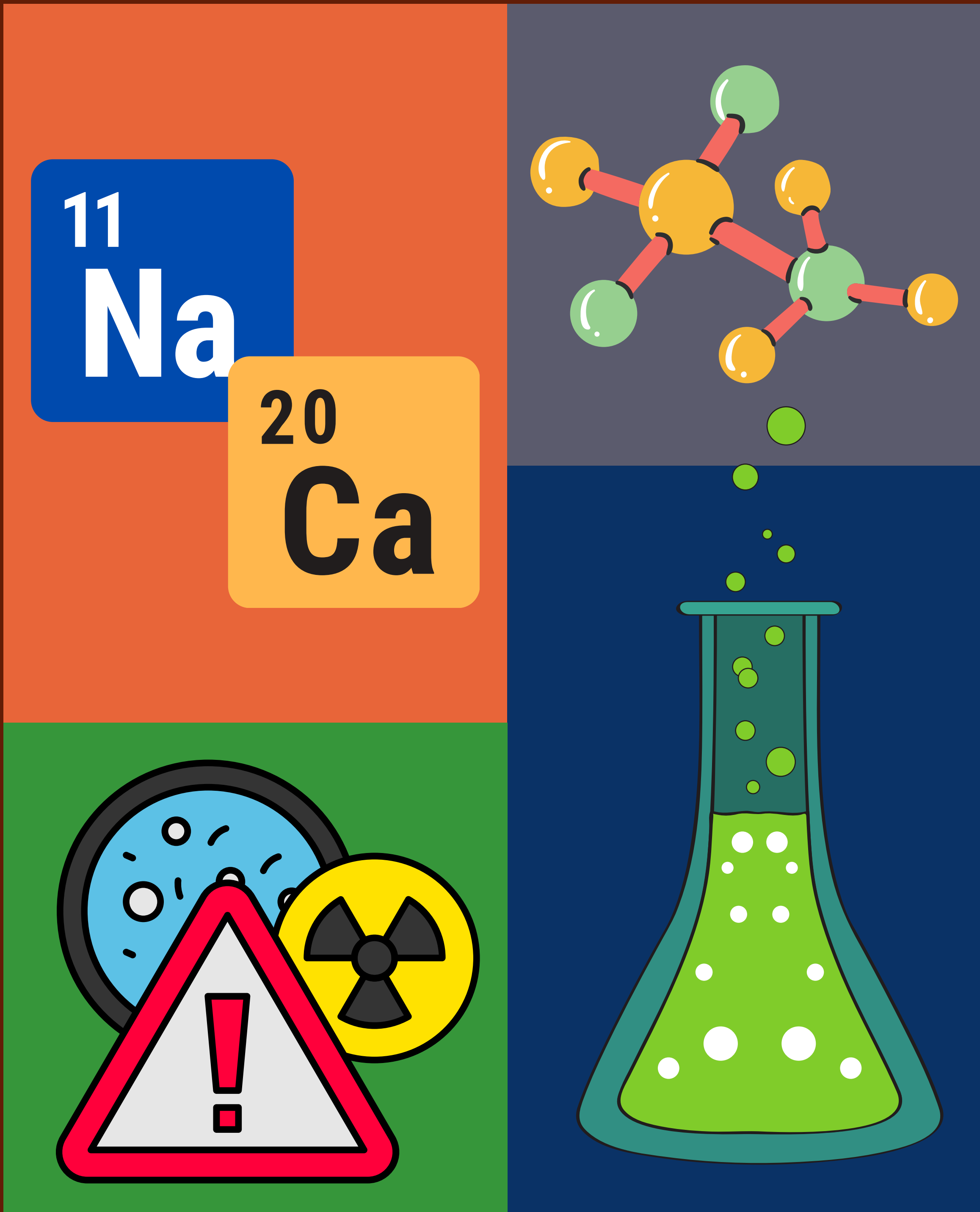


CLASS 10 NOTES

SCIENCE

Metals & Non-Metals

PRASHANT KIRAD

Metal & Non-Metal

Metals:

Metals are a group of elements characterized by their luster, conductivity (thermal and electrical), malleability, and ductility. They typically have high melting and boiling points and tend to lose electrons to form positively charged ions (cations) in chemical reactions. Common examples include iron, copper, gold, and aluminum.

