MANAS STUDIES

For Academic and Competitive Excellence

Most Expected Questions

For Class – XII

PHYSICS

Board Examination 2023-24

With Best Wishes

LECTRIC CHARGES & FIELDS + GAUSS THEOREM

1. Four point charges q_A = 2 µC, q_B = –5 µC, q_C = 2 µC, and q_D = –5 µC are located at the corners of a square ABCD of side 10 cm. What is the force on a charge of 1 µC placed at the centre of the square? **(zero)**
2. An electric dipole with dipole moment 4×10^{-9} C m is aligned at 30° with the direction of a uniform electric field of magnitude 5×10^{4} NC^{-1} . Calculate the magnitude of the torque acting on the dipole. **(10^{-4} N m)**
3. A point charge of 2.0 µC is at the centre of a cubic Gaussian surface 9.0 cm on edge. What is the net electric flux through the surface? **(2.26×10^5 N m^2C^{-1})**
4. A conducting sphere of radius 10 cm has an unknown charge. If the electric field 20 cm from the centre of the sphere is 1.5×10^3 N/C and points radially inward, what is the net charge on the sphere? **(6.67 nC)**
5. An infinite line charge produces a field of 9×10^4 N/C at a distance of 2 cm. Calculate the linear charge density. **(10 µC/m)**
6. A hollow charged conductor has a tiny hole cut into its surface. Show that the electric field in the hole is $(\sigma/2\varepsilon_0)\ \hat{n}$, where $\hat{n}$ is the unit vector in the outward normal direction, and σ is the surface charge density near the hole.

ELECTRIC POTENTIAL & CAPACITANCE

7. (a) Calculate the potential at a point P due to a charge of 4×10^{-7} C located 9 cm away. **(4×10^4 V)**
   (b) Hence obtain the work done in bringing a charge of 2×10^{-9} C from infinity to the point P. **(8×10^{-5} J)**
8. Two charges 3×10^{-8} C and -2×10^{-8} C are located 15 cm apart. At what point on the line joining the two charges is the electric potential zero? Take the potential at infinity to be zero. **(9 cm and 45 cm)**
9. A slab of material of dielectric constant K has the same area as the plates of a parallel-plate capacitor but has a thickness (3/4)d, where d is the separation of the plates. How is the capacitance changed when the slab is inserted between the plates?
10. Two charges 5×10^{-8} C and -3×10^{-8} C are located 16 cm apart. At what point(s) on the line joining the two charges is the electric potential zero? Take the potential at infinity to be zero. **(40 cm from the positive charge)**
11. A regular hexagon of side 10 cm has a charge 5 µC at each of its vertices. Calculate the potential at the centre of the hexagon. **(2.7×10^6 V)**
12. A spherical conductor of radius 12 cm has a charge of 1.6×10^{-7}C distributed uniformly on its surface. What is the electric field
    (a) Inside the sphere (zero)
    (b) Just outside the sphere (10^5 N/C)

(c) At a point 18 cm from the centre of the sphere? (4.4×10^4 N/C.)

13. A parallel plate capacitor with air between the plates has a capacitance of 8 pF (1 $pF = 10^{-12}\ F$). What will be the capacitance if the distance between the plates is reduced by half, and the space between them is filled with a substance of dielectric constant 6? **(96 pF)**

14. In a parallel plate capacitor with air between the plates, each plate has an area of 6×10^{-3} m^2 and the distance between the plates is 3 mm. Calculate the capacitance of the capacitor. If this capacitor is connected to a 100 V supply, what is the charge on each plate of the capacitor? **(17.71 pF & 1.771×10^{-9} C)**

15. A 12 pF capacitor is connected to a 50 V battery. How much electrostatic energy is stored in the capacitor? **(1.5×10^{-8} J)**

16. A charge of 8 mC is located at the origin. Calculate the work done in taking a small charge of – 2 × 10– 9 C from a point P (0, 0, 3 cm) to a point Q (0, 4 cm, 0), via a point R (0, 6 cm, 9 cm). **(1.27 J).**

17. Two tiny spheres carrying charges 1.5 μC and 2.5 μC are located 30 cm apart. Find the potential and electric field: (a) at the mid-point of the line joining the two charges. **(2.4×10^5 V, 4×10^5 V/m)**

(b) at a point 10 cm from this midpoint in a plane normal to the line and passing through the mid-point. **(2×10^5 V, 6.6×10^5 V/m)**

18. If one of the two electrons of a H_2 molecule is removed, we get a hydrogen molecular ion H_2^+. In the ground state of an H_2^+, the two protons are separated by roughly 1.5 Å, and the electron is roughly 1 Å from each proton. Determine the potential energy of the system. **(−19.2 eV)**

19. Two charges $-q$ and $+q$ are located at points (0, 0, $-a$) and (0, 0, a), respectively. (a) What is the electrostatic potential at the points (0, 0, z) and (x, y, 0)? **(zero)**

(b) Obtain the dependence of potential on the distance rr of a point from the origin when rr/aa >> 1.

