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) An α-particle is 4 times heavier than a proton. If a proton and an α-particle are moving with the same velocity, how do their de-Broglie wavelengths compare?
(a) $\lambda p = \lambda\alpha$ (b) $\lambda p = 4\lambda\alpha$ (c) $\lambda p = \lambda\alpha/2$ (d) $\lambda p = \lambda\alpha/4$.

(ii) An unpolarized light of intensity I_0 passes through a polaroid. The intensity of the transmitted light is
(a) I_0 (b) $I_0/2$ (c) $I_0/4$ (d) $2I_0$

(iii) Two coherent sources of different intensities interfere with each other. The ratio of maximum intensity to the minimum intensity is 49:25. The intensities of the sources are in the ratio
(a) 25:1 (b) 36:1 (c) 9:4 (d) 625:1

(iv) The wavelength associated with a light wave in free space of frequency 3×10^{18}Hz is
(a) 2Å (b) 20 Å (c) 200 Å (d) 0.2 Å

(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 these.

(vi) For BCC crystal structure, the coordination number is
(a) 6 (b) 12 (c) 8 (d) 4

(vii) How fast a particle must travel so that its mass becomes three times its rest mass?
(a) 0.5C (b) $(2\sqrt{3})C$ (c) $(\frac{2\sqrt{2}}{3})C$ (d) C
Where, C= the velocity of light in free space

(viii) In Compton effect a photon can transfer
(a) negligible energy to the electron (b) whole of its energy to the electron
(c) less than its energy to the electron (d) none of these

(ix) If a and r be respectively the lattice constant and radius of an atom in a SC structure then

(a) $a = \frac{4r}{\sqrt{3}}$ (b) $a = 2r$ (c) $a = \frac{r}{2}$ (d) $a = \frac{2r}{\sqrt{2}}$

(x) At velocity resonance, the phase difference between the external driving force and the steady state displacement of the particle of a forced harmonic oscillator is

(a) π (b) $\pi/2$ (c) $\pi/3$ (d) 0

Group – B

2. (a) What do you mean by interference of light? What are the essential conditions for sustained interference?

(b) Calculate the fringe width of interference pattern in Young's double slit experiment with two slits 10^{-3}m apart on a screen 1 m away. [λ = 5893 Å]

(c) Two polarizing sheets have their polarizing directions parallel so that the intensity of the transmitted light is a maximum. Through what angle must either sheet be turned so that intensity becomes one half of the initial value?

(d) Prove that for Newton's Rings in reflected light the diameters of dark rings are proportional to square root of the natural numbers.

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

3. (a) Explain the difference between interference and diffraction of light.

(b) Write down the expression for the intensity distribution of light due to Fraunhoffer single slit diffraction. Obtain the conditions for principal maximum and minimum in Fraunhofer diffraction due to a single slit. Draw the intensity distribution curve.

(c) Show that when a ray is incident at the Brewster's angle on a glass plate, the reflected ray is perpendicular to the refracted ray.

2 + (2 + 4 + 2) + 2 = 12

Group – C

4. (a) Establish the equation of motion of a damped harmonic oscillator subjected to a resistive force that is proportional to the first power of its velocity. If the damping is less than critical, show that the motion of the system is oscillatory with its amplitude decaying exponentially with time.

(b) 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.

(c) What is relaxation time and how does it vary with damping coefficient 'γ' of the damped oscillator?

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

5. (a) Derive an expression for the average power supplied by the sinusoidal force driving a mechanical oscillator over a complete cycle in the steady state.

   (b) Show that in the steady state the time-averaged input power equals the time averaged power dissipated through damping.

   (c) A series L-C-R circuit is subjected to a sinusoidal emf $V = V_0 coswt$. Find an expression for the amplitude of current. Discuss the phenomenon of resonance in such a circuit. Write the expression for quality factor.

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

Group – D

6. (a) Write down the expression of Planck's black body radiation law and explain all the terms. Derive the Stefan's law from Planck's black body radiation law.

   (b) Explain the phenomenon of Compton effect. Write down an expression for the Compton shift in wavelength.

   (c) An X-ray photon is found to have doubled its wavelength on being scattered by 90°. Find the energy of incident photon.

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

7. (a) State the de-Broglie hypothesis of matter waves. Show that the group of waves associated with a particle moves with the velocity of the particle. Also find a relation between the phase and group velocities.

   (b) Show that an electron moving through a potential difference of 150V has a de Broglie wavelength of 1Å.

   (c) State Heisenberg's uncertainty principle. Using uncertainty principle show that electron cannot exist within the nucleus.

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

Group – E

8. (a) Show that in a cubic crystal of side 'a' the inter-planar spacing between consecutive parallel planes of Miller indices (hkl) is $d_{hkl} = \frac{a}{\sqrt{(h^2+k^2+l^2)}}$.

   (b) Calculate the inter-planar spacing for a (321) plane in a SC lattice whose lattice constant is 4.2×10^{-8} cm.

   (c) What are Miller indices? Find the Miller Indices of a plane having intercepts of 2a, ∞ and c/2 on the X,Y,Z axes respectively where a, b, c are primitive vectors of the unit cell.

   (d) Draw the following planes in the case of SC structure (i) (100), (ii) (111).

4 + 2 + (2 + 2) + 2 = 12

9. (a) Define atomic packing factor. Find out the packing factor for BCC structure.

(b) X-rays of wavelength 0.71Å are reflected from the (110) plane of a rock salt crystal of lattice constant a = 2.82Å. Calculate the corresponding glancing angle for second order reflection.

(c) Copper has FCC structure and atomic radius 0.1278 nm. Calculate the density and the inter-planner spacing for (321) planes. Take atomic weight of copper as 63.5.

(d) If a unit cell has the following characteristics: a=b=10.5Å, c=6Å, $\alpha = \beta = \gamma = 90°$, identify to which crystal system does the unit cell belong?

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

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Backlog Submission link	https://classroom.google.com/c/MjMwMTcxNTE0MjQz/a/Mjg4ODMyMjI5MjAz/details