Physical properties of metals include:

Exam me aayega

1. **Lustre:** Metals exhibit a characteristic shine or luster when freshly polished, attributed to their ability to reflect light.
2. **Conductivity:** Metals are excellent conductors of heat and electricity due to the mobility of electrons in their atomic structure.
3. **Malleability:** Metals can be easily hammered or rolled into thin sheets without breaking, displaying malleability.
4. **Ductility:** Metals can be drawn into thin wires without breaking, demonstrating ductility.
5. **High Melting and Boiling Points:** Metals generally have high melting and boiling points compared to nonmetals.
6. **Solid State at Room Temperature:** Most metals are solid at room temperature, except for mercury, which is a liquid.
7. **Density:** Metals are typically dense materials, meaning they have a high mass per unit volume.
8. **Sonorous:** Metals often produce a characteristic ringing sound when struck, known as sonorousness.

These properties collectively contribute to the wide range of practical applications of metals in various industries, from construction to electronics.

Chemical Properties of Metals: E.M.A

1. **Reaction with Oxygen:**
   - Metals react with oxygen to form metal oxides. The general equation for this reaction is:

Metal+Oxygen→Metal Oxide

Potassium and sodium metals are extremely reactive, undergoing vigorous reactions with the oxygen in the air. In the presence of air, they can readily catch fire and burn. To prevent these reactive metals from reacting with oxygen, moisture, and carbon dioxide in the air, they are stored in kerosene oil. This protective measure ensures that the metals remain stable and do not undergo combustion when exposed to atmospheric conditions.

2. **Reaction with Water:**
   - Some metals react with water to form metal hydroxides and release hydrogen gas. The general equation is:

Metal+Water→Metal Hydroxide+Hydrogen

3. **Reaction with Acids:**
   - Metals react with acids to produce salts and hydrogen gas. The general equation is:

Metal+Acid→Salt+Hydrogen

4. **Reaction with Salts:**
   - Metals can displace less reactive metals from their salts in solution. The reactivity series helps predict such displacement reactions.
5. **Reaction with Non-Metallic Elements:**
   - Metals can react with non-metallic elements to form compounds. For example, metals react with sulfur to form metal sulfides.

Activity 3.10

CAUTION: This Activity needs the teacher's assistance.

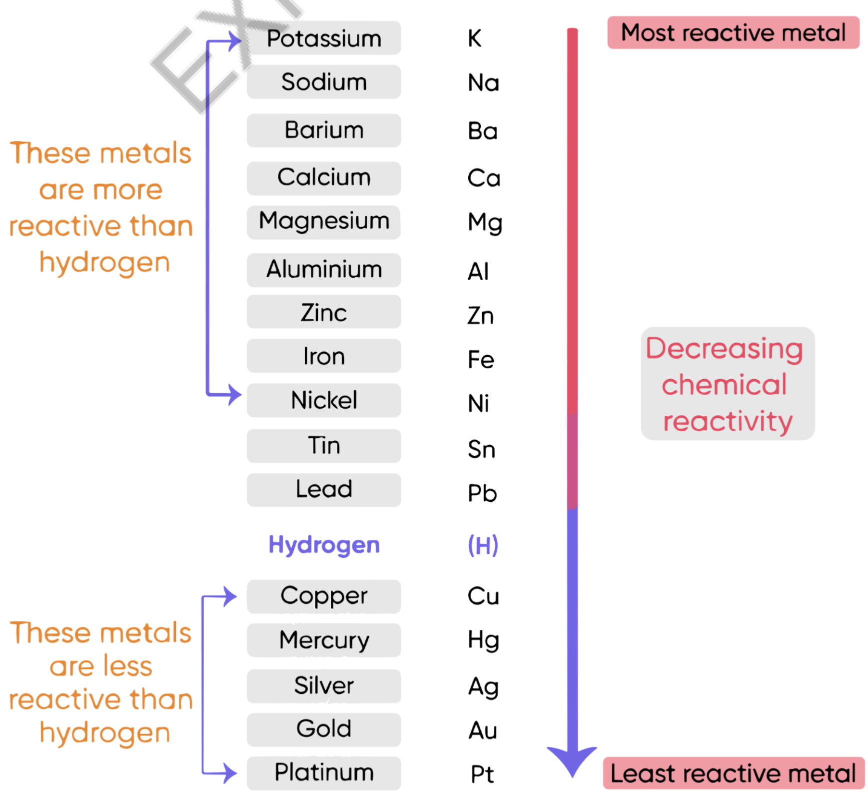
- Collect the samples of the same metals as in Activity 3.9.
- Put small pieces of the samples separately in beakers half-filled with cold water.
- Which metals reacted with cold water? Arrange them in the increasing order of their reactivity with cold water.
- Did any metal produce fire on water?
- Does any metal start floating after some time?
- Put the metals that did not react with cold water in beakers half-filled with hot water.
- For the metals that did not react with hot water, arrange the apparatus as shown in Fig. 3.3 and observe their reaction with steam.
- Which metals did not react even with steam?
- Arrange the metals in the decreasing order of reactivity with water.

