CENTRE FOR ADVANCEMENT OF STANDARDS IN EXAMINATIONS
(GEMS ASIAN SCHOOLS)
COMMON REHEARSAL EXAMINATIONS 2024
(ALL INDIA SENIOR SCHOOL CERTIFICATE EXAMINATION)

Subject: PHYSICS **Time: 3 hours**

Subject Code: 042 **Max. Marks: 70**

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. All the sections are compulsory.

(3) Section A contains sixteen questions, twelve MCQs 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, and Section D contains two case study-based questions of 4 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.

$c = 3 \times 10^8$ m/s

$h = 6.34 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_o = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_o = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$1/(4\pi\ \varepsilon_o) = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron = 9.1×10^{-31} kg

Mass of neutron = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{23} per gram mole

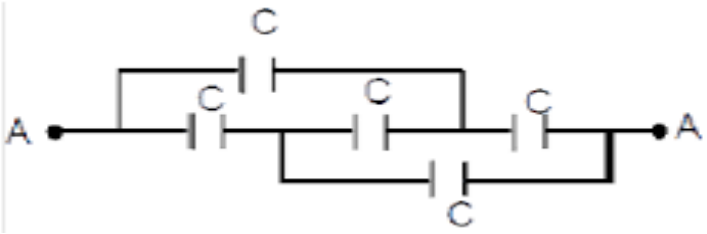
Boltzmann constant = 1.38×10^{-23} JK^{-1}

SECTION A

1. An electron enters uniform electric field maintained by parallel plates and of value 'E' V m^{-1} with a velocity 'v 'ms^{-1}. The plates are separated by a distance 'd' metre. What is the acceleration of the electron in the field? 1

(a) eE/m (b) - eE/m (c) ed/m (d) ed^2/m

2 Five equal capacitors, each with capacitance C are connected as shown. The equivalent capacitance between A and B is. 1

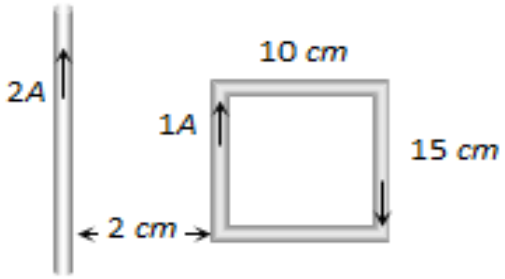


(a) C (b) 5C (c) C/5 (d) 3C

3 For an electron orbit to be non-radiating, it should be 1

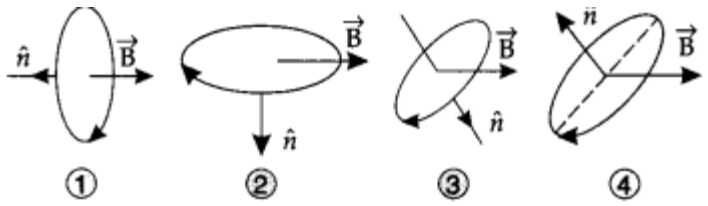
(a) such that the angular momentum should be integral multiple of h/2π.
(b) circular in nature
(c) elliptical in nature
(d) none of these

4. What is the net force on the rectangular coil? 1



(a) 25 x 10^{-7} N moving towards wire (b) 25 x 10^{-7} moving away from wire
(c) 35 x 10^{-7} N moving towards wire (d) 35 x 10^{-7} moving away from wire

5. A current carrying loop is placed in a uniform magnetic field in four different orientations as shown in figure. Arrange them in the decreasing order of potential energy. 1



(a) 4, 2, 3,1 (b) 1, 4, 2, 3
(c) 4, 3, 2,1 (d) 1, 2, 3, 4

6. Biot-Savart law indicates that the moving electrons (velocity V) produce a magnetic field B such that 1

(a) B ⊥ V
(b) B || V
(c) it obeys inverse cube law
(d) it is along the line joining the electron and point of observation

