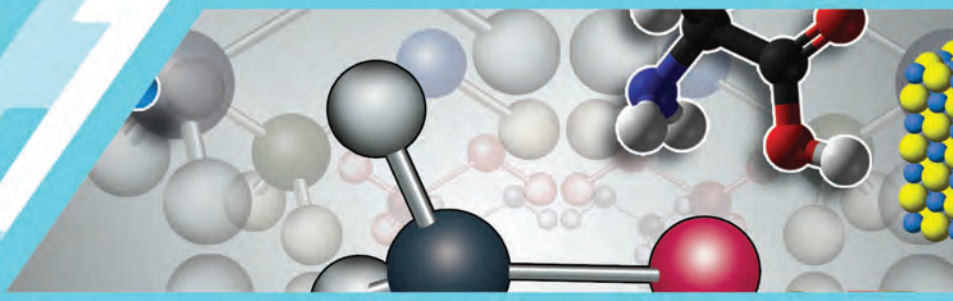


3 Chemical Bonding

Children were amazed to see pictures of different types of molecules at the science exhibition. So many atoms held together like beads strung in a necklace!

In the same way, atoms and molecules are arranged in an interconnected manner in our body and the various substances in our surroundings. Do you know why atoms and molecules are thus connected to one another in elements and compounds? Have you ever thought about it?

It is the force of attraction between the constituent particles of matter that holds them together. Let us learn about these forces that hold atoms and molecules together, and also how to write the chemical formulae of compounds.

Some substances are given below. Differentiate them into elements and compounds, and list them.

Potassium, oxygen, water, common salt, nitrogen, helium, hydrogen, sugar

Element	Compound
Potassium	Water
.....	.....
.....	.....
.....	.....
.....	.....

Table 3.1

You know that there are two atoms in one molecule of hydrogen. If so, how many atoms are there in each substance given below?

Molecule	Number of atoms
Oxygen (O_2)	2
Water (H_2O)	3
Nitrogen (N_2)	.....
Helium (He)	.....
Methane (CH_4)	.....
Sugar ($C_{12}H_{22}O_{11}$)	.....

Table 3.2

It can be understood from Table 3.2 that some molecules have more than one atom.

- Why do atoms in a molecule stay together?
- Why do atoms combine to form molecules?
- How do atoms combine?
- Do all atoms combine in the same way?
- Do all atoms combine with other atoms?

Have you ever thought about such things? How many atoms are there in a molecule of noble gases?

.....

Generally, they do not combine with other atoms. Try to find out the reason for this by observing the table given below.

Element (Symbol)	Atomic number	Electron 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
Radon (Rn)	86	2,8,18,32,18,8

Table 3.3

- How many electrons are there in the outermost shell of noble gases except helium?

.....

The arrangement of eight electrons in the outermost shell, as in noble gases, is known as octet configuration.

Atoms with octet configuration in the outermost shell are found to be more stable. Such atoms are generally reluctant to participate in chemical reactions. Therefore, noble gases are also called inert gases.

The atomic number of helium is 2. The maximum number of electrons that can be accommodated in the first shell of helium is also 2. Therefore, the duplet configuration of helium is stable like that of the other noble gases.

Observe the electron configuration of magnesium and oxygen in Table 3.4 given below.

Element	Atomic number	Electron configuration
Magnesium	12	2,8,2
Oxygen	8	2, 6

Table 3.4

- Are these atoms stable?
- How can they attain stability?
- What is the name of the compound formed when these atoms combine together?

When magnesium and oxygen combine to form magnesium oxide, by means of chemical bonding, the atoms get stability by attaining octet configuration.

The force of attraction that holds together the constituent particles of a compound is called a chemical bond.

Ionic Bond

You have learned that the chemical name of table salt is sodium chloride. Let us examine the chemical bond in sodium chloride.

- What are the constituent elements of sodium chloride?

  .....

- Write the electron configuration of sodium atom (atomic number -11)

  .....

- How many electrons are there in the outermost shell of a sodium atom?

  .....

- How does the sodium atom attain octet electron configuration?

  .....

Examine the chemical equation and the illustration (Figure 3.1) of the formation of sodium ion by the removal of one electron from sodium atom.

$$Na \rightarrow Na^{+} + 1e^{-}$$

The outermost electron can be removed from the sodium atom only by overcoming the attractive force of the nucleus. The energy required for this is the ionisation energy or ionisation enthalpy.

