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Chemistry

Metal and Non-metal

Lecture :- 3

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METALS AND NON-METALS

Difference between Metals and Non-Metals

Property	Metals	Non-metals
Physical State	Generally exists in solid state Except: Hg (liquid at room temp.) Ga: 30°C Cs: 28.5°C	They exists in solid and gaseous state Except: Br (liquid)
Lustre	They have shining surface Except: lead (dull appearance)	They lack luster Except: Iodine, diamond, and graphite
Hardness	Are hard in nature Except: Na, K, Cs, Hg, Ga, Zn (soft metals, can be cut by knife)	Are soft in nature Except: Diamond is the hardest natural substance known
Ductility	Beaten into sheets Au and Ag are more malleable Except: Hg, Na, K, Zn	They are not malleable
Malleability	Drawn into wire, Au and Ag more ductile Except: Hg, Na, K, Zn Ag → Metal with highest conductivity	They lack ductility
Melting and Boiling point	They have high melting and boiling point High BP = 5650°C (Rhenium - Re) Except: Hg	Low melting and boiling point Except: Diamond, Graphite, Si, C, B

Density	They have high density Except: Na and K (they float on water) Highest density: Osmium	Have low density Except: Diamond
Brittleness	They are hard Except: Zn	Are brittle Except: gases
Alloy-formation	Stainless steel is alloy of Ni, Cr, and Fe German Silver: Cu, Zn and Ni	Do not form Except: Carbon is allowed with iron to form steel
Thermal and electrical conductivity	Are good conductor of heat Except: Lead and Hg	Bad conductor of heat and electricity Except: graphite which is a good conductor of electricity
Sonority	They are sonorous	Are not sonorous
Types of ion	Cation	Anion
Nature of oxides	Basic in nature	Acidic in nature

Chemical Properties of Metals

- Reaction of metal with oxygen (burning in air or formation of oxides)

Almost all metals combine with oxygen (or air) to metal oxides

Metal + Oxygen $\longrightarrow$ Metal Oxide

e.g. (i) $4Al(s) + 3O_2(g) \xrightarrow{\Delta} 2Al_2O_3(s)$ + HCl $\longrightarrow AlCl_3 + H_2O$

Aluminium Oxide

(ii) $2Cu(s) + O_2(g) \xrightarrow{\Delta} 2CuO(s)$

Copper Oxide

Generally, metal oxides are basic in nature

Reaction of metal with oxygen

Exception:

- Some metal oxides such as Aluminium oxide, Zinc oxide show both acidic and basic behaviour, such metal oxides which react with both acids as well as bases to produce salt and water are called amphoteric oxides

e.g. (i) $Al_2O_3(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2O(l)$

acting as basic oxide — Aluminium Chloride

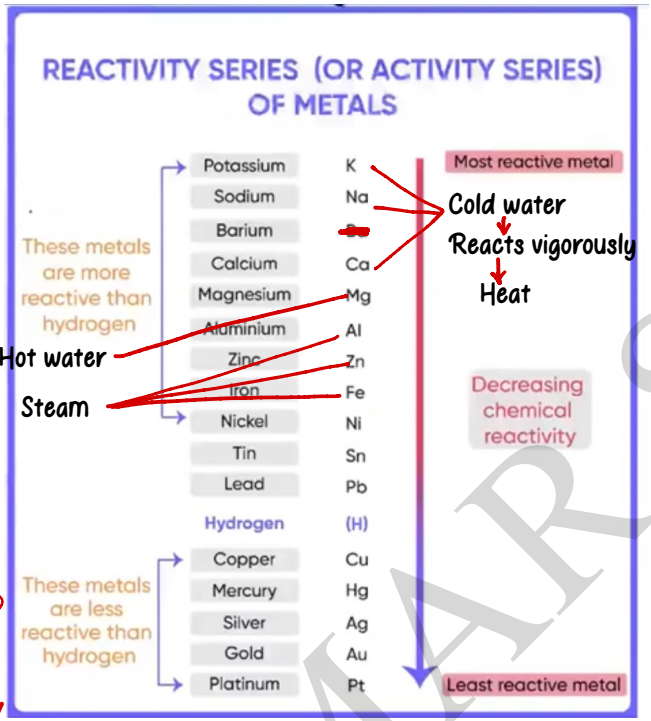
(ii) $Al_2O_3(s) + 2NaOH(aq) \rightarrow 2NaAlO_2 + H_2O$

