# St. Paul's School

## Class XII – Half Yearly Examination (2024-25)

## Physics (042)

**Time: 3 Hrs** **M.M : 70**

***General instructions:***

*(i) There are 33 questions in this question paper. All questions are compulsory.*

*(ii) This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.*

*(iii) Section A contains sixteen MCQ of 1 mark each, Section B contains five questions of 2 marks each, Section C contains seven questions of 3 marks each, section D contains two case study based questions of 4 marks and Section E contains three long questions of 5 marks.*

### SECTION A

**1.** Two similar spheres having $+Q$ and $-Q$ charges are kept at a certain distance. The force F acts between the two charges. If at the middle of two spheres, another similar sphere having $+Q$ charge is kept, then it experiences a force in magnitude and direction as **(1)**

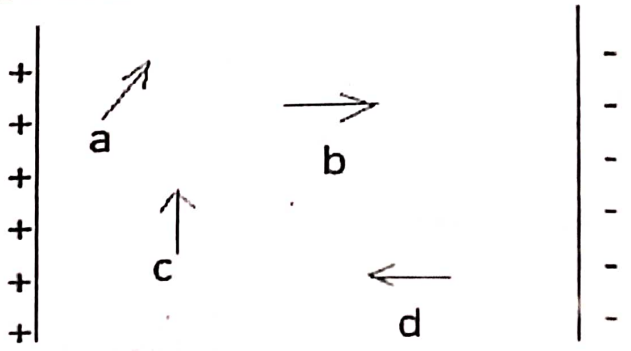
(a) zero having no direction.

(b) 8F towards $+Q$ charge.

(c) 8F towards $-Q$ charge.

(d) 4F towards $-Q$ charge.

**2.** Four electric dipoles a, b, c and d are present in a constant electrostatic field as shown in the figure. Their dipole moments are indicated by the arrows. Which of the following statements is incorrect? **(1)**



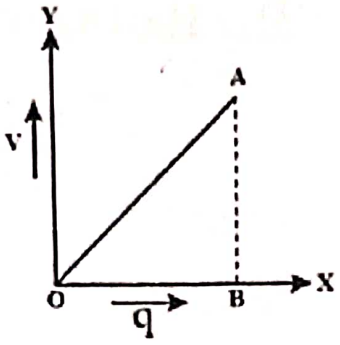

(a) Dipole 'a' is in a state of minimum potential energy

(b) Dipole 'c' experiences maximum torque

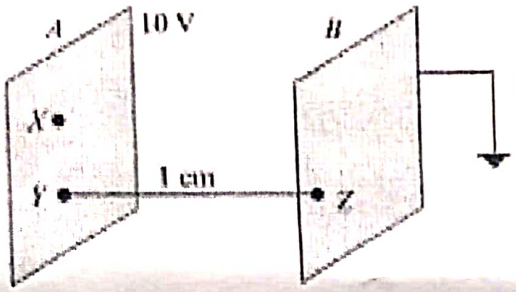
(c) Dipoles b and d are in equilibrium

(d) Dipole 'c' has zero potential energy

3. The charge q on a capacitor varies with potential difference as shown in the figure. **(1)**
The area under the curve represents-
(a) electric field between the plates.
(b) electric flux between the plates.
(c) energy density.
(d) energy stored by the capacitor.

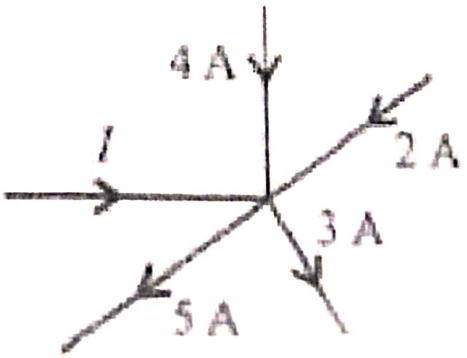



4. Two identical metallic plates A and B are kept parallel to each other in air, separated by *1 cm* distance as shown in the figure. The work done in moving a charge of *20 nC* from *X* to *Y* is- **(1)**
(a) 1000 J (b) 20 J (c) 200 J (d) Zero




5. The relaxation time in conductors **(1)**
(a) increases with the increases of temperature.
(b) decreases with the increases of temperature.
(c) it does not depends on temperature.
(d) all of sudden changes at 400 K.

