METALS & NON-METALS

INTRODUCTION

There are 118 chemical elements known at present on the basis of their properties all these elements can be broadly divided into two main groups metals and non-metals.

A majority of the known elements are metals. All metals are solid except mercury, which is a liquid metal. There are 22 non metals, out of which 10 nonmetals are solids, one nonmetal (bromine) is a liquid and remaining 11 nonmetals are gases.

METALS

The elements which are hard, lustrous and polished, drawn into thin wires (ductile), hammered into sheets (malleable) and good conductor of heat and electricity are called metals. Such as gold, silver, copper, aluminium (Al is the most abundant metal) and zinc.

Exceptions :- Sodium and potassium are soft metals which can be cut with a knife.

NON-METALS

The elements which are usually brittle and can not be used to make sheets or wires, can not be polished and bad conductor of heat and electricity (except graphite) are called non-metals. Such as sulphur, phosphorus, oxygen, nitrogen etc.

Oxygen is the most abundant element on the earth.

OCCURRENCE

Generally, metals and non-metals occurs in nature in free as well as in combined state. The metals which can not be affected by air and water are occur in native or free state and such metals are known as native metals. For example, gold and platinum.

The reactive metals such as sodium, potassium, calcium, aluminium, copper etc. are found in nature in combined state in the form of compounds.

The silver and copper metals occur in nature, in free as well as in the combined state.

The non-metals, which are usually reactive are found in the form of compounds, and other which are less reactive, found in free state. For example, oxygen and nitrogen (Air).

Thus most of the metals and non-metals are formed in nature in the form of compounds. These are as follows :

OCCURRENCE OF METALS

S. No.	Compounds	Minerals
1.	Oxides	Aluminium occurs as oxide in bauxite ore ($Al_2O_3.2H_2O$), and Fe in magnetite (Fe_3O_4), copper in cuprite (Cu_2O)
2.	Carbonates	Limestone ($CaCO_3$), Calamine ($ZnCO_3$)
3.	Sulphides	Copper pyrites ($CuFeS_2$) and Cinnabar (HgS)
4.	Sulphates	Epsom salt ($MgSO_4.7H_2O$). Gypsum ($CaSO_4.2H_2O$)
5.	Phosphates	Rock phosphate [$Ca_3(PO_4)_2$]
6.	Silicates	China clay ($Al_2O_3.2SiO_2.2H_2O$)

OCCURRENCE OF NON-METALS

S. No.	Non-Metals	Free-State	Combined State
1.	Oxygen	Air (21%)	Water, Earth's Crust.
2.	Nitrogen	Air (78%)	Animal Kingdom, Chili Salt Petre
3.	Hydrogen	Coal gas	Petroleum, Coal, Water gas, Natural gas
4.	Carbon	Diamond, Coal, Graphite	Air, Natural gas, Marsh gas, Coal and Rocks.

POSITION OF METALS AND NON-METALS IN THE PERIODIC TABLE

The elements which are placed on the left hand side and in the centre of the periodic table are called metals. Such as sodium potassium, magnesium and calcium. Exception hydrogen, it shows the some characteristic properties of metals and some of non-metals. So, it is also called **notorious element**.

The elements which are placed on the right hand side of the periodic table are called Non-metals. Such as oxygen, nitrogen, chlorine, fluorine etc.

In the periodic table metals and non-metals are separated from each other by a **zig-zag line**. The elements which are placed in the **zig-zag line** show some properties of metals and some properties of non-metals are **called metalloids.** Such as **boron (B), silicon (Si), germanium (Ge), arsenic (As), antimony (Sb), tellurium (Te) and Astatine (At)**. The position of metals, non-metals and metalloids are shown in a simple form in fig. of periodic table –

The metals which are present at the extreme left are known as light metals while those present in the centre of the periodic table are called heavy metal or transition metals.

In general, the metallic character of element decreases on going from left to right side in the periodic table.

For Example :

Sodium is more metallic than aluminium because sodium is on the left hand side of aluminium.

However, on going down the group the metallic character increases.

For Example :

Carbon is non-metal while lead is metal due to their position, carbon placed at the top and lead placed at the bottom in the 14^{th} group of the periodic table.

DO YOU KNOW

1. What are metals ?
2. What are non-metals ?
3. What are native metals ?
4. Which non-metal is most abundant element on the earth ?
5. Which metals & non-metals are found in free state in nature ?
6. Which element (metals & non metals) are found in combined state in nature ?
7. Why copper and silver metals occur in nature, in free as well as in the combined state while sodium potassium , calcium etc. are found in combined state ?

Extended or Long Form of the Periodic Table

s-Block Elements

p-Block Elements

Metals

Non metals

Metalloids

d-Block Elements

f-Block Elements

Group → / Period ↓	IA (1)	IIA (2)	IIIB (3)	VIB (4)	VB (5)	VIB (6)	VIIB (7)	(8)	VIII (9)	(10)	IB (11)	IIB (12)	IIIA (13)	IVA (14)	VA (15)	VIA (16)	VIIA (17)	0 (18)
1	1 H 1.0079 Hydrogen																	2 He 4.0026 Helium
2	3 Li 6.940 Lithium	4 Be 9.0122 Beryllium											5 B 10.811 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Fluonne	10 Ne 20.180 Neon
3	11 Na 22.990 Sodium	12 Mg 24.305 Magnesium											13 Al 26.982 Aluminium	14 Si 28.086 Silicon	15 P 30.974 Phosporus	16 S 32.066 Sulphur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
4	19 K 39.098 Potassium	20 Ca 40.078 Calcium	21 Sc 44.956 Scandium	22 Ti 47.867 Titanium	23 V 50.941 Vanadium	24 Cr 51.996 Chrominum	25 Mn 54.938 Manganese	26 Fe 55.847 Iron	27 Co 58.933 Cobolt	28 Ni 58.693 Nickel	29 Cu 63.546 Copper	30 Zn 65.39 Zinc	31 Ga 62.723 Gallium	32 Ge 72.61 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton
5	37 Rb 85.468 Rubidium	38 Sr 87.62 Strontium	39 Y 88.906 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon
6	55 Cs 132.91 Cesium	56 Ba 137.33 Barium	57 La* 138.91 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 210 Polonium	85 At 210 Astatine	86 Rn 222 Radon
7	87 Fr 223 Francium	88 Ra 226 Radium	89 Ac** 227 Actinium	104 Unq 261 Unnilquadium	105 Unp 262 Unnilquadium	106 Unh 266 Unnilquadium	107 Uns 264 Unnilquadium	108 Uno 269 Unnilquadium	109 Une 268 Unnilquadium	110 Uun 269 Ununnilium	111 Uuu 272 Unnilquadium	112 Uub 277 Ununbium						

The symbols for elements 104-109 used in this table are those proposed by the American Chemical Society and 110-112 proposed by IUPAC

6	*Lanthanide Series	58 Ce 140.12 Cerium	59 Pr 140.91 Praseodymium	60 Nd 144.24 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.96 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.93 Terbium	66 Dy 162.50 Dyspro-	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.93 Thulium	70 Yb 173.07 Ytterbium	71 Lu 174.97 Lutetium
7	**Actinide Series	90 Th 232.04 Thorium	91 Pa 231.04 Protactinium	92 U 238.03 Uranium	93 Np 237 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 262 Lawrencium

IUPAC designations of groups of elements are given in brackets

ELECTRONIC NATURE OF METALS AND NON-METALS

According to electronic view "An element is called metal which form positive ions by losing electrons. For example, sodium is a metal which form sodium ion (Na^+) by losing one electron.

Similarly, Magnesium metal (Mg) forms Mg^{2+} ion by losing two electrons and Al metal form Al^{3+} ion by losing three electrons.

Thus, metals are also known as electropositive elements.

The atoms of metals have 1 to 3 electrons in their outermost shell or valence shell. For example all the alkali metals have one electron in their outermost shell. (Lithium – 2,1; Sodium – 2, 8, 1; Potassium – 2, 8, 8, 1, ...etc) Since, sodium, magnesium and aluminium are metals whose atomic number are 11, 12 & 13 respectively. So, the electronic configuration of these are –

Metals	K shell	L shell	M shell
Sodium	2	8	1
Magnesium	2	8	2
Aluminium	2	8	3

The outermost shells of these elements contain 1, 2 and 3 electrons. It's clear that metals have only 1 to 3 electrons in the valence shell or outermost shell of their atoms. **The no. of outermost electrons which lost easily by an atom is called its valency.**

An element is called non-metal which form negative ions by gaining of electrons. For example, oxygen is a non-metal which form O^{-2}: ions by gaining two electrons.

Similarly, Chlorine, Fluorine and Iodine form Cl^-, F^- and I^- ion by gaining one electron

Thus, non-metals are also known as electronegative elements.

The atoms of non-metals have usually 4 to 8 electrons in their outermost shell.

For Example :

The atomic number of carbon, nitrogen, oxygen, fluorine and neon are 6, 7, 8, 9 and 10 respectively. The electronic configuration of these non-metals are as follow –

Non-metals	K	L
Carbon	2	4
Nitrogen	2	5
Oxygen	2	6
Fluorine	2	7
Neon	2	8

Their outermost shell contain 4, 5, 6, 7 and 8 electron. Non-Metals have two exceptions : hydrogen and helium

Hydrogen is a non-metal, have 1 electron in its outermost shell or valence shell of its atom and Helium have 2 electrons in its valence shell of its atom.

Q. According to electronic concept what are metals & non-metals ?
Q. What is valency ?
Q. Name the element which is notorious.
Q. Where are the metals and non metals placed in the periodic table ?
Q. What are metalloids ?
Q. Name the three elements which are metalloids.

PHYSICAL PROPERTIES OF METALS AND NON-METALS

The important physical properties of metals and non-metals are given below :

1. **Physical State :**

Most of the metals are solid under normal condition of temperature and pressure. For example, iron, copper, magnesium and aluminium.

Exception : Mercury (Hg) which exist in liquid state at room temperature.

Non-Metals can exist in all the three physical state i.e., solid, liquid and gases.

