

Menofia University

Faculty of Science

Subject: Quantum Mechanics (PG)

Time allowed: 2 hrs Date of exam: - 12- 2018

Answer the following questions

1. Find the eigen values and the eigen vectors of the spin-half particle. Discuss orthonormality in this problem.

(75)

2. Prove that for the number state  $|n\rangle$ :

a.  $a|n\rangle = \sqrt{n} |n-1\rangle$

b.  $a^+|n\rangle = \sqrt{n+1} |n+1\rangle$

c.  $|n\rangle = \frac{(a^+)^n}{\sqrt{n!}} |0\rangle$

(45)

3. a. Discuss the perturbation theory for non-degenerate levels.

- b. Calculate the energy of the ground state to first order in  $\gamma$  of a particle of mass 'm' subject to a one-dimensional potential

$V(x) = \frac{1}{2}m\omega^2 x^2 + \gamma x^4$ ; The ground-state energy eigen function is

$$u_{00} = \left(\frac{m\omega}{\pi\hbar}\right)^{\frac{1}{4}} \exp\left(-\frac{m\omega}{2\hbar}x^2\right) \quad (60)$$

NB: Pauli spin matrices are

$$[\sigma_x] = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, [\sigma_y] = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}, [\sigma_z] = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$