Metals and Non-Metals

Metals

Those elements which forms positive ions by losing electrons are called metals. e.g. copper, iron, aluminium, sodium etc.

Important Physical Properties of Metals

(i) **Physical State** All the metals except mercury exist in the solid state at room temperature.

(ii) **Lusture** All the metals have a shiny appearance. This shiny appearance is known as metallic lusture, so metals are used for making jewellery and decorations.

(iii) **Malleability** The property of beating a metal with hammer into sheets is called malleability. Gold and silver are most malleable metals.

(iv) **Ductility** The property that allows metals to be drawn into wires is called ductility. Gold and silver are most ductile metals. Copper and aluminium wires are used in electric fittings.

(v) **Conductivity** Metals are good conductor of heat and electricity. They quickly transmit heat from one end to the other. Silver is the best conductor followed by gold, copper and aluminium. Lead (Pb) is the poorest conductor of heat.

(vi) **Hardness** Metals are usually hard. It is therefore, difficult to cut them but sodium, potassium and magnesium are soft metals and thus, they are easily cut with knife.

(vii) **Melting and Boiling Points** Metals generally have high melting and boiling points but sodium and potassium metals have low melting and boiling points.

Reactivity Series of Metals

- The arrangement of metals in order of decreasing reactivities is called reactivity or activity series. In this series, the most reactive metal is placed at the top whereas the least reactive metal is placed at the bottom.
- As we go down the series, the chemical reactivity of metals decreases.
- All metals which are placed above hydrogen in the activity series, can lose electrons more readily than hydrogen. These metals are called more reactive than hydrogen.
- On the other hand, all metals which are placed below hydrogen in the reactivity series lose electrons less readily than hydrogen and hence, they are regarded as metals less reactive than hydrogen.

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

- Due to their high reactivity potassium and sodium react with moisture present in air. Hence, these are kept submerged in kerosene oil.
- Due to their low reactivity copper, silver, gold, etc., usually do not react with acid.

Important Chemical Properties of Metals

(i) Reaction with Oxygen

Metals react with oxygen to form oxides these oxides are alkaline or basic in nature.

$$\underset{\text{(Sodium reacts vigorously)}}{4Na} + \underset{\text{(Oxygen)}}{O_2} \longrightarrow \underset{\text{(Sodium oxide)}}{2Na_2O}$$

$$\underset{\text{(Magnesium) (Metal)}}{2Mg} + \underset{\text{(Oxygen)}}{O_2} \longrightarrow \underset{\text{(Magnesium oxide) (Basic oxide)}}{2MgO}$$

$$\underset{\text{(Aluminium)}}{4Al} + \underset{\text{(Oxygen)}}{3O_2} \longrightarrow \underset{\text{(Aluminium oxide)}}{2Al_2O_3}$$

$$\underset{\text{(Iron)}}{4Fe} + \underset{\text{(Oxygen)}}{3O_2} \longrightarrow \underset{\text{(Ferric oxide)}}{2Fe_2O_3}$$

(ii) Reaction with Water

Different metals behave differently in their reaction with water and evolve hydrogen. Sodium reacts violently with water.

$$\underset{\text{(Sodium)}}{2Na} + \underset{\text{(Water)}}{2H_2O} \longrightarrow \underset{\text{(Sodium hydroxide)}}{2NaOH} + \underset{\text{(Hydrogen)}}{H_2}$$

$$\underset{\text{(Magnesium)}}{Mg} + \underset{\text{Hot water}}{2H_2O} \longrightarrow \underset{\text{(Magnesium hydroxide)}}{Mg(OH)_2} + \underset{\text{(Hydrogen)}}{H_2}$$

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Steam)}}{H_2O} \longrightarrow \underset{\text{(Zinc oxide)}}{ZnO} + \underset{\text{(Hydrogen)}}{H_2}$$

$$\underset{\text{(Aluminium)}}{2Al} + \underset{\text{(Boil water)}}{6H_2O} \longrightarrow \underset{\text{(Aluminium hydroxide)}}{2Al(OH)_3} + \underset{\text{(Hydrogen)}}{3H_2}$$

Copper (Cu), silver (Ag) and gold (Au) being least reactive metals do not react with water.

