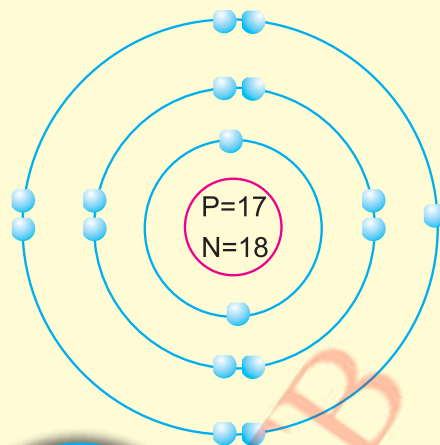
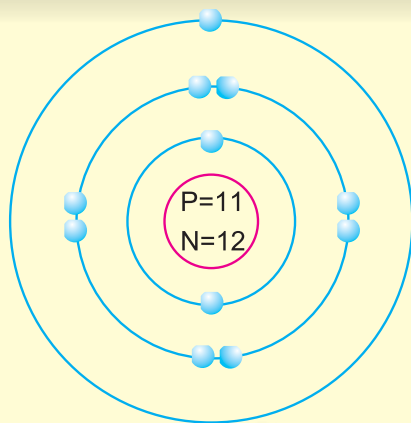




What do you think about the structure of an atom?

What is Periodic Table?

What is electronic configuration?

O4

Structure of an Atom

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Describe and draw the structure of an atom in terms of electrons, protons and neutrons.
- Describe how an atom is electrically neutral.
- Differentiate between atomic number and mass number.
- Determine the atomic number and mass number of elements on the basis of the number of protons, electrons and neutrons.
- Show the arrangement of electrons in K, L and M shells of elements.
- Draw the atomic structures of first eighteen elements in the Periodic Table.
- Explain that the Periodic Table is a way to organize elements in a systematic order.
- Recognize periods and groups in the Periodic Table.

VOCABULARY

Electron

A negatively charged particle of an atom found around its nucleus

Proton

A positively charged particle of an atom found in its nucleus

Neutron

A neutral particle of an atom found in its nucleus

Atomic number

Number of protons present in an atom

Mass number

Total number of protons and neutrons present in an atom

Isotopes

Atoms of the same element having different mass numbers

Recall what you have learnt:

We have learnt as under:

Atom

An atom is the smallest particle of an element that can take part in a chemical reaction. Atoms of a particular element are alike but they are different from the atoms of other elements.

Structure of an atom

The major part of an atom is empty. Its central part is called nucleus. Modern research on atomic structure shows that it consists of a number of smaller particles, the most important of which are (**Figure 4.1**):

- Proton
- Electron
- Neutron

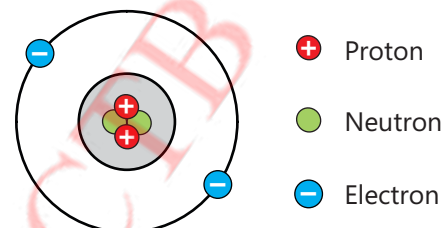


Figure 4.1 Structure of helium atom

(i) Proton

Protons are the positively charged particles present in the nucleus of an atom. A proton carries a unit positive charge on it.

(ii) Electron

Electrons are the negatively charged particles revolving around the nucleus of an atom in different orbits. An electron carries a unit negative charge on it.

(iii) Neutron

Neutrons are the neutral particles. They have no charge on them. They are also present in the nucleus of an atom.

Protons, electrons and neutrons are known as the fundamental particles of an atom. The number of protons present in the nucleus of an atom is equal to the number of electrons present around the nucleus. It means that the number of positive charges is equal the number of negative charges present there. The atom is therefore, electrically **neutral particle**.

Symbol

One or two letters from the English or Latin name of an element used to represent its one atom is called **symbol**. Usually the first capital letter of the name of the element is used as symbol. If there are two letters in the symbol, the first is capital and the second is small. For example, H is the symbol of hydrogen and Na is the symbol of sodium taken from its Latin name (Natrium).

Atomic number (Z)

The number of protons present in an atom of an element is called atomic number of that element. It is denoted as **Z**. All the atoms of an element have the same number of protons.