For Example :

Carbon, sulphur, phosphorus and iodine are solid non-metals. Bromine is liquid and oxygen, nitrogen, chlorine, fluorine are gaseous non-metals

2. **Hardness :**

Most of the metals are hard except **sodium** and **potassium** which are soft metals and can be easily cut with a knife. The hardness of metals varies from metal to metal. For example, Iron, Aluminium, Magnesium, Copper etc.

Non-metals are soft. **Except :- diamond, it is an allotrope of carbon.**

3. **Malleability :**

The property of metal in which they can be beaten with a hammer to form thin sheets without breaking is called malleability.

Metals are generally malleable **except sodium, potassium and calcium. Gold and silver are the most malleable metals, Aluminium and copper** are also highly malleable metals. All of these metals can be beaten with a hammer to form very thin sheets are called foils.

Non-metals do not show this property due to brittleness, they are broken into small pieces. For example, sulphur, coal and phosphorus are brittle non-metals.

4. **Ductility :**

Ductility is also an important property of metals. **The ability of metals to be drawn (stretched) into thin wires is called ductility.** Generally, wires are made up of Iron, Copper and Aluminium. **Gold and Silver are the most ductile metals.**

Exception : Sodium, Potassium and Calcium are not ductile while Sn and Pb are less ductile.

For Example : 1 g of Gold can be drawn (stretched) into a very fine thin wire of about 2 kilometer.

Copper and Aluminium are also very ductile, and therefore, these can be drawn into thin wires which are used in electrical wiring.

Non-metals are not ductile i.e., it can not be drawn into thin wire (due to brittleness). They are easily snapped on stretching.

For Example : Sulphur, Phosphorus and Coal when stretched, all of these are broken into small pieces and do not form thin wire.

Thus non-metals can not show this property.

5. **Conductivity :**

The property of metal by which heat and electric current flow through them is called conductivity.

Metals are good conductor of heat and electricity, because their atoms contain free electrons which conduct electric current and heat. For example silver, copper and aluminium. **Silver is the best conductor of heat and electricity. Copper metal is the next best conductor of electricity.** Since silver metal is expensive, So copper and aluminium are commonly used for making electric wire.

Non-Metals are bad conductor of heat and electricity, due to lack of free electrons in their atoms.

Exception : Graphite is good conductor of heat & electricity due to the presence of one free electron in each carbon atom.

To show that metal is a good conductor of heat.

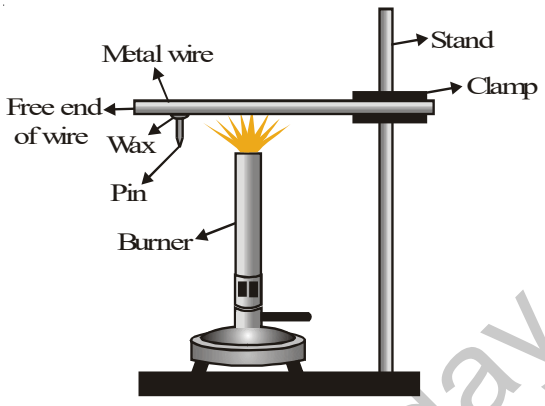
Experiment : Take a small aluminium wire and clamp it on a stand as shown in fig. as below. Then fix a pin to the free end of the wire with the help of wax.

Now, heat the aluminium wire with a candle or burner near its clamped end.

Observation : After some time the other end also becomes hot, wax melt and the pin falls down.

Result : This shows that metals are good conductor of heat. This experiment also shows that metals have high melting point (on over heating, the Al wire do not melt).

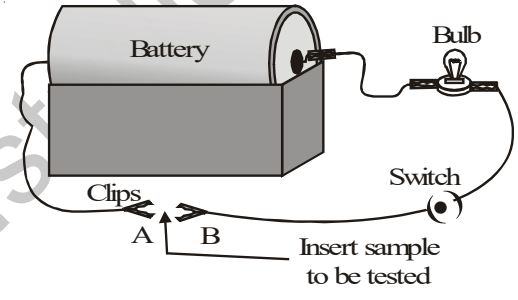
We can repeat this activity with copper or Iron metal also but results are same.



Metal is a good conductor of heat

To show that metal is a good conductor of electricity.

Experiment : Take a dry cell, a bulb fitted in a holder, connecting wire which consists of copper wire, crocodile clips and a switch. Set up all apparatus & electric circuit as shown in fig.



Metals are good conductors of electricity

Observation : The bulb glows at once when switch is on.

Result : The above activity shows that metals are good conductor of electricity.

6. **Sonorous :**

The property in which metals produce a ringing sound when hit with an object is called sonorous.

Metals are sonorous but non-metals are non sonorous i.e., when struck with a hammer they do not produce sound.

Q. Which element is the hardest natural occuring substance ?
Q. Name two metals which are soft & can be cut with knife ?
Q. Give one example of metal which is liquid at room temperature ?
Q. Give one example of non-metal which conduct electricity ?
Q. Write the name of three metals which are not ductile ?

7. **Lustrous :**

Most of the metals have metallic lustre (shine) and they can be polished. The shining appearance of metal is known as metallic lustre.

For Example : Gold, Silver and Copper metals have metallic lustre (Chamak) and they can be polished. The shiny appearance of metals make them useful for making jewellery and decoration pieces. For example gold and silver are used for making jewellery due to their shining and brightness. The shiny appearence of metals make them good reflectors of light. Silver metal in an excellent reflector of light. So, it is used in making mirror.

Non-metals are not lustrous and not be polished.

Exception : Graphite (allotrope of C) and iodine are lustrous non-metal.

8. **Densities :**

Metals are very heavy and they have very high densities (except sodium and potassium metals which have low densities).

For Example : The density of mercury is very high (13.6 g/cm^3)

Non-metals are light substances, so they have low densities.

For Example : The density of sulphur is 2 g/cm^3 which is quite low.

Exception : Iodine and Diamond have high densities.

The smaller metal atom has the lesser density. **Osmium (Os)** has maximum density (22 g/cm^3) among all elements.

9. **Melting and Boiling Point :**

Most of the metals have high melting and boiling points (Except : Sodium and Potassium).

For Example : The melting point of tungsten metal is 3410°C, which is very high. Therefore it is used in filament of electric bulbs.

Non-Metals have generally low melting and boiling points.

Exception : Diamond, which is the allotrope of carbon has very high melting point (3730°C) other exceptions are carbon, boron and silicon which have very high melting points.

10. **Colour :** Most of the metals are white or silvery grey in colour. Exceptionally, gold has a yellow colour and copper has a reddish brown.

Non-metals are generally colourless gases.

Exceptionally chlorine is greenish yellow colour gas, bromine is brown liquid and iodine is violet colour solid.

CHEMICAL PROPERTIES OF METALS AND NON-METALS

The important chemical properties of metals and non-metals are discussed below :

1. **Reaction with Oxygen :**

All the metals react with oxygen to form metal oxides. Which are basic in nature **(Except Al_2O_3 and ZnO, These oxides show basic as well as acidic behavior and are known as amphoteric oxide)** and some of them react with water to form alkaline solution, which turns red litmus paper blue.

For Example : Sodium metal reacts with oxygen of air to form basic oxide called sodium oxide

$$4Na + O_2 \longrightarrow 2Na_2O$$

Sodium oxide

It reacts with water to give an alkali called sodium hydroxide. It turn red litmus paper blue.

$$Na_2O + H_2O \longrightarrow 2NaOH$$

Sodium hydroxide

Similarly potassium also react with O_2 of air and form basic oxide called potassium hydroxide.

$$4K + O_2 \longrightarrow 2K_2O$$

$$K_2O + H_2O \longrightarrow 2KOH$$

Since sodium & potassium metals are highly reactive that they react vigorously with the oxygen (of air). They catches fire and start burning when kept open in the air. In fact, K and Na metals are stored in kerosene to prevent their reaction with the oxygen, moisture and CO_2 of air.

The reactions of metals and non-metals with O_2 is clear by the following activity.

The experiment to show that metals and non-metals react differently with oxygen.

Experiment : Take a small piece of magnesium ribbon and hold it with a pair of tongs & burn it over the flame of burner.

Observation : Magnesium ribbon burns with brilliant light and converted into solid residue called ash. Collect this ash in a breaker and add some water.

Now, dissolve it by stirring and test the solution with both (blue and red) litmus papers.

Result : The red litmus paper becomes blue but blue litmus paper remains unaffected.

This shows that the solution is basic or alkaline.

$$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$$

$$MgO(s) + H_2O(\ell) \longrightarrow Mg(OH)_2(aq)$$

$$Mg(OH)_2(aq) + \text{Red litmus} \longrightarrow \text{Blue}$$

Now, take a small amount of sulphur, powdered in a deflagrating spoon and heat it on a burner flame, till it catches fire. Then introduce the spoon into a gas jar. After burning add some water to the gas jar and shake it well.

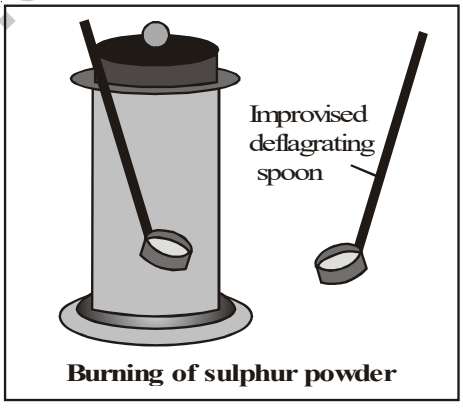
Observations: Test the solution with both (blue and red) litmus papers. The blue litmus paper becomes red and red litmus do not affected.

This shows that aqueous solutions of SO_2 is acidic in nature.

$$S(s) + O_2(g) \longrightarrow SO_2(g) \; ; \; 2SO_2 + O_2 \rightarrow 2SO_3$$

$$SO_3(g) + H_2O(\ell) \longrightarrow H_2SO_4(aq)$$

$$H_2SO_4(aq) + \text{Blue litmus} \longrightarrow \text{Red}$$



Burning of sulphur powder

Similarly, Iron reacts with oxygen of moist air to form a brown layer of iron oxide (rust) on its surface.

