CHEMISTRY
PART - I

Standard
IX

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Department of General Education

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2024

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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.

Chemistry

9

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Dear students,

You are familiar with the fact that the study of science is possible only through various activities like experiment, observation, data collection, data analysis and consolidation of inferences. You might have been inspired by the research done by eminent scientists to prove universal facts. With the developments in scientific concepts, diverse branches of science are emerging day by day. Chemistry is one such branch which is evolving tremendously. Almost every object that we use not only in the fields of agriculture, industry and health but also in our daily life is a gift of chemistry. Emphasis should be given to the comprehension of basic ideas and acquisition of problem solving skills, which are essentially needed for the study of chemistry.

The elementary concepts of chemistry, like atomic structure, classification of elements, chemical bonding, different types of chemical reactions and chemical compounds are included in this text. Due importance is given to the planning of various activities like experiments, seminars, quiz, projects and analysis. The text lays emphasis on the potential of continuous evaluation in order to enhance self assessment and helps in the completion of assessment through learning activities. The extended activities in each unit stresses the realisation of the practicability of learning concepts and the development of creativity.

Chemistry should be learnt with interest and enjoyment. Concepts which appear to be complicated can be easily acquired through group discussions and activities among teachers and students.

Let the study of chemistry be a delightful experience through team work and collaboration.

With love and regards.

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Certain icons are used in this textbook for convenience

For further reading (Not considered for evaluation)

Continuous assessment questions

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THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a [1]**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

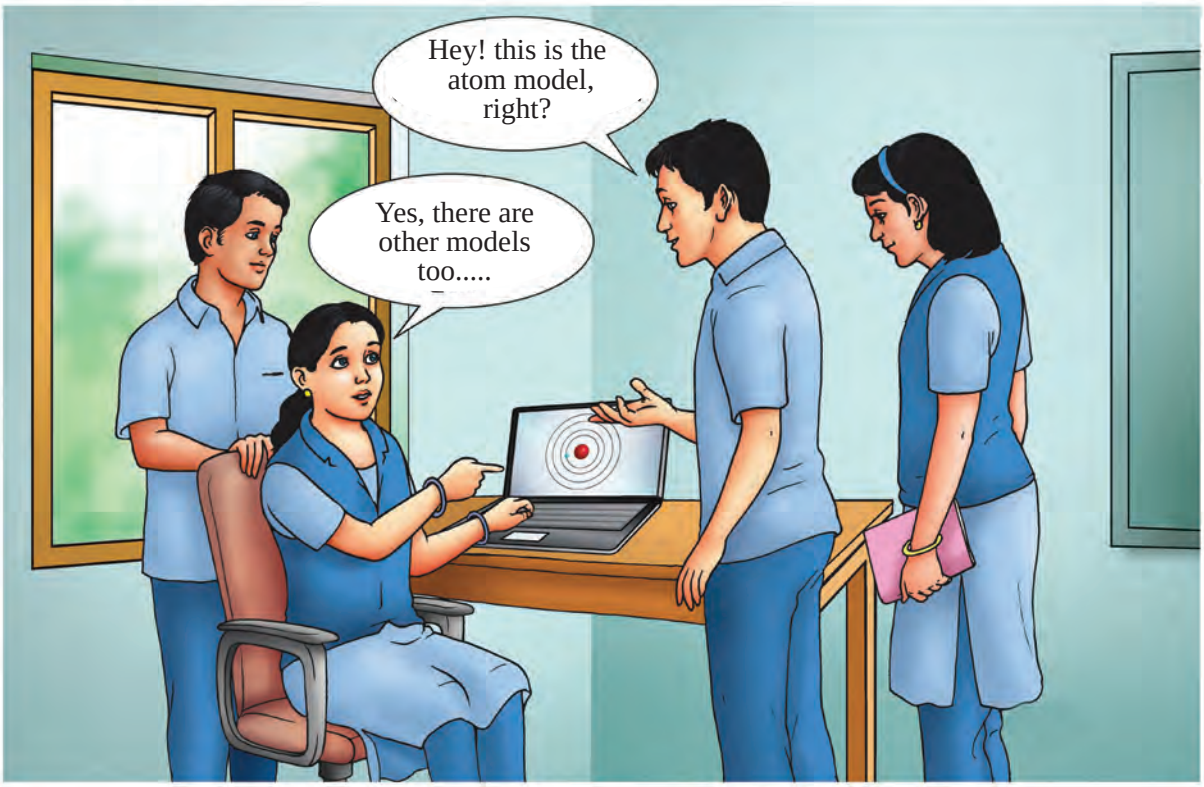
FRATERNITY assuring the dignity of the individual and the [2][unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

---

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)

1 Structure of Atom



Look at the picture. Here the students are discussing the structure of atoms.
Can you identify the atoms in the substances that are familiar to you?

Analyse Table 1.1

Substance	Constituent elements	Chemical formula of the molecule	Ratio of number of atoms
Sugar	Carbon, Hydrogen, Oxygen	$C_{12}H_{22}O_{11}$	12:22:11
Glucose	Carbon, Hydrogen, Oxygen	$C_6H_{12}O_6$	1:2:1
Water	Hydrogen, Oxygen	H_2O	2:1

Table 1.1

You have seen that the molecules of each substance contain atoms combined in a particular ratio. Molecules are particles which show all the properties of the substance and have a free existence.

How do molecules of different substances differ?

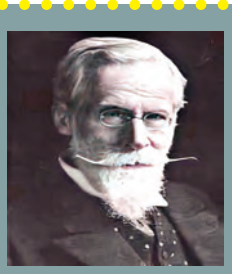
- The constituent elements of the molecules.
- The ratio of the number of constituent atoms in them.

You have understood that the molecules are formed by atoms.

You have learnt that atoms contain particles smaller than them. What are the important particles in an atom?

- Electron
- .....
- .....

These are known as subatomic particles. Let us learn more about these particles in this unit.



William Crookes
1832 - 1919

Discharge Tube Experiments and Discovery of Electrons

In 1875 William Crookes, the physicist conducted experiments by passing electricity at high voltage through a glass tube in which both sides are fixed with metal plates as electrodes (Figure 1.1).

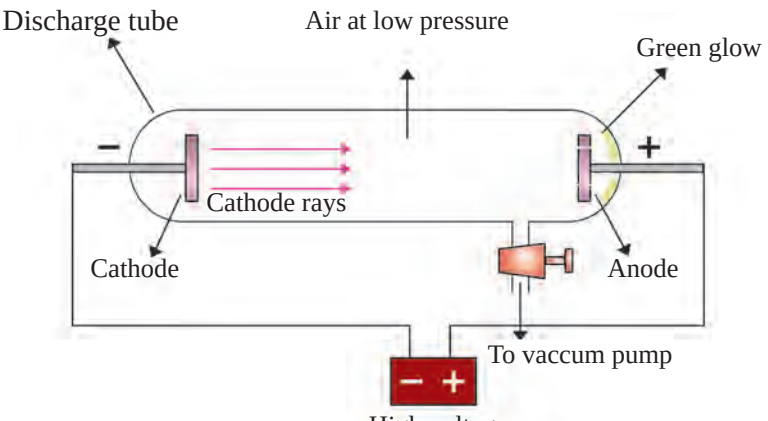


Fig. 1.1

As air is an insulator, electricity does not pass through the air in the tube at normal pressure. But, when the tube was evacuated

gradually, it was seen that electricity passed through it (electric discharge). When a perforated positive electrode (anode) was used, a light green glow was observed on the zinc sulphide coated glass wall behind it. The glow is due to the rays emitted from the cathode. These rays came to be known as cathode rays. Scientists conducted more experiments on cathode rays and identified their various characteristics.

Discovery of Cathode Rays

In the first half of the 19th century itself, it was found that gases conduct electricity at low pressure. Michael Faraday studied the changes that occur when electricity passes through gases at low pressure. But the studies became very complicated due to the lack of efficient suction pumps and the difficulty in arranging the evacuated glass tubes. In 1854, Henrich Giesler developed discharge tubes and suction pumps. When modified Giesler tubes became available, Julius Plucker conducted various experiments using them. He found out that when electricity passes through the tube, a glow is formed on the opposite side of the cathode and the position of this glow can be changed in the presence of a magnet.

Later, the scientists Johan Williams Hittorff (1869) and Eugen Goldstein (1876) continued these experiments. They discovered that some rays originating from the cathode were responsible for this glow.

Main characteristics of cathode rays

- Cathode rays cast shadows of opaque objects placed in its path indicating that cathode rays travel in straight lines (Figure 1.2).

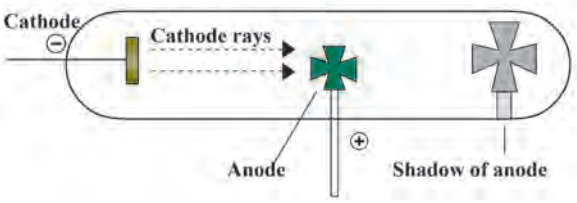


Fig. 1.2

- If a small paddle wheel is placed in the path of the cathode rays, it rotates. Thus we can understand that particles in the cathode rays have mass (Figure 1.3).

Fig. 1.3

- When an electric field is applied on both sides of the rays, they are found to be attracted towards the positive side.

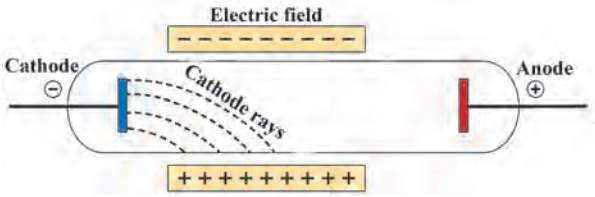


Fig. 1.4

From this we can infer that cathode rays have negative charge (Figure 1.4).

- The path of the cathode rays gets deflected in the magnetic field also.

The properties of the cathode rays do not change on changing the gas inside the tube or the metals with which the electrodes are made. This indicates that the particles in the cathode rays are present in all substances. These particles are electrons.

J. J. Thomson
1856 - 1940

The ratio of electrical charge to mass of an electron (e/m ratio) was determined by J. J. Thomson. When scientists accepted the studies done by Thomson on cathode rays, it was proved that there were particles smaller than atoms. In 1906, he received the Nobel prize in physics for the discharge tube experiments and the discoveries that followed.

The mass of electron

The e/m ratio of an electron is 1.76×10^{11}C/kg. But J. J. Thomson was unable to find out the charge and mass separately. Later, Robert Millikan, through his famous oil drop experiment, found out that electron has 1.6×10^{-19}C negative charge and from this, he calculated the mass of electron as 9.1×10^{-31}kg.
(C = coulomb)

- How was it proved that electrons have mass?
- Cathode rays, cast shadows of opaque objects placed in their path. What can be inferred from this?

Proton

In 1886 Eugen Goldstein, the German scientist conducted discharge tube experiments with perforated cathode and he discovered rays known as canal rays. As they originated from the metal placed at the positive side (anode), they were known as Anode rays. He studied the characteristics of these rays and identified the presence of positive charge in them. The behaviour of these canal rays varied with the nature of gases taken in the discharge tubes. The smallest and lightest positive particles in the canal rays were obtained when the discharge tube was filled with hydrogen. It was Earnest Rutherford who discovered that this was a subatomic particle and named it proton.

Eugen Goldstein
1850 - 1930

Plum Pudding Model of the Atom

J. J. Thomson proposed his plum pudding model when the presence of negative particles were identified in atoms (Figure 1.5). According to this model, negatively charged electrons are embedded in a positively charged sphere. The total number of positive charges and negative charges in the sphere will be equal. So, an atom is electrically neutral. But Thomson model failed to explain the results of several experiments. Hence this model was rejected.

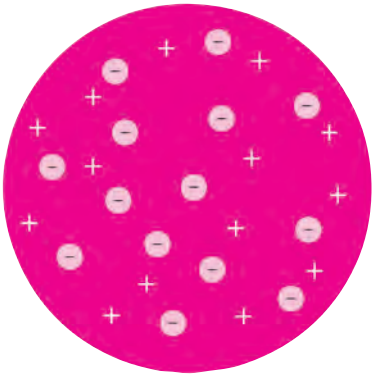
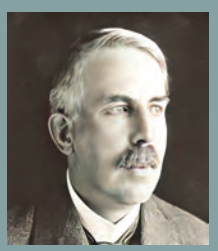


Fig. 1.5
Plum pudding model

Radioactivity

Radioactivity is a phenomenon in which certain elements like uranium and thorium emit radiations on their own. It was discovered by Henry Bequerel in 1896. Mainly three types of radiations are emitted as a result of radioactivity. They are alpha (α) rays with positive charge and mass, beta (β) rays with negative charge and gamma (γ) rays with no charge and no mass.

Rutherford's Gold Foil Experiment



Earnest Rutherford
1871 - 1937

In 1911, under the leadership of Earnest Rutherford, Hans Geiger and Earnest Marsden conducted experiments by bombarding alpha rays on a very thin gold foil. These experiments helped in bringing more clarity about the structure of atom. Rutherford bombarded a very thin gold foil with the alpha rays which originated from radioactive substances and tried to find out the deflections that occurred in their path. The alpha particles which passed through the gold foil were made to strike on the photographic film arranged around it. He made the following observations (Figure 1.6).

- Most of the alpha particles passed through the gold foil undeflected.
- Some of the alpha particles deflected by a small angle from the straight line when they hit the gold foil.
- A very few alpha particles (approximately 1 in 20000) bounced back. i.e., deflected by 180º.