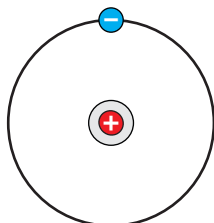
Mass number (A)

The total number of protons plus neutrons present in an atom of an element is called **mass number** of that element. It is denoted as **A**.

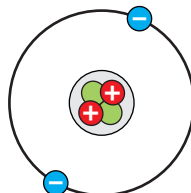


Activity 4.1 Assessment

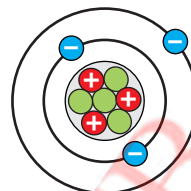
- Examine the structures shown below:



Hydrogen atom



Helium atom



Lithium atom

- Record your observation in the chart given below:

Name of element	Symbol	Atomic Number (Z)	Mass number (A)

Mathematically we can write:

$$\text{Mass number} = \text{Number of protons} + \text{Number of neutrons}$$

$$A = Z + \text{Number of neutrons.}$$

$$\text{Number of neutrons} = A - Z$$

We can find the number of protons, electrons and neutrons in an atom of an element by knowing its atomic number and mass number. For example atomic number of phosphorus is 15 and its mass number is 31. Since atomic number is the number of protons present in an atom, it means that:

The number of protons in phosphorus atom = 15

We know that, in an atom, the number of protons is equal to the number of electrons.

Hence, the number of electrons in phosphorus atom = 15

Mass number = Number of protons + Number of neutrons

$A = Z + \text{Number of neutrons.}$

Number of neutrons = $A - Z$

Number of neutrons in phosphorus atom = $31 - 15 = 16$



Activity 4.2 Assessment

- Find out and write the number of protons, electrons and neutrons in the atoms of the following elements:

Name of element	Symbol	Atomic Number (Z)	Mass Number (A)	No. of protons	No. of electrons	No. of neutrons
Oxygen	O	8	16			
Magnesium	Mg	12	24			
Phosphorus	P	15	31			
Potassium	K	19	39			



Informative

- The symbol of an element is used to represent one atom of that element.
- Atomic number given on the symbol of an element in the Periodic Table indicates the number of protons present in one atom of that element.
- The number of electrons present in an atom is equal to the number of protons.

In this chapter we will learn about:

- Atom – An electrically neutral particle
- Energy levels or shells
- Distribution of electrons in K, L and M shells
- Atomic structures of first 18 elements
- Periodic Table

4.1 ATOM – AS A NEUTRAL PARTICLE

We have learnt about charge and that like charges repel each other and opposite charges attract each other. The number of positively charged protons present in an atom is equal to the number of negatively charged electrons present there. It means that the total positive charge on an atom (due to protons) is equal to the total negative charge on it (due to electrons). The equal amounts of positive and negative charges cancel the effect of each other. An atom is therefore electrically neutral particle (Figure 4.2).

