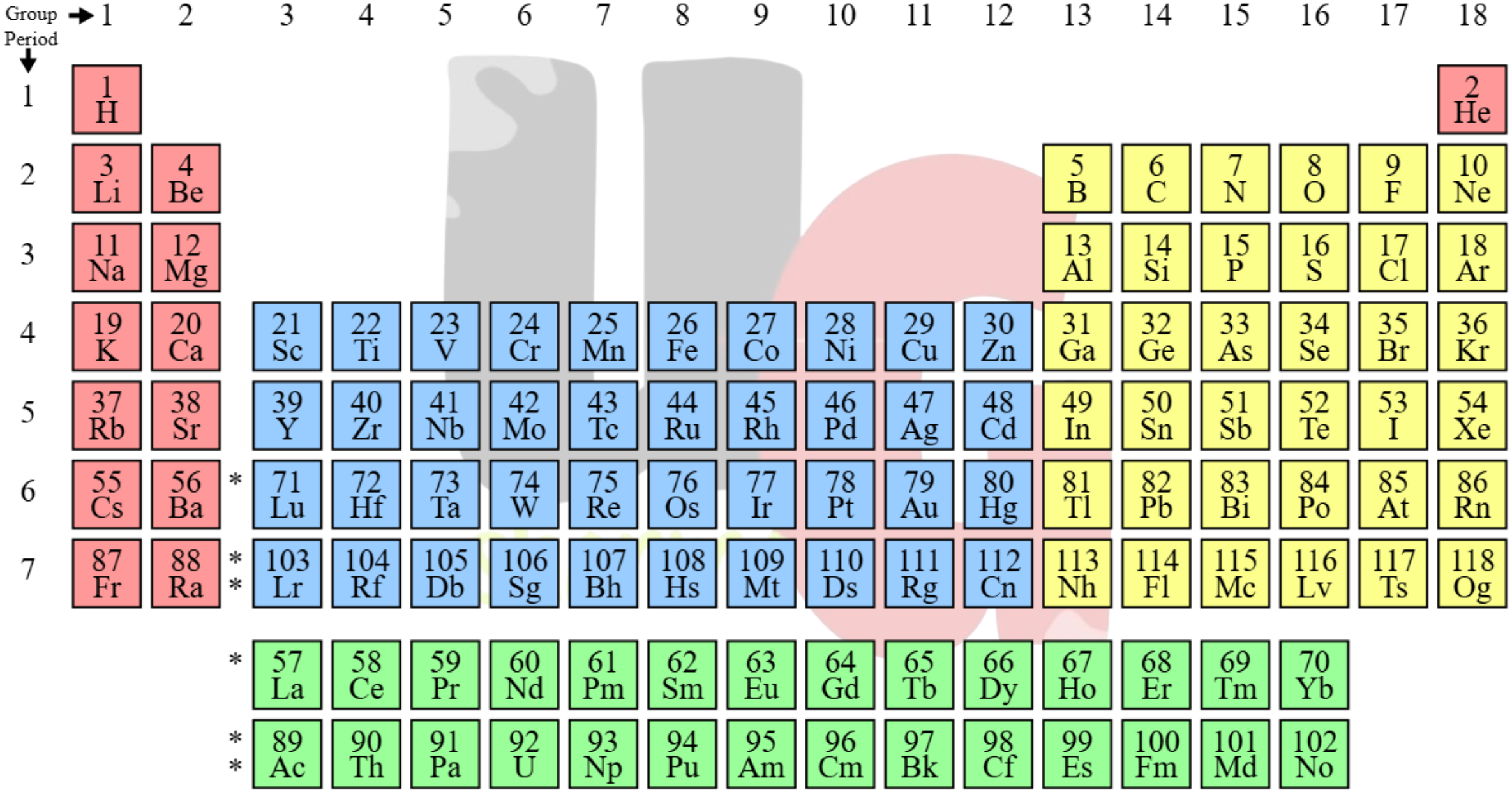
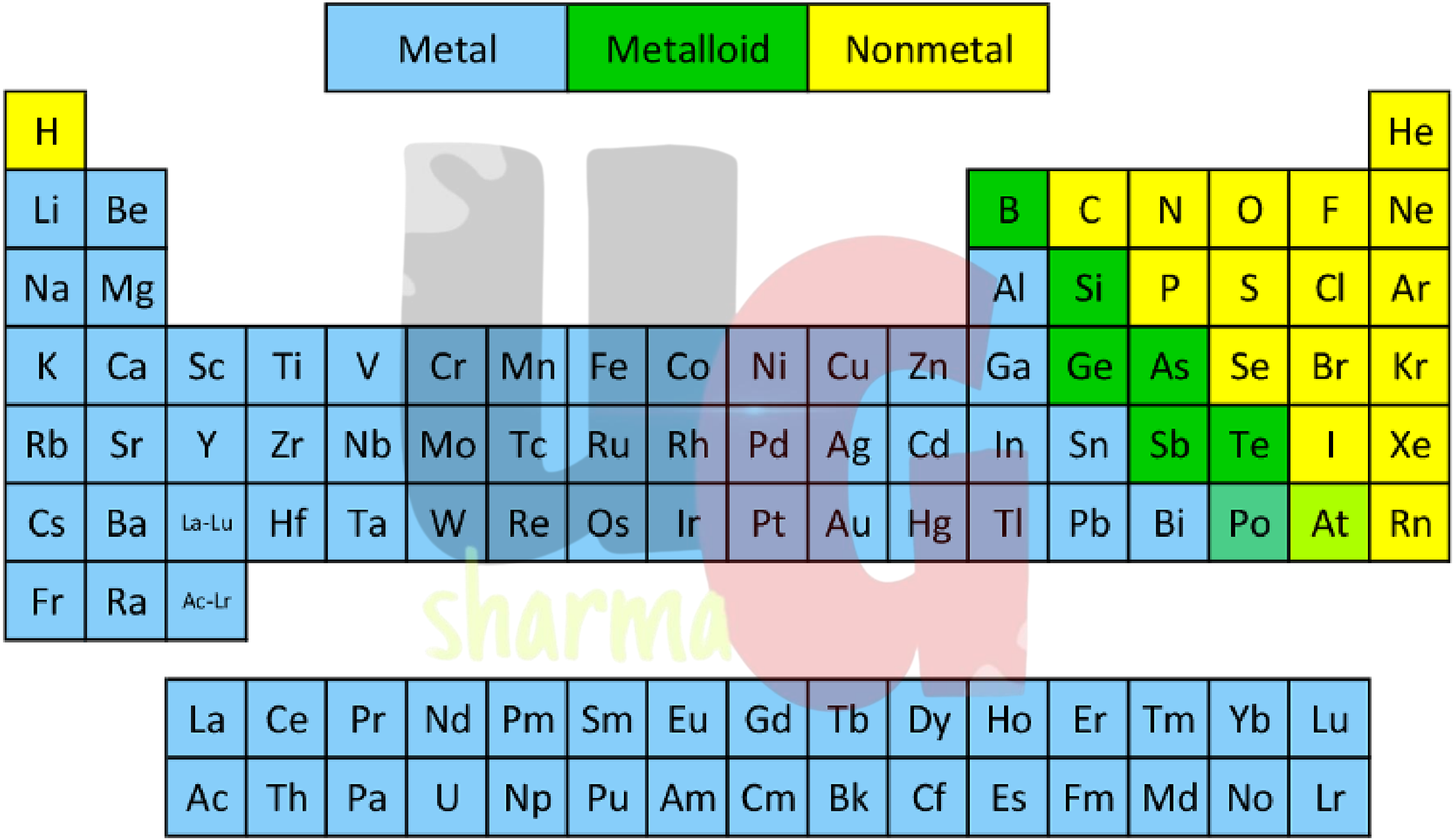
Metals and Non Metals

CHAPTER 3

Metals & Non – metals




Metal
Metalloid
Nonmetal
H
He
Li
Be
B
C
N
O
F
Ne
Na
Mg
Al
Si
P
S
Cl
Ar
K
Ca
Sc
Ti
V
Cr
Mn
Fe
Co
Ni
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Br
Kr
Rb
Sr
Y
Zr
Nb
Mo
Tc
Ru
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Sn
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Cs
Ba
La-Lu
Hf
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W
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At
Rn
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Ra
Ac-Lr
La
Ce
Pr
Nd
Pm
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
Ac
Th
Pa
U
Np
Pu
Am
Cm
Bk
Cf
Es
Fm
Md
No
Lr

All elements can be classified as metals, non – metals & metalloids according to their physical properties.

Metal

Metals are those elements that conduct heat & electricity, and are malleable & ductile.

Or,

Metals are electropositive elements (except hydrogen) because they form positive ions by losing electrons.

E.g :- Al^{+3} , Na^{+} , Mg^{+2} ,etc.

Eg :- Copper, Silver, Aluminium, Iron, etc

Non - Metal

Non – metals are those elements that do not conduct heat & electricity and are neither malleable nor ductile.

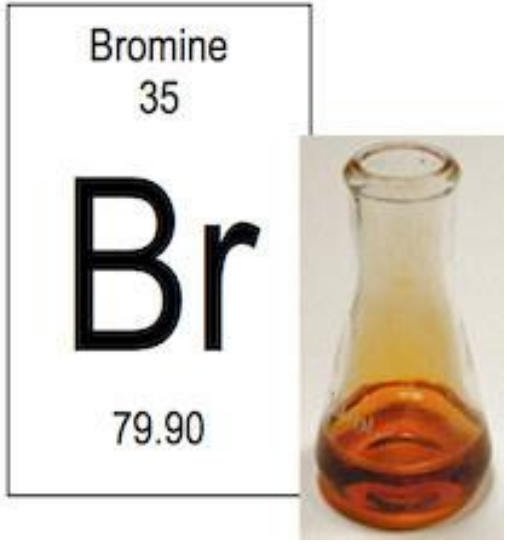
Or,

Non – metals are electronegative elements because they can form negative ions by gaining electrons.

E.g :- Cl^-, O^{-2}, N^{-3}, F^{-1}, etc.

Eg :- Hygrogen, Bromine, Iodine, Carbon, etc.

- There are 22 non metals. Out of these, all are either solid or gases except bromine (which is liquid at room temperature).



Physical properties of metals and non - metals

Property	Metals	Non-Metals
1. Lustre	Metals have shining surface.	They do not have shining surface. • Except Iodine.
2. Hardness	They are generally hard. • Except Sodium, Lithium and Potassium which are soft and can be cut with knife.	Generally soft. • Except Diamond, a form of carbon which is the hardest natural substance.
3. State	Exist as solids. • Except Mercury.	Exist as solids or gaseous. • Except Bromine.
4. Malleability	Metals can be beaten into thin sheets. • Gold and Silver are the most malleable metals.	Non-metals are non-malleable.

