Metals and non-metals are fundamentally different due to their electronic structure and resulting chemical properties. Metals generally lose electrons to form positive ions, are good conductors of heat and electricity, and are typically solid at room temperature, while non-metals gain electrons to form negative ions, are poor conductors, and can exist in all three states of matter at room temperature.

What are Metals?

The Majority elements in the periodic table are metals. This includes alkali metals, transition metals, lanthanides, actinides and alkaline earth metals. Metals are separated by non-metals on a periodic table through a zigzag line starting from carbon, till radon. The elements between the two are phosphorus, selenium and iodine.

These elements and elements right to them in the periodic table are non-metals. Elements present just to the left of the line are termed as semimetals or metalloids. These will have the combined properties of both metals and non-metals.

Classification of Elements

Metals and Non-metals One-Shot

Non-metals occupy the upper right-hand portion of the periodic table. Considering the properties of non-metals, it is not shiny, malleable or ductile nor are they good conductors of electricity. These properties of non-metals provide one means by which we can distinguish metals from non-metals.

Properties of Non-metals have less in common with each other than metals. Their physical and chemical properties vary widely. Some non-metals are solids and some are gases at room temperature.

What are Non metals?

Very few elements in the periodic table are non-metals. These are present on the right-hand side in the periodic table. Elements that come under non-metals are sulphur, carbon, all halogens, phosphorus, hydrogen, oxygen, selenium, nitrogen and noble gases.

In the periodic table, non-metals are located left of the halogens and to the right of the metalloids. ***Since noble gases and halogens are also non-metals, these elements are often referred to as non-metals.***

Properties of Metals

Physical Properties of Metals

Some physical properties of metals are listed below.

- Shiny (lustrous) in nature
- Metal is a good conductor of electricity and heat
- Density and melting point is high
- Mouldable (Malleable)
- Ductile
- At room temperature, it is in solid form except for mercury
- Opaque

Chemical Properties of Metals

Some chemical properties of metals are listed below.

- Easily corrodible
- Can lose electrons
- Form basic oxides
- Have ***low electronegativities***
- Good ***reducing agents***

Properties of Non-Metals

Physical Properties of Non-metals

Some physical properties of non-metals are listed below.

- Poor conductors of electricity and heat
- Non-Ductile metals
- Brittle solids
- Maybe solids, liquids or gases at room temperature
- These are not sonorous
- Transparent

Chemical Properties of Non-metals

Some chemical properties of non-metals are listed below.

- The number of electrons in the outer shell is generally 4-8
- ***Easily gain or lose valence electrons***
- Form acidic oxides whenever they come in contact with oxygen
- High electronegative elements
- ***Great oxidizing agents***

Non-metals and metals take different forms (allotropes). They have different shapes and properties. Allotropes are elements that exist in two or more than two different physical forms.

- **Example 1:** A non-metal carbon – two allotropes of carbon are diamond and graphite.
- **Example 2:** A metal such as iron – two allotropes of iron are austenite and ferrite

Have a look at the given table depicting the major differences between Metals And Non-metals for better understanding.

Differences Between Metals and Non-metals

A reactivity series is a vital tool for chemists. It helps us to understand the properties of metals and the differences between them.

Metals	**Non-metals**
These are solids at room temperature except mercury	These exist in all three states
These are very hard except sodium	These are soft except diamond
These are malleable and ductile	These are brittle and can break down into pieces
These are shiny	These are non-lustrous except iodine
Electropositive in nature	Electronegative in nature
Have high densities	Have low densities

Q1

What is called non-metal?

Q2

What is called Metal?

Q3

What are the uses of non-metal?

Q4

Which non-metal is essential for our life?

Q5

Which non-metal is used as a fuel?

Chemistry of Metals and Non-Metals

1. Introduction

Elements in the periodic table are broadly classified into:

- **Metals**
- **Non-metals**
- (and **Metalloids**, which have intermediate properties)

Metals and non-metals differ in their **physical and chemical properties**, **occurrence**, **reactivity**, and **uses**.

