2024

PHYSICS

(Theory)

Full Marks : 70

Pass Marks : 21

Time : Three hours

All questions are compulsory.

The figures in the right margin indicate full marks for the questions.

Question Nos. 1 to 10 are "Very Short Answer" type questions carrying 1 mark each.

1. State Coulomb's law. 1

2. Define the relaxation time of the free electrons drifting in a conductor. 1

3. Define one henry. 1

4. What is wattless current? 1

5. Which gas causes the depletion of the ozone layer in the upper atmosphere of the earth? 1

6. A monochromatic light travels from a rarer to a denser medium. Does the decrease in speed imply a reduction in the energy carried by a light wave? 1

7. Define a wavefront. 1

8. What is the ratio of nuclear densities of two nuclei having mass number 1:4 ? 1

9. Why is nuclear fusion not possible in the laboratory ? 1

10. Which type of biasing gives a semiconductor diode very high resistance? 1

Question Nos. 11 to 20 are 'Short Answer Type-II' questions carrying 2 marks each.

11. State Kirchhoff's law for an electrical network. 2

12. If the speed of a charged particle moving through the magnetic field is increased, what happens to the radius of curvature of the charged particle? 2

13. Draw the magnetic field lines produced by a current carrying circular loop. Mark the direction of current and the direction of magnetic field. 2

14. Two spherical bobs, one metallic and the other of glass, of the same size are allowed to fall freely from the same height above the ground. Which of the two would reach earlier and why? 2

15. How are infra-red rays produced? Write their two important uses. 2

16. Light from a point source in air falls on a spherical glass surface whose radius of curvature and refractive index are 20 cm and 1.5 respectively. If the distance of light source from the glass surface is 100 cm, then at what position image will be formed ? 2

17. Although the surfaces of a goggle lens are curved it does not have any power. Why? 2

18. State two conditions for sustained interference of light. 2

19. What is the approximate radius of $_{29}Cu^{64}$? Given, $R_0 = 1.2 \times 10^{-15}$ m 2

20. Explain how a potential barrier is developed in a p-n junction diode. 2

Question Nos. 21 to 26 are 'Short Answer Type-I' questions carrying 3 marks each.

21. A fully charged parallel plate capacitor is connected across an uncharged identical capacitor. Show that the energy stored in the combination is less than that stored initially in the single capacitor. 3

OR

A parallel plate capacitor with air between the plates has a capacitance of $12\mu F$. If the distance between the plates is reduced by half, and the space between them is filled with mica of dielectric constant 5, what will be the new capacitance ? 3

22. Obtain the expression for the equivalent emf and the equivalent internal resistance of two cells connected in series. 3

OR

Obtain the expression for the equivalent emf and the equivalent internal resistance of two cells connected in parallel. 3

23. Derive an expression for the self-inductance of a long air-cored solenoid of length *l* and number of turns N. 3

OR

Derive an expression for the mutual inductance of two long coaxial solenoids of same length wound one over the other. 3

24. An electron and alpha particle have the same de-Broglie wavelength associated with them. How are their kinetic energies related to each other? 3

OR

If the frequency of the incident radiation on the cathode of a photocell is doubled, how the following change ? 3

(i) kinetic energy of the electrons

(ii) photoelectric current

(iii) stopping potential

Justify your answer.

25. In the Rutherford scattering experiment, the distance of closest approach for an α-particle is d_0. If α-particle is replaced by a proton, then how much kinetic energy in comparison to α-particle will be required to have the same distance of closest approach d_0 ? 3

OR

A nucleus of mass $(M + \Delta m)$ is at rest and it decays into two daughter nuclei of equal mass $\frac{M}{2}$ each. The speed of the light is c. What is the speed of the daughter nuclei? 3

26. Pure Si at 500 K has equal number of electron (n_e) and hole (n_h) concentration of $1.5 \times 10^{16}\ m^{-3}$. Doping by indium increases n_h to $4.5 \times 10^{22}\ m^{-3}$. Calculate the number of electrons. Identify the type of semiconductor after doping. 2+1=3

OR

What is the number density of donor atoms which must be added to a pure germanium semiconductor to produce an N-type semiconductor of conductivity 6.4×10^2 $ohm^{-1}m^{-1}$? The mobility of electrons in N-type germanium is $4 \times 10^{-1} m^2 V^{-1} s^{-1}$. Neglect contribution of holes to conductivity. 3

Question Nos. 27 to 29 are 'Long Answer Type' questions carrying 5 marks each.

