CHAPTER 8

CHEMICAL REACTIVITY

SUBJECTIVE PART
LONG QUESTION ANSWERS

Introduction

Importance of metals:
The different kinds of materials around us exist in variety of forms. Things like aero planes, trains, building frames, automobiles or even different machines and tools, are due to different properties of various metals.

Non-metals and their position in periodic table:
The non-metals exist as gases, liquids and soft or hard solids. They occupy upper right positions in the Periodic Table. Carbon, nitrogen, phosphorus, oxygen, sulphur, most of the halogens and the noble gases are non-metals. They show a variety of chemical reactivates. They form different ionic and covalent compounds, many of which are solids or gases.

8.1 Metals

Q.1 What are metals? How are they categorized? Write down their physical and chemical properties.

Ans: Metals:

"Metals are the elements (except hydrogen) which are electropositive and form cations by losing electrons."

Examples: Sodium, Potassium, iron, Silver etc.

Importance of metals:

Things like aeroplanes, trains, building frames, automobiles or even different machines and tools are due to different properties of metals.

Position of metals in periodic table:

They are present on the lower and left side of the periodic table.

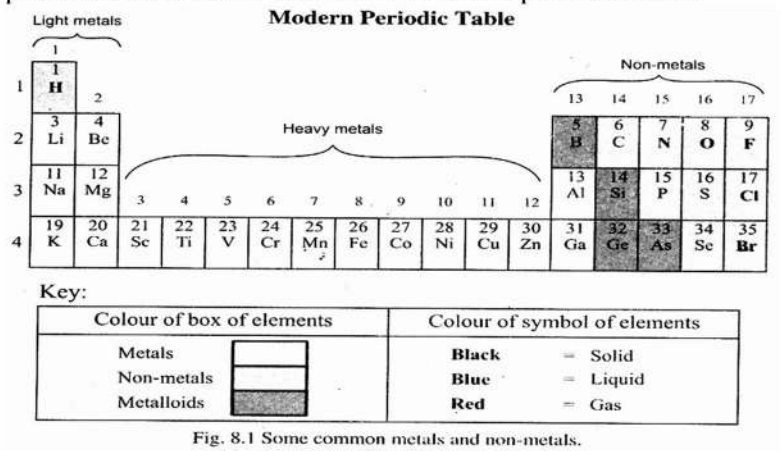

Fig. 8.1 Some common metals and non-metals.

Categories of metals:

Metals can be categorized as:

i. **Very reactive:** potassium, sodium, calcium, magnesium and aluminum.
ii. **Moderately reactive:** zinc, iron, tin and lead.
iii. **Least reactive or noble:** copper, mercury, silver and gold.

Physical characteristics:

i. Almost all metals are solids (except mercury)
ii. They have high melting and boiling points.
iii. They possess metallic luster and can be polished.
iv. They are malleable (can be hammered into sheets), ductile (can be drawn into wires) and give off a tone when hit.
v. They are good conductor of heat and electricity.
vi. They have high density.
vii. They are hard (except sodium and potassium)

Chemical properties:

i. They easily lose electrons and form positive ions.
ii. They readily react with oxygen to form basic oxides.
iii. They usually form ionic compounds with non-metals.
iv. They have metallic bonding.

DO YOU KNOW

- The most abundant metal is aluminum
- The most precious metal is platinum
- The most useable metal is iron
- The most reactive metal is cesium
- The most valuable metal is uranium
- The lightest metal is lithium ($d = 0.53\ g\ cm^{-3}$)
- The heaviest metal is osmium ($d = 22.5\ g\ cm^{-3}$)
- The least conductor of heat is lead.
- The best conductor metals are silver and gold
- The most ductile and malleable metals are gold and silver

Q.2 Write a compressive note on the electropositive character of metals

Ans: Electropositive character / Metallic character:

"Metals have the tendency to lose their valance electrons. This property of a metal is termed as electropositivity or metallic character or electropositive character."

Valency of metals:

"The number of electrons lost by an atom of a metal is called its valency."

The more easily a metal loses its electrons is the more electropositive.