6. The value of current I in the given circuit is **(1)**
(a) 4.5 A (b) 3.7 A (c) 2.0 A (d) 2.5 A




7. The ratio of voltage sensitivity and current sensitivity of a moving coil galvanometer is **(1)**
(a) 1/G (b) $1/G^2$ (c) G (d) $G^2$

A current carrying loop is placed in a uniform magnetic field. The torque acting on it does not depend upon the **(1)**

(a) shape of the loop.
(b) area of the loop.
(c) value of current.
(d) magnetic field.

9. Why transformers are installed in our locality during electric supply? **(1)**

(a) To produce electricity.
(b) To reduce current supply.
(c) To stabilize street lights.
(d) To step down the voltage.

10. In an L-C-R series circuit, at resonance **(1)**

(a)the current and voltage are in phase.
(b)the impedance is maximum.
(c)the current is minimum.
(d)the quality factor is independent of R.

11. In the given figure current from A to B in the straight wire is decreasing. The direction of induced current in the loop is **(1)**

(a) clockwise
(b) anticlockwise
(c) both A & B
(d) have no induced current.


12. Curie temperature is the temperature above which **(1)**

(a) a ferromagnetic material becomes diamagnetic.
(b) a ferromagnetic material becomes paramagnetic.
(c) a paramagnetic material becomes diamagnetic.
(d) a paramagnetic material becomes ferromagnetic.

For 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 (a), (b), (c) and (d) as given below.

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

13. **Assertion (A):** Potential energy of a charged parallel plate capacitor increases on increasing the distance between its plates. **(1)**
**Reason (R):** Potential difference between the plates increases due the increase of distance between the plates

14. **Assertion (A):** The drift velocity of electrons in a metallic wire will decrease, if the temperature of the wire is increased. (1)
**Reason(R):** On increasing temperature, conductivity of metallic wire decreases.

15. **Assertion (A):** A bar magnet is brought near a copper ring along its axis with constant velocity and stopped very near to ring, an induced current is produced in the ring which is maximum when the bar magnet stops. (1)
**Reason(R):** When the bar magnet stops very near to the ring the magnetic flux through it is maximum.

16. **Assertion (A):** If the frequency of alternating current in an ac circuit consisting of an inductance coil is increased then current gets decreased. (1)
**Reason(R):** The current is inversely proportional to frequency of alternating current.

## SECTION B

17. A polythene piece rubbed with wool is found to have a negative charge of $3\times10^{-7}\,C$. (2)
(a) Estimate the number of electrons transferred (from which to which?).
(b) Is there a transfer of mass from wool to polythene?

18. Explain why current flows through an ideal capacitor when it is connected to an ac source but not when it is connected to a dc source in a steady state. (2)

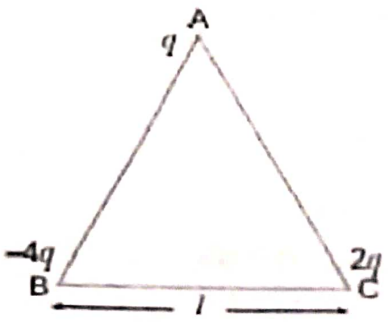
19. What is Lorentz force? An electron beam projected along +x –axis, experiences a force due to a magnetic field along the +y-axis. What is the direction of the magnetic field? (2)

20. A short bar magnet placed with its axis at $30°$ with a uniform external magnetic field of $0.25\ T$ experiences a torque of magnitude equal to $4.5\times10^{-2}\ Nm$. What is the magnitude of magnetic moment of the magnet? (2)

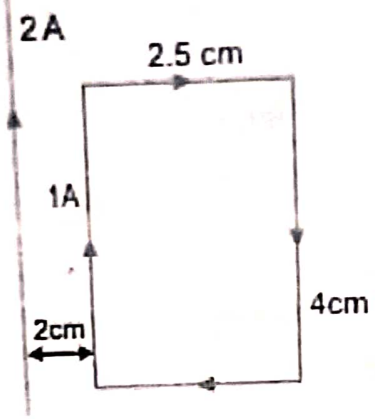
21. Write Faraday's law of electromagnetic induction. Express it mathematically. (2)

