BK BIRLA CENTRE FOR EDUCATION

SARALA BIRLA GROUP OF SCHOOLS
SENIOR SECONDARY CO-ED DAY CUM BOYS' RESIDENTIAL SCHOOL

MID-TERM EXAMINATION 2023-24

PHYSICS (042)

Class : XII
Date : 21/10/2023
Admission No.:

Duration: 3 Hrs
Max. Marks: 70
Roll No.:

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. $m_e = 9.1 \times 10^{-31}$ kg iii. $e = 1.6 \times 10^{-19}$ C iv. $\mu_0 = 4\pi \times 10^{-7}$ $Tm\boldsymbol{A}^{-1}$
v. $h = 6.63 \times 10^{-34}$ Js vi. $\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2N^{-1}m^{-2}$ vii. Avogadro's number = 6.023×10^{23} per gram mole

SECTION-A

1. The quantization of charge indicates that;
   (a) Charge, which is a fraction of charge on an electron, is not possible
   (b) A charge cannot be destroyed
   (c) Charge exists on particles
   (d) There exists a minimum permissible charge on a particle

2. The electrostatic potential on the perpendicular bisector due to an electric dipole is;
   (a) Zero (b) 1 (c) Infinite (d) Negative

3. An electric dipole placed in an electric field of intensity 2×10^5 N/C at an angle of 30° experiences a torque equal to 4 Nm. The charge on the dipole of dipole length 2 cm is;
   (a)7 μC (b) 8 mC (c) 2 mC (d) 5 mC

4. The rate of flow of electric charge through any cross-section of a conductor is known as;
   (a)Electric flux (b) Electric potential (c) Electric current (d) Electric field
5. The nature of parallel and anti-parallel currents are;
   (a) Parallel currents repel and anti-parallel currents attract.

(b) Parallel currents attract and anti-parallel currents repel.
(c) Both currents attract.
(d) Both currents repel.

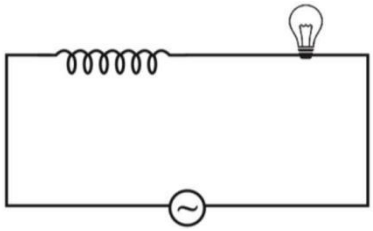
6. An ammeter of resistance 0.81 Ohm reads up to 1 A. The value of the required shunt to increase the range to 10 A is;
(a) 0.9 ohm (b) 0.09 ohm (c) 0.03 ohm (d) 0.3 ohm

7. If the magnetizing field on a ferromagnetic material is increased, its permeability;

(a) decreases (b) increases
(c) remains unchanged (d) first decreases and then increases

8. The large scale transmission of electrical energy over long distances is done with the use of transformers. The voltage output of the generator is stepped-up because of;
(a) reduction of current (b) reduction of current and voltage both
(c) power loss is cut down (d) (a) and (c) both

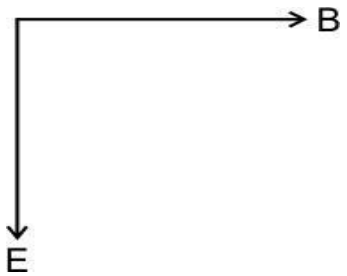
9. An iron cored coil is connected in series with an electric bulb with an AC source as shown in figure. When iron piece is taken out of the coil, the brightness of the bulb will;



(a) decrease (b) increase (c) remain unaffected (d) fluctuate

10. A 5 ohm resistor, a 5 mH inductor and a 5 μF capacitor, joined in series resonate with an ac source of frequency ω_o. If only the resistance is changed to 10 ohm, the circuit resonates at a frequency ω_1. If only the inductor is changed to 20 mH, the circuit resonates at a frequency ω_2. Find the ratio ω_1/ω_2.
(a) 0.5 (b) 1 (c)2 (d)4

11. The diagram below shows the electric field (E) and magnetic field (B) components of an electromagnetic wave at a certain time and location.