7 A charged particle oscillates about its mean equilibrium position with a frequency of 10^9 Hz. The frequency of electromagnetic waves produced by the oscillator is 1

(a) 10^6 Hz (b) 10^7 Hz (c) 10^8 Hz (d) 10^9 Hz

8 In a fission reaction $_{92}U^{236} \rightarrow X^{117} + Y^{117} + 2_0n^1 + \varepsilon$. The binding energy per nucleon of X and Y is 8.5 MeV whereas of $_{92}U^{236}$ is 7.6 MeV. The total energy liberated will be about: 1

(a) 2 MeV (b) 20 MeV (c) 2,000 MeV (d) 200 MeV

9 How does the magnifying power of a telescope change on increasing the linear diameter of its objective? 1

(a) Power increases on increasing diameter
(b) Power decreases on decreasing diameter
(c) Power decreases on increasing diameter
(d) Power doesn't depend on diameter

10 To observe diffraction, the size of the obstacle 1

(a) should be $\lambda/2$, where λ is the wavelength.
(b) should be of the order of wavelength.
(c) has no relation to wavelength.
(d) should be much larger than the wavelength.

11 If E and B denote electric and magnetic fields respectively, which of the following is dimensionless? 1

(a) $\sqrt{(\mu_0\varepsilon_0)}$ E/B
(b) $\mu_0\varepsilon_0$ E/B
(c) $\mu_0\varepsilon_0$ (B/E)2
(d) $E/\varepsilon_0 \times \mu_0/B$

12 The best metal to be used for photoemission is: 1

(a) Potassium
(b) Lithium
(c) Sodium
(d) Cesium

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 and 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)**: For the scattering of α-particles at a large angle, only the nucleus of the atom is responsible. 1
Reason(R): Nucleus is very heavy in comparison to α particle.

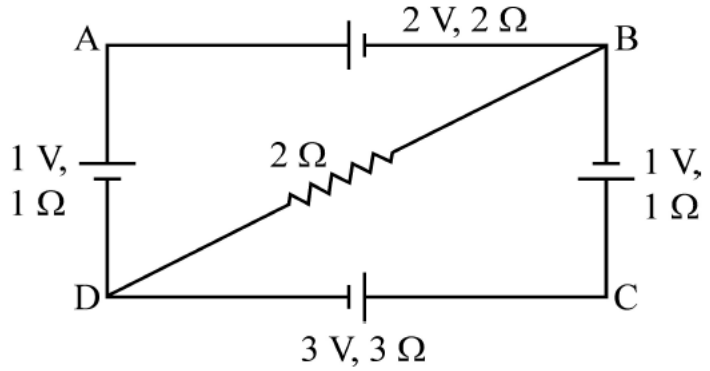
14 **Assertion(A)**: A variable capacitor is connected in series with a bulb through AC source. If the capacitance of variable capacitor is decreased, the brightness of bulb is reduced. 1
Reason(R): The reactance of capacitor increases if capacitance is reduced.

15 **Assertion(A)**: The focal length of lens does not change when red light is replaced by blue light. 1
Reason(R): The focal length of lens does not depends on colour of light used.

16 **Assertion(A)**: An N-type semiconductor has a large number of electrons but still it is electrically neutral. 1
Reason(R): An N-type semiconductor is obtained by doping an intrinsic semiconductor with a pentavalent impurity.

SECTION B

17 Using Kirchhoff's rules, calculate the current through B and D in the circuit diagram as shown in the figure. 2



18 It is required to construct a transformer which gives 12 V from a 240 V AC supply. The number of turns in the primary is 4800. 2
(i) Calculate the number of turns in the secondary.
(ii) State whether, coil in the secondary has to be thick or thin. Justify your answer.

19 Arrange the following electromagnetic radiations in ascending order of their frequencies: 2
(i) Microwave
(ii) Radio wave
(iii) X-rays
(iv) Gamma rays
Write two uses of any one of these.

