

Learning Objectives



After studying the unit, the student will be able to:

- Understand how molecules are formed and what is a chemical bond
- Explain Octet rule
- Draw Lewis dot structure of atoms
- Understand different types of bonds
- Differentiate the characteristics of ionic bond, covalent bond and coordinate bond
- Understand redox reactions
- Find out the oxidation number of different elements

Introduction

We already know that atoms are the building blocks of matter. Under normal conditions no atom exists as an independent (single) entity in nature, except Noble gases. However, a group of atoms is found to exist together as one species. Such a group of atoms is called molecule. Obviously there should be a force to keep the constituent atoms together as the thread holds the flowers together in a garland. This attractive force which holds the atoms together is called a bond.



Figure 5.1 Flowers held together by thread

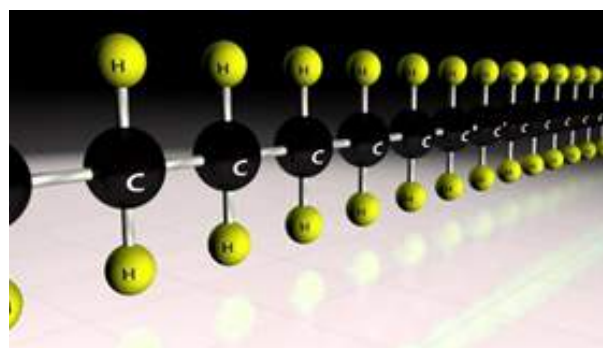


Figure 5.2 Atoms held together by bond

A Chemical bond may be defined as the force of attraction between the two atoms that binds them together as a unit called molecule.

5.1 Kossel – Lewis approach to chemical bonds

5.1.1 Octet rule

Atoms of various elements combine together in different ways to form chemical compounds. This phenomenon raised many questions.

- Why do atoms combine?
- How do atoms combine?
- Why do certain atoms combine while others do not?

To answer such questions different theories have been put forth from time to time and one of such theory which explained the formation of molecules is Kossel-Lewis theory.

Kossel and Lewis gave successful explanation based upon the concept of electronic configuration of noble gases about why atoms combine to form molecules. Atoms of noble gases have little or no tendency to combine with each other or with atoms of other elements. This means that these atoms must be having stable electronic configurations. The electronic configurations of noble gases are given in Table 5.1.

Table 5.1 The electronic configurations of noble gases

Name of the element	Atomic number	Shell electronic configuration
Helium (He)	2	2
Neon (Ne)	10	2,8
Argon (Ar)	18	2,8,8
Krypton (Kr)	36	2,8,18,8
Xenon (Xe)	54	2,8,18,18,8

Except Helium, all other noble gases have eight electrons in their valence shells. Even helium has its valence shell completely filled and hence no more electrons can be added. Thus by having stable valence electronic configuration, the noble gas atoms neither have any tendency to gain nor lose electrons and their valency is zero. They are so inert that they even do not form diatomic molecules and exist as monoatomic gaseous atoms.



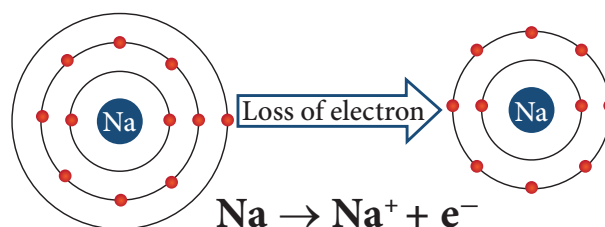
More to Know

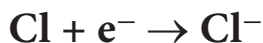
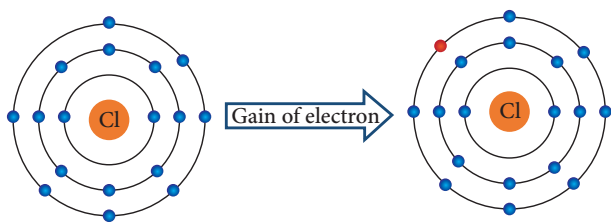
The number of electrons lost from a metal atom is the valency of the metal and the number of electrons gained by a non-metal is the valency of the non-metal

Based on the noble gas electronic configuration, Kossel and Lewis proposed a theory in 1916 to explain chemical combination between atoms and this theory is known as 'Electronic theory of valence' or Octet rule. According to this, atoms of all elements, other than inert gases, combine to form molecules because they have incomplete valence shell and tend to attain a stable electronic configuration similar to noble gases. Atoms can combine either by transfer of valence electrons from one atom to another or by sharing of valence electrons in order to achieve the stable outer shell of eight electrons.

The tendency of atoms to have eight electrons in the valence shell is known as the 'Octet rule' or the 'Rule of eight'

For example, Sodium with atomic number 11 will readily lose one electron to attain Neon's stable electronic configuration. Similarly, chlorine has electronic configuration 2,8,7. To get the nearest noble gas (i.e. argon) configuration, it needs one more electron. So chlorine readily gains one electron from other atom and obtains stable electronic configuration. Thus elements tend to have stable valence shell (eight electrons) either by losing or gaining electrons.





Which atoms tend to lose electrons?

Which are tend to gain electrons?

Atoms that have 1,2,3 electrons in their valence shell tend to lose whereas atoms having 5,6,7 valence electrons tend to gain.

Table 5.2 Unstable electronic configuration

Element	Atomic number	Electron distribution	Valence electrons
Boron	5	2, 3	3
Nitrogen	7	2, 5	5
Oxygen	8	2,6	6
Sodium	11	2, 8, 1	1

Activity 1

Write the electronic distribution of the following elements and find out whether they have stable electronic configuration.

Element	Atomic number	Electron distribution	Valence electrons	Stable	Unstable
Hydrogen	1	1	1		✓
Fluorine	9				
Krypton	36				
Xenon	54				



Walther Kossel
(1888-1956)



Gilbert N Lewis
(1875-1946)

5.2 Lewis dot structure

When atoms combine to form compounds, their valence electrons involve in bonding. Therefore, it is helpful to have a method to depict the valence electrons in the atoms. This can be done using Lewis dot symbol method. The Lewis dot structure or electron dot symbol for an atom consists of the symbol of the element surrounded by dots representing the electrons of the valence shell of the atom. The unpaired electron in the valence shell is represented by a single dot whereas the paired electrons are represented by a pair of dots.