Example:

i. Sodium (Na) atom can lose 1 electron to form a positive ion

$$Na_{(s)} \longrightarrow Na^{+}_{(g)} + 1e^{-}$$

So the valency of sodium metal is1.

ii. Zinc (Zn) metal can lose 2 electrons from its valence shell. Therefore, its valency is 2.

$$Zn_{(s)} \longrightarrow Zn^{2+}_{(g)} + 2e^{-}$$

Trends of Electropositivity:

a. Trends in Groups:

Electropositive character increases down the group because size of atoms increases.

Example:

Lithium metal is less electropositive than sodium which is in turn less electropositive than potassium.

b. Trends in Periods:

Electropositive character decreases across the period from left to right in periodic table because size of atoms decrease due to increase of nuclear charge.

It means elements in the start of a period are more metallic. This character decreases as we move from left to right along the period.

Q.3 (Ex. Q.12) compare the ionization energies of alkaline earth metals are what is relationship between electropositive and ionization energy.

Ans: Electropositive and ionization energy.

Dependence of electropositive character:

Electropositive character depends upon the ionization energy which in turn depends on size and nuclear charge of the atom. Small sized atoms with high nuclear charge have high ionization energy. In this way atoms having high ionization energy are less electropositive or metallic. That is the reason alkali metals have the largest size and the lowest ionization energy in their respective periods. Therefore, they have the highest metallic character.

Sodium Atom
$3s^1$ electron configuration
having atomic size 186 pm,
and ionization energy 496 $kJmol^{-1}$.

Magnesium Atom
$3s^2$ electron configuration
having atomic size 160pm,
and ionization energy 738 $kJmol^{-1}$.

Example: Comparison of sodium and magnesium metals

sodium	magnesium
• Sodium Atom $3s^1$ electron configuration having atomic size 186 pm	• Magnesium Atom $3s^2$ electron configuration having atomic size 160pm
• Ionization energy of sodium is 496 $kjmol^{-1}$.	• Ionization energy of magnesium 1450 $kjmol^{-1}$.

Comparison of second ionization energy and first ionization energy of alkaline earth metals:

Ionization energy of magnesium is high but the 2nd ionization energy of magnesium is very high. It becomes very difficult to remove second electron from the Mg^+ ion as nuclear charge attracts the remaining electrons strongly. As a result of this attraction size of the ion decreases.

Similarly all the elements of alkaline earth metals have high ionization energies as compared to alkali metals

Metal	Atomic Number	Electronic Configuration	IE	Metal	Atomic Number	Electronic Configuration	IEI	IE2
Li	3	[He] $2\ s^1$	520	Be	4	[He] $2s^2$	899	1787
Na	11	[Ne] $3\ s^1$	496	Mg	12	[Ne] $3s^2$	738	1450
K	19	[Ar] $4\ s^1$	419	Ca	20	[Ar] $4s^2$	590	1145

Rb	37	[Kr] 5 s^1	403	Sr	38	[Kr] $5s^2$	549	1064
Cs	55	[Xe] 6 s^1	376	Ba	56	[Xe] $6s^2$	503	965

Note: *Low ionization energies of alkali metals make them more reactive than alkaline earth metals.*

Q.4 How you can compare physical properties of alkali and alkaline earth metals?

Ans: Comparison of physical properties of alkali and alkaline earth metals:

Property	Sodium	Magnesium	Calcium
Appearance	Silvery white having a metallic luster, very soft and can be cut with knife	Silvery white and hard	Silvery grey and fairly harder
Atomic size, ionic size (pm)	186, 102	160, 72	197,99
Relative density	0.98 g cm^{-3} Floats on water	1.74 g cm^{-3}	1.55 g cm^{-3}
Malleability	very malleable and ductile	Malleable and ductile	Malleable and ductile
Conductivity	Good conductor of heat and electricity	Good conductor of heat and electricity	Good conductor of heat and electricity
M.P	97°C	650°C	851°C
B.P	883°C	1090 °C.	1484°C
Ionization energy	496 kJ/mol	738, 1450 kJ/mol	590,1145 kJ/mol
Flame in air	Golden yellow	Brilliant white	Brick red

Q.5 Describe reactivates of alkali and alkaline earth metals,

OR

Compare chemical properties and reactivates of akali and alkaline earth metals?

