PHYSICS - I
(PHYS 1001)

Time Allotted: 3 hrs **Full Marks: 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Two sources are said to be coherent when the waves produced by them are
(a) same wavelength
(b) same wavelength and same phase
(c) same wavelength and constant phase difference
(d) same amplitude and constant phase difference.

(ii) The fringe width β in Young's double slit experiment with light of wavelength λ=400 nm is 0.4 mm. If λ = 600 nm, then β will be
(a) 0.66 mm (b) 0.6 mm
(c) 0.4 mm (d) 0.12 mm

(iii) The relaxation time is defined as the time during which the amplitude of a damped oscillator
(a) grows to e times the initial value
(b) decays to $1/e$ times the initial value
(c) grows to e^2 times the initial value
(d) decays to $1/e^2$ times the initial value

(iv) The effective number of atoms per unit cell of BCC crystal is
(a) 4 (b) 3
(c) 2 (d) 1.

(v) If the wavelength of the light used in single slit diffraction is increased then the width of the central maximum
(a) decreases (b) increases
(c) remains same (d) none of (a),(b) & (c)

(vi) An electron being accelerated through a potential difference 100 volt, is associated with de Broglie wavelength
(a) 1.227 A° (b) 0.1227 A°
(c) 122.7 A° (d) 12.27 A°

(vii) If v_g be the group velocity of the wave group representing a particle moving with velocity v, then

(a) $v_g > v$ (b) $v > v_g$

(c) $v_g = v$ (d) $v_g = \frac{1}{v}$

(viii) The Compton shift is maximum when scattering angle is

(a) 45° (b) 90°

(c) 180° (d) 60°

(ix) If the refractive index of water is 1.33, the angle of polarization of light reflected from water is

(a) $\cos^{-1}(1.33)$ (b) 53.1°

(c) 36.9° (d) 1.33°

(x) In the process of Laser, Spontaneous emission rate depends on

(a) the number of atoms in excited state

(b) intensity of the exciting radiation

(c) both (a) and (b)

(d) the number of atoms in the ground state.

Group – B

2. (a) Write the conditions for sustained Interference Pattern .

(b) Newton's rings are obtained in reflected light of wavelength 5800Å. The diameter of the 8th dark ring is 0.4 cm. Find the radius of curvature of the lens (R) and the thickness of the air film corresponding to 8th dark ring (t).

(c) How circularly polarised light differs from unpolarised light?

(d) Write the expression for intensity due Fraunhofer diffraction at double slit and hence find the conditions for maxima and minima.

2 + (2 + 1) + 3 + 4 = 12

3. (a) Two polaroids are crossed to each other. Now one of them is rotated 60°. What percentage of incident unpolarised light will pass through the system?

(b) A plane polarized light of wavelength 5893Å is incident on a thin quartz plate cut with faces parallel to the optic axis. Calculate the minimum thickness of the retardation plate for which the O-ray and E-ray waves will combine to produce circularly polarized light. [Given that, $\mu_e = 1.553$ and $\mu_o = 1.544$].

(c) Write a short note on positive and negative crystal.

(d) Explain briefly the basic operational principle of Optical Fibre and mention any two applications of it.

3 + 3 + 3 + 3 = 12

Group – C

4. (a) A wave with the equation $\Psi(x, t) = A \exp i(ax-bt)$ (a, b being constant) has frequency ν. Assuming the wave to satisfy classical wave equation. Find its wavelength?

   (b) Write down the differential equation of a series LCR circuit driven by a sinusoidal voltage. Identify the natural frequency of the circuit. Find out the condition that this circuit will show an oscillatory decay and find out the relaxation time.

   (c) Draw the variation of velocity amplitude of the forced vibration with the applied frequency for different damping constant. Distinguish between the amplitude resonance and velocity resonance.

3 + (2 + 2 + 2) + (1 + 2) = 12

5. (a) The damped frequency of vibration of a body is 200 Hz. The amplitude of vibration becomes $\frac{1}{e}$ of the initial amplitude after 1 second. Calculate the frequency of free vibration.

   (b) Consider the equation of motion for a damped harmonic motion
   $d^2x/dt^2 + 2\gamma\, dx/dt + \omega_0^2 = 0$
   Where, γ = damping factor and ω_0 = natural frequency of vibration.
   A damped oscillator represented by the above equation has frequency $\omega_0 = 10\pi$/sec. If the amplitude of oscillation reduces to half of its initial value in 30 sec, calculate (i) damping factor (ii) Relaxation time (iii) quality factor.

   (c) Write down the equation of forced vibration. In the steady state forced vibration describe how the phase of driven system changes with frequency of the driving force.

2 + (2 + 2 + 2) + (1 + 3) = 12

Group – D

6. (a) Write down the energy and momentum conservation equation in Compton effect. Through what angle must a 0.20 MeV photon be scattered by a free electron so that it loses 10% of its energy?

   (b) Why Compton effect cannot be observed with visible light but can be observed due to X-rays? Calculate the Compton wavelength in Å for an electron.

   (c) Write down the Planck's radiation law for blackbody explaining all terms.

(2 + 1 + 2) + (3 + 2) + 2 = 12

7. (a) If an electron is subjected to a potential difference of V volts then prove that the corresponding de Broglie wavelength is $\frac{12.26}{\sqrt{v}}$ Å .

   (b) Derive the relation between phase velocity and group velocity of a wave packet in terms of wavelength of the matter waves.

   (c) State Hisenberg's uncertainty principle and justify that the electron cannot exist in an atomic nucleus.

(2 + 2) + 3 + (2 + 3) = 12

Group – E

8. (a) The distance between (1, 0, 0) plane in a simple cubic structure is 0.125nm. What is the size of the unit cell? What is the radius of the atom?
   (b) Ni has FCC structure. Its lattice constant is 3.52 Å; atomic weight of Ni is 58.71. Calculate its radius, Atomic packing factor and density.
   (c) Find the Miller Indices of a plane having intercepts of 4a, -2b and 6c on the X,Y,Z axes respectively where a, b, c are primitive vectors of the unit cell.
   (d) Show that the Atomic packing factor of FC is 74%.

(2 + 2) + 3 + 2 + 3 = 12

9. (a) Show that all primitive cells are unit cell but all unit cells may or may not be primitive cell.
   (b) What are Miller Indices? Find the Miller Indices of a crystal plane whose intercepts are $[a, 2b, c]$ in simple cubic crystal.
   (c) A cubic crystal has lattice constant 4.3Å and density 963 kg/m^3. If its atomic weight is 63, then what type of cubic cell does it form?
   (d) What is the basis of dividing the crystal systems into different types and how many different Bravais lattices are shown in crystal structure?
   (e) Sketch the direction of [102].

2 + 3 + 3 + (1 + 1) + 2 = 12