विद्या सर्वार्थि साधिका

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PERIODIC TEST - 2

Class : XII

Subject: Physics (042) M.M : 70

Date : 03-10-2023 Time : 3 hours

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.

SECTION A

1. An ac voltage $v = v_0\, sin\omega t$ is applied to series combination of a resistor R and an element X. The instantaneous current in the circuit is $I = I_0 \sin(\omega t + \frac{\pi}{4})$. Which of the following is correct? (1)

   (A) X is a capacitor and $X_C = \sqrt{2}R$
   (B) X is an inductor and $X_L = \sqrt{2}R$
   (C) X is a capacitor and $X_C = R$
   (D) X is an inductor and $X_L = R$

2. A rectangular, a square and a circular loop all in the (x-y) plane, are moving out of a uniform magnetic field with a constant velocity $\vec{v} = v\hat{\imath}$. The magnetic field is directed along the negative z-axis direction. The induced emf, during the passage of these loops, out of the field region, will not remain constant for _____. (1)

   (A) square loop only
   (B) rectangular loop only
   (C) circular loop only
   (D) all three loops

3. The SI unit of inductance is henry. It can be expressed as _____. (1)

   (A) weber/ampere (B)volt/ampere-second (C) joule/ampere (D) ohm-second

4. A piece of copper and germanium are cooled from room temperature to 80 K. The resistance of _____. (1)

   (A) both copper and germanium increase
   (B) copper increases and germanium decreases
   (C) both copper and germanium decrease
   (D) copper decreases and germanium increases

5. A magnetic needle is kept in a non-uniform magnetic field. It experiences _____. (1)

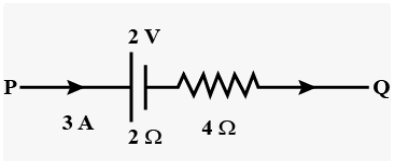
   (A) no force and no torque
   (B) a torque but not a force
   (C) a force and a torque
   (D) a force but not a torque.

6. An electron enters a uniform magnetic field with speed *v*. It describes a semicircular path and comes out of the field. The final speed of the electron is _____. (1)

   (A) zero (B) v (C) $v/2$ (D) $2v$

7. A steady current flows in a metallic conductor of non-uniform cross section. The quantity constant along the conductor is _____. (1)
(A) current (B) drift speed (C) electric field (D) resistance

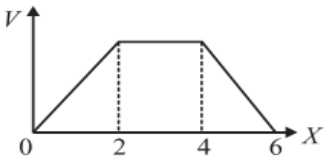
8. If 3A of current is flowing between points P and Q in the circuit, then the potential difference between P and Q is _____. (1)

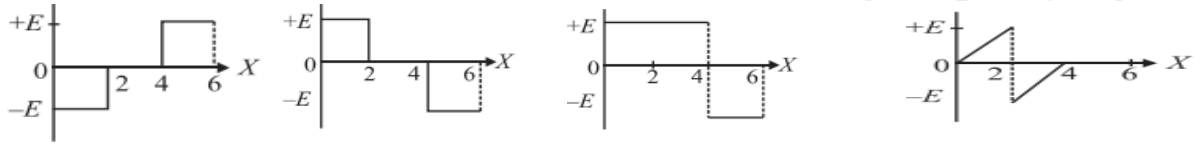


(A) 14 V (B) 16 V (C) 18 V (D) 20 V

9. In an LCR – series circuit, the power delivered by ac source of circuit is maximum when ___. (1)
(A) $X_L = X_C \; and \; Z = R$ (C) $X_L < X_C \; and \; Z \neq R$
(B) $X_L = X_C \; and \; Z \neq R$ (D) $X_L > X_C \; and \; Z \neq R$

10. The electric potential V as a function of distance X is shown in the figure. The graph of the magnitude of electric field intensity E as a function of X is _____. (1)





(A) (B) (C) (D)

11. A charge Q is enclosed by a Gaussian spherical surface of radius R. If the radius is doubled, then the outward flux will _____. (1)
(A) increaase four times (B) remain the same (C) be doubled (D) be reduced to half

12. A charge q is placed at the centre of line joining two equal charges Q. The system of three charges will be in equilibrium if q is equal to _____. (1)
(A) -Q/2 (B) +Q/2 (C) –Q/4 (D) +Q/4

In the following questions (Q.No. 13 to 16), a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.
(A) Both A and R are true, and R is the correct explanation of the assertion.
(B) Both A and R are true, but R is not the correct explanation of the assertion.
(C) A is true, but R is false.
(D) A is false, but R is true.

13. Assertion: In electromagnetic waves, the phase difference between electric and magnetic field vectors is zero. (1)
Reason: Velocity of em wave in a material medium is given by $\frac{1}{\sqrt{\varepsilon\mu}}$ where ε is permittivity and μ is permeability of the medium.

14. Assertion: Work done in moving a charge between any two points in a uniform electric field is independent of the path followed by the charge, between them. (1)
Reason: Electrostatic force is a conservative force.

