Class 10 CHAPTERS – 3 METALS AND NON-METALS [Quick Revision Notes]

About 118 elements are known today. There are more than **90 metals, 22 non metals** and a few metalloids.

Sodium (Na), potassium (K), magnesium(Mg), aluminium(Al), calcium(Ca), Iron(Fe), Barium(Ba) are some **metals.**

Oxygen(O), hydrogen(H), nitrogen(N), sulphur(S), phosphorus(P), fluorine(F), chlorine(Cl), bromine(Br), iodine(I) are some **non-metals**

Physical properties of metals:

Solid at room temperature **except mercury , Gallium**

Ductile : They can be drawn into wires

Malleable : They can be hammered into very thin sheets called foils. Gold and Silver are most malleable.

Sonorous(produce sound when stuck)

Lustrous (natural shine freshly cut)

Have **high melting point. Cesium** and **gallium** have very low melting point.

Generally **good conductor** of heat and electricity, except lead and mercury which are comparatively poor conductors. **Silver** and **copper** are best conductors.

Have high density. **Sodium** and **potassium** can be cut with knife, they have **low density**.

Physical properties of non-metals:

Occur as solid or **gas. Bromine** is **liquid**.

Generally **bad conductors** of heat and electricity. **Graphite** a natural form of carbon is a **good conductor**.

Non-sonorous.

Non-lustrous, only **iodine** has lustre.

Carbon is a non-metal that can exist in different forms. Each form is called an allotrope. Diamond, an allotrope of carbon, is the hardest natural substance known and has a very high melting and boiling point. Graphite, another allotrope of carbon, is a conductor of electricity.

Chemical properties of metals:

Metals form **basic** oxides like Magnesium oxide(MgO), while non-metals form **acidic** oxides (as in acid rain).

1. Reaction with air

Metals can burn in air, react or don't react with air to form metal oxides.

Metal + oxygen ------> Metal Oxide

Some metals like Na and K are kept immersed in kerosene oil **as they react vigorously** with air and catch fire.

Some metals like **Mg,Al, Zn, Pb react slowly** with air and form a protective layer.

Mg can also burn in air with a white dazzling light to form its oxide

Fe and Cu don't burn in air but combine with oxygen to form oxide. When heated iron filings burn when sprinkled over flame.

Metals like silver, **platinum and gold don't burn or react** with air.

2Na + O2 ------> Na2O

2Mg + O2 ------> 2MgO

2Cu + O2 ------> 2CuO

4Al + 302 ------> 2Al2O3

Amphoteric Oxides : metal oxides which react with both acids as well as bases to form salt and water e.g. Al2O3, ZnO.

Al2O3 + HCl ------> AlCl3 + H2O

Al2O3 + NaOH ------> NaAlO2 + H2O

2. Reaction with water : In general metals react with water to form a metal oxide or hydroxide and hydrogen gas.

Na + H2O (cold water) ------> NaOH + H2 + heat energy

K + H2O (cold water) ------> KOH + H2 + heat energy

The reaction is so violent that the evolved hydrogen immediately catches fire so they are stored in kerosene.

Ca + H2O (Hot water) ------> Ca(OH)2 + H2

Mg + H2O (Hot water) ------> Mg(OH)2 + H2

In case of Ca and Mg, the metal starts floating due to dubbles of hydrogen gas sticking to its surface.

Al + H2O (stem)------> Al2O3 + H2

Fe + H2O (stem)------> Fe3O4 + H2

3. Reaction with dilute acids: Metals react with dilute hydrochloric acid and dilute sulphuric acid to form salt and hydrogen gas.

Fe + 2HCl ------> FeCl2 + H2

Mg + 2HCl ------> MgCl2 + H2

Zn + 2HCl ------> ZnCl2 + H2

2Al + 6HCl ------> 2AlCl3 + 3H2

Copper, mercury and silver don't react with dilute acids as they cannot displace hydrogen from acids as they are less reactive than hydrogen.