20 (a) Draw energy band diagrams of an n-type and p-type semiconductor at temperature T > 0K. Mark the donor and acceptor energy levels with their energies. 2
(b) A semiconductor has equal electron and hole concentration of $6 \times 10^8\,m^{-3}$. On doping with certain impurity, electron concentration increases to $9 \times 10^{12}\,m^{-3}$. Calculate the new hole concentration.

21 (a) Draw a graph showing variation of photo-electric current (I) with anode potential (V) for different intensities of incident radiation. Name the characteristic of the incident radiation that is kept constant in this experiment. 2
(b) If the potential difference used to accelerate electrons is doubled, by what factor does the de-Broglie wavelength associated with the electrons change?

OR

(a) What is the nuclear radius of ^{125}Fe, if that of ^{27}Al is 3.6 fermi?
(b) Plot a graph showing the variation of potential energy of a pair of nucleons as a function of their separation.

SECTION C

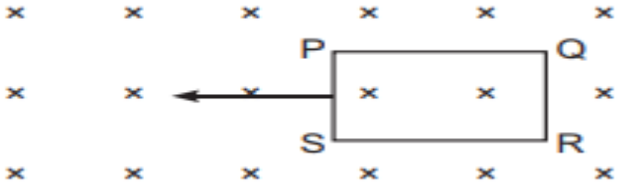
22 (a) Plot a graph showing the variation of resistivity with temperature for a metallic conductor. 3

(b) Prove that the current density of a metallic conductor is directly proportional to the drift speed of electrons.

23 Distinguish between paramagnetic and diamagnetic substances. A magnetizing field of 1500 A/m produces a flux of 2.4×10^{-5} weber in a bar of iron of cross-sectional area 0.5 cm^2. Calculate the permeability of the iron-bar used. 3

24 (a) A metallic rod of 'L' length is rotated with angular frequency of 'ω' with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius L, about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field B parallel to the axis is present everywhere. Derive an expression for the current induced in the rod, if the resistance of the rod is R. 3

(b) The closed loop (PQRS) of wire is moved into a uniform magnetic field at right angles to the plane of the paper as shown in the figure. Predict the direction of the induced current in the loop.



OR

In a series LCR circuit connected to an ac source of variable frequency and voltage $V = V_m \sin \omega t$.

(i) Draw a plot showing the variation of current (I) with angular frequency (ω) for two different values of resistance R_1 and R_2 ($R_1 > R_2$).

(ii) Write the condition under which the phenomenon of resonance occurs. For which value of the resistance out of the two curves, a sharper resonance is produced?

(iii) Define Q-factor of the circuit and give its significance.

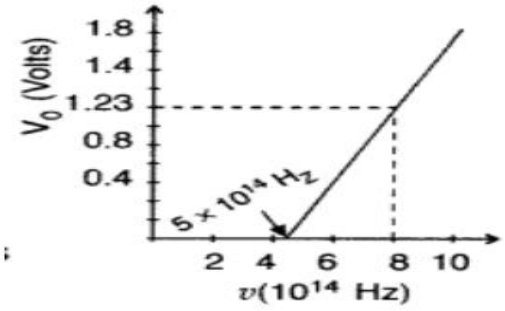
25 (a) Deduce the expression for the refractive index of glass in terms of angle of prism and angle of minimum deviation. 3

(b) Explain briefly how the phenomenon of total internal reflection is used in fibre optics.

26 a) State the principle which explains propagation of wave from one point to another point. 3

b) Construct a refracted wave front using the above principle, when a plane wave front of light travels from medium 1 to medium 2, so that speed of light is greater in medium 2 compared to medium 1 and hence prove Snell's law.

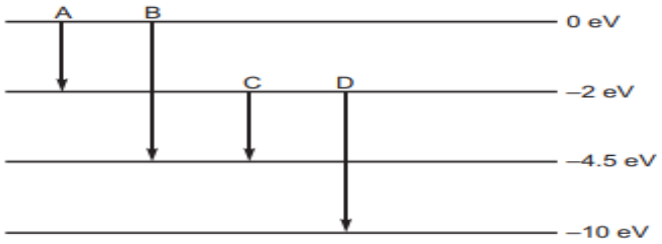
27 (a) Using the graph shown in the figure for stopping potential v/s the incident frequency of photons, calculate Planck's constant. **3**



(b) The work function (W), of a metal X, equals 3×10^{-19} J. Calculate the number (N) of photons, of light of wavelength 26.52 nm, whose total energy equals W.