Ans: Alkali metals:

"The elements in Group 1 (Li, Na, K, Rb, Cs, Fr) of the periodic table are called 'Alkali' metals".

Properties:

i. Alkali metals are extremely reactive elements because of their ns^1 valence shell electronic configuration.

ii. There is only one electron in their valence shell, it can be easily given out.

iii. They are always found in nature as cations with + I oxidation state.

iv. They readily form salts with non-metals.

Alkaline earth metals

"The elements in group 2 (Be, Mg, Ca, Sr, Ba, Ra) are called alkaline earth metals."

Properties:

i. The alkaline earth metal atoms are smaller and have more nuclear charge.

ii. They have two electrons in their valence shells.

iii. They are also reactive elements because of ns^2 valence shell electronic configuration but less reactive than alkali metals because of small size and more nuclear charge.

Comparison of chemical properties and reactivates:

Alkali Metals	Alkaline Earth Metals

1. Occurrence They are very reactive and always occur in combined form	They are fairly reactive and also occur in combined form
2. Electropositivity These are highly electropositive. They have ionization energy values ranging from 520 $kJmol^{-1}$ for Li to 376 $kJmol^{-1}$ for Cs.	They are less electropositive. They have ionization energy values ranging from 1757 $kJmol^{-1}$ for Be to 965 $kJmol^{-1}$ for Ba.
3. Reaction with water They react with water vigorously at room temperature to give strong alkaline solution and hydrogen gas $2Na+2H_2O \longrightarrow 2Na\,OH+H_2$	They react with water less vigorously and on heating they produce weak bases $Mg + H_2O \longrightarrow MgO + H_2$ $MgO + H_2O \longrightarrow Mg(OH)_2$
4. Reaction with Oxygen. They immediately tarnish in air giving their oxides which form strong alkalies in water $4Na + O_2 \longrightarrow 2Na_2O$ $Na_20+H_2O \longrightarrow 2NaOH$	They are less reactive towards oxygen and oxides are formed on heating $2Mg+O_2 \longrightarrow 2MgO$
5. Reaction with Hydrogen They form ionic hydrides with H_2 at high temperature $2M+H_2 \longrightarrow 2MH$	They give hydrides under strong conditions of temperature and pressure $Ca + H_2 \longrightarrow CaH_2$
6. Reaction with Halogens They react violently with halogens at room temperature to give halides $2Na+Cl_2 \longrightarrow 2NaCI$	They react slowly with halogen to give their halides $Ca + Cl_2 \longrightarrow CaCl_2$
7. Reaction with Nitrogen They do not form nitrides directly	They form stable nitrides when heated with nitrogen $3Mg+N_2 \longrightarrow Mg_3N_2$
8. Reaction with Carbon They do not react with carbon directly	They give stable carbide on heating with carbon. $Ca+2C \longrightarrow CaC_2$

Q.6 Write down the uses of sodium, magnesium and calcium.

Ans: Uses of sodium:

i. Sodium-potassium alloy is used as a coolant in nuclear reactors.
ii. It is used to produce yellow light in sodium vapour lamps.
iii. It is used as a reducing agent in the extraction of metal like Ti.

Uses of magnesium:

i. Magnesium is used in flash lights and in fireworks.
ii. It is used in the manufacture of light alloys.
iii. Magnesium ribbon is used in Thermite process to ignite aluminium powder
iv. Magnesium is used as anode for prevention of corrosion.

Uses of calcium:

i. It is used to remove sulphur from petroleum products.
ii. It is used as reducing agent to produce Cr, U and Zn.

Q.7 Explain transition metals and inertness of Noble metals.

Ans: Transitions metals:

The elements in which d or f-orbital are in the process of filling, constitute a group of

metals called transition metals.

Types of transition elements:

i. Outer transitions elements **ii. Inner transition elements**

i. Outer transitions elements:

The elements in which d-orbital are in the process of filling, constitute a group of metals called outer transition metals or d-group elements.