(c)How much work is done in moving a small test charge from the point (5, 0, 0) to (– 7, 0, 0) along the x-axis? Does the answer change if the path of the test charge between the same points is not along the x-axis? **(zero)**

20. An electrical technician requires a capacitance of 2 μF in a circuit across a potential difference of 1 kV. A large number of 1 μF capacitors are available to him each of which can withstand a potential difference of not more than 400 V. Suggest a possible arrangement that requires the minimum number of capacitors. **(6 × 3 i.e., 18 capacitors)**

21. What is the area of the plates of a 2 F parallel plate capacitor, given that the separation between the plates is 0.5 cm? **(1130 km^2)**

22. A 4 μF capacitor is charged by a 200 V supply. It is then disconnected the supply and is connected to another uncharged 2 μF capacitor. How much electrostatic energy of the first capacitor is lost in the form of heat and electromagnetic radiation? **(2.67×10^{-2} J)**

23. A spherical capacitor has an inner sphere of radius 12 cm and an outer sphere of radius 13 cm. The outer sphere is earthed, and the inner sphere is given a charge of 2.5 µC. The space between the concentric spheres is filled with a liquid of dielectric constant 32.

(A) Determine the capacitance of the capacitor. **(5.5 × 10−9 F)**

(B) What is the potential of the inner sphere? **(4.5×10^2 V)**

(C) Compare the capacitance of this capacitor with that of an isolated sphere of radius 12 cm. Explain why the latter is much smaller **(1.33×10^{-11} F)**

24. A parallel plate capacitor is to be designed with a voltage rating 1 kV, using a material of dielectric constant 3 and dielectric strength about 10^7 V m^{-1}. (Dielectric strength is the maximum electric field a material can tolerate without breakdown, i.e., without starting to conduct electricity through partial ionization.) For safety, we should like the field never to exceed, say 10% of the dielectric strength. What minimum area of the plates is required to have a capacitance of 50 pF? **(19 cm^2)**

CURRENT ELECTRICITY

25. The storage battery of a car has an emf of 12 V. If the internal resistance of the battery is 0.4 Ω, what is the maximum current that can be drawn from the battery?

26. A battery of emf 10 V and internal resistance 3 Ω is connected to a resistor. If the current in the circuit is 0.5 A, what is the resistance of the resistor? What is the terminal voltage of the battery when the circuit is closed? (8.5V, 17 Ω)

27. (a) Three resistors 1 Ω, 2 Ω, and 3 Ω, are combined in series. What is the total resistance of the combination? (6 Ω)

(b) If the combination is connected to a battery of emf 12 V and negligible internal resistance, obtain the potential drop across each resistor. (P.D across 1 Ω is 2 V, 2 Ω is 4 V, and 3 Ω is 6 V.)

28. (a) Three resistors 2 Ω, 4 Ω and 5 Ω, are combined in parallel. What is the total resistance of the combination? (20/19 Ω)

(b) If the combination is connected to a battery of emf 20 V and negligible internal resistor, and the total current drawn from the battery (total current is 19 A.)

29. At room temperature (27. 0^o C) the resistance of a heating element is 100 Ω. What is the temperature of the element if the resistance is found to be 117 Ω, given that the temperature coefficient of the material of the resistor is 1.70 × 10−4 $C^{o\,-1}$

30. A negligibly small current is passed through a wire of length 15 m and uniform cross-section 6.0 × 10−7 m2, and its resistance is measured to be 5.0 Ω . What is the resistivity of the material at the temperature of the experiment? (2 × 10−7 Ω m)

31. A silver wire has a resistance of 2.1 Ω at 27.5 CCo , and a resistance of 2.7 Ω at 100 $CCoo$. Determine the temperature coefficient of resistivity of silver. **(0.0039 $^{o\,C-1}$)**

32. A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds to a steady state value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27.0 ^{o} ? Temperature coefficient of resistance of nichrome averaged over the temperature range involved is 1.70 × 10−4 $CC^{o\,-1}$. **(867.5 °C)**

MOVING CHARGES AND MAGNETISM

33. A circular coil of wire consisting of 100 turns, each of radius 8.0 cm carries a current of 0.40 A. What is the magnitude of the magnetic field B at the centre of the coil? **(3.14 × 10−4 T)**

34. A long straight wire carries a current of 35 A. What is the magnitude of the field B at a point 20 cm from the wire? (3.5 × 10^{-5} T)

35. A long straight wire in the horizontal plane carries a current of 50 A in the north to south direction. Give the magnitude and direction of B at a point 2.5 m east of the wire. **(4 × 10^{-6} T, vertically upward)**

