

CHEMICAL REACTIVITY

CONCEPTUAL LINKAGE

Before reading this chapter, the student must know the:

- Symbols of Elements
- Writing equations

TIME ALLOCATION

Teaching periods	= 07
Assessment periods	= 02
Weightage	= 06%



LEARNING OUTCOMES

After reading this chapter, the Student will be able to:

- Show how cation and anions are related to the terms metals and non-metals. (Applying)
- Explain why alkali metals are not found in free state in nature. (Analyzing)
- Identify elements as an alkali metals or an alkaline earth metal. (Applying)
- Explain the difference in ionization energies of alkali and alkaline earth metals. (Understanding)
- Describe the position of sodium and magnesium in periodic table, their simple uses and properties. (Understanding)
- Differentiate between soft and hard metals. (Analyzing)
- Describe the inertness of noble metals. (Understanding)
- Identify the commercial value of Silver, Gold and Platinum. (Analyzing)
- Compile some important reactions of halogens. (Applying)
- Name some elements, which are found in uncombined state in nature. (Understanding)

8.0 Introduction to Chemical Reactivity

The chemical reactivity of a substance is the ability of that substance to undergo chemical changes. During chemical reactions, the molecules or atoms come close to each other and linked through bonds to form a new compound, (Fig 8.1).

The Chemical reactions are in process all around us, the process of cooking food, digestion of this food stuff in our

body, our clothing, medicines, burning of gasoline in our vehicles all these processes are the Chemical reactions. In this chapter we will discuss this process of chemical reactivity.

The reactivity of a substance is due to the tendency of donating or accepting or sharing the electrons, determined by the electropositive or electronegative characters. As the values of these characters increases, the ability to react also increases.

It is to be noted that the substances react to gain the lowest energy state, where they expend less energy to exist. The elements in this regard attain the electronic configuration of the nearest noble gas, which is the least energy state.

The chemical reactions on the basis of their speed are divided into 3 categories, the slow reactions, moderate reactions and fast reactions. Rusting of iron is the example of slow reaction, the organic reactions mostly are of

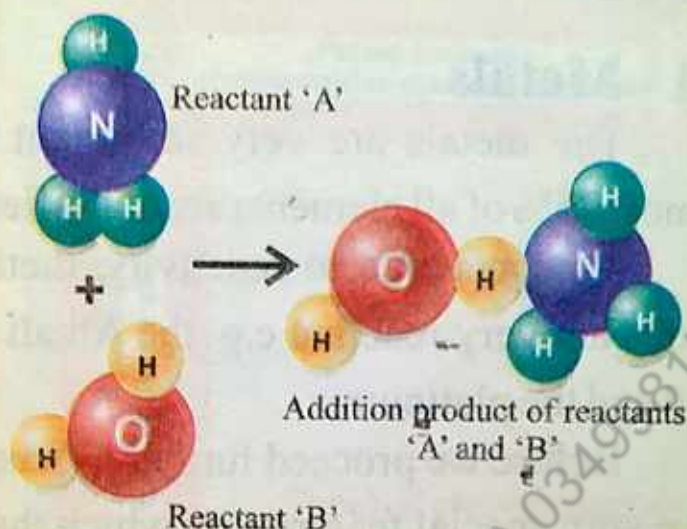


Figure: 8.1: Molecular view of an addition product by the reaction of two reactants 'A' and 'B'

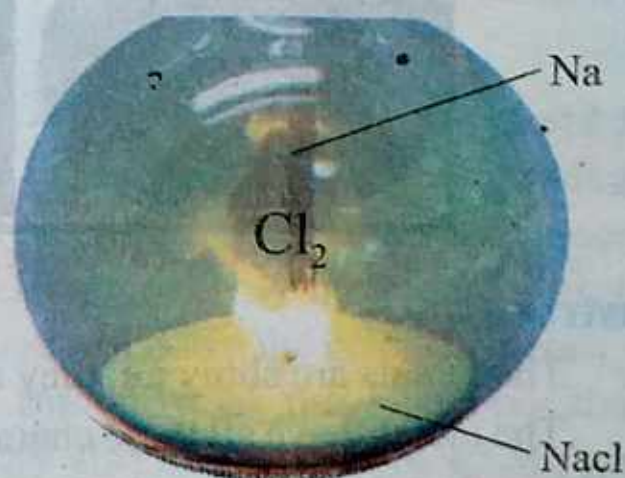


Figure: 8.2 Reaction between Sodium Metal and Chlorine gas is very fast and exothermic, as seen here in this picture.

moderate speed, and reactions between the ionic compounds are very fast (fig. 8.2).

8.1 Metals

The metals are very important and vital of our use in this world. Almost 75% of all elements are classified as metals.

As concerned to reactivity, metals show mix behavior, some of the metals are very reactive e.g. the Alkali metals, and some are quite inert like gold and the platinum.

Before we proceed further let's understand the nature of metals, which have very special features, by which they are recognized and separated from the other elements. These characteristics are:

Conduction

Metals are good at conducting electricity and heat, so they are used in almost all applications of electricity.

Ductile and Malleable

The metals have very special character, that they can be transformed in any desired shape. Moreover metals can be drawn into wires of small diameters, (ductile). (Fig 8.3)



Figure 8.3: Copper made coin and wire

Lustrous

The metals are shiny i.e. they are lustrous.

The metals have all these characters, and a single of these characters is if lacking, then the compound is not categorized as a metal. e.g. the plastics, although are malleable and ductile, and may have luster too, but they are not conductors, hence they are not metals.

