Heisenberg Uncertainty Principle Chemistry Questions with Solutions

Q1. If uncertainty in the position of an electron is zero, the uncertainty in its momentum will be-

a.) $<h/4\pi$
b.) $>h/4\pi$
c.) zero
d.) infinite

Correct Answer- (d) infinite

Q2. Which of the following is a correct relation according to Heisenberg's Uncertainty principle?

a.) $\Delta x \times \Delta P \leq \frac{h}{4\Pi}$
b.) $\Delta x \times \Delta v \leq \frac{h}{4\Pi}$
c.) $\Delta x \times \Delta P \geq \frac{h}{4\Pi}$
d.) $\Delta x \times \Delta v \geq \frac{h}{4\Pi}$

Correct Answer. (c.) $\Delta x \times \Delta P \geq \frac{h}{4\Pi}$

Q3. The uncertainty principle applies to-

a.) macroscopic particles
b.) microscopic particles
c.) gases
d.) none of the above

Correct Answer - (b.) microscopic particles

Q4. Uncertainty principle can be easily understood with the help of-

a.) Dalton's effect
b.) Crompton's effect
c.) electron effect
d.) rhombic effect

Correct Answer- (b.) Crompton's effect

Q5. The particles that are indistinguishable and obey both Heisenberg's uncertainty principle and Pauli's exclusion principle obey-

a.) Fermi-Dirac statistics
b.) Bose-Einstein statistics
c.) Maxwell Boltzmann distribution
d.) Sigmund distribution

Correct Answer. (a.) Fermi-Dirac statistics

Q6. Heisenberg's uncertainty principle rules out the exact simultaneous measurement of ____ and ____.

Answer. Position and velocity.
It is impossible to accurately determine the position velocity of a small microscope particle such as an electron, proton, or neutron at the same time.

Q7. The particles that are indistinguishable and obeys Heisenberg uncertainty principle and don't obey Pauli's exclusion principle are ____.

Answer. The particles that are indistinguishable and obeys Heisenberg uncertainty principle and don't obey Pauli's exclusion principle are Bose-Einstein statistics.

Q8. If the uncertainty in the velocities of two particles A and B with masses of 1.0 × 10^{-27} kg and 1.0 × 10^{-31} kg, respectively, is the same, what will be the ratio of uncertainty in their positions?

Answer. $\Delta x_A m_A \Delta v_A = \Delta x_B m_B \Delta v_B$
Given, $\Delta v_A = \Delta v_B$
Therefore, $\Delta x_A m_A = \Delta x_B m_B$
$\Delta x_A 1.0 \times 10^{-27}$ kg = $\Delta x_B 1.0 \times 10^{-31}$ kg
$\Delta x_A / \Delta x_B = 1.0 \times 10^{-31}$ kg/1.0×10^{-27} kg = 1/10000.

Q9. Which scientists developed the uncertainty principle and the concept of matter's wave nature?
Answer. Heisenberg and de Broglie developed the uncertainty principle and the concept of matter's wave nature.

Q10. What are the limitations of Heisenberg's Uncertainty Principle?

Answer. According to Heisenberg's uncertainty principle, "it is impossible to calculate the position and momentum of a small moving object like an electron simultaneously and accurately." The principle only applies to microscopic particles and not to macroscopic particles.

Q11. What is the order of wavelength associated with a 200g golf ball moving at a speed of 5mh^{-1}.

Answer. The wavelength associated with a golf ball can be calculated as-

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{0.2 \times 5/3600} = 2.4 \times 10^{-30} m$$

Q12. Why is it impossible to measure position and momentum at the same time?

Answer. Consider the measurement of an electron's position to demonstrate Heisenberg's uncertainty principle. A photon must collide with an object and return to the measuring device in order to determine its position. Since photons have finite momentum, a momenta transfer will occur when the photon collides with the electron. The electron's momentum will increase as a result of this momenta transfer. As a result, any attempt to measure a particle's position increases the uncertainty in the value of its momentum.
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Q13. What does the Heisenberg uncertainty principle imply?

Answer. According to Bohr's theory, an electron is a material particle. Its position and momentum can be calculated precisely. However, when an electron is considered in the form of a wave, as proposed by de-Broglie, it is not possible to determine the exact position and velocity of the electron at a given instant because the wave extends across a region of space.
Werner Heisenberg proposed the Heisenberg uncertainty principle in 1927, which states that "it is impossible to measure simultaneously the exact position and exact momentum of a body as small as an electron."

