

Quantum Numbers Chemistry Questions with Solutions

Q1: When atoms gain, lose, or share electrons they do so in order to have an electron configuration of a noble gas.

- a) True.
- b) False.

Answer: a) TRUE

Explanation: Atoms may gain, lose, or share electrons in order to create bonds. When Na and Cl combine to make NaCl, for example, Na loses an electron and becomes Na^+ , while Cl gains an electron and becomes Cl^- . It's worth noting that Na^+ now has the same amount of electrons as Ne, whereas Cl^- now has the same number as Ar. This demonstrates that atoms create bonds in order to achieve a noble gas's stable electron configuration. Nevertheless, there are exclusions to this generalisation.

Q2: Which of the following quantum numbers governs the spatial orientation of an atomic orbital?

- (a) Spin quantum number
- (b) Magnetic quantum number
- (c) Azimuthal quantum number
- (d) Principal quantum number

Answer: (b) Magnetic quantum number

Q3: Quantum Numbers are solutions of _____

- a) Heisenberg's Uncertainty Principle
- b) Einstein's mass energy relation
- c) Schrodinger's Wave Equation
- d) Hamiltonian Operator

Answer: c) Schrodinger's Wave Equation

Explanation: When the Schrodinger Wave Equation is used to calculate the wave function for an atom, the solutions found are known as Quantum Numbers, which are essentially n , l , and m .

Q4: What is the maximum number of electrons in a shell?

- a) n
- b) $2n^2$
- c) n^2

d) $2n$

Answer: b) $2n^2$

Explanation: The total number of electrons in a shell is $2n^2$, and the number of orbitals in that shell is n^2 , which is half the total number of electrons in that shell.

Q5: What is the range of Azimuthal Quantum Number, l ?

- a) 0 to n
- b) 0 to $n-1$
- c) 0 to s
- d) 0 to $s-1$

Answer: b) 0 to $n-1$

Explanation: The Azimuthal Quantum Number, l , has a value ranging from 0 to $n-1$. It assists us in determining which subshell an electron belongs to.

Q6: What are the possible subshells when $n = 4$? How many orbitals are contained by each of these subshells?

Answer:

When $n = 4$, the l values that can be used are 0, 1, 2, and 3. This means that the 4s, 4p, 4d, and 4f subshells are the four options.

- The 4s subshell possesses 1 orbital and can retain up to 2 electrons.
- The 4p subshell includes 3 orbitals and can retain up to 6 electrons.
- The 4d subshell includes 5 orbitals and can retain up to 10 electrons.
- The 4f subshell does have 7 orbitals and can retain up to 14 electrons.

And hence, a total of 4 subshells are feasible for $n = 4$.

Q7: What are the values of principal quantum number (n) and azimuthal quantum number (l) for 3s and 4p orbitals?

Answer:

Principal quantum number (n): It defines the main shell to which an electron belongs.

For, 3s orbital $n = 3$ and 4p orbital $n = 4$

If n = the principal quantum number, then one value lesser than n is the azimuthal quantum number ($n-1$).

For 3s orbital,

Azimuthal quantum number, $l = 3 - 1 = 2$

For 4p orbital, $n = 4$

∴ Azimuthal quantum number $l = 4 - 1 = 3$.

Q8: What is Spin Quantum Number?

Answer:

The spin quantum number is the fourth quantum number, indicated by s or m_s . The inherent angular momentum of an electron in an atom is indicated by the spin quantum number. It describes an electron's quantum state, including its energy, orbital shape, and orientation.

A spin quantum number can only have the values $+1/2$ or $-1/2$ (also known as 'spin up' and 'spin down'). The value of spin is a quantum state that is more difficult to grasp than the direction in which an electron spins.

Q9: The quantum numbers $+1/2$ and $-1/2$ for an electron represent two quantum mechanical spin states which have no classical analogue. Explain this statement.

Answer:

The statement implies that electron spin quantum states $+1/2$ and $-1/2$ exist. The spin quantum number is a property that is conserved. The spin of an electron is described by these two states $+1/2$ and $-1/2$. It is a phrase used only in Quantum physics to describe the property of an electron, and it has no confirmation in Classical physics. As a result, the phrase "no classical analogue" is employed.

Q10: What is Schrodinger Wave Equation?

Answer:

The Schrodinger wave equation is a mathematical expression that describes the energy and position of an electron in space and time while accounting for the electron's matter wave nature within an atom.

It is based on three basic factors. They are:

- Classical plane wave equation,
- Broglie's Hypothesis of matter-wave, and

- Conservation of Energy.

The Schrodinger equation describes the form of the wave functions or probability waves that influence the motion of some smaller particles in great detail. The equation also illustrates how external influences affect these waves.

Moreover, by determining the Schrödinger equation we acquire Ψ and Ψ^2 , which helps us evaluate the quantum numbers as well as the orientations and the shape of orbitals where electrons are found in a molecule or an atom.

Q11: Describe the properties of an electron associated with each of the following four quantum numbers: n , l , m_l , and m_s .