Explanation:

Answer: In this activity, metal samples are placed in cold water to observe reactions. Reactive metals are arranged by increasing reactivity. Fire and floating observations are noted. Non-reactive metals with cold water are tested in hot water and steam. The final arrangement is based on decreasing reactivity with water, considering reactions with hot water and steam. Teacher assistance is required for safety.

Reactivity Series of Metals:

The reactivity series ranks metals based on their tendency to undergo displacement reactions. Higher-ranked metals can displace lower-ranked ones from their compounds in solution. For example, zinc can displace copper from copper sulfate. The series helps predict outcomes in chemical reactions.



Non-Metals:

Non-metals are elements that lack typical metallic properties. They are generally poor conductors of heat and electricity and may exist in various forms, such as solids, liquids, or gases. Non-metals often gain electrons in chemical reactions and tend to form covalent bonds. Examples include oxygen, nitrogen, carbon, and fluorine. They play essential roles in diverse chemical and biological processes.

Physical Properties of Non-Metals: E.M.A

States of Matter: Non-metals can exist in different states - solid, liquid, or gas.

- **Conductivity:** Poor conductors of heat and electricity.
- **Luster:** Lack metallic luster, often appearing dull or matte.
- **Malleability and Ductility:** Not malleable or ductile; tend to be brittle.
- **Density:** Generally have lower density compared to metals.
- **Melting and Boiling Points:** Lower melting and boiling points than metals.
- **Solubility:** Some non-metals are sparingly soluble in water.
- **Brittleness:** Non-metals are often brittle in solid form.
- **Color:** Can exhibit various colors; for example, sulfur is yellow, and iodine is purple.

Examples: Oxygen, nitrogen, sulfur, phosphorus.

Chemical properties of non-metals include:

- **Combustibility:** Some non-metals, like hydrogen and carbon, can undergo combustion reactions.
- **Reaction with Oxygen:** Non-metals may react with oxygen to form oxides. For example, sulfur reacts with oxygen to form sulfur dioxide.
- **Acid-Base Reactions:** Non-metals can react with bases to form salts. For instance, sulfuric acid, a non-metal compound, reacts with sodium hydroxide to form sodium sulfate and water.

- **Hydrogen Ion Formation:** Non-metals may accept electrons to form negatively charged ions (anions) in reactions with metals.
- **Covalent Bonding:** Non-metals form covalent bonds by sharing electrons with non-metals.
- **Reaction with Water:** Some non-metals, such as sulfur and phosphorus, react with water to produce acids.
- **Reaction with Metals:** Non-metals can displace less reactive metals from their salts in solution, forming new compounds.

Metals & Non-Metals:

When metals interact with nonmetals, they combine to create ionic compounds. Conversely, when nonmetals engage with other nonmetals, they form covalent compounds.

Ionic Compounds:

E.M.A

1. **Definition:**
   - Ionic compounds are chemical compounds composed of positively charged ions (cations), usually derived from metals, and negatively charged ions (anions), usually derived from nonmetals.
2. **Formation:**
   - Ionic compounds are formed by transferring electrons from the metal atom to the nonmetal atom. This transfer results in the formation of ions with opposite charges.
3. **Ionic Bonding:**
   - Ionic bonding is the electrostatic attraction between positively charged ions (cations) and negatively charged ions (anions). This attraction holds the ions together in a stable compound.
4. **Examples:**
   - Common examples of ionic compounds include sodium chloride ($NaCl$), potassium iodide (KI), and magnesium oxide (MgO).