Physical properties of metals and non - metals

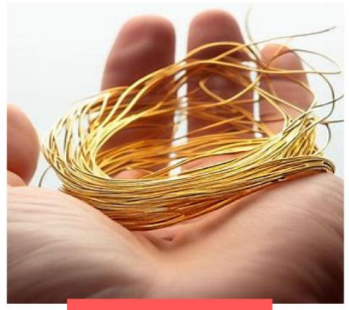
5. Ductility	Metals can be drawn into thin wires.	They are non-ductile.
6. Conductor of heat & electricity	Metals are good conductors of heat and electricity. • Silver (Ag) and Copper (Cu): Best conductors of heat. • Lead (Pb), Mercury (Hg) poor conductor of heat.	Non-metals are poor conductor of heat and electricity. • Except Graphite.
7. Density	Generally have high density and high melting point. • Except Sodium and Potassium.	Have low density and low melting point.
8. Sonorous	Metals produce a sound on striking a hard surface.	They are not sonorous.
9. Oxides	Metallic oxides are basic in nature.	Non-metallic oxides are acidic in nature.

Gold is the most ductile metal. You will be surprised to know that a wire of about 2 km length can be drawn from one gram of gold.

EXCEPTION :-

1. All metals except mercury exist as solids at room temperature.
2. Metals have high melting points but gallium and caesium have very low melting points. These two metals will melt if you keep them on your palm.
3. Iodine is a non-metal but it is lustrous.
4. Carbon is a non-metal that can exist in different forms. Each form is called an allotrope. Diamond, an allotrope of carbon, is the hardest natural substance known and has a very high melting and boiling point. Graphite, another allotrope of carbon, is a conductor of electricity.
5. Alkali metals (lithium, sodium, potassium) are so soft that they can be cut with a knife. They have low densities and low melting points

Physical Properties of Metals

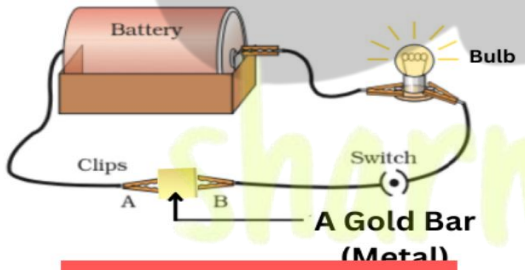


Ductility

Malleability

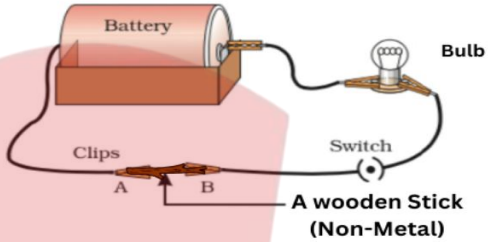
Lustre

Solidity



Good Conductor of Electricity

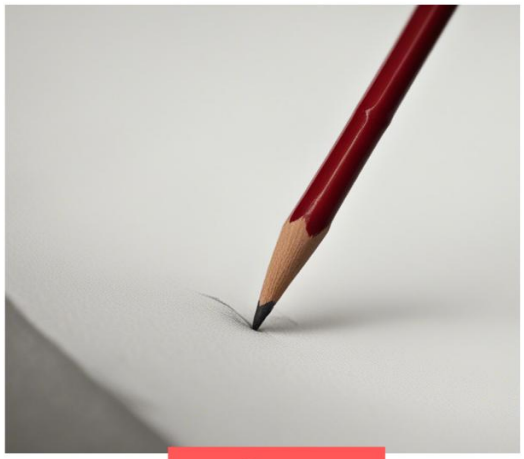
Physical Properties of Non-Metals



Bad Conductor of Electricity

Dullness

Brittleness



Softness

QUESTIONS

1. Give an example of a metal which
   (i) is a liquid at room temperature.
   (ii) can be easily cut with a knife.
   (iii) is the best conductor of heat.
   (iv) is a poor conductor of heat.
2. Explain the meanings of malleable and ductile.

Chemical properties of metals

Reaction of metals with air (oxygen)

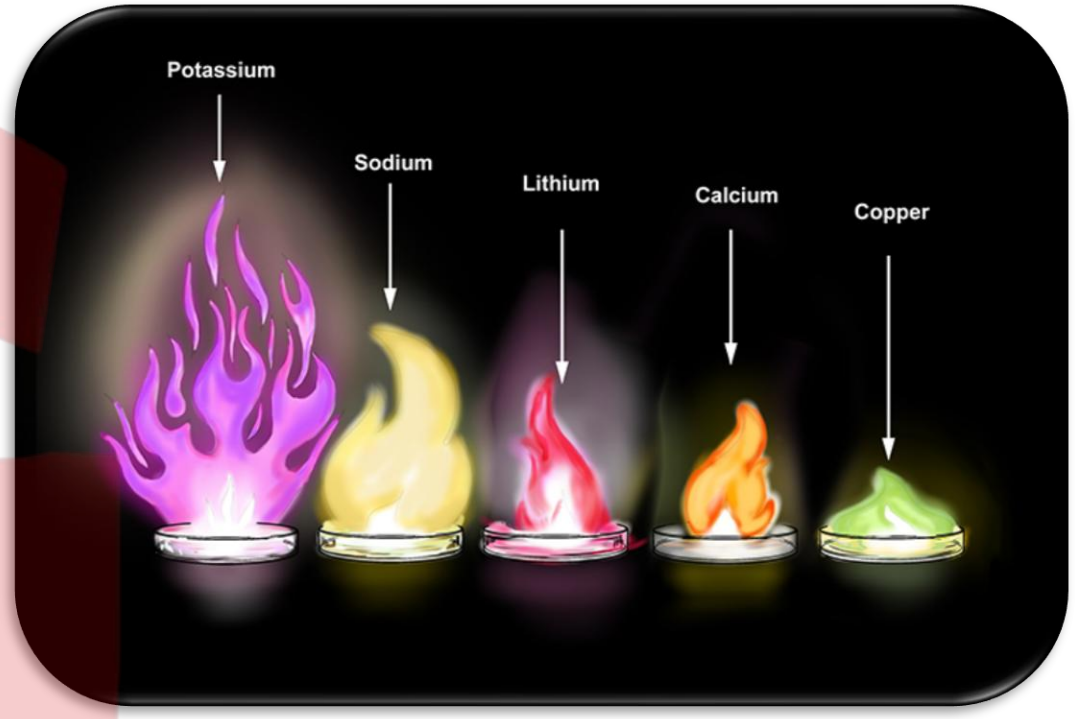
Metal + oxygen ⟶ Metal oxide

Eg :- $2Cu + O_2 \rightarrow 2CuO$

Copper(II) Oxide (Black)

$4Al + 3O_2 \rightarrow$

$2Mg + O_2 \rightarrow$



NOTE :- Metallic oxides are basic in nature . So, they react with acid to form salt and water.

$2Na + O_2 \rightarrow Na_2O$

$Na_2O + 2HCl \rightarrow NaCl + H_2O$

Similarly,

$MgO + H_2SO_4 \rightarrow$

$K_2O + H_2SO_4 \rightarrow$

$CaO + HCl \rightarrow$

$Al_2O_3 + H_2SO_4 \rightarrow$

Amphoteric Oxide

Those metal oxides which reacts with both bases as well as acids to form salt and water.

Eg :- Zinc oxide, Aluminium oxide, etc

Zinc oxide

Reaction of Zinc with Oxygen

$$2Zn\,(s) + O_2\,(g) \longrightarrow 2ZnO\,(s)$$

Zinc + Oxygen → Zinc Oxide (Amphoteric Oxide)

Zinc Oxide Acting as a Basic Oxide

$$ZnO\,(s) + 2HCl\,(aq) \longrightarrow ZnCl_2\,(aq) + H_2O\,(l)$$

Zinc Oxide + Hydrochloric Acid (acid) → Zinc Chloride (salt) + Water

Zinc Oxide Acting as an Acidic Oxide

$$ZnO\,(s) + 2NaOH\,(aq) \longrightarrow Na_2ZnO_2(aq) + H_2O\,(l)$$

Zinc Oxide + Sodium Hydroxide (Base) → Sodium Zincate (salt) + Water

Reaction of Aluminium with Oxygen

$$4Al + 3O_2 \longrightarrow Al_2O_3$$

Aluminium + Oxygen → Aluminium Oxide

Aluminium Oxide Acting as a Basic Oxide

$$Al_2O_{3(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_2O_{(l)}$$

Aluminium Oxide + Hydrochloric Acid → Aluminium Chloride + Water

Aluminium Oxide Acting as a Acidic Oxide

$$Al_2O_{3(s)} + 2NaOH_{(aq)} \longrightarrow 2NaAlO_{2(aq)} + H_2O_{(l)}$$

Aluminium Oxide + Sodium Hydroxide → Sodium aluminate + Water

Most metal oxides are insoluble in water but some of these dissolve in water to form alkalis. Sodium oxide and potassium oxide dissolve in water to produce alkalis as follows –

$Na_2O + H_2O \rightarrow 2NaOH$

$K_2O + H_2O \rightarrow 2KOH$

- Sodium (Na) and potassium (K) react so vigorously that they catch fire if kept in open so they are kept immersed in kerosene.
- Surfaces of Mg, Al, Zn, Pb are covered with a thin layer of oxide which prevent them from further oxidation.
- Fe does not burn on heating but iron fillings burn vigorously.
- Cu does not burn but is coated with black copper oxide.
- Gold (Au) and silver (Ag) does not react with oxygen.

Reaction of metals with Water

Metal + Water → Metal oxide + Hydrogen
Metal oxide + Water → Metal hydroxide

METAL + WATER ⟶ METAL HYDROXIDE + HYDROGEN

$$Ba + 2H_2O \longrightarrow Ba(OH)_2 + H_2$$

Potassium and sodium react violently with water (even cold water) violently.

$$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g) + \text{heat energy}$$
$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g) + \text{heat energy}$$

In case of sodium and potassium, the reaction is so violent and exothermic that the evolved hydrogen immediately catches fire.

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

The reaction of calcium with water is less violent. The heat evolved is not sufficient for the hydrogen to catch fire.

