PLEDGE

“India is my Country. All Indians are my Brothers and sisters.

I love my country, and I am Proud of its rich and varied heritage.

I Shall always strive to be worthy of it.

I Shall give my Parents, teachers and all elders respect,

and treat everyone with courtesy. I shall be Kind to animals

To my country and my people, I pledge my devotion

In their well-being and prosperity alone lies my happiness.”

Pydimarri Venkata Subba Rao

PREFACE

"Welcome to the world of physics and chemistry!

This textbook is designed to introduce you to the fundamental principles and concepts that govern our natural world.

Physics and chemistry are the building blocks of science, and understanding them is essential for navigating the complexities of our modern world. From the smallest atoms to the vastness of space, these subjects help us make sense of the world around us.

In this book, we will explore the basics of physics and chemistry, including motion, energy, forces, matter, and chemical reactions. We will use simple language, examples, and illustrations to make these concepts accessible and engaging.

Our goal is to inspire curiosity, foster critical thinking, and provide a solid foundation for further learning. We hope this book will spark a lifelong passion for discovery and exploration.

Let's embark on this journey together and uncover the wonders of physics and chemistry!"

NOTE: - The textbook is designed for AICU students to help them grasp the concepts covered in Physics and Chemistry in the Foundation and Bridge Course. This book is helpful for students who are away from modern education.

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1. REFLECTION OF LIGHT

INTRODUCTION:

Reflection of light is the process where light bounces off a surface. When light encounters a smooth and shiny surface, such as a mirror or a still body of water, it reflects off at the same angle it hits the surface, obeying the law of reflection. This law states that the angle of incidence (the angle between the incident ray and the normal, or perpendicular line to the surface) is equal to the angle of reflection (the angle between the reflected ray and the normal).

Reflection is responsible for many everyday phenomena, such as seeing your reflection in a mirror, the visibility of objects due to sunlight reflecting off them, and the formation of images in optical devices like telescopes and microscopes. It's also fundamental in the study of optics and plays a crucial role in technologies like lasers, fiber optics, and reflective coatings.

Light:

(i) Light is the form of energy, and its speed in a vacuum is $3x10^{8\ m/s.}$

(ii) It helps us to see the objects.

(iii) It helps plants produce food with the help of photosynthesis.

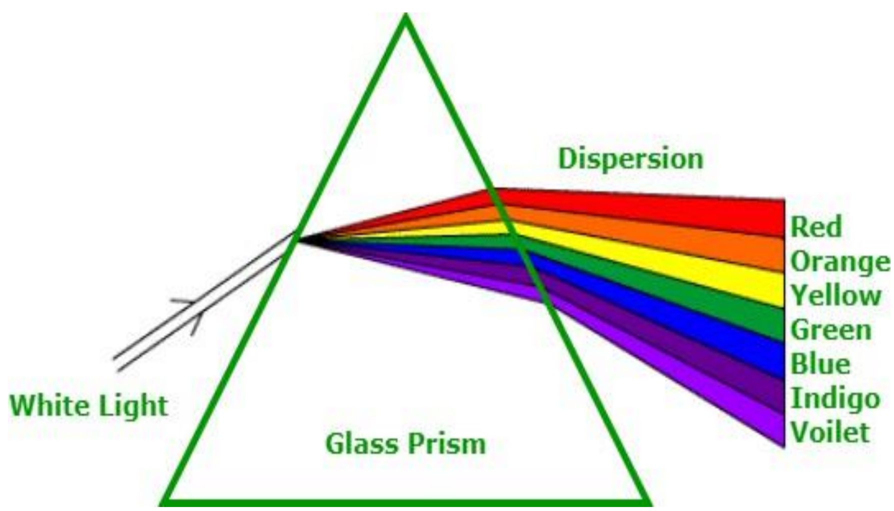
(iv) The path light travels is called a ray of light.

Reflection of light:

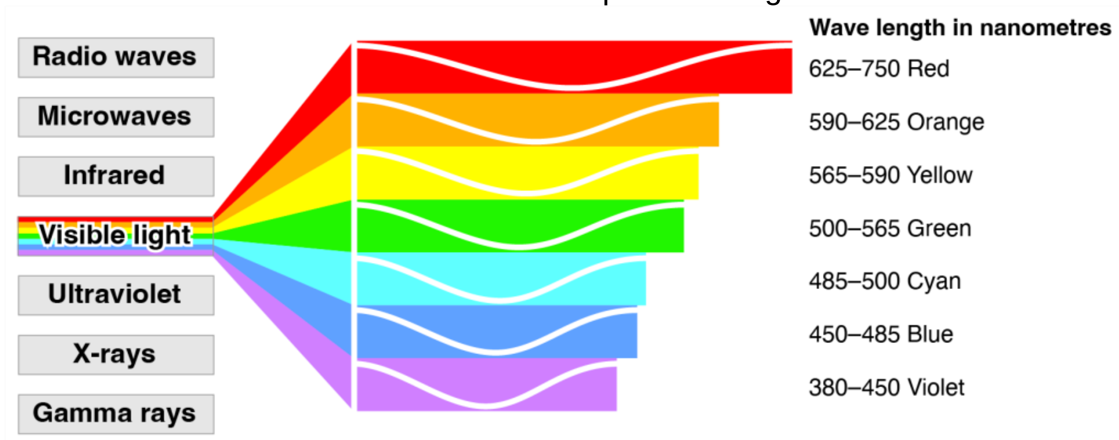
The bouncing back of light rays after hitting any surface is called the reflection of light.

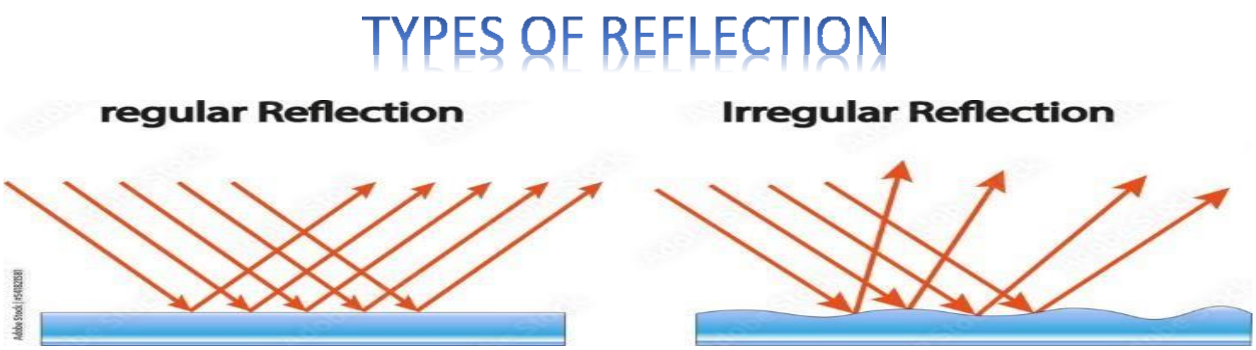
Dispersion of light:

The phenomenon of splitting visible light into its component colors.



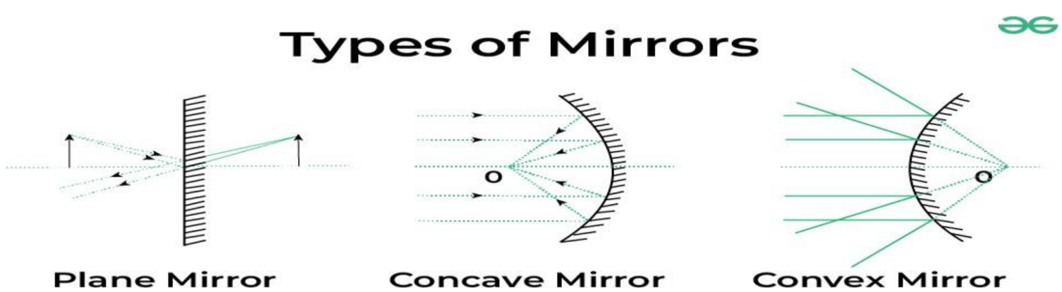
Spectrum of light:
A band of seven colors was obtained due to the dispersion of light.



