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Candidates must write the Set No. on the title page of the answer book.

**DAV PUBLIC SCHOOLS, ODISHA ZONE
HALF YEARLY EXAMINATION (2023-24)**

- Please check that this question paper contains **8** printed pages.
- Set number given on the right hand side of the question paper should be written on the title page of the answer book by the candidate.
- Check that this question paper contains **33** questions.
- Write down the Serial Number of the question in the left side of the margin before attempting it.
- 15 minutes time has been allotted to read this question paper. The question paper will be distributed 15 minutes prior to the commencement of the examination. The students will read the question paper only and will not write any answer on the answer script during this period.

CLASS- XII

SUBJECT: PHYSICS (042)

Time Allowed: 3 Hours

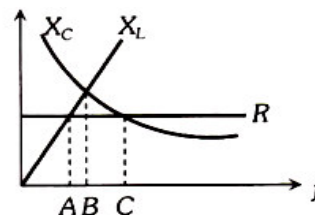
Maximum Marks: 70

General Instructions:

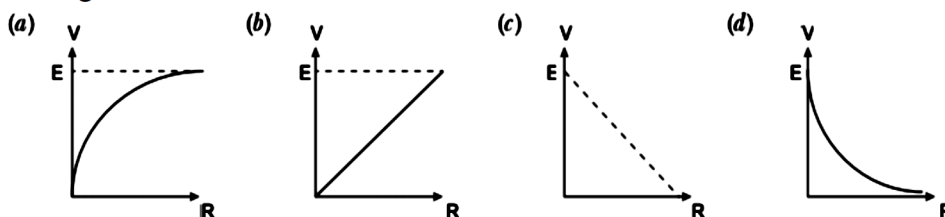
- (1) There are 33 questions in all. All questions are compulsory.
- (2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
- (3) All the sections are compulsory.
- (4) **Section A** contains sixteen questions, twelve MCQ and four Assertion Reasoning based 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**, two questions 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. $m_e = 9.1 \times 10^{-31}$ kg
 - iii. $e = 1.6 \times 10^{-19}$ C
 - iv. $\mu_0 = 4\pi \times 10^{-7}$ TmA⁻¹
 - v. $h = 6.63 \times 10^{-34}$ Js
 - vi. $\epsilon_0 = 8.854 \times 10^{-12}$ C²N⁻¹m⁻²
 - vii. Avogadro's number = 6.023×10^{23} per gram mole

SECTION-A

1. The figure shows variation of R , X_L and X_C with frequency 'f' in a series LCR circuit. Then for what frequency point, the circuit is inductive.



- (a) A (b) B (c) C (d) A and B
2. A charge q is placed at one corner of a cube of side ' l '. The total electric flux through the cube is
- (a) $\frac{q}{\epsilon_0}$ (b) $\frac{q}{2\epsilon_0}$ (c) $\frac{q}{4\epsilon_0}$ (d) $\frac{q}{8\epsilon_0}$
3. A parallel plate air capacitor is charged to a potential difference of V volts. With battery connected the distance between the plates of the capacitor is decreased using an insulating handle. As a result the potential difference between the plates
- (a) increases. (b) decreases. (c) does not change. (d) becomes zero.
4. The drift velocity of the free electrons in a conducting wire carrying a current I is v . If in a wire of the same metal, but of double the radius, the current be $2I$, then the drift velocity of the electrons will be
- (a) $v/4$ (b) $v/2$ (c) v (d) $4v$
5. A cell of emf E and internal resistance r is connected across an external resistor R . The graph showing the variation of P.D. across R versus R is



