Physics 402 Quiz 1, February 1, 2018

1) For a harmonic oscillator system, which of the following is zero?

a) $\langle 0|x^2|0\rangle$

b) $\langle 2|x^2|2\rangle$

c) $\langle 2|a^2 + (a^\dagger)^2|2\rangle$

d) $\langle 0|a^2(a^\dagger)^2|0\rangle$

e) 17

2) We add a perturbation λx^2 to a harmonic oscillator Hamiltonian. The first order shift in the ground state $|0\rangle$ is a linear combination $c_n|n\rangle$ of the original harmonic oscillator eigenstates. For how many n is c_n not zero?

a) 1

b) 2

c) 3

d) 4

e) ∞

3) The first order shift in the energy of the ground state for the perturbation in the previous question is

a)
$$\lambda\langle 0|x^2|0\rangle$$

b)
$$\lambda\sum_n \frac{\langle 0|x^2|n\rangle}{E_n - E_0}$$

c)
$$\lambda\sum_n \frac{\langle n|x^2|0\rangle}{E_n - E_0}$$

d)
$$\lambda\langle 1|x^2|1\rangle$$

e)

zero

4) A Hamiltonian H_0 has two states $|A\rangle$ and $|B\rangle$ with the same energy E. Which of the following is true about the system if we add a small perturbation λH_1 to the Hamiltonian?
a) The perturbed system will have energy eigenstates with energies close to E and these will be close to $|A\rangle$ and $|B\rangle$.
c) The perturbed system will have energy eigenstates with energies close to E but these won't necessarily be close to $|A\rangle$ and $|B\rangle$
b) The perturbed system will have energy eigenstates close to $|A\rangle$ and $|B\rangle$ but their energies won't necessarily be close to E.
d) The perturbed system will usual have neither energy eigenstates with energies close to E nor energy eigenvectors close to $|A\rangle$ and $|B\rangle$

5) A particle is in the ground state of an infinite square well potential located on the interval $[0, L]$; call the wavefunction for this particle $\psi_0(x)$. If we perturb the system by adding a potential $\lambda V(x)$, the shift in ground state energy will be equal to

a) $V(L/2)$

b) $\int_0^L dx V(x)$

c) $\int_0^L dx V(x) \psi_0(x)$

d) $\int_0^L dx V(x) |\psi_0(x)|^2$

e) All of the above are correct

6) If we use the formula

$$E_n^2 = \sum_{m \neq n} \frac{|\langle m|H_1|n\rangle|^2}{E_n - E_m} \tag{1}$$

to calculate the second order shift in energy for the ground state (i.e. the lowest energy $n = 0$ state) of a quantum system, the result will always be

a) positive

b) negative

c) zero

Hint: the answer is apparent from the formula.

Please fill in:

Answers

1	2	3	4	5	6