## SECTION C

22. As shown in the figure, three-point charges $q$, $-4q$ and $2q$ are placed at the vertices of an equilateral triangle ABC of side '$l$'. Obtain the expression for the magnitude of the resultant electric force acting on the charge $q$ (3)




23. A rectangular loop of wire of size 2.5 cm × 4 cm carries a steady current of 1 ampere. A straight wire carrying 2 A current is kept near the loop as shown. If the loop and the wire are coplanar, find the (3)
(a) torque acting on the loop and
(b) the magnitude and direction of the force on the loop due to the current carrying wire.




24 A 4 $\mu F$ capacitor is charged by a *200 V* supply. It is then disconnected from the supply and is connected to another uncharged *2* $\mu F$ capacitor. How much electrostatic energy of the first capacitor is lost in the form of heat and electromagnetic radiation? **(3)**

25. The coil of an *AC* generator having *N* turns, each of area *A*, is rotated with a constant angular velocity $\omega$. Deduce an expression for the alternating emf generated in the coil. State its underlying principle. **(3)**

26. Using the concept of free electrons in a conductor, derive the expression for the conductivity of a wire in terms of number density and relaxation time. Hence obtain the relation between current density and the applied electric field E. **(3)**

**OR**

Show, on a plot, variation of resistivity of (i) a conductor, and (ii) a typical semiconductor as a function of temperature. Using the expression for the resistivity in terms of number density and relaxation time between the collisions, explain how resistivity in the case of a conductor increases while it decreases in a semiconductor, with the rise of temperature.

27. (a) In an experimental arrangement of two coils $C_1$ and $C_2$ placed coaxially parallel to each other, find out the expression for the emf induced in the coil $C_1$ (of $N_1$ turns) corresponding to the change of current $I_2$ in the coil $C_2$ (of $N_2$ turns). **(3)**
(b) How does the mutual inductance of a pair of coils change when number of turns in the coils is increased?

**OR**

The currents flowing in the two coils of self-inductance $L_1=16\ mH$ and $L_2=12\ mH$ are increasing at the same rate. If the power supplied to the two coils are equal, find the ratio of
(a) induced voltages,
(b) the currents and
(c) the energies stored,in the two coils at a given instant.

28. Write three points of differences between paramagnetic, diamagnetic and ferromagnetic materials, giving one example for each. **(3)**

## SECTION D

**Case Study Based Question**

**Read the following paragraph and answer the following questions that follow**

**29.** Gaussian surface is the surface around a charge (point or continuous distribution) is an imaginary closed surface, such that the intensity of electric field at all points on its surface is same. Gaussian surface is an imaginary geometric surface and it may be in empty space or embedded in a solid body. **(4)**

(i) Charge $q$ is first kept in a sphere of radius $7\ cm$ and then it is kept in a cube of side $7\ cm$. The outgoing flux
(a) will be more in case of sphere
(b) will be more in case of cube
(c) will be same in both cases
(d) cannot be determined

(ii) The electric flux through a cubical Gaussian surface enclosing net charge q is $q/\varepsilon_0$, while the electric flux through one face of the cube is
(a) $q/\varepsilon_0$ (b) $q/4\varepsilon_0$
(c) $q/6\varepsilon_0$ (d) $q/8\varepsilon_0$

(iii) The electric flux of a flat square having an area of $10\ m^2$ placed in a uniform electric field of $8000\ N/C$ passing perpendicular to it is
(a) $8 \times 10^5\ Nm^2/C$ (b) $8 \times 10^4\ Nm^2/C$
(c) $16 \times 10^5\ Nm^2/C$ (d) $4 \times 10^4\ Nm^2/C$

(iv) Gauss's law is valid for
(a) any open surface
(b) any closed surface
(c) only regular closed surface
(d) only irregular open surface