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

Iron oxide

When iron is exposed to moist air, a reddish-brown coating of a mixture of ferric oxide (Fe_2O_3) and ferric hydroxide [$Fe(OH)_3$] is deposited on the surface of the metal. This reddish-brown coating is known as rust, and this process is known as rusting.

Q. Saloni took a piece of burning charcoal and collected the gas evolved in a test tube.

(a) How will she find the nature of the gas ?

(b) Write down word equations of all the reactions taking place in this process.

Ans. (a) Add 10 ml water in the test tube and check it with red and blue litmus paper. No change in the colour of red litmus paper. Blue litmus is changed to red. It shows that the gas evolved is acidic in nature.

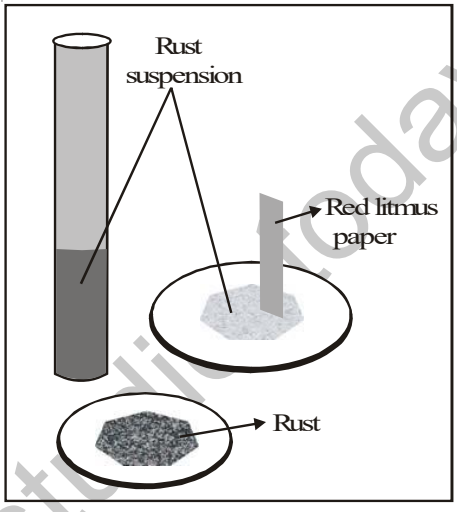
Ans. (b) Carbon + Air → Carbon dioxide.

Carbon dioxide + water → Carbonic acid

To show the nature of rust (iron oxide)

Experiment : Take a spoonful of rust and dissolve it in a very little amount of water and shake it well

Observation : Test the solution with red and blue litmus papers. The red litmus paper becomes blue but blue litmus do not affected.



Result : This activity shows that rust is a basic in nature.

Zinc and lead react with oxygen to form a protective coating of an oxide layer.

$$2Zn + O_2 \longrightarrow 2ZnO$$

Zinc oxide

$$2Pb + O_2 \longrightarrow 2PbO$$

Lead oxide

When copper metal reacts with oxygen of air (at about 300°C) cupric oxide or copper (II) oxide is formed which gets deposited on the surface of the copper metal.

$$2Cu + O_2 \xrightarrow{300°C} 2CuO$$

At 1000°C Cu change into cuprous oxide or copper (I) oxide.

$$4Cu + O_2 \xrightarrow{1000°C} 2Cu_2O$$

When a copper metal is exposed to moist air for long time, it acquires a dull green coating (malachite green) which is a mixture of copper hydroxide [$Cu(OH)_2$] and copper carbonate ($CuCO_3$).

The equation of this reaction is as follows :

$$2Cu + \underbrace{H_2O + CO_2 + O_2}_{\text{moisture}} \xrightarrow{\text{slow}} Cu(OH)_2 + CuCO_3$$

Gold, platinum and silver do not react with oxygen (Air), they are called noble metals or native metals.

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

Acidic Oxides : The oxides of carbon, sulphur and phosphorus are acidic, which dissolve in water to form acid and they turn blue litmus paper red.

For Example : Carbon reacts with oxygen of air to form **carbon dioxide** gas which dissolves in water to form an acid which is called **carbonic acid**.

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$

$$CO_2(g) + H_2O(\ell) \longrightarrow H_2CO_3(aq)$$

carbonic acid

When phosphorus is burnt in air, phosphorus pentoxide is formed which dissolve in water to form phosphoric acid.

$$P_4(s) + 5O_2(g) \longrightarrow 2P_2O_5(s)$$

Phosphorous pentoxide

$$2P_2O_5(s) + 6H_2O(\ell) \longrightarrow 2H_3PO_4$$

Phosphoric acid

Neutral Oxides : Those non-metallic oxides which have no action on any type of litmus papers are known as neutral oxides.

For example : Carbon monoxide (CO), water (H_2O), Nitric oxide (NO), and Nitrous oxide (N_2O).

2. Reaction with water :

The reaction of a metal with water depends on a chemical reactivity. Some metals react with cold water, some react with hot water. Some react only with steam whereas others do not react.

Sodium react with water vigorously along with evolution of H_2 gas and heat. After reaction the solution formed (NaOH) is basic in nature.

(i) $2Na + 2H_2O \longrightarrow 2NaOH + H_2$

(ii) Magnesium reacts very slowly with cold water but reacts rapidly with boiling water to form magnesium oxide and hydrogen gas.

$$Mg + H_2O \longrightarrow MgO + H_2$$

(Boiling water)

This reaction shows that magnesium is less reactive than sodium.

(iii) Zinc reacts rapidly only with steam to form zinc oxide and hydrogen.

$$Zn + H_2O \longrightarrow ZnO + H_2O$$

zinc (steam)

This reaction shows zinc is less reactive than magnesium.

(iv) When steam is passed over red hot iron, iron oxide is formed and $H_2(g)$ is evolved.

(i.e. iron is less reactive metal)

$$3Fe + 4H_2O \square\square\square Fe_3O_4 + 4H_2$$

(steam) Iron oxide

(v) less reactive metals such as Pb, Cu, Ag, Au etc. do not displace hydrogen from water.

Base on the chemical reactions, the metals can be arranged in the order of decreasing reactivities, known as reactivity (or activity) series of metals. Thus, we have

$$K > Ba > Ca > Na > Mg > Al > Zn > Fe > Ni > Sn > Pb > H_2 > Cu > Hg > Ag > Pt > Au$$

(Most reactive) (Least reactive)

Non-metals do not react with water or steam to evolve hydrogen gas. Because non-metals can not give electrons to reduce the hydrogen ions of water to hydrogen gas.

3. Reactions with Acids :

Non-metals do not react with acids but highly reactive metals react with acids and produce hydrogen gas that burns with a 'pop' sound. Only less reactive metals such as copper, silver, gold etc. do not liberate hydrogen gas from dilute hydrochloric (HCl) and dilute sulphuric acid (H_2SO_4).

For Example :

(i) Sodium is highly reactive metal which react violently with dilute HCl acid to form sodium chloride and hydrogen gas.

$$2Na(s) + 2HCl(aq) \longrightarrow 2NaCl(s) + H_2(g)$$

Similarly,

$$2Na(s) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + H_2(g)$$

Sodium sulphate

(ii) Magnesium reacts quite rapidly with dil. HCl and dil H_2SO_4, forming $MgCl_2$ and $MgSO_4$ and hydrogen gas.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

Magnesium chloride

$$Mg(s) + H_2SO_4(aq) \longrightarrow MgSO_4 + H_2(g)$$

Magnesium sulphate

Similarly,

(iii) $Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2 + H_2(g)$

Zinc chloride

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4 + H_2$$

Zinc sulphate

Zinc is less reactive than magnesium.

(iv) $2Al(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2$

Aluminium Aluminium chloride

$$2Al(s) + 3H_2SO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

Aluminium sulphate

(v) Iron reacts slowly with dilute HCl or H_2SO_4 to give hydrogen.

$$Fe(s) + 2HCl(aq) \longrightarrow FeCl_2(aq) + H_2(g)$$

Ferrous chloride Iron (II) chloride

$$Fe(s) + H_2SO_4(aq) \longrightarrow FeSO_4(aq) + H_2(g)$$

Ferrous sulphate Iron (II) sulphate

(vi) Copper does not react with dilute HCl/H_2SO_4 acids.

$Cu(s) + HCl(aq) \longrightarrow$ No reaction

Therefore, the reactivity order of metals with acid is

$$Na > Mg > Zn > Al > Fe > Cu$$

Non-metals do not react with dilute acids.

To study the reactivity of metals & non metals towards different acids at room temperature & on warming

Experiment : Take samples of metals non metals listed in following table in separate test tubes and label them as A, B, C, D, E & F. With the help of a dropper add 5 drops of dil HCl to each test tube & observe the reaction carefully. If no reaction occurs in the cold solution, warm the test tube gently. Bring a burning matchstick near the mouth of each test tube. Repeat the same activity using dilute sulphuric acid instead of the dilute hydrochloric acid. Record observations.

Reaction of metals and non-metals with acids

Test tube Label	Metal / Non Metal	Reaction with Dilute Hydrochloric Acid		Reaction with Dilute Sulphuric Acid	
		Room Temperature	Warm	Room Temperature	Warm
A	Magnesium (ribbon)	React vigorously	More vigorously	Vigorously	More vigorously
B	Aluminium (foil)	React vigorously	Rate of reaction	Vigorously	More vigorously
C	Iron (filings)	React slowly	Increases	slowly	Rate increases
D	Copper (peeled flexible wire	No reaction	No reaction	React slowly	Rate increases
E	Charcoal (powder)	No reaction	No reaction	No reaction	No reaction
F	Sulphur (powder)	No reaction	No reaction	No reaction	No reaction

Conclusion :

(i) When metals & non metals reacts with acids, there is difference in reactivity. Magnesium is more reactive than aluminium & aluminium is more reactive than iron. Copper do not react with dilute H_2SO_4 even on heating. Copper reacts with sulphuric acid. The reactivity order is Mg > Al > Fe > Cu

(ii) Non-metals do not react with acids.

(iii) On warming rate of reaction increases.

(iv) When acid react with metal hydrogen gas is evolved out.

Q. One day Reeta went to a jeweller's shop with her mother. Her mother gave an old gold jewellery to the goldsmith to polish. Next day when they brought the jewellery back, they found that there was a slight loss in its weight. Can you suggest a reason for the loss in weight

4. Reaction with Bases :

Some metals react with alkalis such as sodium hydroxide (NaOH) to produce hydrogen gas.

To show that metals produces H_2 (g)

Experiment : Take a clean test tube and prepare a fresh solution of sodium hydroxide by dissolving 3–4 pellets of it in 5 ml of water. Then, drop a piece of aluminium foil into the test tube. Now, bring a burning match stick near the mouth of the test tube.

Observation : Pop sound is produced which indicates the presence of hydrogen gas.

Result : This activity shows that hydrogen gas is evolved, when metals react with alkali.

