



RRB

Junior Engineers (JE)

Railway Recruitment Board

Volume - 4

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General Science



# Index

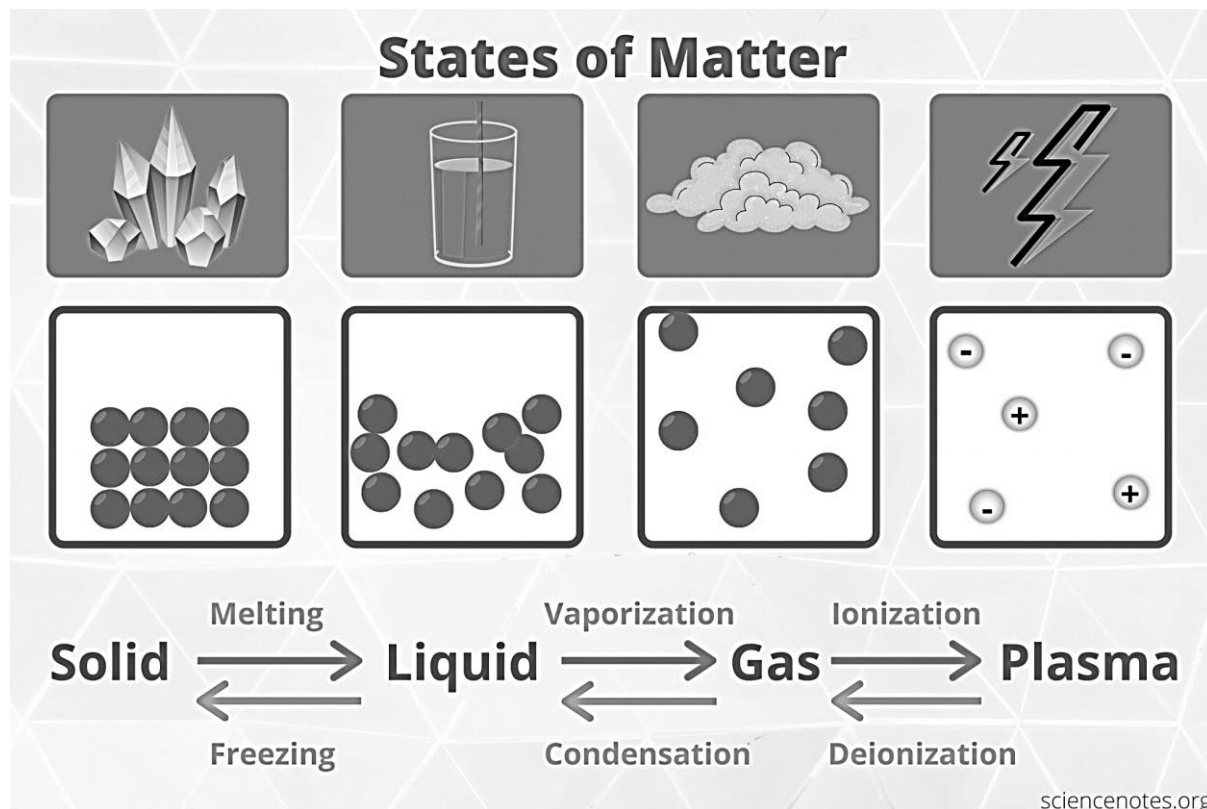
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# 1 CHAPTER

## Chemistry

### States of Matter



### Solids

- Matters which have **fixed volume** and **shape**.
- Eg - stone, wood, brick, ice, sugar, salt, coal, etc.
- **All metals** are solid **except mercury** and **gallium**.

### Properties of solids

- Fixed volume.
- Fixed shape.
- High density.
- Heavy.
- Do not flow.

### Liquids

- Matters which have **fixed volume** but **indefinite shape**.
- Eg - milk, water, petrol, kerosene, alcohol, oil, etc.
- Since **liquid** can **flow**, it is also called **fluid**.

### Properties of liquids

- Definite volume.
- No definite shape.
- Get the shape of container in which they are kept.

- Cannot be compressed much.
- Have less density compare to solid.
- Lighter than solid.
- Liquids flow and hence are called fluids.

## Gas

- Matters which have **indefinite shape** and **volume**.
- Eg - air, oxygen, hydrogen, nitrogen, carbon-dioxide, etc.

### Properties of gases

- Indefinite shape
- No fixed volume.
- Get the shape and volume of container.
- Fill the container completely.
- Have very low density.
  - So, gases are light.
- Can flow easily and hence are called fluids.

## Cause of different physical states of matters

The physical states of matter depend upon three main factors:

- The **force of attraction** between particles.
- The **space** between the **particles**.
- The **kinetic energy** of particles.

### Solids

- The **force of attraction** between the particles of solids is **very strong**.
- There are **minimum spaces** between the particles of solids.
- The particles of solids have **minimum kinetic energy**.
- Because of great force of attraction **particles** of solids are **closely packed** together.
  - This makes the **space** between particles of solids **almost negligible**.
- The **lowest kinetic energy** of particles is **not able to move the particles** of solids.
- Hence, the great force of attraction and least space between particles of solids and lowest kinetic energy of particles **keep the particles at fixed places**.
- Because of the combination of these characters **matter** exists in **solid state**.

### Liquids

- The **force of attraction** between particles is strong but **less strong than solids**.
- The **space** between particles is **more than** that of **solids** but not less than liquids.
- The **kinetic energy** of particles is **greater than solid**.
- **Strong force of attraction** keeps the particles of **liquids packed** together.
  - But the **force** of attraction between particles of liquids is **less strong** than that of solid.
  - Because of this particles of **liquids** are **loosely packed** compared to solid.
- The **kinetic energy of particles** of **liquids** is **greater** than that of **solids**.
- Because of more space between **particles** and more **kinetic energy than solids** the particles of liquids slide over one another.
- These characters make a matter to exist in liquid state.
- **Liquid** can **flow** because its particles can slide over one another.