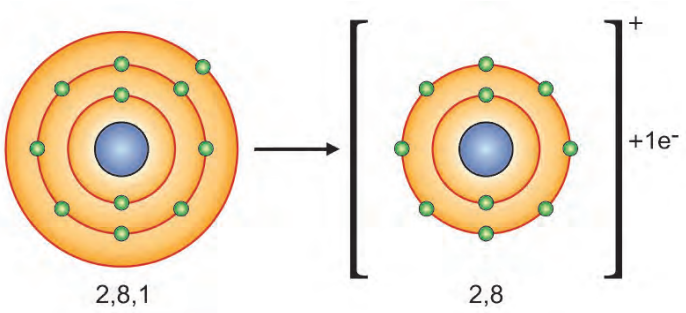


Fig. 3.1

The amount of energy required to remove the most loosely bound electron from the outermost shell of an isolated gaseous atom of an element is called its ionisation energy.

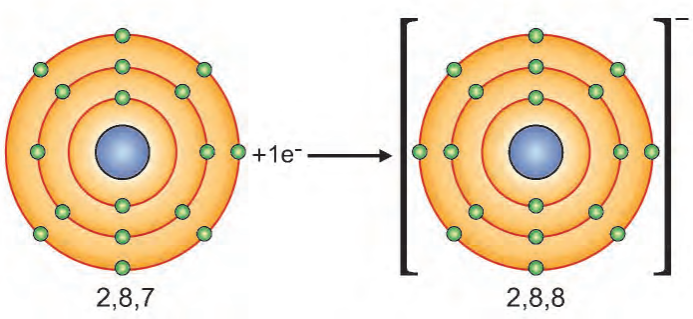
- Write the electron configuration of a chlorine atom (atomic number -17).

.....

- How many electrons are needed for the chlorine atom to attain octet electron configuration?

.....

Note the illustration (Figure 3.2) and the chemical equation given below. Here, a chlorine atom accepts an electron to become a chloride ion.



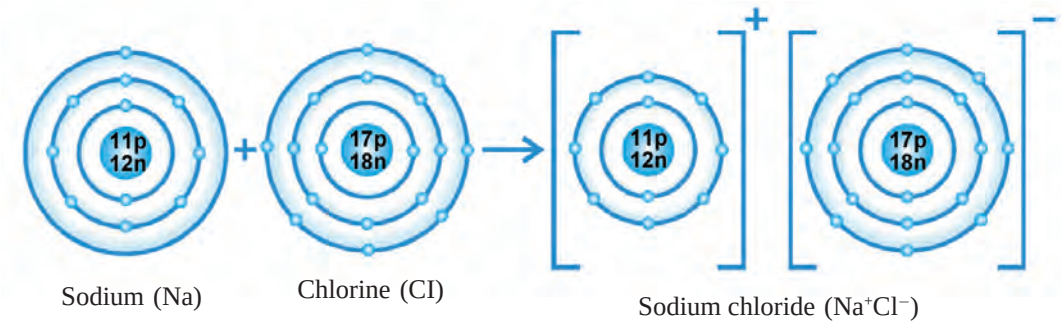
$$Cl + le^{-} \rightarrow C1^{-}$$

Fig. 3.2

Energy is released when atoms become negative ions by accepting electrons. This energy difference is called electron gain enthalpy.

> Electron gain enthalpy is the energy released when an electron is added to a neutral gaseous atom to form a negative ion.

Analyse the illustration (Figure 3.3) regarding electron transfer and the arrangement of electrons in shells in each atom during the formation of sodium chloride.



Sodium (Na) Chlorine (CI) Sodium chloride (Na^+Cl^-)

Fig. 3.3

Construct the molecular structure of NaCl using Ghemical software.

Note the formation of sodium ion (Na^+) from sodium atom and chloride ion (Cl^-) from chlorine atom after the chemical reaction.

Electron Dot Diagram

The method of representing electrons of the outermost shell using dots around the symbol of an element was first introduced by the chemist Gilbert N. Lewis. Cross symbols are also used instead of dots. Only valence electrons are marked around the symbol of an element.

You know that the electron configuration of sodium is 2, 8, 1 and that of chlorine is 2, 8, 7.

Note the electron dot diagram of sodium atom given below.

Represent the electron dot diagram of chlorine atom.

.....

Note the electron dot diagram of the formation of sodium chloride.

Fig. 3.4

Analyse the electron dot diagram (Figure 3.4) of the formation of sodium chloride and the illustration (Figure 3.3) showing the arrangement of electrons in shells during the formation of sodium chloride. Complete Table 3.5 and record it in your science diary.

Gilbert Newton Lewis

(1875-1946)

Gilbert Newton Lewis, a physical chemist, was the Dean of the University of California. The concepts of electron pair and covalent bond was proposed by him. Electron dot formula of atoms and molecules was his contribution. He made numerous contributions to various fields such as chemical thermodynamics, photochemical reactions and isolation of isotopes. His major research areas were relativity and quantum physics. He formulated the definitions of acids and bases. He coined the term 'photon' for the smallest unit of radiant energy.

