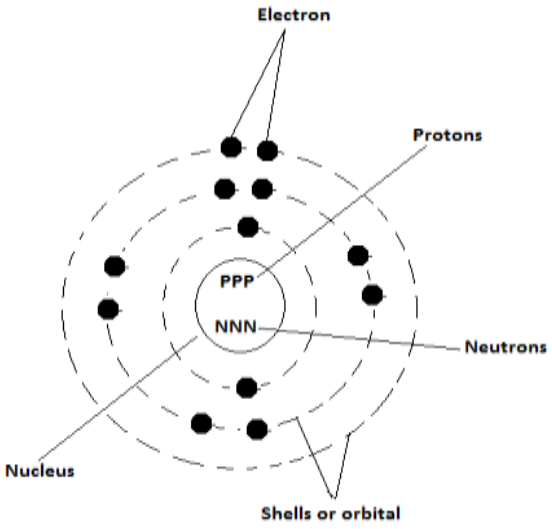
CHAPTER ELEVEN

THE ATOM, IONIC AND COVALENT BONDING:

Atomic structure:

- The atom is the smallest indivisible particle of an element or matter, which is capable of taking part in a chemical reaction. - Even though the atom is very small and cannot be seen even with a microscope, scientists have various ways of getting information about the atom.



- The atom is round in shape, and at its central part can be found a structure called the nucleus. - Surrounding the nucleus are the orbitals or shells, in which the electrons move. - There are different types of atoms with varying number of electrons and shells.
- Each shell has a maximum number of electrons it can hold.
- While the first orbital or shell can hold a maximum of two electrons, the second can hold up to eight electrons and the third can hold a maximum of eighteen electrons.
- The electrons are negatively charged and each carry a charge of-1.
- Within the nucleus of an atom can be found two types of sub-atomic particles and these are (i) the protons (ii) the neutrons. - Each proton carries or bears a charge of +1.
- Within an atom which is neutral, the number of positive charges (protons) is always equal to that of the negative charges (electrons). - For

this reason, the atom is said to be electrically or electrostatically neutral. - Therefore if such an atom has two protons, then it will have two electrons and these protons and neutrons will cancel the effect of each other, rendering the atom to become neutral. - The neutrons are neutral since they bear no electrical charge, and the neutrons and the protons are collectively referred to as the nucleons.

The atomic number:

This is also known as the proton number and it is represented by the symbol Z. The atomic number of an element is the number of protons or electrons within its atom. Therefore if the atom of an element contains 8 electrons, then its atomic number will be 8, and if it contains only 2 electrons then its atomic number will be 2. Also if an atom contains 5 protons, then its atomic number is 5, and if there are 3 protons then the atomic number will be 3. The atomic number can be used to differentiate one element from another, since each element has an atomic number which is different from that of any other element.

The mass number:

This is also referred to as the nucleon number, and it is represented by the symbol A. The mass number refers to the total number of protons and neutrons found within an atom. Since the number of protons and electrons within an atom are the same, then the mass number may also be defined as the total number of electrons and protons within the atom.

(Q1) Within an atom there are 5 electrons and 2 neutrons. Find its mass number.

Soln:

Number of electrons = 5.

Number of neutrons = 2.

Mass number = 5 + 2 = 7.

(Q2) There are 2 neutrons and 6 protons within an atom. Determine its mass number.

Soln:

Number of neutrons = 2.
Number of protons = 6.
Mass number = 2 + 6 = 8.

(Q3) An atom has a mass number of 10. If it contains 2 electrons, how many neutrons does it contain?

Soln:

Mass number = 10.

Number of electrons = 2.

Number of neutrons =?

Mass number = Number of neutrons + number of electrons.

=>10 = number of neutrons + 2,

=> 10 – 2 = Number of neutrons

=>Number of neutrons = 8.

(Q4) An atom which contains 3 electrons has a mass number of 8. Determine the number of neutrons that it contains.

Soln:

Number of electrons = 3.

Mass number = 8.

Number of neutrons =?

Mass number = Number of electrons + number of neutrons.

=>8 = 3 + number of neutrons,

=>Number of neutrons = 8 – 3 = 5.

(Q5) An atom has 4 protons and a mass number of 12. How many neutrons does it contain?

Soln:

Mass number = number of protons + the number of neutrons.

=>Mass number = 4 + number of neutrons.

=>12 = 4 + number of neutrons

=>Number of neutrons = 12 – 4 = 8.

(Q6) An atom whose mass number is 10 contains 8 neutrons. Determine the number of protons that it contains.

Soln:

Number of neutrons = 3.

Mass number = 10.

Mass number = Number of neutrons + number of protons.

=>10 = 8 + number of protons,

=>number of protons = 10 – 8 = 2.