What is the direction of propagation of the em wave?
(a) perpendicular to E and B and out of the plane of the paper
(b) perpendicular to E and B and into the plane of the paper

(c) parallel and in the same direction as E
(d) parallel and in the same direction as B

12. Which of the following statement is NOT true about the properties of electromagnetic waves?
(a) These waves do not require any material medium for their propagation
(b) Both electric and magnetic field vectors attain the maxima and minima at the same time
(c) The energy in electromagnetic wave is divided equally between electric and magnetic fields
(d) Both electric and magnetic field vectors are parallel to each other

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:** Electric lines of force never cross each other.
Reason: Electric field at a point superimpose to give one resultant electric field.

14. **Assertion:** Ohm's law is applicable for all conducting elements.
Reason: Ohm's law is a fundamental law.

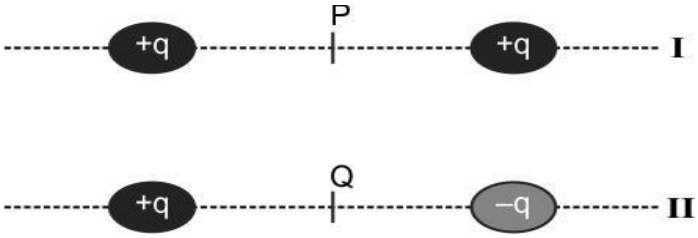
15. **Assertion:** Diamagnetic materials can exhibit magnetism.
Reason: Diamagnetic materials have permanent magnetic dipole moment.

16. **Assertion:** An induced emf appears in any coil in which the current is changing.
Reason: Self-induction phenomenon obeys Faraday's law of induction.

SECTION-B

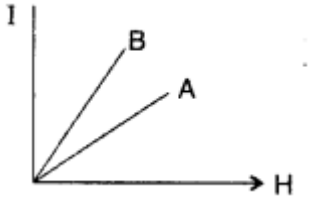
17. What will the force between two small spheres that have 2 X 10^{-7} C and 3 X 10^{-7}C be, if they are suspended in the air and have 30 cm of distance between them? 2

18. (a) If electric field strength at a point is zero at a given point, then what can you say about the electric potential at that point? Explain.
(b) In the two instances below, state whether electric field intensity and electric potential are zero or non-zero at the mid-point joining the two-point charges. 2



19. Derive the equation of the balanced state in a Wheatstone bridge using Kirchhoff's laws. 2

20. The figure shows the variation of intensity of magnetisation versus the applied magnetic field intensity, H, for two magnetic materials A and B: 2

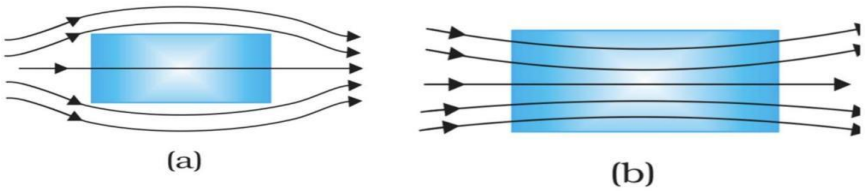


(a) Identify the materials A and B.

(b) Why does the material B, has a larger susceptibility than A, for a given field at constant temperature?

OR

A uniform magnetic field gets modified as shown in figure when two specimens A and B are placed in it.



(i)Identify the specimen A and B.

(ii) How is the magnetic susceptibility of specimen 'A' different from that of specimen 'B'?

21. Identify the part of the electromagnetic spectrum which: 2

(a) produces heating effect,

(b) is absorbed by the ozone layer in the atmosphere,

Write any one method of the production of each of the above radiations.

SECTION-C

22. Derive an expression for the torque experienced by an electric dipole kept in a uniform electric field. 3

OR State

Gauss' law in electrostatics. Use this law to derive an expression for the electric field due to an infinitely long straight wire of linear charge density $\boldsymbol{\lambda}$ cm^{-1}.

