Unit–3

MATTER

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CONTENTS

Introduction

This unit is about matter and its properties. The understanding of this content will give you some insight about chemistry. Before discussing the chemical principles, it is very essential that you get to know the basic chemical concepts. Every discipline has its own language and specific skills to deal with. Similarly, chemistry requires a specific language and certain skills to deal with. Without knowing the fundamentals of chemistry, one cannot acquire a firm understanding of chemistry.

Allah has created a vast variety of materials in this universe. You have seen many materials in your daily life e.g wood, iron, water etc. Since several materials are present in nature, therefore they are classified into groups by scientists in order to make their understanding and study easy.

Everything is made up of matter. It is the property of matter that it has certain mass and occupies certain volume. All matter is made up of several atoms either of the same kind or of different kinds and hence it can be different from each other. For example, gold is composed of one type of gold atoms, whereas "water" is made up of two different types of atoms i-e hydrogen and oxygen atoms.

In this unit, you will get to know the difference between elements, compounds and mixtures. You will also study how chemical reactions happen. You will also learn how chemical equations are balanced.

Objectives

At the end of this Unit, you will be able to:

- differentiate between different states of matter.
- describe molecular theory of matter.
- discuss structure of an atom
- differentiate elements, compound and mixtures
- write different chemical formulae
- design different chemical reactions
- identify metals from nonmetals
- distinguish acids, bases, and neutralizations
- balance the chemical equations

3.1 Matter and its States

Anything that has mass and occupies some space is matter. All kind of objects are composed of matter. Matter is everywhere around us in any form. Water, bricks, chairs, tables, books are all made up of matter. We can directly sense the matter. Matter is made up of atoms of elements. Around eighty years before, scientists believed that "atom" was the smallest constituent of matter. That was the time, when atom was considered to be the "building block of matter"

Ernest Rutherford's (1911) discovery revealed that an atom is made up of a positively charged central part called "nucleus" and negatively charged particles called electrons are revolving around it.

In 1932, scientists discovered that the nucleus of an atom is made up of smaller particles called protons and neutrons. Moreover they discovered that there is positive charge on protons, negative charge on electrons while neutrons have no charge. The protons and neutrons are called nucleons as they are found in the nucleus. By that time, they were considered as the smallest constituent of matter.

Scientists discovered the fact that like charges repel each other and unlike charges attract each other. This fact made them wonder that how protons are confined within nucleus and do not fly part. In 1947 they discovered other particles called "mesons". After the discovery of "mesons", they got answer of their question. According to them mesons hold the protons and neutrons together to form the nucleus.

Scientists continued their experiments to explore more about atom. In 1968 they discovered something astonishing and amusing about protons and neutrons. They also discovered that protons and neutrons are made up of smaller particles called "quarks". They discovered six different kinds of quarks: Up, down, strange, charm, top and bottom.

Protons have two up and one down quark. Whereas neutrons have two down and one up quarks. The quarks are held together by particles called gluons.

According to some scientists, quark is the smallest piece of matter. But some are still in search of other particles.

Properties of matter

There are various quantitative, measurable properties of matter. For example mass, volume weight, color, density as well as qualitative properties e.g taste and smell.

Examples

In this universe all physical objects are made of matter: air, water, stars, galaxies, planets, rocks, etc. Living organisms such as human beings, animals and plants are also composed of matter.

Composition
In order to understand the structure and composition of matter, scientists made many efforts e.g cutting or breaking matter into smaller and smaller pieces. Living organisms are made up of cells, which are composed of molecules; these molecules are sets of atoms bounded together. Each atom, in turn, is a grouping of elementary particles.

States of matter
Scientists have classified matter into certain broad categories, known as "states" with reasonably different properties.

i. Solids
Solid is the state of matter in which atoms and molecules are so strongly bonded together that they retain their shape up to a certain temperature and pressure.
Examples: rocks, table, knife, mirror etc.

ii. Liquids
Liquid is the state of matter in which molecules and atoms are weakly bonded together. Liquids do not have a proper shape.
Examples: water, glycerin, petrol, diesel etc

iii. Gases
The state of matter in which there is weak or loose bonding among atoms or molecules of the elements is called gases. In gases molecules or atoms can move independently from each other. Gases do not exhibit a proper volume, they tend to expand and occupy the whole volume available.
Examples: air, water vapour, helium.

iv. Plasma
According to Wikipedia, Plasma is identified as the fourth state of matter. Plasma is made by heating a gas until its atoms and molecules break up (called ionized) into negatively charged electrons and positively charged ions. Differing from other states of matter, the charged particles in a plasma will react strongly to electric and magnetic fields (i-e electromagnetic fields). The formed ions will re-unite into a gas if plasma gets cold.

On the earth the lightning and aurora (colorful lights on the sky in the countries situated on poles) make plasma. Artificial (man-made) uses of plasma include fluorescent tubes, neon signs, and plasma displays used for television or computer screens. Scientists are experimenting with plasma to make a new kind of nuclear power, called fusion, which would be much better and safer than ordinary nuclear power, and would produce much less radioactive waste.

Key Points

1. Anything that carries mass, occupies space and can be felt is called matter.
2. The smallest particle of matter is an "atom".
3. Protons and Neutron are found in neucleous, hence known as "Nucleons".
4. Rutherford proposed the structure of an atom, according to him an atom consists of a central heavier part called nucleus having positive charge and negatively charged particles (electrons) are revolving around the Nucleus.
5. A Matter is found in four states viz. solid, liquid, gas and plasma.
6. Any kind of matter is ultimately composed of smaller molecules, atoms or ions, these molecules, atoms or ions are basic elements like (hydrogen, oxygen, iron, sodium and potassium etc.)
7. In solids molecules or atoms are so closely packed that they have definite shape, and fixed volume. e.g Salts, table, knife, book and brick .
8. Liquid is the state of matter in which molecules and atoms are weakly bonded together. They do not have a proper shape. Whereas they have a fixed volume. Examples: water, glycerin, petrol, diesel
9. Gases do not have a proper volume, they tend to expand and occupy the whole volume available. They also have no shape. Examples: air, water vapour, helium.
10. The fourth state of matter is "Plasma". It is prepared by heating a gas until its atoms and molecules break up (called ionized) into negatively charged electrons and positively charged ions. Plasma is used in fluorescent tubes, plasma displays, neon signs, and television or computer screens.

Self Assessment Exercise 01

Q.1 Fill in the Blanks with correct Options.

i. Anything which has mass or weight and __________________ is called matter.

ii. The charge on proton is _____________whereas there is ______________charge on neutron.

iii. ____________has _____________quarks.

Q.2 Pick correct answer from the given options.

i. there is _____________charge on neutron.

a. positive b. negative
c. no charge d. no known charge

ii. Matter exist in __________________forms

a. 2 b. 3
c. 4 d. 5

iii. A state of matter which has no definite shape nor fixed volume is called_______________

a. Plasma b. solid
c. Gas d. liquid

iv. Mostly _______________form of matter is found on starts and sun.
a. Molecule b. Plasma
c. Gas d. quark

v. There are __________different type of quarks:
a. two b. six
b. three c. four

Q.3 Answer the following questions:

i. Describe different states of matter in detail.
ii. Differentiate solids, liquids and gases on the bases of shape, volume and arrangement of molecules.
iii. What is plasma? Describe its applications in our daily life.

3.2 Molecular Theory of Matter

Scientists developed the kinetic molecular theory of matter during nineteenth century to explain the behaviour of atoms and molecules that make up the matter.

To begin with, we will consider matter as composed of small particles. This theory assumes that these particles are constantly in motion. These atoms and molecules change their velocity and direction constantly. That is the reason; the molecular theory of matter is also known as kinetic molecular theory. This theory is very useful in explaining the properties of the states of matter in terms of energy of particles and forces that act between them.

The following are the postulates of the molecular theory

1. **All kind of matter is made of tiny particles.**
2. **These particles are in constant motion.**
3. **The amount of motion is proportional to temperature. An increase in temperature results in increase in motion.**
4. **The rate of motion of the particles of solids, liquids and gases is different. The rate at which these particles interacts is also different.**

Now we will discuss molecular theory in three states of matter.

i. The movement of molecules in Solids
ii. The movement of molecules in Liquids
iii. The movement of molecules in Gases

The movement of molecules in Solids

We know that the matter in any state, is made from the smallest particle called atom. In solids the particles are closely packed together in very orderly arranged planes. In fact, there is some empty space between them. These Molecules are not at rest but move continuously. In solids the movement of molecules is vibratory. Because of their constant motion, they are not quite orderly as this image represents. Molecules vibrate about a central point, but do not change their positions. Despite these continual changes, the strong attractions between particles trap them in the same small volume with the same particles surrounding it. This is the reason solids maintain their shape and volume.

The distance between the molecules is very small so that force of attraction is very strong.

Effect of temperature on the structure of solid

The increased temperature leads to increase velocity of the particles. As the particles move faster, they collide with the particles around them with more force, pushing them slightly farther apart and leading to a small increase in volume of the solid. If a solid is heated enough, the motion of the particles becomes sufficiently increased to push the other particles around them completely; it can push neighbouring particles out of the way completely and move to a new position. For those neighbouring particles to make way, however, they must push other particles around them aside. In this way the systematized structure of solids collapses, and solid becomes liquid.

The movement of molecules in Liquids

In liquids the distance between molecules is large as compared to the solids so that the molecules move from one place to other easily. Their mutual attraction is very much less because of this reason liquid has no specific shape. The movement of molecule is not as fast that the molecules escape from the liquid. If molecules escape from the liquids this process is called vapourization.

The particles in a liquid are moving fast enough to break attractions, push other particles out of the way, and move throughout the liquid. Because particles are moving throughout the liquid, some of them eventually come to the liquid's surface. A particle's direction of movement may carry it beyond the surface into the space above the liquid, but the attraction of other particles break the attractions pulling it back .the liquids are converted into gases by this process. This conversion of liquid state to gaseous state is called vapourization or evaporation.

The particles moving up and away from the surface are usually pulled back by attractions to other particles still in the liquid, but sometimes they are moving fast enough to escape and join the other gas particles above the liquid.

The movement of molecules in Gases

In gases the mutual distance between molecules is very large. The force of attraction is very weak. That is the reason; gases have no specific shape and volume. In gases, density of molecules is very low. In gases, the molecules collide with each other and change their direction. When gases are compressed, the volume of the gases decreases.

