

CSM – 59/16
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 **three** of the remaining questions, selecting at least **one** from each Section.*

SECTION – A Techofworld.In

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

(a) (i) Discuss spectral distribution of black body radiation for two different temperatures.

(ii) Wein's radiation law is given by

$$E(\lambda, T) = \frac{ae^{-b/\lambda T}}{\lambda^5} . \text{ Derive Wein's}$$

displacement law from it. 10+10 = 20

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- (b) (i) Show that if a state $\Psi(x)$ has mean momentum $\langle p \rangle$, then $e^{-ip_0 x/\hbar} \Psi(x)$ has mean momentum $\langle p \rangle - p_0$.

- (ii) A quantum system is described by the

$$\text{Hamiltonian } H = \frac{p^2}{2m} + \frac{1}{\cosh^2 x}. \text{ Show}$$

that $\Psi(-x) = \pm \Psi(x)$. $\Psi(x)$ is an eigen state of the Hamiltonian. 10+10 = 20

- (c) (i) Show that in the vector coupling model

one may define an operator $\vec{L} \cdot \vec{S} = \frac{1}{2} (\vec{J}^2 - \vec{L}^2 - \vec{S}^2)$. Does this operator commute with J^2 ?

- (ii) Calculate Lande's g factor for a single electron. 10+10 = 20

- (d) (i) Why is the Na - D line a doublet?

- (ii) What is Raman Shift? Explain that it depends on the nature of the substance but not on the wavelength of the original line. 5+15 = 20

2. (a) Derive the expression for probability current

density in non-relativistic quantum theory.
Show that it satisfies a continuity equation.

- (b) Find how E_n depends on the principle quantum number n , for a quantum system described by the Hamiltonian

$$H = \frac{p^2}{2m} + \alpha x^4. \quad 30+30 = 60$$

3. The ground state wave function for a 1d SHO is

$$\text{proportional to } e^{-\frac{m\omega x^2}{2\hbar}} :$$

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- (a) Normalize this wave function.
(b) Calculate the uncertainty in x and p_x in this state.
(c) Verify that these uncertainties satisfy Heisenberg uncertainty relation.

$$20+30+10 = 60$$

4. (a) Discuss quantitatively the rotational and vibrational spectra of CO molecule.
(b) What is the principle of Mossbauer Spectroscopy. Discuss the effect of magnetic field on it.

$$35+25 = 60$$

SECTION – B

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

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- (a) Calculate the binding energy for the mirror nuclei K^{39} and Ca^{39} from the semi-empirical binding energy equation. What do you infer from this about the relative stabilities ?
- (b) What are the roles of moderators and reflectors in fission reactor ? How critical size of a reactor is determined ?
- (c) Calculate the threshold kinetic energy of proton to produce anti-proton through the reaction $p+p \rightarrow p+p+p+\bar{p}$.
- (d) Write the truth table for XOR and NOR gates. Design a two input XOR gate using NOR gates exclusively.
6. (a) Discuss parity violation in β -decay. Mention how this can be experimentally verified.
- (b) What are the limitations of nuclear shell model ?

45+15 = 60

7. (a) What are the different processes through which charged particles and γ -rays lose energy when pass through matter ?
- (b) Give simple explanation of nuclear fission on the basis of liquid drop model.
- (c) The Kinetic energy of the α -particle emitted from Po^{210} has been found to be 5.3 MeV. Calculate α -disintegration energy.

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8. (a) What is meant by feedback in an amplifier ? Draw block diagram of a feedback amplifier and obtain an expression for close loop voltage gain of the amplifier.
- (b) What is the criterion of oscillation in an amplifier. Explain the action of a Hartley Oscillator.
- (c) Explain Meissner effect in superconductor.

20+20+20 = 60