**30.** When a pure resistance $R$, pure inductor $L$ and an ideal capacitor of capacitance $C$ is connected in series to a source of alternating e.m.f., then current at any instant through the three elements has the same amplitude and is represented as $I = I_0 sin\omega t$. However, voltage across each element has a different phase relationship with the current . The effective resistance of $RLC$ circuit is called impedance ($Z$) of the circuit and the voltage leads the current by a phase angle $\Phi$. **(4)**

A resistor of $12\ \Omega$, a capacitor of reactance $14\ \Omega$ and a pure inductor of inductance 0.1 H are joined in series and placed across $200\ V, 50\ Hz$ AC supply.

(i) The value of inductive reactance is
(a) $15\ \Omega$ (b) $31.4\Omega$ (c) $20\ \Omega$ (d) $30\ \Omega$

(ii) The value of impedance is
(a) $20\ \Omega$ (b) $15\ \Omega$ (c) $30\ \Omega$ (d) $21.13\Omega$

(iii) What is the impedance of $LCR$ circuit in series at the electric resonance?
(a) $Z > R$ (b) $Z < R$ (c) $Z = R$ (d) $Z = 0\ \Omega$

(iv) What is the phase difference between current and voltage in *LCR* at the resonant frequency?

(a) $90^0$ (b) $180^0$ (c) $60^0$ (d) $0^0$

## SECTION E

(a) Derive the expression for the capacitance of a parallel plate capacitor. **(5)**

(b) A parallel plate capacitor each with plate area A and separation '*d*' is charged to a potential difference *V*. The battery used to charge it is then disconnected. A dielectric slab of thickness d and dielectric constant K is now placed between the plates. What change if any, will take place in

(i) charge on the plates,

(ii) electric field intensity between the plates,

(iii) capacitance of the capacitor?

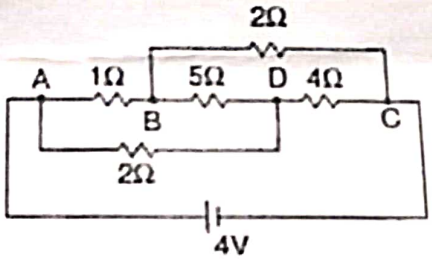
Justify your answer in each case.

**OR**

(a) Derive an expression for the electric potential at any point along the axial line of an electric dipole.

(b) Find the electrostatic potential at a point on equatorial line of an electric dipole.

**32.** (a) Calculate the current drawn from the battery by the network of resistors shown in the figure. **(5)**



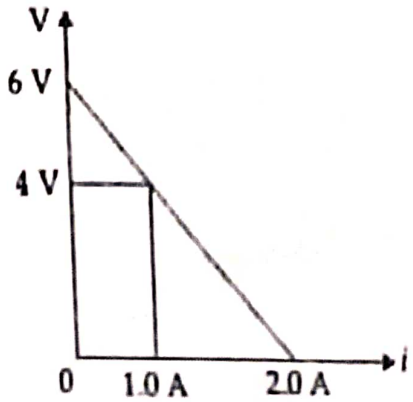

(b) By using Kirchhoff's laws obtain balance condition of a Wheatstone bridge.

**OR**

(a) The figure shows a plot of terminal voltage '*V*' versus the current '*i*' of a given cell. Calculate from the graph

(i) emf of the cell and

(ii) internal resistance of the cell.




(b)A cell of emf *4 V* and internal resistance *1* Ω is connected to a d.c. source of *10 V* through a resistor of *5* Ω. Calculate the terminal voltage across the cell during charging.

33. (a) Draw a labelled diagram of moving coil galvanometer. Describe briefly its principle and working. **(5)**

(b)Answer the following

(i) Why is it necessary to introduce a cylindrical soft iron core inside the coil of a galvanometer?

(ii) Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity. Explain, giving reason.

**OR**

(a) State Biot's Savart Law. Use this law to obtain an expression for the magnetic field at the centre of a circular current carrying loop.

(b) A circular coil of wire consisting of 100 turns, each of radius 8.0 cm carries a current of 0.40 A. What is the magnitude of magnetic field B at the centre of the coil?