The equation of this reaction is given below –

$$2Al + 2NaOH + 2H_2O \longrightarrow 2NaAlO_2 + 3H_2$$

Aluminium Sodium hydroxide Sodium meta aluminate

Similarly,

$$Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2 \uparrow$$

Sodium zincate

$$Sn + 2NaOH + H_2O \longrightarrow Na_2SnO_3 + 2H_2 \uparrow$$

Sodium stannate

Some non-metals also react with alkalies but do not produce hydrogen gas.

$P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\text{Sodium hypophosphite}}{3NaH_2PO_2} + \underset{\text{phosphine}}{PH_3\uparrow}$

$4S + 6NaOH \longrightarrow \underset{\text{Sodium thiosulphate}}{Na_2S_2O_3} + \underset{\text{Sod. sulphide}}{2Na_2S} + 3H_2O$

$Cl_2 + 2NaOH \longrightarrow \underset{\text{Sodium chloride}}{NaCl} + \underset{\text{Sodium hypochlorite}}{NaClO} + H_2O$

5. Displacement Reaction :

When a more reactive metal is placed in a salt solution of less reactive metal, then the more reactive metal replaces the less reactive metal from its salt solution. This reaction is called displacement reaction.

For Example : When a strip of zinc metal is put in the blue colour of copper sulphate solution. After few time the blue colour of the solution fades and red colour copper metal deposited on the zinc strip.

$\underset{\text{copper sulphate (blue)}}{CuSO_4} + Zn \longrightarrow \underset{\text{zinc sulphate (colourless)}}{ZnSO_4} + Cu$

Thus, zinc is a more reactive metal which easily displaces copper from its solution.

$\underset{\text{(copper sulphate)}}{CuSO_4} + \underset{\text{(iron)}}{Fe} \longrightarrow \underset{\text{(ferrous sulphate)}}{FeSO_4} + \underset{\text{(Copper)}}{Cu}$

$FeSO_4 + Cu \longrightarrow$ No reaction

A more reactive non-metal displaces a less reactive non-metal from its salt solution.

For Example : When chlorine gas is passed through a solution of sodium bromide then bromine gas is liberated. But bromine cannot displace chlorine from its salt solution (NaCl)

$NaBr\ (aq) + Cl_2\ (g) \longrightarrow 2NaCl\ (aq) + Br_2\ (g)$

$NaCl\ (aq) + Br_2\ (g) \longrightarrow$ No reaction

Thus, chlorine is more reactive than bromine.

Q. Why aluminium foils are used to wrap food items?

Q. Why immersion rods for heating liquids are made up of metallic substances?

Q. Why copper cannot displace zinc from its salt solution?

Q. Why sodium and potassium are stored in kerosene?

Q. Can you store lemon pickle in an aluminium utensil? Explain –

Uses of Metals and Non-metals :

Uses of Common metals :

(1) Gold, silver and platinum are used in making jewellery.

(2) Zinc is used for galvanization of iron to protect it from rusting.

(3) Iron is used in making machines.

(4) Copper is used in making electric wires.

(5) Aluminium is used in cooking utensils wrapping material, aeroplanes, ships, cars and thermite process.

(6) Metals such as titanium, chromium, manganese, zirconium etc. play an important role in the country's economy and defence. So, these metals are known as strategic metals. These metals and their alloys are used in atomic energy, Space science projects, jet engines, high grade steels and defence equipment.

(7) Some metals play an important role in the functioning of living systems in animals and human beings. Iron is a constituents of haemoglobin in blood which carries oxygen. Magnesium is present in chlorophyll of green leaves.

Some important uses of Non-Metals :

(1) Non-metal such as oxygen plays very important role in our daily life.

(2) Sulphur is used in the manufacture of sulphuric acid, antiseptic skin ointments and in the rubber industry (for the vulcanization of rubber).

(3) Graphite is used as a dry lubricant.

(4) Phosphorus is used in fertilizers to enhance the growth of plants and it also used in crackers.

(5) Chlorine tablet and bleaching powder are used in water purification process.

(6) Hydrogen and oxygen can be used for cutting and welding metals as oxy-hydrogen flame.

(7) Iodine (Purple coloured solution) which is applied on wounds as antiseptic.

(8) Hydrogen is also used in hydrogenation of vegetable oils (Vegetable ghee).

Table : Composition and Uses of Alloys

Name of the alloy	Composition	Uses
Steel	Iron + Carbon	Construction material, machine parts.
Stainless steel	Iron + Chromium + Nickel	For making cooking utensils and cutlery, surgical implements.
Brass	Copper + Zinc	For making cooking utensils, decorative statues, nuts and bolts.
Bronze	Copper + Tin	For making cooking utensils, coins, medals statues.
German silver	Copper + Zinc + Nickel	For making table ware.
Duralumin	Aluminium + Copper + Magnesium + Manganese	For making aircraft bodies, automobile parts.
Alnico	Aluminium + Nickel + Cobalt	For making magnets.
Gun metal	Copper + Tin + Zinc	For making gun-barrels

METALLURGY FOR COMPETITIVE EXAMINATION

MINERALS AND ORES

Minerals : Minerals are those substances which are obtained from mines. Almost all the metals are found in the form of different compounds in earth crust which are extracted by mining.

Ores : The natural occurring minerals, from which metals can be extracted commercially and economically are known as ores. Therefore it can be stated that all ores are minerals but all minerals are not ores because commercial extraction of metal is not possible from all the minerals. Ores contains higher quantity of certain metals and due to this reason extraction of metal is possible.

Ex : In earth crust aluminum is found as two minerals bauxite and sand, out of these minerals aluminium is extracted economically from bauxite ($Al_2O_3 \cdot 2H_2O$) than from sand ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$). Therefore bauxite is considered as an ore of aluminium, although both sand and bauxite are its minerals.

The process of extraction of pure metal from its ore is called as metallurgy. The process of metallurgy depends upon the nature of ore and the types of impurities present in it, therefore there is not a universal method for extraction of all metals. For each metal different methods of extraction are used.

General steps involved in metallurgical process are as follows :

(i) Grinding or ore,

(ii) Concentration of ore,

(iii) Conversion of concentrated ore to metal oxide.

(iv) Reduction of metal oxide,

(v) Purification of metal.

METALLURGY OF COPPER

- **Ores of copper :** Copper is found in free state embedded in rocks. In combined state main ores of copper are as follows :

S.No	Combined state	Name of ore	Formula of ore
1	Oxides	Cuprite or ruby copper	Cu_2O
2	Sulphide	Copper pyrites, copper glance	$CuFeS_2 \cdot Cu_2S$
3	Carbonate	Malachite	$CuCO_3 \cdot Cu(OH)_2$
4	Carbo	Azurite	$Cu(OH)_2 \cdot CuCO_3$

- **Extraction of Copper :** Extraction of copper depends on the type of ore.

(A) **From free copper :** Rocks of copper, found in nature are broken up into small pieces with the help of crushers finely divided powder is passed through stream of water than impurities i.e. are washed away with stream of water and non remaining copper is method and falled in frames, on cooling these copper block are taken out.

(B) **From oxide or carbonate ore :**

(i) The powdered ore is treated with dilute sulphuric acid to obtain copper sulphate solution. On electrolysis copper metal is obtained.

(ii) The oxide and carbonate ores are finely grinded and calcinated. Due to this moisture and CO_2 is removed from oxide. The oxides, so formed is mixed with coke, heated in a reverbatory furnance and reduced to copper metal.

(C) **From sulphide ores :** The main important ore of copper is sulphide ore or copper pyrites 78% of the total production of copper in world is extracted from these ores.

The extraction process for copper pyrites and copper glance is similar. Different steps involving in it are as follows :

(i) **Grinding of ore :** In crushers ores are grinded (broken) into smaller pieces and with the help of stamp mill they are converted into fine powder.

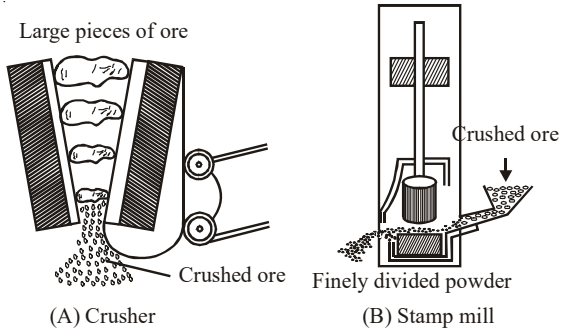
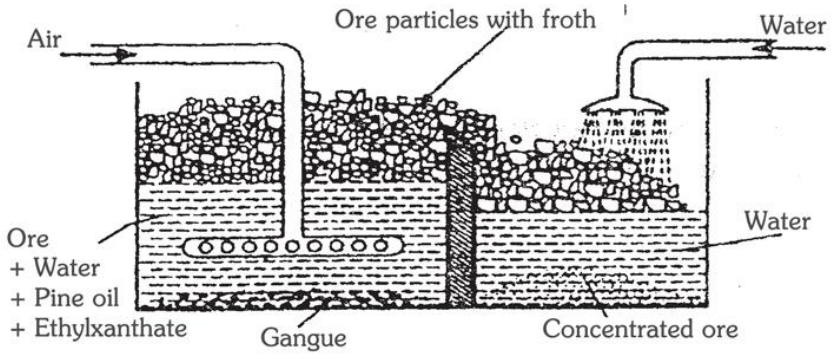


Figure : Grinding of ore

(ii) **Concentration :** Concentration of ore is done by froth floatation method. Powdered ore is mixed with pine oil and agitated by a blowing air due to which froth is produced in large amount. The particles of copper sulphide are concentrated on the surface in the froth and stones, sand etc. settled down at the bottom. Froth is collected in another tank where particles of copper sulphide settle down.



Froth floatation process

(iii) **Roasting :** Concentrated ore is roasted in presence of air in the reverbatory furnaces. In this sulphur dioxide is produced. Some part of copper and iron sulphides are converted into oxides, with copper pyrite some amount of arsenic and antimony are found. Oxides of arsenic and antimony are volatiole and so in, reverberatory furnace they are removed as vapours. Copper pyrites, on roasting, is converted into cuprous sulphide and ferrous sulphide.

$$2CuFeS_2 + O_2 \longrightarrow CuS + 2FeS + SO_2$$

These sulphides are partially oxidised into cuprous oxide and ferrous oxide.

$$Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$$

$$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$$

So in this way roasted ore contains has Cu_2S, FeS, FeO, CuO and SiO_2 (in little quantity).

