Metals

Non-Metals

Chemical Properties of Metals

Ionic Compounds

Covalent Compounds

Metallurgy (Extraction of Metals from Ores)

Corrosion

Alloy

Metals

The elements that lose electrons and form positive ions are called metals. They are also called electropositive elements. **For example:** lithium, sodium, potassium, magnesium, aluminium, copper gold, silver, etc.

Hydrogen is a nonmetal but it is placed in the in the group of metals because like metals it also loses electron and forms positive ion.

Physical properties of metals

Metals are malleable, ductile, hard, good conductors of heat and electricity, and sonorous. They are generally solids and have high melting and boiling points.

Lusture: The property of an element due to which it has a shiny appearance is called metallic lusture.

Malleability : The property of metals to be beaten into thin sheets is called malleability. Gold and silver are most malleable metals.

Ductility: The property of metals to be drawn into thin wires is called ductility. Gold is most ductile metal.

Sonority: The property of metals which produce a ringing sound when struck is called Sonority.

Thermal Conductivity: The property of the metals by which they conduct heat is called thermal conductivity. Generally, metals are good conductors of heat.

Electrical conductivity: the property of the metals by which they conduct electricity is called electrical conductivity. Generally, metals are good conductors of electricity.

Points to remember

- Mercury is metals which is liquid at room temperature.
- Gold and silver are most malleable
- Gold is the most ductile metal. Silver, copper and aluminium are next to gold.
- Are poor conductors of heat – lead and mercury
- sodium, potassium, lithium can be cut with knife
- Zinc is metal which is not malleable and ductile
- Gallium and cesium are metals but they have very low melting point
- The most abundant in earth crust is aluminium.
- Magnesium and manganese react with dil HNO_3.
- Gold, silver, platinum, lead and copper do not react with water.
- Aluminium, iron and zinc react with steam only .

- Gold, platinum, silver do not react with oxygen even at high temperature.

Non-metals

The elements that gain electrons and form negative ions are called nonmetals. They are also called electronegative elements. E.g. chlorine, sulphur, oxygen, bromine, phosphorus, nitrogen, etc.

Physical properties of Non-metals

- Nonmetals are not malleable and ductile but they are brittle.
- Nonmetals are solid, liquid and gas at room temperature.
- Nonmetals are not good conductors of heat and electricity.
- Nonmetals have low melting and boiling points.
- Nonmetals are soft.

Chemical properties of non- metals

- Nonmetals form acidic or neutral oxides when react with air.
- Nonmetals do not react with water and steam.
- Nonmetals do not displace hydrogen with dilute acids.
- Nonmetals form covalent chlorides with chlorine.
- Nonmetals react with hydrogen to form stable hydrides.

Points to remember:

- Bromine is liquid at room temperature
- iodine and graphite are lustrous
- diamond is hardest non-metals.
- carbon and gas carbon are non-metals which are good conductors of electricity.
- oxygen is most abundant nonmetals in earth crust

Allotropy and allotropes: The phenomenon in which an element can exist in two or more different physical forms is called allotropy and the different physical forms of an element are called allotropes.

Allotropes of carbon are graphite, diamond and Buckminster fullerene.

Allotropes of sulphur are monoclinic sulphur and rhombic sulphur.

Chemical properties of metals

1. Metals react with water to form metal hydroxide and hydrogen gas.

Examples:

Metal + water(l) → metal hydroxide + H_2

Metal + water(g) → metal oxide + H_2

$2K + H_2O(l) \rightarrow 2KOH + H_2$

$Mg + H_2O(g) \rightarrow MgO + H_2$

$3Fe + 4H_2O(g) \rightarrow Fe_3O_4 + 4H_2$

2. Metals react with acids to form metals salts along with evolution of hydrogen gas

Metal + dilute acid → Metal salt + hydrogen gas

$2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$

$Ca + H_2SO_4 \rightarrow CaSO_4 + H_2$

Amphoteric oxides : The metal oxides which show the properties of both acidic oxides as well as basic oxides are called amphoteric oxides. They react with both acids and bases to produce salt and water.

E.g. aluminium oxide and zinc oxide

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

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

Sodium aluminat

$ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

(Sodium zincate)

Self protecting metals

The metals that react with air to form a thin layer of their oxide over them to protect from further corrosion of oxidation are called self protecting metals. E.g. aluminium, zinc, magnesium, lead, etc.

Anodizing

The process of forming a thick layer of aluminium oxide over aluminium metal is called anodizing. During anodizing process - a clean aluminium article is made anode and is electrolysed with dil H_2SO_4 . The oxygen gas produced at anode reacts with aluminium to make a thicker protective layer of its oxide.

Hydrogen gas does not evolve when a metal reacts with nitric acid because nitric acid is strong oxidising agent. It oxidises the hydrogen gas produced to water and itself gets reduced to any of nitrogen oxides i.e. N_2O, NO or NO_2 .

