

# **CHEMISTRY**

**Standard IX**

**Part-1**



**Government of Kerala  
Department of General Education**

State Council of Educational Research and Training (SCERT) Kerala  
2019

## 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. 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. 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.*

*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.*

*The educational portal 'Samagra' and the Q.R.code incorporated text book make the class room learning process effortless and stimulating. National Skills Qualification Framework (N.S.Q.F), Disaster management techniques relevant to contemporary issues and the ICT possibilities are considered in this textbook.*

*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. J.Prasad**  
Director, SCERT

# **CONSTITUTION OF INDIA**

## **Part IV A**

### **FUNDAMENTAL DUTIES OF CITIZENS**

#### **ARTICLE 51 A**

*Fundamental Duties- It shall be the duty of every citizen of India:*

- (a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
- (b) to cherish and follow the noble ideals which inspired our national struggle for freedom;
- (c) to uphold and protect the sovereignty, unity and integrity of India;
- (d) to defend the country and render national service when called upon to do so;
- (e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;
- (f) to value and preserve the rich heritage of our composite culture;
- (g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;
- (h) to develop the scientific temper, humanism and the spirit of inquiry and reform;
- (i) to safeguard public property and to abjure violence;
- (j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievements;
- (k) who is a parent or guardian to provide opportunities for education to his child or, as the case may be, ward between age of six and fourteen years.

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## THE SYMBOLS USED IN THE TEXTBOOK



Additional Information  
(Need not be assessed)



ICT Possibilities for Concept Clarity



Let Us Assess



Extended Activities

# 1

## STRUCTURE OF ATOM



Figure 1.1

What a variety of materials are there in our surroundings! What might be the reason for this diversity in nature? How have these many materials been formed in the surroundings? How can we make new materials according to our needs?



Figure 1.2

We now know that all the substances in our surroundings are made up of extremely small particles called molecules. What concepts do we have about molecules?

- What is a molecule?
- What are the characteristics of molecules of a substance?

We have already learned that molecules can be sub divided into minute particles and these are called atoms. That means molecules of all substances are made of extremely small particles called atoms.

John Dalton proposed the atomic theory in 1807 for the study on atoms and for finding out how matter has been formed. The ideas proposed in the atomic theory have lasted for nearly one century. The world of science couldn't put forward sufficient observations, results or inferences for denying this theory scientifically.

What are the major concepts of Dalton's atomic theory? Read the short note given below.

### Dalton's Atomic Theory

The views put forward by John Dalton were based on logical thinking. These were not supported by any experimental observations or scientific evidences. Yet this theory could logically explain the basic ideas regarding the formation of substances and its characteristics. Hence this theory existed for many years.



**John Dalton  
(1766-1844)**

Proponent of Atomic Theory. He had colour blindness. So this disease came to be known as Daltonism.

#### Major ideas of atomic theory

- Matter is made up of minute particles called atoms.
- Atoms cannot be divided during chemical reactions. Atoms can neither be created nor destroyed.
- Atoms of the same elements are identical in properties, size and mass.
- Atoms of different elements differ in their properties and mass.
- Atom is the smallest particle that can take part in chemical reactions.
- Compounds are formed when atoms of two or more elements combine in a simple ratio.



- What are the characteristics of the atom of an element, according to the atomic theory?
- What differences can you infer between the atoms of different elements?

Note down what you have understood. Compare your findings with that of your friends and improve them.

### Particles Smaller than Atoms



Figure 1.3

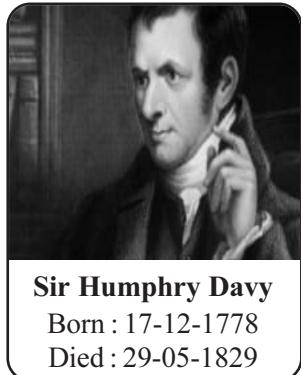
Even when the atomic theory existed, studies on matter and inquiries on the possibilities of dividing atom had been continuing. The observation and results of numerous experiments conducted by scientists have contradictory to that of atomic theory. Some of them are listed below.

- Rub a comb on dry hair. Bring this comb near small bits of paper. What do you observe?
- Take an inflated balloon, rub it on dry hair for some time. Now place it on the surface of a wall and withdraw your hand. What do you observe?
- Find out more instances from daily life.

How do things like comb and balloon acquire the capacity to attract? What might be present in these substances that results in an attraction? Given below are the observations, experiments and assumptions of some scientists that led us to these facts. Concepts about substances have been formed by continuous and progressive observations and experiments over decades.

## Scientists, Experiments, Findings

### Sir Humphry Davy (1778-1829)

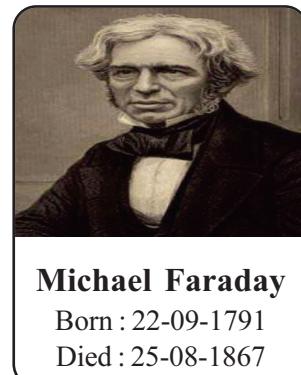


**Sir Humphry Davy**

Born : 17-12-1778

Died : 29-05-1829

By using electricity, Sir Humphry Davy isolated many elements from compounds. Potassium, Sodium, Calcium, Magnesium, Strontium, Barium and Boron are some among them. He conducted experiments which involve the passage of electricity through liquids. On the basis of these experiments he understood the presence of electric charges in substances. He established that there are two types of charges (positive charge and negative charge) and it is these electric charges that enable a substance to react with another substance.



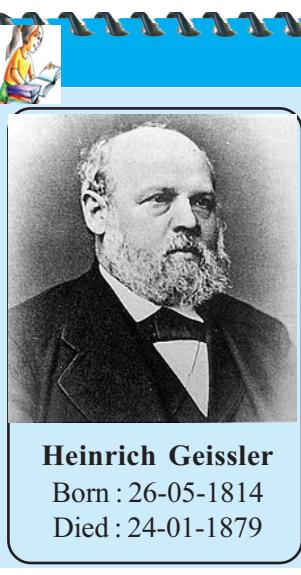
**Michael Faraday**

Born : 22-09-1791

Died : 25-08-1867

### Michael Faraday (1791-1867)

Michael Faraday is known as the father of electricity. From the experiments conducted along with Sir Humphry Davy, he found that electricity can pass through liquids. It is found that some liquid substances can be separated into their components by passing electric current through them (Electrolysis). Thereafter he proposed the laws in connection with this (Law of Electrolysis). However they failed to explain the reasons behind this process.



**Heinrich Geissler**

Born : 26-05-1814

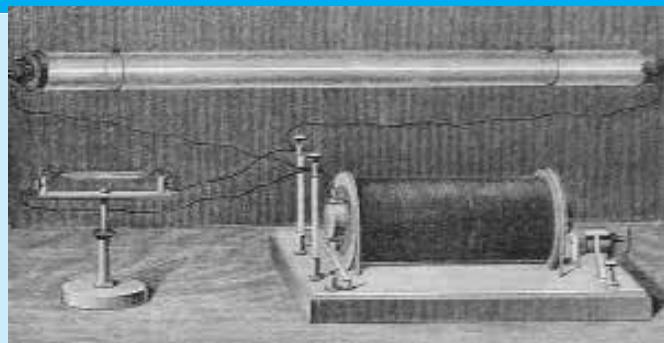
Died : 24-01-1879

### Heinrich Geissler (1814-1879)

In 1857, Heinrich Geissler, the German Physicist and glass blower (skilful in making of glass), invented Discharge Tube (Vacuum Tube). The invention of this revealed that electricity can pass through gases as well. The experiments conducted by Geissler and Plucker accelerated the studies about the nature of substances.



## Geissler's Vacuum Tube



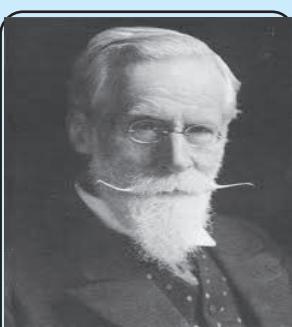
**Julius Plucker**

Born : 16-06-1801

Died : 22-05-1868

### Julius Plucker ( 1801-1868)

Electric current passes through gases at a very low pressure. This is known as electric discharge. It was found that if the pressure inside the tube decreases beyond a lower limit during the time of electric discharge, a glow of light will be seen on the sides of glass tube. If a magnet is placed near the glow (such that the glow is inside the magnetic field), the position of the glow will be changed. This clearly indicates, the presence of electric charge in the rays emerged from the gases in discharge tube.



**William Crookes**

Born: 17-06-1832

Died: 04-04-1919

### William Crookes (1832-1919)

In 1875, William Crookes conducted some experiments using a modified form of the Geisslers discharge tube which helped in the clarification of the nature of gases. The changes observed in Cathode-Ray-Tube (CRT) experiments, when pressure is decreased inside the tube, and the study of the characteristics of cathode rays led to these facts (Figure A, Figure B). Further studies led to the discovery of facts such as atoms can be divided and atoms are made up of extremely minute subatomic particles smaller than atoms. (Picture tube of T.V and x-ray tube are Cathode-Ray-Tubes)



Figure A



Figure B



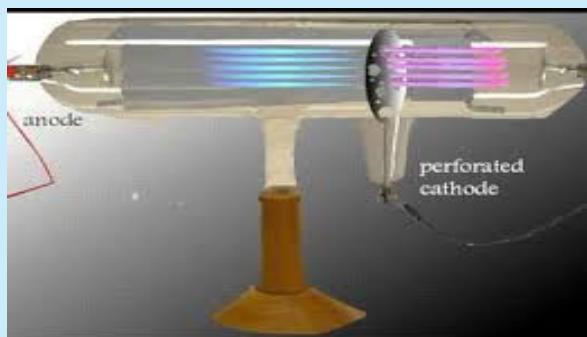
**Eugen Goldstein**

Born: 05-09-1850

Died: 25-12-1930

### **Eugen Goldstein (1850-1930)**

He was the scientist who recognized the presence of positive charge in gases by conducting the discharge tube experiments. In 1886, he produced anode rays using discharge tube and found the presence of positive charge by studying the features of anode rays. These experiments and results gave too many evidences to oppose Dalton's atomic theory.



Discharge tube



**Wilhelm Roentgen**

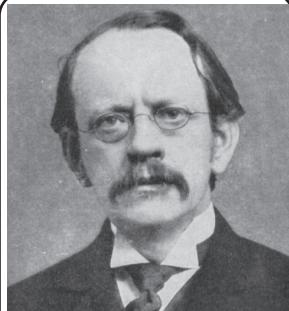
Born: 27-03-1845

Died: 10-02-1923

### **Wilhelm Roentgen (1845-1923)**

The experiments conducted by Wilhelm Roentgen using Crookes discharge tube led to the discovery of X-rays on 8 November 1895. He placed an aluminium plate on the path of cathode rays and reflected the rays. A special type of rays emerged which were then called X-rays. Later it continued to be known as X-ray itself. It was an accidental discovery that happened while doing studies on the characteristics of substances. X-ray is widely used in medical science, industry, construction field etc.

## J J Thomson (1856-1940)



**J J Thomson**

Born: 18-12-1856

Died: 30-08-1940

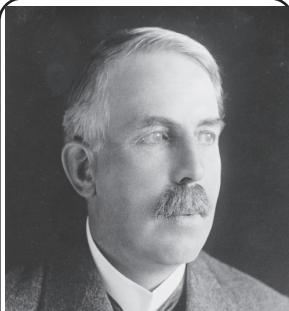
J J Thomson's experiments helped in changing the ideas about an atom that existed at that time and in forming new concepts. He proved that the rays originating from the cathode are made up of negatively charged particles. He also made it clear that these particles possess mass and energy. When an electric discharge was passed, all the gases gave the same negative particles irrespective of the nature of the gas. Hence he substantiated that these particles are common to all substances. He proved that they are much smaller particles than the atom and are part of atoms.

In 1897, the scientific world approved the discoveries of J J Thomson. Thus it is proved that an atom can be divided. The negatively charged particle in the atom is the **electron**.



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Resource for VI and VIII in  
School Resource. Basic  
Science Standard VIII  
Chemistry - Atomic Structure  
- Discharge Tube Experi-  
ment.