In gases, the separation of the particles is much more than in a solid or liquid. For example, in the air, the average distance between particles is around ten times the diameter of each particle. This leads to the gas particles themselves taking up only about 0.1% of the total volume. The other 99.9% of the total volume is empty space.

Each particle in a gas moves freely in a straight line path until it collides with another gas particle or with particles of a liquid or solid. The particles are usually moving fast enough to break any attraction that might form between them, so after two particles collide, they bounce off each other and continue on their way alone.

Key Points

1. Kinetic molecular theory describes the behaviour of atoms and molecules of matter.
2. This theory is very useful in explaining the properties of the states of matter in terms of energy of particles and forces that act between them.
3. Matter is made of tiny particles which are in constant motion.
4. The movement of molecules in solids is vibratory; the molecules do not change their position.
5. According to Kinetic Molecular Theory molecules are in constant motion.
6. Increase in temperature increases the motion of the molecules and at a certain temperature solid changes into liquid.
7. Due to less attraction and more space between molecules of liquids, liquids have no definite (fixed) shape.
8. When high energy molecules come at the surface of the liquid they leave the surface of the liquid thus causing coolness.
9. Loss of liquid (water) at normal temperature is called evapouration.
10. Gases can be compressed easily, whereas liquids and solids cannot be compressed easily.
11. The molecules of gas are very farther apart from each other, the distance between molecules of gas is almost ten times the diameter of the molecule.
12. The attractive force between the particles of matter is inversely proportional to the distance between the individual particles of the matter.

Self Assessment Exercise 2

Q.1: Fill in the blanks with suitable words or phrases.

i. The particles of gas change their ____________ and ___________ constantly.

ii. Kinetic Molecular Theory is very useful in explaining the __________ of the states of matter in terms of energy of particles and forces that act between them.

iii. In gases the mutual distance between molecules is very large hence ____________ is very weak.

iv. The___________ between the molecules determine the strength between the molecules.

Q.2: Choose the correct option.

i. Which one of the following statements is not consistent with the kinetic-molecular theory of gases?

(a) Individual gas molecules are relatively far apart.

(b) The actual volume of the gas molecules themselves is very small compared to the volume occupied by the gas at ordinary temperatures and pressures.

(c) The average kinetic energies of different gases are different at the same temperature.

(d) There is no net gain or loss of the total kinetic (translational) energy in collisions between gas molecules.
(e) The theory explains most of the observed behavior of gases at ordinary temperatures and pressures

ii. Which statement is false?
(a) The density of a gas is constant as long as its temperature remains constant.
(b) Gases can be expanded without limit.
(c) Gases diffuse into each other and mix almost immediately when put into the same container.
(d) The molecular weight of a gaseous compound is a non-variable quantity.
(e) Pressure must be exerted on a sample of a gas in order to confine it.

iii. Which of the following statements is not a part of kinetic molecular theory?
(a) Matter is composed of particles that are in constant motion.
(b) Particle velocity increases as the temperature increases.
(c) Particles in a system cannot transfer energy to each other.
(d) Particle interactions involve electrostatic attractions and repulsions.

iv. In which of the following groupings of terms are the three terms closely related?
(a) Kinetic energy, energy of motion, cohesive forces
(b) Potential energy, energy of attraction, disruptive forces.
(c) Kinetic energy, electrostatic interactions, disruptive forces
(d) Potential energy, electrostatic interactions, cohesive forces

v. In the liquid state, disruptive forces are
(a) Roughly of the same magnitude as cohesive forces.
(b) Very weak compared to cohesive forces.
(c) Dominant over cohesive forces.
(d) Unimportant.

vi. The phrases "particles close together and held in fixed positions" and "completely fills the container" apply, respectively, to
(a) Liquids and solids.
(b) Solids and gases.
(c) Gases and liquids.
(d) Liquids and gases.

Q.3: Answer the following questions:

i. How Kinetic Molecular theory is helpful to determine the properties of matter?
ii. Compare and contrast movement of molecules in solids, liquids and Gases?

3.3 Structure of Atom

"The atom is a basic unit of matter consisting of a dense, central nucleus surrounded by a cloud of negatively charged electrons".

The electron is an elementary particle. The nucleus may consist of a proton or a combination of protons and neutrons. Both proton and neutron have same mass equal to $1.67x10^{-27}$ Kg. A proton is made of two up quarks and one down quark. A neutron is made of one up quark and two down quarks. The combination of quarks to form hadrons is mediated by elementary particles called gluons. It means that whole mass is concentrated in the centre of atom.

The smallest particle of matter that has specific structure and the same structure is repeated throughout the material is called an atom.

An atom cannot be divided further without modifying the characteristics of the material. Atom is the basic unit of matter like a brick in the building. For example, if you have 1 kg, 1 g or 1 atom of fresh air, all of these systems have the same qualities. If we divide an atom of fresh air into ingredients, atom loses its material qualities. For example, if you have 50 crystals of sugar but you taste only one crystal, all the remaining crystals will have the same qualities.

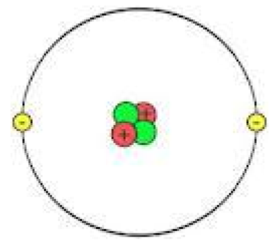
The main subatomic particles of an atom are electrons, protons and neutrons. These subatomic particles have different qualities. The mass of electrons is than proton and neutron. Electrons are negatively charged. Protons are much bigger and bulky than electrons and have positive charge. Neutrons are massive and heavy like protons; however there is no charge on neutrons. Every atom is composed of a variety of these subatomic particles. Let's examine one form of atom i-e hydrogen atom.

A Hydrogen Atom

The figure shows that the hydrogen atom is composed of one proton and one electron. The subatomic particles in an atom are not motionless. The electron is regularly rotating around the center of the atom i-e nucleus. The centrifugal force of the rotating electron keeps the two subatomic particles from touching each other much as the global spinning keeps it from crashing into the sun. Keeping this into account, an atom of any element would seem to be like this:

Atom is incredibly small. The diameter of one hydrogen atom, for example, is approximately $5x10^{-11}$ m. Electron spins very far from the nucleus. In an electronically neutral atom, the positively charged protons are balanced by equal number of electrons. As you have observed that hydrogen is the simplest element with only one proton and one electron. Helium is the second simplest atom in which there are two protons and two electrons revolving around the nucleus. To keep the nucleus from pushing apart, helium has two neutrons in its nucleus. As neutrons have no charge, so atom as a whole is electrically neutral. Neutrons operate like nuclear glue, holding protons, and thus nucleus, together.

Atom of an hydrogen element



Atom of Helium element

A Helium Atom

From the above picture, you can observe that helium is bigger than hydrogen. Addition of electrons, protons and neutrons in an atom increases its size. There are two ways of measuring the size of an atom:

We can evaluate the dimensions of an atom in two ways:

i. using the atomic number (Z) or
ii. using the mass number (A).

3.3.1 Atomic Number (Z) and Mass Number (A)

The Number of protons in an atom is called its atomic number. The arrangement of elements in the modern periodic table is in order of increasing atomic number. In a neutral atom, the number of electrons equal to its atomic number.

The combined number of protons and of neutrons in a particular atom is known its mass number.

With the increase in atomic number, atomic mass always increases. The sequence of elements suggested by Mendeleev was almost exactly the same as the one used today. Although there are a couple of peculiar exceptions. In general, it is acceptable to consider that atoms of elements getting heavier as you go down a column or to the right across a row in the periodic table.

Example

For hydrogen, atomic number (Z) = 1. As the number of electron in an atom is equal to the number of protons therefore hydrogen atom has one electron. Similarly the atomic number (A) of hydrogen atom is 1.

For helium, atomic number (Z) = 2. It shows that there are two electrons in the outer orbits of helium atom. The mass number (A) of helium = 4. It means that there are two protons and two neutrons in helium atom. The atomic number and the mass number of an element (X) can be denoted as follows:

$$^{A}_{Z}\mathbf{X}$$

Thus, helium can be represented as:

$$^{4}_{2}\mathbf{He}$$

3.3.2 Distribution of Electrons in Shell

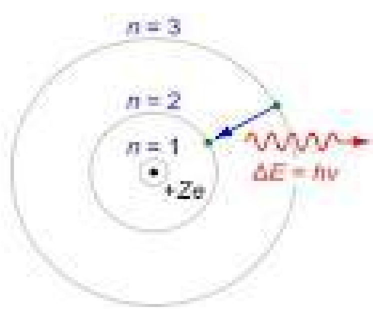
Before you get to know about the distribution of electrons in different shells, you should be familiar with atomic model. Scientists have presented several atomic models but here one of the most famous atomic model is being described.

Bohr's Model of Atom

In 1913, Niels Bohr presented a model. According to atomic model of Bohr, an electron revolves around the nucleus in a well defined circular path. He presented following two main postulates to explain the stability of atom mainly hydrogen atom

(i) An electron can have only a definite circular path around the nucleus with specific energy values. He named **orbit** or **energy level** to this circular path

(ii) Electron may go to next higher energy level (orbit) when given a definite amount of energy. In other words, an electron absorbs energy when it goes to higher energy level from a lower energy level.



On the other side, an electron will emit out a definite amount of energy when it comes from a higher energy level to lower energy level. If E2 is energy of an electron in higher energy level and E1 is energy of electron in lower energy level, then energy released ΔE will be expressed as,

$$\Delta E = E2 - E1$$

$$\Delta E = hv$$

If the electron remains in the same orbit, the energy would neither be released nor absorbed. These orbits, therefore, were called **stationary orbits** or **stationary states**. Although Bohr model could explain a number of aspects related to hydrogen atom but it could not explain stability of atoms having more than one electron. After the nature of electron was studied in detail, it was found that an electron cannot remain in a fixed circular orbit as envisaged by Bohr. Bohr model was rejected on this ground. Based on the nature of electron, concept of circular orbit was modified and a three dimensional shell with definite energy came into existence.

Shells

The shells are similar to circular path/energy levels. These shells are represented by letters *K, L, M, N* etc. Each shell is associated with a definite energy. The energies of these shells go on increasing as we move away from the nucleus. The maximum number of electrons which can be accommodated in each shell is given by $2n^2$, where n can take values 1, 2, 3….etc.

