2025

PHYSICS

(Theory)

Full Marks : 70

Pass Marks : 21

Time: Three hours

Attempt all Questions.

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

You may use the following values of physical constants wherever necessary :

$e = 1.6\times10^{-19}C$

$m_e = 9.1\times10^{-31}kg$

$k = \frac{1}{4\pi\epsilon_0} = 9\times10^{9}Nm^2C^{-2}$

$\epsilon_0 = 8.854\times10^{-12}\ N^{-1}m^{-2}C^2$

$h = 6.63\times10^{-34}Js$

$1\ a.m.u = 1.66\times10^{-27}kg = 931.5\ MeV$

Rydberg's Constant, $R = 1.097\times10^{7}m^{-1}$

Question Nos. 1 to 7 are 'Multiple Choice Type' questions carrying 1 mark each.

Choose the correct answer out of the four alternatives and rewrite the correct answer.

1. The SI unit of the surface integral of electric field is – 1

(A) Vm (B) V

(C) NC^{-1} (D) Cm^{-3}

2. Which of the following substance have negative temperature coefficient of resistance ? 1

(A) metal (B) metal and semiconductor

(C) semiconductor (D) metal and alloy

3. Two short bar magnets of 1cm have magnetic moments 1.20 Am^2 and 1.00 Am^2 respectively . They are placed on a horizontal table parallel to each other and north pole pointing towards south . What is the magnitude of resultant magnetic field at the middle of line joining them if their separation is 20cm? (neglect earth's magnetic field) 1

(A) 3.6×10^{-5} T (B) 5.8×10^{-5} T

(C) 3.6×10^{-4} T (D) 2.2×10^{-4} T

4. When monochromatic red light is used instead of blue light in a convex lens, its focal length 1

(A) does not change (B) increases

(C) decreases (D) remain same

5. The maximum kinetic energy of photoelectrons emitted from a metal surface when photons of energy 5.6 eV fall on it, is 4eV. The stopping potential in volts is – 1

(A) 1.6 V (B) 3.2V

(C) 4V (D) 5.6V

6. If a star converts all the helium (He) nuclei completely into oxygen (O) nuclei , the energy released per oxygen nucleus is (mass of helium nucleus=4.0026a.m.u, mass of oxygen nucleus = 15.9994 a.m.u) 1

(A) 7.6 MeV (B) 56.12MeV

(C) 10.24MeV (D) 23.9MeV

7. If temperature of semiconductor is fall, the forbidden energy gap is – 1

(A) increased

(B) remain unchanged

(C) decreased

(D) sometimes increased and sometimes decreased

Question Nos 8 to 17 are "Very short Answer" type questions carrying 1mark each.

8. Two charged metallic spheres with radii R_1 and R_2 respectively are brought in contact and then separated they carry same charge after separation. What is the ratio of electric fields at the surface of two sphere after separation ? 1

9. How does the mobility of electron in a conductor change, if the potential difference applied across the conductor is double keeping the length and temperature of the conductor constant? 1

10. A proton and alpha particle are moving northward with same velocity in a region of magnetic field of 3T directed downward. The magnetic force experienced by both proton and alpha particle. Which have greater magnetic force? 1

11. Draw the phasor diagram to represent current and supply voltage for an AC circuit containing capacitance only. 1

12. The magnetic field in a plane electromagnetic wave is given by

$B_y = 2\times10^{-7} \text{ Sin } (0.5\times10^3 x + 1.5\times10^{11} t)$ T 1

Find the wavelength of the given electromagnetic wave.

13. What is the angle of incidence if a ray incident normally on a plane mirror ? 1

14. When tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the center of the obstacle. Why? 1

15. A blue lamp mainly emits light of wavelength 4500Å. The lamp is rated at 150 W and 8% of energy is emitted as visible light. How many photons are emitted by lamp per second? 1

16. Name the hydrogen spectral line which lies in the region of visible range of electromagnetic spectrum. 1

17. What is the effect on the width of a depletion region of a p-n junction diode if the doping concentration is increased? 1

Question Nos 18 to 27 are "Short Answer Type -II" questions carrying 2 marks each.