15. Assertion: A current carrying square loop made of a wire of length L is placed in a magnetic field. It experiences a torque which is lesser than the torque on a circular loop made of the same wire carrying the same current in the same magnetic field: (1)
Reason: A square loop occupies less area than a circular loop, both made of wire of the same length.

16. Assertion: Conductivity of an electrolyte is much higher than that of a metal at room temperature. (1)
Reason: Free electron density in metals is much greater than the density of ions in electrolytes.

SECTION B

17. When an ideal capacitor is charged by a dc battery, no current flows. However, when an ac source is used, the current flows continuously. How does one explain this, based on the concept of displacement current? (2)

OR

The electric filed of a plane electromagnetic wave in vacuum is represented by $E_y = 60\cos[2\pi\ x\ 10^8(t - x/c)]$ and $E_x = 0,\ E_z = 0$.
(a) What is the direction of propagation of the wave?
(b) Compute the amplitude of magnetic field of the electromagnetic wave.
(c) Write the expression representing the corresponding magnetic field.

18. Two isolated metal spheres A and B have radii R and 2R respectively, and have same charge q. Find which of the two spheres have greater (i) capacitance and (ii) energy density just outside the surface of the spheres. (2)

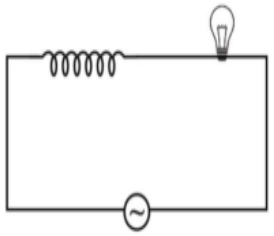
19. Derive an expression for drift velocity of electrons in a conductor. Hence deduce Ohm's law. (2)

20. Find the condition under which charged particles of a particular speed can be selected from particles moving with different speeds in the presence of electric and magnetic fields. (2)

21. (a) Define the term 'electric flux'. Write its SI units. (2)
(b) What is the electric flux due to electric field $\vec{E} = 3\ x\ 10^3\hat{\imath}$ N/C through a square of side 10 cm, when it is held normal to $\vec{E}$?

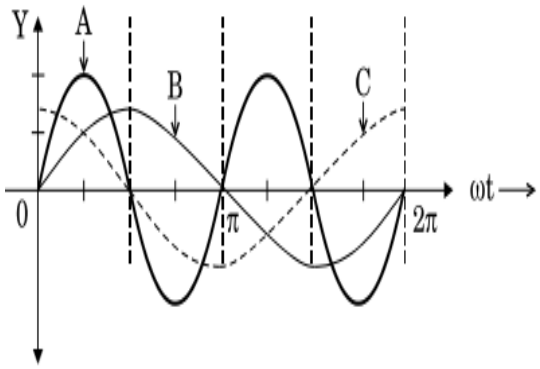
SECTION C

22. An inductor L of inductance X_L is connected in series with a bulb B and an ac source. How would brightness of the bulb change when (a) an iron rod is inserted in the inductorand (b) a capacitor of reactance $X_C = X_L$ is inserted in series in the circuit? Justify your answer in each case. (3)



OR

A device 'X' is connected to an ac source $\boldsymbol{V = V_0\ sin\omega t}$. The variation of voltage, current and power in one cycle is shown in the following graph:
(a) Identify the device 'X'.
(b) Which of the curves A, B and C represent the voltage, current and the power consumed in the circuit?
(c) How does its impedance vary with frequency of the ac source?
(d) What is the phase relation between voltage and current in the circuit?



23. Distinguish between dia magnetic and para magnetic substances in terms of (3)
(i) magnetic susceptibility (ii) magnetic permeability and (iii) the effect of temperature.

24. (a) How are electromagnetic waves produced? (3)
(b) What is the source of the energy carried by a propagating electromagnetic wave?
(c) Identify the electromagnetic radiations used for
(i) radar system used in aircraft navigation and
(ii) treatment of cancer.

25. A 0·5 m long solenoid of 10 turns/cm has area of cross-section 1 cm^2. Calculate the voltage induced across its ends if the current in the solenoid is changed from 1 A to 2 A in 0·1 s. (3)

26. (a) How can a moving coil galvanometer be converted into an ammeter? (3)
(b) To increase the current sensitivity of a moving coil galvanometer by 50%, its resistance is increased so that the new resistance becomes twice its initial resistance. By what factor does its voltage sensitivity change?

27. Derive the equation of the balanced state in a Wheatstone bridge using Kirchhoff's laws. (3)

28. (a) A parallel plate capacitor C_1 having charge Q is connected, to an identical uncharged capacitor C_2 in series. What would be the charge accumulated on the capacitor C_2? (3)

(b) Three identical capacitors each of capacitance $3\mu F$ are connected, in turn, in series and in parallel combination to the common source of V volt. Find out the ratio of the energies stored in two configurations.

