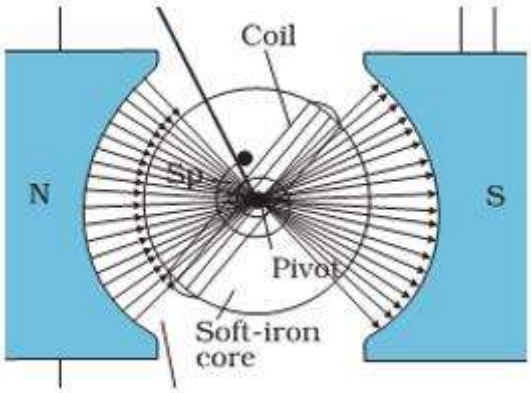
Marking Scheme

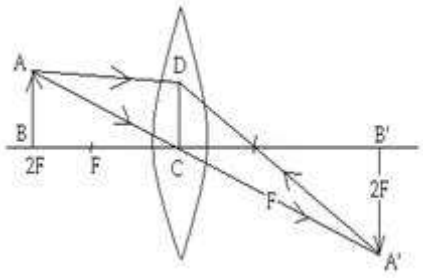
Q.No.	ANSWER	MARKS
1	Answer: a Explanation: If a point charge is situated at infinity, the electric field lines coming out of it will be in the form of parallel straight lines. As we know that field lines cut the equipotential surfaces orthogonally, therefore the equipotential surfaces must be plane surfaces. They can be considered the surface of a sphere of infinite radius	1
2	Answer: b Explanation: If the distance of a point charge, kept on the axis of a dipole, is sufficiently large than the separation between the charges of a dipole, then it can be shown that electric field E at a distance r from the dipole varies as E α 1r3. Now if the distance becomes 2r, electric field intensity will decrease by a factor of 23=8 times. Therefore, the force F will now become F/8	1
3	Answer: c Explanation: As the frequency of the incident radiation increases, the kinetic energies of the emitted electron increase as well and therefore requires more repulsive force to be applied to stop them. Thus, the stopping potential increases. The value of saturation current increases, as the intensity of the incident radiation, increases. The value of stopping potential decreases, as the frequency decreases	1
4	Answer: c Explanation: The radius of an electron orbit in a hydrogen atom is of the order of 10^{-11} m. It is equal to the most probable distance between the nucleus and the electron in a hydrogen atom in its ground state.	1
5	Answer: a Explanation: A stationary charge does not produce any magnetic field and it does not suffer any interaction against the external magnetic field. Hence the force exerted is zero.	1
6	Answer: c Explanation: When a material is ferromagnetic, the magnetic susceptibility, χ, is large and positive. For a diamagnetic material it is negative and for a paramagnetic material, it is small and positive	1

7	Answer: a Explanation: In a moving coil galvanometer, the current (I) passing through the galvanometer is directly proportional to its deflection (θ), i.e. $I = G\theta$ Where $G = kNAB$ ➔ Galvanometer constant N = number of turns in the coil; A = area of coil; B = strength of the magnetic field; k = torsional constant of the spring that means restoring torque per unit twist.	1
8	Answer: b Explanation: The magnetization refers to the amount of dipole formation in a given volume when it is subjected to a magnetic field. It is given by the ratio of the magnetic moment to the volume. Thus Pm = M/V.	1
9	Answer: a Explanation: A Transformer does not work on DC and operates only on AC, therefore it Step up or Step down the level of AC Voltage or Current, by keeping frequency of the supply unaltered on the secondary side.	1
10	Answer: b Explanation: The value of c is the same for all types of electromagnetic waves because the constants μ_0 and ε_0 do not depend on the frequency or wavelength of the electromagnetic waves. So, the velocity of electromagnetic wave in free space is given as: $c = 1/\sqrt{\mu_0\varepsilon_0}$	1
11	Answer: a Explanation: A change in the magnetic field induces an emf. When there is an emf, there has to be current. Hence, when the magnet is moved inside a coil, the current in it increases.	1
12	Answer: a Explanation: $1/\lambda = R\,[1/n^2_1 - 1/n^2_2]$ $1/\lambda = 1.098 \times 10^7\,[1/2^2 - 1/3^2]$ $\lambda = 36 \times 10^{-7}/5 \times 1.098$ $\lambda = 6557 \times 10^{-10}$ m.	1
13	Answer (a) When a light of single frequency falls on the electrons of inner layer of metal, then this electron comes out of the metal surface after a large number of collisions with atom of it's upper layer.	1
14	Answer (a) In semiconductors the energy gap between conduction band and valence band is small (1 eV). Due to temperature rise, electron in the valence band gain thermal energy and may jumpy across the small energy gap, (to the conduction band). Thus conductivity increases and hence resistance decreases.	1
15	Answer (d) According to classical electromagnetic theory, an accelerated charged particle continuously emits radiation. As electrons revolving in circular paths are constantly experiencing centripetal acceleration, hence they will be losing their energy	1
	continuously and the orbital radius will go on decreasing, form spiral and finally the electron will fall in the nucleus.	
16	Answer: (a) Both A and R are true and R is the correct explanation of A.	1

17	: P-type semiconductors are made from germanium impurities that include indium. In n-type semiconductors, electrons are the major charge carriers. In p-type semiconductors, holes are the major charge carriers.	1 1
18	If radiation of frequency (ν) greater than threshold frequency (ν_0) irradiate the metal surface,electrons are emitted out from the metal. So Einstein's photoelectric equation can be given as Kmax= 1⁄2 $mv^2 = h\nu - h\nu_O$ Characteristic properties of photons: (i)Energy of photon is directly proportional to the frequency (or inversely proportional to the wavelength. (ii) In photon-electron collision, total energy and momentum of the system of two constituents remains constant.	1 1
19	To have large light gathering power and a large magnifying power, Telescopes should have larger focal length and of larger aperture compared to the eyepiece. Or Advantages of reflecting type telescope over Refractive type telescope: i) free from chromatic and spherical aberration ii) less mechanical support is required	1 1 1 1
20		1 1
21	53.Given m=3 and f=-15cm $m=\frac{v}{u}$ $v = 3u$ $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ u=-20cm 54. $R_1 = +10cm$ $R_2 = -15cm$,$f = 12cm$ $\frac{1}{f}=(n-1)(\frac{1}{R_1}-\frac{1}{R_2})$ $\frac{1}{12}=(n-1)(\frac{1}{10}-\frac{1}{-15})$ $(n-1) = 0.5$ $n = 1 + 0.5 = 1.5$	1 1
22	The atomic mass of Fe = 55.93494.0 u The atomic mass of Al = 27.98191 u The Q value of this nuclear reaction is given as Q = [(mass of Fe) –(2 mass of Al)] c2 = [55.93494 – 2 × 27.9819119] c2 Q = (−0.02888 c2) u But we know that 1 u = 931.5 Mev/c2 Q = −0.02888 × 931.5 = −26.902 MeV The Q value of the fission is negative. Therefore, fission is not possible. For a possible fission reaction, the Q value should be positive	1 1 1

23	Let P be the pt where test charge (+qo) is present then electric field at pt. P will be zero if Field at pt. P due to +q = field at p+. P due to + 9q————1 $\vec{E} \Rightarrow \vec{EA} = \frac{K(+q)}{x^2} \vec{EB} = \frac{K(+9q)}{(10a-x)^2}$ Substituting in eq. 1 $\frac{K(+q)}{x^2} = \frac{K(+9q)}{(10a-x)^2}$ $(10a-x)^2 = 9x^2 \Rightarrow 10a-x = 3x$ $10a = 4x \Rightarrow x = \frac{10}{4}9$ $x = 2.5$ a from change (+q) Or 10 a - x = 10a - 2.5a = 7.5 a from change (+9q)	3
24	. As (hv)2 to 1 / (hv)infinity to 1 = $(1/1^2 - 1/2^2) / (1/1^2 - 1/\text{infinity}2)$ = ¾	3
25	If is defined as the average velocity with which free electrons gets drifted in a direction opposite to that of electric field. If m is the mass of the electron and e be the charge of electron, Then on application of the electric field E, acceleration acquired by the electron is $a = \frac{eE}{m}$ first eq. of motion $v = u + at$  since average initial velocity u = O V= υ d t = τ (relaxation time) =>vd = a τ $vd = \frac{e\,E\,\tau}{m}$ where e is the charge on electron, E is the electric field intensity, τ is the relaxation time and m is the mass of electron.	3

26	A radial magnetic field is one in which plane of the coil always lies in the direction of the magnetic field. It can be obtained by  (a) Properly cutting the pole pieces concave in shape. (b) Placing soft iron cylindrical core between the pole pieces.	3
27	(i) microwaves (ii) Gamma rays (iii) Gamma rays (iv) X-rays	3
28	Self -induction is the phenomenon of production of induced emf in the coil when a changing current passes through it. SI unit of self- inductance if Henry. Factors on which self- inductance depends (i) the total no. of turns in the coil. (j) The area of cross section of coil. (k) The permeability of the core of the coil.	3
29	i) (b) diverging in nature ii) (c) 40 cm iii) (a) -26.7 cm iv) c) 1 D OR (a)-10D	4
30	i) b) 82^0 Ii) (a) Red iii) b) Deviation iv) a) 18^0 36^0 OR b) 45^0	4

