About 118 elements are known at present. On the basis of their properties, all the elements can be divided into two groups i.e. Metals and Non – Metals. Apart from these, some elements show properties of both metals and non metals. These are called metalloids.

Metals: those elements which form positive ions by losing electrons are called metals, like copper, gold, iron, aluminium etc.

Physical properties of Metals:

1. Electronic configuration of metals: Metal atoms generally possess 1, 2 or 3 electrons in their outermost shells or valence shells. For example, the electronic configurations of sodium, magnesium and aluminum are given below. Thus, sodium, magnesium and aluminum are metals as they have 1, 2 and 3 electrons respectively in their outermost shells. Exceptions: Hydrogen and helium have in their outermost shells 1 and 2 electrons respectively, but they are not metals. In these cases, the outermost shell is the first and only shell (K shell).

2. Electropositive character: Metals have high electro positivity, i.e., the metal atoms have a high tendency to lose their valence electrons and become positive ions (cations). By losing electron(s), a metal atom tends to acquire the stable configuration of the nearest noble gas.

$Na - 1e^- \longrightarrow Na^+$ (Neon-like configuration)

3.Malleability: Metals are malleable, i.e., they can be beaten into very thin sheets. For example, gold and silver are among the most malleable metals.

4.Ductility: Metals are ductile, i.e., they can be drawn into wires. All the metals are not equally ductile. Gold and silver are among the most ductile metals. It is estimated that 100 mg of silver can be drawn into a wire of about 200 metres in length. A gold piece of the size of a 50-paisa can be stretched into a 10-km-long wire. Because of its ductile nature, copper is used in electrical wires.

5. Thermal and electrical conductivity: All metals are good conductors of heat and electricity. Silver is the best conductor of heat and electricity, while lead is the poorest. The utensils we use in kitchen are made of zinc, copper and aluminum because these metals are good conductors of heat. All metals are good conductors of electricity because they contain free or mobile electrons. These free electrons conduct electric current. Silver and copper are among the best conductors of electricity. The electrical conductivity of metals decreases with the rise in temperature. This is because with the rise in temperature, the vibration of electrons increases which creates hindrance to the flow of free electrons or valence electrons. Exception: Graphite is a good conductor of electricity although it is a nonmetal.

6. Lustre: Metals possess a characteristic shining appearance called metallic lustre, and they can be polished. Exceptions: Graphite and iodine are lustrous but they are nonmetals.

7. Tensile strength: Metals have high tensile strength.

8.Density: Metals have high densities, except sodium, potassium, etc., which have low densities. Because of low densities, sodium, potassium, magnesium and aluminum are called light metals.

9. State: Metals are generally solids at room temperature, except mercury, which is a liquid at room temperature.

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10. Melting point and boiling point: Metals have high melting and boiling points. But there are exceptions—sodium and potassium melt and boil at low temperatures. Gallium and caesium can melt if kept on palm.

11. Sound: Metals, when struck with a hammer, produce a characteristic sound known as metallic sound.

12. Alloy formation: Metals can form a homogeneous mixture in combination with other metals. Such a mixture is called an alloy. For example, copper and zinc mix up to form brass.

13. Hardness: Most metals are very hard. However, sodium and potassium are soft metals which can be cut with a knife.

Activity series of Metals: The reactivity of metals differs from metal to metal. Some of the metals are more reactive, while others are less reactive towards chemical reagents. The metals that can lose electrons easily and form positively charged ions are more reactive. Those that cannot lose electrons easily are less reactive. Metals can be arranged in the order of decreasing reactivity in a series. This series is called the activity or reactivity series of metals. The series has been derived after studying many chemical reactions. Copper (Cu), mercury (Hg) and silver (Ag) react with HNO_3, but do not produce H_2. In these reactions, the metal is oxidized to the metal ion and NO_3^- ion is reduced to NO_2 or other nitrogen species. It may be asked, why hydrogen, being a nonmetal, has been included in the activity series. It is because hydrogen, like metals, can part with its electron to form a positive ion or cation.