Thus, the first shell can have two electrons whereas the second shell can have 8 electrons. Similarly the maximum number of electrons present in third and fourth shells would be 18 and 32, respectively. Each shell could be further sub-divided into various sublevels of energy called **sub-shells.** These sub-shells are denoted by letters *s, p, d, f,* etc .

Sub Shells

Each shell is consisting of one or more sub shells. Each sub shell is further consists of orbitals. For example, the first (K) shell has one sub shell, known as "1s"; the second (L) shell has two sub shells, known as "2s" and "2p"; the third shell has "3s", "3p", and "3d"; and so on. The various possible sub shells are given in the following table:

Sub Shell Label	ℓ	Maximum Number of Electrons	Shells Containing it	Historical Name
s	0	2	Every shell	Sharp
p	1	6	Second shell & higher	Principal
d	2	10	3rd shell and higher	Diffuse
f	3	14	4th shell and higher	Fundamental
g	4	18	5th shell and higher	(next in alphabet after f)

Number of electrons in each Sub Shell: The shells are filled by electrons according to the following theoretical constraints:

- Each **s** sub shell holds at most 2 electrons
- Each **p** sub shell holds at most 6 electrons
- Each **d** sub shell holds at most 10 electrons
- Each **f** sub shell holds at most 14 electrons
- Each **g** sub shell holds at most 18 electrons

Therefore, the "K" shell, which contains only an "**s**" sub shell, can carry up to 2 electrons; the **"L"** shell, which contains an "**s**" and a "**p**", can carry up to 2+6=8 electrons; and so forth. The general formula for the calculation of electrons in any shell is $2n^2$. The number of electrons in sub shells is according to Aufbau principle.

Electronic configuration of elements

From the above discussions, you are aware that shells of different energies exist in an atom. The electrons occupy these shells according to the increasing order of their energy. You also know that the first shell can have two electrons whereas the second shell can accommodate eight electrons. Keeping these points in mind, let us now study the filling of electrons in various shells of atoms of different elements.

Hydrogen atom has only one electron. Thus electronic configuration of hydrogen can be represented as 1. The next element helium (He) has two electrons in its atom. Since the first shell can accommodate two electrons; hence, this second electron can also be placed in first shell.

The electronic configuration of helium can be represented as 2. The third element, Lithium (Li) has three electrons. Now the two electrons occupy the first shell whereas the third electron goes to the next shell of higher energy level, i.e. second shell. Thus, the electronic configuration of Li is 2, 1. Similarly, the electronic configurations of beryllium (Be) and boron (B) having four and five electrons respectively can be written as follows:

Be - 4 electrons Electronic configuration - 2, 2.
B - 5 electrons Electronic configuration - 2, 3.

The next element carbon (C) has 6 electrons. Now the sixth electron also goes to the second shell which can accommodate eight electrons. Hence, the electronic configuration of carbon can be represented as 2, 4. Similarly, the next element nitrogen having 7 electrons has the electronic configuration 2, 5.

The following table shows the description of different elements.

Element/ Symbol	**No of Electrons**	**Arrangement Electrons in Shell**	**Electron Distribution in Shells & Sub Shells**		**Valences**
Hydrogen, H	1	1 in first shell	1	$1s^1$	1
Helium, He	2	2 in first shell	2	$1S^2$	0
Lithium, Li	3	2 in first shell, + 1 in second shell	2,1	$1S^2$, $2S^1$	1
Beryllium, Be	4	2 in first shell, + 2 in second shell	2,2	$1S^2$, $2S^2$	2
Boron, B	5	2 in first shell + 3	2,3	$1S^2$, $2S^2$,$2P^1$	3

Table: Electronic distribution in shells of first five elements

3.3.3 Valence and Valences

We have just discussed the electronic configuration of six elements. We can see from the above table that electrons are located in different shells around the nucleus. The electrons in the last shell (popularly known as valence shell) determine the chemical properties of the atoms. These electrons are known as valence electrons. Valency or combining capacity of an atom of an element depends on the number of these electrons. You have also seen the valences of different elements along with their electronic configuration in the above table. These electronic configurations are helpful in studying the nature of bonding between various elements.

3.3.4 Isotopes

So far we have only discussed electronically neutral atoms i.e. atoms with no net positive or negative charge on them. Atoms, however, can have positive or negative charge on them by losing or gaining of electrons. Such atoms having positive or negative charge are called ions. Ions may be of two types:

i. **Cation**
   If an atom loses one or more electrons, eventually gets positive charge and is called cation.

ii. **Anion**
   If an atom gains one or more electrons, it attains negative charge and is called the anion.

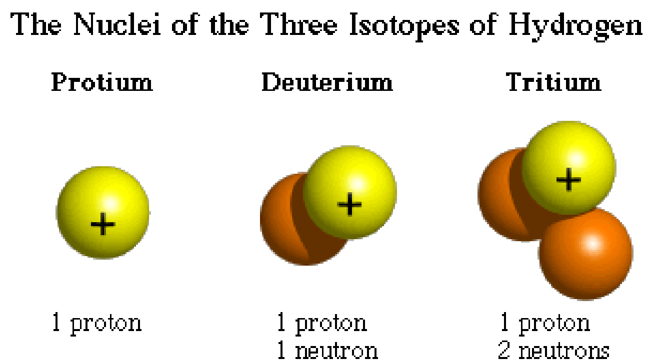
As an example we describe hydrogen atom.

Isotopes are those atoms of an element which have the same atomic numbers but different atomic masses or mass numbers.

For example, an isotope of hydrogen (commonly known as deuterium) contains 1 neutron. Since the atomic number is the number of protons plus neutrons, two isotopes of an element will have different atomic mass but same atomic number, i.e. same number of protons but different number of neutrons as shown in the following figure:

Three Isotopes of Hydrogen

Hydrogen (Protium)	Deuterium	Tritium
Atomic Mass = 1	Atomic Mass = 2	Atomic Mass = 3
Atomic Number = 1	Atomic Number = 1	Atomic No = 1



Atoms of a particular element having different number of neutrons are called isotopes. By definition, the atoms of a particular element must contain the same number of protons but may have a distinct number of neutrons which differs from atom to atom, without changing the designation of the atom as a particular element. The number of nucleons (protons and neutrons) in the nucleus, known as the mass number, is not the same for two isotopes of any element. For example, carbon-12, carbon-13 and carbon-14 are three isotopes of the element carbon with mass numbers 12, 13 and 14 respectively. The atomic number of carbon is 6 (every carbon atom has 6 protons); therefore the neutron numbers in these isotopes are 6, 7 and 8 respectively.

A nuclide is an atom with a specific number of protons and neutrons in the nucleus, for example carbon-13 with 6 protons and 7 neutrons. The nuclide concept (referring to individual nuclear species) emphasizes nuclear properties over chemical properties, while the isotope concept (grouping all atoms of each element) emphasizes chemical over nuclear.

The neutron number has drastic effects on nuclear properties, but its effect on chemical properties is negligible in most elements, and still quite small in the case of the very lightest elements, although it does matter in some circumstances (for hydrogen, the lightest of all elements, the isotope effect is large enough to strongly affect biology). Since isotope is the older term, it is better known than nuclide, and is still sometimes used in contexts where nuclide might be more appropriate, such as nuclear technology and nuclear medicine.

An isotope and/or nuclide is specified by the name of the particular element (this indicates the atomic number implicitly) followed by a hyphen and the mass number (e.g. helium-3, helium-4, carbon-12, carbon-14, uranium-235 and uranium-239).

When a chemical symbol is used, e.g., "C" for carbon, standard notation is to indicate the number of nucleons with a superscript at the upper left of the chemical symbol and to indicate the atomic number with a subscript at the lower left (e.g. $_{2}He^{3}$,$_{2}He^{4}$, $_{6}C^{12}$, $_{6}C^{14}$, $_{92}U^{235}$, $_{92}U^{239}$ respectively). Since the atomic number is implied by the element symbol, it is common to state only the mass number in the superscript and leave out the atomic number subscript (e.g. He^3, He^4, C^{12}, C^{14}, U^{235}, and U^{239}respectively).

Some isotopes are radioactive and are therefore described as radioisotopes or radionuclides, while others have never been observed to undergo radioactive decay and are described as stable isotopes. For example, C^{14} is a radioactive form of carbon while C^{12} and C^{13} are stable isotopes.

Key Points

1. The smallest particle of matter that has specific structure and the same structure is repeated throughout the material is called an atom. Electrons and protons are present in all the atoms. The number of electrons and protons in any neutral atom is always same.
2. Thomson proposed the plum-pudding model of the structure of atom.
3. Rutherford's model of the structure of atom suggested that most of the mass and all of positive charge of an atom is concentrated in its nucleus and the electrons revolve around it.
4. An electron can have only a definite circular path around the nucleus with specific energy values. This circular path is called **orbit** or **energy level.**
5. The neutrons are neutral particles present in the nucleus.
6. Atomic number is the number of protons present in the nucleus of an atom.
7. Mass number gives the number of protons and neutrons present in an atom
8. Isotopes have same atomic number but different mass numbers.
9. Atoms of a particular element having different number of neutrons are called isotopes.
10. Bohr's model gave the idea of definite orbits or stationary states.
11. The electrons occupy various shells in an atom in the increasing order of their energy.
12. The maximum number of electrons which can be accommodated in a shell can be found by formula $2n^2$.
13. There are five sub-shells.

Self Assessment Exercise 3

Q.1 Fill in the blanks.

i. The nucleus consists of ——————and ——— as subatomic particles.
ii. The model which resembled the solar system was proposed by——
iii. Anode rays travel towards—————————— pole.
iv. An electron has —————— charge.
v. The number of electrons in ______________ of an atom refers to its valence number

Q.2 Classify the following statements as true or false.

i. The plum pudding model was proposed by Rutherford.
ii. Cathode is the negatively charged electrode.
iii. Neutrons are constituents of atoms of all elements.
iv. The number of electrons present in a neutral atom is always equal to the number of protons.

