

METALS AND NON-METALS

- **Introduction and physical properties of metals**



METALS AND NON-METALS

INTRODUCTION

There are 118 chemical elements known at present.

On the basis of their properties, all the elements can be divided into two main groups.

❖ Metals

❖ Non-metals



Silver



Gold



Iron nails

On the basis of their properties, all the elements can be divided into two main groups.

❖ Metals

❖ Non-metals

A close-up photograph of a large pile of yellow sulfur crystals. The crystals vary in size and shape, from small, sharp-edged pieces to larger, more rounded chunks. They are a bright, pale yellow color and appear to be stacked on top of each other.

Sulphur

A close-up photograph of a stack of shiny, reflective copper pipes. The pipes are arranged in a slightly overlapping, diagonal pattern, creating a sense of depth. The lighting highlights the metallic texture and the warm, golden-brown color of the copper. The background is blurred, making the pipes the central focus.

Copper



Carbon



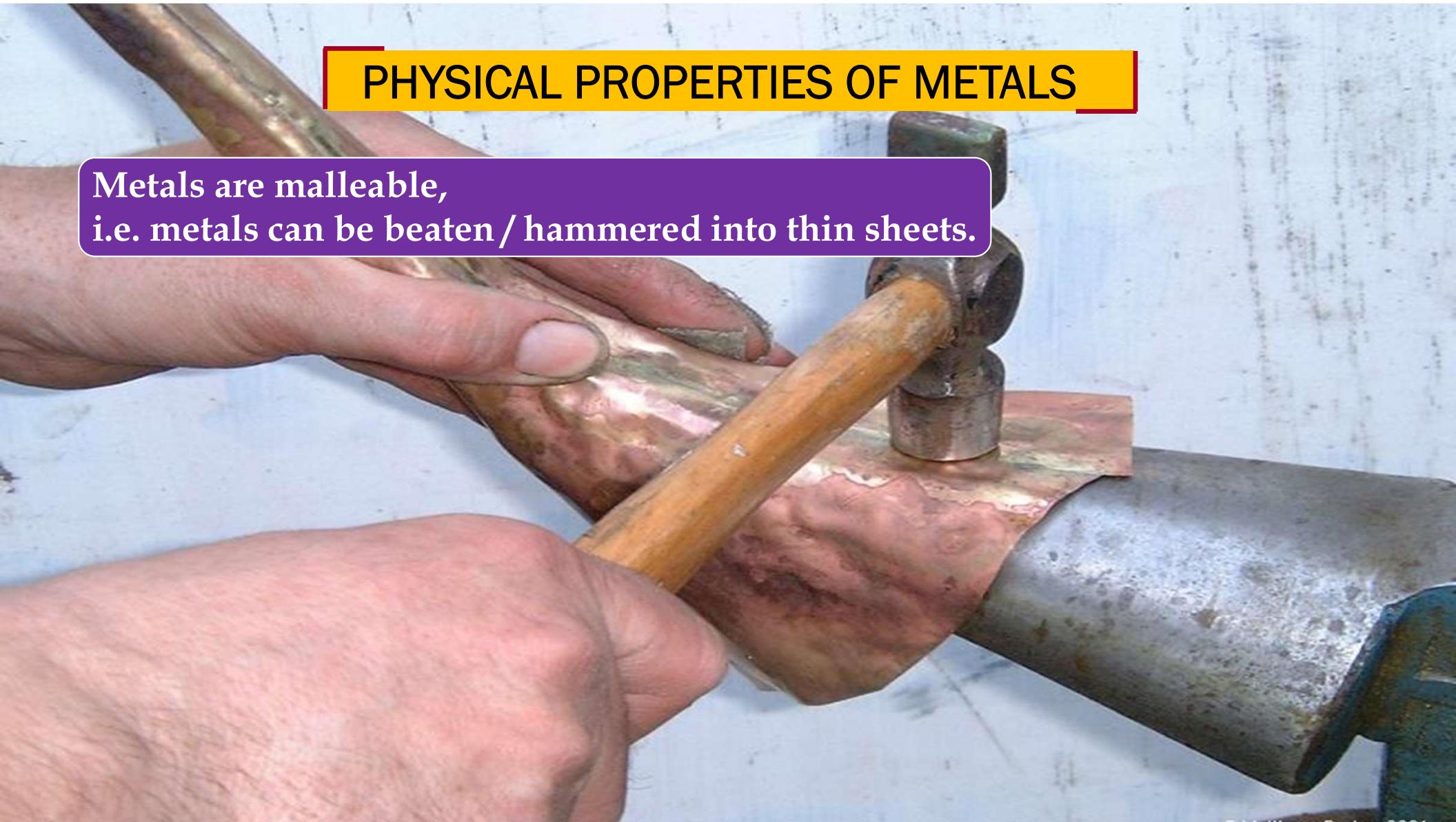
Chlorine gas

Both, metals as well as non-metals are used in our daily life.



PHYSICAL PROPERTIES OF METALS

Metals are malleable,
i.e. metals can be beaten / hammered into thin sheets.



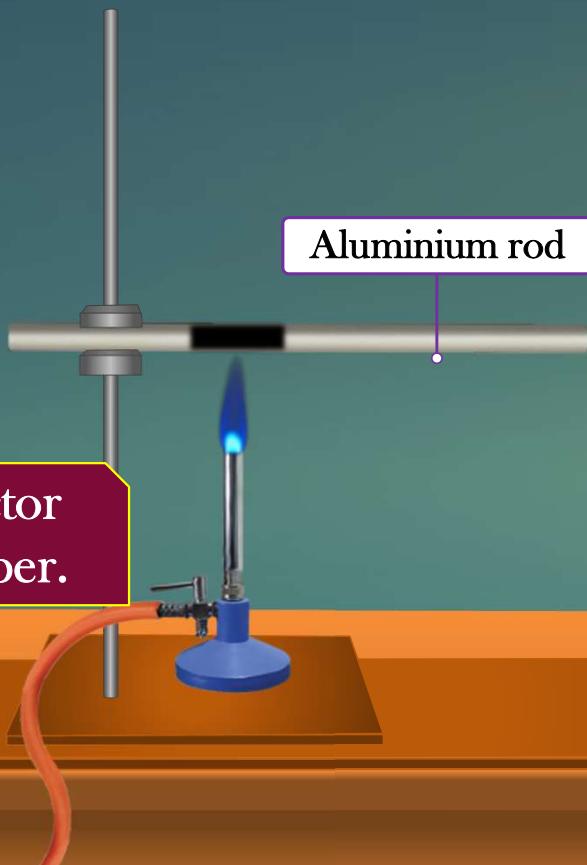
**Metals are ductile,
i.e. metals can be drawn or stretched into thin wires.**



**About 1 g of gold can be drawn into a thin wire of
about 2 km long.**

Metals are good conductors of heat.

Silver is the best conductor
of heat followed by copper.



The poorest conductors of heat among the metals are **Lead** and **Mercury**.





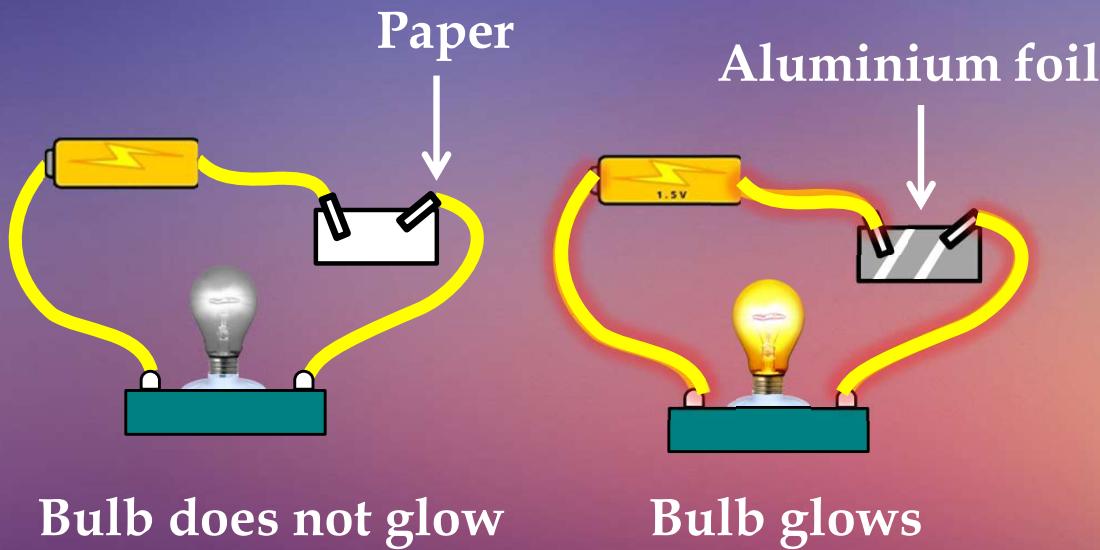
The cooking utensils and water boilers,
are usually made of copper or aluminium.

METALS AND NON-METALS

- **Physical properties of metals**

PHYSICAL PROPERTIES OF METALS

Metals are good conductors of electricity.



Silver is the best conductor of electricity followed by copper.

Metals are lustrous (or shiny), and can be polished.



Metals are generally hard (except sodium and potassium).



