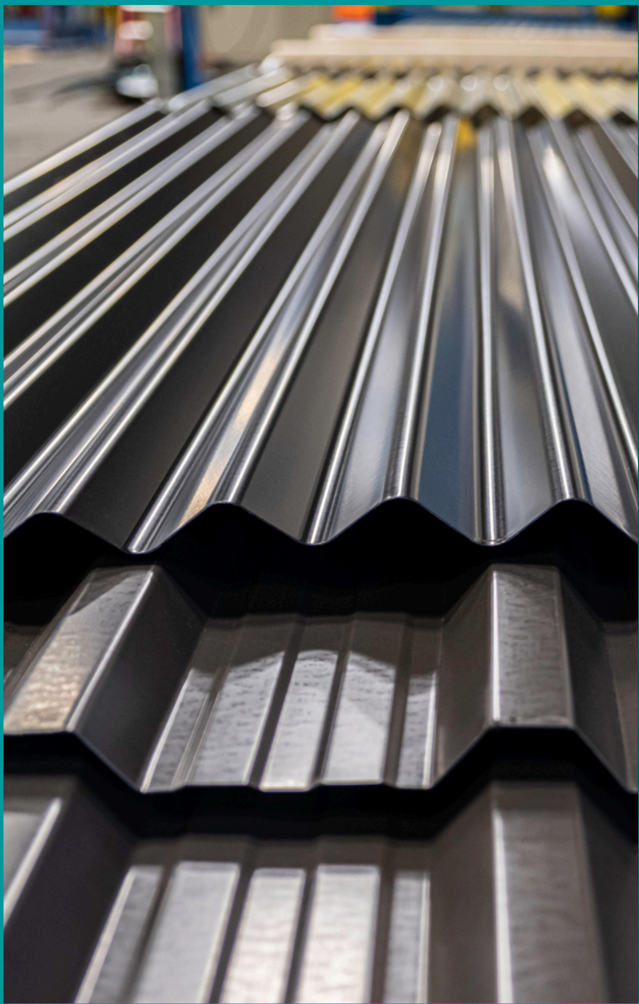
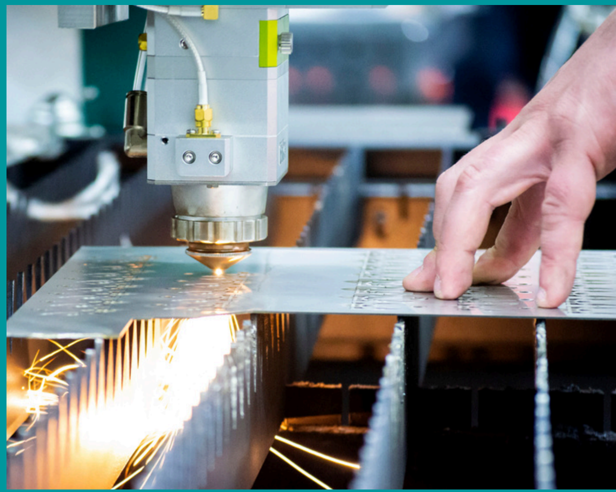





CLASS 10 NOTES

SCIENCE

Metals and Non Metals

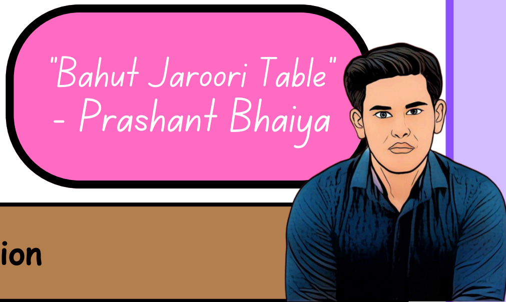
PRASHANT KIRAD

Metals

Those elements which form ions by losing electrons are called metals.