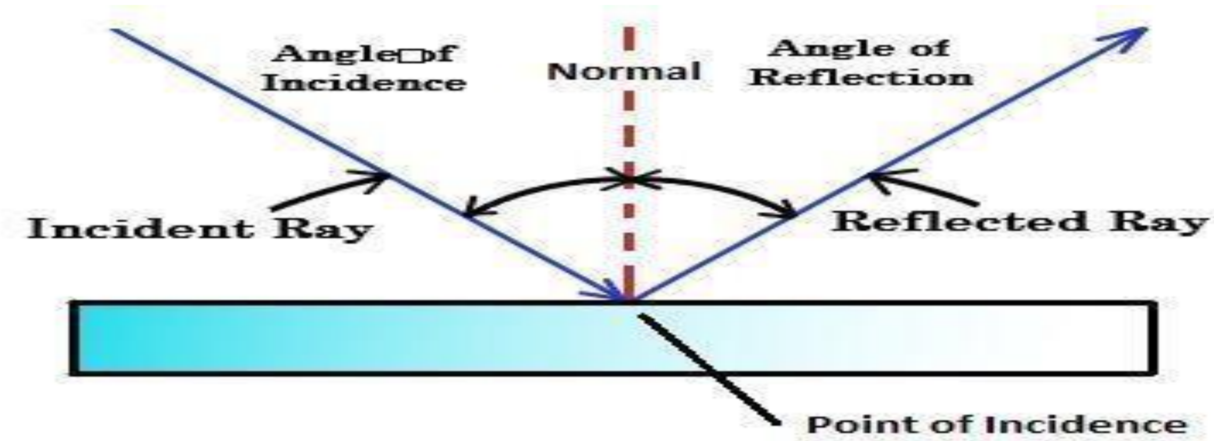


1. **Regular reflection:** When a beam of parallel light is incident on a smooth, flat surface, the reflected rays will also be parallel.
2. **Irregular reflection:** when a beam of parallel light rays is incident on a rough surface, the reflected rays scatter in different directions.

Mirror: A mirror is a surface that reflects almost all incident light.



Plane mirror: a straight, highly polished, smooth, reflecting surface.
Concave mirrors are spherical mirrors that are curved inward.
Convex mirror: the spherical mirror that is curved outward.



Definitions:

Incident ray: the ray of light that falls on the surface.

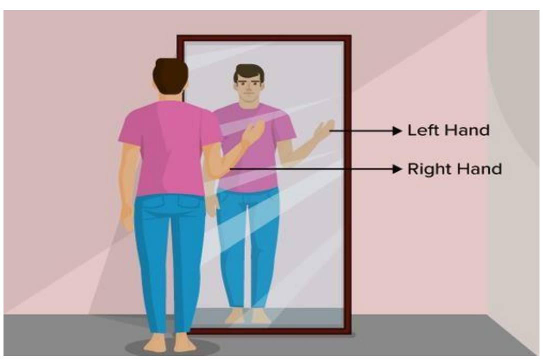
Reflected ray: The ray of light bounces back from the surface.

Point of incidence: the point where the incident ray strikes the surface.

Normal: the perpendicular line drawn onto the surface at the point of incidence.

The angle of incidence: The angle made by the incident ray with the normal at the point of incidence.

The angle of reflection: The angle made by the reflected ray with the normal at the point of incidence.

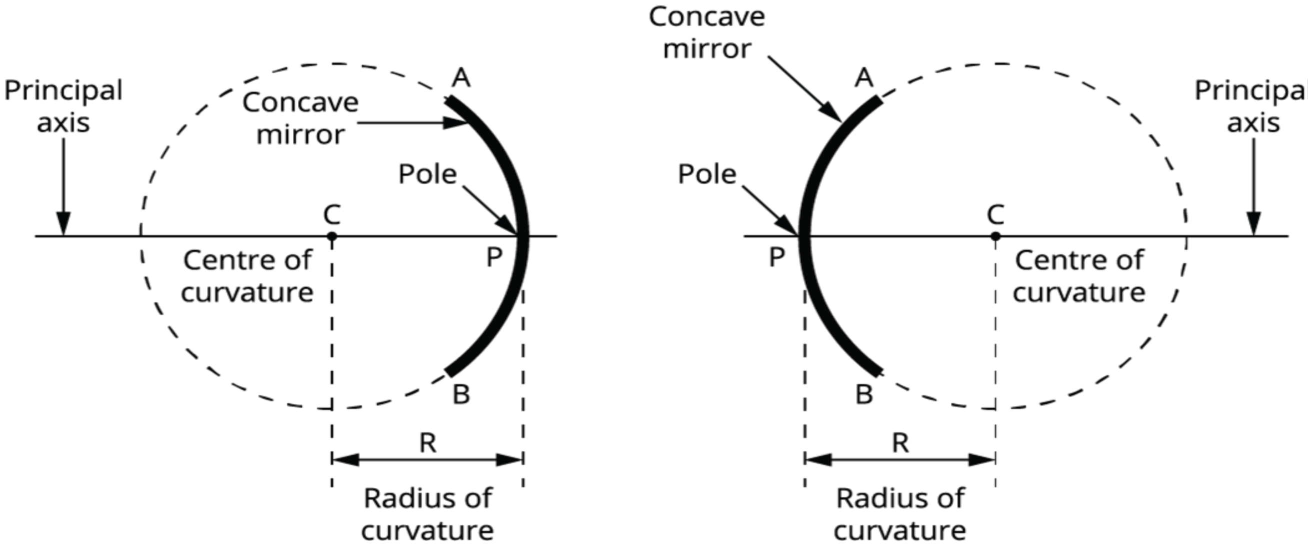


Lateral inversion: The term "lateral inversion" describes a picture inverted in terms of left and right. In the mirror, the left-side virtual image of an object is seen on the right side, and vice versa.

Real image: A real image is formed by the actual intersection of light rays.

Virtual image: A virtual image is formed by the imaginary intersection of light rays.

Terms related to spherical mirrors:



Aperture: The portion available for reflection is called the aperture**;** APB is the aperture.

Pole: It is the geometric centre of the reflecting surface. It is denoted by P.

Centre of Curvature: It is the centre of the sphere of which the mirror forms a part. C is the centre of curvature.

Principal Axis: It is a straight line passing through the centre of curvature and the pole. The line passing through P and C in the figure is the principal axis.

The radius of Curvature (R): It is the radius of the sphere of which the mirror forms a part. PC is the radius of curvature.

Principal Focus: Consider a parallel beam of light incident on a spherical mirror.

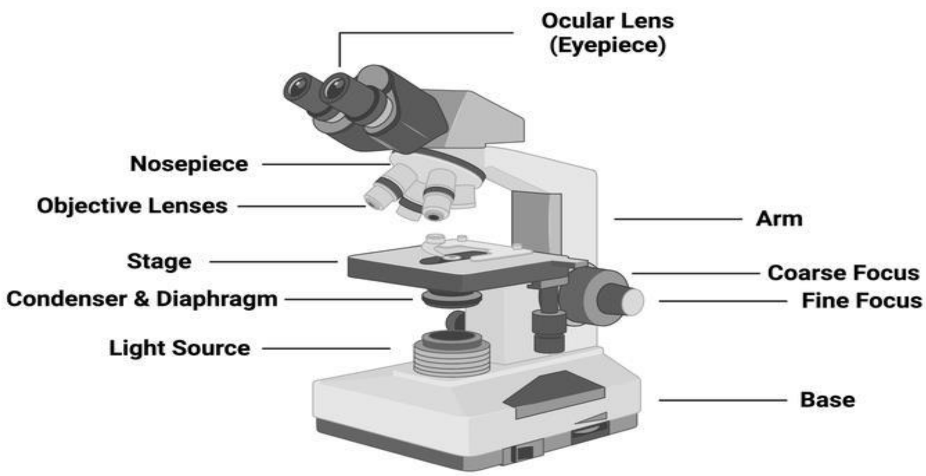
Case (i): In the case of a concave mirror, the parallel beam after reflection converges at a point F, which is called the principal focus**.**

Case (ii): In the case of a convex mirror, it appears to diverge from the focus **(F).**

Thus, a concave mirror is called a converging mirror, and a convex mirror is called a diverging mirror**.**

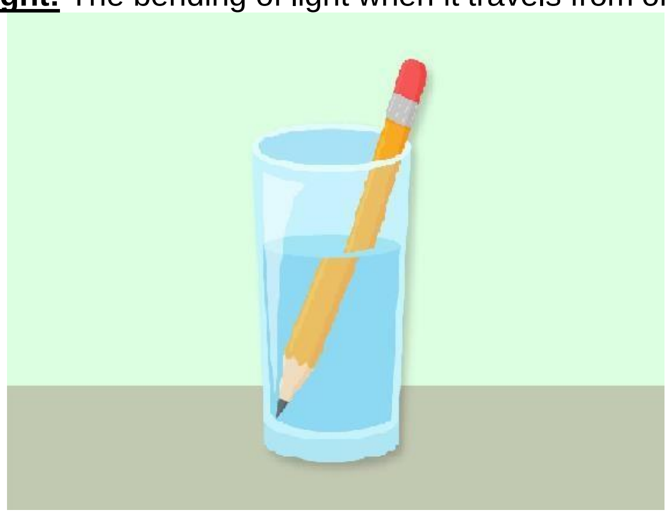
Focal Length: It is the distance between the pole and the principal focus. PF is the focal length. It is denoted by ‘f’. It is measured in m or cm.