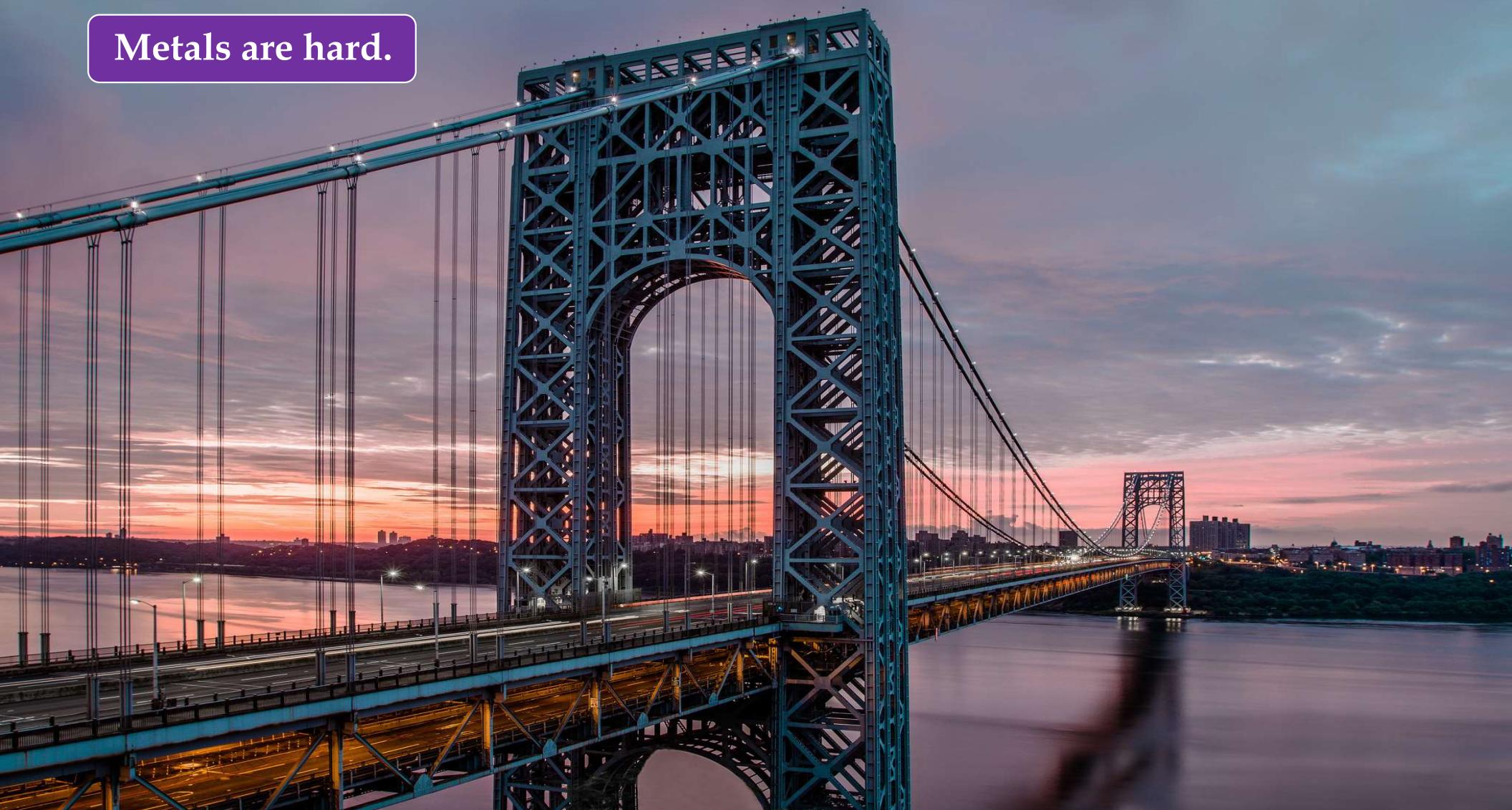
Sodium

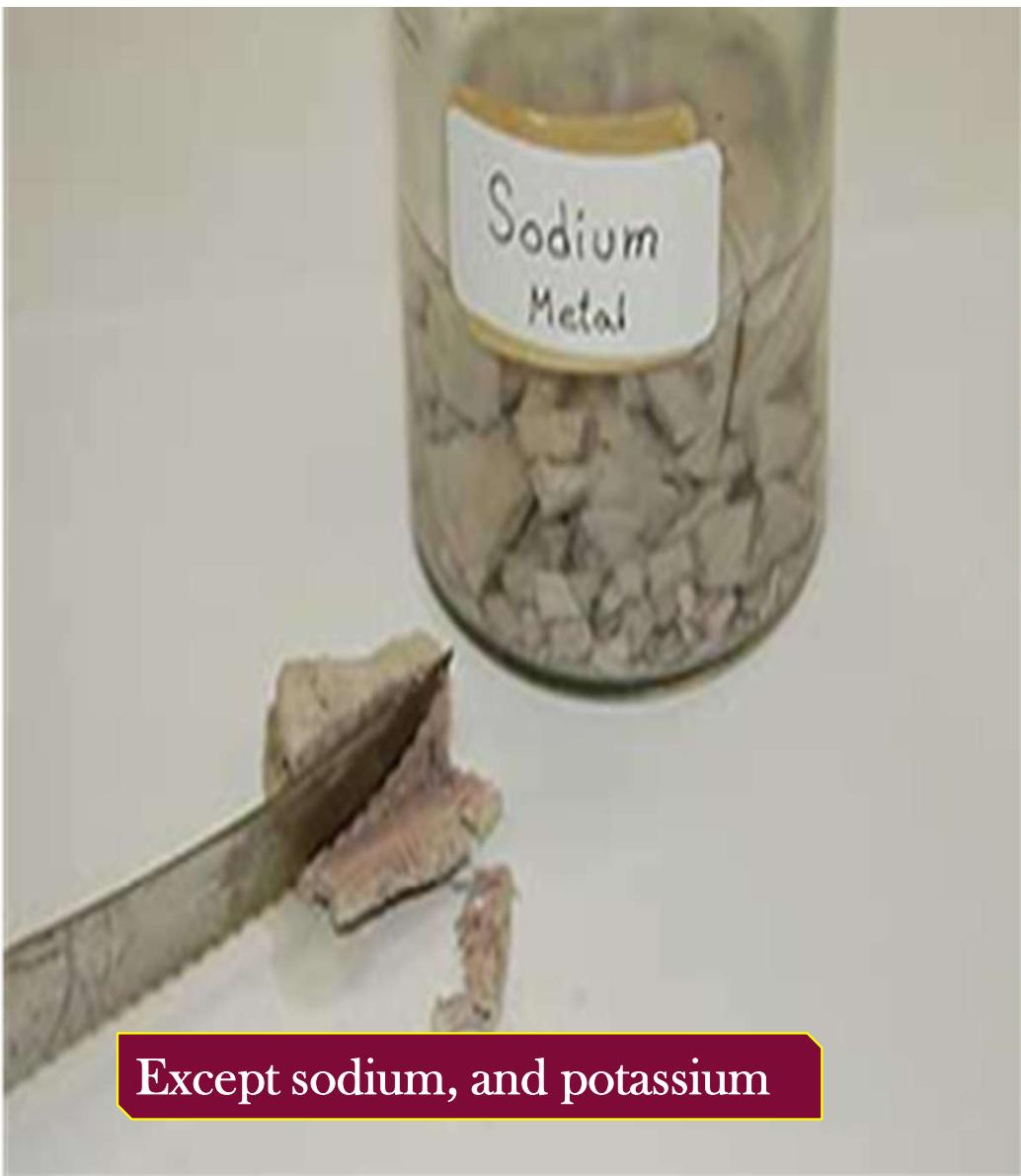


Potassium

Sodium and potassium are soft metals can be easily cut with a knife.

Metals are hard.





Except sodium, and potassium



Metals are solids at room temperature
(except mercury which is a liquid metal).



Metals have high melting points and

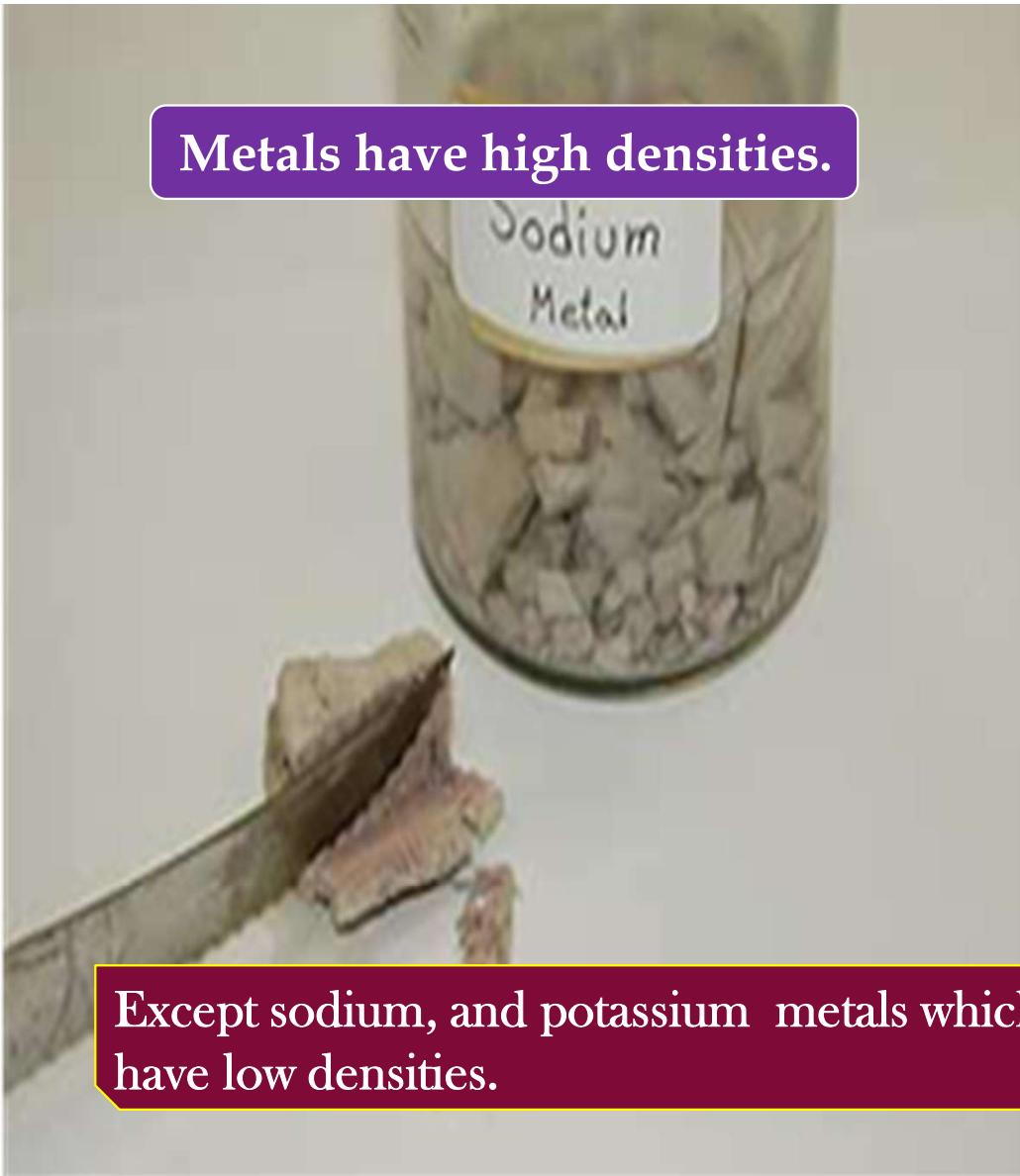




Metals have high melting points and boiling points.

Except sodium and potassium which have low melting and boiling points.

Metals have high densities.



Except sodium, and potassium metals which have low densities.

Metals are sonorous.
i.e. metals make sound when struck with an object.

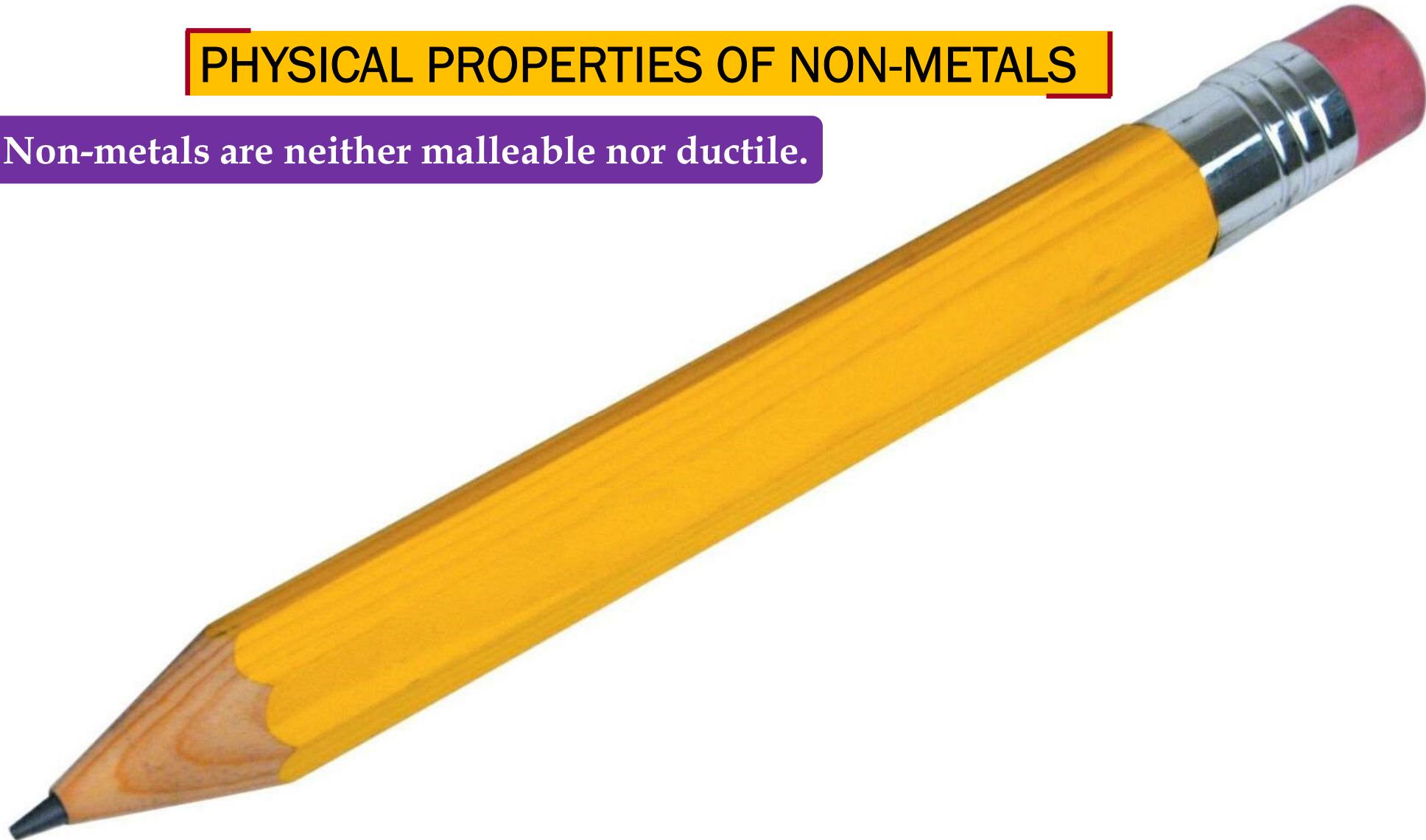


METALS AND NON-METALS

- **Physical properties of non-metals**

PHYSICAL PROPERTIES OF NON-METALS

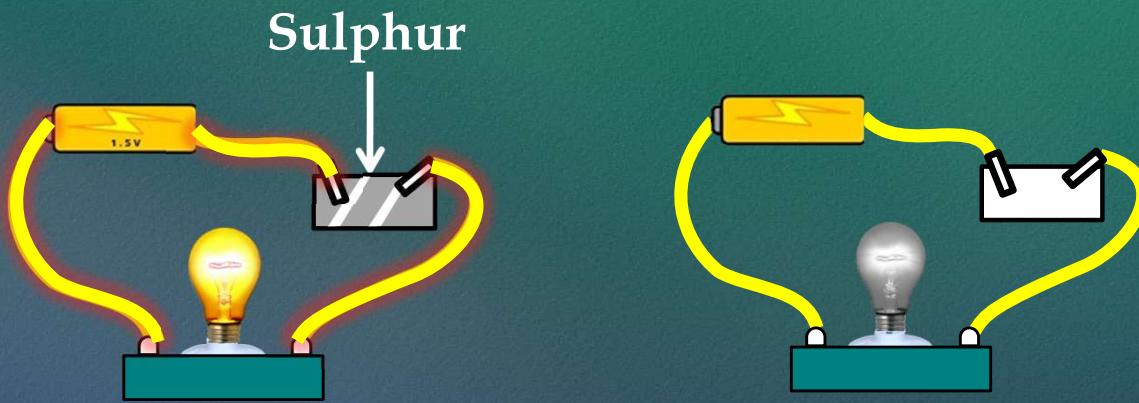
Non-metals are neither malleable nor ductile.



Non-metals are brittle (break easily).



Non-metals do not conduct heat and electricity.



Except carbon in the form of graphite.

Non-metals are non lustrous, they are dull.



Carbon



Diamond

Non-metals are generally soft.

Except carbon in the form of diamond is very hard.



Non-metals are not strong. They are easily broken.

Except carbon in the form of diamond.



Non-metals may be solid, liquid or gases at the room temperature.



Sulphur in solid state



Bromine in liquid state



Chlorine in gaseous state



Non-metals have comparatively low melting points and boiling points.

Except diamond which is a non-metal having high melting point and boiling point.

For example melting point of sulphur is 115°C which is quite low.





Melting point of **diamond** is more than **3500°C** which is very high.

Non-metals have low densities.

Non-metals are non-sonorous.

Non-metals have different colours.

Chlorine



Sulphur



Red phosphorus



Non-metals
have different
colours.

Bromine



Graphite



White phosphorus



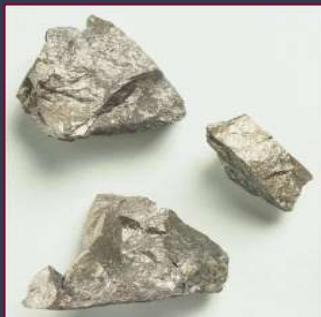
METALS AND NON-METALS

- **Chemical properties of metals**
 - **Reactivity Series of metals**

CHEMICAL PROPERTIES OF METALS

REACTIVITY SERIES

K is most reactive



Gold is least reactive

As we move up, reactivity increases as increasing order of their reactivity in the form of series is called the reactivity series of the metal.



K	Potassium	I	D
Na	Sodium	E	E
Ca	Calcium	N	C
Mg	Magnesium	C	R
Al	Aluminium	R	E
Zn	Zinc	E	A
Fe	Iron	A	S
Pb	Lead	S	E
[H]	[Hydrogen]	E	S
Cu	Copper	S	S
Hg	Mercury		
Ag	Silver		
Au	Gold		

METALS AND NON-METALS

- **Chemical properties of metals**
 - Reaction of metals with oxygen

1.

REACTION WITH OXYGEN

Na and K being most reactive, react with oxygen at room temperature to form oxides.



Magnesium does not react with oxygen at room temperature but on heating, magnesium burns in air with intense light and heat to form Magnesium oxide.