Smelting : Roasted ore is mixed with coke and silica and smelting is done is blast furnace. The height of the furnace is 15 to 20 feet and the diameter is 3 to 5 feet. The blast furnace is made up of steel and lined inside with fire proofbricks. There is jacket surrounding the furnace in which hot water flows. When a stream of hot air is blown through tuyeres fixed at the lower part of furnace, the combustion of coke takes place. During smelting cuprous and ferrous sulphide reacts to form ferrous oxide and cuprous sulphide.

$$Cu_2O + FeS \longrightarrow Cu_2S + FeO$$

The FeO, so obtained reacts with silica to form ferrous silicate ($FeSiO_3$).

$$\underset{\text{Ferrous oxide}}{FeO} + \underset{\text{Silica}}{SiO_2} \longrightarrow \underset{\text{Ferrous silicate (slag)}}{FeSiO_3}$$

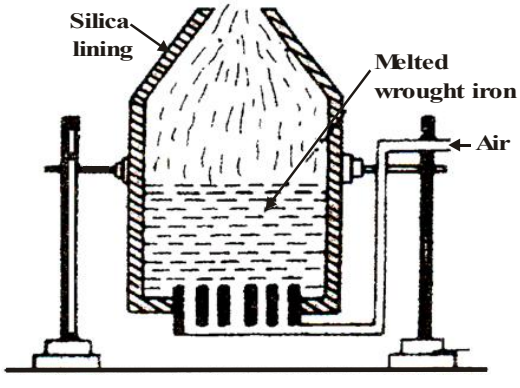
Ferrous silicate is fusible and known as slag. Due to light weight it collects on the surface of metal and removed through a small opening in the furnace. In molten matte FeS and CuS are present in fused state, this liquid is called as copper matte.

(iv) **Production of blister copper : (Bassemer process)**

Copper matte is transfered from the blast furnace to the bassemer converter. Copper sulphide is oxidized to cuprous oxide which reacts with copper sulphide and converts into copper metal.

$$Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2$$

Copper, in the melted state is poured into sand frames. On cooling dissolved SO_2 released due to which blisters are formed on the surface of metal, so this copper is known as blister copper. It contains nearly 98 percent copper.



Bassemer Converter

(v) **Refining of copper :**

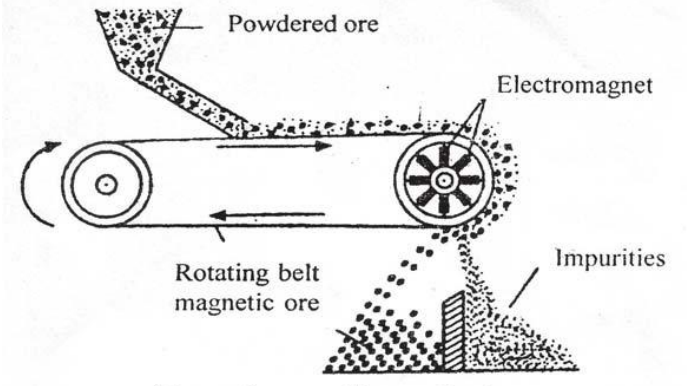
(a) **Polling :** In blister copper some metal oxides are present in small quantity. To purify this blister copper is fused (melted) and is churned with logs of green wood. The gaseous hydrocarbon present in logs of green wood reduces copped oxide to copper.

(b) **Electrolytic refining :** Pure copper is obtained by electrolytic refining process. Acidic copper sulphate is taken in an electrolytic cell, impure copper rod act as an anode while the pure copper rod act as a cathode. On providing electric current pure copper is collected on cathode while the impurities remains at the anode as anode mud. Copper obtained by this method is nearly 100 percent pure.

- **Extraction of iron :** This metal is found mainly in the form of oxides. For its extractor mainly or carbonate ores are used process is completed in following steps.

(i) **Grinding of ores :** With the help of crusher ores, obtained from mines, are crushed into small pieces afterwards with the help of stamp mill, it is converted into fine powder.

(ii) **Concentration :** concentration of ore is done by magnetic separation method.



Magnetic seperation method

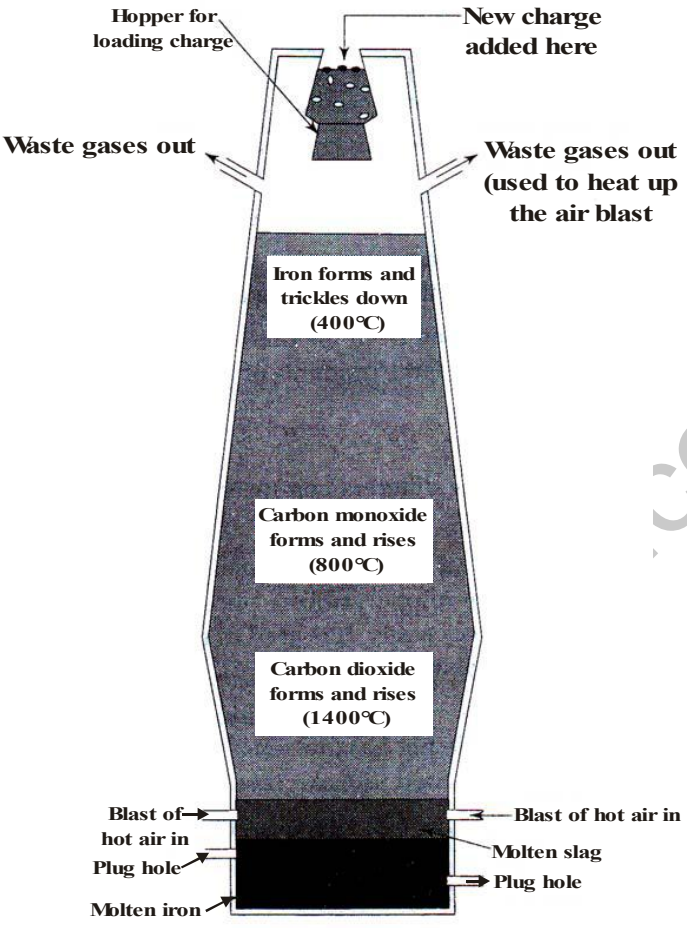
(iii) **Roasting :** Concentrated ore is subjected to roasting process in a reverberatory furnace carbon, phosphorus, sulphur arsenic etc. are present as impurities. Due to roasting the volatile substances like sulphur dioxide, phosphorus penta oxide and oxide of antimony and arsenic are removed from the ores and due to excess of roasting ferrous oxide is converted into ferric oxide.

(iv) **Smelting :** Smelting of roasted ore is done in blast furnace. Blast furnace plays a very important role in the metallurgy of iron. For this process, blast furnace of 80-100 feet height and internal diameter of 20-25 feet is used.

From top of the furnace charge (iron ore, coke and small amount of lime stone) is introduced. The temperature of the furnace have increase from top to bottom. Tuyeres are present from which hot air is blown due to which coke on combustion produces carbon monoxide, which converted ore into metal.

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

Thus iron is collected a bottom and impurities of silica, carbon and phosphorous get dissolved in it.



Extraction of iron by blast furnace process

Function of limestone ($CaCO_3$) : Due to the action of heat, limestone decomposes to calcium oxide and carbon dioxide.

$$\underset{\text{(limestone)}}{CaCO_3} \xrightarrow{\Delta} \underset{\text{(calcium oxide)}}{CaO} + CO_2$$

The silica impurity of the iron ore reacts with the calcium oxide obtained from lime stone to form molten calcium silicate, reffered to as slag.

$$\underset{\text{(flux)}}{CaO} + SiO_2 \longrightarrow \underset{\text{(slag)}}{CaSiO_3}$$

Molten slag floats over molten iron at the bottom of the furnace.

As extraction proceeds, more and more limestone, ore and coke are fed into the top of the furnace and the molten slag and iron are tapped off at the bottom.

The iron obtained from the blast furnace is called cast iron or pig iron. It is brittle due to the presence of large amounts of carbon and other dissolved impurities.

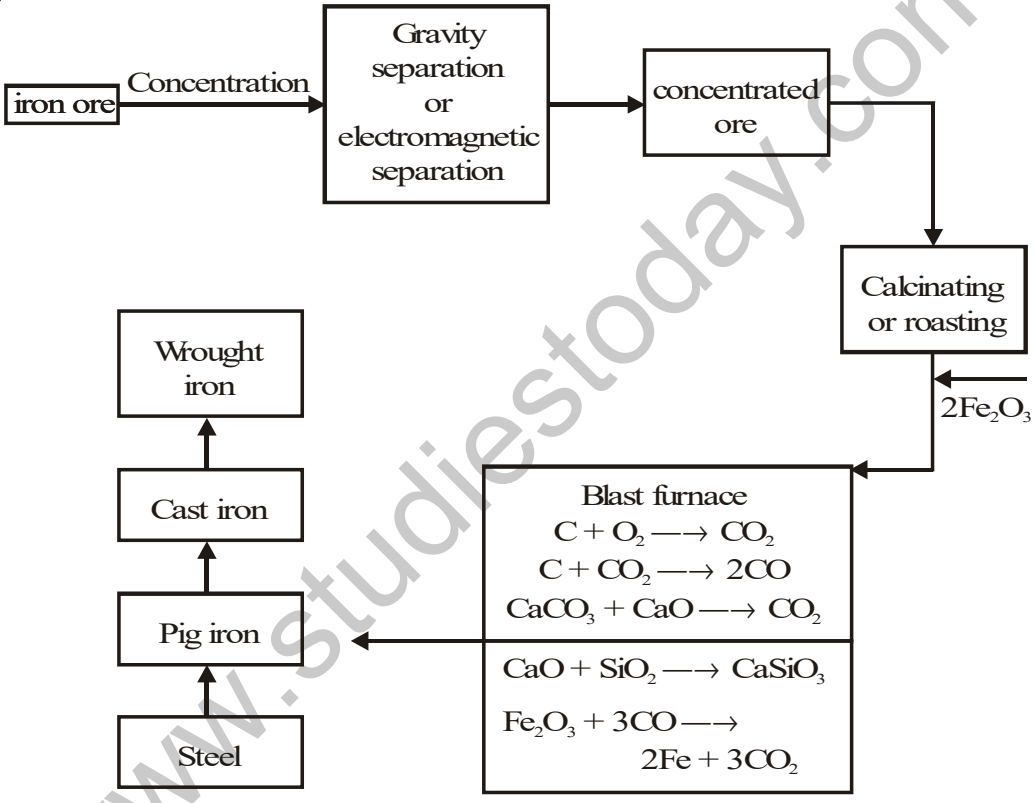
COMMERCIAL FORMS OF IRON

There are three different commercial forms of iron. They are cast iron, wrought iron and steel.