React vigorously with acidic solutions to give H_2	Potassium	K	React vigorously with water
	Barium	Ba	
	Calcium	Ca	
	Sodium	Na	
React with acids to give H_2	Magnesium	Mg	React slowly with water but readily with steam to give H_2
	Aluminium	Al	
	Zinc	Zn	
	Chromium	Cr	
	Iron	Fe	
	Cadmium	Cd	
	Cobalt	Co	
	Nickel	Ni	
	Tin	Sn	
	Lead	Pb	
	Hydrogen	H	
Do not react with acids to give H_2	Copper	Cu	
	Mercury	Hg	
	Silver	Ag	
	Platinum	Pt	
	Gold	Au	

Significance of activity series:

1. The metals above hydrogen in the activity series have greater tendency than hydrogen to give up electrons in their solutions. Such metals are called electropositive metals. The electropositive character of metals becomes less pronounced as we go down the series. For example, lithium (Li), the first metal in the series is the most electropositive, while gold (Au), the last metal in the series is the least electropositive.

2. The metals above hydrogen in the series can liberate hydrogen when treated with an acid solution. Thus, magnesium and zinc react with dilute solutions of sulphuric acid to produce hydrogen gas. In these reactions, electrons released by metals are accepted by H^+ or H_3O^+ icons present in the acid solution.

$$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$$

3. A more electropositive metal can replace a less electropositive metal from the solution of a salt of the less electropositive metal. For example, when an iron rod is dipped into a solution of copper sulphate, reddish coloured copper is deposited on the iron rod.

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$$

Chemical Properties of Metals:

1. Reaction with Oxygen: this is also called burning in air or formation of oxides. Almost all the metals combine with oxygen (or air) to form metal oxide, which are black in colour. Metal + Oxygen → Metal Oxide.

Aluminium forms aluminium oxide as: $4Al + 3O_2 \longrightarrow 2Al_2O_3$

Copper is heated in air, to form copper (II) oxides: $2Cu + O_2 \longrightarrow 2CuO$

Metal oxides are basic in nature. Some metal oxides dissolve in water to form alkalis. Some of the metal oxides (Al2O3, ZnO, etc) have acidic as well as basic characteristics. These oxides are called amphoteric oxides, react with both bases and acids. For example, ZnO reacts with dil. HCl to form $ZnCl_2$ and H_2O:

$ZnO + HCl \longrightarrow ZnCl_2 + H_2O$ (basic nature)

ZnO reacts with NaOH solution, to form sodium zincate and water:

$ZnO + NaOH \longrightarrow Na_2ZnO_2 + H_2O$ (acidic nature). Another case of aluminium oxide, it reacts with dil HCl to form $AlCl_3$ and water:

$Al_2O_3 + HCl \longrightarrow AlCl_3 + H_2O$ (basic nature)

It reacts with NaOH to form sodium aluminate and water:

$Al_2O_3 + NaOH \longrightarrow NaAlO_2 + H_2O$

Order of reactivity of metals with oxygen: different metals react with oxygen at different rates, e.g. sodium (Na) and potassium (K) catch fore, if left in the open. Hence, these are most reactive metals. To prevent accidental fires, these metals are kept immersed in kerosene oil. Magnesium (Mg) burns in air only by heating. Zinc (Zn) burns only on strong heating while iron (Fe) does not burn in the form of rod or block but burns in the form of filings. Copper (Cu) does not burn on heating but blister copper burns. Silver and gold do not react with oxygen. Hence, the order of reactivity of these metals with oxygen is: K>Na>Mg>Zn>Fe>Cu>Ag

2. Reaction with water: metals react with water and produce a metal oxide and hydrogen gas Metal oxides that are soluble in water dissolves further to form metal hydroxides. All metals do not react with water as the metal placed lower in the reactivity series are less reactive towards water.

Metal + Water → Metal Oxide + Hydrogen gas

Metal Oxide + Water → Metal Hydroxide

- Metals like sodium and potassium react violently with cold water. In case of sodium and potassium, the reaction is very violent and exothermic. The heat evolved is sufficient for hydrogen to catch fire. That's why, Na and K catch fire when kept in water and keeping this in mind, both these metals are kept in 'kerosene' in order to avoid contact with both air and water.

$K + H_2O(cold) \longrightarrow KOH + H_2 + Heat$ $Na + H_2O(cold) \longrightarrow NaOH + H_2 + Heat$

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• The reaction of calcium with water is less violent. The heat evolved is not sufficient for the hydrogen to catch fire. Calcium floats over water because the bubbles of hydrogen gas formed stick on the surface of metal.