	Sodium		Chlorine	
	Before chemical reaction	**After chemical reaction**	**Before chemical reaction**	**After chemical reaction**
Electron configuration				
Number of electrons				
Number of protons				
Charge				

Table 3.5

Note the equation of the electron transfer during the formation of sodium chloride.

$$Na \rightarrow Na^{+} + 1e^{-}$$

$$Cl + 1e^{-} \rightarrow Cl^{-}$$

During the formation of sodium chloride, sodium atom donates an electron and gets converted to sodium ion (Na^+). Chlorine atom accepts an electron to form chloride ion (Cl^-). The positive ions formed by losing electrons during chemical reactions are called cations and the negative ions formed by accepting electrons are called anions. In sodium chloride, the sodium ion and chloride ion are held together by an ionic bond. The electrostatic force of attraction between the oppositely charged ions in an ionic compound is responsible for keeping them together.

The electrostatic force of attraction that holds together the oppositely charged ions in an ionic compound is called ionic bond. Ionic bond is also known as electrovalent bond.

You might have seen the burning of magnesium ribbon in air. What is the compound formed here?

Note the given chemical equation for the chemical reaction that has happened.

$$2Mg + O_2 \rightarrow 2MgO$$

The electron dot diagram of the formation of magnesium oxide is given below (Figure 3.5). Examine the figure and complete the table (Table 3.6).

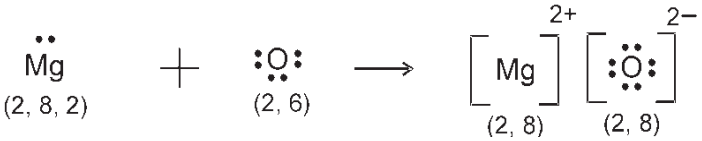


Fig. 3.5

	Magnesium (Atomic number -12)		Oxygen (Atomic number – 8)	
	Before chemical reaction	**After chemical reaction**	**Before chemical reaction**	**After chemical reaction**
Electron configuration				
Number of electrons				
Number of protons				
Charge				

Table 3.6

- Which are the ions present in magnesium oxide?

.....

- How many electrons are transferred from magnesium to oxygen during the formation of magnesium oxide?

.....

It can be understood that an ionic bond is formed between magnesium and oxygen by the transfer of electrons during the formation of magnesium oxide.

The compounds that are formed by ionic bonding are known as ionic compounds or electrovalent compounds.

Characteristics of ionic compounds

- Ionic compounds are generally soluble in polar solvents such as water.
- They are non volatile and hard.
- They exist as crystals in solid state.
- Generally, they have high melting points and boiling points.
- Though ionic compounds are not conductors of electricity in solid state, they conduct electricity in molten and aqueous states.

Covalent Bond

You know that the molecules of hydrogen (H_2), oxygen (O_2) nitrogen (N_2), fluorine (F_2) and chlorine (Cl_2) are formed of two atoms. Have you ever thought how atoms are held together in such diatomic molecules?

Let us examine the formation of fluorine molecule. The distribution of electrons of fluorine is given in Figure 3.6.

- How many electrons are there in the outermost shell of fluorine?

.....

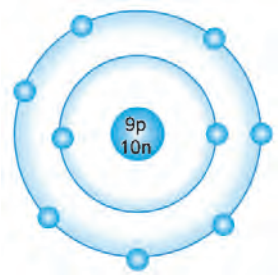


Fig. 3.6

- How many more electrons are required for one fluorine atom to attain octet configuration?

.....

Is it possible to transfer electrons from one fluorine atom to another? If so, what type of arrangement might have taken place between the atoms in order to attain octet configuration?

Analyse the electron dot diagram (Figure 3.7) illustrating the way in which two fluorine atoms are bonded in fluorine molecule.

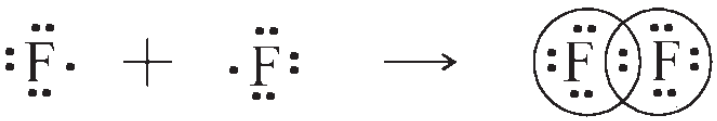


Fig. 3.7

It is clear that octet configuration is attained by the sharing of electrons.

- How many electrons are donated by each fluorine atom for sharing?

.....

- How many pairs of electrons are shared in the chemical bonding of fluorine molecule?

.....

You have understood that atoms in fluorine molecule engage in bond formation by the sharing of electrons.

The chemical bond formed as a result of the sharing of electrons between the combining atoms is called a covalent bond. The covalent bond formed by the sharing of one pair of electrons is a single bond.

A single bond is represented by a small line (–) between the symbols of the combining elements in molecules. The single bond in fluorine molecule can be represented using symbols as F–F.

Let us examine the nature of chemical bonding in oxygen, which is a diatomic molecule.