Q.3 Multiple choice questions.

i. **An alpha particle has**
- (a) 2 protons only.
- (b) 2 neutrons only
- (c) 2 protons and 2 neutrons
- (d) 2 neutrons

ii. **Isotopes have**
- (a) Same mass number
- (b) Same atomic number
- (c) Different atomic number
- (d) Same mass as well as atomic number

iii. **The mass of a neutron**
- (a) Is less than that of a proton?
- (b) Is greater than that of a proton.
- (c) Is equal to that of a proton.
- (d) Zero

iv. **The filling of second shell starts with**
- (a) He
- (b) Li
- (c) C
- (d) N

v. **The electronic configuration of Cl is**
- (a) 2, 8
- (b) 2, 8, 4
- (c) 2, 8, 6
- (d) 2, 8, 7

vi. **Which of the following elements has completely filled shell?**
- (a) H
- (b) O
- (c) Ne
- (d) Mg

viii. **Which type of orbital looks like a figure-8 when drawn?**
- a) s-orbital
- b) p-orbital
- c) d-orbital
- d) f-orbital

Q.4 Answer the following questions.

1. How can you say that electrons are present in all types of matter?
2. Define an orbit.
3. Calculate the number of neutrons present in $^{19}_{9}F$
4. The mass number of iron is 56. If 30 neutrons present in its atom, what is its atomic number?
5. Which of the following are isotopes?

a. $^{12}_{6}C$

b. $^{14}_{6}C$

c. $^{14}_{7}N$

6. What are stationary states?
7. What will happen to the energy of electron when it goes from an orbit of higher energy to that of a lower energy?
8. What is a shell?
9. How many electrons can be present in a *L*-shell?
10. How many shells are present in the nitrogen atom?
11. Name any two elements which have the completely filled first shell.
12. Write the electronic configuration of an element having atomic number11.

3.4 Elements, Composed & Mixtures

Elements

An element is a pure substance that is made up of only one kind of atoms and cannot be further broken down or subdivided into simpler substances by any physical or chemical means. For example, all atoms of Oxygen are same whereas all the atoms of copper are also alike but they are different from Oxygen in size and other properties. The smallest part of an element retains its properties as it is. Elements are different from one another. An element can be represented by using a symbol. The elements can be distinguished from one another due to their properties. In the world, everything is made up of combination of elements. Up till now, overall 112 elements have been discovered. Out of these 112 elements, ninety (92) elements are found in natural form.

All elements are made up of atoms. The atom is the smallest part of an element that can take part in any chemical change.

Examples of Elements

The symbols C, Ca, Ag, and Na represent the elements carbon, calcium, silver and sodium respectively.

Compounds

A compound is defined as a pure substance made up of two or more types of elements (atoms) chemically combined in a fixed proportion, and it can be further subdivided into simpler substances only by chemical means but not by physical means e.g. if salt and other compounds are dissolved in water and electricity is passed through it, then it can be subdivided into Na and Cl. Compounds have properties that are different from its component elements, and always contains the same ratio of its component atoms.

A molecule is the smallest part of a compound, whose properties are the same as those of the compound. A compound can be represented by a chemical formula.

Characteristic Properties of Compounds:

- Elements in a compound are present in a definite proportion
  Example- 2 atoms of hydrogen + 1 atom of oxygen become 1 molecule of compound-water.
- Compounds have a definite set of properties
  Elements making a compound do not retain their original properties. Example: hydrogen (element, which is combustible and non-supporter of combustion) + oxygen (element, which is non-combustible and supporter of combustion) becomes water (compound, which is non-combustible and non-supporter of combustion)

Examples of Compounds

The chemical formulae H_2O and FeS represent the compounds of water and Ferrous sulfide (Iron sulfide) respectively.

Mixtures

A mixture is defined as an impure substance made up of two or more types of elements (atoms) or compounds or both mechanically mixed in any proportion, and it can be further subdivided into simpler substances by physical (mechanical) means.

The constituents of a mixture retain their original properties. The constituents of a homogenous mixture are uniformly mixed throughout the mixture. The properties and composition of a homogenous mixture are the same throughout the mixture.

The constituents of a heterogeneous mixture are not uniformly mixed throughout the mixture. The properties and composition of a heterogeneous mixture are not the same throughout the mixture. Homogeneous mixture is also known as a solution.

Examples of Mixtures

Stainless steel is a mixture (alloy) of iron, carbon, chromium, and nickel. Carbon gives hardness to the mixture. Chromium and nickel give a silvery look to the mixture. Potassium sulfide solution is a homogenous mixture. A mixture of water and oil is heterogeneous in nature.

Compounds Compared to Mixtures

The physical and chemical properties of compounds are different from those of their constituent elements. This is one of the main criteria for distinguishing a compound from a mixture of elements or other substances because a mixture's properties are generally closely related to and dependent on the properties of its constituents.

Another criterion for distinguishing a compound from a mixture is that the constituents of a mixture can usually be separated by simple, mechanical means such as filtering, evaporation, or use of a magnetic force, but the components of a compound can only be separated by a chemical reaction. Conversely, mixtures can be created by mechanical means alone, but a compound can only be created (either from elements or from other compounds or a combination of the two) by a chemical reaction.

Some mixtures are so intimately combined that they have some properties similar to compounds and may easily be mistaken for compounds. One example is alloys. Alloys are made mechanically, most commonly by heating the constituent metals to a liquid state, mixing them thoroughly, and then cooling the mixture quickly so that the constituents are trapped in the base metal. Other examples of compound-like mixtures include inter-metallic compounds and solutions of alkali metals in a liquid form of ammonia.

Key Points

1. An element is a pure substance that is made up of only one kind of atoms and cannot be further broken down or subdivided into simpler substances by any physical or chemical means.
2. An abbreviation used to write the name of an element is called symbol.
3. The symbols C, O, Fe, S, and Al represent Carbon, Oxygen, Iron, Sulphur and Aluminum.
4. A compound is defined as a pure substance made up of two or more types of elements (atoms) chemically combined in a fixed proportion.
5. When two elements combine in a fixed proportion they lose their identities in a compound.
6. A mixture is defined as an impure substance made up of two or more types of elements (atoms) or compounds or both mechanically mixed in any proportion.
7. The constituents of a mixture retain their original properties.
8. The constituents of a homogenous mixture are uniformly mixed throughout the mixture. The properties and composition of a homogenous mixture are the same throughout the mixture.

Self Assessment Exercise 4

Q.1 Do as directed.

i. Can an element be broken down into a simpler substance?
   a. True
   b. False

ii. What is a compound?
   a. A compound is a substance made up of one kind of mixture.
   b. A compound is a substance made up of one kind of element.
   c. A compound is a substance made up of two or more elements.

iii. What is a mixture?
   a. A mixture is two or more substances combined.
   b. A mixture is two or more elements combined.
   c. A mixture is two or more atoms combined.

iv. Mixtures can be separated. Which of the following represents a way a mixture cannot be separated?
   a. Filtration
   b. Distillation
   c. Heating

v. Which of the following is a compound?
   a. Gold

b. Alcohol
c. Helium.

vi. Are there more compounds or more elements?
a. There are more compounds
b. There are more elements
c. The number of compounds is equal to number of elements

vii. Can compounds be separated?
a. Yes
b. No

viii. Which of the following sets contains only compounds?
a. carbon, gold, water
b. alcohol, salt, sugar
c. hydrogen, oxygen, sulphur
d. coal gas, cooking oil, nitrogen

ix. Which of the following contains only mixtures?
a. seawater, salt, copper
b. blood, air, soil
c. brass, glucose, water
d. household bleach, distilled water, orange juice

x. Which of the following observations about mixtures and compounds is true?
a) Both mixtures and compounds always contain a fixed proportion of elements by mass.
b) Unlike compounds, very little or no exchange of energy occurs during the formation of mixtures.
c) A mixture cannot be easily separated into its constituents while constituents of a compound can be easily separated.
d) Compounds and mixtures can be separated into its constituents by chemical methods.

Q.2 Classify the following substances into elements, compounds and mixtures.
glucose , bronze ,neon, alcohol, calcium, milk, hydrogen, magnesium chloride, potassium nitrate, platinum, sea water, tin, zinc, water, vapour, and bromine

3.5 Chemical Formula

In the previous sections, we have already discussed that compounds are made up of elements. As Symbol is used to represent an element similarly in order to represent a compound, a formula is used. A formula gives us information about the number and kind of atoms in a molecule.

The understanding about structure of an atom and valence shell is necessary for understanding chemical formula. You have read in the previous sections about valence shell. As you know that the outer most shell of an atom is called valence shell. If the number of electrons in a valence shell is 2,8, or 18 (as in case of He, Ne, and Kr),such atoms neither can take nor can give away electrons. In other cases where there is no such situation then atoms try to complete their outer most shells such as 2,8,18 and so on. Atoms try to complete their outermost shells in the following ways.

i. By gaining electrons or losing electrons from their outermost shells.
ii. By sharing electrons and thus gaining noble gas configuration.

When an atom or group of atoms acquire positive or negative charge by losing or gaining electrons, these atoms or group of atoms are called radicals. Atoms having positive charge are called positive radical and atoms or group of atoms having negative charge are called negative radicals. These are the types of radicals on the basis of charges. Another classification of radicals is on the basis of number of atoms. If a radical consists of a single atom of an element, it is called a simple radical. Na^{+1}, Mg^{+2} ,Al^{+3}, C^{+4} 'N^{-3} ,O^{-2} , Cl^{-1} are examples of simple radicals .But if a radical consists of two or more than two atoms of different elements ,then it is called a compound or poly-atomic radical. CO_3^{-2}, NO_3^{-1},

NH_4^{-1}, SO_4^{-2}, HCO_3^{-1} are some of the examples of compound radicals. The positive or negative signs on the right upper corner of atoms or molecules is called the valency of these radicals. Valency is in fact combining capacity of an atom with another atom or group of atoms. An atom which has an unpaired electron and bears no electrical charge is called a free radical. For example H^0, Cl^0 are free radicals.

Definition

A chemical formula or molecular formula is a way of expressing information about the atoms that constitute a particular chemical compound. In order to describe chemical compounds, chemical formulas are used. As a symbol represents the name of an element, the formula represents the name of a chemical compound.

A formula can also be defined as a collection of symbols in a compound. For example Ammonia contains one atom of Nitrogen and three atoms of Hydrogen, so its formula will be NH_3.

Functions of a Formula

The chemical formula recognizes each element present in a compound by its chemical symbol and specifies the number of atoms of each element present in each discrete molecule of that compound.

It also tells the type and ratio of atoms of each element present in a formula.