18. A capacitor of unknown capacitance is connected across by a battery of Vvolt. The charge stored on it is 360μC. When potential difference across is reduced to 120V, the charge store in it becomes 120μC. Calculate the potential V and unknown capacitance. 2

19. Find the relation between drift velocity and electric current. 2

20 A straight wire of length $\frac{\pi}{2}$ m is bent into a circular shape. If the wire carries a current of 5A, calculate the magnetie field due to it before bending at a point of distance 0.01 times the radius of circle formed from it. 2

21 State Faraday's law of electromagnetic induction. 2

22. A bulb is connected in series with inductance coil. Predict your observation when this combination is connected in turn across –

(i) AC source and

(ii) DC battery 1+1=2

23 Name the electromagnetic wave which is –

(i) obtained from nuclear disintegration and

(ii) detected by photo cell and photographic film 1+1=2

24. A convex lens is in contact with a concave lens. The magnitude of ratio of the focal length of concave lens to convex lens is $\frac{3}{2}$. Their equivalent focal length is 30 cm. Find the focal length of the convex lens and concave lens. 1+1=2

25. Draw the geometrical shape of wavefront when –

(i) light emerges out of convex lens if a plane wavefront incident on it

(ii) reflection of plane wavefront from a concave mirror. 1+1=2

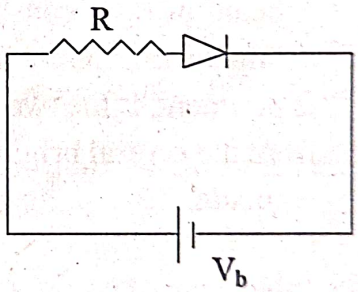
26. The ground state energy of hydrogen atom is –13.6eV.

(i) What is kinetic energy of an electron in second excited state?

(ii) What is potential energy of an electron in third excited state? 1+1=2

27. Assume that the silicon diode in the circuit shown in figure require a minimum current of 1mA to be above the knee voltage of 0.7 V of its I-V characteristics. Also assume that the voltage across the diode is independent of current above the knee voltage.

If V_b = 5V, what should be the maximum value of R so that voltage is above knee voltage. 2

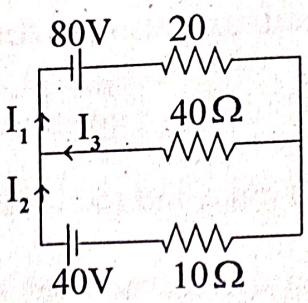


Question Nos. 28 to 33 are "Short Answer Type -I" questions carrying 3 marks each.

28. A storage battery of emf 8.0 V and internal resistance 0.5 Ω is being charged by a 120 V dc supply using a series resistor of 15.5 Ω. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit? 2+1=3

OR

In the given circuit, find the value of I_1, I_2 and I_3



1+1+1=3

29. A circular coil of radius 10cm , 500 turns and resistance 2Ω is placed with its plane perpendicular to the horizontal component of the earth's magnetic field . It is rotated about its vertical diameter through 180° in 0.25s. Estimate the magnitude of emf and current induced in the coil. Horizontal component of earth's magnetic field at that place is 3.0×10^{-5} T. 2+1=3

OR

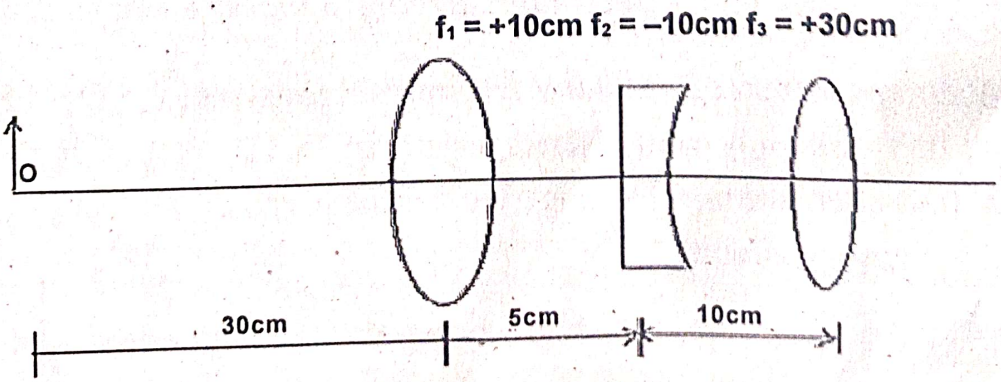
A series LCR circuit with R=20Ω, L=2H and C=50μF is connected to a 200V AC source of variable frequency.

