CSM – 59/20

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 that showed the inadequacy of classical mechanics. 20

   (b) Derive Schrodinger's wave equation for a free particle in one dimension and obtain its eigenvalues. 20

(c) (i) The work function of a metal is 2.0×10^{-19} J :

(A) Find the thrashold frequency for photoelectric emission.

(B) It the metal is exposed to a light beam of frequency 6.0×10^{14}Hz, what will be the stopping potential ? Given Planck's Constant $h = 6.6 \times 10^{-34}$ Js. 10

(ii) Considering matter waves for microscopic system, calculate the de Broglie Wavelength of an electron moving with a velocity 2×10^{7} m/s.

Given Planck's Constant $h = 6.6 \times 10^{-34}$ J.s

mass of the electron $me = 9.1 \times 10^{-31}$ kg.

10

(d) What is Raman Effect ? Explain theoretically the observed characteristics of the Raman Spectrum of a diatomic molecule. How is it used to explain the structure of a molecule ?

20

2. (a) Solve the Schrödinger Equation for the one-dimensional potential step defined by

$V(x) = 0 \quad x < 0$

$V(x) = +V_0 \quad x > 0$

Explain reflection and transmission by such a potential step. 30

(b) Use the WKB formula for the calculation of lifetime in the α-decay of radioactive nucleus. 30

3. (a) Discuss the difference between Normal Zeeman effect and Anomalous Zeeman effect. Describe the experimental arrangement for normal Zeeman effect and explain anomalous Zeeman effect. 20

(b) Describe Stern-Gerlach experiment for the existence of space quantization. 20

(c) (i) What are L-S and J-J coupling schemes ? Discuss the selection rules applicable in each case. 10

(ii) Obtain the eigenvalues of the square of the total angular momentum (L^2) and its Z-component L_Z. 10

4. (a) Explain the phenomenon of Nuclear Magnetic Resonance (NMR). Discuss some important applications of NMR phenomenon. 30

(b) Explain Mössbauet effect. Describe the experimental arrangement of Mössbauer spectrometer with a neat diagram. Illustrate some important applications of Mössbauer Spectroscopy. 30

SECTION – B

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

(a) (i) Obtain the Weizsacker's semi empirical mass formula for a nucleus. Explain the contribution of each term. 10

(ii) Explain Meson theory of nuclear forces. 10

(b) Explain the salient features of nuclear shell model. Discuss the successes and limitations of shell model. 20

(c) (i) Explain violation of parity in beta decay. 10

(ii) Explain ϕ-value of nuclear reactions. 10

(d) (i) Explain nuclear fission and nuclear fusion processes. 10

(ii) Discuss the source of energy in Sun and Stars. 10

6. (a) (i) Discuss, in detail, the classification of elementary particles. 15

(ii) Analyse the following decays or reactions for possible violation of the basic conservation laws. State the type of interaction involved in each process :

$$k^+ \rightarrow \pi^+ + \pi^+ + \pi^\circ + \pi^-$$

$$\pi^- + p \rightarrow \Lambda^\circ + \Sigma^\circ$$

$$\Omega^- \rightarrow \Sigma^- + k^\circ$$

$$\pi^+ + n \rightarrow \Lambda^\circ + k^+$$ 15

(b) (i) Explain, in detail, the Quark structure of hadrons. 15

(ii) Discuss the elementary ideas about unification of forces. 15

7. (a) (i) Explain band theory of solids. Discuss how this theory leads to the classification of conductors insulators and semiconductors. 20

(ii) Give an account of cubic crystal structure. 10

(b) (i) What is Meissner effect ? Explain how a superconductor behaves like a perfect diamagnet. 10

(ii) Illustrate the applications of Josephson Junction. 10

(iii) Write a note on the properties of high temperature super conductors. 10

8. (a) Explain with necessary theory working of a Hartley Oscillator. 20

(b) Explain the different characteristics of an ideal operational amplifier. 20

(c) (i) State and prove De Morgan's laws. 10

(ii) Explain how a NAND gate is a Universal gate. 10