- Metal oxide + Acid → Salt + water
- Non-metal oxide + Base → Salt + water

Order of reactivity of metal with oxygen:

1. Different metals react with oxygen at different rates
2. Sodium and potassium react vigorously with oxygen catch fire if left open that's why kept in kerosene oil
3. At room temp. the surface of magnesium and aluminium are covered with thin layer of oxide which prevents the metal from further oxidation. They burn in air only by heating
4. Zinc burns only on strong heating
5. Iron burns in the form of fillings
6. Gold and Silver do not react with oxygen even at high temp.

Reactivity Series



TRICK

K
Na
Car
Mangi
Al
Zn
Ferrari
Phir bhi
Kya
Mili → Hg
Ag
Audi

* H के ऊपर वाले Metals → वो Acid के साथ React करने पे H_2 evolve करते है लेकिन निचे वाले they don't

Reaction of metal with water

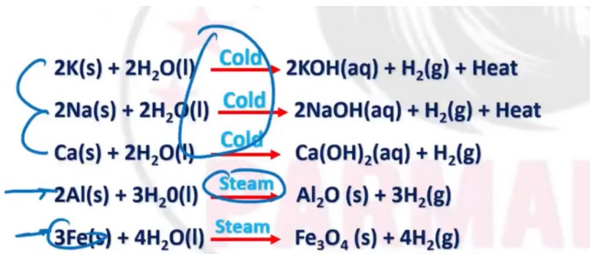
- Metal react with water and produce a metal oxides and hydrogen gas. Metal oxides that are soluble in water dissolves in it further to form metal hydroxide
- All the metals do not react with water as the metals placed lower in the reactivity series are less reactive towards water
- Metal + Water ⟶ Metal Hydroxide

- Gold (Au) → dissolves in Aqua Regia

↓

$HCl : HNO_3$

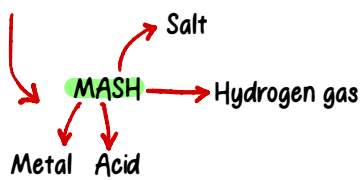
3:1



Reaction of Metal with acid:

- Except few less reactive metals (such as Cu, Hg, Ag, Au, Pt, etc.), all metals react with dilute sulphuric acid and hydrochloric acid to produce salt and hydrogen gas

- Metal + Dilute Acid → Salt + Hydrogen



$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)\uparrow$

- Hydrogen gas is not evolved when a metal reacts with nitric acid. This is due to strong oxidising nature of nitric acid. It oxidises the H, produce to water and itself get reduced to any of the nitrogen oxide (NO, NO_2, N_2O). But magnesium (Mg) and manganese (Mn) react with dilute HNO_3 to evolve H_2 gas

- Metal + HNO_3 → Salt + NO_2 /$N_2O\uparrow$ + H_2O
- Exceptional case (Only for Mn and Mg)
- Metal (Mn/Mg) + HNO_3 → Salt + $H_2\uparrow$

Reaction of metals with solutions of other metal salt

- $Metal_1 + Metal_2Salt \longrightarrow Metal_1Salt + Metal_2$
- $Cu(s) + 2AgNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2Ag(s)$

- $Metal_1$ is more reactive
- $Metal_2$ is less reactive

Reaction with Oxygen:

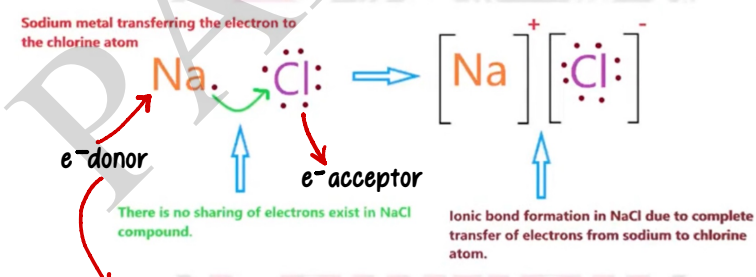
- Non-metals do not react with water, steam or dilute acid
- The reason is that they act as an electron acceptor and cannot H+ ions of acids to reduce them to hydrogen gas
- But on heating, readily form oxides or salts with conc. acids

$$S(s) + 2H_2SO_4(conc.) \xrightarrow{\Delta} 3SO_2(g) + 2H_2O(l)$$

$$S(s) + 6HNO_3(conc.) \xrightarrow{\Delta} H_2SO_4(aq) + 6NO_2(g) + 2H_2O(aq)$$

Reaction between Metals and Non-metals Ionic Bond Formation:

- Ionic Bond Formation of NaCl:-



H — H

↓

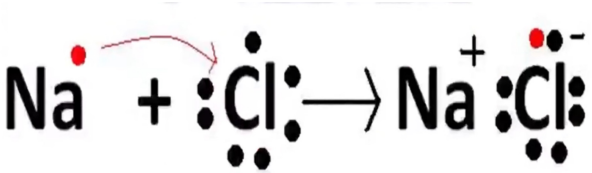
Sharing of e⁻

↓

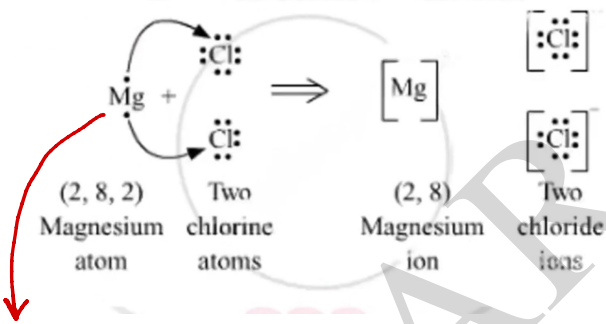
Covalent bond (weak bond)

Transfer of e → Electrovalent bond (ionic bond)

↳ ionic compounds (very strong)



Ionic Bond Formation of $MgCl_2$:-



Ionic bond formation

Properties of Ionic Compound:

1. Physical nature: Ionic compounds are hard crystalline solids because of strong force of attraction between the positive and negative ions. These compounds are generally brittle and break into pieces when pressure is applied

2. Melting and Boiling point: these compounds have high melting and boiling points as large as the amount of energy is required to break strong inter-ionic attraction

3. Solubility: these compounds are soluble in water (polar solvent) and insoluble in organic solvents (non-polar solvent) like kerosene, benzene, ether, petrol, etc.

4. Conduction of electricity: the conduction of electricity through a solution involves movement of charged particle. Ionic and electrovalent compounds are good conductors of electricity, but they conduct electricity either in molten form or in their aqueous solution