Symbols other than dots, like crosses or circles may be used to differentiate the electrons of the different atoms in the molecule.

Table 5.3 Lewis dot structure

Element	Atomic number	Electron distribution	Valence electrons	Lewis dot structure
Hydrogen	1	1	1	H•
Helium	2	2	2	•He•
Beryllium	4	2, 2	2	•Be•
Carbon	6	2, 4	4	•C•
Nitrogen	7	2, 5	5	•N•
Oxygen	8	2,6	6	•O•

Activity 2

Write the electronic dot symbol for the following elements.

Element	Atomic number	Electron distribution	Valence electrons	Stable	Lewis dot structure
Boron					
Argon					
Chlorine					
Sodium					
Fluorine					



More to Know

Note that dots are placed one to each side of the letter symbol until all four sides are occupied. Then the dots are written two to a side until all valence electrons are accounted for. The exact placement of the single dots is immaterial.

5.3 Types of chemical bond

All the elements differ with each other in their valence shell electronic configuration. So the way in which they combine to form compounds also differs. Hence, there are different types of chemical bonding possible between atoms which make the molecules. Depending on the type of bond they show different characteristics or properties. Such types of bonding that are considered to exist in molecules are categorized as shown below. Among these, let us learn about the Ionic bond, Covalent bond and Coordinate bond in this chapter and other types of bond in the higher classes.

5.3.1 Ionic (or) Electrovalent bond

An ionic bond is a chemical bond formed by the electrostatic attraction between positive and negative ions. The bond is formed between two atoms when one or more electrons are

transferred from the valence shell of one atom to the valence shell of the other atom. The atom that loses electrons will form a cation (positive ion)

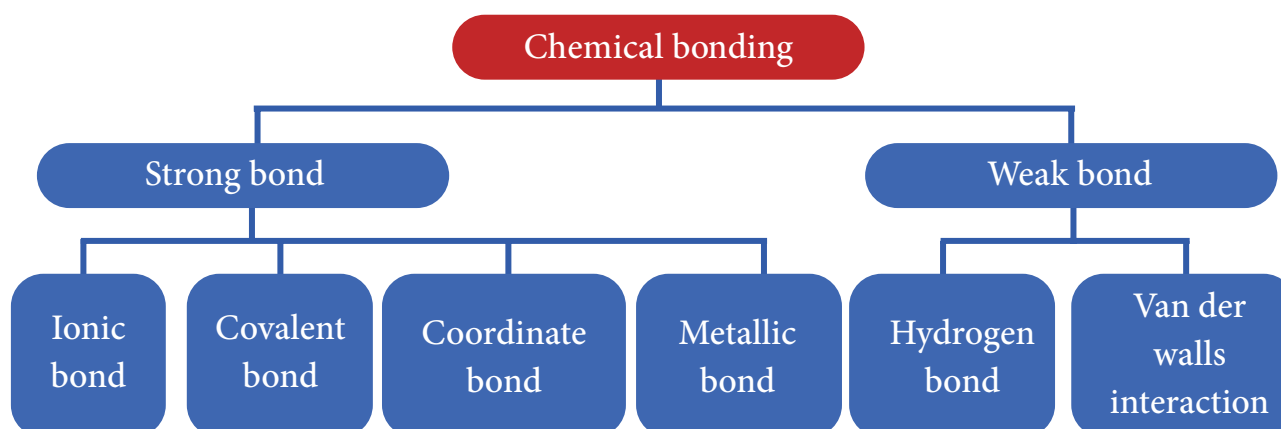


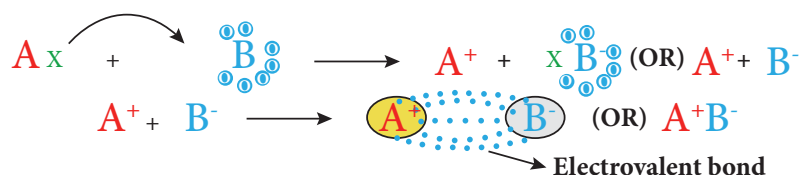
and the atom that gains electrons will form an anion (negative ion). These oppositely charged ions come closer to each other due to electrostatic force of attraction and thus form an ionic bond. As the bond is between the ions, it is called ***Ionic bond*** and the attractive forces being electrostatic, the bond is also called ***Electrostatic bond***. Since the valence concept has been explained in terms of electrons, it is also called as ***Electrovalent bond***.

Formation of ionic bond

Let us consider two atoms A and B. Let atom A has one electron in excess and atom B has one electron lesser than the stable octet electronic configuration. If atom A transfer one electron to atom B, then both the atoms will acquire stable octet electronic configuration. As the result of this electron transfer, atom A will become positive ion (cation) and atom B will become negative ion (anion). These oppositely charged ions are held together by electrostatic force of attraction which is called ***Ionic bond*** or ***Electrovalent bond***.

In general, ionic bond is formed between a metal and non-metal. The compounds





containing ionic bonds are called ionic compounds. Elements of Group 1 and 2 in periodic table, i.e. alkali and alkaline earth metals form ionic compounds when they react with non-metals.



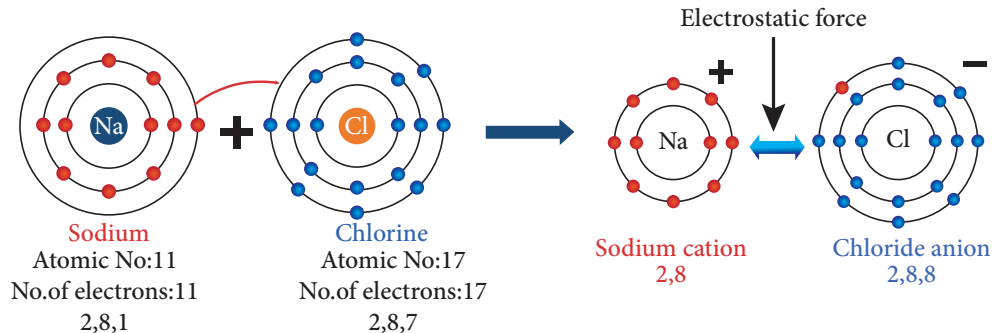
More to Know

The number of electrons that an atom of an element loses or gains to form an electrovalent bond is called its **Electrovalency**.

