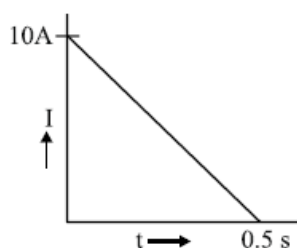


GENERAL INSTRUCTIONS:

- (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 two questions 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
 $c = 3 \times 10^8 \text{ m/s}$, $m_e = 9.1 \times 10^{-31} \text{ kg}$, $e = 1.6 \times 10^{-19} \text{ C}$, $\mu_0 = 4\pi \times 10^{-7} \text{ TmA}^{-1}$,
 $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{N}^{-1} \text{m}^{-2}$, Avagadro Number $N_A = 6.02 \times 10^{23}$ per gram mole

Section A

- 1 The curve of binding energy per nucleon as a function of atomic mass number has a sharp peak for helium nucleus. This implies that helium nucleus is 1
(A) radioactive (B) unstable
(C) easily fissionable (D) more stable nucleus than its neighbours
- 2 A bulb is rated (100 W, 110 V). It is operated by current of 1.0 A supplied by a step down transformer. If the input voltage and efficiency of the transformer are 220 V and 0.9 respectively, the input current drawn from the mains is 1
(A) $\frac{1}{2}$ A (B) $\frac{3}{8}$ A (C) $\frac{5}{9}$ A (D) $\frac{4}{7}$ A
- 3 Which of the following statement is true for the radio waves and the gamma rays? 1
(A) The energy of gamma rays is lesser than that of the radio waves.
(B) The frequency of the radio waves is higher than that of gamma rays.
(C) The radio waves and the gamma rays have the same energy.
(D) The energy of radio waves is lesser than that of the gamma rays.
- 4 In a coil of resistance 100 Ω a current is induced by changing the magnetic flux through it. The variation of current with time is as shown in the figure. The magnitude of change in flux through coil is 1



- (A) 250 Wb (B) 275 Wb
(C) 225 Wb (D) 200 Wb

- 5 The distance of closest approach of an alpha particle is d when it moves with a speed v towards a nucleus. Another alpha particle is projected with higher energy such that the new distance of the closest approach is $d/2$. What is the speed of projection of the alpha particle in this case?
 (A) $v/2$ (B) $\sqrt{2}v$ (C) $2v$ (D) $4v$
- 6 A point object is placed at the centre of a glass sphere of radius 6 cm and refractive index 1.5. The distance of virtual image from the surface of the sphere is
 (A) 2 cm (B) 4 cm (C) 6 cm (D) 12 cm
- 7 A plane wavefront is incident on a concave mirror of radius of curvature R . The radius of the refracted wavefront will be
 (A) $2R$ (B) R (C) $R/2$ (D) $4R$
- 8 A point charge situated at a distance r from a short electric dipole on its axis, experience a force F . If the distance of the charge is $2r$, the force on the charge will be
 (A) $F/16$ (B) $F/8$ (C) $F/4$ (D) $F/2$
- 9 Two particles A and B of the same mass but having charges q and $4q$ respectively, are accelerated from rest through different potential differences V_A and V_B such that they attain same kinetic energies. The value of $\frac{V_A}{V_B}$ is
 (A) $\frac{1}{4}$ (B) $\frac{1}{2}$
 (C) 2 (D) 4
- 10 A coil contains N turns of insulated copper wire of diameter d and resistivity ρ wound on a cylinder of diameter D . What is the total resistance between the two ends of the coil of copper wire? (given: $D \gg d$)
 (A) $\frac{4\rho ND}{d^2}$ (B) $\frac{8\rho ND}{d^2}$
 (C) $\frac{2\rho ND}{d^2}$ (D) $\frac{12\rho ND}{d^2}$
- 11 A galvanometer having a coil resistance of $48\ \Omega$, shows full-scale deflection for a current of 2.0 A . It can be converted into an ammeter of range $(0 - 10\text{ A})$ by connecting :
 (A) in series a resistance of $8\ \Omega$ (B) in parallel a resistance of $8\ \Omega$
 (C) in parallel a resistance of $12\ \Omega$ (D) in series a resistance of $12\ \Omega$
- 12 Which of the following substances has relative magnetic permeability $\mu_r \gg 1$
 (A) Aluminium (B) Copper
 (C) Nickel (D) Bismuth

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 the correct explanation of Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

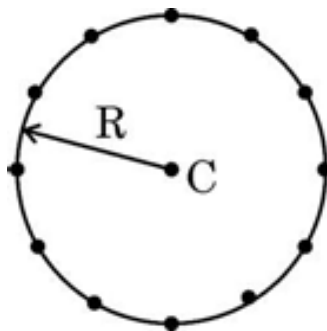
C. If Assertion is true but Reason is false.