## Ernest Rutherford ( 1871-1937)



**Ernest Rutherford**

Born: 30-08-1871

Died: 19-10-1937

The discovery of electron energized the search for other particles in an atom. Even though the presence of positive charge in substances has been identified earlier, it is Rutherford who proved it authentically. He conducted experiments by passing positively charged alpha particles through a very thin gold foil. The alpha rays that come out through the gold foil were allowed to fall on a circular photographic film. (Figure 1.4A) He made some inferences by analyzing the observation. He substantiated that the major portion of an atom is empty and there is a small part inside the atom where all the positive charge is concentrated. This central region of an atom is called the **nucleus**. In 1911 the scientific world recognised the presence of a positively charged centre in an atom. On the basis of his further experiments, in 1920, it was proved that particles that were responsible for the positive charge are protons. Its charge was found to be equal and opposite to that of an electron. It is determined that the mass of a proton is equal to the mass of a hydrogen atom. Along with that, he also predicted the presence of a chargeless particle in the nucleus.



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School Resources Basic  
Science - standard 8-  
Chemistry - Atomic Structure  
Gold foil Experiment



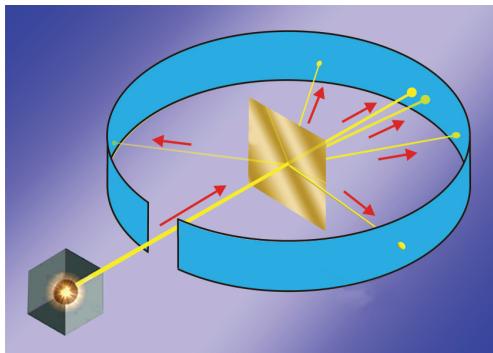


Figure 1.4 A

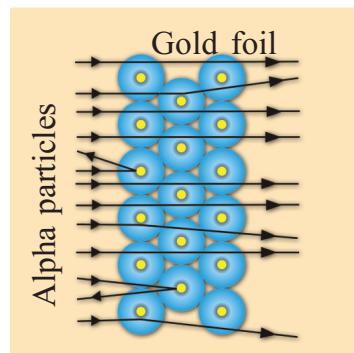
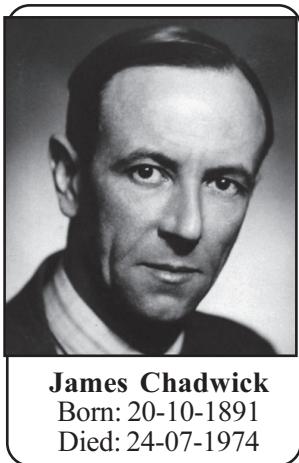


Figure 1.4 B



**James Chadwick**  
Born: 20-10-1891  
Died: 24-07-1974

### James Chadwick (1891-1974)

James Chadwick learned and conducted experiments under the guidance of Rutherford. In 1932, he proved scientifically that, inside the nucleus of an atom, there are neutral particles having mass equal to that of protons. This chargeless particle is the **neutron**. The total mass of an atom is concentrated in the nucleus because the particles protons and neutrons that possess mass are in the nucleus.

Atoms of all elements are made up of the particles namely **electron, proton and neutron**. The difference in the number of these particles make an element different from that of others.

### Features of Electron, Proton and Neutron

Electron	Proton	Neutron
<ul style="list-style-type: none"><li>Negative charge</li><li>Mass is very less (<math>\frac{1}{1837}</math> part of the mass of a hydrogen atom)</li><li>Seen outside the nucleus</li></ul>	<ul style="list-style-type: none"><li>Positive charge</li><li>Mass equal to that of hydrogen atom</li><li>Seen in the nucleus</li></ul>	<ul style="list-style-type: none"><li>Chargeless</li><li>Mass equal to that of a hydrogen atom</li><li>Seen in the nucleus.</li></ul>

Table 1.1

### Atom is electrically neutral

There are electrically charged particles in an atom-negatively charged electrons and positively charged protons. But, the presence of electric charge hasn't been felt to atoms or to molecules made up of atoms. Why is it so?



## Rutherford's Planetary Model of Atom

Rutherford, through his experiments, found that atom has a centre and the whole mass of an atom is concentrated in the nucleus. It is he who suggested a more or less acceptable model of an atom. This model is known as the planetary model of atom. It can be assumed that parts of an atom are arranged as in solar system.

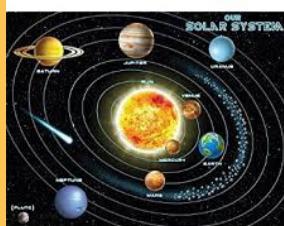


Figure 1.5 A

- \* Solar system has a centre
- \* Sun is at the centre
- \* Planets revolve around the sun in orbits

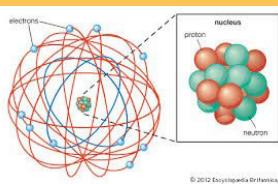
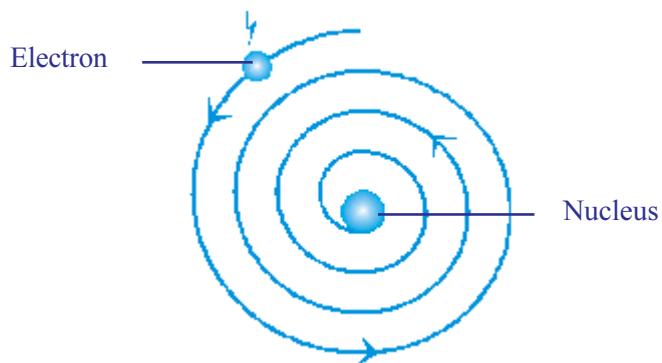


Figure 1.5 B

- \* Atom also has a centre
- \* Nucleus is at the centre
- \* Electrons revolve around the nucleus in shells

The atomic model proposed by Rutherford was generally acceptable. But according to this model electrons should eventually collapse into the nucleus as they loss their energy while revolving within the field of attraction of the nucleus.

But this does not happen in atoms. Rutherford failed to give an explanation to this doubt of the scientific world. So this model was eventually discarded.



Pictorial representation of the limitation of Rutherford's Atom Model.

Figure 1.6



**Niels Bohr**  
Born: 07-10-1885  
Died: 18-11-1962



### Bohr's model of Atom

Niels Bohr proposed a new atomic model by giving a better explanation to the Rutherford model. This model is known as Bohr's model. Bohr model is utilized for giving a lucid explanation to the features of an atom. According to Bohr Model, the revolving paths traced by electrons are called orbits (shells).

### Main ideas of the Bohr Model

- Electrons revolve around the nucleus of an atom 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.
- The shells around the nucleus can be numbered from near the nucleus as 1, 2, 3, 4, 5.... or represented by the letters K, L, M, N, O.....

### Mass Number & Atomic Number



Name of Particle	Position in the Atom	Mass used for practical purposes
Proton	Nucleus	1 u
Electron	.....	0
Neutron	.....	1 u

Table 1.2

Complete and analyse the Table 1.2.

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

- What is the mass of a proton?
- What about 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 two protons and two neutrons - - - - -
  - Is there any 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 fundamental particle of an atom that can be displaced when atoms rub against each other or they undergo chemical reactions with other atoms? - - - - -
- Give reasons - - - - -

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 mentioned 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.*

- If you know the atomic number of an atom the number of which all particles can be found?
- Give reasons - - - - -
- What is in case you know the mass number ? - - - - -

  
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Atomic Number	= Number of protons
	= Number of electrons
Mass Number	= Number of protons + Number of Neutrons
Number of Neutrons	= Mass Number - Atomic Number

Symbols are used to represent elements. The symbol of an element represents one of its atoms.



## 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.

If we include the mass number and atomic number to the symbol of an atom, more details about the atom can be inferred. We write the mass number on the top left side of the symbol and atomic number on the bottom left side of the symbol. See how a sodium atom ( $Z=11$ ,  $A=23$ ) is represented in this manner.



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

Symbols	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 shells	Number of shells	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. Filling up of electrons in shells of higher energy happens only after the shells of lower energy are filled.



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

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

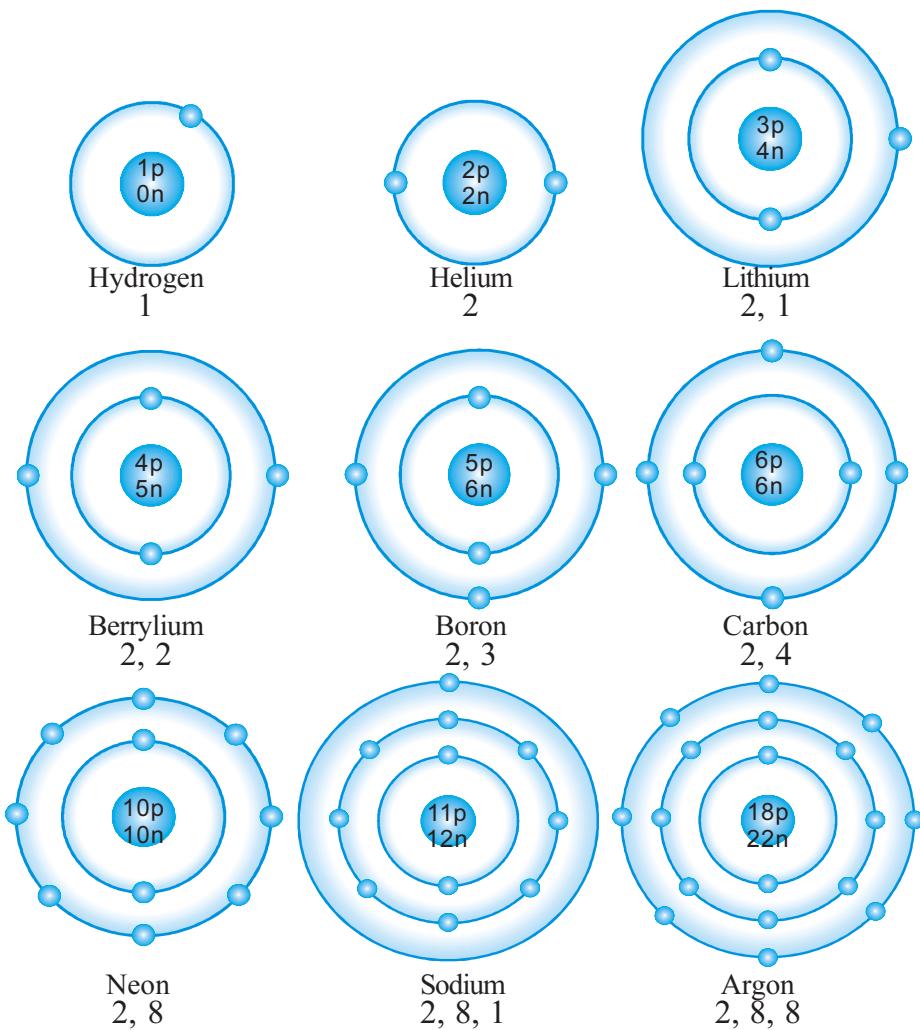


Figure 1.7

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



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

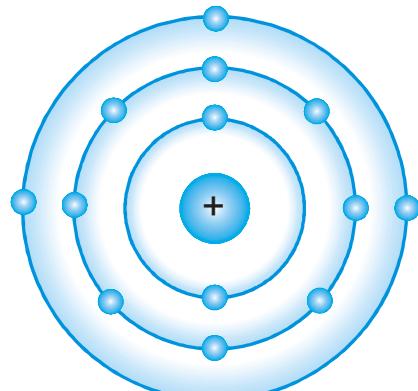


Figure 1.8

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 (Figure. 1.11).

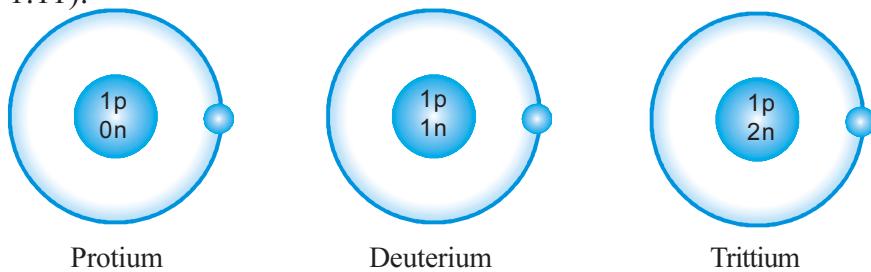


Figure 1.9

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			

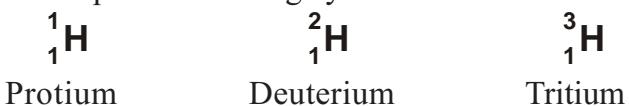
Table 1.7

- Which is the particle that differs in its number in these atoms?
- What inferences can you arrive at when the mass number and atomic number of these elements are examined?