They exhibit a variety of oxidation states 'transition metals' of 4^{th}, $5^{th}$and the 6^{th} period of the periodic table. There are three series of transition elements; each series consisting of ten element

ii. Inner transition elements:

The elements in which f-orbital are in the process of filling, constitute a group of metals called inner transition metals or d-group elements.

There are 2 series of inner transitions elements placed at the bottom of the periodic table these series are lanthanides and actinides.

Inertness of Nobel Metals:

Chemical behavior of the first transition series is similar to active metals except copper. Three transition metals belonging to group 11 are copper, silver and gold.

Gold and silver are relatively inactive metals because they do not lose electrons easily and are called nobel metals.

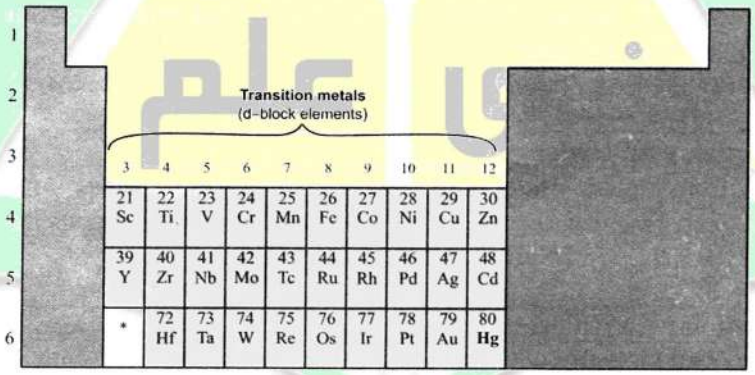

Fig. 8.2 The Transition Elements in the Periodic Table.

Q.8 Write a note on properties and uses of silver, gold and platinum.

Ans: a. Properties of Silver:

i. It is white lustrous metal.

ii. It is an excellent conductor of heat and electricity.

iii. It is also highly ductile and malleable metal.

iv. Its polished surfaces are good reflectors of light.

v. Formation of thin layer of oxide or sulphide on its surface makes it relatively unreactive.

vi. Under normal conditions of atmosphere, air does not affect silver.

vii. It tarnishes in presence of sulphur containing compounds like H_2S.

Uses of silver:

i. Being very soft metal, it is rarely used as such.

ii. Alloys of silver with copper are widely used in making coins, silver-ware and ornaments.

iii. Compounds of silver are widely used in photographic films and dental preparations.

iv. Silver also has important applications in mirror industry.

b. Properties of Gold:

i. It is a yellow soft metal.

ii. It is most malleable and ductile of all the metals.
iii. One gram of gold can be drawn into a wire of one and a half kilo meter long.
iv. Gold is very non-reactive or inert metal.
v. It is not affected by atmosphere.
vi. It is even not affected by any single mineral acid or base.

Uses of Gold:

i. Because of its inertness in atmosphere, it is an ornamental metal as well as used in making coins.
ii. Gold is too soft to be used as such.
iii. It is always alloyed with copper, silver or some other metal.

Composition of pure gold

Purity of gold is shown by carats.
The number of parts by weight of gold that is present in 24 parts of alloy is called carats.
Twenty four carat gold is pure. 22 carats **gold** means that 22 parts pure gold is alloyed with 2 parts of either silver or copper for making ornaments and jewelry.

White gold

White gold is an alloy with Palladium nickel or zinc.

c. Properties and Uses of Platinum:

i. It is used to make jewelry items because of its unique characteristics like colour, beauty, strength, flexibility and resistance to tarnish.
ii. It provides a secure setting for diamonds and other gemstones, enhancing their brilliance.
iii. Platinum alloyed with palladium and rhodium are used as catalyst in auto- mobiles as catalytic convertor.
iv. They convert most of the gases being emitted by vehicles into less harmful carbon dioxide, nitrogen and water vapour. .
v. Platinum is used in the production of hard disk drive coatings and fibre optic cables.
vi. Platinum is used in the manufacturing of fibre glass reinforced plastic and glass for liquid crystal displays (LCD).

Q.9 What are non metals? Explain electronegative characteristics of non-metals

Ans: Non-Metals:

"The elements which form negative ions (anions) by gaining electrons are called non-metals"
Non-metals are electronegative in nature and form acidic oxides.
Examples: Oxygen, Sulphur, Phosphorous and Nitrogen etc.

