

5.73

Quiz 12 ANSWERS

1.

The matrices for x and p , evaluated in the harmonic oscillator eigenbasis, have the general nonzero matrix elements:

$$\langle n | x | n+1 \rangle = x_{n,n+1} = \left[\frac{\hbar}{2\omega\mu} \right]^{1/2} (n+1)^{1/2}$$

$$p_{n,n+1} = -i \left[\frac{\hbar\omega\mu}{2} \right]^{1/2} (n+1)^{1/2}$$

A. x and p are Hermitian. Write the “other” nonzero matrix element (be careful about \mathbf{p} !)

$$x_{n+1,n} = \left[\frac{\hbar}{2\omega\mu} \right]^{1/2} (n+1)^{1/2}$$

$$p_{n+1,n} = +i \left[\frac{\hbar\omega\mu}{2} \right]^{1/2} (n+1)^{1/2}$$

B. What are the general “selection rules” for nonzero matrix elements of x , p , and x^2 ?

For x , $\Delta n = \boxed{\pm 1}$

For p , $\Delta n = \boxed{\pm 1}$

For x^2 , $\Delta n = \boxed{0}$ and $\boxed{\pm 2}$

C. If you multiply x times x , the matrix multiplication cartoon helps:

Based on the cartoon, what is the general selection rule for nonzero matrix elements of x^k ?

$$\Delta n = \pm k, \pm(k-2), \dots, \pm 1 \text{ (if } k \text{ is odd) or } 0 \text{ (if } k \text{ is even)}$$

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