L1

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CLASS X - SCIENCE

METALS AND NON-METALS

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PK HITS🔥

- Chemical Properties of Metal
- Reactivity Series (Give reasons type of questions)
- Exceptional Cases (HNO_3 reaction with metals)
- Metallurgy
- Calcination/Roasting
- Electrolytic Refining

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Metals	Non-Metals	Metalloids	Inert Elements
Elements that form positive ions by losing electrons.	Elements that typically gain electrons to form negative ions or share electrons.	Elements with properties intermediate between metals and non-metals. They can exhibit both behaviors.	Elements with a stable electronic configuration, found in Group 18 of the periodic table. They rarely react.
e.g. Sodium, Aluminum, Silver, etc.	e.g. Carbon, Sulfur, Oxygen, Nitrogen, etc.	e.g Silicon, Boron	e.g. Helium, Neon, Argon

Gold

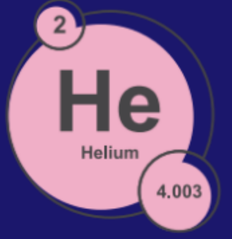
Copper

Diamond

Carbon

Silicon

Boron



PHYSICAL PROPERTIES OF METALS AND NON METALS

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Property	Metals	Non-Metals
Hardness	Generally hard. **Exception: Sodium and Potassium.**	Generally soft. **Exception: Diamond.**
Lustre	Lustrous (shiny appearance).	Non-lustrous. **Exception: Iodine.**
Malleability	Malleable (can be beaten into sheets). **Exception: Mercury.**	Non-malleable, brittle.
Ductility	Ductile (can be drawn into wires). **Exception: Mercury.**	Non-ductile.
Sonority	Sonorous (produce sound when struck).	Non-sonorous.
Electrical Conductivity	Good conductors of electricity.	Poor conductors. **Exception: Graphite.**
Heat Conduction	Good conductors of heat. **Exceptions: Lead.**	Poor conductors of heat.
Melting Point	High melting point. **Exceptions: Gallium.**	Low melting point.

FACTS AND EXCEPTIONS ABOUT METALS

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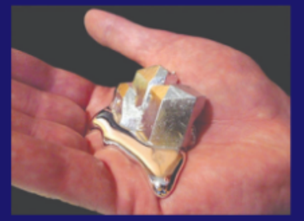
- Metals are hard except alkali metals like sodium, potassium, lithium, which can be cut with a knife.
- Gold is the most malleable metal while platinum is the most ductile metal (but costly).
- Silver is the best conductor of electricity.
- The only metal found in liquid at room temperature is mercury (Hg) - used in thermometers.
- Gallium and Cesium have low melting points due to which they melt in the human palm



FACTS AND EXCEPTIONS ABOUT NON-METALS

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- The only non-metal found in liquid is bromine.

- Diamond is the hardest naturally occurring substance and it is the best conductor of heat. Non metals also have very unique characteristics .

- Graphite and Iodine are lustrous.

- Graphite is a good conductor of electricity.

CHEMICAL PROPERTIES OF METALS

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1. REACTION WITH AIR(OXYGEN)

Almost all metals combine with oxygen to form *metal oxides.*

Metal + Oxygen → Metal oxide

$2Cu + O_2 \rightarrow 2CuO$ **(black substance)**

Most other metal oxides are insoluble in water but sodium and potassium oxides dissolve in water to form alkalis:

Base

$Na_2O + H_2O \rightarrow 2NaOH$

$K_2O + H_2O \rightarrow 2KOH$

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Different metals show different activities towards oxygen.

Metal	Reactivity towards oxygen
Potassium, Sodium	React vigorously and catch fire when exposed to air. Stored in kerosene for safety.
Zinc, Magnesium, Aluminum, lead	Develop a protective oxide layer, preventing further oxidation.
Iron	Iron filings burn vigorously, forming iron(III) oxide: $4Fe + 3O_2 \rightarrow 2Fe_2O_3$
Silver and Gold	Do not react with oxygen, even at high temperatures.