5. **Properties:**
   - Ionic compounds generally have high melting and boiling points.
   - They are usually solid at room temperature.
   - They conduct electricity when dissolved in water or melted, as ions are free to move.

Eg.

$Mg \longrightarrow Mg^{2+} + 2e^-$
2,8,2 → 2,8 (Magnesium cation)

$Cl + e^- \longrightarrow Cl^-$
2,8,7 → 2,8,8 (Chloride anion)

$Na \rightarrow Na^+ + e^-$
2,8,1 → 2,8 (Sodium cation)

$Cl + e^- \rightarrow Cl^-$
2,8,7 → 2,8,8 (Chloride anion)

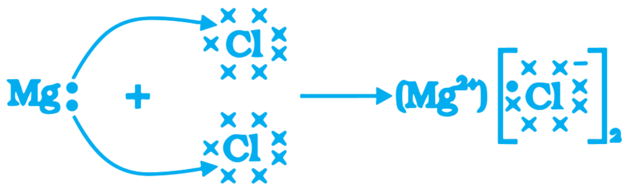


Figure 3.6 *Formation of magnesium chloride*

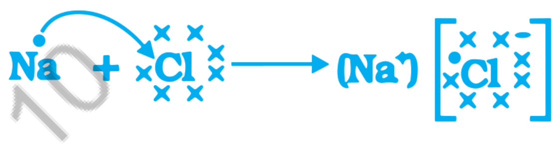


Figure 3.5 *Formation of sodium chloride*

Properties of Ionic Compounds:

1. **High Melting and Boiling Points:**
   - Ionic compounds typically have high melting and boiling points due to strong electrostatic forces holding ions together in a three-dimensional lattice.
2. **Solubility in Water:**
   - Many ionic compounds are soluble in water because water molecules surround and separate the ions, facilitating their movement.
3. **Conductivity:**
   - Ionic compounds conduct electricity when dissolved in water or molten, as ions become free to move and carry an electric charge.
4. **Brittleness:**
   - Solid ionic compounds are often brittle because when force is applied, layers of ions with like charges align, leading to repulsion and cleavage.

Occurrence of Metals:

- Metals are predominantly obtained from the Earth's crust, which serves as a major reservoir for these elements.
- Seawater contains soluble salts like sodium chloride and magnesium chloride.
- The naturally occurring elements or compounds found in the Earth's crust are referred to as minerals.
- Minerals that can be profitably processed to extract metals are specifically termed ores.

Extraction of Metals from Ores: E.M.A

Metallurgy Definition:

- Metallurgy is the systematic process of extracting metals in their pure state from respective ores and refining them for practical use.

Extraction Techniques Based on Reactivity:

- Extraction methods vary depending on the position of metals in the activity series.

Highly Reactive Metals:

- Metals with high reactivity, such as Potassium (K), Sodium (Na), Calcium (Ca), and Magnesium (Mg), are typically extracted through electrolysis. Their strong bonding with other components prevents reduction by heating with carbon.

Moderately Reactive Metals:

- Moderately reactive metals like Zinc (Zn), Iron (Fe), and Lead (Pb) are generally extracted through reduction processes using agents like coke (C).