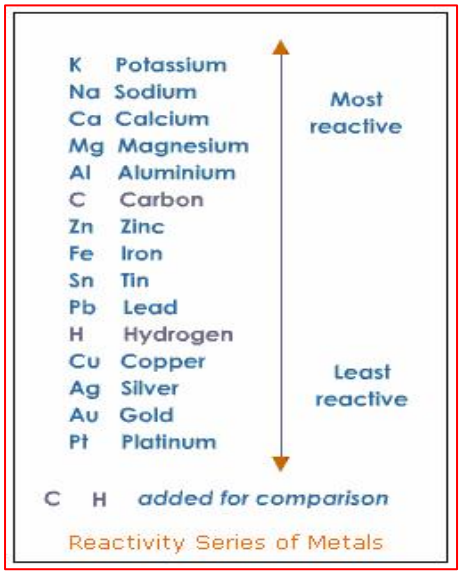
Aquaregia

Aquaregia is the mixture of concentrated hydrochloric acid and nitric acid in the ratio 3:1. It is called 'Royal water' because it can dissolve gold and platinum.

Reactivity series :

The series of metals in which they are arranged in order of their decreasing reactivity is called reactivity of activity series.

Reactivity: The tendency of an element to attain a completely filled outermost shell by losing or gaining electrons is called reactivity.



Reactivity Series of Metals

Ionic compounds

The compounds formed by losing or gaining electrons or by the transfer of electrons from metal to nonmetal are called ionic compounds or electrovalent compounds. Ionic bonds are formed between metals and nonmetals. For example:

NaCl, MgO, $CaCl_2$, NaOH, Al_2O_3, etc.

Properties of ionic compounds

- Ionic compounds are solids and hard because of strong force of attraction between positive and negative ions. They are brittle.
- Melting and boiling points of ionic compounds are high because a large amount of energy is required to break the inter-ionic attraction.
- Solution of ionic compound in water contains ions which move towards oppositely charged electrodes when electricity is passed. This is why ionic compounds are very good conductors of electricity.
- Ionic compounds in a solid state do not conduct electricity because movement of ions in solid state is not possible due to rigid structure. So they conduct electricity only in molten state.

Covalent compounds

The compounds formed by sharing of electrons between nonmetals are called covalent compounds. Covalent bonds are formed between nonmetals.

Example: HCl, H_2O, NH_3, CH_4, CO_2, SO_2, N_2, O_2, etc.

Properties of Covalent Compounds

- The covalent compounds are usually liquids due to the weak forces of attraction between their molecules.
- They usually have low melting and boiling points because the force of attraction between molecules is very weak and a small amount of energy is required to break these forces.
- They do not conduct electricity because they do not contain ions in molten state.
- They are usually insoluble in water because they form covalent compounds.

Metallurgy

Minerals

The elements and compounds which are found naturally in the earth crust are called minerals.

Ores

The minerals from which metals can be extracted easily and profitably are called ores. An ore contains good percentage of metals and less impurities.

All ores are minerals but all minerals are not ores because there may be some minerals from which metals cannot be extracted easily and profitably.

Gangue

The unwanted materials or the impurities like soil and sand present in an ore are called gangue.

Extraction of metals

There are three main steps that are used in the extraction of metals. They are

a. Enrichment or concentration of ore.
b. Conversion of ore into metal (reduction).
c. Refining of metals.

Enrichment of ore

The process of removing impurities from an ore is called enrichment of ore. The methods used for removing impurities from ore are based on the differences in the physical and chemical properties of the ore and gangue

Nature of elements in the bottom of reactivity series The metals in the bottom of reactivity series are least reactive or unreactive, so they are found in free-state.

E.g. gold, platinum, and copper.

Roasting

The process of converting a sulphide ore into its oxide by heating strongly in the presence of air is called roasting. SO_2 gas is released during roasting.

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

Sulphide ores are converted into metal oxides.

Sufficient supply of air is required.

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

Calcinations

The process of converting a carbonate ore into its oxide by heating strongly in the absence of air is called calcination. CO_2 gas is released during calcination.

$$ZnCO_3 \rightarrow ZnO + CO_2$$

Conversion of sulphide or carbonate ores into corresponding oxides is necessary because it is very much easier to convert a metal oxide into free metal than metal sulphide or metal carbonate.

Carbonate ores are converted into metal oxides.

No air is required i.e. it is carried out in absence of air.

$$ZnCO_3 \longrightarrow ZnO + CO_2$$

Extraction of metals low in the activity series

The oxides low in the activity series can be reduced to metals by heating alone.

Example:

When cinnabar (HgS mercuric sulphide- ore of mercury) is heated in the air, it is first converted into mercuric oxide. On further heating it reduces to mercury.

$$2HgS + 3O_2 \longrightarrow 2HgO + 2SO_2$$

$$2HgO \longrightarrow 2Hg + O_2$$

When cuprous sulphide is heated in air, it is first converted into cuprous oxide. On further heating it reduces to copper metal.

$$2Cu2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$$

$$2Cu_2O + Cu2S \longrightarrow 6Cu + SO_2$$

Extraction of metals in the middle of activity series

The metals of medium reactivity are present as sulphide or carbonate ores. As it is easier to obtain metal from its oxide, they are first converted into their metal oxides by using roasting and calcination and then are reduced to free metal.