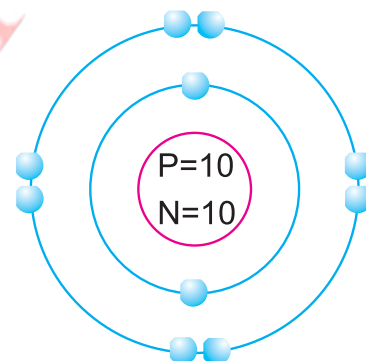


Figure 4.2 Neon atom

4.2 SHELLS OR ORBITS

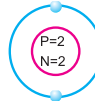
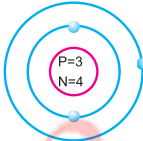
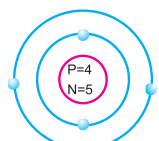
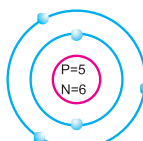
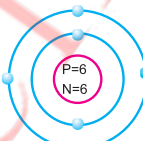
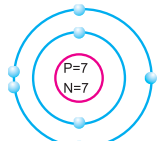
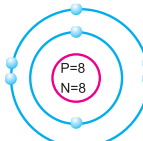
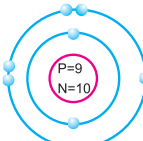
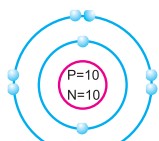
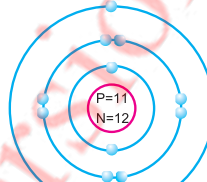
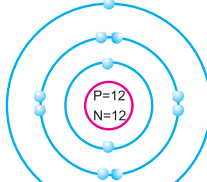
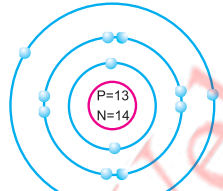
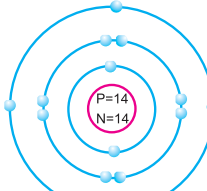
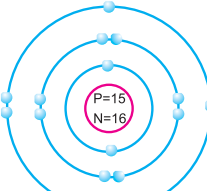
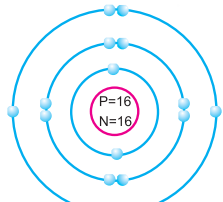
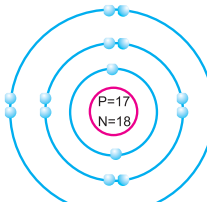
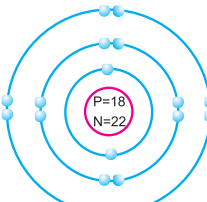
Areas around the nucleus of an atom where electrons are found are known as shells or orbits. First, second, third and fourth shells are named as K, L, M and N respectively. An integer 'n' is used to describe the position of these shells around the nucleus of an atom. For the first K shell $n = 1$, for the second L shell $n = 2$, for the third M shell $n = 3$ and for the fourth N shell $n = 4$. The maximum number of electrons which each shell can accommodate can be determined by using the formula $2n^2$ **Table (4.1)**.

Table 4.1 electrons in different shells around an atom

Shell	Value of n	Name of the shell	Maximum of number of electrons = $2n^2$
First	1	K	$2n^2 = 2 \times 1^2 = 2 \times 1 = 2$
Second	2	L	$2n^2 = 2 \times 2^2 = 2 \times 4 = 8$
Third	3	M	$2n^2 = 2 \times 3^2 = 2 \times 9 = 18$
Fourth	4	N	$2n^2 = 2 \times 4^2 = 2 \times 16 = 32$

4.3 ATOMIC STRUCTURES OF FIRST 18 ELEMENTS

Atomic structures of first eighteen (18) elements of the Periodic Table are shown as follows:

 Hydrogen (${}^1_1\text{H}$)	 Helium (${}^4_2\text{He}$)	 Lithium (${}^7_3\text{Li}$)
 Beryllium (${}^9_4\text{Be}$)	 Boron (${}^{11}_5\text{B}$)	 Carbon (${}^{12}_6\text{C}$)
 Nitrogen (${}^{14}_7\text{N}$)	 Oxygen (${}^{16}_8\text{O}$)	 Fluorine (${}^{19}_9\text{F}$)
 Neon (${}^{20}_{10}\text{Ne}$)	 Sodium (${}^{23}_{11}\text{Na}$)	 Magnesium (${}^{24}_{12}\text{Mg}$)
 Aluminum (${}^{27}_{13}\text{Al}$)	 Silicon (${}^{28}_{14}\text{Si}$)	 Phosphorus (${}^{31}_{15}\text{P}$)
 Sulphur (${}^{32}_{16}\text{S}$)	 Chlorine (${}^{35}_{17}\text{Cl}$)	 Argon (${}^{40}_{18}\text{Ar}$)



Mini Exercise

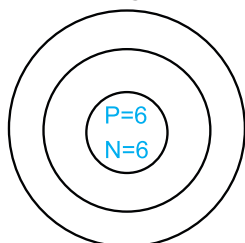
- Draw diagrams of atomic structures of the following atoms:

(a) Magnesium	(Z = 12, A = 24)	(b) Aluminum	(Z = 13, A = 27)
(c) Silicon	(Z = 14, A = 28)	(d) Phosphorus	(Z = 15, A = 31)
(e) Sulphur	(Z = 16, A = 32)		

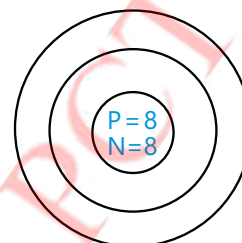


Activity 4.3

Complete the structures of the given atoms by filling electrons in different shells.