2. Physical Properties

Property	Metals	Non-Metals
Appearance	Lustrous (shiny)	Dull (except iodine and graphite)
State at Room Temperature	Solid (except mercury, which is liquid)	Mostly gases or brittle solids
Malleability	Malleable (can be hammered into sheets)	Non-malleable; break when hammered
Ductility	Ductile (can be drawn into wires)	Non-ductile
Conductivity	Good conductors of heat and electricity	Poor conductors (except graphite)
Density and Strength	Generally high	Generally low
Melting/Boiling Point	High	Low (except diamond, which is very high)
Sonority	Sonorous (produce ringing sound)	Non-sonorous

3. Chemical Properties

A. Reaction with Oxygen

- **Metals** form **metal oxides**, which are basic in nature.
  - e.g., $4Na+O_2 \rightarrow 2Na_2O$
- **Non-metals** form **non-metal oxides**, which are acidic.
  - e.g., $C+O_2 \rightarrow CO_2$

B. Reaction with Water

- **Metals** (like Na, K, Ca) react with water to form hydroxides and release hydrogen gas.
  - e.g., $2K+2H_2O \rightarrow 2KOH+H_2\uparrow$

- **Non-metals** generally do not react with water.

C. Reaction with Acids

- **Metals** react with dilute acids to produce salt and hydrogen gas.
  - e.g., $Zn+H_2SO4 \rightarrow ZnSO_4+H_2\uparrow$
- **Non-metals** do not react with dilute acids.

D. Reaction with Bases

- Some **metals** (like Zn, Al) react with strong bases (alkalis) to form complex salts.
  - e.g., $Zn+2NaOH \rightarrow Na_2ZnO_2+H2\uparrow$
- Some **non-metal oxides** (like CO_2) react with bases to form salts and water.
  - e.g., $CO_2+2NaOH \rightarrow Na_2CO_3+H_2O$

E. Displacement Reactions

- More reactive **metals** can displace less reactive metals from their compounds.
  - e.g., $Fe+CuSO_4 \rightarrow FeSO_4+Cu$

4. Position in the Periodic Table

- **Metals**: Found on the **left** and **middle** of the periodic table.
- **Non-metals**: Found on the **right side**, mainly in groups 14–18.
- **Metalloids**: Elements like B, Si, As, which show mixed properties.

5. Occurrence in Nature

- **Metals** are found as:
  - **Native state** (e.g., gold, silver)
  - **Ores** (e.g., bauxite for aluminum, hematite for iron)
- **Non-metals** occur:
  - As **diatomic gases** (O_2, N_2)
  - In **compounds** (e.g., sulfur in sulfides)

6. Extraction of Metals

- **Reactive metals** (e.g., Na, K, Ca) → extracted by **electrolysis**.
- **Less reactive metals** (e.g., Fe, Zn) → extracted by **reduction with carbon**.
- **Least reactive metals** (e.g., Au, Ag) → occur in **free state**, require minimal processing.

7. Uses of Metals and Non-Metals

Metals	Non-Metals
Iron – construction, tools	Oxygen – respiration, welding
Copper – electrical wiring	Chlorine – water purification
Aluminum – aircraft, utensils	Sulfur – vulcanization of rubber
Gold – jewelry, electronics	Nitrogen – fertilizers, food packaging
Zinc – galvanization	Carbon (graphite) – electrodes, pencils

8. Alloys and Compounds

- **Alloys**: Mixtures of metals or metals with non-metals.
  - E.g., Bronze (copper + tin), Steel (iron + carbon), Brass (copper + zinc)
- **Metal Compounds**:
  - Usually **ionic**, high melting points, soluble in water, conduct electricity when molten or in solution.
- **Non-metal Compounds**:
  - Usually **covalent**, lower melting points, often poor conductors.

9. Environmental and Biological Roles

- **Essential Metals**: Iron (haemoglobin), calcium (bones), potassium (nerve function).
- **Toxic Metals**: Lead, mercury – harmful to health.
- **Essential Non-Metals**: Oxygen (respiration), nitrogen (proteins), phosphorus (DNA).

Metals and non-metals play crucial roles in chemistry and everyday life. Understanding their distinct properties and behaviours allows scientists and engineers to choose appropriate materials for various applications—from infrastructure to healthcare.