Properties	Solids	Liquids	Gases
Shape	Definite shape	Do not have a definite shape, will take the shape of the container	No definite shape
Volume	Definite volume. As intermolecular forces between the constituent particles are strong	Definite volume. As intermolecular forces between the constituent particles are strong	No definite volume. As intermolecular forces between the constituent particles are weak
Compressibility	Negligible	Negligible	High
Diffusion	Can diffuse into liquids	Diffusion is higher than solids	Highly diffusible as particles move randomly at high speed
Fluidity or rigidity	Very rigid and cannot flow from one place to another	Less rigid and are capable of flowing from higher to lower levels	No rigidity and can flow most easily among the three states of matter. They usually flow from high pressure to low pressure areas

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## Gases

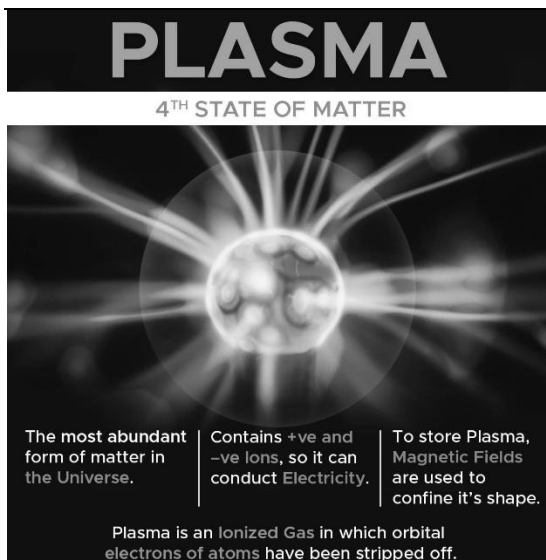
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- The **force of attraction** between particles of gas is almost **negligible**.
- The **space** between particles of solid is **greatest**.
- The particles of gases have the **greatest kinetic energy**.
  - Because of negligible force of attraction the **particles of gases** are **loosely packed** consequently there are lots of spaces between their particles.
  - Because of the **greatest kinetic energy** the particles of **gas move** with **high speed**.
- Because of **negligible** force of **attraction** between **particles** and greatest kinetic energy the particles of gas have a tendency to escape out.
  - Because of these characteristics a matter exists in gaseous state.

- A **matter** exists in **solid** state because of the **greatest** force of **attraction** between its **particles** which makes the **particles closely packed**.
- A matter exists in **liquid** state because of **less force of attraction** between its particles than a solid, which makes the **particles** closely packed but allow them to **slide** over one another.
- A matter exists in **gaseous** state because of an almost **negligible force of attraction** between its particles, which is unable to keep the particles bonded together.

## Other states of matter

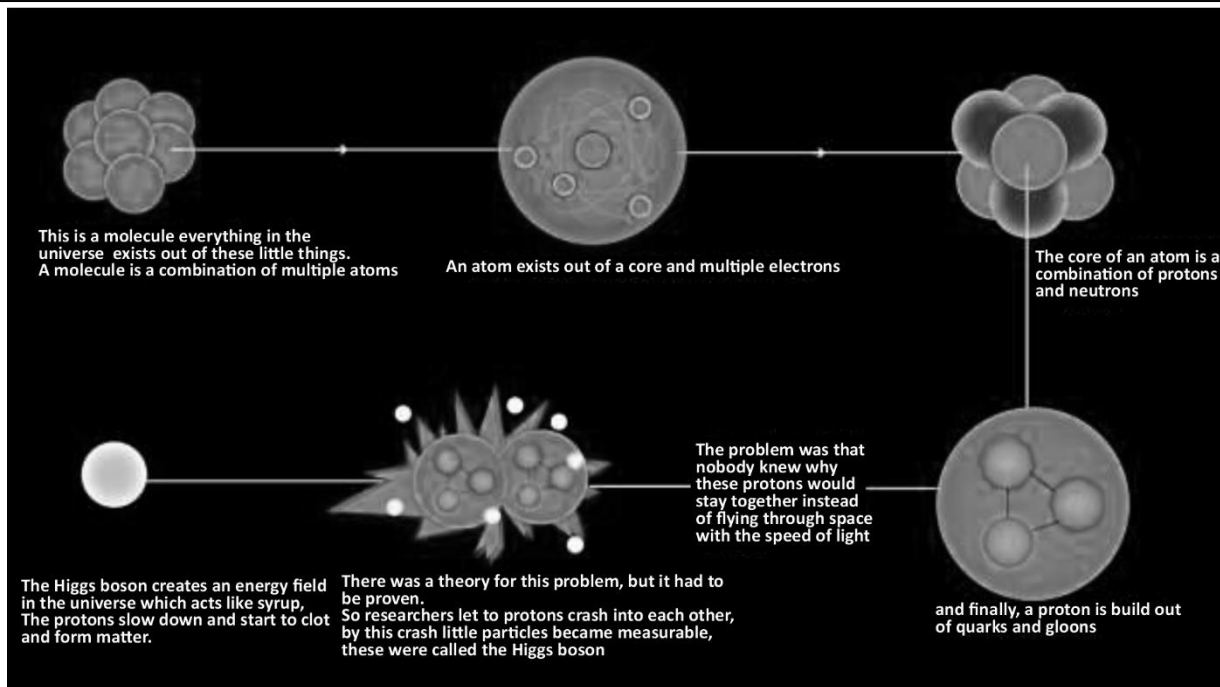
### Plasma



- **Fourth state** of matter.
- **Similar to gas**.
- Particles of plasma are made of **free electrons** and **ions**.
- Do **not** have a **definite shape** or a **definite volume** unless enclosed in a container.
- Defined as **electrically neutral** medium of **positive** and **negative particles**.
- Plasma is one of the **most commonly occurring states** of matter in universe.
- Plasma **occurs naturally** in the stars.
- All **stars** are made of **plasma**.
  - Because of the **presence of plasma stars glow**.
- Plasma is formed because of **nuclear fusion** in stars.
  - Our **sun glows** because of presence of plasma.
  - **Plasma TV** got its name because of presence of plasma in it.
  - Plasma is also found in **fluorescent light** or **neon sign**.
  - Plasma is formed when **electricity** is **passed** in a **fluorescent tube** or **neon sign**, which makes them glow.