36. A horizontal overhead power line carries a current of 90 A in the east to west direction. What is the magnitude and direction of the magnetic field due to the current 1.5 m below the line? **(1.2 × 10^{-5} T, towards the South)**

37. What is the magnitude of magnetic force per unit length on a wire carrying a current of 8 A and making an angle of 30° with the direction of a uniform magnetic field of 0.15 T? (0.6 N m^{-1})

38. A 3.0 cm wire carrying a current of 10 A is placed inside a solenoid perpendicular to its axis. The magnetic field inside the solenoid is given to be 0.27 T. What is the magnetic force on the wire? (8.1 × 10−2 N)

39. Two long and parallel straight wires A and B carrying currents of 8.0 A and 5.0 A in the same direction are separated by a distance of 4.0 cm. Estimate the force on a 10 cm section of wire A. (2 × 10−5 N)

40. A closely wound solenoid 80 cm long has 5 layers of windings of 400 turns each. The diameter of the solenoid is 1.8 cm. If the current carried is 8.0 A, estimate the magnitude of B inside the solenoid near its centre. **(2.5 × 10^{-2} T)**

41. A square coil of side 10 cm consists of 20 turns and carries a current of 12 A. The coil is suspended vertically, and the normal to the plane of the coil makes an angle of 30o with the direction of a uniform horizontal magnetic field of magnitude 0.80 T. What is the magnitude of torque experienced by the coil. **(0.96 N m)**

42. Two moving coil meters, M1 and M2 have the following particulars: R1 = 10 Ω, N1 = 30, A1 = 3.6 × 10−3 m2, B1 = 0.25 T R2 = 14 Ω, N2 = 42, A2 = 1.8 × 10−3 m2, B2 = 0.50 T
(The spring constants are identical for the two meters).
Determine the ratio of
(a) current sensitivity **(1.4)**
(b) voltage sensitivity of M2 and M1. **(1)**

43. In a chamber, a uniform magnetic field of 6.5 G (1 G = 10−4 T) is maintained. An electron is shot into the field with a speed of 4.8 × 106 m s−1 normal to the field. Explain why the path of the electron is a circle. Determine the radius of the circular orbit. (e = 1.6 × 10−19 C, me = 9.1 × 10−31 kg) **(4.2 cm)**

44. A circular coil of 30 turns and radius 8.0 cm carrying a current of 6.0 A is suspended vertically in a uniform horizontal magnetic field of magnitude 1.0 T. The field lines make an angle of 60° with the normal of the coil. Calculate the magnitude of the counter-torque that must be applied to prevent the coil from turning. **(3.1333 N m)**

MAGNETISM & MATTER

45. A short bar magnet placed with its axis at 30º with a uniform external magnetic field of 0.25 T experiences a torque of magnitude equal to 4.5 × 10–2 N m. What is the magnitude of the magnetic moment of the magnet? **(0.36 J T^{-1})**

46. A short bar magnet of magnetic moment m = 0.32 J T–1 is placed in a uniform magnetic field of 0.15 T. If the bar is free to rotate in the plane of the field, which orientation would correspond to its (a) stable **(–4.8 × 10–2 J)** and (b) unstable equilibrium? **(4.8 × 10–2 J)**
What is the potential energy of the magnet in each case?

47. A closely wound solenoid of 800 turns and area of cross section 2.5 × 10–4 m2 carries a current of 3.0 A. Explain the sense in which the solenoid acts like a bar magnet. What is its associated magnetic moment? **(0.6 J T^{-1})**
If the solenoid is free to turn about the vertical direction and a uniform horizontal magnetic field of 0.25 T is applied, what is the magnitude of torque on the solenoid when its axis makes an angle of 30° with the direction of applied field? **(7.5 × 10^{-2} N $^{-m}$)**

48. A bar magnet of magnetic moment 1.5 J T^{-1} lies aligned with the direction of a uniform magnetic field of 0.22 T. (a) What is the amount of work required by an external torque to turn the magnet so as to align its magnetic moment: (i) normal to the field direction **(0.33 J)** (ii) opposite to the field direction? **(0.66 J)** (b) What is the torque on the magnet in cases (i) and (ii)? **(0.33 J, 0)**

49. A closely wound solenoid of 2000 turns and area of cross-section 1.6 × 10–4 m2 , carrying a current of 4.0 A, is suspended through its centre allowing it to turn in a horizontal plane.
(a) What is the magnetic moment associated with the solenoid? **(1.28 A m^2)**

(b) What is the force and torque on the solenoid if a uniform horizontal magnetic field of 7.5×10^{-2} T is set up at an angle of 30º with the axis of the solenoid? **(4.8×10^{-2} N – m)**