31	(a) convex lens (b) $\frac{1}{\upsilon}-\frac{1}{U}=\frac{1}{f}$ $When \quad U \to \infty$ $\frac{1}{\upsilon}=\frac{1}{f}$ i.e $\upsilon = f$  In the given graph f = 10cm. (c) $\Delta ABC \; and \; A'B'C \; are \; similar$ $\therefore \frac{A'B'}{AB}=\frac{B'C}{BC}$ ----(1) ΔDCF and $A'B'F$ are similar $\therefore \frac{A'B'}{DC}=\frac{B'F}{FC}$ $\Rightarrow \frac{A'B'}{DC}=\frac{B'F}{FC}=\frac{A'B'}{AB}$ —-(2) $(\because DC = AB)$ Combining equation (1) & (2) $\frac{B'C}{BC}=\frac{B'F}{BF}$ Using sign conventions $B'C = +\upsilon$ $BC = -U$ $B'F = B'C = FC$ $B'F = +\upsilon - f$	5

$FC = +f$

$\Rightarrow \frac{\upsilon}{-U} = \frac{\upsilon - f}{f}$

$\upsilon f = -\upsilon U + fU$

Divide by U υ f

$\frac{1}{U} = \frac{-1}{f} + \frac{1}{\upsilon}$

Or

$\frac{1}{f} = \frac{1}{\upsilon} - \frac{1}{U}$

Hence derived

OR

Ans. Wavelength of the light beam, $\therefore x = 3 \times 650 \frac{D}{d} = 1950\left(\frac{D}{d}\right) nm$

$n\lambda_2 = (n-1)\lambda_1$

$\lambda_1 = 650nm$

$\therefore n = 5$

Wavelength of another light beam, $\lambda_2 = 520nm$

Distance of the slits from the screen = D

Distance between the two slits = d

(a) Distance of the nth bright fringe on the screen from the central maximum is given by the relation,

$x = n\lambda_1\left(\frac{D}{d}\right)$

For third bright fringe. N=3

$\therefore x = 3 \times 650 \frac{D}{d} = 1950\left(\frac{D}{d}\right) nm$

(b) Let the nth bright fringe due to wavelength λ_2 and $(n-1)$th bright fringe due to wavelength λ_1 coincide on the screen. We can equate the conditions for bright fringes as:

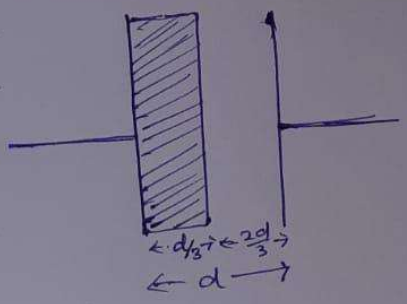
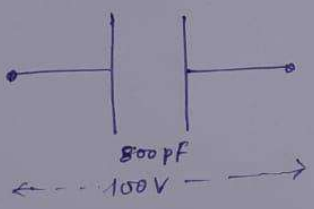
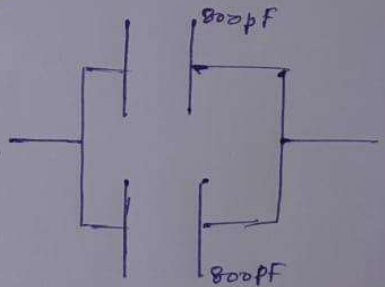
$n\lambda_2 = (n-1)\lambda 1$

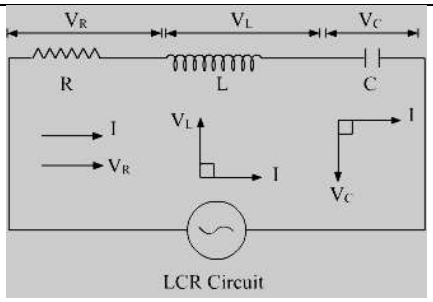
520n=650n-650

650=130n

$\therefore n = 5$

	Hence, the least distance from the central maximum can be obtained by the relation: $x = \lambda_2 \frac{D}{d}$ $= 5 \times 520 \frac{D}{d} = 260 \frac{D}{d} nm$ Note: The value of *d* and *D* are not given in the question.	
32	(a) Resultant capacitance in parallel C =3+3+3 =9micro farad (b) (b) Given system can be seen as series combination of two capacitors as shown n he figure. $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$ $\frac{1}{C} = \frac{d_1}{K_1 \varepsilon_0 A} + \frac{d_2}{K_2 \varepsilon_0 A}$ $C = \varepsilon_0 A K_1 K_2 \left(\frac{1}{K_2 d_1 + K_1 d_2} \right)$  OR	

	(a) The system will behave like a capacitor with plate separation $\frac{2d}{3}$. Before inserting the plate, capacitance $C_0 = \frac{\epsilon_0 A}{d}$ After inserting plate capacitance is $C = \frac{\epsilon_0 A}{2d/3} = \frac{3}{2}\left(\frac{\epsilon_0 A}{d}\right) = \frac{3}{2}C_0$  (b)   Charge stored in the capacitor before connecting to the other $q = CV$ $= 800 \times 10^{-12} \times 100$ $= 8.0 \times 10^{-8} C$ After redistribution of charges, charge on each capacitor $q' = 4.0 \times 10^{-8} C$ Total energy stored in the combination $U = 2 \times \frac{1}{2}\frac{q'^2}{C} = \frac{(4.0 \times 10^{-8})^2}{800 \times 10^{-12}}$ $\boxed{U = 2.0 \times 10^{-6} J}$	
33	Let an alternating Emf $E = E_0 \sin\omega t$ is applied to a series combination of inductor L, capacitor C and resistance R. Since all three of them are connected in series the current through them is same. But the voltage across each element has a different phase relation with current.	5



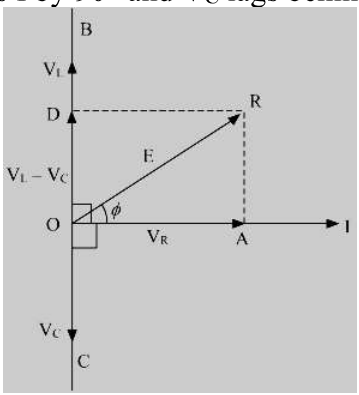
The potential difference V_L, V_C and V_R across L, C and R at any instant is given by $V_L = IX_L$, $V_C = IX_C$ and $V_R = I_R$

Where I is the current at that instant.

X_L is inductive reactance and

X_C is capacitive reactance.

V_R is in phase with I. V_L leads I by 90° and V_C lags behind I by 90°



In the phases diagram,

V_L and V_C are opposite to each other. If $V_L > V_C$ then resultant $(V_L - V_C)$ is represent by OD. OR represent the resultant of V_R and $(V_L - V_C)$. It is equal to the applied Emf E.

$$E^2 = V_R^2 + (V_L - V_C)^2$$

$$E^2 = I^2 + \left[R^2 + (X_L - X_C)^2\right]$$

$$\text{or } I = \frac{E}{\sqrt{R^2 + (X_2 - X_C)^2}}$$

The term $\sqrt{R^2 + (X_2 - X_C)^2}$ is called impedance Z of the LCR circuit.

$$Z = \sqrt{R^2 + (X_2 - X_C)^2} = \sqrt{R^2 + \left(L\omega - \frac{1}{c\omega}\right)^2}$$

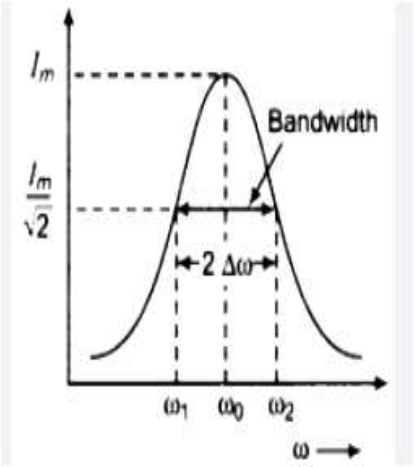
Emf leads current by a phase angle ϕ

$$\tan\phi = \frac{V_L - V_C}{R} = \frac{X_L - X_C}{R} = \frac{L\omega - \frac{1}{c\omega}}{R}$$

When resonance takes place

$$\omega L = \frac{1}{\omega C}$$

Impedance of circuit becomes equal to R. Current becomes maximum and is equal to E/R



OR

(a) Here $V = V_o \sin \omega t$

$I = I_o \sin(\omega t + \frac{\pi}{2})$

Since current is leading the voltage by $\frac{\pi}{2}$, hence the circuit must be capacitive and the element "X" must be a **capacitor.**

Its reactance is given by $X_c = \frac{1}{\omega C}$

(b) Graph of voltage and current w.r.t time in fig(b)

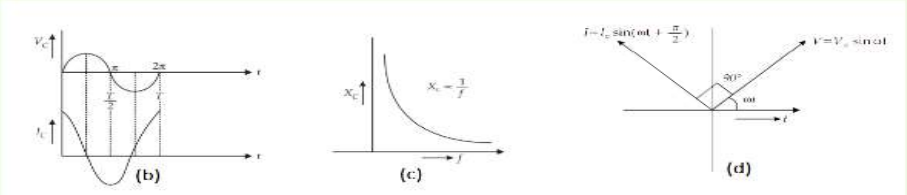
(c) Graph showing the variation of X_C with frequency f in fig(c)

Since $X_c = \frac{1}{2\pi fC}$

$X_c \propto \frac{1}{f}$

Hence, reactance is inversely proportional to the frequency.