Cast iron : Cast iron is the cheapest form of iron. It contains 2.5-5% carbon and other impurities like sulphur, silicion, phosphorus, etc. It is brittle and has a low tensile strength. It rusts easily. It is used to make articles like manhole lids, radiators, railings, etc, and in making steel.

Wrought iron : It is the purest form of iron containing about 0.2% carbon. It is malleable and ductile but has low tensile strength than steel It can be welded and does not rust easily. It is used to make cores of electromagnets, iron nails, pipes, bolts, gates, etc.

Steel : Steel is an alloy of iron with 0.1-1.5% of carbon. It is prepared by mixing molten iron with scrap iron and limestone. The charge is heated in an oxygen converter and oxygen is blown into the molten mixture. Limestone converts the impurities into slag and most of the carbon escapes as carbon dioxide.



Flow chart for the extraction of iron

ALUMINIUM

Aluminium is the most abundant element in the earth's crust. The important ores of aluminium are –

(i) Bauxite – $Al_2O_3 . 2H_2O$ (ii) Corundum – Al_2O_3 (iii) Cryolite – Na_3AlF_6 (iv) kaolin – $Al_2Si_2O_7 .2H_2O$

Aluminium is chiefly extracted from bauxite ore.

- Crude bauxite is crushed, ground, dried and heated with concentrated caustic soda solution (naOH). Bauxite dissolves in NaOH forming sodium aluminate solution. The undissolved impurities are filtered off.

$$\underset{\text{(bauxite)}}{Al_2O_3} + 2NaOH \longrightarrow \underset{\text{(sodium aluminate)}}{2NaAlO_2} + H_2O$$

- Sodium aluminate solution is diluted with water and treated with a little aluminium hydroxide to cause precipitate formation. Hydrolysis takes place and a white precipitate of $Al(OH)_3$ is formed.

$$NaAlO_2 + 2H_2O \xrightarrow{\text{hydrolysis}} \underset{\text{(white ppt.)}}{Al(OH)_3\downarrow} + NaOH$$

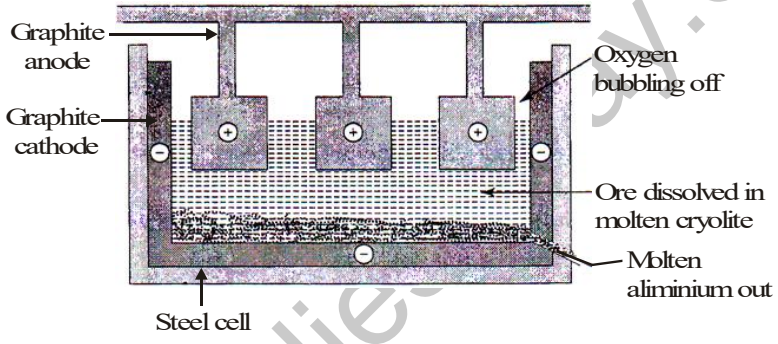
- The aluminium hydroxide precipitate is filtered, washed, then heated to get pure aluminium oxide (alumina).

$$2Al(OH)_3 \xrightarrow{\Delta} \underset{\text{(Alumina)}}{Al_2O_3} + 3H_2O$$

- Electrolytic reduction of alumina

Aluminium is extracted from alumina by electrolysis. Alumina (Al_2O_3) is mixed with a calculated quantity of cryolite (Na_3AlF_6) and melted in an iron cell. Pure alumina melts at 2045°C. So, cryolite is added to lower its melting point.

The iron cell is lined with carbon, which acts as the cathode. Graphite rods acts as the anode. Electric current is passed through the circuit (Fig). Molten aluminium is liberated at the cathode and sinks to the bottom of the cell from where it is removed. Oxygen gas is liberated at the anode.



Electrolytic reduction of alumina

$$2al_2O_3 \xrightarrow{\text{electrolysis}} 4Al + 3O_2$$

As the metal is removed, fresh amounts of pure alumina are added. The anode has to be replaced from time to time, because oxygen gas attacks the graphite anodes and eats them away.

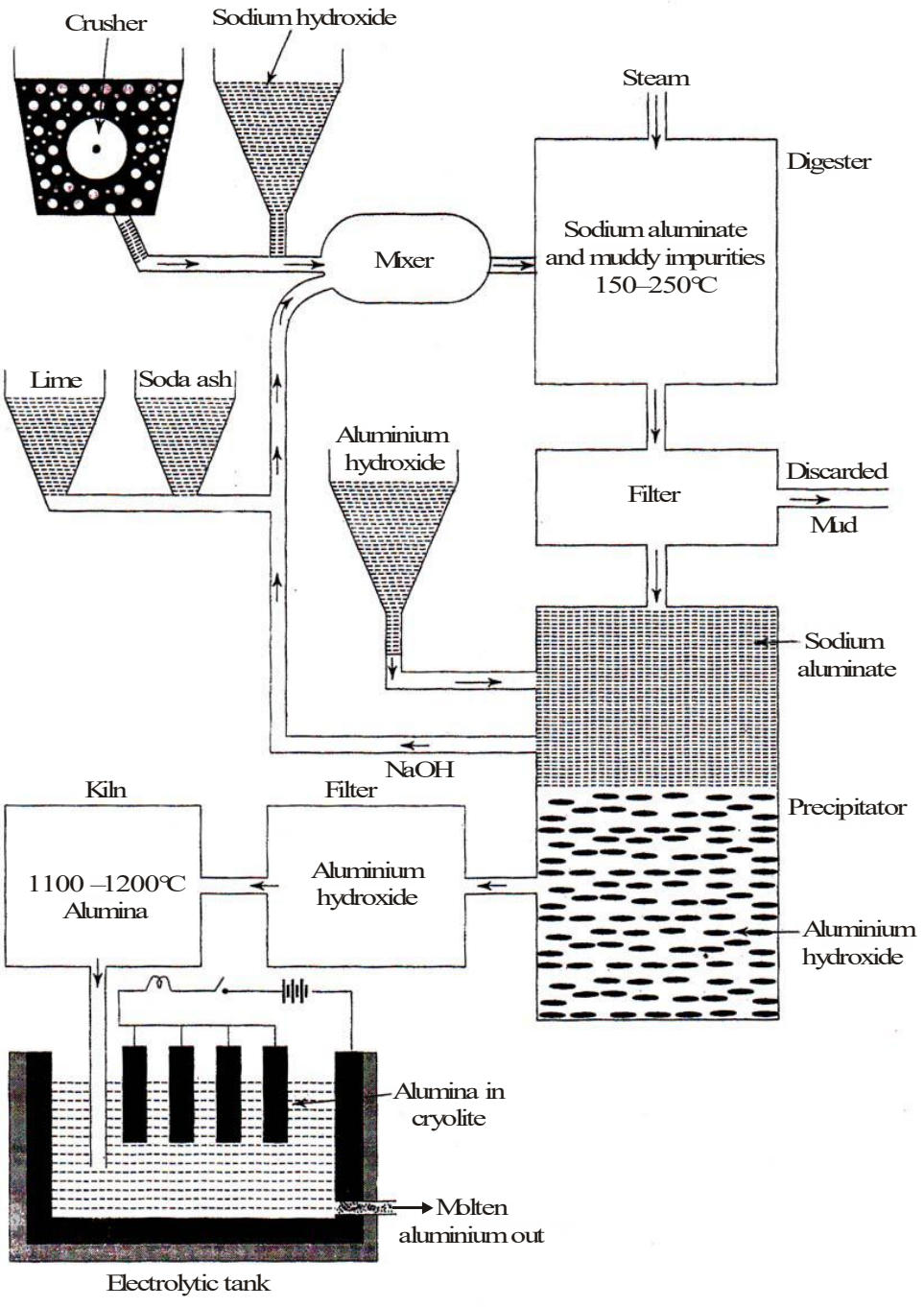
Uses of aluminium

1. It is used for making electrical wires and cables.
2. It is used as a reducing agent in metallurgy.
3. It is used for making cooking utensils, foils, saucepans, TV aerials, ships, aeroplanes and even space rockets.
4. It is used for making silver paints and mirros.
5. It is used in making alloys, such as duralumin and magnalium, which are used for making aircraft bodies.

DO YOU KNOW

Thermit Welding

Aluminium and iron are involved in competition reaction to repair railway tracks. Aluminium and iron (III) oxide are being heated together, to give molten iron. This is run into gaps between railways lines. The process iscalled thermit welding.