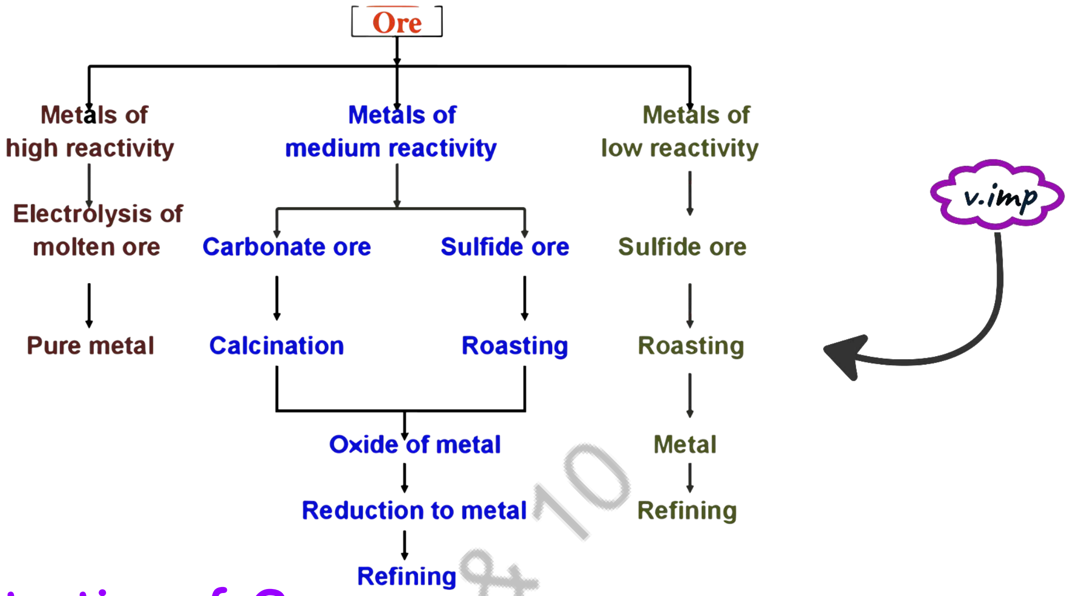
Less Reactive Metals:

- Less reactive metals, for instance, Copper (Cu) and Mercury (Hg), are extracted from their oxides through heating alone, a method known as self-reduction.

Very Less Reactive Metals:

- Metals with very low reactivity, such as Silver (Ag), Gold (Au), and Platinum (Pt), exist in nature in the metallic form and do not require extraction processes.

Steps involved in the extraction of metals from their ores



The concentration of Ores:

Impurities and Gangue:

- Undesirable impurities, such as soil and sand, present in ores are termed gangue or matrix.

Enrichment or Concentration:

- The process of removing gangue from the ore is known as enrichment or concentration of the ore.

(I) Extraction of Metals of LOW Reactivity:

Self-Reduction:

Sulfide ores of less electropositive metals like Mercury (Hg), Lead (Pb), and Copper (Cu) undergo self-reduction when heated in air. No external reducing agent is used in this process.

Examples:

Cinnabar (HgS):

$2HgS(Cinnabar)+3O_2(g)+heat \rightarrow 2HgO(crude\text{-}metal)+2SO_2(g)$

$2HgO(s)+heat \rightarrow 2Hg(l)+O_2(g)$

Copper Glance (Cu_2S):

Cu_2S(Copper-pyrite)$+3O_2(g)+$heat$\rightarrow 2Cu_2O(s)+2SO_2(g)$

$2Cu_2O(s)+Cu_2S(s)+$heat$\rightarrow 6Cu$(crude metal)$+SO_2(g)$

Galena (PbS):

$2PbS$(Galena)$+3O_2(g)+$heat$\rightarrow 2PbO(s)+2SO_2(g)$

$PbS(s)+2PbO(s)\rightarrow 2Pb$(crudemetal)$+SO_2(g)$

(II) Extraction of Metals of MEDIUM Reactivity:

- These metals are usually preset as sulphides or carbonates in nature.
- These sulphides or carbonates are first converted into oxides because it is easy to extract metals from its oxides.
- Sulphides are converted into oxides by **roasting** and carbonates are converted into oxides by **calcination**.
- **Roasting:** Roasting involves heating of ore lower than its melting point in the presence of air or oxygen. Example of Zinc Sulphide ores.

$$\underset{\text{Zinc sulphide}}{2ZnS(s)} + \underset{\text{Oxygen (from air)}}{3O_2(s)} \xrightarrow[\Delta]{\text{Roasting}} \underset{\text{Zinc oxide}}{2ZnO(s)} + \underset{\text{Sulphur dioxide}}{2SO_2(g)}$$

- **Calcination**: Calcination involves thermal decomposition of carbonate ores. Example of Zinc carbonate ore:

$$\underset{\text{Zinc carbonate}}{ZnCO_3(s)} \xrightarrow[\Delta]{\text{Calcination}} \underset{\text{Zinc oxide}}{ZnO(s)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