(d) Phase diagram for device X is shown in fig.(d)



Subject- Physics (Theory)

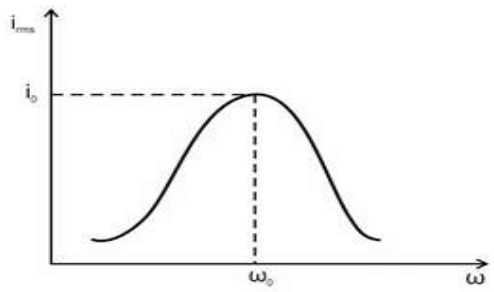
Time- 3 Hours **Session- (2024-25)** **Maximum Mark- 70**

General Instructions

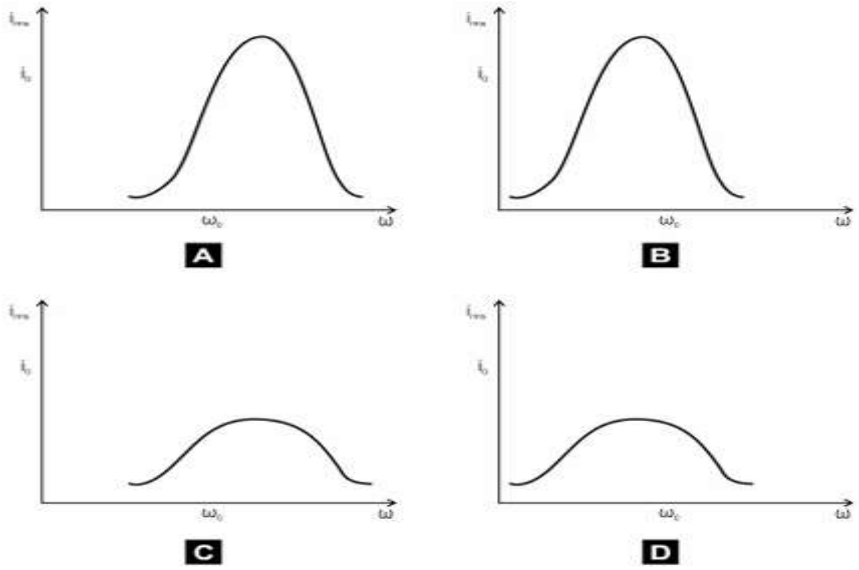
(1) There are 33 questions in all. All questions are compulsory.
(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
(3) All the sections are compulsory.
(4) **Section A** contains **sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each**, **Section B** contains **five questions of two marks each**, **Section C** contains seven questions of three marks each, **Section D** contains **two case study-based questions of four marks each** and **Section E** contains **three long answer questions of five marks each**.
(5) There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants where ever necessary
i. $c = 3 \times 10^8$ m/s
ii. Mass of electron = 9.1×10^{-31} kg
iii. Mass of Proton = 1.7×10^{-27} kg
iv. $e = 1.6 \times 10^{-19}$ C
v. $\mu_0 = 4\pi \times 10^{-7}$ T m $\boldsymbol{A^{-1}}$
vi. $h = 6.63 \times 10^{-34}$ J s
vii. $\varepsilon_0 = 8.854 \times 10^{-12}$ $\boldsymbol{C^2N^{-1}m^{-2}}$
viii. Avogadro's number = 6.023 X $\boldsymbol{10^{23}}$ per gram mole.

SECTION-A

1.The graph below shows the frequency response of an LCR circuit when connected to an AC source.

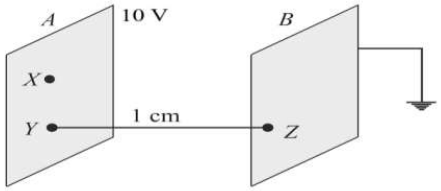


Which of the following graphs CORRECTLY represents the change in the frequency response of the LCR circuit if the capacitance and the inductance of the circuit are increased and resistance is decreased?



(a) A (b) B (c) C (d) D

2.Two identical metallic plates A and B are kept parallel to each other in air, separated by 1 cm distance as shown in the figure. The work done in moving a charge of 20 nC from X to Y is-



(a) 1000 J

(b) 20 J

(c) 200 J

(d) Zero

3. Two equal and opposite charges of 2×10^{-10}C are placed at a distance of 1cm forming a dipole and are placed in an electric field of 2×10^{5}N/C. The maximum torque on the dipole is

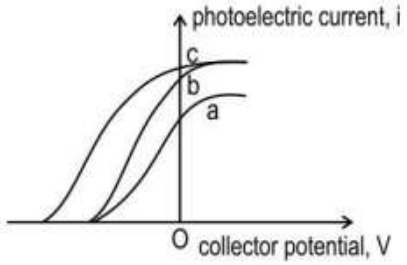
(a) $2\sqrt{2} \times 10^{-6}$Nm

(b) 8×10^{8}Nm

(c) 4×10^{-9}Nm

(d) 4×10^{-7}Nm

4. Study the following graphs between photoelectric current (i) vs. collector potential (V) for three different radiations a, b, and c of frequencies fa, fb, fc respectively with corresponding intensities Ia, Ib, and Ic respectively falling on a given photosensitive surface.



If

A. $f_a \neq f_b$; $I_a = I_b$
B. $f_b = f_c$; $I_b = I_c$
C. $f_a = f_b$; $I_a \neq I_c$
D. $f_b \neq f_c$; $I_b \neq I_c$

Select the correct option: -

(a) A

(c) C

(b) B

(d) D

5.According to Bohr atom model, in which of the following transitions will the frequency be maximum?

(a) n=3 to n=2

(c) n=4 to n=3

(b) n=5 to n=4

(d) n=2 to n=1

6. What happens to the magnetic needle kept in a non-uniform magnetic field?

(a) It experiences force but not torque

(b) It experiences torque but not force

(c) It experiences both force and torque

(d) It neither experiences force nor torque.

7. The resistance of a galvanometer is 50Ω and the current required to give full scale deflection is 100μA. In order to convert it into an ammeter for reading upto10A,it is necessary to put a resistance of

(a) $5 \times 10^{-2}\Omega$

(c) $5 \times 10^{-4}\Omega$

(b) $5 \times 10^{-5}\Omega$

(d) $5 \times 10^{-3}\Omega$

8. Two wires of same length are shaped into a square and a circle. If they carry same current, ratio of their magnetic moment is

(a) 2: π

(c) π: 4

(b) π: 2

(d) 4: π

9. In a transformer, number of turns in the primary is 140 and that in the secondary are 280. If current in primary is 4A, then that in the secondary is

(a) 4 A

(c) 6 A

(b) 2 A

(d) 10 A

10. $\vec{E}$ and $\vec{B}$ represent the electric and magnetic field of an electromagnetic wave respectively. The direction of propagation of the wave is along

(a) $\vec{E} \times \vec{B}$

(c)$\vec{E}$

(b) $\vec{B}$

(d) $\vec{B} \times \vec{E}$

11. The current in the primary coil of a pair of coils changes from 7A to 3A in 0.04s. The mutual inductance between the two coils is 0.5H. The induced emf in the secondary coil is

a) 50V

b) 100V

b) 75V

c) 220

12. In Rutherford's α -particle scattering experiment, what will be correct angle for α scattering for an impact parameter b = 0?

(a) 90^o

(b) 270^o

(c) 0^o

(d) 180^o

For the questions 13 to 16, two statements are given- one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (i), (ii), (iii) and (iv) as given below:

(a)Both assertion (A) and reason (R) are true and reason is correct explanation of assertion.

(b) Both assertion (A) and reason (R) are true but reason is not the correct explanation of the assertion.

(c) Assertion (A) is true but reason (R) is false.

(d) Assertion (A) is false but reason (R) is true.

13. **Assertion:** The photoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies.

Reason: The energy of electrons emitted from inside the metal surface, is lost in collision with the other atoms in the metal.

14. **Assertion:** A pure semiconductor has negative temperature coefficient of resistance.

Reason: On raising the temperature, more charge carriers are released, conductance increases and resistance decreases

15. **Assertion:** Work done in moving a charge between any two points in an electric field is independent of the path followed by the charge, between these points.

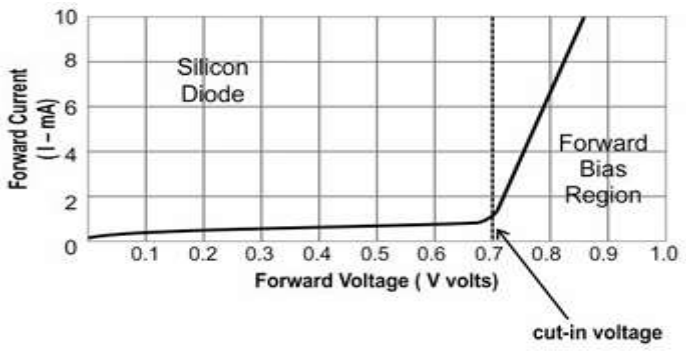
Reason: Electrostatic force is a non-conservative force.