### Bose-Einstein Condensate (BEC)

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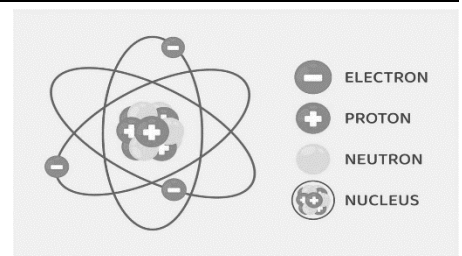


- **Fifth state of matter.**
- **Satyendra Nath Bose and Albert Einstein** were predicted about this state of matters, that's why it got its name as **Bose-Einstein Condensate (BEC)**.
- Plasma and BEC are has **opposite** characters.
  - Plasma is a **super hot and super excited atom**
  - Condensate has **super cool and super unexcited atoms**.
- BEC was obtained by **cooling the vapour of rubidium-87** at super **low temperature** by Eric Cornell and Carl Wieman on June 5 1995.
- After sometimes Wolfgang Ketterle also obtained BEC from **sodium-23** at MIT, USA.
- Cornell, Wieman and Ketterle got **Nobel Prize** in Physics for this achievement in 2001.

## Atomic Structure

### Fundamental Constituents of an Atom

- An atom contains **three basic particles** namely protons, neutrons and electrons.
- The **nucleus** of the atom contains **protons** and **neutrons**.
  - **Protons** are **positively charged**.
  - **Neutrons** are **neutral**.
- The **electrons** are located at the **outermost regions** called the **electron shell**.



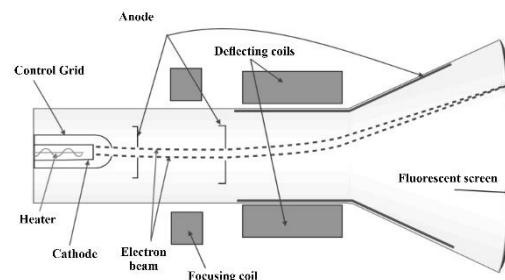
## Electron

- **J. J. Thomson**, in **1897**, discovered **negatively charged particles** emitted by the **cathode** towards the anode in a cathode ray experiment.
- These **negatively charged particles** are **Electrons**.

### Cathode ray experiment

- **J. J. Thomson** discovered the **existence of electrons**.
- He did this using a cathode ray tube, which is a **vacuum-sealed tube** with a **cathode** and **anode** on one end that created a **beam** of electrons travelling towards the other end of the tube.
- The air inside the **chamber** is subjected to **high voltage** and **electricity** flows through the air from the **negative electrode** to the **positive electrode**.

- The **characteristics** of cathode rays (electrons) **do not depend** upon the **material** of **electrodes** and the **nature** of the **gas** present in the cathode ray tube.
- The experiment showed that the **atom** was **not** a **simple, indivisible** particle and contained **at least one subatomic particle** – the electron.



## Protons

- **Ernest Goldstein**, in 1886, discovered that with a different condition in the same chamber, **anode** emitted **positively charged particles** known as **Canal rays** or later named as **Protons**.

## Neutrons

- **J. Chadwick** discovered a subatomic particle with **no charge** and a **mass** equivalent to **protons** in the nucleus of all atoms.
- These **neutrally charged** particles are Neutrons.

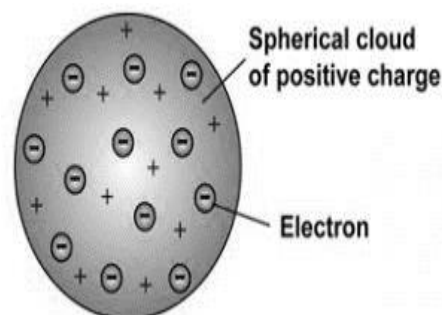
## Properties of electrons, protons, and neutrons

Property	Electrons	Protons	Neutrons
Charge	Negatively Charged	Positively Charged	No Charge
Affinity	Attracts to positively charged	Attracts to negatively charged	Get attracted neither to positive nor negative
Weight	Mass is negligible	1 a.m.u	1 a.m.u
Location	Outside the nucleus	Within the nucleus	Inside the nucleus

Different Models on Structure of an Atom

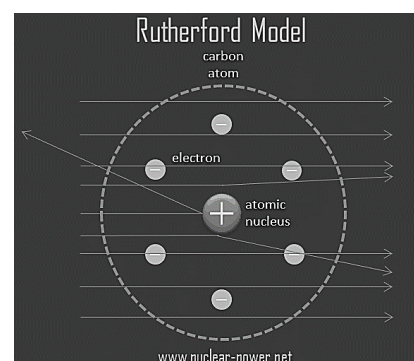
### Thomson's Model of an Atom

- **J. J. Thomson** proposed that the structure of an atom is similar to that of a **Christmas pudding** where electrons are embedded like currants in the sphere.
- He **proposed** that:
  - The **structure** of an **atom** is a **positively charged sphere** that embeds electrons in it
  - An atom is **electrically neutral** as the **protons** and **electrons** are **equal** in magnitude
- **Drawbacks** of Thomson's Model:
  - Thomson's structure of an atom **failed** to **explain** the **arrangement** of **protons** and **electrons** in its structure.