50. A short bar magnet has a magnetic moment of 0.48 J T–1. Give the direction and magnitude of the magnetic field produced by the magnet at a distance of 10 cm from the centre of the magnet on

(a) the axis **(0.96×10^{-4} T)**

(b) the equatorial lines (normal bisector) of the magnet. **(0.48×10^{-4} T)**

ELECTROMAGNETIC INDUCTION

51. 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, what is the induced emf in the loop while the current is changing? **(7.5 × 10–6 V)**

52. A 1.0 m long metallic rod isrotated with an angular frequency of 400 rad s–1 about an axis normal to the rod passing through its one end. The other end of the rod is in contact with a circular metallic ring. A constant and uniform magnetic field of 0.5 T parallel to the axis exists everywhere. Calculate the emf developed between the centre and the ring. (100 V)

53. A circular coil of radius 8.0 cm and 20 turns is rotated about its vertical diameter with an angular speed of 50 rad s–1 in a uniform horizontal magnetic field of magnitude 3.0 × 10–2 T. Obtain the maximum and average emf induced in the coil. If the coil forms a closed loop of resistance 10 Ω, calculate the maximum value of current in the coil. Calculate the average power loss due to Joule heating. Where does this power come from? (0.018 W)

54. A horizontal straight wire 10 m long extending from east to west is falling with a speed of 5.0 m s–1, at right angles to the horizontal component of the earth's magnetic field, 0.30 × 10–4 Wb m–2.

(a) What is the instantaneous value of the emf induced in the wire? (1.5 × 10−3 V)

(b) What is the direction of the emf?

(c) Which end of the wire is at the higher electrical potential?

55. Current in a circuit falls from 5.0 A to 0.0 A in 0.1 s. If an average emf of 200 V induced, give an estimate of the self-inductance of the circuit. (4 H)

56. A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s, what is the change of flux linkage with the other coil? (30 Wb)

57. A jet plane is travelling towards west at a speed of 1800 km/h. What is the voltage difference developed between the ends of the wing having a span of 25 m, if the Earth's magnetic field at the location has a magnitude of 5 × 10–4 T and the dip angle is 30°. (3.125 V)

58. An air-cored solenoid with length 30 cm, area of cross-section 25 cm2 and number of turns 500, carries a current of 2.5 A. The current is suddenly switched off in a brief time of 10–3 s. How much is the average back emf induced across the ends of the open switch in the circuit? Ignore the variation in magnetic field near the ends of the solenoid. (6.5 V)

ALTERNATING CURRENT

59. A 100 Ω resistor is connected to a 220 V, 50 Hz ac supply. (a) What is the rms value of current in the circuit? (2.2 A) (b) What is the net power consumed over a full cycle? (484 W)

60. (a) The peak voltage of an ac supply is 300 V. What is the rms voltage? (212.1 V) (b) The rms value of current in an ac circuit is 10 A. What is the peak current? (14.1 A)

61. A 44 mH inductor is connected to 220 V, 50 Hz ac supply. Determine the rms value of the current in the circuit. (15.9 A)

62. A 60 µF capacitor is connected to a 110 V, 60 Hz ac supply. Determine the rms value of the current in the circuit. (2.49 A)

63. Obtain the resonant frequency ω_r of a series L circuit with L = 2.0H, C = 32 µF and R = 10 Ω. What is the Q-value of this circuit? (25)

64. A charged 30 µF capacitor is connected to a 27 mH inductor. What is the angular frequency of free oscillations of the circuit? (1.1 × 103 rad s−1)

65. A series L circuit with R = 20 Ω, L = 1.5 H and CC = 35 µF is connected to a variable-frequency 200 V ac supply. When the frequency of the supply equals the natural frequency of the circuit, what is the average power transferred to the circuit in one complete cycle? (2000 W)

66. A radio can tune over the frequency range of a portion of MW broadcast band: (800 kHz to 1200 kHz). If its L circuit has an effective inductance of 200 µH, what must be the range of its variable capacitor? [Hint: For tuning, the natural frequency i.e., the frequency of free oscillations of the L circuit should be equal to the frequency of the radiowave.] (87.9 pF to 197.8 pF)

67. A power transmission line feeds input power at 2300 V to a stepdown transformer with its primary windings having 4000 turns. What should be the number of turns in the secondary in order to get output power at 230 V? (400 turns)

68. At a hydroelectric power plant, the water pressure head is at a height of 300 m, and the water flow available is 100 m3s–1. If the turbine generator efficiency is 60%, estimate the electric power available from the plant (gg = 9.8 ms–2). (176 MW)

69. A plane electromagnetic wave travels in vacuum along the z-direction. What can you say about the directions of its electric and magnetic field vectors? If the frequency of the wave is 30 MHz, what is its wavelength? (10 m)

70. A radio can tune in to any station in the 7.5 MHz to 12 MHz bands. What is the corresponding wavelength band? (40 m to 25 m)

71. The amplitude of the magnetic field part of a harmonic electromagnetic wave in vacuum is B0= 510 nT. What is the amplitude of the electric field part of the wave? (153 N/C)

72. Suppose that the electric field amplitude of an electromagnetic wave is E0=120 N/C and that its frequency is ν = 50.0 MHz.

