Chemical Bonding

(English Medium)

Exercise 38:

Solution 1.1:

C. 2
Atomic number of helium is 2. It has 2 electrons in its outermost orbit.

Solution 1.2:

D. Kr
Krypton has atomic number 36 and it is an inert group element with a stable configuration of the outermost orbit.

Solution 1.3:

B. 18
Chloride ion (Cl^-) is formed when chlorine atom (17) gains one electron. It thus has 18 electrons.

Solution 1.4:

A. Ionic
The force of attraction between sodium ions and chloride ions forms an ionic bond in a NaCl crystal.

Solution 1.5:

B. It will form positive ion.
An element with 13 electrons has electronic configuration 2, 8, 3. Thus, this element has a tendency to lose electrons and form a positive ion to achieve octet configuration.

Exercise 39:

Solution 1.6:

C. 8 or 2
Helium has 2 electrons in the outermost orbit and other inert gas elements have 8 electrons in their outermost orbit.

Solution 1.7:

A. 3
3 electrons from each of the combining atoms are shared by two atoms for the formation of a triple bond.

Solution 1.8:

A. H_2O
The electronegativities of oxygen and hydrogen in H_2O molecule are different. Thus, it forms a polar covalent bond.

Solution 1.9:

B. 2
Electronic configuration of oxygen is 2, 8, 6 and that of neon is 2, 8, 8. Thus, oxygen requires two electrons to achieve the electronic configuration similar to that of neon.

Solution 1.10:

C. Double bond
Electronic configuration of oxygen is 2, 6. It requires two electrons to achieve octet configuration. Thus, in oxygen molecule, two electrons from each oxygen atoms are shared to form two covalent bonds.

Solution 1.11:

A. NaOH
Sodium is a highly active metal. When it reacts with water, it forms sodium hydroxide (NaOH) and hydrogen gas (H_2).

Solution 1.12:

D. Water
NaCl is an ionic compound easily soluble in polar compounds such as water and insoluble in non-polar compounds.

Solution 1.13:

B. H
Hydrogen has one electron in its valence shell. It gains one electron and forms a dual closed shell configuration like helium.

Solution 2.1:

Element is the basic unit of a substance. Two or more than two atoms of the same element or different elements combine in a definite proportion to form a molecule.
Example –

Two atoms of oxygen combine to form a molecule of oxygen.
Two atoms of hydrogen and one atom of oxygen combine to form one molecule of water.

Solution 2.2:

The properties of molecules depend on two factors:

1. The manner in which the atoms are combined to form a molecule.
2. The electronic configuration of atoms present in the molecule.

Solution 2.3:

The 18^{th} group of the periodic table contains the inert gas elements. The elements in this group show a stable outer shell configuration. As a result of this closed shell configuration, inert gases do not possess any chemical reactivity.

Solution 2.4:

Octet configuration is a state of attaining 8 electrons in the outermost shell or valence shell of an atom.

Solution 2.5:

Rule of octet, proposed by Lewis states that, 'when one or more atoms exchange their valence orbit electrons or share the electrons, they attain octet configuration such as inert gases'.

Solution 2.6:

Atoms of elements which have 1, 2 or 3 electrons in their valence orbit generally possess the tendency to lose electrons and form positive ions.

Solution 2.7:

Atoms of elements which have 5, 6 or 7 electrons in their valence orbit generally possess the tendency to gain 3, 2 or 1 electrons respectively and form negative ions.

Solution 2.8:

Formula of Aluminium chloride is $AlCl_3$.
In this molecule, aluminium loses 3 electrons to three atoms of chlorine.

