

PHYSICS

(Paper II)

Time Allowed : Three Hours
Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any three of the following:
 - (a)(i) The wave function of a particle is

$$\psi(x) = A \exp(-x^2/a^2 + ik_0 x)$$

Find the expectation values of position (x) and momentum (p) for the particle. 10
 - (a)(ii) A 200 eV increase in the energy of an electron changes its De Broglie wavelength by a factor of two. Calculate the initial De Broglie wavelength of the electron. 10
 - (b)(i) What is the lowest non zero angular momentum for an elementary particle? Name at least three elementary particles having such an angular momentum. 10
 - (b)(ii) Write the spectral symbol of the term with $S = 1/2$, $J = 5/2$ and $g = 6/7$. 10
 - (c)(i) A sample is irradiated by a 5000 Å radiation to give a Raman line at 5050.5 Å. Calculate the Raman frequency. 10
 - (c)(ii) Explain, both red and violet degraded bands have been observed in electronic band systems, but rotation-vibration spectra show bands degraded to red only. 10
 - (d)(i) Treating CH molecule as an united atom, derive its resultant molecular electronic states. 10
 - (d)(ii) Calculate the moment of inertia of HCl molecule from the expression $v_{\text{HCl}} = 20.68 (J+1)$, where $J = 0, 1, 2, \dots$ 10
2. (a) Solve the one dimensional Schrodinger wave equation with potential:

$$V(x) = \begin{cases} 0 & \text{for } x < -a \\ V_0 & \text{for } -a < x < a \\ 0 & \text{for } x > a \end{cases}$$
20
 - (b) Distinguish between a classical and a quantum mechanical harmonic oscillator. Explain the existence of zero point energy. 15
 - (c) Show that the motion of a classical particle is analogous to the motion of a wave packet, which can be constructed by superposition of a large number of plane waves. Construct such a wave packet and derive an expression for its group velocity. 25
3. (a) Derive an expression for the spin-orbit interaction energy in one electron system. Calculate the energy separation between the levels $^2P_{1/2}$ and $^2P_{3/2}$. 20
 - (b) Write the electronic configuration of mercury ($Z = 80$). Obtain the spectral term for the normal and the first excited configuration of the atom. 20
 - (c) Derive an expression for the electrical conductivity of metals on the basis of free electron theory of metals. 20

4. (a) A diatomic gas is found to have a number of absorption bands in the ultraviolet region. Each band is also observed to have a fine structure. How can the observed spectrum be explained and analyzed? 25
- (b) Explain the nature, origin and significance of 21 cm hydrogen line. 20
- (c) Calculate the change in rotational constant (B_v) when deuterium is substituted for hydrogen in a hydrogen molecule. 15

SECTION 'B'

5. Answer any three of the following.
- (a)(i) Explain why a neutral particle such as neutron possesses a finite value of magnetic moment, and how it is determined. 10
- (a)(ii) Write down the electronic configuration of ${}^7\text{Li}$, ${}^{13}\text{C}$ and ${}^{25}\text{Mg}$ in the ground state of the nuclear shell model. 10
- (b)(i) Explain how neutrino was discovered from the β -decay of radioactive nuclei. 10
- (b)(ii) Show that for a cubic lattice, the difference between the successive h, k, l planes is given by
- $$d_{h,k,l} = a / (\sqrt{h^2 + k^2 + l^2}) \quad 10$$
- (c)(i) Discuss the variation of free carrier concentration with temperature for an intrinsic and extrinsic semiconductors. 12
- (c)(ii) Explain the effect of negative and positive voltage feedback on an amplifier characteristics. 8
- (d)(i) Show that a negative logic OR gate is like a positive logic AND gate. 10
- (d)(ii) Distinguish between Hadrons and Leptons. 10
6. (a) Which conservation laws are obeyed in nuclear reactions? Explain the significance of Q value of a nuclear reaction. 30
- (b) Explain shell model of the nucleus. Give evidence for nuclear shell structure. What are the limitations of the shell model? 30
7. (a) Explain Meissner effect and Josephson effect. Describe their applications in the field of superconductivity. 20
- (b) Distinguish between particle and antiparticle. How antiparticles were discovered? 20
- (c) Mention the conservation laws for strong, electromagnetic, and weak interactions. 20
8. (a) What are the main applications of JFET? Discuss their advantages over bipolar transistors. Explain the working of n-channel JFET with the help of a schematic diagram. 30
- (b) Write down the characteristics of an ideal operational amplifier. Explain the term virtual ground. Draw a circuit diagram showing virtual ground in an operational amplifier. 30