Microscope: The device that is used to see tiny objects.



Telescope: The device that is used to see distant objects.

Refraction of light: The bending of light when it travels from one medium to another.



2. MOTION AND ITS DESCRIPTION

INTRODUCTION:

Motion refers to the change in position of an object concerning its surroundings over time. It's a fundamental concept in physics and can be described in terms of various parameters such as distance, displacement, speed, velocity, and acceleration.

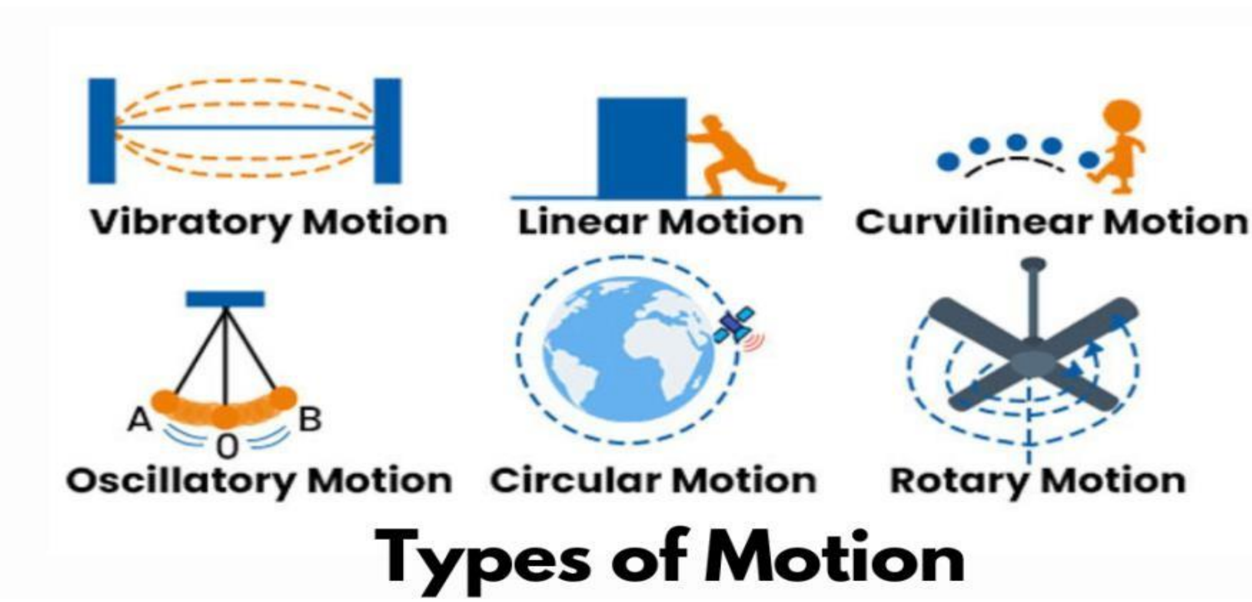
Motion can be described using graphs, equations, and mathematical formulas. It's studied in various branches of physics, including classical mechanics, kinematics, and dynamics, and applies to many real-world scenarios, from the motion of celestial bodies in space to the movement of vehicles on Earth. Understanding motion allows scientists and engineers to analyze and predict the behaviour of objects and systems, leading to advancements in technology and our understanding of the universe.

Motion: If an object changes its position to its surroundings over time, then it is said to be in motion.

Rest: If an object does not change its position to its surroundings with time, then it is said to be at rest.

Types of motion :

- Translatory
1. Linear motion
2. Curvilinear motion
- Rotational motion
- Oscillatory motion (periodic motion)
- Random motion



Translatory motion: When an object moves from one place to another over a period of time, the position of the object changes; its motion is called translatory motion.

A vehicle is moving on the road in a straight path, but sometimes in a curved path as well. So, we can say that *rectilinear and curvilinear or circular motions* of an object are *translatory.*

Rectilinear motion: Motion in a straight line is called rectilinear motion.

For example: 1. a man walking on the road; 2. vehicles on the road; 3. a march past soldiers.

Curvilinear motion or circular motion:

The motion of an object moving in a curved path is called curvilinear motion.

For example: 1. the earth's motion around the sun; 2. an athlete running around a circular path.

Rotational Motion: *A body moving about a fixed axis is called rotational motion.* Rotational motion is non-uniform with a changing rate of rotation. In rotatory motion, the body rotates on its axis.

For example: 1. rotation of the hands of a clock; 2. rotation of the fan; 3. spinning the top on the ground.

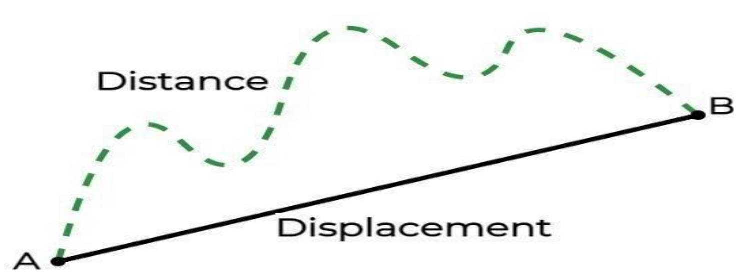
Oscillatory Motion: A motion that repeats itself at regular intervals of time is called oscillatory motion. It is also known as periodic motion. For example, a swing in motion, a water wave, and a pendulum bob in a clock.

Random motion: If the motion of moving objects is not in a definite direction, it is known as random motion. For example, the motion of fish in the water.

Displacement: The shortest path or shortest distance between two points is called 'Displacement'. Displacement is the vector quantity.

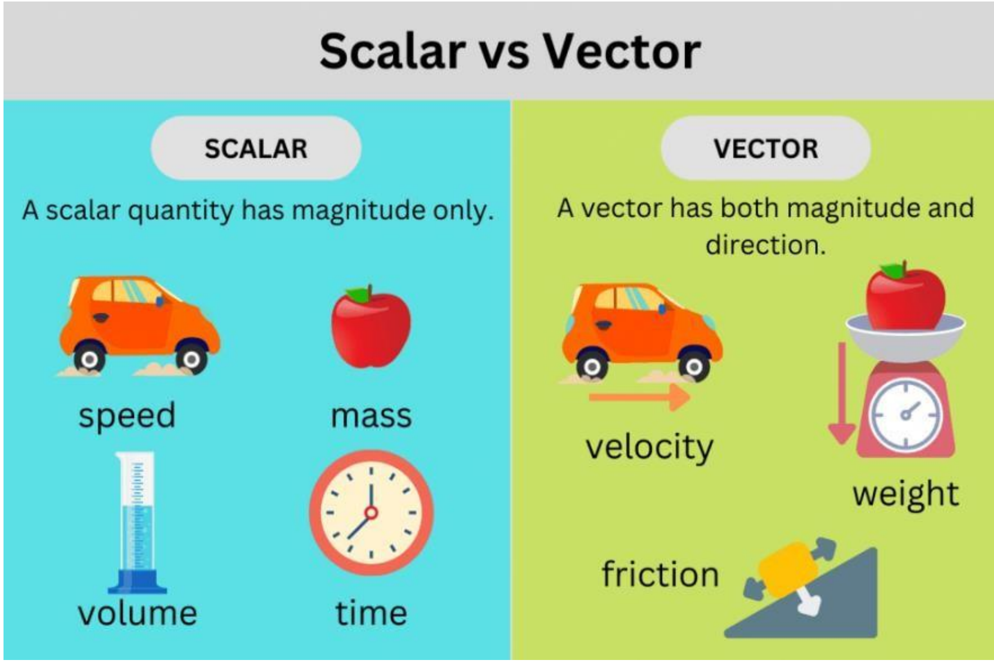
Distance: Distance is defined as the length of the actual path from the initial position to the final position of an object. Distance is the scalar quantity.