Solution 2.9:

$Mg \rightarrow Mg^{2+} + 2e^-$
Magnesium Magnesium ion electron

$2Cl + 2e^- \rightarrow 2Cl^-$
Chlorine electron Chloride ion

$Mg^{2+} + 2Cl^- \rightarrow MgCl_2$
Magnesium chloride

Exercise 40:

Solution 2.10:

Common salt is sodium chloride. Sodium atom loses one electron to attain a stable octet configuration and forms sodium ion (Na^+). This sodium ion attracts chloride ion (Cl^-) which possesses a negative charge.
Sodium metal is highly reactive, however, sodium ion possess electronic configuration such as that of a closed shell and so, it becomes inert.
Hence, the properties of NaCl depend on the sodium ion. Properties of sodium ion differ from that of sodium metal and thus, common salt is harmless for edible purposes.

Solution 2.11:

In the crystal structure of sodium chloride, six chloride ions are present around each sodium ion and simultaneously, six sodium ions are present around each chloride ion.

Solution 2.12:

Solid ionic compounds have a crystal like structure. In this crystal structure, no unpaired electrons are present. Thus, solid ionic compounds are non-conductors.

Solution 2.13:

In solid crystal structures of ionic compounds, no unpaired electrons are present. However in melted or aqueous solutions of the same compounds, ionisation of atoms present in the molecules is possible. Thus, they can conduct electricity.

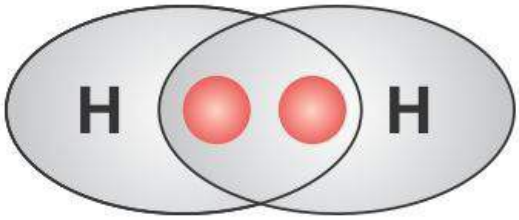
Solution 2.14:

Atoms which do not lose or gain electrons of their outermost orbit easily do not form ionic bonds.

Solution 2.15:

Doublet closed configuration is a state of stable configuration with only two electrons in the valence shell of an atom. Doublet closed configuration is shown by helium gas.

Solution 2.16:



Solution 2.17:

Atomic number of chlorine is 17 and its electronic configuration is 2, 8, 7.
To attain octet configuration, chlorine tends to gain one electron. However in a chlorine molecule, two atoms of chlorine are present and each require one electron to attain octet configuration.

Here, both the chlorine atoms, share one-one electron from each other and form a covalent bond to attain octet configuration.

Solution 2.18:

Electron pair in a chlorine molecule is a pair of electrons, one from each of the chlorine atoms which take part in the formation of a covalent bond.
The electron pair is shared equally between the two chlorine atoms resulting in the formation of covalent bond in chlorine molecule.

Solution 2.19:

The number of electrons gained, lost or shared in the bonding of one atom with another is called the valency of that atom.

Solution 2.20:

Valency of chloride ion in barium chloride as well as in chlorine molecule is 1.

Solution 2.21:

Two covalent bonds are formed by two-two electrons from each oxygen atom, in an oxygen molecule.

Solution 2.22:

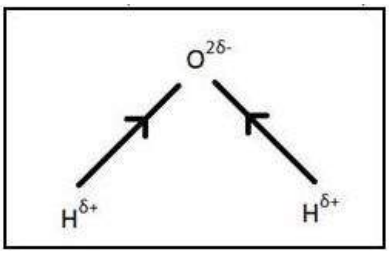
Electronic configuration of oxygen is 2, 6. It requires two electrons to achieve octet configuration. Thus, in oxygen molecule, two electrons from each oxygen atom are shared to form two covalent bonds. Hence, oxygen is also called a divalent compound.
On the other hand, electronic configuration of nitrogen is 2, 5. It requires three electrons to achieve octet configuration. Thus, in nitrogen molecule, three electrons from each nitrogen atom are shared to form three covalent bonds. Hence, nitrogen is also called a trivalent compound.

Solution 2.23:

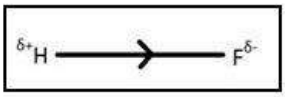
In a covalent compound, when the combining atoms are of two different elements then the bond will be attracted towards the atom with more electronegativity. Such a bond is called a polar covalent bond.