D. If both Assertion and Reason are false.

- 13 **Assertion(A)** : In Lyman series, the ratio of minimum and maximum wavelength is $\frac{3}{4}$. 1
Reason(R) : Lyman series constitute spectral lines corresponding to transition from higher energy to ground state of hydrogen atom.
- 14 **Assertion (A)** : The phase difference between any two points on a wavefront is zero. 1
Reason (R) : All points on a wavefront are at the same distance from the source and thus oscillate in the same phase.
- 15 **Assertion (A)** : Electrostatic force is a conservative force. 1
Reason (R) : In an electrostatic field, the work done between two points per unit positive charge depends on the path followed.
- 16 **Assertion (A)** : The image of an object placed between f and $2f$ from a convex lens can be seen on a screen. If the screen is removed, image is not formed. 1
Reason (R) : Rays from a given point on the object placed between f and $2f$, after passing through a convex lens, do not converge on a point in space.

SECTION - B

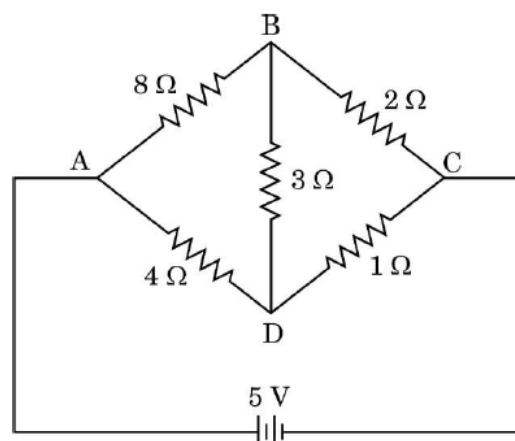
- 17 Twelve negative charges of same magnitude are equally spaced and fixed on the circumference of a circle of radius R as shown in Fig. Relative to potential being zero at infinity, find the electric potential and electric field at the centre C of the circle. 2



- 18 A cell is connected across an external resistance 12Ω and supplies 0.25A current. When the external resistance is increased by 4Ω , the current reduces to 0.2 A . Calculate (i) the emf, and (ii) the internal resistance, of the cell. 2

OR

The figure shows a network of resistors connected across a battery. Find the current supplied by the battery of emf 5 V and internal resistance $\frac{2}{3}\Omega$.



- 19 A small magnetised needle P is placed at the origin of x-y plane with its magnetic moment pointing along the y-axis. Another identical magnetised needle Q is placed in two positions, one by one. 2

Case 1 : at (a, 0) with its magnetic moment pointing along x-axis.

Case 2 : at (0, a) with its magnetic moment pointing along y-axis.

(a) In which case is the potential energy of P and Q minimum?

(b) In which case is P and Q not in equilibrium?

Justify your answers.

OR

A wire of length l is in the form of a circular loop A of one turn. This loop is reshaped into loop B of three turns. Find the ratio of the magnetic fields at the centres of loop A and loop B for the same current through them. 2

- 20 (a) How is an electromagnetic wave produced? 2
(b) Sketch a schematic diagram depicting the electric and magnetic fields for an electromagnetic wave propagating along z-axis.

OR

In a plane electromagnetic wave in free space, the electric field oscillates sinusoidally at a frequency of 1.5×10^{10} Hz with amplitude 36 Vm^{-1} . Find: 2

(a) the wavelength of the wave, and

(b) the amplitude of the associated magnetic field.

- 21 (a) Draw a graph to show the variation of the number of scattered particles detected (N) in Geiger-Marsden experiment as a function of scattering angle (θ). 2
(b) Discuss briefly two conclusions that can be drawn from this graph and how they lead to the discovery of nucleus in an atom.

SECTION C

- 22 A potential difference V is applied across a conductor of length l and uniform cross-section area A . How will the (i) electric field E , (ii) drift velocity v_d , and (iii) current density j be affected when (a) V is doubled and (b) l is halved (keeping other factors constant)? Explain. 3

- 23 A proton with kinetic energy 1.3384×10^{-14} J moving horizontally from north to south, enters a uniform magnetic field B of 2.0 mT directed eastward. Calculate: 3

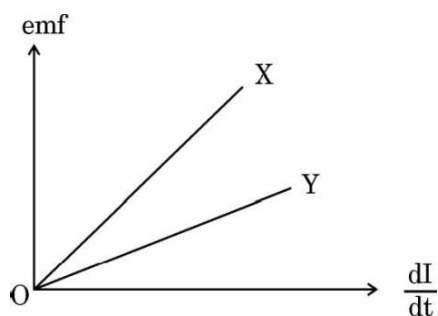
(a) the speed of the proton

(b) the magnitude of acceleration of the proton

(c) the radius of the path traced by the proton

[Take (q/m) for proton = $1.0 \times 10^8 \text{ C/kg}$]

- 24 (a) State faraday's laws of electromagnetic induction. 3
(b) The figure shows the variation of induced emf as a function of rate of change of current for two identical solenoids X and Y. One is air cored and the other is iron cored. Which one of them is iron cored? Why?