Physical properties of metals

- LUSTRE
- CONDUCTIVITY
- DUCTILITY
- DENSITY
- SOLID STATE
- SONOROUS
- HIGH MP AND BP
- MALLEABILITY



Properties	Description/Defination
Lustre	Metals have a shiny appearance, known as metallic lustre, which is due to the reflection of light from their surface.
Malleability	Metals can be hammered or rolled into thin sheets without breaking. This property is known as malleability.
Conductivity	Metals are excellent conductor of heat and electricity. Silver and copper are particularly good electrical conductors, which is why they are widely used in electrical circuits.
Ductility	Metals can be drawn into thin wires. This property is called ductility. Copper and aluminum are common examples, often used for electrical wiring.
High Melting and Boiling Points	Most metals have high melting and boiling points due to the strong bonding between their atoms. For example, iron and tungsten have very high melting points.
Solid State	Most metals are solid at room temperature, with the exception of mercury, which is liquid.
Density	Metals typically have high density, meaning they are heavy for their size.
Sonorous	Metals produce a ringing sound when struck, a property known as sonority. This is why metals like iron and brass are used in making bells and musical instruments.

Chemical properties of metals

- RXN WITH WATER
- RXN WITH SALTS
- RXN WITH OXYGEN
- RXN WITH NON METALLIC ELEMENTS
- RXN WITH ACIDS

- **Reaction with oxygen:** When metals react with oxygen, they form metal oxides. Most metal oxides are basic in nature, meaning they can react with acids to form salt and water.

  Metals + Oxygen → Metal Oxide

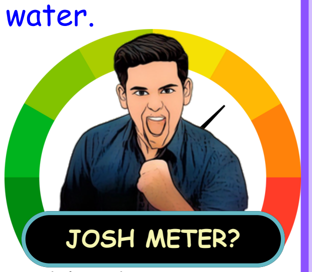
VIP (very important portion)

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.

- **Reaction with Water:** Metals react with water to form metal hydroxides and hydrogen gas. The reactivity with water varies among metals:

  Highly reactive metals (like sodium and potassium) react vigorously with cold water.
  Less reactive metals (like magnesium) react with hot water.
  Least reactive metals (like iron) react with steam.

  Metals + Water → Metal Hydroxide + Hydrogen



- **Reaction with Acids:** Metals react with dilute acids to produce salt and hydrogen gas. This reaction is more vigorous with more reactive metals.

  Metals + Acid → Salt + Hydrogen

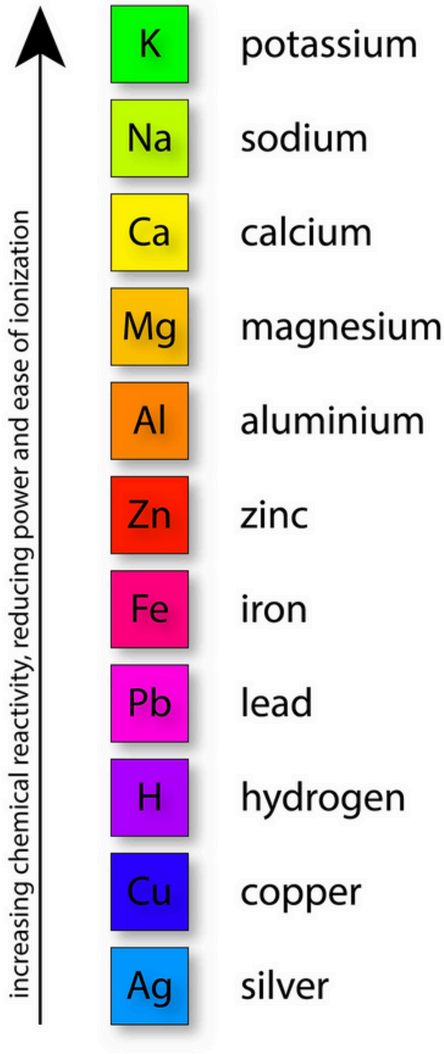
- **Displacement Reaction:** A more reactive metal can displace a less reactive metal from its compound in solution. This is known as a displacement reaction.
  Example: $CuSO4 + Zn \rightarrow ZnSO4 + Cu$

- **Reaction with Non-metals:** Metals can react with non-metals to form ionic compounds, where metals lose electrons to form cations and non-metals gain electrons to form anions.
  Example: $2\,Na + Cl2 \rightarrow 2\,NaCl2$

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:

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.

Reactivity series of Metals:

The reactivity series of metals is a list that ranks metals from most reactive to least reactive. This series is useful for predicting how metals will react with water, acids, and other substances, as well as in displacement reactions.

EMA

Non-Metals

Those elements which form negative ions by gaining electrons are called non-metals.