(iii) Reaction with Acids

- Metals which are more reactive than hydrogen, evolve hydrogen on reaction with acids. Copper, silver and gold do not react with dilute hydrochloric acid but copper reacts with sulphuric acid and nitric acid.
- Although with nitric acid, metals (except magnesium and manganese) do not evolve hydrogen.

$$\underset{\text{(Magnesium)}}{Mg} + \underset{\text{(Hydrochloric acid)}}{2HCl} \longrightarrow \underset{\text{(Magnesium choride)}}{MgCl_2} + \underset{\text{(Hydrogen)}}{H_2}$$

$$\underset{\text{(Sodium)}}{2Na} + \underset{\text{(Hydrochloric acid)}}{2HCl} \longrightarrow \underset{\text{(Sodium chloride)}}{2NaCl} + \underset{\text{(Hydrogen)}}{H_2}$$

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Hydrochloric acid)}}{2HCl} \longrightarrow \underset{\text{(Zinc chloride)}}{ZnCl_2} + \underset{\text{(Hydrogen)}}{H_2}$$

(iv) Replacement Reactions

A more reactive metal can replace less reactive metals from their salt solutions. Less reactive metals cannot replace more reactive metals.

$$\underset{\text{(Iron)}}{Fe} + \underset{\text{(Copper sulphate) (Blue)}}{CuSO_4} \longrightarrow \underset{\text{(Copper)}}{Cu} + \underset{\text{(Iron sulphate) (Green)}}{FeSO_4}$$

$$\underset{\text{(Magnesium)}}{Mg} + \underset{\text{(Copper sulphate) (Blue)}}{CuSO_4} \longrightarrow \underset{\text{(Magnesium sulphate)}}{MgSO_4} + \underset{\text{(Copper)}}{Cu}$$

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Copper sulphate) (Blue)}}{CuSO_4} \longrightarrow \underset{\text{(Zinc sulphate) (Colourless)}}{ZnSO_4} + \underset{\text{(Copper)}}{Cu}$$

Non-Metals

Those elements which form negative ions by gaining electrons are called **non-metals,** e.g. carbon, iodine, sulphur, oxygen, hydrogen etc. The non-metals are either solids or gases except bromine which is a liquid.

Physical Properties of Non-metals

(i) **Malleability and ductility** Non-metals are neither malleable nor ductile. However, diamond an allotropic form of carbon, is of ductile nature, since it is quite hard.

(ii) **Brittleness** Non-metals are brittle in nature. For instance, sulphur is a brittle solid. If it is hammered, it breaks into pieces.

(iii) **Physical state** Most of the non-metals are soft (if solid). Only diamond, an allotropic form of carbon is the hardest known substance.

(iv) **Lustre** Non-metals do not have lustre, i.e. shining surface. However, diamond, graphite (a form of carbon) and iodine have lustre, even though they are non-metals.

(v) **Electrical and thermal conductivity** Non-metals are generally poor conductors of heat and electricity. Graphite, another allotrope of carbon, is a conductor of electricity.

(vi) **Melting and boiling points** Generally, non-metals have low melting and boiling points. But non-metals that are solids have comparatively higher boiling points, e.g. B, Si, C etc.

The gases like nitrogen, oxygen, carbon dioxide etc., which constitute air are all poor conductors of electricity.

Chemical Properties of Non-metals

The chemical properties of non-metals is due to their electronegative nature, i.e. tendency to gain electrons in their valence shells to achieve the configuration of nearest noble gas elements.

$$\underset{\substack{\text{(Non-metal)}\\(2,\,4)}}{X} + 4e^- \longrightarrow \underset{(2,\,8)}{X^{4-}}$$

1. Reaction with Water

Non-metals do not react with water or steam to evolve hydrogen gas. This is because non-metals cannot give electrons to hydrogen in water therefore, hydrogen gas cannot be released.

