CHEMISTRY

Standard

IX

Part-1

Government of Kerala
Department of Education

State Council of Educational Research and Training (SCERT) Kerala
2016

The National Anthem

Jana-gana-mana adhinayaka jaya he
Bharatha-bhagya-vidhata,
Punjab-Sindh-Gujarat-Maratha
Dravida-Utkala-Banga
Vindhya-Himachala-Yamuna-Ganga
Uchchala-Jaladhi-taranga
Tava subha name jage,
Tava subha asisa mage,
Gahe tava jaya gatha.
Jana-gana-mangala-dayaka jaya he
Bharatha-bhagya-vidhata,
Jaya he, jaya he, jaya he,
Jaya jaya jaya jaya he!

Pledge

India is my country. All Indians are my brothers and sisters.

I love my country, and I am proud of its rich and varied heritage. I shall always strive to be worthy of it.

I shall give my parents, teachers and all elders respect, and treat everyone with courtesy.

To my country and my people, I pledge my devotion. In their well-being and prosperity alone lies my happiness.

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Dear Students,

Science is the knowledge that man has gained through the process of experimentation, observation and analysis. Science is nothing but truth. Man is continuously marching towards progress by observing and analysing the changes happening around him and by making new discoveries as he moves on. Much of our material gains owe to the development happening in the field of science. Study of science is a pre-requisite for all those who aim at better growth and success. Science text books are instruments for this.

Chemistry has played a significant role in giving new dimensions to human civilization and also in improving the living standards of individuals. It can be said without doubt that there is no branch of science other than chemistry that has influenced mankind to such a great extent. The contributions of chemistry to the field of agriculture, industry, medicine and daily life is incomparable. Hence it can be said that the study of chemistry is the study of the progress of man.

Study of science should be made a pleasant experience by giving emphasis to the basic methods of science like experimentation, observation, analysis and elucidating inferences. While familiarising ourselves with new concepts and areas of knowledge, we should also be keen on acquiring and developing certain values and attitudes. It is indeed needed to scale greater heights by ensuring the continuation and development of knowledge and capabilities gained in lower classes. These aims have been kept in mind while preparing the new chemistry text book.

Study of science should be made a joyous experience by making the maximum use of, the learning activities, experiences and discussions provided in the Textbooks as well as the facilities available in the school premises and laboratories. Let this book help you in cultivating a scientific temper along with values while acquiring knowledge.

Wishing you the best...

Dr. P.A. Fathima
Director, SCERT

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Contents

The symbols used in the textbook

Additional Information
(Need not be assessed)

ICT Possibilities for Concept Clarity

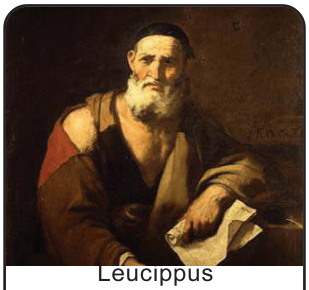
Significant Learning Outcomes

Let Us Assess

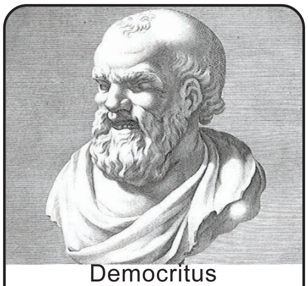
Extended Activities

1 STRUCTURE OF ATOM

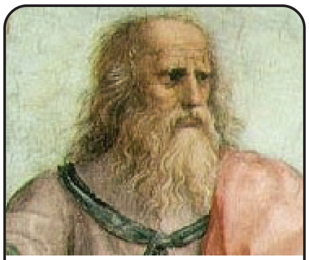
Have you ever had the same doubt as that of the student in the picture? What do you know about an atom?



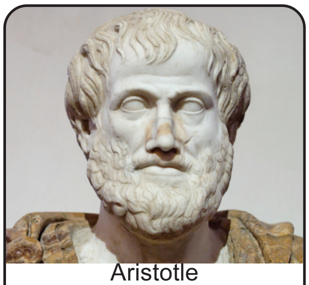
Leucippus
(460-370 BC)



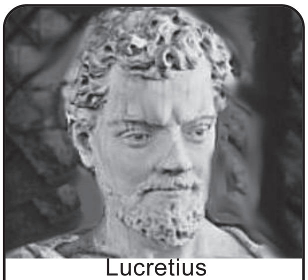
Democritus
(460-370 BC)



Plato
(428-348 BC)



Aristotle
(384-322 BC)



Lucretius
(99-55 BC)

Certain concepts were formulated right from the very ancient period about the basic constituents of substances. Some of these significant developments are given below for your reference.

Basic constituents of matter

- *Kanada,* the Hindu sage who lived in India during the 6th century, put forward the theory that everything in the universe was made of minute particles called 'paramanu'.
- In 4th century BC, the Greek philosophers Leucippus and Democritus suggested that the universe was formed of very tiny particles named atoms (A-tomio = indivisible).
- Greek philosophers Plato and Aristotle did not approve atomic theories. They argued that the universe is formed of four elements viz. soil, air, water and fire.
- Lucretius, a Roman who lived in the 1st century BC, put forward the idea that substances were made of indivisible particles.
- According to the '*panchabhutha*' theory that prevailed in ancient India, the universe was made of the *panchabhuthas* namely *Vayu* (air), *Jalam* (water), *Bhoomi* (earth), *Aakasam* (ether) and *Agni* (fire).

All these theories were philosophical. They had no scientific base at all.

Most of the atomic theories put forward in ancient times became irrelevant in the wake of the scientific researches carried out later.

Law of Conservation of Mass

Let us do an experiment.

Materials required : Barium chloride
Sodium sulphate
Water
Conical flask
A small test tube

Procedure

Prepare aqueous solutions of barium chloride and sodium sulphate separately in the test tube and a conical flask. Find the mass, along with the solutions by keeping test tube vertically inside the concinal flask Fig.1.1 (a). By inverting the conical flask, the solution in the test tube is transferred into the flask (Fig.1.1 (b)).

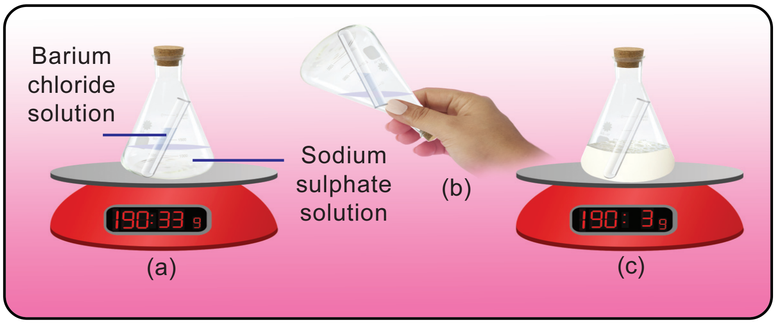


Figure 1.1

- What do you observe?
- Find the mass of the apparatus after the chemical reaction is complete (Fig.1.1(c)).
- Is the first mass equal to the present mass?
- What do you infer?


Antoine Lavoisier (1743-1794)

Lavoisier is best remembered for his discovery of the role of oxygen that is played in combustion. He discovered that during respiration, oxygen is absorbed and carbon dioxide is given out. He also identified the presence of oxygen in nitric acid, sulphuric acid and phosphoric acid. He named the elements oxygen and hydrogen.

Based on such observations, Antoine Lavoisier, a French scientist, proposed in 1774 the law of conservation of mass as given below.

Law of Conservation of Mass

Mass is neither created nor destroyed in a chemical reaction.

Law of Definite Proportion

We know that water is a compound.

- What are the elements present in water?

We get water from different natural sources. Water can also be produced by the combustion of hydrogen in the air. Whatever be the source or the method of preparation, we can prove that the ratio of masses of hydrogen and oxygen in water is 1:8.

It is from this ratio that we ascertain that the molecular formula of water is H_2O.

It can also be seen that the ratio of masses of carbon and oxygen in carbon dioxide is 3:8.

Examine the ratio of masses of the constituent elements of some other compounds.


Joseph Proust
(1754 – 1826)

Carbon monoxide (Carbon, Oxygen)	3:4
Methane (Carbon, Hydrogen)	3:1
Sulphur dioxide (Sulphur, Oxygen)	1:1

We can determine the molecular formula of these compounds from these ratios.

On the basis of such discoveries, the French scientist Joseph Proust put forward the Law of Constant Proportion in 1799.

Law of Constant Proportion

There exists a simple whole number ratio between the masses of the combining elements in a compound.

These laws of chemical combination derived from reliable scientific experiments gave clear indication about the mass and indivisible nature of the minute particles of matter.

Daltons Atomic Theory


John Dalton
(1766 – 1844)

In addition to the atomic theory, he proposed the Law of Multiple Proportion and the Law of Partial Pressure. He suffered from colour blindness. Hence colour blindness came to be known as Daltonism.

The atomic theory introduced by the British chemist, John Dalton in 1807, to give a proper explanation to the laws of chemical combination was a turning point in the progress of science. Dalton accepted the word 'atom' used by the Greek. See the following ideas put forward by him.

- Matter is made up of very small particles called atoms.
- Atoms cannot be divided during chemical reactions.
- Atoms can neither be created nor be destroyed.
- Atoms of the same elements will be identical in properties, size and mass.
- Atoms of different elements will have different properties and masses.
- Atom is the smallest particle that can take part in chemical reactions.
- Atoms of two or more elements combine in a small ratio to form compounds.

Relative Atomic Mass

The mass of a microscopic particle like atom is in fact very small. As a result of the recent advancement in scientific techniques several methods are now available to determine the accurate masses of atoms. Earlier the 'Relative Atomic Mass' method was used. In this method, the mass of any atom is expressed by comparing it with the mass of a particular atom. For this purpose, the hydrogen atom, being the smallest in size and possessing the least mass was taken as a unit. The masses of other atoms were stated by comparing them with that of hydrogen. But due to certain scientific reasons, $1/12^{th}$ mass of a carbon atom with atomic mass 12 (Carbon - 12) is now accepted as the atomic mass unit (u).

Can atoms be divided?

By the end of the 19^{th} century, understanding the structure and properties of atoms became the main area of scientific research.

It was believed that atoms with which substances were made of were chargeless. Later, it is understood that, in certain situations, substances acquire electrical charge. Try to do the activities given below. (Fig. 1.2, 1.3)

Rub a plastic comb or rubber balloon on dry hair for some time.

Figure 1.2

Bring the comb or balloon near small pieces of paper. What do you observe?

Polyester dress worn immediately after ironing, sticks to the body.

This indicates that substances acquire electrical charge due to friction.

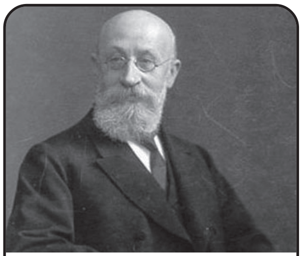
Figure 1.3

If so, won't substances contain particles with electrical charge?

The experiments conducted by the English scientists, Humphrey Davy and Michael Faraday by passing electricity through solutions, gave clear indication of the presence of charged particles in substances. This strengthened the belief that atoms may contain charged particles still smaller than atoms. Later experiments led scientists to the discovery of microscopic particles with in the atoms and thus to the development of concepts regarding atomic structure. Let's learn about them in detail.

Humphrey Davy
(1778 - 1829

Michael Faraday
(1791 – 1867)



Goldstein
(1850-1930)

J. J.Thomson
(1856-1940)

Refer resources for VI and VIII in IT@School Edubuntu. Look in the following order. Basic Science STD VIII → Chemistry → Structure of an atom → Discharge tube experiments

Minute particles in an atom

In 1886, the German scientist Goldstein, who was engaged in discharge tube experiments, predicted the presence of positively charged particles in substances.

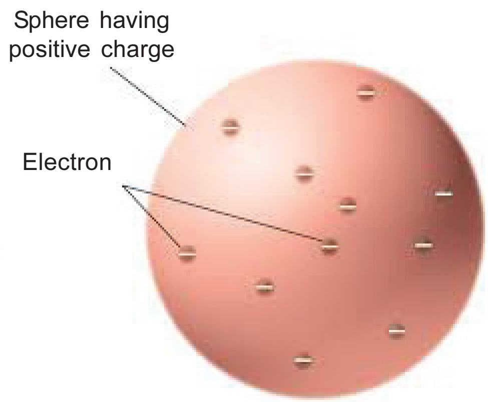
In 1897, through discharge tube experiments, J J Thomson, the English scientist discovered negatively charged particles in an atom. These particles has a mass of 1/1837th mass of a hydrogen atom. These particles are called **electrons.**

Thomson's Model of Atom

J. J. Thomson proposed his atom model on being convinced of the presence of positively and negatively charged particles in an atom.

Look at the picture of the atom model proposed by Thomson (Fig.1.4). Thomson compared the distribution of electrons in an atom to a plum pudding. Accordingly:

- the negatively charged electrons are embedded in over a sphere of positive charge.
- the total number of units of positive charge of the sphere are equal to the total number of negatively charged electrons. Hence an atom is electrically neutral.



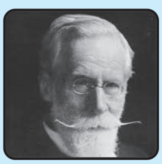
Thomson's model of atom

Figure 1.4

Though Thomson's model explained the presence of electrons and the neutral nature of atoms, it was inadequate to explain the experimental observations made later.

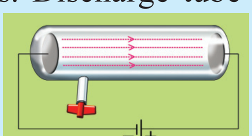
Discharge Tube Experiments

William Roentgen
(1845-þ1923)

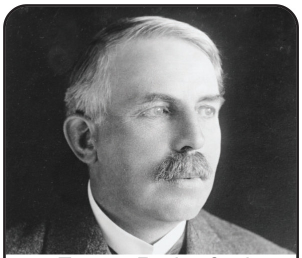


William Crooks
(1832-þ1919)

Usually gases do not allow electricity to pass through them. Discharge tube is a device prepared to study the passage of electricity through gases. Scientists like Goldstein, William Crooks, Michael Faraday, J.J. Thomson and William Roentgen conducted discharge tube experiments. Discharge tube experiments led William Roentgen to the discovery of X-rays in 1895.



Discharge tube



Ernest Rutherford
(1871-1937)

Rutherford's Model of Atom

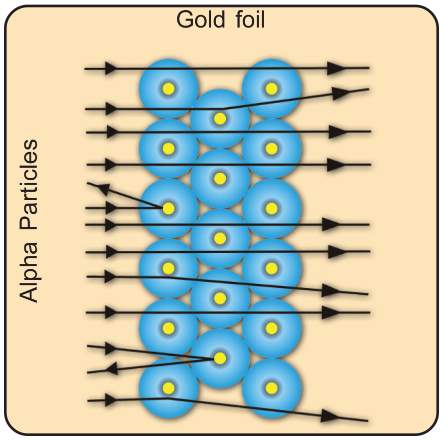


Figure 1.5

In 1911, Ernest Rutherford conducted the gold foil experiment by making positively charged alpha particles (α) fall on a thin gold foil. This helped to give clarity to the structure of an atom. Observe the picture of the gold foil experiment (Fig.1.5) and evaluate it.

Refer resources for VI and VIII. IT@School Edubuntu. Look in the following order. Basic Science STD VIII → Chemistry→ Structure of an atom → Gold foil experiment.

- Do all alpha particles pass through the gold foil?
- What inference can you arrive at from the deflection occurred to some of the alpha particles?
- What may be the reason for the reflection of only a very small number of alpha particles?

Evaluate Table1.1 containing the observations and inferences of Rutherford based on gold foil experiment.

Observation	Inference
• Most of the alpha particles passed through the gold foil without any deviation.	• Most of the space in an atom is empty.
• Some alpha particles deviated in small angles.	• Since positively charged alpha particles are deflected, we can infer that there are positively charged parts in an atom. These positively charged parts are concentrated in a small space in atoms.
• Only a small number of alpha particles bounced back.	• There is a small centre in an atom which consists of the entire mass and positive charge. The positive charged alpha particles moving towards this centre reflect

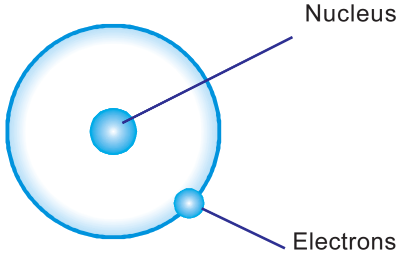
Table 1.1

The experiments of Rutherford confirmed the presence of a positively charged centre within an atom. This centre was named **nucleus**. Rutherford confirmed the presence of positively charged particles within the nucleus which are called **protons**.

The mass of the protons was determined to be almost equal to that of a hydrogen atom.

Rutherford proposed an atom model based on his observations. See the postulates of Rutherford's atom model given below.

- An atom has a centre called nucleus.
- Compared to the size of an atom, the size of the nucleus is very small.
- All the positively charged particles and most of the mass are concentrated in the nucleus of atoms.
- Negatively charged electrons revolve around the nucleus in circular paths.

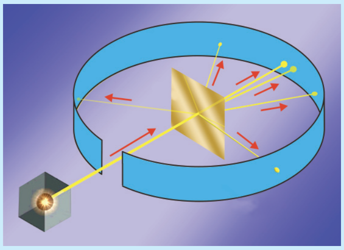


Rutherford's model of hydrogen atom

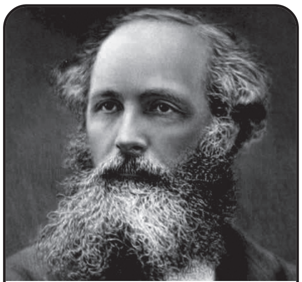
Figure 1.6

Rutherford's atom model is known as Planetary model of atom. Identify the similarities of this model with the solar system and write them in a tabular form.