16. **Assertion:** Propagation of light through an optical fiber is due to total internal reflection taking place at the core-cladding interface.

Reason: Refractive index of the material of the cladding of the optical fiber is less than that of the core.

SECTION-B

17. Shown below is the V-I characteristics curve for a forward-biased Si diode.



A Si diode along with a resistor R is connected in series to a battery of 2 V. If the value of R is 1000 Ω, will the diode now operate above its cut-in voltage? Justify your answer by showing the necessary mathematical calculations.

18. A proton and an alpha particle are accelerated through the same potential. Which one of the two has (i) greater value of de-Broglie wavelength associated with it, and (ii) less kinetic energy? Justify your answers.

19. A ray of light passes through an equilateral prism such that angle of incidence is equal of emergence and the later is equal to 3/4th of the angle of prism. Calculate the angle of deviation. Refractive index of prism is 1.5.

20. At room temperature 27°C, the resistance of a heating element is 100Ω. What is the temperature of the element if the resistance is found to be 117Ω, given that the temperature coefficient of the material of the resistor is $1.7 \times 10^{-4}°C^{-1}$?

21. A biconvex lens has a focal length 2/3 times the radius of curvature of either surface. Calculate the refractive index of lens material.

OR

A biconvex lens made of a transparent material of refractive index 1.5 is immersed in water of refractive index 1.33. Will the lens behave as a converging or a diverging lens? Give reason.

SECTION-C

22.The table below represents the binding energy per nucleon and mass number of a few elements.

Element	Mass Number	Binding energy per nucleon (MeV)
Hydrogen	1	0
Helium`	2	7.4
Lithium	6	4.9
Iron	56	8.8
Gold	197	7.7
Uranium	238	7.5

Study the table and answer the following questions.

(a) What does the binding energy per nucleon of hydrogen signify?

(b) Which element has the highest mass defect per nucleon among the given elements? Give reason.

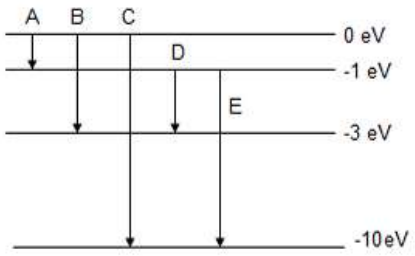
(c) Of lithium and gold which element has a more tightly bound nucleus? Give reason.

23. Consider a uniform electric field $E = 3 \times 10^3 \hat{i}$ N/C.

a) What is the flux of this field through a square of side 10cm whose plane is parallel to the y-z plane?

b) What is the flux through the same square if the normal to its plane makes angle 60° with the x-axis?

24. The energy levels of an atom of an element are shown in the following diagram. Which one of the level transitions will result in the emission of photons of wavelength 620 nm? Support your answer with mathematical calculations.



25. Explain with the help of a circuit diagram, how the value of an unknown resistance can be determined using a Wheatstone bridge?

26. An electron emitted by a heated cathode and accelerated through a potential difference of 2kV, enters a region with uniform magnetic field of 0.15T. Determine the trajectory of the electron if the field

a) is transverse to its initial velocity.

b) makes an angle of 30° with the initial velocity.

27.Which constituent radiation of the electro-magnetic spectrum is used?

(a) To photograph internal parts of human body.

(b) For air aircraft navigation.

Give their frequency range.

28. Two concentric circular loops of radius 1cm and 20cm are placed coaxially.

(a) Find mutual inductance of the arrangement.

(b) If the current passed through the outer loop is changed at a rate of 5A/ms, find the emf induced in the inner loop. Assume the magnetic field on the inner loop to be uniform.

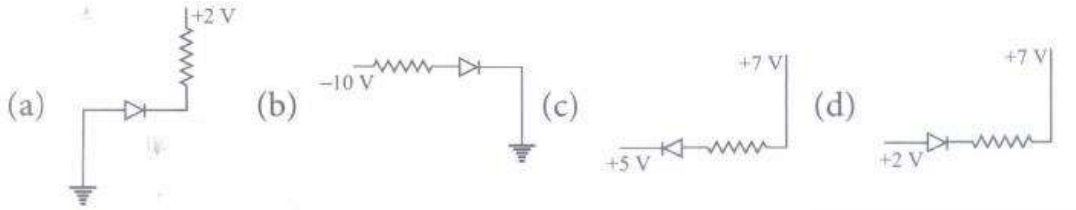
OR

Derive an expression for the self-inductance of a long air-cored solenoid of length l and number of turns N.

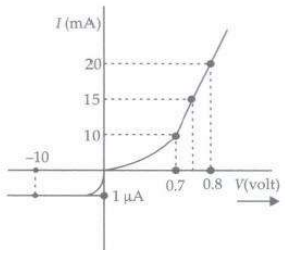
SECTION- D

29. When the diode is forward biased, it is found that beyond forward voltage V = V_k, called knee voltage, the conductivity is very high. At this value of battery biasing for p-n junction, the potential barrier is overcome and the current increases rapidly with increase in forward voltage. When the diode is reverse biased, the reverse bias voltage produces a very small current about a few microamperes which almost remains constant with bias. This small current is reverse saturation current.

(i) In which of the following figures, the p-n diode is forward biased.



(ii) The V-I characteristic of a diode is shown in the figure. The ratio of forward to reverse bias resistance is



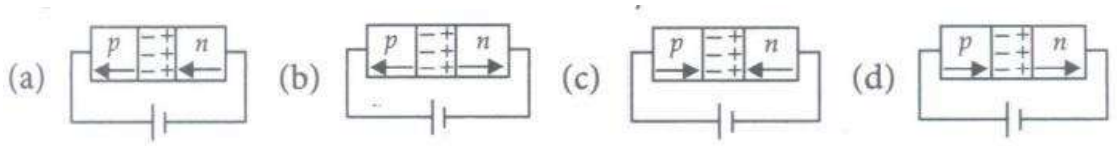
(a) 100

(b) 10^6

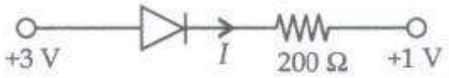
(c) 10

(d) 10^{-6}

(iii) In the case of forward biasing of a p-n junction diode, which one of the following figures correctly depicts the direction of conventional current (indicated by an arrow mark)?



(iv) If an ideal junction diode is connected as shown, then the value of the current I is:



(a) 0.013 A

(b) 0.02 A

(c) 0.01 A

(d) 0.1 A

OR

(v) Based on the V-I characteristics of the diode, we can classify diode as

(a) bilateral device

(b) ohmic device

(c) non-ohmic device

(d) passive element

30. **Sparking brilliance of diamond:**

The total internal reflection of light is used in polishing diamonds to create a sparking brilliance. By polishing the diamond with specific cuts, it is adjusted so that most of the light rays approaching the surface are incident with an angle of incidence more than critical angle. Hence, they suffer multiple reflections and ultimately come out of diamond from the top. This gives the diamond a sparkling brilliance.

(i) Light cannot easily escape a diamond without multiple internal reflections. This is because:

(a) Its critical angle with reference to air is too large

(b) Its critical angle with reference to air is too small

(c) The diamond is transparent

(d) Rays always enter at angle greater than critical angle

(ii) The critical angle for diamond is 24.40. Its refractive index is

(a) 2.42

(b) 0.413

(c) 1

(d) 1.413

(iii) The basic reason for the extraordinary sparkle of suitably cut diamond is that

(a) It has low refractive index

(b) It has high transparency

(c) It has high refractive index

(d) It is very hard

(iv) A diamond is immersed in a liquid with a refractive index greater than water. Then theoretical angle for total internal reflection will

(a) Will depend on the nature of the liquid

(b) decrease

(c)remains the same

(d) increase

OR

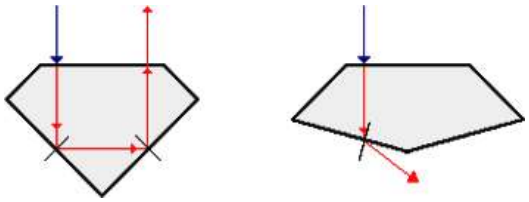
(v) The following diagram shows the same diamond cut in two different shapes. The brilliance of diamond in the second diamond will be:

(a) less than the first

(b)greater than the first

(c) same as first

(d) will depend on the intensity of light.



SECTION-E

31. A device X is connected across an ac source of voltage $V = V_o \sin \omega t$. The current through X is given as $I = I_o \sin (\omega_o t + \pi/2)$.

(i) Identify the device X and write the expression for its reactance.

(ii) Draw graphs showing variation of voltage and current with time over one cycle of ac for X.

(iii) How does the reactance of the device X vary with frequency of the ac? Show the variation graphically.

(iv) Draw the phasor diagram for the device X.

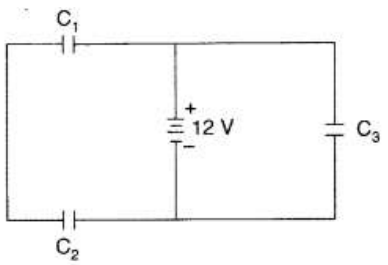
OR

(i) Derive the expression for the current flowing in an ideal capacitor and its reactance when connected to an ac source of voltage $V = V_o \sin \omega t$.