8.1.1 Electropositive Character of Metals

The metals are electropositive in nature, i.e. they tend to lose electrons during the chemical reactions, and hence gain positive charge. The relative reactivity of elements depends upon the electropositive or the electronegative character of the elements, this is because, the chemical reactions involve the transfer of electrons from

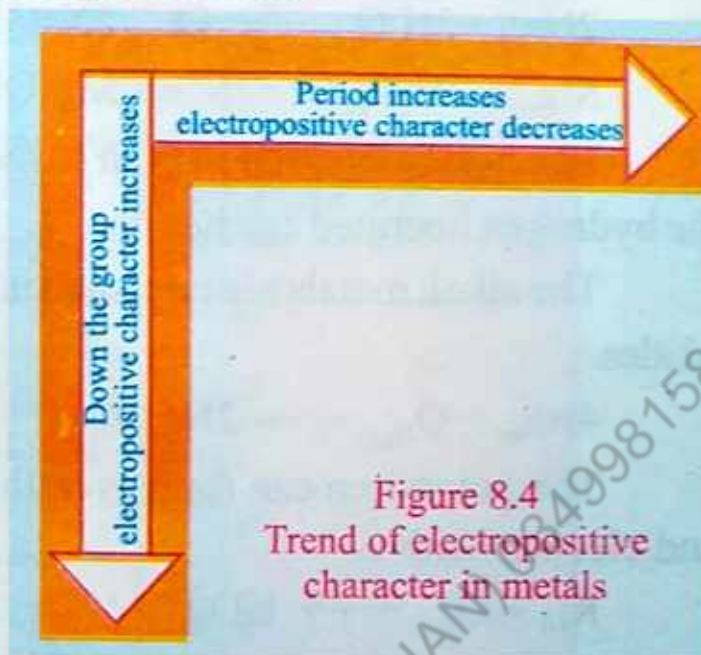


Figure 8.4
Trend of electropositive character in metals

one to another atom and hence new compounds are formed. The elements that have greater tendency to donate or accept the electrons are more reactive. In the periodic table the electropositivity of metals increases down the groups and decreases along the period.

Hence the reactivity of the metals is also increases down the groups, and reactivity of metals decreases along the periods.

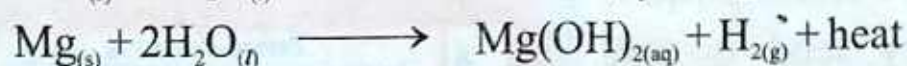
But remember that this is not the case with the non-metals, where the electronegative character counts, rather than the electropositive character, which is just opposite to the electropositive character.

8.1.2 Comparison of Reactivity between Alkali Metals and Alkaline Earth Metals

The alkali metals comprise the Gr-1 of the alkali metals, and the alkaline earth metals comprise Gr-2 of the periodic table. The alkali metals are soft, very reactive having a high value of electropositivity. They do not occur in free state. As described earlier, the electropositivity increases down the group of metals, so the reactivity also increases down the group in metals, so "K" is much reactive than the "Na". Similarly, as the electropositivity decreases along a period, so the reactivity also decreases, hence "Mg" and "Ca" are less reactive than their counterparts "Na" and "K" respectively.

For example, the alkali metals react vigorously with water to form the product hydroxides, while the alkaline earth metals react comparatively

slowly.

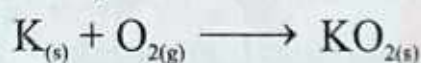


The heat is evolved in both cases, but in the first case it is so large that the hydrogen liberated catches fire.

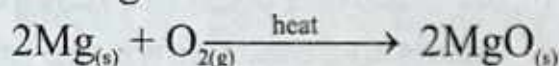
The alkali metals are tarnished in air quite easily to form corresponding oxides.



The potassium can form even the superoxide, being more reactive and electropositive.



In comparison to this, the alkaline earth metals react with oxygen of air by heating.



8.1.3 Inertness of Noble Metals

The noble metals are the metals that are resistant to corrosion and oxidation in moist air. They are usually precious and rare in the Earth's crust palladium, silver, osmium, iridium, platinum, and gold are the common examples of the noble metals, of these the silver, gold and copper are also called coinage metals.

Most of the noble metals are used in jewelry making.

The noble metals tend to be inert toward the common reagents, and do not dissolve in common substances, that's why the jewelry made up of these metals do not tarnishes after long periods.

The important reason for the inertness of the noble metals is their

Interesting Information

Due to inertness of noble metals they are used for making jewelry articles, as well as for making some other products, e.g., silver is used in mirror making in photographic films, in dental fillings with other compounds. Platinum is used as catalyst, in LCD screen, in computer CD and hard disk. Gold is used in electronics industry for making many electronic parts.

Group	Period	IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII B	IB	IIB	IIIA	IVB	VB	VIB	VII B	VIII B	IX	X	XI	XII		
	1	H																					
	2	Li	Be									B	C	N	O	F	Ne						
	3	Na	Mg									Al	Si	P	S	Cl	Ar						
	4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr				
	5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe				
	6	Cs	Ba	*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn				
	7	Fr	Ra	**	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo				
		Lanthanides										Actinides											
		57	58	59	60	61	62	63	64	65	66	67	68	69	70	71							
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu							
		89	90	91	92	93	94	95	96	97	98	99	100	101	102	103							
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr							
		Metals										Metalloids										Dotted Synthetically Prepared	

electronic arrangement. They have the stable electronic configuration and hence do not need to accept or donate electrons from others, so they tend to be inert at normal conditions.

8.2 Non-metals

There is no rigorous definition for the term "nonmetal", it covers a general spectrum of behavior. The common properties considered characteristic of a nonmetal include:

- Poor conductors of heat and electricity when compared to metals.
- They form acidic oxides (whereas metals generally form basic oxides).
- In solid form, they are dull and brittle, rather than metals which are lustrous, ductile or malleable.
- Usually have lower densities than metals.
- They have significantly lower melting points and boiling points than metals.
- Non-metals have high electronegativity.