Illustration 1 - Formation of Sodium Chloride (NaCl)

The atomic number of Sodium is 11 and its electronic configuration is 2, 8, 1. It has one electron excess to the nearest stable electronic configuration of a noble gas - Neon. So sodium has a tendency to lose one electron from its outermost shell and acquire a stable electronic configuration forming sodium cation (Na^+).

The atomic number of chlorine is 17 and its electronic configuration is 2, 8, 7. It has one electron less to the nearest stable electronic configuration of a noble gas - Argon. So chlorine has a tendency to gain one electron to acquire a stable electronic configuration forming chloride anion (Cl^-).



When an atom of sodium combines with an atom of chlorine, an electron is transferred from sodium atom to chlorine atom forming sodium chloride molecule thus both the atoms achieve stable octet electronic configuration.



What is the most important food additive you have in your kitchen?

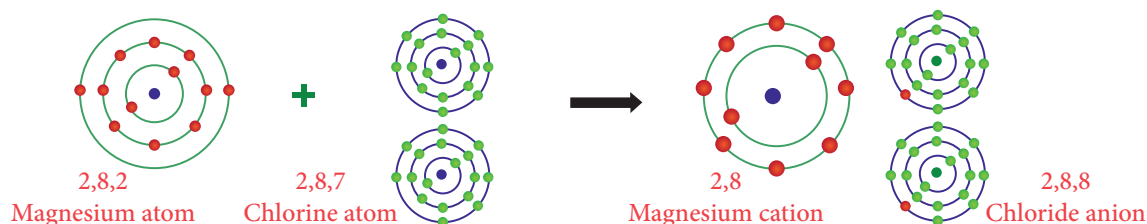


Definitely it is common salt. It is formed by the combination of a highly reactive metal called sodium and a poisonous gas called chlorine. The chemical bonding between sodium and chlorine alters the properties and makes it edible.

Illustration 2 - Formation of Magnesium Chloride (MgCl_2)

The atomic number of Magnesium is 12 and the electronic configuration is 2, 8, 2. It has two electron excess to the nearest stable electronic configuration of a noble gas - Neon. So magnesium has a tendency to lose two electrons from its outermost shell and acquire a stable electronic configuration forming magnesium cation (Mg^{2+}).





As explained earlier two chlorine atoms will gain two electrons lost by the magnesium atom forming magnesium chloride molecule (MgCl_2)

Activity 3

Try to draw the electron distribution diagram as above for the formation of Calcium Chloride (CaCl_2) molecule with the help of given data.

Element	Atomic number	Electron distribution	Valence electrons	Number of electrons lost	Number of electrons gained	Formed Cation / Anion
Calcium	20					
Chlorine	17					

Practice:

Draw the diagram to represent the bonding in the following ionic compounds.

- Magnesium fluoride (MgF_2)
- Calcium oxide (CaO)
- Lithium chloride (LiCl)

Characteristics of Ionic compounds

The nature of bonding between the atoms of a molecule is the primary factor that determine the properties of compounds. By this way, in ionic compounds the atoms are held together by a strong electrostatic force that makes the compounds to have its characteristic features as follows:

a. Physical state – These compounds are formed because of the strong electrostatic force between cations and anions which are arranged in a well-defined geometrical pattern. Thus Ionic compounds are crystalline solids at room temperature.

b. Electrical conductivity – Ionic compounds are crystalline solids and so their ions are tightly held together. The ions, therefore, cannot move freely, so they do not conduct electricity in solid state. However, in molten state and their aqueous solutions conduct electricity.

c. Melting point–the strong electrostatic force between the cations and anions hold the ions tightly together, so very high energy is required to separate them. Hence ionic compounds have high melting and boiling points.

d. Solubility – Ionic compounds are soluble in polar solvents like water. They are insoluble in non-polar solvents like benzene (C_6H_6), carbon tetra chloride (CCl_4).

e. Density, hardness and brittleness–Ionic compounds have high density and they are quite hard because of the strong electrostatic force between the ions. But they are highly brittle.

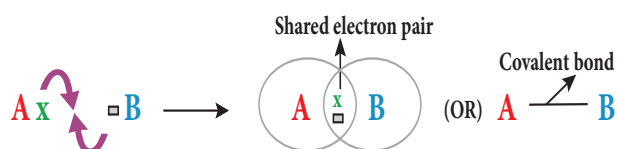
f. Reactions – Ionic compounds undergo ionic reactions which are practically rapid and instantaneous.

5.3.2 Covalent bond

Atoms can combine with each other by sharing the unpaired electrons in their outermost shell. Each of the two combining atoms contributes one electron to the electron pair which is needed for the bond formation and has equal claim on the shared electron pair. According to Lewis concept when two atoms form a covalent bond between them, each of the atoms attains the stable electronic configuration of the nearest noble gas. Since the covalent bond is formed because of the sharing of electrons which become common to both the atoms, it is also called as *Atomic bond*.

Formation of Covalent bond

Let us consider two atoms A and B. Let atom A has one valence electron and atom B has seven valence electrons. As these atoms approach nearer to each other, each atom contributes one electron and the resulting electron pair fills the outer shell of both the atoms. Thus both the atoms acquire a completely filled valence shell electronic configuration which leads to stability.



More to Know

Covalent bonds are of three types:

1. Single covalent bond represented by a line (—) between the two atoms. Eg. H—H
2. Double covalent bond represented by a double line (=) between the two atoms. Eg. O=O
3. Triple covalent bond represented by a triple line (\equiv) between the two atoms. Eg. N \equiv N

Illustration 1 – Formation of hydrogen molecule (H₂)

Hydrogen molecule is formed by two hydrogen atoms. Each having one valence electron (1s¹), it is contributed to the shared pair and both atoms acquire stable completely filled electronic configuration.