(ii) Draw its phasor diagram.

(iii)If resistance is added in series to capacitor what changes will occur in the current flowing in the circuit and phase angle between voltage and current?

32. Three identical capacitors C_1 C_2 and C_3 of capacitance 6 μF each are connected to a 12 V battery as shown. Find
(i) charge on each capacitor
(ii) equivalent capacitance of the network
(iii) energy stored in the network of capacitors.



OR

(a) Why electric lines of force are always normal to the equipotential surface at every point?

(b) Sketch the equipotential surface along with electric lines of force for-

(i) Two positive charges of same magnitude

(ii) A uniform electric field.

(c) An electric dipole of dipole moment 1.4×10^{-8} Cm is placed inside a uniform electric field of 10^5 Vm^{-1}in stable equilibrium position. Amit wants to rotate the dipole and he shifted it to the unstable equilibrium position. Calculate the amount of work is done by Amit.

33. (a) Define a wave front.

(b) Using Huygens's construction of secondary wavelets draw a diagram showing the passage of a plane wave front from a denser to a rarer medium. Using it verify Snell's law.

OR

(a) Draw a labeled ray diagram showing the formation of a final image by a compound microscope at least distance of distinct vision.

(b) The total magnification produced by a compound microscope is 20. The magnification produced by the eyepiece is 5. The microscope is focused on a certain object. The distance between the objective and eyepiece is observed to be 14 cm. If least distance of distance vision is 20cm, calculate the focal length of the objective and the eyepiece.

Subject- Physics (Theory)

Time- 3 Hours **Session- (2024-25)** **Maximum Mark- 70**

Marking Scheme

Q1	**B**	1 M
Q2	**D**	1 M
Q3	**D**	1 M
Q4	**C**	1 M
Q5	**D**	1 M
Q6	**C**	1 M
Q7	**C**	1 M
Q8	**C**	1 M
Q9	**B**	1 M
Q10	**A**	1 M
Q11	**A**	1 M
Q12	**D**	1 M
Q13	**A**	1 M
Q14	**A**	1 M
Q15	**C**	1 M
Q16	**C**	1 M
Q17	A Si diode along with a resistor R is connected in series to a battery of 2 V. If the value of R is 1000 Ω, will the diode now operate above its cut-in voltage? Justify your answer by showing the necessary mathematical calculations. We shall find the maximum value of R for which the diode operates at a voltage just above its cut-in voltage. Since the diode and resistor are connected in series . we get $V = V_R + V_D$, VR = 2 – 0.7 = 1.3 V	2 M

	At cut-in voltage the current through the diode is 1mA ∴Rmax = VR/I Rmax = 1.3/1 x 10^{-3}= 1.3 x 1000 = 1300 Ω Hence, at 1000 Ω the diode will operate above its cut-in voltage.	
Q18	(i)Here, $\lambda \propto \frac{1}{\sqrt{mq}}$ So,$\lambda_p > \lambda_\alpha$ (ii)K∝ q Thus, Kp< Kα	2 M
Q19	Angle of deviation, D=i+i'-A=30^0	2 M
Q20	$R_T = R_0 [1+ \alpha (T-T_0)]$, by using this formula T=1027^0C	2 M
Q21	$\frac{1}{f} = (n-1)(\frac{1}{R1} - \frac{1}{R2})$ And f=2/3 R n_l=1.75 OR f_w =+ve The bi convex lens will behave as a converging lens.	2 M
Q22	(a) Binding energy per nucleon of hydrogen is 0 MeV which signifies it does not require energy to separate the nucleons in the nucleus of hydrogen as it has only 1 proton and no neutrons. (b) The binding energy per nucleon of iron is the maximum. This implies that its mass defect per nucleon is the maximum. (c) The higher the binding energy per nucleon, the more tightly bound will be the nucleus Thus gold has a more tightly bound nucleus as it has greater binding energy than lithium.	3 M

Q23	$\vec{E}$=3X10$^3\hat{\imath}$ N/C, l=10 cm= 10X10^{-2}m (a) $\vec{A}$ =10$^{-2}\hat{\imath}$ m^2 $\phi = \vec{E}.\vec{A}$= 30 Nm^2/C (b) $\phi = \vec{E}.\vec{A}$ =EAcos60^0= 15 Nm^2/C	3 M
Q24	The energy of the photon of wavelength λ is $E=hc/\lambda$ Here, λ = 620 nm = 620 x 10^{-9} m E=6.62X10^{-34}x 3x10^8/620x10^{-9}=2 eV i.e. Transition D will result in the emission of photons of wavelength 620 nm.	3 M
Q25	By using Kirchoff's rule prove the condition for balanced wheastone bridge. i.e. P/Q=R/S	3 M
Q26	Given, B = 0.15 T V = 2kV = 2 x 103V When the electron is accelerated through a potential difference V, it gains kinetic energy which is given by $eV = \frac{1}{2}mv^2$ $\Rightarrow v = \sqrt{\frac{2eV}{m}}$ $= \sqrt{\frac{2\times1.6\times10^{-19}\times2\times10^3}{9.1\times10^{-31}}}$ $= 2.652\times10^7 ms^{-1}$ (a) When the applied field is transverse to the initial velocity: When the electron moves normal to the direction of the magnetic field, it experiences force which is normal to both its direction of motion and the direction of the magnetic field. This force provides centripetal force to the electron and makes it to move along a circular path. The radius of the circular path is given by : $\frac{mv^2}{r} = Bev$ $r = \frac{mv}{Be}$ $= \frac{9.1\times10^{-31}\times2.652\times10^7}{0.15\times1.6\times10^{-19}}$ $= 10^{-3} m = 1mm.$	3 M

	(b) When the applied field is inclined to its initial velocity. The velocity of the electron can be resolved into two components (i) V cos θ along the direction of the filed (ii) V sin θ along normal to the field. Where as due to the component V sin θ, the electron moves along circular path, the component V cos θ makes the electron to move in straight line/path. Thus the electron moves in a helical path. r=MvsinΘ/Be	
Q27	(a) X rays(ν=3X10^{16} to 3X10^{19} Hz) (b) Micro wave(ν=300 MHz to 300GHz)	3 M
Q28.	(a)Let there be two concentric circular coils of radii r and R respectively. Where R>>r. If a current I_1, flows through the outer coil, then magnetic field developed at its centre is $B=\mu_0 I_1/2R$ As r is very small, magnetic field on the inner loop may be assumed to be uniform at $B= \mu_0 I_1/2R$ ∴ Magnetic flux linked with inner loop $\phi_2=B(\pi r^2)=\mu_0 I_1(\pi r^2)/2R$ $\because \phi_2=MI_1$ $M=\phi_2/I_1=9.87X10^{10}$ H (b) E=M di/dt=4.935X10^{-6} V OR Correct derivation of self-inductance.	3M
Q29	(i)c (ii) d (iii) d (iv) c (v) c	4 M
Q30	(i)b (ii) a (iii) c (iv) d (v) d	4 M
Q31	(i)X→Capacitor and write the expression of Xc (ii) Draw graph (iii)Graph between Xcvs f. (iv)Draw the phasor diagram. **OR** (i)Expression for current and capacitive reactance.	5 M

	(ii)Draw the phasor diagram (iii)If resistance is added to the capacitor then the circuit becomes RC circuit. The impendence of the circuit is:- $Z=\sqrt{(R2 + XC2)}$ As Z > R, current will be reduced In Rc circuit, voltage lags behind the current by a phase angle ϕ, $\tan\phi = -Xc/R$	
Q32	(i)$Q=CV=3X10^{-6}X12=36X10^{-6}C=Q_1=Q_2$ $Q3=C3V=6X10^{-6}X12=72X10^{-6}C$ (ii)C_1 and C_2 are in series. $1/C_s = 1/C_1 + 1/C_2$ $Cs=3\ \mu F$ C3 and Cs are in parallel $Cp=C_3+Cs=9\ \mu F$ (iii)$U=1/2\ CV^2= 6.48X10^{-4}$ J **OR** (a) The equipotential surfaces are always perpendicular to the direction of the field. This is because if the electric field is not perpendicular to the equipotential surface there would have existed some nonzero component along the surface. (b) Draw as per question. (c) W=PE(cosΘ1-cosΘ2) Use this formula. At stable equilibrium Θ1=0 and At un stable equilibrium Θ2=180 .	5 M
Q33	(a) Define wavefront. (b) Proof of Snells law by wave theory. **OR** (a) Draw the ray diagram	5 M

	(b) $M=m_0 X me$ $m_0=M/me = 20/5=4$ for eye piece $me=1+D/fe$ $fe=5cm$ Also, $me=Ve/Ue$ $Ue=-20/5=-4$ cm. Distance between the lens=14 $Ue+V_0=14$ $V_0=10cm$ $m_0=1-vo/f_0$ $f_0=2cm.$	

Subject- Physics (Theory)

Time- 3 Hours **Session- (2024-25)** **Maximum Mark- 70**

General Instructions

(1) There are 33 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.
(3) All the sections are compulsory.
(4) **Section A** contains **sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each**, **Section B** contains **five questions of two marks each**, **Section C** contains seven questions of three marks each, **Section D** contains **two case study-based questions of four marks each** and **Section E** contains **three long answer questions of five marks each**.
(5) There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants where ever necessary
i. $c = 3 \times 10^8$ m/s
ii. Mass of electron = 9.1×10^{-31} kg
iii. Mass of Proton = 1.7×10^{-27} kg
iv. $e = 1.6 \times 10^{-19}$ C
v. $\mu_0 = 4\pi \times 10^{-7}$ T m $\boldsymbol{A^{-1}}$
vi. $h = 6.63 \times 10^{-34}$ J s
vii. $\varepsilon_0 = 8.854 \times 10^{-12}$ $\boldsymbol{C^2N^{-1}m^{-2}}$
viii. Avogadro's number = 6.023 X $\mathbf{10^{23}}$ per gram mole.