AMPHOTERIC OXIDES

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Metal oxides that react with both acids, as well as bases to produce salts and water, are called *amphoteric oxides.*

Example - Zinc Oxide, Aluminum Oxide

Sb, Zn
Pb, Sn, Be

ZnO Al_2O_3

Sab Zan
Padho
Bano Znab

Aluminium oxide reacts with acids:

- $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$

Aluminium oxide reacts with bases:

- $Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$

Acid Baso

2. REACTION WITH WATER

- Metals react with water and produce *a metal oxide and hydrogen gas.*
- Metal oxides that are soluble in water dissolve in it to further form *metal hydroxide.*
- However, *all metals do not react with water.*

Metal + Water → Metal oxide + Hydrogen

$2Na\ (s) + 2H_2O\ (l) \rightarrow 2NaOH\ (aq) + H_2\ (g) + Heat$

Oxides like Na_2O, K_2O, CaO, and MgO are soluble in water and form metal hydroxides.

Metal oxide + Water → Metal hydroxide

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Metal	Reactivity towards water
Na and K	React violently with cold water. The reaction is exothermic, and the evolved hydrogen catches fire. $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g) + \text{heat energy}$ $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g) + \text{heat energy}$
Ca	Reacts less violently. The heat evolved is insufficient for hydrogen to catch fire. Bubbles of hydrogen make calcium float. $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$
Mg	Does not react with cold water. Reacts with hot water to form magnesium hydroxide and hydrogen. Floats due to hydrogen bubbles. $Mg(OH)_2$
Al, Fe, Zn	Do not react with cold or hot water but react with steam to form metal oxide and hydrogen. $2Al(s) + 3H_2O(g) \rightarrow Al_2O_3(s) + 3H_2(g)$ $3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$
Pb, Cu, Ag, Au	Do not react with water at all.

3. REACTION WITH ACIDS

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Metals react with acids to give *salt and hydrogen gas.*

Metal + Dilute acid → Salt + Hydrogen

Me H_2 nahi doonga!

- ***Hydrogen gas (H_2)*** *is not evolved when a metal reacts with nitric acid (HNO_3). This is because HNO_3 is a strong oxidizing agent. It oxidizes the H_2 produced to water and itself gets reduced to any of the nitrogen oxides (N_2O, NO, NO_2).*
- *However, magnesium (Mg) and manganese (Mn) react with very dilute HNO_3 to evolve H_2 gas.*
- ***Copper (Cu) does not react with dilute hydrochloric acid (HCl).***

AQUAREGIA

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- Aqua regia, is a freshly prepared mixture of concentrated hydrochloric acid and concentrated nitric acid in a 3:1 ratio.
- *It can dissolve gold, even though neither of these acids can do so alone.*
- Aqua regia is a highly corrosive, fuming liquid and is one of the few reagents capable of dissolving gold and platinum.

1L + 3L

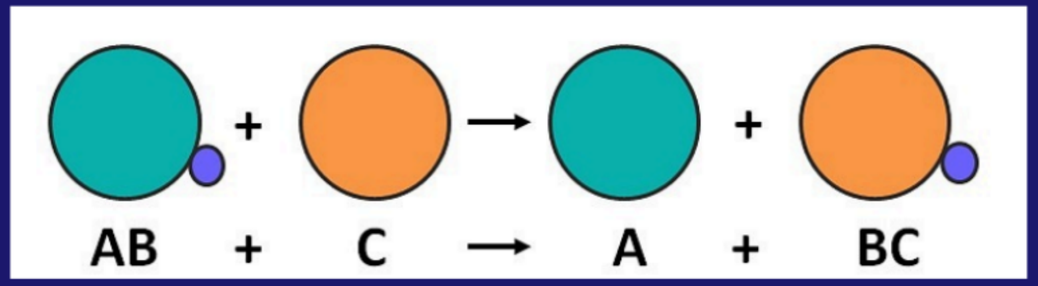
$$HNO_3 + 3HCl \rightarrow NOCl + Cl_2 + 2H_2O$$

1 3

4. REACTION OF METALS WITH OTHER METAL SALTS

Reactive metals can displace less reactive metals from their compounds in solution or molten form. It is a displacement reaction.