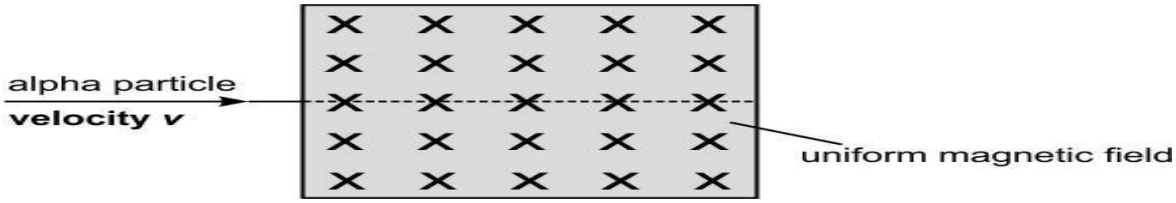
23. A variable resistor R is connected across a cell of emf E and internal resistance r. 3

(a) Draw the circuit diagram.

(b) Plot the graph showing variation of potential drop across R as function of R.

(c) At what value of R current in circuit will be maximum.

24. An alpha particle is moving with a velocity v. It enters a magnetic field (B) as shown below. The magnetic field is perpendicular and into the plane of paper. 3



A uniform electric field is applied in the same region as the magnetic field so that the alpha particle passes un-deviated through the combined fields.

(a) What should be the direction of the electric field?

(b) Without any change in the electric and magnetic field, the alpha particle is replaced by the following particles:

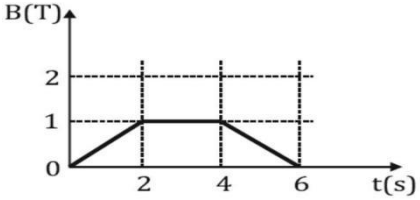
(i) proton moving with a velocity v

(ii) electron moving with a velocity v/2

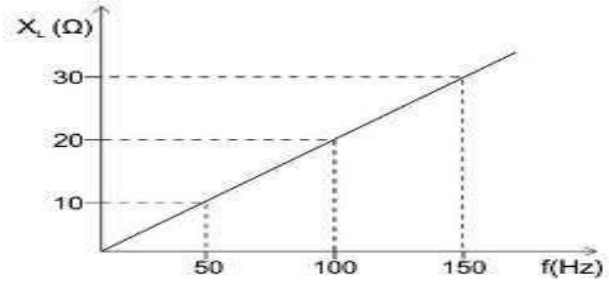
Will there be any change a deviation in the path of the particles? Give a reason for your answer.

25. A small compass needle of magnetic moment 'm' is free to turn about an axis perpendicular to the direction of uniform magnetic field 'B'. The moment of inertia of the needle about the axis is 'I'. The needle is slightly disturbed from its stable position and then released. Prove that it executes simple harmonic motion. Hence deduce the expression for its time period. 3

26. The magnetic field through a circular loop of wire, 12cm in radius and 8.5Ω resistance, changes with time as shown in the figure. The magnetic field is perpendicular to the plane of the loop. Calculate the current induced in the loop and plot a graph showing induced current as a function of time. 3



27. An inductor of inductance 'L' is connected to an AC source, V = 100 sin ωt. The graph below represents the variation of inductive reactance (X_L) of the inductor with the frequency of an alternating source. 3



(a) What is the self-inductance of the inductor?

(b) If the ac source is replaced by a battery such that V = 100 V, then what is the inductive reactance of the inductor? Give reason.

(c) When the frequency is 50 Hz, what is the average power dissipated by the inductor over a complete cycle in the circuit? Justify your answer.

28. (a) How does oscillating charge produce electromagnetic waves? 3

(b) Sketch a schematic diagram depicting oscillating electric and magnetic fields of an em wave propagating along + z-direction.