Gold Foil Experiment



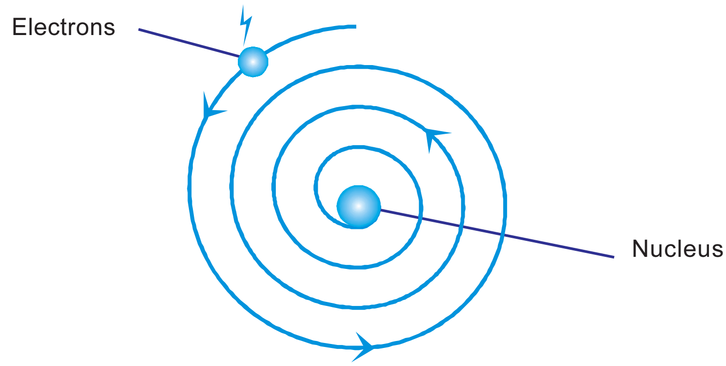
Gold is the most malleable metal. It can be converted into very thin foils. Alpha particles contain 2 units of positive charge and 4 units of mass. Rutherford allowed alpha particles to fall on a thin gold foil from a source. A photographic film was placed around the gold foil to observe the deviations from the trajectory of alpha particles.



James Clerk Maxwell
(1831-1879)

Limitations of Rutherford's atom model

According to the Electromagnetic Theory put forward by the Scottish scientist **James Clerk Maxwell**, a charged body in circular motion continuously emits energy as radiations. Electrons which revolve around the nucleus are negatively charged. Hence while electrons revolve around the nucleus, they should emit electromagnetic radiations, lose energy and come closer to the nucleus. Finally the negatively charged electrons should collapse into the nucleus. But this does not happen in an atom. Rutherford's model failed to explain this.



Pictorial representation of the limitation of Rutherford's atom model.

Figure 1.7

Niels Bohr
(1885- 1962)

Bohr Model of Atom

The Danish Scientist Niels Bohr put forward an atom model by resolving the limitations of Rutherford's atom model.

Analyse the main ideas of the Bohr atom model given below.

- Electrons revolve around the nucleus in fixed paths called orbits or shells.
- Electrons in each shell have a definite energy. Hence shells are also called Energy levels.
- As long as an electron revolves in a particular orbit, its energy remains constant.
- The energy of the shells increases as the distance from the nucleus increases.

Refer resources for VI and VIII in IT@School Edbuntu. Look in the following order.Basic Science STD VIII → Chemistry → Structure of atom → Construction of atom model

The shells around the nucleus can be numbered from near the nucleus as 1, 2, 3, 4, ….or represented by the letters K, L, M, N, …… as shown in Fig.1.8.

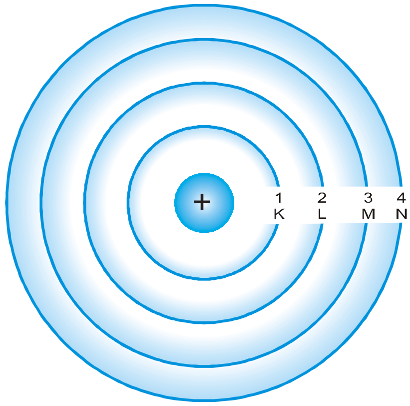


Figure 1.8

James Chadwick (1891- 1974)

A chargeless particle too - within an atom!

The actual mass of an atom should be equal to the sum of the mass of particles present in it. Scientists realised the fact that there is no relation between the total mass of particles i.e. electrons and protons in an atom, and the actual mass of the atom. For example, while calculating the mass of helium atom, it was found that the value obtained was only one-half that of the actual mass.

What can be infered from this?

In 1920, Rutherford predicted that nucleus may contain neutral particles having mass equal to that of protons.

In 1932, the British scientist James Chadwick confirmed the presence of neutral particles within the nucleus of an atom. These particles are called **neutrons**. The mass of neutrons determined is slightly higher than that of protons.

Fundamental particles within an atom

It is discovered that an atom contains particles like electrons, protons and neutrons. These particles are known as the fundamental particles of an atom. Look at their properties in Table1.2. Try to fill in the blanks.

Name of particle	Position in the atom	Charge	Mass	Mass used for practical purposes
Proton	Nucleus	....	1.00727u	1u
Electron	....	....	0.00548 u	0
Neutron	....	....	1.00866 u	1u

Table 1.2

Mass of fundamental particles

One atomic mass unit (u) = 1.6605x10^{-27}kg.

Proton – 1.6726 x 10^{-27} kg

Electron – 9.109 x 10^{-31} kg

Neutron – 1.6749 x 10^{-27} kg

Mass Number & Atomic Number

Evaluate the mass of fundamental particles given in Table 1.2.

Which are the fundamental particles whose masses are mainly responsible for the mass of an atom? Give reason.

- What is the mass of a proton?
- What is the mass of a neutron? _ _ _ _ _ _ _ _ _ _ _ _ _ _
- What will be the mass of an atom having only one proton and one neutron?_ _
- Find the mass of an atom having 2 protons and 2 neutrons_ _
- What will be the mass of an atom having 4 protons and 5 neutrons?_ _
- Is there a relation between the total number of protons and neutrons in an atom and its mass?

  _

The total number of protons and neutrons in an atom is called the **mass number**. This is represented by the letter ‘A’.

You might have understood the position and charge of the fundamental particles in an atom.

- Which is the particle of an atom that has the possibility of changing its position, which can be exchanged when atoms rub against each other, collide or chemically react with other atoms?

  _

- Why? _

Since the atom is electrically neutral, the number of protons and electrons are equal in an atom.

The protons in an atom do not undergo any change in any of the circumstances explained above. Hence the number of protons in an atom gains utmost significance. Therefore an atom is identified by the number of protons in it.

The total number of protons in an atom is called its **atomic number**. The letter 'Z' is used to represent the atomic number.

- Which are the particles whose numbers you can find out if you know the atomic number of an atom?
- Why? ____________________
- And if you know the mass number ____________

Use Kalzium application of IT@School Edubuntu

Atomic Number	=	Number of protons
	=	Number of electrons
Mass Number	=	Number of Protons + Number of Neutrons
Number of Neutrons	=	Mass Number – Atomic Number

Other fundamental particles in atom

Besides the fundamental particles like protons, electrons and neutrons, some other particles are discovered in the nucleus of an atom. They include mesons, neutrino, anti-neutrino, positrons, etc.

You have studied that symbols are used to represent elements. The symbol of an element represents one of its atoms.

If we include the mass number and atomic number to the symbol of an atom, you can infer more details about the atom. We write the mass number on the left side above the symbol and atomic number on the left below the symbol. See how a Sodium atom (Z=11, A=23) is represented in this manner.

$$^{23}_{11}\text{Na}$$

Symbols of certain atoms are given in Table 1.3. Complete the table.

Symbol	Atomic Number	Mass Number	Protons	Electrons	Neutrons
$^{1}_{1}\text{H}$					
$^{4}_{2}\text{He}$					
$^{7}_{3}\text{Li}$					
$^{12}_{6}\text{C}$					
$^{20}_{10}\text{Ne}$					
$^{40}_{18}\text{Ar}$					

Table 1.3

Electronic configuration of an atom

Analyse the electronic configuration of atoms of elements from atomic number 1 to 18 in the following table (Table 1.4).

Element	Atomic number	Number of Electrons	Electronic configuration (shell wise)				
			K	L	M	N	O
H	1	1	1				
He	2	2	2				
Li	3	3	2	1			
Be	4	4	2	2			
B	5	5	2	3			
C	6	6	2	4			
N	7	7	2	5			
O	8	8	2	6			
F	9	9	2	7			
Ne	10	10	2	8			
Na	11	11	2	8	1		
Mg	12	12	2	8	2		
Al	13	13	2	8	3		
Si	14	14	2	8	4		
P	15	15	2	8	5		
S	16	16	2	8	6		
Cl	17	17	2	8	7		
Ar	18	18	2	8	8		

Table 1.4

- What is the maximum number of electrons that can be accommodated in K shell?_ _

- What is the maximum number of electrons that can be accommodated in L shell?_ _

Filling up of electrons in shells is based on the following principles:

1. The maximum number of electrons that can be accommodated in any given shell is $2n^2$ (n = shell number)

Complete Table 1.5 regarding the filling up of electrons in shells

Name of shell	Shell number	Maximum number of electrons
K	1	$2 \times 1^2 = 2$
L	2	$2 \times 2^2 = 8$
M	3	....
N	....	....

Table 1.5

2. Shells with lower energy will be filled with the maximum number of electrons first. Thereafter shells having higher energy get filled.

3. The maximum number of electrons that can be contained in the outermost shell of an atom is 8.

Bohr model of atoms of certain elements are given below (Fig.1.9). Assess their electronic configuration.

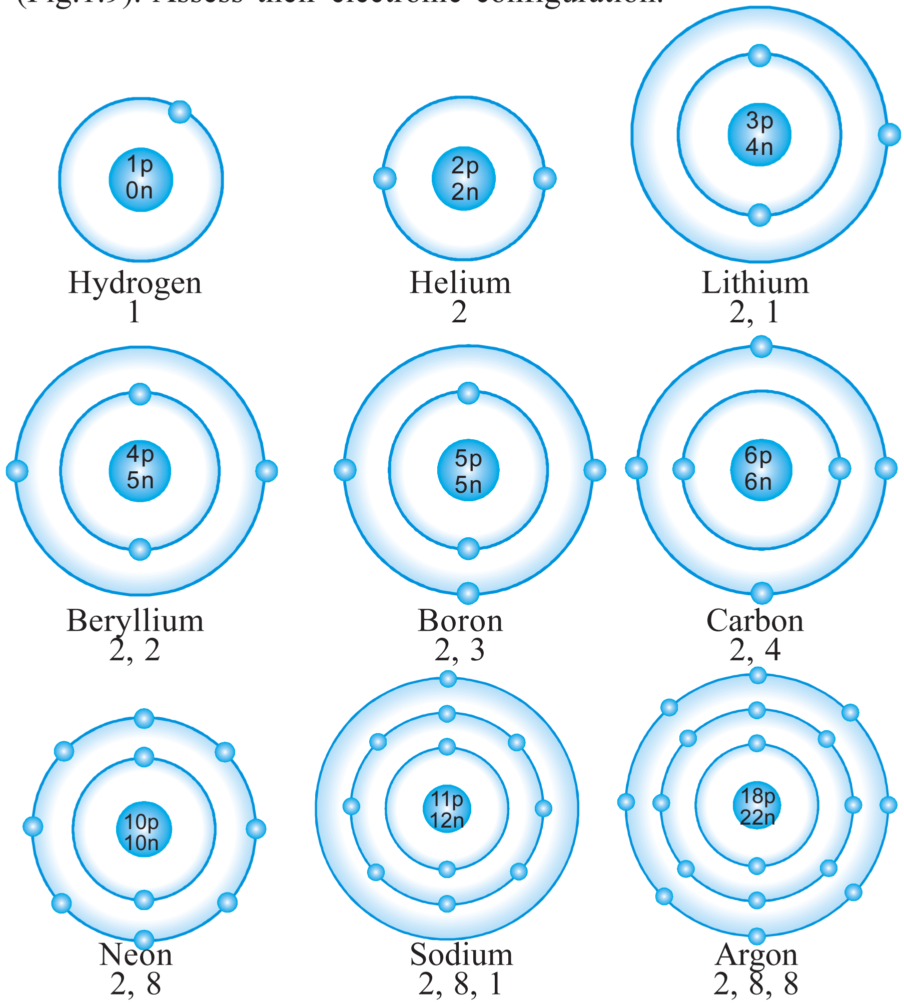


Figure 1.9

Find the electronic configuration of the following atoms and draw their Bohr model.

$^{14}_{7}N$ $^{24}_{12}Mg$ $^{32}_{16}S$

The symbol of the aluminum atom is $^{27}_{13}Al$. Bohr model of the atom is given in Fig.1.10. Analyse this and complete Table 1.6.

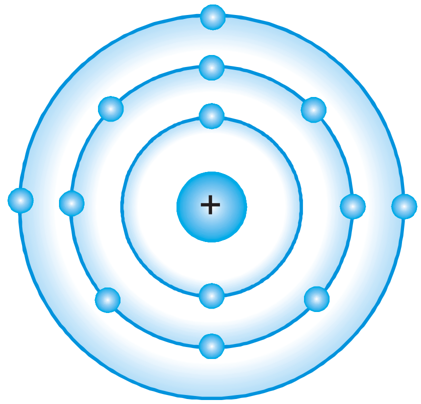


Figure 1.10

Atomic number	
Mass number	
Number of protons	
Number of electrons	
Number of neutrons	
Electronic configuration	

Table 1.6

Isotopes

You would have understood that the number of protons in an atom determines the element. Analyse the given Bohr models (Fig.1.11)

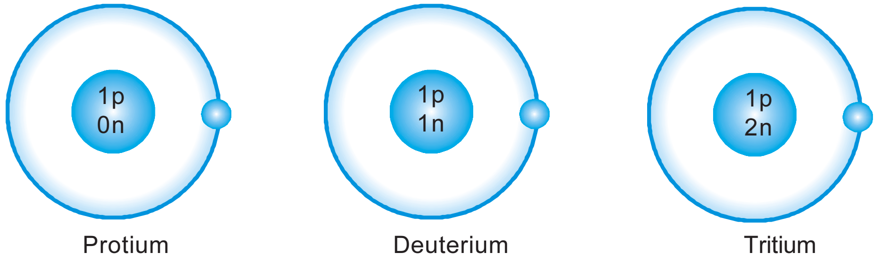


Figure 1.11

Complete Table 1.7 providing details related to these atoms.

Name of Atom	Protium	Deuterium	Tritium
Number of protons			
Number of neutrons			
Number of electrons			
Atomic number			
Mass number			

Table 1.7

- Among these atoms, which is the particle that differs in number? _
- What inferences can you arrive at when you examine the atomic number and mass number of these elements?

As the numbers of protons in these atoms are the same, they are atoms of the same element.

Atoms of the same element having the same atomic number but different mass number are called **isotopes**.

Protium, deuterium and tritium are isotopes of hydrogen. Look how they are represented using symbols.

$^{1}_{1}H$ Protium $^{2}_{1}H$ Deuterium $^{3}_{1}H$ Tritium

The isotopes of an element show slight difference in their physical properties. But their chemical properties are the same.

Most of the elements have isotopes. To identify the isotopes, mass number is written along with the name of the element.

e.g. Isotopes of carbon is given in Table 1.8

Isotope	Symbol
Carbon - 12	$^{12}_{6}C$
Carbon - 13	$^{13}_{6}C$
Carbon - 14	$^{14}_{6}C$

Table 1.8

Isotopes are of great importance in diverse fields. Deuterium, the isotope of hydrogen, is used in atomic reactors.

Isobars and Isotones

Isobars are atoms having the same mass number but different atomic number. $^{40}_{20}Ca$, $^{40}_{18}Ar$ are examples of isobars. Atoms with the same number of neutrons are called isotones. $_7N^{15}$, $_6C^{14}$ are examples of isotones. isotones and isobars are atoms of different elements.

An isotope of carbon, Carbon-14 is used to determine the age of fossils and prehistoric objects.

An isotope of phosphorous, Phosphorous-31 is used as tracers for identifying the nutrient exchange in plants.

Iodine-131 and Cobalt-60 are used in medical science for diagnosis and treatment of ailments like cancer and tumor.

Uranium – 235 is used in atomic reactors as fuel.

Symbols of certain isotopes are given in Table 1.9. Complete the table writing their atomic number, mass number, number of protons, electrons and neutrons.

Symbol	Atomic number	Mass number	Protons	Electrons	Neutrons
$^{15}_{8}O$					
$^{16}_{8}O$					
$^{17}_{8}O$					

Table 1.9

Higg's Boson, the God particle

The Standard Model theory on the origin of universe is as important as the theory of evolution in biology. According to the Standard Model theory, the universe is formed from 17 fundamental particles, which include Fermions known as matter components and Bosons, known as energy carriers. However how these particles get mass could not be satisfactorily explained until recently. Higg's Boson is the fundamental particle proposed for explaining this phenomenon. On July 4, 2012, scientists in the CERN Laboratory in Geneva declared that Higg's Boson, a particle similar to the one predicted by the Standard Model, was discovered.

You now know how the concepts regarding the structure of an atom developed down the ages as well as about the different models of atom.

Researches and experiments conducted in the later years have helped in formulating and understanding the fundamental particles and the structure of an atom in detail. More details regarding the structure of the atom can be studied in higher classes.

Significant Learning Outcomes

The learner

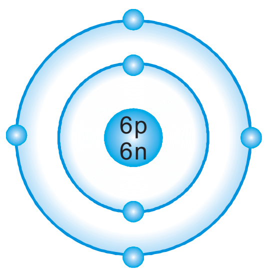
- explains the earlier concepts regarding the fundamental constituents of substances.
- explains the Law of Conservation of Mass, Law of Constant Proportion etc.
- explains the fundamental ideas in Dalton's Atom Theory.
- explain Relative Atomic Mass.
- explains the context that led to the discovery of fundamental particles in an atom.
- explains the features of the fundamental particles in an atom.
- explains and draws various atom models (Thomson, Rutherford, Niels Bohr).
- explains mass number, atomic number etc.
- explains the distribution of electrons in various orbits.
- illustrates Bohr models of different atoms.
- defines Isotopes and Isotones.