Only seventeen elements in the periodic table are generally considered nonmetals, compared to over eighty metals, but nonmetals make up most of the crust, atmosphere and oceans of the earth. Bulk tissues of living organisms are composed almost entirely of nonmetals. Many nonmetals (hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine, and iodine) are diatomic while rest are polyatomic. In the periodic table the non-metal elements are located at the right corner, as shown in figure 8.5.

In the non-metals, the electronegative character decreases down the group, and hence the reactivity also decreases. So the "F" is more reactive than the "Cl", which is more reactive than the "Br".

8.2.1 Electronegative Character

As already explained in section 3.2.5 that electronegativity is the ability of an atom to attract shared electron pair, this character is much more effect in non metals rather than metals because of the high nuclear charge and smaller size of non metals as compare to metals.

The electronegative character increases along the period and decreases down the group, (noble gases are the exception). Thus fluorine is the element which has highest electronegativity value of 4.0.

The electronegative character and reactivity of elements are directly related with each other, so fluorine is also the most reactive

element in non metals and reactivity of all non metals decreases down the group and increases along the period.

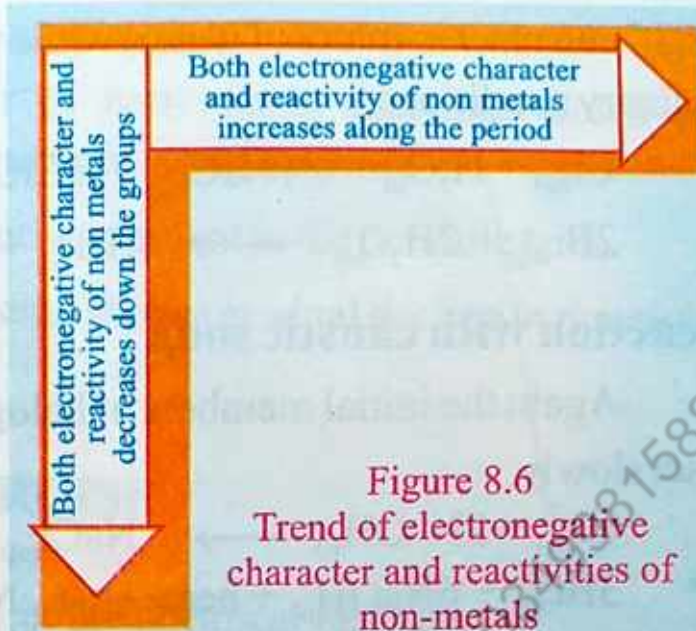


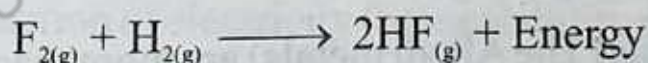
Figure 8.6
Trend of electronegative character and reactivities of non-metals

8.2.2 Comparison of Reactivity of the Halogens

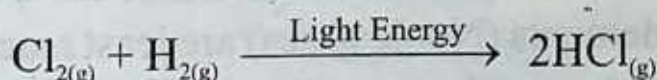
In the periodic table, the halogens are the most electronegative in their respective period, and so they are also most reactive among the non-metals of their periods. Among themselves, the halogens show a decline in the electronegativity down the group, so their reactivity also decreases down the group. This is further explained by the following reactions.

Reaction with hydrogen

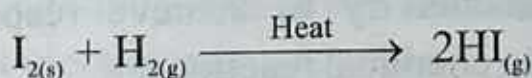
All halogens react with hydrogen, but under different conditions, for example, the "F₂" reacts violently,



Cl₂ reacts in a little presence of energy (light energy is sufficient),



And Iodine shows sluggish reaction.



Reaction with water

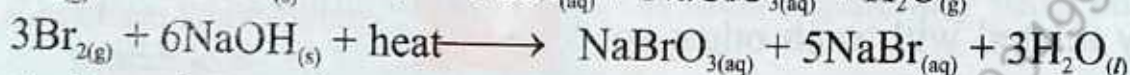
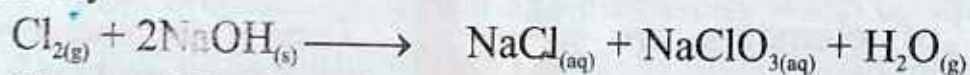
The "F₂" reacts explosively with water, "Cl₂" and "Br₂" react readily,

("Cl₂" can react in traces of water) while the "I₂" do not reacts with water under ordinary conditions.



Reaction with caustic soda

Again the initial members of halogens reacts fast, and the last members react slowly.



As it can be seen in equations that Cl₂ is reacting directly with caustic soda, while Br₂ reacts on heating, this proves the decline in reactivity down the group.

SUMMARY OF THE CHAPTER

- ❖ Chemical reactivity of a substance is the ability of a substance to undergo chemical reaction, this is because of the tendency of every substance to attain the lowest energy state.
- ❖ Chemical reactions involve migration of electrons.
- ❖ Metals are electropositive in nature, i.e they tend to donate electrons during the chemical reactions.
- ❖ The electropositive character of metals increases down the group and decreases along the periods.
- ❖ Group 1 elements (The Alkali metals) are more reactive than the Group 2 (alkaline earth metals) elements.
- ❖ The Group 18 elements (Noble gases) are least reactive of all elements in the periodic table, and they are also called inert gases.
- ❖ All the other elements try to achieve respective the noble gas configuration during chemical reactions.
- ❖ The non-metals which are situated at right corner of the periodic table are electronegative in nature, i.e. they accept electrons during chemical

reactions.

- ❖ The electronegative character of non metals decreases down the groups, and increases from left to right along a period.
- ❖ Fluorine is the most electronegative element in the periodic table.
- ❖ The Group 17 elements (Halogens) show a gradual decline in reactivity down the group.

EXERCISE

Q1. Fill in the blanks with appropriate words.