(a) Determine, B_0, ω, k, and λ. (400 nT, 3.14 × 108 rad/s, 1.05 rad/m, 6.0 m)

(b) Find expressions for E and B.

73. In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of 2.0 × 1010 Hz and amplitude 48 V m−1

(a) What is the wavelength of the wave? (0.015 m)

(b) What is the amplitude of the oscillating magnetic field? (1.6 × 10−7 T)

74. About 5% of the power of a 100 W light bulb is converted to visible radiation. What is the average intensity of visible radiation

(a) at a distance of 1m from the bulb? (0.398 W m2)

(b) at a distance of 10 m? Assume that the radiation is emitted isotopically and neglect reflection. **(**0.00398 W m2**)**

RAY OPTICS & OPTICAL INSTRUMENTS

75. A small candle, 2.5 cm in size is placed at 27 cm in front of a concave mirror of radius of curvature 36 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Describe the nature and size of the image. If the candle is moved closer to the mirror, how would the screen have to be moved?

76. A 4.5 cm needle is placed 12 cm away from a convex mirror of focal length 15 cm. Give the location of the image and the magnification. Describe what happens as the needle is moved farther from the mirror

77. A tank is filled with water to a height of 12.5 cm. The apparent depth of a needle lying at the bottom of the tank is measured by a microscope to be 9.4 cm. What is the refractive index of water? If water is replaced by a liquid of refractive index 1.63 up to the same height, by what distance would the microscope have to be moved to focus on the needle again? (1.7 cm)

78. A small bulb is placed at the bottom of a tank containing water to a depth of 80 cm. What is the area of the surface of water through which light from the bulb can emerge out? Refractive index of water is 1.33. (Consider the bulb to be a point source.) (2.6 m^2)

79. A prism is made of glass of unknown refractive index. A parallel beam of light is incident on a face of the prism. The angle of minimum deviation is measured to be 40°. What is the refractive index of the material of the prism? (≃ 1.53)

The refracting angle of the prism is 60°. If the prism is placed in water (refractive index 1.33), predict the new angle of minimum deviation of a parallel beam of light. (10°)

80. Double-convex lenses are to be manufactured from a glass of refractive index 1.55, with both faces of the same radius of curvature. What is the radius of curvature required if the focal length is to be 20 cm? (22 cm)

81. A beam of light converges at a point P. Now a lens is placed in the path of the convergent beam 12 cm from P. At what point does the beam converge if the lens is

(a) a convex lens of focal length 20 cm (Real & 7.5 cm right side)

(b) a concave lens of focal length 16 cm? (Real & 48 cm right side)

82. An object of size 3.0 cm is placed 14 cm in front of a concave lens of focal length 21 cm. Describe the image produced by the lens. What happens if the object is moved further away from the lens?

83. What is the focal length of a convex lens of focal length 30 cm in contact with a concave lens of focal length 20 cm? Is the system a converging or a diverging lens? Ignore thickness of the lenses. (−60 cm)

84. A compound microscope consists of an objective lens of focal length 2.0 cm and an eyepiece of focal length 6.25 cm separated by a distance of 15 cm. How far from the objective should an object be placed in order to obtain the final image at

(a) the least distance of distinct vision (25cm)

(b) at infinity?

What is the magnifying power of the microscope in each case?

85. A person with a normal near point (25 cm) using a compound microscope with objective of focal length 8.0 mm and an eyepiece of focal length 2.5 cm can bring an object placed at 9.0 mm from the objective in sharp focus. What is the separation between the two lenses? (9.47 cm) Calculate the magnifying power of the microscope. (88)

86. A small telescope has an objective lens of focal length 144 cm and an eyepiece of focal length 6.0 cm. What is the magnifying power of the telescope? What is the separation between the objective and the eyepiece? (150 cm)

87. A small pin fixed on a table top is viewed from above from a distance of 50 cm. By what distance would the pin appear to be raised if it is viewed from the same point through a 15 cm thick glass slab held parallel to the table? Refractive index of glass = 1.5. Does the answer depend on the location of the slab? (5 cm)

88. At what angle should a ray of light be incident on the face of a prism of refracting angle 60° so that it just suffers total internal reflection at the other face? The refractive index of the material of the prism is 1.524. ($i < 30°$)

89. A man with normal near point (25 cm) reads a book with small print using a magnifying glass: a thin convex lens of focal length 5 cm.