As the number of protons in these atoms are the same, they are atoms of the same elements.

*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. See how they are represented using symbols.



The isotopes of an element show slight differences 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 the Table 1.8

Isotope	Symbol
Carbon-12	$^{12}_6\text{C}$
Carbon -13	$^{13}_6\text{C}$
Carbon -14	$^{14}_6\text{C}$

Table 1.8

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

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.





### Isobars are Isotones

**Isobars** are atoms having the same mass number but different atomic number  $^{40}_{20}\text{Ca}$ ,  $^{40}_{18}\text{Ar}$  are examples of isobars.

Atoms with the same number of neutrons are called **isotones**.

$^7\text{N}^{15}$ ,  $^6\text{C}^{14}$  examples of isotones.

Isotones and isobars are atoms of different elements.

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

Uranium - 235 is used as a fuel in atomic reactors.

Symbols of certain elements are given in the 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
$^{15}_8\text{O}$					
$^{16}_8\text{O}$					
$^{17}_8\text{O}$					

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 the way in which 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 have familiarised the concepts regarding how the structure of an atom developed and 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 atom can be studied in higher classes.

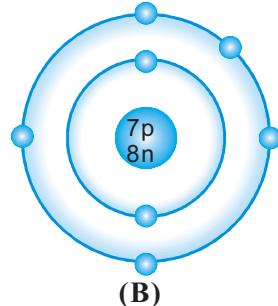
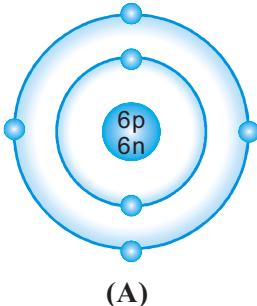


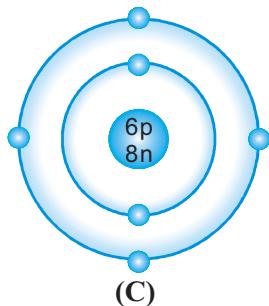
### Let us assess

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

Scientist	Contribution
John Dalton	Law of Electrolysis
Michael Faraday	Planetary Model of Atom
J.J. Thomson	Atomic theory
Rutherford	Discovered electron

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





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



- 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.

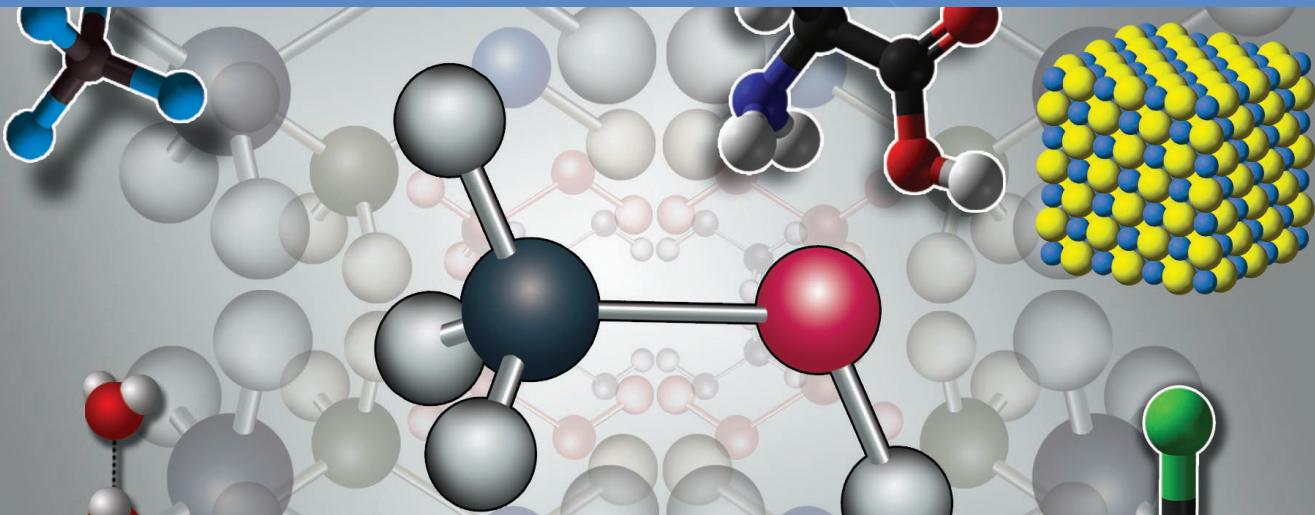


### *Extended activities*

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 18.
4. Draw and exhibit the Bohr model of elements having atomic number 1 to 10.

# 2

## CHEMICAL BONDING



A wide variety of substances are present in our surroundings. You have understood that all these substances are made of molecules which in turn are made of atoms. Based on the number of atoms present in molecules, substances are classified into two as elements and compounds. You have learned that molecules of compounds are formed by the combination of atoms of different elements. If so

- How do atoms combine together?
- Why do atoms combine together?
- Do atoms always combine in the same manner?
- How are the atoms in molecules held together?

Have you ever thought about these things?

### Electronic configuration and stability

Atoms combine to form molecules in order to attain stability. You might have seen the picture of periodic table. The elements in group 18 of the periodic table are Noble Gases or Inert gases. What might be the reason for calling them so?



Observe Table 2.1 indicating the electronic configuration of noble gases.

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

How many electrons are present in the outermost shell of these elements except in the case of helium?

What is the maximum number of electrons that can be accommodated in the outermost shell of an element?

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

Octet electron configuration in an atom is a stable arrangement. Noble gases possess this arrangement and are hence stable. Therefore, normally these gases do not take part in chemical reactions.

The helium atom contains only one shell. The maximum number of electrons that can be accommodated in the first shell is 2. Hence the duplet configuration of helium is stable.

Analyse the electronic configuration of elements given 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

- Do the elements in the Table 2.2 have stability? Why?



- If not, how do they attain stability?

Let us see

**Atoms acquire stability by attaining an eight electron configuration in their valence shell through chemical bonding.**

You are familiar with the compounds formed by the elements given in Table 2.2, aren't you? Write the names of few compounds.

.....

How are the atoms in these molecules held together?

*The attractive force that holds together the atoms in a molecule is called **chemical bonding**.*

### Ionic Bonding

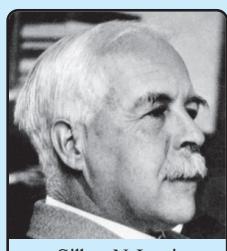
Which are the atoms that combine to form sodium chloride? Analyse the electronic configuration of each of these atom (Table 2.2).



- How many electrons are present in the outermost shell of sodium atom?
- What about the number of electrons in the outermost shell of chlorine?
- How do sodium and chlorine attain stability?



#### 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 valence electrons are labeled around the symbol of an element.

- Analyse the electron transfer in each atom during the formation of sodium chloride illustrated in Bohr model (Figure 2.1).
- Does any change happen to the charge of sodium and chlorine atoms after the electron transfer process? Discuss.

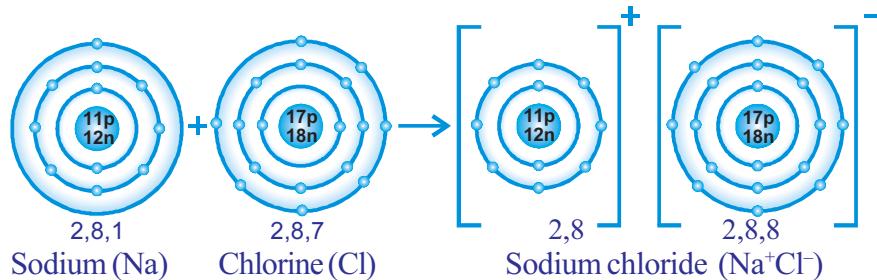


Figure 2.1

Figure 2.2 represents the electron dot diagram that illustrates the transfer of electrons between sodium and chlorine atoms. This diagram represents only the electrons present in the outermost shell because these are the electrons participating in chemical bonding.

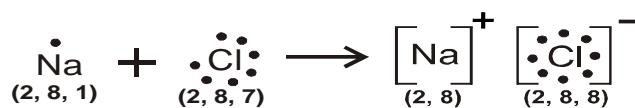


Figure 2.2

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?
- How are the atoms called after they get charged?
- The electron transfer during the formation of sodium chloride can be written in the form of an equation.



During the formation of sodium chloride, sodium atom donates an electron and gets converted to sodium ion ( $\text{Na}^+$ ). Positive ions

are called **cations**. Chlorine accepts an electron to form chloride ion ( $\text{Cl}^-$ ). 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 type of 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 ( $\text{MgO}$ ) is formed from magnesium and oxygen.

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

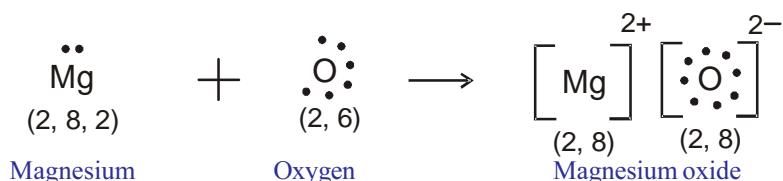


Figure 2.3

	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

Notice the change happening 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. From this you can understand that the type of chemical bond in magnesium oxide is ionic bond.

In the same way, see how the ionic bonding in sodium oxide is represented. (Figure 2.4)

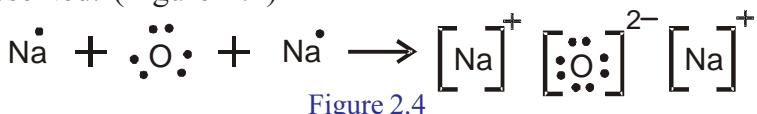


Figure 2.4

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<sub>2</sub>)

Compounds formed by ionic bonding are called ionic compounds.

### Covalent bonding

Fluorine (F<sub>2</sub>), chlorine (Cl<sub>2</sub>), oxygen (O<sub>2</sub>), nitrogen (N<sub>2</sub>) etc are diatomic molecules. Let's examine the formation of these molecules.

Bohr model of fluorine atom is given in Figure 2.5

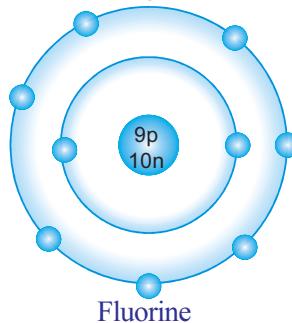


Figure 2.5

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

Is there a possibility of transferring electrons from one fluorine atom to another fluorine atom? Is ionic bonding possible in this molecule? Discuss.

How can the two fluorine atoms attain an octet arrangement? -----

The way in which the two fluorine atoms in a fluorine molecule

undergo chemical bonding is illustrated in the Figure 2.6. Analyse it.

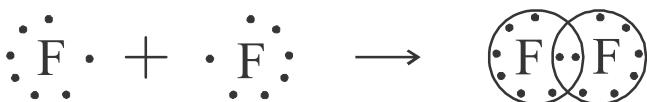


Figure 2.6

- 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.*

The bonded electrons are generally stated in pairs. 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 (Figure 2.7).

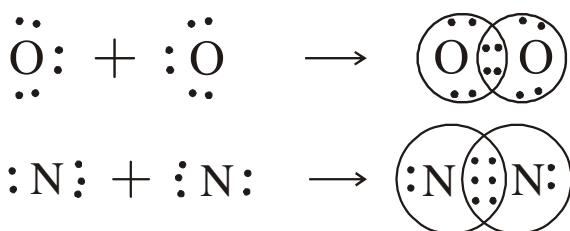


Figure 2.7

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 called 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 symbolized as  $O = O$  and  $N \equiv N$  respectively.

Complete the Table 2.5 given below related to covalent bonding.

Molecules of elements	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 ( $HCl$ ) molecule (Figure 2.8)

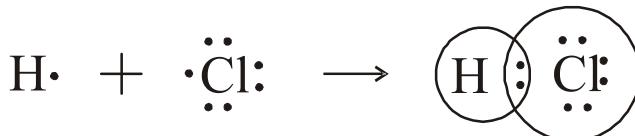


Figure 2.8

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

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

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 carbon tetrachloride molecule (Figure 2.9).