- What is the atomic number of oxygen?

.....

- Write the electron configuration of oxygen.

.....

- How many more electrons are required for one oxygen atom to attain the octet configuration?

.....

See the illustration (Figure 3.8) of chemical bond in an oxygen molecule.

Fig. 3.8

Construct the molecular structure of F_2, O_2, N_2 using Ghemical software.

- How many pairs of electrons are shared in the oxygen molecule?

.....

A double bond is the covalent bond formed by the sharing of two pairs of electrons.

The covalent bond (double bond) in oxygen molecule can be represented by using symbols as O = O .

Look at the illustration (Figure 3.9) of chemical bond in nitrogen molecule.

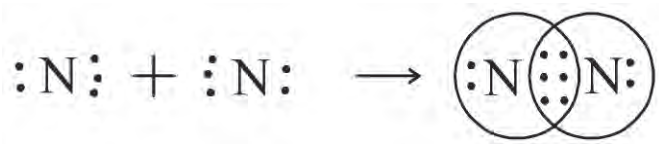


Fig. 3.9

- How many pairs of electrons are shared here to complete octet configuration?

.....

A triple bond is the covalent bond formed by the sharing of three pairs of electrons.

The covalent bond (Triple bond) in nitrogen molecule can be represented by using symbols as $N \equiv N$.

Illustrate the chemical bond in hydrogen molecule using electron dot diagram.

Here, a single bond is formed by the sharing of one pair of electrons between hydrogen atoms and thereby stability is attained by gaining the electron configuration of the nearest noble gas, helium.

You have understood the covalent bonding in elemental molecules such as H_2, N_2, O_2, F_2. Let us examine the nature of the chemical bond in certain molecules of compounds.

Construct the molecular structure of HCl and H_2O using Ghemical software.

See the representation (Figure 3.10) of the chemical bond in hydrogen chloride molecule.

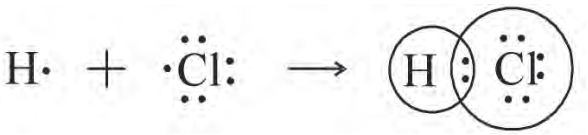


Fig. 3.10

Here, one pair of electrons is shared between hydrogen and chlorine. Hence, a single bond is present in hydrogen chloride.

- Represent the covalent bond in hydrogen chloride using symbols.

.....

The chemical bond in hydrogen chloride molecule is represented in Figure 3.10. Similarly, represent the bond in hydrogen fluoride.

See the representation of chemical bond in water molecule (Figure 3.11).

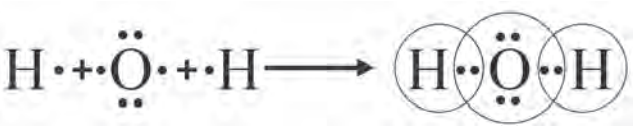


Fig. 3.11

- How many covalent bonds are formed here?

.....

Compounds formed by covalent bonding are called covalent compounds. When non-metals combine together, usually covalent compounds are formed.

General characteristics of covalent compounds

- Covalent compounds exist in solid, liquid and gaseous states.
- They are generally insoluble in water.
- They are soluble in organic solvents like kerosene, carbon tetrachloride, benzene etc.
- Their melting and boiling points are usually low.
- Generally, they are not conductors of electricity.

Electronegativity

Is the shared pair of electrons in HF molecule attracted equally by both the atoms?

The relative ability of an atom to attract the shared pair of electrons between the covalently bonded atoms towards itself is called electronegativity.

Various electronegativity scales have been put forward to compare the electronegativity of elements. The electronegativity scale proposed by the American scientist Linus Pauling is the most widely used.

In the electronegativity scale proposed by Linus Pauling, elements are assigned electronegativity values between 0 and 4. In this scale, the most electronegative element is fluorine.

A part of Pauling's electronegativity scale is given below (Figure 3.12).