- The metal oxides thus obtained are then reduced to the corresponding metals by reduction process. Depending upon the reactivity of metals, reduction is done in different ways as:
  - **Smelting(Reduction with Carbon):** In this process, the roasted or calcined ore is mixed with suitable quantity of coke or charcoal (which act as reducing agent) and is heated to a high temperature above its melting point. Zinc Example:

$$\underset{\text{Zinc oxide}}{ZnO(s)} + \underset{\text{Coke}}{C(s)} \longrightarrow \underset{\text{Zinc}}{Zn(s)} + \underset{\text{Carbon monoxide}}{CO(g)}$$

  - **Thermite process:** It is the technique, to reduce metal oxide using more reactive metal powder as fuel. Aluminium, magnesium, titanium are some metals which are used as fuel in thermite process. In this process, a mixture of concentrated oxide ore and metal powder (i.e., thermite) is taken in a steel crucible and kept on sand. A mixture of magnesium powder and barium peroxide (called ignition mixture) is used to ignite the reaction mixture. A large amount of hat is evolved during the reaction which melts the metal. Example

$Cr_2O_3(s) + 2Al(s)$ ------>. $2Cr(l) + Al_2O_3(s)$

$Fe_2O_3(s) + 2Al(s)$ ----->. $2Fe(l) + Al_2O_3(s)$ + Heat

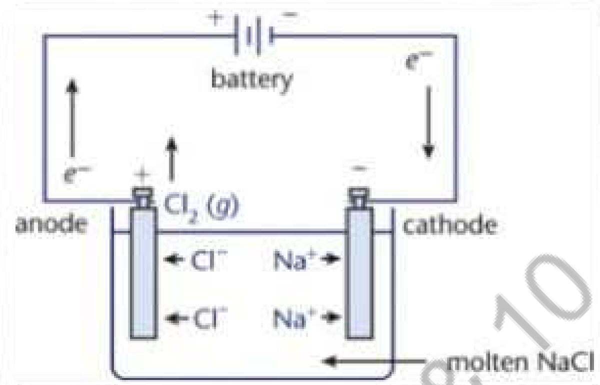
[Gold-Schmidt aluminothermic reduction]

- **Electrolytic reduction:** Highly reactive metals like Na, K, Mg, Ca, Al, etc, are reduced by electrolysis of their respective oxides, hydroxides of chloride in molten state. On passing electric current into the molten solution, metal is liberated at cathode while impurities are settled down as anode mud generally. Example: Reduction of sodium from NaCl (by electrolysis) as-

$$NaCl \rightarrow Na^+(l) + Cl^-(l)$$

At cathode: reduction of $2Na^+(l) + e^- \rightarrow Na(l)$

At anode: oxidation of $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$



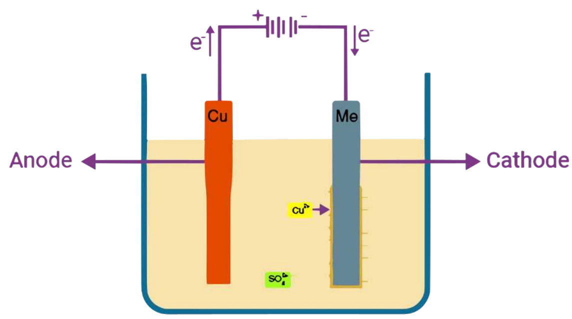
- **Refining/Purification of Metal:** The reduced metals obtained are generally impure which may be associated with following types of impurities as -
  - Uncharged (not reduced) ore.
  - Other metals that are produced by simultaneous reduction of their compounds originally present in the ore
  - Non-metals like silicon, carbon, phosphorous etc.
  - Slag, flux etc., which is present in residual condition.
  - These impurities can be removed by "refining of metals".

These Impurities are removed by "**refining of metals**"as:

- **Electrolytic Refining (Purification of copper):** Process In this process, a thick block of impure metal is used as anode and a thin strip of pure metal is used as cathode. A solution of metal salt (to be refined) is used as an electrolyte. When electric current is passed, metal ions from the electrolyte are reduced as metal which get deposited on the cathode. An equivalent amount of pure metal from the anode gets oxidised to metal ion and goes into the electrolyte and from there it goes to cathode and deposit.