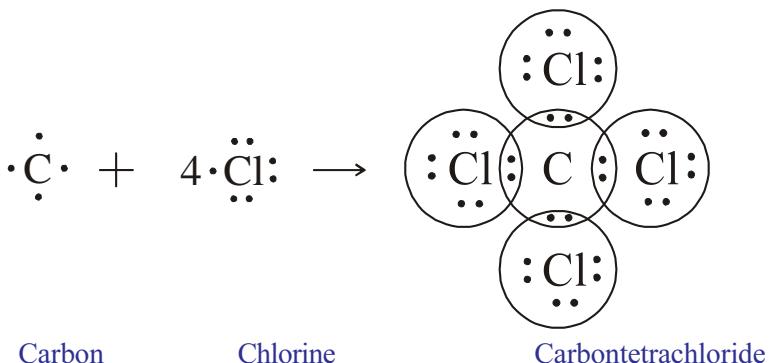
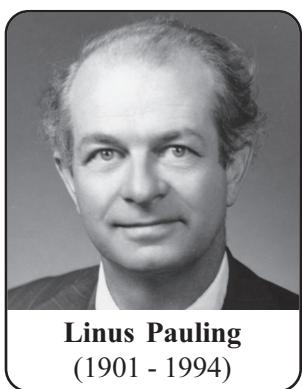


Figure 2.9

- How many pairs of electrons are shared by the carbon atom with each chlorine atom?
- 
- What is the total number of electron pairs shared by carbon atom with all the chlorine atoms?
  - How can we represent the molecule using symbols?

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

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



### 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. In this scale, fluorine is the most electronegative element.



Analyse the part of Pauling's electronegativity scale given in Figure 2.10

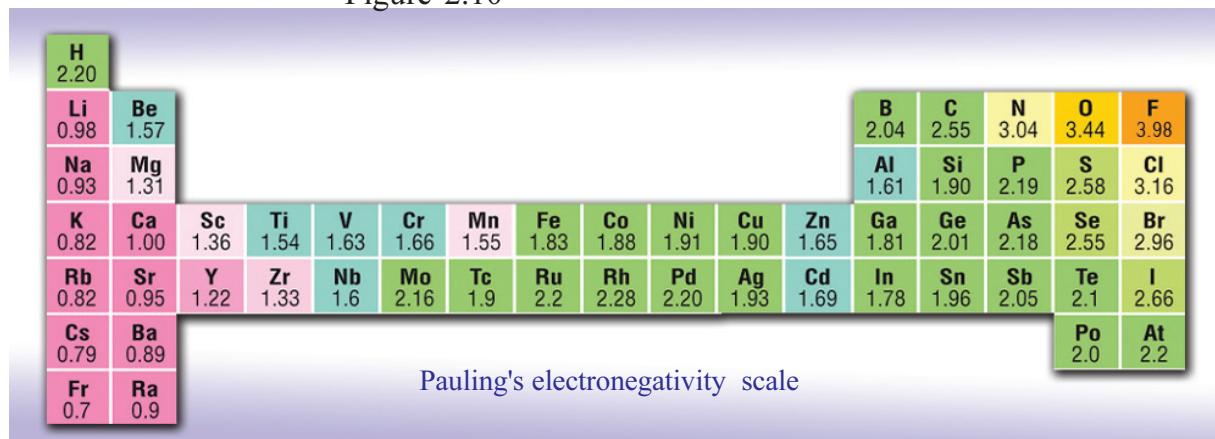


Figure 2.10

Some compounds and their nature are shown in Table 2.6. Complete the table by finding out the difference in electronegativity 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 (NaCl)		Ionic
Methane ( $\text{CH}_4$ )		Covalent
Magnesium chloride ( $\text{MgCl}_2$ )		Ionic
Sodium oxide ( $\text{Na}_2\text{O}$ )		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:  $\text{H}_2$ ,  $\text{N}_2$  etc.

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

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

The chlorine atom having 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  $\delta^-$ ) and the hydrogen atom develops a partial positive charge (Delta positive  $\delta^+$ ). This can be represented as shown below.



Such compounds having partial electrical charges within the molecule are called **polar compounds**. HF, HBr,  $\text{H}_2\text{O}$  are examples of polar compounds. In polyatomic molecules, the geometrical shape of the molecule is also a factor that determines its polar nature. Water ( $\text{H}_2\text{O}$ ), ammonia ( $\text{NH}_3$ ) 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, $\text{CCl}_4$ , 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 take part in chemical bonding and attain stability. When the atoms combine together, they transfer or share electrons.



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

During the formation of sodium chloride, sodium atom donates one electron and this electron 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 the 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 compounds. 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 <sub>4</sub>	C	6	.....	4	4
	Cl	.....	2,8,7	.....	.....

Table 2.8

## From valency to chemical formula

Imagine that magnesium (<sub>12</sub>Mg) and Chlorine (<sub>17</sub>Cl) combine together. According to this, complete the table given below.

Element	Atomic number	Electronic configuration	Number of electrons donated or received
Mg	12	-----	-----
Cl	17	-----	-----

Table 2.9

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

-----

Then, there will be one magnesium atom and two chlorine atoms in the molecule of magnesium chloride. Hence the chemical formula of magnesium chloride will be MgCl<sub>2</sub>.

**Chemical formula** is a method of indicating the number of atoms in a molecule using symbols.

See how aluminum fluoride is formed by combining aluminum with fluorine.

Element	Atomic number	Electronic configuration	Number of electrons donated or received
Al	13	-----	-----
F	9	-----	-----

Table 2.10

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

-----

Write the chemical formula of aluminum fluoride.

-----

Write the chemical formula of the compounds given below.

- Sodium oxide
- Aluminium chloride



- Aluminum oxide

Valeency has a prominent role in deciding the chemical formula of a compound.

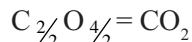
- Let's find an easy way to write the chemical formula of aluminum oxide using valencies.
  - Which are the constituent elements of aluminium oxide?
  - What are the valencies of aluminium and oxygen?
- 
- Write the symbols of constituent elements together in such a way that symbol of the element having lesser electronegativity comes first.



- Inter change the valencies of each elements and write them as subscripts (base index)

You have understood that the chemical formula of aluminum oxide is  $\text{Al}_2\text{O}_3$

- Let's write the chemical formula of carbon dioxide
- What are the constituent elements? -----,
- The element having lesser electronegativity is carbon. If so write the symbols of elements together.
- Since the valency of carbon is 4 and that of oxygen is 2, we can write  $\text{C}_2\text{O}_4$ .
- Divide each base index by the common factor of base indexes.



- If the subscript is 1, it need not be written. Then we can write as  $\text{C}_1\text{O}_2 = \text{CO}_2$

Complete the table given below

Elements				Compound	
Name	Valency	Name	Valency	Name	Chemical formula
Potassium	1	Oxygen	2	Potassium oxide	$\text{K}_2\text{O}$
Zinc	2	Bromine	1	...	...
Carbon	...	Chlorine	...	Carbontetrachloride	$\text{CCl}_4$
Magnesium	2	Fluorine	1	...	...

Table 2.11



Some elements and their valencies are given below. Using these, write the chemical formulae of 4 compounds.

Elements	Valancy
O	2
Cl	1
Li	1
Zn	2



## Let us assess

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

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. Electronegativity values of some elements are given. Analysing 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 ( $\text{SO}_2$ )  
Water ( $\text{H}_2\text{O}$ )  
Calcium fluoride ( $\text{CaF}_2$ )  
Carbon dioxide ( $\text{CO}_2$ )
3. Some elements and their valencies are given.

Elements	Valency
Ba	2
Cl	1
Zn	2
O	2

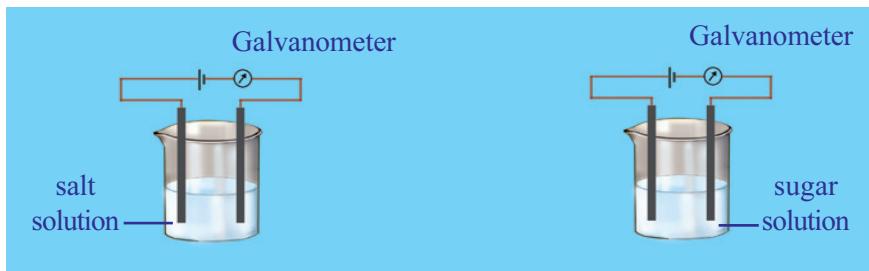
- a) Write the chemical formula of barium chloride  
b) Write the chemical formula of zinc oxide.  
c) The chemical formula of calcium oxide is  $\text{CaO}$ . What is the valency of calcium?





## Extended activities

1. Draw the electron dot diagram of chemical bonds in methane ( $\text{CH}_4$ ) and ethane ( $\text{C}_2\text{H}_6$ ).
2. Conduct the experiment 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. (eg. beads, seeds)  
(Electronegativity values : P=3.44, Q=3.16, R=1.31, S=2.58)
  1. P, R
  2. P, S
  3. Q, R



## REDOX REACTIONS AND RATE OF CHEMICAL REACTIONS



Various changes are happening around us. These include both physical changes and chemical changes. Chemical changes result in the formation of new compounds.

Given below is a table showing the mass of the reactants and the products when hydrogen combines with chlorine to form hydrogen chloride in two situations.

Situation	Mass of Reactants		Mass of Product
	Hydrogen	Chlorine	Hydrogen chloride
1.	2 g	71 g	73 g
2.	4 g	142 g	146 g

Table 3.1

- Write down the total mass of the reactants and also the total mass of product in the above experiment.

Situation 1: ....., .....

Situation 2: ....., .....

Given below is a table showing the mass of the reactants and the products when hydrogen combines with oxygen to form water, in two situations.

Situation	Mass of Reactants		Mass of Product
	Hydrogen	Oxygen	Water
1.	2 g	16 g	18 g
2.	4 g	32 g	36 g

Table 3.2



**Antoine Lavoisier  
(1743-1794)**

Lavoisier found out the role of oxygen that at in combustion. He discovered that during respiration oxygen is absorbed and carbon dioxide is released. He also noticed the presence of oxygen in nitric acid, sulphuric acid and phosphoric acid. He named the elements 'oxygen' and 'hydrogen'.

- Write down the total mass of the reactants and the total mass of product in the above experiment.

Situation 1: ....., .....

Situation 2: ....., .....

- What is the relation between the total mass of the reactants and the total mass of product?

**In a chemical reaction mass is neither created nor destroyed. This is the law of conservation of mass.**

This law was proposed by the scientist Antoine Lavoisier.

That is, the total mass of the reactants will be equal to the total mass of the products.

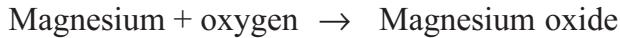
If so, total number of atoms of each element in the reactant side and that in the product side in a chemical reaction are equal, aren't they?

### Balancing of chemical equation

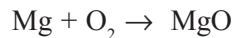
A piece of magnesium is burned in air. What do you observe?

What is the white powder formed?

How can you represent this chemical reaction?



If we use symbols and chemical formulae.



This is the chemical equation.

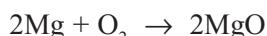
- Which are the reactants here?  
-----
- Which is the product?  
-----

Note down the number of atoms in the reactant side and the number of atoms in the product side in the table below.

Total number of atoms in the reactant side		Total number of atoms in the product side	
Mg	O	Mg	O
.....	.....	.....	.....

Table 3.3

- Is the number of atoms of each element equal on both sides?  
-----
- The number of which atom is not equal on both sides?  
-----
- \* How many product molecules are needed to equalize the number of oxygen atoms on both sides?  
-----
- How will you represent two molecules of magnesium oxide?  
-----
- Now, is the number of magnesium atoms equal on both sides?  
-----
- How many magnesium atoms are needed in the reactant side to equalize the number of magnesium atoms on both sides?  
-----
- Then how can you rewrite the above equation?



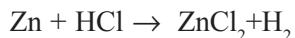
Is the total number of atoms of each element in the molecules present in the reactant side and that in the product side equal in this equation?

Now, won't the mass on both sides be the same?

In this manner, equalising the number of atoms of each element in molecules in the reactant side and that in the product side is called **balancing of equation**.



Now let's look at another example.



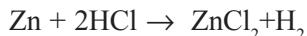
Tabulate the total number of atoms of each elements in the reactant side and that in the product side of the above reaction.

Total number atoms in the reactant side			Total number of atoms in the product side		
Zn	H	Cl	Zn	H	Cl
1	1	1	1	2	2

Table 3.4

- How many Zn atoms are there in the reactant side and in the product side?
- 
- Which are the atoms showing a difference in their number?
- 
- In order to make them equal on both sides how many molecules of HCl should be taken as reactant.
- 

Now rewrite the equation

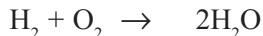


Let's balance the chemical equation  $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$

Total number of atoms in the reactant side		Total number of atoms in the product side	
H	O	H	O
2	2	2	1

Table 3.5

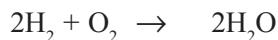
When the number of oxygen atoms in the product side is made 2.



