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Paper Code : BS-PH-101

PHYSICS-1

Time Allotted: 3 Hours | *Full Marks*: 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

The questions are of equal value.

Group – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for *any ten* of the following: 1×10=10

(i) The value of a for which $\vec{A} = \hat{i}2ax + \hat{j}2y + \hat{k}4z$ is solenoidal is equal to

(a) 2 (b) 3

(c) –3 (d) 1

(ii) Moment of inertia of solid sphere of Mass M and radius R is

(a) $\frac{5}{2}MR^2$ (b) $\frac{1}{2}MR^2$

(c) $\frac{2}{3}MR^2$ (d) $\frac{2}{5}MR^2$

(iii) In a conservative field,

(a) work done is zero (b) line integral is independent of path

(c) curl is not equal to zero (d) divergence is zero

(iv) In Fraunhofer diffraction the incident wavefront is

(a) Plane (b) Circular

(c) Cylindrical (d) Elliptical

(v) In a quarter wave plate, the phase difference between E-ray and O-ray will be

(a) π (b) $\pi/4$

(c) $\pi/2$ (d) 0

(vi) Clausius-Mossotti equation can be expresses as

(a) $\left(\frac{\epsilon_\gamma - 1}{\epsilon_\gamma + 1}\right) = \frac{N\alpha_e}{3\epsilon_0}$ (b) $\left(\frac{\epsilon_\gamma + 2}{\epsilon_\gamma - 1}\right) = \frac{N\epsilon_0}{3\alpha_e}$

(c) $\left(\frac{\epsilon_\gamma - 1}{\epsilon_\gamma + 2}\right) = \frac{N\alpha_e}{3\epsilon_0}$ (d) $\left(\frac{\epsilon_\gamma + 1}{\epsilon_\gamma - 2}\right) \propto \frac{N\alpha_e}{3\epsilon_0}$

(vii) Material which shows negative susceptibility is

(a) Paramagnetic (b) Diamagnetic

(c) Ferromagnetic (d) Anti ferromagnetic

(viii) The value of Bohr magneton (μ_B) is equal to

(a) (em/4πh) (b) (eh/4πm)

(c) (e/4πmh) (d) (4m/πeh)

(ix) The wave function $\psi_m(x)$ and $\psi_n(x)$ are orthogonal to each other then find the correct option.

(a) $\int_{-\infty}^{+\infty} \psi_m^* \psi_n dx = 1$ (b) $\int_{-\infty}^{+\infty} \psi_m^* \psi_n dx = 0$

(c) $\int_{-\infty}^{+\infty} \psi_m^* \psi_n dx = \frac{1}{2}$ (d) $\int_{-\infty}^{+\infty} \psi_m \psi_n dx = 1$

(x) Average energy of an electron in a metal at $T = 0K$ is

(a) $\frac{3}{2}\epsilon_F$ (b) ϵ_F

(c) $\frac{5}{3}\epsilon_F$ (d) $\frac{3}{5}\epsilon_F$

(xi) The statistics obeyed by ${}_2He^4$ atom is

(a) MB statistics (b) BE statistics

(c) FD statistics (d) Any of these

(xii) Heisenberg's uncertainty relation is

(a) $\Delta x\, \Delta t \geq \frac{h}{2}$ (b) $\Delta x\, \Delta p_x \geq \frac{h}{2}$

(c) $\Delta x\, \Delta p_x \leq h$ (d) $\Delta x\, \Delta p_x = 1$

(xiii) In the limit of high temperature and large wavelength, Planck's law of radiation reduces to

(a) Rayleigh-Jeans Law (b) Wien's displacement Law

(c) Wien's Law (d) Stephan's Law

(xiv) The value of $[\hat{x}, \hat{P}_x]$:

(a) $ih/2\pi$ (b) 0

(c) $-ih/2\pi$ (d) 1

(xv) The number of possible arrangements of two fermions in three cells is

(a) 9 (b) 6

(c) 3 (d) 1

Group – B

(Short Answer Type Questions)

Answer *any three* of the following. 5×3=15

2. (a) An oscillator executing SHM has zero displacement at time $t = 0$. If the displacement are 1mm and 1·5 mm at instants 0·1 and 0·2 seconds, calculate the frequency and amplitude of oscillation.

(b) What do you mean by population inversion? What is stimulated emission? 2+3=5

3. (a) How Fraunhofer diffraction differs from Fresnel diffraction?

(b) Write the expression for intensity due Fraunhofer diffraction at double slit and hence find the conditions for maxima and minima. 2+3=5

4. (a) Establish the relation $\vec{D} = \varepsilon_0\vec{E} + \vec{P}$ where the parameters have their usual meaning.

(b) Distinguish between nonpolar and polar molecules. Give examples. 3+2=5

5. (a) State Kirchhoff's law of radiation and prove that good absorbers are good radiators too.

(b) A 5 kilowatt radio transmitter operates at a frequency of 500kHz. Find the number of photon it emits. 2+3=5

6. (a) What are the basic postulates of quantum mechanics?

(b) Show that the energy difference between two consecutive energy levels of a 1-dimensional potential box with rigid walls is given by $\Delta E = \frac{h^2\pi^2}{2ml^2}(2n-1)$. 2+3=5

Group – C

(Long Answer Type Questions)

Answer *any three* of the following. 15×3=45

7. (a) Establish the differential equation of damped harmonic motion and solve the equation for light damping.

(b) A cubical box of L cm side and density ρ is floating on water of density $\sigma(\rho < \sigma)$. The block is slightly depressed and released. Shows that it will execute S.H.M. also determine the time period of oscillation.

(c) The motion of a particle in S.H.M. is given by $y = a\sin\omega t$. If it has speed u when the displacement is y_1, and a speed v when the displacement is y_2, show that the amplitude of the motion is a $\left[\frac{v^2y_1^2-u^2y_2^2}{v^2-u^2}\right]^{1/2}$ (1+4)+5+5=15

8. (a) Write down Maxwell's wave equation for free space with physical significance and from there proves that velocity of EM wave is velocity of light.

(b) Write down the Maxwell's modification of Ampere's law.

(c) Derive molecular field theory on ferromagnetism. (4+2)+4+5=15

9. (a) What is Heisenberg's uncertainty principle?

(b) Derive Compton wavelength at an angle 90°.

(c) Compute the smallest possible uncertainty in the position of an electron moving with velocity 3×10^7 m/s. The rest mass of electron is $9{\cdot}1 \times 10^{-31}$kg.

(d) Prove that the product of phase velocity and group velocity for a de Broglie wave is equal to the square of the velocity of light. 2+4+5+4=15

10. (a) Derive Schrödinger time independent wave equation.

(b) Write down Schrödinger equation for one dimensional motion of a free particles in a one dimensional potential box. Find its eigenfunction and eigen energy.

(c) Find the energy difference between the ground state and 1st excited state of an electron moving in a one dimensional potential box of length 1Å. 6+(3+3)+3=15

11. (a) Write down about (i) macrostate (ii) microstate (iii) ensemble.

(b) Give an expression of B-E statistics and hence obtain Plank's law of black body radiation.

(c) 3 distinguishable particles each of which can be in one of the E, 2E, 3E, 4E energy state of total energy 6E. Find all possible number of distributions of all particles in the energy states. Find no. of microstate in each case. 3+(1+5)+6=15