SECTION-A

Q1. Which of the following relation indicates the speed of electromagnetic wave in free space?
(A) E_0/B_0 (B) B_0/E_0 (C) $1/\sqrt{(\mu_0\epsilon_0)}$ (D) Both (A) and (C)

Q2. The work function for a metal surface is 4.14 eV. The threshold wavelength for this metal surface is-
(A) 4125 A^0 (B) 2062.5 A^0 (C) 3000 A^0 (D) 6000 A^0

Q3. Magnifying power of a microscope depends on-
(A) Colour of light only (B) focal length of objective only
(C) Focal Length of eyepiece only (D) focal length of eyepiece and objective both

Q4. The transformer ratio in step-up transformer is-
(A) 1 (B) Greater than one (C) Less than one (D) Depends on other factors

Q5. Two light sources are said to be coherent when both the sources of light emit light of-

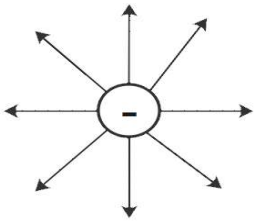
(A) The same amplitude and phase
(B) The same intensity and wavelength
(C) The same speed
(D) The same wavelength and constant phase difference

Q6. A surface $\mathbf{S=5\,\hat{j}}$ is kept in an electrical field $\vec{\mathbf{E}}=2\hat{\mathbf{i}}+4\hat{\mathbf{j}}+7\hat{\mathbf{k}}$. How much electric flux will come out through this surface?

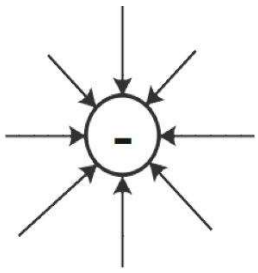
(A) 50 Units (B) 40 Units (C) 30 Units (D) 20 Units

Q7. Which of the following figure represents the field lines due to a single negative charge?

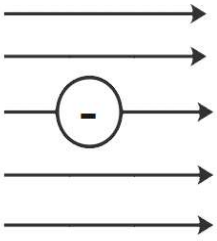
(A)



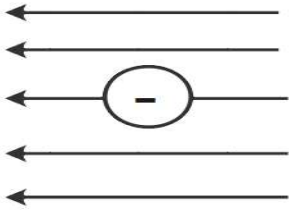
(B)



(C)



(D)



Q8. When a 220 V AC is applied to a capacitor C, then

(A) The phase of voltage and current is same

(B) Between the plates of capacitor, maximum voltage is 220V

(C) Average power delivered to the capacitor per cycle is zero

(D) Charge on the plate is not in phase with the applied voltage

Q9. An electron of charge e moves parallel to uniform lines of force in magnetic field B with velocity v. Force acting on electron is-

(A) Bev (B) 0 (Zero) (C) B/ev (D) Be/v

Q10. The magnetic flux across a loop of resistance 10Ω is given by $\phi=5t^2-4t+1$ weber. How much current is induced in the loop after 0.2 second?

(A) 0.4 A (B) 0.04 A (C) 0.2 A (D) 0.02 A

Q11. Particles which can be added to the nucleus of an atom without changing its chemical properties are called-

(A) Neutrons (B) Electrons (C) Protons (D) Alpha Particles

Q12. In the Bohr's model of hydrogen atom, if atomic radius of the first orbit is R_0 then the radius of the 3rd orbit will be?

(A) $9\ R_0$ (B) R_0 (C) $3R_0$ (D) $R_0/3$

For Questions 13 to 16, two statements are given –one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

A. If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true but Reason is false.

D. If both Assertion and Reason are false.

Q13. **Assertion (A):** Electrical conductivity of semiconductors decreases with increasing temperature.

Reason (R): With decrease in temperature, large number of electrons from the valence band can jump to the conduction band.

Q14. **Assertion (A):** The alternating current lags behind the emf by a phase angle of, $\pi/2$ when AC flows through an inductor.

Reason (R): The inductive reactance increases as the frequency of AC source increases.

Q15. **Assertion (A):** An ammeter is always connected in series whereas a voltmeter is connected in parallel.

Reason (R): An ammeter is a low-resistance galvanometer while a voltmeter is high-resistance galvanometer

Q16. **Assertion (A):** For making permanent magnets, steel is preferred over soft iron

Reason (R): As retentivity of steel is smaller

SECTION-B

Q17. A converging lens of refractive index 1.5 is kept in a liquid medium having same refractive index. What would be the focal length of the lens in this medium?

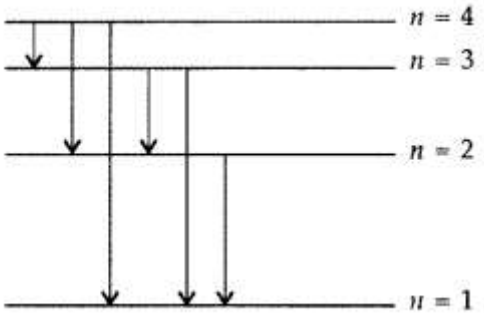
Q18. In a parallel plate capacitor with air between the plates, each plate has an area of 6×10^{-3} m^2 and the separation between the plates is 3 mm.

(1) Calculate the capacitance of the capacitor.

(2) If the capacitor is connected to 100V supply, what would be the charge on each plate?

Q19. Two nuclei have mass numbers in the ratio 1: 8. What is the ratio of their nuclear radii?

Q20. The figure shows energy level diagram of hydrogen atom



(a) Find out the transition which results in the emission of a photon of wavelength 496 nm.

(b) Which transition corresponds to the emission of radiation of maximum wavelength? Justify your answer.

Q21. A wire of resistance 6 R is bent in the form of a circle. What is the effective resistance between the ends of the diameter?

OR

With the help of a suitable diagram, explain the formation of depletion region in a p-n junction. How does its width change when the junction is

(i) forward biased, and

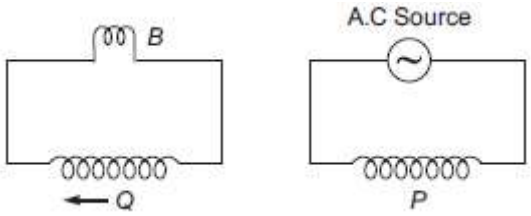
(ii) reverse biased?

SECTION-C

Q22. A long straight solid metal wire of radius R carries a current I uniformly distributed over its circular cross section. Find the magnetic field at a distance r from the axis of the wire

(a) Inside the wire (b) Outside the wire

Q23. A coil Q is connected to low voltage bulb B and placed near another coil P is shown in the figure. Give reason to explain the following observations:



(a) The bulb 'B' lights.
(b) Bulb gets dimmer if the coil Q is moved towards left.
(c) State and explain Lenz law.

Q24. (a) Write three characteristics properties of nuclear force.
(b) Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions that can be drawn from the graph.

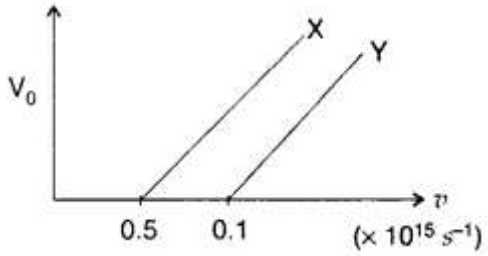
Q25. Answer the following questions: -
(a) Name the electromagnetic waves which are used for the treatment of certain forms of cancer. Write their frequency range.
(b) Thin ozone layer on the top of stratosphere is crucial for human survival. Why?
(c) Why is the amount of the momentum transferred by the electromagnetic waves incident on the surface is so small?

Q26. Define Wavefront. Using Huygens principle, verify the laws of reflection at a plane surface.

OR

Define Wavefront. Using Huygens principle, verify the laws of refraction at a plane surface.

Q27. The following graph shows the variation of stopping potential V0 with the frequency v of the incident radiation for two photosensitive metals X and Y :



(i) Which of the metals has larger threshold wavelength? Give reason.
(ii) Explain, giving reason, which metal gives out electrons, having larger kinetic energy, for the same wavelength of the incident radiation.
(iii) If the distance between the light source and metal X is halved, how will the kinetic energy of electrons emitted from it change? Give reason.

Q28. State two conditions required for obtaining coherent sources.
In Young's arrangement to produce interference pattern, show that dark and bright fringes appearing on the screen are equally spaced.

SECTION-D

CASE STUDY BASED QUESTIONS

Q29. Wheatstone bridge is an arrangement of four resistances P, Q, Rand S connected as shown in the figure. Their values are so adjusted that the galvanometer G shows no deflection. The bridge is then said to be balanced when this condition is achieved happens. In the setup shown here, the points Band D are at the same potential and it can be shown that P/Q=R/S.