- 25 A point light source rests on the bottom of a bucket filled with a liquid of refractive index $n = 1.25$ up to height of 10 cm. Calculate: 3
 (a) the critical angle for liquid-air interface
 (b) radius of circular light patch formed on the surface by light emerging from the source.
- 26 (a) In diffraction due to a single slit, the phase difference between light waves reaching a point on the screen is 5π . Explain whether a bright or a dark fringe will be formed at the point. 3
 (b) What should the width of each slit be to obtain eight maxima of two double-slit patterns (slit separation d) within the central maximum of the single slit pattern?
 (c) Draw the plot of intensity distribution in a diffraction pattern due to a single slit.
- 27 (a) Prove that the density of a nucleus is independent of its mass number. 3
 (b) Draw a graph showing variation of nuclear potential energy versus distance between the two nucleons. From the graph write any two characterises properties of nuclear force.

OR

- (a) Distinguish between nuclear fission and fusion giving an example of each. 3
 (b) Explain the release of energy in nuclear fission and fusion on the basis of binding energy per nucleon curve.
- 28 (a) A germanium crystal is doped with antimony. With the help of energy-band diagram, explain how the conductivity of the doped crystal is affected. 3
 (b) Briefly explain the two processes involved in the formation of a p-n junction.

SECTION D

Case Study Based Questions

- 29 **Read the following paragraph and answers the questions:** 4
 A pure semiconductor like Ge or Si, when doped with a small amount of suitable impurity, becomes an extrinsic semiconductor. In thermal equilibrium, the electron and hole concentration in it are related to the concentration of intrinsic charge carriers. A p-type or n-type semiconductor can be converted into a p-n junction by doping it with suitable impurity. Two processes, diffusion and drift take place during formation of a p-n junction. A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for the application of an external voltage. A p-n junction diode allows currents to pass only in one direction when it is forward biased. Due to this property, a diode is widely used to rectify alternating voltages, in half-wave or full wave configuration.
- (i) When Ge is doped with pentavalent impurity, the energy required to free the weakly bound electron from the dopant is about
 (A) 0.001 eV (B) 0.01 eV
 (C) 0.72 eV (D) 1.1 eV
- (ii) At a given temperature, the number of intrinsic charge carriers in a semiconductor is $2 \times 10^{10} \text{ cm}^{-3}$. It is doped with pentavalent impurity atoms. As a result, the number of holes in it becomes $8 \times 10^3 \text{ cm}^{-3}$. The number of electrons in the semiconductor is
 (A) $2 \times 10^{24} \text{ m}^{-3}$ (B) $4 \times 10^{23} \text{ m}^{-3}$
 (C) $1 \times 10^{22} \text{ m}^{-3}$ (D) $5 \times 10^{22} \text{ m}^{-3}$

(iii) During the formation of a p-n junction -

(A) electrons diffuse from p-region into n-region and holes diffuse from n-region into p-region.

(B) both electrons and holes diffuse from n-region into p-region.

(C) electrons diffuse from n-region into p-region and holes diffuse from p-region into n-region.

(D) both electrons and holes diffuse from p-region into n-region.

(v) An ac voltage $V = 0.5 \sin(100 \pi t)$ volt is applied, in turn, across a half-wave rectifier and a full-wave rectifier. The frequency of the output voltage across them respectively will be

(A) 50 Hz, 100 Hz

(C) 50 Hz, 50 Hz

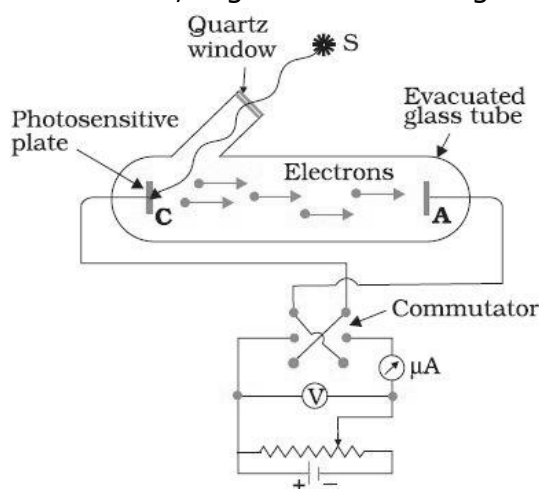
(B) 25 Hz, 100 Hz

(D) 25 Hz, 50 Hz

30 **Read the following paragraph and answers the questions:**

4

Photoelectric emission:- The photoelectric emission experiment involves shining a monochromatic light of sufficient frequency onto a photosensitive metal plate inside an evacuated glass tube, which causes electrons to be ejected. The emitted electrons (photoelectrons) flow to a collector plate, creating a photoelectric current that can be measured by a micro-ammeter. The experiment allows for controlling the light's intensity and frequency and the potential difference between the plates to study how these factors affect the ejected electrons. A crucial condition is that the light's frequency must be above a certain "threshold frequency" for the metal, below which no emission will occur, regardless of the light's intensity.