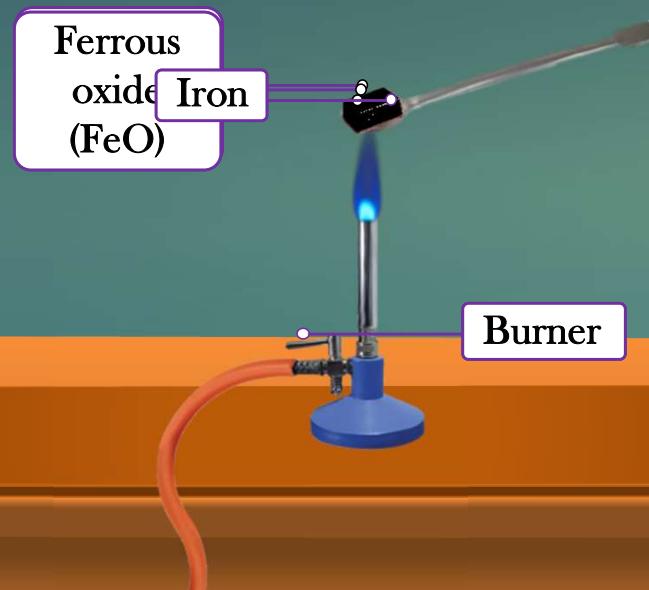


Zinc burns in air only on strong heating to form zinc oxide.



Iron $\xrightarrow{3}$ Fe does not burn $\xrightarrow{O_2}$ on strong heating $\xrightarrow{\Delta}$ Fe_3O_4
But Iron filings burn $\xrightarrow{O_2}$ vigorously when Iron oxide
sprinkled in the flame of the burner.

Iron (Fe) filings on strong heating form
iron oxide.

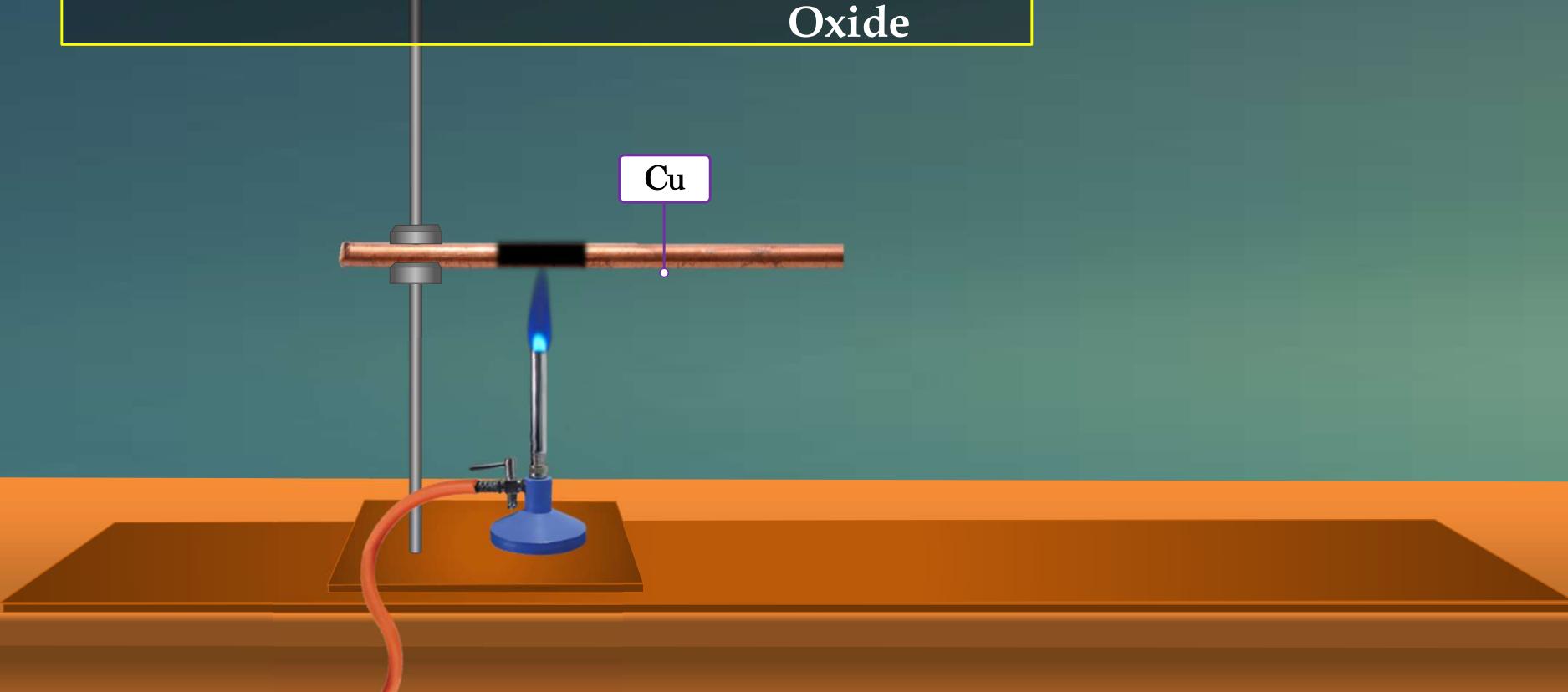


Copper is least reactive.



Copper does not burn, but in Oxygen heating, the **Copper Oxide** is heated.

with a black coloured layer of copper oxide.



K } Room
Na } temperature

Ca } Heat
Mg }

Al } Strong Heating
Zn }

Fe } Heat Filings

Pb

Cu } Strong
Hg } Heating

Ag

Au

METALS AND NON-METALS

- **Chemical properties of metals**
 - **Reaction of water with metal oxides**
 - **Nature of oxides**

REACTION WITH WATER

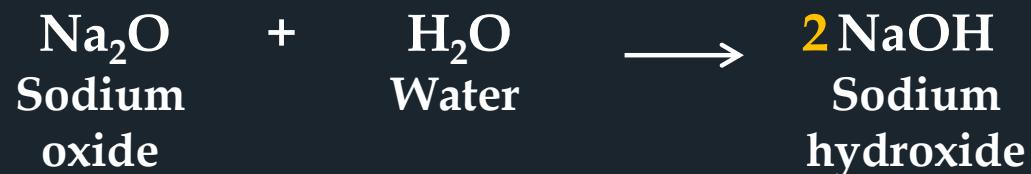
2.

REACTION WITH WATER

Most metal oxides are insoluble in water but some of these dissolve in water to form alkalis.



K and **Na** oxides dissolve in water to produce alkalis as follows.



NATURE OF OXIDES



Behaves like Base?



Metal oxides are BASIC in nature.

Exception:- $\text{Al}_2\text{O}_3, \text{ZnO}$

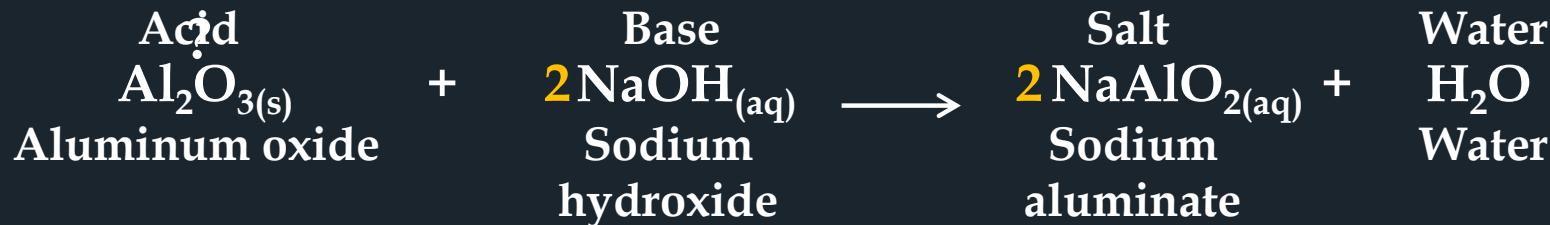
AMPHOTERIC OXIDES

Non-metal oxides are ACIDIC in nature.

Behaves like Acid

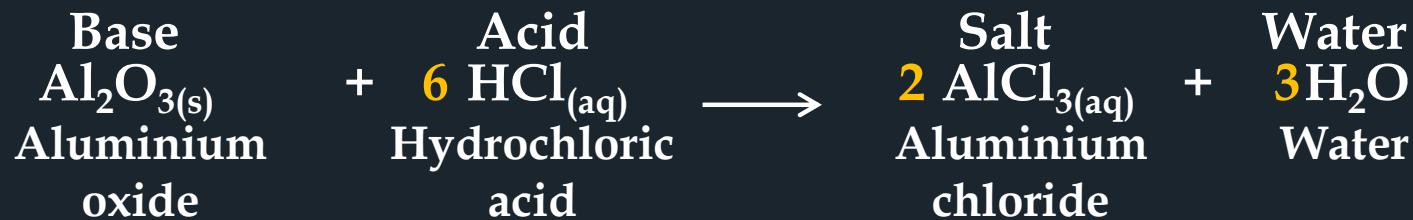


In presence of base Al_2O_3 is
acting like an acid



Oxides which react with acids as well as bases to produce salts and water are known as AMPHOTERIC OXIDES. e.g. Al_2O_3 , ZnO

In presence of base Al_2O_3 is
acting like an Base



METALS AND NON-METALS

- **Chemical properties of metals**
 - **Reaction with water
(High reactive metals)**

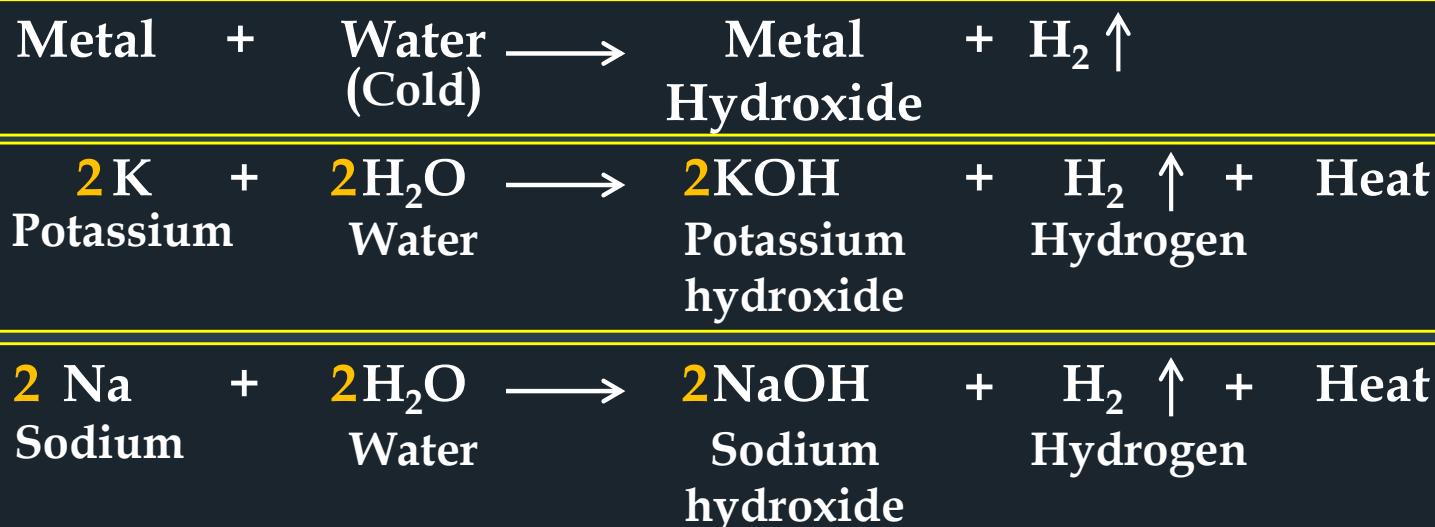
2.

REACTION WITH WATER

Potassium and Sodium are stored in Kerosene because they react with both Water as well as Oxygen in the Air at normal room temperature.

Na and K react with water to evolve hydrogen gas which immediately catches fire producing a lot of heat.

Metals like K and Na react vigorously with cold water.

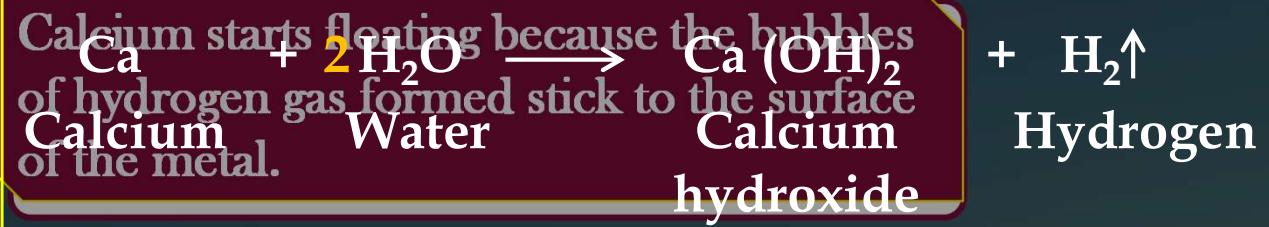


METALS AND NON-METALS

- **Chemical properties of metals**
 - **Reaction with water
(Medium reactive metals)**

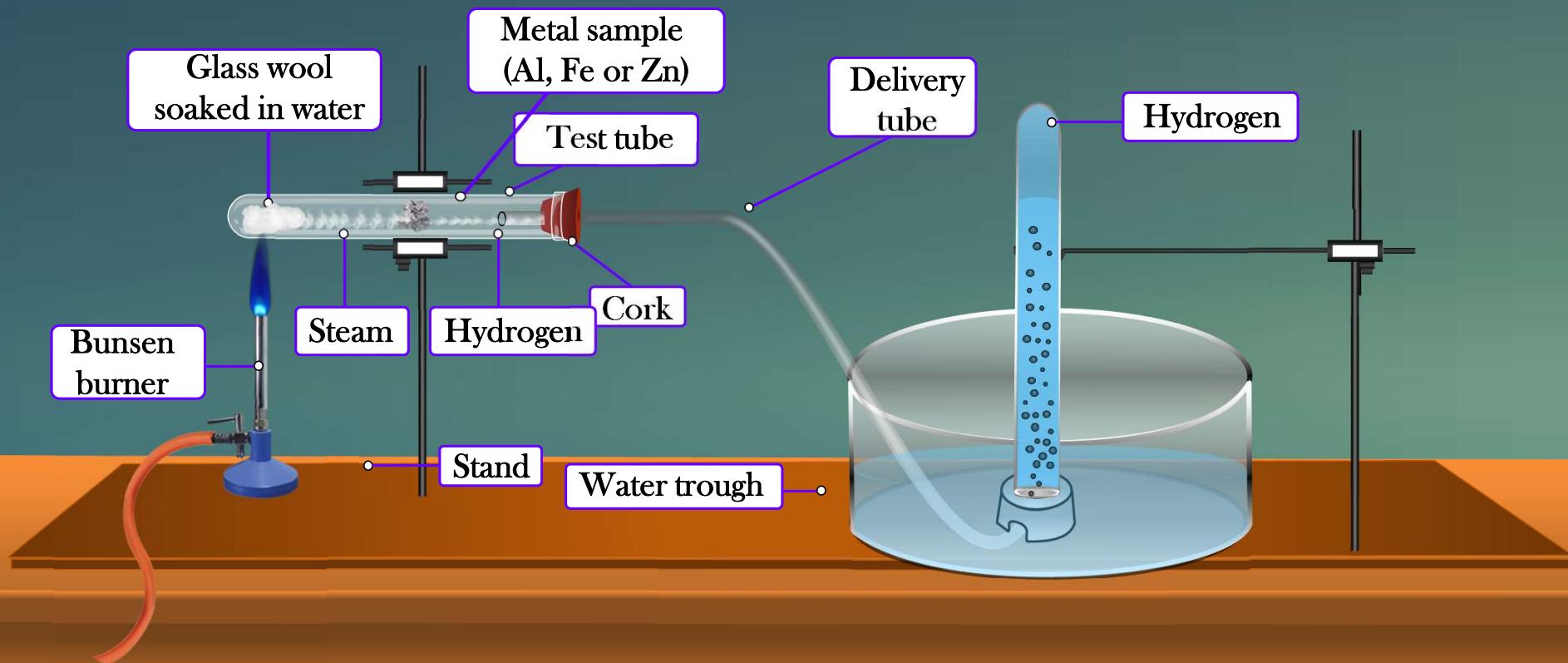
2.