- i) are involved in the chemical reaction.
- ii) Metals are in nature while are electronegative in nature.
- iii) The are most reactive metals.
- iv) The noble gases are least of all elements.
- v) When difference between electronegativities is more than 2, the nature of bond is
- vi) The alkali metals found only in state.
- vii) Iron is a hard metal while Sodium is metal.
- viii) Among halogens is most reactive.
- ix) The chemical reactions involve a change.
- x) NaOH is also known as

Q2. Choose the correct answer.

- i) The metals are characterized by:
(a) conduction of electricity (b) malleability and ductile nature
(c) lustrous nature (d) all of above
- ii) In a group the reactivity of metals:
(a) increases (b) decreases
(c) no effect at all (d) increases first and then decreases
- iii) The electronegativity is the tendency of an atom:
(a) to attract electron pair of bond
(b) to repel electron pair of bond
(c) to attract another atom (d) to repel another atom

- iv) The halogen means:
 - (a) water producer
 - (b) salt producer
 - (c) taste producer
 - (d) steam producer
- v) The noble gases do not react due to:
 - (a) smaller size
 - (b) less charge
 - (c) stable electronic structure
 - (d) high electronegativity

Q3. Answer the following short questions.

- i) Based on the speed how many types of chemical reactions exists.
- ii) Define term metals.
- iii) How electropositive character of metals show trend in periodic table?
- iv) What is electronegativity? How electronegativity shows variation in periodic table?
- v) Write down three most abundant elements of human and of earth crust?
- vi) Write chemical equations of three reactions of water.
- vii) What is caustic soda? Write three uses of caustic soda
- viii) Differentiate between noble gases and noble metals?
- ix) Write uses of halogens.
- x) Differentiate between soft and hard metals.

Q4. Answer the following questions with reasoning.

- i) What is the relation between chemical reactivity and the energy of a system?
- ii) Explain what electronic configuration Mg and Br₂ achieve after they react.
- iii) Why K is more reactive than Mg?
- iv) Explain why group 18 elements do not react?
- v) Among halogen which member is most reactive and why?

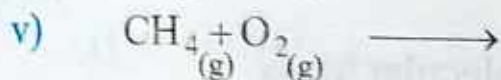
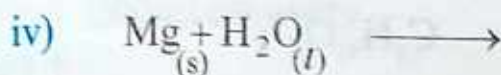
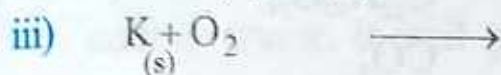
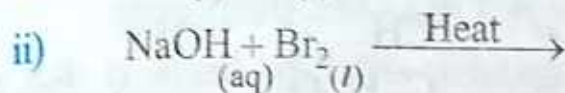
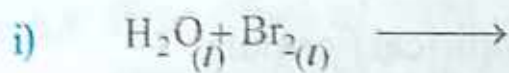
Q5. What is the metal? How they differ from non metals?

Q6. What is the difference between reactivity of metals and non metals?

Q7. What is electronegativity? How it effects the nature of the chemical bonding and bond polarity?

Q8. Compare the reactivity of alkali metals and alkaline earth metals?

- Q9. What are halogens? Discuss their chemical reactivity.
- Q10. Give an account on the properties of non metals? Also describe their importance.
- Q11. Complete and balance the following chemical reactions.



Appendix "A"

Answers to Activities:

Activity 1.2: Compound

Benzene

Sucrose

CO₂

(C₆H₁₀O₅)_n

Empirical Formula

= CH

= C₁₂H₂₂O₁₁

= CO₂

= C₆H₁₀O₅

Activity 1.3: Compound

NaCl

CO₂

Glucose

Al(OH)₃

Molecular Mass

= 58.5

= 44

= 180

= 78

Activity 1.4:

100gms of CO₂ has 4.101×10^{24} atoms

100gms of Glucose has 8.027×10^{24} atoms

Activity 2.1:

N = 1s², 2s², 2p³

P = 1s², 2s², 2p⁶, 3s², 3p³

Activity 4.1

O₂ = $\begin{array}{c} \times \times \\ \text{O} \times \times \text{O} \\ \times \times \end{array}$

CO₂ = $\begin{array}{c} \times \times \quad \times \times \\ \text{O} \times \times \text{C} \times \times \text{O} \\ \times \times \quad \times \times \end{array}$

NH₃ = $\begin{array}{c} \times \times \\ \text{H} \times \times \text{N} \times \times \text{H} \\ \times \times \\ \text{H} \end{array}$

N₂ = $\times \text{N} \times \times \text{N} \times$

C₂H₆ = $\begin{array}{c} \text{H} \quad \text{H} \\ \times \quad \times \\ \text{H} \times \text{C} \times \text{C} \times \text{H} \\ \times \quad \times \\ \text{H} \quad \text{H} \end{array}$

Activity 5.1: 310K

Activity 6.1: 3%

Activity 6.2: If 10.5g NaHCO_3 is dissolved in 250ml water, it gives 0.5M sodium bicarbonate solution.

Activity 6.3: If 16.67ml of 12M H_2SO_4 is dissolved in 400ml, it yields required 0.5M H_2SO_4 solution.

Activity 6.4: If 40ml of 10% solution of Glucose is diluted to 200ml by adding water, it will give required 2% solution of Glucose in 200ml quantity.

Activity 7.1

i) HNO_3 = +5

ii) NO_2 = +4

iii) NOCl = +3

Appendix "B"

Answer of numerical problems in exercise.