SECTION-D (Case Study Based Questions)

29. **Read the following paragraph and answer the questions that follow.** **4**

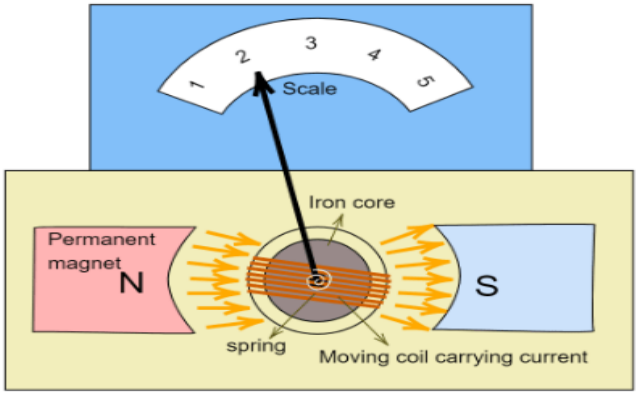
Moving coil galvanometer operates on Permanent Magnet Moving Coil (PMMC) mechanism and was designed by the scientist Darsonval.

Moving coil galvanometers are of two types

(i) Suspended coil

(ii) Pivoted coil type or tangent galvanometer,

Its working is based on the fact that when a current carrying coil is placed in a magnetic field, it experiences a torque. This torque tends to rotate the coil about its axis of suspension in such a way that the magnetic flux passing through the coil is maximum.



Front view of a Moving Coil Galvanometer

(i) A moving coil galvanometer is an instrument which;

(a) is used to measure emf

(b) is used to measure potential difference

(c) is used to measure resistance

(d) is a deflection instrument which gives a deflection when a current flows through its coil

(ii) To make the field radial in a moving coil galvanometer;

(a) number of turns of coil is kept small (b) magnet is taken in the form of horse-shoe

(c) poles are of very strong magnets (d) poles are cylindrically cut

(iii) The deflection in a moving coil galvanometer is;

(a) directly proportional to torsional constant of spring

(b) directly proportional to the number of turns in the coil

(c) inversely proportional to the area of the coil

(d) inversely proportional to the current in the coil

(iv) In a moving coil galvanometer, having a coil of N-turns of area A and carrying current I is placed in a radial field of strength B. The torque acting on the coil is;

(a) NA^2B^2I (b) $NABI^2$ (c) N^2ABI (d) NABI

OR

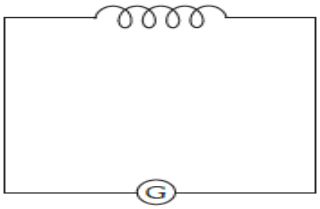
(iv) To increase the current sensitivity of a moving coil galvanometer, we should decrease;

(a) strength of magnet (b) torsional constant of spring

(c) number of turns in coil (d) area of coil

30. ***Read the para given below and answer the questions that follow:*** 4

When a current I flows through a coil, flux linked with it is $\phi = LI$, where L is a constant known as self-inductance of the coil.



Any charge 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 the decay of current flowing through the coil. Also, value of self-inductance depends on the number of turns in the solenoid, its area of cross-section and the permeability of its core material.

(i) The inductance in a coil plays the same role as;

(a) inertia in mechanics (b) energy in mechanics

(c) momentum in mechanics (d) force in mechanics

(ii) A current of 2.5 A flows through a coil of inductance 5 H. The magnetic flux linked with the coil is;

(a) 0.5 Wb (b) 12.5 Wb (c) zero (d) 2 Wb

(iii) The inductance L of a solenoid depends upon its radius R as

(a) $L \propto R$ (b) $L \propto 1/R$ (c) $L \propto R^2$ (d) $L \propto R^3$

(iv) The unit of self-inductance is

(a) Weber ampere (b) $Weber^{-1}$ ampere (c) Ohm second (d) Farad

OR

(iv) The induced emf in a coil of 10 henry inductance in which current varies from 9 A to 4 A in 0.2 second is;

(a) 200 V (b) 250 V (c) 300 V (d) 350 V

SECTION-E

31. (a) A camera usually operates at 1.5 V and this potential difference is not sufficient to emit light energy using flash. For this purpose, the flash circuit of the camera has a capacitor that is charged to 300 V-330 V using various electrical components. If the voltage generated across the plates of the capacitor is 300 V and the capacitance of the parallel plate capacitor used is 100 μF, then find

the energy released when the trigger button on the camera is pressed. 5

(b) How much charge does the 100 µF capacitor charged to 300 V hold?

