Chapter 15: Metals

1. Distinguish between metals and nonmetals

<table>
<thead>
<tr>
<th>Metal</th>
<th>Non metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid at room temperature</td>
<td>Solid, liquid, gas at room temperature</td>
</tr>
<tr>
<td>Metals are sonorous</td>
<td>Nonmetals are non sonorous</td>
</tr>
<tr>
<td>Malleable and ductile</td>
<td>Brittle</td>
</tr>
<tr>
<td>Good conductor of heat and electricity</td>
<td>Bad conductor of heat and electricity (except Graphite)</td>
</tr>
<tr>
<td>Lustrous (except sodium)</td>
<td>Non-lustrous ((iodine, Graphite, silicon)</td>
</tr>
<tr>
<td>Electron doner and hence electro + ve</td>
<td>Electron acceptor – hence electro -ve</td>
</tr>
<tr>
<td>Form ionic bond</td>
<td>Form both electronic and covalent bond</td>
</tr>
<tr>
<td>Displace hydrogen from acid</td>
<td>Donot displace hydrogen from acid</td>
</tr>
<tr>
<td>Turns red litmus to blue</td>
<td>Turns Blue litmus to red</td>
</tr>
<tr>
<td>Oxides of metal in aq soln reacts with Zn to produce H₂</td>
<td>Oxides of non metal in aq soln reacts with carbonates to produce CO₂</td>
</tr>
</tbody>
</table>

2. How do metals react with air?

Metal + oxygen --------> metallic oxide

Eg: 2 Mg + O₂ --------> 2MgO
    4Al + O₂ --------> 2Al₂O₃

3. What is rust? Give its chemical formula.

1. It is a process of oxidation.
2. It is process of formation of a brownish hydrated oxide of iron on the surface of iron when it is exposed to air and moisture.
   The chemical formula of rust is Fe₂O₃·2H₂O

3. Explain the reaction of metals with the non metals.

   Metal + Nonmetal --------> ide

1. 3Mg + N₂ --------> Mg₃N₂  (Magnesium nitride)
2. Ca + H₂ --------> CaH₂  (Calcium hydride)

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3. \[ 2Al + Cl_2 \rightarrow 2AlCl_3 \] (Aluminium chloride)

4. \[ Fe + S \rightarrow FeS \] (Ferrous sulphide)

4. **Explain the reaction metal with water**

Metal + H\(_2\)O --------> Metallic hydroxide + H\(_2\)↑

1. \[ 2Na + H_2O \rightarrow 2NaOH + H_2 \] Sodium hydroxide

2. \[ Mg + H_2O \rightarrow Mg(OH)_2 + H_2 \] Magnesium hydroxide

**Reaction of metal with steam:**

\[ Zn + H_2O \rightarrow ZnO + H_2 \uparrow \]

\[ Mg + H_2O \rightarrow MgO + H_2 \uparrow \]

\[ 3Fe + H_2O \rightarrow Fe_3O_4 + H_2 \uparrow \]

(Note: Platinum and Gold do not react with water)

5. **Describe the Lane process of manufacture of hydrogen.**

1. Take a hard glass tube open at both ends.
2. Fix it horizontally using Stand.
3. Take 5 gm of iron fillings in that tube.
4. Fit the mouth of the tube with rubber stopper at each end.
5. Insert a glass tube through each of two holes.
6. Connect the glass tube to a boiler and another to balloon.
7. Heat the tube containing iron fillings till iron becomes red hot.
8. Red hot iron decomposes steam to ferric oxide and hydrogen.
9. Hydrogen is collected in the balloon.