### Rutherford's Model of an Atom

- **Rutherford** conducted an experiment **bombarding** the **alpha ( $\alpha$ )-particles** on a **gold foil**.
- He observed the **trajectory** of the **alpha ( $\alpha$ )-particles** after passing through an atom and **drafted** some **postulates** of the experiment, which are:
  - **Most** of the **space** in an **atom** is **empty** as the **particles** **passed** through the **gold foil** without any **hindrance**
  - The **positively charged centre** is called the **Nucleus**, and all the **mass** of an atom **resides** in the **centre**.
    - The particles **deflected 180°** after **bombarding** the **nucleus**
  - The **electrons orbit** the centre in a **defined path**
  - The **size** of the **nucleus** is **small** compared to the total size of the atom
- **Drawbacks** of the Model:
  - Although **Rutherford** presented an **entirely new model** regarding the structure of the atom, there were a lot of drawbacks which he failed to explain, are-
    - The **electrons revolve** in an **unstable path**, and they undergo **acceleration radiating energy**.

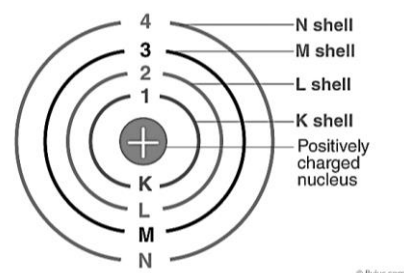




- When the **electrons revolve**, they **lose energy**.
- Soon electrons would **collapse** into the **nucleus**.
- This tendency would make an **atom highly unstable** while the **atom is highly stable**
- Rutherford's structure of an atom **failed to explain** the **atomic number** concept as it explained only the presence of protons in the nucleus

## Bohr's Model of an Atom

- Bohr devised a model in order to **overcome** the **objections** that **Rutherford's model** raised.
- So, he stated the following **postulates**:
  - An atom **permits** only a **discrete** amount of **orbitals** for the **electrons to orbit** and make the outer structure of an atom
  - While revolving, the **negatively charged particles do not lose energy** in these **orbitals** or **energy levels**
  - When the **electron jumps** from **one energy shell to another**, a change in magnitude takes place
- Bohr's model gives an **elaborative explanation** on the structure of an atom and **overcomes** the **objections** faced by all the other models on the structure of an atom.



## Distribution of Electrons in Distinct Shells

- Bohr-Bury Scheme **suggested** the **arrangement** of **particles** in **different orbits**.
- The following are the rules to write the number of particles in different orbitals:
  - The formula  $2n^2$  gives the accommodation of the **maximum number of electrons** in each shell,  $n=1, 2, 3, 4$  for  $K=2, L=8, M=18, N=32$ .
  - The **outermost orbit** can hold a **maximum of 8 electrons**.
  - The electrons fill the inner levels first as they **follow** the **stepwise filling of orbitals**
- **Number of electrons in K-shell:**  $n = 1$ 
  - $2n^2 = 2 \times 1^2 = 2$
  - Maximum number of electrons in K-shell, first shell = 2
- **Number of electrons in L-shell,  $n = 2$ ,**
  - $2n^2 = 2 \times 2^2 = 8$
  - Maximum number of electrons in L-shell, Second shell = 8
- Using the **formula  $2n^2$**  number of **electrons** in any shell can be **calculated**.

## Valency

- **Valence Electrons** - The negatively charged particles present in the outermost shell.
  - These valence electrons are **responsible** for the **valency** of an atom.
- **Valency** - tendency of an atom to react with the other atoms of the same or various elements.
  - The atoms that fill the **outermost paths** show **chemical activity** towards other valence electrons.
  - This reactivity is **responsible** for the **formation** of **molecules** between two or more atoms.
- The valency **becomes zero** for an **atom** when the **outer bounds** have **eight electrons** or **no electrons** to lose.
- The particle with **eight electrons** in the **outermost shell** is an octet, and these molecules are **mostly inert** in nature.
- **Eg:**
  - **Magnesium (Mg)** has a configuration (2, 8, and 2), so the valency is two.
  - **Oxygen (O)** (2, 8, and 6) has the valency two as the number electrons it can gain is two to achieve a packed outer energy level.
  - **Helium (He)** has 2 electrons in its outer shell, Neon (Ne) (2, 8, and 8) has eight electrons in its outer shell.
    - Hence, they do not show any chemical activity.

## Atomic Number (Z)

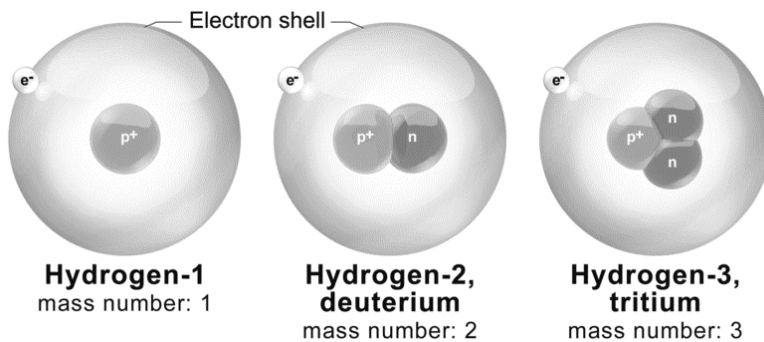
- Atomic number = **number of protons** present in one atom of an element.
- As the atom is **electrically neutral**, the number of **protons** and **electrons** are the same.
- The notation **Z** denotes an **Atomic number**.
- The atomic number of Hydrogen is one as it has **only one proton**.
  - **Number of Protons** present in an atom = Atomic number (Z)
  - **Number of Electrons** present in an atom = Atomic number (Z)
  - **Number of Neutrons** = Mass number (A) - Atomic number (Z)

## Mass Number (A)

- Measure of the **total** number of **protons** and **neutrons** in the nucleus of an atom.
- The notation **A** indicates the Mass number.
- N = total number of **neutrons**.
- Mass Number = **Atomic Number + Number of Neutrons** in the Nucleus
  - $A = Z + n^{\circ}$
- aka **Nucleon** number.