Chapter No.1

Q5. 1mg of Nicotine (in an average cigarette) has 3.716×10^{18} molecules

Q6. Compound Molar Mass

K_2SO_4 = 174

MnCl_2 = 126

$\text{Al}(\text{OH})_3$ = 78

$\text{Fe}(\text{NO}_3)_3$ = 242

$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ = 249.5

Q8. 16.33g of 'S' = 0.51 moles of 'S'

Chapter No.5

Q10. 525.17cc

Q11. 1.2 atm

Chapter No.6

Q7. 2.38M

Q8. 45gms

Chapter No.7

Q7. In KMnO_4 'Mn' has +7 Oxidation Number

Glossary of Chemical terms

Absolute zero: The lowest temperature that can be obtained, equal to -273.16°C or 0 K .

Accuracy: The closeness of a measurement to an accepted value.

Acid: A substance that when dissolved in water dissociates and can donate a hydrogen (proton) to another molecule. Examples include sulphuric acid and nitric acid. Under these conditions nitric acid dissociates according to the following equation:



Activation energy, (Ea): It is the minimum energy that is required for a successful reaction between colliding molecules.

Addition reaction: A reaction whereby two or more substances react together to form a product whose molecular mass is the sum of the molecular masses of the reactants.

Adsorption: If any compound, solid, liquid or gas, is loosely held by weak attraction to the surface of a solid it is said to have undergone adsorption. This process is much weaker and less permanent than absorption.

Alcohol: An organic compound that contains the -OH functional group.

Aldehyde: An organic compound containing the -CHO group.

Alkali: Water soluble hydroxide of one of the alkali metals.

Alkali metals: Group IA elements.

Alkaline earths: Group IIA elements.

Allotrope: Different physical forms of an element are known as allotropes. For example, diamond and graphite are allotropes of carbon.

Alloy: An alloy consists of an intimate mixture of two elements, usually metals to give a metal compound or solid solution. Bronze is an alloy of copper and tin and brass of copper and zinc. By varying the composition it is possible to alter the chemical and physical properties of the alloy such as conductivity, ductility and corrosion resistance.

Alpha particles: These are particles possessing a positive charge, and are emitted from radioactive elements. The particles are actually helium nuclei, i.e. helium atoms that had lost their outer electrons. The study of the alpha particle played a major part in the development of modern atomic theory. Rutherford bombarded other elements with alpha particles to produce nuclear disintegration.

Amalgam: Liquid mercury has the ability to dissolve other metals to produce alloys and these alloys are called amalgams. Amalgam examples are gold/mercury, silver/mercury and copper/mercury all of which are used in dentistry.

Amorphous Solids: Solids that have indistinct shapes, because their particle arrangements lack order.

Amphoteric substance: It is the substance that act as a proton donor (an acid) in one reaction and a proton acceptor (a base) in a different reaction.

Anion: An atom, or group of atoms, carrying one or more negative charges. Cl^- and SO_4^{2-} are anions.

Anode: In an electrochemical cell or electrolytic cell, the anode is the electrode where oxidation takes place.

- Atmosphere:** Atmosphere is the cloud of gases around us, the main constituents of atmosphere are 78% Nitrogen, 21% Oxygen, 0.93% Argon gas and 0.03% Carbondioxide.
- Atom:** The smallest particle of an element which can take part in chemical reactions and display the chemical properties of that element.
- Atomic mass (Relative):** The atomic mass of an element (more correctly the relative atomic mass) is the mass of one atom of that element, divided by $1/12$ th of the mass of one atom of the carbon isotope ^{12}C . In older textbooks, the relative atomic mass was called the atomic weight.
- Atomic Mass Number (mass number, A):** The total number of protons and neutrons in the nucleus of an atom.
- Atomic mass unit:** The atomic mass unit is $1/12$ th of the mass of one atom of the carbon isotope ^{12}C .
- Atomic number:** The atomic number of an element is the number of protons in its nucleus.
- Aufbau principle:** The system of rules whereby electrons are accommodated in atomic orbitals.
- Avogadro number (N_A):** The number of atoms, molecules or ions, 6.02×10^{23} , contained in one mole of a given substance.
- Base:** A substance which can accept a proton, H^+ from an acid.
- Base unit:** One of the set of seven units on which the SI system is based.
- Beta particles:** Beta particles are very fast moving electrons. The particles have a velocity of between 30-99% speed of light, and it is this velocity which gives the beta particles greater penetrating power than alpha particles.
- Boiling point:** The temperature at which the vapour pressure of a liquid is equal to the atmospheric pressure. A liquid is said to "boil" when its temperature is raised to its boiling point.
- Bond:** A chemical link between two atoms. In an ionic bond the attraction is between opposite charges on two neighboring ions. In a covalent bond the two atoms share a pair of electrons.
- Boyle's law:** At constant temperature, the volume of a given mass of gas is inversely proportional to its pressure.
- Buffer:** A substance that resists changes in pH when moderate amounts of acid or base are added.
- Calorie:** An obsolete non-SI unit of heat energy. $1 \text{ calorie} = 4.184 \text{ J}$.
- Calorimeter:** A device that is used to measure enthalpy changes for chemical and physical processes.
- Catalyst:** A substance which speeds up the rates of certain chemical reactions, without being permanently used up in the process.
- Cathode:** In an electrochemical or electrolytic cell, the electrode where reduction takes place.
- Cation:** An atom or group of atoms bearing one or more positive charges. Cu^{2+} and NH_4^+ are cations.
- Caustic soda:** Sodium hydroxide, NaOH .
- Chalcogen:** Group VIA elements.

