Metals and Non- Metals

Physical Properties- The easiest way to group substances is by comparing their physical properties.Metallic lustre – Metals, in their pure state having a shining surface. This property is called Metallic lustre, eg. Iron, Copper, Aluminium and Magnesium.

1) Hardness – Metals like Iron, Copper, aluminum and magnesium are hard. Metals like Sodium and Potassium can be cut with a sharp knife. They are soft.
2) Malleability – The property of metals to be beaten into thin sheets is called malleability. Gold and Silver are most malleable metals.
3) Ductility – The ability of metals to be drawn into thin wires is called ductility. Gold is most ductile.
4) Conductivity – The ability to allow flow of heat and electric current is called conductivity. Metals are good conductors of heat and have high melting point. Silver and Copper are best conductors of heat. Lead and mercury are poor conductors of heat.

Non- Metals

1) Physical state – The non-metals are either solids or gases except bromine which is a liquid.
2) Iodine is a non-metal which is lustrous.
3) Carbon exists in different allotropic forms eg. Diamond and Graphite. Diamond is the hardest substance known and graphite is a good conductor of electricity.

Metals

1) Lithium, sodium & potassium are so soft that they can be cut with knife. The have low densities.
2) All metals except Mercury exist as solids at room temperature. Gallium and Caesium have very low melting point..

Chemical Properties of Metals

1) Metals on burning in air form Metal Oxides. For e.g.
   a) Copper when heated in air forms Copper (II) oxide, a black oxide.
      $2Cu + O_2 \rightarrow 2CuO$
      (Copper) (Copper (II) oxide)
   b) Aluminium forms Aluminium Oxide : $4Al + 3O_2 \rightarrow 2Al_2O_3$

Aluminum oxide, Zinc oxide are amphoteric oxides as they react with both acids as well as bases to form salt and water.For e.g.

$Al_2O_3 + 6\ HCl \rightarrow 2AlCl_3 + 3H_2O$

$Al_2O_3 + 2NaOH \rightarrow 2\ NaAlO_2 + H_2O$ Some metals oxides dissolve in water to form alkalis.

$Na_2O(s) + H_2O\ (I) \rightarrow 2\ NaOH\ (aq)$

$K_2O\ (s) + H_2O\ (I) \rightarrow 2\ KOH\ (aq)$

Different metals show different reactivities towards oxygen. Metals such as a K and Na react vigorously with air. To protect them, they are kept immersed in kerosene. At ordinary temp. surface of metals such Mg, Al, Zn, Pb are covered with layer of oxide which prevents metals from further oxidation.

-Fe and Cu do not burn but react with oxygen on heating to form their oxides.

-Gold and Silver do not react with oxygen even at high temp.

2) **<u>Reaction of Metals with water</u>**

Metal + H_2O → Metal oxide + Hydrogen

Soluble metal oxide + water → Metal Hydroxide

Rate of reaction of different metals is different

- Na,K react violently with cold water

$2Na\ (s) + 2H_2O(1) \rightarrow 2NaOH(aq) + H_2\ (g) + Heat\ energy$

$2K\ (s) + 2H_2O(l) \rightarrow 2KOH\ (aq) + H_2\ (g) + Heat\ energy$

Metals like Al, Fe, Zn do not react with cold water or hot water. They react with steam.

$2Al\ (s) + 3H_2O(g) \rightarrow Al_2O_3(s) + 3H_2\ (g)$

$3\ Fe\ (s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2\ (g)$

3) **<u>Reaction of Metals with Acids</u>**

Metal + dilute acid → Salt + Hydrogen

H_2 gas is not evolved when metals react with nitric acid as it is a strong oxidizing agent.

It oxidizes H_2 to produce H_2O, itself gets reduced to oxides of nitrogen (N_2O, NO, NO_2). Mg and Mn react with very dilute HNO_3 to evolve H_2 gas. The reactivity decreases in the order **<u>Mg>Al>>Zn>Fe.</u>**

Cu does not react with dilute HCl.

4) **Reaction of metals with solutions of other metal salts**

Reactive metals displace less reactive metals from their compounds in solutions or molten form.

When iron nail is kept in an aqueous Copper sulphate, the blue color of $CuSO_4$ (aq) fades away and changes to green in color as Fe displaces Cu from $CuSO_4$ solution. E.g.

$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

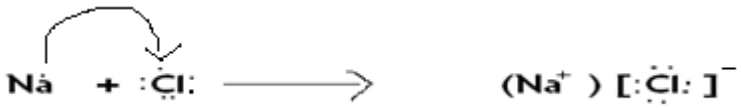
How do metals and non-metals react?