He arrived at the following assumptions from these observations.

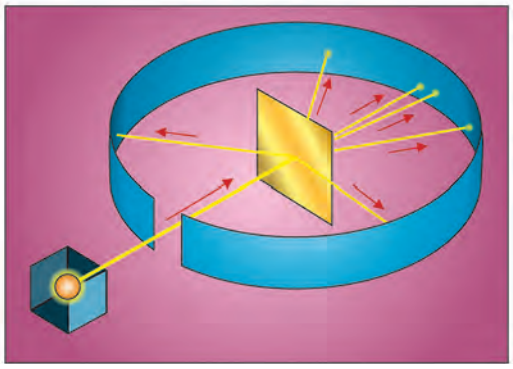


Fig. 1.6
Gold foil experiment diagram

- Majority of the alpha particles passed through the foil undeflected since most part of the atom was empty.
- Some of the alpha particles got deflected by a small angle due to the repulsion caused when they passed by the positively charged region inside the atom.
- The entire positive charge of an atom is concentrated in a very small volume at the centre of the atom. This centre is extremely small when compared to the size of the atom. The alpha particles which bounced back were those that were directed to this centre. He called this centre nucleus.

Rutherford atom model can be briefed as follows:

- Atom has a centre called nucleus.
- The size of the nucleus is extremely small when compared to the size of the atom.
- The entire positive charge and most of the mass of the atom are concentrated in the nucleus.
- Electrons revolve very fast around the nucleus in circular paths or orbits.

This model is known as the planetary model of an atom.

Limitations of Rutherford's atom model

According to the electromagnetic theory, a charged body in motion should continuously emit energy. Hence, negatively charged electrons revolving around the nucleus should continuously lose energy and collapse into the nucleus. But this does not happen. Therefore Rutherford atom model failed to explain the stability of an atom.

James Chadwick
1891 - 1974

Neutron

The real mass of the nucleus was found to be very much greater than that calculated by Rutherford on the basis of the number of protons. But he failed to prove this discrepancy through experiments. Later, in 1932, James Chadwick found out that there are some neutral particles in the nucleus and that they have mass approximately equal to that of a hydrogen atom. He named them neutrons since they were chargeless.

Niels Bohr Atom Model

Niels Bohr
1885 - 1962

To overcome the limitations of Rutherford atom model, the Danish scientist Niels Bohr proposed his atom model in 1913.

The main concepts of Bohr Atom model:

- Electrons revolve around the nucleus of an atom in fixed orbits.
- Electrons in each orbit have a definite energy. So orbits are also known as energy levels.
- As long as the electrons revolve in a particular orbit their energy does not change. So, the orbits are known as stationary energy levels.
- The energy of the orbit increases as the distance from the nucleus increases.
- Energy is emitted when the electrons shift from orbits of higher energy to orbits of lower energy. Energy is absorbed when the electrons shift from orbits of lower energy to orbits of higher energy.
- Orbits can be represented by giving numbers 1, 2, 3, 4, 5.... etc.

In the studies that followed, orbits were also called shells.

The energy levels 1, 2, 3, 4..... etc., can be considered as shells K, L, M, N... etc., respectively (Figure 1.7).

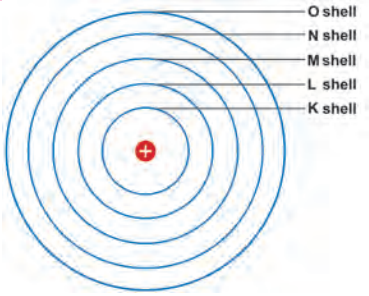


Fig. 1.7
Energy level

Some properties of the subatomic particles like electron, proton and neutron are given in Table 1.2. Complete the following table and record it in your science diary.

Name of particle	Position in atom	Charge	Mass	Mass in practical use
Proton	.....	.....	1.00727 u	1 u
Electron	.....	.....	0.000548 u	0
.....	Nucleus	.....	1.00866 u	1 u

Mass of the atoms is stated in unified atomic mass unit (u).

Table 1.2

- The mass of an electron is $\frac{1}{1837}$ part of the mass of a proton.

You are now familiar with different models of the atom. These models have helped to simplify many concepts in chemistry. Later, scientists proposed many more atom models. We can learn more about these models in higher classes.

- Some statements are given. Which of them are related to J. J. Thomson?
  a) Proposed the idea of the orbit.
  b) Conducted discharge tube experiments.
  c) Discovered neutron.
  d) Discovered electron.
  e) Proposed the plum pudding model.
- Prepare a questionnaire about the scientists who conducted research on atomic structure and their contributions. Conduct a quiz programme in your classroom based on this.

Atomic Number and Mass Number

The number of protons is very important in the case of an atom. It is the number of protons in an atom that determines the element to which the atom belongs. The total number of protons in an atom is known as its atomic number. This is represented using the letter Z.

Atomic number = number of protons
= number of electrons

- What are the particles in the nucleus of an atom?

.....

The total number of protons and neutrons in an atom is known as its mass number. This is represented using the letter A.

- What is the mass number of an atom having 2 protons and 2 neutrons?

.....

Mass number = number of protons + number of neutrons
= atomic number + number of neutrons

Number of neutrons = mass number - number of protons
= mass number - atomic number = (A-Z)

Elementary Particles

You know that an atom can be divided and that it contains the particles electron, proton and neutron. Can these be divided again? As an electron cannot be divided further, it is an elementary particle. But, protons and neutrons are formed by the combination of three quarks each. Hence, they are not considered elementary particles.

When we represent an atom using its symbol, we write mass number and atomic number on the top left and the bottom left respectively.

e.g. ${}^{35}_{17}Cl$, ${}^{40}_{20}Ca$

- Find the number of protons, electrons and neutrons in chlorine and calcium atoms.

${}^{35}_{17}Cl$
- Proton : .....
- Electron : .....
- Neutron : .....

${}^{40}_{20}Ca$
- Proton : .....
- Electron : .....
- Neutron : .....

- Complete the table given below and record it in your science diary.

Symbol	Atomic number	Mass number	Number of protons	Number of electrons	Number of neutrons
${}^{1}_{1}H$					
${}^{7}_{3}Li$					
${}^{16}_{8}O$					
${}^{23}_{11}Na$					
${}^{20}_{10}Ne$					
${}^{48}_{22}Ti$					
${}^{235}_{92}U$					
${}^{232}_{90}Th$					
${}^{65}_{30}Zn$					

Electron Configuration in an Atom

- According to the Bohr atom model, where is the electron situated in an atom?

.....

- What are the symbols given to the energy levels 1, 2, 3 and 4?

.....

The arrangement of electrons in an atom is done in accordance with certain laws.

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

Orbit number (n)	Name	Maximum number of electrons that can be accommodated ($2n^2$)
1	K	$2\times 1^2 = 2$
2	L	$2\times 2^2 = 8$
3	M	.....
4	N	.....

Table 1.3

2. Normally, filling up of electrons in higher energy orbits will take place only after the lower energy orbits are filled.
3. The maximum number of electrons that can be accommodated in the outermost orbit of an atom is 8.

Electron configuration is the representation of the filling of electrons in the orbits.

Let us write the electron configuration of some elements. Complete Table 1.4 and record it in your science diary.

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

Table 1.4

Only the electron configuration of elements from atomic number 1 to 18 can be written accurately in this way. Writing electron configuration of elements with atomic number greater than 18 can be learned in higher classes.

Orbit Electron Configuration-Diagrammatic Representation

See the orbit electron configuration of hydrogen given below (Figure 1.8).

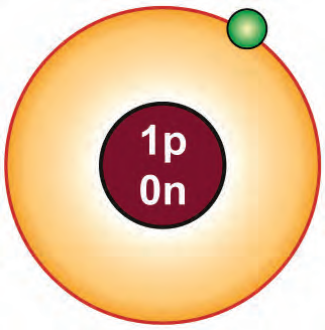


Fig. 1.8

The number of electrons in hydrogen atom = 1

See the orbit electron configuration of boron, having atomic number 5 and mass number 11 given below (Figure 1.9).

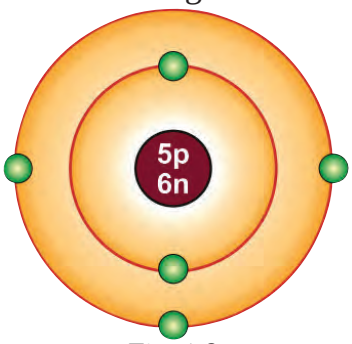
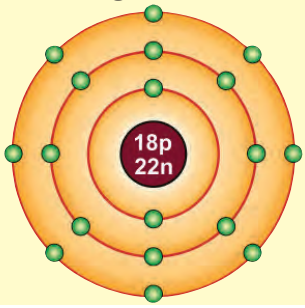


Fig. 1.9

?

- Diagrammatically represent the orbit electron configuration of $^{27}_{13}Al$.
- The orbit electron configuration of an atom is given.



Analyse the figure and find the following.

Atomic number.....Mass number.....

Number of protons.....Number of neutrons.....

Electron configuration.....

- Write the electron configuration of elements from atomic number 1 to 18 and represent their shell electron configuration in the science diary.

Isotopes

The number of which subatomic particle determines an element? (proton/neutron)

See Figure 1.10 given below.

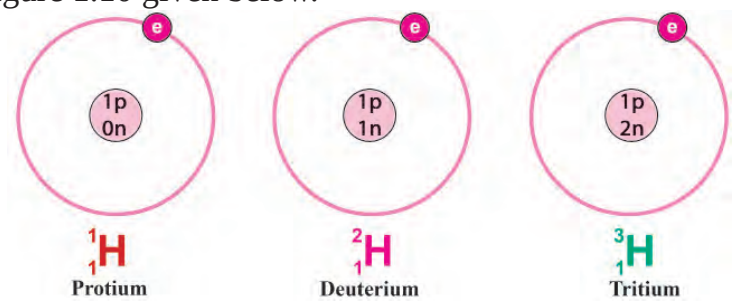


Fig. 1.10

Complete Table 1.5 regarding these atoms.

Name of atom	Proton	Neutron	Electron	Atomic number	Mass number
Protium	1	.....	.....	.....	.....
Deuterium	.....	1	.....	.....	.....
Tritium	.....	.....	1	.....	.....

Table 1.5

- What is the atomic number of these atoms?

  .....

- Which is the element having atomic number 1?

  .....

Then, all these three are hydrogen atoms.

- In the number of which particle do these atoms differ?

  .....

- Are the mass numbers of these atoms same?

  .....

- Which of them has no neutron in the nucleus?

  .....

- These are the isotopes of hydrogen. Can you define an isotope?

Isotopes are different atoms of the same element having the same atomic number but different mass numbers.

Isotopes exhibit the same chemical properties. But they show slight variations in physical properties.

Heavy water is the oxide of deuterium, an isotope of hydrogen. Heavy water is used in nuclear reactors.

Let us see whether hydrogen alone has isotopes. See the Figure 1.11 given below.

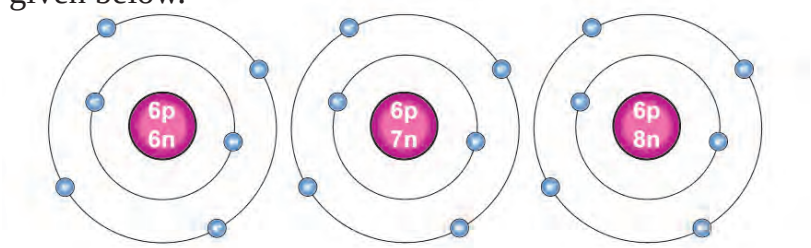


Fig. 1.11

..... Proton	..... Proton	..... Proton
..... Electron	..... Electron	..... Electron
..... Neutron	..... Neutron	..... Neutron

^{12}C, ^{13}C and ^{14}C are the natural isotopes of carbon. The most stable and the most abundant isotope of carbon is ^{12}C. Now, you have understood that carbon also has isotopes.

The amount of ^{13}C among the isotopes of carbon is approximately 1.1 %. This isotope is used to study the metabolic processes in plants and animals. ^{14}C is a radioactive isotope. This is used to determine the age of fossils. You have noticed that only the isotopes of hydrogen have specific names.

Some other isotopes and their uses are given in Table 1.6.

Isotope	Uses
Iodine-131	To study the functioning of Thyroid gland and in its treatment
Uranium-235	Fuel in nuclear reactors
Cobalt-60	Cancer treatment
Sodium -24	To detect the leakage in industrial pipelines
Iron-59	To diagnose Anaemia

Table 1.6

Isobars

Orbit electron configuration of argon (Ar), potassium (K) and calcium (Ca) is given below (Figure 1.12).

Analyse the figure and complete Table 1.7. Record it in your science diary.

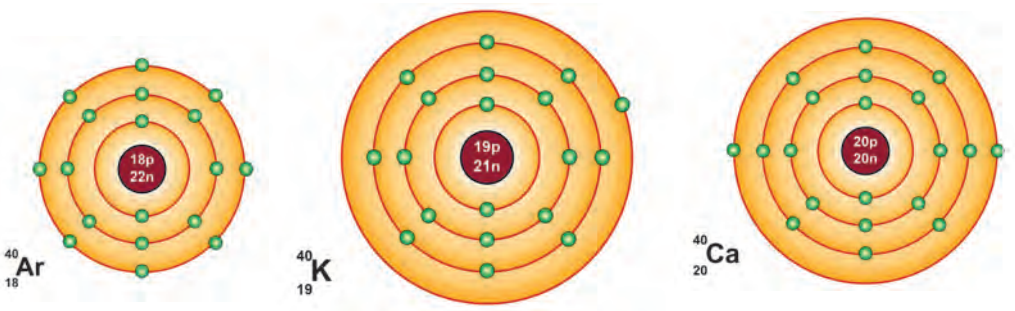


Fig. 1.12

Element	Proton	Electron	Neutron	Atomic number	Mass number
Ar	18				
K		19			
Ca			20		

Table 1.7

- What is the peculiarity of the mass numbers of these elements?

