No.

Date.

Ex.2.12 | Ch.2 | P40 | Chloe | 2025.7.17

解：$\hat{x}=\sqrt{\frac{\hbar}{2m\omega}}(\hat{a}_++\hat{a}_-)$, $\hat{p}=i\sqrt{\frac{\hbar m\omega}{2}}(\hat{a}_+-\hat{a}_-)$

$\langle x\rangle_n=\int_{-\infty}^{+\infty}\psi_n^*(x)\hat{x}\psi_n(x)dx=\sqrt{\frac{\hbar}{2m\omega}}\int_{-\infty}^{+\infty}\psi_n^*(x)(\hat{a}_++\hat{a}_-)\psi_n(x)dx$

$=\sqrt{\frac{\hbar}{2m\omega}}\int_{-\infty}^{+\infty}\psi_n^*(x)\left[\sqrt{n+1}\,\psi_{n+1}(x)+\sqrt{n}\,\psi_{n-1}\right]dx=0$ (正交性)

$\langle p\rangle_n=i\sqrt{\frac{\hbar m\omega}{2}}\int_{-\infty}^{+\infty}\psi_n^*(x)(\hat{a}_+-\hat{a}_-)\psi_n(x)dx=0$ (同理)

$\langle x^2\rangle_n=\frac{\hbar}{2m\omega}\int_{-\infty}^{+\infty}\psi_n^*(x)(\hat{a}_+^2+\hat{a}_+\hat{a}_-+\hat{a}_-\hat{a}_++\hat{a}_-^2)\psi_n(x)dx$

$=\frac{\hbar}{2m\omega}[(n+1)+n]=\frac{\hbar}{2m\omega}(2n+1)$

$\langle p^2\rangle_n=-\frac{\hbar m\omega}{2}\int_{-\infty}^{+\infty}\psi_n^*(x)(\hat{a}_+^2-\hat{a}_+\hat{a}_--\hat{a}_-\hat{a}_++\hat{a}_-^2)\psi_n(x)dx$

$=-\frac{\hbar m\omega}{2}(0-(n+1)-n+0)=\frac{\hbar m\omega}{2}(2n+1)$

$\sigma_{x_n}=\sqrt{\langle x^2\rangle_n-\langle x\rangle_n^2}=\sqrt{\frac{\hbar}{2m\omega}(2n+1)}$

$\sigma_{p_n}=\sqrt{\langle p^2\rangle_n-\langle p\rangle_n^2}=\sqrt{\frac{\hbar m\omega}{2}(2n+1)}$

$\sigma_{x_n}\cdot\sigma_{p_n}=\frac{\hbar}{2}(2n+1)\geq\frac{\hbar}{2}$ (满足不确定原理)