(c) An electron and alpha particle have the same de Broglie wavelength associated with them. How are their kinetic energies related to each other?

28 (a) The energy levels of a hypothetical hydrogen-like atom are shown in the figure. Find out the transition, from the ones shown in the figure, which will result in the emission of a photon of wavelength 275 nm. **3**



(b) Which of these transitions corresponds to the emission of radiation of (i) maximum and (ii) minimum wavelength?

SECTION D

Case Study Based Questions

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

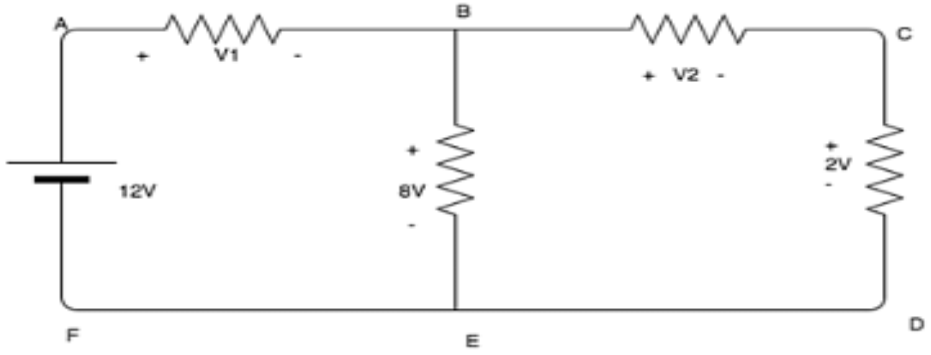
Electron move more easily through some conductors than others when potential difference is applied. The opposition of a conductor to current is called its resistance.

Collisions are the basic cause of opposition. When potential difference is applied across the ends of a conductor, its free electrons get accelerated.
On their way, they frequently collide with positive metal ions, i.e., their motion is opposed and this opposition to the flow of electron is called resistance. The number of collisions that the electrons make with atoms/ions depends on the arrangement of atoms or ions in the conductor. A long wire offers more resistance than short wire because there will be more collisions. A thick wire offers less resistance than a thin wire because in a thick wire more area of cross section is available for the flow of electrons. The resistance of metal increases when their temperature increases. Certain alloys such as constantan and manganin show very small changes of resistance with temperature and are used to make standard resistors. The resistance of semiconductor and insulator decreases as their temperature increases.

i. The dimensions of a block are $1cm \times 1cm \times 100cm$.If the specific resistance of the material is $3 \times 10^{-7}\ \Omega m$ then the resistance between two opposite rectangular bases is

(a) $3 \times 10^{-9}\ \Omega$ (b) $3 \times 10^{-7}\ \Omega$ (c) $3 \times 10^{-5}\ \Omega$ (d) $3 \times 10^{-1}\ \Omega$

ii. Calculate the value of V_1 and V_2.



(a) 4V, 6V (b)5V, 6V (c)6V, 7V (d)7V, 8V

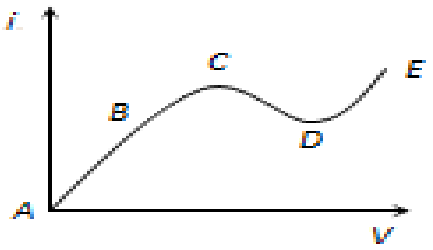
iii. Two wire of the same material have lengths L and 2L and areas of cross section 4A and A respectively. The ratio of their specific resistance would be