Carbon atom (Z = 6, A = 12)



Oxygen atom (Z = 8, A = 16)

4.4 PERIODIC TABLE

Scientists have arranged the elements in a table called the Periodic Table (**Figure 4.3**). Elements in the Periodic Table are arranged on the basis of their properties and arrangement of electrons around the nuclei in their atoms. Elements kept in columns (groups) have same number of electrons in their outermost shells. They have similar properties. In the rows (periods) from left to right, elements are arranged in an order of increasing atomic numbers.

Periods																		Groups									
1	Key Hydrogen 1 → Atomic number H → Symbol 1.0 → Mass number → Name																	18									
1	Hydrogen 1 H 1.0																	Helium 2 He 4.0									
2	Lithium 3 Li 6.9	Beryllium 4 Be 9.0															Boron 5 B 10.8	Carbon 6 C 12.0	Nitrogen 7 N 14.0	Oxygen 8 O 16.0	Fluorine 9 F 19.0	Neon 10 Ne 20.2					
3	Sodium 11 Na 23.0	Magnesium 12 Mg 24.3															Aluminium 13 Al 27.0	Silicon 14 Si 28.1	Phosphorus 15 P 31.0	Sulphur 16 S 32.1	Chlorine 17 Cl 35.5	Argon 18 Ar 39.9					
4	Potassium 19 K 39.1	Calcium 20 Ca 40.1	Scandium 21 Sc 45.0	Titanium 22 Ti 47.9	Vanadium 23 V 50.9	Chromium 24 Cr 52.0	Manganese 25 Mn 54.9	Iron 26 Fe 55.9	Cobalt 27 Co 58.9	Nickel 28 Ni 58.7	Copper 29 Cu 63.5	Zinc 30 Zn 65.4	Gallium 31 Ga 69.7	Germanium 32 Ge 72.6	Arsenic 33 As 74.9	Selenium 34 Se 79.0	Bromine 35 Br 79.9	Krypton 36 Kr 83.8									
5	Rubidium 37 Rb 85.5	Strontium 38 Sr 87.6	Yttrium 39 Y 88.9	Zirconium 40 Zr 91.2	Niobium 41 Nb 92.9	Molybdenum 42 Mo 95.9	Technetium 43 Tc (99)	Ruthenium 44 Ru 101.1	Rhodium 45 Rh 102.9	Palladium 46 Pd 106.4	Silver 47 Ag 107.9	Cadmium 48 Cd 112.4	Indium 49 In 114.8	Tin 50 Sn 118.7	Antimony 51 Sb 121.8	Tellurium 52 Te 127.6	Iodine 53 I 126.9	Xenon 54 Xe 131.3									
6	Cesium 55 Cs 132.9	Barium 56 Ba 137.3	Lanthanides 57-71	Hafnium 72 Hf 178.5	Tantalum 73 Ta 181.0	Tungsten 74 W 183.9	Rhenium 75 Re 186.2	Osmium 76 Os 190.2	Iridium 77 Ir 192.2	Platinum 78 Pt 195.1	Gold 79 Au 197.0	Mercury 80 Hg 200.6	Thallium 81 Tl 204.4	Lead 82 Pb 207.2	Bismuth 83 Bi 209.0	Polonium 84 Po (210)	Astatine 85 At (210)	Radon 86 Rn (222)									
7	Francium 87 Fr (223)	Radium 88 Ra (226)	Actinides 89-103																								

Figure 4.3 The Periodic Table Of Elements

4.4.1 Periods

Horizontal rows of elements in the Periodic Table are called periods. **Table 4.2** given below shows the number of elements kept in different periods of the Periodic Table based on an order of their increasing atomic numbers.

Table 4.2 Different Periods of the Periodic Table

Period No.	Name of the Period	Number of Elements	Range of Atomic Numbers
1 st	Short Period	2	1 to 2
2 nd	Normal Period	8	3 to 10
3 rd	Normal Period	8	11 to 18
4 th	Long Period	18	19 to 36
5 th	Long Period	18	37 to 54
6 th	Very Long Period	32	55 to 86
7 th	Very Long Period	32	87 to 118*

4.4.2 Groups

Columns of the Periodic Table are called **groups**. There are eighteen groups in the Periodic Table. Groups are numbered on the basis of number of electrons in the outermost shells or valence shells of their atoms. For example, each element of group 1 contains one electron in the outermost shell or valence shell of its atoms. Each element of group 2 contains two electrons in the outermost shell or valence shell of its atoms.