Physical properties of Non-metals:

- Lack of luster: Non-metals are generally not shiny.
- Brittleness: Non-metals are brittle and break easily when hammered.
- Poor conductivity of heat and electricity: Non-metals do not conduct heat and electricity well, except for graphite, which is a good conductor of electricity.
- Low Melting and Boiling point: Non-metals generally have lower melting and boiling points than metals.
- Low Density: Non-metals usually have lower densities compared to metals.

Chemical properties of Non-metals:

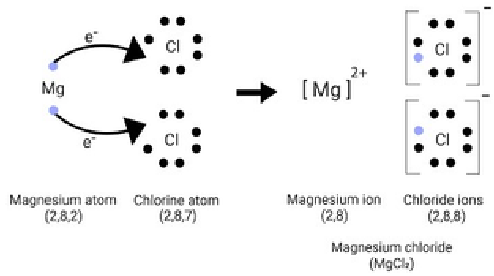
- Combustibility: Some non-metals, like hydrogen and carbon, can undergo combustion reactions.
- Reaction with Oxygen: Non-metals may react with oxygen to form oxides. For example, sulfur reacts with oxygen to form sulfur dioxide.
- Acid-Base Reactions: Non-metals can react with bases to form salts. 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 and Non-Metals

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

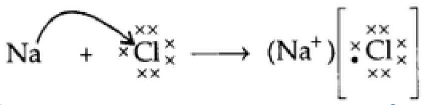
Ionic compounds: Ionic compounds are chemical compounds composed of positively charged ions (cations), usually derived from metals, and negatively charged ions (anions), usually derived from nonmetals.

- 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.
- 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.
- Properties: 1. Ionic compounds generally have high melting and boiling points.
  2. They are usually solid at room temperature.
  3. They conduct electricity when dissolved in water or melted, as ions are free to move.
- Examples: Common examples of ionic compounds include sodium chloride (NaCl), potassium iodide (KI), and magnesium oxide (MgO).



$$Na \longrightarrow Na^+ + e^-$$
2,8,1 → 2,8 (sodium cation)

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



Properties of Ionic Compounds:

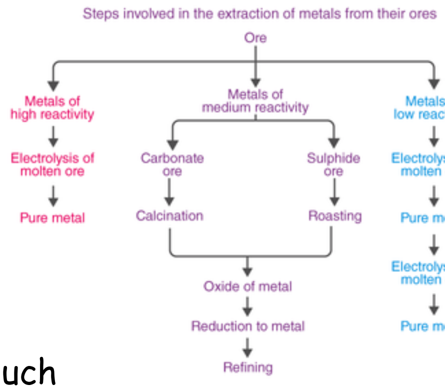
- High Melting and Boiling Points: Ionic compounds typically have high melting and boiling points due to strong electrostatic forces holding ions together in three-dimensional lattice.
- Solubility in Water: Many ionic compounds are soluble in water because water molecules surround and separate the ions, facilitating their movement.

- **Conductivity:** Ionic compounds conduct electricity when dissolved in water or molten, as ions become free to move and carry an electric charge.
- **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.

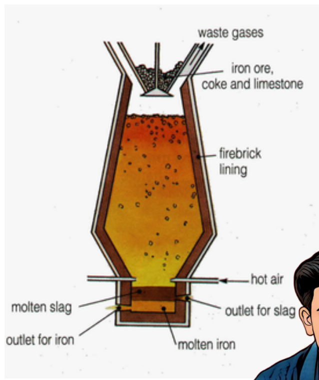
Extraction of metals from ores

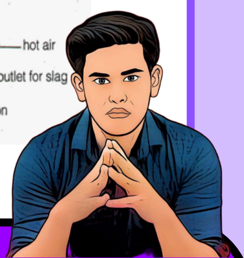


Metallurgy: Metallurgy is the science and process of extracting metals from their ores, refining them, and preparing them for use.

Metal 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.





"Reactivity Series pakka exam me aayegi"
- Prashant Bhaiya

The concentration of ores:

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

- **Gravity Separation:** Using the difference in the density of ore and impurities.
- **Froth Flotation:** Involves the separation of ore from impurities by using froth formed
  by certain chemicals.
- **Magnetic Separation:** Used when either the ore or the impurities are magnetic.

Extraction of Metals of LOW Reactivity:

Direct 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.