2. Reaction with Acids

- Non-metals do not react with dilute acids to release hydrogen gas. The reason is that a non-metal is an electron acceptor, it cannot supply electrons to the H^+ ions of acids to reduce them to hydrogen gas.
- Thus, it cannot displace hydrogen gas from acids. But on heating with concentrated acids, these form oxides or salts.

$$S(s) + 2H_2SO_4(\text{conc.}) \xrightarrow{\text{Heat}} 3SO_2(g) + 2H_2O(l)$$

$$S(s) + 6HNO_3(\text{conc.}) \xrightarrow{\text{Heat}} H_2SO_4(aq) + \underset{\substack{\text{(Reddish}\\\text{brown vapour)}}}{6NO_2(g)} + 2H_2O(aq)$$

$$2P(s) + 5H_2SO_4(\text{conc.}) \xrightarrow{\text{Heat}} \underset{\text{Phosphoric acid}}{2H_3PO_4(aq)} + 5SO_2(g) + 2H_2O(aq)$$

$$P(s) + 5HNO_3(\text{conc.}) \xrightarrow{\text{Heat}} H_3PO_4(aq) + 5NO_2(g) + H_2O(l)$$

3. Displacement Reaction

Non-metals also show displacement reaction like metals.

e.g. $\underset{\text{Chlorine}}{Cl_2} + 2NaBr \longrightarrow 2NaCl + \underset{\substack{\text{Sodium}\\\text{bromide}}}{\underset{\substack{\text{Sodium}\\\text{chloride}}}{}} \underset{\text{Bromine}}{Br_2}$

Properties	Metals	Non-metals
Physical	• Metals are solid at room temperature except mercury.	• Non-metals may be solid, e.g., C, liquid, e.g., Br_2 or gases e.g., O_2, Cl_2 at room temperature.
	• They are lustrous.	• They are non-lustrous (except iodine).
	• They are malleable and ductile.	• They are non-malleable and non-ductile.
	• They are sonorous (produce ringing sound).	• They are non-sonorous.
	• They are good conductor of heat and electricity.	• They are bad conductor of heat and electricity (except graphite).
	• They have high tensile strength.	• They have low tensile strength.
	• They are usually hard.	• They are usually soft.
	• They are very strong.	• They are not very strong.
	• They have high melting and boiling points.	• They have low melting and boiling points.
Chemical	• They form basic oxides which on dissolving in water, forms base. $4Na + O_2 \longrightarrow 2Na_2O$ $Na_2O + H_2O \longrightarrow \underset{\text{base}}{2NaOH}$	• They form acidic and neutral oxides like CO_2, SO_2, (acidic) and CO, N_2O, NO (neutral), etc.
	• They displace hydrogen from acids.	• They do not displace hydrogen from acids.
	• They react with water to evolve hydrogen gas.	• They do not react with water to evolve hydrogen gas.

Corrosion

The wasting away of a metal layer-by-layer due to the formation of metal compounds on the surface is called corrosion. Corrosion in case of iron is called rusting. Iron is widely used metal. It corrodes faster when exposed to moist air. The presence of air (oxygen) and water is essential for rusting.

Prevention from Corrosion

Corrosion of metals can be prevented by following processes

(i) **Painting** The most common method of preventing corrosion is to coat the metals surface with paint.

(ii) **Greasing** A coat of oil or grease also protects metals from corrosion by air and moisture.

(iii) **Galvanisation** Another common method of protecting iron from rusting is to coat its surface with a thin layer of a non-corrosive metals like zinc. This process is called galvanisation.

(iv) **Electroplating** Iron and steel are protected from corrosion by coating them with a layer of tin or chromium metals which are resistant to corrosion. This is done by electroplating. A thin layer of tin, deposited on the inner surface of iron containers, makes them safe for storing food.

(v) **Alloying** Some metals when alloyed with other metals become more resistant to corrosion. e.g. iron when alloyed with chromium and nickel forms stainless steel. It is resistant to corrosion and does not rust at all.

