

**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**

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

(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

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

- (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 :

20×3 = 60

- (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  $\beta$ -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  $\gamma$ -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  $\alpha$ -particle emitted from  $\text{Po}^{210}$  has been found to be 5.3 MeV. Calculate  $\alpha$ -disintegration energy.

$$20+20+20 = 60$$

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.

$$20+20+20 = 60$$