Hydrogen gas is not evolved when a metal reacts with nitric acid (HNO3) . Metal generally cannot react with nitric acid as it is a strong oxidizing agent. Hydrogen gas produced is oxidised to water when metals react with nitric acid.

But Mg and Mn, react with very dilute nitric acid to evolve hydrogen gas.

Mg + 2HNO3 ------> $Mg(NO_3)_2 + H_2$

$Mn(s) + 2HNO_3(aq) \rightarrow Mn(NO_3)2 + H2$

Aqua regia, (Latin for 'royal water') is a mixture of concentrated hydrochloric acid and concentrated nitric acid in the ratio of 3:1. It can dissolve gold, even though neither of these acids can do so alone. *Aqua regia* is a highly corrosive, fuming liquid. It is one of the few reagents that is able to dissolve gold and platinum.

4. Reaction of metals with other metal salts :

All metals are not equally reactive. Reactive metals can displace less reactive metals from their compounds in solution. This forms the basis of reactivity series of metals.

Reactivity series is a list of metals arranged in order of their decreasing activities.

K > Na > Ca> Mg > Al > Zn > Fe> Pb > **H** >Cu > Hg > Ag > Au > Pt

A metal can displace all metals from their compound which are below or after it in this series.

Fe + CuSO4 ----------> FeSO4 + Cu

Zn + CuSO4 --------> ZnSO4 + Cu

Reaction between Metals and Non-Metals:

– Reactivity of elements can be understood as a tendency to attain a completely filled valence shell.

– Atom of metals can lose electrons from valence shells to form cations (+ve ions).

– Atom of non-metals gain electrons in valence shell to form anions (–ve ions).

– Oppositely charged ions attract each other and are held by strong electrostatic forces of attraction forming ionic compounds.

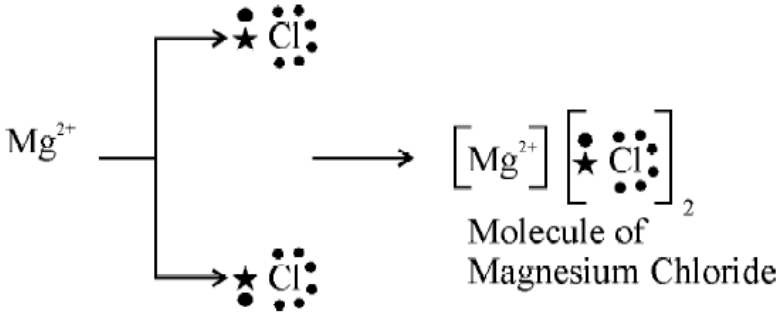
Formation of MgCl2

$Mg \text{ --------> } Mg^{2+} + 2e^{-1}$

2,8,2 2,8 (Magnesium ion)

$Cl_2 + 2e^{-1} \text{ ----------> } 2Cl^{-1}$

2,8,7 2,8,8 (Chloride ion)



Properties of Ionic Compounds:

– Are solid and mostly brittle.

– Have high melting and boiling points. More energy is required to break the strong inter-ionic attraction.

– Generally soluble in water and insoluble in kerosene, petrol.

– Conduct electricity in solution and in molten state. In both cases, free ions are formed and conduct electricity.

Chemical properties of Non metals:

Reaction with hydrogen: Non-metals react with hydrogen to form covalent hydrides. For example, nitrogen, oxygen, sulphur and chlorine react with hydrogen to form ammonia, water, hydrogen sulphide and hydrogen chloride, respectively.

$N_2 + 3H_2 \text{ --------> } 2NH_3$

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

$S + H_2 \text{ --------> } H_2S$

$Cl_2 + H_2 \text{ --------> } 2HCl$

Reaction with Oxygen: They form covalent oxides with oxygen e.g. carbon and sulphur.

C + O2 → CO2 and S + O2 → SO2

The oxides of non-metals are acidic, except CO, N_2O and NO, which are neutral.

