Class 12 - Physics Date: 11.02.2023

Time Allowed: 3 hours **Maximum Marks: 70**

General Instructions:

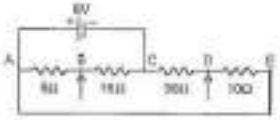
1. There are 35 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
3. Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
4. There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

Section A

1. Hole is **[1]**

   a) Gap between valence band and conduction band
   b) Particle similar to that of electron
   c) A vacancy created when an electron leaves a covalent bond.
   d) An anti-particle of electron.

2. Four resistors are connected as shown in the following figure. A 6 V battery of negligible resistance is connected across terminals A and C. The potential difference across terminals B and D will be: **[1]**



   a) 1.5 volt
   b) 0 volt
   c) 3 volt
   d) 2 volt

3. A concave mirror of focal length f in air is used in a medium of refractive index 2. What will be the focal length of the mirror in the medium? **[1]**

   a) $\frac{f}{2}$
   b) 2f
   c) 4f
   d) None of these

4. At 0 K temperature, a p-type semiconductor: **[1]**

   a) does not have any charge carriers
   b) has few holes but no free electrons
   c) has few holes and few free electrons
   d) has equal number of holes and free electrons

5. If in a parallel plate capacitor, which is connected to a battery, we fill dielectrics in the whole space of its plates, then which of the following increases? **[1]**

a) V and E
b) Q and C
c) Q and V
d) E and C

6. Consider two straight parallel conductors A and B separated by a distance x and carrying individuals currents i_A and i_B respectively. If the two conductors attract each other, it indicates that: **[1]**

a) the magnetic lines of induction are parallel
b) the two currents are parallel in direction
c) the two currents are anti-parallel in direction
d) the magnetic lines of induction are parallel to length of conductors

7. A coil having an area A_0 is placed in a magnetic field which changes from B_0 to $4B_0$ in time interval t. The emf induced in the coil will be: **[1]**

a) $\frac{3B_0}{A_0 t}$
b) $\frac{4A_0B_0}{t}$
c) $\frac{4B_0}{A_0 t}$
d) $\frac{3A_0B_0}{t}$

8. Energy E of a hydrogen atom with principal quantum number n is given by: $E = -(13.6/n^2)$ eV. The energy of a photon ejected when the electron jumps from n = 3 state to n = 2 state of hydrogen is approximately: **[1]**

a) 3.4 eV
b) 0.85 eV
c) 1.5 eV
d) 1.9 eV

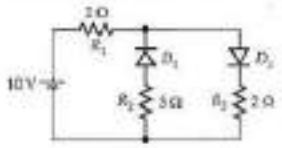
9. By a monochromatic wave, we mean: **[1]**

a) a single ray of a single colour
b) a wave having a single wavelength
c) a single ray
d) many rays of a single colour

10. The electrical potential on the surface of a sphere of radius r due to a charge 3×10^{-6} C is 500 V. The intensity of electric field 1 on the surface of the sphere is: $\left[\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{Nm}^2\text{C}^{-2}\right]$ (in NC^{-1}) **[1]**

a) > 20
b) < 10
c) between 10 and 20
d) < 5

11. The given circuit has two ideal diodes connected as shown in the figure below. The current flowing through the resistance R_1 will be **[1]**



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

12. The diameter of the objective of a telescope is a, its magnifying power is m and wavelength of light is λ. The resolving power of the telescope is: **[1]**

a) $\frac{a}{1.22\lambda m}$
b) $\frac{\lambda m}{1.22a}$

c) $\frac{1.22\lambda}{a}$ d) $\frac{a}{1.22\lambda}$

13. The cathode of a photoelectric cell is changed such that the work function changes from W_1 to W_2 ($W_2 > W_1$). If the currents before and after changes are I_1 and I_2, all other conditions remaining unchanged, then (assuming $h\nu > W_2$), **[1]**

a) $I_1 = I_2$ b) $I_1 < I_2$

c) $I_1 < I_2 < 2I_1$ d) $I_1 > I_2$

14. A charge Q is kept at the centre of a circle of radius r. If permittivity of free space is ϵ_0 then the work done in carrying a charge q along the diameter of the circle will be: **[1]**

a) $\frac{qQ}{(8\pi\epsilon_0 r)}$ b) zero

c) $\frac{qQ}{(4\pi\epsilon_0\epsilon_r r)}$ d) $\frac{qQ}{(2\pi\epsilon_0)}$

15. The wavelength of light diminishes μ times in the medium. A diver from inside water (μ = 1.33) looks at an object whose natural colour is green. He sees the object as: **[1]**

a) Red b) Blue

c) Green d) Yellow

16. **Assertion (A):** Density of all the nuclei is same. **[1]**
Reason (R): Radius of nucleus is directly proportional to the cube root of mass number.

a) Both A and R are true and R is the correct explanation of A. b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false. d) A is false but R is true.

17. **Assertion (A):** When cooking in microwave ovens, metal containers are used. **[1]**
Reason (R): The energy of microwaves can be easily transferred to the food through metal.

a) Both A and R are true and R is the correct explanation of A b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false d) A is false but R is true.