Q14. What will be the uncertainty in the position of an electron (mass = 9.10^{-31} kg) moving at 300 ms^{-1} with an accuracy of 0.001 percent?

Answer.

Given- m = 9.10^{-31} kg, h = 6.62×10^{-34} J.s, v = 0.003 m/s
Accordig to Heisenberg Uncertainty Principle

$$\Delta x \times \Delta v \geq \frac{h}{4\Pi}$$

On substituting the values, we will get

$$\Delta x \times 9.1 \times 10^{-31} \times 0.003 = \frac{6.62 \times 10^{-34}}{4 \times 3.1416}$$

$\Delta x = 1.92 \times 10^{-2}$ m

Q15. Suppose the velocity of an electron in an atom is known to have an accuracy of 2×10^3 ms^{-1} (reasonably accurate compared with orbital velocities). What is the electron's minimum uncertainty in position, and how does this compare with the approximate 0.1 nm size of the atom?

Solution.
Given- $\Delta v = 2 \times 10^3$ ms^{-1}
Mass of an electron, m = 9.1×10^{-31} kg
Plank's constant, h = 6.626×10^{-34} J.s
According to Heisenberg Uncertainty Principle

$$\Delta x \times \Delta P \geq \frac{h}{4\Pi}$$

Where p is the momentum, p = mv

$$\Delta x \times (m\Delta v) \geq \frac{h}{4\Pi}$$

Therefore, minimum uncertainty in the position can be calculated as-

$$\Delta x_{min} = \frac{h}{4\Pi m \Delta v}$$

$$\Delta x_{min} = \frac{6.626 \times 10^{-34} J.s}{4\Pi \times 9.1 \times 10^{-31} kg \times 2 \times 10^3 ms^{-1}}$$

$\Delta x_{min} \cong 2.89 \times 10^8$ m

$\Delta x_{min} \cong 28.9$ nm

Siz of the atom, x = 0.1 nm
Therefore, the ratio of uncertainty in the position with the size of the atom is-
$\Delta x/x$ = 28.9 nm/0.1 nm
$\Delta x/x$ = 289
Hence, the uncertainty in the position is 289 times the size of the atom.

Practise Questions on Heisenberg Uncertainty Principle

Q1. Which of the following statements are correct?

a.) The Heisenberg Uncertainty Principle applies to electrons but not protons.
b.) It is impossible to determine simultaneously both the position and time of an electron with accuracy.
c.) It is impossible to determine simultaneously both the time and mass of an electron with accuracy.
d.) It is impossible to determine simultaneously both the time and energy of an electron with accuracy.

Correct Answer. (d.) It is impossible to determine simultaneously both the time and energy of an electron with accuracy.

Q2. If the position of the electron is measured within an accuracy of +0.002 nm, the uncertainty in the momentum of the electron would be-

a.) 5.637×10^{-23} kg ms^{-1}
b.) 4.637×10^{-23} kg ms^{-1}
c.) 2.637×10^{-23} kg ms^{-1}
d.) 3.637×10^{-23} kg ms^{-1}

Correct answer- (c.) 2.637×10^{-23} kg ms^{-1}.

Q3. Which law found the correlation between the lifetime of the half-life of the alpha emitter and the alpha energies?

Answer. Geiger's law found the correlation between the lifetime of the half-life of the alpha emitter and the alpha energies.

Q4. The uncertainty in an electron's momentum is 1.0×10^{-5} kg m s^{-1}. What will be its uncertainty of position?

Answer. The uncertainty in the position of electron is-

$$\Delta x = \frac{h}{4\Pi \Delta P}$$

$$\Delta x = \frac{6.626 \times 10^{-34}}{4 \times 3.1416 \times 1.0 \times 10^{-5}} = 5.27 \times 10^{-30} m$$

Q5.The wavelength of an electron and a photon is 1.00 nm. Determine
(a) their momenta,
(b) photon energy,
(c) electron kinetic energy.

Answer.

(a.) The De Broglie hypothesis states that-

p = h/λ

$$\frac{6.626 \times 10^{-34}}{1 \times 10^{-9}} = 6.62 \times 10^{-25} kgms^{-1}$$

Regardless of electron or photon, the value remains constant.

(b.) λ = 1 nm

E = hc/λe = 1243.1 eV = 1.234 keV

(c.) Momentum, p = h/λ =6.63×10^{-25} kgm/s

Kinetic energy of electron is $P^2/2m = 2.415 \times 10^{-19}$ J = 1.51 eV

Click the PDF to check the answers for Practice Questions.