Alloy	Percentage composition	Uses
Bronze	Cu = 89%, Sn = 11%	For making statues, coins, utensils etc.
Brass	Cu = 70%, Zn = 30%	For making utensils, parts of machinery, condenser tubes, wires, etc.
Duralumin	Al = 90%, Cu = 4%	Making parts of aeroplanes and automobiles, pressure cookers, etc.
Magnalium	Al = 95%, Mg = 5%	Balance beams, some light instruments.
Gun metal	Cu = 90%, Sn = 10%	For making gun barrels.
Bell metal	Cu = 80%, Sn = 20%	For making bells and gongs.
German silver	Cu = 60%, Zn = 20%, Ni = 20%	For making silverware, resistance wires.
Dental alloy	Ag = 34%, Hg = 53%, Sn = 12.5%, Cu = 2%, Zn = 0.5%	For filling cavities of teeth.
Solder	Pb = 50%, Sn = 50%	For soldering two metal or wires metal pieces.
Stainless steel	Fe = 73%, Cr = 18%	Utensils, cycle and automobile parts, shaving

Practice Exercise

1. All the ..... can be divided into two main groups, i.e. **metals** and **non-metals**. Metals can be distinguished from ..... on the basis of their physical and chemical properties. Properties of non-metals are ..... to those of metals.
Choose the correct order to fill up the blanks.
(a) matters, compounds, opposite
(b) elements, Compounds, similar
(c) elements, non-metals, opposite
(d) compounds, elements, similar

2. Which of the following statements is correct about metals?
(a) All metals are solid at room temperature.
(b) They are non-lustrous
(c) They are good conductor of heat
(d) They are usually soft

3. The substance the will be flattened on beating with a hammer is
(a) crystal of iodine (b) jump of sulphur
(c) piece of coal (d) zinc granule

4. Materials which can be drawn into wires are called ductile. Which of the following is not a ductile material?
(a) Silver (b) Copper
(c) Sulphur (d) Aluminium

5. Metals are generally hard. Which of the following metals is an exception and can be cut with a knife?
(a) Iron (b) Sodium
(c) Gold (d) Magnesium

6. Which of the following is very hard?
(a) Copper (b) Sodium
(c) Potassium (d) Coal

7. Most suitable metal for making jewellery is
(a) magnesium (b) gold
(c) iron (d) cooper

8. Which of the following is not true about metals?
(a) They are lustrous (b) They are brittle
(c) They are sonorous (d) They are ductile

9. A non-metal having metal like lusture is
(a) Sulphur (b) Carbon
(c) Iodine (d) phosphorus

10. Then non-metal which is liquid at room temperature is
(a) iodine (b) chlorine
(c) carbon (d) bromine

11. The good conductor of electricity is
(a) graphite (b) diamond
(c) phosphorus (d) carborundum

12. Which of the following elements is a metalloid?
(a) Lead (b) Tin
(c) Silicon (d) Barium

13. Identify the metal which is stored submerged in Kerosene.
(a) Iron (b) Sodium
(c) Aluminium (d) Sulphur

14. Metals generally react with dilute acids to produce hydrogen gas. Which one of the following metals does not react with dilute hydrochloric acid?
(a) Magnesium (b) Aluminium
(c) Iron (d) Copper

15. Which of the following reacts with cold water vigorously?
(a) Carbon (b) Sodium
(c) Magnesium (d) Sulphur

16. Which of the following elements catches fire when exposed to air?
I. Sodium II. Aluminium
III. Phosphorus IV. Sulphur
Choose the correct option.
(a) I and IV (b) II and IV
(c) I and III (d) II and III

17. Complete the following equation:
$Mg + CuSO_4 \longrightarrow ... + Cu$
(a) MgO (b) $MgSO_4$
(c) CuS (d) MgS

18. Which of the following metals does not react with water?
(a) copper (b) silver
(c) gold (d) All of these

19. Acid (like HCl) can be stored in vessel made up of
(a) aluminium (b) iron
(c) copper (d) zinc

20. Which of the following in not a use of aluminium?
(a) Making body of aeroplanes
(b) Making packaging materials for food items.
(c) Making electric wires
(d) Making pressure cooker.

Answers

1.	*(c)*	2.	*(c)*	3.	*(d)*	4.	*(c)*	5.	*(b)*	6.	*(a)*	7.	*(b)*	8.	*(b)*	9.	*(c)*	10.	*(d)*
11.	*(a)*	12.	*(c)*	13.	*(b)*	14.	*(d)*	15.	*(b)*	16.	*(c)*	17.	*(b)*	18.	*(d)*	19.	*(c)*	20.	*(c)*