18. **Assertion (A):** The net magnetic flux coming out of a closed surface is always zero. **[1]**
Reason (R): Unlike poles of equal strength exist together.

a) Both A and R are true and R is the correct explanation of A. b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false. d) A is false but R is true.

Section B

19. The energy of a hole is higher, the farther below it is from the top of the valence band. Give reason. **[2]**

20. In a head-on collision between an α - particle and a gold nucleus, the minimum distance of approach is 3.95×10^{-14} m. Calculate the energy of the α-particle. **[2]**

21. Show that the magnetic field B at a point in between the plates of a parallel-plate capacitor during charging is $\frac{\epsilon_0\mu_0 r}{2}\frac{dE}{dt}$ (symbols having usual meaning). **[2]**

OR

Which of the following belong to the electromagnetic spectrum : α-rays, β-rays, cathode rays, X-rays, ultraviolet

rays, microwaves, ultrasonic waves, radiowaves, infrared rays? Arrange them in the order of increasing frequency.

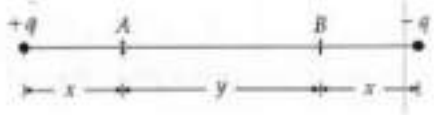
22. A potential barrier of 0.60 V exists across a p-n junction, **[2]**

i. If the depletion region is 6.0×10^{-7} m thick, what is the intensity of the electric field in this region?

ii. If an electron with speed 5.0×10^{5} ms^{-1} approaches the p-n junction from the n-side, with what speed will it enter the p-side?

23. In Fig. the potentials at points A and B are V_A and V_B respectively. Calculate $V_A - V_B$ for the given **[2]**

arrangement.



OR

A point charge q moves from a point P to a point S along the path PQRS in a uniform electric field $\vec{E}$ acting along the positive direction of the X-axis. The coordinates of the points P, Q, R and S are (a, b, 0), (2a, 0, 0), (a, -b, 0) and (0, 0, 0) respectively. Find the work done by the field in the process.

24. Monochromatic radiation of wavelength 640.2 nm (1nm = 10^{-9}m) from a neon lamp irradiates a photosensitive material made of caesium on tungsten. The stopping voltage is measured to be 0.54 V. The source is replaced by an iron source and its 427.2 nm line irradiates the same photocell. Predict the new stopping voltage. **[2]**

25. Give reasons for **[2]**

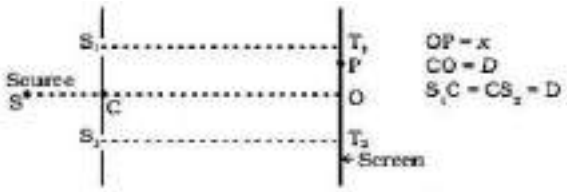
i. Lighter elements are better moderators for a nuclear reactor than heavier elements,

ii. Very high temperatures as those obtained in the interior of the sun are required for fusion reaction to take place.

Section C

26. Using the postulates of Bohr's model of hydrogen atom, obtain an expression for the frequency of radiation emitted when the atom makes a transition from the higher energy state with quantum number n_i to the lower energy state with quantum number $n_f (n_f < n_i)$. **[3]**

27. Consider a two-slit interference arrangements (Figure) such that the distance of the screen from the slits is half the distance between the slits. Obtain the value of D in terms of λ such that the first minima on the screen fall at a distance D from the center O. **[3]**



28. The current through two inductors of self-inductance 12 mH and 30 mH is increasing with time at the same rate. **[3]**
Draw graphs showing the variation of the

i. emf induced with the rate of change of current in each inductor.

ii. energy stored in each inductor with the current flowing through it.

iii. compare the energy stored in the coils, if the power dissipated in the coils is the same.

OR

i. Define self-inductance. Write its SI unit.

ii. A long solenoid with 15 turns per cm has a small loop of area 2.0 cm^2 placed inside the solenoid normal to its axis. If the current carried by the solenoid changes steadily from 2.0 A to 4.0 A in 0.1 s, then what is the induced

emf in the loop while the current is changing?

29. A parallel plate capacitor made of circular plates each of radius R = 6.0 cm has a capacitance C = 100 pF. The capacitor is connected to a 230 V ac supply with an angular frequency of 300 rad s^{-1}. **[3]**

a. What is the rms value of the conduction current?

b. Is the conduction current equal to the displacement current?

c. Determine the amplitude of B at a point 3.0 cm from the axis between the plates.

OR

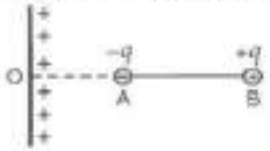
Name the type of EM waves having a wavelength range of 0.1 m to 1 mm. How are these waves generated? Write their two uses.

