

9. How  $\langle J^2 \rangle$ ,  $\langle J_x^2 \rangle$ ,  $\langle J_y^2 \rangle$  and  $\langle J_z^2 \rangle$  are related?

10. Define  $r_s$  and  $r_k$  matrices.

SECTION B — (5 × 4 = 20 marks)

11. (a) What does  $|a\rangle \langle a|$  signify? Explain.

Or

(b) Using Dirac's notation, show that the Trace  $Q = \sum_i \langle i | Q | i \rangle$ .

12. (a) Discuss iterative technique used in variation method.

Or

(b) Explain why Stark effect is not observable for the ground state of hydrogen atom.

13. (a) What is meant by Harmonic perturbation?

Or

(b) Explain the reason for the potential scattering.

14. (a) Show that  $[J^2, J_x] = 0$ .

Or

(b) If

$$C_+ = \hbar \sqrt{l(l+1) - m(m+1)} \text{ and } C_- = \hbar \sqrt{(l+m)(l-m+1)},$$

obtain the matrix element  $\langle \psi_{m+1}^* | L_x | \psi_m \rangle$ , where  $L_+ \psi_m = C_+ \psi_{m+1}$  and  $L_- \psi_m = C_- \psi_{m-1}$ .

15. (a) Show that  $[\alpha_x, \alpha_y, \alpha_z] = 2\alpha_x$  where  $\alpha_x, \alpha_y, \alpha_z$  are Dirac's matrices.

Or

(b) State the properties of  $r$ -matrices (any two).

SECTION C — (5 × 8 = 40 marks)

16. (a) Discuss the salient features of interaction picture. Obtain the characteristic equation.

Or

(b) Considering the behaviour of an electron in a periodic potential (Kronig-Fenny model), obtain the condition for the solutions of the wave function to exist, if the wave nature is as shown here.