This is called the balancing condition. If any three resistances are known, the fourth can be found.The practical form of Wheatstone bridge is slide wire bridge or Meter bridge. Using this the unknown resistance can be determined as $S=(100-l)\times R/l$, where l is the balancing length of the Meter bridge.

(i) In a Wheatstone bridge circuit, P=5Ω,Q=6Ω,R=10Ω and S=5Ω What is the value of additional resistance to be used in series with S, so that the bridge is balanced?

(a) 9Ω

(b) 7Ω

(c) 10Ω

(d) 5Ω

(ii) A Wheatstone bridge consisting of four arms of resistances P, Q, R, S is most sensitive when

(a) all the resistances are equal

(b) all the resistances are unequal

(c) the resistances P and Q are equal but R > > P and S > > Q

(d) the resistances P and Q are equal but R < < P and S < < Q

(iii) When a metal conductor connected to left gap of a meter bridge is heated, the balancing point

(a) shifts towards right (b) shifts towards left

(c) remains unchanged (d) remains at zero

(iv) The percentage error in measuring resistance with a meter bridge can be minimized by adjusting the balancing point close to

(a) 0 (b)·20cm (c) 50cm (d) 80cm

OR

(v) In a meter bridge experiment, the ratio of left gap resistance to right gap resistance is 2: 3. The balance point from left is

(a) 20 cm (b) 50 cm (c) 40 cm (d) 60 cm

Q30. Semiconductors are materials that have electrical conductivity between that of conductors (such as metals) and insulators (such as non-metals). They play a crucial role in the field of electronics and are the basic for many devices we use today. Moreover, to increase the conductivity of semiconductor materials, doping process is used. Using suitable doping, semiconductors are of two types, n-type and p-type.

(i) What is primary characteristics of a semiconductor material?

(a) High electrical conductivity

(b) Low electrical conductivity

(c) Complete absence of electrical conductivity

(d) None of the above

(ii) Which of the following element is used in the fabrication of semiconductors?
(a) Gold
(b) Copper
(c) Silicon
(d) Aluminium

(iii) What happens to the conductivity of a semiconductor when its temperature increases?
(a) Conductivity increases
(b) Conductivity decreases
(c) Conductivity remains unchanged
(d) It depends on the specific semiconductor material

OR

In a p-type semiconductor, impurity atoms are added to the crystal lattice produce
(a) Extra electrons
(b) Extra protons
(c) Extra neutrons
(d) Holes

(iv) What is the function of the diode in a circuit?
(a) To amplify electrical signal
(b) To store electrical charge
(c) To regulate voltage
(d) To convert AC to DC

Q31.(i) Define electric flux. Write its SI unit, (ii) Using Gauss' law, prove that the electric field at a point due to a uniformly charged infinite plane sheet is independent of distance from it. How is the field directed if
(a)the sheet is positively charged
(b)negatively charged?

OR

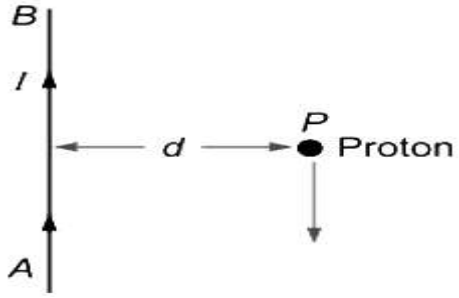
(a) Using Gauss' law, deduce the expression for the electric field due to a uniformly charged spherical conducting shell of radius R at a point (i)outside the shell (ii)inside the shell
Plot a graph showing variation of electric field as a function of $r > R$ and $r < R$.{r being the distance from the centre of the shell).
(c) A uniformly charged solid spherical insulator has a radius of 0.23 m. The total charge in the volume is 3.2 pC. Find the E-field at a position of 0.14 m from the center of the sphere.

Q32. (a) With the help of a diagram, explain the principle and working of a moving coil galvanometer.
(b) What is the importance of a radial magnetic field and how is it produced?
(c) Why is it while using a moving coil galvanometer as a voltmeter a high resistance in series is required whereas in an ammeter a shunt is used?

OR

(i) Derive an expression for the force between two long parallel current carrying conductors.
(ii) Use this expression to define SI unit of current.

(iii) A long straight wire AB carries a current I. A proton P travels with a speed v, parallel to the wire at a distance d from it in a direction opposite to the current as shown in the figure. What is the force experienced by the proton and what is its direction?



Q33. (i) Draw a labelled diagram of astronomical telescope in normal adjustment.
(ii) Draw a schematic arrangement of a reflecting telescope (Cassegrain) showing how rays coming from a distant object are received at the eye-piece. Write its two important advantages over a refracting telescope.

OR

(i) Derive lens maker formula for a double convex lens. Why it is called lens maker formula?
(ii) A biconvex lens has a focal length 3/4 times the radius of curvature of either surface. Calculate the refractive index of the lens.

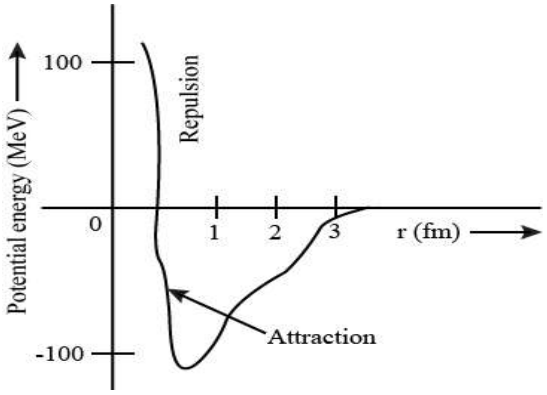
Subject- Physics (Theory)

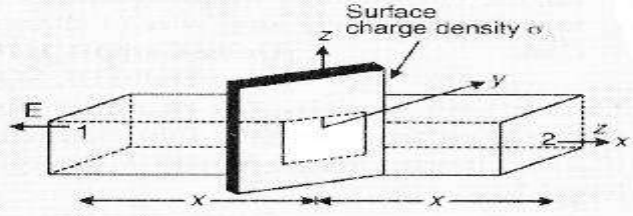
Time- 3 Hours **Session- (2024-25)** **Maximum Mark- 70**

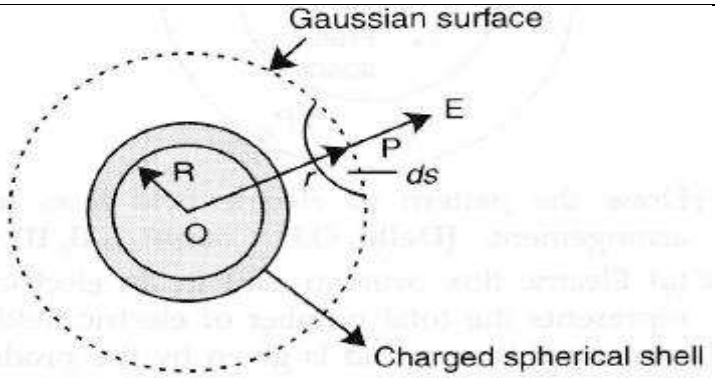
Marking Scheme

Question No.	Key Points	Marks
1	(C) $1/\sqrt{(\mu_0\epsilon_0)}$	1
2	(C) 3000 A^0	1
3	(D) focal length of eyepiece and objective both	1
4	(B) Greater than one	1
5	(D)The same wavelength and constant phase difference	1
6	(D) 20 Units	1
7	(B)	1
8	(C) Average power delivered to the capacitor per cycle is zero	1
9	(B) 0 (Zero)	1
10	(C) 0.2 A	1
11	(A)Neutrons	1
12	(A) 9 R_0	1
13	(D)	1
14	(C)	1
15	(A)	1
16	(B)	1
17	Using lens maker formula, $1/f=(\mu_2/\mu_1-1)(1/R_1-1/R_2)$, $\mu1=\mu2$	1+1

	$\Rightarrow 1/f=0$ $\therefore f=\infty$	
18	(i) $C=\frac{\varepsilon_0 A}{d}$ $C=\frac{8.85\times10^{-12}\times6\times10^{-3}}{3\times10^{-3}}$ F $C=17.7\times10^{-12}$ F $=(17.7\ pF)$ (ii) $Q=CV$ $Q=17.7\times10^{-12}\times100$ C $Q=17.7\times10^{-10}$ C $=1.77$ nC	1+1
19	$R=R_0A^{1/3}$ $\therefore \quad \frac{R_1}{R_2}=\left(\frac{A_1}{A_2}\right)^{1/3}=\left(\frac{1}{8}\right)^{1/3}=\frac{1}{2}$	1+1
20	E 4 → E 2 : 4 → 3 *E* 4 → *E* 2 : 4 → 3 , E = h c /λ , s E 4 − E 2 = − 0.85 + 3.4 = 2.55 e V = E *E* 4 - *E* 2 = - 0.85 + 3.4 = 2.55 *e V* = *E* , therefore, the transition form n=4 to n=2 level results in the emission of photon of wavelength 496 nm. Further, wavelength emitted will be maximum, when energy emitted is minimum. The transition n=4 to n=3 level will give maximum wavelength as energy emitted is minimum.	½+1/2+1/2+1/2
21	resistance is directly proportional to length of the wire so resistance of two halves of wire on both sides of diameter will be R/2 and R/2 these two are connected in parallel so equivalent resistance will be R/4. OR Explanation with diagrams	1+1
22	the magnetic field at a point at distance r from the axis of the wire, when point lies (i) inside is $\Rightarrow B=\mu_\circ\mu_r ir/2\pi rR2$ and (ii) outside is $B=\mu_\circ i/2\pi r$ Derivation	1.5+ 1.5
23	(a) The bulb B lights due to induced current in coil Q because of change in magnetic flux linked with it on a consequence of continuous variation of magnitude of alternating current flowing in P (b) When coil Q moves towards left the rate of change of magnetic flux linked with Q decreases and so lesser current is induced in Q. (c) Statement of lenz law	1+ 1+1
24	(a) (i) Nuclear forces are short range forces.	1.5+1.5