Cinnabar (HgS): $2HgS$ (Cinnabar) + $3O_2$ (g) + heat → $2HgO$ (crude-metal) + $2SO_2$ (g)
: $2HgO$ (s) + heat → $2Hg$ (1) + O_2 (g)

Copper Glance (Cu_2S): Cu_2S (Copper-pyrite) + $3O_2$ (g) + heat → $2Cu_2O$ (s) + $2SO_2$ (g)
: $2Cu_2O$(s) + Cu_2S (s) + heat → $6Cu$ (crude metal) + SO_2 (g)

Galena (PbS): $2PbS$ (Galena) + $3O_2$ (g) + heat → $2PbO$ (s) + $2SO_2$ (g)
: PbS (s) + $2PbO$ (s) → $2Pb$ (crude metal) + SO_2 (g)

Extraction of Metals of MEDIUM Reactivity:

These metals are usually preset as sulphides or carbonates in nature. The extraction of metals of medium reactivity, such as iron, zinc, and lead, typically involves the following steps:

- 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 ore: $2ZnS$ (s) + $3O_2$ (s) → $2ZnO$ (s) + $2SO_2$ (g)

Calcination: Calcination involves thermal decomposition of carbonate ores.

Example of Zinc carbonate ore: $ZnCO_3$ (s) → ZnO (s) + 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): 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.

Example of Zinc: ZnO (s) + C (s) → Zn (s) + 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 heat is evolved during the reaction which melts the metal.

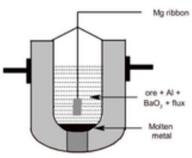


Fig: Alumino-thermite process

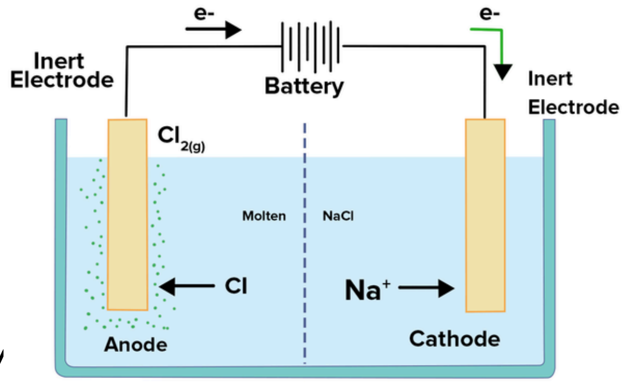
Example: Cr_2O_3 (s) + 2Al (s) → 2Cr(l) + Al_2O_3 (s)

: Fe_2O_3 (s) + 2Al (s) → 2Fe (l) + Al_2O_3 (s) {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: NaCl → Na^+ (l) + Cl^- (s)

At cathode: $Na^+ + e^- \rightarrow Na$
At anode: $2Cl^- \rightarrow Cl_2 + 2e^-$



Refining/Purification of Metal: The reduced metals obtained are generally impure which may be associated with following types of impurities as -

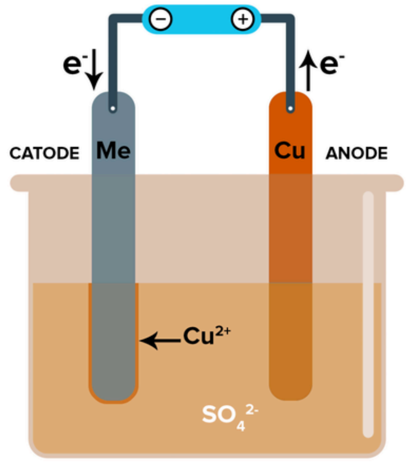
- Uncharged (not reduce associated with following types of ore.
- Other metals that are produced by simultaneous reduction of their compounds originally present in the ore
- Non-metals like silicon, carbon, phosphorous etc.
- Slag, flux etc., which is present in residual condition.
- These impurities can be removed by "refining of metals".

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

Electrolytic Refining (Purification of copper): 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 oxidized to metal ion and goes into the electrolyte and from there it goes to cathode and deposit.

Cu (impure)→Cu (pure) + impurities

At cathode: $Cu^{2+} + 2e^- \rightarrow$ Cu (pure)
At anode: Cu (impure) → $Cu^{2+} + 2e^-$



Corrosion

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.

TOP 7
IMPORTANT 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: $2NaCl\ (l)\ 2Na\ (l) + Cl_2(g)$

(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: $2\,HgS + 3\,O_2 \rightarrow 2\,HgO + 2\,SO_2$

$2\,HgO \rightarrow 2\,Hg + O_2$