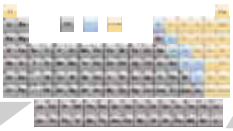
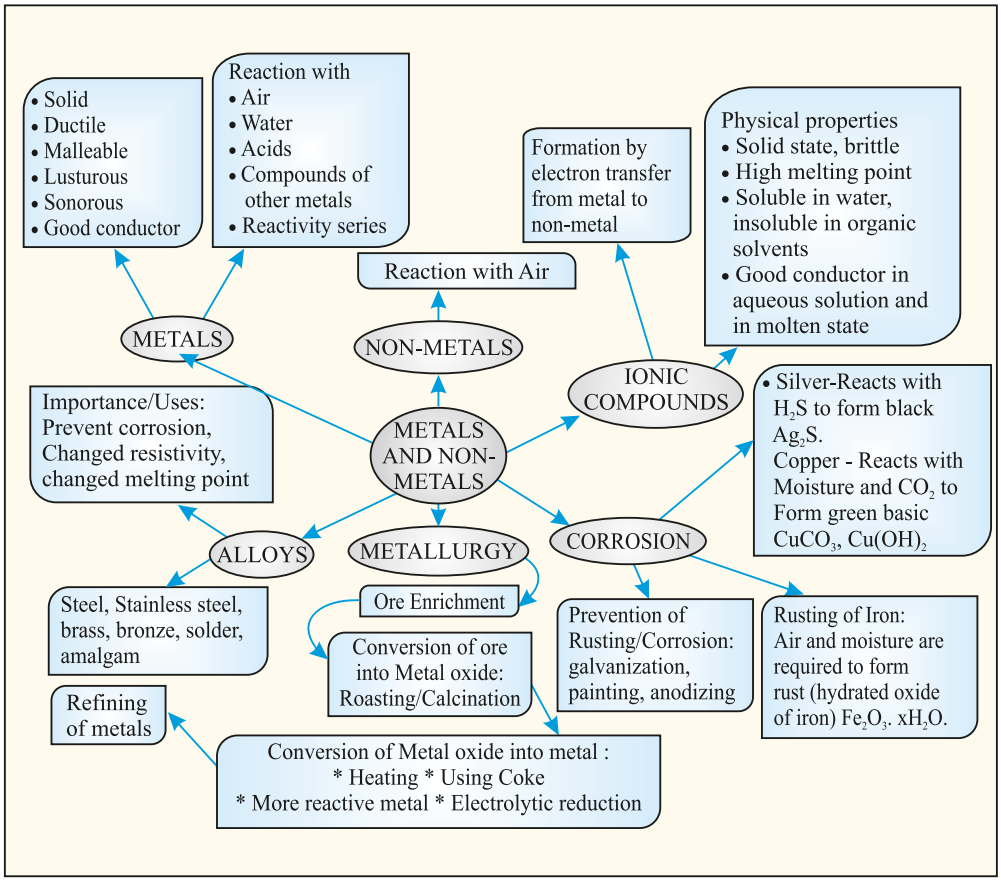