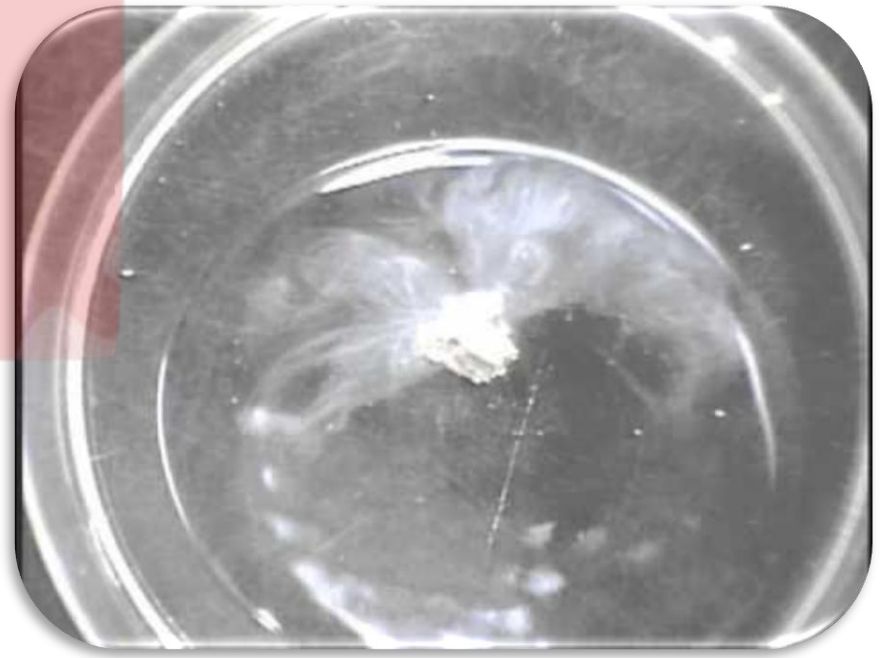
Magnesium reacts with hot water.

$$Mg + H_2O \rightarrow Mg(OH)_2 + H_2$$

Calcium & magnesium start floating due to the bubbles of hydrogen gas sticking to its surface.

Metals like aluminium, iron and zinc do not react either with cold or hot water. But they react with steam to form the metal oxide and hydrogen.

$$2Al(s) + 3H_2O(g) \rightarrow Al_2O_3(s) + 3H_2(g)$$
$$3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$$



Metals such as lead, copper, silver and gold do not react with water at all.

Reaction of Magnesium with Water and Steam

$$Mg\,(s) + 2H_2O\,(l) \longrightarrow Mg(OH)_2\,(aq) + H_2\,(g)$$

Magnesium **Water** **Magnesium Hydroxide** **Hydrogen**

$$Mg\,(s) + H_2O\,(g) \longrightarrow MgO\,(s) + H_2\,(g)$$

Magnesium **Steam** **Magnesium Oxide** **Hydrogen**

Reaction of Metal with Water

Cold Water	Hot Water	Steam	Do not react
Produces Metal Hydroxide + Hydrogen Gas	Produces Metal Hydroxide + Hydrogen Gas	Produces Metal oxide + Hydrogen Gas	No reaction
Example • Sodium (Violently) • Potassium (Violently) • Calcium (less Violently)	**Example** • Magnesium	**Example** • Aluminium • Iron	**Example** • Lead • Copper • Silver • Gold

Copy and complete the following reactions:

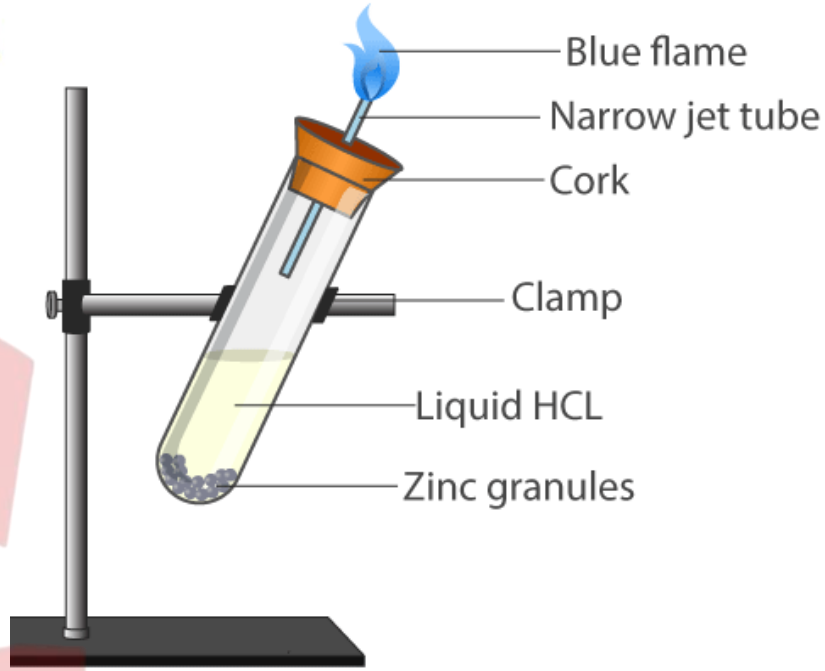
- Magnesium + oxygen →
- Copper + oxygen →
- Calcium + oxygen →
- Iron + oxygen →

Copy and complete the following reactions:

- Sodium + water →
- Potassium + water →
- Calcium + water →
- Iron + steam →

Reaction of metals with acid and base

ACID/ BASE + METALS → SALT + HYDROGEN GAS



Example 1

$$Zn(s) + H_2SO_4\,(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

Example 2

$$2NaOH\,(aq) + Zn\,(s) \rightarrow Na_2ZnO_2\,(aq) + H_2\,(g)$$

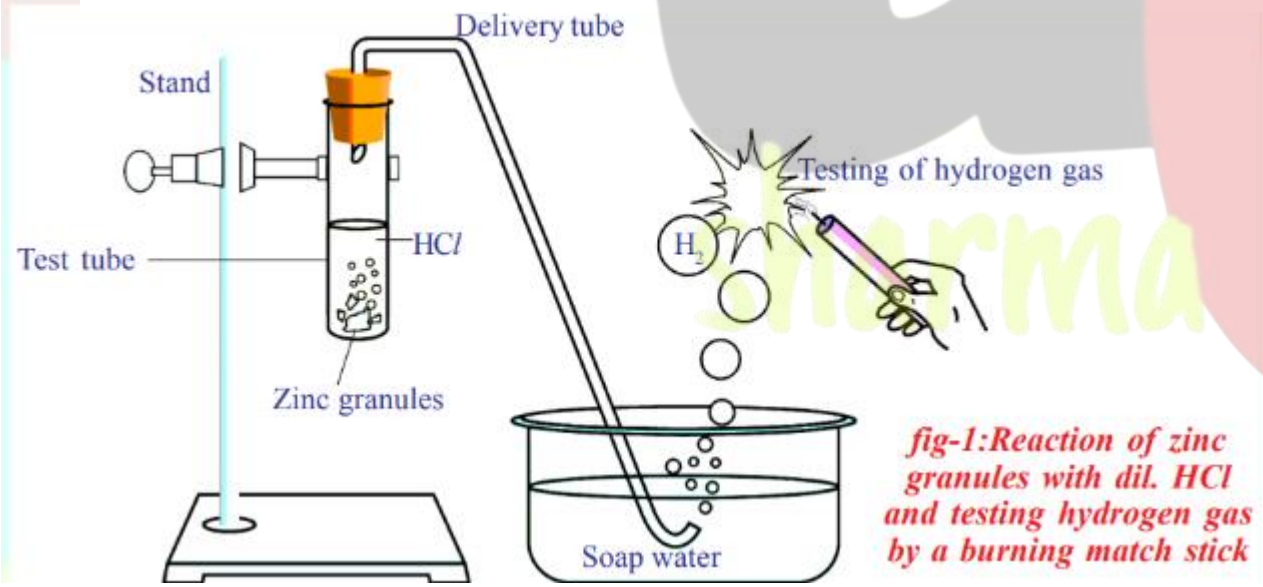


fig-1:Reaction of zinc granules with dil. HCl and testing hydrogen gas by a burning match stick

Copy and complete the following reactions:

- Calcium + hydrochloric acid →
- Zinc + hydrochloric acid →
- Iron + hydrochloric acid →
- Lithium + sulphuric acid →

- Hydrogen gas is not evolved when a metal reacts with nitric acid because HNO_3 is a strong oxidising agent. It oxidises the H_2 produced to water and itself gets reduced to any of the nitrogen oxides (N_2O, NO, NO_2).
- Magnesium (Mg) and manganese (Mn) react with very dilute HNO_3 to evolve H_2 gas.

Aqua regia, (Latin for 'royal water') is a freshly prepared mixture of concentrated hydrochloric acid and concentrated nitric acid in the ratio of 3:1. It can dissolve gold, even though neither of these acids can do so alone. *Aqua regia* is a highly corrosive, fuming liquid. It is one of the few reagents that is able to dissolve gold and platinum.

Reaction of metals with other metal salts

Metal A + Salt solution of metal B → Salt solution of metal A + Metal B

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

More reactive metal displace less reactive metal.

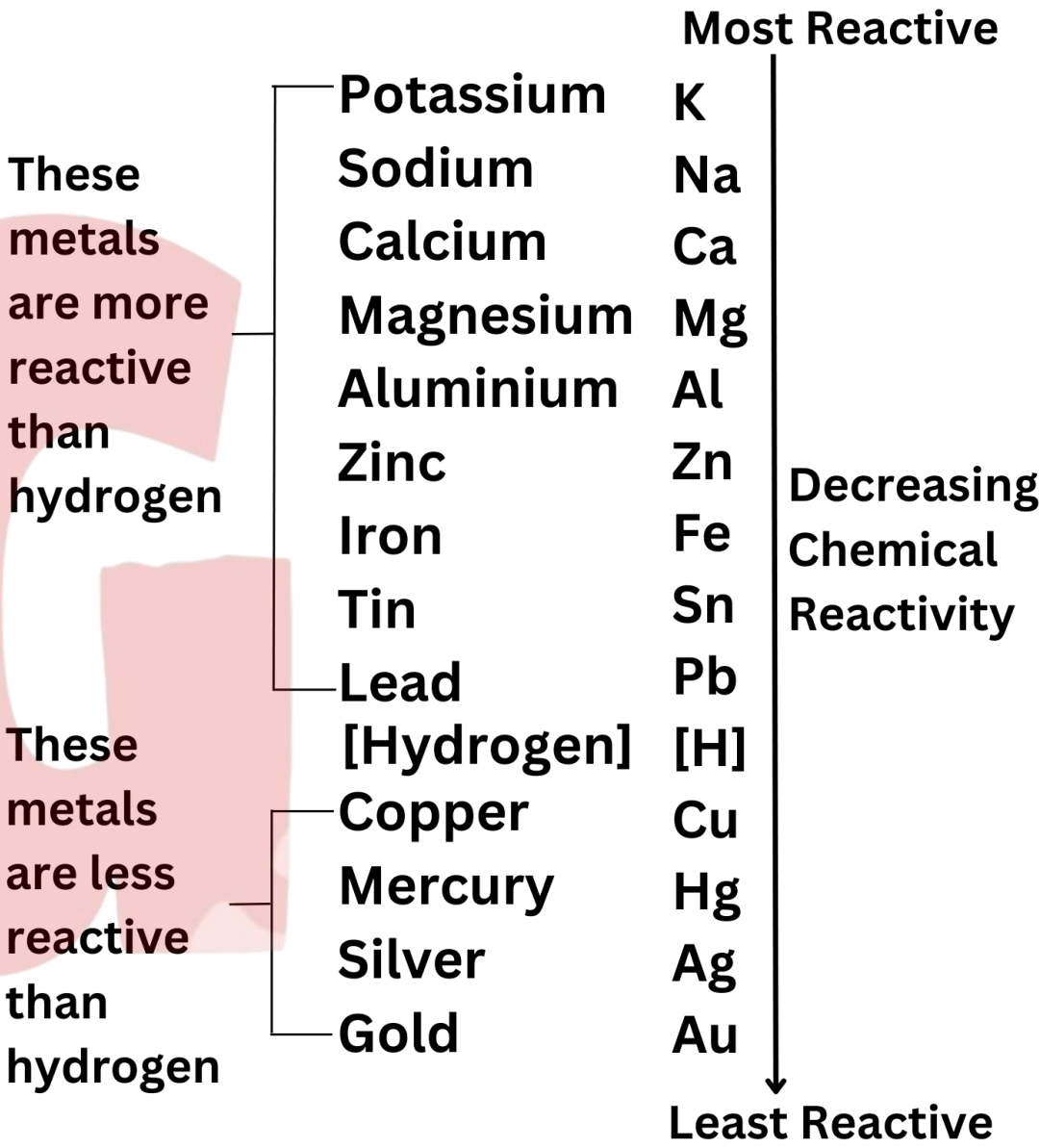
Complete the following reactions:

- Lithium + water →
- Lithium + hydrochloric acid →
- Silver + oxygen →
- Magnesium + sulphuric acid →
- Potassium + oxygen →
- Aluminium + oxygen →
- Manganese + water →
- Sodium + sulphuric acid →
- Lithium + oxygen →
- Nickel + hydrochloric acid →

Reactivity series

A reactivity series refers to the arrangement of metals in the order of their reactivity, from the highest to the lowest.

K	Potassium	Most reactive
Na	Sodium	
Ca	Calcium	
Mg	Magnesium	
Al	Aluminium	
Zn	Zinc	Reactivity decreases
Fe	Iron	
Pb	Lead	
[H]	[Hydrogen]	
Cu	Copper	
Hg	Mercury	
Ag	Silver	
Au	Gold	Least reactive



How to remember the Reactivity Series?

Please	Potassium
Stop	Sodium
Calling	Calcium
Me	Magnesium
A	Aluminium
Careless	(Carbon)
Zebra	Zinc
Instead	Iron
Try	Tin
Learning	Lead
How	(Hydrogen)
Copper	Copper
Saves	Silver
Gold	Gold

Most reactive

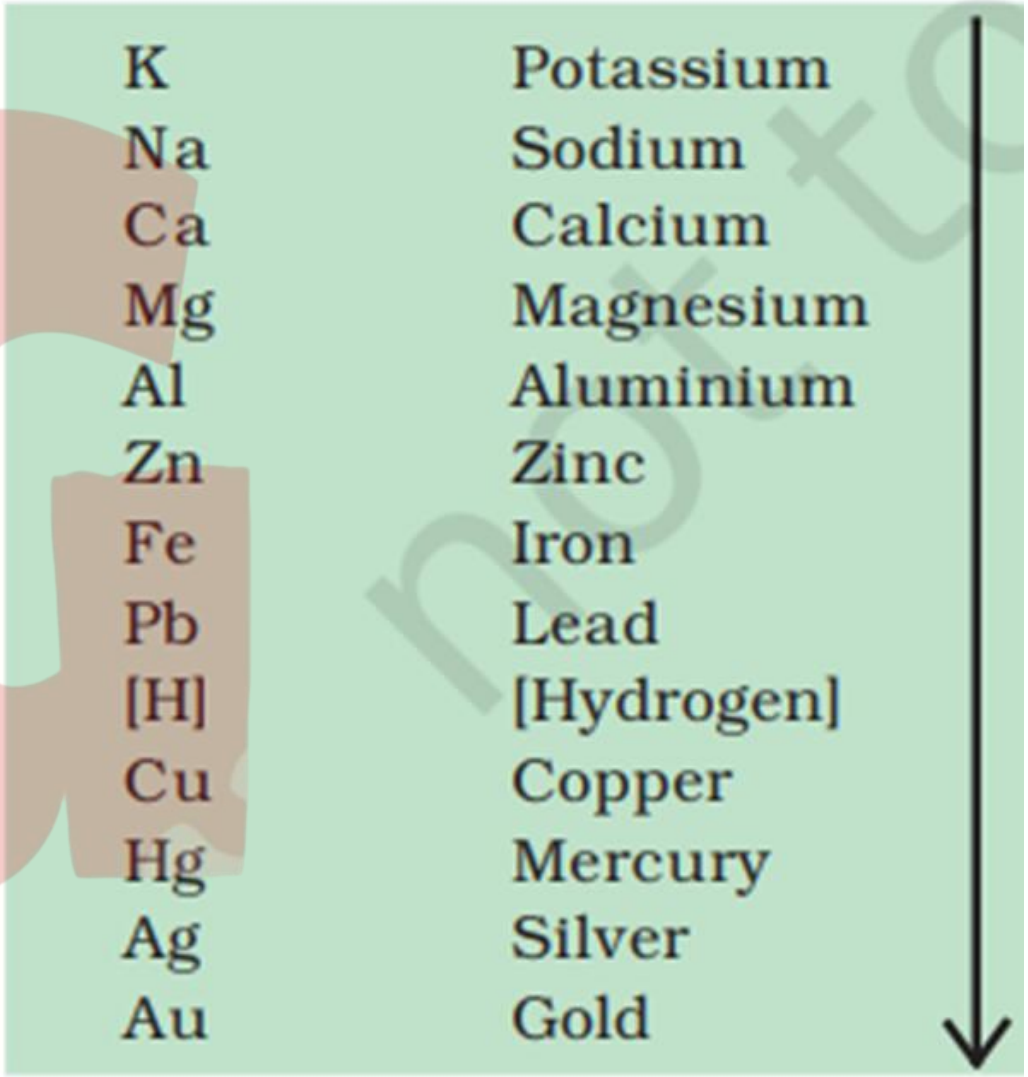
Least reactive

1. What happens when you place a Copper strip in a jar containing the $MgSO_4$ solution?
2. What happens when a Cu coin is dropped in water?

Answer: Since Copper lies below magnesium in the reactivity series, it cannot replace magnesium from its salt solution. Hence, no change is observed when a Cu strip is placed in the $MgSO_4$ solution.

Answer: Cu lies beneath H_2 in the reactivity series and so, Cu cannot displace H_2 from H_2O. Hence, no reaction takes place between Cu and water and the copper coin stays as it is.

$Cu + H_2O \rightarrow$ No reaction



QUESTIONS

1. Why is sodium kept immersed in kerosene oil?
2. Write equations for the reactions of
   (i) iron with steam
   (ii) calcium and potassium with water
3. Samples of four metals A, B, C and D were taken and added to the following solution one by one. The results obtained have been tabulated as follows.

Metal	Iron(II) sulphate	Copper(II) sulphate	Zinc sulphate	Silver nitrate
A	No reaction	Displacement		
B	Displacement		No reaction	
C	No reaction	No reaction	No reaction	Displacement
D	No reaction	No reaction	No reaction	No reaction

Use the Table above to answer the following questions about metals A, B, C and D.

(i) Which is the most reactive metal?

(ii) What would you observe if B is added to a solution of Copper(II) sulphate?

(iii) Arrange the metals A, B, C and D in the order of decreasing reactivity.

4. Which gas is produced when dilute hydrochloric acid is added to a reactive metal? Write the chemical reaction when iron reacts with dilute H_2SO_4.
5. What would you observe when zinc is added to a solution of iron(II) sulphate? Write the chemical reaction that takes place.

Reaction of metal & Non - metal

Table 3.3 Electronic configurations of some elements

Type of element	Element	Atomic number	Number of electrons in shells			
			K	L	M	N
Noble gases	Helium (He)	2	2			
	Neon (Ne)	10	2	8		
	Argon (Ar)	18	2	8	8	
Metals	Sodium (Na)	11	2	8	1	
	Magnesium (Mg)	12	2	8	2	
	Aluminium (Al)	13	2	8	3	
	Potassium (K)	19	2	8	8	1
	Calcium (Ca)	20	2	8	8	2
Non-metals	Nitrogen (N)	7	2	5		
	Oxygen (O)	8	2	6		
	Fluorine (F)	9	2	7		
	Phosphorus (P)	15	2	8	5	
	Sulphur (S)	16	2	8	6	
	Chlorine (Cl)	17	2	8	7	

Reaction b/w metal and non metal occur due to complete transfer of charge (electrons) and form ionic bond.

- Reactivity of elements is the tendency to attain a completely filled valence shell.
- Atoms of the metals lose electrons from their valence shell to form cation. Atom of the non-metals gain electrons in the valence shell to form anion.