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



REACTIVITY SERIES

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

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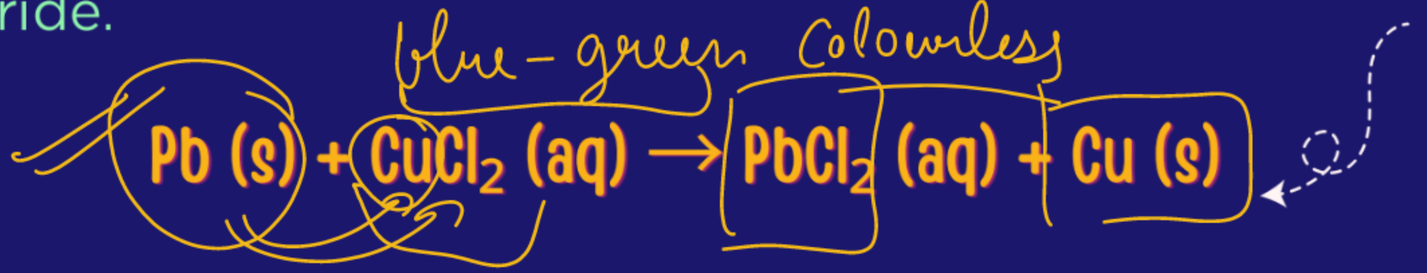
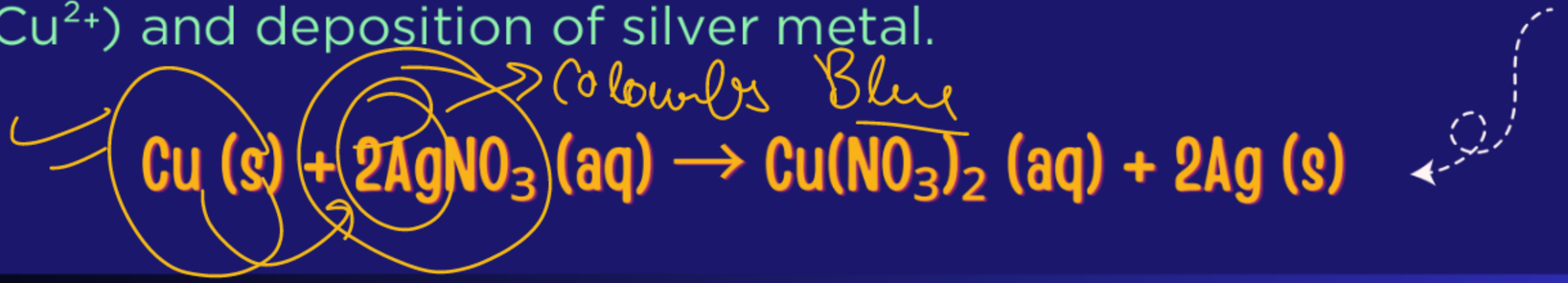
Reaction of lead with copper chloride solution

When a strip of lead metal is introduced in the blue-green solution of copper chloride, the solution turns colorless due to the formation of lead chloride.



Reaction of lead with silver nitrate solution

When a copper wire is introduced in the colorless solution of silver nitrate, the solution starts turning blue due to the formation of copper ions (Cu^{2+}) and deposition of silver metal.



CHEMICAL PROPERTIES OF NON METALS

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1. REACTION WITH AIR(OXYGEN)

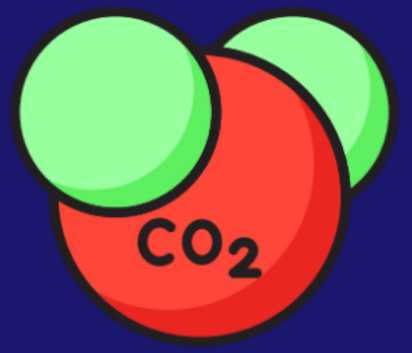
When non-metals react with oxygen, they form **non-metal oxides**.

Non-metal + Oxygen → Non-metal oxide

Example:

- $C(s) + O_2(g) \rightarrow CO_2(g)$
- $S(s) + O_2(g) \rightarrow SO_2(g)$

Neutral
Acidic



- Non-metallic oxides are acidic in nature: CO_2, SO_2, SO_3, etc.
- Non-metallic oxides can also be neutral in nature: CO, H_2O, N_2O, etc.