REACTION WITH WATER





For the metals that do not react with hot water, arrange the apparatus as shown in the figure and observe the reaction with steam.



METALS AND NON-METALS

- **Chemical properties of metals**
 - **Reaction with water
(Low reactive metals)**

2.

REACTION WITH WATER (Steam)





K	}	Cold water
Na		
Ca	}	Hot water
Mg		
Al	}	Steam
Zn		
Fe	}	Steam
Pb		
(H)		
Cu	}	Do not
Hg		react
Ag		with
Au		water

Less reactive metals like Cu, Hg, Ag, Au will not react with water as they cannot displace Hydrogen from water.

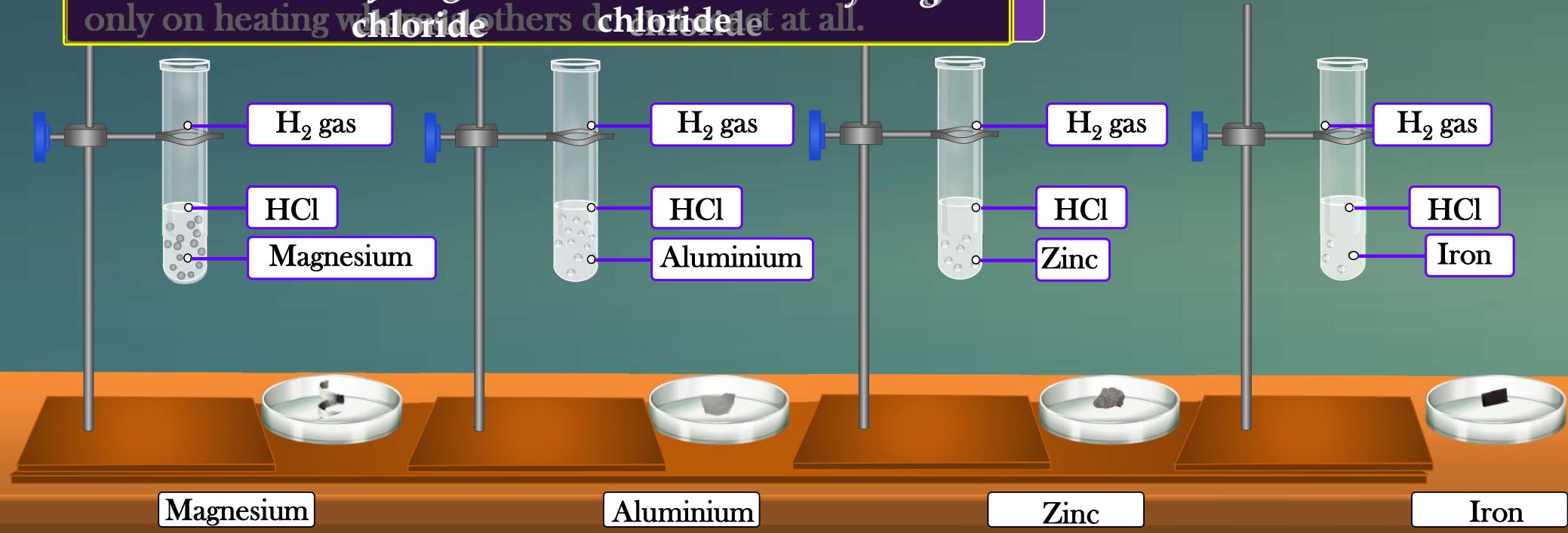
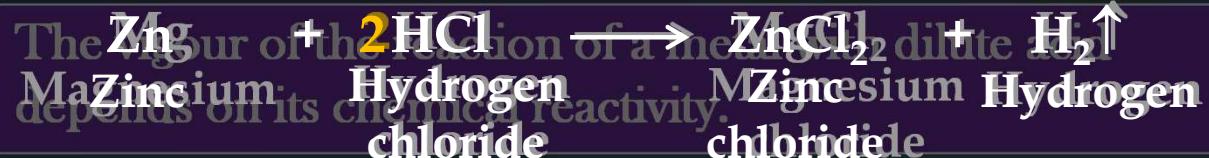
METALS AND NON-METALS

- **Chemical properties of metals**
 - **Reaction with dilute Acids
(dil. HCl)**

REACTION WITH DILUTE ACIDS

3.

REACTION WITH DILUTE HYDROCHLORIC ACID



METALS AND NON-METALS

- **Chemical properties of metals**
 - **Reaction with dilute Acids
(dil. H_2SO_4)**

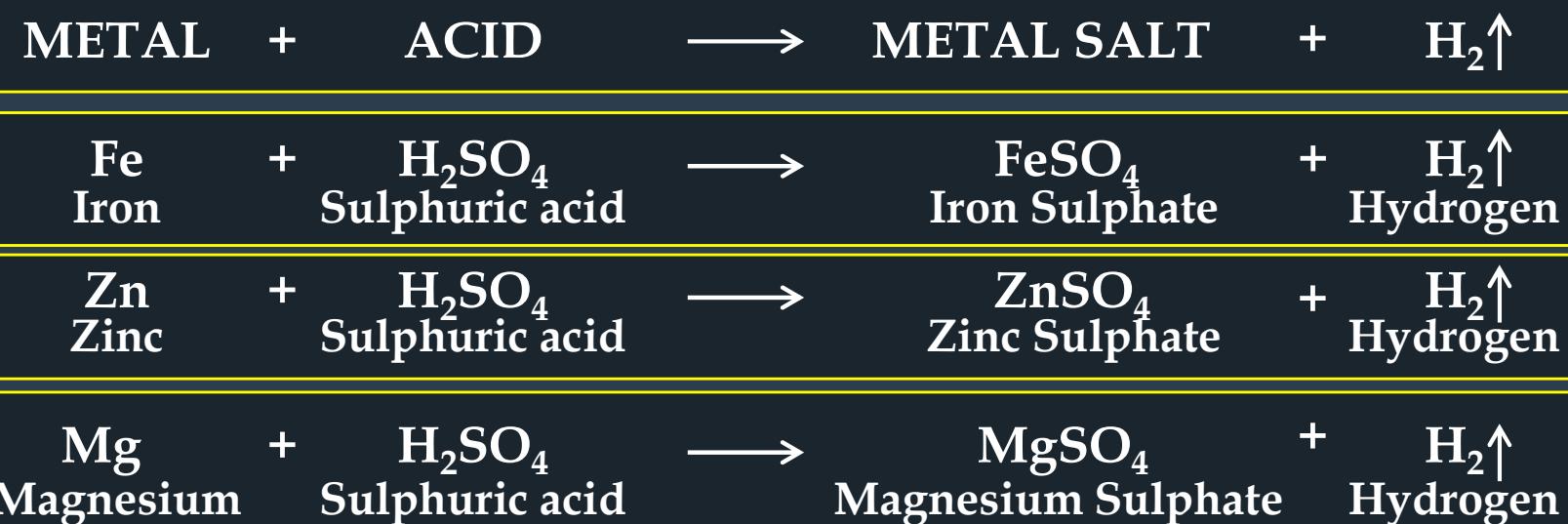
REACTION WITH DILUTE ACIDS

4.

REACTION WITH DILUTE SULPHURIC ACID

Copper does not react with dilute hydrochloric acid (or dilute sulphuric acid) at all.

This shows that copper is even less reactive than iron.



METALS AND NON-METALS

- Chemical properties of metals
 - Reaction with dilute Acids
(dil. HNO_3)
 - Aquaregia

REACTION WITH DILUTE ACIDS

5.

REACTION WITH NITRIC ACID

- ❖ When metal reacts with HNO_3 , H_2 gas is not evolved.
- ❖ HNO_3 is a strong oxidizing agent. It oxidizes H_2 into H_2O .
- ❖ Itself reduces to NO (Nitric oxide), NO_2 (Nitrogen Dioxide), N_2O (Nitrous Oxide).
- ❖ When metal reacts with HNO_3 , H_2 gas is not evolved.

a.

Magnesium reacts with very dilute nitric acid to form magnesium nitrate and hydrogen gas :

b.

Manganese reacts with very dilute nitric acid to form manganese nitrate and hydrogen gas :



AQUAREGIA ('Royal water' in latin)

It is a freshly prepared mixture of conc. HCl and conc. HNO₃ in the ratio 3:1.

It is highly corrosive and a fuming liquid.

It can dissolve gold and platinum.

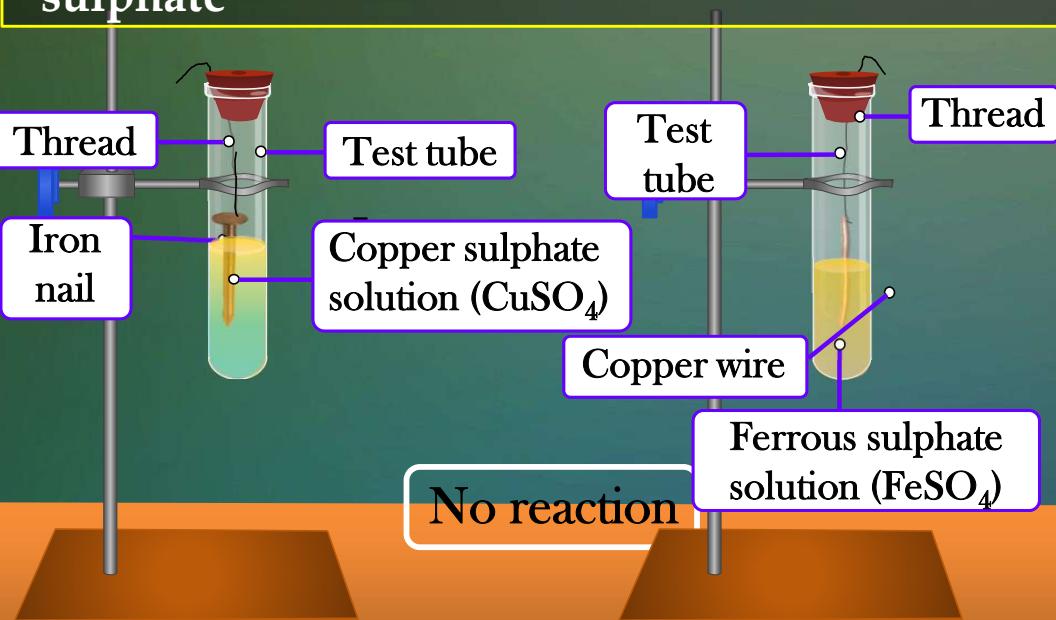
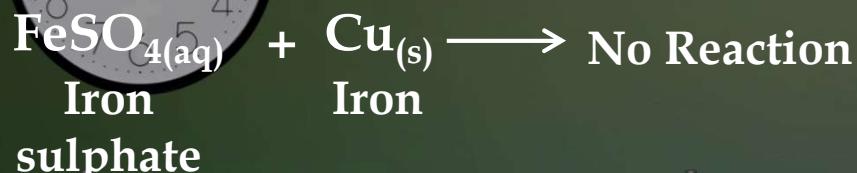
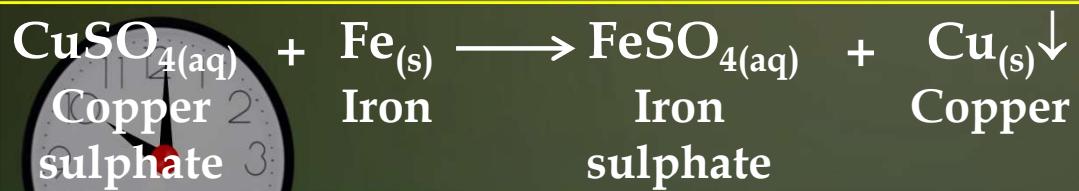


METALS AND NON-METALS

- **Chemical properties of metals**
 - **Reaction of metals with salt solutions
of metals.**

6.

REACTION OF METAL WITH SOLUTIONS OF OTHER METAL SALTS



K	Potassium
Na	Sodium
Li	Lithium
Ca	Calcium

Mg	Magnesium
Al	Aluminium

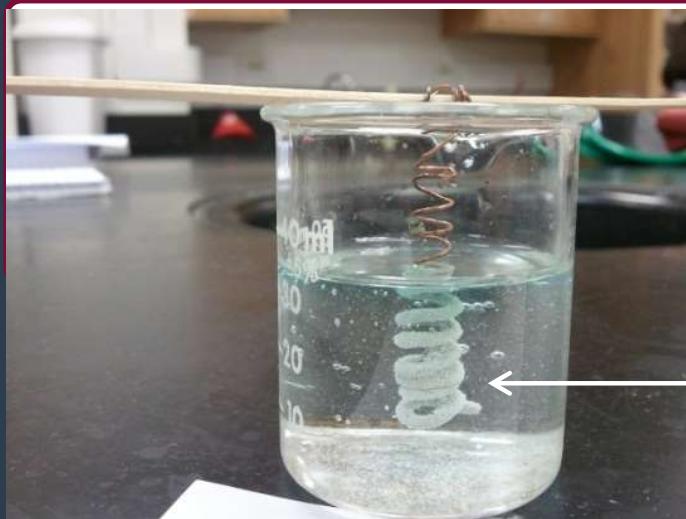
Zn	Zinc
Fe	Iron
Sn	Tin
Pb	Lead

Cu	Copper
Hg	Mercury
Ag	Silver

Au	Gold
----	------

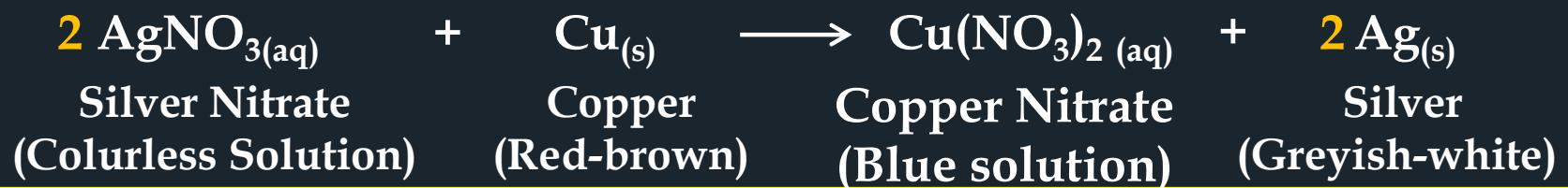
REACTIVITY DECREASES

REACTION OF COPPER WITH SILVER NITRATE



As kept immersed in time, the solution shining greyish-white d on copper strip :

Silver



METALS AND NON-METALS

- **Chemical properties of metals**
 - **Reaction of metals with chlorine**
 - **Reaction of metals with hydrogen**

7.