  .....

- Are the atomic numbers the same?

  .....

These atoms are known as isobars.

Isobars are atoms having the same mass number and different atomic numbers.

They are atoms of different elements in which the number of nucleons (proton + neutron) are equal.

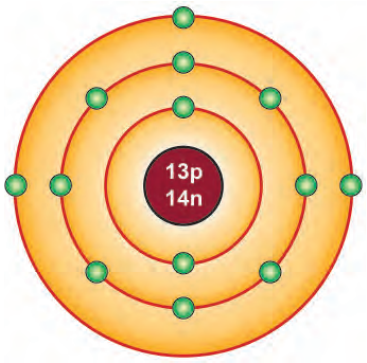
Isotones

Atoms in which the number of neutrons is equal are known as isotones

e.g. $^{15}_{7}N$, $^{14}_{6}C$

Let's Assess

1. Some observations related to experiments on cathode rays are given. Write the inference based on each observation.
   a. A paddle wheel placed in the path of cathode rays rotates.
   b. A shadow is formed if an object is placed in the path of cathode rays.
   c. When an electric field is applied perpendicular to the path of cathode rays, the rays deflect towards the positive plate.
2. The atomic number of an atom is 16 and mass number is 32.
   a. How many electrons, protons and neutrons are present in this atom?
   b. Write the electron configuration of this atom.
   c. Draw the orbit electron configuration of this atom.
3. Electrons are present in the K, L and M shells of an atom.
   a. Which of these shells has the highest energy?
   b. If M shell contains only 3 electrons, write the atomic number of this atom.
   c. What is the number of electrons in this atom?
   d. If the nucleus of this atom contains 16 neutrons, what is its mass number?
4. The orbit electron configuration of an atom is given below.



   a. What is the mass number of this atom?
   b. Write its electron configuration.
5. The symbols of some elements are given.

$$^{24}_{12}Mg,\quad ^{12}_{6}C,\quad ^{15}_{7}N,\quad ^{14}_{6}C,\quad ^{24}_{11}Na$$

a. Select a pair of isotopes from the given elements. Write the reason for selecting it.

b. Select a pair of isobars from the given elements.

6. Match the items in column A & B suitably.

A	B
Plum pudding model	James Chadwick
Planetary model of atom	Goldstein
Canal rays	J. J. Thomson
Neutron	Rutherford

7. The atomic number and mass number of an element are 15 and 31 respectively.
   a. What is the number of valence electrons in this atom?
   b. How many neutrons are present in this atom?
   c. Draw the orbit electron configuration of this atom.

8. Isotope of an element is used to determine the age of fossils.
   a. Which is this isotope?
   b. Which are the other two main isotopes of this element?
   c. Write the number of neutrons in each isotope.

Extended Activities

1. Prepare a presentation on scientists connected to the history of atom and their contributions and present it in the classroom.
2. Prepare a timeline chart on the main events that led to the discovery of different subatomic particles.
3. You have learned about isotopes. Find more examples for radio isotopes. Prepare an article on the uses of each radio isotope and publish it in the science magazine. Use word processor for this work.
4. If you get a chance to conduct an interview with Rutherford, what questions would you ask him? Prepare a questionnaire.

2 Periodic Table

The students in the picture are trying to make a model of the periodic table as part of group activity. You have learned that the periodic table, in which elements are scientifically classified, is helpful in the study of chemistry.

Moreover, you are familiar with the early attempts at the classification of elements, and the periodic law proposed by Dmitri Ivanovich Mendeleev.

In 1869, when Mendeleev prepared the periodic table, there was no clarity regarding the structure of atom or subatomic particles. However, Mendeleev's periodic table had many merits.

List the merits of Mendeleev's periodic table.

•

•

•

•

You are also aware of certain demerits of Mendeleev's periodic table. What are they?

•

•

You have also learned about isotopes.

- How do isotopes of the same element differ from one another?

.....

You know that elements are arranged on the basis of atomic mass in Mendeleev's periodic table.

Since isotopes have different atomic masses, it is necessary to assign different positions for them in the periodic table.

For e.g. ${}_{1}^{1}H$, ${}_{1}^{2}H$ and ${}_{1}^{3}H$ are the isotopes of hydrogen. As per Mendeleev's periodic table, it is not possible to assign a specific position to each of them on the basis of atomic mass.

Henry Moseley
(1887 - 1915)

Through his X-ray diffraction experiments, Henry Moseley proved that properties of elements depend mainly on atomic number rather than atomic mass. He then revised Mendeleev's periodic law. This is known as modern periodic law.

Modern Periodic Law

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

On the basis of modern periodic law, Moseley arranged elements in the increasing order of atomic number and designed the modern periodic table.

Let us have a look at the merits of the modern periodic table.

- As you know, one of the demerits of Mendeleev's periodic table is that elements having different properties are included in the same group. For e.g. hard metals like copper (Cu) and silver (Ag) were included along with soft metals like sodium (Na) and potassium (K). But, in the modern periodic table, Moseley was particular about including elements with similar properties in the same group. Hence, if we know the properties of an element, we get an idea of the properties of other elements belonging to the same group.
- In Mendeleev's periodic table, there is no specific position for isotopes of the same element. But, in the modern periodic table, the elements are arranged in the ascending order (increasing order) of their atomic numbers. Thus, this limitation of Mendeleev's periodic table was overcome.
- Another limitation of Mendeleev's periodic table is that the ascending order of atomic mass is not strictly followed. For e.g. the element potassium (K, atomic mass-39) is placed after argon (Ar, atomic mass-40). Since elements are arranged on the basis of atomic number, this kind of irregularity in atomic mass is irrelevant in modern periodic table.

Periodic tables of various forms have been developed from time to time.

The periodic table which includes 118 elements is widely used now.

In the periodic table, the horizontal rows are called periods and the vertical columns are called groups. The elements belonging to the same group exhibit similarity in chemical and physical properties.

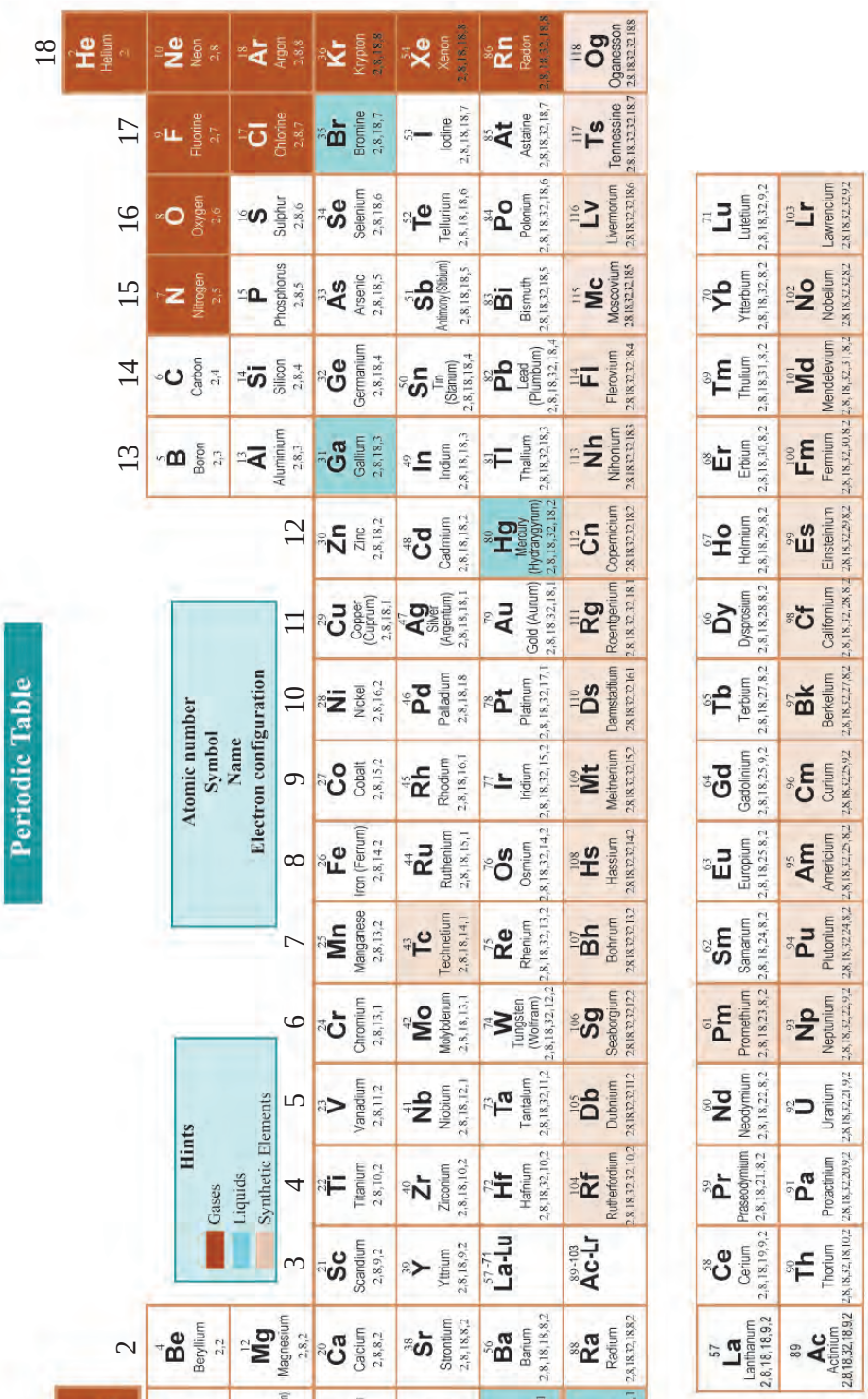

Periodic Table
Hints
Gases
Liquids
Synthetic Elements
Atomic number
Symbol
Name
Electron configuration
1 H Hydrogen 1
2 He Helium 2
3 Li Lithium 2,1
4 Be Beryllium 2,2
5 B Boron 2,3
6 C Carbon 2,4
7 N Nitrogen 2,5
8 O Oxygen 2,6
9 F Fluorine 2,7
10 Ne Neon 2,8
11 Na Sodium (Natrium) 2,8,1
12 Mg Magnesium 2,8,2
13 Al Aluminium 2,8,3
14 Si Silicon 2,8,4
15 P Phosphorus 2,8,5
16 S Sulphur 2,8,6
17 Cl Chlorine 2,8,7
18 Ar Argon 2,8,8
19 K Potassium (Kalium) 2,8,8,1
20 Ca Calcium 2,8,8,2
21 Sc Scandium 2,8,9,2
22 Ti Titanium 2,8,10,2
23 V Vanadium 2,8,11,2
24 Cr Chromium 2,8,13,1
25 Mn Manganese 2,8,13,2
26 Fe Iron (Ferrum) 2,8,14,2
27 Co Cobalt 2,8,15,2
28 Ni Nickel 2,8,16,2
29 Cu Copper (Cuprum) 2,8,18,1
30 Zn Zinc 2,8,18,2
31 Ga Gallium 2,8,18,3
32 Ge Germanium 2,8,18,4
33 As Arsenic 2,8,18,5
34 Se Selenium 2,8,18,6
35 Br Bromine 2,8,18,7
36 Kr Krypton 2,8,18,8
37 Rb Rubidium 2,8,18,8,1
38 Sr Strontium 2,8,18,8,2
39 Y Yttrium 2,8,18,9,2
40 Zr Zirconium 2,8,18,10,2
41 Nb Niobium 2,8,18,12,1
42 Mo Molybdenum 2,8,18,13,1
43 Tc Technetium 2,8,18,14,1
44 Ru Ruthenium 2,8,18,15,1
45 Rh Rhodium 2,8,18,16,1
46 Pd Palladium 2,8,18,18
47 Ag Silver (Argentum) 2,8,18,18,1
48 Cd Cadmium 2,8,18,18,2
49 In Indium 2,8,18,18,3
50 Sn Tin (Stanum) 2,8,18,18,4
51 Sb Antimony (Stibium) 2,8,18,18,5
52 Te Tellurium 2,8,18,18,6
53 I Iodine 2,8,18,18,7
54 Xe Xenon 2,8,18,18,8
55 Cs Caesium 2,8,18,18,8,1
56 Ba Barium 2,8,18,18,8,2
57-71 La-Lu
72 Hf Hafnium 2,8,18,32,10,2
73 Ta Tantalum 2,8,18,32,11,2
74 W Tungsten (Wolfram) 2,8,18,32,12,2
75 Re Rhenium 2,8,18,32,13,2
76 Os Osmium 2,8,18,32,14,2
77 Ir Iridium 2,8,18,32,15,2
78 Pt Platinum 2,8,18,32,17,1
79 Au Gold (Aurum) 2,8,18,32,18,1
80 Hg Mercury (Hydrargyrum) 2,8,18,32,18,2
81 Tl Thallium 2,8,18,32,18,3
82 Pb Lead (Plumbum) 2,8,18,32,18,4
83 Bi Bismuth 2,8,18,32,18,5
84 Po Polonium 2,8,18,32,18,6
85 At Astatine 2,8,18,32,18,7
86 Rn Radon 2,8,18,32,18,8
87 Fr Francium 2,8,18,32,18,8,1
88 Ra Radium 2,8,18,32,18,8,2
89-103 Ac-Lr
104 Rf Rutherfordium 2,8,18,32,32,10,2
105 Db Dubnium 2,8,18,32,32,11,2
106 Sg Seaborgium 2,8,18,32,32,12,2
107 Bh Bohrium 2,8,18,32,32,13,2
108 Hs Hassium 2,8,18,32,32,14,2
109 Mt Meitnerium 2,8,18,32,32,15,2
110 Ds Darmstadium 2,8,18,32,32,16,1
111 Rg Roentgenium 2,8,18,32,32,18,1
112 Cn Copernicium 2,8,18,32,32,18,2
113 Nh Nihonium 2,8,18,32,32,18,3
114 Fl Flerovium 2,8,18,32,32,18,4
115 Mc Moscovium 2,8,18,32,32,18,5
116 Lv Livermorium 2,8,18,32,32,18,6
117 Ts Tennessine 2,8,18,32,32,18,7
118 Og Oganesson 2,8,18,32,32,18,8
57 La Lanthanum 2,8,18,18,9,2
58 Ce Cerium 2,8,18,19,9,2
59 Pr Praseodymium 2,8,18,21,8,2
60 Nd Neodymium 2,8,18,22,8,2
61 Pm Promethium 2,8,18,23,8,2
62 Sm Samarium 2,8,18,24,8,2
63 Eu Europium 2,8,18,25,8,2
64 Gd Gadolinium 2,8,18,25,9,2
65 Tb Terbium 2,8,18,27,8,2
66 Dy Dysprosium 2,8,18,28,8,2
67 Ho Holmium 2,8,18,29,8,2
68 Er Erbium 2,8,18,30,8,2
69 Tm Thulium 2,8,18,31,8,2
70 Yb Ytterbium 2,8,18,32,8,2
71 Lu Lutetium 2,8,18,32,9,2
89 Ac Actinium 2,8,18,32,18,9,2
90 Th Thorium 2,8,18,32,18,10,2
91 Pa Protactinium 2,8,18,32,20,9,2
92 U Uranium 2,8,18,32,21,9,2
93 Np Neptunium 2,8,18,32,22,9,2
94 Pu Plutonium 2,8,18,32,24,8,2
95 Am Americium 2,8,18,32,25,8,2
96 Cm Curium 2,8,18,32,25,9,2
97 Bk Berkelium 2,8,18,32,27,8,2
98 Cf Californium 2,8,18,32,28,8,2
99 Es Einsteinium 2,8,18,32,29,8,2
100 Fm Fermium 2,8,18,32,30,8,2
101 Md Mendelevium 2,8,18,32,31,8,2
102 No Nobelium 2,8,18,32,32,8,2
103 Lr Lawrencium 2,8,18,32,32,9,2
I
II
III
IV
V
VI
VII