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2. REACTION OF NON-METAL OXIDE WITH WATER

Generally non-metals do not react with water because they cannot displace hydrogen from water

Non-metal oxide + water → Non-metal oxide

Example:

- $CO_2\ (g) + H_2O\ (l) \rightarrow H_2CO_3\ (aq)$ (Carbonic Acid)
- $SO_3\ (g) + H_2O\ (l) \rightarrow H_2SO_4\ (aq)$
- $2NO_2\ (g) + H_2O\ (l) \rightarrow HNO_2\ (aq) + HNO_3\ (aq)$

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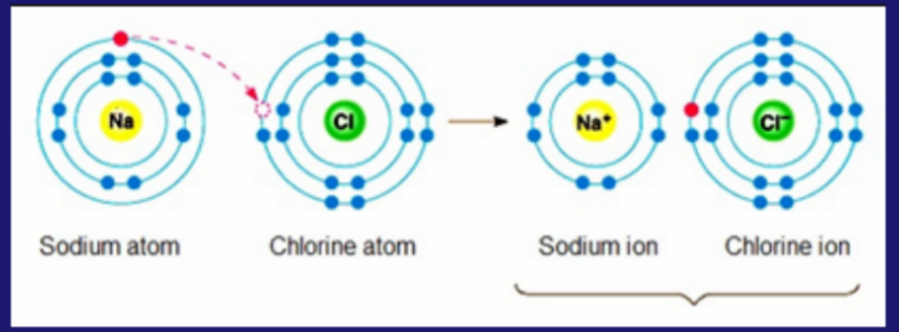
REACTION OF METAL AND NON-METAL (IONIC COMPOUND)

When metals react with non-metals, electrons are transferred from the metal atoms to the non-metal atoms, forming ions. The compound formed is called an **Ionic compound**.

cation
Anion

Metal + Non-metal → Ionic compound

Example - Common salt (NaCl)



NaCl

FORMATION OF IONIC COMPOUND

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

2,8,1 2,8

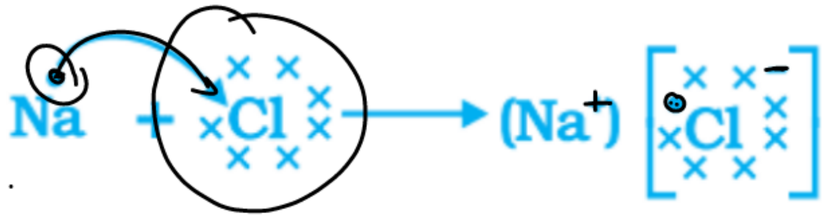
(Sodium cation)

Nacl

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

2,8,7 2,8,8

(Chloride anion)



Sodium Chloride

$Mg \longrightarrow Mg^{2+} + 2e^-$

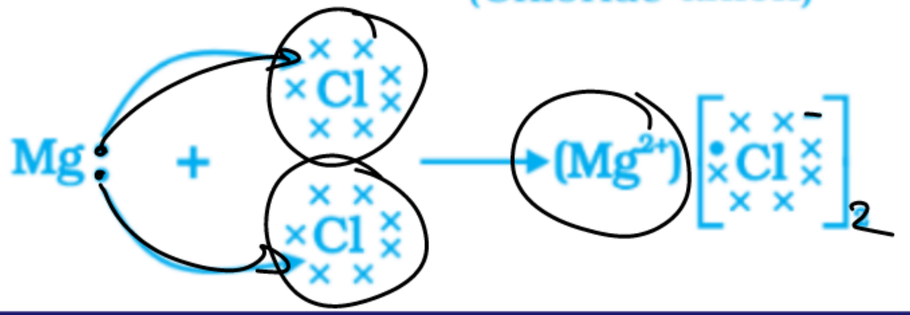
2,8,2 2,8

(Magnesium cation)