SECTION D

29. An equipotential surface is a surface with a constant value of potential at all points on the surface. Equipotential surfaces offer an alternative visual picture in addition to the picture of electric field lines around any charge configuration. Equipotential surfaces of a single point charge are concentric spherical surfaces centred at the charge. The electric field at every point is normal to the equipotential surface passing through that point. To move a unit test charge against the direction of the component of the field, work would have to be done.

(i) What is the work done in moving a unit charge along an equipotential surface? (1)
(ii) Two point charges A = +3 nC and B = +1 nC placed 5 cm apart in air. Calculate the work done to move charge B towards charge A by 1cm. (1)
(iii) Draw the equipotential surfaces corresponding to a field that uniformly increases in magnitude but remain constant (say x) direction. (2)

OR

(iii) Draw the equipotential surfaces due to an electric dipole. Locate the points where the potential due to the dipole is zero.

30. Electromagnetic induction is the production of an electromotive force (emf) across an electrical conductor in a changing magnetic field. The emf is also induced by varying current in the coil or by changing area. The emf when produced due to the motion of the conductor is termed as motional emf. There are many appliances functioning based on electromagnetic induction principle. One of the interesting natural phenomena is explained using emi principle here. The migratory bird's pattern is one of the mysteries in the field of science. There has been a suggestion that electromagnetic induction may provide a clue to the as migratory patterns. The earth's magnetic field has existed throughout evolutionary history. It would be of great benefit to migratory birds to use this field to determine the direction. Electromagnetic induction seems to be the reasonable mechanism to determine the direction in the case migratory birds.
(i) State the law which gives the polarity of induced emf. (1)

(ii) The magnetic flux through a circuit of resistance R changes by an amount $\Delta\phi$ in a time Δt. The total electric charge Q that passes any point in the circuit during the time Δt is represented by _____. (1)

(A) $Q = \Delta\phi/R$ (B) $Q = \Delta\phi$ (C) $Q = R\Delta\phi$ (D) $Q = R/\Delta\phi$

(iii) A migratory siberian bird is flying in the sky with a velocity of 10 m/s and the distance between two feathers is 2cm. The earth's magnetic field B perpendicular to the feathers is 4×10^{-5} T. How much emf generated between the two feathers? (2)

OR

(iii) An aeroplane having a wing span of 35 m flies due north with a speed of 90 m/s, given $B = 4 \times 10^{-5}$ T. How much potential difference would be developed between the tips of the wings?

SECTION E

31. (a) Derive an expression for the electric field E due to a dipole of length '2a' at a point distant r from the centre of the dipole on the axial line and draw a graph of E versus r for r >> a. (5)

(b) If this dipole were kept in a uniform external electric field E, diagrammatically represent the position of the dipole in (i) stable and (ii) unstable equilibrium and write the expressions for the torque acting on the dipole in both the cases.

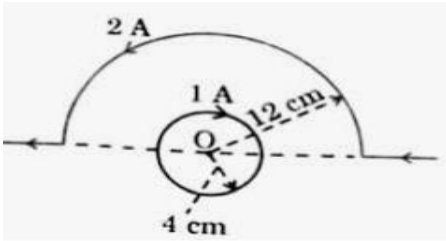
OR

(a) Use Gauss's theorem to find the electric field due to a uniformly charged infinitely large plane thin sheet with surface charge density σ.

(b) An infinitely large thin plane sheet has a uniform surface charge density +σ. Obtain the expression for the amount of work done in bringing a point charge q from infinity to a point, distant r, in front of the charged plane sheet.

32. Using Biot-Savart law, derive the expression for the magnetic field due to a circular current carrying loop of radius r at its centre. (5)

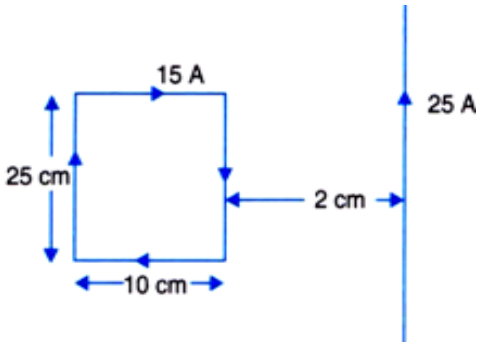
A current carrying circular loop and a straight wire bent partly in the form of a semicircle are placed as shown in the figure. Find them magnitude and direction of net magnetic field at point O.



OR

(a) Two long straight parallel conductors carry steady currents I_1 and I_2 in opposite direction and separated by a distance r. Obtain the expression for force between the conductors.

(b) Calculate the net force on the rectangular coil due the current carrying straight conductor as shown in the figure.



33. State the principle of an ac generator and explain its working with the help of a labelled diagram. Obtain the expression of the emf induced in a coil having N turn each of cross-sectional area A, rotating with the constant angular speed in a magnetic field ω, directed perpendicular to the axis of rotation. (5)

OR

(a) Draw and explain the principle, construction and working of a step up transformer.

(b) Write the main assumption involved in deriving the above relations.

(c) Write any two reasons due to which energy losses may occur in actual transformers.