Flow chart for the extraction of aluminium

Quick Revision

- Metal and non-metal elements are classified according to their physical and chemical properties.
- Reactive metals do not naturally ocur in their pure state.
- Gold and platinum are non-reactive, as such occur in their pure from.
- Metals are malleable, ductile and have lustre, high specific gravity and refractivity to light.
- Metals are good conductor of heat and electricity.
- All metals are solid except mercury, which is a liquid.
- Metals have mostly high melting point.
- Tungsten has high tensile strength.
- Non-metals are mostly poor conductor of heat and electricity.
- Non-metals have generally low melting point.
- Gallium has very low melting point and seven melts in hand.
- Iodine is denser than many metals.
- Sodium is very soft and can be cut by a knife.
- Graphite though being a non-metal, is a good conductor of electricity.
- When metallic magnesium is burnt, it forms basic oxide, white non-metallic sulphur forms acidic oxide.
- Most metals when burnt combine with oxygen to form basic oxides and non-metals form acidic oxides.
- Most metals when burnt combine with oxygen to form basic oxides and non-metals form acidic oxides.
- Copper is non-magnetic while iron is magnetic.
- Gold and platinum do not react with air, water and acids, thus called 'noble metals'.
- Sodium is very reactive in air, therefore, kept in kerosene.
- Sodium reacts with cold water to form sodium hydroxide and hydrogen.
- Magnesium reacts violently with steam but mildly with cold water.
- Most metals react with acids to form salts and hydrogen.
- Copper cannot displace iron in iron compounds.
- Iron, magnesium and zinc are more reactive than copper.
- More reactive metals have high tendency to form compounds.
- More reactive metals displace less reactive metals form their salt solutions, but less reactive metals cannot displace more reactive metals.
- Titanium is highly resistant to corrosion and is very strong.
- Some metals react with acids (hydrochloric acid) and displace the hydrogen atom from their molecules.
- Air and water or moisture are necessary for corrosion to take place.

SUMMATIVE EXERCISE

1. Which is the most reactive metal of the following ?

(A) Copper (B) Sodium (C) Calcium (D) Iron

2. Malleability is the characteristic property of :-

(A) Silver (B) Mercury (C) Plastic (D) Potassium

3. Which of the following can be beaten into thin sheet:-

(A) Coal (B) Phosphorus (C) Aluminium (D) Sulphur

4. Sulphur dioxide (SO_2) is :-

(A) Acidic oxide (B) Basic oxide (C) Neutral oxide (D) None of these

5. Which of the following is a property of non-metals?

(A) Low melting points (B) Poor conductor of electricity

(C) Low densities (D) All of these

6. The non-metals having shining surface is :-

(A) Carbon (B) Sulphur (C) Iodine (D) Phosphorus

7. Carbon monoxide is a/an :-

(A) Acidic oxide (B) Basic oxide (C) Amphoteric oxide (D) Neutral oxide

8. Which among the following elements is metalloid:-

(A) Beryllium (B) Barium (C) Boron (D) Bismith

9. The metal which is soft and can be cut with a knife is :-

(A) Zinc (B) Copper (C) Sodium (D) Magnesium

10. Which metal is found in the liquid state at room temperature ?

(A) Zinc (B) Magnesium (C) Calcium (D) Mercury

11. The metal which can replaces copper from its salt solution is :-

(A) Silver (B) Mercury (C) Zinc (D) Gold

12. The metal which does not react with air :-

(A) Sodium (B) Calcium (C) Gold (D) Aluminium

13. Which of the following is best conductor of heat and electricity :-

(A) Silver (B) Copper (C) Aluminium (D) Iron

14. The non-metal which is liquid at room temperature is :-

(A) Chlorine (B) Fluorine (C) Bromine (D) Iodine

15. Antimony and arsenic are category of ..... :-

(A) Metal (B) Non-metal (C) Metalloid (D) Mineral

16. The non-metal which is used for the manufacture of fertilizers is :-

(A) Chlorine (B) Sulphur (C) Phosphorus (D) None of these

WHICH OF THE FOLLOWING STATEMENT IS CORRECT

(i) All non-metals are ductile.

(ii) Metals are good conductors of heat and electricity.

(iii) Non-metals are used in water purification.

(iv) Hydrogen is a gas that burns with a 'pop' sound.

(v) Phosphorus catches fire, when exposed to air.

(vi) The oxides of non-metals are basic.

(vii) The coal, pencil lead and plastic show the property of malleability.

(viii) The metal produce a ringing sound.

(ix) The oxide of magnesium is acidic in nature.

(x) Metal react with sodium hydroxide to produce hydrogen gas.

(xi) The zinc metal replaces the iron metal from its salt solution.

FILL IN THE BLANKS

1. Iron is ..... reactive than copper.
2. Metals react with acids to produce ..... gas.
3. Copper does not react with ..... acid.
4. ..... is used in crackers.
5. Phosphorus is stored in .....
6. ..... non-metal is catches fire if exposed to air,
7. Sulphurous acid turns ..... litmus paper .....
8. When a copper vessel is exposed to moist air for long time. It acquires ..... coating.
9. Metallic oxides are ..... in nature.
10. The iron nail and the aluminium wire ..... on beating.
11. Metals are ..... conductors of heat and .....

MARK 'T' IF THE STATEMENT IS TRUE AND 'F' IF IT IS FALSE

1. Coal can be drawn into thin wire.
2. Phosphorous is a very reactive non-metal.
3. Aluminium foils are used to wrap food items.
4. Calcium is stored in kerosene.
5. Generally, non-metals react with acid.
6. Metals can gain electrons to form negative ion.
7. Platinum can not affected by air and water.
8. Metals and non-metals are separated by a zig-zag line.

MATCH THE FOLLOWING

Math the substances given in column A with their uses given in column B.

	Column-A		Column-B
(A)	Gold	(i)	Antiseptic
(B)	Silver	(ii)	Dry lubricant
(C)	Aluminium	(iii)	Jewellery
(D)	Carbon	(iv)	Decorating sweets
(E)	Mercury	(v)	Wrapping food
(F)	Copper	(vi)	Fuel
(G)	Zinc	(vii)	Electric wire
(H)	Silicon	(viii)	Thermometers
(I)	Graphite	(ix)	Semi-conductors
(J)	Sulphur	(x)	Galvanisation

VERY SHORT ANSWER TYPE QUESTIONS

1. Which property of metals makes them suitable for use in jewellary ?
2. Name two non-metals which oxides are acidic in nature.
3. Name two oxides which are neutral in nature.
4. Name one non-metal which is liquid at room temperature.
5. Name the metal that burns in air with a brilliant white flame.
6. Which is more metallic : Potassium or aluminium ? Give reason.

SHORT ANSWER TYPE QUESTIONS

1. Give reason for the following :-
   (a) Electrical wires cannot be made out of sulphur. Why ?
   (b) Copper cannot displace zinc from its salt solution. Why ?
   (c) Phosphorus is stored in water why ?
   (d) What happens, when metals react with alkali?
   (e) What happens when CO_2 is dissolved in water ?
   (f) Metals are electropositive in nature, why ?
   (g) Complete the following equation :

   $Na_2O + H_2O \longrightarrow$

LONG ANSWER TYPE QUESTIONS

1. What happens when iron nails are placed in copper sulphate solution ? Write word equations of the reactions involved.
2. What happens when dilute sulphuric acid is poured on a copper plate ?
3. What is the nature of Na_2O ? What happens when it is dissolve in water ? Write equation.
4. State three reasons for believing that sodium is a metal.
5. Differentiate between metals and non-metals.
6. Write a short note on the physical properties of non-metals.
7. What is the action of water on :

   (i) Magnesium (ii) Sodium (iii) Iron

METALS & NON-METALS — ANSWER KEY — EXERCISE

1. B **2.** A **3.** C **4.** A **5.** D **6.** C **7.** D **8.** C **9.** C **10.** D

11. C **12.** C **13.** A **14.** C **15.** C **16.** C

Correct statement

1. (ii), (iii), (iv), (v), (xiii), (x) and (xi)

Fill in the Blanks

1. More **2.** H_2 **3.** Dil HCl/H_2SO_4 **4.** Phosphorus **5.** Water **6.** Phosphorus
7. Blue, red **8.** Dull green **9.** Acidic **10.** Change their shape

11. Good, electricity

Mark 'T' if the statement is true and 'F' if it is false

1. F **2.** T **3.** T **4.** F **5.** F **6.** F **7.** T **8.** T

Match the following

(A) → (iii) ; (B) → (iv) ; (C) → (v) ; (D) → (vi) ; (E) → (viii) ; (F) → (vii) ; (G) → (x) ; (H) → (ix) ; (I) → (ii) ; (J) → (i)

Very short answer type:

1. Ductility **2.** Sulphur and phosphorus **3.** Carbon monoxide (CO), N_2O

4. Bromine (Br) **5.** Mg **6.** K

Short answer type

(a). Because sulphur is a non-metal. It can not show the property of ductility due to brittleness.

(b). Cu is a less reactive metal than Zn.

(c). Due to high reactivity.

(d). H_2 gas is evolved.

(e). Carbonic acid is formed.

(f). Because metals lose their electrons easily to get inert gas configuration.