E.g.: Formation of NaCl

$Na \rightarrow Na^+ + e^-$

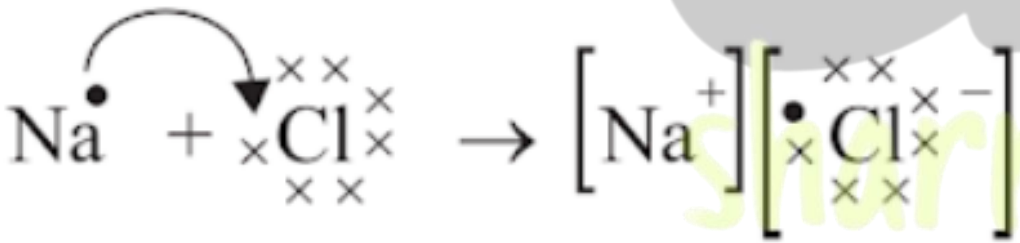
2, 8, 1 2, 8

Sodium cation

$Cl + e^- \rightarrow Cl^-$

2, 8, 7 2, 8, 8

Chloride anion



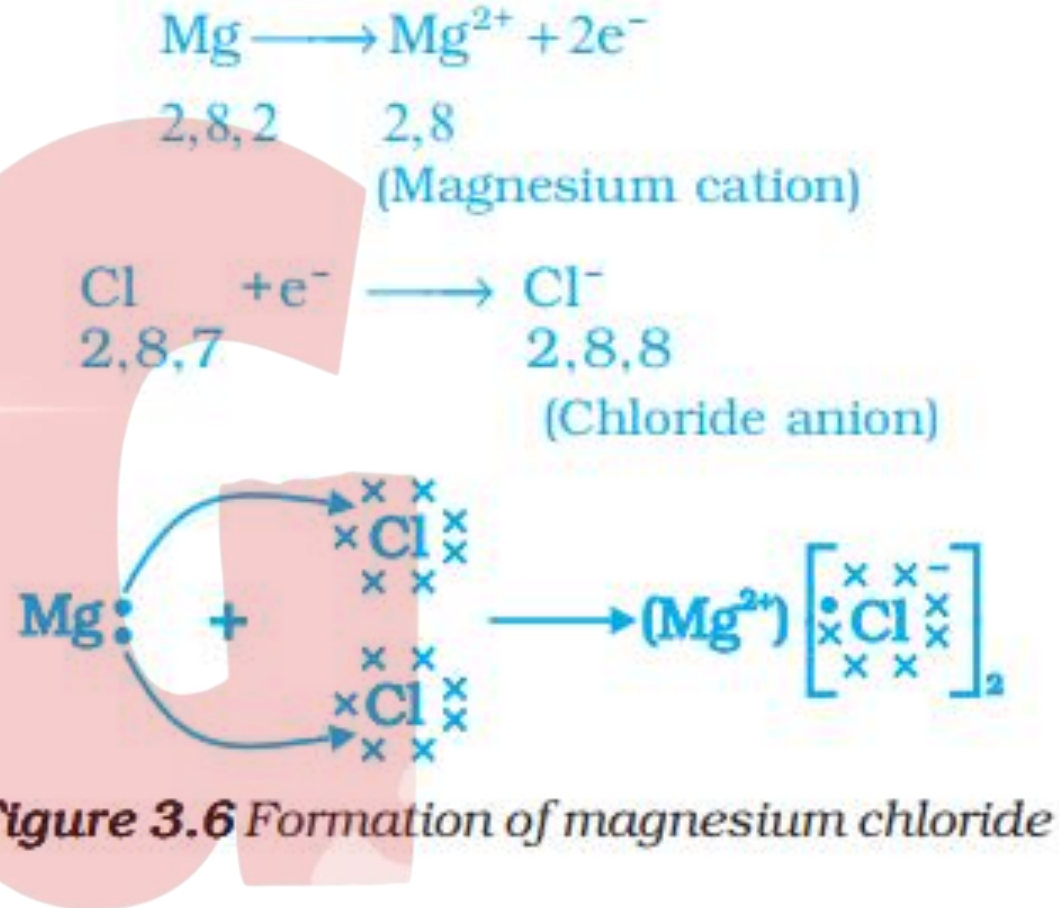


Figure 3.6 *Formation of magnesium chloride*

Ionic compound

The compounds formed by the transfer of electrons from a metal to a non-metal are called ionic compounds or electrovalent compounds.

Properties of ionic compounds :-

1. **Physical nature**: They are solid and hard, generally brittle. Because they have strong force of attraction.
2. **Melting and Boiling Point**: They have high melting and boiling point due to strong inter ionic force of attraction.
3. **Solubility** : Generally soluble in water and insoluble in solvents such as kerosene, petrol etc.
4. **Conduction of electricity** : Ionic compounds conduct electricity in molten and solution form but not in solid state.

Table 3.4 Melting and boiling points of some ionic compounds

Ionic compound	Melting point (K)	Boiling point (K)
NaCl	1074	1686
LiCl	887	1600
$CaCl_2$	1045	1900
CaO	2850	3120
$MgCl_2$	981	1685

QUESTIONS

1. (i) Write the electron-dot structures for sodium, oxygen and magnesium.
   (ii) Show the formation of Na_2O and MgO by the transfer of electrons.
   (iii) What are the ions present in these compounds?
2. Why do ionic compounds have high melting points?

Occurrence of metals

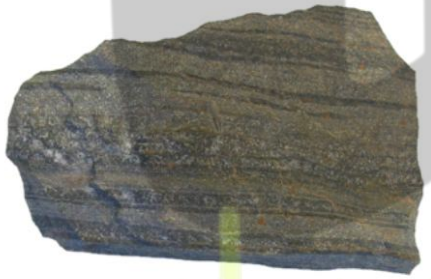
Minerals: The elements or compounds which occur naturally in the earth's crust are called minerals.

Ores: Minerals that contain very high percentage of particular metal and the metal can be profitably extracted from it, such minerals are called ores.

MINERALS

All minerals are not ores

ORES



All ores are minerals

Schist

Hübnerite

pseudomorph

uvarovite

Topaz

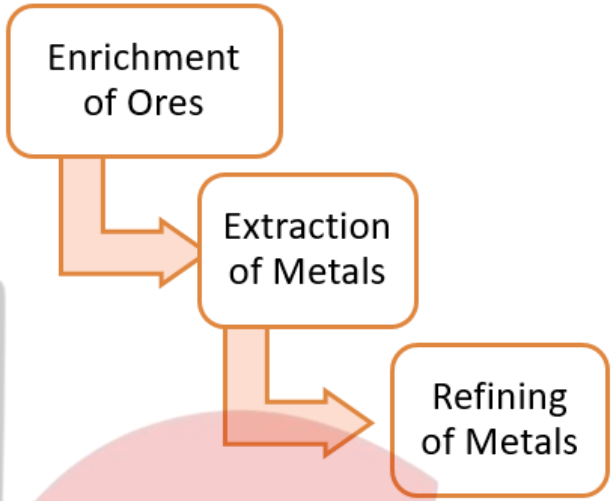
Pyrite

Grossular

Galena

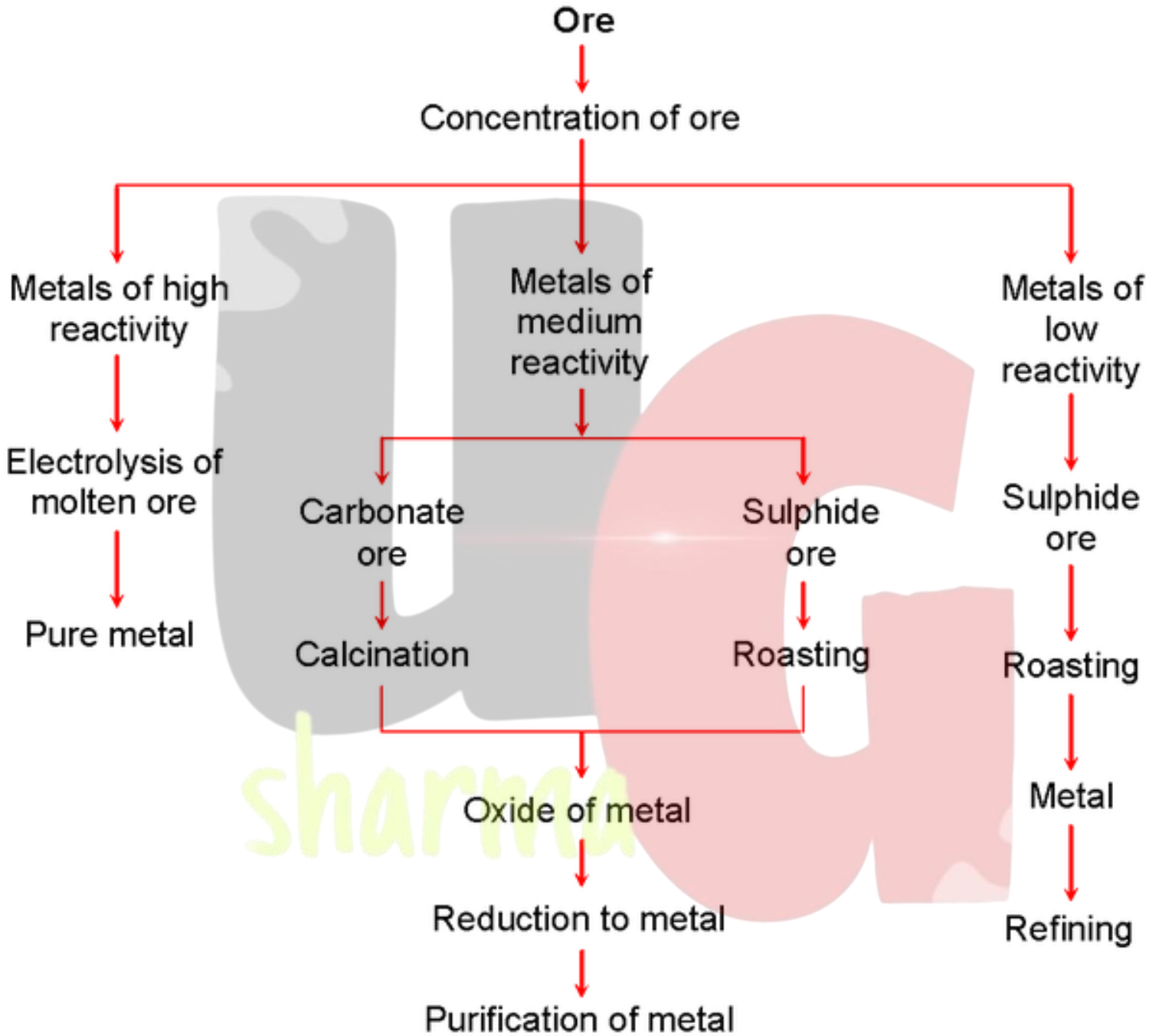
- Metals are found in the Earth's crust and in seawater (some soluble salts such as sodium chloride, magnesium chloride, etc).

Extraction of Metals from Ores



Step 1. Enrichment of ores.
Step 2. Extraction of metals.
Step 3. Refining of metals.

- The metals at the bottom of the reactivity series are the least reactive. They are often found in a free state. For example, gold, silver, platinum and copper are found in the free state. Copper and silver are also found in the combined state as their sulphide or oxide ores.
- The metals at the top of the activity series (K, Na, Ca, Mg and Al) are so reactive that they are never found in nature as free elements.
- The metals in the middle of the reactivity series (Zn, Fe, Pb, etc.) are moderately reactive. They are found in the earth's crust mainly as oxides, sulphides or carbonates.

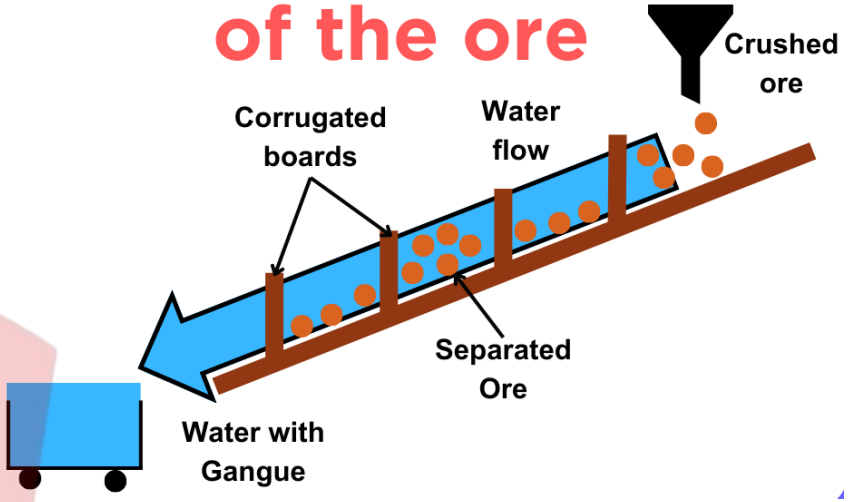

Ore
Concentration of ore
Metals of high reactivity
Metals of medium reactivity
Metals of low reactivity
Electrolysis of molten ore
Pure metal
Carbonate ore
Calcination
Sulphide ore
Roasting
Sulphide ore
Roasting
Metal
Refining
Oxide of metal
Reduction to metal
Purification of metal

Enrichment of ores

Enrichment of ores, also called concentration, is the process of removing impurities (gangue) from an ore to increase the concentration of the desired metal

Gangue :- Ores mined from the earth are usually contaminated with large amounts of impurities such as soil, sand, etc., called gangue.