Let us assess

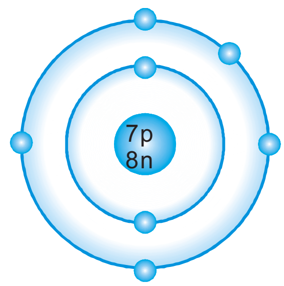
1. Names of some scientists and their contributions are given in a disordered way in the following table. Match them suitably.

Scientist	Contribution
John Dalton	Law of conservation of mass
Lavoisier	Law of constant proportion
Joseph Proust	Planetary model of atoms
J. J. Thomson	Atomic theory
Rutherford	Plum pudding model of atom

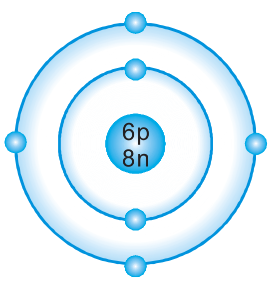
2. Atomic number of an atom Z=17, Mass number =35.
   a) Find the number of protons, electrons and neutrons in the atom.
   b) Write the electronic configuration of different shells.
   c) Draw the Bohr model of atom.
3. The mass number of an atom is 31. The M shell of this atom contains 5 electrons.
   a) Write the electronic configuration.
   b) What is the atomic number of this atom?
   c) How many neutrons does this atom have?
   d) Draw the Bohr model of the atom.
4. Bohr models of atoms A, B, C, D are given (Symbols are not real).
   a) Write the atomic number, mass number and electronic configuration of the atoms.
   b) Among these, which are isotopes? Why?



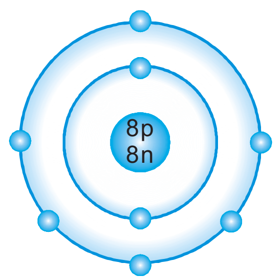
(A)



(B)



(C)



(D)

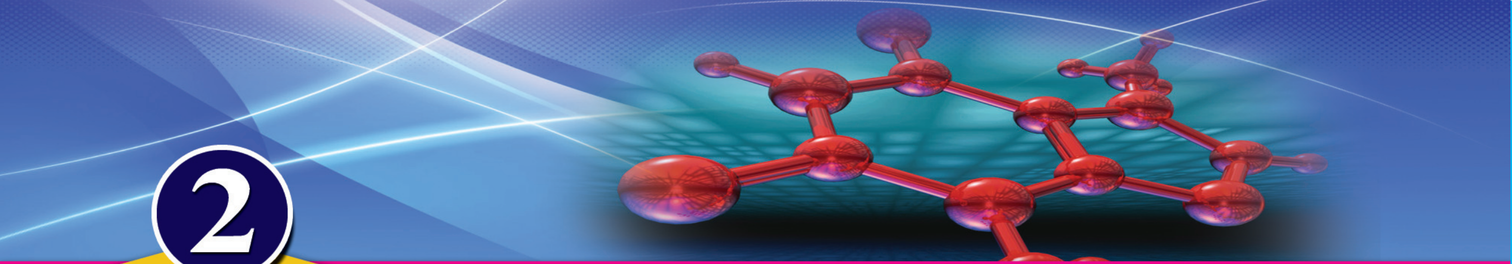
5. Symbols (not real symbols) of some atoms are given.

   $^{17}_{8}P$ $\quad$ $^{36}_{18}Q$ $\quad$ $^{16}_{8}R$

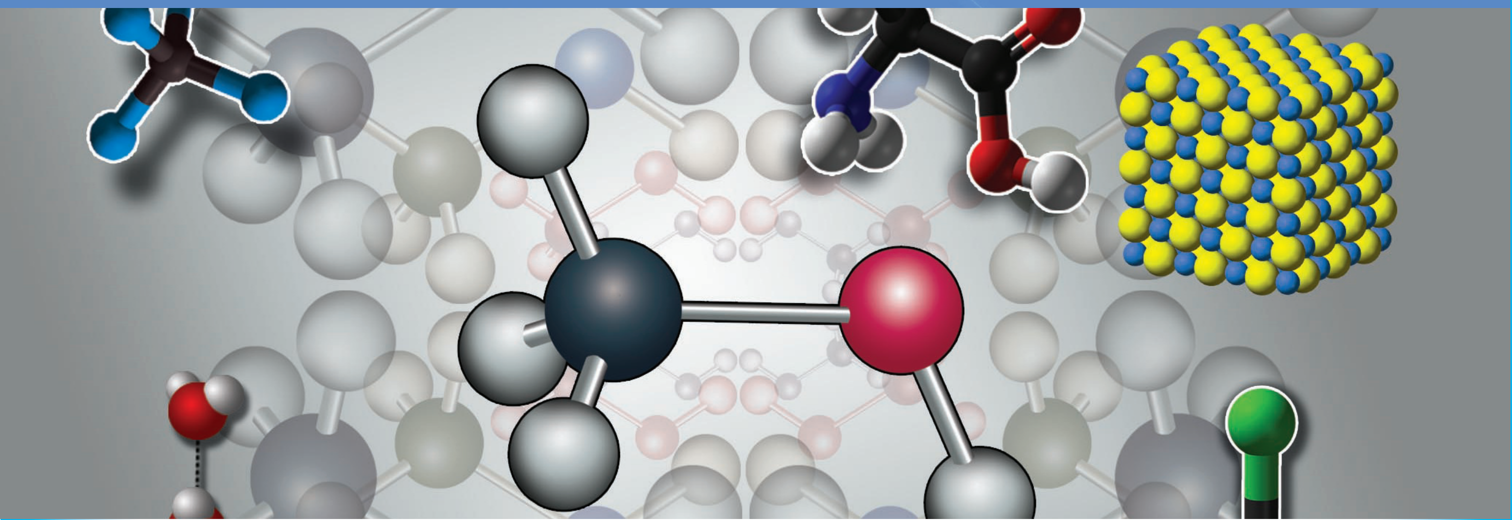
   a) Find the atomic number and mass number of these elements.
   b) Which among these are isotopic pairs?
   c) Draw the Bohr model of atom Q.

Extended Activities

1. Prepare a science magazine including photos, profiles and contributions of philosophers and scientists related to the history of atoms.
2. Construct and exhibit Bohr models of various atoms using different materials viz. beads, seeds, etc.
3. Prepare a table illustrating the electronic configuration of elements with atomic number from 1 to 36.
4. Draw and exhibit Bohr models of atoms of elements with atomic number 1 to 20.
5. Prepare a table featuring more examples of isotopes, isobars and isotones.



2 CHEMICAL BONDING



Atoms undergo chemical combination to form different types of molecules and compounds. Have you ever thought why atoms combine together? Do atoms of all the elements combine in this manner? Let's examine.

Electronic configuration and stability

Analyse the electronic configuration of a few elements given in Table 2.1.

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

Table 2.1

Normally these elements do not take part in chemical reactions, because they are chemically stable elements.

What peculiarity do you see in the electronic configuration of these elements except helium? ----------------------

Except helium, all elements have eight electrons in their outermost shell. Therefore atoms which contain eight electrons in their outermost shell can be considered to be chemically stable.

The arrangement of eight electrons in the outermost shell of atoms is called **Octet Electron Configuration**.

The helium atom contains only one shell. The maximum number of electrons that can be accommodated in the first shell is two. Therefore, the 'two electron' pattern system of helium is stable.

Analyse the electronic configuration of elements in Table 2.2.

Element	Atomic number	Electronic configuration
Magnesium	12	2,8,2
Oxygen	8	2,6
Sodium	11	2,8,1
Chlorine	17	2,8,7

Table 2.2

- Is the number of electrons in the outermost shell of these elements the same as that of the elements in Table 2.1?
- You are familiar with the compounds of these elements. Write the names of some compounds. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
- How are atoms in these compounds held together?

The attractive force that holds the atoms together in the formation of a molecule is called **Chemical Bonding**.

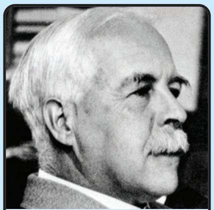
Through chemical bonding, atoms attain eight electrons in their outermost shell and thus gain stability by acquiring the lowest energy state. How do atoms of each element in Table 2.2 attain stability by acquiring the octet electronic configuration? Let's familiarise ourselves with some of these methods.

Ionic bonding

Which are the atoms that combine to form sodium chloride? Analyse the electronic configuration of each atom (Table 2.2).

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

Electron dot Diagram



Gilbert N Lewis
1875 - 1946

The method of representing electrons using dots around the symbol of an element was first introduced by the American chemist Gilbert N Lewis. In addition to dots, cross symbols are also used. Only outermost shell electrons are labelled around the symbol of an element.

- What about the number of electrons in the outermost shell of chlorine?
- How do chlorine and sodium attain stability?
- Analyse (Fig.2.1) the electron transfer in each atom during the formation of sodium chloride.

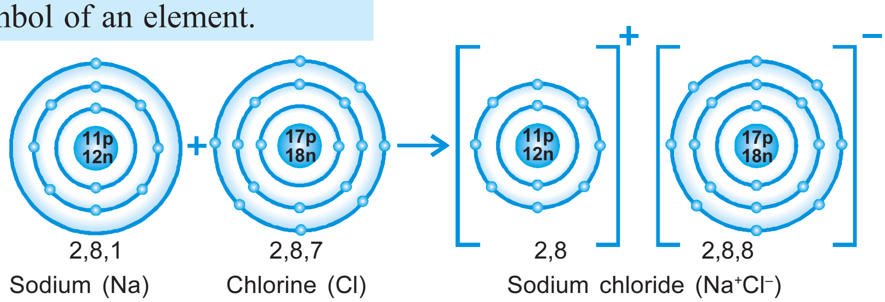


Figure 2.1

Fig 2.2 is an electron dot diagram which illustrates the transfer of electrons between sodium and chlorine atoms. The diagram represents only electrons in the outermost shell because they are the only electrons participating in chemical bonding.

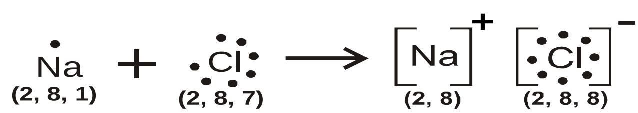


Figure 2.2

Complete Table 2.3 by examining the arrangement of electrons before and after the chemical reaction during the formation of sodium chloride.

	Sodium		Chlorine	
	Before the chemical reaction	After the chemical reaction	Before the chemical reaction	After the chemical reaction
Electronic configuration				
Number of electrons				
Number of protons				
Charge				

Table 2.3

- Which atom donated the electron? How many?
- Which atom accepted the electron? How many?

- Electron transfer during the formation of sodium chloride can be written in the form of an equation.

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

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

During the formation of sodium chloride, sodium atom donates an electron and gets converted to sodium ion (Na^{+}). Positive ions are called **cations**. Chlorine accepts an electron to form chloride ion (Cl^{-}). Negative ions are called **anions**. Through this, sodium and chlorine atoms complete an octet in their outermost shell and attain stability. The oppositely charged ions thus formed are held together by electrostatic force of attraction. This attractive force is called **ionic bond**. Sodium chloride contains ionic bond.

Ionic bond is a chemical bond formed by electron transfer. In an ionic bond, the ions are held together by the electrostatic force of attraction between the oppositely charged ions.

Let's see how magnesium oxide (MgO) is formed from magnesium and oxygen.

Complete Table 2.4 after examining the electron dot diagram given below (Figure 2.3)

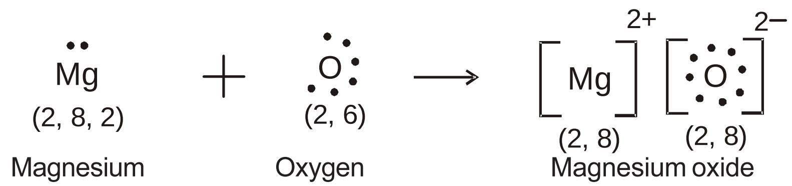


Figure 2.3

	Magnesium		**Oxygen**	
	Before the chemical reaction	**After the chemical reaction**	**Before the chemical reaction**	**After the chemical reaction**
Electronic configuration				
Number of electrons				
Number of protons				
Charge				

Table 2.4

You might have noticed the change happened to the number of electrons in the outermost shell of magnesium and oxygen upon attaining stability. You have now understood how magnesium and oxygen attained stability. You also know the type of chemical bond in magnesium oxide.

In the same way, see how the ionic bond in sodium oxide is represented.

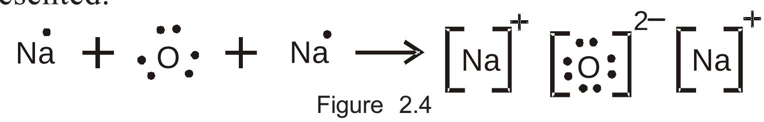


Figure 2.4

Draw the electron dot diagram of the ionic bonding in the following compounds.

Hints: (Atomic Number Na = 11, F = 9, Mg = 12)

- Sodium fluoride (NaF)
- Magnesium fluoride (MgF_2)

Compounds formed by ionic bonding are called ionic compounds.

Covalent Bonding

Fluorine (F_2), chlorine (Cl_2), oxygen (O_2), nitrogen (N_2) etc. are diatomic molecules. Let's examine the formation of these molecules.

Bohr model of fluorine atom is given in Figure 2.5

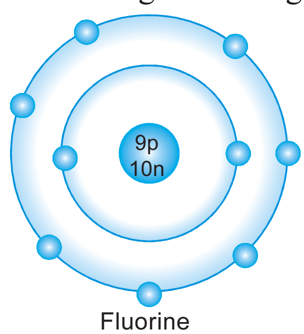


Figure 2.5

- What is the atomic number of fluorine? ____________
- Write the electronic configuration ________________
- How many electrons are required for one fluorine atom to attain the octet?

  ____

Is there a possibility of transferring electrons from one fluorine atom to another fluorine atom? Think of it.

How can the two fluorine atoms attain an octet arrangement?

- -

The manner in which the two fluorine atoms in a fluorine molecule undergo chemical bonding is illustrated in the Figure 2.6. Analyse it.

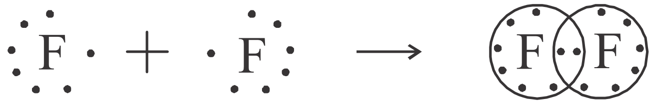


Figure 2.6

- What happens during the formation of fluorine molecule - electron transfer or electron sharing?- - - - - - - - - - - - - - -
- How many pairs of electrons are shared? - - - - - - - - - - - - - -

The chemical bond formed as a result of the sharing of electrons between the combining atoms is called a **covalent bond**.

Since one pair of electrons is shared in the formation of fluorine molecule, the bond is a **single bond**. A single bond is represented by a small line between the symbols of the combining elements (F-F).

The atomic number of chlorine is 17.

Write its electronic configuration. - - - - - - - - - - - - - - - - - - -

Draw the electron dot diagram of a chlorine atom. Also draw the electron dot diagram of the formation of a chlorine molecule by the combination of two chlorine atoms.

Determine the number of electron pairs shared.

Now, examine the diagram illustrating the chemical bonding in the molecules of oxygen and nitrogen (Fig.2.7).

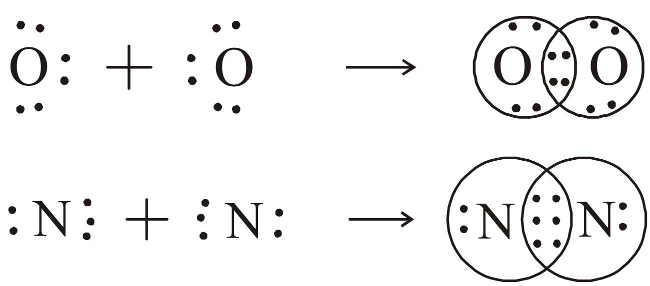


Figure 2.7

How many pairs of electrons are shared in these molecules? Covalent bond formed by sharing two pairs of electrons is a **double bond**.

If three pairs of electrons are shared to form a covalent bond, then it is a **triple bond**.

You might have understood that an oxygen molecule contains a double bond and a nitrogen molecule contains a triple bond. It can be symbolised as O=O and N≡N respectively.

Complete Table 2.5 given below related to covalent bonding.

Molecules	Number of electron pairs shared	Chemical Bond
F_2		Single bond
Cl_2		
O_2		
N_2		

Table 2.5

Let's examine how covalent bonds are formed when the combining atoms are different.

Evaluate the illustration showing the formation of a chemical bond in hydrogen chloride molecule (Fig.2.8).

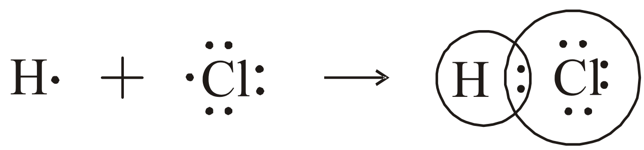


Figure 2.8

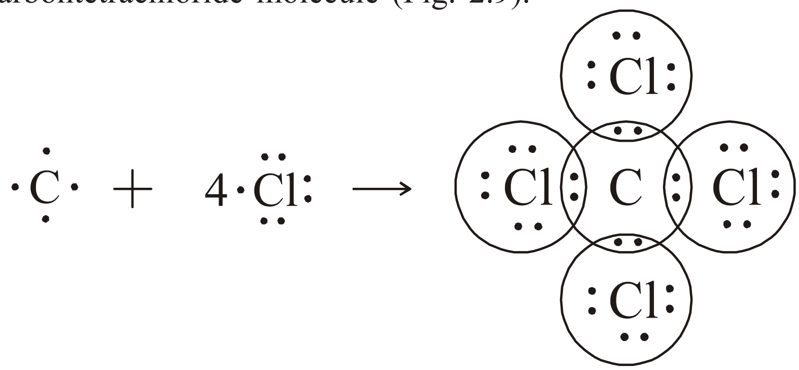
- How many electron pairs are shared?
- Represent the chemical bond using symbols.