Fig. 2.1

Newly Discovered Elements

In 2016, four new elements were added in the periodic table. They were placed in the 7th period.

Atomic number	Symbol	IUPAC name
113	Nh	Nihonium
115	Mc	Moscovium
117	Ts	Tennessine
118	Og	Oganesson

The element nihonium got its name from the Japanese word 'Nihon'. This word is used to represent 'Japan' in Japanese Language. It also means 'the land of the rising sun'. Experiments related to the discovery of the element moscovium were carried out mainly in the laboratories in Moscow. The element tennessine derived its name on the basis of experiments conducted in Tennessee State. The three elements mentioned above got their names from places associated with their discoveries. But the element oganesson was named in honour of Prof. Yuri Oganesson, a nuclear scientist. This is the second instance where an element was named after a living scientist. Previously, seaborgium, the element with atomic number 106 was named after a scientist in this way. It was in honour of Glenn Seaborg, an American chemist.

Let us study more about the properties of elements and the merits of their scientific classification in detail.

Electron Configuration of Elements and their Positions in the Periodic Table

Analyse the modern periodic table (Figure 2.1) and answer the following questions.

- How many periods are there?

  .....

- Write the total number of groups.

  .....

- Which period has the least number of elements?

  .....

- Are the number of elements in period 2 and 3 the same?

.....

- How many elements are included in the 4th period?

.....

- What all information about an element can be obtained from the periodic table? Note down in the science diary.

  - Name
  - Symbol
  -
  -
  -

Elements of group 1 are given in the table. Complete Table 2.1.

Complete Table 2.1 and verify using Kalzium software.

Name of the element	Symbol	Atomic number	Electron configuration
Lithium	Li	3	-
Sodium	Na	11	-
Potassium	-	-	2,8,8,1
Rubedium	Rb	-	2,8,18,8,1
Caesium	-	55	2,8,18,18,8,1
Francium	Fr	-	2,8,18,32,18,8,1

Table 2.1

- Have you noticed any peculiarity regarding the number of outermost electrons in the elements of group 1?

.....

- With the help of periodic table, write the electron configuration of the elements in group 2.

.....

It is clear that the number of outermost electrons of the elements in a given group are the same.

Chemical properties of elements are based on the number of outermost electrons in them. Usually, these electrons take part in chemical reactions.

Based on the common characteristics of elements in each group,

they can be considered as families. A table enlisting the various families of elements is given below.

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

Table 2.2

Main Group Elements

Examine the elements belonging to group 1, group 2 and groups 13 to 18 in the periodic table (Figure 2.1).

- Which of these elements are familiar to you?

  .....

- Write the examples of metals among these elements.

  .....

- Do these elements include non-metals? .....

  e.g. .....

Do these groups include elements belonging to the solid state, liquid state and gaseous state?

.....

In solid state .....

In liquid state .....

In gaseous state .....

Complete this activity using Kalzium software

Metalloids are also present in these groups. Elements exhibiting the properties of both metals and non-metals are known as metalloids. e.g. silicon (Si), germanium (Ge), arsenic (As), antimony (Sb) etc.

The elements in group 1 and group 2 and groups 13 to 18 are known as main group elements.

Let us examine another characteristic of the main group elements.

Main group elements in periods 2 and 3 in the periodic table are given below.

	1	2	13	14	15	16	17	18
Period 2	3 Li 2, 1	4 Be 2, 2	5 B 2, 3	6 C 2, 4	7 N 2, 5	8 O 2, 6	9 F 2, 7	10 Ne 2, 8
Period 3	11 Na 2, 8, 1	12 Mg 2, 8, 2	13 Al 2, 8, 3	14 Si 2, 8, 4	15 P 2, 8, 5	16 S 2, 8, 6	17 Cl 2, 8, 7	18 Ar 2, 8, 8

Table 2.3

- How does electron filling take place in the outermost shell of these elements?
- What change do you observe in the number of outer electrons on moving from left to right along a period?

On moving along a period from left to right, there is an increase of one electron in the outermost shell of main group elements until eight electrons are gained.

Characteristics of main group elements

- They show similarity in properties in a group.
- They include different types of elements such as metals, non-metals and metalloids.
- They represent elements belonging to different physical states.

- Which are the families included in main group elements?
- In which groups are metalloids present?

How to find the group number of main group elements.

A few elements of group 1 and 2 are given in Table 2.4. Complete the table and record it in your science diary.

Name of element	Symbol	Atomic number	Electron configuration	Number of electrons in the outermost shell	Group number
Lithium	Li	3	2, 1	1	1
Sodium	Na	-	-		
Potassium	-	19	2, 8, 8, 1		
Beryllium	Be	4	-	-	2
Magnesium	-	12	-		
Calcium	Ca	-	2, 8, 8, 2		

Table 2.4

- What is the relation between the number of outermost electrons and group number here?

.....

In the elements of group 1 and 2, the number of outermost electrons represent the group number.

Let us examine whether groups 13 to 18 follow the same relation. Complete Table 2.5 on the basis of the periodic table.

Name of element	Symbol	Atomic number	Electron configuration	No. of the outermost electrons	Group number
Boron	B	5	2, 3	3	13
Carbon	C	6	-	-	-
Nitrogen	N	7	-	-	-
Oxygen	O	8	-	-	-
Fluorine	F	9	-	-	-

Table 2.5

- Find the number which is added to the number of outermost electrons to get the group number of elements in group 13 to 18?

- Have you ever thought why the number 10 is added to the number of outermost electrons?

You know that transition elements are present in groups 3 to 12.

- In how many groups are they distributed?

.....

The position of transition elements is after the second group elements in the periodic table. The elements from group 13 to 18 are placed after these 10 groups of transition elements.

It is clear why the number 10 is added to the number of outermost electrons to get the group number of groups 13 to 18.

Name of element	Symbol	Atomic number	Electron configuration	Group number
Boron	B	5	2, 3	3 + 10 = 13
Carbon	C	6	2, 4	4 + 10 = 14
Nitrogen	N	7	2, 5	5 + 10 = 15
Oxygen	O	8	2, 6	6 + 10 = 16
Fluorine	F	9	2, 7	7 + 10 = 17
Neon	Ne	10	2, 8	8 + 10 = 18

Table 2.6

How to find the period number of elements

Complete Table 2.7 with the help of the periodic table.

Name of element	Symbol	Atomic number	Electron configuration	No. of shells	Period number
Hydrogen	H	1	1	1	1
Helium	He	2	-	1	-
Lithium	Li	-	-	2	-
Beryllium	Be	4	2, 2	-	2
Sodium	Na	11	-	-	-
Magnesium	Mg	-	-	-	-
Potassium	K	-	2, 8, 8, 1	-	4
Calcium	Ca	20	2, 8, 8, 2	-	-

Table 2.7

Can you find any relation between the period number and the number of shells of the given elements?

.....

The number of shells in the atoms of elements is their period number.

Noble Gases

Certain data regarding the main group elements are given in the following table. Complete Table 2.8 and record it in your science diary.

Name of element	Symbol	Atomic number	Electron configuration	Group number
Helium	He	2	2	18
Neon	Ne	-	-	-
Argon	Ar	18	-	-
Krypton	Kr	-	2, 8, 18, 8	-

Table 2.8

- You know that the elements given in the table are noble gases. To which group do they belong?

  .....

- What peculiarity do you notice in the number of the outermost electrons of elements except helium?

  .....

If elements other than hydrogen and helium have 8 electrons in their outermost shell, they attain stability. It is to attain this stability that atoms of all elements undergo chemical reactions. (You can learn more about this in the next unit.)

Usually, 18th group elements do not take part in chemical reactions because of the stable arrangement of electrons.

Elements $_{8}P$, $_{10}Q$, $_{12}R$, $_{18}S$ are given. (symbols are not real)

a. Write down the electron configuration of these elements.

b. Which among these are noble gases?

Transition Elements

The elements present in the ten groups from group 3 to group 12 in the periodic table are called transition elements.

- Which transition elements are familiar to you? List them with the help of the periodic table.

.....

- Are all of them metals?

.....

- From which period onwards can you locate transition elements in the periodic table?

.....

12th Group Elements

Though elements of group 12 are considered as transition elements, they are not transition elements in the strict sense. You will learn about this in higher classes.

The elements of group 1 and 2 are generally more metallic in nature and are placed on the left side of the periodic table. Meanwhile, the elements from group 13 to 18 are placed on the right side of the periodic table and are generally less metallic in nature. Based on this, how will you indicate the position of the transition elements?

The transition elements lie in between the more metallic elements and the comparatively less metallic ones.

The elements from group 3 upto group 12 are known as the transition elements because they indicate a regular change or transition from more metallic elements of group 2 to less metallic elements of group 13.

Let us consider another peculiarity of the transition elements.

The electron configuration of a few elements in the 4th period is given in Table 2.9.

Group number	1	2	3	4	5
Electron configuration	19 K 2, 8, 8, 1	20 Ca 2, 8, 8, 2	21 Sc 2, 8, 9, 2	22 Ti 2, 8, 10, 2	23 V 2, 8, 11, 2

Table 2.9

It is evident from the table that in the elements of group 1 and 2, the electron is being added to the last shell.

- However, in groups 3, 4 and 5, electrons are being added to the penultimate shell.

- With the help of the periodic table, examine whether the same pattern is followed in groups 6 to 12.

Complete this activity using Kalzium software

In ten groups from group 3 to 12 (transition elements) electron filling takes place in the penultimate shell.

You have learnt that elements in the same group show similarity in properties.

Generally, transition metals also show such similarity in groups.

Let us examine whether they exhibit any peculiarity along a period.

Analyse the transition elements of 4th period given in Table 2.9.

- Do they have any peculiarity in the number of outermost electrons?

.....

Usually, transition elements in the same period have the same number of outermost electrons. Hence, they show similarity in properties along a period too.

You have seen coloured chemicals in your lab. Examine the chemicals given in Table 2.10. Find their molecular formulae and identify their colours with the help of your teacher. Complete the table and record it in your science diary.

Name of chemical	Molecular formula	Colour
Nickel sulphate	.....	-
Copper sulphate	.....	-
Calcium carbonate	.....	-
Potassium permanganate	.....	-
Cobalt nitrate	.....	-
Potassium dichromate	.....	-
Ferrous sulphate	.....	-

Table 2.10

It is clear that transition elements are present in the coloured compounds given in the table.

Usually, transition elements form coloured compounds.

- Elements included in groups 3 to 12 are transition elements.
- Filling of electron takes place in the penultimate shell.
- Generally, they exhibit similarity in chemical properties in groups as well as periods.
- They are metals.
- They generally form coloured compounds.