- (a) $E = J/k$ (b) $E = J k$ (c) $E = k/J$ (d) $k = J E$
6. The electric field intensity E , current density J and specific resistance k are related to each other through the relation
- (a) $E = J/k$ (b) $E = J k$ (c) $E = k/J$ (d) $k = J E$
7. An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true?
- (a) The electron will be accelerated along the axis.
 (b) The electron path will be circular about the axis.
 (c) The electron will experience a force at 45° to the axis and hence execute a helical path.
 (d) The electron will continue to move with uniform velocity along the axis of the solenoid.
8. Three needles N_1 , N_2 and N_3 are made of a diamagnetic, a paramagnetic and a ferromagnetic substance respectively. A magnet, when brought close to them, will
- (a) repel N_1 weakly, attract N_2 weakly and attract N_3 strongly.
 (b) attract all three of them.
 (c) attract N_1 and N_2 strongly but repel N_3 .
 (d) attract N_1 strongly, N_2 weakly and repel N_3 weakly.

9. In a coil of self-inductance 5 H, the rate of increase of current is 2 A s^{-1} . Then emf induced in the coil is
 (a) 10 V. (b) -10 V. (c) 5 V. (d) -5 V.
10. Two identical coaxial coils P and Q carrying equal amount of current in the same direction are brought nearer. The current in
 (a) P increases while in Q decreases. (b) Q increases while in P decreases.
 (c) both P and Q increases. (d) both P and Q decreases.

11. Four charges are arranged at the corners of a square ABCD, as shown. The force on a unit positive charge kept at the centre O is



- (a) zero.
 (b) along the diagonal AC.
 (c) along the diagonal BD.
 (d) perpendicular to side AB.

12. The electromagnetic wave which is produced by Klystron Valve is
 (a) infrared. (b) ultra violet. (c) X- ray. (d) micro wave.

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 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.

13. **Assertion (A):** If a charged particle is kept in the path of electromagnetic wave, the particle oscillates.

Reason (R): Electromagnetic waves contain both momentum and energy.

14. **Assertion (A):** The resistivity of a semiconductor decreases with increase in temperature.

Reason (R) : With increase in temperature the number density of charge carrier decreases.

15. **Assertion (A):** When a charged particle enters perpendicular to a uniform magnetic field, work done on the charged particle is zero.

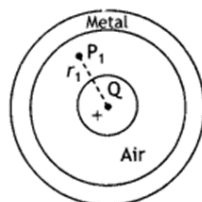
Reason (R) : In a complete cycle the displacement of the charged particle is zero.

16. **Assertion (A):** The voltage and current in a series AC circuit are given by $V = V_0 \sin \omega t$ and $I = I_0 \cos \omega t$. The power dissipated in the circuit is zero.

Reason(R) : Power in AC circuit is given by $P = V_{\text{rms}} I_{\text{rms}} \cos \Phi$.

SECTION-B

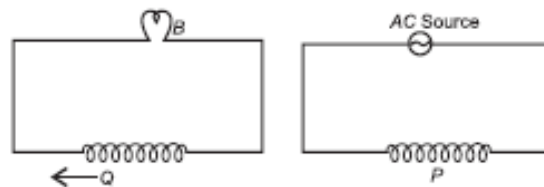
17. A small metal sphere carrying charge +Q is located at the center of a spherical cavity in a large uncharged metallic spherical shell. Write the charges on the inner and outer surfaces of the shell. Write the expression for the electric field at the point P_1 .



18. Two charges $5 \times 10^{-8} \text{ C}$ and $-3 \times 10^{-8} \text{ C}$ are located 16 cm apart. At what point on the line joining the two charges in between them is the electric potential zero? Take the potential at infinity to be zero.

OR

- (a) Calculate the potential at a point P due to a charge of $4 \times 10^{-7} \text{ C}$ located 9 cm away.
 (b) Hence obtain the work done in bringing a charge of $2 \times 10^{-9} \text{ C}$ from infinity to the point P.
 Does the answer depend on the path along which the charge is brought?
19. A storage battery of emf 8.0 V and internal resistance 0.5Ω is being charged by a 120 V dc supply using a series resistor of 15.5Ω . What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?
20. Derive an expression for radius of the circular path described by a charged particle while projected perpendicular to the direction of uniform magnetic field. Hence show that the frequency of revolution is independent of the speed of the particle.
21. A coil Q is connected to low voltage bulb B and placed near another coil P as shown in the figure. Give reasons to explain the following observations:
 (a) The bulb B lights.
 (b) Bulb gets dimmer if the coil Q is moved towards left.