Let's now see the formation of a carbontetrachloride molecule (CCl_4).

Draw the electron dot diagram of carbon and chlorine.

- How many electrons are required for a carbon atom to complete its octet? ---------------------------
- How many electrons are required for a chlorine atom to complete its octet? ---------------------------
- How many chlorine atoms have to combine with a carbon atom to complete its octet? ---------------------
- Which type of chemical bond is possible in carbontetrachloride molecule?------------------

See the illustration of the chemical bond formation in carbontetrachloride molecule (Fig. 2.9).



Carbon Chlorine Carbontetrachloride

Figure 2.9

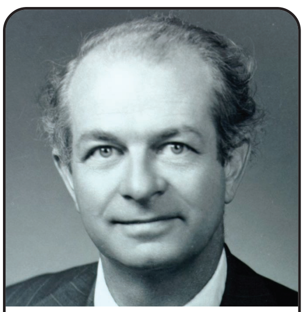
- How many pairs of electrons are shared by a chlorine atom?

- How many pairs of electrons are shared by a carbon atom?
- How can we represent the molecule using symbols?

Compounds formed by covalent bonding are called **covalent compounds**. Usually, covalent compounds are formed when nonmetals combine.

Examples of some covalent compounds are given. Illustrate the chemical bond in these compounds using electron dot diagram.

CH_4, HF, H_2O



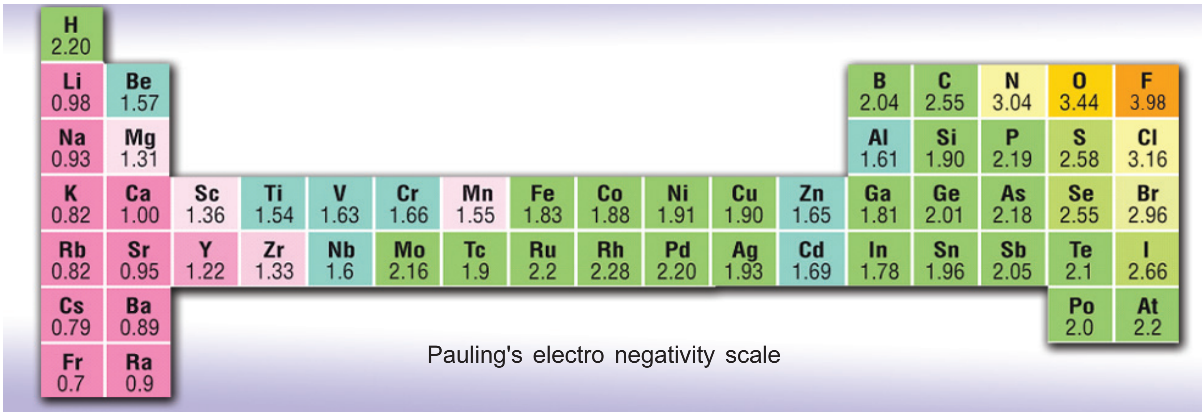
Linus Pauling
(1901 - 1994)

Electronegativity

The electron pairs shared in a covalent bond are attracted by both the combining atoms. In a covalent bond the relative ability of each atom to attract the bonded pair of electrons towards itself is called **electronegativity.**

Different types of electronegativity scales are proposed to compare the electronegativity of elements. Among these the electronegativity scale proposed by the American scientist Linus Pauling is widely accepted. This is a relative scale with values for electronegativity of elements ranging from 0 to 4. Fluorine is the most electronegative element.

A part of Pauling's electronegativity scale is given below (Fig. 2.10). Analyse it.



Pauling's electro negativity scale

Figure 2.10

Some compounds and their nature are shown in table 2.6. Complete the table by finding out the electronegativity difference between the constituent elements.

Compounds	Difference in electronegativity of constituent elements	Nature of the compound
Carbon monoxide (CO)	3.44 – 2.55 =0.89	Covalent
Sodium chloride (NaCI)	3.16 – 0.93 =2.23	Ionic
Methane (CH_4)		Covalent
Magnesium chloride ($MgCI_2$)		Ionic
Sodium oxide (Na_2O)		Ionic

Table 2.6

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

Polar Nature

The two atoms in homo diatomic molecules have the same electronegativity values. Hence they attract the shared pair of electrons equally. Eg: H_2, N_2 etc

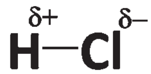
But it is not so in molecules of compounds. Consider the case of hydrogen chloride molecule (HCI).

- What is the electronegativity of hydrogen? _ _ _ _ _ _ _ _ _ _
- What is the electronegativity of chlorine?_ _ _ _ _ _ _ _ _ _ _
- The atomic nucleus of which of these elements has a greater tendency to attract the shared pair of electrons?. _

Water, a polar compound

Water is a polar molecule. The basis of the peculiar feature of water is its polar nature. Hence it exists in liquid state even though the molecular mass is low. The ability of water to dissolve many organic and inorganic compounds, thereby making it a universal solvent is also due to its polar nature.

The chlorine atom with a higher electronegativity attracts the shared pair of electrons 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.



Hydrogen chloride

Such compounds having partial electrical charge separation within the molecule are called **polar compounds**. HF, HBr, H_2O are examples of polar compounds. In polyatomic molecules, the geometrical shape of the molecule is also a factor that determines its polar nature. Water (H_2O), ammonia (NH_3) etc. are such compounds.

The difference in the nature of the chemical bonding reflects in the properties of the compounds as well.

Analyse the properties of ionic compounds and covalent compounds given in Table 2.7. Sodium chloride is an ionic compound and wax is a covalent compound. Compare the properties of these compounds with the information given in the table.

Properties	Ionic compound	Covalent compound
State	Solid	Exists in solid, liquid and gaseous states
Solubility in water	Generally Soluble in water	Generally Insoluble in water. Soluble in organic solvents like kerosene, CCl_4, benzene, etc.
Electrical conductivity	Conducts electricity in aqueous and molten states	Generally not a conductor of electricity
Melting point Boiling point	High	Usually low

Table 2.7

Valency

Atoms of elements enter into chemical bonding and attain stability. When the atoms combine together, they transfer or share electrons.

Valency is the combining capacity of an element. It can be treated as the number of electrons lost, gained or shared by an atom during chemical combination.

During the formation of sodium chloride, sodium atom donates one electron and it is accepted by chlorine atom. What is the valency of these elements?

- How many electrons does magnesium donate during the formation of magnesium oxide? _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
- How many electrons are accepted by oxygen? _ _ _ _ _ _ _ _
- How is valency and electron transfer related in this case? _
- How many electron pairs are shared during the formation of hydrogen chloride?_ _
- What will be the valency of each atom? _ _ _ _ _ _ _ _ _ _ _ _ _ _

Complete Table 2.8 given below. Analyse the change in the electronic arrangement of elements during the formation of each compound. Find how they are related to valency.

Compounds	Constituent elements	Atomic number	Electronic configuration	Number of electrons transferred or shared	Valency
NaCl	Na	11	....	1	1
	Cl	17	....	....	....
MgO	Mg	12	....	2	2
	O	8	....	....	....
HF	H	1	....	1	1
	F	......	2,7	....	....
CCl_4	C	6	....	4	4
	Cl	......	2, 8, 7	....	....

Table 2.8

From Valency to Chemical Formula

See the chemical formulae of a few compounds given below.

Sodium chloride	-	NaCl
Magnesium chloride	-	$MgCl_2$
Aluminium chloride	-	$AlCl_3$
Carbontetrachloride	-	CCl_4

Why does the number of chlorine atoms differ in these compounds? Try to find out by analysing the valency of the elements Na, Mg, Al, Cl, and C.

Analyse Table 2.9.

Element	Valency	Chemical formula of the compound	
Na Cl	1 1	Na_1Cl_1	NaCl
Mg O	2 2	Mg_2O_2	MgO
Al Cl	3 1	Al_1Cl_3	$AlCl_3$
C Cl	4 1	C_1Cl_4	CCl_4
C O	4 2	C_2O_4	CO_2

Table 2.9

Examine the above table and identify how to write chemical formula from valency. Compare your findings with the following.

- First write the element with lower electronegativity.
- Exchange the valency of each element and write as suffix.
- Divide the suffix with the common factor.
- If the suffix is 1, it need not be written.

Symbols of some elements and their valencies are given in the Table 2.10 given below. Write the chemical formulae of the compounds formed when they combine each other.

Element	Valency
Cl	1
Li	1
O	2
Zn	2
Ca	2

Table 2.10

Oxidation and Reduction

You are familiar with the reaction between magnesium and chlorine to form magnesium chloride. See the chemical equation for this reaction.

$$Mg + Cl_2 \rightarrow MgCl_2$$

- Write the electronic configuration of magnesium and chlorine. How many electrons does a magnesium atom donate? How much charge will it get? _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

- Let's complete the equation for this process.

$$Mg \rightarrow Mg^{2+} + \_ \_ \_ \_ \_ \_$$

- How many electrons are accepted by chlorine atom? What will be the charge acquired by it?_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

- Complete the equation of this process.

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

In this reaction, magnesium donates electrons and chlorine **gains** electron.

Oxidation is the process of donation of electrons and **reduction** is the process of accepting electrons. In this process, magnesium reduces chlorine by donating electrons to it. Therefore, magnesium is considered as the reducing agent in this process. Since chlorine oxidises magnesium by accepting electrons it is considered as the oxidizing agent.

You are familiar with the electronic configuration of Mg, Na, Cl, F, etc.

From the given chemical equations, identify the oxidizing agent and the reducing agent by writing the chemical equations of oxidation and reduction.

$Mg + Cl_2 \longrightarrow MgCl_2$

$2Na + F_2 \longrightarrow 2NaF$

Oxidation Number

Oxidation number is the number indicating the oxidation state of an element in a compound. In ionic compounds the oxidation number is the number of units of charge gained by the atom after bond formation. For example in NaCl the oxidation number of Na is +1 and that of Cl is -1.

In MgO the oxidation number of Mg is +2 and that of Oxygen in -2. In $FeCl_3$ oxidation number of Fe is +3. In the case of covalent compounds, oxidation number is found out by assuming that the shared electrons are completely displaced to the more electronegative atom.

For example, in a hydrogen chloride molecule it is assumed that, chlorine acquires a negative charge by accepting an electron and hydrogen acquires a positive charge by losing an electron. The oxidation number of hydrogen is taken as +1 and that of chlorine as –1.

$$H_2^0 + Cl_2^0 \rightarrow 2H^{+1}Cl^{-1}$$

In homo diatomic molecules, since electrons are equally shared by the atoms, their oxidation number is considered as zero.

The sum of the oxidation numbers of all elements in a compound is zero.

- During the formation of hydrogen chloride, from hydrogen and chlorine, does the oxidation number of hydrogen, increase or decrease? _
- What change takes place in the oxidation number of chlorine?_ _
- Based on the oxidation number, which is the oxidizing agent? Which will be the reducing agent?

The process in which the oxidation number increases is called **oxidation** and the process in which the oxidation number decreases is called **reduction**. As oxidation and reduction take place simultaneously, the overall process is known as a **redox process.**

The molecule which contains the atom whose oxidation number decreases during the process is called the oxidizing agent and that in which oxidation number of an atom increases is the reducing agent.

In the following chemical reactions, which is the oxidizing agent? Which is the reducing agent? Analyse the oxidation number and find out.

$$C^0 + 2Cl_2^0 \rightarrow C^{+4}Cl^{-1}$$

Given below is the equation of the reaction between zinc and hydrochloric acid also indicating the oxidation numbers.

$$Zn^0 + 2H^{+1}Cl^{-1} \rightarrow Zn^{+2}Cl_2^{-1} + H_2^0$$

Analyse and find out the following.

In this process,

- The oxidation number of zinc increases/decreases from ……… to ……….
- The oxidation number of hydrogen increases/decreases from ……… to ………
- Which is the oxidizing agent? Which is the reducing agent?

- -

Method of determining the oxidation number

See the common oxidation numbers of some elements given in Table 2.11

H	-	+1	Mg	-	+2	F	-	-1
Na	-	+1	Ca	-	+2	Cl	-	-1
K	-	+1	Al	-	+3	O	-	-2

Table 2.11

How can we find out the oxidation number of an atom in a compound whose oxidation number is not known? Let's try.

How to determine the oxidation number of sulphur in H_2SO_4.

From Table 2.11

Oxidation state of hydrogen = +1

Oxidation state of oxygen = –2

Let the oxidation state of sulphur be '*x*'.

We know the sum of oxidation states of all atoms in a compound is zero. Therefore,

$$[2 \times (1+)] + x + (4 \times 2-) = 0$$
$$2 + x - 8 = 0$$
$$x - 6 = 0$$
$$x = +6$$

The oxidation number of sulphur in H_2SO_4 is +6

Similarly, find the oxidation number of Mn in $KMnO_4$, MnO_2, Mn_2O_3, Mn_2O_7.

Significant Learning Outcomes

The Learner

- explains the relation between outermost shell electronic configuration of elements and their stability.
- describes ionic bonding with examples and draws the electron dot diagram of ionic compounds.
- explains covalent bonding with examples and draw electron dot diagram of covalent compounds.
- explains single bond, double bond and triple bond with examples.
- determines the electronegativity difference in elements of compounds and identifies the character of chemical bond.
- distinguishes ionic and covalent compound by comparing their properties.
- explains valency of elements and finds the valency of different elements.
- By knowing the valencies of constituent elements in compounds, writes molecular formula of compounds.
- explains oxidation and reduction and identifies oxidizing agents and reducing agents in chemical reactions.
- determines the unknown oxidation number of an atom in a compound.

Let us assess

1. Complete the table given below and answer the following questions (Symbols used are not true.)

Element	Atomic number	Electronic configuration
P	9	2, 7
Q	17	....
R	10	....
S	12	....

a) Which element in the table is the most stable one? Justify your answer.

b) Which element donates electrons in chemical reaction?

c) Write the chemical formula of the compound formed by combining element S with P.

2. Examine the following chemical equations and answer the questions. (Hint: Atomic Number Mg=12 Cl=17)

$$Mg + Cl_2 \longrightarrow MgCl_2$$

$$Mg \longrightarrow Mg^{2+} + \text{........}$$

$$Cl + 1e^- \longrightarrow \text{.......}$$

a) Complete the chemical equations.

b) Which is the cation? Which is the anion?

c) Which type of chemical bond is present in $MgCl_2$?

3. The oxidation state of oxygen is -2. Find the oxidation state of the other atoms in the following compounds.

1. H_2O 2. H_2CO_3 3. HNO_3 4. H_3PO_4

4. Electronegativity values of some elements are given. Using these values, find whether the following compounds are ionic or covalent.

(Electronegativity of Ca=1.0, O = 3.5, C = 2.5, S = 2.58, H = 2.2, F = 3.98)

Sulphur dioxide (SO_2)

Water (H_2O)

Calcium fluoride (CaF_2)

Carbon dioxide (CO_2)

5. Some elements and their valencies are given.

Element	Valency
Ba	2
Cl	1
Zn	2
O	2

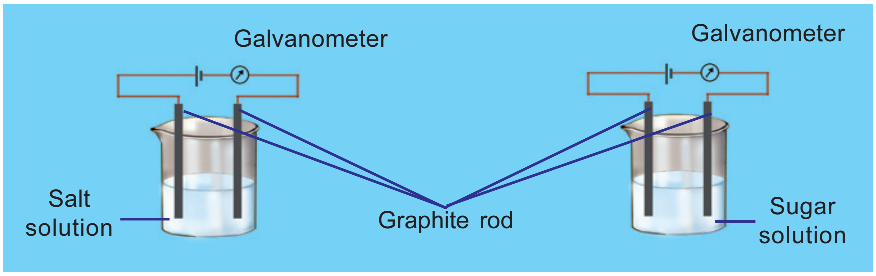
a) Write the chemical formula of barium chloride.

b) Write the chemical formula of zinc oxide.

c) The chemical formula of calcium oxide is CaO. What is the valency of calcium?

Extended Activities

1. Draw the electron dot diagram of chemical bonds in methane (CH_4) and ethane (C_2H_6).
2. Perform the experiments arranging the apparatus as shown in figure.