- Chemical bond:** The force that holds atoms together in the form of a compound.
- Combustion reaction:** The reaction of a substance with oxygen, producing oxides, heat, and light; burning.
- Compound:** A pure substance that consists of two or more elements chemically combined in fixed proportions.
- Concentration:** An expression of the amount of solute that is present in a given amount of solution.
- Constant-pressure calorimeter:** A calorimeter (such as a coffee-cup calorimeter) that is open to the atmosphere.
- Critical temperature:** The temperature above which a real gas will not liquefy, no matter how high its pressure.
- Covalent bond:** A chemical bond between two atoms formed by sharing an electron pair between these atoms.
- Crystalline solids:** Solids that have organized particle arrangements and, therefore, have distinct shapes.
- Daniell cell:** An electrochemical cell made up of a zinc anode and a copper cathode.
- Dilution:** The addition of water or another appropriate solvent to a solution in order to reduce the concentration of solute.
- Dipole:** A separation of negative and positive charge by a short distance. in molecular compound called a dipole.
- Dipole-dipole force:** An intermolecular attraction between opposite charges of polar molecules.
- Distillation:** A technique of purification based on the difference in boiling points of constituents.
- Dissociation:** The process in which a bigger molecule breaks into two or more simpler units.
- Double bond:** A covalent bond between two atoms resulting from the sharing of two pairs of electrons. Normally written as $C=C$, $C=O$, $C=N$, $N=O$.
- Electrochemical cell:** A device which can generate an electric current by exploiting the energy of a redox reaction between two electrodes (usually metals) having different electrode potentials.
- Electrode:** A conductor (usually a metal or graphite) in contact with an electrolyte, such as a salt solution of molten salt.
- Electrolysis:** The conduction of an electric current from an outside source through an electrolyte, whereby chemical reactions take place at the electrodes.
- Electrolyte:** A solution capable of conducting electricity, usually a solution of a salt in water. Alternately, a substance capable of conducting an electric current, such as a molten salt.
- Electron:** A particle of mass 9.11×10^{-31} kg, carrying the fundamental negative electric charge, -1.60×10^{-19} C.
- Electron affinity:** The energy liberated when an element acquires an electron to form an anion.
- Electronegativity:** A measure of the ability of an element to polarize a covalent bond in

which it takes part.

Electronic Configuration: Shorthand notation that shows the number and arrangement of electrons in an atom's orbitals.

Element: A substance which cannot be decomposed by chemical means into a simpler substance.

Empirical formula: A formula for a substance which expresses the simplest relationship between its constituent elements. For example, the empirical formula for ethanoic acid is CH_2O , although its molecular formula is $\text{C}_2\text{H}_4\text{O}_2$.

Endothermic reaction: A reaction that results in a net absorption of energy.

Enthalpy: The total kinetic energy and potential energy of a substance.

Entropy: A measure of the disorder in a system.

Enzyme: An enormous protein molecule that acts as a biological catalyst.

Evaporation: A physical process whereby a liquid passes into the gas phase, not necessarily at the boiling point of that liquid.

Excited state: An atom is said to be in an excited state if an electron has absorbed energy sufficient to promote that electron to an energy level which is higher than that in which it finds itself in the ground state. For example, the single electron of hydrogen in the ground state is in the level $n = 1$. If the electron is in the level $n = 2$ or higher, the atom is in an excited state.

Exothermic reaction: A reaction which takes place with a release of energy to the environment. In an exothermic reaction, the potential chemical energy of the products is less than that of the reactants.

Free Electron: An electron that is not bonded to an atom or molecule and so is free to move under external electric or magnetic fields.

Galvanic cell: See Daniell cell.

Gamma rays: Electromagnetic radiation with very high energy and frequency in the range 10^{20} Hz. These are the three types of rays produced by radioactive disintegration, but gamma rays are the only one comprised of electromagnetic radiation. Gamma rays have a very short wavelength, and have the greatest penetrating power of all radioactive emissions.

Greenhouse effect: Warming of the Earth's surface as a result of atmospheric pollution by gases. It is now feared that the warming effects are being undesirably increased, causing climate changes and melting polar icecaps.

Ground state: The state of an atom where all electrons have the minimum energy.

Halogens: This important group of elements occupies Group 17 of the periodic table.

Heavy water: A molecule of water contains two atoms of hydrogen and one of oxygen. Most water comprises of hydrogen/oxygen but a small percentage is composed of another hydrogen isotope, deuterium and oxygen. Deuterium differs from hydrogen by having one neutron in the nucleus of each atom. Deuterium water is given the formula D_2O . There is approx. 1 part in 5000 D_2O in normal water and it can be concentrated by electrolysis. D_2O had a higher boiling point (101.4°C) and melts at 3.6°C .

Homogeneous mixture: A mixture in which the different components are mixed so that they appear to be a single substance; a solution.

Heterogeneous mixture: A mixture in which the different components can be seen distinctly

Hydrides: Binary compound of hydrogen with other elements.

Hydrogen bonding: A special type of dipole-dipole interaction involving hydrogen atoms and electronegative elements such as oxygen and nitrogen.

Ideal gas: A gas which obeys the gas laws perfectly.

Indicator: A substance which shows a colour change after completion of a chemical reaction.

Inert gas: Group 18 elements.

Intermolecular forces: A force of attraction between molecules to hold them close.

Intramolecular forces: Forces that are exerted within a molecule or polyatomic ion; an example is covalent bonds.

Ion: An atom, or group of atoms, bearing an electrical charge. Ions may be monoatomic (Na^+) or polyatomic (SO_4^{2-}).

Isomer: Two compounds are said to be isomers if they have the same molecular formula, but different structural formulae.

Isotope: Two or more different forms of an element differing only in their mass numbers.

Kinetic energy: The energy of a body acquired by virtue of its motion.

Kinetic theory of gases: The concept that gases consist of perfectly elastic molecules of negligible volume, moving randomly, and creating pressure by collisions with the walls of the container.

Lattice energy: The energy liberated when a crystal lattice is formed by the electrostatic binding of its constituent cations and anions.

Limiting reactant: The reactant that is completely consumed during a chemical reaction, limiting the amount of product.

Litmus: An indicator of vegetable origin, which turns red in acids and blue in alkalis.

