ANANDALAYA
PRE-BOARD EXAMINATION
Class: XII

Subject: Physics (042) — Marks: 70

Date : 18-12-2023 — Time : 3 Hours

General Instructions:

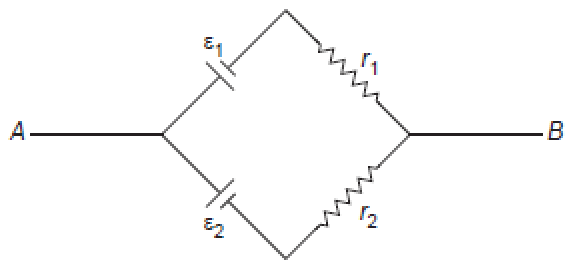
1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections – Section A, Section B, Section C, Section D and Section E.
3. Section A contains sixteen questions - twelve MCQ and four Assertion-Reasoning based - 1 mark each, Section B contains five questions 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.
4. 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.
5. Use of calculators is not allowed.
6. You may use the following values of physical constants wherever necessary.
   The values of some physical constants:
   $e = 1.6 \times 10^{-19}$ C, h = 6.6×10^{-34} Js, mass of electron = 9.1×10^{-31} kg
   $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ Nm^2C^{-2}, $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}.

SECTION A

1. A hollow metal sphere of radius 5 cm is charged so that the potential on its surface is 10 V. The potential at the centre of the sphere is _________. (1)
   (A) 0 V (B) Same as at point 5 cm away from the surface
   (C) 10 V (D) Same as at point 25 cm away from the surface

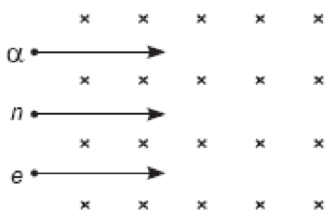
2. A capacitor is charged by a battery. The battery is removed and another identical uncharged capacitor is connected in parallel. The total electrostatic energy of resulting system _______. (1)
   (A) increases by a factor of 4. (B) decreases by a factor of 2.
   (C) remains the same. (D) increases by a factor of 2.

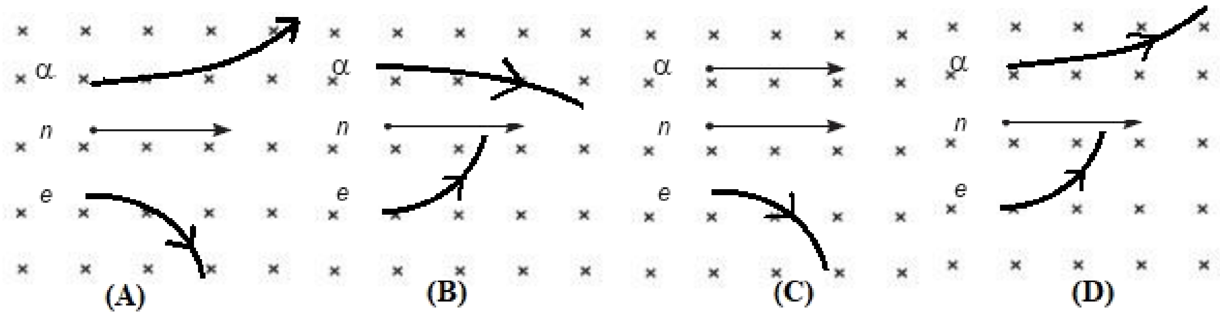
3. Two batteries of ε_1 and ε_2 ($\varepsilon_2 > \varepsilon_1$) and internal resistance r_1 and r_2 respectively are connected in parallel as shown in figure. (1)



   (A) The equivalent emf ε_{eq} of the two cells is between ε_1 and ε_2, i.e., $\varepsilon_1 < \varepsilon_{eq} < \varepsilon_2$.
   (B) The equivalent emf ε_{eq} is smaller than ε_1.
   (C) The ε_{eq} is given by $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$ always.
   (D) ε_{eq} is independent of internal resistances r_1 and r_2.