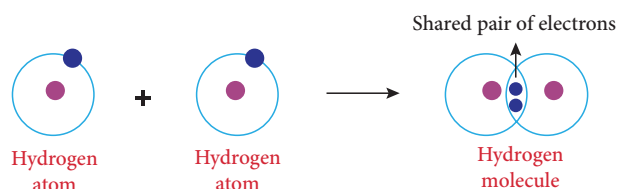
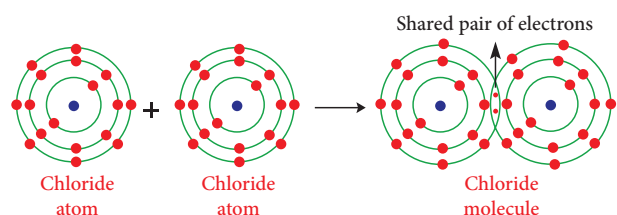


Illustration 2 – Formation of chlorine molecule (Cl₂)

Chlorine molecule is formed by two chlorine atoms. Each chlorine atom has seven valence electrons (2,8,7). These two atoms achieve a stable completely filled electronic configuration (octet) by sharing a pair of electrons.



Activity 4

Try to draw the electron distribution diagram as above for the formation of Fluorine (F₂) molecule with the help of given data.

Element	Atomic number	Electron distribution
Fluorine	9	2, 7

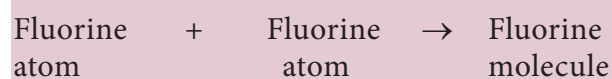


Illustration 3 – Formation of methane molecule (CH₄)

Methane molecule is formed by the combination of one carbon and four hydrogen atoms. The carbon atom has four valence electrons (2, 4). These four electrons are shared with four atoms of hydrogen to achieve a stable electronic configuration (octet) by sharing a pair of electrons.

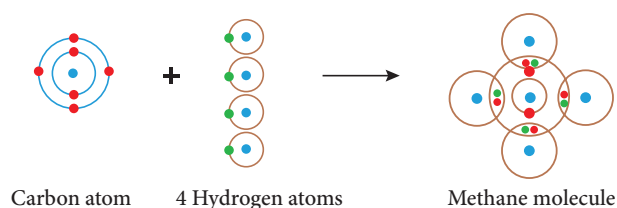
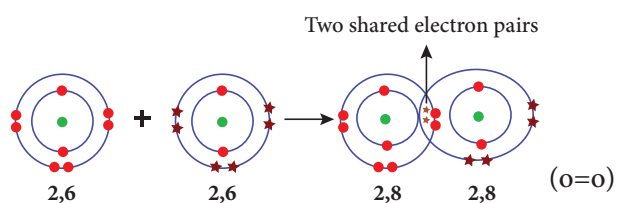


Illustration 4 – Formation of oxygen molecule (O₂)

Oxygen molecule is formed by two oxygen atoms. Each oxygen atom has six valence electrons (2, 6). These two atoms achieve a stable electronic configuration (octet) by sharing two pair of electrons. Hence a double bond is formed in between the two atoms.



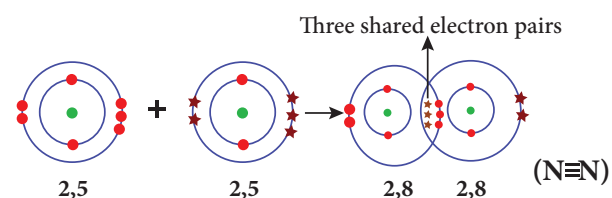
Practice:

Draw the diagram to represent the bonding in the following covalent compounds.

1. Carbon tetrachloride (CCl₄)
2. Carbon di oxide (CO₂)
3. Water (H₂O)
4. Ammonia (NH₃)

Illustration 5 – Formation of nitrogen molecule (N₂)

Nitrogen molecule is formed by two nitrogen atoms. Each nitrogen atom has five valence electrons (2, 5). These two atoms achieve a stable completely filled electronic configuration (octet) by sharing three pair of electrons. Hence a triple bond is formed in between the two atoms.



Characteristics of Covalent compounds

As said earlier, the properties of compounds depend on the nature of bonding between their constituent atoms. So the compounds containing covalent bonds possess different characteristics when compared to ionic compounds.

a. Physical state – Depending on force of attraction between covalent molecule the bond may be weaker or stronger. Thus covalent compounds exist in gaseous, liquid and solid form. Eg. Oxygen-gas; Water-liquid; Diamond-solid.

b. Electrical conductivity – Covalent compounds do not contain charged particles (ions), so they are bad conductors of electricity.

c. Melting point – Except few covalent compounds (Diamond, Silicon carbide), they have relatively low melting points compared to Ionic compounds.

d. Solubility – Covalent compounds are readily soluble in non-polar solvents like benzene (C₆H₆), carbon tetra chloride (CCl₄). They are insoluble in polar solvents like water.

e. **Hardness and brittleness** – Covalent compounds are neither hard nor brittle. But they are soft and waxy.

f. **Reactions** – Covalent compounds undergo molecular reactions in solutions and these reactions are slow.

Activity 5

Take a glass of water and add a spoon of sugar. Take another glass of coconut oil and add a spoon of sugar. Observe the difference in solubility in these two and try to find out the reason with the help of your teacher.



More to Know

Polar solvents contain bonds between atoms with very different electronegativities, such as oxygen and hydrogen. Ionic compounds are soluble in polar solvents. Ex: water, ethanol, acetic acid, ammonia

Non polar solvents contain bonds between atoms with similar electronegativities, such as carbon and hydrogen. Covalent compounds are soluble in non-polar solvents. Ex: acetone, benzene, toluene, turpentine

Fajan's Rule:

As we know, a metal combine with a non-metal through ionic bond. The compounds so formed are called ionic compounds. A compound is said to be ionic when the charge of the cation and anion are completely separated. But in 1923, Kazimierz Fajans found, through his X-Ray Crystallographic studies, that some of the ionic compounds show covalent character. Based on this, he formulated a set rules to predict whether a chemical bond is ionic or covalent. Fajan's rules are formulated by considering the charge of the cation and the relative size of the cation and anion.