6. **Explain the reaction of metals with Dilute Acids.**

   I. Reaction of metal with dilute hydrochloric acid (HCl):

   Metal + Acid --------> Metallic salts + H\(_2\)↑

   \[ 2Na + 2HCl \rightarrow 2NaCl + H_2 \uparrow \]
\[
\begin{align*}
Mg &+ 2HCl \rightarrow MgCl_2 + H_2 \\
Zn &+ 2HCl \rightarrow ZnCl_2 + H_2 \\
2Fe &+ 6HCl \rightarrow 2FeCl_3 + H_2 \\
\end{align*}
\]

**II. Reaction of metal with Dilute Sulphuric Acid (H\(_2\)SO\(_4\)) :**

\[
\begin{align*}
2Na &+ H_2SO_4 \rightarrow Na_2SO_4 \\
Mg &+ H_2SO_4 \rightarrow MgSO_4 \\
\end{align*}
\]

**III. Reaction of metal with Conc Sulphuric Acid (H\(_2\)SO\(_4\)) :**

\[
\begin{align*}
Cu &+ H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O \\
Zn &+ H_2SO_4 \rightarrow ZnSO_4 + SO_2 + 2H_2O \\
\end{align*}
\]

**IV. Reaction of metal with Nitric acid :**

\[
\begin{align*}
Zn &+ HNO_3 \rightarrow Zn(NO_3)_2 + H_2 \\
Mg &+ HNO_3 \rightarrow Mg(NO_3)_2 + H_2 \\
\end{align*}
\]

**V. Reaction of metal with moderately conc HNO\(_3\) :**

\[
\begin{align*}
3Cu &+ 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O \\
\end{align*}
\]

* Trick: 3 : 8 --- NO \(^{\uparrow}\) ------ colourless fumes

**VI. Reaction of metals with Conc Nitric acid HNO\(_3\) :**

\[
\begin{align*}
Cu &+ 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2N_2O \\
\end{align*}
\]

* Trick: 1 : 4 --- NO\(_2\) \(^{\uparrow}\) ------ Reddish brown fumes

**Note:**
1. Gold, silver, and platinum do not react with water.
2. Reactivity of Au < Cu < Fe < Zn < Al < Mg.
3. Iron takes more time to react with HCl because it has the lowest reactivity.
7. **What are minerals?**
Ans: Elements or inorganic compounds of metals that are found in nature along with other earthly impurities are called Minerals.

8. **What are Ores?**
Ans: Minerals from which metals can be extracted are Ores.

9. **What are the different types of ore?**

<table>
<thead>
<tr>
<th>Oxides Ores of metals</th>
<th>Molecular formula</th>
<th>Metal Extracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bauxite</td>
<td>Al₂O₃H₂O</td>
<td>Aluminium</td>
</tr>
<tr>
<td>Haematite</td>
<td>Fe₂O₃</td>
<td>Iron</td>
</tr>
<tr>
<td>Limonite</td>
<td>Fe₂O₃. 2H₂O</td>
<td>Iron</td>
</tr>
<tr>
<td>Magnetite</td>
<td>Fe₃O₄</td>
<td>Iron</td>
</tr>
<tr>
<td>Cuprite</td>
<td>Cu₂O</td>
<td>Copper</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sulphide Ores of Metals</th>
<th>Molecular formula</th>
<th>Metal Extracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Glance</td>
<td>Cu₂S</td>
<td>copper</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>CuFeS₂</td>
<td>copper</td>
</tr>
<tr>
<td>Iron Pyrite</td>
<td>FeS₂</td>
<td>Iron</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carbonate Ores of metals</th>
<th>Molecular formula</th>
<th>Metal Extracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siderite</td>
<td>FeCO₃</td>
<td>Iron</td>
</tr>
<tr>
<td>Azurite</td>
<td>Cu₃(CO₃)₂(OH)₂</td>
<td>Copper</td>
</tr>
<tr>
<td>Malachite</td>
<td>Cu₂ CO₃(OH)₂</td>
<td>Copper</td>
</tr>
<tr>
<td>Limestone</td>
<td>CaCO₃</td>
<td>Calcium</td>
</tr>
</tbody>
</table>
10. Define metallurgy?
Ans: It is technology of extraction of metals from ores and refining to required form.