SI Units: meter (m)



Scalar: A physical quantity that has only one magnitude is a scale.

Vector: A physical quantity that has both magnitude and direction is a vector.



Differences between vector and scalar quantities.

Quantity	Scalar	Vector
Definition	A physical quantity that has only one magnitude.	A physical quantity that has both magnitude and direction.
Examples	Mass, time, distance, volume, speed, and temperature.	Weight, velocity, displacement, acceleration, and momentum.
Quantity	Yes	Yes
Direction	No direction	It has direction and is denoted by $\rightarrow$

Speed: Speed can be defined as the distance covered by an object in one second.

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{time taken}}$$

Instantaneous speed: The instantaneous speed is the speed of an object at a particular moment (instant) in time. Instantaneous speed is the maximum speed that may be achieved over a short period.

Units of speed: The units of speed are meters per second or m/s.
The other commonly used unit is kilometre/hour, or km/h.

Velocity: Velocity can be defined as the rate of change of Displacement of an object.

Velocity $= \frac{Displacement\ of\ an\ object}{Time\ is\ taken}$

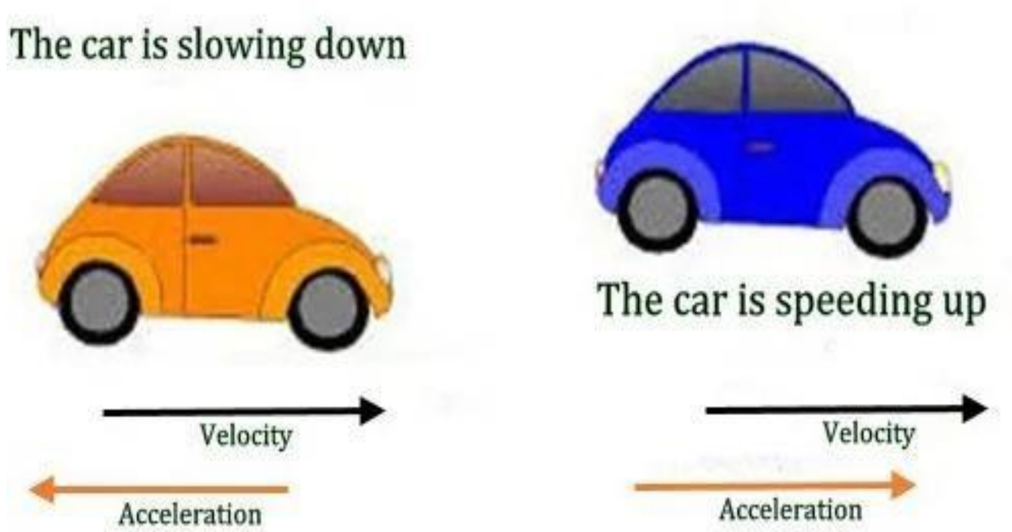
Units of Velocity: The units of velocity are meters per second (m/s).

The other commonly used unit: Kilometer/hour (km/h).

Acceleration: The rate of change of velocity is called acceleration. It is a vector quantity.

$$\text{Acceleration} = \frac{change\ in\ velocity}{Time\ taken\ for\ change}$$

$$= \frac{Final\ velocity - Initial\ velocity}{Time} = \frac{v-u}{t}$$



Units of acceleration: The units of acceleration are meters per second or m/s^2.

3. FORCE AND MOTION

INTRODUCTION:

Force is a fundamental concept in physics that describes the interaction between objects that results in a change in motion. It can cause an object to accelerate, decelerate, or change direction.

Effects on Motion: Forces can cause changes in the motion of objects.

They can: cause objects to accelerate or decelerate.

Change the direction of motion.

cause objects to deform or break.

maintain the motion of objects in the absence of friction or other opposing forces.

Understanding force is essential for analyzing and predicting the motion of objects in various scenarios, from everyday situations like driving a car to complex phenomena like the motion of planets in space. It forms the basis for many branches of physics, including mechanics, dynamics, and engineering.

Force: A push or pull acting on an object is called force.

Units of force: the S.I. unit of force is Newton. It is denoted by 'N'.

S.I., in its full form, is an international system of units.

Types of force:

1. Contact forces.
2. Field forces.

1. Contact forces: "The force that results when there is direct physical contact between two interacting objects is called the contact force.".

2. Field force: The force that results when there is no physical contact between two interacting objects is called field force."

Types of contact force:

1. Muscular force.
2. Normal force.
3. Tension force.
4. Friction force.

TYPES OF CONTACT FORCE

1. <u>Muscular force</u>: The force that is exerted by body muscles is called muscular force.

Example: Playing cricket

2. <u>Normal force:</u> The force that a solid surface exerts on any object in a normal (perpendicular to the surface) direction is called normal force.

Example: Normal force and gravitational forces acting on a body.

3. <u>Tension force:</u> the force exerted by a string in the opposite direction of the force acting on it. Within its elastic limit, it is called tension.

Example: drawing water from a well.

4. <u>Friction force:</u> The force that opposes the relative motion of a surface in contact is called the force of friction.

Example: When you try to push a heavy rock.

Types of field force:

1. Magnetic force.
2. Gravitational force.
3. Electrostatic force.

Types of Field Force

1. Magnetic force: The force of the attraction or repulsion that arises due to magnets is called magnetic force.

Example: magnetic force attracts iron nails when they are bought near a magnet.

2. Gravitational force: The attractive force between any two objects at a distance is called gravitational force.

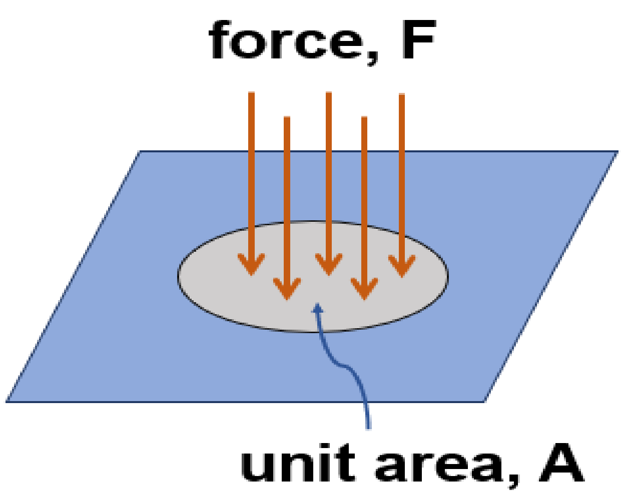
Example: The force that acts on a vertically thrown ball.

3. Electrostatic force: The force exerted by a charged body on another charged body is called electrostatic force.

Example: The combed comb attracts pieces of paper.

Pressure: A force acting on a unit area of a surface is called pressure.

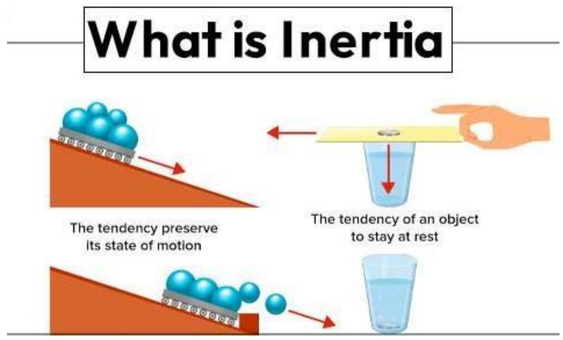
PRESSURE = $\frac{FORCE}{AREA\ ON\ WHICH\ IT\ ACTS}$



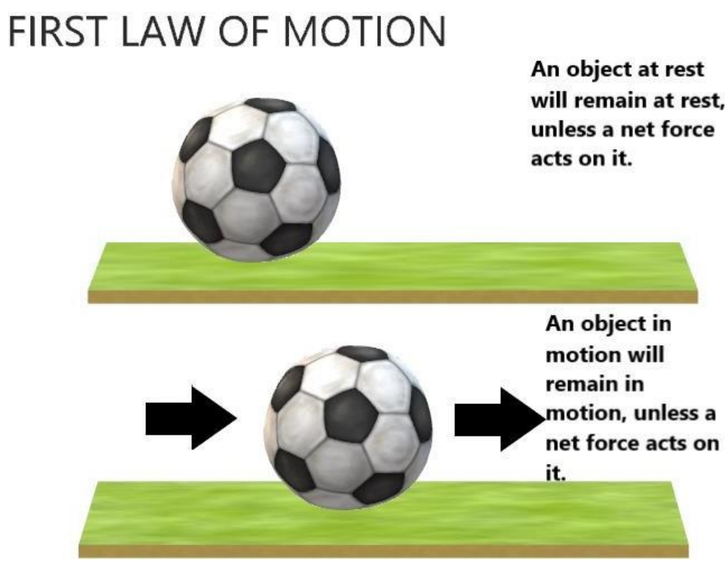
UNITS OF FORCE: The units of pressure in the SI system are newtons per meter ^{2} (or N/M2).