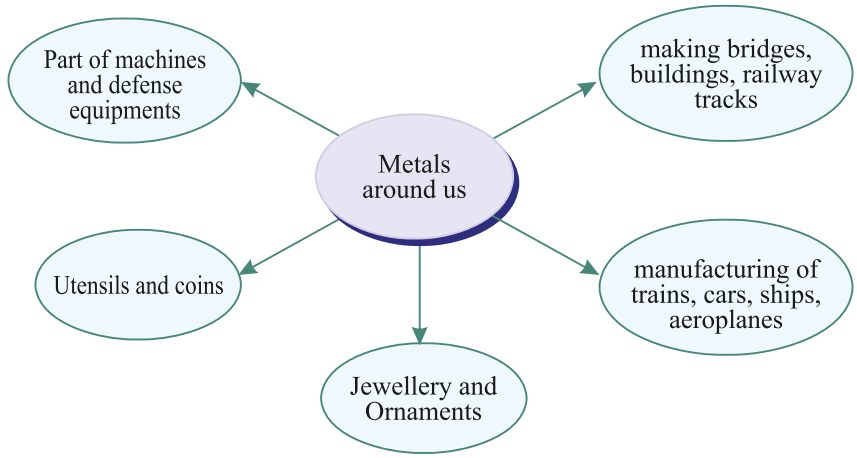
Chapter - 3

Metals And Non-Metals

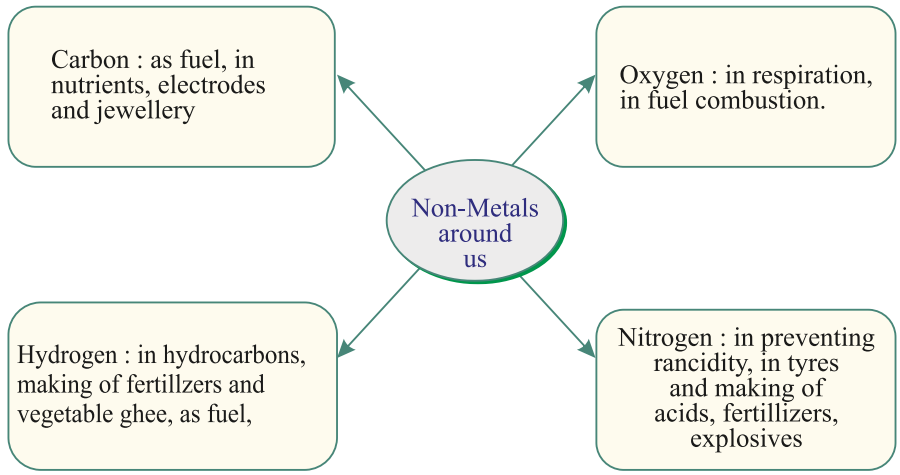


Metals and Non Metals

- About 118 elements are known till date. There are more than 90 metals, 22 non metals and few metalloids.
- Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg), Iron (Fe), Aluminium (AI) are some metals.



- Oxygen(O), Nitrogen(N), Hydrogen(H), Sulphur(S), Phosphorus(P), Fluorine(F), Bromine(Br) are a few non metals.



- Differences between metals and non-metals

Metals	Non-Metals
• Solid at room temperature except mercury	• Exist in all the three states, chlorine-gas, Bromine-Liquid, iodine-solid
• Ductile and malleable	• Non-ductile and non-malleable
• Sonorous and lustruous	• Non-sonorous and non-lustruous (iodine and graphite are shiny)
• Generally have high melting point, cesium and gallium have low melting point.	• Have low melting point, except diamond.
• Generally good conductors of heat and electricity, except lead and mercury.	• Poor conductors, except graphite.
• Have high density, but sodium and potassium have low density.	• Have low density.
• Metal oxides can be basic or amphoteric in nature.	• Oxides of non-metals are generally acidic in nature, while a few are neutral oxides.
• Many metals displace hydrogen from dilute acids and release hydrogen gas.	• Non metals cannot displace hydrogen from dilute acids.
• Metal oxides are ionic in nature.	• Non metal oxides are covalent in nature.

Chemical Properties of Metals

1. Reaction with air

Metals can either burn, react or don't react with air

Metal + Oxygen ⟶ Metal oxide

Some metals like Na and K are kept immersed in kerosene as they react vigorously with air. Metals like Mg, Aℓ,Zn and Pb react slowly with air and form a protective layer. Mg can burn in air but combine with oxygen to form oxide. Fe and Cu do not burn in air but combine with oxygen to form their oxides. Iron filings burn when sprinkled in the flame of burner. Silver, platinum and gold show no reaction with air.

$$2Na + O_2 \longrightarrow Na_2O$$

$$3Fe + 2O_2 \longrightarrow Fe_3O_4$$

- **Amphoteric oxides:** These are metal oxides which react with both acids as well bases to produce salt and water. e.g. ZnO, Al_2O_3

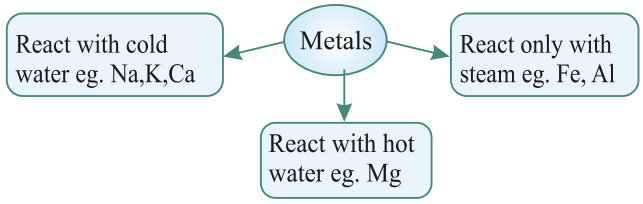
$$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$$

$$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$$

(Sodium aluminate)

- **Anodizing of metals:** In anodizing, aluminium is made anode and graphite as cathode, oxygen gas is released by the electrolysis of sulphuric acid, which reacts with aluminium to form a thick protective oxide layer on the surface of metal.