(i) What is the value of stopping potential at threshold frequency? **(1 Mark)**

(ii) The work function of a substance is 1.6 eV. Find the longest wavelength of light that can produce photoemission from the surface of substance. **(1 Mark)**

(iii) Maximum kinetic energy of a photoelectron is E when the wavelength of incident light is λ . If energy becomes four times when wavelength is reduced to one-third, then what will be the work-function of the metal? **(2 Mark)**

SECTION E

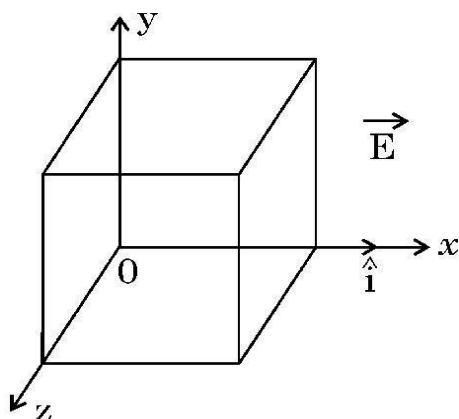
31 (a) A dielectric slab of dielectric constant 'K' and thickness 't' is inserted between plates of a parallel plate capacitor of plate separation d and plate area A. Obtain an expression for its capacitance. 5

(b) Two capacitors of different capacitances are connected first (1) in series and then (2) in parallel across a dc source of 100 V. If the total energy stored in the combination in the two cases are 40 mJ and 250 mJ respectively, find the capacitance of the capacitors.

OR

(a) Using Gauss's law, show that the electric field $\mathbf{E}$ at a point due to uniformly charged infinite plane sheet is given by $\mathbf{E} = \frac{\sigma}{\epsilon_0} \hat{n}$ where symbols have their usual meanings. Draw necessary diagram. 5

(b) Electric field $\mathbf{E}$ in a region is given by $\mathbf{E} = (5x^2 + 2) \hat{i}$ where $\mathbf{E}$ is in N/C and x is in meters. A cube of side 10 cm is placed in the region as shown in figure. Calculate (i) the electric flux through the cube, and (ii) the net charge enclosed by the cube.



32 (a) Obtain an expression for the mutual inductance of two long coaxial solenoids, each of length l but having different number of turns N_1 and N_2 and radii r_1 and r_2 ($r_2 > r_1$). Write any two factors on which the mutual inductance of two long coaxial solenoids depends. 5

(b) Calculate the self-inductance of a coil using the following data obtained when an AC source of frequency $\frac{200}{\pi}$ Hz and a DC source is applied across the coil.

AC SOURCE		
S.NO.	V (Volts)	I (A)
1	3.0	0.5
2	6.0	1.0
3	9.0	1.5

DC SOURCE		
S.NO.	V (Volts)	I (A)
1	4.0	1.0
2	6.0	1.5
3	8.0	2.0

OR

(a) Find the condition for resonance in a series LCR circuit connected to a source $v = v_0 \sin \omega t$. Give the factors on which the resonant frequency of a series LCR circuit depends. Plot a graph showing the variation of electric current with frequency in a series LCR circuit. 5

(b) A series R-C circuit with $R = 200 \Omega$ and $C = \frac{50}{\pi}$ F is connected across an AC source of $V_0 = 100$ V and frequency $\nu = 50$ Hz. Calculate (i) impedance of the circuit (Z) and (ii) voltage across the resistor.

- 33 (a) Give any two differences between the interference pattern obtained in Young's double-slit experiment and a diffraction pattern due to a single slit. 5
- (b) Draw an intensity distribution graph in case of a Young's double-slit interference pattern.
- (c) In Young's double-slit experiment using monochromatic light of wavelength λ , the intensity of light at a point on the screen, where path difference is A , is K units. Find the intensity of light at a point on the screen where the path difference is $\lambda/6$.

OR

- (a) Draw a labelled ray diagram of a compound microscope showing image formation at least distance of distinct vision. Write an expression for its magnifying power. 5
- (b) Write any four advantages of a reflecting type telescope over a refracting type telescope.
- (c) A telescope consists of two lenses of focal length 100 cm and 5 cm. Find the magnifying power when the final image is formed at infinity.