You can predict the formula of an ionic compound based on the loss and gain of electrons, to reach a noble gas configuration. However, you really can't make that type of prediction with covalent compounds, because they can combine in many ways, and many different possible covalent compounds may result.

Most of the time, you have to know the formula of the molecule you're studying. But you may have several different types of formulas, and each gives a slightly different amount of information. There are several types of chemical formulas that you can use to represent chemical bonds. These include empirical formulas, molecular (or *true*) formulas, and structural formulas

Empirical formula: Just the elements

The *empirical formula* indicates the different types of elements in a molecule and the lowest whole-number ratio of each kind of atom in the molecule. For example, suppose that you have a compound with the empirical formula:

Three different kinds of atoms are in the compound, C, H, and O, and these are in the lowest whole-number ratio of 2 C to 6 H to 1 O. So the actual formula (called the *molecular formula* or *true formul*a) may be any of the following, or another multiple of 2:6:1.
Empirical formula of glucose ($C_6H_{12}O_6$) is CH_2O.

Molecular or True Formula: Inside the Numbers

The *molecular formula*, or *true formula*, tells you the kinds of atoms in the compound and the actual number of each atom.

You may determine, for example, that the following empirical formula is actually the molecular formula, too, meaning that there are actually two carbon atoms, six hydrogen atoms, and one oxygen atom in the compound:

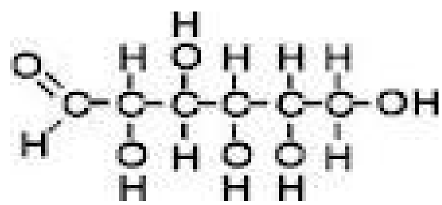
For ionic compounds, this formula is enough to fully identify the compound, but it's not enough to identify covalent formula that stands for the exact compound you have in mind, you often must write the structural formula instead of the molecular formula.
The molecular formula of glucose is $C_6H_{12}O_6$.

Molecular Formula = n x Empirical formula

$$\text{Where, } n = \frac{\text{Molecular mass of a compound}}{\text{Empirical formula mass}}$$

Structural Formula and the Bonding Pattern

The structural formula shows the elements in the compound, the exact number of each atom in the compound, and the bonding pattern for the compound.



Structural formula of Glucose.

How to write a Formula: (Criss Cross Method)

While writing a formula of any compound positive radical is written on the left hand side with its valence number on top and negative radical is written on the right side with its valence number. For example sodium chloride is formed from sodium (Na^{+1}) and chloride (Cl^{-1}).

$$Na^{+1} \rightleftarrows Cl^{-1}$$

$Na_1 Cl_1$

NaCl

Other examples of writing Formulae are as under.

Formula of Water

The steps involved in writing the chemical formula of water are as follows:

A. Write down the elements that make up the compound. The water molecule contains hydrogen and oxygen.

B. Determine the valence no .of each element .The valence no. of hydrogen is 1 and the valence no. of oxygen is 2. This means that oxygen can form two bonds with other elements and each of the hydrogen atoms can form one. Using the valencies of hydrogen and oxygen, we know that in a single water molecule, two hydrogen atoms will combine with one oxygen atom. The chemical formula for water is therefore:

$$H^{+1} \rightleftarrows O^{+2}$$

$$H_2O_1$$

$$H_2O$$

To write chemical formula for magnesium oxide. We will follow the following steps.

Write down the elements that make up the compound. For example, a molecule of magnesium oxide contains the elements magnesium and oxygen. Determine the valency of each element. The valency of magnesium is 2, while the valency of oxygen is also 2. In a molecule of magnesium oxide, one atom of magnesium will combine with one atom of oxygen.

$$Mg^{+2} \quad O^{-2}$$

$$Mg^{+2} \quad O^{-2}$$

$$Mg_2 \quad O_2$$

$$MgO$$

Activity

Make formulae of the following compounds with the help of following Radicals.(Sodium sulphate, Potassium permaganate, Calcium chloride, Ammonium bicarbonate, Magnesium phosphate**)**

Name of Positive Radicals	Symbolic Representations	Name of Negative Radicals	Symbolic Representations
Sodium	Na^{+1}	Oxide	O^{-2}
Potassium	K^{+1}	Sulphate	SO_4^{-2}
Calcium	Ca^{+2}	Nitrate	$NO_3^{-!}$
Aluminum	Al^{+3}	Carbonate	CO_3^{-2}
Hydrogen	H^{+1}	Phosphate	PO_4^{-3}
Ammonium	NH^{+1}	Bicarbonate	HCO_3^{-1}
Magnesium	Mg^{+2}	Permagnate	MnO_4^{-1}

Table 1: Table showing common compound radicals and their formulae

Activity 1

Calculate the valence numbers of and radicals from these formulae. (Potassium bromide, Calcium carbonate, potassium per mangnate, sodium Thiosulphate, Aluminum chloride, Sulphuric acid, Sodium hydroxide, Ferrous sulphate etc)

Key Points

1. A chemical formula is the symbolic representation of a chemical compound.
2. A chemical formula tells the number and kind of atoms of each element present in a compound.
3. There are three types of a chemical Formula; empirical formula, molecular formula and structural formula.
4. Empirical formula tells the simplest ratio between atoms of elements in a Compound.
5. Molecular formula tells the actual number of atoms of each kind in a compound.
6. Structural formula tells the arrangement of atoms and bonds in any chemical compound.
7. Valency of an atom is its combining capacity with other atoms.
8. Molecular formula can be calculated by,
9. Molecular formula = n x Empirical formula

Self Assessment Exercise 5

Q.1 Fill in the blanks with correct answers.

i. The formula of ______________________ is $Na_2 CO_3$.
ii. The___________formula shows the simplest ratio between atoms of the elements.
iii. The atoms which have 8 electrons in outermost orbits are called _________________ elements.
iv. $MnO_4^{-1}$is an example of _____________________ radical.

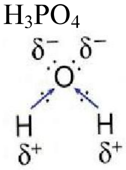
Q.2 Choose the correct answer from the given options.

i. $C_6H_{12} O_6$ is the formulaof Glucose ,what is its empirical formula.

(a). $C_6 H_{12} O_6$ (b) $c_2H_6 O_2$
(c) $CH_2 O$ (d) $C_3 H_2 O$

ii. Correct formula of Phosphoric acid may be ;

(a). $H_3(PO_4)_2$ (b) $H_3(PO_4)_2$
(c) H_3PO_4 (d) $H_{3(}(PO_4)_3$



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iii. This structure is __________ formula of water

(a) Molecular formula (b) Empirical formula
(c) Structural formula (d) Polimer of water

iv. Which of the following elements has three valence electrons?
(a) Lithium (b) Boron
(c) Nitrogen (d) More than one of the above

v. Cations have:
(a) Positive charge (b) Negative charge
(c) No charge (d) It is impossible to predict the charge on a cation.

vi. The chemical name for Fe_2O_3 is:
(a) Iron oxide (b) Iron (II) oxide
(c) Iron (III) oxide (d) Iron (VI) oxide

Q.3 Match the columns.

Name of Chemical compounds	**Chemical Formulae**
Hydrogen cyanide	$NaCO_3$
Carbon dioxide	CO_2
Sodium carbonate	Ba_2SO_4
Ammonium hydroxide	HCN
Barium sulphate	$NH_4\,OH$

Q.4 Answer the following questions:

i. Define Formula, also give examples?
ii. Compare and contrast types of chemical formulae with the help of examples?
iii. Sodium is a simple positive radical, make as many compounds taking different negative or compound radicals with sodium, and write their molecular formulae.
(**Hint;** Sodium,+ Bromide = Sodium bromide.
(Na^{+1} Br^{-1} = NaBr)

3.6 Chemical Reactions

Chemical changes are such changes during which:

i. Compounds loose their original identity
ii. Chemical composition of compound is changed
iii. Formation of new compound occurs
iv. There is either no reversibility or difficulty in reversibility
v. Some portion of the matter would be consumed into energy
vi. Mostly a chemical reaction is related with such changes

You have seen that if you keep iron nails in humid air, after some time there will be rust on them. What happened there? The oxygen present in the air combined with iron; as a result, a brown colored compound (iron oxide) is formed. During this process, iron has lost its original composition and formed into a new compound. In other words, iron has lost its original form. The chemical composition is changed altogether therefore it is a chemical change.

Similarly when electricity is passed into water, the water will be divided into its constituents. This is also a chemical change because water has lost its original identity. Two gases, hydrogen and oxygen are produced as a result of this. The chemical arrangement of these gases is entirely different from water. There is difficulty for the recombination of these gases.

If you light a candle, it will be converted into carbon, water and gas. This is also a chemical change because the candle will loose its identity. New compounds will be formed whose chemical composition will be different from composition of candle. It will be not possible to join these gases and carbon to remake a candle again from the products.

The chemical changes are related with chemical properties. Here are some chemical changes and there are certain chemical properties associated with them.

Chemical Change	Action	Chemical Properties
To make an oxide with the combination of	Sulpur + oxygen	Dioxide oxidation
Yeast raise decay of things	Milk sour	Fermentation
Corrosion	Rusting of iron	Rusting
Electrically passage from solution	Passage of electricity from water	Electrolysis

Therefore in chemistry, a reaction happens when two or more molecules interact and something happens. A **chemical reaction** is a process that leads to the transformation of one set of chemical substances to another. Chemical reactions can be either spontaneous, requiring no input of energy, or non-spontaneous, typically following the input of some type of energy, such as heat, light or electricity.

There are certain questions: What molecules are they? How do they interact? What happens? Those are all the possibilities in reactions. The possibilities are infinite. There are a few key points you should know about chemical reactions.

1. A chemical change must occur. You start with one compound and turn it into another. That's an example of a chemical change. A steel garbage can rusting is a chemical reaction. That rusting happens because the iron (Fe) in the metal combines with oxygen (O_2) in the atmosphere. When a refrigerator or air conditioner cools the air, there is no reaction. That change in temperature is a physical change. Nevertheless, a chemical reaction can happen inside of the air conditioner.
2. A reaction could include ions, molecules, or pure atoms. We said molecules in the previous paragraph, but a reaction can happen with anything, just as long as a chemical change occurs (not a physical one). If you put pure hydrogen gas (H_2) and pure oxygen gas in a room, they can be involved in a reaction. The slow rate of reaction will have the atoms bonding to form water very slowly. If you were to add a spark, those gases would create a reaction that would result in a huge explosion. Chemists would call that spark a catalyst.
3. Single reactions often happen as part of a larger series of reactions. Take something as simple as moving your arm. The contraction of that muscle requires sugar for energy. Those sugars need to be metabolized. You'll find that proteins need to move in a certain way to make the muscle contract. A whole series (hundreds actually) of different reactions are needed to make that simple movement happen.