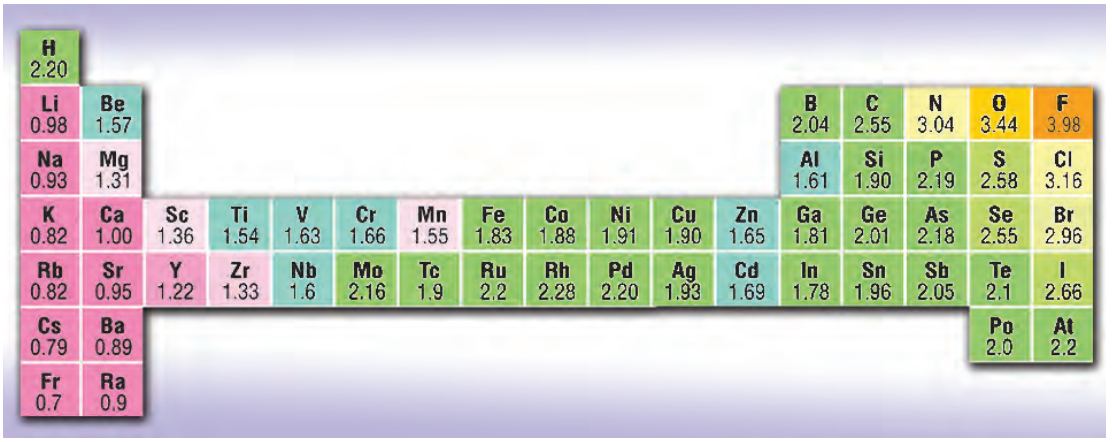


Fig. 3.12

If the difference in electronegativity values between the constituent elements in a compound is 1.7 or more, it generally shows ionic character and if it is less than 1.7, it shows covalent character.

?

- Analyse Figure 3.12 and find the electronegativity difference of the constituent elements. Record it in your science diary.

Compounds	Difference in electronegativity of constituent elements	Nature of compound
Sodium chloride (NaCl)	3.16 - 0.93 =	Ionic
Hydrogen chloride (HCl)	3.16 - 2.20 =	Covalent
Sodium oxide (Na_2O)		
Calcium chloride ($CaCl_2$)		
Methane (CH_4)		
Magnesium fluoride (MgF_2)		

- Make a table of different compounds. Explain the nature of chemical bond in them using electronegativity scale. Conduct a seminar in your class based on this.

Polar Nature

Since the electronegativity values of both the atoms in a diatomic molecule of an element are equal, the shared pair of electrons is attracted by them equally. e.g. H_2, N_2, O_2 etc. But it is not so in molecules of compounds. Consider hydrogen chloride (HCl) molecule.

Examine Figure 3.12 and answer the questions given below.

- What is the electronegativity value of hydrogen?

  .....

- What is the electronegativity value of chlorine ?

  .....

- The nucleus of which of these atoms has a greater tendency to attract the shared pair of electrons involved in covalent bonding?

  .....

Construct the molecular structure of CO, HF and NH_3 using Ghemical software.

The chlorine atom, which has a higher electronegativity, attracts the shared pair of electrons more strongly towards its nucleus. As a result, the chlorine atom in hydrogen chloride develops a partial negative charge (delta negative, δ^-) and the hydrogen atom develops a partial positive charge (delta positive, δ^+). This can be represented as shown below.

$\overset{\delta+}{H}-\overset{\delta-}{Cl}$

Hydrogen chloride

Covalent molecules in which partial opposite charges are formed in atoms are called polar molecules. CO, HF, HCl, H_2O, NH_3 etc., are examples of polar compounds.

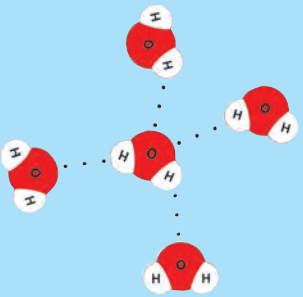
Water: A polar compound

Water is a polar molecule. The reason for the specific features of water is its polar nature. Due to its polar nature, a peculiar attractive force called hydrogen bond also exists between the molecules. Hence, it exists in liquid state though its molecular mass is low. The ability of water to dissolve many organic and inorganic compounds makes it a universal solvent. This is also due to its polar nature.

Polar Nature and Geometric Shape of Molecules

The geometric shape of molecules is also a factor that determines the polarity of compounds. Though there is a large difference in electronegativity between the atoms in molecules like CO_2, CCl_4, BeF_2, they do not exhibit polar nature due to their peculiar geometric shape.

Hydrogen Bonding



A partial positive charge is formed in the hydrogen atom which is covalently bonded to an atom with higher electronegativity. Hydrogen bonding is the electrostatic force of attraction between hydrogen with partial positive charge and an electronegative atom of the same or a different molecule. One of the reasons for the peculiar properties of water is the presence of a hydrogen bond. The low density of ice compared to that of water is also due to hydrogen bonding. Hydrogen, which is covalently bonded to elements such as fluorine, oxygen and nitrogen, generally exhibits hydrogen bonding. Molecules like ammonia and hydrogen fluoride and biomolecules like protein and nucleic acid are also examples of molecules with hydrogen bonding.

Valency

When atoms combine to form molecules, electron transfer or sharing of electrons occurs between the atoms.

The number of electrons lost, gained or shared by an atom during a chemical reaction is its valency.

We have studied the formation of sodium chloride. Here, sodium donates one electron and chlorine atom accepts one electron. Hence the valency of both sodium and chlorine is 1.