REACTION OF METALS WITH CHLORINE

Metals react with chlorine to form ionic chlorides.

i.

Sodium is a metal. So, sodium readily reacts with chlorine to form an ionic chloride called sodium chloride.



ii.

Calcium is a metal which reacts vigorously with chlorine to form an ionic chloride called calcium chloride.

iii.

Zinc combines directly with chlorine to form zinc chloride.



iv.

Iron combines with chlorine, when heated to form iron (III) chloride.



8.

REACTION OF METALS WITH HYDROGEN

Most of the metals do not combine with hydrogen. Only a few reactive metals like sodium, potassium, calcium and magnesium react with hydrogen to form metal hydrides.

i.

When hydrogen gas is passed over heated sodium, then sodium hydride is formed.



ii.

When hydrogen gas is passed over heated calcium, then calcium hydride is formed.



CHEMICAL PROPERTIES OF NON-METALS

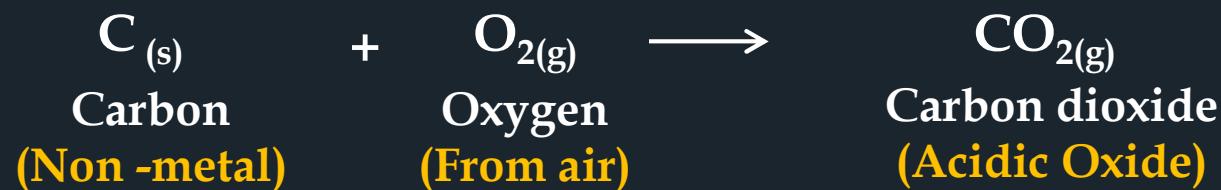
1.) Reaction of Non - Metals with Oxygen

Non - metals react with oxygen to form acidic oxides or neutral oxides.

i.

Carbon is a non-metal.

When carbon burns in air it reacts with the oxygen of air to form an acidic oxide called carbon dioxide.



ii.

Sulphur is a non-metal.

When sulphur is burnt in air, it reacts with the oxygen of air to form an acidic oxide called sulphur dioxide.



2. Reaction of Non - Metals with Water

Non - metals do not react with water (or steam) to evolve hydrogen gas.

This is because non-metals can not give electrons to reduce the hydrogen ions of water into hydrogen gas.

3. Reaction of Non - Metals with Dilute Acids

Non - metals do not react with dilute acids.

Non-metals do not displace hydrogen from acids.

In order to displace hydrogen ions (H^+) of an acid and convert them into hydrogen gas, electrons should be supplied to the hydrogen ions (H^+) of the acid.

Now, a non - metal, being itself an acceptor of electrons, cannot give electrons to the hydrogen ions of the acid to reduce them to hydrogen gas.

4. Reaction of Non - Metals with Chlorine

i.

Hydrogen is a non-metal.

So, hydrogen reacts with chlorine to form a covalent chloride called hydrogen chloride.



5. Reaction of Non-metals with Hydrogen

i.

Sulphur is a non-metal which combines with hydrogen to form a covalent hydride called hydrogen sulphide.



USES OF METALS

Metals are used for a large number of purposes.
Some of the uses of metals are given below :

Copper and aluminium metals are used to make wires.



Iron, copper and aluminium metals are used to make house-hold utensils and factory equipment.

FALK
Culinaire



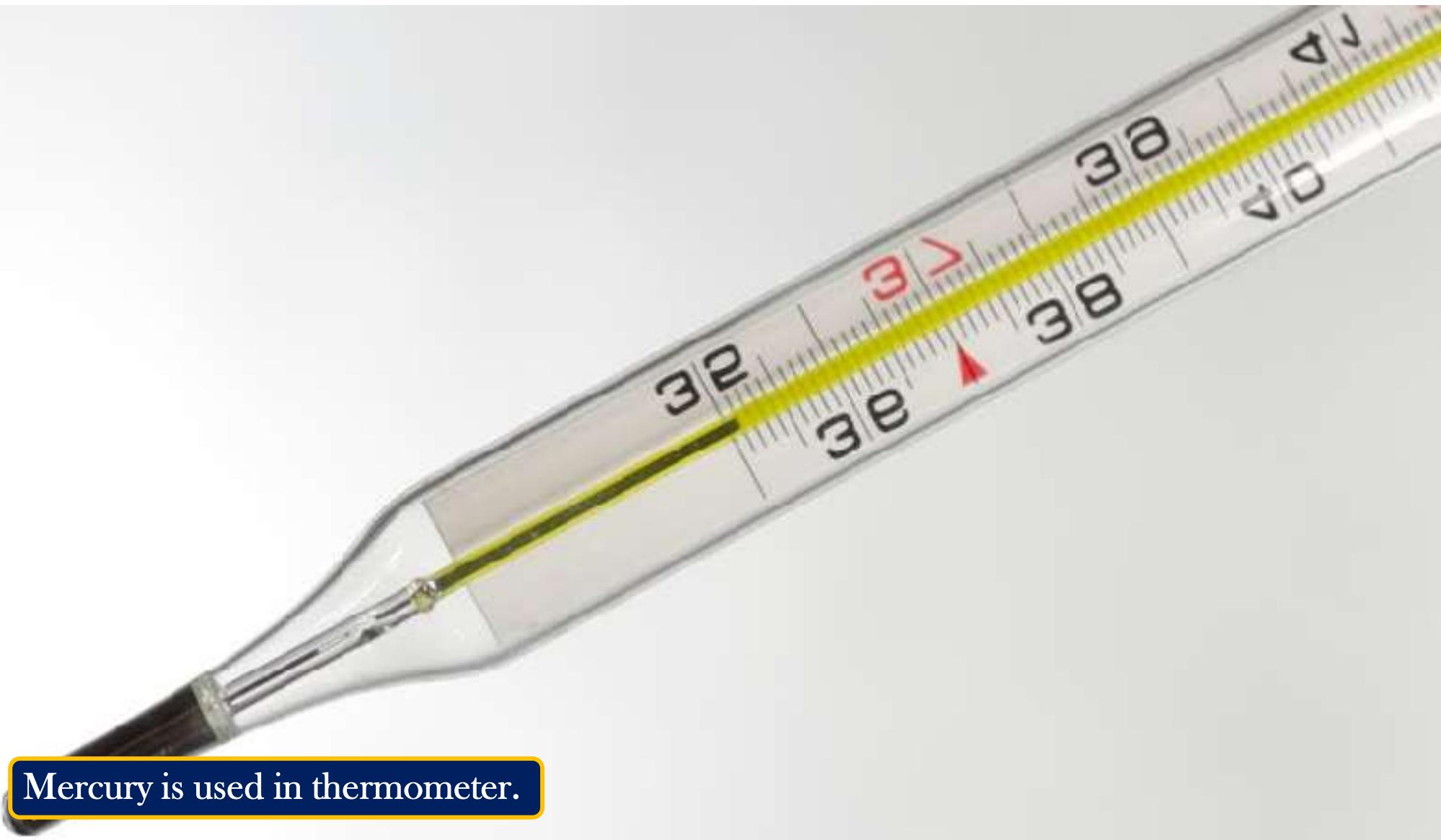
Zinc is used for galvanizing iron to protect it from rusting.



Chromium and nickel metals are used for electroplating and in the manufacture of stainless steel.

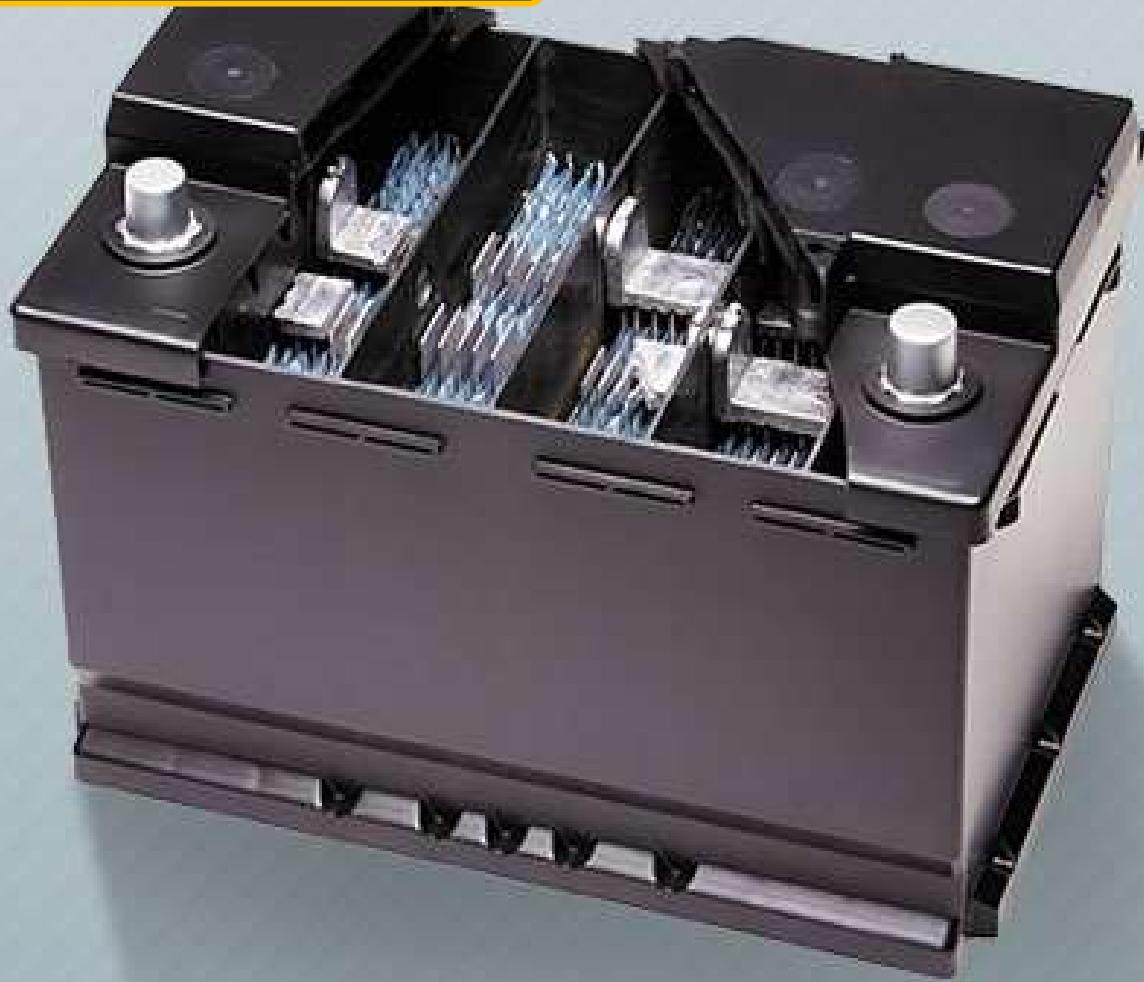


Silver and gold metals are used to make jewellery.



Mercury is used in thermometer.

Lead metal is used in making car batteries.



USES OF NON-METALS

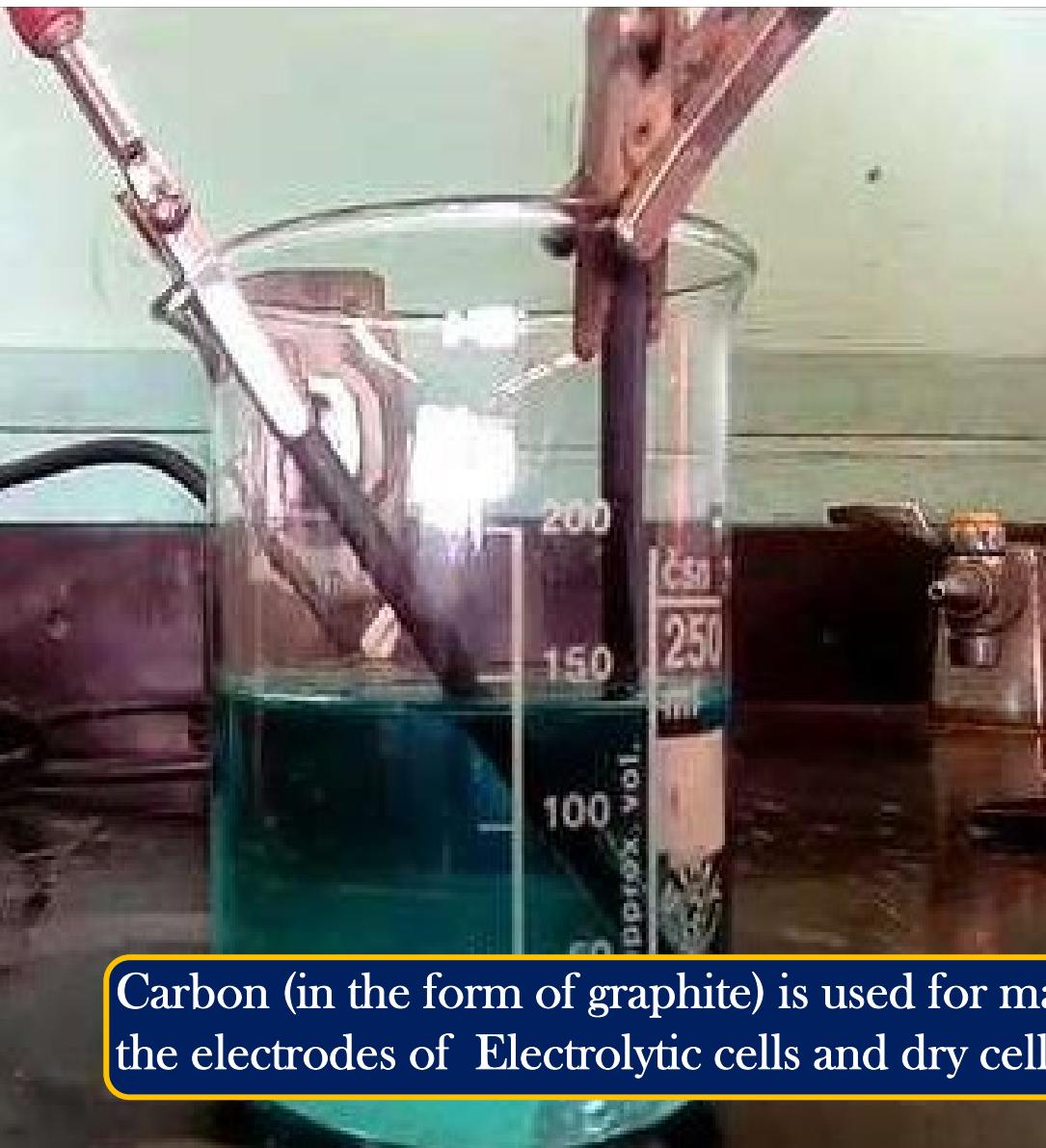
The important uses of non-metals are as follows:

Hydrogen is used in the hydrogenation of vegetable oils to make vegetable ghee (or vanaspati ghee).