11. Explain the meaning of following terms in metallurgy.
I. Gangue: Unwanted impurities in ore.

II. Concentration of Ore: - Removing unwanted impurities
- Increasing the % of desired component
- It is also called as enrichment of ore.

III. Roasting: Heating ore below its melting point in presence of air to oxidise the ore.

IV. Calcination: Heating ore below its melting point in absence of air to remove water and carbon di oxide and to bring about its decomposition.

V. Flux: The substance added to ore to remove the gangue material is called flux.

VI. Slag: Fluid formed when Flux combines with the impurities in the ore during extraction of metal is called Slag.

12. Distinguish between Roasting and calcination

<table>
<thead>
<tr>
<th>Roasting</th>
<th>Calcination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Heating in the presence of air</td>
<td>1. Heating in the absence of air</td>
</tr>
<tr>
<td>2. Sulphide ores are roasted</td>
<td>2. Carbonate ores are calcined</td>
</tr>
</tbody>
</table>

- \( 2\text{ZnS} + 3\text{O}_2 \xrightarrow{\Delta} 2\text{ZnO} + 2\text{SO}_2 \uparrow \)
- \( \text{CaCO}_3 \xrightarrow{\Delta} \text{CaO} + \text{CO}_2 \uparrow \)
Extraction of Iron

1. Give the chemical symbol and Electronic configuration of Iron
   Ans: Fe = 26 = 1s², 2s² 2p⁶, 3s² 3p⁶, 4s² 3d⁶

2. Name the ores of Iron.
   Ans: 1. Haematite - Fe₂O₃
       2. Limonite - Fe₂O₃ . 2H₂O
       3. Magnetite - Fe₃O₄
       4. Siderite - FeCO₃

3. Explain the Concentration of Haematite ore by Hydraulic washing.
   1. The haematite ore contain impurities like Clay and silica.
   2. These are removed by washing crushed ore with the stream of water.
   3. Lighter impurities are washed away.
   4. Heavier Ore particles and silica settle at the bottom Can be separated easily.

3. Explain the process of extraction of iron with neat labeled diagram of blast furnace.
   Ans:
   1. Concentrated ore, lime stone and coke Are taken in the ratio 8 : 1 : 4 .this mixture is called as Charge
   2. Charge is introduced in the blast furnace from the top.
   3. Hot air is blown from the base of the furnace.
   4. The following reactions takes place:
\[
\text{Fe}_2\text{O}_3 + \text{CaCO}_3 + \text{C} \quad 8 : 1 : 4 \\
\]  
1. \(\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2\)  
2. \(\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3 \quad \text{--Slag}\)  
3. \(2\ \text{C} + \text{O}_2 \rightarrow 2\text{CO}\)  
4. \(\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2\)

**4. What is the role of coke in extraction of iron?**  
Ans: 1. Coke is used as reducing agent  
2. Coke combines with oxygen to produce carbon mono oxide.  
3. CO is better reducing aren't than coke so it reduce iron Oxide to iron.  
\[
2\ \text{C} + \text{O}_2 \rightarrow 2\text{CO} \\
\]  
\[
\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2 \\
\]  
**5. What is the role of limestone in extraction of iron?**  
1. Lime stone used as flux.  
2. It helps to remove silica from ore  
3. Lime stone decomposes to form CaO  
4. CaO (Calcium Oxide) reacts with Silica to form Calcium silicate (CaSiO₃) which is removed as slag.  

**6. What is the role of slag (Calcium silicate) for molten iron in blast furnace?**  
1. Slag floats on the molten iron and act as the protecting layer.  
2. It prevent reverse oxidation of iron into iron oxide.  

**7. What is the other name of pig Iron?**  
Ans: Cast iron
8. **Name the impurities present in pig iron.**
   Ans: Sulphur, phosphorous, Silicon And carbon.

9. **What are the uses of pig Iron ?**
   1. Pig iron is used to make stands for wooden benches and desks
   2. Used to make dosa pans and and lid for covering manholes of sewage system.
   3. Used to make machinery spare parts
   4. It is also used to make steel.