2. **Reaction with water:** Metals react with water differently. Not all metals react with water



$$2K + 2H_2O \longrightarrow 2KOH + H_2\uparrow$$

$$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2\uparrow$$

$$Mg + 2H_2O \longrightarrow Mg(OH)_2 + H_2\uparrow$$

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

$$2Al + 3H_2O(g) \longrightarrow Al_2O_3 + 3H_2\uparrow$$

$$3Fe + 4H_2O(g) \longrightarrow Fe_3O_4 + 4H_2\uparrow$$

3. **Reaction with dilute acids:**

(i) Most metals react with dilute HCl and dilute H_2SO_4 to form salt and hydrogen gas.

$$\text{Metal} + \text{dilute acid} \longrightarrow \text{salt} + \text{hydrogen gas}$$

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2\uparrow$$

$$Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2\uparrow$$

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$$

- Copper, mercury and silver don't react with dilute acids.

(ii) With dilute nitric acid: As metals react with dilute nitric acid, hydrogen gas produced is oxidised to water. Mg and Mn are exceptions.

$$Mg + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2 \uparrow$$

Aqua Regia: It is a mixture of concentrated HCl and concentrated HNO_3 in a 3:1 ratio. It dissolves gold and platinum.

4. **Reaction with other metal compounds:**

$$\text{Metal A} + \underset{\text{of metal B}}{\text{Salt solution}} \longrightarrow \underset{\text{Metal A}}{\text{Salt solution of}} + \text{Metal B}$$

More reactive metals can displace less reactive metals from their compounds in solution. This forms the basis of reactivity series of metals.

- **Reactivity series of metals:** It is an arrangement of metals in decreasing order of their reactivity.

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

Decreasing reactivity

$$Cu + 2AgNO_3 \longrightarrow Cu(NO_3)_2 + 2Ag$$

Copper being more reactive displace silver.

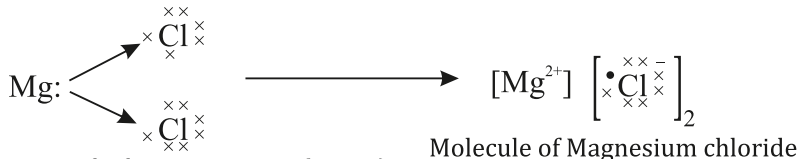
5. **Reaction between metals and non-metals:**

- Reactivity of elements can be understood as a tendency to attain a completely filled valence shell arrangement.
- Atom of metals lose valence electron(s) to form cations (+ve ions)
- Atoms of non-metals can gain electron(s) in valence shell to form anions (–ve ions)
- Oppositely charged ions attract each other forming an ionic compound.

Formation of $MgCl_2$

$$\underset{(2,8,2)}{Mg} \longrightarrow \underset{(2,8)}{Mg^{2+}} + 2e^-$$

$$\underset{(2,8,7)}{2Cl} + 2e^- \longrightarrow \underset{(2,8,8)}{2Cl^-}$$



(Electron transfer from Mg atom to Cl atoms)

Molecule of Magnesium chloride

- Properties of Ionic compounds: Are solid and mostly brittle.
- Have high melting and boiling points. More energy is required to overcome the strong inter-ionic force of attraction.
- Generally soluble in water, but insoluble in inorganic solvents like kerosene, petrol,etc.
- Conduct electricity in aqueous solutions and in molten state. In both cases, free ions are formed and conduct electricity.

Occurance of Metals

- **Minerals:** Compounds of metals present in earth's crust can be termed as minerals.
- **Ores:** Mineral from which metal can be economically obtained is called an ore e.g. sulphide ores, carbonate ores, oxide ores. Not all the minerals are ores.
- Metals at the bottom of reactivity series like gold, platinum, silver, copper occur in free state. But copper and silver also occur in sulphide and oxide ores.
- Metals of moderate reactivity (Zn, Fe,Pb) occur mainly as oxide, sulphide or carbonate ores. Metals of high reactivity (K,Na,Ca,Mg,Aℓ) are found in combined states.