(a)1:2 (b)8:1 (c)1:8 (d) 1:1

OR

A wire of resistance R is stretched to twice of its original length. Its new resistance will be
(a)4R (b)R/9 (c)3R (d)R/3

iv. From the graph between current I and V identify the portion corresponding to the negative resistance



(a) AB (b)BC (c)CD (d)DE

30 Read the following paragraph and answer the questions that follow. 4

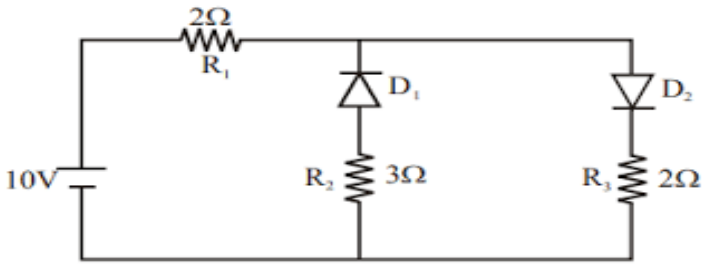
Consider a thin p-type silicon (p-Si) semiconductor wafer. By adding precisely, a small quantity of pentavalent impurity, part of the p-Si wafer can be converted into n-Si. There are several processes by which a semiconductor can be formed. The wafer now contains p-region and n- region and a metallurgical junction between p-region and n- region. Two important processes occur during the formation of a p-n junction: diffusion and drift. We know that in an n-type semiconductor, the concentration of electrons (number of electrons per unit volume) is more compared to the concentration of holes. Similarly, in a p-type semiconductor, the concentration of holes is more than the concentration of electrons. During the formation of p-n junction, and due to the concentration gradient across p- side and n- side , holes diffuse from p- side to n-side (p → n) and electrons diffuse from n-side to p-side (n → p). This motion of charge carries gives rise to diffusion current across the junction.

i. Diffusion current in a p-n junction is greater than the drift current in magnitude

(a) if the junction is forward-biased
(b) if the junction is reverse-biased
(c) if the junction is unbiased
(d) in no case

ii. In a semiconductor diode, the barrier potential offers opposition to
(a) holes in P-region only
(b) free electrons in N-region only
(c) majority carriers in both regions
(d) majority as well as minority carriers in both region

iii. The given circuit has two ideal diodes connected as shown in the figure below. The current flowing through the resistance $\mathbf{R_1}$ will be



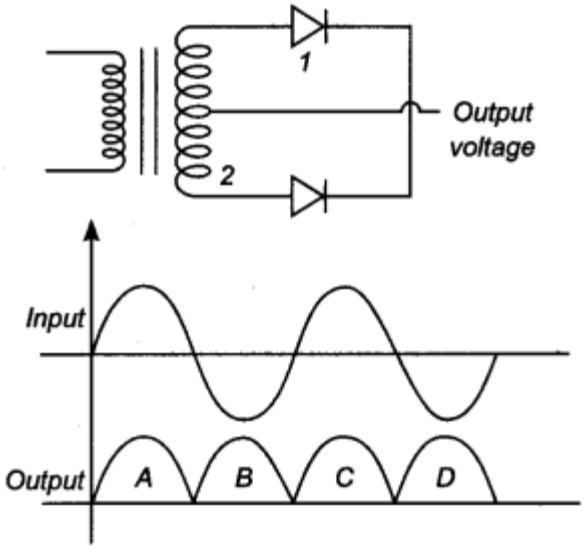
(a) 3.13A (b) 2.5A (c) 10.0A (d) 1.43A

OR

iii. Consider the junction diode as ideal. The value of current flowing through **AB** is

(a) 0A (b) 10^{-2}A (c) 10^{-1}A (d) 10^{-3}A

iv. A full-wave rectifier circuit along with the input and output voltages is shown in the figure. The contribution to output voltage from diode 2 is



(a) A, C (b) B, D (c) B, C (d) A, D

SECTION E

31 (a) Using Gauss law, derive an expression for the electric field intensity at any point outside a uniformly charged thin spherical shell of radius R and charge density σ C/m^2 . Draw the field lines when the charge density of the sphere is (i) positive and (ii) negative. **5**