- When the size of the cation is small and that of anion is large, the bond is of more covalent character
- Greater the charge of the cation, greater will be the covalent character

This can be summarized as follows:

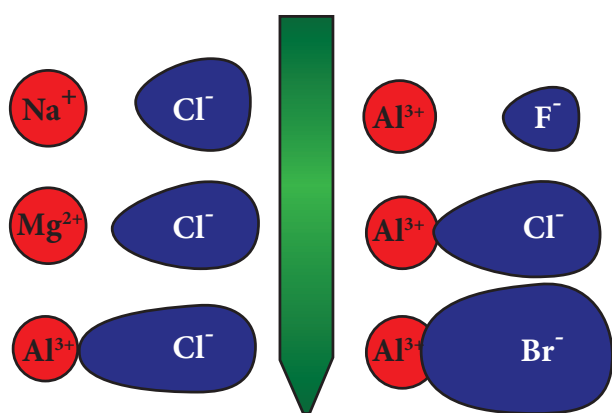
Ionic	Covalent
Low positive charge	High positive charge
Large cation	Small cation
Small anion	Large anion

Table 5.4 Difference between Ionic and Covalent compounds

Ionic Compounds	Covalent Compounds
Formed by the transfer of electrons from a metal to a non-metal atom	Formed by sharing of electrons between non-metal atoms
Strong electrostatic force of attraction between cations and anions	Mutual sharing of electrons and so weak force of attraction between atoms
Solids at room temperature	Gases, liquids and soft solids
Conducts electricity in molten state or in solutions	Non-conductors of electricity
Have high melting and boiling points	Have low melting and boiling points
Soluble in polar solvents	Soluble in non-polar solvents
Hard and brittle	Soft and waxy
Undergo ionic reaction which are fast and instantaneous	Undergo molecular reactions which are slow

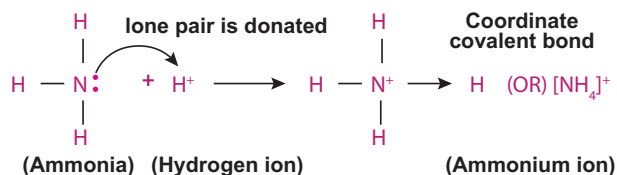


For example, in sodium chloride, low positive charge (+1), a fairly large cation and relatively small anion make the charges to separate completely. So it is ionic. In aluminium triiodide, higher is the positive charge (+3), larger is the anion and thus no complete charge separation. So is covalent. The following picture depicts the relative charge separation of ionic compounds:



5.3.3 Coordinate covalent bond

In the formation of normal covalent bond each of the two bonded atoms contribute one electron to form the bond. However, in some compounds the formation of a covalent bond between two atoms takes place by the sharing of two electrons, both of which comes from only one of the combining atoms. This bond is called



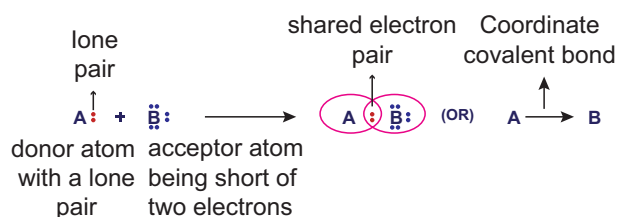
Coordinate covalent bond or Dative bond.

Mostly the lone pair of electrons from an atom in a molecule may be involved in the dative bonding. The atom which provides the electron pair is called **donor atom** while the

other atom which accepts the electron pair is called **acceptor atom**. The Coordinate covalent bond is represented by an arrow (\rightarrow) which points from the donor to the acceptor atom.

Formation of Coordinate covalent bond

Let us consider two atoms A and B. Let atom A has an unshared lone pair of electrons and atom B is in short of two electrons than the octet in its valence shell. Now atom A donates its lone pair while atom B accepts it. Thus the lone pair of electrons originally belonged to atom A are now shared by both the atoms and the bond formed by this mutual sharing is called Coordinate covalent bond. ($A \rightarrow B$)



Examples (NH_4^+ , $\text{NH}_3 \rightarrow \text{BF}_3$)

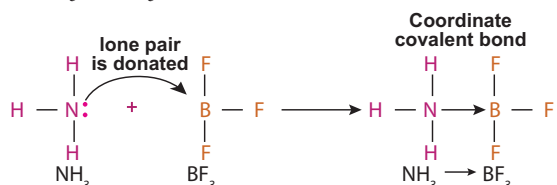
Illustration 1 - Formation of coordinate covalent bond in ammonium ion (NH_4^+)

Ammonium ion is formed by one ammonia (NH_3) molecule and one hydrogen (H^+) ion. In ammonia molecule the central nitrogen atom has five valence electrons (2,5) among which three electrons are shared with three hydrogen atoms and still it has an unshared lone pair of electrons. This lone pair electrons are donated to a Hydrogen ion and thus a $\text{N} \rightarrow \text{H}$ coordinate covalent bond is formed in ammonium ion molecule (NH_4^+)

Illustration 2 - Formation of coordinate covalent bond between $\text{NH}_3 \rightarrow \text{BF}_3$ molecules

In some cases, the donated pair of electrons comes from a molecule as a whole which is already formed to another acceptor

molecule. Here the molecule ammonia (NH_3) gives a lone pair of electrons to Boron tri fluoride (BF_3) molecule which is electron deficient. Thus a Coordinate covalent bond is formed between NH_3 (donor molecule) and BF_3 (acceptor molecule) and is represented by $\text{NH}_3 \rightarrow \text{BF}_3$.



Characteristics of coordinate covalent compounds

The compounds containing coordinate covalent bonds are called coordinate compounds.

a. Physical state – These compounds exist as gases, liquids or solids.

b. Electrical conductivity – Like covalent compounds, coordinate compounds also do not contain charged particles (ions), so they are bad conductors of electricity.

c. Melting point – These compounds have melting and boiling points higher than those of purely covalent compounds but lower than those of purely Ionic compounds.

d. Solubility – Insoluble in polar solvents like water but are soluble in non-polar solvents like benzene, CCl_4 , and toluene.

e. Reactions – Coordinate covalent compounds undergo molecular reactions which are slow.

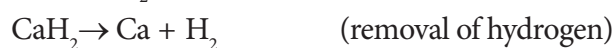
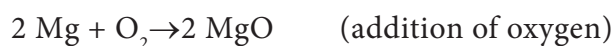
5.4 Oxidation, Reduction and Redox reactions

Look at the following pictures. When an apple is cut and left for sometimes, its surface turns brown. Similarly, iron bolts and nuts in

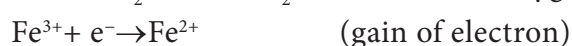
metallic structures get rusted. Do you know why are these happening? It is because of a reaction called oxidation.



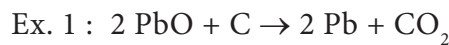
Oxidation: A chemical reaction which involves addition of oxygen or removal of hydrogen or loss of electrons is called oxidation.