$Ca + H_2O$ (cold) $\longrightarrow$ $Ca(OH)_2 + H_2$

• Metals like Al and Fe do not react either with cold or hot water. They react with steam and form the metal oxide and hydrogen.

$Al + H_2O$ (steam) $\longrightarrow$ $Al_2O_3 + H_2$ $Fe + H_2O$ (steam) $\longrightarrow$ $Fe_3O_4 + H_2$

• Lead, copper, silver and gold do not react with water at all. Thus, the reactivity order of metals towards water is: K>Na>Ca>Mg>Al>Fe>Pb>Cu>Ag>Au

3. Reaction with acids: metals usually react with acids to displace hydrogen from acids. The less reactive metals, however, do not displace hydrogen from acids. A more electropositive metal reacts with an acid more rapidly than does a less electropositive metal.

• Reaction with dil HCl: except a few less reactive metals like Cu, Hg, Ag, Au, Pt etc, all metals react with dil sulphuric acids and hydrochloric acid to produce salt an hydrogen gas. Metal + dil Acid $\longrightarrow$ Salt + Hydrogen

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

• Reaction with dil. HNO_3: hydrogen gas is not evolved when metal reacts with nitric acid. This is due to strong oxidizing nature of nitric acid. It oxidizes the H_2 produced to water and itself get reduced to any of the nitrogen oxides (N_2O, NO, NO_2), but magnesium (Mg) and Manganese (Mn) react with very dil HNO3 to evolve H_2 gas. Metal + $HNO_3 \longrightarrow$ Salt + NO_2/N_2O (g) + H_2O

• Exception (only for Mg and Mn): Metal (Mn/Mg) + $HNO_3 \longrightarrow$ Salt + H_2

• Aqua – Regia (Latin for Royal Water): it is a freshly prepared mixture of conc. HCl and Conc. HNO3 in the ratio of 3:1. It can dissolve gold, even though neither of these acids can do so alone. Aqua regia is a highly corrosive, fuming liquid. It is ne of the few reagents that is able to dissolve gold and platinum.

4. Reaction with other Metal salts: reactive metals can displace a comparatively less reactive metal from its compound in aqueous salt solution or in molten salts.

Metal A + Salt Sol. of B $\longrightarrow$ Salt Sol. Of A + Metal B.

$Cu + AgNO3 \longrightarrow Cu(NO3)_2 + Ag$

5. Reaction with Chlorine: Metals combine with chlorine to produce ionic chloride of metals. The metal atom lose electron and become positively charged ions. On the other hand, chlorine receives the electron and become negatively charged (Cl^-)

6. Reaction with Hydrogen: Not all metals combine with hydrogen. Some reactive metals such as Lithium, Sodium, Potassium and calcium combine with hydrogen to form hydrides of metals. These hydrides are ionic compounds in which hydrogen is present as hydride ion (H^-).

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Non-Metals: those elements which form negative ions by gaining electrons are called metals like carbon, iodine, Sulphur, oxygen, hydrogen etc. Non-metals are either solids or gases except bromine which is liquid.

Physical properties of Non-Metals

1. They are brittle and cannot be used to make sheets or wire.
2. They do not have lustre and cannot be polished. Only graphite and iodine are lustrous.
3. They are generally bad conductor of heat and electricity. The only exception is Graphite which is a good conductor. Nonmetals have 4,5,6,7,8 electrons in their outermost shell. These electrons are not free and hence they do not conduct electricity.
4. They can be easily broken. Their tensile strength is low.
5. They have lo melting and boiling point, except for Graphite.
6. Non metals are generally light and have low densities.
7. The solid non metals like Sulphur and phosphorus are soft, but carbon (diamond) is the hardest known substance.
8. Unlike metals, non metals do not produce any sound.
9. Non metals exists in all three states. Solid like Carbon, Sulphur, phosphorus, iodine. Liquid like bromine. Gaseous like Hydrogen, oxygen, nitrogen, chlorine.
10. All non metals except hydrogen are electronegative. They have a tendency to gain electron and become negatively charged ions.