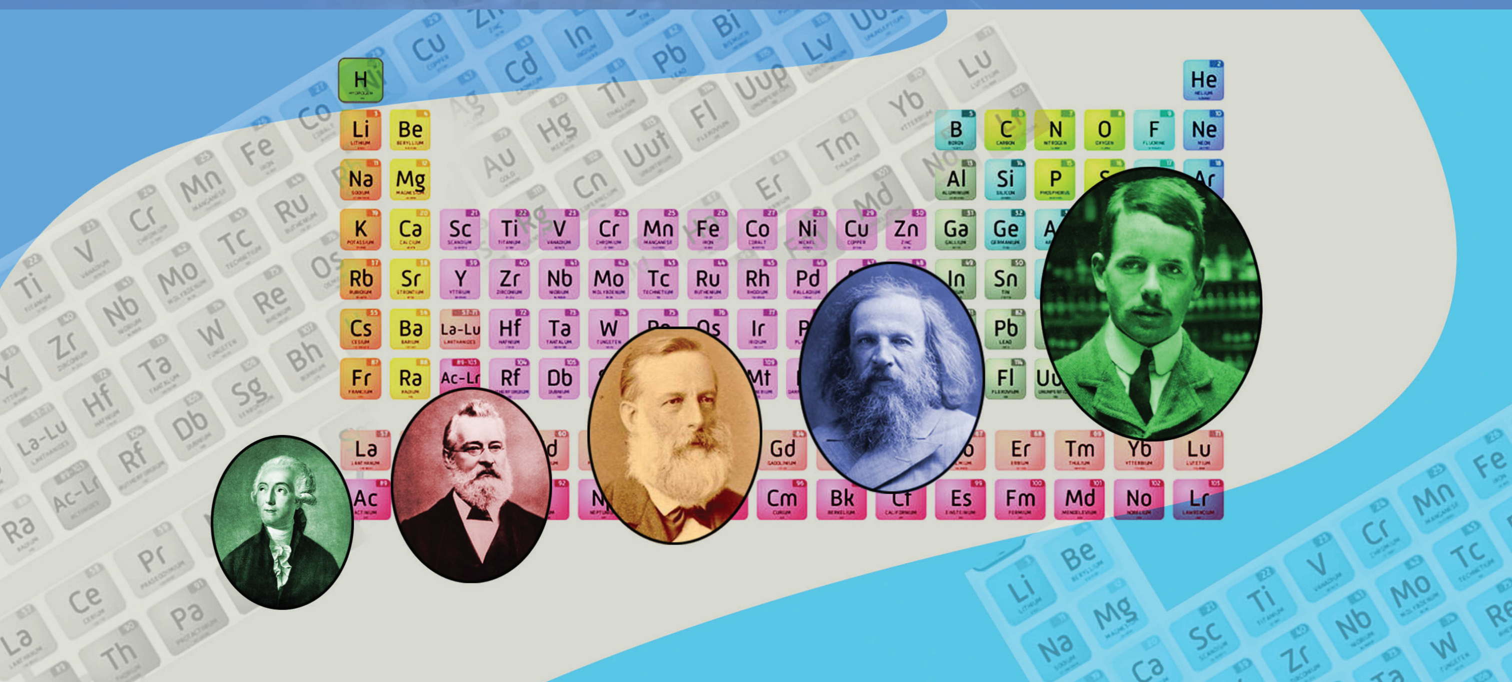
Record your observations and identify what type of compounds sodium chloride and sugar are.

3. P, Q, R, S are four elements. Their atomic numbers are 8, 17, 12 and 16 respectively. Find the type of chemical bond in these compounds formed by combining the following pairs of elements. Construct and exhibit the type of bonds using different substances (e.g. pearls).

(Electronegativity values: P=3.44, Q=3.16, R=1.31, S=2.5)

1. P, R
2. P, S
3. Q, R

3 CLASSIFICATION OF ELEMENTS AND THE PERIODIC TABLE



We live in a world of substances with great diversity. By now, you have understood that substances are formed by the combination of various elements. Which are the elements that you are familiar with? List them. Don't you know that the molecules of different compounds are formed by the combination of atoms of elements.

Give examples of a few compounds known to you

- -

Which are the elements present in them? List them. The study of elements and compounds is of great importance in Chemistry. In 1800, there were only 31 known elements. By 1865, their number became 63. Now 118 elements have been discovered. About ninety of them are seen in nature while others are artificially made. Efforts to discover new elements are still going on.

You know that it is not easy to study elements and their numerous compounds separately. Have you ever all the thought of some ways to make this study easy?

Can't you easily select your favorite book from the library? How is this possible?

- -

Isn't it the same reason why pharmacists are able to locate medicines effortlessly in medical stores?

You might have discussed in the biology class that the study of innumerable plants and animals have been made easy by classifying them comprehensively.

In the same way the classification might also help to make the study of elements easy. For example, metals like lithium, sodium and potassium are soft and react vigorously even with cold water. Copper, silver and gold are very hard and do not undergo corrosion easily.

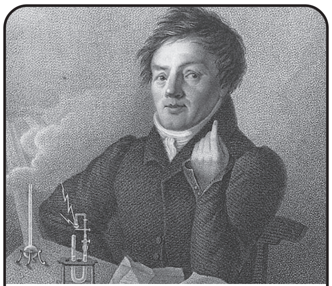
Efforts like this for the classification of elements based on the similarities in their properties had begun a long time back.

Let us familiarise ourselves with some of them.

Earlier attempts for classification of elements

In **1789,** the French scientist **Antoine Lavoisier** classified the then known elements into metals and non-metals. But he was not able to duly classify metalloids that show the properties of both metals and nonmetals.

In **1807,** the British scientist **John Dalton** put forward the Atomic Theory. This theory established that each element has a fixed atomic mass. This gave a new sense of direction to the classification of elements.



Dobereiner
(1780-1849)

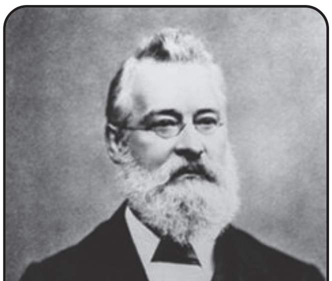
In **1829,** The German scientist **J.W.Dobereiner** classified elements having similar properties into groups of three called **Triads**. The peculiarity of these groups was that the atomic mass of the second element was approximately the arithmetic mean of the first and third elements. This peculiarity was noticeable in their properties also. But all elements could not be classified in this way.
See the examples of Dobereiner's triads given in Table 3.1.

Element	Atomic mass	Element	Atomic mass	Element	Atomic mass
Li	7	Ca	40	Cl	35.5
Na	23	Sr	88	Br	80
K	39	Ba	137	I	127

Table 3.1

ChanCourtoise
(1820-1886)

In **1862**, the French scientist **ChanCourtoise** put forward the idea of **Telluric Helix** to classify elements. He noticed that when elements are arranged spirally in the ascending order of their atomic masses in a cylindrical fashion, elements of similar properties will line up vertically.



Newlands
(1837-1898)

In **1863,** the English chemist **John Alexander Newlands** arranged elements in the increasing order of atomic mass (Table 3.2). He noticed that every eighth element had properties similar to those of the first element. Based on this, Newlands proposed the **Law of Octaves**. But this peculiarity could be noticed in elements upto calcium only.

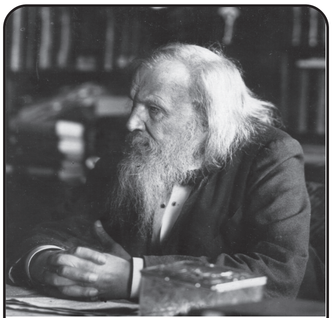
Octaves of Newlands

Element	Li	Be	B	C	N	O	F
Atomic mass	7	9	11	12	14	16	19
Element	Na	Mg	Al	Si	P	S	Cl
Atomic mass	23	24	27	29	31	32	35.5
Element	K	Ca					
Atomic mass	39	40					

Table 3.2

Lothar Meyer
(1830-1895)

In **1868**, the German scientist **Julius Lothar Meyer** plotted atomic volumes, boiling points and melting points separately against the atomic masses of elements. From the graphs, he found that the elements of similar properties remained at similar positions. From this, he arrived at the conclusion that atomic mass is the fundamental property of elements.



Mendeleev
(1834-1907)

Mendeleev's Periodic Table

The classification of elements by the Russian chemist **Dmitri Ivanovich Mendeleev** became a milestone in the history of elemental classification.

In 1869, he arranged the then known 63 elements in horizontal and vertical columns and gave shape to the Periodic Table (Table 3.3). He found that the chemical and physical properties of elements repeat at regular intervals when they were arranged in the increasing order of atomic masses. Based on this Mendeleev proposed the **Periodic Law** of elements.

Mendeleev's Periodic Law

The physical and chemical properties of elements are periodic functions of their atomic masses.

Group	I	II	III	IV	V	VI	VII	VIII
Oxide Hydride	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4
Periods	A B	A B	A B	A B	A B	A B	A B	Transition series
1	H 1.008							
2	Li 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998	
3	Na 22.99	Mg 24.31	Al 29.98	Si 28.09	P 30.974	S 32.06	Cl 35.453	
4 First series Second series	K 39.102 Cu 63.54	Ca 40.08 Zn 65.37	....	Ti 47.90	V 50.94 As 74.92	Cr 50.20 Se 78.96	Mn 54.94 Br 79.909	Fe 55.85 Co 58.93 Ni 58.71
5 First series Second series	Rb 85.47 Ag 107.87	Sr 87.62 Cd 112.04	Y 88.91 In 114.82	Zr 91.22 Sn 118.69	Nb 92.91 Sb 121.75	Mo 95.94 Te 127.60	Tc 99 I 126.90	Ru 101.07 Rh 102.91 Pd 106.4
6 First series Second series	Cs 132.90 Au 196.97	Ba 137.34 Hg 200.59	La 138.91 Ti 204.37	Hf 178.49 Pb 207.19	Ta 180.95 Bi 208.98	W 183.85		Os 190.2 Ir 192.2 Pt 195.09

Table 3.3

Fractional values for atomic mass

Most of the elements have isotopes. Therefore, while determining atomic mass, the average mass of the different isotopes is considered as the atomic mass of the atom.

For example, in chlorine gas, the isotopes of chlorine viz. chlorine – 35 and chlorine–37 are found in the ratio 3:1. The method of determining the atomic mass of chorine is given below.

$$\frac{(3 \times 35) + (1 \times 37)}{4} = \frac{105 + 37}{4} = \frac{142}{4} = 35.5$$

The vertical columns in the periodic table are known as **groups** and the horizontal rows are known as **periods**.

Evaluate Mendeleev's Periodic Table (Table 3.3) and find the following:

- Total number of periods _ _ _ _ _ _ _ _ _ _ _ _ _ _
- Total number of groups _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
- Are the elements showing similar properties arranged in same groups or same periods?

  _
- Why are some columns vacant in Mendeleev's Periodic Table?

  _
- Is the increasing order of atomic mass strictly followed? Evaluate and assess this on the basis of the position of cobalt (Co) and nickel (Ni) and that of tellurium (Te) and iodine (I).

Isn't it clear that inspite of the many advantages, Mendeleev's Periodic Table also has some limitations too? Some of them are listed below.

Advantages

- For the first time, elements were comprehensively classified in such a way that elements of similar properties were placed in the same group. This has made the study of Chemistry easy.
- When the classification was made in such a way that the elements of similar properties came in the same group, it was noticed that certain elements could not be placed in their proper groups. The reason for this was wrongly determine atomic masses, and consequently those wrong atomic masses were corrected.

eg:- The atomic mass of beryllium was known to be 14. Mendeleev reassessed it as 9 and assigned beryllium a proper place.

- Columns were left vacant for elements which were not known at that time and their properties were predicted also. This gave an impetus to experiments in Chemistry.

eg: Mendeleev gave names Eka aluminium and Eka silicon to those elements which were to come below aluminum and silicon respectively in the periodic table and predicted their properties. Later when

Mendelevium the 101th

The element with atomic number 101 is named as Mendelevium as a tribute to Mendeleev. Its symbol is Md.

these elements, gallium and germanium were discovered the prediction of Mendeleev turned out to be true.

Limitations

- Elements with large difference in properties were included in the same group.

  eg:-Hard metals like copper (Cu) and silver (Ag) were included along with soft metals like sodium (Na) and potassium (K)

- No proper position could be given to the element hydrogen. Non-metallic hydrogen was placed along with metals like lithium (Li), sodium (Na) and potassium (K).

- The increasing order of atomic mass was not strictly followed throughout.

  eg:- Co & Ni, Te & I

- As isotopes are atoms of same element having different atomic masses, they should have been given different positions while arranging them in the order of atomic mass. But, this was not done

Modern Periodic Table

In **1869**, while Mendeleev was framing the Periodic Table, there was no clear understanding about the fundamental particles or the structure of the atom.


Henry Moseley
(1887-1915)

In **1913**, the English physicist **Henry Moseley,** through his **X-ray diffraction** experiments, proved that the properties of elements depended on the atomic number and not on the atomic mass. According to this, the periodic law of Mendeleev and the periodic table were modified. Consequently, the modern periodic table was prepared by arranging elements in the increasing order of atomic number.

When elements are arranged in the increasing order of atomic number, those with the same properties repeat at regular intervals.

Modern Periodic Law

The chemical and physical properties of elements are periodic functions of their atomic numbers.

Modern Periodic Table (Table 3.4) is given below. Analyse it and find out the following.

Periodic Table

Hints
- Gases
- Liquids
- Synthetic Elements

Atomic number
Symbol
Name
Electron in configuration

1 H Hydrogen 1																	2 He Helium 2
3 Li Lithium 2,1	4 Be Beryllium 2,2											5 B Boron 2,3	6 C Carbon 2,4	7 N Nitrogen 2,5	8 O Oxygen 2,6	9 F Fluorine 2,7	10 Ne Neon 2,8
11 Na Sodium (Natrium) 2,8,1	12 Mg Magnesium 2,8,2											13 Al Aluminium 2,8,3	14 Si Silicon 2,8,4	15 P Phosphorus 2,8,5	16 S Sulphur 2,8,6	17 Cl Chlorine 2,8,7	18 Ar Argon 2,8,8
19 K Potassium (Kalium) 2,8,8,1	20 Ca Calcium 2,8,8,2	21 Sc Scandium 2,8,9,2	22 Ti Titanium 2,8,10,2	23 V Vanadium 2,8,11,2	24 Cr Chromium 2,8,13,1	25 Mn Manganese 2,8,13,2	26 Fe Iron (Ferrum) 2,8,14,2	27 Co Cobalt 2,8,15,2	28 Ni Nickel 2,8,16,2	29 Cu Copper (Cuprum) 2,8,18,1	30 Zn Zinc 2,8,18,2	31 Ga Gallium 2,8,18,3	32 Ge Germanium 2,8,18,4	33 As Arsenic 2,8,18,5	34 Se Selenium 2,8,18,6	35 Br Bromine 2,8,18,7	36 Kr Krypton 2,8,18,8
37 Rb Rubidium 2,8,18,8,1	38 Sr Strontium 2,8,18,8,2	39 Y Yttrium 2,8,18,9,2	40 Zr Zirconium 2,8,18,10,2	41 Nb Niobium 2,8,18,12,1	42 Mo Molybdenum 2,8,18,13,1	43 Tc Technetium 2,8,18,14,1	44 Ru Ruthenium 2,8,18,15,1	45 Rh Rhodium 2,8,18,16,1	46 Pd Palladium 2,8,18,18	47 Ag Silver (Argentum) 2,8,18,18,1	48 Cd Cadmium 2,8,18,18,2	49 In Indium 2,8,18,18,3	50 Sn Tin (Stanum) 2,8,18,18,4	51 Sb Antimony (Stibium) 2,8,18,18,5	52 Te Tellurium 2,8,18,18,6	53 I Iodine 2,8,18,18,7	54 Xe Xenon 2,8,18,18,8
55 Cs Caesium 2,8,18,18,8,1	56 Ba Barium 2,8,18,18,8,2	57 La Lanthanum 2,8,18,18,9,2	72 Hf Hafnium 2,8,18,32,10,2	73 Ta Tantalum 2,8,18,32,11,2	74 W Tungsten (Wolfram) 2,8,18,32,12,2	75 Re Rhenium 2,8,18,32,13,2	76 Os Osmium 2,8,18,32,14,2	77 Ir Iridium 2,8,18,32,15,2	78 Pt Platinum 2,8,18,32,17,1	79 Au Gold (Aurum) 2,8,18,32,18,1	80 Hg Mercury (Hydrargyrum) 2,8,18,32,18,2	81 Tl Thallium 2,8,18,32,18,3	82 Pb Lead (Plumbum) 2,8,18,32,18,4	83 Bi Bismuth 2,8,18,32,18,5	84 Po Polonium 2,8,18,32,18,6	85 At Astatine 2,8,18,32,18,7	86 Rn Radon 2,8,18,32,18,8
87 Fr Francium 2,8,18,32,18,8,1	88 Ra Radium 2,8,18,32,18,8,2	89 Ac Actinium 2,8,18,32,18,9,2	104 Rf Rutherfordium 2,8,18,32,32,10,2	105 Db Dubnium 2,8,18,32,32,11,2	106 Sg Seaborgium 2,8,18,32,32,12,2	107 Bh Bohrium 2,8,18,32,32,13,2	108 Hs Hassium 2,8,18,32,32,14,2	109 Mt Meitnerium 2,8,18,32,32,15,2	110 Ds Darmstadtium 2,8,18,32,32,16,1	111 Rg Roentgenium 2,8,18,32,32,18,1	112 Cn Copernicium 2,8,18,32,32,18,2	113 Uut Ununtrium 2,8,18,32,32,18,3	114 Fl Flerovium 2,8,18,32,32,18,4	115 Uup Ununpentium 2,8,18,32,32,18,5	116 Lv Livermorium 2,8,18,32,32,18,6	117 Uus Ununseptium 2,8,18,32,32,18,7	118 Uuo Ununoctium 2,8,18,32,32,18,8

58 Ce Cerium 2,8,18,19,9,2	59 Pr Praseodymium 2,8,18,21,8,2	60 Nd Neodymium 2,8,18,22,8,2	61 Pm Promethium 2,8,18,23,8,2	62 Sm Samarium 2,8,18,24,8,2	63 Eu Europium 2,8,18,25,8,2	64 Gd Gadolinium 2,8,18,25,9,2	65 Tb Terbium 2,8,18,27,8,2	66 Dy Dysprosium 2,8,18,28,8,2	67 Ho Holmium 2,8,18,29,8,2	68 Er Erbium 2,8,18,30,8,2	69 Tm Thulium 2,8,18,31,8,2	70 Yb Ytterbium 2,8,18,32,8,2	71 Lu Lutetium 2,8,18,32,9,2
90 Th Thorium 2,8,18,32,18,10,2	91 Pa Protactinium 2,8,18,32,20,9,2	92 U Uranium 2,8,18,32,21,9,2	93 Np Neptunium 2,8,18,32,22,9,2	94 Pu Plutonium 2,8,18,32,24,8,2	95 Am Americium 2,8,18,32,25,8,2	96 Cm Curium 2,8,18,32,25,9,2	97 Bk Berkelium 2,8,18,32,27,8,2	98 Cf Californium 2,8,18,32,28,8,2	99 Es Einsteinium 2,8,18,32,29,8,2	100 Fm Fermium 2,8,18,32,30,8,2	101 Md Mendelevium 2,8,18,32,31,8,2	102 No Nobelium 2,8,18,32,32,8,2	103 Lr Lawrencium 2,8,18,32,32,9,2

Table 3.4

- Total number of periods ____________________
- The shortest period ____________________
- Number of elements in the third period ____________
- Total number of groups ____________________

You may know that elements having similar properties are included in the same group of the periodic table?