  Gangue: Ores are found mixed with earthly impurities like soil, sand,etc. known as gangue. The gangue is removed from the ore.

  Metallurgy: It is the step-wise process of obtaining metal from its ore. These steps are

  1. Enrichment of ore.
  2. Obtaining metal from enriched ore.
  3. Refining of impure metal to obtain pure metal.

  Obtaining Metals low in the reactivity series: These metals can be obtained by heating the ore in air at high temperature.

* Mercury from cinnabar:

Sulphide $\xrightarrow{\Delta}$ oxide $\xrightarrow{\Delta}$ metal $\xrightarrow{\Delta}$ refining

HgS $\xrightarrow{\Delta}$ HgO $\xrightarrow{\Delta}$ Hg $\xrightarrow{\Delta}$ Hg(pure)

* Copper from copper sulphide

$$2Cu_2S + 3O_2 \xrightarrow{heat} 2Cu_2O + 2SO_2 \uparrow$$

$$2Cu_2O + Cu_2S \xrightarrow{heat} 6Cu + SO_2 \uparrow$$

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 (Roasting)

$$2ZnS + 3O_2 \xrightarrow{heat} 2ZnO + 2SO_2\uparrow$$

Metal ore heated strongly in limited supply of air (Calcination)

$$ZnCO_3 \xrightarrow{heat} ZnO + CO_2\uparrow$$

Reduction of metal oxide:

1. **Using coke:** Coke as reducing agent.

$$ZnO + C \xrightarrow{heat} Zn + CO\uparrow$$

2. **Using Displacement Reaction:** highly reactive metal like Na, Ca and Al are used to displace metals of lower reactivity from their compounds.

$$MnO_2 + 4Al \xrightarrow{heat} 3Mn + 2Al_2O_3 + heat$$

$$Fe_2O_3 + 2Al \xrightarrow{heat} 2Fe + Al_2O_3 + heat$$

In the above reaction mclten iron is 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

* Are obtained by electrolytic reduction. Sodium is obtained by electrolysis of its molten chloride

$$NaCl \longrightarrow Na^{+} + Cl^{-}$$

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

At cathode:

$$Na^{+} + e^{-} \longrightarrow Na$$

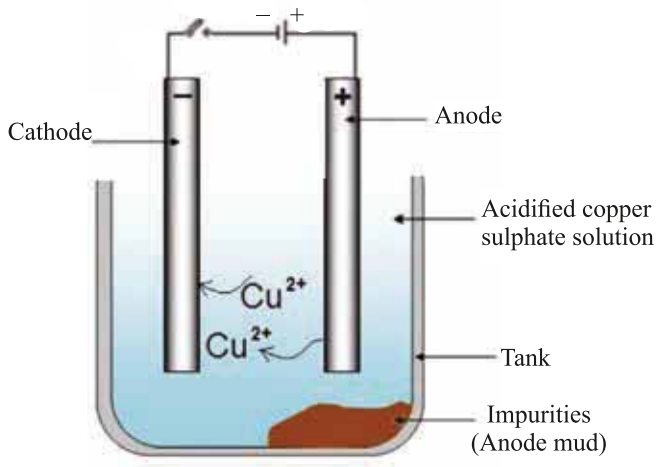
At anode:

$$2Cl^{-} \longrightarrow Cl_2 + 2e^{-}$$

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 amount of dilute sulphuric acid.
- From anode copper ions are released in the solution and equivalent amount of copper from solution is deposited at cathode.
- Insoluble impurities containing silver and gold gets deposited at the bottom of anode as anode mud.