The ion:

As already stated, an atom is neutral since it contains the same number of negative and positive charges. Since these charges cancel the effect of each other, the atom becomes neutral. For certain reasons, an atom can either become positively or negatively charged and such an atom is referred to as an ion. An ion is therefore an atom which is either positively or negatively charged. There are positive and negative ions and examples are Na^{+}, Ca^{2+} and Cl^{-}. An ion is always formed when an atom gains or loses an electron or electrons.

Positive ions:

- These are ions in which the number of positive charges (protons), is greater than that of the negative charges (electrons). -
Positive ions are always formed, when an atom loses an electron or a number of electrons.
- For example, an atom which contains 5 electrons also contains 5 protons.

- If it loses an electron, its number of electrons or negative charges becomes 4, while its number of protons or positive charges remains the number. Since the atom now contains more positive charges than negative charges, then it has become a positive ion.

Negative ion:

- This is an atom in which the negative charges are more than that of the positive charges.
- Such an ion is always formed when an atom gains an electron or a number of electrons.
- For example, an atom containing 2 electrons also contains 2 protons.
- If it gains an additional electron, then its number of negative charges becomes 3, while its number of positive charges still remains 2.
- Since it now contains more negative charges than positive charges, then it has now become a negatively charged ion.

Atomic symbol:

- If X = the element, A = its mass number and Z = its atomic number, then the atomic symbol of the element X is written as $^{A}_{Z}X$.
- For example, the atomic symbol $^{23}_{11}\mathrm{Na}$ represents the element sodium, whose mass number is 23 and whose atomic number is 11.
- Also the symbol $^{24}_{12}\mathrm{Mg}$ represents the element magnesium, whose mass number is 24 and whose atomic number is 12.

(Q1) The atomic symbol of an element is $^{10}_{7}P$.

(a) What is the mass number?
(b) Write down its atomic number.

(c) Find the number of neutrons.

Soln:

(a) The mass number = 10.
(b) The atomic number = 7.

=>It contains 7 electrons.

(c) From Mass number = Number of neutrons + number of electrons,

=>10 = Number of neutrons + 7,

=>10 – 7 = 3 = number of neutrons,=> It contains 3 neutrons.

(Q2) An element has an atomic symbol $^{12}_{8}X$.. Determine

(a) its atomic number.

(b) the number of protons it contains.

(c) its mass number.

(d) the number of neutrons it contains.

Soln:

(a) The atomic number = 8.
(b) The number of protons = the atomic number = 8.
(c) The mass number = 12.
(d) Number of neutrons = Mass number – Number of electrons = 12 – 8 = 4.

(Q3) Write the atomic symbol of an element Y, which contains 8 electrons and 5 neutrons.

Soln:

Since there are 8 electrons =>the atomic number = 8.

The mass number = Number of electrons + Number of neutrons

=>The mass number = 8 + 5 = 13.

The required atomic symbol is $^{13}_{8}\mathrm{Y}$.

(Q4)An element B has 10 protons and 8 neutrons. Write down its atomic symbol.

Soln:

Since the number of protons = 10, then the atomic number = 10.

Number of neutrons = 8.

Mass number = Number of neutrons + the number of protons.

Mass number = 10 + 8 = 18.

The atomic symbol is $^{18}_{10}\mathrm{B}$.

Isotopes:

These are two or more atoms which have the same atomic number, but different mass numbers. Within an atom, the number of protons is always fixed or constant but the number of neutrons may vary. If the number of neutrons vary, then the mass number of the atom will also vary. For this reason, it is therefore possible to have two atoms of the same element, which have the same atomic number but different mass numbers, and such two atoms are called isotopes. Examples of isotopes are:

(a) $^{37}_{17}\mathrm{Cl}$ and $^{35}_{17}\mathrm{Cl}$
(b) $^{10}_{8}\mathrm{X}$ and $^{12}_{8}\mathrm{X}$

Electronic configuration: This shows the number of electrons within each orbital of an atom.

(Q1) Write the electronic configuration of an element X whose atomic number is 7.

Soln:

N/B: Since the first orbital can take a maximum of 2 out of the 7 electrons found in the element X, then the rest must be found in the second orbital.

Soln:

The required electronic configuration is 2 : 5.

(Q2)Write down the electronic configuration of an atom, whose atomic number is 12.

Soln:

Since the first orbital can contain a maximum of 2 electrons, and the second one a maximum of 8, then the required electronic configuration is 2 : 8 : 2, since the given atom contains 12 electrons.

(Q3)The atomic symbol of sodium is given as $^{23}_{11}\mathrm{Na}$. Write down its electronic configuration.

Soln:

Since the atomic number of sodium = 11, then its electronic configuration is 2 : 8 : 1.