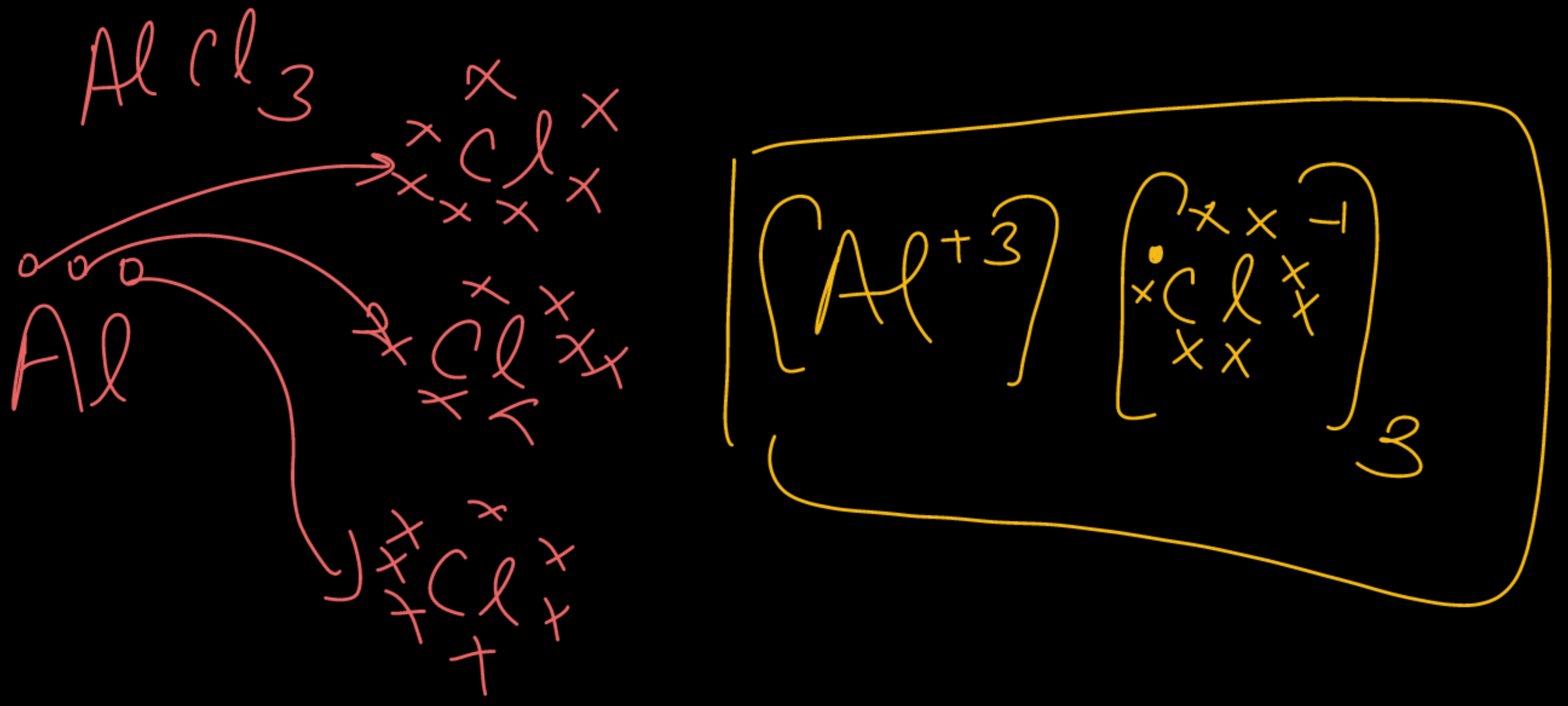
$Cl + e^- \longrightarrow Cl^-$

2,8,7 2,8,8

(Chloride anion)



Magnesium Chloride


AlCl3
Al
Cl
Cl
Cl
[Al+3]
[Cl]-3
3

MgS

Al_2O_3

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IONIC BOND

It is a type of linkage formed from the electrostatic attraction between oppositely charged ions in a chemical compound.

PROPERTIES OF IONIC COMPOUNDS

- **Physical nature**: They are solid and hard, generally brittle.
- **Melting and boiling point**: They have high melting and boiling point.
- **Solubility**: Generally soluble in water and insoluble in solvents such as kerosene, petrol, etc.
- **Conduction of electricity**: Ionic compounds conduct electricity in molten and solution form but not in solid state.

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(2023)

Q.Aluminium is used for making cooking utensils. Which of the following properties of aluminium are responsible for the same?

(i) Good thermal conductivity

(ii) Good electrical conductivity

(iii) Ductility

(iv) High melting point

a) (i) and (ii)

b) (i) and (iii)

c) (ii) and (iii)

d) (i) and (iv)

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(2019)

Q. A metal and a non-metal that exist in liquid state at the room temperature are respectively:

(a) Bromine and Mercury

(b) Mercury and Iodine

(c) Mercury and Bromine

(d) Iodine and Mercury

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(2021)

Q.Which of the following pairs will give displacement reactions?