Magnetic separation



Extracting Metals Low in the Reactivity Series

- Metals low in the reactivity series are very unreactive.
- The oxides of these metals can be reduced to metals by heating alone.
- For example, cinnabar (HgS) is an ore of mercury. When it is heated in air, it is first converted into mercuric oxide (HgO). Mercuric oxide is then reduced to mercury on further heating.

$$2HgS(s) + 3O_2(g) \xrightarrow{Heat} 2HgO(s) + 2SO_2(g)$$

$$2HgO(s) \xrightarrow{Heat} 2Hg(l) + O_2(g)$$

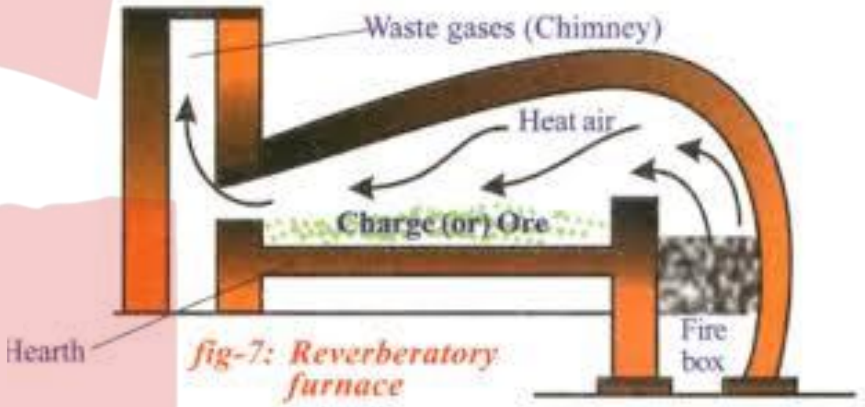


fig-7: Reverberatory furnace

Similarly,

$$2Cu_2S + 3O_2(g) \xrightarrow{Heat} 2Cu_2O(s) + 2SO_2(g)$$

$$2Cu_2O + Cu_2S \xrightarrow{Heat} 6Cu(s) + SO_2(g)$$

Extracting Metals in the middle of the Reactivity Series

- The metals in the middle of the reactivity series such as iron, zinc, lead, copper, are moderately reactive.
- These are usually present as sulphides or carbonates in nature.
- These ores can be converted into oxide by using either **roasting** or **calcination.**

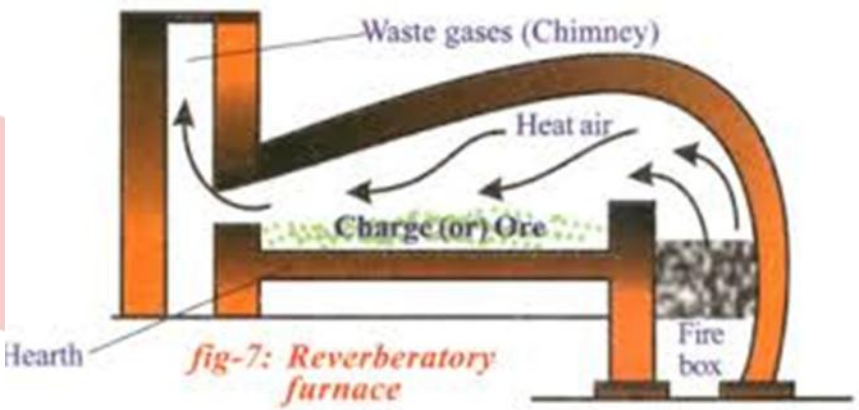


fig-7: Reverberatory furnace

Roasting : The sulphide ores are converted into oxides by heating strongly in the presence of excess air. This process is called roasting.

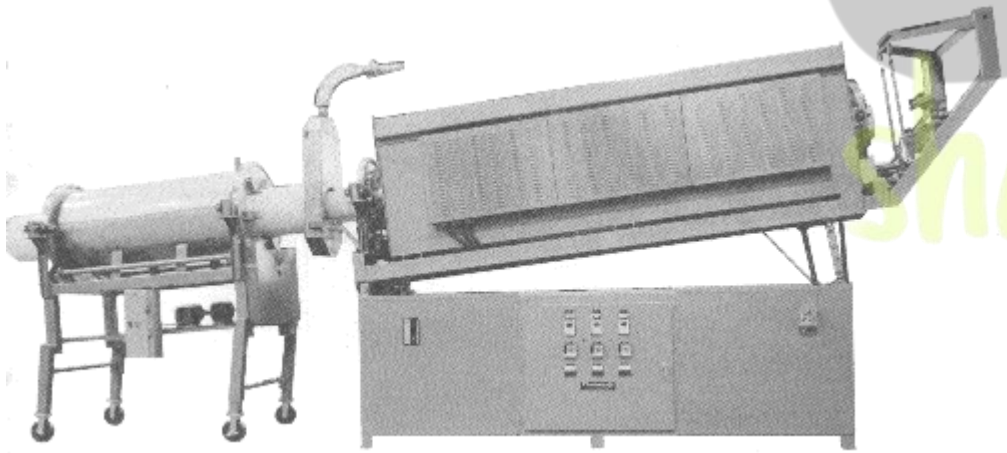
$$2ZnS(s) + 3O_2(g) \xrightarrow{Heat} 2ZnO(s) + 2SO_2(g)$$

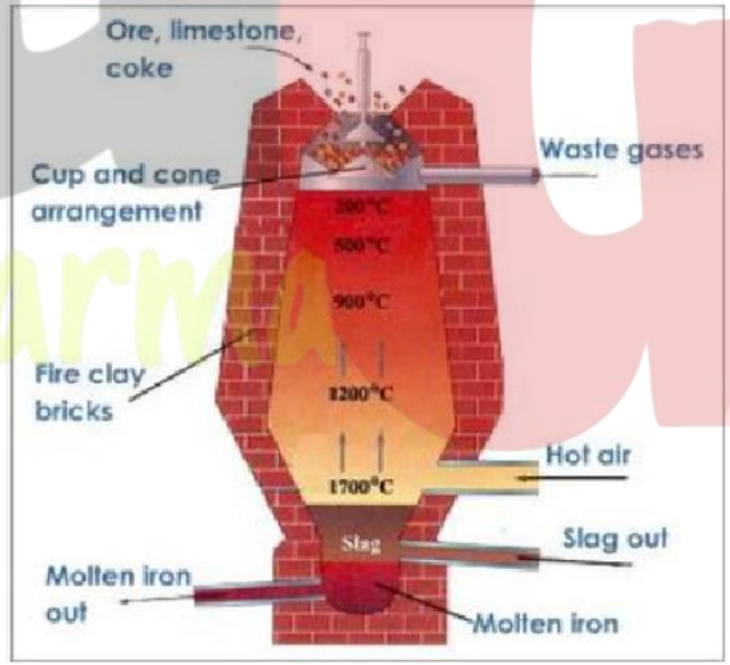
Calcination : The carbonate ores are changed into oxides by heating strongly in limited air. This process is called calcination.

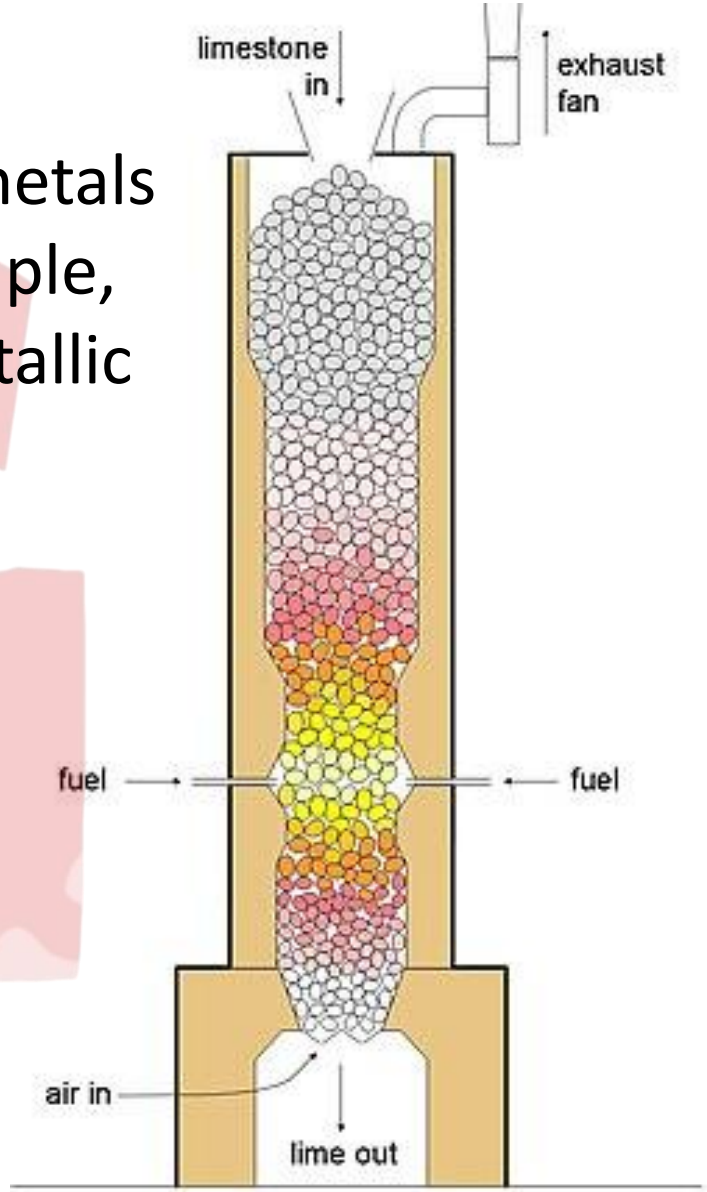
$$ZnCO_3(s) \xrightarrow{Heat} ZnO(s) + CO_2(g)$$

The metal oxides are then reduced to the corresponding metals by using suitable reducing agents such as carbon. For example, when zinc oxide is heated with carbon, it is reduced to metallic zinc.

$$ZnO(s) + C(s) \rightarrow Zn(s) + CO(g)$$







- The highly reactive metals such as sodium, calcium, aluminium, etc., are used as reducing agents because they can displace metals of lower reactivity from their compounds.
- For example, when manganese dioxide is heated with aluminium powder, the following reaction takes place –

$$3MnO_2(s) + 4Al(s) \rightarrow 3Mn(l) + 2Al_2O_3(s) + Heat$$

- These displacement reactions are highly exothermic.
- The amount of heat evolved is so large that the metals are produced in the molten state.