You will learn about transition metals in detail in higher classes.

Lanthanoids and Actinoids

Have you noticed the number of elements included in the 6th period of the periodic table?

- Identify the position of lanthanum (atomic number -57) and the 14 elements following it.

.....

- Similarly, find the position of actinium (atomic number-89) and the 14 elements following it in the 7th period.

.....

In the 6th period, lanthanum and the 14 elements following it, have been arranged separately at the bottom of the periodic table. The elements from lanthanum, (La, atomic number-57) to lutetium (Lu, atomic number-71) are known as lanthanoids.

In the 7th period, actinium and the 14 elements following it have been given a separate position below lanthanoids. The elements from actinium (Ac, atomic number-89) to lawrencium (Lr, atomic number-103) are called actinoids.

Lanthanoids and actinoids are known as inner transition elements. Lanthanoids are also called rare earths. Actinoids coming after uranium (U) are man-made elements.

You are familiar with situations in which transition elements and their compounds are used in our daily life. Write an assignment based on this topic.

Periodic Trend in the Periodic Table

Depending on the position in groups and periods, the chemical and physical properties of elements show a regular change.

You are aware that electron configuration of elements and number of shells vary with atomic number.

Transuranium Elements

All the 118 elements discovered till now are included in the modern periodic table. Among elements from atomic number 1 to 92, the elements except technitium (atomic number 43) and promethium (atomic number 61) are naturally occurring. Elements coming after atomic number 92 are made artificially. Artificial elements are less stable and exhibit radio activity. The elements coming after uranium (atomic number-92) are known as transuranium elements.

Size of atom - In group and period

Though atoms are extremely minute particles, properties of an element are closely related to the size of its atom. The size of an atom can be expressed in terms of atomic radius. It is the distance from the centre of the nucleus to the outermost shell containing electrons. The size of an atom depends mainly on two factors.

- Nuclear charge
- Number of shells

A few elements of group 1 are given in Table 2.11.

Name of element	Symbol	Atomic number	Electron configuration	Number of shells
Lithium	Li	3	2, 1	2
Sodium	Na	11	2, 8, 1	3
Potassium	K	19	2, 8, 8, 1	4
Rubidium	Rb	37	2, 8, 18, 8, 1	5

Table 2.11

- What change do you observe in the number of shells, on moving down the group?

  .....

- How does the increase in the number of shells influence the size of an atom?

  .....

Nuclear charge depends on the number of protons present in the nucleus.

- What change do you observe in the number of protons with the increase in the atomic number?

  .....

- If so, what happens to the nuclear charge with the increase in the atomic number?

  .....

With an increase in nuclear charge, the force of attraction between the nucleus and the outermost electron increases.

- If so, what happens to the size of the atom?

  .....

Though nuclear charge increases down a group, its effect is overcome by the increase in the number of shells and hence, the size of the atom increases.

The electron configuration of the elements belonging to the 2nd period of the periodic table is given below.

Group	1	2	13	14	15	16	17
Period 2	Li 2, 1	Be 2, 2	B 2, 3	C 2, 4	N 2, 5	O 2, 6	F 2, 7

Table 2.12

- Do you observe any change in the number of shells on moving along a period from left to right?

.....

- Does the nuclear charge increase?

.....

Nuclear charge increases on moving along a period from left to right, but there is no change in the number of shells.

- What happens to the attractive force of nucleus towards the outermost electrons (increases/ decreases)?

.....

- What change takes place in the size of the atom?

.....

Moving along a period from left to right, there is no change in the number of shells. But nuclear charge increases gradually. The attractive force of nucleus on the outermost electron increases. Hence, the size of the atom gradually decreases.

You have seen the change in the size of the atom in group and period.

- If so, where can you locate the comparatively bigger atoms in the periodic table?

.....

- Where are the smaller atoms located?

.....

Moving down the group, the size of an atom increases. The size of an atom decreases on moving from left to right along a period.

You will learn about periodic trends such as ionisation energy, electronegativity etc., in the next unit.

Screening Effect (Shielding Effect)

The number of shells increases down a group. As a result, the outermost electrons move away from the nucleus. As the number of electrons in the inner shells increases, the attractive force of the nucleus on the outermost electrons decreases gradually. This is known as screening effect.

Let's Assess

1. The symbols of a few elements are given. Write the electron configurations of these elements and find the period and group to which they belong.

   a) $^{23}_{11}Na$ b) $^{27}_{13}Al$ c) $^{35}_{17}Cl$ d) $^{16}_{8}O$ e) $^{20}_{10}Ne$ f) $^{12}_{6}C$

2. The electron configuration of element X is 2, 8, 8, 1. (Symbol is not real.)
   a. Find the atomic number of X.
   b. To which group does it belong?
   c. What is its period number?
   d. To which family does it belong?
   e. Write the electron configuration of the noble gas which comes just before X.

3. There are 3 shells in an atom of element P. There are 7 electrons in its outermost shell. (Symbol is not real.)
   a. Write the electron configuration of element P.
   b. What is its atomic number?
   c. To which period does it belong?
   d. To which group does it belong?
   e. Draw the model of this atom.

4. The element M belongs to the 3rd period and group 1. (Symbol is not real)
   a. Write the electron configuration of this element.
   b. Write its name and symbol.
   c. To which family does this element belong?
   d. Write the electron configuration of the element belonging to the same period and group 13.

5. Electron configurations of elements P, Q, R and S are given. (Symbols are not real)

   P – 2, 7 Q – 2, 8

   R – 2, 8, 1 S – 2, 8, 7

   a. Which of these elements belong to the same period?
   b. Which of these elements belong to the same group?
   c. Identify the noble gas among these.
   d. Find the group number and period number of element S.

6. Electron configurations of a few elements are given.

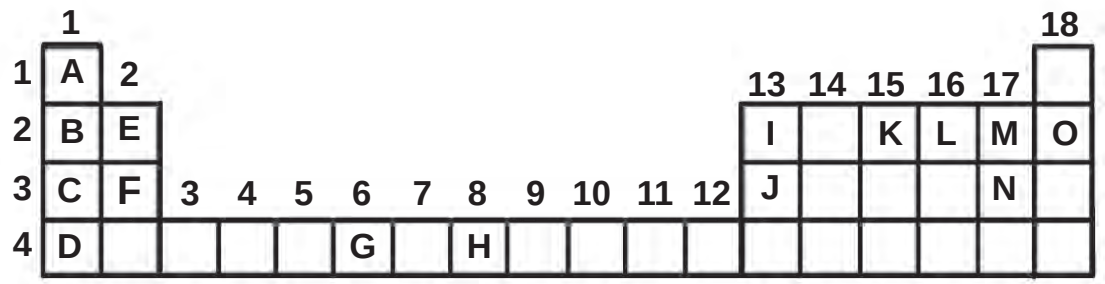
   A – 2, 1 B – 2, 8, 1 C – 2, 8, 7

   (Symbols are not real)

   a. Which of these elements has bigger atom, A or B?

   b. Which atom is bigger, B or C?

7. A portion of the modern periodic table is given. (Symbols are not real)
   Answer the following questions.



   a. Which of these elements belong to the halogen family?

   b. Which are the transition elements?

   c. Write the elements of group 1 in the decreasing order of their atomic size.

   d. Which element has smaller atom, B or I?

   e. Write the elements of period 3 in the increasing order of their atomic size.

   f. Which of these are alkaline earth metals?

   g. Which element has 8 electrons in its outermost shell?

   h. Find the real symbols of the given elements with the help of the periodic table.

8. An element belonging to the 2nd period has 2 electrons in the outermost shell of its atom.

   a. Write the electron configuration of this element.

   b. Write the electron configuration of the noble gas belonging to the same period.

   c. What is its group number?

   d. Write the electron configuration of an element in the same group and in the third period.

9. Analyse the table and answer the following questions.

Element	Mass number	Number of neutrons
A	9	5
B	35	18
C	39	20
D	40	22

(Hint : Symbols are not real)

a. Find the atomic number of these elements.

b. Write their electron configurations.

c. Which among these is a noble gas?

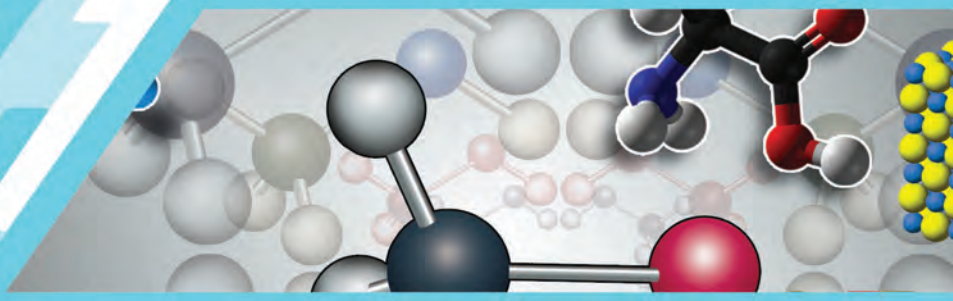
d. To which family does the element B belong?

e. To which period and group does the element C belong?

f. Which of these elements belong to the same period?

Extended Activities

1. Two English alphabets have not been used as symbols of elements so far. Find them with the help of the periodic table.
2. Prepare the biography of scientists involved in the classification of elements and publish it in the science magazine.
3. Draw a model of the modern periodic table and exhibit it in your class room.
4. Prepare a table including the symbol, the electron configuration, and the physical state of elements having atomic number 1 to 36, using Kalzium software.
5. Using cardboard pieces, design a periodic table as shown in the figure given in the first page of this unit.



3 Chemical Bonding

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

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

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

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

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

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

Table 3.1

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

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

Table 3.2

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

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

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

.....

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

Element (Symbol)	Atomic number	Electron configuration
Helium (He)	2	2
Neon (Ne)	10	2,8
Argon (Ar)	18	2,8,8
Krypton (Kr)	36	2,8,18,8
Xenon (Xe)	54	2,8,18,18,8
Radon (Rn)	86	2,8,18,32,18,8

Table 3.3

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

.....

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

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

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

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

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

Table 3.4

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

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

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

Ionic Bond

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

- What are the constituent elements of sodium chloride?

  .....

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

  .....

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

  .....

- How does the sodium atom attain octet electron configuration?

  .....

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

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

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

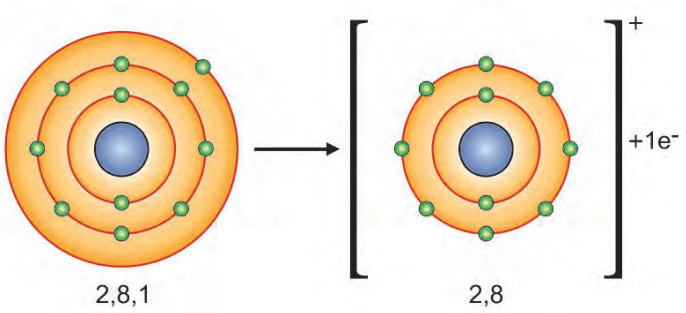


Fig. 3.1

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

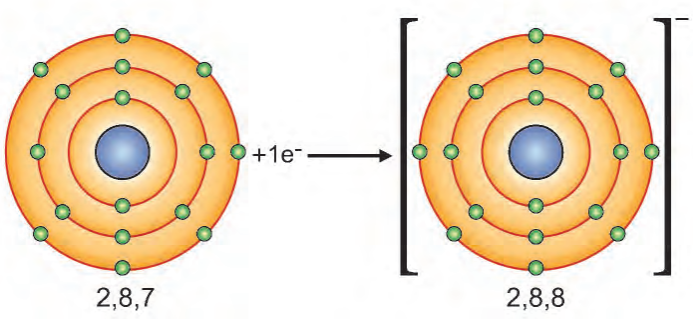
- Write the electron configuration of a chlorine atom (atomic number -17).

.....

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

.....

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



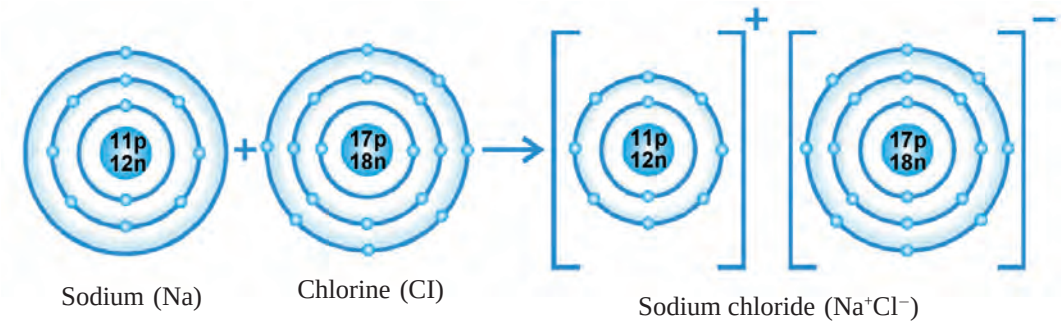
$$Cl + le^{-} \rightarrow C1^{-}$$

Fig. 3.2

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

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

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



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

Fig. 3.3

Construct the molecular structure of NaCl using Ghemical software.

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

Electron Dot Diagram

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

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

Note the electron dot diagram of sodium atom given below.

Represent the electron dot diagram of chlorine atom.

.....