Phosphorous burns with a bright dazzling flame giving white fumes of phosphorous pentoxide at room tempreture. so stored in water. $4P + 5O_2$ ----------> $2P_2O_5$

Reaction with Acid: Non-metals do not react with dilute acids. A non metal is an electron acceptor. It cannot supply H^+ ions. So it does not displace hydrogen from dilute acids.

Cl + HBr ---> HCl + Br_2 ; Cl + HI ---> HCl + I_2

Reaction with Water: □ some of the oxides of non-metals form acids on dissolution in water.

CO2 + H2O → H2CO3 (Carbonic acid)

SO2 + H2O → H2SO3 (Sulphurous acid)

Other oxides like CO, N_2O etc are neutral.

C (red hot coke) + H_2O ----------> $\underbrace{CO + H_2}$ water gas

Reaction with Chlorine : Non-metals react with chlorine to form covalent chlorides. For example, hydrogen reacts with chlorine to form hydrogen chloride and phosphorus reacts to form phosphorus trichloride.

H2 + Cl_2 ----------> 2HCl ; $P_4 + 6Cl_2$ ----------> $4PCl_3$

Occurrence of Metals

Minerals: elements of compounds occurring naturally are minerals.

Ores: Mineral from which metal can be profitably extracted is an ore. For example, Sulphide ore, oxide ore, carbonate ore.

Metals at the bottom of activity series like gold, platinum, silver , copper generally occur in free state. But copper and silver also occur in sulphide and oxide ores.

Metals o f medium reactivity (Zn, Fe, Pb etc.) occur mainly as oxides, sulphides or carbonates.

Metals of high reactivity (K, Na, Ca, Mg andAl) are very reactive and thus found in combined state.

Gangue or matrix: ores are naturally found mixed impurities like soil, sand, etc. called gangue.

Metallurgy: The process of obtaining metal from its ore. They are:

(i) Enrichment of ore after crushing and grinding

(ii) Obtaining metal from enriched ore.

(iii) Refining of impure metal to obtain pure metal.

Enrichment of ore after crushing and grinding : The substance added to the ore to remove the matrix called flux results in the formation of a fusible compound called slag.

The processes used for removing the gangue from the ore are based on the differences between the physical or chemical properties of the gangue and the ore. At first the ore is crushed to powder.

The fine particles of ore is separated by physical processes like hydraulic washing, froth-floatation, and magnetic separation or by chemical processes, depending on the nature of the ore and its impurities

Obtaining metal from enriched ore or reduction:

Extracting Metals Low in the Activity Series: By heating the ores in air at high temperature.

*Mercury from cinnabar

2HgS + 3O2 ---Heat--> 2HgO + 2SO2

2HgO ------Heat----> 2Hg + O2

* Copper from copper sulphide

Cu2S + 3O2 ------Heat----> 2Cu2O _ 2SO2

2Cu2O + Cu_2S ------Heat----> 6Cu + SO2

Extracting Metals in the Middle of Activity Series :

Metals are easier to obtain from oxide ores, thus, sulphide and carbonate ores are converted into oxides.

Metal ore heated strongly in excess of air is calledRoasting

2ZnS + 3O2 ------Heat----> 2ZnO + 2SO2

Metal ore heated strongly in limited or no supply of air (Calcination)

ZnCO3 ------Heat----> ZnO + CO2

Reduction of Metal Oxide:

It is easier to obtain a metal from its oxide, as compared to its sulphides and carbonates. Therefore, the metal sulphides and carbonates must be converted into metal oxides

1. USING COKE: Coke as a reducing agent as it is cheap.

ZnO + C ------Heat----> Zn + CO

2. USING DISPLACEMENT REACTION : highly reactive metal like Na, Ca and Al are used to displace metals of lower reactivity from their compounds.

MnO_2 + 4Al ------Heat----> 3Mn + 2Al2O3 + heat

Fe_2O_3 + 2Al ------Heat----> 2Fe + Al2O3 + heat

Displacement reactions are highly exothermic. The amount of heat evolved is so large that the metals are produced in the molten state Therefore molten iron iso formed and is used to join railway tracks. This is called Thermit reaction.

