QUANTUM MECHANICS H.W №3

Salwa Al Saleh

PROBLEM (1)

Express the position and momentum operators X and P in terms of a and $a^\dagger$

PROBLEM(2)

Verify the commutation relations of the triple H', a and $a^\dagger$ stated in the lecture notes, recall the canonical commutation relation $[X, P] = i\hbar I$.

PROBLEM (3)

Find $\langle X \rangle$, $\langle P \rangle$, $\langle X^2 \rangle$ and $\langle P^2 \rangle$.

PROBLEM(4)

A quantum harmonic oscillator, in the 2nd excited state, having an energy of $2.45 eV$, find its angular frequency , and period.

PROBLEM (5)

Find the eigenfunction $\psi_1(x)$, and show that it is orthogonal to $\psi_0(x)$ seen in the lecture.

PROBLEM (6)

From problem (3), verify the uncertainty relation for position and momentum .

PROBLEM (7)

Verify that $a^\dagger|n\rangle = \sqrt{n+1}|n+1\rangle$

PROBLEM (8)

Write the operators a and $a^\dagger$ as matrices acting on the vector states :

$$|0\rangle = \begin{pmatrix} 1 \\ 0 \\ 0 \\ \vdots \end{pmatrix} \quad |1\rangle = \begin{pmatrix} 0 \\ 1 \\ 0 \\ \vdots \end{pmatrix} \quad |2\rangle = \begin{pmatrix} 0 \\ 0 \\ 1 \\ \vdots \end{pmatrix} \dots$$