The reactivity of elements is the tendency to attain a completely filled valence shell. For ex. Na atom loses one electron to attain a stable octet and form Na^+ ion whereas chlorine atom gains an electron to attain a stable octet & forms Cl^- ion. Ex.

$Na \rightarrow Na^+ + e^-$ (formation of Na^+ ion)

[Formation of Cl^- ion]

$Cl + e^- \rightarrow Cl^-$



Properties of ionic compounds

1. Physical nature: they are hard, crystalline solids. They are generally brittle.
2. They have high melting and boiling point.
3. Generally soluble in water and insoluble in organic solvents.
4. They conduct electricity in aqueous solution and in molten state.

Occurrence of metals

1. Free state: Metals found in the elemental form. Ex Au, Ag, Pt, Cu
2. Combined state: Metals found in the form of compound as oxides, sulphides, carbonates etc. E.g.Cu, Ag, Na, K, Ca, Mg, Al, Zn, Fe, Pb etc.

   Minerals: elements or compounds found naturally in the earth's crust.Ores: the minerals from which metals can be extracted profitably.

Extraction of Metals:

Metallurgy: Several steps involved in the extraction of pure metal from its ores.

- Steps involved in extraction:
  1. Enrichment of ore
  2. Extraction of metal from the enriched ore
  3. Refining of metals
- Enrichment of ore: The process of removing impurities from the ores.
  1. Gangue: Unwanted substances which contaminate ores. Ex: soil, sand etc.
  2. Physical or chemical properties decide the method employed for concentration of the ore.
- Extraction of metal from concentrated ore:

1. Extracting metals low in the reactivity series.

- Ores can be reduced to metal by heating alone.

  Ex: Cinnabar (HgS) : an ore of mercury

- Conversion of sulphide to oxide
- Decomposition of oxide to metal

$2HgS(s) + 3O_2(g) \xrightarrow{heat} 2HgO(s) + 2SO_2(g)$

$2HgO(s) \xrightarrow{heat} 2Hg(l) + O_2(g)$

Similarly copper glance (Cu_2S) yields copper.

$2Cu_2S(s) + 3O_2(g) \xrightarrow{heat} 2Cu_2O(s) + 2SO_2(g)$

$2Cu_2O + Cu_2S \xrightarrow{heat} 6Cu(s) + SO_2(g)$

2. Extracting Metals in the middle of the reactivity series

- Fe, Zn, Pb, Moderately active elements.
- Found as sulphides or carbonates
- It is easier to extract metals from the oxides than from sulphides or carbonates.

a. Conversion of the carbonates and sulphides to oxides.

Sulphide ores and carbonate ores are converted to oxides.

Roasting: Heating the ore strongly in the presence of the excess of air.

$2ZnS(s) + 3O_2 \xrightarrow{Heat} 2ZnO(s) + 2SO_2(g)$

Calcination: Heating the ore strongly in the absence of air

$$ZnCO_3(s) + \xrightarrow{Heat} ZnO(s) + CO_2(g)$$

b. Reduction of metal oxide to metal:

Metal oxide + reducing agent → Metal + oxidized reducing agent

Reduction using carbon as reducing agent

$$ZnO(s) + C(s) \xrightarrow{Heat} Zn(s) + CO(g)$$

Reduction by more active metals as reducing agent

Oxides of manganese (MnO_2) and Chromium (Cr_2O_3) are reduced to metal by heating with aluminium.

$$3MnO_2(s) + Al(s) \xrightarrow{Heat} 3Mn(l) + 2Al_2O_3(s) + heat$$

Corrosion:

- The process of slow wasting away of metal by the action of atmospheric gases and moisture is called corrosion.
- Silver objects : Black deposit (Silver sulphide)

  Copper objects : Green deposit (Basic copper carbonate)

  Iron objects : Brown flaky deposit (Hydrated ferric oxide)

- **Conditions necessary for corrosion of iron**.
  1. Presence of air (oxygen)
  2. Presence of water
- **Prevention of corrosion**
  1. Painting
  2. Oiling
  3. Greasing
  4. Galvanizing: Coating iron objects with a thin layer of zinc.
  5. Chrome plating: Coating iron objects with chromium by electrolysis
  6. Anodising: Making layer of oxide on aluminium
  7. Alloying: Making homogeneous mixtures of 2 or more metals or a metal with non-metal.
- **Why do we make alloys:** For altering the properties. E.g
  1. Increasing hardness: Adding carbon to iron.
  2. Making corrosion resistant: Adding Ni and Cr to iron. (stainless steel)
  3. Lowering melting point: Mixing tin + lead. (solder)

4. Reducing electrical conductivity: Mixing Cu and Zn to make Brass
5. Reducing reactivity: Adding mercury to sodium.
6. Alloys of metal with mercury are called Amalgams.