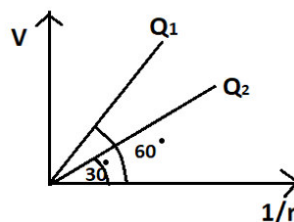


SECTION-C

22. An electric dipole is held in a uniform electric field.
 (a) Using a suitable diagram show that it does not undergo any translational motion.
 (b) Derive an expression for torque acting on it and specify its direction.
23. If 'n' mercury drops of same size each having the charge 'q' and radius 'r', coalesce to form a bigger drop of charge 'Q' and radius 'R', then how will the following vary with respect to single small drop?
 (a) Total charge on bigger drop.
 (b) Potential on the bigger drop.
 (c) Capacitance of the bigger drop.

OR

- (a) The figure shows the variation of potential V with $\frac{1}{r}$ for two point charges Q_1 and Q_2 , where V is potential at a distance r due to a point charge. Determine the ratio $\frac{Q_1}{Q_2}$.

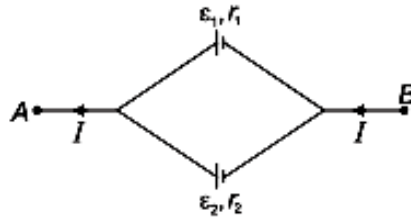


- (b) Consider two conducting spheres of radii R_1 and R_2 with $R_1 > R_2$. If the two are at same potential, determine the ratio of charge density of the smaller sphere to that of the larger one in terms of R_1 and R_2 .

24. (a) State the Kirchhoff's laws.
 (b) A battery of 10V and negligible internal resistance is connected across the diagonally opposite corners of a cubical network consisting of 12 resistors each of resistance 1Ω . Determine the equivalent resistance of the network.

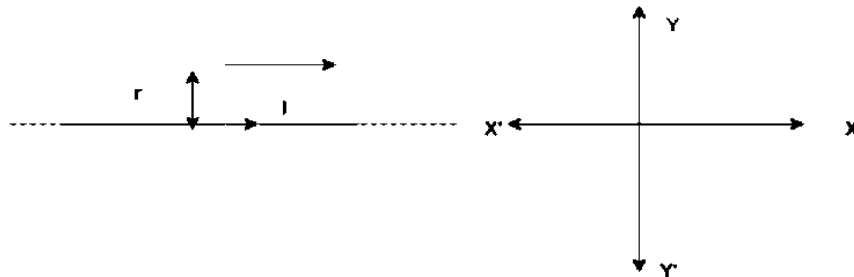
OR

Two cells of emfs ϵ_1, ϵ_2 and internal resistances r_1 and r_2 respectively are connected in parallel as shown in the figure.

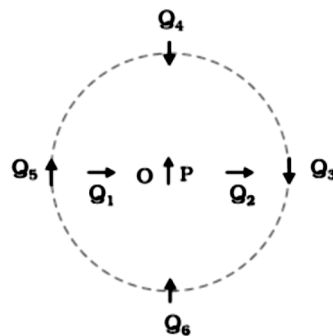


Deduce the expression for

- (a) the equivalent emf of the combination.
 (b) the equivalent resistance of the combination.
25. A particle of mass m and charge q is in motion at speed v parallel to a long straight conductor carrying current I as shown below. Find magnitude and direction of electric field required so that the particle goes undeflected.



26. The figure shows a small magnetised needle P placed at a point O. The arrow shows the direction of its magnetic moment. The other arrows show different positions (and orientations of the magnetic moment) of another identical magnetised needle Q.