(a) What is the closest and the farthest distance at which he should keep the lens from the page so that he can read the book when viewing through the magnifying glass? (−4.16 cm, -5cm)

(b) What is the maximum and the minimum angular magnification (magnifying power) possible using the above simple microscope? (5, 6)

90. An angular magnification (magnifying power) of 30X is desired using an objective of focal length 1.25 cm and an eyepiece of focal length 5 cm. How will you set up the compound microscope?

91. A small telescope has an objective lens of focal length 140 cm and an eyepiece of focal length 5.0 cm. What is the magnifying power of the telescope for viewing distant objects when

(a) the telescope is in normal adjustment (i.e., when the final image is at infinity)? (28)

(b) the final image is formed at the least distance of distinct vision? (33.6)

92. A Cass grain telescope uses two mirrors. Such a telescope is built with the mirrors 20 mm apart. If the radius of curvature of the large mirror is 220 mm and the small mirror is 140 mm, where will the final image of an object at infinity be? (315 mm left to the small mirror)

WAVE OPTICS

93. Monochromatic light of wavelength 589 nm is incident from air on a water surface. What are the wavelength, frequency and speed of (a) reflected, and (b) refracted light? Refractive index of water is 1.33.

94. Young's double-slit experiment, the slits are separated by 0.28 mm and the screen is placed 1.4 m away. The distance between the central bright fringe and the fourth bright fringe is measured to be 1.2 cm. Determine the wavelength of light used in the experiment. (600 nm)

95. 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 λ, is K units. What is the intensity of light at a point where path difference is λ/3? (K/3 units)

96. 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.

(a) Find the distance of the third bright fringe on the screen from the central maximum for wavelength 650 nm. (1950 $D/$)nm

(b) What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincide? (2600 D/d) nm

97. In a double-slit experiment the angular width of a fringe is found to be 0.2° on a screen placed 1 m away. The wavelength of light used is 600 nm. What will be the angular width of the fringe if the entire experimental apparatus is immersed in water? Take refractive index of water to be 4/3. (0.15°)

98. Light of wavelength 5000 Å falls on a plane reflecting surface. What are the wavelength and frequency of the reflected light? (6×10^{14} Hz, 5000 A°)

For what angle of incidence is the reflected ray normal to the incident ray? (45°)

99. In double-slit experiment using light of wavelength 600 nm, the angular width of a fringe formed on a distant screen is 0.1°. What is the spacing between the two slits? (3.44 × 10−4 m)

100. A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1 m away. It is observed that the first minimum is at a distance of 2.5 mm from the centre of the screen. Find the width of the slit. (0.2 mm)

DUAL NATURE OF RADIATION & MATTER

101. Find the (a) maximum frequency (7.24 × 1018Hz)
(b) minimum wavelength of X-rays produced by 30 kV electrons. (0.0414 nm)

102. The work function of caesium metal is 2.14 eV. When light of frequency 6 × 1014 Hz is incident on the metal surface, photoemission of electrons occurs. What is the (a) maximum kinetic energy of the emitted electrons (0.345 eV) (b) Stopping potential (0.345 V) (c) maximum speed of the emitted photoelectrons? (332.3 km/s.)

103. The photoelectric cut-off voltage in a certain experiment is 1.5 V. What is the maximum kinetic energy of photoelectrons emitted? (2.4 × 10−19 J)

104. Monochromatic light of wavelength 632.8 nm is produced by a helium-neon laser. The power emitted is 9.42 mW.
(a) Find the energy and momentum of each photon in the light beam (3.141 × 10−19 J, (1.047 × 10−27 kg m/s)
(b) How many photons per second, on the average, arrive at a target irradiated by this beam? (Assume the beam to have uniform cross-section which is less than the target area) (3 × 1016 photons/s)
(c) How fast does a hydrogen atom have to travel to have the same momentum as that of the photon? (0.621 m/s)

105. The energy flux of sunlight reaching the surface of the earth is 1.388 × 103 W/ m2. How many photons (nearly) per square metre are incident on the Earth per second? Assume that the photons in the sunlight have an average wavelength of 550 nm. (3.84 × 1021 photons/m^2/s)

106. In an experiment on photoelectric effect, the slope of the cut-off voltage versus frequency of incident light is found to be 4.12 × 10–15 V s. Calculate the value of Planck's constant. (6.59 × 10−34 J s)

107. A 100W sodium lamp radiates energy uniformly in all directions. The lamp is located at the centre of a large sphere that absorbs all the sodium light which is incident on it. The wavelength of the sodium light is 589 nm. (a) What is the energy per photon associated with the sodium light? (2.11 eV) (b) At what rate are the photons delivered to the sphere? (2.96 × 10^{20} photons/s)

108. The threshold frequency for a certain metal is 3.3 × 1014 H. If light of frequency 8.2 × 1014 Hz is incident on the metal, predict the cut-off voltage for the photoelectric emission. (2.03 V)