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

Fig. 3.4

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

Gilbert Newton Lewis

(1875-1946)

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

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

Table 3.5

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

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

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

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

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

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

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

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

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

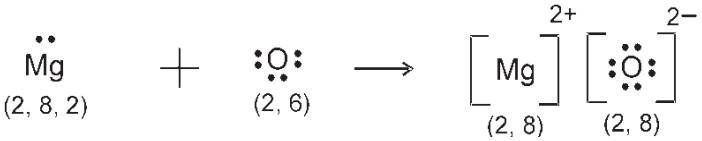


Fig. 3.5

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

Table 3.6

- Which are the ions present in magnesium oxide?

.....

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

.....

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

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

Characteristics of ionic compounds

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

Covalent Bond

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

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

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

.....

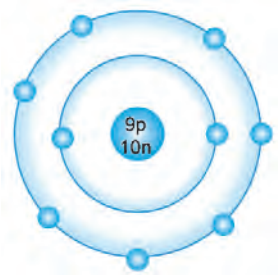


Fig. 3.6

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

.....

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

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

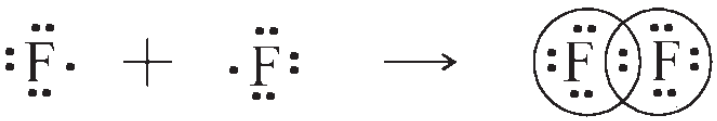


Fig. 3.7

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

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

.....

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

.....

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

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

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

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

- What is the atomic number of oxygen?

.....

- Write the electron configuration of oxygen.

.....

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

.....

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

Fig. 3.8

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

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

.....

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

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

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

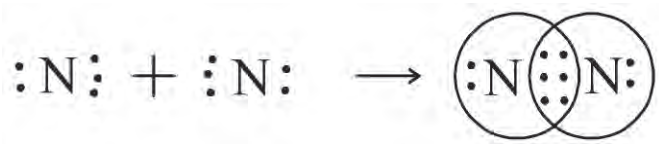


Fig. 3.9

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

.....

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

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

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

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

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

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

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

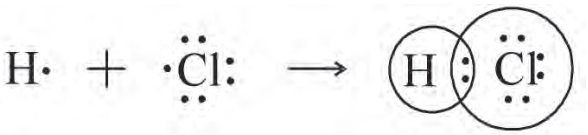


Fig. 3.10

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

- Represent the covalent bond in hydrogen chloride using symbols.

.....

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

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

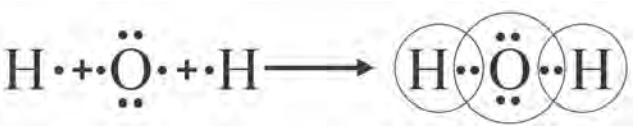


Fig. 3.11

- How many covalent bonds are formed here?

.....

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

General characteristics of covalent compounds

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

Electronegativity

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

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

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

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

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

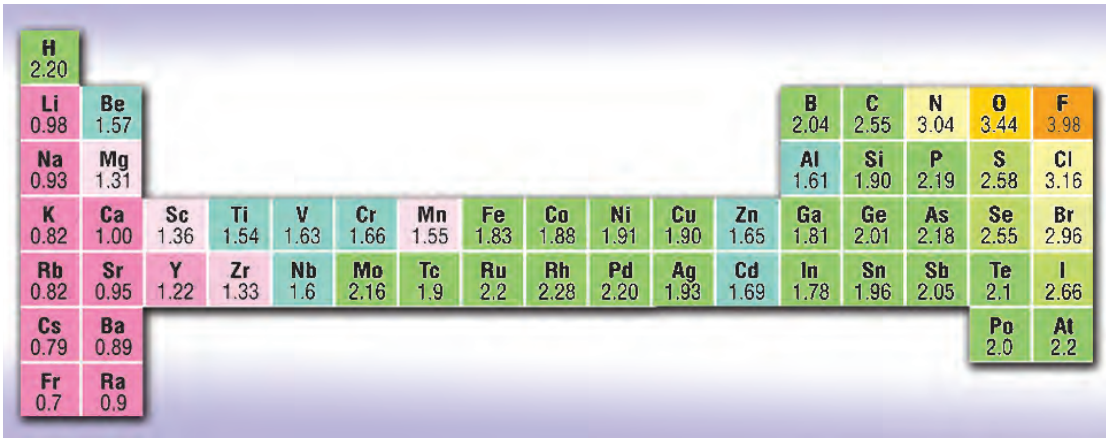


Fig. 3.12

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

?

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

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

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

Polar Nature

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

Examine Figure 3.12 and answer the questions given below.

- What is the electronegativity value of hydrogen?

  .....

- What is the electronegativity value of chlorine ?

  .....

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

  .....

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

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

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

Hydrogen chloride

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

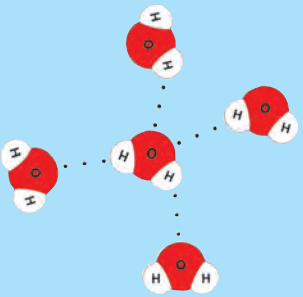
Water: A polar compound

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

Polar Nature and Geometric Shape of Molecules

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

Hydrogen Bonding



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

Valency

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

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

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

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

Intermolecular Forces

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

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

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

Elements Exhibiting Variable Valency

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

Chemical Formula

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

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

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

Table. 3.7

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

.....

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

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

- What are the constituent elements of aluminium oxide?

.....

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

.....

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

.....

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

AlO

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

Al_2O_3

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

Let us find out the chemical formula of carbon dioxide.

- What are the constituent elements of carbon dioxide?

.....

- Write the symbols of elements together considering their electronegativity.

.....

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

.....

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

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

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

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

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

How to write the chemical formulae of acids and bases

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

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

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

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

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

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

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

Table 3.8

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

- Which is the positive ion present in sodium hydroxide?

  .....

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

  .....

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

  .....

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

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

Chemical formulae of salts

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

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

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

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

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

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

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

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

.....

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

.....

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

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

.....

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

.....

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

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

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

.....

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

.....

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

.....

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

.....

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

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

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

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

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

Let's Assess

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

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

a) Complete the following table accordingly.

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

b) Write the chemical formula of calcium fluoride.

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

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

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

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

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

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

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

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

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

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

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

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

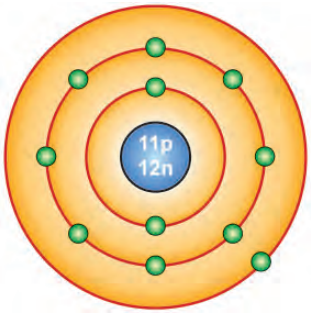
Element	Atomic number	Electron configuration
P	12	……..
Q	…….	2,7
R	10	……..
S	17	……..

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

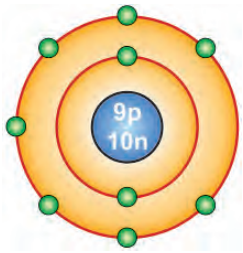
(b) Which element donates electrons during chemical reactions?

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

10. Atom models of two elements are represented below.



Sodium



Fluorine

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

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

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

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

P – 2,8,6

Q – 2,8,1

R – 2,8,8

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

(b) What is the atomic number of Q?

(c) Draw the atom model of Q.

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

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

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

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

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

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

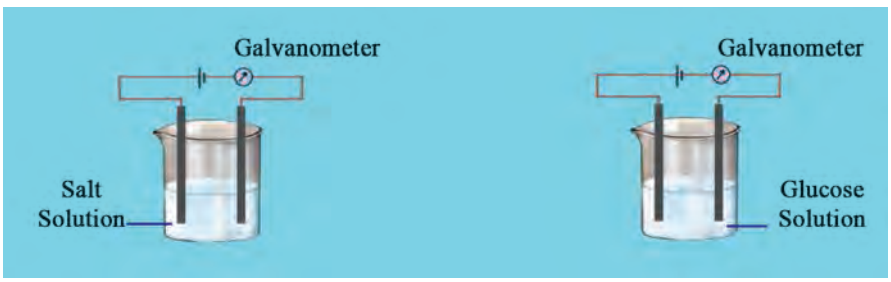
Extended Activities

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

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

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

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



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

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

4 Redox Reactions

Look at the picture of children doing experiments in the laboratory. Several chemical reactions are conducted there.

What changes are generally observed during chemical reactions?

Let us do an experiment.

Take a trough and fill three fourth of it with water. Add two drops of phenolphthalein to it and stir well. Cut a small piece of sodium and put it into the trough carefully (Figure 4.1).

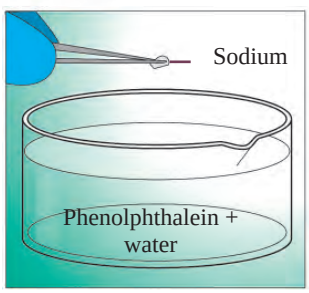


Fig. 4.1

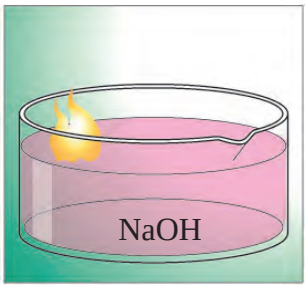


Fig. 4.2

What changes can be observed? (Figure 4.2)

- What is the reason? Analyse the chemical equation and find out.

$$2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$$

.....

You have learnt that chemical changes are accompanied by energy changes.

Is there any change in the total mass of substances during chemical reactions?

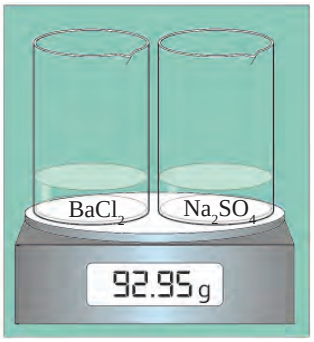


Fig. 4.3

During the combustion of fuels and the burning of paper, the total mass appears to be decreasing. Is this true? Let us do an experiment.

Take 20 mL barium chloride ($BaCl_2$) solution in a beaker. Take 20 mL sodium sulphate (Na_2SO_4) solution in another beaker. Place both the beakers together on an electronic balance and note the reading (Figure 4.3). Now, pour the solution from one beaker to the other. What do you observe? (Figure 4.4)

.....

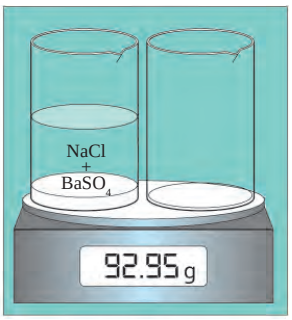


Fig. 4.4

After some time, note the reading of the electronic balance again. Compare this with the previous reading. What is your inference?

.....

Is there any change in the total mass as a result of this chemical reaction?

.....

In this chemical reaction, barium chloride reacts with sodium sulphate to form barium sulphate and sodium chloride.

Let us write the equation of this chemical reaction.

.....

$$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4\downarrow + 2\ NaCl$$

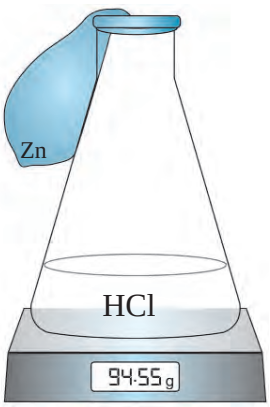


Fig. 4.5

Now, let us do another experiment.

Take 20 mL dilute hydrochloric acid (HCl) in a conical flask. Drop some zinc (Zn) granules in a balloon. Fix the balloon firmly to the mouth of the conical flask as shown in the Figure 4.5. Place the conical flask on an electronic balance and note the mass.

Then, carefully raise the balloon and drop the zinc granules into the acid in the flask.

- What do you see? (Figure 4.6)

.....

- Note the reading of the electronic balance. Compare this reading with the previous one. What do you understand?

.....

- Which gas is collected in the balloon?

.....

Let us write the equation of the chemical reaction.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$$

- What can be inferred from these experiments?

.....

- Does the total mass change during chemical reactions?

.....

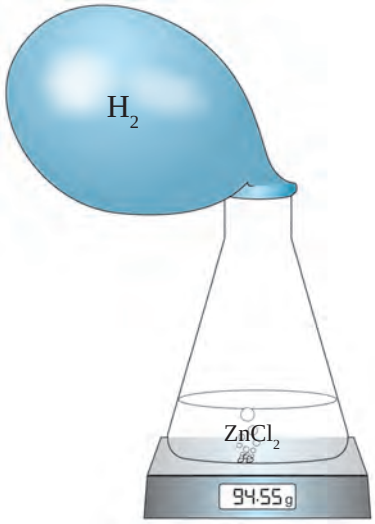


Fig. 4.6

The major products, formed during the combustion of fuels and burning of paper are carbon dioxide and water vapour. They are lost in the atmosphere. If these products are collected without any loss and weighed, what will be the observation?

There will be no change in the total mass in such experiments too.

Based on experiments and observations, the French scientist Antoine Lavoisier, stated the law of conservation of mass. Based on this law:

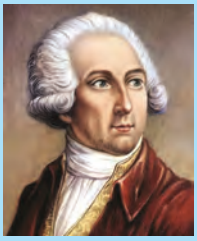
In a chemical reaction, the total mass of the reactants will be equal to the total mass of the products.

The total mass remains unchanged in a chemical reaction. Why? Let us examine.

The atomic mass of elements are expressed using the unit, unified atomic mass unit (u).