Reduction: A chemical reaction which involves addition of hydrogen or removal of oxygen or gain of electrons is called reduction.



Redox reactions: Generally, the oxidation and reduction occurs in the same reaction (simultaneously). If one reactant gets oxidised, the other gets reduced. Such reactions are called oxidation-reduction reactions or Redox reactions.



Oxidation (LEO)	addition of Oxygen
	removal of Hydrogen
	loss of electron
Reduction (GER)	removal of Oxygen
	addition of Hydrogen
	gain of electron

Activity 6

Take about one gram of copper powder in a china dish. Place the dish on a tripod stand with wire gauze and heat the copper powder using a Bunsen burner. Is there any change in colour?

Yes, the brown copper turns into black. This is because of the formation of copper oxide. Copper when heated reacts with atmosphere oxygen forming black Copper oxide.

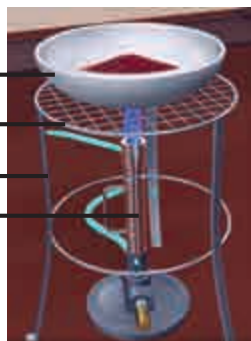


China dish contain
with copper powder

Wire Gauze

Tripod Stand

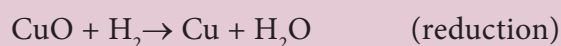
Bunsun Burner



Activity 7

Take the copper oxide obtained from the above activity and pass hydrogen gas over the hot CuO and observe the change in colour. Is there any change in colour?

Yes, the black colour slowly turns into brown. This is because copper oxide loses oxygen to form copper.

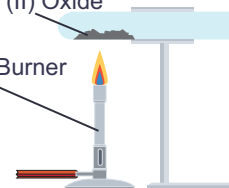


You can also watch the YouTube videos in the below link to know about this reaction.
<https://www.youtube.com/watch?v=tEwp2fi1mpI>

<https://youtu.be/gJWZ8nHn59Y>

Copper (II) Oxide

Bunsen Burner



Oxidising agents and Reducing agents

Substances which have the ability to oxidise other substances are called Oxidising agents. These are also called as electron acceptors because they remove electrons from other substances.

Example: H_2O_2 , MnO_4^- , CrO_3 , $\text{Cr}_2\text{O}_7^{2-}$

Substances which have the ability to reduce other substances are called Reducing agents. These are also called as electron donors because they donate electrons to other substances.

Example: NaBH_4 , LiAlH_4 and metals like Palladium, Platinum.

Oxidation reactions in daily life:

In nature the oxygen present in atmospheric air oxidises many things, starting from metals to living tissues.

- The shining surface of metals tarnishes due to the formation of respective metal oxides on their surfaces. This is called corrosion.
- The freshly cut surfaces of vegetables and fruits turns brown after some time because of the oxidation of organic compounds present in them.
- The oxidation reaction in food materials that were left open for a long period is responsible for spoiling of food. This is called Rancidity.

Oxidation number

Oxidation number of an element is defined as the formal charge which an atom of that element appears to have when electrons are counted.



More to Know

Painting, oiling, greasing, galvanising and alloying are some of the methods to prevent corrosion.

- The spoilage of food can be prevented by adding preservatives like Vitamin C and Vitamin E.
- Keeping food in air tight containers helps to slow down the oxidation process. Also filling the pouch with Nitrogen gas will remove oxygen like in potato chips bags.

Oxidation number also called Oxidation state, the total number of electrons that an atom either gains or losses in order to form a chemical bond with another atom. The sum of oxidation numbers of all the atoms in the formula for a neutral compound is ZERO. The sum of oxidation numbers of an ion is the same as the charge on that ion. Negative oxidation number in compounds of two unlike atoms is assigned to the more electronegative atom.



More to Know

Electronegativity is the tendency of an atom in a molecule to attract towards itself the shared pair of electrons.

For example,

- Oxidation number of K and Br in KBr molecule is +1 and -1 respectively.
- Oxidation number of N in NH_3 molecule is -3
- Oxidation number of H is +1 (except hydrides)
- Oxidation number of oxygen in most cases is -2

(Oxidation Number = ON)



More to Know

One of the most valuable metals Gold has high resistance to corrosion.

Problems on determination of Oxidation Number

ON of neutral molecule is always zero

Illustration 1 – Oxidation Number of H and O in H_2O

Let us take ON of H = +1 and ON of O = -2

$$2 \times (+1) + 1 \times (-2) = 0$$

$(+2) + (-2) = 0$ thus, ON of H is +1 and ON of O is -2

Illustration 2 – Oxidation Number of Na and Cl in NaCl

ON of Na = +1 and ON of Cl = -1

$(+1) + (-1) = 0$ thus, ON of Na is +1 and ON of Cl is -1

Illustration 3 – Oxidation Number of S in H_2SO_4

Let ON of S be (x) and we know ON of H = +1 and O = -2

$$2 \times (+1) + (x) + 4 \times (-2) = 0$$

$$(+2) + (x) + (-8) = 0$$

$(x) = +6$ therefore, ON of S is +6

Illustration 4 – Oxidation Number of Cr in $\text{K}_2\text{Cr}_2\text{O}_7$

Let ON of Cr be x and we know ON of K = +1 and O = -2

$$2 \times (+1) + 2 \times (x) + 7 \times (-2) = 0$$

$$(+2) + (2x) + (-14) = 0$$

$$2x = +12$$

$x = +6$ therefore, ON of Cr in $\text{K}_2\text{Cr}_2\text{O}_7$ is +6

Illustration 5 – Oxidation Number of Fe in FeSO_4

Let ON of Fe be x and we know ON of S = +6 and O = -2

$$(x) + 1 \times (+6) + 4 \times (-2) = 0$$

$$(x) + (+6) + (-8) = 0$$

$x = +2$ therefore, ON of Fe in FeSO_4 is +2

Problems:

1. Find the oxidation number of Mn in KMnO_4
2. Find the oxidation number of Cr in $\text{Na}_2\text{Cr}_2\text{O}_7$
3. Find the oxidation number of Cu in CuSO_4
4. Find the oxidation number of Fe in FeO

Points to remember

- Kossel and Lewis gave explanation based upon the concept of electronic configuration of noble gases about why atoms combine to form molecules.
- Having stable valence electronic configuration, the noble gas atoms neither have any tendency to gain nor lose electrons.
- Kossel and Lewis proposed a theory in 1916 to explain chemical combination between atoms and this theory is known as 'Electronic theory of valence' or Octet rule.
- The Lewis dot structure or electron dot symbol for an atom consists of the symbol of the element surrounded by dots representing the electrons of the valence shell of the atom.
- There are different types of chemical bonding possible between atoms which

make the molecules. Depending on the type of bond they show different characteristics or properties.

