7. (a) State Heisenberg's uncertainty principle explaining each terms.

   (b) State and explain de Broglie's hypothesis. Show that the relativistic de Broglie's wave length is given by $\lambda_{relativistic} = \frac{h}{\sqrt{E_k(E_k + 2m_0c^2)}}$, the notations have their usual meaning.

   (c) A particle has a kinetic energy 20 times of its rest energy. Find the speed of the particle in terms of velocity of light in vacuum (c).

   (d) Show that the rest mass m_0 of a particle of momentum P and kinetic energy 'T' are related by $m_0 = \frac{P^2c^2 - T^2}{2Tc^2}$ (c = velocity of light in vacuum).

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

Group – E

8. (a) Find the relation between the atomic radius and the lattice constant for a Body centred cubic crystal and Face centred cubic crystal.

   (b) Derive Bragg's law related to X-ray diffraction from crystal planes.

   (c) A beam of *X*-rays of wavelength 0.842Å is incident on a crystal at a glancing angle $8^0 5'$, when first order Bragg's reflection occurs. Calculate the glancing angle for third order reflection.

   (d) Within a cubic unit cell, sketch the following directions: $[1\bar{1}1]$ and [010].

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

9. (a) Explain Miller indices.

   (b) Calculate the Miller indices of a plane with intercepts a/2, b, 3c and hence find the inter-planar spacing (where a, b, c have their usual meanings).

   (c) What is co-ordination number? Show that atomic packing factor increases with co-ordination number.

   (d) The atomic diameter of an atom of iron (BCC) is 0.2482 nm and atomic weight is 55.85 kg/kmol. Calculate the lattice constant.

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

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) Missing orders are found in case of double slit diffraction pattern due to
   (a) unequal value of two slit widths
   (b) superposition of diffraction maxima and interference minima
   (c) superposition of diffraction minima and interference maxima
   (d) oblique incidence of light.

   (ii) Two mutually perpendicular S.H.M. with equal time periods but different amplitudes are superimposed. If the phase difference between these oscillations is 45^0, then they form a
   (a) circle (b) parabola (c) straight line (d) ellipse.

   (iii) The nearest neighbour distance of a simple cubic crystal of unit cell length 'a' is
   (a) $\frac{a}{2}$ (b) a (c) $2a$ (d) $\frac{3a}{2}$.

   (iv) De Broglie wavelength of a particle with mass m and kinetic energy E for non-relativistic case is
   (a) $\lambda = \sqrt{\frac{2mE}{h}}$ (b) $\lambda = \sqrt{2mE}$ (c) $\lambda = \frac{h}{\sqrt{2mE}}$ (d) $\lambda = 0$.

   (v) If in Newton's ring experiment the air film is replaced by oil then the radius of the rings of same order will
   (a) increase (b) decrease
   (c) remain same (d) none of these.

(vi) Which of the following is a biaxial crystal?
(a) Calcite (b) Quartz (c) Argonite (d) None of these.

(vii) The coordination number in FCC lattice is,
(a) 12 (b) 4 (c) 8 (d) 6.

(viii) The resonant frequency of an electrical oscillator (L-C-R) is given by,
(a) $\nu = 2\pi\sqrt{LC}$ (b) $\nu = \frac{1}{2\pi\sqrt{LC}}$ (c) $\nu = \frac{2\pi}{\sqrt{LC}}$ (d) $\nu = 2\pi\sqrt{\frac{L}{C}}$

(ix) Relative velocities of two photons moving in vacuum with velocity 'c' in opposite direction is,
(a) c (b) zero (c) 2c (d) all of them.

(x) Compton shift $\Delta\lambda$ and Compton wave length λ_c are equal if the angle of scattering is
(a) 0^0 (b) 90^0 (c) 180^0 (d) 360^0.

Group – B

2. (a) Find the expression of fringe width in case of Young's double slit interference pattern.

(b) Newton's rings are obtained in reflected light of wavelength 5900Å. The diameter of the 10th dark ring is 0.5 cm. Find the radius of curvature of the lens (R) and the thickness of the air film corresponding to 10th dark ring (t).

(c) Find the state of polarization when x and y components of the electric field are, $E_x = E_0 \cos(\omega t + kz)$ and $E_y = (E_0/\sqrt{2}) \cos(\omega t + kz + \pi)$.

(d) What do you mean by spontaneous and stimulated emission of a radiation?

5 + (2 + 1) + 2 + 2 = 12

3. (a) 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 $\mu_o = 1.544$].

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

(c) A monochromatic light of wavelength 5500Å is incident on a single slit of width 0.3 mm and gets diffracted. Find the diffraction angles for the 1st and the 2nd minima.

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

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

Group – C

4. (a) The potential energy of a particle of mass 'm' is given by $\frac{1}{2}m\omega^2x^2$, where ω is a constant. Show that the particle is executing a simple harmonic motion.

(b) If $Y = A\cos(\omega t - kx)$ represents a harmonic wave, establish the differential equation for the wave propagation and find its velocity of propagation.

(c) A particle is simultaneously under two simple harmonic motions at right angles to each other, represented by $x = a\sin\omega t$, $y = b\sin(\omega t + \delta)$.
(i) Show that the resultant motion is represented by

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab}cos\delta = sin^2\delta.$$

(ii) What will be the trajectory of the particle when $\delta = \pi/2$ and $a = b$?

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

5. (a) A particle is subjected to a linear restoring force and damping (proportional to velocity). Write down the differential equation of motion explaining each term.

(b) Solve the equation for weak damping and prove that the amplitude of vibration decreases exponentially with time.

(c) Show that for weakly damped motion, the logarithm of the ratio of successive amplitudes on the same side above the mean position is constant.

(d) A vibrator of mass 1 gm is acted upon by a restoring force of 10^7dyne/cm of displacement, a retarding force of 4×10^3 dyne/velocity and a driving force $10^5\cos(t)$ dyne. Find the value of the amplitude at steady state and the quality factor.

2 + (3 + 2) + 2 + 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) What is the origin of modified and unmodified line in Compton effect?

(c) Write down the Planck's radiation law for blackbody explaining all terms. Using it, show that the wave length at which we get maximum radiation density per unit volume per unit time is inversely proportional to the absolute temperature of it.

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