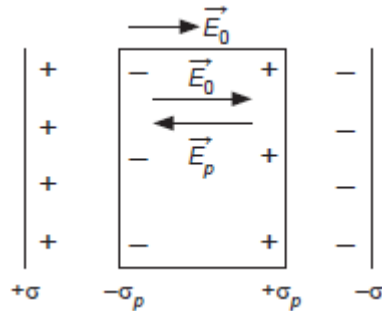
- (a) In which configuration is the system not in equilibrium?
 (b) In which configuration is the system in (i) stable, and (ii) unstable equilibrium?
 (c) Which configuration corresponds to the lowest potential energy among all the configurations shown? Give reason to your answer.
27. In a series LCR circuit with an ac source of effective voltage 50 V, frequency $\nu = \frac{50}{\pi}$ Hz, $R = 300\Omega$, $C = 20\mu\text{F}$ and $L = 1.0\text{H}$. Find
- (a) the impedance of the circuit.
 (b) the rms current in the circuit.
 (c) power factor of the circuit.

28. An electromagnetic wave travelling through a medium has electric field vector given by $E_y = 4 \times 10^5 \cos(3.14 \times 10^8 t - 1.57 x)$ N/C, where x is in m and t in s . Then find:
- speed of wave,
 - refractive index of medium, and
 - amplitude of magnetic field vector.

SECTION-D

29. Case Study Based Questions-

The induced dipole moment developed per unit volume in a dielectric slab on placing it inside the electric field is called polarisation. Let \vec{E}_0 be the uniform external electric field. When a dielectric slab is placed in uniform electric field, then the molecules get polarised, due to which $-\sigma_p$ (charge density due to polarisation) will appear near the positive plate and $+\sigma_p$ will appear in the dielectric near the negative plate. Therefore, due to polarization of molecules, electric field will appear in the opposite direction, and the net electric field inside the dielectric will be reduced. So, the dielectric constant is defined as the ratio of the electric field in vacuum to the electric field in medium.



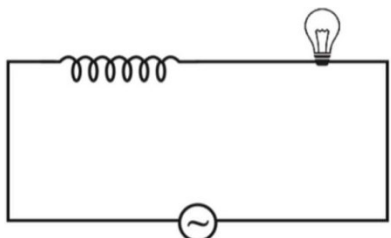
- If the dielectric constant of the medium is 4 then magnitude of \vec{E}_p is
 (a) $\frac{E_0}{4}$ (b) $4E_0$ (c) $\frac{3E_0}{4}$ (d) $\frac{4E_0}{3}$
- Instead of dielectric slab if a conducting slab of thickness half of separation between the two plates is introduced, then the electric field inside the conducting slab is
 (a) $\frac{\sigma}{\epsilon_0}$ (b) $\frac{2\sigma}{\epsilon_0}$ (c) $\frac{\sigma}{2\epsilon_0}$ (d) zero
- If the separation between the two plates is 'd' and thickness of the dielectric slab of dielectric constant 2 is d/2, then the capacitance of the capacitor becomes
 (a) (3/4) times the capacitance in vacuum. (b) (4/3) times the capacitance in vacuum.
 (c) 2 times the capacitance in vacuum. (d) 4 times the capacitance in vacuum.
- If a dielectric of dielectric constant 'K' fills the whole space between the two plates of the capacitor with battery remaining connected in the circuit, then the energy stored in the capacitor becomes
 (a) K times the energy in vacuum. (b) (1/K) times the energy in vacuum.
 (c) K² times the energy in vacuum. (d) (K+1) times the energy in vacuum.

OR

- The potential difference between the plates of the capacitor in vacuum is V. If the battery is disconnected and then the capacitor is completely filled by a dielectric of dielectric constant 'K', then the potential difference between the two plates becomes
 (a) K V. (b) V/K. (c) K² V. (d) (K+1) V.