4. A neutron, an electron and an alpha particle moving with equal velocities, enter a uniform magnetic field going into the plane of the paper as shown. Which one of the following options represents the path followed by them? (1)





5. When current in a coil change from 5 A to 2 A in 0.1 s, average voltage of 50 V is produced. The self-inductance of the coil is _______. (1)
(A) 1.67 H (B) 6 H (C) 3 H (D) 0.67 H

6. If the rms current in a 50 Hz ac circuit is 5 A, the value of the current 1/300 seconds after its value becomes zero is __________. (1)
(A) $5\sqrt{2}$ A (B) $5\sqrt{\frac{3}{2}}$ A (C) $\frac{5}{6}$ A (D) $\frac{5}{\sqrt{2}}$ A

7. A charged particle oscillates about its mean equilibrium position with a frequency of 10^9 Hz. For producing electromagnetic waves which one of the following is not true? (1)
(A) They will have frequency of 10^9 Hz.
(B) They will have frequency of 2×10^9 Hz.
(C) They will have a wavelength of 0.3 m.
(D) They fall in the region of radio waves.

8. Careful measurement of the electric field at the surface of a black box indicates that the net outward flux through the surface of the box is 8.0×10^3 Nm^2/C. What is the net charge inside the box? (1)
(A) $+\frac{8.0\times10^3}{\varepsilon_0}$ C (B) $-\frac{8.0\times10^3}{\varepsilon_0}$ C (C) $+8000\varepsilon_0$ C (D) $-8000\varepsilon_0$

9. The de Broglie wavelength of a particle of kinetic energy K is λ. What would be the wavelength of the particle, if its kinetic energy were K/4? (1)
(A) λ (B) 2λ (C) 3λ (D) 4λ

10. Ratio of the radii of the nuclei with mass numbers 8 and 27 would be _________. (1)
(A) $\frac{27}{8}$ (B) $\frac{8}{27}$ (C) $\frac{2}{3}$ (D) $\frac{3}{2}$

11. The fringe width in a young's double slits experiment is 2 x 10^{-4} m. The entire apparatus is immersed in a liquid of refractive index 4/3. What is the new fringe width? (1)
(A) 1.5×10^{-4} m (B) 2.6×10^{-4} m (C) 2×10^{-4} m (D) 3×10^{-4} m

12. A p-type semiconductor can be obtained by adding ___________. (1)
(A) arsenic to pure silicon. (B) gallium to pure silicon.
(C) antimony to pure germanium. (D) phosphorus to pure germanium.

For question numbers 13 to 10, two statements are given-one labelled Assertion and the other labelled Reason. Select the correct answer from the options given below.
(A) Both Assertion and Reason are true and Reason is the correct explanation of Assertion
(B) Both Assertion and Reason are true but Reason is NOT the correct explanation of Assertion.
(C) Assertion is true but Reason is false
(D) Assertion is false and Reason is true.

13. Assertion: The capacitive reactance limits the amplitude of the current in a purely capacitive circuit. (1)
Reason: Capacitive reactance is proportional to the frequency and the capacitance.

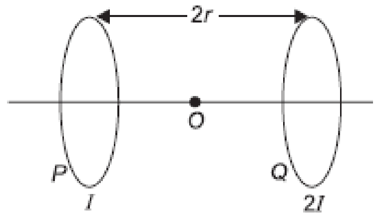
14. Assertion: Two equipotential surfaces cannot cut each other. (1)
Reason: Two equipotential surfaces are parallel to each other.

15. Assertion: An object is placed at a distance of ‘f’ from a convex mirror of focal length ‘f’ its image will form at infinity. (1)
Reason: The distance of image in convex mirror can never be infinity

16. Assertion: Bohr had to postulate that the electrons in stationary orbits around the nucleus do not radiate. (1)
Reason: According to classical physics all moving electrons radiate.

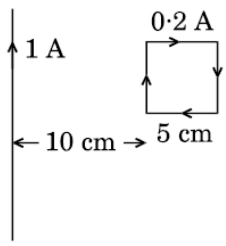
SECTION B

17. Two identical circular loops, P and Q, each of radius r and carrying currents I and 2I respectively are lying in parallel planes such that they have a common axis. (2)
The direction of current in both the loops is clockwise as seen from O which is equidistant from both loops. Find the magnitude of the net magnetic field at point O.



OR

A square loop of sides 5 cm carrying a current of 0·2 A in the clockwise direction is placed at a distance of 10 cm from an infinitely long wire carrying a current of 1A as shown. Estimate (i) the resultant magnetic force, and (ii) the torque, if any, acting on the loop.



18. (a) An em wave is travelling in a medium with a velocity $\vec{v} = v\hat{i}$. The electric field oscillations, of this em wave, are along the y-axis. Draw a sketch showing the propagation of the em wave, indicating the direction of the oscillating electric and magnetic fields. (2)
(b) How are the magnitudes of the electric and magnetic fields related to the velocity of the em wave?