What is (i) the amplitude of current and (ii) average power transferred to the circuit in one complete cycle at resonance ? Also calculate the potential drop across the resistance. 1+1+1=3

30. A beam of light consisting of two wavelengths 800nm and 600nm is used to obtain the interference fringe a screen placed 1.4m away in a young's double slit experiment. If the two slit are separated by 0.28mm . Calculate the least distance from the central bright maximum where the bright fringes of two wavelengths coincide. 3

OR

Find the position of image formed by lens combination given in the figure 3



31. The work function of caesium metal is 2.14 eV. When light of frequency 6×10^{14} Hz is incident on the metal surface , photo – emission of electron occurs. Calculate – 1+1+1=3

(a) maximum kinetic energy of the emitted electrons

(b) stopping potential

(c) maximum velocity of the emitted electrons

OR

What is the de- Broglie wavelength of 1+1+1=3

(i) a bullet of mass 0.045 kg travelling at a speed of 1.0m/s

(ii) a ball of mass 0.06 kg moving at speed of 0.1m/s

(iii) a dust particle of mass 1.0×10^{-9} kg drifting with a speed of 2.2 m/s.

32. Suppose, we think of fission of a $^{56}_{26}Fe$ nucleus into two equal fragments of $^{28}_{13}Al$ .Is the fission energetically possible? Argue by working out Q of the process. 3

Given m ($^{56}_{26}Fe$)=55.934u and m($^{28}_{13}Al$)=27.98191u.

OR

An electron beam of energy 12.75eV is used to bombard gaseous hydrogen at room temperature . Find three possible series of hydrogen spectrum will be liberated. 3

33. Describe the working of PN junction diode as full wave rectifier . 3

OR

A semiconductor of silicon can be formed into n-type semiconductor by doping with impurity, explain it on the basis of valence band model. 3

Question Nos 34 to 36 are "Long Answer Type" questions carrying 5 marks each.

34. State Gauss's law in electrostatics. Using this theorem, derive an expression for the electric field intensity due to an infinite plane sheet of charge density σ .
Two large thin metal plates are parallel and close to each other. On the inner surface have charge of opposite sign and of magnitude 17.0×10^{-22} C/m^2. Find electric field between the two parallel plates. 1+3+1=5

OR

What is electric dipole? Obtain the expression for the electric potential due to an electric dipole (consisting of two charges q and – q separated by a small distance 2a) at a point far away from the dipole. Why don't we consider the electric potential due to a charge q at its own location? 1+3+1=5

35. Define magnetic field intensity. Derive an expression for the magnetic field intensity at a point lying on the equatorial line of a bar magnet. 1+4=5

OR

State Ampere's circuital law. Using Ampere's circuital law, obtain an expression for the magnetic field due to an infinitely long straight wire carrying current at a point P at a distance r from the wire. Find the magnitude and direction of magnetic field due to a straight wire carrying current along north-south direction at a point 5cm below the wire. 1+3+1=5

36 . A point object lying on the principal axis in a medium of refractive index n_1 in front of the double convex lens of refractive index of n_2 ($n_2 > n_1$) of radii R_1 and R_2. Find the relationship among the refractive indices , two radii and focal length of the lens.

A double convex lens made of glass of refractive index 1.5 has its both surfaces of equal radii of curvature of 20cm each. Find its focal length . 4+1=5

OR

Deduce the expression for the refractive index of glass prism in terms of angle of prism and angle of minimum deviation . If angle of prism A=δ_m (angle of minimum deviation) of an equilateral prism, find the refractive index of the prism. 4+1=5