All chemical reactions can be placed into one of six categories. Here they are, in no particular order:

1) Combustion: A combustion reaction is when oxygen combines with another compound to form water and carbon dioxide. These reactions are exothermic, meaning they produce heat. An example of this kind of reaction is the burning of naphthalene:

$$\mathbf{C_{10}H_8 + 12\ O_2 \text{ ---> } 10\ CO_2 + 4\ H_2O}$$

2) Synthesis: A synthesis reaction is when two or more simple compounds combine to form a more complicated one. These reactions come in the general form of:

$$\mathbf{A + B \text{ ---> } AB}$$

One example of a synthesis reaction is the combination of iron and sulfur to form iron (II) sulfide:

$$\mathbf{8\ Fe + S_8 \text{ ---> } 8\ FeS}$$

3) Decomposition: A decomposition reaction is the opposite of a synthesis reaction - a complex molecule breaks down to make simpler ones. These reactions come in the general form:

$$\mathbf{AB \text{ ---> } A + B}$$

One example of a decomposition reaction is the electrolysis of water to make oxygen and hydrogen gas:

$$2\ H_2O \text{ ---> } 2\ H_2 + O_2$$

4) **Single displacement:** This is when one element trades places with another element in a compound. These reactions come in the general form of:

A + BC ---> AC + B

One example of a single displacement reaction is when magnesium replaces hydrogen in water to make magnesium hydroxide and hydrogen gas:

$$Mg + 2\ H_2O \text{ --->} Mg(OH)_2 + H_2$$

5) **Double displacement:** This is when the anions and cations of two different molecules switch places, forming two entirely different compounds. These reactions are in the general form:

AB + CD ---> AD + CB

One example of a double displacement reaction is the reaction of lead (II) nitrate with potassium iodide to form lead (II) iodide and potassium nitrate:

$$Pb(NO_3)_2 + 2\ KI \text{ ---> } PbI_2 + 2\ KNO_3$$

6) **Acid-base:** This is a special kind of double displacement reaction that takes place when an acid and base react with each other. The H^+ ion in the acid reacts with the OH^- ion in the base, causing the formation of water. Generally, the product of this reaction is some ionic salt and water:

$$HA + BOH \text{ ---> } H_2O + BA$$

One example of an acid-base reaction is the reaction of hydrobromic acid (HBr) with sodium hydroxide:

$$HBr + NaOH \text{ --->} NaBr + H_2O$$

Key Points

1. When two or more molecules interact and something happens. A **chemical reaction** is a process that leads to the transformation of one set of chemical substances to another.
2. When oxygen combines with another compound to form water and carbon dioxide. This reaction is called combustion.
3. When two atoms or compounds combine to form a single compound, this is called a synthesis reaction.
4. When a single compound is broken down to give two or more than two substances, this type of reaction is known as decomposition.
5. When a more electronegative element or atom displaces less electronegative atom from a compound, this type of reaction is called single displacement reaction.
6. When ions of two compounds are exchanged giving entirely different compounds. This is called double displacement reaction.
7. When an acid react with base, water and salt is formed. This type of reaction is called neutralization reaction.
8. When a reaction is taking place and heat is evolved during this reaction, this reaction is called exothermic reaction.
9. When heat is absorbed during any reaction .this is called endothermic reaction.

Self Assessment Exercise 6

Q.1 Answer the following questions:

i. Define a chemical reaction and write the names of types of reactions.

Q.2 How displacement and double displacement reactions are different .Explain your answer with the help of reactions equations.

Q.3 What type of reactions photosynthesis and respiration are? Give their types and write their chemical equations.

Q.4 Choose the correct answer from the given options.

i. $HCl + NaOH \dashrightarrow NaCl + H_2O$ is a reaction of type.

a. Combustion. b. Displacement.
c. Double displacement d. Synthesis.

ii. In exothermic reaction heat energy is

a. Absorbed. b. Evolved.
c. Remains constant. d. No answer

iii. A chemical reaction is certainly

a. Chemical change. b. Physical change.
c. No change d. Simple mixing of molecules.

iv. Reactions mostly and very often require heat.

a) Decomposition reactions b) Neutralization
c) Exothermic reactions. d) Combustion reactions.

v. In combustion reactions one of the elements is

a) Nitrogen b) Oxygen
c) Hydrogen d) Sulpher

vi. The equation $C_6 H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O$ which type of reaction

a) Decomposition reaction b) Oxidation /Combustion
c) Displacement d) Synthesis reaction.

vii. The equation $CaO + H_2O \longrightarrow Ca(OH)_2$ is a type of reaction.

a) Exothermic b) Endothermic
c) Reduction d) Oxidation

3.7 Acid, Base and Neutralizations

ACID

The word acid is derived from Latinacidus / acēre which means sour. Acids are sour in taste. Acids react with some metals to produce H_2. Acids carbonate salts releasing CO_2.

It is a substance which reacts with a base. Usually, acids can be known as tasting sour, reacting with bases like sodium carbonate and metals like calcium. Aqueous acids have less than 7 pH, where an acid of lower pH is typically stronger, and it turns blue litmus paper into red. Such substances or chemicals containing the property of an acid are called to be acidic.

Examples:

i. Tartaric acid which is used in baking,
ii. Sulphuric acid which is used in car batteries,
iii. Acetic acid present in vinegar.

These three examples illustrate that acids can be solutions, liquids, or solids. In addition to it, gases like hydrogen chloride can be acids too. Strong acids and some concentrated weak acids are corrosive, but there are exceptions such as carboranes and boric acid.

There are three common definitions for acids:

i. The Arrhenius definition: it states that acids are substances which increase the concentration of hydronium ions ($H_3O^{\pm}$) in solution.
ii. The Brønsted-Lowry definition: His definition is an expansion: an acid is a substance which can act as a proton donor. By the Brønsted-Lowry definition, any compound which can easily be deprotonated can be considered an acid. Examples include alcohols and amines which contain O-H or N-H fragments.
iii. And the Lewis definition. An acid is a substance which can accept a pair of electrons.

The majority of acids we encounter in our everyday lives is aqueous solutions, or can be dissolved in water, and these two definitions are most relevant. The reason why pHs of acids are less than 7 is that the concentration of hydronium ions is greater than 10^{-7} moles per liter. Since pH is defined as the negative logarithm of the concentration of hydronium ions, acids thus have pHs of less than 7.

Strong Acids (strong electrolytes)

HCl hydrochloric acid
HNO_3 nitric acid
$HClO_4$ perchloric acid
H_2SO_4 sulfuric acid

Weak Acids (weak electrolytes)

CH_3COOH acetic acid
H_2CO_3 carbonic

Bases

In chemistry, a base is a substance that can accept hydrogen ions (protons) or more generally, donate electron pairs. Bases are bitter in taste. These turn red litmus into blue. These are slippery to the touch.

A soluble base is considered as an alkali if it contains and releases hydroxide ions (OH^-) quantitatively.

According to Brønsted-Lowry theory, bases are proton (hydrogen ion) acceptors, while the more general Lewis theory defines bases as electron pair donors, allowing other Lewis acids than protons to be included.

According to oldest Arrhenius theory, bases are hydroxide anions, which is strictly applicable only to alkali. In water, by altering the auto-ionization equilibrium, bases give solutions with a hydrogen ion activity lower than that of pure water, i.e. a pH higher than 7.0 at standard conditions. Examples of common bases are sodium hydroxide and ammonia. Metal oxides, hydroxides and especially alkoxides are basic, and counter anions of weak acids are weak bases.

Strong Bases (strong electrolytes)

NaOH	sodium hydroxide
KOH	potassium hydroxide
$Ca(OH)_2$	calcium hydroxide

Weak Base (weak electrolyte)

NH_3 (ammonia)

Neutrilization

Bases can be considered as the chemically opposite of acids. Neutralization is a process between acid and base. Acids are considered as opposites because the effect of an acid is to increase the hydronium ion (H_3O^+) concentration in water. Whereas bases reduce this concentration.

Bases and acids are typically present in aqueous solution forms. Aqueous solutions of bases react with aqueous solutions of acids to produce water and salts in aqueous solutions in which the salts separate into their component ions. If the aqueous solution is a saturated solution with respect to a given salt solute any additional such salt present in the solution will result in formation of a precipitate of the salt.

Neutralization Reactions

Acid + Base → Salt + Water

When an acid like HClis combined with a base like NaOH, following reaction occurs:

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

When an acid and a base are combined, water and salt are the products.

Salts are ionic compounds having a positive ion other than H^+ and a negative ion other than the hydroxide ion, OH^-

Double displacement reactions of this type are called “neutralization reactions”.

When a strong acid and a strong base are combined inproper amounts, where $[H^+]$ equals $[OH^-]$, a neutral solution results in which ph=7.

The acid and base neutralize each other, and the acidic and basic properties are no more present.

Key Points

1. Acids are Sour in taste. Acids react with some metals to produce H_2. Acids carbonate salts releasing CO_2.
2. Aqueous acids have less than 7 pH, where an acid of lower pH is typically stronger, and it turns blue litmus paper into red.
3. Arrhenius defines acid as a species which gives hydrogen ion in aquous solution and increase the concentration of hrdronium ions in solution.
4. Brønsted-Lowry defines an acid as a substance which can act as a proton donor. By the Brønsted-Lowry definition, any compound which can easily be deprotonated can be considered an acid
5. According to Lewis an acid is a substance which can accept a pair of electrons.
6. Strong acids are also strong electrolytes, whereas weak acids are weak electrolytes.
7. HCl (hydrochloric acid), HNO_3 (nitric acid), $HClO_4$ (perchloric acid) and H_2SO_4 (sulphuric acid) are examples of strong acids.
8. CH_3COOH (acetic acid), H_2CO_3 (carbonic acid) are examples of weak acids.
9. Base are those substances which are bitter in taste, turns red litmus into blue, and are slippery when touched.
10. All soluble bases are called alkalies, but all bases are not alkalies.
11. According to Brønsted-Lowry theory, bases are proton (hydrogen ion) acceptors, while the more general Lewis theory defines bases as electron pair donors.
12. Strong bases in alkali form are strong electrolytes whereas weak alkalies are weak electrolytes.
13. Sodium hydroxide, potassium hydroxide and calcium hydroxide are examples of strong bases, while ammonia and soap are examples of weak bases.
14. Acids neutralize the effects of bases.
15. When acids react with bases, salt and water is formed .This process is called neutralization.