K
Na
Ca
Mg
Al — Electrolysis

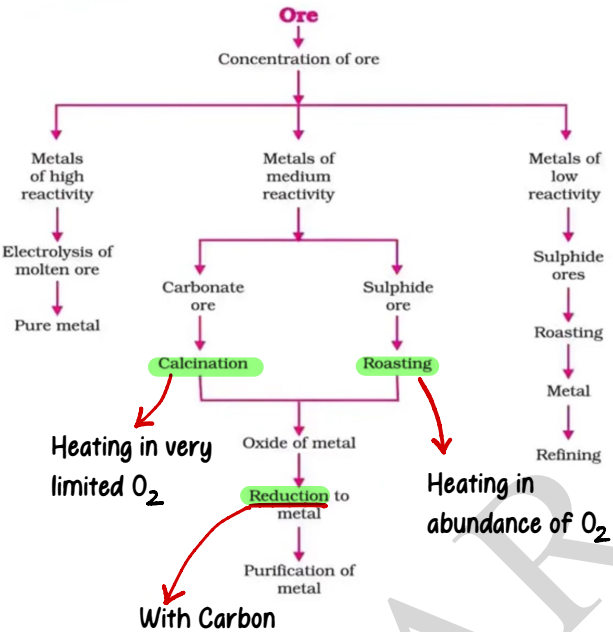
Zn
Fe
Pb
Cu — Reduction with Carbon

Ag
Au — Native state

Extraction of Metals from Ores

Metal + Impurities → Gangue

Metal	Mineral	Formula
Gold	Native Gold	Au
Silver	Argentite (in Galena)	Ag_2S
Copper	Malachite	$Cu_2CO_3(OH)_2$
	Azurite	$Cu_3(CO_3)_2(OH)_2$
	Chalcopyrite	$CuFeS_2$
Mercury	Cinnabar	HgS
Iron	Hematite	Fe_2O_3
	Magnetite	Fe_3O_4 High % of Fe
	Pyrite	FeS_2
Tin	Cassiterite	SnO_2
Lead	Galena	PbS



- Refining → Electrolytic refining
- Pure metal → Cathode
- Impure metal → Anode
- Metal Salt → Electrolyte
- $3MnO_2 + 4Al \rightarrow 2Al_2O_3 + 3Mn$
- Thermite process: $Fe_2O_3 + Al \rightarrow Fe + Al_2O_3$

Heat evolve → Exothermic → Displacement

Railway tracks join

More reactive

Electrolysis reaction:

- NaCl

Cathode: $Na^+ + e^- \rightarrow Na$

Anode: $2Cl^- \rightarrow Cl_2 + 2e^-$

Corrosion

1. Iron → Brown (Iron Oxide)
2. Copper → Green (Copper Carbonate)
3. Silver → Black (Silver Sulfide)

Alloying

- Alloy: homogenous mixture/solution of two or more metals/non-metals

Alloy	Composition
Steel	C + Fe + Ni
Stainless Steel	Cr + Fe + Ni
Solder	Pb + Sn
Bronze	90% ← Cu + Sn → 10%
Brass	30% ← Cu + Zn → 70% (B C U Z)
Gun Metal	Cu + Zn + Sn
German Silver	Cu + Zn + Ni
Nichrome	Ni + Cr + Fe
Magnalium	Mg + Al
Duralumin	Al + Mn + Cu
Constantan	Cu + Ni

Rolled gold — Cu + Al

Gold (Au)

22 carat

22 parts Au

2 parts Cu Ag

- Alloys have low conductivity compared to their respective metals

- Galvanisation/Anodising
  - Zinc coating done physically
  - Aluminium layering done electrolytically

- Purest form of Iron: Wrought iron

- Soft silvery metal, with low density that reacts vigorously with water and corrodes quickly in air and has atomic no 3: Lithium (white gold)

- Element used to make coils in water heaters: Nichrome

- Metal earlier called Wolframite and has the highest melting point: Tungsten (W)

- Element found in water and responsible for cancer: Arsenic

- NO_3 (nitrate): Blue baby syndrome

- Gallium is used in LED semiconductor technology

- Silicon dioxide: it has high melting point

- Potash alum → $KAl(SO_4)_2.12H_2O$ → Metal sulphate, composed of potassium, aluminium, and sulphate ions in the ratio 1:1:2 → Plays an important role as a flame retardant, a mordant and as astringent

- The process in which a carbonate ore is heated strongly in the absence of air to convert it into metal oxide is called Calcination

- Fool's gold: Pyrite

- Boron is an example of metalloid

- Gypsum: $CaSo_4.2H_2O$
- Celestine: $SrSO_4.2H_2O$
- Epsom salt: $MgSo_4.7H_2O$

- Constantan is an alloy of copper and nickel

- Talonite ore is a combination of cobalt and chromium

- Amalgam: Hg