Physics

Paper-II

Time Allowed: Three hours **Maximum Marks: 300**

The figures in the margin indicate full marks for the questions.

Candidates should answer Question No. **1** and **5** which are compulsory and any **three** of the remaining questions, selecting at least **one** from each section.

SECTION-A

1. Answer any three of the following : 20×3=60

   (a) What do you mean by tunneling through a barrier? A particle travelling with energy E along X-axis has a potential barrier defined as:

$$V_{(x)} = \begin{cases} 0 & \text{for } x < 0 \\ V_0 & \text{for } 0 < x < a \\ 0 & \text{for } x > a \end{cases}$$

   Derive the expression for the reflection and transmission coefficients of the particle. 5+5+10=20

   (b) Write down Schrödinger wave equation for one dimensional simple harmonic oscillator and interpret energy eigen value and eigen functions. In this reference explain the concept of zero point energy and draw neat energy level diagram. 10+10=20

   (c) State and prove the Heisenberg's uncertainty principle. Show that the wave function for which a minimum exists in the product of the uncertainty of position and momentum is a Gaussian. 10+10=20

   (d) Calculate the transmission coefficient of a particle through potential step of height V_0, if the energy of the particle is E when (i) $E > V_0$ (ii) $E < V_0$. 20

2. (a) Solve the Schrödinger wave equation for the hydrogen atom and derive the eigen function for its ground state. How do the theoretical values of energy levels agree with the experimental results? 12+8=20

(b) Explain why Pauli introduced a set of 2×2 spin matrices and obtain the commutative relation satisfied by the three components of the spin vector.

If σ_x, σ_y and σ_z are Pauli spin matrices and $\bar{A}$ and $\bar{B}$ any constant vector, show that

$$(\bar{\sigma} \cdot \bar{A})(\bar{\sigma} \cdot \bar{B}) = (\bar{B} \cdot \bar{A}) + i\bar{\sigma}(\bar{A} \times \bar{B})$$ 10+10=20

(c) Deduce the commutation relation for the components Lx, Ly, Lz of the orbital angular momentum and show that all the three components commute with $L^2 = Lx^2 + Ly^2 + Lz^2$. 20

3. (a) What is meant by the spin of electron? Describe Stern Gerlach experiment for its verification. Discuss its signficance. 5+10+5=20

(b) What is Zeeman effect? Distinguish between normal and anamolous Zeeman effect. Discuss experimental arrangement for observing normal Zeeman effect. 5+5+10=20

(c) (i) What is JJ coupling? Explain JJ coupling in case of two electron spectra. Draw Vactor model diagram depicting JJ coupling.

(ii) Compare LS and JJ coupling scheme. 12+8=20

4. (a) Explain general characteristics of a diatomic molecular spectra. What is the cause of excited energy levels in a molecule? What do you mean by electronic, rotational and vibrational energy level? 10+5+5=20

(b) What is Raman effect? Explain its importance. How Raman effect explained on the basis of quantum theory? Explain the origin of stokes and Anti-stokes lines in Raman spectrum. Explain molecular structure on the basis of Raman effect. 2+3+5+10=20

(c) What is Luminescence? Explain difference between Fluorescence and phasphorescence. Bringout clearly the difference between Raman effect and flourescence. 5+10+5=20

SECTION-B

5. Answer any **three** of the following :

   (a) What different energies contribute to the nuclear binding energy? On this basis establish the semi-empirical mass formula. 10+10=20

   (b) What is the evidence for the shell structure of the nuclei? Stating the main assumptions explain the shell model of the nucleus. Discuss its achievements, failures and limitations. 5+15=20

   (c) What are elementary particle and anti-particles? How are various particles and their anti-particles classified? Explain in brief regarding each. 5+10+5=20

   (d) What is an op-amp? Define the following parameters: input off-set voltage, input resistance, CMMR and slew rate.

   Draw circuit diagram of summing amplifier and derive the voltage gain. State any assumption. 10+10=20

6. (a) Discuss the Meson theory of nuclear forces. Nuclear forces are exchange forces, substantiate. 10+10=20

   (b) What is nuclear fusion? This process is not possible at ordinary temperature and pressure, why? State the condition required for the sustained (or maintained) fusion reaction. 5+5+10=20

   (c) What is Meissner effect? Show how London equation lead to this effect? Discuss Londons equations for high-frequency effect on superconductors. 5+5+10=20

7. (a) Draw circuit diagrams of a transistor in all three modes. Explain the meaning of α, β and γ parameters of a transistor and establish the relationship between them. 10+10=20

   (b) State explain the De Morgan's theorems which convert a sum into a product form and vice versa. Simplify the given Boolean expression and realise an equivalenet circuit using basic gates:

   $y = A + \bar{A}B + \bar{A}\bar{B}C + \bar{A}\bar{B}\bar{C}D$ 10+10=20

Physics

Paper-I

Time Allowed: Three hours **Maximum Marks: 300**

Figure in the margin indicate full marks for the questions.