## Isotopes

- The atoms of the **same elements** with the **same atomic number** and **different mass numbers**.
- **Hydrogen** has **three isotopes**: *Protium, Deuterium, Tritium*.



## Isobars

- The atoms of **different molecules** with the **same mass number**.
- **Eg**, in **Calcium**, atomic number 20, and **argon**, atomic number 18, the mass number of both these elements is 40.
  - This shows that the total number of **nucleons** is the **same** in the atoms.

## Metals, Non- metals and Metalloids

### Metalloids

- Elements which have the properties of both metals and non-metals are known as metalloids.
  - For example, Boron, Arsenic, etc.

METALS	NON-METALS
<p><b>Physical Properties</b></p> <ul style="list-style-type: none"> <li>• Solid.</li> <li>• Lustrous.</li> <li>• Malleable and ductile.</li> <li>• Hard and have high density.</li> <li>• Good conductors of heat and electricity.</li> <li>• High melting and boiling points.</li> </ul> <p><b>Chemical Properties</b></p> <ul style="list-style-type: none"> <li>• React with dilute acids to liberate hydrogen gas</li> <li>• React with oxygen to form basic oxides.</li> <li>• Do not combine with hydrogen.</li> <li>• React with water to form metal oxides or metal hydroxides.</li> <li>• Electropositive i.e. form positive ions by losing electrons.</li> <li>• Reducing agents.</li> </ul>	<p><b>Physical Properties</b></p> <ul style="list-style-type: none"> <li>• Solids, liquids and gases.</li> <li>• Non-lustrous.</li> <li>• Non-malleable and non-ductile.</li> <li>• Varying hardness and have low density.</li> <li>• Poor conductors of heat and electricity.</li> <li>• Low melting and boiling points.</li> </ul> <p><b>Chemical Properties</b></p> <ul style="list-style-type: none"> <li>• Do not displace hydrogen on reaction with dilute acids.</li> <li>• React with oxygen to form acidic or neutral oxides</li> <li>• Combine with hydrogen to form stable hydrides.</li> <li>• Do not react with water.</li> <li>• Electronegative i.e. form negative ions by gaining electrons.</li> <li>• Oxidising agents.</li> </ul>
<p><b>Corrosion</b></p> <p>The eating up of metals by the action of air and moisture or a chemical on their surface.</p> <p><b>Alloys</b></p> <p>It is a homogeneous mixture of two or more metals (or a metal and a non-metal). For e.g. Brass is an alloy of 2 metals-copper and zinc.</p>	<p><b>Rusting</b></p> <p>The corrosion of iron is known as rusting. Rust is hydrated iron (III) oxide, <math>Fe_2O_3 \cdot xH_2O</math>. Presence of air and water are the two conditions necessary for rust. It can be prevented by painting, applying grease, by galvanization and by alloying.</p>
<p><b>Ionic Compounds</b></p> <ol style="list-style-type: none"> <li>1. Usually crystalline solids.</li> <li>2. Have high melting point and boiling point.</li> <li>3. Conduct electricity when dissolved in water or melted.</li> <li>4. Usually soluble in water and insoluble in organic solvent.</li> </ol>	<p><b>Covalent Compounds</b></p> <ol style="list-style-type: none"> <li>1. Usually liquids / gases, few are solids.</li> <li>2. Have low melting and boiling point.</li> <li>3. Do not conduct electricity.</li> <li>4. Usually insoluble in water and soluble in organic solvents.</li> </ol>

**Table 5.6 Modern Periodic Table**

Metals      Metalloids      Non-metals

The zigzag line separates the metals from the non-metals.

GROUP NUMBER

GROUP NUMBER																		18	
1	2	GROUP NUMBER										13	14	15	16	17	18		
1	2											3	4	5	6	7	8	9	10
1	2											3	4	5	6	7	8	9	10
2	3	4	GROUP NUMBER										5	6	7	8	9	10	
2	3	4											5	6	7	8	9	10	
3	11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
3	11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
6	55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	
6	55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	
7	87	88	89	104	105	106	107	108	109	110	111	112	114	114	114	114	114	114	
7	87	88	89	104	105	106	107	108	109	110	111	112	114	114	114	114	114	114	

\* Lanthanoides

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Cerium 140.1	Praseodymium 140.9	Neodymium 144.2	Promethium (145)	Samarium 150.4	Europium 152.0	Gadolinium 157.3	Terbium 158.9	Dysprosium 162.5	Holmium 164.9	Erbium 167.3	Thulium 168.9	Ytterbium 173.0	Lutetium 175.5
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
Thorium 232.0	Protactinium (231)	Uranium 238.1	Neptunium (237)	Plutonium (242)	Americium (243)	Curium (247)	Berkelium (245)	Californium (251)	Einsteinium (254)	Fermium (253)	Mendelevium (256)	Nobelium (254)	Lawrencium (257)

\*\* Actinoides

### Properties of Metalloids

- They have a metallic luster but behave like non-metals.
- They are brittle, shiny substances
- They are solid at ambient temperatures and have relatively high melting points.