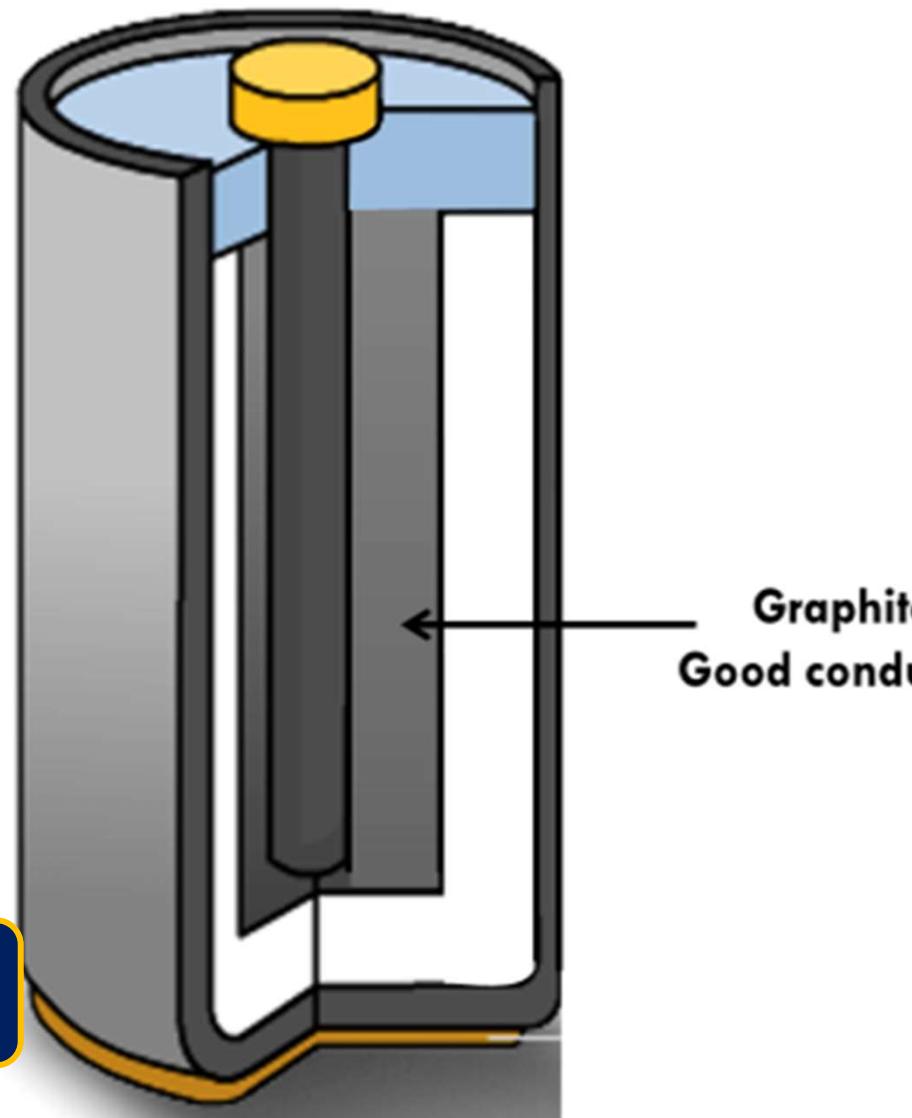




Hydrogen is used in the manufacture of ammonia
(whose compounds are used as fertilizers).



Carbon (in the form of graphite) is used for making the electrodes of Electrolytic cells and dry cells .





Nitrogen is used in the manufacture of ammonia, nitric acid and fertilizers.



Due to its inertness, nitrogen is used to preserve food materials.



Sulphur is used as a fungicide and in making of gun powder and vulcanization of rubber.

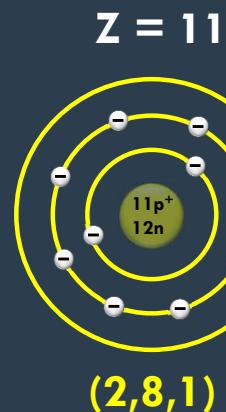
HOW DO METALS AND NON-METALS REACT

Formation of Sodium Chloride

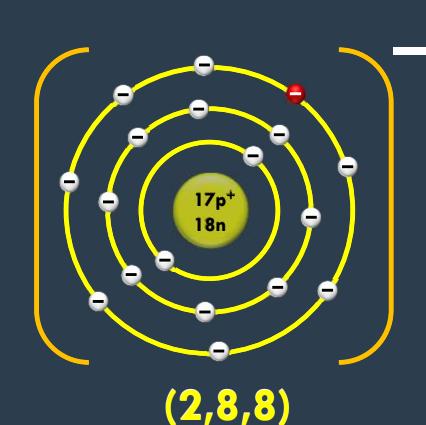
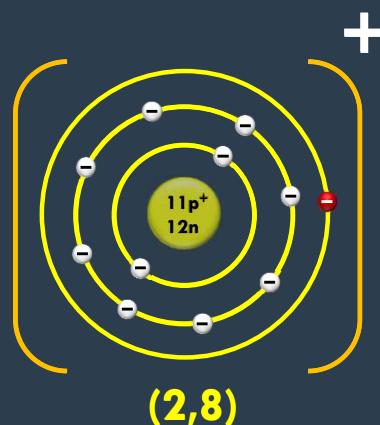
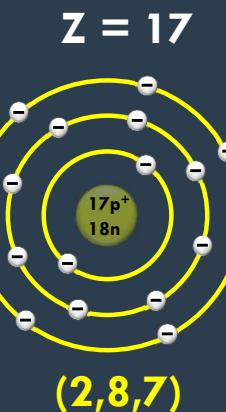
This force of attraction is called as an **Ionic bond**.
there is a force of attraction between Na^+ and Cl^- .

IONIC BOND

Sodium (Na)



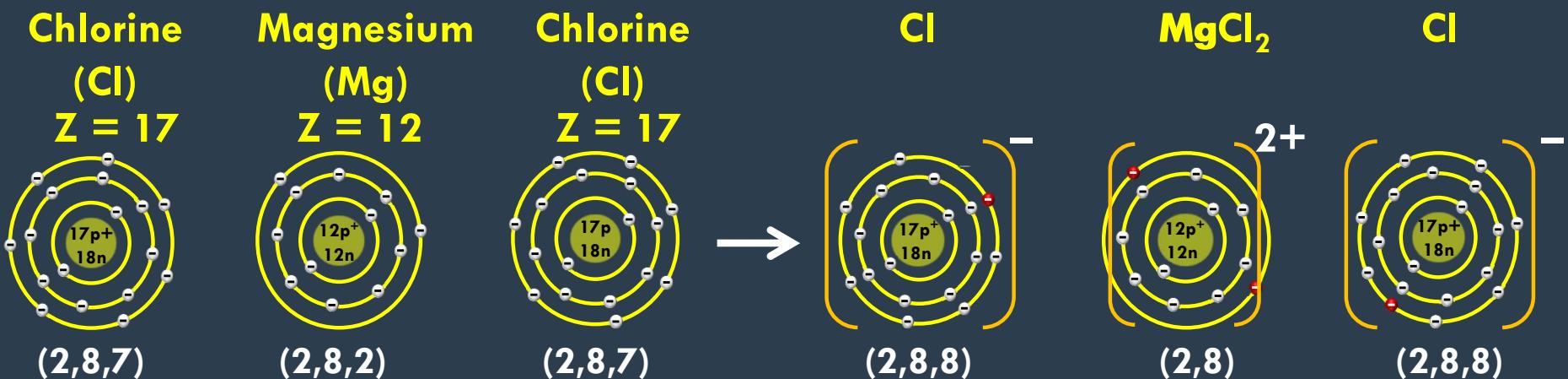
Chlorine (Cl)



NaCl

Formation of magnesium chloride

Since Mg has to donate 2 electrons to become stable, but Cl accepts only $1e^-$ to become stable, hence 1 Mg requires 2 atoms of Cl.



A chemical bond formed by the transfer of electrons from one atom to another atom is called as **IONIC BOND** or **ELECTROVALENT BOND**.

Compounds formed by the transfer of electrons from a metal to a non-metal are known as **IONIC** or **ELECTROVALENT COMPOUNDS**.

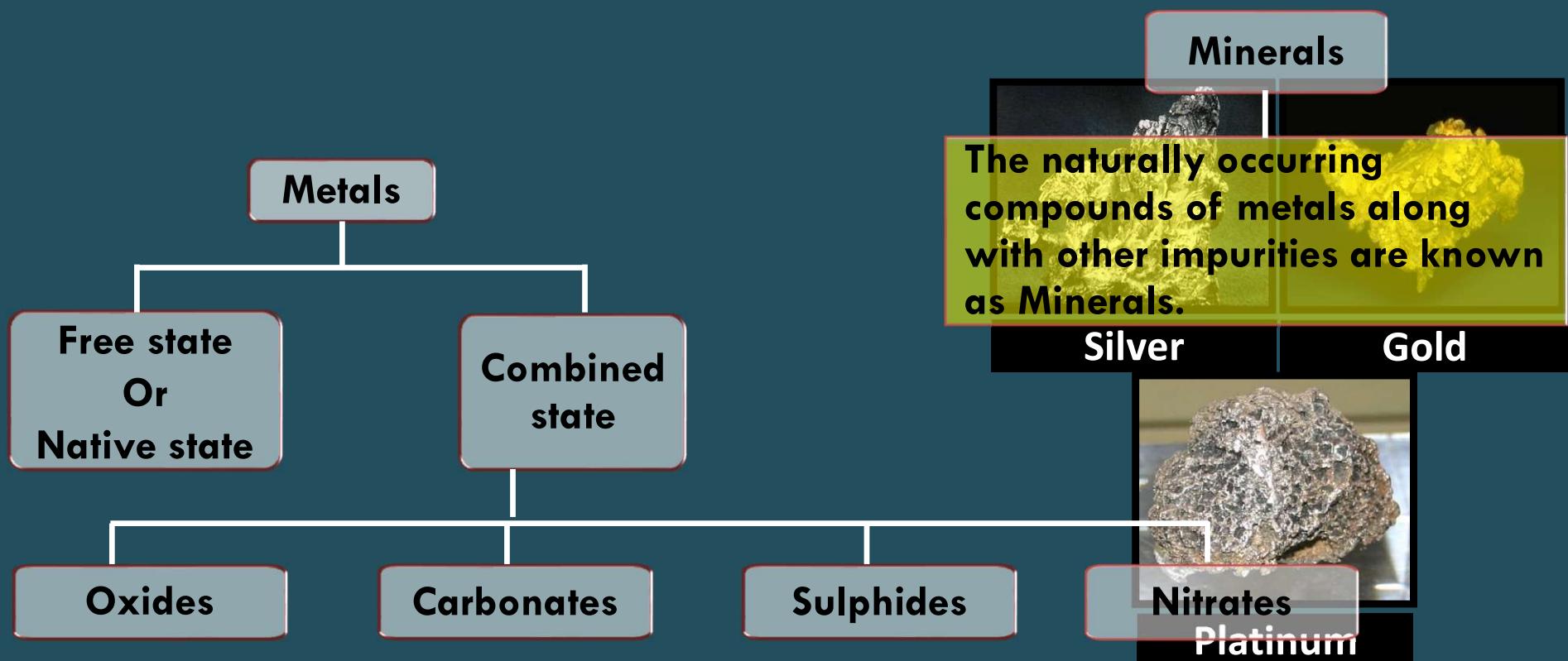
PROPERTIES OF IONIC COMPOUNDS

-  Hard, because of strong force of attraction between positive and negative ions.
-  High melting and boiling points.
-  Generally soluble in water.
-  Good conductors of electricity.
-  They are generally brittle.

METALS AND NON-METALS

- **Occurrence of metals**

OCCURENCE OF METALS



Mine A

50%

700 ft

95%

1000 ft.

The naturally occurring compounds of metals along with other impurities are known as Minerals.

Minerals

Ores

Gangue

Mine C

80%

500 ft.

Ores contain many types of impurities such as soil, sand and rocky substances along with the metal compounds. These impurities are called gangue.

The minerals from which metals are extracted profitably and conveniently are called as ores.

METALS AND NON-METALS

- **Occurrence of metals**
 - **Metallurgy**

METALLURGY INCLUDES:

- ❖ REMOVAL OF GANGUE
- ❖ REDUCTION
- ❖ REFINING

Concentration of ores

The naturally occurring compounds of metals along with other impurities are known as Minerals.