Chemical Properties of Non-Metals

1. Reaction with Oxygen: nonmetals combine with oxygen to form acidic oxides. Some of these oxides dissolve in water to produce acids. $C + O_2 \longrightarrow CO_2$, then $CO_2 + H_2O \longrightarrow H_2CO_3$. But other oxides like Carbon monoxide and nitrous oxide are neutral to litmus.
2. Reaction with acids: unlike metals, nonmetals do not react with acids to liberate hydrogen gas. Some nonmetals, however, react with oxidizing acids to produce oxo acids. For example, Sulphur reacts with concentrated nitric acid to form H_2SO_4 and NO_2. $S + HNO_3 \longrightarrow H_2SO_4 + NO_2 + H_2O$
3. Reaction with Chlorine: nonmetals react with chlorine to form chlorides. For example, phosphorus reacts with chlorine to form phosphorus trichloride.
   $P_4 + Cl_2 \longrightarrow 4PCl_3$
4. Reaction with Hydrogen: nonmetals combine with hydrogen to form hydrides. Here are some examples:

a. Sulphur combines with hydrogen to form hydrogen sulphide:
$H_2 + S \longrightarrow H_2S$.

b. Nitrogen combines with Hydrogen to form ammonia: $N_2 + 3H_2 \longrightarrow NH_3$

5. Reaction with water: nonmetals in general do not react with water. Thus is because nonmetals do not lose electrons to reduce H+ ions present in water. However, very reactive nonmetals like fluorine (F_2) reacts with water to produce hydrogen fluoride and oxygen.

$2F_2 + H_2O \longrightarrow 4HF + O_2$

Difference between physical properties Metals and Nonmetals:

1. Metals have lustre called metallic lustre.	Nonmetals do not possess any metallic lustre. Exceptions Iodine and graphite possess metallic lustre.
2. Metals are generally electropositive.	Nonmetals are generally electronegative. Exception Hydrogen is a nonmetal but it is electropositive.
3. Metals are generally good conductors of heat and electricity	Nonmetals are generally bad conductors of heat and electricity Exceptions Graphite is a nonmetal but it is a good conductor of electricity. Hydrogen, though a nonmetal, is a good conductor of heat.
4. Metals are usually solids at ordinary temperature Exception Mercury is a metal but it is a liquid at ordinary temperature.	Nonmetals are gases or solids at ordinary temperature. Exception Bromine is a nonmetal but it is a liquid at ordinary temperature.
5. Metals are malleable and ductile, have high density, and reflect light. Exceptions Sodium and potassium are metals but their densities are less than that of water.	Nonmetals are not malleable and ductile, have low density, and do not reflect light. Exception Plastic sulphur is ductile.
6. Metals when hammered emit a characteristic sound called metallic sound.	Nonmetals do not emit metallic sound.

Difference between chemical properties of Metals and Nonmetals:

Metals	Nonmetals
1. Metals form positive ions. Examples: Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, etc.	Nonmetals form negative ions. Examples: Cl^-, S^{2-}, N^{3-}, etc.
2. Oxides of metals are basic in nature, i.e., the oxides of metals react with water to give bases or alkalis. $Na_2O + H_2O \longrightarrow 2NaOH$ $CaO + H_2O \longrightarrow Ca(OH)_2$	Oxides of nonmetals are acidic in nature, i.e., the oxides of nonmetals react with water to give acids. $CO_2 + H_2O \longrightarrow \underset{\text{carbonic acid}}{H_2CO_3}$ $SO_2 + H_2O \longrightarrow \underset{\text{sulphurous acid}}{H_2SO_3}$ $SO_3 + H_2O \longrightarrow \underset{\text{sulphuric acid}}{H_2SO_4}$
3. Metals dissolve in dilute acids to produce hydrogen gas. $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$ Exceptions Some metals do not produce hydrogen when treated with an acid under ordinary circumstances.	Nonmetals generally do not dissolve in dilute acids.
4. Metals in general do not combine with hydrogen. Exceptions Some metals (Na, Ca, Li, Be, etc.) combine with hydrogen to form non-volatile unstable hydrides.	Nonmetals combine with hydrogen to form stable compounds.
5. Metallic chlorides are generally not hydrolyzed by water, or are only partially hydrolyzed. $NaCl + H_2O \longrightarrow$ No hydrolysis $AlCl_3 + 3H_2O \longrightarrow Al(OH)_3 + 3HCl$	Chlorides of nonmetals are usually hydrolyzed by water. $PCl_3 + 3H_2O \longrightarrow 3HCl + H_3PO_3$ $SiCl_4 + 4H_2O \longrightarrow Si(OH)_4 + 4HCl$