### Melting Temperatures of Metalloids

Element	Melting Temperature (°C)
Boron	2079
Silicon	1410
Germanium	938.3
Arsenic	817
Tellurium	449.5
Antimony	631

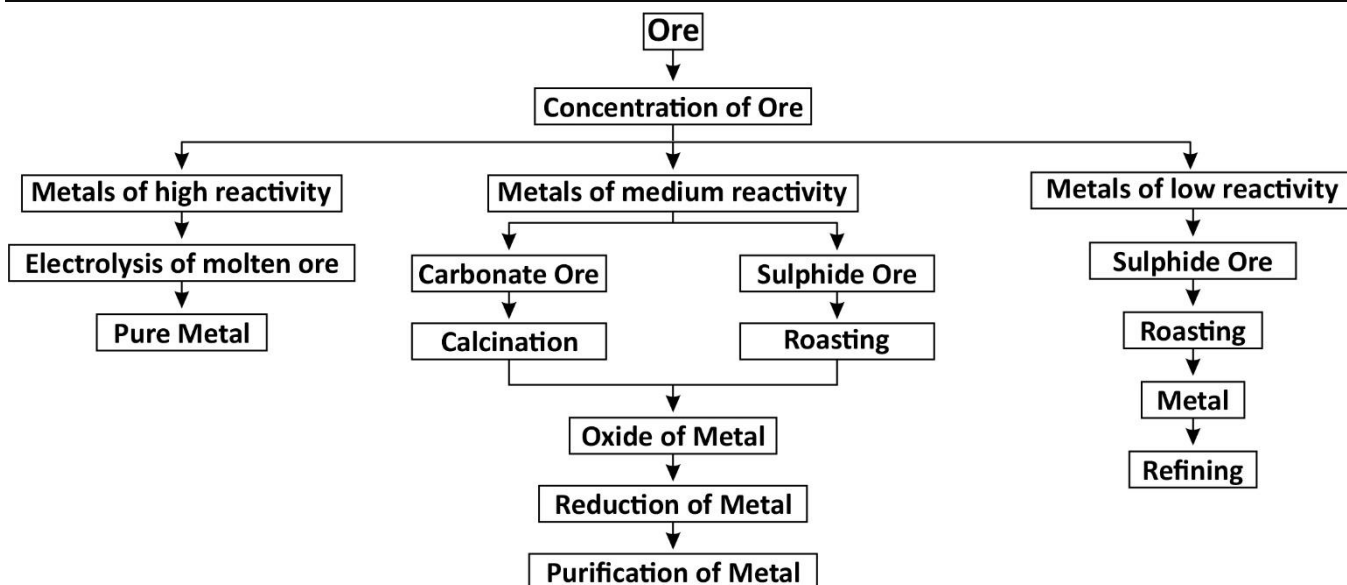
- They are good electric conductors but poorer than metals.
- They have intermediate energies of ionisation and values of electronegativity
- Like non-metals, they form anions, have multiple oxidation states, and form covalent bonds
- They form metallic alloys.

### Metalloids and their applications

Element	Description	Application
Boron	An allotropic semimetal that is extremely hard and heat resistant. Has an atomic number of 5.	Used with silicon to make thermal shock-resistant glass.
Silicon	A grey and shiny semiconductive metal. It has high melting (1,410 °C) and boiling points (3,265 °C). Has an atomic number of 14.	Commonly used for semiconductors.
Germanium	Is hard and brittle in its elemental form. Has an atomic number of 32.	Less commonly used for semiconductors.

Element	Description	Application
Arsenic	A steel-grey semimetal known for being poisonous. It has an atomic number of 33.	Often used as an insecticide.
Tellurium	Brittle in its elemental form. It is a chalcogen, along with selenium and sulfur. It has an atomic number of 52.	Used as a steel additive to improve machinability.
Antimony	A hard and brittle semimetal with an atomic number of 51.	Used to colour paints; often alloyed with lead.

## Metallurgical Principles and methods



- **Metallurgy** - a process that is used for the extraction of metals in their pure form.
- **Minerals** - The compounds of metals mixed with soil, limestone, sand, and rocks.
- Metals are **commercially extracted** from **minerals** at **low cost** and minimum effort.
  - These minerals are known as **ores**.
- A **substance** which is added to the **charge** in the **furnace** to remove the **gangue** (impurities) is known as **flux**.
- Metallurgy **deals** with the **process** of **purification** of **metals** and the **formation** of **alloys**.

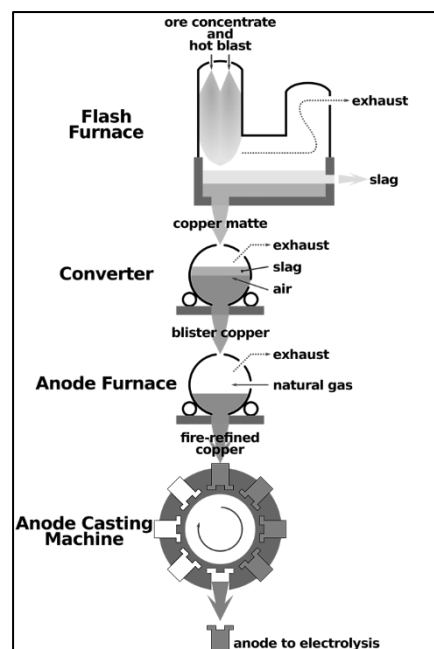
## Steps in Metallurgical Process

- The following are the various **steps** in the metal extraction or metallurgical process:
  - **Crushing** and **grinding** the ore.
  - The **concentration of ore**, is also known as ore enrichment.
  - **Metal extraction** from concentrated ore.
  - Impure metals are **refined** or **purified**.

### Fig. Copper Flash Smelting Process

## Principles of Metallurgy

- The metallurgical process can be **classified** as the following:
  - Crushing and grinding
    - The **first process** in **metallurgy**.
    - Crushing of ores into a **fine powder** in a **crusher** or **ball mill**.
- This process is known as **pulverization**.
  - Concentration of ores
    - aka **ore dressing**.
    - It is the process of **removing impurities** from ore.
    - In metallurgy, we concentrate the ores mainly by the following **methods**.
  - Hydrolytic method
    - The **ore** is **poured** over a sloping, **vibrating corrugated table** with grooves.