	(ii) Nuclear forces are primarily attractive and extremly strong. (iii) Nuclear forces are independent of charge.  (b)	
25	(a) Gamma(γ) rays are used for the treatment of certain forms of cancer. Their frequency range is 3×1019 Hz to 5×1024 Hz. (b) The thin ozone layer on top of stratosphere absorbs most of the harmful ultraviolet rays coming from the Sun towards the Earth. They include UVA, UVB and UVC radiations, which can destroy the life system on the Earth. Hence, this layer is crucial for human survival. (c) Momentum transferred = EnergySpeed of light=hvc≈10−22 (for ν~1020 Hz) Thus, the amount of the momentum transferred by the em waves incident on the surface is very small.	1+1+1
26	Definition of wavefront and derivation of laws of reflection. OR Definition of wavefront and derivation of laws of refraction.	1+2
27	(i) Since, $\lambda \propto 1$ v $\lambda \propto 1\ \nu$ As the threshold frequency of metal Y is greater than of metal X. Thus metal X has greater threshold wavelength. (ii) The kinetic energy of the emitted electrons depends on the work function of metal Y is greater than that X The kinetic energy of electrons emitted from metal X will have greater kinetic energy . (iii) If the distance between light source and metal is changed , the intensity of the light falling on the surface will decrease. But the kinetic energy of the emitted electron is independent of the intensity of the light falling and hence there will be no change in the kinetic energy of the emitted electrons.	1+1+1

28	Two required conditions for coherent sources and showing that In Young's arrangement to produce interference pattern, show that dark and bright fringes appearing on the screen are equally spaced.	1+2
29	(i) (b) 7Ω, (ii) (a) all the resistances are equal, (iii) (a) shifts towards right, (iv) (c) 50 cm or 40 cm	1+1+1+1
30	(i) (b) Low electrical conductivity, (ii) (c)Silicon, (iii) (a) Conductivity increases or (d) Holes (iv) (d) To convert AC to DC	1+1+1+1
31	$\phi = \oint \vec{E}.\vec{dS}$ Its SI unit is $N.m^2C^{-1}$ or V–m. (b)  Outward flux through the Gaussian surface, is $2EA = \sigma A/\varepsilon_0$ $\therefore \quad E = \sigma/2\varepsilon_0$ Vectorically, $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$, where $\hat{n}$ is a unit vector normal to the plane away from it. (c) For positively charged sheet, the field is directed away from the sheet. For negatively charged sheet, the field is directed towards the plane sheet. OR	1+3+1 OR 3+2



∴ Total electric flux through the Gaussian surface is given by.

$$\phi = \oint_s E dS = E \oint_s dS$$

Now, $\oint_s dS = 4\pi r^2$

$$\therefore \quad \phi = E \times 4\pi r^2 \qquad \ldots(i)$$

Since the charge enclosed by the Gaussian surface is q, according to the Gauss's theorem,

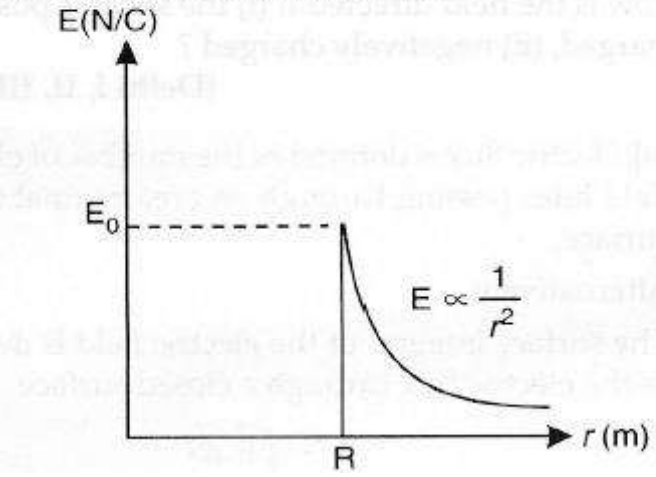
$$\phi = \frac{q}{\varepsilon_0} \qquad \ldots(ii)$$

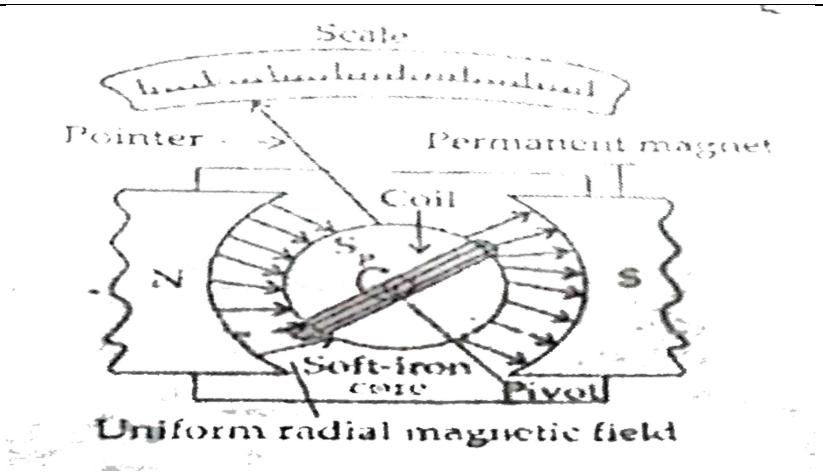
From equations (i) and (ii), we obtain

$$E \times 4\pi r^2 = \frac{q}{\varepsilon_0}$$

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2} \qquad (\text{for } r > R)$$

(ii) When point P lies inside the spherical shell : In such a case, the Gaussian surface encloses no charge. According to the Gauss's law,

	$E \times 4\pi r^2 = 0$ *i.e.*, $E = 0\ (r < R)$ A graph showing the variation of electric field as a function of *r* is shown below.  (b) The electric field at a position of 0.14 m from the center of the sphere is approximately 1.24 x 10^4 N/C.	
32	(a) Moving coil galvanometer : It is a device used for the detection and measurement of small electric current . Principle : The working is based on the fact that a current carrying coil suspended in a magnetic field experiences a torque . Construction : It consists of a coil having a large number of turns of insulated copper wire wound on a metallic frame . The coil is suspended by means of a phosphorbronze strip and is surrounded by a horse shoe magnet NS . A hair spring is attached to lower end of the coil . The other end of the spring is attached to the scale through a pointer . Working : When current is passed , say along ABCD , the couple acts on it . Since the plane remains always parallel to the magnetic field in all position of the coil (radial field) , the force on the vertical arms always remains perpendicular to the place of the coil .	3+1+1 OR 3+1+1



(b) Radial magnetic field : It is the field in which the plane of the coil always lies in the direction of the magnetic field . A radial magnetic field is produced by(i) properly cutting the magnetic pole pieces in the shape of concave faces and (ii) using a soft iron core within the coil .

(c) A galvanometer can be converted into a voltmeter by connecting a high resistance in series with galvanometer to draw a very small current . A galvanometer can be converted into an ammeter by connecting a low resistance shunt is parallel with galvanometer to draw large value of current. .OR

(a) Derivation

(b) Definition of Ampere

(c)

$$i.e.,\ \vec{B} = -\frac{\mu_0 I}{2\pi d}\hat{k}$$

$$\text{Force } \vec{F} = q\vec{v} \times \vec{B}$$

$$= e\,(-v\hat{j}) \times \left(-\frac{\mu_0 I}{2\pi d}\hat{k}\right)$$

$$= \frac{\mu_0\, evI}{2\pi d}\hat{i}$$

That is the magnetic force has magnitude μ 0 e v I 2 π d $\mu 0\ e\ v\ I\ 2\ \pi\ d$ and is directed along positive X - axis i.e,, in the plane of paper perpendiculer of → v v → and to the right.

33	(i)Correct diagram of astronomical telescope in normal adjustment (ii)Diagram of reflecting type telescope and its two advantages OR	2+2+1 OR 3+2

	(i)derivation of lens maker formula and statement of why it is called so. (ii) $1/f = (n - 1)(1/R_1 - 1/R_2)$ For biconvex lens $R_1 = +R$, $R_2 = -R$ Given $f = 2/3R$ $\therefore 3/2R = (n-1)(2/R) \Rightarrow (n-1) = 3/4 \Rightarrow n = 1 + 3/4 = 7/4$.	