30. Case Study Based Questions-

When a current flows through a coil, flux linked with it is $\Phi = LI$, where L is a constant known as self inductance of the coil. Any change in current sets up an induced emf in the coil. Thus, self inductance of a coil is the induced emf set up in it when the current passing through it changes at the unit rate. It is a measure of the opposition to the growth or decay of current flowing through the coil. Also the value of self-inductance depends on the number of turns in the solenoid, its area of cross-section and the relative permeability of its core material.



- (i) Self-inductance comes into play due to
- (a) increase in current. (b) decay in current.
(c) Both (a) and (b) (d) flow of steady current.
- (ii) If an iron rod is inserted in the core region of the coil, the brightness of the bulb
- (a) increases. (b) decreases. (c) remains same. (d) first increases and then decreases.
- (iii) If the ac source is replaced by a dc source in the figure, the reactance of the inductor at steady state becomes
- (a) zero. (b) infinite. (c) same. (d) none of these.
- (iv) Keeping other parameters constant, if diameter of the coil is doubled then the inductance becomes
- (a) 2 times. (b) 4 times. (c) (1/2) times. (d) (1/4) times.

OR

- (iv) The self inductance of the coil is L . If a magnetic material is introduced in the core so that the self inductance becomes $(L/10)$, then the relative magnetic permeability of the material is
- (a) 10. (b) 5. (c) 100. (d) 0.1.

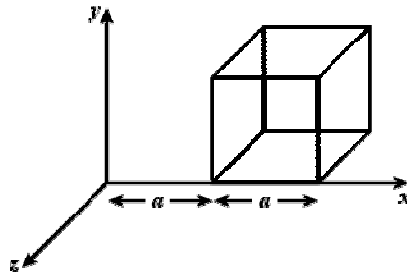
SECTION-E

31. A series LCR circuit is connected to an ac source $V = V_m \sin \omega t$.
- (a) Draw the phasor diagram to derive the expression for the impedance of the circuit.
- (b) Find the phase difference between applied voltage and current. Hence write the expression for current.
- (c) Plot a graph to show the variation of current with frequency of the source.

OR

- (a) Draw the arrangements for windings of primary and secondary coil in a transformer with two coils on separate limbs of the core. State its working principle.
- (b) Write assumptions used and deduce the expression for the ratio of secondary to primary voltage in terms of the number of turns and currents in the two coils.
- (c) Explain why ac is preferred for long distance power transmission.

32. (a) State Gauss's law. Use it to deduce the expression for the electric field due to a uniformly charged thin spherical shell at points (i) inside and (ii) outside the shell.
- (b) A cube with each side 'a' is placed in an electric field $\vec{E} = 2x\hat{i}$, directed towards x-axis. Find out the net charge inside the cube.



OR

- (a) Two point charges q and $-q$ are placed at a distance $2a$ apart. Calculate the electric field at a point P situated at a distance x along the perpendicular bisector of the line joining the charges. Write the expression for electric field when $x \gg a$.
- (b) Two point charges q and $2q$ are located at points $(0,0)$ and (a,a) respectively. Let \hat{i} and \hat{j} be the unit vectors along x-axis and y-axis respectively. Determine the force exerted by q on $2q$ in terms of \hat{i} and \hat{j} .
33. (a) Using Biot-Savart's law, derive an expression for magnetic field at any point on axial line of a current carrying circular loop.
- (b) A circular coil of 'N' turns and diameter 'd' carries a current 'I'. It is unwound and rewound to make another coil of diameter '2d', current 'I' remaining the same. Calculate the ratio of the magnetic moments of the new coil and the original coil.

OR

- (a) Write the expression for the force per unit length between two infinitely long straight parallel wires carrying currents in the same direction. Hence define one ampere.
- (b) A wire AB is carrying a steady current of $12A$ and is lying on the table. Another wire CD carrying current $5A$ is held directly above AB at a height of $1mm$. Find the mass per unit length of the wire CD so that it remains suspended at its position when left free. Give the direction of the current flowing in CD with respect to that in AB .
(Take $g = 10 \text{ ms}^{-2}$)