You are familiar with the chemical reaction in which hydrogen, having atomic mass 1u and oxygen having atomic mass 16u combine together to form water. Let us write the equation of this chemical reaction.

$$2H_2 + O_2 \rightarrow 2H_2O$$



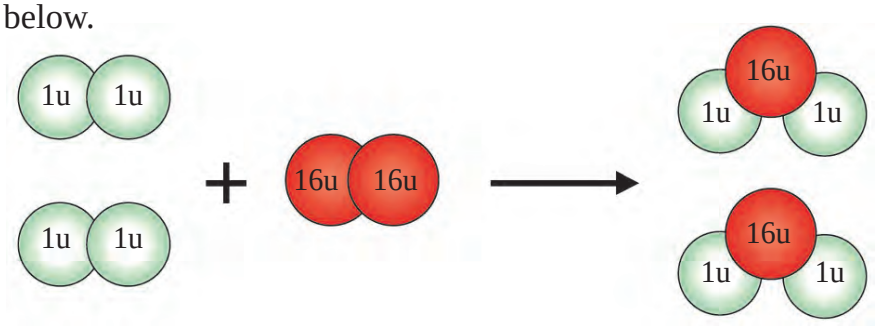
Antoine Lavoisier

(1743 - 1794)

Discovered the role of oxygen in the process of combustion. Found out that oxygen is inhaled and carbon dioxide is exhaled during respiration. Discovered the presence of oxygen in acids.

Proposed the names of hydrogen and oxygen. Classified the known elements into metals and non metals. This versatile genius was guillotined in 1794 following the political consequences of the French Revolution of 1789.

See the symbolic representation of this chemical reaction given below.



$2H_2 + O_2 \longrightarrow 2H_2O$

Analyse Table 4.1 given below.

Total mass of the reactants	4 u + 32 u = 36 u
Total mass of the products	18 u + 18 u = 36 u

Table 4.1

We can see that the total mass of the reactants and the total mass of the products are equal.

When reactants combine in a specific mass proportion to form products, the atoms in them undergo a rearrangement. There will not be any change in the total number of atoms or in the total mass.

- Carbon and oxygen combine to form carbon dioxide. Analyse the symbolic representation of this chemical reaction.

$C + O_2 \longrightarrow CO_2$

Complete Table 4.2 given below.

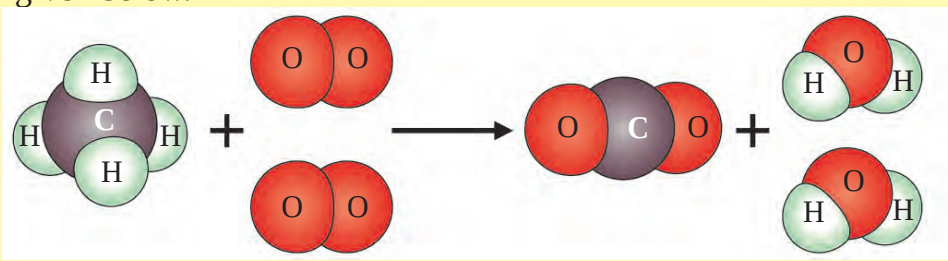
Total mass of the reactants	.....
Total mass of the products	.....

Table 4.2

Record your inference.

.....

Methane (CH_4) burns in air to form carbon dioxide and water vapour. The symbolic representation of this chemical reaction is given below.



Write down the equation of the chemical reaction.

Check whether this chemical reaction obeys the law of conservation of mass. (Hint : H=1 u, C=12 u, O=16 u.)

Balancing of Chemical Equations

Chemical equation is the symbolic representation of a chemical reaction using symbols and chemical formulae. When a chemical reaction is written in accordance with the law of conservation of mass, the total mass of the reactants must be equal to the total mass of the products. This can be done by equalising the number of atoms of the same type on either sides of the equation.

You know that oxygen and hydrogen are diatomic molecules

- How are these molecules represented using symbols?

Oxygen ....., Hydrogen .....

- What is the total number of atoms in water (H_2O) molecule?

.....

- Calculate the number of molecules and the total number of atoms present in $5H_2O$.

Total number of molecules ..... Total number of atoms .....

Consider the formation of water from hydrogen and oxygen. Let us have a look at the method of balancing this chemical equation.

Step 1

$$\text{Hydrogen} + \text{Oxygen} \rightarrow \text{Water}$$

$$H_2 + O_2 \rightarrow H_2O$$

Observe Table 4.3.

Number of atoms in the reactants	Hydrogen = 2	Oxygen = 2
Number of atoms in the products	Hydrogen = 2	Oxygen = 1

Table 4.3

The number of oxygen atoms in the products also must be 2. How is this possible? Let us make the number of water molecules 2.

Step 2

$$H_2 + O_2 \rightarrow 2H_2O$$

Observe Table 4.4.

Number of atoms in the reactants	Hydrogen = 2	Oxygen = 2
Number of atoms in the products	Hydrogen = 4	Oxygen = 2

Table 4.4

The number of hydrogen atoms in the reactants also must be 4. How is this possible?

Let us make the number of hydrogen molecules in the reactants 2.

Step 3

$$2H_2 + O_2 \rightarrow 2H_2O$$

Analyse Table 4.5.

Number of atoms in the reactants	Hydrogen = 4	Oxygen = 2
Number of atoms in the products	Hydrogen = 4	Oxygen = 2

Table 4.5

The number of the same type of atoms in the reactants as well as the products are the same now. The balanced chemical equation of the reaction between hydrogen and oxygen to form water is given below.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Balancing a chemical equation is the method of equalising the number of the same type of atoms in both the reactants and the products. The equation thus obtained is known as a balanced chemical equation.

Let us practice balancing equations, using other chemical equations.

1. Magnesium + Oxygen → Magnesium oxide

Step 1 $Mg + O_2 \rightarrow MgO$

Step 2 $Mg + O_2 \rightarrow 2MgO$

Step 3 $2Mg + O_2 \rightarrow 2MgO$

Balanced chemical equation $\mathbf{2Mg + O_2 \rightarrow 2MgO}$

2. Hydrogen + Chlorine → Hydrogen chloride

Step 1 $H_2 + Cl_2 \rightarrow HCl$

Step 2 $H_2 + Cl_2 \rightarrow \underline{2}HCl$

Balanced chemical equation $\mathbf{H_2 + Cl_2 \rightarrow 2HCl}$

3. Zinc + Hydrochloric acid → Zinc chloride + Hydrogen

Step 1 $Zn + HCl \rightarrow ZnCl_2 + H_2$

Step 2 $Zn + \underline{2}HCl \rightarrow ZnCl_2 + H_2$

Balanced chemical equation $\mathbf{Zn + 2HCl \rightarrow ZnCl_2 + H_2}$

4. Aluminium + Oxygen → Aluminium oxide

Step 1 $Al + O_2 \rightarrow Al_2O_3$

Step 2 $Al + \underline{3}O_2 \rightarrow Al_2O_3$

Step 3 $Al + 3O_2 \rightarrow \underline{2}Al_2O_3$

Step 4 $\underline{4}Al + 3O_2 \rightarrow 2Al_2O_3$

Balanced chemical equation $\mathbf{4Al + 3O_2 \rightarrow 2Al_2O_3}$

5. Nitrogen + Hydrogen → Ammonia

Step 1 $N_2 + H_2 \rightarrow NH_3$

Step 2 $N_2 + H_2 \rightarrow \underline{2}NH_3$

Step 3 $N_2 + \underline{3}H_2 \rightarrow 2NH_3$

Balanced chemical equation $\mathbf{N_2 + 3H_2 \rightarrow 2NH_3}$

?

- Balance the chemical equations given below and record them in science diary.

$H_2 + I_2 \rightarrow HI$

$Na + H_2O \rightarrow NaOH + H_2$

$Mg + HCl \rightarrow MgCl_2 + H_2$

Oxidation and Reduction

You have learnt how the atoms of elements combine to form molecules of compounds. Atoms engage in chemical bonding by losing, gaining or sharing electrons.

Chemical equations

While writing chemical equations, the physical states of reactants and products, energy changes, presence of catalysts, temperature, pressure etc. are also indicated usually.

E.g.

$N_2(g) + 3H_2(g) \xrightarrow{Fe} 2NH_3(g) + Heat$

You know how sodium (Na) and chlorine (Cl) combine to form sodium chloride (NaCl).

Which atom loses electron and becomes a positively charged ion in this process? Let us write the equation of the chemical reaction.

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

The process involving loss of electrons in a chemical reaction is called oxidation.

Which atom gains electron and becomes a negatively charged ion?

Let us write the equation of the chemical reaction.

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

The process involving gaining of electrons in a chemical reaction is called reduction.

The positively charged sodium ion (Na^{+}) and the negatively charged chloride ion (Cl^{-}) combine together to form sodium chloride (NaCl).

$$Na^{+} + Cl^{-} \rightarrow NaCl$$

Given below are some equations of oxidation.

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

$Ca \rightarrow Ca^{2+} + 2e^{-}$

$Mg \rightarrow Mg^{2+} + 2e^{-}$

$Zn \rightarrow Zn^{2+} + 2e^{-}$

$Al \rightarrow Al^{3+} + 3e^{-}$

Sodium (Na), potassium (K) etc. are metals. Generally, metals undergo oxidation during chemical reactions.

See some equations of reduction given below.

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

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

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

$O + 2e^{-} \rightarrow O^{2-}$

Fluorine (F), chlorine (Cl) etc. are non-metals. Generally, non metals undergo reduction during chemical reactions.

Positive ions also can gain electrons and change into atoms. Such reactions are also reduction reactions.

e.g.

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

$Cu^{2+} + 2e^{-} \rightarrow Cu$

Similarly negative ions lose electrons and change into atoms. Such reactions are also oxidation reactions.

e.g.

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

$S^{2-} \rightarrow S + 2e^{-}$

Oxidising agent and reducing agent

Look at the chemical equation regarding the formation of sodium chloride.

$$2Na + Cl_2 \rightarrow 2NaCl$$

Which atom undergoes oxidation ?

Sodium loses electron and undergoes oxidation.

Which atom supports oxidation? (sodium/chlorine)

Chlorine gains electron and helps oxidation.

The species that helps oxidation in a chemical reaction is the Oxidising agent.

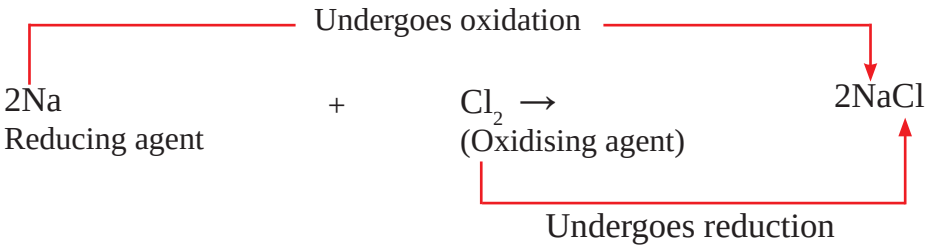
The oxidising agent gets reduced in a chemical reaction.

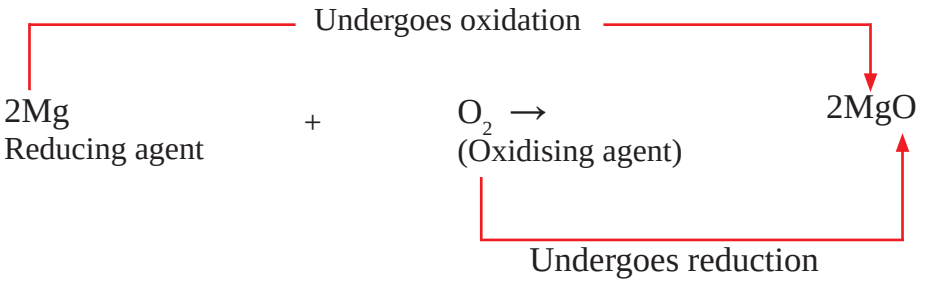
In the above chemical reaction, chlorine undergoes reduction. Which atom supports reduction? (sodium/chlorine)

Sodium donates electron and helps reduction.

The species that helps reduction is the reducing agent. The reducing agent gets oxidised in a chemical reaction.

See the illustrations given below.





- Analyse the chemical reactions given below and complete the table.

1) $Mg + F_2 \rightarrow MgF_2$

2) $Ca + Cl_2 \rightarrow CaCl_2$

3) $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Sl.No.	Equation of oxidation	Equation of reduction	Oxidising agent	Reducing agent
1	$Mg \rightarrow Mg^{2+} + 2e^-$	.....	F	.....
2	.....	$Cl + 1e^- \rightarrow Cl^-$	.....	Ca
3	$Fe \rightarrow Fe^{3+} + 3e^-$	.....	O	.....

Oxidation Number

You are familiar with the valency of elements.

Analyse Table 4.6 given below.

Element	Atomic number	Electron configuration	Valency
Sodium (Na)	11	2, 8 1	1
Potassium (K)	19	2, 8, 8, 1	1
Fluorine (F)	9	2, 7	1
Chlorine (Cl)	17	2, 8, 7	1
Magnesium (Mg)	12	2, 8, 2	2
Calcium (Ca)	20	2, 8, 8, 2	2
Oxygen (O)	8	2, 6	2
Aluminium (Al)	13	2, 8, 3	3

Table 4.6

Is it possible to guess whether an element loses or gains electron in a chemical reaction from its valency? Oxidation number is used to indicate it.

When an electron is lost, a positive ion is formed and when an electron is gained, a negative ion is formed.

If all the chemical bonds in a compound are considered to be ionic, the charge formed on each atom is considered as its oxidation number or oxidation state.