- An ionic bond is formed by the electrostatic attraction between positive and negative ions. It is also called as Electrovalent bond.
- The covalent bond is formed because of the sharing of electrons which become common to both the atoms. It is also called as Atomic bond.
- In some compounds the formation of a covalent bond between two atoms takes place by the sharing of two electrons, both of which comes from only one of the combining atoms. This bond is called Coordinate covalent bond or Dative bond.
- Substances which have the ability to oxidise other substances are called Oxidising agents. These are also called as electron acceptors because they remove electrons from other substances.
- Substances which have the ability to reduce other substances are called Reducing agents. These are also called as electron donors

A-Z GLOSSARY

Chemical bond	the force of attraction between the two atoms that binds them together as a unit called molecule.
Octet rule or Rule of eight	The tendency of atoms to have eight electrons in the valence shell
Strong bonds	Ionic bond, Covalent bond, Coordinate covalent bond, Metallic bond
Weak bonds	Hydrogen bond, Van der Waals interactions
Ionic / Electrovalent bond	Bond formed between cation and anion because of the transfer of electrons from one atom to other atom
Covalent bond	Bond formed between atoms by the mutual sharing of electrons
Coordinate covalent bond	Bond formed between atoms by mutual sharing of electrons which are supplied by one atom
Oxidation	chemical reaction which involves in the addition of oxygen or removal of hydrogen or loss of electrons

**Reduction**

chemical reaction which involves in the addition of hydrogen or removal of oxygen or gain of electrons

Redox reaction

oxidation and reduction occurs in the same reaction simultaneously

Oxidising agents

Substances which have the ability to oxidise other substances

Reducing agents

Substances which have the ability to reduce other substances

Oxidation number

the formal charge which an atom has when electrons are counted

**TEXT BOOK EXERCISES****I. Choose the correct answer:**

- Number of valence electrons in carbon is
a) 2 b) 4 c) 3 d) 5
- Sodium having atomic number 11, ready to _____ electron/ electrons to attain the nearest Noble gas electronic configuration.
a) gain one b) gain two
c) lose one d) lose two
- Atoms having 1,2 or 3 electrons in its valence shell will readily form _____
a) cation b) anion
- The element that would form anion by gaining electrons in a chemical reaction is _____
a) Potassium b) Calcium
c) Fluorine d) Iron
- Bond formed between a metal and non metal atom is usually _____
a) ionic bond b) covalent bond
c) coordinate bond
- _____ compounds have high melting and boiling points.
a) Covalent b) Coordinate c) Ionic
- Covalent bond is formed by _____

- transfer of electrons
- sharing of electrons
- sharing a pair of electrons



- Oxidising agents are also called as _____ because they remove electrons from other substances.
a) electron donors b) electron acceptors
- Elements with stable electronic configurations have eight electrons in their valence shell. They are ____
a) Halogens b) Metals
c) Noble gases d) non metals

II. Answer in brief

- How do atoms attain Noble gas electronic configuration.
- CCl_4 is insoluble in water but NaCl is soluble in water. Give reason.
- Explain Octet rule with an example.
- Write a note on different types on bonds?
- Find the odd one out.
 - H_2 , Cl_2 , NaCl , O_2 , N_2
 - H_2O_2 , MnO_4^- , LiAlH_4 , $\text{Cr}_2\text{O}_7^{2-}$
- Correct the wrong statements.
 - Ionic compounds dissolve in non polar solvents

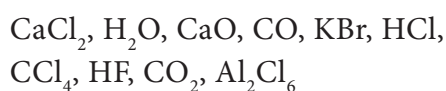
- b. Covalent compounds conduct electricity in molten or solution state.

7. Complete the table give below.

Element	Atomic number	Electron distribution	Valence electrons	Lewis dot structure
Lithium	3			
Boron	5			
Oxygen	8			

8. Draw the electron distribution diagram for the formation of Carbon di oxide (CO₂) molecule.

9. Fill in the following table according to the type of bonds formed in the given molecule.



Ionic bond	Covalent bond	Coordinate covalent bond

10. Choose the correct answer form the choices given below.

The property which is characteristics of an Ionic compound is that

- it often exists as gas at room temperature
- it is hard and brittle
- it undergoes molecular reactions
- it has low melting point

11. Identify the following reactions as oxidation or reduction

- $\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$
- $\text{Fe}^{3+} + 2 \text{e}^- \rightarrow \text{Fe}^+$

12. Identify the compounds as Ionic/ Covalent/Coordinate based on the given characteristics.

- Soluble in non polar solvents -
- undergoes faster/instantaneous reactions -
- Non conductors of electricity -
- Solids at room temperature -

13. An atom X with atomic number 20 combines with atom Y with atomic number 8. Draw the dot structure for the formation of the molecule XY.

14. Considering MgCl₂ as ionic compound and CH₄ as covalent compound give any two differences between these two compounds.

15. Why are Noble gases inert in nature?

III. Answer in detail

- List down the differences between Ionic and Covalent compounds.
- Give an example for each of the following statements.
 - a compound in which two Covalent bonds are formed
 - a compound in which one ionic bond is formed
 - a compound in which two Covalent and one Coordinate bonds are formed
 - a compound in which three covalent bonds are formed
 - a compound in which Coordinate bond is formed
- Identify the incorrect statement and correct them.
 - Like covalent compounds, Coordinate compounds also contain charged particles (ions), so they are good conductors of electricity.
 - Ionic bond is a weak bond when compared to Hydrogen bond.



- c. Ionic or electrovalent bonds are formed by mutual sharing of electrons between atoms.
- d. Loss of electrons is called Oxidation and Gain of electron is called Reduction.
- e. The electrons which are not involved in bonding are called valence electrons.
4. Discuss in brief about the properties of Coordinate covalent compounds.
5. Find the oxidation number of the elements in the following compounds.
- C in CO_2
 - Mn in MnSO_4
 - N in HNO_3

IV. LIFE SKILLS - Debate

Divide the class into groups. Debate on the following statement.