27. State Gauss's law in electrostatics. Use this law to derive an expression for the electric field due to an infinitely long straight wire with uniform linear charge density λ. 1+4=5

OR

Define capacitance of a conductor. Derive the formula for effective capacitance of a series combination of n capacitors. 1+4=5

28. Derive an expression for the force per unit length between two straight parallel conductors carrying current. Two wires carry currents of 10 A and 20 A respectively and they repel each other with a force of 0.4 Nm^{-1} . What will be the distance between them? (Given $\mu_0 = 4\pi \times 10^{-7} TmA^{-1}$) 3+2=5

OR

Derive the expression for the torque on a rectangular current carrying loop placed in a uniform magnetic field.

A coil of area 100 cm^2 having 500 turns carries a current of 1 mA. It is suspended in a uniform magnetic field $10^{-3} wb\ m^{-2}$. Its plane making an angle of 60° with the lines of field. What is the torque acting on the coil ? 3+2=5

29. Draw the ray diagram for refraction occurs from rarer to denser medium at a convex spherical refracting surface and derive the relation $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$, where the symbols have their usual meanings. 1+4=5

OR

State Huygen's principle, using this principle draw a diagram to show how a plane wave front incident at the interface of the two media gets refracted when it propagates from a rarer to a denser medium. Hence verify Snell's law of refraction. 1+1+3=5

Question Nos. 30 to 36 are 'Multiple Choice Type' questions carrying 1 mark each. Choose the correct answer out of the four alternatives and rewrite the correct answer.

30. Current density is a – 1

(A) scalar quantity

(B) vector quantity

(C) dimensionless quantity

(D) none of these

31. If the rate of change of current of 2 As^{-1} induces an emf of 10 mV in a solenoid, the self inductance of the solenoid is – 1

(A) 5 mH

(B) 2 mH

(C) 0.2 mH

(D) 0.5 mH

32. The velocity of light in a glass block of refractive index 1.5 is – 1

(A) $1.5 \times 10^8\ ms^{-1}$

(B) $2 \times 10^8\ ms^{-1}$

(C) $3 \times 10^8\ ms^{-1}$

(D) $2 \times 10^9\ ms^{-1}$

33. What should be increased to increase the angular magnification of a simple microscope ? 1

(A) The power of the lens

(B) The focal length of the lens

(C) Lens aperture

(D) Object size

34. The minimum energy required to remove an electron is called – 1

(A) Stopping potential

(B) Kinetic energy

(C) Work function

(D) Threshold frequency

35. In the photoelectric phenomenon if the ratio of the frequency of incident radiation incident on a photosensitive surface is 1:2:3, the ratio of the photo electric current is – 1

(A) 1 : 2 : 3

(B) $\sqrt{1} : \sqrt{2} : \sqrt{3}$

(C) 1 : 4 : 9

(D) 1 : 1 : 1

36. In full wave rectifier, input a.c. current has a frequency ν. The output frequency of current is – 1

(A) $\nu/2$

(B) ν

(C) 2ν

(D) 0

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...pe ?

...e power of the lens

...he focal length of the lens

... Lens aperture

... Object size

...e minimum energy required [illegible]

(A) Stopping potential

(B) Kinetic energy

(C) Work function

(D) Threshold frequency

In the photoelectric [illegible] frequency of the incident radiation [illegible] 1
incident on a [illegible] the ratio of the photo electric current [illegible]
is–

(A) 1:2:3

(B) [illegible]

(C) 1:4:9

(D) 1:1:1

36. In full wave rectifier, input a.c. current has a frequency ν. The output frequency 1
of current is–

(A) $\nu/2$

(B) ν

(C) 2ν

(D) 0

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