Sodium chloride (NaCl) is composed of sodium ion (Na^+) and chloride ion (Cl^-). In ionic compounds, the charge of such ions are the oxidation number. So, the oxidation number of sodium is +1 and that of chlorine is −1.

- The oxidation number of magnesium is +2 and that of oxygen is −2 in magnesium oxide (MgO). What do you understand from this?

Covalent compounds are formed by the sharing of electrons. In such compounds, the oxidation number is assigned assuming

that the shared electrons are shifted to the more electronegative element.

For example, in the covalent compound HF, it is considered that the more electronegative fluorine (F) attracts the electron pair and attains –l oxidation number. Hydrogen is assumed to lose one electron and it attains +1 oxidation number.

- The sum of the oxidation numbers of all atoms in a compound is zero.
- In element molecules, electrons are equally shared by the atoms. So, at elemental state the oxidation number is considered to be zero.

Method of calculating oxidation number

The common oxidation number of certain elements in their compounds are given in Table 4.7.

Is it possible to find out the oxidation number of an element in a compound, whose oxidation number is not known?

Let us examine Table 4.7 and see how the oxidation number of nitrogen (N) in HNO_3 can be found out.

Oxidation number of H = +1

Oxidation number of O = –2

Let the oxidation number of nitrogen be *x*. We know that the sum of oxidation numbers of atoms in a molecule is zero.

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

Table 4.7

Then, in HNO_3

$(+1) + (1 \times x) + (-2 \times 3) = 0$

$+1 + x + (-6) = 0$

$x - 5 = 0$

$x = +5$

Oxidation number of nitrogen in HNO_3 = +5

- Find out the oxidation number of nitrogen in HNO_2 and NO_2

Let us find out the oxidation number of chromium (Cr) in potassium dichromate ($K_2Cr_2O_7$). If the oxidation number of chromium is considered to be '*x*',

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

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

$2x - 12 = 0$

$2x = +12$

$x = \frac{+12}{2}$

$= +6$

Oxidation number of chromium in $K_2Cr_2O_7$ = +6

- Find out the oxidation number of chromium in Cr_2O_3 .
- Find out the oxidation number of manganese (Mn) in the following compounds and record it in your science diary.

  (Hint: Oxidation number of O = −2, K = +1.)

  a) MnO_2 b) Mn_2O_7 c) $KMnO_4$

Construct and compare the structures of MnO_2, Mn_2O_7 using Ghemical software.

Oxidation number and oxidation - reduction reactions

Analyse the chemical equation of the formation of sodium chloride (NaCl).

$$2Na + Cl_2 \rightarrow 2NaCl$$

During the formation of sodium chloride sodium loses one electron and gets one positive charge and chlorine gains one electron and gets one negative charge. So the oxidation number of sodium is +1 and the oxidation number of chlorine is –1.

- What is the oxidation number of sodium and chlorine in their elemental state?

.....

Let us write the chemical equation including their oxidation numbers.

$$2\overset{0}{Na} + \overset{0}{Cl_2} \rightarrow 2\overset{+1\ -1}{NaCl}$$

- What happened to the oxidation number of sodium as a result of this reaction (increased/decreased)?

.....

- What happened to the oxidation number of chlorine?

.....

Oxidation number increases during oxidation reactions. Reduction reactions involve a decrease in oxidation number.

- Which atom undergoes oxidation during the formation of sodium chloride?

  .....

- What is the oxidising agent in this reaction? Why?

  .....

- Which atom undergoes reduction in this reaction? Why?

  .....

- What is the reducing agent in this case?

  .....

Analyse the chemical equation given below. Find out the oxidation number of atoms and complete Table 4.8.

$$H_2 + Cl_2 \rightarrow 2HCl$$

• The atom whose oxidation number is increased.	.....
• The atom which has undergone oxidation.	.....
• The atom whose oxidation number is decreased.	.....
• The atom which has undergone reduction.	.....
• Oxidising agent	.....
• Reducing agent	.....

Table 4.8

Let us analyse another chemical equation.

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

Write the oxidation number of each atom.

Find out the following.

- The oxidation number of magnesium changes from ..... to .....
- The change that happened to magnesium. (oxidation/ reduction)
- What is the oxidising agent in this case? …… (Mg/HCl)
- What is the reducing agent? …… (Mg/HCl)

- Analyse the chemical reaction given below and complete Table 4.9.

$$C + O_2 \rightarrow CO_2$$

Element	Oxidation number		Oxidation/ Reduction	Oxidising agent/ Reducing agent
	Before reaction	After reaction		
C	…….	+4	…….	…….
O	…….	…….	Reduction	…….

Table 4.9

The equation for the chemical reaction between hydrogen and chlorine to form hydrogen chloride is given below.

$$\overset{0}{H_2} + \overset{0}{Cl_2} \rightarrow 2\overset{+1\ -1}{HCl}$$

- Which atom has undergone oxidation in this reaction?

  .....

- Which atom has undergone reduction?

  .....

Here, oxidation and reduction take place simultaneously. Such reactions are called redox reactions.

In a redox reaction, oxidising agent undergoes reduction and reducing agent undergoes oxidation.

Some familiar redox reactions in daily life are given below.

- Glucose molecules decompose and release energy during cellular respiration.
- Formation of oxide coating on the surface of metals.
- Combustion of fuels.
- Decomposition of organic substances in the presence of oxygen.
- Production of electricity in electrochemical cells.

- Analyse the above redox reactions and present a seminar on the importance of redox reactions in daily life.

Let's Assess

1. The unbalanced chemical equation regarding the formation of ammonia from nitrogen and hydrogen is given below.

$$N_2 + H_2 \rightarrow NH_3$$

   a) Balance the chemical equation.

   b) Find out the total number of atoms of the same type in both the reactants and the products.

   c) If 28 g of nitrogen combines with 6 g of hydrogen, find out the mass of ammonia formed. (Hint : Atomic mass H=1u N=14u)

2. $C + 4HNO_3 \rightarrow 2H_2O + CO_2 + 4NO_2$

   a) Find out and mark the oxidation number of carbon in this reaction.

   b) What happens to the oxidation number of carbon in this reaction?

   c) What happens to carbon-oxidation or reduction?

   d) What are the oxidising and reducing agents in this reaction?

3. Find out the oxidation number of sulphur in the following compounds.

   (Hint : Oxidation number H = +1, O = –2)

   a) SO_2 b) SO_3 c) H_2SO_3 d) H_2SO_4

4. Certain statements are given below. Write whether they are true or false.

a) The process involving an increase in oxidation number is oxidation.

b) The process involving a decrease in oxidation number is oxidation.

c) In a chemical reaction, oxidising agent undergoes reduction.

d) In a chemical reaction, oxidising agent undergoes oxidation.

5. Balance the chemical equations given below.

   a) $SO_2 + O_2 \rightarrow SO_3$ b) $H_2O_2 \rightarrow H_2O + O_2$

   c) $CH_4 + O_2 \rightarrow H_2O + CO_2$ d) $Fe + HCl \rightarrow FeCl_2 + H_2$

6. Two chemical reactions are given below. Find out the oxidation number of atoms and check whether these reactions are redox reactions.

   a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ b) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

7. The gaseous fuel carbon monoxide burns in oxygen to form carbon dioxide.

   a) Write the balanced equation of this chemical reaction.

   b) Is this a redox reaction? Why?

   c) What is the oxidising agent in this reaction? What is the reducing agent?

8. Analyse the chemical equation given below.

$$Ca + 2HCl \rightarrow CaCl_2 + H_2$$

a) Mark the oxidation number of atoms before and after the chemical reaction.
b) Which atom undergoes oxidation?
c) Which atom undergoes reduction?
d) What are the oxidising and reducing agents?

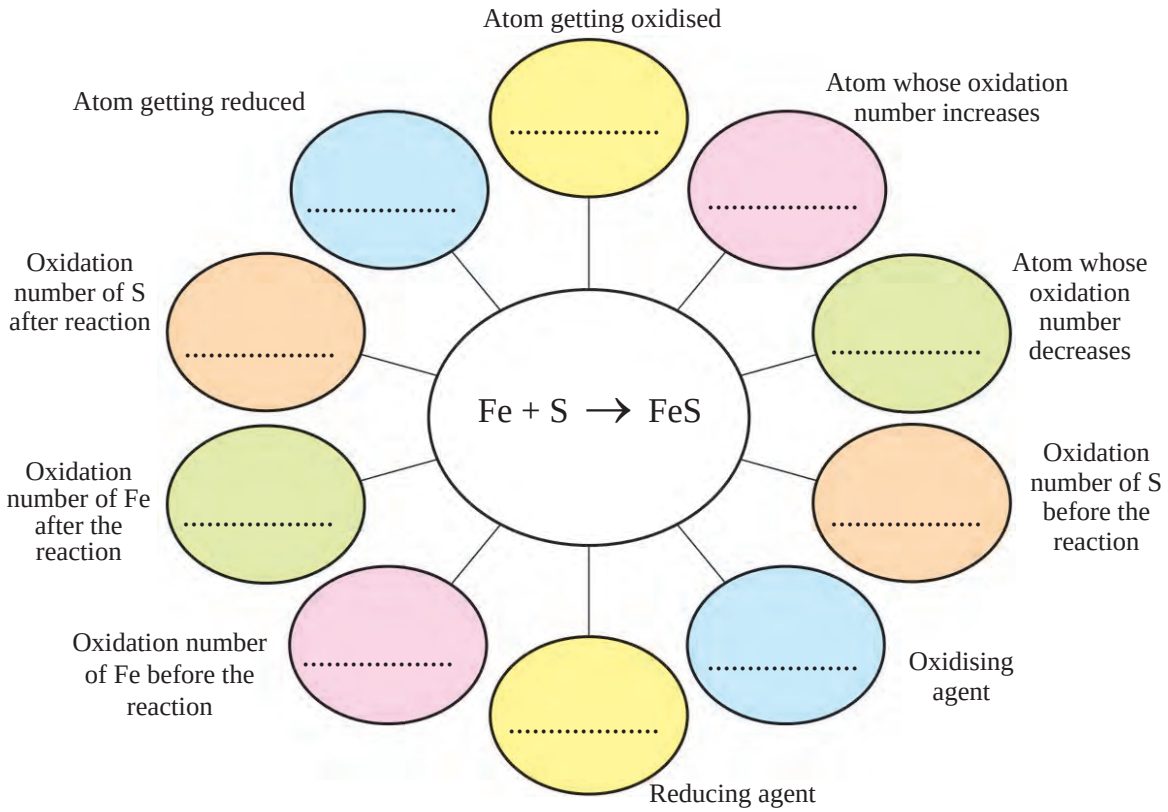
9. Analyse the chemical equations given below and find out whether they are redox reactions.

a) $NaOH + HCl \rightarrow NaCl + H_2O$

b) $H_2S + Cl_2 \rightarrow 2HCl + S$

10. A chemical reaction is given in the concept map below. Find out the oxidation number of each atom. On the basis of this, fill up the blanks.

(Hint : Valency S = 2, Fe = 2)



Extended Activities

1. Mix iron powder and sulphur in the mass ratio 7:4 in a china dish. Heat the mixture well. After sometime cool the china dish. Check whether iron can be separated using magnet.

   Examine whether the product dissolves in carbon disulphide.

   What is your inference?

   Write down the equation of the chemical reaction. Check whether it is a redox reaction.

2. Take some sand in a tray. Place calcium carbide (CaC_2) on it. Place some more sand on top of it. Place some ice cubes on the sand. Ignite the ice cubes carefully. What do you see?

   Calcium carbide reacts with water and forms acetylene (C_2H_2) gas. Acetylene is an inflammable gas.

   Write the chemical equation of the combustion.

   Check whether it is a redox reaction.

3. Make a mixture of aluminium powder and powdered iodine crystals in the mass ratio 1 : 2. Make a heap of it in a china dish. Make a small hole at the top of the heap. Add one or two drops of water into the hole. What do you see?

   Here aluminium and iodine combine to form aluminium triiodide.

   The valency of Al = 3 I = 1

   a) Write the equation of the chemical reaction.

   b) Find out the oxidation number of each atom. Check whether it is a redox reaction.

4. Conduct a study tour to understand the importance of redox reactions in industry.

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.

CHILDREN'S RIGHTS

Dear Children,

Wouldn't you like to know about your rights? Awareness about your rights will inspire and motivate you to ensure your protection and participation, thereby making social justice a reality. You may know that a commission for child rights is functioning in our state called the ***Kerala State Commission for Protection of Child Rights.***

Let's see what your rights are:

- Right to freedom of speech and expression.
- Right to life and liberty.
- Right to maximum survival and development.
- Right to be respected and accepted regardless of caste, creed and colour.
- Right to protection and care against physical, mental and sexual abuse.
- Right to participation.
- Protection from child labour and hazardous work.
- Protection against child marriage.
- Right to know one's culture and live accordingly.
- Protection against neglect.
- Right to free and compulsory education.
- Right to learn, rest and leisure.
- Right to parental and societal care, and protection.

Major Responsibilities

- Protect school and public facilities.
- Observe punctuality in learning and activities of the school.
- Accept and respect school authorities, teachers, parents and fellow students.
- Readiness to accept and respect others regardless of caste, creed or colour.

Contact Address:

Kerala State Commission for Protection of Child Rights

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Email: childrights.cpcr@kerala.gov.in, rte.cpcr@kerala.gov.in

Website : www.kescpcr.kerala.gov.in

Child Helpline - 1098, Crime Stopper - 1090, Nirbhaya - 1800 425 1400

Kerala Police Helpline - 0471 - 3243000/44000/45000