- A **jet of water** is allowed to **flow** over the **surface**.
    - The denser ore particles **settle** in the **grooves**, and the **impurities** are **washed away** by water.
  - Magnetic separation
    - The **crushed ore** is placed on a **conveyor belt**.
    - This belt **rotates** around **two wheels** in which one of the **wheels** is **magnetic**, and therefore the **magnetic particles** get **attracted** to the **magnetic wheel** and fall apart from the **non-magnetic particles**.
  - Froth floatation
    - The **crushed ore** is taken in a **large tank** which contains **oil** and **water**.
    - A **current of compressed air** is **passed** through it.
    - The ore gets **wet** by **oil** and is **separated** from the **impurities** in the form of **froth**.
    - **Ore** is **lighter**, and so it **comes** on the **surface** and impurities are left behind.
  - Roasting and calcination
    - **Roasting** - The process of heating a concentrated ore in the **presence of oxygen**.
- This process is applied in the case of **sulfide ores**.
  - **Calcination** - For ores containing **carbonate** or **hydrated oxides**, heating is done in the **absence of air** to melt the ores.

## Important ores and alloys

### Ores

- A mineral from which a metal can be extracted economically is called an ore.
- In it, a metal is present in appreciable quantities and from which the metal can be extracted economically.
- The main active substances present in nature, especially in the atmosphere are oxygen and carbon dioxide.
- In the earth's crust, sulphur and silicon are found in large quantities.
- Sea-water contains large quantities of chloride ions (obtained from dissolved sodium chloride).
- Most active metals are highly electropositive and therefore exist as ions.
- It is for this reason that most of the important ores of these metals occur as
  - Oxides
  - Sulphides
  - carbonates
  - halides
  - silicates
- Some sulphide ores undergo oxidation by air to form sulphates.
  - This explains the occurrence of sulphate ores.
- Ores are invariably found in nature in contact with rocky materials.
  - These rocky or earthy impurities accompanying the ores are termed as gangue or matrix.

### Important metals and their ores

Important metals and their ores		
Metal	Ores	Chemical Formula
Sodium (Na)	Chile saltpeter	$\text{NaNO}_3$
	Trona	$\text{Na}_2\text{CO}_3 \cdot 2\text{NaHCO}_3 \cdot 3\text{H}_2\text{O}$
	Borax	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
	Common salt	$\text{NaCl}$
Aluminium (Al)	Bauxite	$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
	Corundum	$\text{Al}_2\text{O}_3$
	Felspar	$\text{K Al Si}_3 \text{O}_8$
	Cryolite	$\text{Na}_3\text{AlF}_6$
	Alunite	$\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 4 \text{Al}(\text{OH})_3$
	Kaolin	$3 \text{Al}_2\text{O}_3 \cdot 6 \text{SiO}_2 \cdot 2\text{H}_2\text{O}$
	Potassium (K)	Nitre (salt peter)
Carnalite		$\text{KCl} \cdot \text{MgCl}_2 \cdot 6 \text{H}_2\text{O}$
Magnesium (Mg)	Magnesite	$\text{MgCO}_3$
	Dolomite	$\text{MgCO}_3 \cdot \text{CaCO}_3$
	Epsom salt	$\text{MgSO}_4 \cdot 7 \text{H}_2\text{O}$
	Kieserite	$\text{MgSO}_4 \cdot \text{H}_2\text{O}$
	Carnalite	$\text{KCl} \cdot \text{MgCl}_2 \cdot 6 \text{H}_2\text{O}$

Calcium (Ca)	Dolomite	$\text{CaCO}_3 \cdot \text{MgCO}_3$
	Calcite	$\text{CaCO}_3$
	Gypsum	$\text{CaSO}_4 \cdot 2 \text{H}_2\text{O}$
	Fluorspar	$\text{CaF}_2$
	Asbestos	$\text{CaSiO}_3 \cdot \text{MgSiO}_3$
Strontium (Sr)	Strontianite	$\text{SrCO}_3$
	Silestine	$\text{SrSO}_4$
Copper (Cu)	Cuprite	$\text{Cu}_2\text{O}$
	Copper glance	$\text{Cu}_2\text{S}$
	Copper pyrites	$\text{CuFeS}_2$
Silver (Ag)	Ruby Silver	$3 \text{Ag}_2\text{S} \cdot \text{Sb}_2\text{S}_3$
	Horn Silver	$\text{AgCl}$
Gold (Au)	Calaverite	$\text{AuTe}_2$
	Silvenites	$[(\text{Ag}, \text{Au}) \text{Te}_2]$
Barium (Ba)	Barytes	$\text{BaSO}_4$
Zinc (Zn)	Zinc blende	$\text{ZnS}$
	Zincite	$\text{ZnO}$
	Calamine	$\text{ZnCO}_3$
Mercury (Hg)	Cinnabar	$\text{HgS}$
Tin (Sn)	Cassiterite	$\text{SnO}_2$
Lead (Pb)	Galena	$\text{PbS}$
Antimony (Sb)	Stibnite	$\text{Sb}_2\text{S}_3$
Cadmium (Cd)	Greenocite	$\text{CdS}$
Bismuth (Bi)	Bismuthite	$\text{Bi}_2\text{S}_3$
Iron (Fe)	Haemetite	$\text{Fe}_2\text{O}_3$
	Lemonite	$2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$
	Magnetite	$\text{Fe}_3\text{O}_4$
	Siderite	$\text{FeCO}_3$
Cobalt (Co)	Iron Pyrite	$\text{FeS}_2$
	Copper Pyrites	$\text{CuFeS}_2$
	Smelite	$\text{CoAsS}_2$
Nickel (Ni)	Milarite	$\text{NiS}$
Magnese (Mn)	Pyrolusite	$\text{MnO}_2$
	Magnite	$\text{Mn}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
Uranium (U)	Carnetite	$\text{K}(\text{UO})_2 \cdot \text{VO}_4 \cdot 3\text{H}_2\text{O}$
	Pitch blende	$\text{U}_3\text{O}_8$

## Alloys

- Alloys are mixtures of two or more metals and are formed by mixing molten metals thoroughly.
  - In a few cases, non-metals are mixed with metals to produce alloys.
- Alloying produces a metallic substance with more useful properties than the original pure metals from which it is made.
  - For example, the alloy brass is made from copper and zinc.