Total number of atoms in the reactant side		Total number of atoms in the product side	
H	O	H	O
2	2	4	2

Table 3.6

In order to make the number of hydrogen atoms in the reactant side 4, shouldn't we take 2 hydrogen molecules?

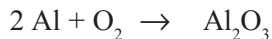


Let us balance the equation  $\text{Al} + \text{O}_2 \rightarrow \text{Al}_2\text{O}_3$

Total number of atoms in the reactant side		Total number of atoms in the product side	
Al	O	Al	O
1	2	2	3

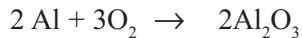
Table 3.7

If we make the number of aluminium atoms 2.



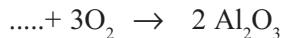
Is the number of oxygen atoms on either side equal? How can we make it equal?

The number of oxygen atoms in the reactant side is 2 and the number of oxygen atoms in the product side is 3, isn't it? In order to make them equal on both sides, the number of oxygen atoms should be increased to 6. Then how many oxygen molecules are needed in the reactant side?



Now, is the number of aluminium atoms equal on both sides?

Then make the number of aluminium atoms equal on both sides.



Is this a balanced chemical equation?

Some chemical equations are given below. Note down the number of reactant atoms and that of product atoms in the table given below.

1.  $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$
2.  $\text{N}_2 + \text{H}_2 \rightarrow \text{NH}_3$
3.  $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$
4.  $\text{SO}_2 + \text{O}_2 \rightarrow \text{SO}_3$
5.  $\text{BaCl}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2\text{HCl}$

No.	Reactant atoms	Product atoms
1.	C-1, O-2	C-1, O-2
2.		
3.		
4.		
5.		

Table 3.8



Balance the equations which are unbalanced

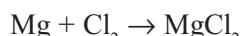
1.

2.

3.

## Oxidation and Reduction

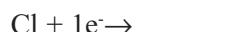
You are familiar with the reaction between magnesium and chlorine to form magnesium chloride. See the chemical equation for this reaction.



- The electronic configuration of magnesium and chlorine are 2, 8, 2 and 2, 8, 7 respectively. How many electrons does a magnesium atom donate? What charge will it get?  
-----
- Let us complete the equation for this process,



- How many electrons are accepted by each chlorine atom? What will be the charge acquired by each atom?  
-----
- Complete the equation of this process.



In this reaction, magnesium donates electrons and chlorine accepts electrons.

Oxidation is the process of loss of electrons.

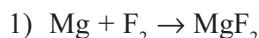
Reduction is the process of gain of electrons.

The atom which loses electron is called the reducing agent and the atom which gains electron is called the oxidising agent.

- In the above chemical reaction, which atom is oxidised?  
-----
- Which atom is reduced?  
-----

- Which is the oxidising agent in this chemical reaction?  
-----
- Which is the reducing agent in this chemical reaction?  
-----

Analyse the following equations and list the oxidised atom, reduced atom, oxidising agent and reducing agent.



Oxidised atom	.....
Equation of oxidation	$Mg \rightarrow Mg^{2+} + 2e^-$
Reduced atom	.....
Equation of reduction	$F + e^- \rightarrow F^-$
Oxidising agent	.....
Reducing agent	.....

Table 3.9



Oxidised atom	.....
Equation of oxidation	.....
Reduced atom	.....
Equation of reduction	.....
Oxidising agent	.....
Reducing agent	.....

Table 3.10

Analyse the following equations and complete the Table 3.11 given below.

1.  $Mg \rightarrow Mg^{2+} + 2e^-$   
 $F + 1e^- \rightarrow F^-$
2.  $Na \rightarrow Na^+ + 1e^-$   
 $Cl + 1e^- \rightarrow Cl^-$
3.  $Fe \rightarrow Fe^{2+} + 2e^-$   
 $O + 2e^- \rightarrow O^{2-}$

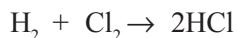
Equation of oxidation	Reducing agent	Equation of reduction	Oxidising agent
$Mg \rightarrow Mg^{2+} + 2e^-$	Mg	$F + 1e^- \rightarrow F^-$	F
.....	.....	.....	.....
.....	.....	.....	.....

Table 3.11



## Oxidation number

Oxidation number of an atom in a molecule is the formal charge assigned on the atom, if all the bonds in the substance are considered to be ionic. Consider the reaction between hydrogen and chlorine to form hydrogen chloride



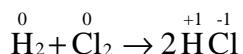
Here as you know, a covalent bond is formed by sharing the electrons between hydrogen and chlorine.

- Oxidation number of an atom in a covalent compound is found out by assuming that the electron pair is shifted to the more electronegative atom.
- Oxidation number of an atom in a molecule of an element will be zero as the electrons are shared equally between the atoms.
- The sum of the oxidation numbers of the constituent atoms in a molecule will be zero.

In the formation of hydrogen chloride, 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.

- What is the oxidation number of hydrogen in  $\text{H}_2$ ?  
-----
- What is the oxidation number of chlorine in  $\text{Cl}_2$ ?  
-----

Now let us rewrite the equation by including the oxidation numbers.



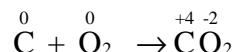
- In this reaction, does the oxidation number of hydrogen increase or decrease?  
-----
- What change takes place in the oxidation number of chlorine?  
-----

The process in which the oxidation number increases is called oxidation.

The process in which the oxidation number decreases is called reduction

- During the formation of hydrogen chloride, which atom was oxidised?  
-----
- Which is the reducing agent?  
-----
- Which atom was reduced during this reaction?  
-----
- Which is the oxidising agent?  
-----

Analyse oxidation numbers in the given equation and list the oxidising agent and reducing agent in the table given below.

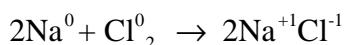


Element	Oxidation number before the reaction	Oxidation number after the reaction	Oxidation/reduction happened
C	0	+4	--
O	0	-2	--

Table 3.12

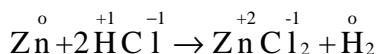
- Oxidising agent .....  
.....
- Reducing agent .....  
.....

Analyse the oxidation number and note down the oxidising agent and reducing agent in the following reaction.



- Oxidation number of which atom is increased? -----
- The oxidised atom is -----
- Oxidation number of which atom is decreased? -----
- The reduced atom is -----
- Oxidising agent -----
- Reducing agent -----

Let us consider another eqation.



- The oxidation number of zinc increases/decreases from .... to .....
- The oxidised atom is .....
- The oxidation number of hydrogen increases/ decreases from ..... to .....
- The reduced atom is .....
- Here HCl is the oxidising agent and Zn is the reducing agent.

### Method of determining the oxidation number

See the common oxidation numbers of some elements given in Table 3.13.

Element	oxidation number	Element	oxidation number
H	+1	F	-1
K	+1	Cl	-1
Na	+1	O	-2
Ca	+2	Br	-1
Al	+3	I	-1

Table 3.13

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

How do you determine the oxidation number of sulphur in  $\text{H}_2\text{SO}_4$ ?

From the Table 3.13

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  $\text{H}_2\text{SO}_4$  is +6.

Find the oxidation number of Mn in  $\text{KMnO}_4$  (oxidation number of K is +1, oxidation number of O is -2)

Oxidation state of potassium = +1

Oxidation state of oxygen = -2

Let the oxidation state of Mn be 'x'.

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

$$(+1) + x + (-8) = 0$$

$$x - 7 = 0$$

$$x = +7$$

- Similarly find the oxidation number of Mn in  $\text{MnO}_2$ ,  $\text{Mn}_2\text{O}_3$  and  $\text{Mn}_2\text{O}_7$ .

In the case of ions, their charge and oxidation number are always the same.

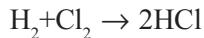
Examples:

+2 in  $\text{Fe}^{2+}$

+3 in  $\text{Fe}^{3+}$

+2 in  $\text{Cu}^{2+}$

## Redox Reactions



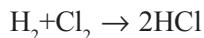
Which atom is oxidised in this reaction?

---

The atom which gets reduced is

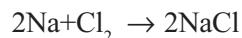
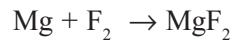
---

You know that these two reactions constitute the complete chemical reaction.



Here the process of oxidation and reduction take place simultaneously. Hence these two reactions together are known as redox reaction.

Some more examples:



## Rate of chemical reaction

You might have observed a wide variety of chemical reactions in



your daily life. Some of these reactions are given below. Expand the list.

- Burning of firewood
- Rusting of iron
- Bursting of crackers
- 
- 

Do these reactions occur at the same rate?

Are these situations where the speed of chemical reactions is to be increased or decreased?

Have you ever thought of reducing the rate of the rusting of iron considerably. Similarly, don't we wish the firewood to burn faster?

What are the methods usually adopted to make firewood burn faster?

- Provide more air
- 
- 

Doesn't this indicate that some factors influence the rate of chemical reactions? Let us study the rate of chemical reactions and the important factors influencing it.

### **1. Nature of the reactants and the rate of chemical reaction.**

Are the rates of reaction of zinc (Zn) and magnesium (Mg) with dilute HCl the same? Let us do an experiment.

What are the materials required for the experiment?

-----  
-----  
-----



Isn't it necessary to take Zn and Mg in almost the same size?

- Note down the procedure of this experiment.  
-----
- Which gas is formed during the reaction?  
-----

- Try to write the chemical equations

Experiment 1 (when Zn was added):

-----  
Experiment 2 (when Mg was added):  
-----

- In which test tube was the reaction faster?  
-----
- Is there any difference in the concentration of the acid used in these experiments?  
-----
- What is the factor that influenced the rate of reaction here?  
-----

The nature of reactants is one of the factors which influences the rate of chemical reaction.

## 2. Concentration and rate of chemical reaction



We have found out the influence of the nature of the reactants on the rate of chemical reactions. Now let us see the relationship between concentration of the reactants and the rate of chemical reaction.

Examine how magnesium reacts with hydrochloric acid (HCl) of different concentrations.

- What are the materials required?  
-----
- Isn't it necessary to have magnesium ribbons of equal mass?  
-----
- What about the volume of HCl?  
-----

Now let us do the experiment. Observe Figure 3.1.

Take magnesium ribbons of equal mass in both the test tubes. Add concentrated HCl to one test tube and dilute HCl to the other in equal volume.



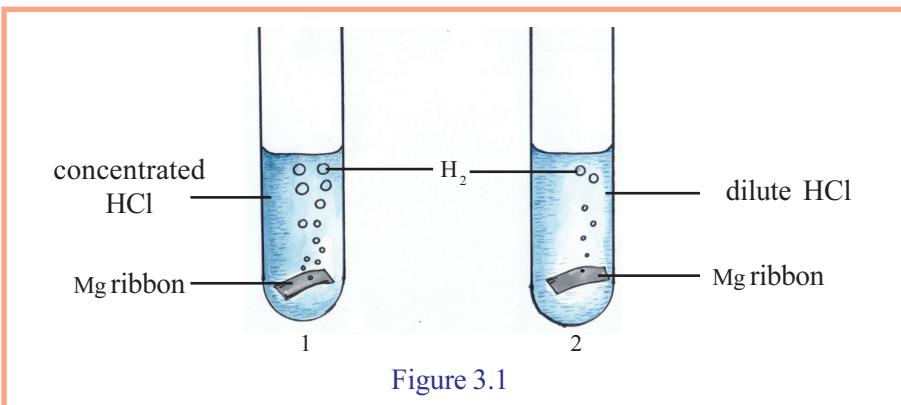


Figure 3.1

Note down your observation.

Test tube 1: -----

Test tube 2: -----

Write the balanced chemical equation for the reaction.

- 
- In which test tube is the rate of reaction greater?
- 
- Which test tube contains more HCl molecules per unit volume?
- 

An increase in the number of molecules lead to increase in the rate of reaction? Let see the reason for this.

As the concentration of reactants increases, the number of molecules per unit volume and the number of effective collisions increase. Consequently the rate of reaction increases.



## Collision Theory

According to this theory reactant molecules have to collide against each other for chemical reaction to occur. All collisions between reactant molecules need not result in chemical reaction. Only when the reactant molecules have energy greater than a certain minimum energy, they undergo effective collisions which result in product formation. An increase in the number of molecules and an increase in their energy will result in an increase in the number of effective collisions within a specified time.