Solution 2.24:

In water two polar covalent bonds are present, one each between a hydrogen atom and an oxygen atom.



In hydrogen fluoride, one polar covalent bond is present.



Solution 2.25:

Compounds showing both types of bonds i.e. ionic and covalent bond are:

1. Sodium hydroxide
2. Sodium nitrate
3. Calcium carbonate
4. Ammonium sulphide

Solution 2.26:

The molecules of water form hydrogen bonds with cotton. Hence, cotton clothes do not dry faster.

Solution 2.27:

Molecules of water are combined with each other through hydrogen bonds. Hence, molecules of water are not in free form.

Solution 3.1:

Chemical bond is a bond by which the atoms in the molecule of a compound are combined and held together by a strong combining force.
There are two types of chemical bonds; ionic bond and covalent bond.
Ionic Bond: Ionic bond is the bond formed by a strong force of attraction between two oppositely charged ions.
Example – In sodium chloride (NaCl), ionic bond is present between the two elements; sodium and chlorine which form sodium ion and chloride ion respectively.
Covalent Bond: The bond formed between two combining atoms by sharing of electrons of the outermost orbit to achieve octet configuration is called a covalent bond.
Example – In oxygen molecule, the two atoms of oxygen achieve octet configuration by sharing two-two electrons from each of the oxygen atoms and form two covalent bonds between oxygen atoms.

Solution 3.2:

Ionic bond is the bond formed by a strong force of attraction between two oppositely charged ions.
Example –
In sodium chloride (NaCl), ionic bond is present between the two elements; sodium and chlorine.
$Na + 1/2\ Cl_2 \rightarrow NaCl$
In the above reaction, electron transfer takes place from sodium ion to chlorine atom. It can be explained as follows:
Sodium atom has one electron in its valence shell. It loses one electron to achieve octet configuration and it forms a cation Na^+
$Na \rightarrow Na^+ + e^-$
Chlorine atom has seven electrons in its valence shell. It gains one electron from sodium atom to achieve octet configuration and it forms anion Cl^-.

$Cl + e^- \rightarrow Cl^-$

Electrons get transferred from sodium to chlorine atoms and form their respective ions. Sodium forms cation Na^+ and chlorine forms anion Cl^-. Electrostatic forces of attraction hold these oppositely charged ions together by an ionic bond and form the compound NaCl.

$Na^+ + Cl^- \rightarrow Na^+Cl^-$ or NaCl

Solution 3.3:

Properties of ionic compounds are:

1. **Physical nature:** Ionic compounds are solid, hard and brittle. Their physical nature is attributed to the strong electrostatic force of attraction between the oppositely charged ions in the compound.

1. **Solubility:** Ionic compounds are easily soluble in polar compounds like water and are relatively insoluble in non-polar compounds like ether and carbon tetrachloride.

1. **Melting and boiling points:** Ionic compounds have high melting and boiling points. Ionic compounds have crystalline structure. In this solid structure, the ions are held strongly by the forces of attraction. Thus, more energy is required to break their bonds and thus, their melting and boiling points are high.

1. **Electrical conductivity:** Solid ionic compounds are non-conductors. They have a crystal like structure. In this crystal structure, no unpaired electrons are present. However, melted or aqueous solutions of the same compound can conduct electricity due to ionisation of atoms present in the molecules.

Solution 3.4:

Covalent compounds are held together by covalent bonds formed by sharing of electrons.
Example – Oxygen molecule, water molecule

Properties of covalent compounds:

1. Covalent compounds are held by weak forces of attraction. Thus, they are liquids or gases at room temperature.
2. They have low melting and boiling points as less energy is required to break the bonds present between covalent compounds.
3. They are soft and flexible in nature.
4. When dissolved, they do not conduct electricity as ions are not formed in aqueous solution of covalent compounds.