Non- metallic character:

"*The tendency of an element to gain electrons and from negative ions is called non-metallic character or electronegative character or electronegativity.*"

Valency of non-metals:

The valency of some non-metals depends upon the number of electrons accepted by them.

Examples:

i. Valency of chlorine atom is 1, as it accepts only I electron in its outermost shell.

$$Cl + 1e^- \longrightarrow Cl^-$$

ii. Oxygen atom can accept 2 electrons, therefore, its valency is 2.

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

Dependence of non-metallic character:

The non-metallic character depends upon the electron affinity and electro negativity of the atom. Small size elements having high nuclear charge are electronegative in nature. They have high electron affinity. Therefore, they possess non-metallic nature.

Trend of non-metallic character:

a. Trends in groups:

Non-metallic character decreases in a group downward.

b. trends in periods:

It increases in a period from left to right up to halogens. That is the reason fluorine is the most non-metallic in character.

Example of non-metals:

The non-metals are, therefore, elements in Group-14(Carbon), Group-15 (nitrogen and phosphorus), Group-I6 (oxygen, sulphur and selenium) and in group-17 halogens (fluorine, chorine, bromine and iodine) of the periodic table.

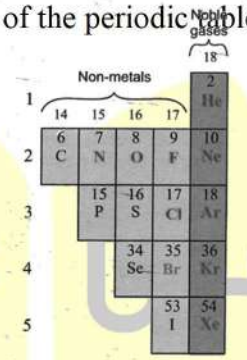

Fig. 8.3 The Non-Metals in Periodic Table

Q.10 What are physical and chemical properties of non metals?

Ans: Physical properties of non-metals:

Physical properties of non-metals change gradually but uniquely in a group of non- metals. Non-metals usually exist in all three physical states of matter. The non-metals at the top of the group are usually gases while others are either liquids or solids.

Major physical properties of non-metals:

i. Solids non-metals are brittle (break easily).

ii. Non-metals are non-conductor of heat and electricity (except graphite).

iii. They are not shiny, they are dull except iodine (it is lustrous like metals).

iv. They are generally soft (except diamond).

v. They have low melting and boiling points (except silicon, graphite and diamond).

vi. They have low densities.

Chemical properties of non-metals:

i. Their valence shells are deficient of electrons, therefore, they readily accept electrons to complete their valence shells and become stable.

ii. They form ionic compounds with metals and covalent compounds by reacting with other non-metals e.g. CO_2, NO_2, etc.

iii. Non-metals usually do not react with water.

iv. They do not react with dilute acids because non-metals are itself electron acceptors.

v. They form acidic oxides.

Trend of electro negativity:

Electro negativity of first member of group 14, 15, 16 and 17 are higher than that of other members of the group decreasing their electro negativity.

The decreasing order of electronegativity is as under.

All halogens (X_2) combine with hydrogen to give hydrogen halides (HX).

$$H_2 + F_2 \xrightarrow{\text{dark and cold}} 2HF$$

$$H_2 + Cl_2 \xrightarrow{\text{sunlight}} 2HCl$$

$$H_2 + Br_2 \xrightarrow{\text{only on headting}} 2HBr$$

$$H_2 + I_2 \xrightarrow[\text{and catalyst}]{\text{heating}} 2HI$$

Trend of chemical reactivity of halogen:

i. The chemical affinity for H_2 decreases down the group from F_2 to Br_2

ii. Fluorine combines with hydrogen even in the dark and cold state. Chlorine reacts with hydrogen in the presence of sunlight.

iii. Bromine and iodine react with hydrogen only on heating.

iii. Reaction with water:

Flourine (F_2) decomposes water in cold state and in dark. Chlorine decomposes water in presence of sunlight. Bromine only react with water under special conditions. Iodine does not give this reaction.

$$2F_2 + 2H_2O \xrightarrow[\text{Cold state}]{\text{Dark and}} 4HF + O_2$$

$$Cl_2 + H_2O \xrightarrow{\text{sunlight}} HCl + HOCl$$

$$Br_2 + H_2O \xrightarrow{\text{heat}} HBr + BOBr$$

$$I_2 + H_2O \longrightarrow \text{No reaction}$$

iv. Reaction with methane:

$$F_2 > Cl_2 > Br > I_2$$

Reaction with fluorine: (F_2) reacts violently with methane (CH_4) in dark.

