CSM – 59/17

Physics

Paper – II

Time : 3 hours

Full Marks : 300

The figures in the right-hand margin indicate marks.

Candidates should attempt Q. No. 1 from Section – A and Q. No. 5 from Section – B 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 :

   (a) Describe any four experiments which showed the inadequacy of classical mechanics. 20

   (b) (i) State and explain Heisenberg's uncertainty principle. 10

(ii) Explain de Broglie hypothesis. Give the values for the frequency, wavelength and phase velocity for de Broglie wave associated with a moving particle. 10

(c) (i) Write down Schrödinger's equation independent of time in the case of a linear harmonic oscillator. 10

(ii) If σ_x, σ_y and σ_z are Pauli's spin matrices and A and B are constant vectors, show that $(\sigma \cdot A)(\sigma \cdot B) = (A \cdot B) + i\sigma \cdot (A \times B)$. 10

(d) Solve the Schrödinger's equation for the hydrogen atom and discuss the radial wave function. 20

2. (a) (i) Obtain the transmission and reflection probabilities of a particle facing a potential step. 14

(ii) Explain the concept of wave-particle duality. 6

(b) Use the WKB approximation method to illustrate the problem of alpha-decay of radioactive nucleus. 20

(c) (i) Is it possible to measure any two components of angular momentum operator J simultaneously ? Explain. 10

(ii) Find the eigen functions and eigen values for the operator sin $(d/d\phi)$. 10

3. (a) With a neat diagram describe Stern-Gerlach experiment and explain its importance. 10

(b) Consider the hydrogen atom in the $D_{3/2}$ state. Give the different possible orientations of the J vector space. 10

(c) Consider two electrons, one in the 3p and the other in the 3d sub-shell. Obtain the possible L, S and J values and the term symbols for this two electron system. 15

(d) Find the values of L and S for the ground state for oxygen atom. 5

(e) State and explain normal and anomalous Zeeman effect. Outline the quantum theory of Zeeman effect. 20

4. (a) Distinguish between rotational, vibrational and electronic spectra of diatomic molecules. 15

(b) Explain Raman effect with the help of an energy level diagram. How is Raman Spectroscopy used for structure determination? 15

(c) Explain the phenomenon of Nuclear Magnetic Resonance (NMR). Illustrate some applications of NMR phenomenon. 15

(d) Discuss the salient features and applications of Mössbauer spectroscopy. 15

SECTION – B

5. Answer any three questions of the following :

(a) (i) Explain 'mass defect' and 'binding energy'. Draw a curve indicating variations of binding energy per nucleon as a function of mass number of nuclei. From this curve explain the energy release in nuclear fission and nuclear fusion. 10

(ii) Find the energy release if two ^{2}H can fuse together to form ^{4}He nucleus. The binding energy per nucleon of ^{2}H and ^{4}He are 1.1 MeV and 7.0 MeV respectively. 10

(b) (i) Give a brief account of single particle shell model which predicts the magic numbers. Assuming the shell model to be correct, what should be the spin and parity of the ground state of ^{15}N ? 12

(ii) What are the salient features of nuclear forces ? Explain the meson theory of nuclear forces. 8

(c) (i) Write down Weizsacker's Semi-Empirical Mass Formula (SEMF). Explain the contribution of each term. 10

(ii) Explain the application of SEMF highlighting the mass parabolas. 10

(d) (i) Define Parity. Explain the violation of parity conservation during beta decay process. What is 'internal conversion' ? 8

(ii) Discuss the source of energy in the stars. 5

(iii) What is a nuclear reactor ? Discuss its working principle. What are the essential constituents of a nuclear reactor ? 7

6. (a) (i) Write a detailed note on the classification of elementary particles. 10

(ii) Explain important conservation laws operating in the various interactions between elementary particles. 10

(iii) Describe briefly on Quark Model. Explain Quark model of hadrons. 10

(b) (i) Explain the concept of unification of forces. 15

(ii) Explain the features of Planck mass, Planck length, Planck time, Planck temperature and Planck energy giving suitable examples. 15

7. (a) (i) What are Miller Indices ? Sketch the planes (2, 2, 2), (3, 1, 0) and (1, 1, 1) planes in a cubic crystal with a neat diagram. Obtain the relation between d(hkl) and the lattice constant for a cubic crystal. 6

(ii) Distinguish among Conductors, Insulators and Semiconductors in terms of Band theory of solids. 8

(iii) Briefly explain the Kronig-Penney model. 6

(b) (i) Explain temperature variation of electrical conductivity in semiconductor with relevant theory. 8

(ii) How does the carrier concentration vary in an extrinsic semiconductor ? Explain with relevant theory. 8

(iii) Explain Hall effect in semiconductors. 4

(c) (i) What is 'Meissner effect' ? Explain how type – I and type – II superconductors are distinguished. 6

(ii) How are Cooper pairs formed ? Explain BCS theory of superconductivity. 8

(iii) Discuss London's phenomenological theory of superconductors. 6

8. (a) Distinguish between p-n-p and n-p-n transistors. Discuss the characteristics of Class – A, B and C amplifiers. Mention the applications of push-pull amplifiers. 20

(b) State and explain De Morgan's laws. Discuss the construction and truth table of OR, AND, NOT and NOR gates. 10

(c) Explain the principles of amplitude modulation, frequency modulation and demodulation. 10

(d) Describe the characteristics of an ideal Operational-amplifier. Draw the structure of an operational-amp and explain its working. 10

(e) Distinguish between JFET and MOSFET and explain how they are useful. 10