Extraction of metals of activity series

The highly reactive metals are extracted by the electrolysis of their molten chlorides or oxides.

Example:

When molten sodium chloride is electrolysed, sodium metal is obtained on cathode and chlorine gas is obtained at anode.

$2Na^{+} + 2e^{-} \rightarrow 2Na$

$2Cl^{- -} + 2e^{-} \rightarrow Cl_2$

Reducing agent

The substances that reduce the oxides of metals into free metal are called reducing agents.

Example

Carbon (coke) is the reducing agent used in most metallurgical processes. The highly reactive metals like Na, Ca, Al, etc are used as reducing agents because they can displace metals of low reactivity from their compounds.

$3MnO_2 + 4Al \rightarrow 3Mn + 2Al_2O_3$

Thermit reaction

The reaction between ferric oxide and aluminium is highly exothermic which is used to join railway tracks or cracked machine parts. This is known as thermit reaction.

$Fe_2O_3 + 2Al \rightarrow 2Fe + 2Al_2O_3$

Refining of metals

The process of removing impurities from the extracted metal is called refining. The most widely method used for refining impure metals is electrolytic refining. The electrolyte used in the electrolytic refining is the electricity.

Electrolytic refining In the process of electrolytic refining, the strip of impure metal is made anode and the thin strip of pure metal is made cathode. The solution of molten salt is taken as electrolyte. On passing electricity , the pure metal deposits at cathode.

Anode mud

The insoluble impurities that settle down at the bottom of anode are known as anode mud. The soluble impurities go into the solution.

Corrosion

The process of slowly eating away of metals due to their conversion into oxides, carbonates, sulphides, sulphates, etc by the action of moisture and gases is called corrosion.

Corrosion of iron is called rusting Rusting. The process of depositing a brown flaky substance on the surface of iron due to air and moisture is called rusting. The brown substance is called rust. It is chemically $Fe_2O_3.xH_2O$. Conditions for rusting are - presence of moisture and presence of air.

Prevention of rusting

Rusting of iron can be prevented by painting, applying grease or oil, galvanization, chrome plating, anodizing, making alloys, etc.

Galvanization

The process of depositing a thick layer of zinc metal on iron objects is called galvanization.

Chrome plating

The process of depositing a layer of chromium (Cr) on iron objects is called chrome plating.

Alloying

The process of making homogeneous mixture of a metal with other metal or nonmetal **in molten state is called alloying.**

Alloy

The homogeneous mixture of a metal with other metal or nonmetal in molten state is called an alloy.

- Stainless steel is an alloy of iron, nickel and chromium.
- Brass is an alloy of copper and zinc.
- Bronze is an alloy of copper and tin.
- Solder is an alloy of lead and tin. It has low melting point and is used for welding electrical wires together.

Objectives to make alloys

- Alloys are made to
- Increase hardness
- Make resistant to corrosion
- Decrease melting point
- Change chemical reactivity
- Decrease electrical conductivity
- Increase colour and tensile strength

Meaning of 22-carat gold

The pure gold which has no impurities is called 24 carat. 22 carat gold has 22 parts gold and 2 parts of silver or copper.

The alloy of mercury metal with one or more other metals is called amalgam.

Ores of many metals are oxides because oxygen is very reactive element and it is present in large amount on the earth.

Galvanized objects remain protected against rusting even zinc coating is broken because when the zinc layer on the surface of galvanized iron object is broken, zinc continues to corrode as it is more reactive than iron.

Points to remember

- Highly reactive metals like aluminium, calcium, etc cannot be reduced by carbon because they have more affinity for oxygen than carbon.
- Metals are obtained at cathode. Metals release electron and form positive ions. During electrolysis the metal ions move towards negative electrode i.e. cathode. They get electrons there and change into metals.

- Calcium and magnesium start floating when react with water because bubbles of hydrogen gas formed stick to the surface of the metals and the metals along with H_2 gas become lighter than water.
- Metals like Na, K, Li are kept immersed in kerosene oil because they are highly reactive and can catch fire when kept in open. So to protect them and to prevent accidental fires they are kept immersed in kerosene.
- Nonmetal phosphorus is kept immersed under water because it is highly reactive and can react with air to form its oxides.
- Electric wires are coated with PVC or plastic to protect ourselves from severe shocks as metallic wires are good conductor of electricity.
- Metals are used to make cooking vessels because they are good conductors of heat
- The electrical conductivity and melting point of an alloy is less than that of pure metal.
- Tungsten is used exclusively for filament of electric bulbs because of its high melting point and high resistance
- Carbon can reduce copper oxide to copper as carbon is a strong reducing agent but cannot reduce calcium oxide to calcium because calcium is more reactive than carbon and has great affinity for oxygen than carbon.
- Aqueous solution of sodium chloride is not used in the electrolysis of sodium metal because sodium obtained at cathode will react with water to form sodium hydroxide and hydrogen gas.

$$2Na + H_2O(l) \rightarrow 2NaOH + H_2$$