Based on the common characteristics of elements in each group, they can be grouped as various families. See Table 3.5 given below.

Group Number	Family
1	Alkali metals
2	Alkaline earth metals
3-12	Transition metals
13	Boron family
14	Carbon family
15	Nitrogen family
16	Oxygen family
17	Halogens
18	Noble gases

Table 3.5

Representative Elements

Examine the elements in groups 1 and 2 and also those in groups 13 to 18 of the periodic table.

- Are there elements familiar to you?
- Are there metals in them?
- Are there non-metals included?

Find examples and list them.

Position of Hydrogen in the Periodic Table

The position of hydrogen in the periodic table is still under debate. In most of the periodic tables hydrogen is placed above alkali metals inspite of hydrogen being a non metal. While alkali metals are monoatomic, hydrogen is diatomic. Like alkali metals hydrogen loses one electron in certain chemical reactions. At the same time in some reactions hydrogen gains one electron like halogens. Alkali metals are solids, while hydrogen is a gas. Normally alkali metals have low ionization energy while hydrogen has high ionization energy like halogens.

- Do they include metalloids (eg. Si, Ge, As, Sb etc) exhibiting the characteristics of both metals and nonmetals?
- Are there elements existing in solid, liquid and gaseous states? Find examples.
  - In solid state ----------------------------
  - In liquid state ----------------------------
  - In gaseous state ---------------------------

Now, write the electronic configuration of elements with atomic numbers 1 to 10.

The atoms of the elements of these groups show the periodicity in electron filling. They contain 1 to 8 electrons in their outermost shell. The elements of these groups are called **representative elements**.

Noble gases

The elements helium, neon, argon, krypton, xenon and radon of group 18 in the periodic table are the noble gases. They are monoatomic molecules. Normally, they do not combine with others. Hence they are called inert gases. As they are found in very small quantities they are also called rare gases. Helium is used for filling weather balloons, as it has very low density. Neon gas is used in discharge lamps for the orange colour. Argon gas is filled in electrical bulbs to prevent evaporation of the filament. Radon is a radioactive gas and is found only in very small quantities.

Noble gases

- List the elements in group 18.

- Now try to write their electronic configuration.

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

- These elements do not normally take part in chemical reactions. Find the reason.

Group 18 elements are known as noble gases.

Transition Elements

The elements present in groups 3 to 12 in the periodic table are transition elements.

- Find out whether elements familiar to you are present in these groups.
- Aren't transition elements metals?

- They form coloured compounds.
- They show similarity in chemical properties in groups as well as in a period.
- In compounds, they exhibit different oxidation states. eg. Fe^{2+} and Fe^{3+}

Lanthanoides and Actinoides

Which element is next to Lanthanum with atomic number 57 of group 6 in the periodic table? Find out the position allotted to the elements with atomic number 58 to 71?

In the same way, aren't the elements with atomic number 90 to 103 of period 7 given separate positions at the bottom of the periodic table?

These elements are called **inner transition elements**.

Inner transition elements from cerium (Ce) to lutetium (Lu) of period 6 are called **Lanthanoides**. Inner transition elements from thorium (Th) to lawrencium (Lr) of period 7 are called **actinoides**.

Lanthanoides are also called **rare earths**. Actinoides are man-made artificial elements. (except thorium and uranium)

Periodic Trends in the Periodic Table

What are the characteristics of an element that can be understood from the periodic table? List them.

- Name
- Symbol
- _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
- _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Find the facts related to the element carbon in the periodic table (Table 3.4) and write them.

Periodic tables have also been prepared by recording more information about elements.

See at the electronic configuration of group 1 elements of the periodic table given (Table 3.6).

Element	Atomic Number	Electronic configuration	Group	Period
H	1	1		
Li	3	2, 1		
Na	11	2, 8, 1		
K	19	2, 8, 8, 1		
Rb	37	2, 8, 18, 8, 1		
Cs	55	2, 8, 18, 18, 8, 1		
Fr	87	2, 8, 18, 32, 18, 8, 1		

Table 3.6

What is the peculiarity seen in the electronic configuration of the outermost shell of these elements?

- -

Elements in group 1 exhibit similarity in chemical properties.

Write the electronic configuration of some of the elements in group 2 and analyse them. Do you see a similar trend.

Chemical properties of elements depend on the number of electrons present in their outermost shell.

Now you might have understood the reason for the similarity in the chemical properties of elements present in the same group.

For the elements given in Table 3.6, find the group and period in the periodic table.

Is there any relationship between the group number and the number of electrons present in the outermost shell? What is it?

- -

Write the electronic configuration of group 2 elements and examine. What peculiarity is seen here?

- -

The group number is the same as the number of electrons in the outermost shell for the elements in groups 1 and 2.

Observe (Figure 3.1) the electronic configuration of the second period elements of the groups from 13 to 18 given below.

13	14	15	16	17	18
B 2, 3	C 2, 4	N 2, 5	O 2, 6	F 2, 7	Ne 2, 8

Figure. 3.1

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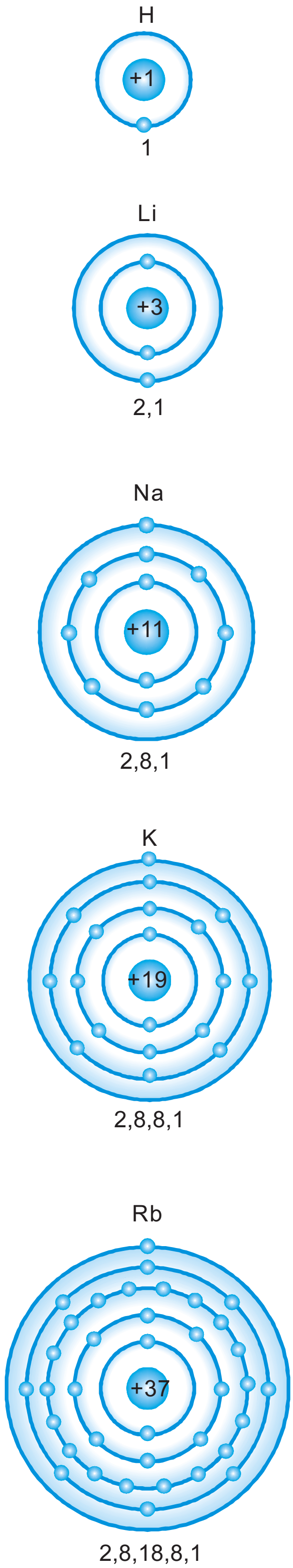

Figure. 3.2

Won't we get the group number of these elements by adding 10 to the number of electrons in the outermost shell?

Analyse Table 3.6 and find whether there is any relation between the number of shells in an atom and the number of periods.

Examine whether it is applicable to other groups also.

The number of shells in an atom and the period number are the same.

Size of an atom in groups

Are you not familiar with the Bohr Model of an atom? See the Bohr model of atoms of certain elements in group 1 (Figure 3.2).

Which among them is the biggest? Which one is the smallest? What happens to the size of atom when we move down the group?

What is the reason for this? --------------------------

As we move from top to bottom of a group in the periodic table, the size of the atom increases as there is an increase in the number of shells.

IUPAC System of Nomenclature of Elements

Earlier nomenclature of elements was done by scientists based on country, place, properties etc. But nowadays, the names of elements are decided by IUPAC (International Union of Pure and Applied Chemistry). Flerovium (F*l*) and Levermorium (Lv) with atomic numbers 114 and 116 respectively are the elements recently named by IUPAC. The elements whose names are yet to be decided are named by using word roots representing numerals. See the word roots used for this, given below.

0 – n	nil
1 – u	un
2 – b	bi
3 – t	tri
4 – q	quad
5 – p	pent
6 – h	hex
7 – s	sept
8 – o	oct
9 – e	enn

Name is given by writing word roots in the order of atomic number and suffixing 'ium' to it.

eg:- 116 – Uuh (ununhexium)
117 – Uus (ununseptium)

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Atomic size in a period

See (Figure 3.3) the representation of the Bohr model of elements with atomic number 3 to 9 in the second period of the periodic table.

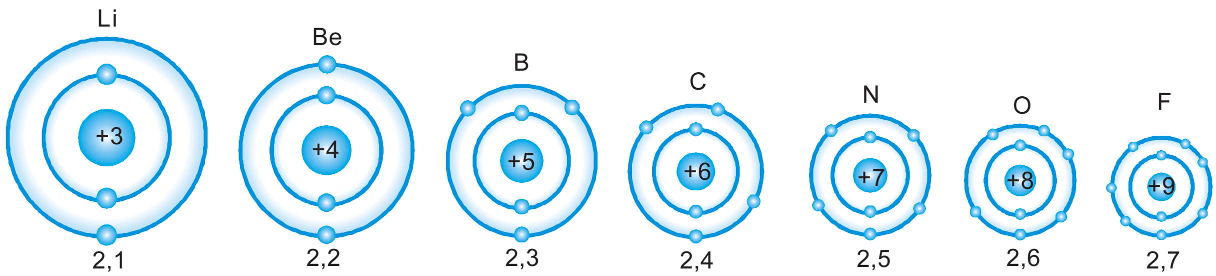

Figure 3.3

Is there an increase in the number of shells with the increase in atomic number here?

What happens to the nuclear charge with increase in the atomic number? _

You may be aware of the fact that positively charged nucleus attracts electrons. Therefore, on moving from left to right in a period, as nuclear charge increases, the force of attraction on the outermost electrons increases and consequently the size of atom decreases.

Ionisation Energy

When metals combine with non metals, the compounds formed are usually ionic in nature.

You have understood how sodium chloride is formed by combining sodium and chlorine atoms. The Bohr models of sodium and chlorine are given below (Figure 3.4)

Atomic Radius

Atomic radius is one of the methods to express the size of an atom. Atomic radius is the distance from the centre of the nucleus to the outer most shell. Atomic radius increases with increase in number of shells in the atom.

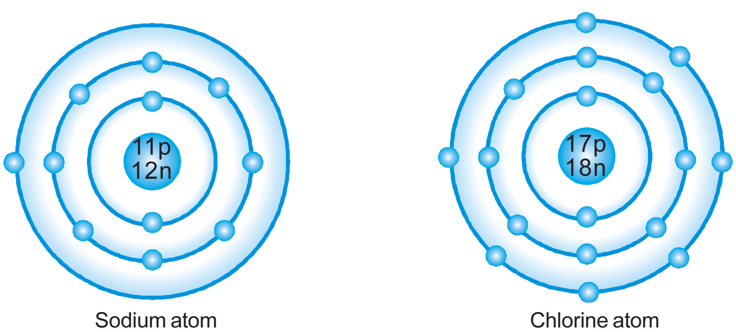

Figure 3.4

- Which among these atoms loses electron? ___________
- Which one gains electrons? ____________________

Atoms become charged when there is transfer of electrons in this way and they are called ions.

Here, sodium ion (Na^+) and chloride ion (Cl^-) are formed. In such a process, metals lose electrons and become positively charged ions. Positive ions are formed when electrons are released from atoms by overcoming the attractive power of the positively charged nucleus. Energy is needed for this. This energy is known as ionization energy.

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

Ionisation energy depends on two important factors.

- Nuclear charge
- Size of the atom

When the size of an atom increases, does the attraction of the nucleus on the outermost electron increase or decrease?

____

Then what is the change in the ionization energy? __________

As the size of atom increases ionization energy decreases.

Ionisation energy decreases as we move down a group due to an increase in the size of the atom. As a result, the tendency to form a positive ion increases. Atomic size decreases as we move from left to right of a period. Hence ionisation energy increases. Consequently the tendency to form a positive ion decreases.

Can you find out how ionization energy changes as we move from top to bottom in a group?

____

What is the general trend in the variation of ionization energy on moving across a period from left to right?

____

You know the relation between nuclear charge and the size of an atom?

Find how ionization energy changes with increase in nuclear charge.

Electronegativity

You know that in the case of two atoms joined by a covalent bond, electronegativity is the ability of each atom to attract the bonded electrons.

Size of the atom is an important factor that influences electronegativity. As the size of an atom increases the distance between the nucleus and the outermost electrons increases. Think about the variation in electronegativity with the change in size of atom along a group and across a period.

Tick (✓) the correct option.

As we move downwards a group,

a) size of atom (increases/decreases)

b) electronegativity (increases/decreases)

As we move in the same period from left to right.

a) size of atom (increases/decreases)

b) electronegativity (increases/decreases)

Electronegativity decreases with increase in the size of an atom. Also, there is decrease in electronegativity with decrease in ionization energy.

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In the periodic table, electronegativity decreases on moving from top to bottom in a group.

In a period, electronegativity increases on moving from left to right.

Metallic and Non-metallic Nature

You have studied the common properties of metals in previous classes.

Elements consists of both metals and non-metals. Do you know the basis for the chemical properties of metals and non-metals? You know that atoms combine together to give compounds. In these chemical reactions, metals are the elements which give away the electrons and those that accept electrons are generally non-metals.

Metals are called **electropositive elements** because they lose electrons to form positive ions. Non metals are called **electronegative elements** because they gain electrons in chemical reactions to form negative ions.

- What is the relationship between metallic character and the size of an atom?

As you know, nonmetallic character decreases with increase in metallic character.

With the help of Bohr model find how the metallic character of first group elements changes on moving from top to bottom in the group. ________________________________

- How do the metallic character and non-metallic character vary while moving from left to right in a period? Arrive at a conclusion by assessing the size of atom.

In the periodic table, while moving from top to bottom in groups metallic character generally increases while nonmetallic character decreases. In periods, as we move from left to right metallic character generally decreases while non-metallic character increases.

Now predict the positions of elements with the highest metallic character and the highest non-metallic character in the periodic table.

Don't you think that there is a relationship between ionization energy and metallic – non-metallic characters?

Is the element with the high ionization energy metallic or non-metallic? ________________________________

Then, what about those having the low ionization energy? _____

Isn't there a relationship between electronegativity and metallic-non-metallic characters? Explain the relationship.

____

Is a highly electronegative element a metal or a non-metal? Then, what about those having low electronegativity? Find them out.

Understand the position of the metalloids using Kalzium software of IT@School Edubuntu

Metalloids

Elements exhibiting the properties of both metals as well as non metals are called metalloids. Silicon (Si), germanium (Ge), arsenic (As), antimony (Sb) and tellurium (Te) belong to this category.

Find the position of these elements in the periodic table.

Do you see any peculiarity?

You must have understood certain periodic trends in the periodic table? Based on these (✓) the correct option given below in table 3.7.

Trends	In group from top to bottom	In period from left to right
Size of atom	decreases/increases	decreases/increases
Metallic character	decreases/increases	decreases/increases
Non metallic character	decreases/increases	decreases/increases
Ionisation energy	decreases/increases	decreases/increases
Electronegativity	decreases/increases	decreases/increases

Table 3.7

Use kalzium software of IT@school edubuntu

Now, you have understood the history of elemental classification and peculiarities of the periodic table. Proper understanding of periodic table is very essential for making the study of chemistry easy. We shall understand more about the elements of periodic table and the trends in periodicity in higher classes.

Significant Learning Outcomes

The learner

- explains the earlier attempts of elemental classifications and the contributions made by the scientists in them.
- explains the merits and demerits of Mendeleev's periodic table.
- explains modern periodic law.
- analyses the electronic configuration of elements and writes the groups and periods in which they are included.
- finds the families of element and lists the members present in them.
- finds the position of representative elements, transition elements, lanthanoids and actinoids in the periodic table and explains their peculiarities.
- explains how the size of the atom varies in groups and periods in the periodic table.
- explains the relationship between the size of the atom, ionization energy and electronegativity.
- explains the variation of metallic character and nonmetallic character of elements in periods and groups.
- attains understanding about metalloids and finds their position in the periodic table.

Let us assess

1. The table given below lists the contributions and names of scientists who made earlier attempts in the classification of elements. Fill in the blanks.