### 3. Surface area of solids and rate of chemical reaction

Let us see how a sample of dilute HCl reacts with a marble piece and then with marble powder of equal mass.

Analyse Figure 3.2 and write the materials required and the



procedure of the experiment.

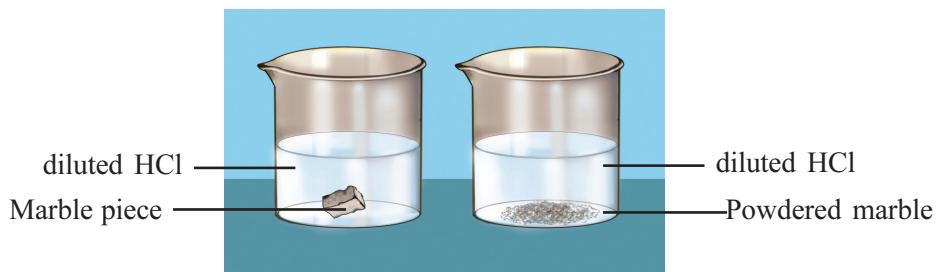


Figure 3.2

Let us write the chemical equation for this reaction.



What is the observation?

- Is there any difference in the rate of reaction in the two beakers?  
-----
- What about the concentration of acid in both the reactions?  
-----
- Is there any difference in the mass of the marble?  
-----
- What about the surface area of marble?  
-----
- In which case is the chance for greater number of acid molecules to get in contact with marble, in a given time?  
-----
- What is the change in the rate of collision when surface area increases?  
-----
- What will happen to the rate of this reaction if marble is further crushed or powdered?  
-----

In the case of reactions involving solids, the surface area is a factor which influences the rate of reaction.

When solids are made into small pieces or powder, their surface area increases. As a result the number of molecules undergoing effective collision also increases. Hence the rate of reaction increases.



Is it clear now, why firewood burns faster when they are cut into small pieces?

Identify more examples from daily life to illustrate the increase in rate of reaction with the increase in surface area.



#### 4. Temperature and Rate of reaction

Let us see the influence of temperature in the reaction between sodium thiosulphate and hydrochloric acid.

Materials required:

Sodium thiosulphate, hydrochloric acid, water, boiling tube, spirit lamp.

Procedure:

Prepare the dilute solution of sodium thiosulphate in a beaker. Take equal volumes of this solution in two boiling tubes. Heat one boiling tube for sometime. Add dilute hydrochloric acid in equal amounts in both the boiling tubes.

- Record the observation
  
- In which of the boiling tubes is the precipitate formed faster?
  
- What is the colour of the precipitate formed?

The colour change is due to the precipitation of sulphur in both the boiling tubes. See the chemical equation.



From this experiment, you can understand which factor has influenced the rate of reaction.

#### Threshold Energy

To take part in a chemical reaction, molecules should attain a certain minimum kinetic energy. This energy is called threshold energy.

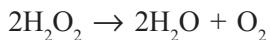
Energy as well as speed of molecules increases when reactants are heated. That is as temperature increases the number of

molecules with threshold energy increases. As a result, the number of effective collisions increases and thus rate of reaction also increases.

Temperature is an important factor which influences the rate of reaction. As temperature increases the rate of reaction also increases.

### 5. Catalyst and Rate of reaction

Hydrogen peroxide( $H_2O_2$ ) is a compound which undergoes decomposition. Usually its aqueous solution is used in chemical reactions. See the chemical equation of its decomposition.



Take some hydrogen peroxide solution in a test tube. Show a glowing incense stick into the test tube.

- What is the observation? Is there any difference occurring in the way in which the incense stick burns?
- 

Now add some manganese dioxide ( $MnO_2$ ) into the test tube. Again show the glowing incense stick.

- Record the observation.
- 

Doesn't it indicate that when manganese dioxide is added, the rate of reaction increases and oxygen is formed faster?

Filter the solution using a filter paper when the reaction is completed.

The substance remaining in the filter paper is manganese dioxide itself. When examined carefully it becomes clear that there is no change in its amount or property.

The presence of manganese dioxide has increased the rate of the reaction. Manganese dioxide acts as a catalyst in this reaction.

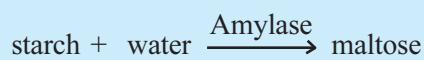
Catalysts are substances which alter the rate of chemical reactions without themselves undergoing any permanent chemical change.





## Biocatalysts

Biological processes occurring in living cells are chemical reactions. These chemical reactions sustain life. These reactions are catalysed by complex. Protein molecules known as enzymes. The enzyme amylase, present in saliva, converts starch into maltose



In this reaction, manganese dioxide acted as a catalyst by increasing the rate of reaction. Such catalysts are called **positive catalysts**.

You have understood that hydrogen peroxide decomposes to form water and oxygen. Then isn't it necessary to reduce the rate of decomposition of hydrogen peroxide during its storage? For this purpose some phosphoric acid ( $\text{H}_3\text{PO}_4$ ) is added to hydrogen peroxide. Here phosphoric acid acts as a **negative catalyst** as it reduces the decomposition rate of hydrogen peroxide.

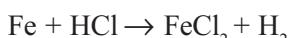
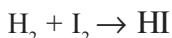
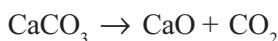
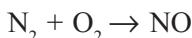
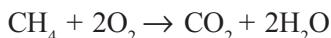
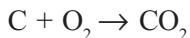
In the manufacture of sulphuric acid, vanadium pentoxide and in the manufacture of ammonia, iron are used as positive catalysts.





## Let us assess

1. Some chemical equations are given below.



a. Which of these are balanced equations?

b. Balance the unbalanced equations.

c. Which among these are redox reactions?

2. The chemical reaction between marble and dilute HCl is given.



a. Which gas is formed here? How can you identify this gas?

b. Suggest any two ways you would choose to increase the rate of this chemical reaction. Explain the reason.

3. Sulphur pieces do not react with cold concentrated nitric acid. But sulphur powder reacts.

a. Explain the reason why the rate of chemical reaction is increased here?

b. Suppose you want to increase the rate of reaction again. Which way you would choose? Give reason.

4. Small amounts of phosphoric acid is usually added to hydrogen peroxide to prevent its decomposition?

a. What is the function of phosphoric acid here?

b. By which name are these type of substances known?

c. Which substance would you add to increase the rate of decomposition of hydrogen peroxide?





## Extended activities

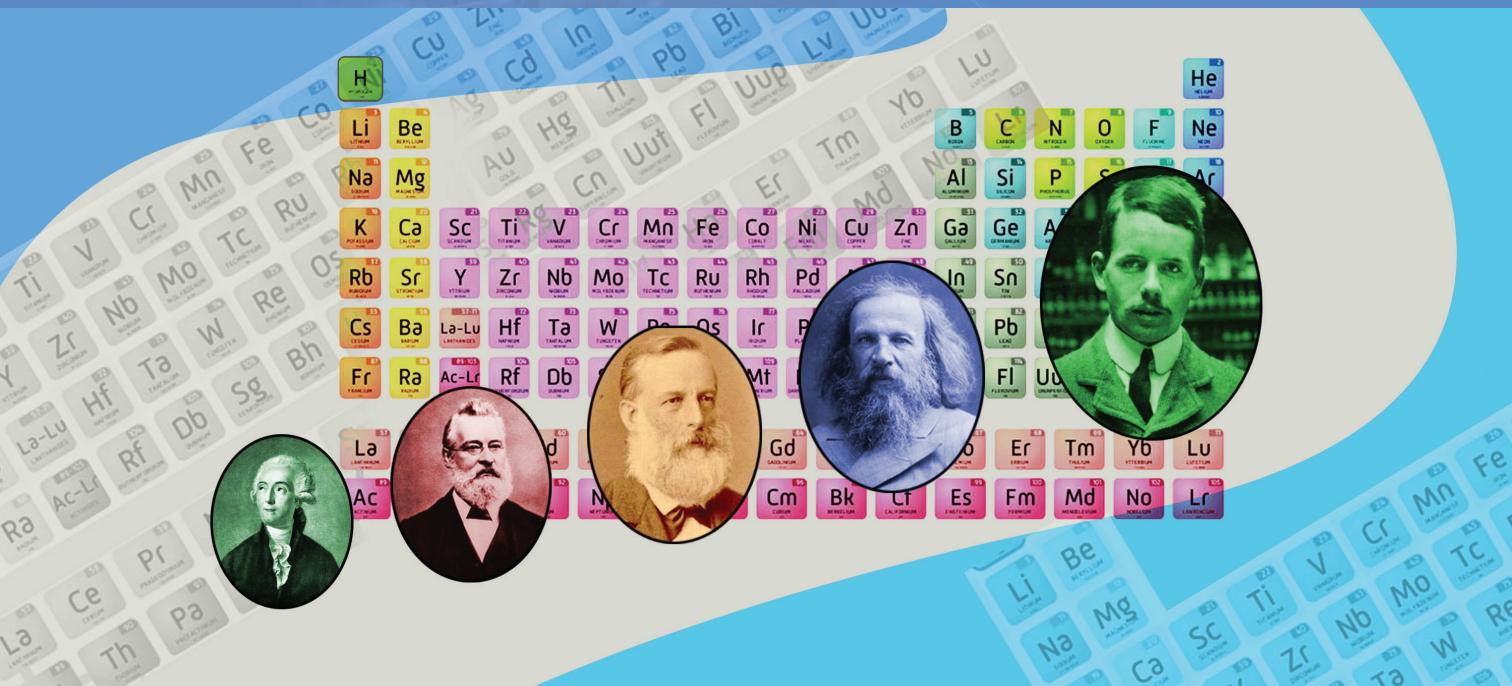
- Find the oxidation number of the elements which are underlined in the compounds given below. Among these find out the elements which show variable oxidation numbers.

MnO<sub>2</sub>, Mn<sub>2</sub>O<sub>7</sub>, K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>, KCrO<sub>3</sub>, MnCl<sub>2</sub>, MgO, MgCl<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, AlCl<sub>3</sub>  
(Hint. Oxidation number O = -2, Cl = -1, K = +1)

- Some apparatus and chemicals are given.  
Zn, Mg, dilute HCl, CaCO<sub>3</sub>, test tube, water.
  - Design an experiment to prove that the nature of reactants can influence the rate of reaction.
  - Write the equations for the chemical reactions.
  - Write the expression for the rate of the reaction.
- The experiments conducted by two students are given below.  
**Experiment – 1**  
2 mL of sodium thiosulphate solution is taken in a test tube, heated and to it 2 mL of HCl solution is added.  
**Experiment – 2**  
2 mL of sodium thiosulphate solution is taken in a test tube and to it 2 mL of HCl solution is added.
  - In which experiment is the precipitate formed quickly? Justify your answer.
  - Write the balanced equation for the reaction.
- Some materials available in the laboratory are given below.  
Magnesium ribbon, marble powder, marble pieces, dilute HCl, concentrated HCl.
  - Which materials will you choose for the preparation of more CO<sub>2</sub> in less time?
  - Write the balanced chemical equation of the reaction.

# 4

## PERIODIC TABLE



You know that all the substances in the universe are formed by the combination of elements. So far about 120 elements have been discovered. Of these only 90 elements are seen in nature. The rest are artificial elements. You might have seen a table of these elements in the science textbook. This is a comprehensive tool for the classification of elements. This is known as the periodic table.

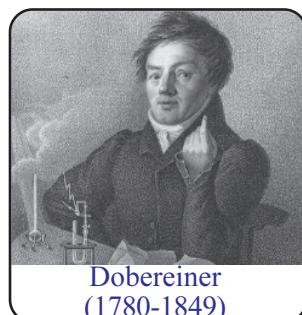
Henry Moseley, through his experiments, proved that the properties of elements depend on their atomic number. According to this, the elements are arranged in the periodic table in the increasing order of their atomic numbers. This table is also known as the ‘Modern Periodic Table’. From this, it is clear that there existed a was a periodic table earlier. Let us look into the early attempts of classification of elements.

### Into the History

It was Lavoisier who first made an attempt to classify elements. In 1789, the known 30 elements were classified into metals and

non-metals. But he was not able to classify metalloids that show the properties of both metals and non-metals. This was one of the limitations of this classification.

After Lavoisier, it was Dobereiner who gave notable contribution in the classification of elements. He formed small groups of three elements showing similar properties. These groups were called **Triads**.