Mass number: The sum of the protons and neutrons in the nucleus of an atom.

Matter: Anything that has mass and takes up space.

Melting point: The temperature at which a transition from the solid to the liquid phase takes place. A solid is said to "melt" when this transition takes place.

Metal: The elements that have lustre, are good conductors and malleable.

Metallic bond: Interatomic forces holding metal atoms in a solid sample of a metal.

Mixture: A sample of matter which consists of two or more pure substances.

Molarity: Concentration of a solute expressed in units of moles dm^{-3} . A solution is said to be molar if it has a concentration of 1.0 mole dm^{-3} .

Mole: Atomic or molecular mass in grams.

SI unit for the amount of matter. One mole of a substance contains 6.023×10^{23} particles (atoms, molecules or ions) representative of that substance.

Molecular formula: A formula which reflects the actual number of each constituent atom in a molecule of a substance.

Monomers: Small molecules that are combined in long chains to produce very large molecules called polymers.

Neutron: An atomic particle having a relative atomic mass of 1, and zero charge.

Nucleus: That central part of the atom where its mass is concentrated, consisting of protons and neutrons.

Orbital: A region where the probability of finding of electron is maximum is called orbitals.

A region in space in an atom where probability of finding the electron is most. Orbitals are designated with symbols, s, p, d and f.

Organic chemistry: The chemistry of the hydrocarbons and their derivatives.

Oxidation: The process whereby a substance loses electrons.

Oxidizing agent: A substance which can accept electrons from another substance.

Oxide: Substance in which some element is combined with oxygen only.

Ozone: An allotrope of oxygen, O_3 .

p-block elements: Elements in Group 13 to Group 18, where the last electrons of an atom lies in p orbitals.

Periodic table: A table in which all the known elements are arranged in increasing values of their atomic numbers.

pH: A function that expresses the acidity or alkalinity of an aqueous solution. pH is related to the hydrogen ion concentration: $pH = -\log[H^+]$.

Phenolphthalein: An indicator which is colourless in acids and pink or purple in alkalis.

Precipitate: An insoluble solid that is formed by an aqueous chemical reaction between two soluble compounds.

Precision: The closeness of a measurement to other measurements of the same object or phenomena.

Pressure: Force exerted on a unit area. Pressure is measured in Pascal, (P), where $1 \text{ Pascal (P)} = 1 \text{ N.m}^{-2}$.

Proton: An atomic particle with relative atomic mass of 1, and unit positive charge, found in the nucleus of the atom.

Qualitative analysis: The branch of analytical chemistry that involves identifying elements, compounds, and ions in samples of unknown or uncertain composition.

Quantitative analysis: The branch of analytical chemistry that involves determining how much of a compound, element, or ion is in a sample.

Quantum mechanical model of the atom: A model that describes atoms as having certain allowed quantities of energy because of the wave-like properties of their electrons.

Radical: Atom or group of atoms having positive charge or negative charge or odd number are called radical.

Reactant: A starting substance in a chemical reaction.

Reaction mechanism: As series of steps that make up an overall reaction.

Reaction Rate: Speed of a chemical reaction.

Real gas: A gas which Exists in nature.

Reducing agent: A reducing agent (reductant) is a substance which can give up electrons to another substance, the oxidizing agent, or oxidant.

Reduction: A reaction in which electrons are taken up by a reactant. It is also defined as the addition of hydrogen or the removal of oxygen.

Redox Reactions: The oxidation and reduction reactions are collectively called redox

reactions.

Relative Atomic Mass: The mass of an atom or molecule compared with $C^{12.0000}$.

Saturated solution: A solution in which no more solute will dissolve under the existing conditions of temperature and pressure.

s-block elements: Elements in Group 1 and Group 2, where the last electrons of an atom lie in s-orbital.

Single bond: a covalent bond in which one pair of electrons is shared between two atoms.

SI units: An international system of coherent units, formed by simple multiplication and/or division within a set of seven base units.

Solute: The substance dissolved in a solvent to form a solution, its quantity in the solution is always lesser.

Solution: A homogeneous mixture of variable composition consisting of two or more substances, one of which is usually a liquid.

Solvent: A liquid which dissolves a solute to form a solution, its quantity in the solution is always greater.

Solubility: The amount of solute that dissolves in a given quantity of solvent (normally 100ml) at a specific temperature.

Standard pressure: A pressure of 1 atmosphere = 760 mmHg.

Standard temperature: A temperature of 0.0°C , or 273.16 K.

S.T.P.: S.T.P. is the abbreviation of standard temperature pressure. (273.16 K and a pressure of 1 atmosphere).

Structural formula: A formula which defines the bonding and arrangement of the atoms present in a compound.

Sublimation: A phase change whereby a solid passes directly into the gas phase without melting.

Supersaturated solution: A solution which contains a higher concentration of solute than would be present if the solution had been saturated at the same conditions of temperature and pressure.

Temperature: The temperature of a sample of matter is a measure of the average kinetic energy of the molecules in that sample.

Thermodynamics: The study of energy and energy transfer.

Unsaturated compound: A compound in which double or triple bonds are present.

Valence electrons: Electrons in the outer electronic shell of an atom, and which are involved in chemical reactions.

Valence shell: The outermost shell of electrons.

Vapour pressure: The pressure exerted by a vapour. At the boiling point, the vapour pressure of a liquid is equal to the pressure exerted on the liquid by the atmosphere.

Vander Waals forces: Weak forces between molecules of molecular solids and liquids.

These include dipole-dipole forces, dispersion forces and hydrogen bonds.

Voltaic cell:

A device which can generate an electric current by exploiting the energy of a redox reaction between two electrodes (usually metals) having different electrode potentials.

Water of crystallization:

Water molecules which form an integral part of the lattice of ionic crystals. The water of crystallization is normally included in the formula for the substance, i.e., $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$.

