INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
HYDERABAD

OPEN QUANTUM SYSTEMS AND QUANTUM THERMODYNAMICS

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Quiz - I

Q3. For an operator $\hat{A}$, which of the following will be true for the rate of change of expectation value of A?

(a) $\frac{d\langle A\rangle}{dt} = \langle \frac{\partial A}{\partial t} \rangle - \frac{i}{\hbar}\langle [H,A] \rangle$
(b) $\frac{d\langle A\rangle}{dt} = \langle \frac{\partial A}{\partial t} \rangle + \frac{i}{\hbar}\langle \{H,A\} \rangle$
(c) $\frac{d\langle A\rangle}{dt} = \langle \frac{\partial A}{\partial t} \rangle + \frac{i}{\hbar}\langle [H,A] \rangle$ [Answer]
(d) $\frac{d\langle A\rangle}{dt} = \langle \frac{\partial A}{\partial t} \rangle - \frac{i}{\hbar}\langle \{H,A\} \rangle$

Q4. Let $\hat{A}$ and $\hat{B}$ be Hermitian operator. Then which of the following is/are true?

(a) $\{\hat{A},\hat{B}\}$ is Hermitian. [Answer]
(b) $[\hat{A},\hat{B}]$ is Anti-Hermitian. [Answer]
(c) $\hat{A}-\hat{B}$ is Anti-Hermitian.
(d) $\hat{A}\hat{B}$ is Hermitian.

Q5. Which of the following is true for two functions f and g, with c as a constant and $\hat{B}$ as a linear operator.

(a) $\langle f|\hat{B}|g\rangle = \langle f|\hat{B}g\rangle$ [Answer]
(b) $\langle f|\hat{B}|cg\rangle = c\langle f|\hat{B}|g\rangle$ [Answer]
(c) $\langle cf|\hat{B}|g\rangle = c\langle f|\hat{B}|g\rangle$
(d) $\langle f|\hat{B}|g\rangle = \langle \hat{B}f|g\rangle$

Q7. Any arbitrary unitary operator can be written as $U = e^{i\alpha}R_{\hat{n}}(\theta)$ where $R_{\hat{n}}$ is the rotation operator around a unit vector $\hat{n}$. Find the value of α, θ, $\hat{n}$ for the following matrices (Can be a numerical)

(a) $\frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$
(b) $\begin{bmatrix} 1 & 0 \\ 0 & i \end{bmatrix}$
(c) $\begin{bmatrix} 1 & 0 \\ 0 & e^{i\pi/4} \end{bmatrix}$

Q9. For an O_2^- ion the Hamiltonian position representation (assume computational basis) is of the form

$$\begin{bmatrix} E_0 & -A \\ -A & E_0 \end{bmatrix}$$

Suppose we prepare the ion in the state

$$\psi = \frac{1}{5}\begin{pmatrix} 3 \\ 4 \end{pmatrix}$$

Then find:

(a) Probability of finding the ion in its ground state E_1: $\Rightarrow 0.02$
(b) Probability of finding the ion in its ground state E_2: $\Rightarrow 0.98$
(c) Probability of finding position of electron on first oxygen atom: $\Rightarrow 0.36$
(d) Probability of finding position of electron on second oxygen atom: $\Rightarrow 0.64$