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**Extraction of aluminium**

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1. **Which metal is commonly known as poor man’s silver**
   Ans: Aluminium

2. **Write note on discovery of aluminium.**
   1. It was first discovered by Hans Christian Oersted by heating
      \[
      \text{AlCl}_3 + 3\text{K} \rightarrow 3\text{KCl} + \text{Al}
      \]
   2. Later it was confirmed by Friedrich Wohler in 1827
   3. In 1807 identified the presence of aluminium in Alum by Humphry Davy.
   4. In 1854 – Commercial production by Herri Saint Clair Deville.

3. **Name the chief ore of aluminium?**
   Ans: Bauxite / Aluminium Oxide / alumina
   
   Molecular formula: \(\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}\)

4. **How the Aluminium is produced from bauxite.**
   Aluminium is produced from bauxite by removing the oxygen atom with the help of reducing
   \[
   \text{Al}_2\text{O}_3 + 6\text{K} \rightarrow 3\text{K}_2\text{O} + 2\text{Al}
   \]
   \(\text{K}\) = reducing agent

5. **What is the process used to extract aluminium on large scale from bauxite?**
   Ans: Aluminium is extracted on large scale by method of electrolysis. This technique was developed by Hall – Heroult.
6. Draw a neat diagram of the apparatus used in extraction of aluminium from alumina and label the parts.

7. Explain the process of extraction of aluminium from bauxite.
   1. Aluminium Extracted from bauxite by process of electrolysis.
   2. Bauxite is an impure aluminium oxide.
   3. First impure ore is treated with NaOH to get sodium aluminate.
      \[ \text{Al}_2\text{O}_3 + \text{NaOH} \rightarrow 2\text{NaAlO}_2 + \text{H}_2\text{O} \]
      **Soln of sodium aluminate**
   4. \( \text{CO}_2 \) is passed through sodium aluminate to form aluminium hydroxide and sodium carbonate.
      \[ 2\text{NaAlO}_2 + \text{CO}_2 + 3\text{H}_2\text{O} \rightarrow 2\text{Al(OH)}_3 + \text{Na}_2\text{CO}_3 \] (filtered and removed)
   5. Aluminium hydroxide is heated to give pure aluminium oxide.
      \[ 2\text{Al(OH)}_3 \rightarrow \text{Al}_2\text{O}_3 + 3\text{H}_2\text{O} \]

**Electrolysis:**
1. Pure Aluminium Oxide is mixed with the molten Cryolite.
2. Molten Cryolite (\( \text{Na}_3\text{AlF}_6 \)) act as solvent.
3. The mixture is taken into Electrolytic chamber with slope base.
4. Inner wall of chamber is made up of carbon lining act as cathode.
5. Graphite rods are taken as anode.
6. When the current is passed molten aluminium collects at lining and flows out of slope base.
7. Later it is refined to get pure aluminium.

8. What are the methods to obtain Ultra pure metal?
   Ans: 1. Fractional Crystallization / Zone refining
      2. Vacuum melting
      3. Chemical Vapour deposition
      4. Liquation process
      5. Electrolytic refining

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9. What is zone refining of metal?

1. Zone refining is based on the principle that different impurities have different degree of solubility.
2. The impure metal is taken in the form of a rod.
3. The rod is encircled by a circular heater that can move from one end to another end.
4. Metal in the rod melts as heater passes on.
5. Pure metal crystallizes and the insoluble impurities pass to adjacent molten part.
6. Process is repeated a few times to get pure metal free of impurities.

10. Explain the liqation process of purifying metals?

1. Liqation process is based on the principle that some metals are fusible and impurities are not fusible at temperature at which metal fuse.
2. This process is applied to metals having low MP like lead, bismuth, mercury.
3. The impure metal is placed on sloping hearth.
4. The temperature is maintained above the MP of the metal.
5. Metal melts and flows down the sloping hearth.
6. Solid impurities are left behind.
11. With help of neat diagram explain the electrolytic method of purification of copper.