Element	Atomic Mass	Element	Atomic Mass	Element	Atomic Mass
Li	7	Ca	40	Cl	35.5
Na	23	Sr	87.6	Br	80
K	39	Ba	137.3	I	127

Table 4.1

In the triads, the atomic mass of the second element was approximately the arithmetic mean of the first and third elements. This helped in finding the relationship between atomic mass and properties of elements. All elements could not be classified into triads, which was the limitation of this classification.

In 1866 when Newlands arranged the known 56 elements in the increasing order of atomic mass, he found that properties of the eighth element is the repetition of those of the first element. He compared this to the seven notes of music.

Just like the eighth note is the repetition of the first note Sa, Ri, Ga, Ma, Pa, Dha, Ni, Sa....

This law is known as the **Law of Octaves**.

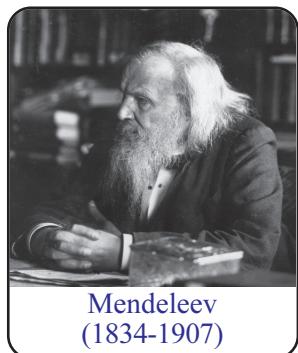
But one of the noted limitations of this was that the elements with higher atomic mass did not obey this rule.

  
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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 4.2

## Classification using Table



It was the Russian scientist Dmitri Ivanovich Mendeleev who created a table for the first time for the classification of elements. Later, Mendeleev came to be known as the father of periodic table. This periodic table which became a milestone in the history of classification of elements had 63 elements when it was created. Mendeleev arranged these elements in the table in the increasing order of their atomic masses. When arranged so, he found that the chemical and physical properties of elements repeat at regular intervals. 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 <sub>2</sub> O RH	RO RH <sub>2</sub>	R <sub>2</sub> O <sub>3</sub> RH <sub>3</sub>	RO <sub>2</sub> RH <sub>4</sub>	R <sub>2</sub> O <sub>5</sub> RH <sub>3</sub>	RO <sub>3</sub> RH <sub>2</sub>	R <sub>2</sub> O <sub>7</sub> RH	RO <sub>4</sub>
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	Ca 40.08	.....	Ti 47.90	V 50.94	Cr 50.20	Mn 54.94	Fe 55.85
	Cu 63.54	Zn 65.37	.....	.....	As 74.92	Se 78.96	Br 79.909	Co 58.93
5 First series Second series	Rb 85.47	Sr 87.62	Y Cd 112.04	In 114.82	Zr 91.22	Nb 92.91	Mo 95.94	Tc 99
	Ag 107.87				Sn 118.69	Sb 121.75	Te 127.60	Ru 101.07
6 First series Second series	Cs 132.90	Ba 137.34	La Hg 200.59	Ti 204.37	Hf 178.49	Ta 180.95	W 183.85	Rh 192.2
	Au 196.97				Pb 207.19	Bi 208.98		Pt 195.09

Table 4.3

## Advantages of Mendeleev's periodic table

- Elements were classified in such a way that elements of similar properties were placed in the same group. Learning chemistry was thus made easier.
- Some elements did not follow the correct ascending order of the atomic masses. He pointed out that this could be due to the wrong determination of atomic mass. Later this led to the correction of the wrongly determined atomic masses.  
(Eg : The atomic mass of beryllium was redetermined from 14 to 9)
- Columns were left vacant for elements which were not known at that time and their properties were also predicted.

### Group and Period

The vertical columns in the periodic table are known as groups. The elements of the groups exhibit similarly in chemical and physical properties. The horizontal rows are known as periods.

## Limitations of Mendeleev's periodic Table

- 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: Cobalt (Co), Nickel (Ni), Tellurium (Te) and Iodine (I).

## Modern Periodic Law

In 1869, while Mendeleev was framing the periodic table, there was no clear idea formed about the fundamental particles or the structure of the atom.

Moseley, through his X-ray diffraction experiments, gave serial number to the elements. It was called atomic number. Based on this the periodic law was modified.

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

## Periodic Table

**H**  
Hydrogen  
<sub>1</sub>

Hints		
Gases	Liquids	Synthetic Elements

<b>Li</b> Lithium <sub>2.1</sub>	<b>Be</b> Beryllium <sub>2.2</sub>	<b>Ti</b> Titanium <sub>2.8,10.2</sub>
<b>Na</b> Sodium (Natrium) <sub>2.8.1</sub>	<b>Mg</b> Magnesium <sub>2.8.2</sub>	<b>V</b> Vanadium <sub>2.8,11.2</sub>
<b>K</b> Potassium (Kalium) <sub>2.8.8.1</sub>	<b>Ca</b> Calcium <sub>2.8.8.2</sub>	<b>Cr</b> Chromium <sub>2.8,13.1</sub>
<b>Rb</b> Rubidium <sub>2.8,18.8.1</sub>	<b>Sr</b> Strontium <sub>2.8,18.8.2</sub>	<b>Mn</b> Manganese <sub>2.8,13.2</sub>
<b>Cs</b> Cesium <sub>2.8,18.8.1</sub>	<b>Ba</b> Barium <sub>2.8,18.8.2</sub>	<b>Fe</b> Iron (Ferrum) <sub>2.8,14.2</sub>
<b>Fr</b> Francium <sub>2.8,18.32,18.8.2</sub>	<b>Ra</b> Radium <sub>2.8,18.32,18.8.2</sub>	<b>Ru</b> Ruthenium <sub>2.8,18.15.1</sub>
<b>Ac-Lr</b> Actinium-Lanthanum <sub>2.8,18.32,18.8.2</sub>	<b>Pr</b> Praseodymium <sub>2.8,18.21,8.2</sub>	<b>Tc</b> Technetium <sub>2.8,18.14.1</sub>
<b>Th</b> Thorium <sub>2.8,18.32,18.10.2</sub>	<b>Pm</b> Promethium <sub>2.8,18.23,8.2</sub>	<b>Os</b> Osmium <sub>2.8,18.32,14.2</sub>
<b>Ac</b> Actinium <sub>2.8,18.32,18.10.2</sub>	<b>Nd</b> Neodymium <sub>2.8,18.22,8.2</sub>	<b>Ta</b> Tantalum <sub>2.8,18.32,11.2</sub>
	<b>Eu</b> Europium <sub>2.8,18.24,8.2</sub>	<b>W</b> Tungsten (Wolfram) <sub>2.8,18.32,12.2</sub>
	<b>Sm</b> Samarium <sub>2.8,18.23,8.2</sub>	<b>Hf</b> Hafnium <sub>2.8,18.32,10.2</sub>
	<b>Dy</b> Dysprosium <sub>2.8,18.25,8.2</sub>	<b>Tb</b> Terbium <sub>2.8,18.27,8.2</sub>
	<b>Ho</b> Holmium <sub>2.8,18.28,8.2</sub>	<b>Y</b> Ytterbium <sub>2.8,18.30,8.2</sub>
	<b>Er</b> Erbium <sub>2.8,18.31,8.2</sub>	<b>Lu</b> Lutetium <sub>2.8,18.32,8.2</sub>
	<b>Tm</b> Thulium <sub>2.8,18.30,8.2</sub>	
	<b>Es</b> Einsteinium <sub>2.8,18.32,8.2</sub>	
	<b>Md</b> Mendelevium <sub>2.8,18.33,8.2</sub>	
	<b>No</b> Nobelium <sub>2.8,18.32,8.2</sub>	
	<b>Lr</b> Lawrencium <sub>2.8,18.33,8.2</sub>	

Atomic number	Symbol	Name	Electronic Configuration
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<b>B</b> Boron <sub>2.3</sub>	<b>C</b> Carbon <sub>2.4</sub>	<b>N</b> Nitrogen <sub>2.5</sub>	<b>O</b> Oxygen <sub>2.6</sub>
<b>Al</b> Aluminum <sub>2.8.3</sub>	<b>Si</b> Silicon <sub>2.8.4</sub>	<b>P</b> Phosphorus <sub>2.8.5</sub>	<b>S</b> Sulphur <sub>2.8.6</sub>
<b>Ga</b> Gallium <sub>2.8.18.3</sub>	<b>Ge</b> Germanium <sub>2.8.18.4</sub>	<b>As</b> Arsenic <sub>2.8.18.5</sub>	<b>Se</b> Selenium <sub>2.8.18.6</sub>
<b>Zn</b> Zinc <sub>2.8,18.2</sub>	<b>In</b> Indium <sub>2.8,18.3</sub>	<b>Sn</b> Tin (Stannum) <sub>2.8,18.4</sub>	<b>Te</b> Tellurium <sub>2.8,18.5</sub>
<b>Ag</b> Silver <sub>2.8,18.1</sub>	<b>Cd</b> Cadmium <sub>2.8,18.2</sub>	<b>Pb</b> Lead (Plumbum) <sub>2.8,18.3</sub>	<b>I</b> Iodine <sub>2.8,18.7</sub>
<b>Cu</b> Copper (Cuprum) <sub>2.8,18.1</sub>	<b>At</b> Antimony (Stibium) <sub>2.8,18.1</sub>	<b>Po</b> Polonium <sub>2.8,18.2</sub>	<b>Xe</b> Xenon <sub>2.8,18.8</sub>
<b>Mn</b> Manganese <sub>2.8,13.2</sub>	<b>Rh</b> Rhodium <sub>2.8,18.16.1</sub>	<b>Tl</b> Thallium <sub>2.8,18.32,18.2</sub>	<b>Rn</b> Radon <sub>2.8,18.32,18.8</sub>
<b>Fe</b> Iron (Ferrum) <sub>2.8,14.2</sub>	<b>Pd</b> Palladium <sub>2.8,18.18.18</sub>	<b>Hg</b> Mercury (Hydroargyrum) <sub>2.8,18.32,18.1</sub>	
<b>Co</b> Cobalt <sub>2.8,15.2</sub>	<b>Ru</b> Ruthenium <sub>2.8,18.15.1</sub>	<b>Au</b> Gold (Aurum) <sub>2.8,18.32,17.1</sub>	
<b>Tc</b> Technetium <sub>2.8,18.14.1</sub>	<b>Re</b> Rhenium <sub>2.8,18.32,13.2</sub>	<b>Ir</b> Iridium <sub>2.8,18.32,14.2</sub>	
<b>Mo</b> Molybdenum <sub>2.8,18.13.1</sub>	<b>Os</b> Osmium <sub>2.8,18.32,13.2</sub>	<b>Pt</b> Platinum <sub>2.8,18.32,12.2</sub>	
<b>Zr</b> Zirconium <sub>2.8,18.12.1</sub>	<b>Ta</b> Tantalum <sub>2.8,18.32,11.2</sub>	<b>Ag</b> Argentum <sub>2.8,18.32,11.2</sub>	
<b>Y</b> Yttrium <sub>2.8,18.9.2</sub>	<b>W</b> Tungsten (Wolfram) <sub>2.8,18.32,10.2</sub>	<b>Pt</b> Platinum <sub>2.8,18.32,10.2</sub>	
<b>La</b> Lanthanum <sub>2.8,18.7-1</sub>	<b>Ta</b> Tantalum <sub>2.8,18.32,10.2</sub>	<b>Os</b> Osmium <sub>2.8,18.32,10.2</sub>	
<b>Ac-Lr</b> Actinium-Lanthanum <sub>2.8,18.32,18.8.2</sub>	<b>Hf</b> Hafnium <sub>2.8,18.32,10.2</sub>	<b>Pt</b> Platinum <sub>2.8,18.32,10.2</sub>	
<b>Ra</b> Radium <sub>2.8,18.32,18.8.2</sub>	<b>Bh</b> Bohrium <sub>2.8,18.32,18.2</sub>	<b>Ir</b> Iridium <sub>2.8,18.32,18.2</sub>	
<b>Fr</b> Francium <sub>2.8,18.32,18.8.2</sub>	<b>Sg</b> Seaborgium <sub>2.8,18.32,18.2</sub>	<b>Pt</b> Platinum <sub>2.8,18.32,18.2</sub>	
<b>Ac-Lr</b> Actinium-Lanthanum <sub>2.8,18.32,18.8.2</sub>	<b>Ds</b> Dubnium <sub>2.8,18.32,18.2</sub>	<b>Os</b> Osmium <sub>2.8,18.32,18.2</sub>	
<b>Th</b> Thorium <sub>2.8,18.32,18.10.2</sub>	<b>Rf</b> Rutherfordium <sub>2.8,18.32,18.10.2</sub>	<b>Rg</b> Roentgenium <sub>2.8,18.32,18.1</sub>	
<b>Ac</b> Actinium <sub>2.8,18.32,18.10.2</sub>	<b>Pm</b> Promethium <sub>2.8,18.32,18.10.2</sub>	<b>Cn</b> Copernicium <sub>2.8,18.32,18.1</sub>	
<b>Fr</b> Francium <sub>2.8,18.32,18.8.2</sub>	<b>Db</b> Dubnium <sub>2.8,18.32,18.2</sub>	<b>Nh</b> Nhastium <sub>2.8,18.32,18.3</sub>	
<b>Ac-Lr</b> Actinium-Lanthanum <sub>2.8,18.32,18.8.2</sub>	<b>Am</b> Americium <sub>2.8,18.32,18.8.2</sub>	<b>Ts</b> Tennessee <sub>2.8,18.32,18.7</sub>	
<b>Th</b> Thorium <sub>2.8,18.32,18.10.2</sub>	<b>Pu</b> Plutonium <sub>2.8,18.32,18.8.2</sub>	<b>Og</b> Oganesson <sub>2.8,18.32,18.8</sub>	

Table 4.4





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Analyse the modern periodic table and complete the following.