(a) $FeSO_4$ solution and Copper metal

(b) $AgNO_3$ solution and Copper metal

(c) $CuSO_4$ solution and Silver metal

(d) NaCl solution and Copper metal

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Q.Which of the following is the correct arrange-ment of the given metals in ascending order of their reactivity?

Zinc, Iron, Magnesium, Sodium

(a) Zinc > Iron > Magnesium > Sodium

(b) Sodium > Magnesium > Iron > Zinc

(c) Sodium > Zinc > Magnesium > Iron

(d) Sodium > Magnesium > Zinc > Iron

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(2022)

Q.An element X is soft and can be cut with a knife. This is very reactive to air and cannot be kept open in air. It reacts vigorously with water. Identify the element from the following

(a) Mg

(b) Na

(c) P

(d) Ca

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(2022)

Q. Aqua regia is a freshly prepared mixture of concentrated HNO_3 and concentrated HCl in the ratio of:

a) 1:3, respectively

b) 2:3, respectively

c) 3:1, respectively

d) 3:2, respectively

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(2021)

Q. What is meant by amphoteric oxides? Choose the amphoteric oxides from the following: Na_2O, ZnO, CO_2, Al_2O_3, H_2O

Answer:

Amphoteric oxides are those oxides that exhibit both acidic and basic properties, i.e., they react with both acids and bases.

From the given options, the amphoteric oxides are: ZnO and Al_2O_3

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(2022)

Q. Name a metal which:

(a) is the best conductor of heat.

(b) has a very low melting point.

(c) does not react with oxygen even at high temperature.

(d) is most ductile.

Answer:

(a) Metal which is the best conductor of heat is silver.

(b) Gallium has a very low melting point.

(c) Silver and gold do not react with oxygen even at high temperature.

(d) Gold is the most ductile metal.

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(2024)

Q. State reasons for the following:

(a) Zinc oxide is an amphoteric oxide.

Answer: Zinc oxide reacts with both acids and bases to form salts and water, indicating it has both acidic and basic properties, making it amphoteric.

(b) Sodium metal is stored in a bottle filled with kerosene oil.

Answer: Sodium is highly reactive with water and oxygen, which can cause it to ignite. Storing it in kerosene prevents it from coming into contact with moisture and air, thus preventing accidental ignition.

(c) In the reactions of nitric acid with metals, generally hydrogen gas is not evolved.

Answer: Nitric acid is a strong oxidizing agent, which means that instead of hydrogen gas, nitrogen oxides are typically produced during the reaction with metals.

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(2024)

Q.(a) Why does calcium start floating when it reacts with water? Write the balanced chemical equation of the reaction.

(b) Name two metals which do not react with water.

(a) Calcium reacts with cold water to form calcium hydroxide and hydrogen gas

$$Ca_{(s)} + 2H_2O_{(l)} \xrightarrow[\text{temperature}]{\text{Room}} Ca(OH)_{2(aq)} + H_{2(g)}$$

The bubbles of hydrogen gas produced stick to the surface of calcium and hence, it starts floating on the surface of water.

(b) Gold and silver do not react with water.

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(2020)

Q(.a) (i) Write two properties of gold which make it the most suitable metal for ornaments.

(ii) Name two metals which are the best conductors of heat.

(iii) Name two metals which melt when you keep them on your palm.

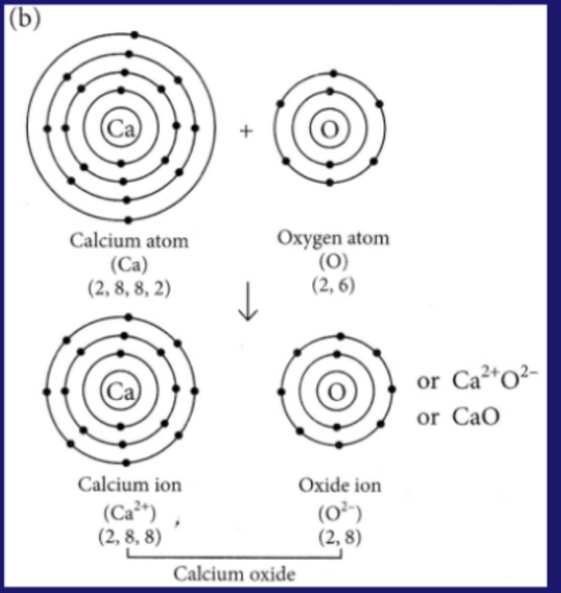
(b) Explain the formation of ionic compound CaO with electron-dot structure.