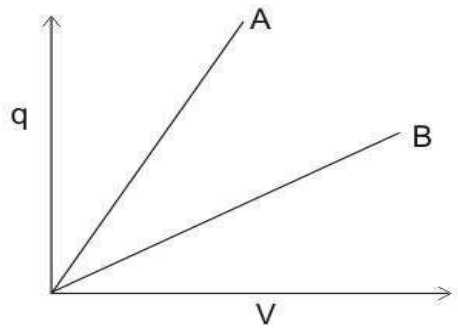
(c) If the distance between the parallel plate capacitor of capacitance 100 µF is increased two times, then calculate the capacitance of the capacitor.

(d) The graph below shows the variation of charge 'q' with potential difference 'V' for a parallel plate capacitor 'C' for scenarios P and Q.

Scenario P - the space between the capacitor 'C' is filled with air.

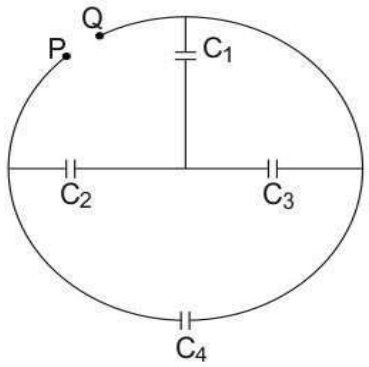
Scenario Q - the space between the capacitor 'C' is filled with a substance of dielectric constant K.

Which of the two lines A or B corresponds to scenario Q? Give a reason for your answer.



OR

(a) Find the effective capacitance between points P and Q, if each capacitor has a capacitance of 6µF.



(b) Find the ratio of charges on capacitors C_1 and C_4, if the potential difference between points P and Q is 10 V.

32.

(a) Draw graphs showing the variations of inductive reactance and capacitive reactance with frequency of applied ac source. 5

(b) Draw the phasor diagram for a series LRC circuit connected to an AC source.

(c) When an alternating voltage of 220V is applied across a device X, a current of 0.25A flows which lags behind the applied voltage in phase by $\pi/2$ radian. If the same voltage is applied across another device Y, the same current flows but now it is in phase with the applied voltage.

(i) Name the devices X and Y.

(ii) Calculate the current flowing in the circuit when the same voltage is applied across the series combination of X and Y.

OR

(a) A series LCR circuit is connected to an ac source. Using the phasor diagram, derive the expression for the impedance of the circuit.

(b) Plot a graph to show the variation of current with frequency of the ac source, explaining the nature of its variation for two different resistances R_1 and R_2 ($R_1 < R_2$) at resonance.

33. (a) Using Ampere's circuital law, obtain an expression for the magnetic field along the axis of a current carrying solenoid of length **l** and having **N** number of turns. 5

(b) In what respect is a toroid different from a solenoid? Draw and compare the pattern of the magnetic field lines in the two cases.

(c) How is the magnetic field, inside a given solenoid made strong?

OR

For a circular coil of radius ***R*** and ***N*** turns carrying current ***I***, the magnitude of the magnetic field at a point on its axis at a distance ***x*** from its centre is given by,

$$B = \frac{\mu_0 I R^2 N}{2\left(x^2 + R^2\right)^{\frac{3}{2}}}$$

(a) Show that this reduces to the familiar result for field at the centre of the coil.

(b) Consider two parallel co-axial circular coils of equal radius ***R***, and number of turns ***N***, carrying equal currents in the same direction, and separated by a distance ***R***. Show that the field on the axis around the mid-point between the coils is uniform over a distance that is small as compared to ***R***, and is given by, B= 0.72 - $\frac{\mu oBNI}{R}$, approximately.

----------ALL THE BEST----------