CORROSION:

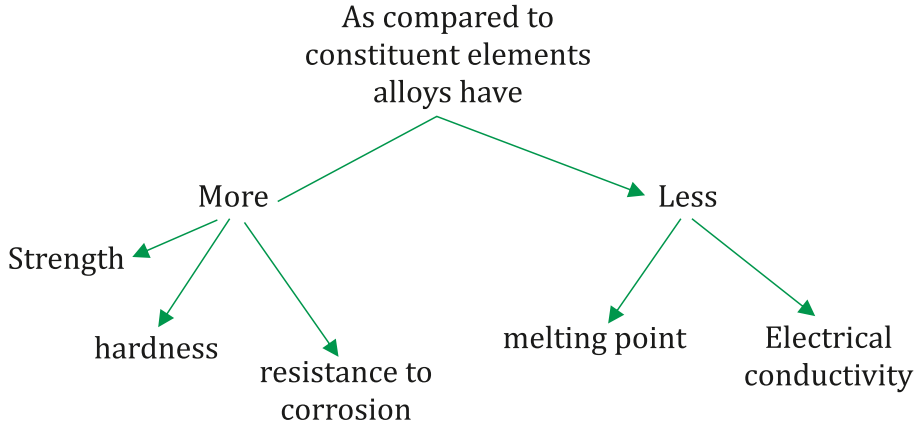
- Metals are attacked by substances in surroundings like moisture, acids, and moist air.

  Silver- it reacts with H_2S in air to form silver sulphide and articles become black.

- Copper- reacts with moist carbon dioxide in air and gains a green coat of basic copper carbonate.
- Iron- acquires a coating of a brown flaky substance called rust. Both air and moisture are necessary for rusting of iron.

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 by mixing 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 (Cu+Zn). Bronze: alloy of copper and tin (Cu+Sn).
- In brass and bronze, melting point and electrical conductivity is lower than that of pure metal.
- Solder: alloy of lead and tin (Pb+Sn) has low melting point and is used for welding electrical wires.



MULTIPLE CHOICE QUESTIONS (1 Mark)

1. Which of the following metal is obtained by electrolytic reduction process?

   (a) Cu (b) Ag

   (c) Fe (d) Al

2. Cinnabar is an ore of which metal?

   a. Tin b. Aluminium

   c. Magnesium d. Mercury

3. Which of the following does not conduct electricity?

   a. Solid KCI b. Fused KCI

   c. Aluminium d. Iron

4. Which of the following is not an ionic compound?

   (a) Sodium oxide (b) Carbon tetrachloride

   (c) Magnesium chloride (d) Sodium chloride

5. Which metal is associated with haemoglobin?

   (a) Calcium (b) Aluminium

   (c) Magnesium (d) Iron

6. The liquid non-metal is

   (a) Carbon (b) Hydrogen

   (c) Bromine (d) Chlorine

7. Choose the correct option for brass:

   (a) Cu-Hg (b) Cu-Mg

   (a) Cu-Fe (d) Cu-Zn

8. The colour of Iron(ll) sulphate soultion is

   (a) Blue (b) Yellow

   (c) Green (d) Orange

9. Electric wires have a coating of insulating material. The material, generally used is -

   (a) Graphite (b) Phosphorus

   (C) PVC (d) Bromine

10. Ore 'X' of metal 'M' release Carbon dioxide on heating. 'X' can be:

(a) MNO_3 (b) MCO_3

(c) MSO_3 (d) MSO_4

11. Which of these melts easily?

(a) Steel (b) Diamond

(c) Stainless steel (d) solder

12. $PbO_{(s)} + C_{(s)} \xrightarrow{\triangle} Pb_{(s)} + CO_{(g)}$

The role of 'C' in the above reaction is of a

(a) catalyst (b) Reducing agent

(c) oxidizing agent (d) solvent

13. Which of the following reaction does not occur?

(a) Lead metal + silver nitrate solution

(b) Lead metal + zinc sulphate solution

(c) Magnesium metal + copper sulphate solution

(d) Copper metal + silver nitrate solution.

14. Copper is used in silver coins to

(a) reduce melting point (b) increase conductivity.

(c) reduce solubility (d) increase hardness.

15. Which of the following property is not shown by metals?

(a) Electrical conduction (b) Sonorous in nature

(c) Dullness (d) Ductility.

MCQ Correct Options:

1	2	3	4	5	6	7	8
D	D	A	B	D	C	D	C
9	10	11	12	13	14	15	
c	b	d	b	b	d	c	

1. Define the following terms: ores, gangue, rust, aqua regia, anodizing.
2. Show the reaction between zinc oxide and sodium hydroxide by a chemical equation.

3. Why food cans are coated with tin and not with zinc?
4. Name any two alloys whose electrical conductivity is less than that of pure metals.
5. Why ionic compounds have high melting point?
6. Which element is displaced by metals from acid?