At cathode: $Cu^{2+} + 2e^- \rightarrow Cu$

At anode: $Cu \rightarrow Cu^{2+} + 2e^-$



Corrosion:

Definition: E.M.A

Corrosion refers to the gradual deterioration of a material, typically a metal, due to the influence of moisture, air, or chemicals in the surrounding environment. An example is the rusting of iron.

Prevention of Corrosion:

1. **Coating with Paints, Oils, or Grease:**
   The application of paint, oil, or grease on metal surfaces forms a protective barrier, preventing the ingress of air and moisture.
2. **Alloying:**
   Alloying metals enhance corrosion resistance. For instance, stainless steel is an alloy that exhibits increased resistance to corrosion.
3. **Galvanization:**
   Galvanization involves coating iron articles with molten zinc. Zinc forms a protective layer, serving as a barrier against corrosion.
4. **Electroplating:**
   Electroplating, achieved through an electric current, involves coating one metal with another. This method not only protects against corrosion but also enhances the aesthetic appearance. Examples include silver plating and nickel plating.
5. **Sacrificial Protection:**
   Magnesium, being more reactive than iron, can act as a sacrificial layer. When coated on iron or steel articles, magnesium serves as the cathode, undergoing a sacrificial reaction instead of the iron, thus protecting the articles.

Alloys:

Definition:

Alloys are uniform mixtures of metals with either other metals or nonmetals. The formation of alloys results in improved properties, including increased hardness, tensile strength, and corrosion resistance.

Examples of Alloys:

1. Brass:
   - Brass is an alloy composed of copper and zinc.
2. Bronze:
   - Bronze is an alloy formed by combining copper and tin.

#Top Seven Questions:

1) Explain why calcium metal after reacting with water starts floating on its surface. Write the chemical equation for the reaction. Name one more metal that starts floating after some time when immersed in water.

Solution: When calcium metal reacts with water, it produces hydrogen gas and calcium hydroxide. The hydrogen gas bubbles stick to the surface of the calcium, creating buoyancy, causing calcium to float on the water's surface. The chemical equation for the reaction is:

$$Ca\ (s) + 2H_2O\ (l) \rightarrow Ca(OH)_2(aq) + H_2(g)$$

Another metal that starts floating after some time when immersed in water is sodium.

2 (a) (i) Write two properties of gold that make it the most suitable metal for ornaments.
(ii) Name two metals which are the best conductors of heat.
(iii) Name two metals that melt when you keep them on your palm.
(iv) Explain the formation of the ionic compound CaO with an electron-dot structure. Atomic numbers of calcium and oxygen are 20 and 8 respectively. **[5M, 2020]**

Solution: (i). The property of gold used in making ornaments is ductility and luster.
(ii). Silver are copper are the best conductors of heat.
(iii). Gallium and cesium are the metals that melt when kept on the palm.
(iv) Atomic no. of Ca - 20, Electronic Configuration 2,8,8,2 Atomic no. of O - 8 Electronic Configuration - 2,6

3. (a)Carbon cannot be used as a reducing agent to obtain Mg from MgO. Why?
(b) How is sodium obtained from molten sodium chloride? Give an equation of the reactions.
(c) How is copper obtained from its sulfide ore? Give equations of the reactions.

Solution: (a) Carbon and MgO:

- Carbon can't reduce MgO; Mg is more reactive.

(b) Sodium from Molten NaCl:

- Na obtained from molten NaCl by electrolysis:

$$2NaCl\ (l) \rightarrow 2Na\ (l) + Cl_2(g)$$

(c) Copper from Sulfide Ore:

- Copper from $CuFeS_2$ by smelting:

$$CuFeS_2(s) + O_2(g) \rightarrow Cu\ (l) + FeO\ (s) + SO_2(g)$$

4. The way, metals like sodium, magnesium, and iron react with air and water is an indication of their relative positions in the 'reactivity series'. Is this statement true? Justify your answer with examples.