109. The work function for a certain metal is 4.2 eV. Will this metal give photoelectric emission for incident radiation of wavelength 330 nm? (3.76 eV)

110. Light of frequency 7.21 × 1014 Hz is incident on a metal surface. Electrons with a maximum speed of 6.0 × 105 m/s are ejected from the surface. What is the threshold frequency for photoemission of electrons? (4.74 × 1014 Hz)

111. Light of wavelength 488 nm is produced by an argon laser which is used in the photoelectric effect. When light from this spectral line is incident on the emitter, the stopping (cut-off) potential of photoelectrons is 0.38 V. Find the work function of the material from which the emitter is made. (2.16 eV)

112. Calculate the

(a) momentum (4.04 × 10−24 kgm/s)

(b) de Broglie wavelength of the electrons accelerated through a potential difference of 56 V. (0.16 nm)

113. What is the

(a) momentum (5.91 × 10−24 kg m/s)

(b) speed (6.496 × 106 m/s)

(c) de Broglie wavelength of an electron with kinetic energy of 120 eV (0.112 nm)

114. The wavelength of light from the spectral emission line of sodium is 589 nm. Find the kinetic energy at which (a) an electron (4.31 μeV) (b) a neutron would have the same de Broglie wavelength. (2.36 neV)

115. What is the de Broglie wavelength of

(a) a bullet of mass 0.040 kg travelling at the speed of 1.0 km/s,

(b) a ball of mass 0.060 kg moving at a speed of 1.0 m/s,

(c) a dust particle of mass 1.0 × 10–9 kg drifting with a speed of 2.2 m/s?

116. An electron and a photon each have a wavelength of 1.00 nm. Find

(a) their momenta,

(b) the energy of the photon, and

(c) the kinetic energy of electron.

117. Show that the wavelength of electromagnetic radiation is equal to the de Broglie wavelength of its quantum (photon).

118. What is the de Broglie wavelength of a nitrogen molecule in air at 300 K? Assume that the molecule is moving with the root-mean square speed of molecules at this temperature. (Atomic mass of nitrogen = 14.0076 u)

119. Ultraviolet light of wavelength 2271 Å from a 100 W mercury source irradiates a photo-cell made of molybdenum metal. If the stopping potential is – 1.3 V, estimate the work function of the metal. How would the photo-cell respond to a high intensity (~105 W m–2) red light of wavelength 6328 Å produced by a He-Ne laser?

120. Monochromatic radiation of wavelength 640.2 nm (1 nm = 10–9 m) from a neon lamp irradiates photosensitive material made of cesium 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.

121. A mercury lamp is a convenient source for studying frequency dependence of photoelectric emission, since it gives a number of spectral lines ranging from the UV to the red end of the visible spectrum. In our experiment with rubidium photocell, the following lines from a mercury source were used: $\lambda 1$ = 3650 Å, 2 = 4047 Å, $\lambda 3$ = 4358 Å, $\lambda 4$ = 5461 Å, $\lambda 5$ = 6907 Å, The stopping voltages, respectively, were measured to be: V_{01} = 1.28 V, V_{02} = 0.95 V, V_{03} = 0.74 V, V_{04} = 0.16 V, V_{05} = 0 V. Determine the value of Planck's constant h, the threshold frequency and work function for the material

122. The work function for the following metals is given: Na: 2.75 eV; K: 2.30 eV; Mo: 4.17 eV; Ni: 5.15 eV. Which of these metals will not give photoelectric emission for a radiation of wavelength 3300 Å from a He-Cd laser placed 1 m away from the photocell? What happens if the laser is brought nearer and place 50 cm away?

123. Compute the typical de Broglie wavelength of an electron in a metal at 27 °C and compare it with the mean separation between two electrons in a metal which is given to be about 2×10^{-10} m.

ATOMS

124. What is the shortest wavelength present in the Paschen series of spectral lines?

125. A difference of 2.3 eV separates two energy levels in an atom. What is the frequency of radiation emitted when the atom makes a transition from the upper level to the lower level?

126. The ground state energy of hydrogen atom is −13.6 eV. What are the kinetic and potential energies of the electron in this state?

127. A hydrogen atom initially in the ground level absorbs a photon, which excites it to the n = 4 level. Determine the wavelength and frequency of the photon.

128. (a) Using the Bohr's model calculate the speed of the electron in a hydrogen atom in the n = 1, 2, and 3 levels.

(b) Calculate the orbital period in each of these levels.

129. The radius of the innermost electron orbit of a hydrogen atom is 5.3 × 10−11 m. What are the radii of the n = 2 and n = 3 orbits?

130. A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. What series of wavelengths will be emitted?

131. The total energy of an electron in the first excited state of the hydrogen atom is about −3.4 eV. (a) What is the kinetic energy of the electron in this state?