In the formation of hydrogen chloride, one electron of chlorine and one electron of hydrogen are shared between hydrogen and chlorine. Hence the valency of both hydrogen and chlorine is 1.

Intermolecular Forces

In addition to covalent bond and ionic bond in molecules, there exist attractive or repulsive forces between microscopic particles such as atoms and molecules, called intermolecular forces. Hydrogen bond is an example of intermolecular force.

- Analyse the change in the electron arrangement in atoms during the formation of each compound and complete the table given below.

Compound	Constituent elements	Atomic number	Electron configuration	The number of electrons shared or transferred by each atom	Valency
NaCl	Na	11	2, 8, 1	1	1
	Cl	17	2, 8, 7	1	1
MgO	Mg				
	O				
HF	H				
	F				
CCl_4	C				
	Cl				
BeF_2	Be				
	F				
H_2O	H				
	O				

Elements Exhibiting Variable Valency

Atoms of various elements exhibit variable valencies. Some of the examples are iron, copper and phosphorus. Iron exhibits valencies 2 and 3 in its compounds. In ferric chloride ($FeCl_3$), the valency of iron is 3. In ferrous chloride ($FeCl_2$), the valency of iron is 2. Copper exhibits 1 and 2 as its valencies. In cupric oxide (CuO), the valency of copper is 2. In cuprous oxide (Cu_2O), the valency of copper is 1. The valency of phosphorus in PCl_3 is 3 and that in PCl_5 is 5.

Chemical Formula

You are already familiar with representing compounds with the symbols of elements. e.g. sodium chloride – NaCl, calcium chloride – $CaCl_2$, aluminium oxide – Al_2O_3 etc. Chemical formula is a method of indicating the number of atoms in a molecule using symbols of elements. Let us see how the chemical formula of a compound can be framed.

Complete the following Table 3.7 regarding the combination of magnesium (Mg) and fluorine (F).

Element	Atomic number	Electron configuration	Number of electrons donated or accepted
Mg	12	.....	.....
F	9	.....	.....

Table. 3.7

- How many fluorine atoms are required to receive the electrons donated by magnesium?

.....

During the formation of magnesium fluoride, one magnesium atom combines with two fluorine atoms. Hence, the chemical formula of magnesium fluoride will be MgF_2.

Let us see how chemical formula can be derived from the valencies of atoms.

- What are the constituent elements of aluminium oxide?

.....

- What is the valency of aluminium? (Atomic number -13)

.....

- What is the valency of oxygen ? (Atomic number – 8)

.....

Write the symbols of constituent elements together in such a way that the symbol of the element having lower electronegativity comes first.

AlO

Interchange the valencies of each element and write them as base index.

Al_2O_3

From this, you have understood that the chemical formula of aluminium oxide is Al_2O_3.

Let us find out the chemical formula of carbon dioxide.

- What are the constituent elements of carbon dioxide?

.....

- Write the symbols of elements together considering their electronegativity.

.....

- The valency of carbon is 4 and that of oxygen is 2. Interchange the valencies and write them as base indices.

.....

Divide each base index with the common factor of the indices.

$$C_{2/2}\ O_{4/2} = C_1O_2$$

If the base index is 1, it need not be written. If so, the chemical formula of carbon dioxide will be C_1O_2 or CO_2.

- The constituent elements of some compounds and the valencies of their constituent elements are given in the following table. Find out the chemical formulae and record them in your science diary.

Element- 1		Element - 2		Chemical formula of the compound
Name	Valency	Name	Valency	
Potassium (K)	1	Oxygen	2	.....
Zinc (Zn)	2	Chlorine	1	.....
Carbon (C)	4	Chlorine	1	.....
Magnesium (Mg)	2	Oxygen	2	.....

How to write the chemical formulae of acids and bases

You have learned about acids and bases in previous classes. Generally, acids release hydrogen ions (H^+) and alkalies release hydroxyl or hydroxide (OH^-) ions when they dissolve in water.

Acids and bases react together to form salt and water. These types of reactions are called neutralisation reactions.

Let us see how the chemical formulae of acids can be written.

Which are the ions derived from hydrochloric acid? Why is it a monobasic acid?

Since one molecule of hydrochloric acid contains one H^+ and one Cl^-, the chemical formula will be HCl.

H^+ and SO_4^{2-} are the ions derived from sulphuric acid. Sulphuric acid is a dibasic acid. Hence, the chemical formula of sulphuric acid is H_2SO_4. The basicity and the negative ions of certain acids are given in Table 3.8. Find their chemical formulae and complete the table.

Negative ion in acid	Basicity	Chemical formula of acid
Cl^-	1	HCl
SO_4^{2-}	2	H_2SO_4
PO_4^{3-}	3	
NO_3^-	1	
CO_3^{2-}	2	
SO_3^{2-}	2	

Table 3.8

Alkalies are bases that dissolve in water. The number of OH^- ions present in alkalies will be equal to the charge of the positive ion.