Attempt any **five** questions. All questions carry equal marks.

1. (a) Describe the formation of Newton's rings by reflection of monochromatic light and explain it. Show that the diameter of a dark ring is directly proportional to the square root of natural number. 10 + 10 = 20

   (b) Distinguish between the Fresnel and Fraunhofer class diffraction. What is half period zone? Explain the rectilinear propagation of light by the half period zone method. 6 + 6 + 8 = 20

   (c) What is meant by double refraction? What are ordinary and extraordinary rays? Explain the phenomenon of double refraction in uniaxial crystal on the basis of Huygen's principle. 6 + 6 + 8 = 20

2. (a) How does the mass vary with velocity? Show that $m = \frac{mo}{\sqrt{1 - v^2 / C^2}}$

   where the symbols have their usual meanings. Draw a graph showing the variation of mass with velocity. 8 + 8 + 4 = 20

   (b) What is spherical aberration?

   State methods to reduce it and obtain the condition to minimize spherical aberration by the combination of two lenses at some separation.

   8 + 6 + 6 = 20

   (c) Define phase velocity and the group velocity and derive their expressions. Show that in non-dispersive medium, the group velocity and the phase velocity are equal.

3. (a)What is meant by the critical constants of a gas? Deduce expressions for the critical constants of a gas in terms of vender Waal's gas constants a & b

   and hence prove that $\frac{RTc}{PcVc} = \frac{8}{3}$ 8 + 12 = 20

(b) Establish clausius-clapeyron's latent heat equation and explain the effect of increase in pressure on (i) Freezing point and (ii) boiling point of water. $8 + 12 = 20$

(c) Explain the difference in reversible and irreversible processes. Explain with examples the physical conditions required for a process to be reversible. $8 + 12 = 20$

4. (a) Write the Plank's distribution law of black body radiation and show that the Plank's formula changes in to the Wein's formula at low wavelengths and in to Rayleigh-Jean's formula at high wavelength.

$8 + 6 + 6 = 20$

(b) What is a parallel resonant circuit? Obtain expressions for the resonance frequency, impedance and current magnification for the circuit. Why is this circuit called the rejector circuit. $8 + 6 + 6 = 20$

(c) The self inductance of two inductive coils are L_1 and L_2. Show that when they are joined in series, the equivalent inductance is $L_1 + L_2$ and when they are joined in Parallel, the equivalent inductance is $\frac{L_1 L_2}{L_1 + L_2}$

$10 + 10 = 20$

5. (a) Write down the Maxwell's equation. Use them to establish the wave equation of electromagnetic wave and prove that the speed of electromagnetic wave in vacuum is $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ $6 + 8 + 6 = 20$

(b) What are scalar and magnetic potentials. Obtain boundary conditions for reflection and refraction of an electro magnetic wave from the boundry surface of two dielectric media. $10 + 10 = 20$

(c) On what principle does a transformer work? How are the transformer used in transmission of electrical energy to the long distances.

$10 + 10 = 20$

6. (a) Write short notes:

(a) Laser

(b) Ruby Laser

(c) He-Ne Laser $6 + 7 + 7 = 20$

(b) Explain the construction and working of the Michelson's interferometer. How is the interferometer adjusted to obtain the localized and circular junctions. 10 + 10 = 20

(c) Deduce expressions for the velocity and acceleration of a particle in simple harmonic motion and represent them graphically. State for a particle executing simple harmonic motion, (i) When will the velocity of particle be maximum and will it be zero (ii) When will the acceleration of particle be maximum and when will it be zero. 8 + 6 + 6 = 20

7. (a) What are generalised coordinates? What is the advantage of using them? Show that the Lagrangian equation of motion for a holonomic system is given by: $\frac{d}{dt}\left(\frac{\partial L}{\partial 9\gamma}\right)\frac{-\partial L}{\partial 9\gamma} = 0$

Where the symbols have their usual meaning. 5 + 5 + 10 = 20

(b) Write down the Hamiltonian and Hamilton's equation for a particle in a central force field in space. 8 + 12 = 20

(c) Write the Lagrangian function and the equations of motion for a three dimensional harmonic oscillator (a) in Cartesian co-ordinates (b) in polar coordinates. 10 + 10 = 20

8. (a) Explain the meaning of time dilation and establish the expression for it. Describe an experiment in brief for its verification. 6 + 8 + 6 = 20

(b) Two particles of masses M_1 and M_2 moving with velocities U_1 and U_2 respectively collide, then

(i) Find the velocities of particles after collision.

(ii) Find the ratio of final kinetic energy to initial kinetic energy.

(iii) Describe the motion before and after collision as viewed from the centre of mass reference of system. The collision may be assumed to be elastic. 8 + 8 + 4 = 20

(c) Explain the meaning of retentivity, coercivity and hysteresis loss with the help of B-H curve for a ferromagnetic substance.

Describe the experimental method with the necessary diagrams to represent the hysteresis curve of a specimen. 10 + 10 = 20