- 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 in the periodic table?

### **Electronic configuration and position in periodic table**

What information regarding an element that can be understood from the periodic table?

Find the facts related to the element carbon in the periodic table (Table 4.4) and write them.

- Name
- Symbol
- -----
- -----

See the electronic configuration of group 1 elements of the periodic table (Table 4.5)

Elements	Atomic number	Electronic configuration
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 4.5

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

-----  
What is the nature of the chemical bond formed by these elements?  
-----

Is it clear that the elements in group 1 exhibit similarity in chemical properties?

Similarly, write the electronic configuration of some elements in group 2 and analyse. Do you find a similar peculiarity. These elements are called Alkaline Earth Elements.

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

Hence the elements present in the same group exhibit similarity in the chemical properties.

Analyse the periodic table (Figure 4.4) and write the group and period of the elements given in Table 4.5. Is there any relationship between the group number and the number of electrons present in the outermost shell? What is it?

Examine the electronic configuration of group 2 elements. What peculiarity is seen here?

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

Observe the electronic configuration of the second period elements from groups 13 to 18.

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

Table 4.6

What is the difference between group number and the electronic configuration of the outer most shell?

We get the group number of these elements by adding 10 to the number of electrons in the outermost shell.

Identify the period number of group 1 elements given in Table 4.5 with the help of the periodic table. Is there any relation between the number of shells and the period number?

Examine Table 4.7. Find out the relationship between the electronic configuration and period number.

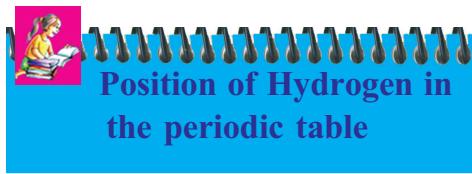
	Na	Ca	Ga	I
Electronic configuration	2,8,1	2,8,8,2	2,8,18,3	2,8,18,18,7
No of shells	-	4	-	5
Period number	3	-	-	5

Table 4.7

The number of shells in an element and the number of the period to which it belongs are the same.

Based on the common characteristic of elements in each group, they can be grouped as different families.

See table 4.8 given below.



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 mono atomic, 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 a low ionization energy while hydrogen has high ionization energy like halogens.

Group number	Family
1	Alkali metals
2	Alkaline earth metals
3 to 12	Transition elements
13	Boron Family
14	Carbon family
15	Nitrogen family
16	Oxygen family
17	Halogens
18	Noble gasses

Table 4.8

### Representative elements

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

- Is there any element familiar to you?
  - Are there metals included?
  - Are there non-metals included?
  - Do they include metalloids exhibiting the characteristics of both metals and non-metals?
- Find examples and write them in a table.
- Are there elements in solid, liquid and gaseous states?
- Find examples.

- In solid state - - - - -
- In liquid state - - - - -
- In gaseous state - - - - -

The elements of these groups show periodicity in filling electrons in their atoms. 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 radom of group 18 in the periodic table are noble gases. They are mono atomic 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 electric bulbs to prevent evaporation of the filament. Radom 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?  
-----
- Do they take part in chemical reaction?  
-----
- Group 18 elements are known as noble gases.

### Transition Elements

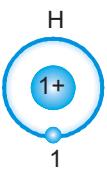
The elements included in groups 3 to 12 in the periodic table are transition elements.

- Transition elements are metals.
- They form coloured compounds
- They show similarities in chemical properties in groups as well as in a period.

### Lanthanoides and Actinoides

Find out the position allotted to the elements with atomic number 57 to 71.

In the same way, the elements with atomic number 89 to 103 of



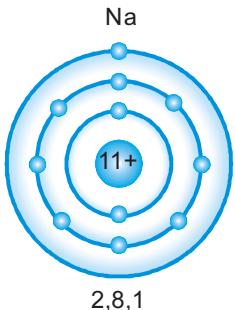
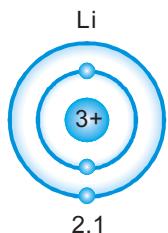
period 7 are given separate positions at the bottom of the periodic table.

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

Inner transition elements from Lanthanum (La) to Lutetium (Lu) of period 6 are called **Lanthanoides**.

Inner transition elements from Actinium (Ac) to Lawrencium (Lr) of period 7 are called **actinoides**.

Lanthanoids are also called **rare earths**. Actinoides after Uranium (U) are artificial.



### Periodic trends in the periodic table Size of an atom in groups

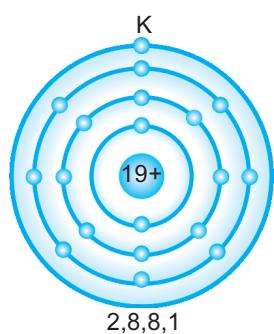
Are you familiar with the Bohr model of an atom? See the Bohr Model of atoms of certain elements in group 1 (Figure 4.1).



Which among them is the biggest atom? Which one is the smallest? What happens to the size of the 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.



### Atomic size in a period

See (Figure 4.2) the representation of the Bohr model of elements with atomic number 3 to 9 in the second period of the periodic table.

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

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

Positively charged nucleus attracts electrons. Therefore on moving from left to right in a period the nuclear charge increases. The force of attraction on the outermost electron increases and consequently the size of an atom decreases.

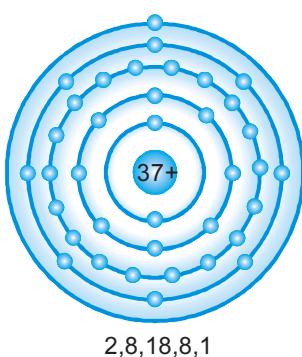


Figure 4.1

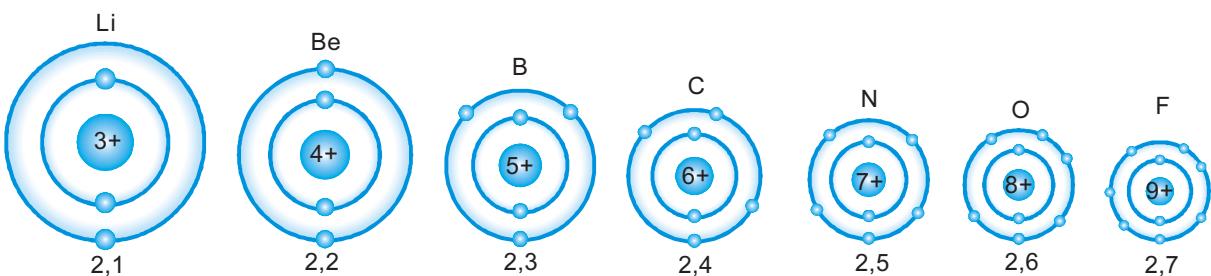


Figure 4.2

### **Ionisation Energy**

You have understood how sodium chloride is formed by combining sodium and chlorine atoms. Isn't it an ionic compound? The Bohr models of sodium and chlorine are given (Figure 4.3).



#### **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 outermost shell. Atomic radius increases with increase in number of shells in the atom.

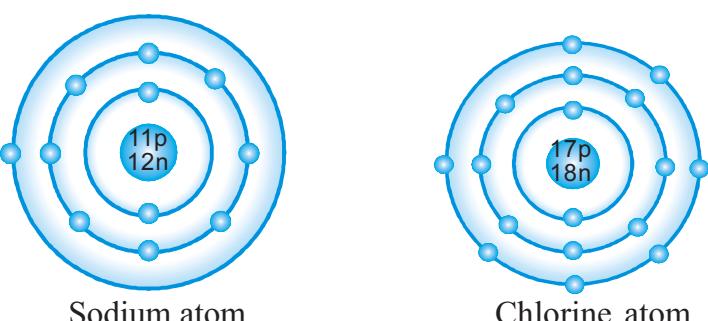


Figure 4.3

- Which among these atoms loses electron? - - - - -
- Which atom gains electrons? - - - - -

Atoms become charged when there is transfer of electrons in this way.

The charged atoms are called ions.

Here, sodium ion ( $\text{Na}^+$ ) and chloride ion ( $\text{Cl}^-$ ) are formed. In such a process, metals lose electron and become positively charged ions. The energy needed to liberate electrons from the atoms is called ionisation 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 ionisation energy.

Ionisation energy depends on two important factors.

- Nuclear charge
- Size of an 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 ionisation energy?

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

-----  

As the size of the atom increases ionisation energy decreases.

What is the general trend in the variation of ionisation 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 ionisation energy changes with increase in nuclear charge.

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

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When metallic character increases, non-metallic character decreases.

With the help of Bohr model (Figure 4.1) find how the metallic character of the first group elements varies 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? Come to a conclusion by assessing the size of an atom.

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

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 in a period. Hence ionisation energy increases. Consequently the tendency to form a positive ion decreases.

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

Is the element with the high ionisation energy metallic or non-metallic? - - - - -

Then, what about those having the low ionisation energy? - - - - -

### **Electronegativity**

You have learned about electronegativity and Pauling scale in the previous chapter.

How does electronegativity vary from top to bottom in a group?

- - - - -  
What happens when we move across a the period?

- - - - -  
Then where will be the position of the elements, with high electro negativity in the periodic table?

- - - - -  
What about the position of the elements with low electro negativity?

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

- - - - -  
Is there any relationship between electronegativity and metallic non-metallic characters? Explain.

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

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.

### **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.

You have understood certain periodic trends in the periodic table? Based on these tick (✓) the correct option in the Table 4.9 given below.

Trends	Down the group	Across the period
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 4.9

Now you have understood the history of the classification of elements and characteristics 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.



### Let us assess

- 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
Classification of elements into metals and non-metals	.....
Modern periodic law	.....

- Complete the table.

Element	Atomic No.	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 to which they belong.

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

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 to?
- d) In which group is this element included?
- e) Write the name and symbol of this element?
- f) To which family of element does this element belong to?
- g) Draw the Bohr atom model of this element.

5. Electronic configuration of elements P, Q, R and S are given below. (Symbols not real)

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. (Symbols not real)

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

- a) Which is the elements with the biggest atom in group 1?
- b) Which is the element having the 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 electro negativity?
- 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.



## NOTES



## *Let's save water*

Keralites mainly depend on wells as the main source of drinking water. We should conserve the wells which are the primary source of ground water in and around our locality. The contamination of such sources of water causes water-borne diseases like typhoid, cholera, jaundice etc.

Precautions to be taken to avoid contamination of ground water sources (wells)

- ▶ Do not bathe or wash clothes near wells.
- ▶ Keep the well covered with nets of proper size.
- ▶ Keep the bucket and rope used to draw water clean.
- ▶ Cattle sheds, compost pits etc., should be built at least 7.5m away from wells.
- ▶ Septic tanks and toilets should be built at a safe distance away from the well.
- ▶ Prevent rain water from flowing into the well by constructing suitable walls around the well.
- ▶ Disinfect well water at adequate intervals.

### *How to disinfect well water?*

Add 2.5 g bleaching powder to 1000 litre water (approx. to size of a small match box). Allow it to settle and pour the clear liquid into the well. This well water can be used for domestic purposes after 6 hours. The following table shows the presence of certain components and their permissible quantity in drinking water. It is also essential to assess the quality of drinking water often. There are government analytical laboratories under different departments for testing the quality of water. Make use of their service.

### *The admissible amount of contents in drinking water:*

Constituent	Permissible quantity
Foul smell/taste	Nil
pH	6.5 - 8.5
Soluble content	500 mg/l
Hardness	300mg/l
Iron	0.3mg/l
Fluoride	0.6 - 1.2 mg/l
Chloride	250mg/l
Choliform bacteria	Nil

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