- Which is the positive ion present in sodium hydroxide?

  .....

- How many OH^- ions, equal to the positive charge on sodium ion will be present in sodium hydroxide?

  .....

- If so, what is the chemical formula of sodium hydroxide?

  .....

- The positive ions of some bases are given in the table below. Find the chemical formulae and complete the table.

Positive ion in the base	Number of OH^- ions that combine with positive ions	Chemical formula	Name of base
Na^+	1	NaOH	Sodium hydroxide
K^+	.....	.....	Potassium hydroxide
Ca^{2+}	2	$Ca(OH)_2$	Calcium hydroxide
Al^{3+}	.....	.....	Aluminium hydroxide
Fe^{3+}	.....	.....	Ferric hydroxide
Cu^{2+}	.....	.....	Cupric hydroxide

Chemical formulae of salts

You know that acids and bases react to form salt and water through neutralization reaction. Salt is formed by the combination of negative ions of acids and the positive ions of bases.

e.g. During the reaction between hydrochloric acid and sodium hydroxide, the Na^+ ion of NaOH and Cl^- of HCl combine to form the salt NaCl.

$$Na^+ \boxed{OH^- + H^+} Cl^- \rightarrow NaCl + H_2O$$

Salts are electrically neutral. During the formation of salts, constituent ions combine in such a way that the sum of the charges of the positive ions and the negative ions is zero.

The sum of the charges of the positive ions and the negative ions in a salt will be zero.

Let us see how the chemical formulae of salts can be written.

- While writing the chemical formulae of salts, first write the symbol of the positive ion and then the symbol of the negative ion.
- Interchange the numbers indicating the charge of each ion/ radical and write them as base indices.
- Simplify the base indices and write them in the smallest possible whole number ratio.

- Which is the positive ion in magnesium hydroxide, $Mg(OH)_2$?

.....

- Which is the negative ion in phosphoric acid (H_3PO_4)?

.....

Let us see how the chemical formula of the salt magnesium phosphate, which is formed from magnesium hydroxide and phosphoric acid, is written.

- To derive the chemical formula, first write the symbol of the positive ion and then the symbol of the negative ion.

.....

- Write the number indicating the charge of each ion/radical as base index after interchanging them.

.....

From this, you have understood that the chemical formula of magnesium phosphate is $Mg_3(PO_4)_2$.

Let us see how the chemical formula of the salt calcium sulphate, formed by the reaction between sulphuric acid and calcium hydroxide, is written.

- Which is the positive ion in calcium hydroxide, $Ca(OH)_2$?

.....

- Which is the negative ion in sulphuric acid (H_2SO_4)?

.....

- To derive the chemical formula, first write the symbol of the positive ion and then the symbol of the negative ion.

.....

- Write the number indicating the charge of each ion/radical as base index after interchanging them.

.....

You got $Ca_2(SO_4)_2$ as the formula after interchanging the base indices.

Note how the base indices are simplified as small whole number ratio.

$$Ca_{2/2}(SO_4)_{2/2} = Ca_1(SO_4)_1 = CaSO_4$$

- Certain positive ions and negative ions are given in the following table. Complete the table by writing the chemical formula and the name of the salt formed from these ions.

Positive ion	Negative ion	Name of salt	Chemical formula
Mg^{2+} (Magnesium ion)	Cl^{-} (Chloride ion)		
Mg^{2+} (Magnesium ion)	SO_4^{2-} (Sulphate ion)		
Ca^{2+} (Calcium ion)	CO_3^{2-} (Carbonate ion)		
NH_4^{+} (Ammonium ion)	Cl^{-} (Chloride ion)		
NH_4^{+} (Ammonium ion)	PO_4^{3-} (Phosphate ion)		
Ca^{2+} (Calcium ion)	PO_4^{3-} (Phosphate ion)		
Na^{+} (Sodium ion)	SO_4^{2-} (Sulphate ion)		

Let's Assess

1. Draw the electron dot diagram of hydrogen (H), helium (He), lithium (Li), beryllium (Be) and fluorine (F).
2. Illustrate the formation of the chemical bond in chlorine (Cl_2) using electron dot diagram as illustrated in fluorine (F_2) molecule.
3. Represent the covalent bond in chlorine molecule using symbols.
4. Represent the formation of ionic bond in the following ionic compounds using electron dot diagram and orbit model.
   a) Sodium fluoride (NaF)
   b) Sodium oxide (Na_2O)
   c) Magnesium fluoride (MgF_2)
   d) Calcium oxide (CaO)

5. Assume that calcium (Ca) and fluorine (F) combine together.

a) Complete the following table accordingly.