Self Assessment Exercise 7

Q.1 Choose the best answer:

i. Which of the following is not an acid?

a) HNO_3 b) CH_3COOH
c) H_2SO_4 d) NaoH

ii. If a solution conducts electricity, it is probably:

a) An acid b) A base
c) Neutral d) Both a and b

iii. If a compound has a pH of 6.5, it has a POH of:

a) 6.5 b) 7.5
c) 3.16×10^{-7} d) 3.16×10^{-8}

iv. Water contains more H^+ ions than OH^- ions. In this case, water is
   a) Neutral
   b) Basic
   c) Acidic
   d) Cannot say

v. When an acid reacts with a base what compounds are formed?
   a) Water only
   b) Metal oxides only
   c) A salt only
   d) A salt and water

Q.2 Answer the following questions

i. Write examples of strong acids and strong bases.
ii. Predict what will happen when an acid combines with a base.
iii. Define acids and bases according to Arrhenius and Lewis.
iv. Elaborate application of acids and bases in our daily life.

3.8 Balancing the Chemical Equation

When elements or compounds are combined, a chemical reaction takes place. In order to represent this reaction in simpler form, a chemical equation is used. Achemical equation describes what happens in a chemical reaction.

The equation identifies the reactants (starting materials) and products (resulting substance), the formulas of the participants, the phases of the participants (solid, liquid, gas), and the amount of each substance.

While writing a chemical equation normally reactants are placed on the left side and product is place at the right side. There is an arrow between them which shows the direction of reaction e.g. The chemical equation of the chemical reaction of silver nitrate and sodium chloride is as follows:

$$Nacl + AgNO_3 \rightarrow AgCl + NaNO_3$$

- Chemical equations are used to graphically illustrate chemical reactions. These consist of chemical or structural formulas of the reactants on the left side of the arrow and those of the products on the right side. They are separated by an arrow (→) which indicates the direction and type of the reaction. The tip of the arrow points in the direction in which the reaction proceeds. There are certain reactions in which products react again and they make reactants again. Such reactants are known as reversible reactions. The two half arrows in opposite directions are used for such reactions. Whereas a double arrow (⟷) pointing in opposite directions is used for equilibrium reactions.

Equations should be balanced according to the stoichiometry, the number of atoms of each species should be the same on both sides of the equation.

1. Chemical Reactions

Chemical reactions are like a 'dance'. The people starting the dance are called **reactants.** The number of people on the dance floor remains the same. During the dance people change partners and form new groups called **products.** This is what happens in a chemical reaction. Atoms swap with one another and produce new chemicals.

Old chemicals (reactants) rearrange to produce new chemicals (products)
Reactants → Products
The arrow means 'produces'

In a chemical reaction atoms are rearranged as old chemical bonds are broken and new chemical bonds are formed. The 'law of conservation of mass' is supported as the weight doesn't change between the mass of the reactants and the mass of the products.

Balancing the Equation of Chemical Reaction

Balancing a chemical equation refers to establishing the mathematical relationship between the quantity of reactants and products. The quantities are expressed as grams or moles. It takes practice to be able to write balanced equations. There are essentially three steps to the process:

1. **Write the unbalanced equation.**
   - Chemical formulas of reactants are listed on the left-hand side of the equation.
   - Products are listed on the right-hand side of the equation.
   - Reactants and products are separated by putting an arrow between them to show the direction of the reaction. Reactions at equilibrium will have arrows facing both directions.

2. **Balance the equation.**
   - Apply the Law of Conservation of Mass to get the same number of atoms of every element on each side of the equation. Tip: Start by balancing an element that appears in only *one* reactant and product.
   - Once one element is balanced, proceed to balance another, and another, until all elements are balanced.
   - Balance chemical formulas by placing coefficients in front of them. Do not add subscripts, because this will change the formulas.

3. **Indicate the states of matter of the reactants and products.**
   - Use (g) for gaseous substances.
   - Use (s) for solids.
   - Use (l) for liquids.
   - Use (aq) for species in solution in water.
   - Write the state of matter immediately following the formula of the substance it describes.

Worked Example Problem

Tin oxide is heated with hydrogen gas to form tin metal and water vapour. Write the balanced equation that describes this reaction.

1. **Write the unbalanced equation.**
   $SnO_2 + H_2 \rightarrow Sn + H_2O$

2. **Balance the equation.**
   Look at the equation and see which elements are not balanced. In this case, there are two oxygen atoms on the left-hand side of the equation and only one on the right-hand side. Correct this by putting a coefficient of 2 in front of water:
   $SnO_2 + H_2 \rightarrow Sn + 2\ H_2O$

This puts the hydrogen atoms out of balance. Now there are two hydrogen atoms on the left and four hydrogen atoms on the right. To get four hydrogen atoms on the right, add a coefficient of2 for the hydrogen gas. Remember, coefficients are multipliers, so if we write 2 H_2O it denotes;

2x2=4 hydrogen atoms and 2x1=2 oxygen atoms.
$SnO_2 + 2\ H_2 \rightarrow Sn + 2\ H_2O$

The equation is now balanced. Be sure to double-check your math. Each side of the equation has 1 atom of Sn, 2 atoms of O, and 4 atoms of H.

3. Indicate the physical states of the reactants and products.

To do this, you need to be familiar with the properties of various compounds or you need to be told what the phases are for the chemicals in the reaction. Oxides are solids, hydrogen forms adiatomic gas, tin is a solid, and the term 'water vapour' indicates that water is in the gas phase:
$SnO_2(s) + 2\ H_2\,(g) \rightarrow Sn(s) + 2\ H_2O(g)$
This is the balanced equation for the reaction.

Key Points

1. Chemical equations are used to graphically illustrate chemical reactions.
2. The compounds or elements which react with each other are called reactants.
3. The reactants are often written on left side of the arrow.
4. The compounds or atoms which are formed as a result of reaction are called products.
5. A double arrow ($\longleftrightarrow$ pointing in opposite directions is used for equilibrium reactions.
6. During a chemical reaction, older bonds are broken down and new bonds are formed.
7. A balanced chemical equation tells the type and number of elements taking part in a reaction.
8. There are two common methods of balancing the chemical equation, a). Hit and trial method and b). ion exchange method.

Self Assessment Exercise 8

Q.1 Answer the following questions:

i. Define a chemical equation.
ii. How a chemical equation is balanced, explain your answer with the help of an example?
iii. Write steps of balancing equation by Oxidation number method.

Q.2 Balance the following equations.

i. $NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$
ii. $KClO_3KCl + O_2 \longrightarrow$
iii. $N_2 + H_2 \longrightarrow NH_3$
iv. $NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + NH_3 + H_2O$
v. $C_8H_{18} + O_2 \longrightarrow CO_2 + H_2O$
vi. $N_2H_4 + N_2O_4 \longrightarrow N_2 + H_2O$
vii. $Al + S \longrightarrow Al_2S_3$
viii. $FeS_2 + O_2 \longrightarrow Fe_2O_3 + SO_2$
ix. $CO + H_2 \longrightarrow CH_3OH$
x. $Fe + H_2O \longrightarrow Fe_3O_4 + H_2$
xi. $NH_3 + CO_2 \longrightarrow CO(NH_2)_2 + H_2O$
xii. $KNO_3 + H_2SO_4 \longrightarrow HNO_3 + K_2SO_4$
xiii. $HCl + CaCO_3 \longrightarrow CaCl_2 + H_2O + CO_2$
xiv. $HCl + Zn \longrightarrow ZnCl_2 + H_2$
xv. $Cu_2S + O_2 \longrightarrow Cu_2O + SO_2$
xvi. Zn + O2 →
xvii. Ca + HNO3 →
xviii. SrCl2 (aq) + AgNO3(aq) →
xix. C3H6O + O2 (g) →

3.9 Metals and Non Metals

Metals

Metals are those substances which are electropositive in nature i.e., they have a tendency to lose electrons. Generally there are 1, 2, or 3 electrons in their outmost shell. On the periodic table, a zig-zag line separates metals from nonmetals.

Physical Properties of metals

Physical state: Generally these are solids except mercury which is a liquid at room temperature.
lustrous: metals have shiny luster which is known as "metallic luster"
Sonorous: while striking on hard surface, they generally produce a sound.
Malleability: Some metals can be flattened into thin sheets. Gold and silver are most malleable.
Ductility: it is the ability of metals to be drawn into thin wires. Gold is the most ductile metal
Electrical conductivity: metals are good conductors of electricity. Silver and copper are the best conductors.
Thermal conductivity: metals are good conductors of heat. Silver and copper are the best conductors whereas lead and mercury are poor conductors.
Hardness: generally these are hard. Alkali metals like sodium, potassium are exceptions.
Melting point: Generally metals have high melting points. The exceptions are gallium, alkali metals like sodium, potassium. If you will put Gallium and caesium on your palm, these will melt.
Densities: Generally metals have less densities

Chemical Properties of metals

- The number of electrons in the outmost shell ranges 1-3.
- Metals can be easily corroded.
- Metals easily lose electrons.
- Metals form oxides that are basic.
- Metals have lower electro negativities.
- Metals are good reducing agents.

Non-metals

These substances are electronegative in nature, i.e. they have a tendency to gain electrons. Generally, there are 4 to 8 electrons in their outmost shell.

Physical Properties of non metals

Physical state: Generally these are either solids or gases except Bromine which is liquid.
Lustrous: Non-metals do not have shiny luster except iodine and graphite.
Sonorous: non-metals are non sonorous.
Malleability: these are not malleable.

Ductility: these are not ductile.
Electrical conductivity: Generally these are not good conductors of electricity except Graphite.
Thermal conductivity: non-metals are poor conductors of heat.
Ha**rdness:** Generally these are soft except diamond which is known as the hardest substance.
Melting point: Generally non-metals have low melting points.
Densities: Generally non metals have low densities

Chemical Properties of Non-metals

- Generally there are 4-8 electrons in the out most shell of non-metals.
- Non-metals willingly gain or share their valence electrons
- Non-metals form oxides that are acidic
- Non-metals have higher electro negativities
- Non-metals are good oxidizing agents

Metalloids

There are 92 elements which occur naturally. Out of these 70 elements are metals while 22 are non-metals. There are certain elements which have intermediate properties of both metals and non metals. Such elements are called metalloids.