Groups 1 and 2 and 13 to 17 contain normal elements. Groups 3 to 12 contain transition elements. The elements of group 18 are called noble gases. **Table 4.3** below shows distribution of different families of elements in groups 1 to 18.

Table 4.3 Different Groups of the Periodic Table

Group No.	Number electrons in valence shell	Family name of elements
1	1	Alkali metals
2	2	Alkaline earth metals
3 to 12		Transition metals

13	3	Boron family
14	4	Carbon family
15	5	Nitrogen family
16	6	Oxygen family
17	7	Halogen family
18	8	Noble gases



Do you know?

- Carbon, hydrogen, oxygen, nitrogen, phosphorus and calcium are the six elements which contribute about 99 % of our body mass.

KEY POINTS

- An atom is the smallest particle of an element that can take part in a chemical reaction.
- Electrons, protons and neutrons are the fundamental particles of an atom.
- Protons and neutrons are located in the central part of an atom called nucleus, whereas, electrons are found around the nucleus in different shells.
- The number of protons present in the nucleus of an atom is equal to the number of electrons found around the nucleus in different shells.
- The number of protons present in the nucleus of an atom of an element is called atomic number of that element.
- Total number of protons and neutrons present in the nucleus of the atom of an element is called mass number of that element.
- The areas around the nucleus of an atom where electrons are found are known as shells.
- First, second, third and fourth shells are named as K, L, M and N shells.
- An integer 'n' is used to describe the position of a shell around the nucleus of an atom.
- The maximum number of electrons which a shell can accommodate can be determined by the formula $2n^2$.
- Scientists have arranged the elements in a table called the Periodic Table.
- Elements in the Periodic Table are arranged on the basis of their properties and arrangement of electrons around the nuclei of their atoms.

QUESTIONS

4.1 Encircle the correct option.

- An element with fifteen protons in its atomic nucleus has atomic number:**
a. 5 b. 10 c. 15 d. 20
- The central part of an atom is called:**
a. electron b. proton c. neutron d. nucleus
- Letter K is used to express the ----- shell around the nucleus of an atom.**
a. 1st b. 2nd c. 3rd d. 4th
- The total number of electrons which M shell can accommodate:**
a. 2 b. 8 c. 18 d. 32
- The particle of an atom having negative charge on it:**
a. electron b. proton c. neutron d. nucleus
- Atomic number of element present in period 2 and group 15 of the Periodic Table:**
a. 4 b. 5 c. 6 d. 7
- How many periods are there in the Periodic Table?**
a. five b. six c. seven d. eight
- Formula showing maximum number of electrons in a shell:**
a. n^2 b. $2n^2$ c. $3n^2$ d. $4n^2$
- The mass of an atom is almost due to the:**
a. electrons b. protons c. neutrons d. nucleus
- The particles of an element having different mass numbers:**
a. protons b. neutrons c. atoms d. isotopes

4.2 Write short answers.

- What is atom?
- Define element.
- What type of charge is present on neutron?
- What do you mean by atomic number?
- What is mass number?

4.3 Constructed Response Questions

- Oxygen is a non-metallic element.
(a) What is atomic number of oxygen?

- (b) In which group of the Periodic Table, oxygen is located?
 - (c) In which period of the Periodic Table, oxygen is located?
 - (d) How many electrons are required by oxygen atom to complete its valence shell
2. Sodium is a metallic element.
- (a) What is symbol of sodium?
 - (b) What is atomic number of sodium?
 - (c) What is the period number of sodium in Periodic Table?
 - (d) What is the group number of sodium in Periodic Table?
 - (e) Name the family of metals, sodium belongs to.
3. Name the members of the following families in the Periodic Table:
- (a) Alkali metals
 - (b) Alkaline earth metals
 - (c) Halogens
 - (d) Nobel gases
4. Name the element having the same period number and group number.
5. What does $\overset{13}{\underset{27}{\text{Al}}}$ indicate?
6. Why do H and Be exist as atoms while He and Ne as molecules?
7. What does electronic configuration mean?
8. What is the difference between an atom and isotope?

4.4 Investigate the isotopes and their uses.

4.5 Project

1. Draw the atomic structures of sodium and magnesium having atomic number 11 and 12 respectively.
2. Draw the atomic structures of chlorine and argon having atomic number 17 and 18.