## Properties of alloys

Alloys are prepared to impart some desirable properties which the individual metals do not possess. These are,

- Change in the chemical reactivity:** Sodium acts vigorously with water, but *Na-Hg* amalgam reacts slowly to suit the requirement of some chemical reactions.
- Hardness:** Silver, gold, and soft metals become hard when alloyed with copper.
- Melting Points:** Melting points of an alloy may be higher or lower than any of its components. Wood-metal, which is an alloy of *Bi*, *Pb*, *Sn* and *Cd*, fuses at  $60^\circ\text{C}$ , while none of these metals fuses at this low temperature.
- Change of colour:** Aluminium bronze is an alloy of aluminium and copper. It is of golden, yellow colour and is used in making decoration articles, jewellery and coins while the colour of aluminium is white and that of copper is red.

- **Corrosion resistance:** Iron gets corroded soon, whereas stainless Steel, an alloy of iron and chromium, resists corrosion.
- **Casting:** An alloy of lead and antimony is known as *type metal* and is used for casting type required in printing works.

### Advantages of alloys

- Alloys do not get corroded or get corroded to a very less extent.
- They are harder and stronger than pure metals (For example, gold is mixed with copper, and it is harder than pure gold)
- They have less conductance than pure metals (For example, copper is a good conductor of heat and electricity, whereas brass and bronze are not good conductors)
- Some alloys have lower melting points than pure metals (For example, solder is an alloy of lead and tin, which has a lower melting point than each of the metals)
- When metal is alloyed with mercury, it is called amalgam.

### Important Alloys

#### Alloys of Silver

Alloy	Percentage composition	Uses
Coin silver	Ag = 90, Cu = 10	For making silver coins.
Silver solder	Ag = 63, Cu = 30, Zn = 7	For soldering and joining metals
Dental alloy	Ag = 33, Hg = 52, Sn = 12.5, Cu = 2.0, Zn = 0.5	For filling teeth
Silver palladium	Ag = 40, Pd = 60	Potentiometers, and winding of some special instruments.

#### Alloys of Iron

Name	Percentage	Uses
Stainless steel	Fe = 73%, Cr = 18%, Ni = 8% and carbon	For making utensils, cutlery and ornamental pieces.
Manganese steel	Fe = 86%, Mn = 13% and carbon	For Making rock drills, safes etc.
Tungsten steel	Fe = 94%, W = 5% and carbon	For making high speed cutting tools.
Invar	Fe = 64%, Ni = 36%	For making watches, meter scales, pendulum rods etc.
Nickel steel	Fe = 98?96%, Ni = 2?4%	For making wire cables, gears, drive shafts etc.
Permalloy	Fe = 21%, Ni = 78% and carbon	For making electromagnets, ocean cables etc.
Chrome steel	Fe = 98?96%, Cr = 2?4%	For making axles, ball bearings and cutting tools such as files.
Alnico	Fe = 60%, Al = 12%, Ni = 20%, Co = 8%	For making permanent magnets.

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**Alloys of Copper**

<b>Alloy</b>	<b>Percentage Composition</b>	<b>Uses</b>
Brass	Cu = 80, Zn = 20	For making utensils, condenser tubes, wires parts of machinery etc.
Bronze or Copper bronze	Cu = 80, Zn = 10, Sn = 10	For making cooking utensils, statues, coins etc.
Aluminium bronze	Al = 95, Cu = 5	Coins, picture frames, cheap jewellery
Gun metal	Cu = 90, Sn = 10	For making gun barrels.
Bell metal	Cu = 90, Sn = 20	For making bells, gongs etc.
Constantan	Cu = 60, Ni = 40	For electrical apparatus
German silver	Cu = 60, Zn = 20, Ni = 20	For making silver wire, resistance wires etc.
Monel metal	Cu = 30, Ni = 67, Fe and Mn = 3	For making acid pumps and acid containers.
Phosphor bronze	Cu = 95, Sn = 4.8, P = 0.2	For making springs, electrical equipment
Gold-copper alloy	Au = 90, Cu = 10	For making gold coins, jewellery, watch cases, spectacle rims etc.

**Alloys of Lead and Tin**

<b>Alloy</b>	<b>Percentage Composition</b>	<b>Uses</b>
Solder	Pb = 50, Sn = 50	For soldering.
Pewter	Pb = 20, Sn = 80	In making cups, mugs and other utensils.
Type metal	Pb = 70, Sb = 20 and Sn = 10	For making printing type.
Rose metal	Pb = 22, Sn = 28, Bi = 50	For making electric fuses.
Britannia metals	Sn = 90, Sb = 8, Cu = 2	For making table wares.



## Alloys of Aluminium

Alloy	Percentage		Uses
Aluminium bronze	Al Cu	95% 5%	Coins, utensils, jewellery picture frames etc.
Magnalium	Al Mg	95% 5%	Light instruments, balance beam, pressure cookers etc.
Duralumin	Al Cu Mg Mn	95% 4% 0.5% 0.5%	Making aeroplanes, automobile parts pressure cookers etc.

## Acids, Bases and Salts

### Indicators

Substances which indicate the acidic or basic nature of the solution by the colour change.

#### Types of Indicator

	Indicator	Smell/Color in acidic solution	Smell/Color in basic solution
Natural Indicator	Litmus	Red	Blue
	Red cabbage leaf extract	Red	Green
	Flower of Hydrogen Plant	Blue	Pink
	Turmeric	No Change	Red

Synthetic Indicator	Phenolphthalein	Colourless	Pink
	Methyl Orange	Red	Yellow

Olfactory Indicator	Onion	Characteristic Smell	No Smell
	Vanilla Essence	Retains Smell	No Smell
	Clove Oil	Retains Smell	Loses Smell

#### Natural Indicators

- Indicators obtained from natural sources.
- Eg:
  - Litmus