Minerals

Ores

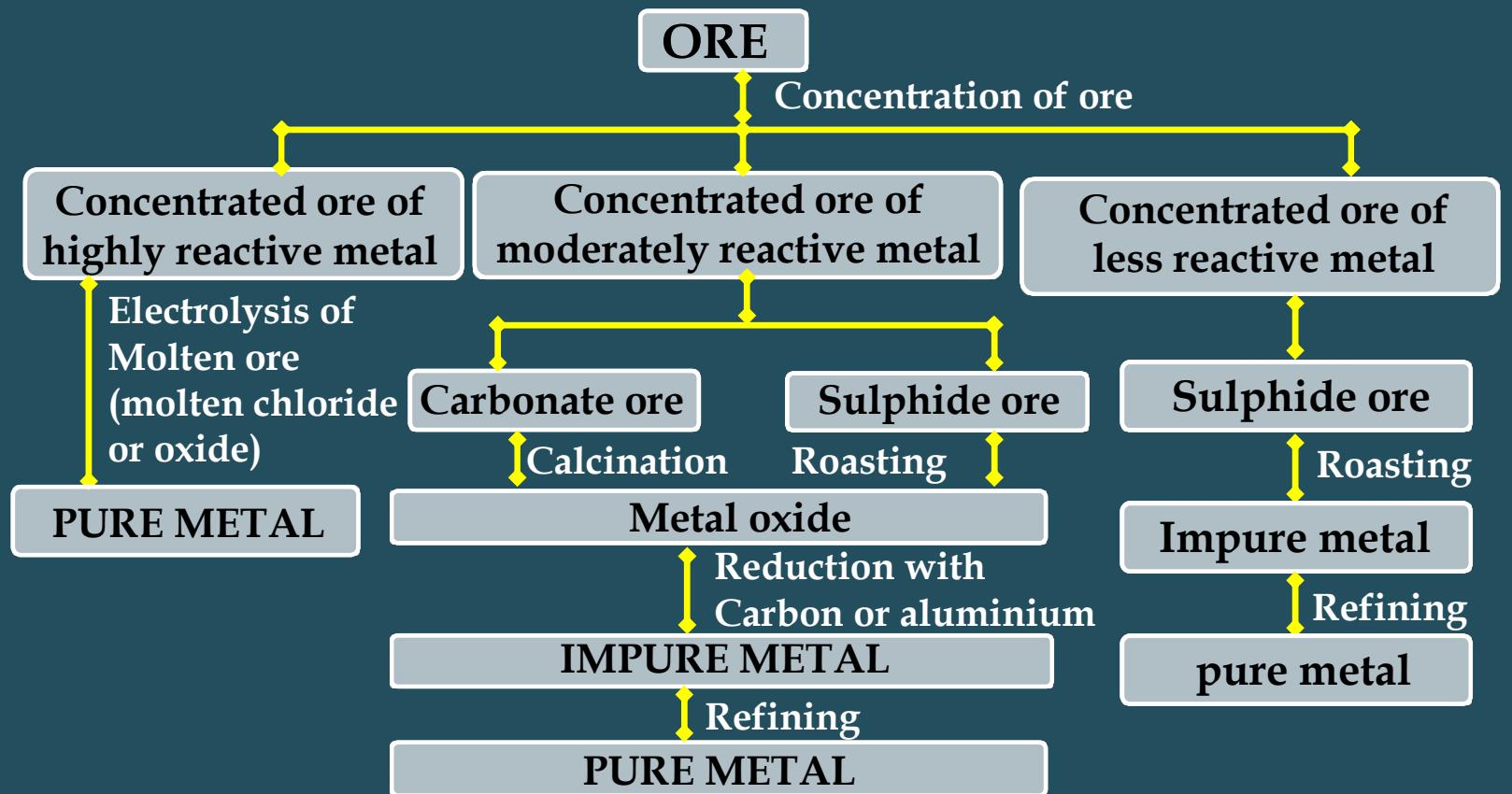
The minerals from which metals are extracted profitably and conveniently are called as ores.

Ores contain many types of impurities such as soil, sand and rocky substances along with the metal compounds. These impurities are called gangue.

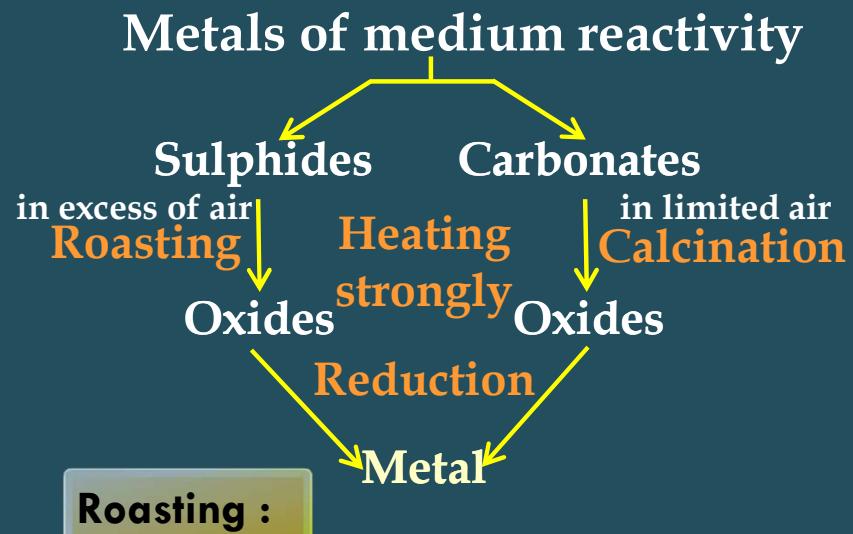
Gangue

Metallurgy

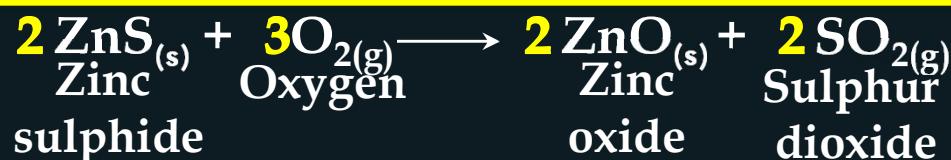
The process used for extraction of metals in their pure form from their ores is called metallurgy.



EXTRACTION OF METAL OF MEDIUM REACTIVITY



The sulphide ores are first converted into oxides by heating strongly in excess of air. This process is known as ROASTING.

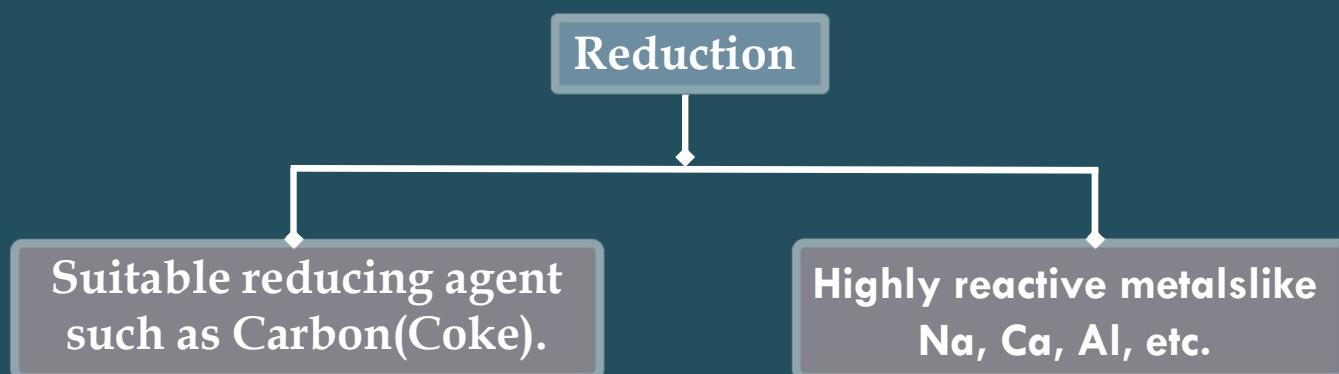


K	Potassium	Higher Reactivity
Na	Sodium	
Li	Lithium	
Ca	Calcium	
Mg	Magnesium	
Al	Aluminium	
Zn	Zinc	
Fe	Iron	
Sn	Tin	

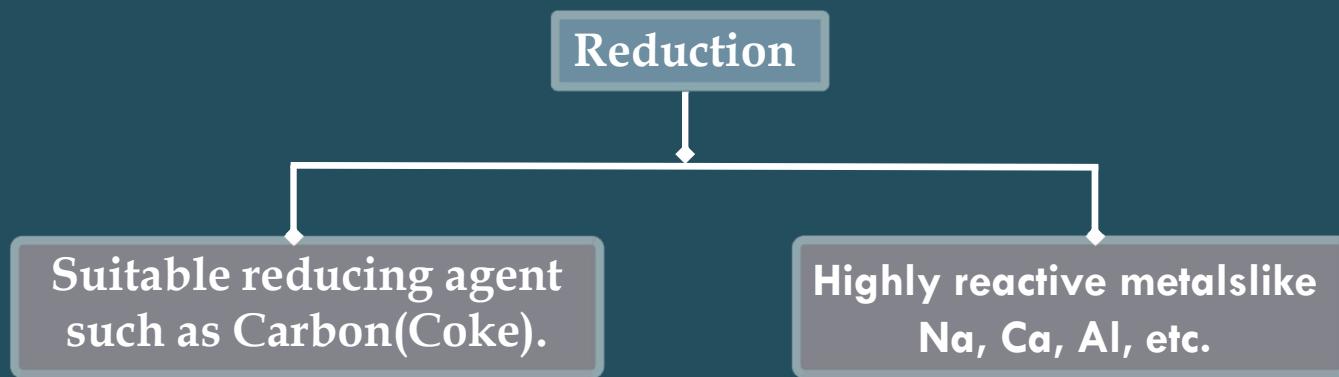
Calcination :

The carbonate ores are changed into oxides by heating strongly in limited air. This process is known as CALCINATION.





This reaction is used to join railway tracks or cracked machine parts.



THERMIT REACTION



The amount of heat evolved in some reactions is so large that the metals are produced in the molten state. These reactions are termed as THERMIT REACTIONS.



METALS AND NON-METALS

- Occurrence of metals
- Extraction of low reactive metals

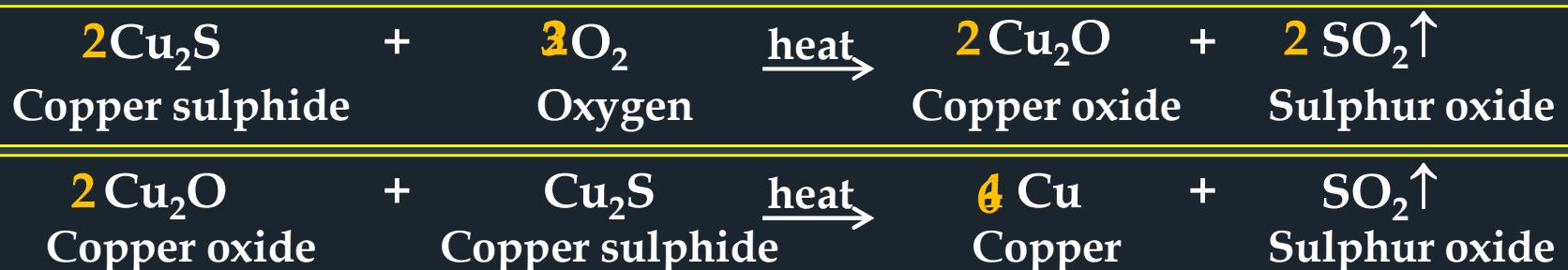
EXTRACTION OF METAL OF LOW REACTIVITY

METAL OF LOW REACTIVITY

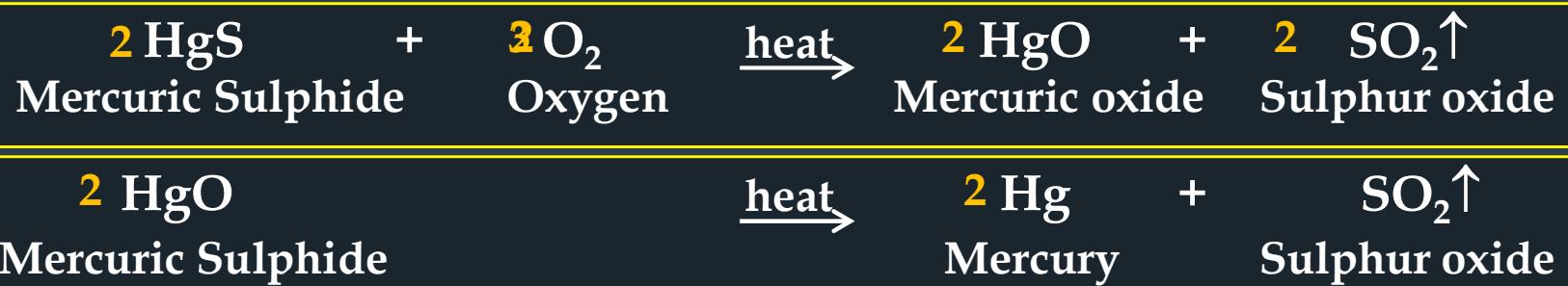
Generally exist in free state
Eg. Au and Pt

Some exist in combined state. (sulphides or oxides)
Eg. Hg and Cu

Extraction of Copper



Extraction of Mercury(Cinnabar)



METALS AND NON-METALS

- **Occurrence of metals**
 - **Refining of metals**

REFINING OF METAL

The metals produced by various reduction processes described above are not very pure.

They contain impurities, which must be removed to obtain pure metals. The most widely used method for refining impure metals is electrolytic refining.

Insoluble in
ELECTROLYTIC REFINING OF COPPER
anode and are known as ANODE MUD.