(Atomic numbers of calcium and oxygen are 20 and 8 respectively)

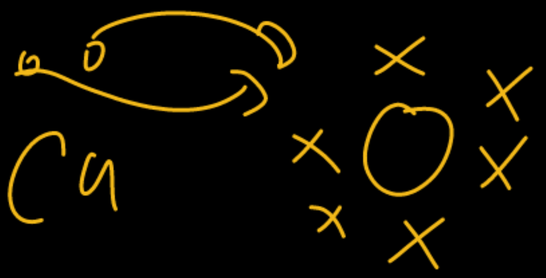
(a) (i) The malleability and ductility properties of gold make it suitable for ornaments.

(ii) Silver and gold.

(iii) Gallium and caesium have so low melting points that they melt even on keeping them on palm.



CaO



$[Ca^{+2}][\ddot{O}^{-2}]$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Metallurgy - The branch of science and technology concerned with the properties of metals and their production and purification.

Minerals - Natural occurring chemical substances obtained by mining.

Ores - An ore is a mineral from which metal is obtained.

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

ORES OF SOME IMPORTANT METALS

Nature of Ore	Metal		Composition
Oxide Ores	Aluminium	Bauxite	$Al_2O_3.2H_2O$
	Copper	Cuprite	Cu_2O
	Iron	Magnetite	Fe_2O_4
Sulphide Ores	Copper	Copper pyrites	$CuFe_2O_2$
		Copper glance	Cu_2S
	Zinc	Zinc blende	ZnS
	Lead	Galena	PbS
	Mercury	Cinnabar	HgS
Carbonate Ores Halide Ores	Calcium	Limestone	$CaCO_3$
	Zinc	Calamine	$ZnCO_3$
	Sodium	Rock salt	NaCl
	Magnesium	Carnallite	KCl $MgCl_2.6H_2O$
	Calcium	Fluorspar	CaF_2
	Silver	Horn Silver	AgCl
Sulphate Ores	Calcium	Gypsum	$CaSO_4.2H_2O$
	Magnesium	Epson Salt	$MgSO_4.7H_2O$
	Barium	Barytes	$BaSO_4$
	Lead	Anglesite	$PbSO_4$


gold

METALLURGY

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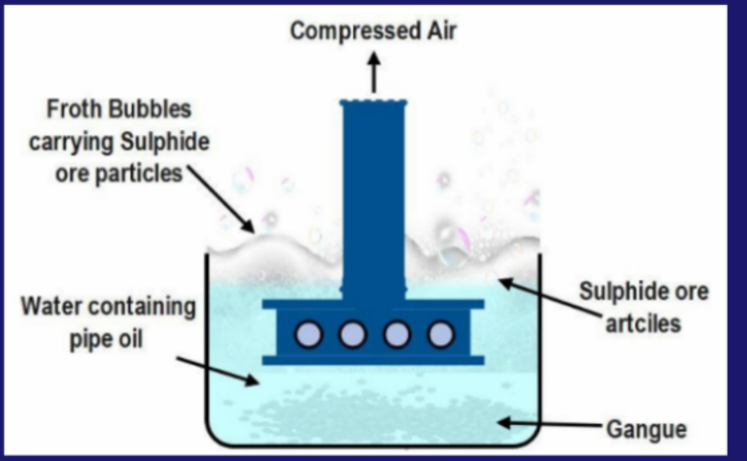
Step 1: Crushing and grinding of ore

The ore is crushed into smaller pieces by putting impact forces through hammer. The ore gets converted to powdered form through grinder.

→ Magnetic Separation

Step 2: Concentration of ore

Before extracting the metal, it is important to remove 'gangue or impurities'.



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Step 3: Extraction of metals:

Metal	Extraction
K, Na, Ca, Mg, Al, Zn	Electrolysis
Zn, Fe, Pb, Cu	Reduction using carbon
Ag, Au	Found in native state

Steps involved in the extraction of metals from ores