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TABLE OF ELEMENTS

Element	Symbol	At.No	At.mass	Element	Symbol	At.No	At.mass
Hydrogen	H	1	1.0079	Selenium	Se	34	78.96
Helium	He	2	4.0026	Bromine	Br	35	79.904
Lithium	Li	3	6.941	Krypton	Kr	36	83.798
Beryllium	Be	4	9.0122	Rubidium	Rb	37	85.4678
Boron	B	5	10.811	Strontium	Sr	38	87.62
Carbon	C	6	12.01	Yttrium	Y	39	88.9058
Nitrogen	N	7	14.0067	Zirconium	Zr	40	91.224
Oxygen	O	8	15.9994	Niobium	Nb	41	92.906
Fluorine	Fr	9	18.9984	Molybdenum	Mo	42	95.94
Neon	Ne	10	20.1797	Technetium	Tc	43	98.9063
Sodium	Na	11	22.9898	Ruthenium	Ru	44	101.07
Magnesium	Mg	12	24.305	Rhodium	Rh	45	102.9055
Aluminium	Al	13	26.9815	Palladium	Pd	46	106.42
Silicon	Si	14	28.0855	Silver	Ag	47	107.8682
Phosphorus	P	15	30.9738	Cadmium	Cd	48	112.411
Sulphur	S	16	32.065	Indium	In	49	114.818
Chlorine	Cl	17	35.453	Tin	Sn	50	118.71
Argon	Ar	18	39.948	Antimony	Sb	51	121.76
Potassium	K	19	39.0983	Tellurium	Te	52	127.6
Calcium	Ca	20	40.078	Iodine	I	53	126.9045
Scandium	Sc	21	44.9559	Xenon	Xe	54	131.293
Titanium	Ti	22	47.867	Caesium	Cs	55	132.9054
Vanadium	V	23	50.9415	Barium	Ba	56	137.327
Chromium	Cr	24	51.9961	Lanthanum	La	57	138.9055
Manganese	Mn	25	54.938	Cerium	Ce	58	140.116
Iron	Fe	26	55.845	Praseodymium	Pr	59	140.9076
Cobalt	Co	27	58.933	Neodymium	Nd	60	144.242
Nickel	Ni	28	58.6934	Promethium	Pm	61	146.9151
Copper	Cu	29	63.546	Samarium	Sm	62	150.36
Zinc	Zn	30	65.409	Europium	Eu	63	151.964
Gallium	Ga	31	69.723	Gadolinium	Gd	64	157.25
Germanium	Ge	32	72.64	Terbium	Tb	65	158.925
Arsenic	As	33	74.9216	Dysprosium	Dy	66	162.5

Element	Symbol	At.No	At.mass	Element	Symbol	At.No	At.mass
Holmium	Ho	67	164.93	Neptunium	Np	93	237.0482
Erbium	Er	68	167.259	Plutonium	Pu	94	244.0642
Thulium	Tm	69	168.93	Americium	Am	95	243.0614
Ytterbium	Yb	70	173.04	Curium	Cm	96	247.0703
Lutetium	Lu	71	174.967	Berkelium	Bk	97	247.0703
Hafnium	Hf	72	178.49	Californium	Cf	98	251.0796
Tantalum	Ta	73	180.9479	Einsteinium	Es	99	252.0829
Tungsten	W	74	183.84	Fermium	Fm	100	257.0951
Rhenium	Re	75	186.207	Mendelevium	Md	101	258.0986
Osmium	Os	76	190.23	Nobelium	No	102	259.1009
Iridium	Ir	77	192.217	Lawrencium	Lr	103	260.1053
Platinum	Pt	78	195.084	Rutherfordium	Rf	104	261.1087
Gold	Au	79	196.9665	Dubnium	Db	105	262.1138
Mercury	Hg	80	200.59	Seaborgium	Sg	106	263.1182
Thallium	Tl	81	204.283	Bohrium	Bh	107	262.1229
Lead	Pb	82	207.2	Hassium	Hs	108	265
Bismuth	Bi	83	208.98	Meitnerium	Mt	109	266
Polonium	Po	84	208.98	Darmstadtium	Ds	110	269
Astatine	At	85	209.98	Roentgenium	Rg	111	272
Radon	Rn	86	222.176	Copernicium	Cn	112	285
Francium	Fr	87	223.0197	Ununtrium	Uut	113	284
Radium	Ra	88	226.0254	Ununquadium	Uuq	114	289
Actinium	Ac	89	227.278	Ununpentium	Uup	115	288
Thorium	Th	90	232.0381	Ununhexium	Uuh	116	292
Protactinium	Pa	91	231.0359	Ununseptium	Uus	117	unknown
Uranium	U	92	238.0289	Ununoctium	Uuo	118	294

Table of Basic S.I units

S/No	Measurement	Unit	Symbol
1	Length	Metre or Meter	m
2	Mass	Kilogram	Kg
3	Time	Second	s
4	Electric current	Ampere	A
5	Temperature	Kelvin	K
6	Amount of substance	Mole	mol
7	Luminous intensity	Candela	cd

Some important derived units with their common names

S/No	Measurement	S.I unit	Commonly used Unit
1	Area	Square metre, (m^2)	m^2 and cm^2
2	Volume	Metre cube, (m^3)	m^3 and cm^3
3	density	Kilogram per metre cube (Kg/m^3)	g/cm^3
4	Energy	Kilogram metre square per second per second ($Kg.m^2.s^{-2}$)	Joule or J
5	Pressure	Newton per square metre (N/m^2)	Atmosphere or mmHg

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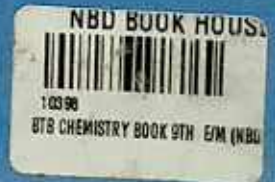
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