Occurrence of metals and nonmetals

Only a few metals are present in the Free State e.g like silver, gold, platinum etc. The majority of metals are found in the collective states as sulphides, silicates, oxides, carbonates, etc.

A few non-metals are present in the free State like neon, helium, argon etc. While some are present in free and combined states like phosphorus, sulphur etc.

Metallurgy

It is science of drawing out of metals from their ores and their refinement.

Ore

It is a mineral from which one or more metals can be taken out profitably.

Minerals

These are naturally occurring substances having one or more elements or their compounds.

Metallurgical processes

This process consists of three major steps. These are as follows:

i. Concentration of the ore
ii. Reduction
iii. Refining

The detail of these steps is as follows:

i. Concentration of the ore is the elimination of impurities from the ore.
ii. Reduction is the process of getting the metal from its compound.
iii. Refining is the process of purifying the impure metals in order to obtain the pure metal.

Chemical Reactions of Metals and Non-metals

a) Reaction with oxygen

When metals react with oxygen these are formed into metallic oxides. The oxides formed are basic oxides because they react with water to form bases.

Example: When Sulphur burns in air ,it is formed into Sulphur-di-oxide. Sulphur-di-oxide reacts with water to form sulphurous acid.

$$S + O_2 \rightarrow SO_2$$
$$SO_2 + H_2O \rightarrow H_2\,SO_3$$

Magnesium burns in air to form magnesium oxide and magnesium reacts with water to form magnesium hydroxide.

$$2\,Mg + O_2 \rightarrow 2\,MgO$$
$$MgO + H_2O \rightarrow Mg\,(OH)^2$$

When non-metals react with oxygen these are formed into non-metallic oxides. The oxides formed are acidic oxides because they react with water to form acids.

b) Metals Replace Metals

When a more reactive metal react it replaces a less reactive metal from its salt solution.
Example: Iron replaces copper from copper sulphate solution to form iron sulphate and copper

$$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$$

Magnesium replaces copper from copper sulphate solution to form magnesium sulphate and copper.

$$Mg + CuSO_4 \rightarrow MgSO_4 + Cu$$

Zinc replaces copper from copper sulphate solution to for zinc sulphate and copper.

$$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$$

Based on the reactivity of metals, they can be arranged in the decreasing order of their activity.

c) Reaction with Water

When metals react with water these form metal hydroxides and hydrogen.
Example: When Magnesium reacts with water it is formed into magnesium hydroxide and hydrogen.

$$Mg + H_2O \rightarrow Mg\,(OH)^2 + H^2$$

When Sodium reacts with water it is formed into sodium hydroxide and hydrogen.

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

Non metals do not react with water.

d) Reaction with Acids

When metals react with acids these are formed into metallic salts and hydrogen.

Example: When Zinc reacts with dilute hydrochloric acid it is formed into zinc chloride and hydrogen.

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

Most of the non metals do not react with acids.

A few non metals like sulphur reacts when reacts with concentrated nitric acid, it is formed into sulphur dioxide, nitrogen dioxide and water.

$$S + 4\ HNO_3 \rightarrow SO_2 + 4\ NO_2 + 2\ H_2O$$

e) Noble Metals

The metals which retain their luster because they do not react with water, air, or acids are called noble metals e.g. silver, gold, platinum etc. gold dissolves in aqua regia. Aqua regia is a mixture of concentrated nitric acid and concentrated hydrochloric acid in 1:3 ratios.

Pure gold is 24 carat. It is very soft and cannot be used for ornaments making, therefore it is combined with some silver or copper to make it hard.

f) Uses of Metals

There are many uses of metals. A few are discussed below:

Aluminum: It is used for making parts of aircrafts, utensils, furniture, wires, vehicles, machines, for packing medicines and food etc.

Iron: It is used for making pins, nuts, bolts, nails, tools, construction of buildings, machines, bridges etc.

Copper: It is used for making vessels, gadgets, wires, electric etc.

Platinum: It is used for making jewellery, electric gadgets, and plugs in vehicles etc.
Gold: It is used for making coins medals, jewellery, etc
Sodium: It is used as compounds e.g. common salt, chemicals etc.
Calcium: It is used as compounds for making cement, glass etc.
Silver: It is used for making jewellery, Coins, medals etc.

g) Uses of Non-metals

Oxygen: It is used for burning of fuels and used by respiration by living things, etc.
Sulphur: It is used for making sulphuric acid, salts of metals etc.

Nitrogen:	It is used for making ammonia which is used for making fertilizers.
Chlorine:	It is used to kill germs in water.
Hydrogen:	It is used for making ammonia which is used for making fertilizers, as fuel in rockets, for welding etc.
Iodine:	It is used as tincture iodine which is an antiseptic

h) Corrosion

It is a process in which the surface of some metals get corroded when are exposed to moist air.

i) Prevention from Corrosion of Metals:

Metals can be prevented from corrosion by:

i) Applying paint

ii) Applying oil or grease.

iii) Alloying (when iron is alloyed with chromium and nickel, it forms stainless steel which is resistant to corrosion)

iv) Galvanization (it is the process of coating the metals with non corrosive metals like zinc)

v) Electroplating (it is process in which metals are coated with non corrosive metals like chromium tin by passing electricity)

Key Points

1. Metals are those substances which are electropositive in nature\
2. Nonmetals substances are electronegative in nature.
3. The metals which retain their luster because they do not react with water, air, or acids are called noble metals.
4. Metallurgy is science of drawing out of metals from their ores and their refinement.
5. Ore is a mineral from which one or more metals can be taken out profitably.
6. Minerals are naturally occurring substances having one or more elements or their compounds.
7. Corrosion is processes in which the surface of some metals gets corroded when are exposed to moist air.
8. Galvanization is the process of coating the metals with non corrosive metals like zinc.
9. Electroplating is process in which metals are coated with non corrosive metals like chromium tin by passing electricity.

Self Assessment Exercise 9

Q.1 Choose the best

i. Of these, the most ductile metal is ___________.
   1. Al
   2. Au
   3. Cu
   4. Ag

ii. Of these, the least dense metal is ___________.
   1. Hg
   2. Au
   3. Cu
   4. Na

iii. Of these, the most reactive metal is ___________.
   1. Fe
   2. Zn
   3. Al
   4. K

iv. Which of the following is displaced by 'Cu'?
   1. Fe^{2+}
   2. Ag^{+}
   3. Zn^{2+}
   4. Al^{3+}

v. Which of the following metals does not displace H_2 gas from dilute HCI or dilute H_2So_4?
1. Mg
2. Cu
3. Zn
4. Al

vi. The metal reacting readily with cold water is ____________.
1. Au
2. Ag
3. Na
4. Mg

vii. Of these, which metal will lose electrons most readily and form cations?
1. K
2. Zn
3. Cu
4. Au

viii. Of these, which ion will get reduced most readily?
1. K^+
2. Zn^{2+}
3. Cu^{2+}
4. Ag^+

ix. Of these, the metal which occurs in a free state is ____________.
1. Na
2. Mg
3. Zn
4. Pt

x. Which of the following metals is extracted only by electrolysis?
1. Zn
2. Al
3. Fe
4. Cu

xi. Which oxide of a metal gets reduced only by coke and not by H_2 gas or CO gas?
1. Fe_2O_3
2. PbO
3. ZnO
4. Cuo

Answers to Self Assessment Questions

Answers of SAQ .1

Q.1:	i.	Occupies space	ii.	Positive, No
	iii.	Two up and one down.		
Q.2:	i.	c.	ii.	d.
	iii.	b.	iv.	d.
	v.	d.	vi.	a.

Q.3 Please consult topic 3.1 for Q.3; I, ii. Iii.

Answers of SAQ.2:

Q.1:	i.	Velocity and motion.	ii.	Behaviour.
	iii.	Attractive forces.	iv.	The forces of attraction.
Q.2:	i.	d.	ii.	a.
	iii.	c.	iv.	a.
	v.	b.	vi.	b.

Q.3: Consult topic 3.2 for part I and ii.

Answers of SAQ.3:

Q.1:	i.	Protons, Neutrons	ii.	Neil Bohr.
	iii.	Negative Pole	iv.	Negative
	v.	Outer most shell		
Q.2:	i	True	ii.	True
	iii.	False.	iv.	True.
Q.3.	i.	c.	ii.	b.
	iii.	b.	iv.	b.
	v.	d.	vi.	c.
	vii.	b.	viii.	b.

Q.4 Consult topic 3.3 for q:4.

Answers of SAQ.4:

Q.1	i.	False	ii.	c.
	iii.	a.	iv.	a.
	v.	b.	vi.	a.
	vii.	No,	viii.	b.
	ix.	b.	x.	b.

Q.2 c, m, e, c, e, m, e, c, c, e, m, e, e, c, c, e..

Answers of SAQ.5:

Q.1	i.	Washing soda,	ii.	Empirical formula
	iii.	Noble gas elements	iv.	Molecular radical.
Q.2	i.	c.	ii.	c.
	iii.	c.	iv.	b.
	v.	a.	vi.	c.

Q.3. (Hydrogen Cyanide= HCN)
(Carbon dioxide = CO_2)
(SodiumCarbonate = Na_2CO_3),
(Ammonium Hydrooxide= NH_4 OH)
(Barium Sulphate = Ba_2 SO_4)..

Q.4. Consult topic 3.5 for questions i to iii.

Answers of SAQ.6:

Q.1.
- i. c.
- ii. b.
- iii. a.
- iv. a.
- v. b.
- vi. b.
- vii. d.

Q.2. Consult Topic 3.6

Answers of SAQ.7:

Q.1
- i. d.
- ii. d.
- iii. b.
- iv. c.
- v. d.

For question 2, consult the relevant section.

Answers of SAQ.8:

For question 1 and 2, see the relevant section

Answer of SAQ.9:

i. 2
ii. 4
iii. 4
iv. 2
v. 2
vi. 3
vii. 1
viii. 4
ix. 4
x. 2
xi. 3

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