Answer:

The value of n dictates the general range of energy values and the possible distances between the nucleus and the electron. The shape of the orbital is dictated by l . The orientation of orbitals with the same l value with regard to one another is determined by m_l . The spin of an electron is determined by m_s .

Q12: Identify the subshell in which electrons with the following quantum numbers are found:

- $n = 2, l = 1$
- $n = 4, l = 2$
- $n = 6, l = 0$

Answer:

- 2p
- 4d
- 6s

Q13: Write a set of quantum numbers for each of the electrons with an n of 4 in a Se atom.

Answer:

n	l	m_l	s
4	0	0	+1/2
4	0	0	-1/2
4	1	-1	+1/2

4	1	0	+1/2
4	1	1	+1/2
4	1	-1	-1/2

Q14: What will be the maximum numbers of electrons having same spin, present in an atom for $n + l = 4$?

Answer:

Given:

$$n + l = 4$$

Let's find the feasible values of n and l for whom total will be 4
Therefore the possible values are $n = 3$ & $l = 1$ and $n = 4$ and $l = 0$.

If $n = 3$ and $l = 1$,

The 3p subshell is represented by $n = 3$ and $l = 1$. As a result, the subshell's maximum number of electrons = 6.

If $n = 4$ and $l = 0$,

The 4s subshell is represented by $n = 4$ and $l = 0$. As a result, the maximum number of electrons in this subshell is equal to two.

Thus, the total number of electrons = $6 + 2 = 8$

Hence, the electrons with the same spin = $8/2 = 4$.

Q15: What is Principal quantum number, Azimuthal quantum number & Magnetic quantum number?

Answer:

Principal Quantum Number (n)

The size and energy of the main shell are related to the principal quantum number (n). The positive integer values of " n " are 1, 2, 3, etc. The size and, to a large extent, the energy of the orbital are determined by the primary quantum number. Only ' n ' determines the energy and size of the orbital for hydrogen atoms and hydrogen-like species (He^+ , Li^{2+} , etc.).

The shell is also identified by its principal quantum number. The orbitals of an atom with a specific value of 'n' form a single shell and are frequently denoted by the letters K, L, M, etc. There is one main shell for each 'n' value.

Shell	K	L	M	N
n	1	2	3	4

Azimuthal Quantum Number (*l*)

The Azimuthal quantum number '*l*' is also identified as orbital angular momentum or subsidiary quantum number. It determines the orbital's three-dimensional shape.

For each number of n, *l* can have n values ranging from 0 to n – 1, i.e., '*l*' can have integer values ranging from 0 to n – 1. One sub-shell is represented by each '*l*' value. Each '*l*' value corresponds to the form of a specific sub-shell in the region surrounding the nucleus.

<i>l</i>	0	1	2	3
Name of the sub-shell	s	p	d	f

The Magnetic Quantum Number (m_l)

The magnetic orbital quantum number ' m_l ' indicates the orbital's spatial orientation in relation to a conventional set of coordinate axes. Integer values between – *l* and *l*, including zero, make up the magnetic quantum number (m_l). As a result, there are ($2l + 1$) integer values of m_l for a given value of *l*: $m_l = -l, (-l + 1), \dots, -1, 0, 1, \dots, (+l - 1)$

When *l* = 0, ($2l + 1$) = 1, and m_l has just one value, we only have one orbital, which is 1s.

When *l* = 1, ($2l + 1$) = 3, m_l has three values: -1, 0 and 1 or three p orbitals with various orientations along the x, y, and z-axes. These are referred to as p_x , p_y , and p_z .

Practise Questions on Quantum Numbers

Q1: The total value of the magnetic quantum number are _____

- a) 2n
- b) 2l
- c) 2n + 1
- d) 2l + 1

Answer: d) $2l + 1$

Explanation: The orientation of electrons in an atom is represented by the magnetic quantum number. m_l has a total value of $2l + 1$. They range in value from $-l$ to $+l$.

Q2: What are the possible m_l values for $l = 4$?

Answer:

Since the value of the magnetic quantum number ranges from $-l$ to l , the possible values of m_l when $l = 4$ are: $-4, -3, -2, -1, 0, 1, 2, 3,$ and 4 .

Q3: What is Quantum Energy?

Answer:

In chemistry and physics, quantum corresponds to a single packet of matter or energy. It refers to the smallest quantity of energy required for a change or the smallest value of any physical attribute in an interaction in practice. The singular variant of the word is quantum. Quanta is the plural of the term.

Q4: What is the spin of an electron?

Answer:

Electron spin is a quantum feature of electrons. It's a form with angular momentum. As a teaching tool, instructors compare electron spin to the planet rotating on its own axis every 24 hours. Spin-up occurs when an electron spins clockwise on its axis; spin-down occurs when the electron spins counterclockwise.

Q5: Principal, azimuthal and magnetic quantum numbers are respectively related to

- a) Size, shape and orientation
- b) Shape, size and orientation
- c) Size, orientation and shape
- d) None of the above

Answer: a) Size, shape and orientation

Explanation: n, l and m are related to size, shape and orientation respectively.