In the following questions , two statements are given- one labeled Assertion (A) and the other labeled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

(a) Both A and R are true, and R is correct explanation of the assertion.

(b) Both A and R are true, but R is not the correct explanation of the assertion.

(c) A is true, but R is false.

(d) A is false, but R is true.

1. **Assertion:** Metals have high melting point.

   Reason: Metals are found in solid state.

2. **Assertion:** Sulphide ores are roasted.

   Reason: It is easier to obtain metal from their oxides.

3. **Assertion:** Anode mud settles at the bottom of electrolytic tank.

   Reason: Anode mud contain soluble impurities.

4. **Assertion:** Zinc oxide is an amphoteric oxide.

   Reason: It reacts with acid as well as base to produce salt and water.

5. **Assertion:** Silver becomes brown in colour when exposed to air.

   Reason: It reacts with hydrogen sulphide and forms silver sulphide .

Read the following passage and answer the questions:

Elements are pure form of matter, which are divided into metals, non-metals and metalloids. Approximately three-quarters of all known chemical elements are metals. The most abundant varieties in the earth's crust are aluminum, iron, calcium, sodium, potassium, and magnesium. The vast majority of metals are found in their ores, but a few such as copper, gold, platinum, and silver frequently occur in the free state because they do not readily react with other elements.

1. Identify the metalloid:

   (a) Carbon (b) Silicon

(c) Helium (d) Mercury

2. Choose the correct statement:
   (a) Metals form acidic oxides
   (b) Metal oxides cause acid rain
   (c) All metals react with hot water.
   (d) Metals form ionic chlorides.
3. Which metal is most abundant in earth's crust?
4. Why gold is used for making jewellery?
5. Which metal can be used for making electric wires: Pb or Al?

2 Marks

1. What is an amalgam? Write the constituent elements of solder.
2. Distinguish between :
   (a) Roasting and calcination (b) Mineral and ore
3. Write the chemical equation for heating of Cu and Fe respectively.
4. What is galvanization? How is it beneficial?
5. Why is hydrogen gas generally not evolved when metals react with dilute nitric acid.Name two metals which evolve hydrogen gas with the same acid.
6. Explain thermite process.
7. "Every ore is a mineral, but not every mineral an ore." Explain.
8. Why can highly reactive metals not obtained from their oxides using coke as a reducing agent?
9. Distinguish between metals and non-metals on the basis of chemical properties.

3 Marks

1. Ionic compounds are good conductors of electricity under specific conditions. Write the two conditions and give reason.
2. Why are metal sulphides and carbonates converted to oxides prior to reduction. Write the equation for the chemical reactions occuring during roasting and calcination of zinc ores.
3. What are alloys? How are they prepared? Name the alloy used for welding electric wires together.

4. Write the differences between electrolytic reduction and electrolytic refining.
5. Describe an activity to study conditions necessary for rusting of iron.
6. Show the formation of molecules of Magnesium oxide, aluminium oxide and potassium chloride by electron transfer.
7. Describe an activity to show the reaction between iron and steam.

5 marks

1. Give reasons:
   (a) Platinum is used to make jewellery.
   (b) Lithium is stored under kerosene.
   (c) Aluminium is a highly reactive metal, yet it is used to make utensils for cooking.
2. Give a detailed account of steps of extracting pure copper from its ore.

HINTS to LA Questions

1. (a) Unreactive metal, does not get corroded by the action of moisture and atmospheric gases. Highly malleable, ductile
   (b) Lithium readily reacts with oxygen gas, formed oxide reacts with moisture producing hydrogen gas, which catches fire.
   (c) Strong and economical metal. Good conductor of heat. On exposure to air it forms aluminium oxide layer all around, which prevents oxidation of the metal inside.
2. Cu_2S ore. $Cu_2S + O_2 \longrightarrow Cu_2O + SO_2$

   $Cu_2S + Cu_2O \longrightarrow Cu + SO_2$

   * pure copper is obtained by electrolytic refining of impure copper.
   * Anode-Impure Copper, Cathode- Pure copper, Electrolytic solution- Aq. Solution of Copper sulphate with few drops of sulphuric acid.
   * Pure metal collects over cathode.