(b) What is the potential energy of the electron in this state?

NUCLEI

132. The three stable isotopes of neon: $^{10}Ne_{20}$, $^{10}Ne_{21}$ and $^{10}Ne_{22}$ have respective abundances of 90.51%, 0.27% and 9.22%. The atomic masses of the three isotopes are 19.99 u, 20.99 u and 21.99 u, respectively. Obtain the average atomic mass of neon.

133. Given the mass of iron nucleus as 55.85u and A=56, find the nuclear density?

134. Find the energy equivalent of one atomic mass unit, first in Joules and then in MeV. Using this, express the mass defect of $_8O^{16}$ in MeV/c ^{2} .

135. Obtain the binding energy (in MeV) of a nitrogen nucleus ($_7N^{14}$), given m($_7N^{14}$) = 14.00307 u

136. Obtain the binding energy of the nuclei $_{26}Fe^{56}$ and $Bi^{209}\ _{83}$ in units of MeV from the following data: m (26 N 56) = 55.934939 u, m(Bi $_{83}$ 209) = 208.980388 u

137. Write nuclear reaction equations for

(i) α-decay of $_{88}Ra^{226}$

(ii) α-decay of $_{94}Pu^{242}$

(iii) β– -decay of $_{15}P^{32}$

(iv) β– -decay of $_{83}Bi^{210}$

(v) β+ -decay of $_6C^{11}$

(vi) β+ -decay of $_{43}Tc^{97}$

(vii) Electron capture of $_{54}Xe^{120}$

138. Obtain approximately the ratio of the nuclear radii of the gold isotope $_{79}Au^{197}$ and the silver isotope $_{47}Ag^{107}$.

139. From the relation $R = R_0A^{1/3}$, where R_0 is a constant and A is the mass number of a nucleus, show that the nuclear matter density is nearly constant (i.e. independent of A).

SEMICONDUCTOR DEVICES

140. In half-wave rectification, what is the output frequency if the input frequency is 50 Hz. What is the output frequency of a full-wave rectifier for the same input frequency?

141. A p-n photodiode is fabricated from a semiconductor with band gap of 2.8 eV. Can it detect a wavelength of 6000 nm?

142. The number of silicon atoms per m^3 is 5×10^{28}. This is doped simultaneously with 5×10^{22} atoms per m^3 of Arsenic and 5×10^{20} per m^3 atoms of Indium. Calculate the number of electrons and holes. Given that $n_i = 1.5 \times 1016\ m^{-3}$. Is the material n-type or p-type?

143. In an n-type silicon, which of the following statement is true:

(a) Electrons are majority carriers and trivalent atoms are the dopants.

(b) Electrons are minority carriers and pentavalent atoms are the dopants.

(c) Holes are minority carriers and pentavalent atoms are the dopants.

(d) Holes are majority carriers and trivalent atoms are the dopants.

144. In a p-type silicon, which of the following statement is true:

(a) Electrons are majority carriers and trivalent atoms are the dopants.

(b) Electrons are minority carriers and pentavalent atoms are the dopants.

(c) Holes are minority carriers and pentavalent atoms are the dopants.

(d) Holes are majority carriers and trivalent atoms are the dopants.

145. Carbon, silicon and germanium have four valence electrons each. These are characterised by valence and conduction bands separated by energy band gap respectively equal to $(Eg)_C$, $(Eg)_{Si}$ and $(Eg)_{Ge}$. Which of the following statements is true?

(a) (Eg)Si < (Eg)Ge < (Eg)C

(b) (Eg)C < (Eg)Ge > (Eg)Si

(c) (Eg)C > (Eg)Si > (Eg)Ge

(d) (Eg)C = (Eg)Si = (Eg)Ge

146. In an unbiased p-n junction, holes diffuse from the p-region to n-region because

(a) free electrons in the n-region attract them.

(b) they move across the junction by the potential difference.

(c) hole concentration in p-region is more as compared to n-region.

(d) All the above.

147. When a forward bias is applied to a p-n junction, it

(a) raises the potential barrier.

(b) reduces the majority carrier current to zero.

(c) lowers the potential barrier.

(d) none of the above.

148. Suppose a pure Si crystal has 5×10^{28} atoms m^{-3}. It is doped by 1 ppm concentration of pentavalent As. Calculate the number of electrons and holes. Given that $n_i = 1.5 \times 10^{16}\ m^{-3}$

149. In a Zener regulated power supply a Zener diode with V_Z = 6.0 V is used for regulation. The load current is to be 4.0 mA and the unregulated input is 10.0 V. What should be the value of series resistor R_S ?

150. The current in the forward bias is known to be more (~mA) than the current in the reverse bias (~µA). What is the reason then to operate the photodiodes in reverse bias?