Experimental set up for the
electrolytic refining of copper

Battery

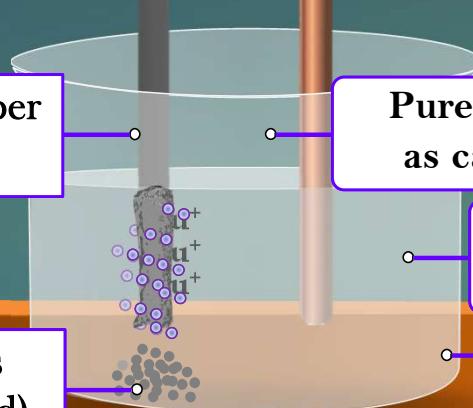
Impure copper
as anode

Pure copper
as cathode

Acidified copper
sulphate solution

Impurities
(Anode mud)

Electrolytic tank





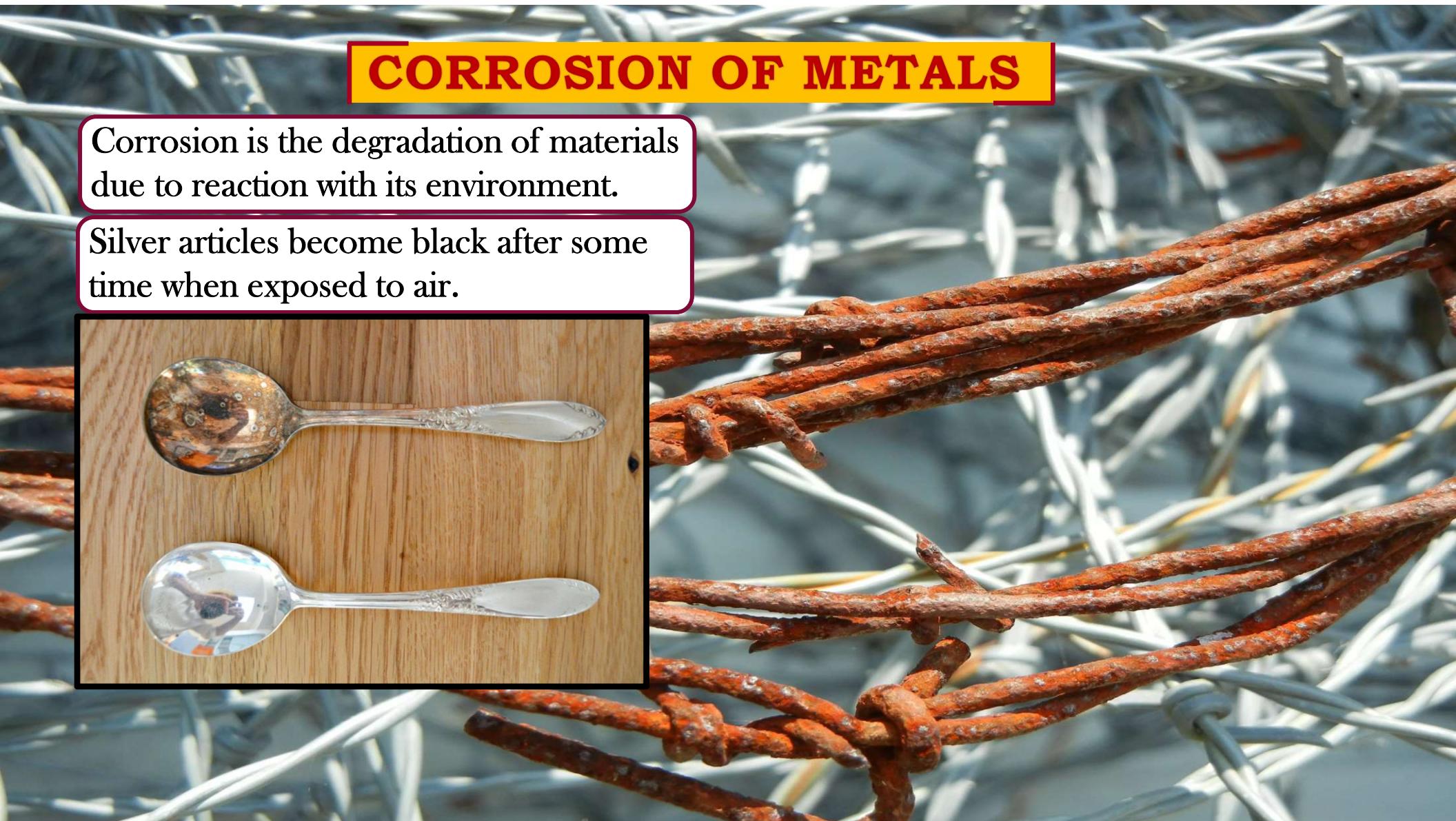
METALS AND NON-METALS

- **Corrosion**

CORROSION OF METALS

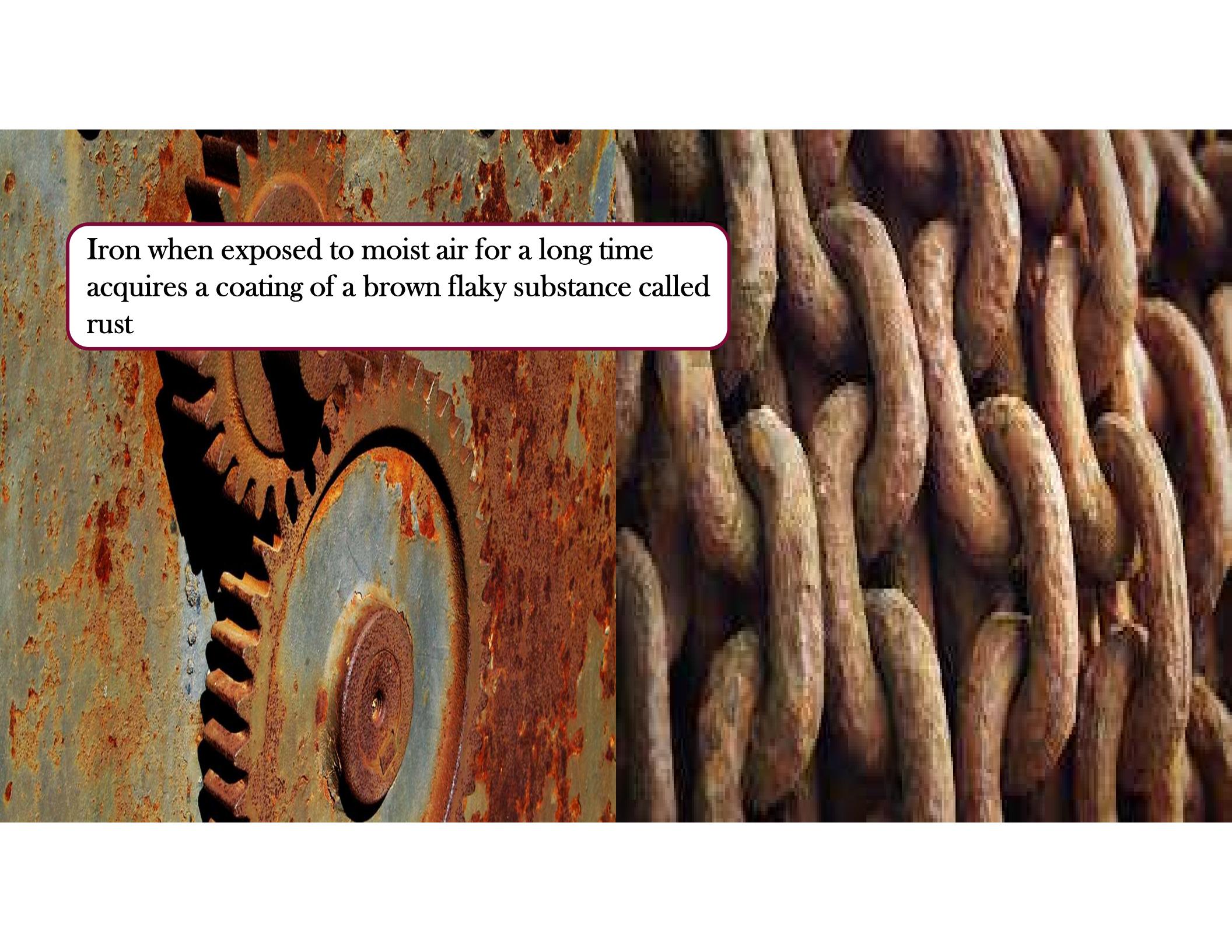
Corrosion is the degradation of materials due to reaction with its environment.

Silver articles become black after some time when exposed to air.



Copper reacts with moist carbon dioxide in the air and slowly loses its shiny brown surface and gains a green coat. This green substance is copper carbonate.

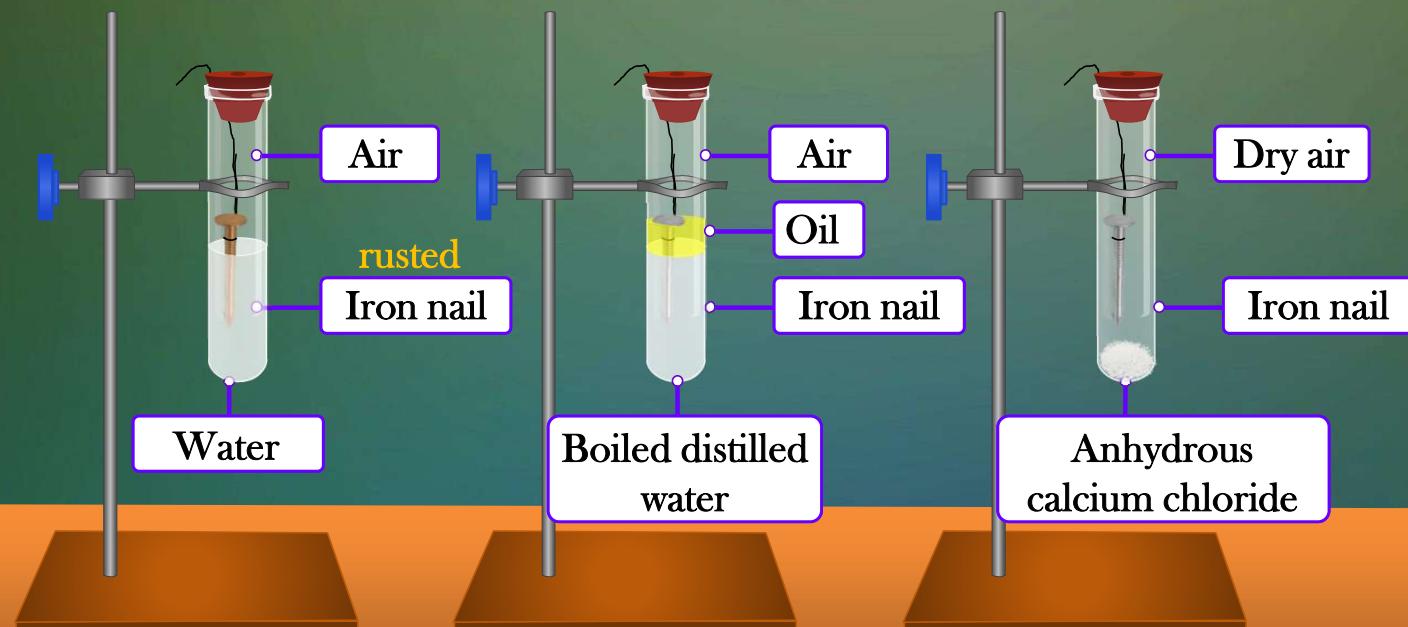




Iron when exposed to moist air for a long time acquires a coating of a brown flaky substance called rust



CONDITION UNDER WHICH IRON RUSTS



METALS AND NON-METALS

- **Methods of preventing corrosion**

GALVANISATION



The process of giving a thin coating of zinc on iron or steel





ALLOYING

A homogenous mixture of 2 or more metals or a metal and a non metal is called as an alloy.



How is it prepared ?

An alloy is prepared by melting the main metal and then dissolving the other elements in it in a specific proportion.

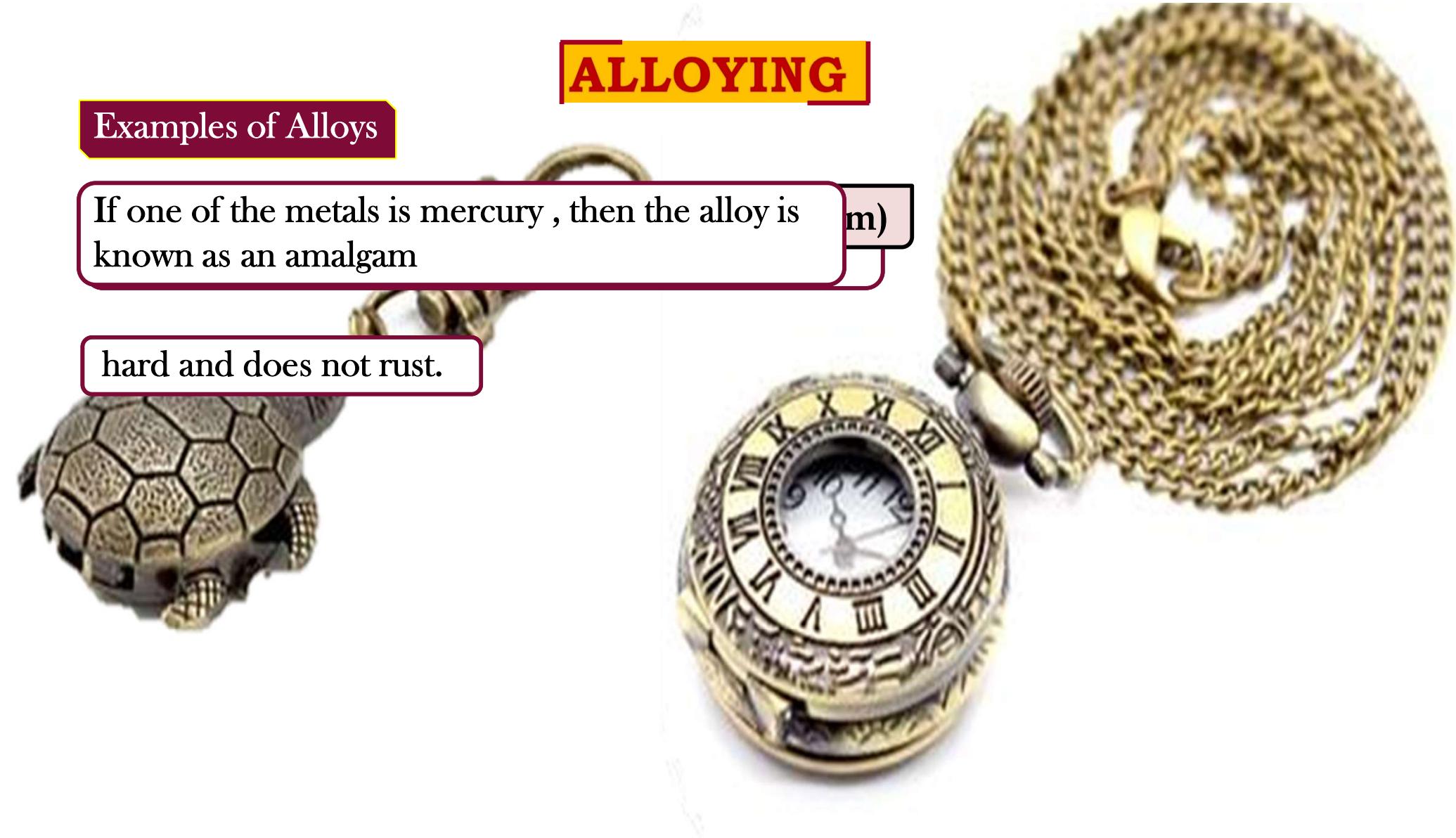


ALLOYING

Examples of Alloys

If one of the metals is mercury , then the alloy is known as an amalgam

hard and does not rust.



PROPERTIES OF ALLOYS

1. The electrical conductivity of alloys is less than that of pure metals.

E.g. Bronze and Brass, alloys of Copper are non conductor of electricity.

2. Pure gold, known as 24 carat gold, is very soft.

It is, therefore, not suitable for making jewellery. It is alloyed with either silver or copper to make it hard.

22 carat gold is used for making ornaments. It means that 22 parts of pure gold is alloyed with 2 parts of either copper or silver.

Thank You