CSM : 16

PHYSICS

PAPER - II

Time Allowed : 3 hours | Full Marks : 100

Marks for each question is indicated against it.

Attempt any 5 (five) questions taking not more than 3 (three) questions from each Part.

PART - A

1. (a) The one-dimensional wave equation for a free particular of mass m is given by

$$\frac{-h^2}{2m}\frac{\partial^2\psi(x,t)}{\partial x^2} = i\hbar\frac{\partial\psi(x,t)}{\partial t}$$

where $\psi(x,t)$ represents the wave function of the particle. Solve the equation by the method of separation of variables. **(7)**

(b) The wave function for a particle confined in a one-dimensional box of lenght L is given by $\psi(x) = A\sin\frac{n\pi x}{L}$. Normalize the wave function and evaluate the expectation values of its momentum. **(5)**

(c) (i) Find the probability that a particle trapped in a box L wide can be found between 0.45 L and 0.55 L for the first excited state.

(ii) Find the expectation value $< x >$ of the position of a particle trapped in a box L wide. **(4+4=8)**

2. (a) Write down the Schr□dinger equation of a one-dimensional harmonic oscillator, solve the equation to obtain the energy eigen values. Also draw a diagram to represent the energy levels and wave functions of the lowest four states of the linear harmonic oscillator. **(8+4=12)**

(b) If L_x, L_y, L_z are the Cartesian components of an angular momentum operator and L is their resultant, evaluate the following commutators $[L_x, L_y], [L_y, L_z], [L_z, L_x]$ and $[L^2, L_x]$. **(8)**

3. (a) Describe the Stern-Gerlach experiment. Give the explanation to the results of this experiment based on quantum mechanical theory. **(10)**

(b) Discuss the general quantum mechanical theory of the Anomalous Zeeman effect, with special reference to the sodium D lines. **(10)**

4. (a) What is Raman Effect? Explain how it is used in the study of molecular structure and tri-atomic molecules. **(10)**

(b) Obtain an expression for the resonance condition in NMR. **(10)**

PART - B

5. (a) What do you understand by the term Binding energy of a nucleus? Show the variation of Binding energy per nucleon with mass number of a nucleus and discuss its characteristics. Calculate the blinding energy of a Helium nucleus.
Given mass of a helium atom = 4.002603 amu, mass of a hydrogen atom = 1.007825 amu and the mass of a neutron = 1.08665 amu. **(2+4+1=7)**

(b) Discuss how the Shell model of a nucleus could explain the origin of Magic numbers in a nucleus. **(7)**

(c) Discuss the basic theory, construction and working of a nuclear reactor. **(6)**

6. (a) What is a neutrino? How does it differ from its anti-particle? Explain how the neutrino hypothesis solves the apparent breakdown of conservation of momentum and energy in β-decay. **(1+1+3=5)**

(b) What is the difference between fermions and bosons? Which of the following particles are fermions and which are bosons? **(1+4=5)**

μ^+, Λ°, K°, Σ^+

(c) Check if the following reactions are allowed or forbidden: **(4)**

(i) $\pi^- + p = \Lambda^\circ + \pi^\circ$

(ii) $p + \bar{p} = 2\pi^+ + 2\pi^- + 2\pi^\circ$

(d) What are coloured quarks and gluons? State the properties of three generations of quarks and leptons. **(2+2+2=6)**

7. (a) Distinguish between metals, insulators and semi-conductors on the basis of band theory of solids. Why does a semi-conductor act as an insulator at 0K? **(10)**

(b) What are Type I and Type II superconductors? Describe the effect of an external magnetic field on the superconducting state of a material. **(10)**

8. (a) Draw the static characteristics of a field effect transistor (FET) and explain the different regions. **(7)**

(b) What is an OP-AMP? Describe the workings of the inverting and non-inverting operational amplifiers. **(7)**

(c) Give the truth tables of two-input OR and AND logic gates. Draw electrical circuits representing each one of them. **(6)**

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