Newton's Laws of Motion.

INERTIA: Inertia is the tendency of an object to stay at rest or keep moving with the same velocity.



Newton's First Law of Motion: Newton's First Law of Motion states that an object will remain at rest or in uniform motion in a straight line unless acted upon by an external force.



Applications for Newton's First Law of Motion:

1. Seatbelts in Cars: When a car suddenly stops, the passengers tend to keep moving forward due to inertia. Seatbelts prevent this by exerting a force on the passengers to bring them to a stop, under Newton's first law.
2. Skating: Ice skating or roller skating provides an example of Newton's first law. When gliding on ice or smooth surfaces, the skater continues moving forward until friction or another force acts upon them to stop their motion.

Momentum:

Momentum is a physics term that describes the quantity of motion an object has. It is calculated as the product of an object's mass and its velocity. Mathematically, momentum (p) is defined as:

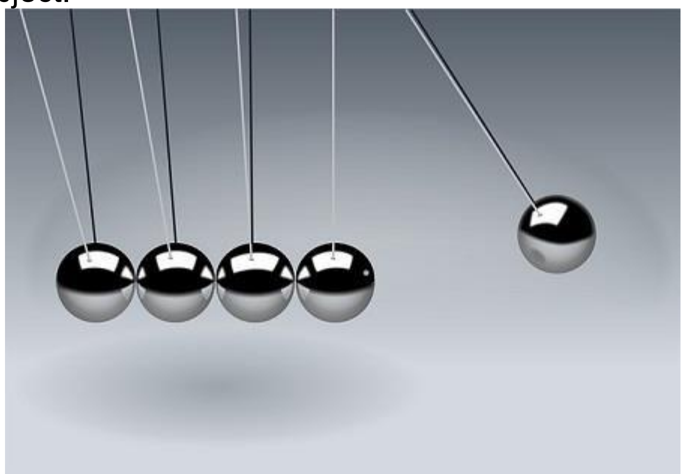
$p = m \times v$

Where:

p is momentum.

m is the mass of the object.

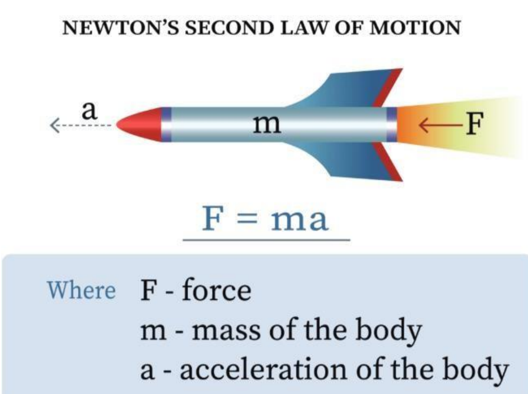
v is the velocity of the object.

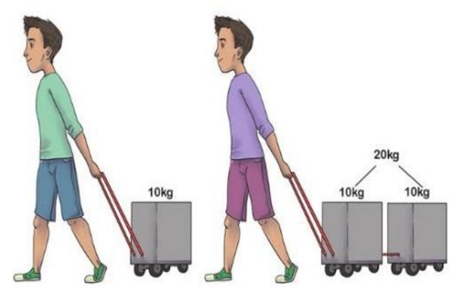


APPLICATIONS NEWTON'S SECOND LAW OF MOTION:

Newton's second law of motion states that the force acting on an object is equal to the mass of the object multiplied by its acceleration. Mathematically, it's expressed as F = ma, where **F** is the force applied to the object, **m** is its mass, and **a** is its acceleration.

This law explains how the velocity of an object changes when subjected to an external force.





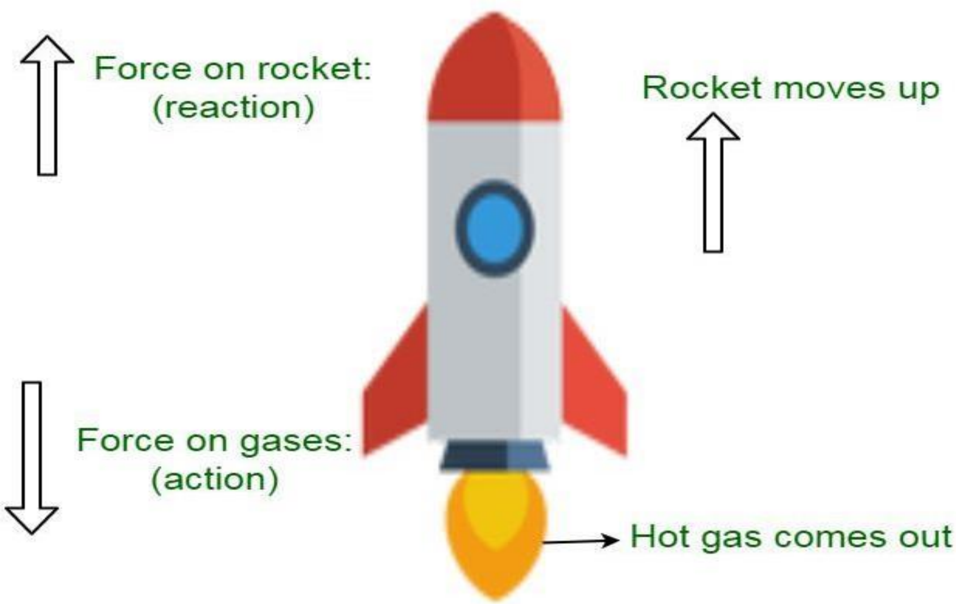
Newton's Third Law of Motion:

Newton's third law of motion states that “for every action, there is an equal and opposite reaction”.

APPLICATIONS OF NEWTON’S THIRD LAW OF MOTION:

Applications of Newton's third law:

1. Walking: When you walk, your foot exerts a backward force on the ground, and the ground exerts an equal and opposite forward force on your foot, propelling you forward.
2. Rocket Propulsion: A rocket's engines expel high-speed exhaust gases downward, which creates a force pushing the rocket upward. The rocket experiences an equal and opposite force downward, according to Newton's third law.
3. Swimming: As you swim, you push the water backwards with your hands and feet, and the water pushes you forward with an equal force in the opposite direction.



4 -THERMAL ENERGY

INTRODUCTION:

Thermal energy is a form of energy associated with the temperature of an object or a system. It originates from the movement of atoms and molecules within a substance. The faster the particles move, the higher the temperature and thermal energy of the object.

This energy plays a crucial role in everyday life and various scientific fields. It's involved in processes like heating, cooling, and phase changes such as melting and boiling. Understanding thermal energy is essential for fields like thermodynamics, engineering, meteorology, and environmental science.

1. **Thermal Energy**: Thermal energy is a form of internal energy associated with the random motion of atoms and molecules within a substance. It is directly related to the temperature of the substance and represents the total kinetic energy of its particles.

2. **Temperature**: Temperature is a measure of the average kinetic energy of the particles in a substance. It determines the direction of heat transfer between two objects in contact and is commonly measured in units such as Celsius (°C), Fahrenheit (°F), or Kelvin (K).

3. **Heat:** Heat is the transfer of thermal energy between two systems due to a temperature difference. It flows from regions of higher temperature to regions of lower temperature until thermal equilibrium is reached. Heat is measured in units of joules (J) or calories (cal).

4. **Conduction:** Conduction is the process of heat transfer through direct contact between particles of matter. It occurs when hotter particles transfer thermal energy to cooler particles by colliding with them, leading to an increase in temperature.