Element	Atomic number	Electron configuration	Number of electrons received or donated
Ca	20	.....	.....
F	9	.....	.....

b) Write the chemical formula of calcium fluoride.

c) Similarly, write the chemical formula of magnesium chloride and aluminium chloride.

6. Some cations and anions are given in the table. Fill in the blanks.

Cation	Anion	Compound
……..	Cl^-	$MgCl_2$
Na^+	…….	NaF
NH_4^+	SO_4^{2-}	…….
K^+	…….	K_2CO_3

7. Complete the following chemical equations and answer the questions given below. (Hint: Atomic number Mg-12, Cl-17)

$Mg \rightarrow Mg^{2+} + \ldots\ldots..$

$Cl + 1e^- \rightarrow \ldots\ldots.$

$\ldots\ldots. + \ldots\ldots. \rightarrow MgCl_2$

(a) Identify the cation and anion in these compounds.

(b) What is the nature of the chemical bond in $MgCl_2$?

8. Complete the following table. (Hint: Atomic number F – 9, Cl – 17, O – 8, N – 7)

Molecule	Number of shared electrons	Chemical bond
F_2		Single bond
Cl_2		
O_2		
N_2		

9. Complete the following table. (Symbols are not real)

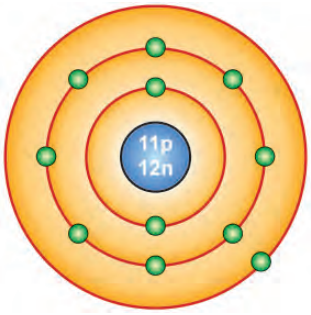
Element	Atomic number	Electron configuration
P	12	……..
Q	…….	2,7
R	10	……..
S	17	……..

(a) Which among these is the most stable element?

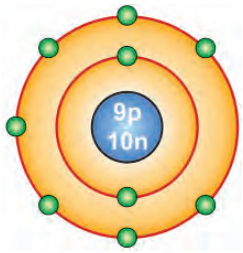
(b) Which element donates electrons during chemical reactions?

(c) Write the chemical formula of the compound formed when the elements P and S combine.

10. Atom models of two elements are represented below.



Sodium



Fluorine

(a) Draw the electron dot diagram of the formation of sodium fluoride.

(b) What is the nature of chemical bond in sodium fluoride?

(c) Write any two characteristics of compounds having this type of bond.

11. The electron configuration of the elements P, Q, R are given below. (Symbols are not real)

P – 2,8,6

Q – 2,8,1

R – 2,8,8

(a) Which is the most stable element among these? What is the reason?

(b) What is the atomic number of Q?

(c) Draw the atom model of Q.

(d) What are the valencies of the elements P and Q?

(e) Write the chemical formula of the compound formed when P and Q combine.

12. A, B, C and D are four elements (Symbols are not real). Information about them are given in the following table.

Element	Atomic number	Electronegativity
A	6	2.55
B	8	3.44
C	12	1.31
D	17	3.16

Based on these, find the type of bond in the compounds formed by the combination of the following pairs of elements.

1. C, B 2. C, D 3. A, B

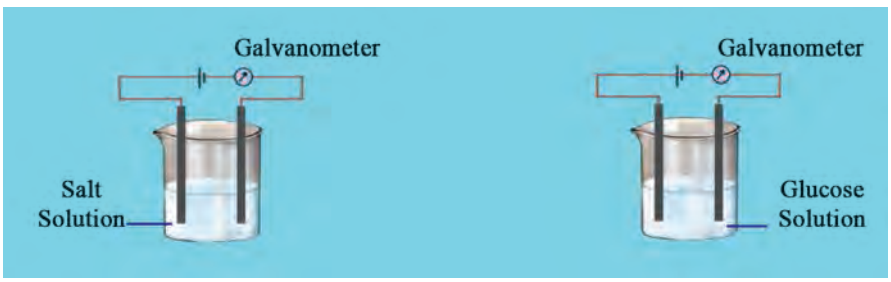
Extended Activities

1. Magnesium nitride is obtained when nitrogen is passed over heated magnesium. Write the chemical equation of this reaction. Find out whether the formed compound is ionic or covalent using the electronegativity scale given in this unit.

   (Hint - Valency : Nitrogen-3, Magnesium -2)

2. Draw the electron dot diagram of the chemical bonds in ethane (C_2H_6), ethene (C_2H_4) and ethyne (C_2H_2). Find out whether these compounds are ionic or covalent. Calculate the total number of bonds in each compound.

3. Conduct the experiment arranging the apparatus as shown in the figure.



Record your observations and identify what types of compounds are sodium chloride and glucose.

4. Draw the chemical bonds in different compounds and exhibit them on the bulletin board.