Metals vs Non-Metals

Property	Metals	Non-Metals
Lustre	Shiny	Dull (except iodine, graphite)
State at Room Temp	Solid (except mercury)	Gases or brittle solids
Malleability	Malleable	Brittle
Ductility	Ductile	Not ductile
Conductivity	Good conductor of heat & electricity	Poor conductor (except graphite)
Sonority	Sonorous (ringing sound)	Non-sonorous
Reaction with Oxygen	Forms basic oxides	Forms acidic oxides
Reaction with Water	May form hydroxide + H_2	Generally unreactive
Reaction with Acids	Produces salt + H_2	Generally no reaction
Reaction with Bases	Forms complex salts (some metals)	May form salt and water (non-metal oxides)
Type of Bond in Compounds	Usually Ionic	Usually Covalent

Position in Periodic Table	Left and center	Right side
Examples	Iron, Copper, Zinc, Aluminium	Sulfur, Oxygen, Nitrogen, Chlorine

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🧠 QUIZ QUESTIONS:

1. **Which of the following is a good conductor of electricity?**
   A. Sulfur
   B. Oxygen
   C. Copper
   D. Phosphorus

2. **Which non-metal is used for water purification?**
   A. Sulfur
   B. Chlorine
   C. Carbon
   D. Iodine

3. **What is formed when a metal reacts with dilute hydrochloric acid?**
   A. Metal hydroxide and hydrogen
   B. Metal chloride and oxygen
   C. Metal chloride and hydrogen
   D. Metal oxide and water

4. **Which of the following metals is in liquid state at room temperature?**
   A. Aluminium
   B. Sodium
   C. Mercury
   D. Zinc

5. **Which property is *not* typical of metals?**
   A. Malleable
   B. Ductile
   C. Brittle
   D. Sonorous

True or False:

6. **All metals react with water.**

7. **Non-metals are generally good conductors of electricity.**

8. **Metal oxides are generally basic in nature.**

9. **Gold and silver are found in free state in nature.**

10. **Sulfur dioxide is a basic oxide.**

Comparative Chemistry of Group 1A, 2A, and 4A Elements

1. Group Overview

Group	Group Number	Common Name	Elements (First Few)	General Electron Configuration
1A	Group 1	Alkali Metals	Li, Na, K, Rb, Cs, Fr	ns^1
2A	Group 2	Alkaline Earth Metals	Be, Mg, Ca, Sr, Ba, Ra	ns^2
4A	Group 14	Carbon Group (Tetreles)	C, Si, Ge, Sn, Pb	ns^2np^2

2. Physical Properties Comparison

Property	Group 1A (Alkali Metals)	Group 2A (Alkaline Earth Metals)	Group 4A (Carbon Group)
State at Room Temp	Soft solids	Harder solids than Group 1A	Solids (except Carbon: graphite/diamond, gas for some allotropes like CO_2)
Density	Low (some float on water)	Higher than Group 1A	Generally higher
Melting/Boiling Point	Low	Higher than Group 1A	Variable – C (very high), Pb (low)
Electrical Conductivity	Good conductors	Good conductors	Variable – C (graphite: good; diamond: poor)
Luster	Shiny (when freshly cut)	Shiny	Dull to shiny (C is dull, Pb is shiny)

3. Chemical Properties

Property	Group 1A (Alkali Metals)	Group 2A (Alkaline Earth Metals)	Group 4A (Carbon Group)
Valency	1	2	4
Reactivity with Water	Very reactive (forms hydroxide + H_2)	Less reactive, increases down the group	Generally non-reactive with water
Reaction with Oxygen	Forms oxides (e.g., Na_2O, K_2O)	Forms oxides (e.g., MgO, CaO)	Forms oxides (CO_2, SiO_2)
Nature of Oxides	Strongly basic	Basic	Amphoteric or acidic
Ion Formation	Forms M^+ ions	Forms M^{2+} ions	Usually forms covalent compounds; C^{4-} or C^{4+} rarely formed
Flame Test Color	Yes (distinct colors e.g., Na = yellow)	Yes (e.g., Ca = brick red, Ba = green)	Not applicable
Hydroxide Solubility	Very soluble and strongly basic	Sparingly soluble but basic	Not generally applicable

4. Oxidation States

Group	Typical Oxidation State(s)	Remarks
1A	+1	Very stable due to noble gas configuration
2A	+2	Stable M^{2+} ions; less reactive than Group 1A
4A	-4, +2, +4	C and Si: usually covalent compounds; Pb often shows +2 due to inert pair effect

5. Oxides and Their Nature

Element	Type of Oxide	Example	Nature
Na	Metal oxide	Na_2O	Strongly basic
Mg	Metal oxide	MgO	Basic
C	Non-metal oxide	CO_2	Acidic
Si	Acidic oxide	SiO_2	Weakly acidic
Sn, Pb	Amphoteric oxides	SnO_2, PbO_2	Amphoteric