19. (a) Draw a labelled ray diagram of a compound microscope. (b) Derive an expression for its magnifying power. (2)

OR

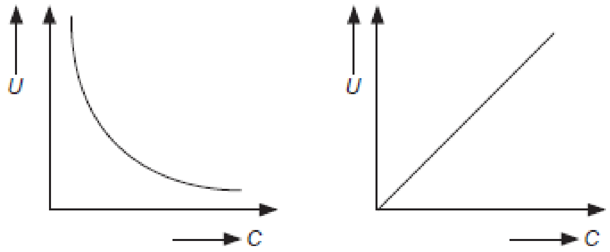
(a) Write the necessary conditions for the phenomenon of total internal reflection to occur.
(b) Write the relation between the refractive index and critical angle for a given pair of optical media.

20. What is the angular momentum of an electron in Bohr’s hydrogen atom whose energy is –3.4 eV? (2)

21. Draw energy band diagram of intrinsic semiconductor at (a) T = 0K and (b) T > 0 K. (2)

SECTION C

22. (a) The energy of a capacitor varying with its capacitance is shown by two graphs (i) and (ii). Find in which of the graphs: (A) charge is constant, and (B) potential difference is constant. (3)

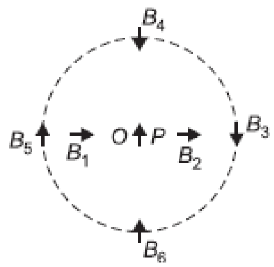


(i) (ii)

(b) How much work is required in turning an electric dipole of dipole moment $\vec{p}$ from its position of stable equilibrium to its position of unstable equilibrium in a uniform electrostatic field $\vec{E}$?

23. Define relaxation time of the free electrons drifting in a conductor. How is it related to the drift velocity of free electrons? Use this relation to deduce the expression for the electrical resistivity of the material. (3)

24. The given 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 magentised needle *B*. (3)



Answer the following questions and justify.

(a) In which configuration(s) the system is not in equilibrium?

(b) In which configuration(s) is the system in stable equilibrium?

(c) Which configuration corresponds to the lowest potential energy among all the configurations shown?

25. 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. (3)

OR

(a) The instantaneous current and voltage of LCR a.c. circuit are given by i = 10 sin 300 t A and V = 200 sin 300 t V. (i) What is the power factor for this circuit? (ii) Calculate the power dissipation in the circuit. (iii) If the inductive reactance is 20 ohms, what is the capacitive reactance for this circuit?

(b) An ac source is connected across an ideal inductor. Show on a graph the nature of variation of the voltage and the current over one complete cycle.

(c) Define wattles current.

26. A convex lens made up of glass of refractive index 1.5 is dipped, in turn, in (i) a medium of refractive index 1.65, (ii) a medium of refractive index 1.33. (a) Will it behave as a converging or a diverging lens in the two cases? (b) How will its focal length change in the two media? (3)

27. How is a wavefront defined? Using Huygen's construction draw a figure showing the propagation of a plane wave reflecting at the interface of the two media. Show that the angle of incidence is equal to the angle of reflection. (3)

28. What is binding energy? A nucleus with mass number A = 240 and BE/A = 7.6 MeV breaks into two fragments each of A = 120 with BE/A = 8.5 MeV. Calculate the energy released. (3)

SECTION D

Question no 29 and 30 are case based questions. Read the paragraph and answer the questions given below.

29. **Diffraction of Light:** (4)

A and B went to purchase a ticket of a music programme. But unfortunately, only one ticket was left. They purchased the single ticket and decided that A would be in the hall during the1st half and B during the 2nd half. Both of them reached the hall together. A entered the hall and found that the seat was behind a pillar which creates an obstacle. He was disappointed. He thought that he would not be able to hear the programme properly.

B was waiting outside the closed door. The door was not fully closed. There was a little opening. But surprisingly, A could hear the music programme.

The sound waves were able to "bend around" the obstacles. In fact, this is more pronounced with longer wavelengths implies that we can hear low frequencies around obstacles better than high frequencies.

B was outside the door. He could also hear the programme. But he noticed that when the door opening is comparatively less he could hear the programme even being little away from the door. This is because when the width of the opening is larger than the wavelength of the wave passing through the gap then it does not spread out much on the other side. But when the opening is smaller than the wavelength the waves spread out greatly – with semi-circular wavefront. The opening in this case functions as a localized source of sound.

(i) A and B could hear the music programme due to phenomenon named __________. (1)

(A) interference. (B) scattering (C) diffraction. (D) dispersion

(ii) The 'bending' is more pronounced with ______ wavelengths. (1)

(A) Longer (B) Shorter (C) fluctuating (D) all

(iii) Write any two differences between diffraction and interference patterns. (2)

OR

(iii) Which part of emw spectrum do we prefer in RADAR? Why?