Reaction with chlorine:

a. In dark: Chlorine (Cl_2) does not react with methane in dark.

b. In bright sunlight: However the presence of bright sunlight the reaction is violent.

$$CH_4 + 2Cl_2 \xrightarrow{\text{Bright sunlight}} C + 4HCl\,.$$

c. In diffused sunlight: In presence of diffused sunlight the reaction of chlorine with methane is slow and gives series of compounds e.g. CH_3Cl, CH_2Cl_2, $CHCl_3$ and CCl_4.

$$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$$

$$CH_3Cl + Cl_2 \longrightarrow CH_2Cl_2 + HCl$$

$$CH_2Cl_2 + Cl_2 \longrightarrow CHCl_3 + HCl$$

$$CHCl_3 + Cl_2 \longrightarrow CCl_4 + HCl$$

v. Reaction with Sodium hydroxide:

Chlorine reacts with **cold dilute NaOH** to give sodium hypochlorite

$$2NaOH + Cl_2 \longrightarrow NaCl + NaOCl + H_2O$$

Cl_2 reacts with **hot concentrated NaOH** to give sodium chloride in

$$6NaOH + 3Cl_2 \longrightarrow 5NaCl + NaClO_3 + 3H_2O$$

Q.13 What is the significance of non metals in daily life?

Significance of Non-metals:

Although non-metals are fewer than metals, yet they are highly significant. They are equally important for human beings, animals and plants. In fact, life would not have been possible without the presence of non-metals on earth.

i. As major components of earth's crust oceans and atmosphere:

Major components of earth's crust, oceans and atmosphere are non-metals: oxygen has the highest percentage in earth' crust (47%) and oceans (86%) and it is second (21%) to nitrogen in atmosphere. It indicates the importance of oxygen in nature.

Maintenance of balance of non-metals:

To maintain the balance for the amount of non-metals in nature, different cycles like water cycle, nitrogen cycle etc have been established naturally.

ii. As essential component of body:

Non-metals are essential part of the body structure of all living things.

Examples:

a. Human body is made up of about 28 elements. But about 96% of the mass of the human body is made up of just 4 elements i.e. oxygen 65%, carbon 18%, hydrogen 10% and nitrogen 3%.

b. Similarly plant bodies are made up of cellulose, which is composed of carbon, hydrogen and oxygen.

iii. Essential for existence life:

Life owes to non-metals as without O_2 and CO_2 (essential gases for respiration of animals and plants respectively), life would not have been possible. In fact, these gases are essential for the existence of life.

iv. Maintenance of life:

All eatables like carbohydrates, proteins, fats, vitamins, water, milk etc which are necessary for the growth and development of body that are made up of non-metals; carbon, hydrogen and oxygen. Its shows non- metals playa vital role for the maintenance of life

v. Survival of life:

The essential compound for the survival of life of both animals and plants is water, which is made up of non-metals. Water is not only the major part by mass of animals and plants bodies, but it is also essential to maintain the life. We can survive without water for days but not for a long period; its shortage may cause death.

vi. Safety of life:

Non-metal nitrogen, which is 78% in atmosphere, is necessary for the safety of life on earth. It controls the fire and combustion processes, otherwise all the things around us could burn with a single flame.

vii. Communication in life:

Non-metals are playing essential role for the communication in life. All fossil fuels which are major source of energy: coal, petroleum and gas are made up of carbon and hydrogen. Even the essential component of combustion of fossil fuels, oxygen is also a non-metal.

viii. Clothing:

Non-metals protect us in a way. The clothes we wear are made of cellulose (natural fiber) or polymer (synthetic fiber).

ix. Manufacture of industrial goods:

In addition to all these, other items used in daily life such as wooden or plastic furniture, plastic sheets and bags, plastic pipes and utensils are made of non-metallic elements.

Even all the pesticides, insecticides, fungicides and germicides consist of non-metals a major constituent.