5. **Convection:** Convection is the process of heat transfer through the movement of fluids (liquids or gases). It occurs when hotter fluid rises and cooler fluid sinks, creating a circulation pattern that redistributes thermal energy within the fluid.

6. **Radiation:** Radiation is the transfer of heat through electromagnetic waves. Unlike conduction and convection, radiation does not require a medium and can occur through a vacuum. Objects emit and absorb thermal radiation based on their temperature and surface properties.

7. Specific Heat: Specific heat is the amount of heat required to raise the temperature of one unit of mass of a substance by one degree Celsius (or Kelvin). It is a property of materials and is commonly measured in units of joules per kilogram per degree Celsius (J/kg°C).

8. Latent Heat: Latent heat is the heat energy absorbed or released during a phase change of a substance (such as melting, freezing, vaporization, or condensation) without a temperature change. It represents the energy required to overcome intermolecular forces and change the arrangement of particles.

9. Thermal Equilibrium: Thermal equilibrium is a state in which two systems are at the same temperature and there is no net heat transfer between them. In thermal equilibrium, the rates of heat transfer between the systems are equal, and their temperatures remain constant over time.

CHANGE OF STATE OF MATTER:

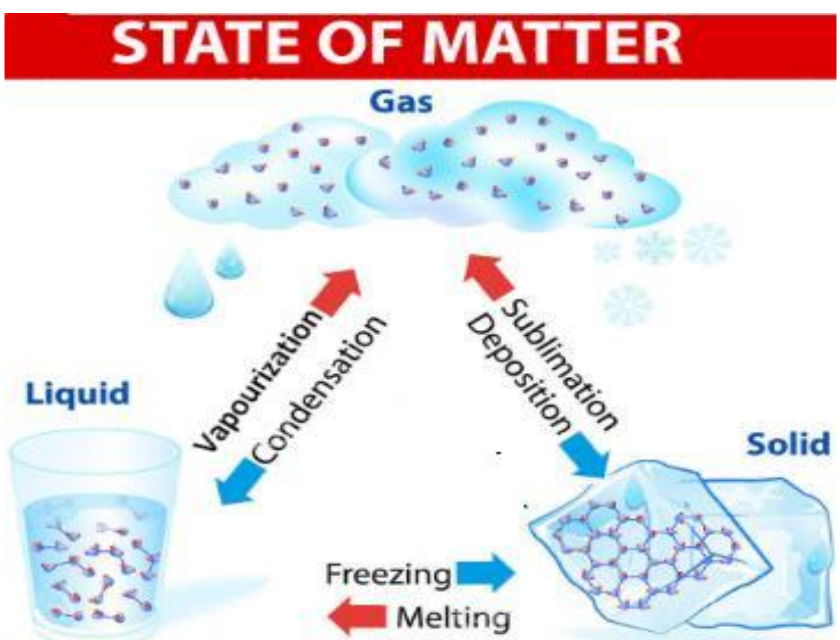
1. Melting: Melting is the process by which a solid substance changes into its liquid state.

2. Boiling is the process of heating a liquid continuously until it gets converted into gas.

3. Freezing: Freezing is the process by which a liquid substance changes into its solid state.

4. Sublimation: Sublimation is the phase transition in which a substance changes directly from its solid state to its gas state without passing through the intermediate liquid state.

5. Deposition: Deposition is the phase transition in which a substance changes directly from its gas state to its solid state without passing through the intermediate liquid state.



EFFECTS OF HEAT ON ATMOSPHERE/CLIMATE:

1. **Evaporation**: the process of escaping molecules from the surface of a liquid at any temperature (or) the process of converting a liquid into gas at any temperature.
2. **Condensation** is the process of converting a gas into a liquid by losing heat.
3. **Humidity**: The amount of water vapour present in the air is called humidity.
4. **Dew**: Dew is a small drop of water that is formed on the ground and other surfaces outdoors during the night.
5. **Fog**: The tiny drops of water in the air that form a thick cloud and make it difficult to see things are called fog.

5 – Sound

INTRODUCTION:

Sound is a form of energy that travels through mediums such as air, water, or solids in the form of waves. These waves create vibrations in the medium, which are detected by our ears and interpreted by our brains as sound. Sound can vary in pitch, volume, and timbre, and it plays a crucial role in communication, music, and many aspects of our daily lives.

Sound: Sound is the vibration of particles in a medium, such as air, that propagates as a wave through that medium. The intensity of sound is measured in decibels (dB), while its frequency is measured in hertz (Hz), and its wavelength is measured in meters (m).

Sound produced by humans: Humans produce sounds through the vibration of vocal cords in the larynx, also known as the voice box. By modulating the airflow through the vocal cords and shaping the oral and nasal cavities, we produce speech, singing, laughter, and various vocal sounds. Additionally, we can also create sounds through activities such as clapping, snapping fingers or tapping objects.

Sound waves have several characteristics:

1. **Amplitude:** This refers to the height or intensity of the wave and corresponds to the loudness of the sound. Greater amplitude indicates a louder sound.
2. **Frequency:** Frequency measures how many wave cycles occur per second and is perceived as pitch. Higher-frequency waves have a higher pitch, while lower-frequency waves have a lower pitch.
3. **Wavelength:** The wavelength is the distance between two consecutive peaks or troughs of a wave and is inversely related to frequency. Shorter wavelengths correspond to higher frequencies, and vice versa.
4. **Speed:** Sound travels at different speeds depending on the medium through which it travels. In general, it travels faster through solids, slower through liquids, and slower through gases like air.
5. **Direction:** Sound waves can travel in all directions from their source, spreading out as spherical or cylindrical waves.
6. **Reflection:** Sound waves can bounce off surfaces (reflection),

Refraction: bend when passing from one medium to another (refraction),

Diffraction: and spread out as they encounter obstacles (diffraction).

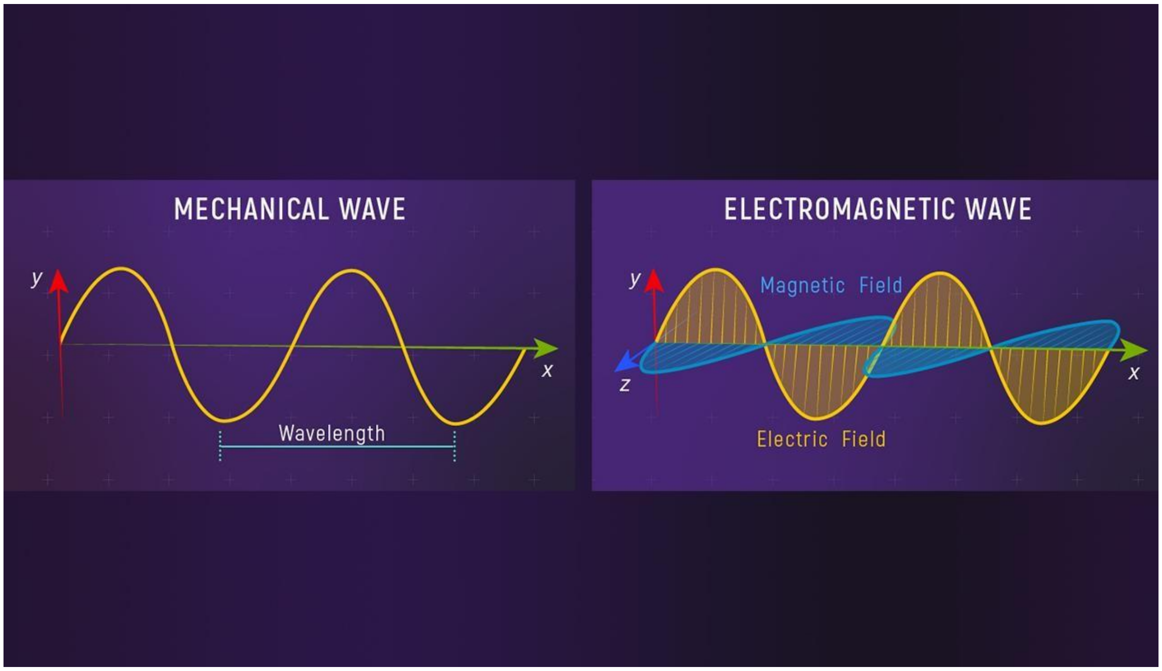
Types of sound waves:

1. **Mechanical wave:** The waves that require the medium for propagation are called mechanical waves.

