QM2 Concept test 3.1

Choose all of the following statements that are correct about bosons.
(1) The spin of a boson is an integer.
(2) The overall wavefunction of identical bosons can be anti-symmetric.
(3) Two bosons cannot occupy the same quantum state.

A. 1 only B. 2 only C. 1 and 2 only D. 1 and 3 only
E. All of the above

QM2 Concept test 3.2

Choose all of the following statements that are correct about the Pauli exclusion principle.
(1) All identical spin-1/2 particles satisfy the Pauli exclusion principle.
(2) An up quark (u) and a $down$ quark (d) cannot occupy the same quantum state simultaneously.
(3) Two electrons in an atom cannot occupy the same quantum state simultaneously.

A. 1 only B. 3 only C. 1 and 2 only D. 1 and 3 only
E. all of the above

QM2 Concept Test 3.7

The stationary states for a particle in an infinite square well ($V(x) = 0$ for $0 \leq x \leq a$) are $A_n \sin\left(\frac{n\pi x}{a}\right)$ where $n = 1,2,3, \ldots$. Choose all of the following statements that are correct about a two particle system in an infinite square well of width a. Ignore spin. A is a normalization constant.

(1) If the two particles are identical bosons, the <u>first excited state</u> of the system is $A[\sin\left(\frac{\pi x_1}{a}\right)\sin\left(\frac{\pi x_2}{a}\right) + \sin\left(\frac{2\pi x_1}{a}\right)\sin\left(\frac{2\pi x_2}{a}\right)]$

(2) If the two particles are identical bosons, the <u>first excited state</u> of the system is $A\sin\left(\frac{\pi x_1}{a}\right)\sin\left(\frac{2\pi x_2}{a}\right)$

(3) If the two particles are identical <u>fermions</u>, the <u>first excited state</u> of the system is $A[\sin\left(\frac{\pi x_1}{a}\right)\sin\left(\frac{2\pi x_2}{a}\right) - \sin\left(\frac{2\pi x_1}{a}\right)\sin\left(\frac{\pi x_2}{a}\right)]$

A. 1 only B. 2 only C. 3 only D. 1 and 3 only E. none of the above

QM2 Concept test 3.10

Suppose at time $t = 0$, $\psi_a(x)$ is the wavefunction for particle 1 in a potential energy well and $\psi_b(x)$ is the wavefunction for particle 2 in the same well. Particles 1 and 2 are non-interacting. Choose all of the following statements that are correct for this two-particle system. Ignore spin. A is a normalization constant.

(1) $\Psi(x_1, x_2) = A[\psi_a(x_1)\,\psi_b(x_2) + \psi_b(x_1)\,\psi_a(x_2)]$ is a possible wavefunction for this system if particles 1 and 2 are identical bosons.

(2) If particles 1 and 2 are identical fermions, the wavefunction must be anti-symmetric at all times.

(3) $\Psi(x_1, x_2) = A\psi_a(x_1)\,\psi_b(x_2)$ can be a possible wavefunction for this system if particle 1 is a boson and particle 2 is a fermion.

A. 1 only B. 2 only C. 1 and 2 D. 1 and 3 E. all of the above