1. Copper is purified by electrolytic refining using the principle of electrolysis.
2. A set of thick copper plates are made as anode.
3. A set of thin copper plates are made as cathode.
4. These are dipped in copper sulphate solution taken in tank.
5. On passing current using a battery, the copper in the anode dissolves into solution and get deposited on cathode plates.
6. The impurities collected at the bottom near anode is called anode smudge.
**Alloy**

**What is an alloy**

A homogeneous mixture of two or more metals or metals and nonmetals combined in suitable proportion is called alloy.

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**Properties of Alloys**

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Composition</th>
<th>Properties</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronze</td>
<td>• 90% copper &lt;br&gt;• 10% tin</td>
<td>• Hard and strong &lt;br&gt;• Doesn’t corrode easily &lt;br&gt;• Has shiny surface</td>
<td>• To build statues and monuments. &lt;br&gt;• In the making of medals, swords and artistic materials.</td>
</tr>
<tr>
<td>Brass</td>
<td>• 70% copper &lt;br&gt;• 30% zinc</td>
<td>• Harder than copper</td>
<td>• In the making of musical instruments and kitchenware.</td>
</tr>
<tr>
<td>Steel</td>
<td>• 99% iron &lt;br&gt;• 1% carbon</td>
<td>• Hard and strong</td>
<td>• In the construction of buildings and bridges. &lt;br&gt;• In the building of the body of cars and railway tracks.</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>• 74% iron &lt;br&gt;• 8% carbon &lt;br&gt;• 18% chromium</td>
<td>• Shiny &lt;br&gt;• Strong &lt;br&gt;• Doesn’t rust</td>
<td>• To make cutlery and surgical instruments.</td>
</tr>
<tr>
<td>Duralumin</td>
<td>• 93% aluminum &lt;br&gt;• 3% copper &lt;br&gt;• 3% magnesium &lt;br&gt;• 1% manganese</td>
<td>• Light &lt;br&gt;• Strong</td>
<td>• To make the body of aeroplanes and bullet trains.</td>
</tr>
<tr>
<td>Pewter</td>
<td>• 96% tin &lt;br&gt;• 3% copper &lt;br&gt;• 1% antimony</td>
<td>• Luster &lt;br&gt;• Shiny &lt;br&gt;• Strong</td>
<td>• In the making of souvenirs.</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Name of the alloy</td>
<td>Constituents</td>
<td>Uses</td>
</tr>
<tr>
<td>--------</td>
<td>------------------</td>
<td>--------------</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>Stainless steel</td>
<td>Iron + Carbon + Chromium + Nickel</td>
<td>Surgical instruments, utensils. It is not attacked by mild chemicals easily.</td>
</tr>
<tr>
<td>2</td>
<td>Invar</td>
<td>Iron + Carbon + Nickel (large quantity)</td>
<td>It is used in precision measuring tapes as it has least coefficient of linear expansion.</td>
</tr>
<tr>
<td>3</td>
<td>Nickel steel</td>
<td>Iron + Carbon + Nickel (small quantity)</td>
<td>Used to make machinery parts.</td>
</tr>
<tr>
<td>4</td>
<td>Brass</td>
<td>Copper + Zinc</td>
<td>Electrical contact parts. Utensils and decorative articles.</td>
</tr>
<tr>
<td>5</td>
<td>Bronze</td>
<td>Copper + Zinc + Tin</td>
<td>Statues, medals, utensils</td>
</tr>
<tr>
<td>6</td>
<td>Duralumin</td>
<td>Aluminium + Copper + Magnesium + Manganese.</td>
<td>Aeroplane body, railway coaches, bus coaches</td>
</tr>
<tr>
<td>7</td>
<td>Alnico</td>
<td>Nickel + cobalt + Iron + Aluminium</td>
<td>Permanent magnets</td>
</tr>
</tbody>
</table>