- The reaction of iron(III) oxide (Fe_2O_3) with aluminium is used to join railway tracks or cracked machine parts. This reaction is known as the thermit reaction.

$$Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(l) + Al_2O_3(s) + Heat$$




What is thermit reaction ?

A thermite reaction is a highly exothermic (heat-releasing) chemical reaction between a metal oxide and a more reactive metal

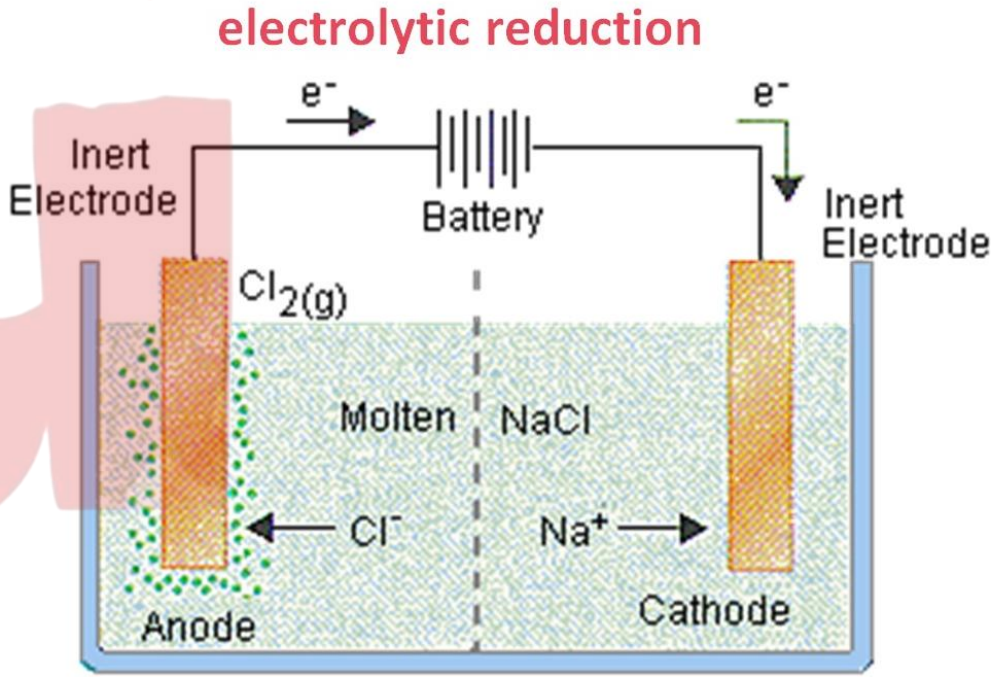
Extracting Metals in the top of the Reactivity Series

- These metals are obtained by electrolytic reduction.
- For example, sodium, magnesium and calcium are obtained by the electrolysis of their molten chlorides.
- The metals are deposited at the cathode (the negatively charged electrode), whereas, chlorine is liberated at the anode (the positively charged electrode). The reactions are –

At cathode $Na^+ + e^- \rightarrow Na$

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

Similarly, aluminium is obtained by the electrolytic reduction of aluminium oxide.

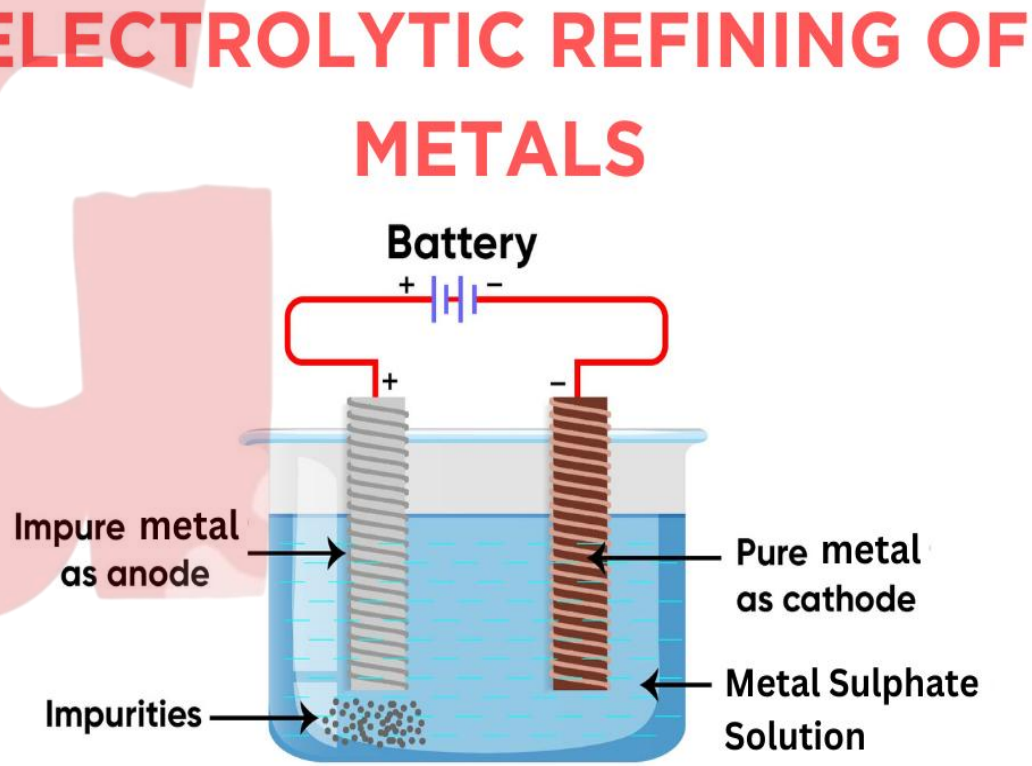


Refining of Metals

- The metals produced by various reduction processes 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.

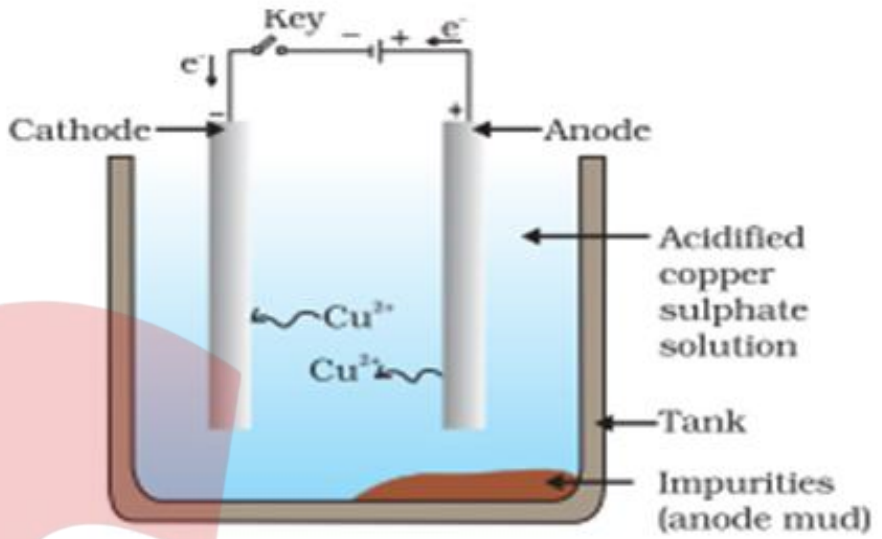
Electrolytic Refining:

- In this process, the impure metal is made the anode and a thin strip of pure metal is made the cathode. A solution of the metal salt is used as an electrolyte.
- On passing the current through the electrolyte, the pure metal from the anode dissolves into the electrolyte.
- An equivalent amount of pure metal from the electrolyte is deposited on the cathode.
- The insoluble impurities settle down at the bottom of the anode and is called anode mud.



Electrolytic refining of copper

1. **Anode** : Impure copper
2. **Cathode** : Strip of pure copper
3. **Electrolyte** : Solution of acidified copper sulphate



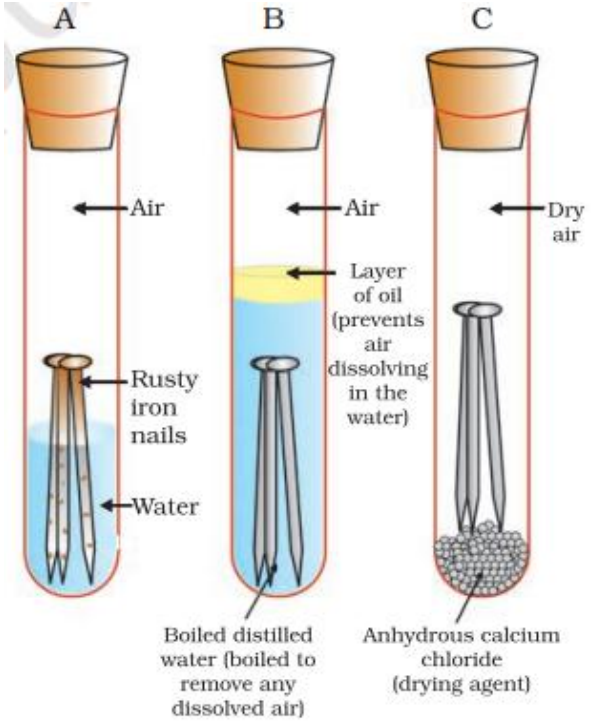
- On passing electric current, pure copper is deposited on the cathode.
- During the process, copper atoms from the anode dissolve into the solution as Cu^{+2} ions, which then migrate to the cathode and deposit as pure copper, while less reactive impurities fall to the bottom as anode mud.

QUESTIONS

1. Define the following terms.
   (i) Mineral (ii) Ore (iii) Gangue
2. Name two metals which are found in nature in the free state.
3. What chemical process is used for obtaining a metal from its oxide?

CORROSION

The surface of some metals get corroded when they are exposed to moist air for a long period of time. This is called corrosion.



Examples:

I. Silver becomes black when exposed to air as it reacts with air to form a coating of silver sulphide.

II. Copper reacts with moist carbon dioxide in the air and gains a green coat of copper carbonate.

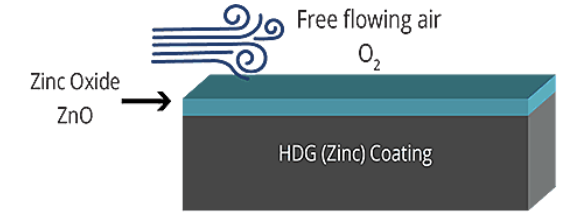
III. Iron when exposed to moist air acquires a coating of a brown flaky substance called rust.