“Sharing and caring improves human harmony like Chemical bond”

- ionic bond
- covalent bond
- coordinate bond

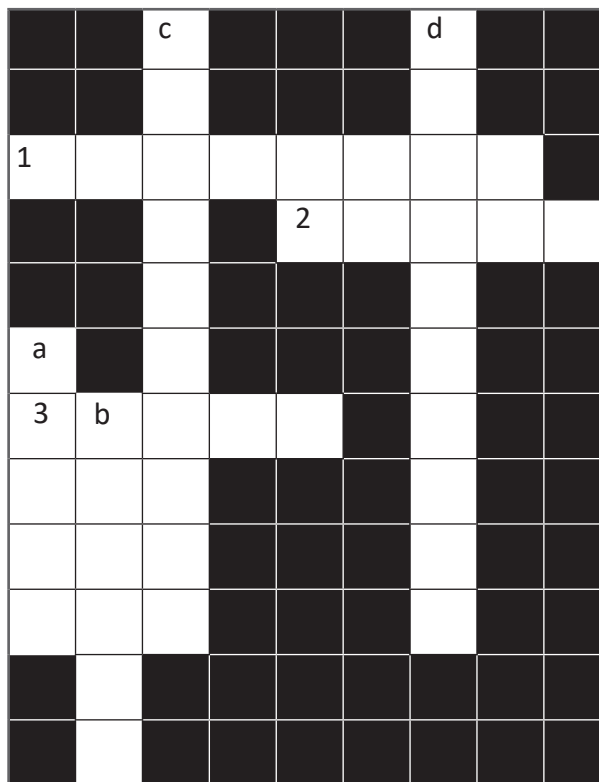
V. Complete the crossword using the clues.

Left to right:

- pair of electrons which do not take part in bond formation
- reaction in which both oxidation and reduction takes place
- rule which says about eight electrons in outermost shell

Top to bottom:

- bond formed by transfer of electrons from one atom to another
- ion with positive charge
- energy required to remove the most loosely bound electron from an isolated gaseous atom of an element
- loss of electron
(lonepair, redox, octet, ionic, cation, ionisation, oxidation)



REFERENCE BOOKS

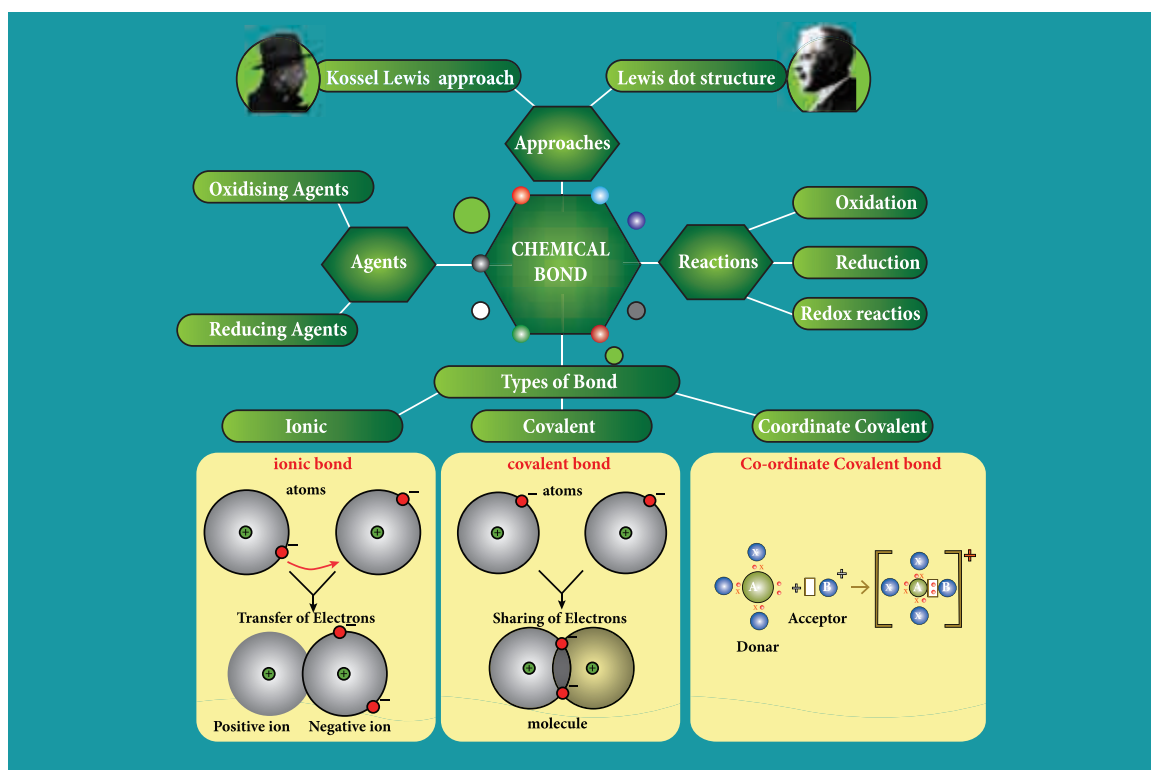
- Modern Inorganic Chemistry – by R.D.Madan
- Textbook of Inorganic Chemistry – by Soni, P.L. and Mohan Katyal.



INTERNET RESOURCES

- <https://youtu.be/G08rZ6xiIuA>
- <https://youtu.be/LkAykOv1foc>
- <https://youtu.be/DEdRcfyYnSQ>





ICT CORNER

Chemical Bonding

Explore this activity to know about the various types of Chemical bonding in compounds and to learn chemical formulae.



Steps

- Copy and paste the link given below or type the URL in the browser.
- In the Simulations section, scroll down and select Ionic & Covalent Bonding option.
- Select any two elements which are highlighted in the periodic table.
- Once selected, two options called Ionic Bond or Covalent Bond will appear. In it, click any one of the options to find number of atoms option. Select the numbers and submit the answers to verify.



Step1



Step2



Step3



Step4

Browse in the link:

URL: <https://teachchemistry.org/periodical/simulations> or Scan the QR Code.

*Pictures are indicative only



B467_SCI_9_T2_EM