Extracting Metals at the Top of Activity Series :

These metals have more affinity for oxygen than carbon.

These metals therefore are obtained by electrolytic reduction from their salt. Sodium is obtained by electrolysis of its molten chloride

$NaCl \text{ ---> } Na^{+1} + Cl^{-1}$

As electricity is passed through the solution metal gets deposited at cathode and non-metal at anode.

At cathode(the negatively charged electrode): $Na^{+1} + e^{-}$ -----> Na

At anode (the positively charged electrode). : $2Cl^{-1}$ ----------> $Cl_2 + 2e^{-}$

Aqueous solution of sodium chloride cannot be used to obtain sodium metal, why?

Ans*:* As current is passed through NaCl(aq) two cations are obtained simultaneously Na+ and H^+. As H^+ ions have more tendency to undergo reduction than Na+ the H+ ions are reduced to form H_2 rather than Na+. Thus at cathode H2 is obtained not Na. Hence the solution of sodium chloride cannot be used to obtain sodium metal. Fused NaOH is used instead

Refining of Metals: : Impurities present in the obtained metal can be removed by electrolytic refining.

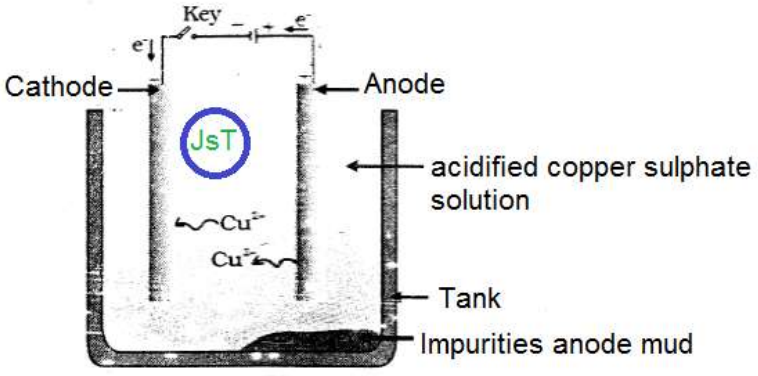
Copper is obtained using this method. Following are present inside the electrolytic tank.

Anode – slab of *impure* copper Cathode – slab of *pure* copper

Solution – aqueous solution of copper sulphate with some dilute sulphuric acid

On passing electricity through electrolytes, from anode copper ions are released in the solution and equivalent amount of copper from solution is deposited at cathode.

Impurities containing silver and gold get deposited at the bottom of anode as anode mud.



Titanium, Chromium, Zirconium are called strategic metals, why?

Sol: Because they are essential for a country's economy and defense.

Corrosion :

– Metals are attacked by substances in surroundings like moisture and acids.

– Silver - it reacts with sulphur in air to form silver sulphide and articles become black.

– Copper - reacts with moist carbon dioxide in air and gains a green coat of copper carbonate.

– Iron-acquires a coating of a brown flaky substance called rust. Both air and moisture are necessary for rusting of iron.

Sometimes rusting is advantageous as it prevents the metal underneath from further damage. eg. On exposure to air, the surface of aluminium is coated with a thin layer of aluminium oxide

Prevention of corrosion:

– Rusting of iron is prevented by painting, oiling, greasing, galvanizing, chrome plating, anodising and making alloys.

– In galvanization, iron or steel is coated with a layer of zinc because zinc is preferably oxidized than iron.

Alloys : These are mixture of metals with metals or non-metals

– Adding small amount of carbon makes iron hard and strong.

– Stainless steel is obtained bymixing iron with nickel and chromium. It is hard and doesn't rust.

– Mercury is added to other metals to make amalgam.

Brass : alloy of copper and zinc. ***Bronze*** : alloy of copper and tin.

– In brass and bronze, melting point and electrical conductivity is lower than that of pure metal.

Solder : alloy of lead and tin has low melting point and is used for welding electrical wires