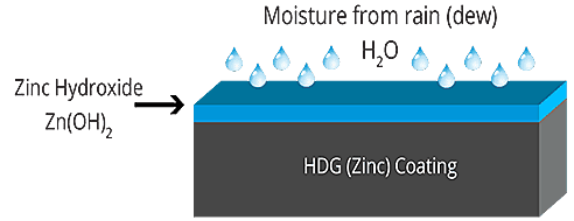
Prevention of Corrosion

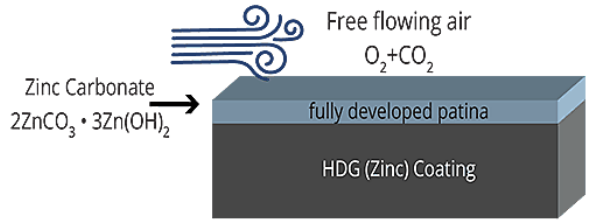
- The rusting of iron can be prevented by painting, oiling, greasing, galvanizing, chrome plating, anodizing or making alloys.

Galvanization : It is a method of protecting steel and iron from rusting by coating them with a thin layer of zinc.

The galvanised article is protected against rusting even if the zinc coating is broken/scratched because Zinc is more reactive than iron, so it corrodes before the steel does.







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. Generally, in India, 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.

Iron pillar at Delhi

The wonder of ancient Indian metallurgy

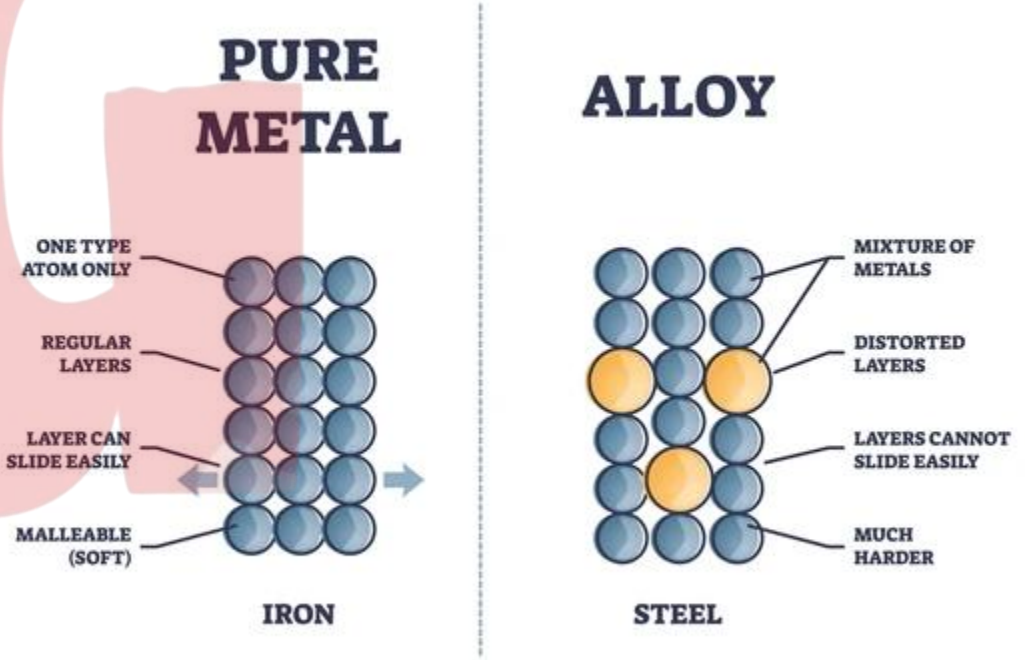
The iron pillar near the Qutub Minar in Delhi was built more than 1600 years ago by the iron workers of India. They had developed a process which prevented iron from rusting. For its quality of rust resistance it has been examined by scientists from all parts of the world. The iron pillar is 8 m high and weighs 6 tonnes (6000 kg).

Alloy

An alloy is a homogeneous mixture of two or more metals or a metal and a non- metal.

Examples of alloy:

1. Iron : Mixed with small amount of carbon becomes hard and strong.
2. (Steel : Iron + Nickel and chromium
3. Brass : Copper + Zinc
4. Bronze : Copper + Tin (Sn)
5. Solder : Lead + tin
6. Amalgam : If one of the metal is mercury (Hg).



Types Of Alloy Metals

Steel

Bronze

Brass

Aluminum

Nichrome

Titanium

Berrylim-copper

Nickel

Copper-Nickel

Niobium

QUESTIONS

1. Metallic oxides of zinc, magnesium and copper were heated with the following metals.

Metal	Zinc	Magnesium	Copper
Zinc oxide			
Magnesium oxide			
Copper oxide			

In which cases will you find displacement reactions taking place?

2. Which metals do not corrode easily?

3. What are alloys?

EXERCISES

1. Which of the following pairs will give displacement reactions?
   (a) NaCl solution and copper metal
   (b) $MgCl_2$ solution and aluminium metal
   (c) $FeSO_4$ solution and silver metal
   (d) $AgNO_3$ solution and copper metal.
2. Which of the following methods is suitable for preventing an iron frying pan from rusting?
   (a) Applying grease
   (b) Applying paint
   (c) Applying a coating of zinc
   (d) All of the above.
3. An element reacts with oxygen to give a compound with a high melting point. This compound is also soluble in water. The element is likely to be
   (a) calcium
   (b) carbon
   (c) silicon
   (d) iron.
4. Food cans are coated with tin and not with zinc because
   (a) zinc is costlier than tin.
   (b) zinc has a higher melting point than tin.
   (c) zinc is more reactive than tin.
   (d) zinc is less reactive than tin.

5. You are given a hammer, a battery, a bulb, wires and a switch.
   (a) How could you use them to distinguish between samples of metals and non-metals?
   (b) Assess the usefulness of these tests in distinguishing between metals and non-metals.
6. What are amphoteric oxides? Give two examples of amphoteric oxides.
7. Name two metals which will displace hydrogen from dilute acids, and two metals which will not.

(2025)

1. The products formed when Aluminium and Magnesium are burnt in the presence of air respectively are : (1 Mark) (2025)

(A) Al3O4 and MgO2
(B) Al2O3 and MgO
(C) Al3O4 and MgO
(D) Al2O3 and MgO2

2. Reaction between two elements A and B, forms a compound C. A loses electrons and B gains electrons. Which one of the following properties will not be shown by compound C ? (1 Mark) (2025)

(A) It has high melting point.
(B) It is highly soluble in water.
(C) It has weak electrostatic forces of attraction between its oppositely charged ions.
(D) It conducts electricity in its molten state or aqueous solution.

3. The metals obtained from their molten chlorides by the process of electrolytic reduction are : (1 Mark) (2025)

(A) Gold and silver
(B) Calcium and magnesium
(C) Aluminium and silver
(D) Sodium and iron

4. The formation of magnesium oxide is correctly shown in option : (1 Mark) (2025)

(A) $Mg : \rightleftharpoons \ddot{O}: \longrightarrow Mg^{2+}\left[:\ddot{O}:^{2-}\right]$

(B) $Mg \bullet \longrightarrow \ddot{O}: \longrightarrow Mg^{+}\left[:\ddot{O}:^{-}\right]$

(C) $Mg : \overset{\ddot{O}:}{\underset{\ddot{O}:}{+}} \longrightarrow Mg^{2+}\left[:\ddot{O}:^{-}\right]_2$

(D) $2Mg \times \longrightarrow \dot{\ddot{O}}: \longrightarrow \left[Mg^{2+}\right]_2\left[:\ddot{O}:^{2-}\right]$

5. (a) "Displacement reactions also play a key role in extracting metals in the middle of the reactivity series." Justify this statement with two examples. (3 Mark) (2025)

(b) Why can metals high up in the reactivity series not be obtained by reduction of their oxides by carbon ?

(c) With the help of an activity, explain the conditions under which iron articles get rusted. 3

6. (i) Name two metals which react violently with cold water. List any three observations which a student notes when these metal are dropped in a beaker containing water. (3 Mark) (2025)

(ii) Write a test to identify the gas evolved (if any) during the reaction of these metals with water.

Answers

1. B / Al2O3 and MgO

2. C / It has weak electrostatic forces of attraction between its oppositely charged ions.

3. B / Calcium and Magnesium

4. A /

$Mg : \rightleftharpoons \ddot{O}: \longrightarrow Mg^{2+}\left[:\ddot{O}:^{2-}\right]$

5. (a) $3\ MnO2(s) + 4\ Al(s) \rightarrow 3\ Mn(l) + 2\ Al2O3(s) + heat\ Fe2O3(s) + 2\ Al(s) \rightarrow 2\ Fe(l) + Al2O3(s) + heat$

(Award marks if explained through statement or any other reactions.)

(b) Metals towards the top of the reactivity series (Na, Mg, Ca) have more affinity for oxygen than carbon.

(c) ➢ Take three test tubes and place clean iron nails in each of them.

➢ Label these test tubes A, B and C.

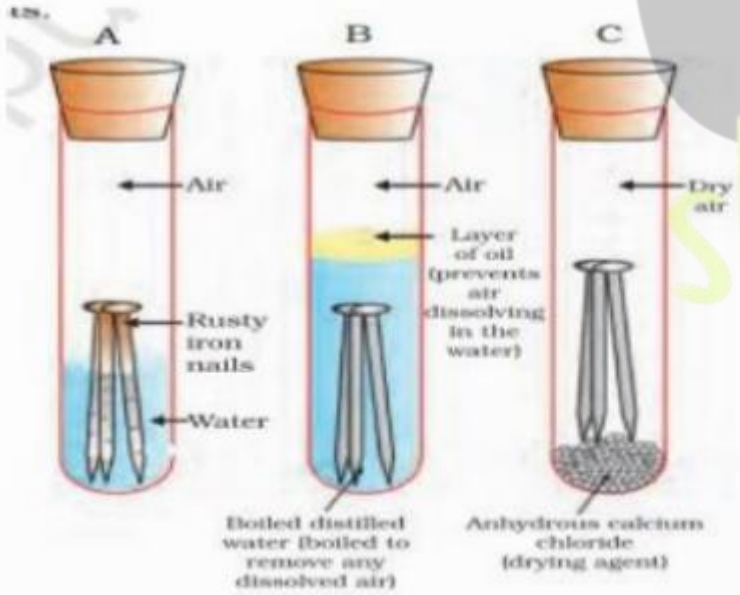
➢ Pour some water in test tube A and cork it.

➢ Pour boiled distilled water in test tube B, add about 1 mL of oil and cork it. The oil will float on water and prevent the air from dissolving in the water.

➢ Put some anhydrous calcium chloride in test tube C and cork it. Anhydrous calcium chloride will absorb the moisture, if any, from the air.

Iron nails rust in test tube A, but they do not rust in test tubes B and C.

Rusting of iron takes place when exposed to both air and water.



6. (i) • Sodium, Potassium, Lithium (any two)

• **Observations:**

➢ A violent reaction occurs.

➢ Large amount of heat is evolved.

➢ Evolved gas may catch fire.

(ii) The gas (bubbles) burns with a pop sound

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