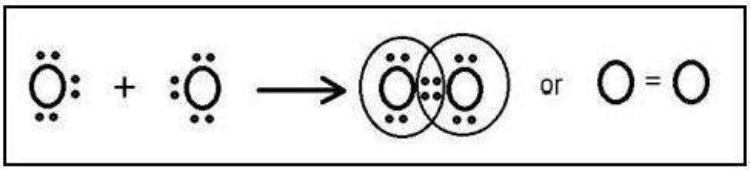
Solution 3.5:

Hydrogen contains one electron in its valence shell. It thus shares electron with another hydrogen atom to attain a closed shell configuration. Thus, a covalent bond between two atoms of hydrogen is formed to form a hydrogen molecule.
Similarly, chlorine has 7 electrons in its valence shell. It requires one electron to achieve octet configuration. It thus shares one electron with another chlorine atom to achieve octet configuration. Thus, a covalent bond between two atoms of chlorine is formed which results in a chlorine molecule.
However, argon already has 8 electrons in its outermost shell. It has an octet configuration

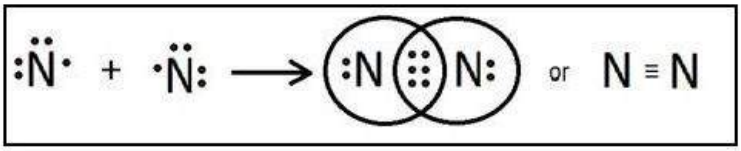
and thus does not form a molecule.

Solution 3.6:

Electronic configuration of oxygen is 2, 6.
An oxygen atom requires two electrons to achieve octet configuration.
Thus in oxygen molecule, two oxygen atoms share two electrons from each of the atoms to attain an octet configuration. Hence two electron pairs are shared between two oxygen atoms forming two covalent bonds. Hence oxygen is also called a divalent compound.



Electronic configuration of nitrogen is 2, 5.
A nitrogen atom requires three electrons to achieve octet configuration.
Thus in a nitrogen molecule, two nitrogen atoms share three electrons from each of the atoms to attain octet configuration. Hence, three electron pairs are shared between two nitrogen atoms forming three covalent bonds. Hence, nitrogen is also called a trivalent compound.



Exercise 41:

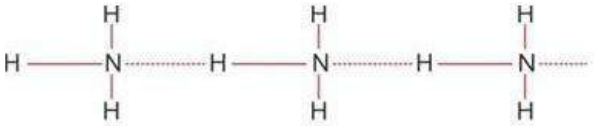
Solution 3.7:

In a covalent compound, when the combining atoms are of two different elements, then the bond will be attracted towards the atom with more electronegativity. Such a bond is called a polar covalent bond.
Example – In a molecule of water, two covalent bonds are present each between a hydrogen atom and an oxygen atom.
In this molecule, the electronegativity of oxygen is much higher as compared to that of hydrogen. Thus, the bonding electron pair of the covalent bond is attracted towards oxygen. As a result of this attraction, a partial positive electric charge is produced on oxygen and a partial negative charge is produced on the hydrogen atoms.

Solution 3.8:

Two or more molecules of any covalent compound, in any state are held together by some definite force of attraction near each other. This force of attraction is called a hydrogen bond. Hydrogen bonds hold different molecules of HF together as seen in the diagram below:

It also holds different molecules of NH_3 together.



Properties of hydrogen bonds:

1. It reduces the rate of evaporation of water at normal temperature.
2. It helps in storage of water in plant and animal cells.

Solution 3.9:

The chemical bond in the following molecules or compounds are:

1. Hydrogen – covalent bond
2. Nitrogen – covalent bond
3. Iodine – covalent bond
4. Magnesium chloride – ionic bond
5. Water – covalent bond
6. Hydrogen chloride – covalent bond
7. Oxygen – covalent bond
8. Chlorine – covalent bond
9. Sodium chloride – ionic bond
10. Sodium fluoride – ionic bond
11. Hydrogen fluoride – covalent bond
12. Potassium bromide – ionic bond