Contribution/Findings	Name of scientist
Triads	....
....	Newlands
Atomic mass – Atomic volume graph	....
Telluric helix	....
....	John Dalton
Classification of elements into metals and nonmetals	....
Modern Periodic Law	....

2. Complete the table

Element	Atomic Number	Electronic Configuration	Group Number	Period Number
Lithium	....	2, 1	1	2
Oxygen	8	....	....	....
Argon	18	....	....	....
Calcium	....	2, 8, 8, 2	....	....

3. Symbols of certain elements are given. Write their electronic configuration and find the period and group in which they are included.

a) $^{12}_{6}C$ b) $^{24}_{12}Mg$ c) $^{35}_{17}Cl$ d) $^{27}_{13}Al$ e) $^{20}_{10}Ne$

4. There are three shells in the atom of element 'X', 6 electrons are present in its outermost shell.

a. Write the electronic configuration of the element.

b. What is its atomic number?

c. In which period does this element belong?

d. In which group is this element included?

e. Write the name and symbol of this element.

f. To which family of element does is this element belong to?

g. Draw and illustrate the Bohr atom model of this element.

5. Electronic configurations of elements P, Q, R and S are given below. (These are not actual symbols).

P – 2, 2

Q – 2, 8, 2

R – 2, 8, 5

S – 2, 8

a) Which among these elements are included in the same period?

b) Which are those included in the same group?

c) Which among them is a noble gas?

d) To which group and period does the element R belong?

6. An incomplete form of the periodic table is given below. Write answers to the questions connecting the position of elements in it.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	A																	
2	B	E											I		K	L	M	
3	C	F											J				N	
4	D					G		H										

a) Which is the element with the biggest atom in group 1?

b) Which is the element having very lowest ionization energy in group 1?

c) Which element has the smallest atom in period 2?

d) Which among them are transition elements?

e) Which of the elements L and M has the lowest electronegativity?

f) Among B and I which has higher metallic character?

g) Which among these are included in the halogen family?

h) Which is the element that resembles E the most in its properties?

Extended Activities

1. Prepare a paper to be presented at a seminar based on the topic 'Earlier attempts of classification of elements'.

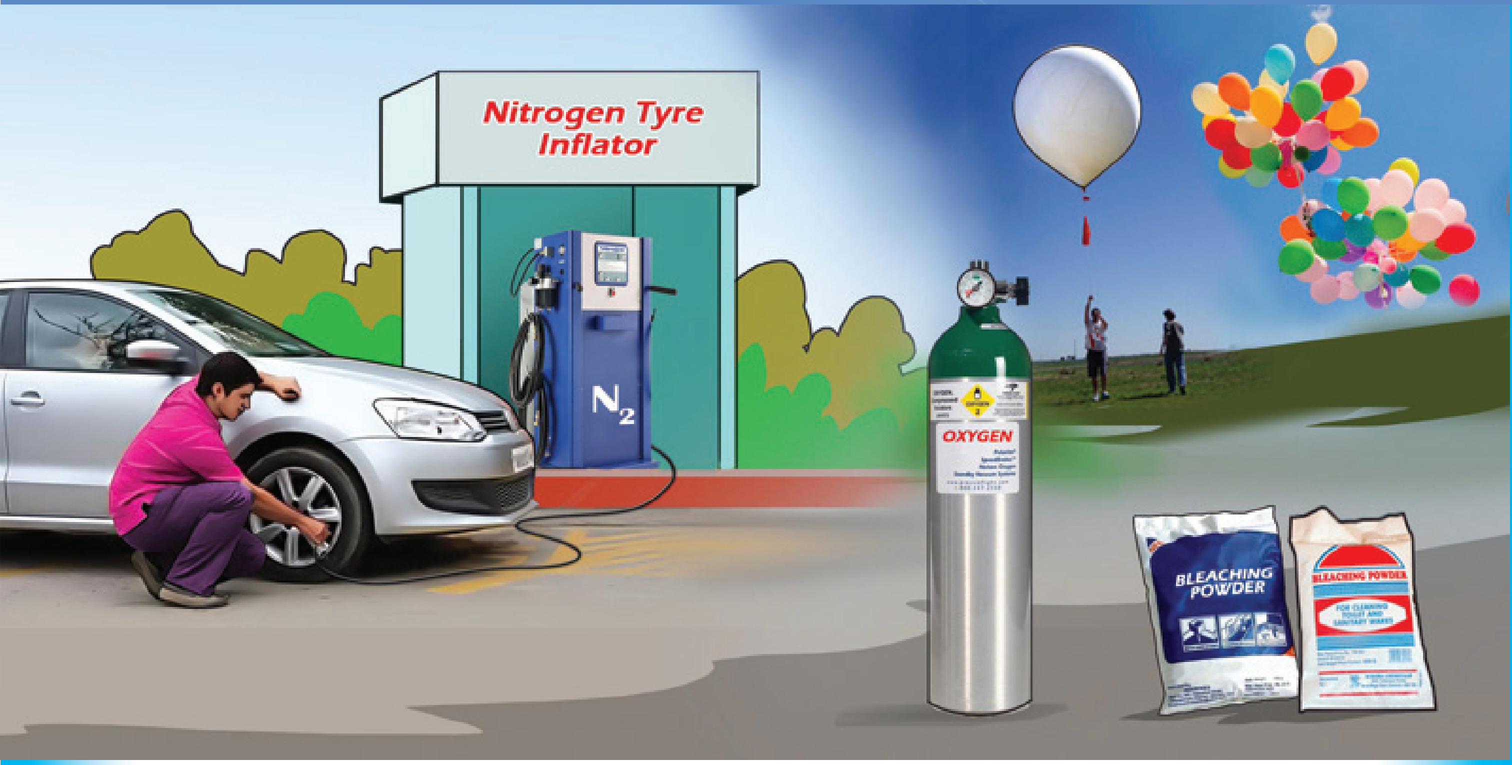
2. Prepare the biographical notes of scientists related to the classification of elements.

3. Draw a model of the modern periodic table and exhibit in classroom.

4. Find the uses of transition elements familiar to you. Prepare a note and present it.

5. Collect more information about rare earth elements. Prepare a note and present it in your class.

4 NON-METALS



You have learnt about the general properties and uses of metals in the previous classes.

What do you observe in the picture shown above?

- Which is the gas filled in the balloons flying high in the air?
- Which is the gas filled in tyres?
- Where have you seen oxygen cylinders being used?
- What is the reason for the odour of bleaching powder?

Non-metals are elements that are as important as metals. Let us learn about certain non-metals in this chapter.

Which are the gases present in air.

Analyse figure 4.1 and the Table 4.1 given below.

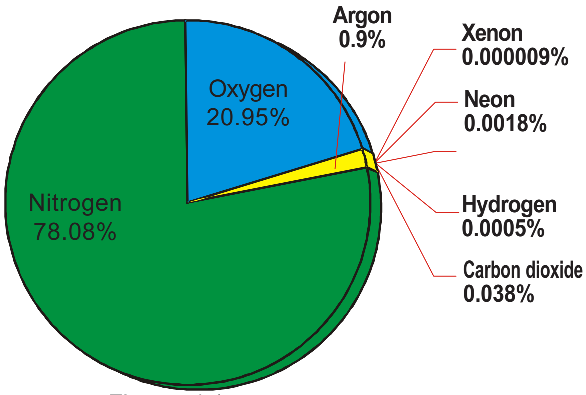


Figure 4.1

Components	Percentage
Nitrogen	78.08
Oxygen	20.95
Argon	0.9
Carbon dioxide	0.038
Others	0.032

Table 4.1

Which is the most abundant gas in air?

Now, let us have a look at the constituent elements of food materials.

Carbohydrates	:	C, H, O
Protein	:	C, H, O, N
Fat	:	C, H, O

Now, let us analyse the constituent elements of some plastics.

PVC	:	C, H, Cl
Polythene	:	C, H

C, H, N, O, Cl are all nonmetals. The important constituent elements of water, air and food materials are non-metals. Non-metals have great importance not only in biological processes but also in the industrial field. Let's familiarise ourselves with certain non metals.

Oxygen – the breath of life

Oxygen, the breath of life, is a gas that is most essential for the existence of life. List some compounds that contain oxygen.

- $C_6H_{12}O_6$
- CuO
- $CaCO_3$
-

It is highly essential to maintain a certain minimum level of oxygen in the atmosphere. Prepare a note on the role of plants in maintaining the level of oxygen constant in the atmosphere and present it in class.

Oxygen in Nature

Oxygen is the most abundant element in the earth's crust. There are many oxygen containing compounds in rocks and soil. Oxygen is present in the free state or in the combined form in water, minerals and living beings.

Analyse Table 4.2 to understand the presence of oxygen on the earth.

Discovery of Oxygen

Joseph Priestley
(1733-1804)

Joseph Priestley discovered oxygen in 1774. But the name 'oxygen' was given by the French scientist, Lavoisier. The name oxygen was derived from the word 'Oxygenes', which means 'acid forming'

Earth's crust	45-50%
Water	88-90%
Minerals	45-50%
Air	21%
Plants	60-70%
Animals	60-70%

Table 4.2

You might have understood that the level of oxygen is very high in nature.

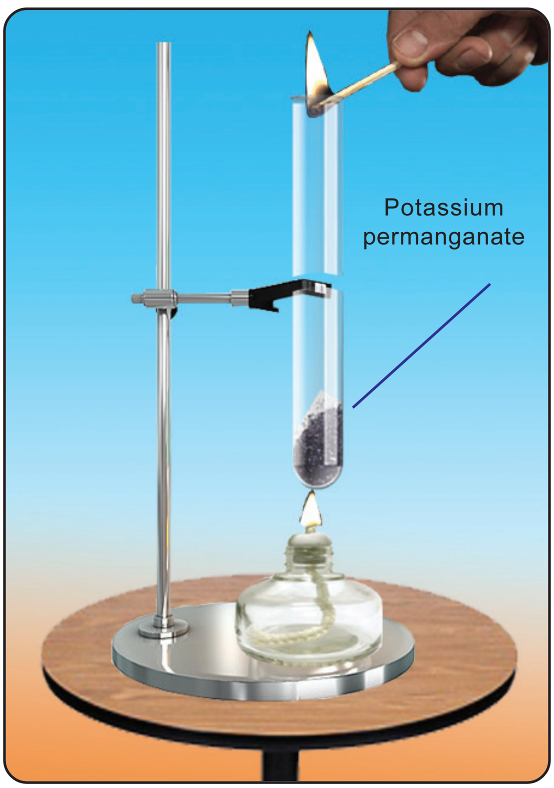


Figure 4.2

Preparation of oxygen

Observe Figure 4.2 showing the classroom experiment for the preparation of oxygen.

What are the materials used for the preparation of oxygen?

- Dry boiling tube
- Crystals of potassium permanganate
-

Let's examine the gas that evolves on heating potassium permanganate.

Insert a glowing splinter into the boiling tube.

What do you observe? _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

The presence of which gas is indicated by the flaring up of the glowing splinter?

_ _

Complete the chemical equation.

$$2KMnO_4 + Heat \rightarrow K_2MnO_4 + MnO_2 + ...$$

Potassium Permanganate	Potassium manganate	Manganese dioxide	

You have learnt about the electrolysis of water. Complete its chemical equation given below.

$$2H_2O \xrightarrow{\text{Electrolysis}} .... + ...$$

Oxygen can be prepared by this method also.

Oxygen is a gas that is used on a large scale in everyday life. Gases can be liquefied by lowering the temperature and applying pressure. Oxygen is industrially produced by the fractional distillation of liquefied air.

Given below are certain properties.

Put a ✓ mark against the correct option related to oxygen from those given below.

Colour	Yes/ No
Odour	Yes/ No
Solubility in water	soluble/ insoluble
Density	more than air/ less than air
Flammability	flammable/ supports combustion

Now let's learn about certain chemical reactions of oxygen.

The process of burning of a substance in oxygen is called **combustion.**

Take a small quantity of sulphur in a spatula and burn it.

What do you observe?

Are you familiar with the smell that comes from it?

- -

Biodecomposition

You know that the remains of plants and animals undergo biodecomposition. This happens due to the action of micro organisms like bacteria and fungi in their biomolecules. These micro organisms generate the energy required for their metabolic activities by oxidising biomolecules.

This is due to the formation of sulphur dioxide when sulphur combines with oxygen.

$$S + O_2 \rightarrow SO_2$$

In the same way oxygen combines with nonmetals like carbon and hydrogen to form carbon dioxide and water respectively. Complete the following chemical equations.

$$C + O_2 \rightarrow \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$2H_2 + O_2 \rightarrow \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Have you noticed that the lustre of metals like aluminium and iron fades gradually. One of the reasons for this is the formation of oxides of these metals when they combine with oxygen.

Given below are some of the uses of oxygen. Add more to the list.

- For combustion
- As an oxidant in rocket fuels
- Artificial respiration
-

Ozone

Oxygen is found as a diatomic molecule consisting of two atoms whereas ozone (O_3) is a molecule composed of three oxygen atoms.

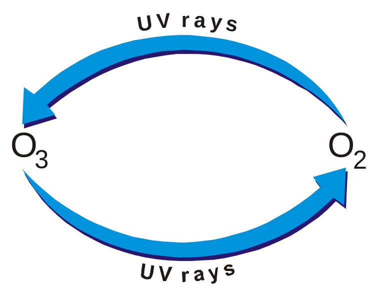
Ozone is present mostly in the stratosphere of the atmosphere. Atmospheric oxygen dissociates on absorption of high energy ultraviolet radiation. The oxygen atoms thus formed combine together to form O_3 molecule.

$$3O_2 \underset{}{\overset{\text{UV rays}}{\rightleftharpoons}} 2O_3$$

Chlorofluorocarbons

Compounds known as CFC or chlorofluorocarbons are a class of compounds containing chlorine, fluorine and carbon. They are easily liquefied by applying pressure. Liquefied CFCs produce a cooling effect on evaporation and hence they are used in appliances like refrigerators, A.C., etc. These appliances when wornout are abandoned, the CFCs are released into the atmosphere. These chlorofluorocarbons cause ozone layer depletion. In order to create awareness about the need to preserve the ozone layer, September 16th is celebrated as International Ozone Day.

Ozone absorbs low energy ultraviolet radiations and decomposes back to oxygen. As a result of this cyclic process, the level of ozone remains constant in the atmosphere.



The energy required for this process is obtained from the ultraviolet radiations emitted by the sun. Due to this, such harmful radiations do not reach the earth excessively.

Ozone Layer Depletion

Chlorofluorocarbons are responsible for the depletion of the ozone layer.

Chlorofluorocarbons released into the atmosphere reach the stratosphere and break down by the action of ultra violet radiation releasing chlorine. This chlorine decomposes ozone molecules into oxygen. This disturbs the equilibrium in the ozone – oxygen cyclic process.

The depletion of ozone in the atmosphere reduces the absorption of ultraviolet rays.

What are the adverse effects caused on living beings and nature by the ultraviolet radiations reaching the earth? Prepare a note.

What can we do to protect the ozone layer and ensure the protection of living beings? List the measures that can be taken.

Today the use of CFC is being controlled in most of the countries. Harmful CFC are replaced now a days with safer substances. This has helped in reducing the rate of depletion of ozone layer.

Nitrogen

Nitrogen is the chief constituent of atmospheric air. Have you ever thought of the advantages of having a greater quantity of nitrogen in the atmosphere?

As you know, the nitrogen molecule has a triple bond in it. Because of this strong bond, nitrogen is almost inert. Oxygen helps in combustion while nitrogen plays an important role in regulating the rate of combustion of oxygen.

Preparation of Nitrogen

Nitrogen can be prepared, in the laboratory, by heating a mixture of ammonium chloride and sodium nitrite. Ammonium nitrite formed in this way is unstable and hence it immediately decomposes to give nitrogen. Look at the equations for the chemical reactions given.

$$NH_4Cl + NaNO_2 \rightarrow NH_4NO_2 + NaCl$$

$$NH_4NO_2 \rightarrow N_2 + 2H_2O$$

Nitrogen is the most abundent gas in the atmosphere.

Industrially, nitrogen is prepared by the fractional distillation of liquefied air.

Nitrogen is an element essential for the growth of plants. Even if the atmosphere contains a large quantity of nitrogen, plants cannot absorb it directly. If so, what are the ways in which plants obtain nitrogen? Write down some of the ways that you have learnt.

Nitrogen Fixation

The bacterium Rhizobium present in soil converts the atmospheric nitrogen directly absorbed by the root of legumes into its compounds. This helps to increase the nitrogen level in the soil.

Assimilation of nitrogen by plants is easier when nitrogen containing compounds are mixed with soil.

During lightning the triple bond in nitrogen breaks and combines with the atmospheric oxygen to form nitric oxide (NO).

$$N_2 + O_2 \rightarrow 2NO$$

Nitric oxide thus formed further combines with more amount of oxygen to form nitrogen dioxide (NO_2). Complete the chemical equation and balance it.

$$NO + O_2 \rightarrow \ldots\ldots\ldots\ldots\ldots$$

Nitrogen dioxide dissolves in rain water in the presence of oxygen and reaches the soil as nitric acid (HNO_3).

$$4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$$

Nitric acid reacts with the minerals in the soil to form nitrate salts which is absorbed by the plants. So it is said that lightning is a boon to plants. But plants get only a very small amount of nitrogen in this way.

Biodegradation of the remains of plants and animals is another way in which the elements required for the growth of plants can be obtained in large quantities.

List some other methods by which plants get nitrogen.

- Use of bio-fertilizers
-

List the merits and limitations of the application of organic fertilizers.