30. A domain in ferromagnetic iron is in the form of a cube of side length 1 μm. Estimate the number of iron atoms in the domain and the maximum possible dipole moment and magnetization of the domain. The atomic mass of iron is 55 g/mole and its density is 7.9 g/cm^3. Assume that each iron atom has a dipole moment of 9.27×10^{-24} A m^2. **[3]**

Section D

31. a. Using Gauss' theorem, obtain an expression for the electric field intensity at a point at a distance r from an infinitely long uniformly charged straight wire. **[5]**

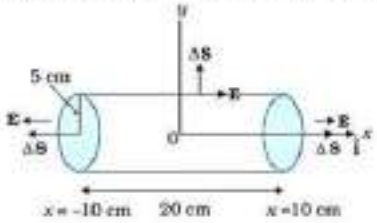
b. An electric dipole AB consists of charges ± 5 nC and separated by a distance of 2×10^{-3} m [Fig].



The dipole is placed near a long line charge having linear charge density 4.5×10^{-4} Cm^{-1}, such that the negative charge is at a distance OA = 2·5 cm from the line charge. Find the force acting on the dipole.

OR

An electric field is a uniform, and in the positive x-direction for positive x, and uniform with the same magnitude but in the negative x-direction for negative x. It is given that $\vec{E} = 200\ \hat{i}$ N/C for x > 0 and $\vec{E} = -200\ \hat{i}$ N/C for x < 0. A right circular cylinder of length 20 cm and radius 5 cm has its centre at the origin and its axis along the x-axis so that one face is at x = +10 cm and the other is at x = -10 cm (Fig).



a. What is the net outward flux through each flat face?

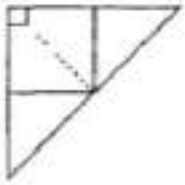
b. What is the flux through the side of the cylinder?

c. What is the net outward flux through the cylinder?

d. What is the net charge inside the cylinder?

32. i. Plot a graph to show variation of the angle of deviation as a function of angle of incidence for light passing through a prism. Derive an expression for refractive index of the prism in terms of angle of minimum deviation and angle of prism. **[5]**

ii. A ray of light incident normally on one face of a right isosceles prism is totally reflected as shown in figure. What must be the minimum value of refractive index of glass? Give relevant calculations.



OR

i. Draw a labelled ray diagram to obtain the real image formed by an astronomical telescope in normal adjustment position. Define its magnifying power.

ii. You are given three lenses of power 0.5 D, 4D and 10 D to design a telescope.

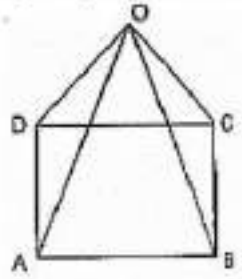
a. Which lenses should be used as objective and eyepiece? Justify your answer.

b. Why is the aperture of the objective preferred to be large?

33. Eight identical resistors 'r', each are connected along the edges of a pyramid having square base ABCD as shown in figure below. Calculate equivalent resistance between A and B. Solve the problem: **[5]**

i. Without using Kirchhoff's laws

ii. By using Kirchhoff's laws.



Section E

34. **Read the text carefully and answer the questions:** **[4]**

A magnetic field can be produced by moving, charges or electric currents. The basic equation governing the magnetic field due to a current distribution is the Biot-Savart law. Finding the magnetic field resulting from a current distribution involves the vector product, and is inherently a calculus problem when the distance from the current to the field point is continuously changing. According to this law, the magnetic field at a point due to a current element of length $d\vec{l}$ carrying current I, at a distance r from the element is dB = $\frac{\mu_0}{4\pi}\frac{I(d\vec{l}\times\vec{r})}{r^3}$.

Biot-Savart law has certain similarities as well as differences with Columb's law for electrostatic field e.g., there is an angle dependence in Biot-Savart law which is not present in the electrostatic case.

(i) What is the direction of magnetic field $d\vec{B}$ at a distance r due to a current element Idl when current I passes through a long conductor ?

(ii) What happens to the magnetic field due to a current carrying wire if the distance of the point from the current carrying wire is reduced to half?

(iii) Two long straight wires are set parallel to each other. Each carries a current i in the same direction and the

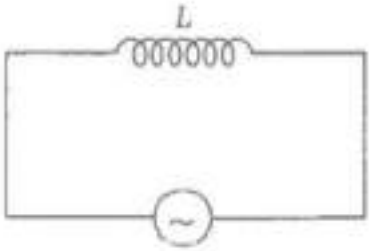
separation between them is 2r. What will be the intensity of the magnetic field midway between them?

OR

A long straight wire carries a current along the z-axis. What will be the magnetic field along the Z axis.

35. **Read the text carefully and answer the questions:** **[4]**

Let a source of alternating e.m.f. $E = E_0 \sin \omega t$ be connected to a circuit containing a pure inductance L. If I is the value of instantaneous current in the circuit, then $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$. The inductive reactance limits the current in a purely inductive circuit and is given by $X_L = \omega L$.



(i) A 100 hertz a.c. is flowing in a 14 mH coil. What will be the reactance in the coil?

(ii) In an inductive circuit, by what value of phase angle does alternating current lags behind e.m.f.?

(iii) How much inductance should be connected to 200 V, 50 Hz a.c. supply so that a maximum current of 0.9 A flows through it?

OR

What will be the maximum value of current when the inductance of 2 H is connected to 150 volts, 50 Hz supply?