Example: sound waves.

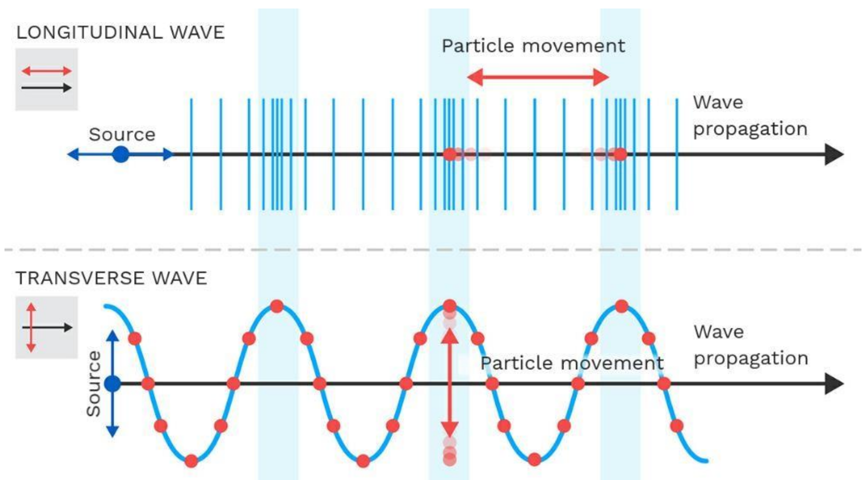
2. **Electromagnetic wave:** The waves that do not require a medium for propagation are called electromagnetic waves.

Example: light waves.



There are two main types of sound waves: longitudinal waves and transverse waves.

1. **Longitudinal Waves:** In longitudinal waves, the particles of the medium move parallel to the direction of the wave's motion. Sound waves in the air are longitudinal waves, where air particles compress and rarefy as the wave passes through. This compression and rarefaction create areas of high and low pressure, resulting in the perception of sound.
2. **Transverse Waves:** Transverse waves are characterized by particles oscillating perpendicular to the direction of the wave's motion. While sound waves in the air are longitudinal, some materials, like solids, can transmit sound as transverse waves. In solids, the particles vibrate perpendicular to the direction of wave propagation.



Most commonly, sound waves in the air, which humans perceive as sound, are longitudinal waves.

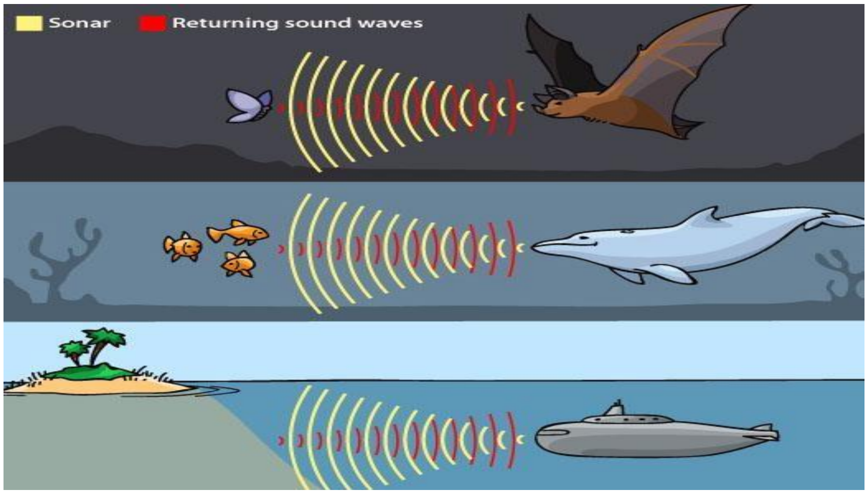
The characteristics of sound include:

1. **Pitch:** Pitch is the perceived frequency of sound waves and determines how high or low a sound is. Higher-frequency sounds have a higher pitch, while lower-frequency sounds have a lower pitch.
2. **Loudness:** Loudness is the perceived intensity or amplitude of sound waves and determines how soft or loud a sound is. Greater amplitude corresponds to louder sounds.
3. **Timbre:** Timbre refers to the quality or colour of a sound and helps distinguish between different sources of sound, even if they have the same pitch and loudness. It's what makes a piano sound different from a guitar playing the same note.
4. **Duration:** Duration is the length of time that a sound persists. It can range from very short, such as a clap, to sustained, such as a musical note held on a piano.
5. **Direction:** Sound waves can travel in all directions from their source, and our ears can detect the direction from which sound is coming.
6. **Speed:** Sound travels at different speeds depending on the medium through which it travels, such as air, water, or solids.
7. **Frequency:** Frequency is the number of cycles of a sound wave that occur per second and is measured in hertz (Hz). It determines the pitch of a sound.

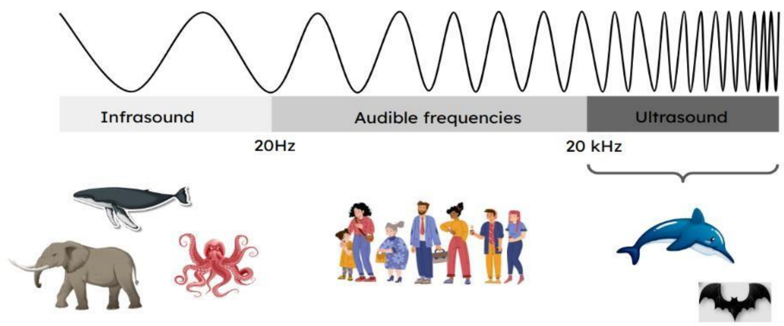
Understanding these characteristics helps in describing and analyzing sound, as well as in various applications such as music, communication, and technology.

An echo is the reflection of sound waves off surfaces, resulting in the repetition of a sound after a short delay.

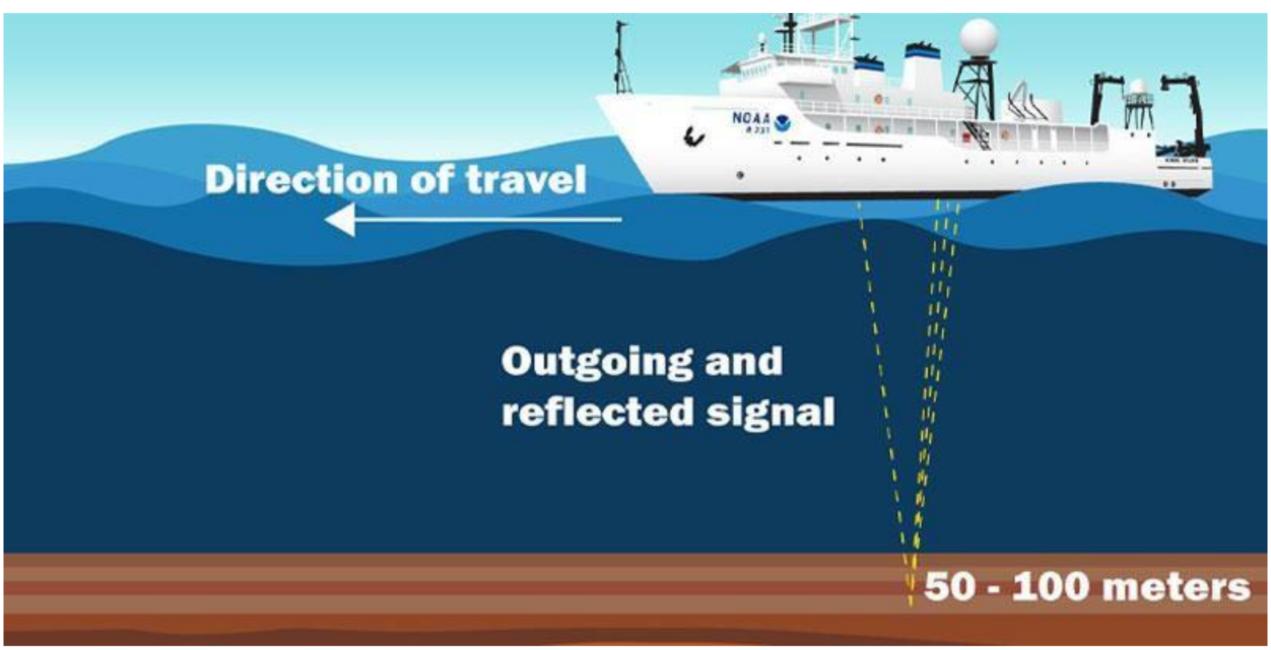
1. **Ultrasonic:** Ultrasonic refers to sound waves with frequencies higher than the upper limit of human hearing, typically above 20,000 hertz (Hz). Ultrasonic waves have various applications, such as medical imaging, cleaning, and detection systems.