30. The phenomenon of photoelectric emission was discovered in 1887 by Heinrich Hertz (1857-1894), during his electromagnetic wave experiments. In his experimental investigation on the production of electromagnetic waves by means of a spark discharge, Hertz observed that high voltage sparks across the detector loop were enhanced when the emitter plate was illuminated by ultraviolet light from an arc lamp. Wilhelm Hallwachs and Philipp Lenard investigated the phenomenon of photoelectric emission in detail during 1886-1902. (4)

These observations have two implications: (i) The maximum kinetic energy of the photoelectrons varies linearly with the frequency of incident radiation, but is independent of its intensity. (ii) For a frequency ν of incident radiation, lower than the cut-off frequency ν0, no photoelectric emission is possible even if the intensity is large. This minimum, cut-off frequency ν_0, is called the threshold frequency. It is different for different metals.

(i) For a given photosensitive material and frequency of incident radiation (above the threshold frequency), the photoelectric current is directly proportional to ______. (1)

(A) work function (B) intensity

(C) Planck's constant (D) all of the above

(ii) The work function of a photosensitive material is 2.4 eV. What will be the stopping potential when an incident frequency of energy 3 eV is used? (1)

(A) 2.4 V (B) 3 V (C) 5.4 V (D) 0.6 V

(iii) Draw a graph to show the variation of photocurrent with collector plate potential when two incident waves of same frequency but with different intensities are used in photoelectric emission. (2)

OR

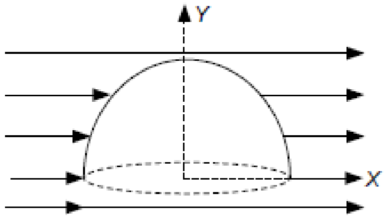
(iii) Give two reasons why wave theory of light could not explain photoelectric effect.

SECTION E

31. (a) Define electric field intensity. Write its SI unit. (5)

(b) Write the magnitude and direction of electric field intensity due to an electric dipole of length $2a$ at the mid-point of the line joining the two charges.

(c) A hemispherical surface lies as shown in a uniform electric field region. Find the net electric flux through the curved surface if electric field is (i) along the x-axis, and (ii) along the y-axis.

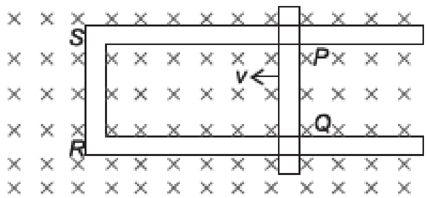


OR

(a) Using Gauss's theorem, deduce an expression for the electric field intensity at any point due to a thin, infinitely long wire of charge/length λ C/m.

(b) Two small balls with equal positive charges q coulomb are suspended by two insulating strings of equal length l metre from a hook fixed to a stand. The whole set up is taken in a satellite into space where there is no gravity. Find the angle between the strings and tension (T) in each string.

32. (a) Figure shows a rectangular loop conducting $PQRS$ in which the arm PQ is free to move. A uniform magnetic field acts in the direction perpendicular to the plane of the loop. Arm PQ is moved with a velocity v towards the arm RS. Assuming that the arms QR, RS and SP have negligible resistances and the moving arm PQ has the resistance r, obtain the expression for (i) the current in the loop (ii) the force and (iii) the power required to move arm PQ. (5)



(b) A circular coil of radius 8.0 cm and 20 turns is rotated about its vertical diameter with an angular speed of 50 rad s^{-1} in a uniform horizontal magnetic field of magnitude 3.0×10^{-2} T. Obtain the maximum and average emf induced in the coil.

OR

(a) Write the function of a transformer. State its principle of working with the help of a diagram. Mention two ways the energy loss occur in this device.

(b) The primary coil of an ideal step-up transformer has 100 turns and transformation ratio is also 100. The input voltage and power are respectively 220 V and 1100 W. Calculate (i) number of turns in secondary, (ii) current in primary, (iii) voltage across secondary, (iv) current in secondary and (v) power in secondary.

33. (a) State briefly the processes involved in the formation of p–n junction explaining clearly how the depletion region is formed. (5)

(b) Using the necessary circuit diagrams, show how the V-I characteristics of a p–n junction is obtained in (i) Forward biasing (ii) Reverse biasing.

OR

Draw the circuit diagram of a full wave rectifier. Describe it's working. Draw its input and output wave form.