Solution: Yes, the statement is true. The reactivity series ranks metals based on their tendency to undergo reactions. Metals like sodium, which reacts vigorously with both air and water, magnesium, which burns in air and reacts with water, and iron, which reacts with oxygen and steam, demonstrate the correlation between their reactivity and their positions in the reactivity series.

5. A non-metal X exists in two different forms, Y and Z. Y is the hardest natural substance, whereas Z is a good conductor of electricity. Identify X, Y, and Z.

Solution: X is carbon. Diamond and graphite are allotropes of carbon. Diamond is the hardest natural substance, and hence Y is diamond. Graphite is a good conductor of electricity, and hence Z is graphite.

6. What are the constituents of solder alloy? Which property of solder makes it suitable for welding electrical wires?

Solution: Constituents of Solder Alloy:

- Typically, tin and lead or lead-free alternatives with elements like silver, copper, or antimony.

Property Suitable for Welding Electrical Wires:

- Low melting point of solder (below 450°F or 232°C), enabling easy melting and secure bonding without damaging the electrical wires.

7. A metal that exists as a liquid at room temperature is obtained by heating its sulfide in the presence of air. Identify the metal and its ore and give the reaction involved.

Solution Mercury is the only metal that exists as a liquid at room temperature. It can be obtained by heating cinnabar (HgS), the sulfide ore of mercury. We can get metals low in activity series by heating or reducing their sulfides or oxides.

The reactions are as follows

$$2\ HgS + 3\ O2 \rightarrow 2\ HgO + 2\ SO2$$

$$2\ HgO \rightarrow 2\ Hg + O2$$

#Compentancy Based Question:

1. Based on the reactivity of different metals with oxygen, water and acids as well as displacement reactions, the metals have been arranged in the decreasing order of their reactivities. This arrangement is known as activity series or reactivity series of metals. The basis of reactivity is the tendency of metals to lose electrons. If a metal can lose electrons easily to form positive ions, it will react readily with other substances. Therefore, it will be a reactive metal. On the other hand, if a meal loses electrons less rapidly to form a positive ion, it will react slowly with other substances. Therefore, such a metal will be less reactive.

1. Which of the following metal is less reactive than hydrogen?
A.Copper B.Zinc C.Magnesium D. Lead

2. Which of the following represents the correct order of reactivity for the given metals?
A. Na>Mg>Al>Cu B. Mg>Na>Al>Cu C. Na>Mg>Cu>Al D. Mg > Al > Na > Cu

3. Hydrogen gas is not evolved when a metal reacts with nitric acid. It is because HNO, is a strong oxidising agent. It oxidises the H, produced to water and itself gets reduced to any of the nitrogen oxides (N,O, NO, NO2). But ______________ and ______________ react with very dilute HNO3 to evolve H2 gas.
A. Pb, Cu B. Na, K C. Mg, Mn D. Al, Zn

4. Which of the following metals reacts vigorously with oxygen?
A. Zinc B. Magnesium C. Sodium D. Copper

2. An ionic compound is a chemical compound in which ions are held together by ionic bonds. An ionic bond is the type of chemical bond in which two oppositely charged ions are held through electrostatic forces. We know that metal atoms have loosely bound valence electrons in their valence shell and non-metal atoms need electrons in their valence shell to attain noble gas configuration. The metal atom loses the valence electrons while non-metal atom accepts these electrons. By losing electrons, metal atoms change to cations and by accepting electrons, non-metals form anions. Ionic compounds are generally solid and exist in the form of crystal. They have high melting and boiling points.

1. Which of the following can change to a cation?
A. Fluorine B. Oxygen C. Potassium D. Neon

2. Which of the following can change to an anion?
A. Iodine B. Magnesium C. Calcium D. Xenon

3. Ionic compounds are soluble in _____________.
A. Kerosene B. Petrol C. Water D. None of these

4. Which of the following statements is correct about ionic compounds?
I. They conduct electricity in solid state.
II. They conduct electricity in solutions.
III. They conduct electricity in molten state.

A. I only B. II only C. III only D. II and III only

5.Select the incorrect statement.
A. Ionic compounds are generally brittle
B. Ions are the fundamental units of ionic compounds
C. Formation of ionic bonds involve sharing of electrons
D.NaCl is an ionic compound.