(h). $Na_2O + H_2O \longrightarrow 2NaOH$

1. Who classified the elements in metals and non-metals?

(A) Lavoisier (B) Priestley (C) Lemaitre (D) Lenoir

2. Which of the following metals occur in their pure state?

(A) Copper (B) Iron (C) Zinc (D) Gold

3. Which of the following metals is liquid at room temperature?

(A) Sodium (B) Mercury (C) Zinc (D) Aluminium

4. Which of the following is a good conductor of heat?

(A) Bromine (B) Chlorine (C) Mercury (D) Iodine

5. Which of the following non-metals occurs as liquid?

(A) Bromine (B) Sulphur (C) Iodine (D) Carbon

6. Which of the following non-metals occurs as a solid?

(A) Sulphur (B) Carbon (C) Iodine (D) All of the above

7. Which of the following non-metal occurs as a gas?

(A) Nitrogen (B) Chlorine (C) Both the above (D) None of the above

8. Which of the following metals has very low melting point and melts even in hand?

(A) Sodium (B) Gallium (C) Potassium (D) Graphite

9. Which of the following is lighter than water?

(A) Potassium (B) Sulphur (C) Iodine (D) Graphite

10. Which of the following is denser than many metals?

(A) Bromine (B) Chlorine (C) Sulphur (D) Iodine

11. Which non-metal is a good conductor of electricity?

(A) Bromine (B) Iodine (C) Graphite (D) Chlorine

12. Magnesium oxide is –

(A) Basic oxide (B) Acidic oxide (C) Neutral oxide (D) None of these

13. Sulphur dioxide is –

(A) Basic oxide (B) Acidic oxide (C) Neutral oxide (D) None of these

14. Which of the following is a noble metal?

(A) Copper (B) Iron (C) Gold (D) Aluminium

15. When medium reacts with cold water, it forms –

(A) Sodium hydroxide and oxygen

(B) Sodium hydroxide and hydrogen

(C) Sodium hydroxide and carbon dioxide

(D) None of these

16. Which of the following is very reactive and kept in kerosene?

(A) Iodine (B) Bromine (C) Sodium (D) Potassium

17. Which of the following reacts violently with steam?

(A) Iron (B) Zinc (C) Magnesium (D) None of these

18. Which metal reacts with dilute hydrochloric acid to produce hydrogen?

(A) Zinc (B) Copper (C) Iron (D) Platinum

19. When iron nail reacts with copper sulphate solution, the reaction is called –

(A) Displacement reaction (B) Replacement reaction

(C) Reduction reaction (D) None of these

20. When iron nail is placed in copper sulphate solution, the bluish colour of copper sulphate turns –

(A) Brownish (B) Yellowish (C) Greenish (D) Colourless

21. When zinc is put in copper sulphate solution, the colour of copper sulphate becomes –

(A) Greenish (B) Yellowish (C) Brownish (D) Colourless

22. Which metals have tendency to form compounds?

(A) More reactive metals (B) Less reactive metals

(C) Both the above (D) None of these

23. Corrosion is a –

(A) Reduction reaction (B) Oxidation reaction

(C) Redox reaction (D) Displacement reaction

24. Which of the following is a magnetic metal?

(A) Copper (B) Aluminium (C) Iron (D) All the above

25. Which of the following is highly resistant to corrosion?

(A) Iron (B) Copper (C) Aluminium (D) Titanium

OBJECTIVE **ANSWER KEY** EXERCISE -2

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	A	D	B	C	A	D	C	B	A	D	C	A	B	C	B
Que.	16	17	18	19	20	21	22	23	24	25					
Ans.	C	C	A	A & B	C	D	A	B	C	D					

EXERCISE-3 SOLVED QUESTIONSBASED ON NCERT

1. Which of the following can be beaten into thin sheets?

(A) Zinc (B) Phosphorus (C) Sulphur (D) Oxygen

Ans. (A) Zinc

2. Which of the following statements is correct?

(A) All metals are ductile (B) All non-metals are ductile.

(C) Generally, metals are ductile. (D) Some non-metals are ductile.

Ans. (C) Generally, metals are ductile.

3. Fill in the blanks.

(i) Phosphorus is a very ..... non-metal.

(ii) Metals are ..... conductors of heat and .....

(iii) Iron is ..... reactive than copper.

(iv) Metals react with acids to produce ..... gas.

Ans. (i) Reactive (ii) Good, electricity (iii) More (iv) Hydrogen

4. Mark 'T' if the statement is true and 'F' if it is false.

(i) Generally, non-metals react with acids.

(ii) Sodium is a very reactive metals.

(iii) Copper displaces zinc from zinc sulphate solution

(iv) Coal can be drawn into wires.

Ans. (i) F (ii) T (iii) F (iv) F

5. Some properties are listed in the following table. Distinguish between metals and non-metals on the basis of these properties.

S.No.	Properties	Metals	Non-metals
1	Appearance		
2	Hardness		
3	Malleability		
4	Ductility		
5	Heat conduction		
6	Conduction of Electricity		

Ans.

S.No.	Properties	Metals	Non-metals
1	Appearance	have metallic lustre	non-metals are dull
2	Hardness	hard	soft
3	Malleability	malleable	non-malleable
4	Ductility	ductile	not-ductile
5	Heat conduction	good conductors	bad conductor
6	Conduction of Electricity	good conductors	bad conductor/ insulator

6. **Give reasons for the following :**

(i) **Aluminium foils are used to wrap food items**

(ii) **Immersion rods for heating liquids are made up of metallic substances.**

(iii) **Copper cannot displace zinc from its salt solution**

(iv) **Sodium and potassium are stored in kerosene.**

Ans. (i) Aluminium is highly malleable metal and it is very easy to make aluminium foil in compare to other metals.

(ii) Immersion rods are made up of metallic substances because metals are good conductors of heat and electricity.

(iii) Copper cannot displace zinc from its solution because zinc is more reactive than copper (i.e., copper is less reactive than zinc.)

(iv) Sodium and potassium metals are very reactive because they react with oxygen and water easily. A lot of heat is produced in the reaction so sodium and potassium are always stored and kerosene.

7. **Can you store lemon pickle in an aluminium utensil? Explain.**

Ans. No. this is because acids react with aluminium.

8. **Match the substances given in Column-A with their uses given in Column-B.**

S.No.	A	B
1	Gold	Thermometers
2	Iron	Electric wire
3	Aluminium	Wrapping food
4	Carbon	Jewellery
5	Copper	Machinery
6	Mercury	Fuel

Ans.

S.No.	A	B
1	Gold	Jewellery
2	Iron	Machinery
3	Aluminium	Wrapping food
4	Carbon	Fuel
5	Copper	Electric wire
6	Mercury	Thermometers

9. **What happens when**

(i) **Dilute sulphuric acid is poured on a copper plate?**

(ii) **Iron nails are placed in copper sulphate solution?**

Write word equations of the reactions involved.

Ans. (i) Copper sulphate is formed and hydrogen gas is liberated.

Copper + Sulphuric acid ⟶ Copper sulphate + Hydrogen (gas)

(ii) Brown coating is deposited on the iron nails. This is because of the displacement of copper from copper sulphate solution by iron.

Iron + Copper Sulphate (solution) ⟶ Iron sulphate (solution) + Copper

10. Saloni took a piece of burning charcoal and collected the gas evolved in a test tube.

(i) How will she find the nature of the gas?

(ii) Write down word equations of all the reactions taking place in this process.

Ans. (i) She will bring a wet litmus paper in contact with the gas. If the gas turns wet blue litmus paper into red, the gas will be acidic.

(ii) (a) Carbon + Oxygen $\longrightarrow$ Carbon dioxide.

(b) Carbon dioxide + Water $\longrightarrow$ Carbonic acid. (from wet litmus)

11. One day Reeta went to a jeweller's shop with her mother. Her mother gave an old gold jewellery to the goldsmith to polish. Next day when theybrought the jewellery back, they found that there was slight loss in its weight. Can you suggest a reason for the loss in weight?

Ans. The jeweller dip the jewellery in the solution of acid, which reacts with the outer covering of metals. Thus there is a net loss of weight in the metal of the ornament.

Metals and Non-metals (Supplement)

List of Common Ions/ Radicals with Positive Valency

Positive Valency 1	Symbol	Positive Valency 1	Symbol
1. Ammonium	NH_4^+	2. Hydrogen	H^+
3. Lithium	Li^+	4. Sodium	Na^+
5. Potassium	K^+	6. Cuprous [Copper (I)]	Cu^+
7. Argentous [Silver (I)]	Ag^+	8. Mercurous [Mercury (I)]	Hg^+
9. Aurous [Gold (I)]	Au^+		

Positive Valency 2	Symbol	Positive Valency 2	Symbol
1. Magnesium	Mg^{2+}	2. Calcium	Ca^{2+}
3. Zinc	Zn^{2+}	4. Barium	Ba^{2+}
5. Nickel	Ni^{2+}	6. Uranium	U^{2+}
7. Cupric [Copper (II)]	Cu^{2+}	8. Argentic [Silver (II)]	Ag^{2+}
9. Mercuric [Mercury (II)]	Hg^{2+}	10. Ferrous [Iron (II)]	Fe^{2+}
11. Plumbous [Lead (II)]	Pb^{2+}	12. Stannous [Tin (II)]	Sn^{2+}
13. Platinous [Platinum (II)]	Pt^{2+}		

Positive Valency 3	Symbol	Positive Valency 3	Symbol
1. Aluminium	Al^{3+}	2. Chromium	Cr^{3+}
3. Bismuth	Bi^{3+}	4. Arsenic	As^{3+}
5. Ferric [Iron (III)]	Fe^{3+}	6. Auric [Gold (III)]	Au^{3+}

Positive Valency 4	Symbol	Positive Valency 4	Symbol
1. Stannic [Tin (IV)]	Sn^{4+}	2. Plumbic [Lead (IV)]	Pb^{4+}
3. Platinic [Platinum (IV)]	Pt^{4+}		

List of Common Ions/ Radicals with Negative Valency

Negative Valency 1	Symbol	Negative Valency 1	Symbol
1. Flouride	F^-	2. Chloride	Cl^-
3. Bromide	Br^-	4. Iodide	I^-
5. Hypochlorite	ClO^-	6. Chlorate	ClO_3^-
7. Bicarbonate or Hydrogen carbonate	HCO_3^-	8. Bisulphite or hydrogen sulphite	HSO_3^-
9. Bisulphide or hydrogen sulphide	HS^-	10. Bisulphate or hydrogen sulphate	HSO_4^-
11. Hydride	H^-	12. Hydroxide	OH^-
13. Auminate	AlO_2^-	14. Permanganate	MnO_4^-
15. Cyanide	CN^-	16. Nitrite	NO_2^-
17. Nitrate	NO_3^-	18. Acetate	CH_3COO^-

Negative Valency 2	Symbol	Negative Valency 2	Symbol
1. Sulphate	SO_4^{2-}	2. Sulphite	SO_3^{2-}
3. Sulphide	S^{2-}	4. Thiosulphate	$S_2O_3^{2-}$
5. Zincate	ZnO_2^{2-}	6. Plumbate	PbO_2^{2-}
7. Oxide	O^{2-}	8. Peroxide	O_2^{2-}
9. Manganate	MnO_4^{2-}	10. Dichromate	$Cr_2O_7^{2-}$
11. Carbonate	CO_3^{2-}	12. Silicate	SiO_3^{2-}
13. Stannate	SnO_3^{2-}	14. Oxalate	$(COO)_2^{2-}$

Negative Valency 3	Symbol	Negative Valency 3	Symbol
1. Nitride	N^{3-}	2. Phosphide	P^{3-}
3. Phosphite	PO_3^{3-}	4. Phosphate	PO_4^{3-}

Negative Valency 4	Symbol
1. Carbide	C^{4-}