- Environment friendly
- Preserves the innate nature of the soil

Compare it with the application of chemical fertilizers.

What are the other uses of nitrogen?

- In the manufacture of nitrogenous fertilizers
- For inflating tyres of vehicles
- Liquid nitrogen is used as a refrigerant
- To avoid the presence of oxygen in food packets
-

Figure 4.3 given below represent the nitrogen cycle. Based on this prepare a note on the fixation of nitrogen in nature.

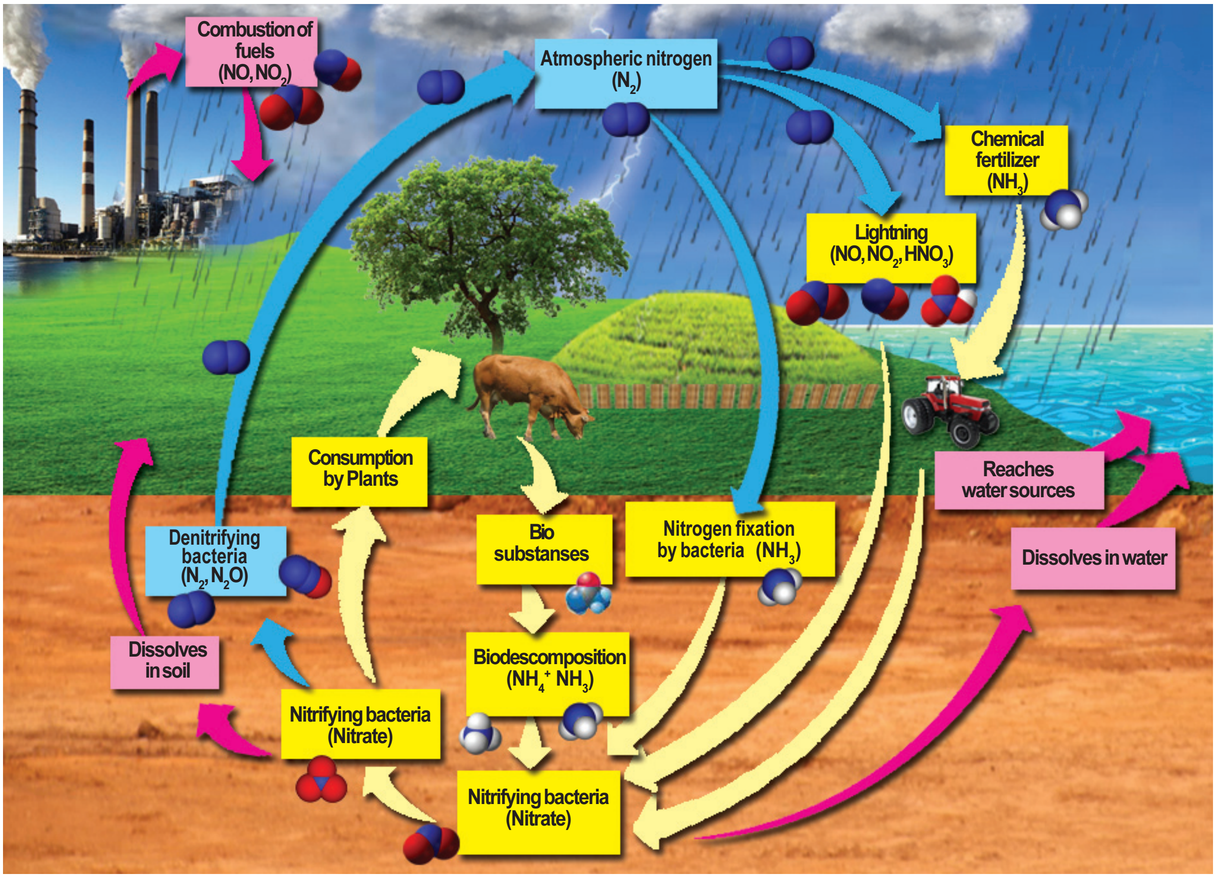


Figure 4.3

Hydrogen

You have already learnt that the most abundant element in the universe is hydrogen.

Discovery of Hydrogen


Henry Cavendish
1731-1810

In 1766 the British scientist Henry Cavendish discovered hydrogen. He called it the inflammable air. The name hydrogen was given from the word 'Hydrogenes' which means 'water forming'.

Hydrogen is the main component in the sun and the stars.

Hydrogen is present in its free state in very small quantities in the air.

An important compound of hydrogen is water. Biomaterials contain large quantities of hydrogen.

List the compounds of hydrogen that you know

- H_2SO_4
-

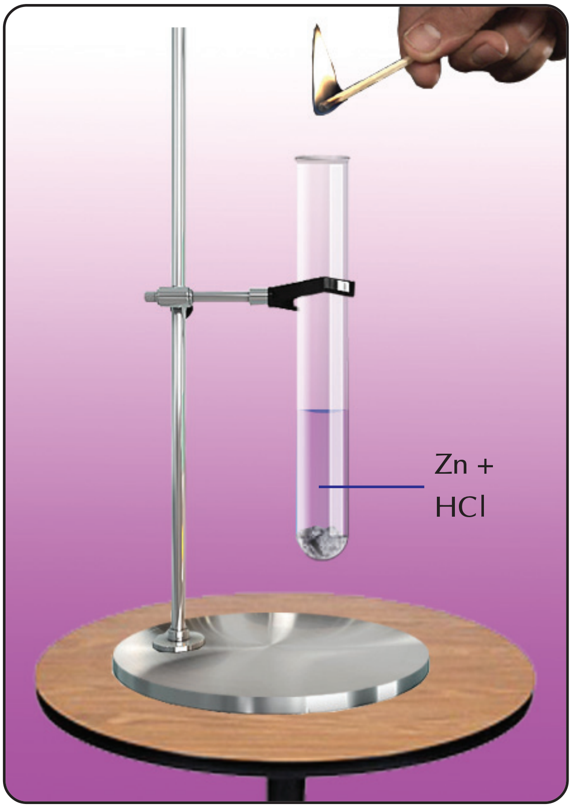


Figure 4.4

Figure 4.5

Preparation of Hydrogen

Take 5mL dilute hydrochloric acid in a test tube and add some zinc granules to it (Figure 4.4). Bring a lighted match stick to the mouth of the test tube. What do you observe?

- -

Which gas burns with a pop sound?

Write the balanced chemical equation for the reaction -

Now let us do another experiment for collecting hydrogen. Fix a balloon to the mouth of the test tube from which hydrogen is coming out as shown in Fig 4.5. What do you observe?

- -

During festivals you might have seen hydrogen balloons rising high up in the air. What is your conclusion about the density of hydrogen from this?

Heavy water

You know that hydrogen combines with oxygen to form water.

Deuterium and tritium are the isotopes of hydrogen. Deuterium reacts with oxygen to form heavy water (D_2O). One out of six thousand (1/6000) parts of water present in nature is heavy water.

Let us look at some uses of heavy water :

- As moderator in nuclear reactors.
- For the preparation of the isotope deuterium.
- As a tracer in chemical reactions.

Given below are some uses of hydrogen:

- In the manufacture of ammonia and methanol

- For converting unsaturated oils into saturated oils
- As a fuel
-

Hydrogen as a fuel

Observe and analyse the graph (Figure 4.6) showing the heat energy released during the combustion of various fuels.

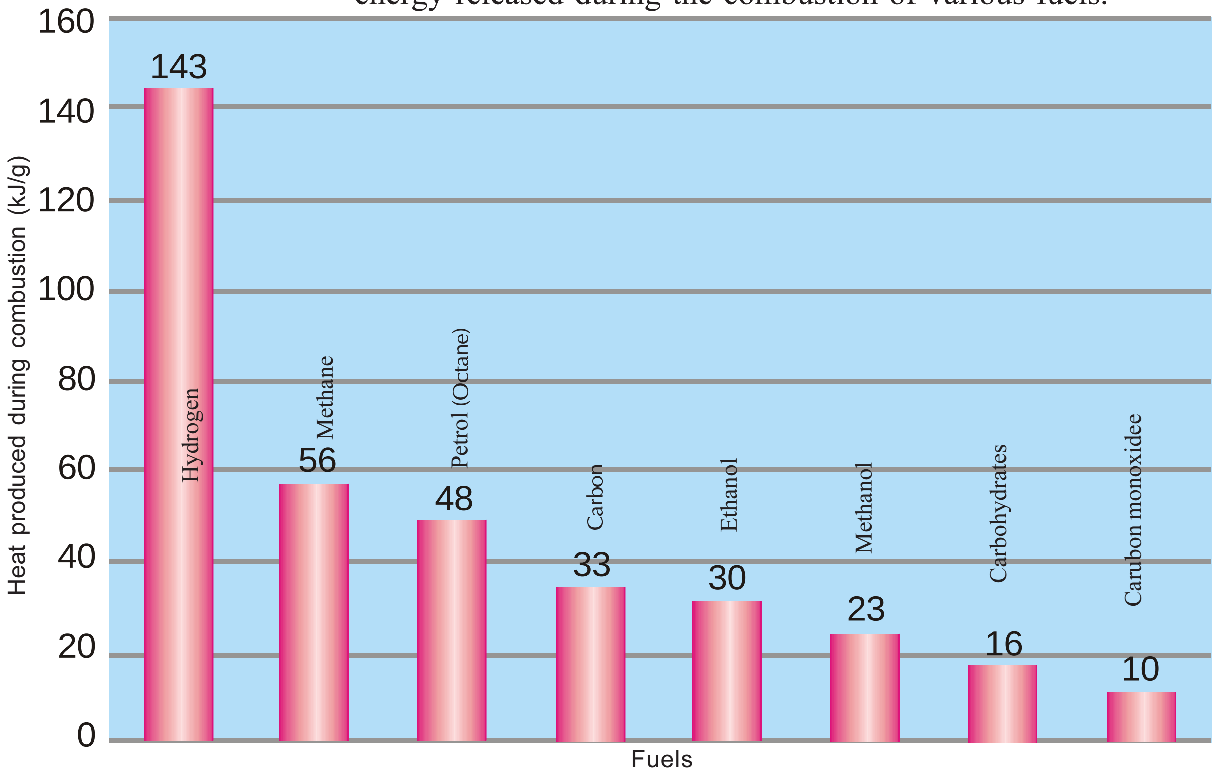


Figure 4.6

> **Fuel cell**
>
> Hydrogen-oxygen fuel cells are special devices that produce electricity using hydrogen gas and oxygen gas.
>
> Advantages of fuel cells:
>
> 1. Non polluting
> 2. Efficiency is high
> 3. Fuel cells are now being used in space crafts and submarines.

The amount of heat energy released during the combustion of unit mass of a fuel is called its **calorific value.**

Which among the fuels given has the highest calorific value?

What is the product formed during the combustion of hydrogen in air?

What are the advantages of using hydrogen as a fuel? Let's list them.

- High calorific value.
- No environmental pollution.
-

In spite of all these merits hydrogen could not be used as a fuel due to certain limitations. Hydrogem is not easily available. Hydrogen is a gas that burns explosively in air. The storage and distribution of hydrogen is difficult. Hydrogen will become a common fuel if these limitations could be overcome which will solve the problems like scarcity of fossil fuels and environmental pollution.

Prepare and present a note on the possibilities of using hydrogen as the fuel of the future.

Chlorine

Havn't you seen bleaching powder being used for the purification of water? Aren't you familiar with the odour of bleaching powder? This odour is that of chlorine, the major constituent of bleaching powder.

Chlorine is not present in the free state in nature because of its high reactivity. List the chlorine containing compounds familiar to you.

- Hydrogen chloride (HCl)
- Sodium chloride (NaCl)
-

Discovery of Chlorine

Carl Wilhem Scheele (1742-1786)

In 1774 the scientist Carl Wilhem Scheele discovered chlorine gas. But at that time he did not know that it was an element. It was Humphrey Davy who identified chlorine as an element in 1810. The name chlorine was obtained from the word 'chloros' which means 'greenish yellow'.

Preparation of Chlorine

The set up for the preparation of chlorine in the laboratory is shown in the picture below (Figure 4.7). Observe the balanced chemical equation for the above reaction.

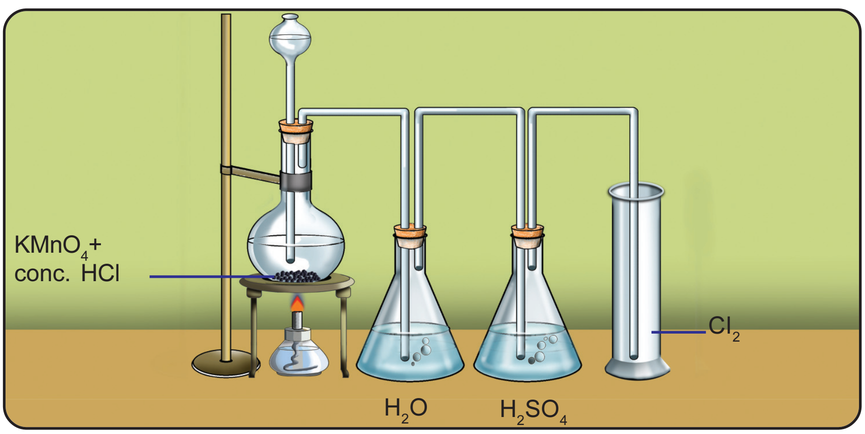


Figure 4.7

$$2KMnO_4 + 16HCl \rightarrow 2\,KCl + 2MnCl_2 + 8H_2O + 5Cl_2$$

What are the reactants required for the preparation of chlorine?

What are the products obtained? ----------------------

Do you know why chlorine gas is passed through water?

Hydrogen chloride vapours coming along with chlorine is removed by passing it through water.

Which method is used to remove the water vapour formed along with chlorine? --------------------------------

Sulphuric acid can absorb the water vapour present in chlorine gas when it is passed through concentrated sulphuric acid.

See the way in which chlorine is being collected in a gas jar. List the properties of chlorine gas (Table 4.3).

Bleaching action of chlorine

Colour	
Odour	
Density	

Table 4.3

Prepare and store chlorine in a gas jar. Put some moist petals of coloured flowers and pieces of coloured paper in the jar. What do you observe?

Chlorine gas can decolourise coloured substances by bleaching.

In the textile industry chlorine is used to bleach cotton fabrics. The bleaching action of chlorine is due to the oxidation of substances.

Is chlorine a saviour or a destroyer?

During the first world war, the chief chemical weapon used by Germany was chlorine gas. Several people were killed and many were seriously injured by the use of this chemical weapon.But, nowadays, chlorine is used as an important disinfectant for the purification of water thus preventing the spread of diseases. We use several chlorine compounds in our daily life.

The chemistry behind bleaching

Chlorine reacts with water to give hydrochloric acid and hypochlorous acid (HClO).

$$Cl_2 + H_2O \rightarrow HCl + HClO$$

The ClO^- ions formed from hypochlorous acid oxidize substances and this forms the basis for the bleaching action of chlorine.

Uses of Chlorine

- For bleaching
- For the preparation of insecticides
- For removing stains in the fabrics
- For purification of water
- For the preparation of bleaching powder

Bleaching powder is prepared by passing chlorine gas over dry slaked lime. Bleaching powder is used as a source of chlorine for various purposes.

Significant Learning Outcomes

The Learner

- describes the presence and importance of oxygen in nature.
- prepares and stores oxygen gas in the laboratory, identifies and lists its uses.
- describes the importance of ozone gas and the process that keeps ozone level constant in the atmosphere.
- describes the causes and remedies for ozone layer depletion.
- describes the preparation of nitrogen in the laboratory, its importance and its uses.
- describes how plants get nitrogen from soil.
- describes the merits and demerits of organic fertilizers and chemical fertilizers and identifies the advantages of using organic fertilizers.
- prepares and stores hydrogen in the laboratory.
- describes heavy water and lists its uses.
- describes the merits and limitations in using hydrogen as fuel.
- prepares and stores chlorine in the laboratory.
- conducts experiments on the bleaching action of chlorine and explains this.

Let us assess

1. Some chemical substances are given below. From these, find out the substances required for the preparation of nitrogen and hydrogen, in the laboratory

   Sulphuric acid,hydrochloric acid, sodium nitrite, zinc, potassium permanganate, ammonium chloride, water.

2. Find the gases for which the following statements are related.

a) Combustible gas obtained by the electrolysis of water

b) Gas used for the purification of water

c) Gas interacting with the rizobium bacteria in the soil

d) Gas formed by the thermal decomposition of $KMnO_4$

3. Certain nonmetals and their uses are given in the wrong order in the table below. Match them correctly.

Element	**Use**
Hydrogen	Disinfectant
Oxygen	Refrigerant
Chlorine	Fuel
Nitrogen	Biodegradation

4. a) What are the chemicals used for the preparation of chlorine in the laboratory?

   b) Why is chlorine passed through sulphuric acid during its preparation?

   c) How will you prepare bleaching powder?

   d) Name the gas that comes out of bleaching powder in the presence of water?

5. "We should give up chemical fertilizers completely and promote the use of organic fertilizers". Do you agree with this statement? Substantiate your answer.

Extended Activities

1. Organize a discussion on how nitrogen cycle is helpful to plants and animals.
2. Organize a seminar based on the topic "Depletion of ozone layer and its remedial measures".
3. Take 5mL hydrogen peroxide solution in a test tube. Add a pinch of manganese dioxide to it. Show a burning match stick that is about to get extinguished into the test tube. What do you observe? Give reasons for your observation.