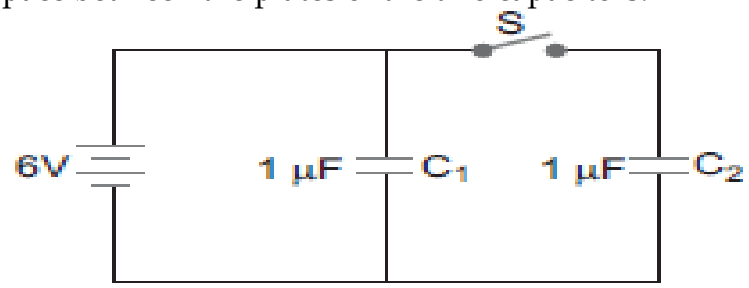
(b) A uniformly charged conducting sphere of 2.5 m in diameter has a surface charge density of 100 μC/m^2 . Calculate the (i) charge on the sphere (ii) total electric flux passing through the sphere

OR

(a) Depict the equipotential surfaces for a system of two identical positive point charges placed a distance 'd' apart.

(b) Deduce the expression for the potential energy of a system of two point charges q_1 and q_2 brought from infinity to the points $\vec{r_1}$ and $\vec{r_2}$ respectively in the presence of external electric field $\vec{E}$.

(c) Figure shows two identical capacitors, C_1 and C_2, each of 1 μF capacitance connected to a battery of 6 V. Initially switch 'S' is closed. After sometimes 'S' is left open and dielectric slabs of dielectric constant K = 3 are inserted to fill completely the space between the plates of the two capacitors.



How will the (i) charge and (ii) potential difference between the plates of the capacitors be affected after the slabs are inserted?

32 (a) State the underlying principle of working of a moving coil galvanometer. Write two reasons why a galvanometer cannot be used as such to measure current in a given circuit. Name any two factors on which the current sensitivity of a galvanometer depends. **5**

(b) A proton and a deuteron having equal momenta enter in a region of uniform magnetic field at right angle to the direction of the field. Depict their trajectories in the field.

OR

(a) State the principle of an ac generator with the help of a labelled diagram. Show diagrammatically how an alternating emf is generated by a loop of wire rotating in a magnetic field. Write the expression for the instantaneous value of the emf induced in the rotating loop.

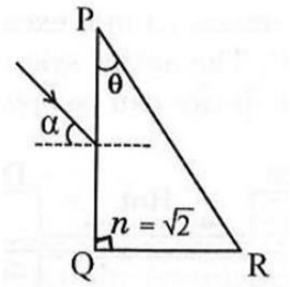
(b) A flux of 25 mWb links with a 1500 turn coil when a current of 3 A passes through the coil. Calculate

(i) the energy stored in the magnetic field, and

(ii) the average e.m.f. induced if the current falls to zero in 150 ms.

33 a) A convex refracting surface of radius of curvature R separates two media of refractive indices n1 and n2 respectively. Draw a ray diagram to show image formation by the surface for a point object, placed on the principal axis at a distance u from the pole, forming real image. Use the diagram to derive a relation between R, n1, n2, u and v, where v is the distance from pole to the image. **5**

b) A parallel beam of light is incident from air at an angle α on the side PQ of a right angled triangular prism of refractive index n = (2)1/2. Light undergoes total internal reflection in the prism at the face PR when α has a minimum value of 450. Calculate the angle θ of the prism.



OR

a) In Young's double slit experiment, a monochromatic source of light S is kept equidistant from the slits S1 and S2. Derive an expression for intensity of light at any point on the screen and hence derive the condition for formation of dark and bright fringes on the screen in terms of path difference and wavelength of light from S1 and S2.

b) A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double-slit experiment.

(i) Find the distance of the third dark fringe on the screen from the central maximum for wavelength 520 nm.

(ii) What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincide? (Separation between the slits is 4 mm and the distance between the screen and plane of the slits is 1.2m.)