6. Hydrides and Chlorides

Property	Group 1A	Group 2A	Group 4A
Hydrides	Ionic (e.g., NaH)	Ionic (e.g., CaH_2)	Covalent (e.g., CH_4, SiH_4)
Chlorides	Ionic (e.g., NaCl)	Ionic (e.g., $CaCl_2$)	Covalent (e.g., CCl_4, $SiCl_4$)

7. Trends Down the Groups

Property	Group 1A	Group 2A	Group 4A
Atomic Size	Increases down the group	Increases down the group	Increases down the group
Ionization Energy	Decreases down the group	Decreases down the group	Decreases down the group
Reactivity	Increases down the group	Increases down the group	Varies: metallic character increases
Metallic Character	Increases	Increases	Increases (C = non-metal, Pb = metal)

8. Unique Characteristics

- **Group 1A (Alkali Metals):**
  - Highly reactive and stored under oil.
  - Soft enough to cut with a knife.
  - Flame colors are diagnostic.
- **Group 2A (Alkaline Earth Metals):**
  - Harder and denser than Group 1A.
  - Form less soluble hydroxides.
  - Important biologically (e.g., calcium in bones).
- **Group 4A (Carbon Group):**
  - Shows a range of bonding types (ionic, covalent, metallic).
  - Carbon has unique allotropes: diamond, graphite, fullerenes.
  - Exhibits the **inert pair effect** in heavier elements (Sn, Pb).

Deduction

The chemistry of Groups 1A, 2A, and 4A shows distinct patterns in terms of **bonding**, **reactivity**, and **physical and chemical behaviour**.

- Group 1A and 2A are typical **s-block metals** with increasing reactivity down the group.
- Group 4A elements exhibit **non-metallic to metallic transition** and form **a wide variety of covalent compounds**, making them crucial in both inorganic and organic chemistry.

COMPARISON TABLE: Group 1A vs 2A vs 4A

Feature	Group 1A (Alkali Metals)	Group 2A (Alkaline Earth Metals)	Group 4A (Carbon Group)
Group Number	1	2	14
Valence Electrons	1	2	4

General Reactivity	Very high	High (less than 1A)	Variable (non-metal to metal trend)
Common Oxidation State	+1	+2	±4, +2 (Pb, Sn), –4 (C, Si rarely)
Nature of Oxides	Strongly basic	Basic	Acidic to amphoteric
Type of Bonding	Mostly ionic	Mostly ionic	Covalent
Hydroxide Solubility	Highly soluble	Sparingly soluble	Not generally formed
Important Elements	Li, Na, K	Be, Mg, Ca	C, Si, Sn, Pb
Flame Test Color	Yes (e.g., Na = yellow)	Yes (e.g., Ca = brick red)	Not applicable
Electrical Conductivity	Excellent	Excellent	Variable (Graphite: good, others not)

Reactivity Trend and Metallic Character

Group 1A → Alkali Metals
Li ↓
Na ↓
K ↑ Reactivity increases
Rb ↓
Cs ↓

Group 2A → Alkaline Earth Metals
Be ↓
Mg ↓
Ca ↑ Reactivity increases
Sr ↓
Ba ↓

Group 4A → Carbon Group
C (non-metal) ↓
Si (metalloid) ↓
Ge (metalloid) ↓
Sn (metal) ↓
Pb (metal) ↑ Metallic character increases

🧠 QUIZ QUESTIONS

1. **Which group has elements with 2 valence electrons?**
   A. Group 1A
   B. Group 2A
   C. Group 4A
   D. Group 3A

2. **Which of the following elements shows metallic properties in Group 4A?**
   A. Carbon
   B. Silicon
   C. Lead
   D. None of the above

3. **What type of bonding is most common in Group 4A compounds like CH_4 or $SiCl_4$?**
   A. Ionic
   B. Metallic
   C. Covalent
   D. Hydrogen

4. **Which group contains elements that are soft and highly reactive with water?**
   A. Group 4A
   B. Group 3A
   C. Group 2A
   D. Group 1A

5. **What is the nature of the oxide formed by carbon?**
   A. Basic
   B. Amphoteric
   C. Neutral
   D. Acidic

✅ True or False

6. **Group 1A elements are less reactive than Group 2A elements.**

7. **Carbon dioxide is an acidic oxide.**

8. **Lead and tin show +2 oxidation states due to the inert pair effect.**

9. **All Group 2A metals react violently with cold water.**

10. **The metallic character increases down Group 4A.**