2. **Sonic:** Sonic refers to sound waves within the range of frequencies that humans can hear, typically between 20 Hz and 20,000 Hz. Sonic waves are responsible for most of the sounds we encounter in daily life, including speech, music, and environmental sounds.
3. **Infrasonic:** Infrasonic refers to sound waves with frequencies below the lower limit of human hearing, typically below 20 Hz. While humans cannot hear infrasonic waves, some animals, such as elephants and whales, are capable of detecting and producing infrasonic signals, which they use for communication over long distances.



SONAR stands for "Sound Navigation and Ranging." It's a technology that uses sound waves to detect and locate objects underwater. SONAR systems emit pulses of sound waves into the water, which bounce off objects and return to the system. By measuring the time it takes for the sound waves to return and analyzing their properties, SONAR can create detailed maps of underwater terrain, locate submerged objects, and even track the movement of marine life. SONAR is widely used in various applications, including marine navigation, underwater exploration, fishing, and military operations.



6 – ELECTRIC ENERGY

INTRODUCTION:

Electric energy is a fundamental form of energy that powers our modern world. It is generated from various sources, including fossil fuels, nuclear energy, and renewable sources such as solar, wind, and hydroelectric power.

Electric energy is versatile and can be easily converted into other forms of energy, such as mechanical energy for powering motors, thermal energy for heating, and light energy for illumination. It is transmitted over long distances through electrical grids using high-voltage transmission lines, allowing it to reach homes, businesses, and industries.

The concept of electric energy is governed by fundamental principles such as Ohm's law, which describes the relationship between voltage, current, and resistance in electric circuits, and the conservation of energy principle, which states that energy cannot be created or destroyed but can only be transformed from one form to another.

Electric energy plays a crucial role in our daily lives, powering everything from lights and appliances in our homes to machinery and equipment in industries. As society continues to advance, the demand for electric energy continues to grow, driving innovation in energy generation, transmission, and utilization technologies.

ELECTRIC ENERGY

Electric energy is the energy generated by the movement of electrons through a conductor, typically in the form of electricity.

TYPES OF ELECTRIC CHARGE PARTICLES

The two types of electric charge particles are positively charged particles, known as protons, and negatively charged particles, known as electrons.

FORCE BETWEEN CHARGES

The force between charges can be attractive or repulsive, depending on the types of charges involved. Like charges (positive-positive or negative-negative) repel each other, while opposite charges (positive-negative) attract each other. This force is described by Coulomb's law.

COULOMB'S LAW

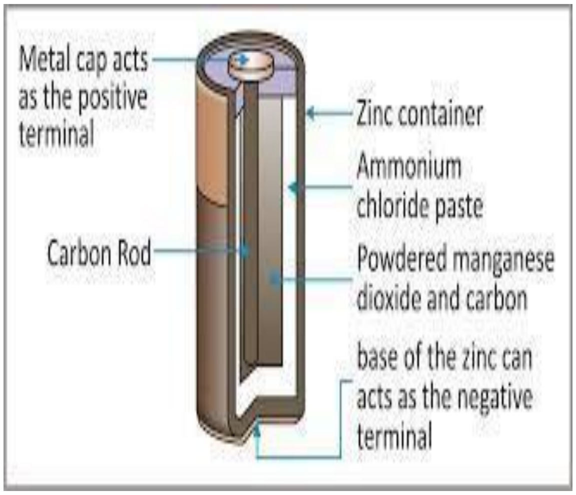
Coulomb's law states that the magnitude of the force between two charges is directly proportional to the product of their magnitudes and inversely proportional to the square of the distance between them.

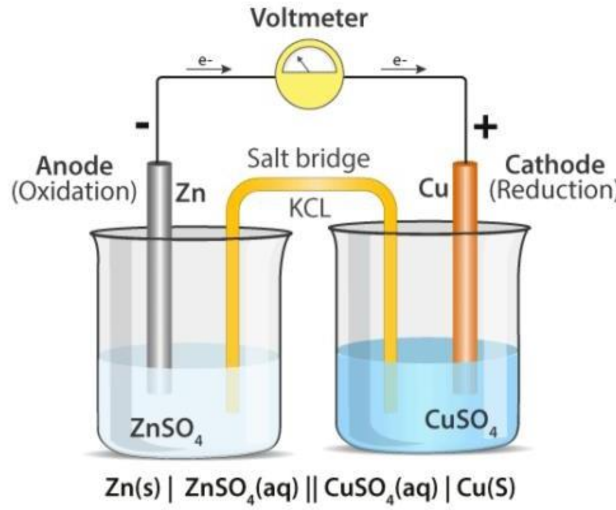
ELECTROSTATIC POTENTIAL

Electrostatic potential, often referred to as voltage, is the measure of electric potential energy per unit charge at a point in space. It represents the work done in bringing a unit positive charge from infinity to that point, without causing any acceleration.

ELECTRIC CELL

An electric cell is a device that converts chemical energy into electrical energy. It typically consists of two different materials (electrodes) immersed in an electrolyte, which facilitates the flow of ions between the electrodes, generating an electric current.





OHM'S LAW

Ohm's law states that the current flowing through a conductor between two points is directly proportional to the voltage across the two points and inversely proportional to the resistance of the conductor. Mathematically, it is expressed as ($V=IR$), where I is the current in amperes (A), V is the voltage in volts (V), and R is the resistance in ohms (Ω).

OHM'S LAW LIMITATIONS

Ohm's law has limitations, particularly in situations where the temperature, voltage, or material properties are not constant. Some specific limitations include:

1. **Non-ohmic materials:** Ohm's law assumes that the resistance of a material remains constant regardless of the applied voltage or current. However, some materials, like semiconductors and certain metals at extreme temperatures, do not obey this linear relationship.

2. Temperature dependence: The resistance of most conductors changes with temperature. Ohm's law does not account for this temperature dependence, leading to inaccuracies in certain situations.

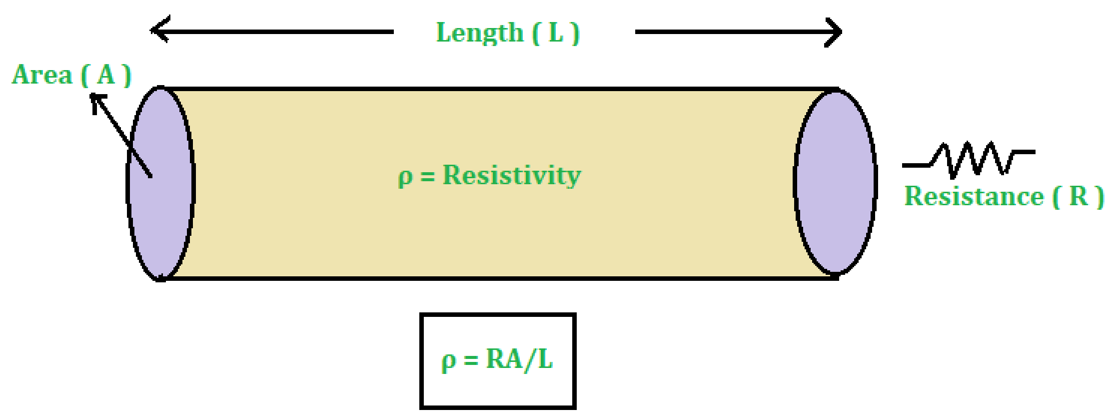
3. **Non-linear circuits:** Ohm's law applies to linear circuits where the relationship between voltage, current, and resistance is constant. In non-linear circuits, such as those containing diodes or transistors, Ohm's law does not accurately predict the behavior.

4. **AC circuits:** Ohm's law is primarily applicable to DC (direct current) circuits. In AC (alternating current) circuits, the relationship between voltage, current, and resistance is more complex due to factors like reactance and impedance.

In summary, while Ohm's law is a fundamental principle in electronics, it has limitations and may not accurately describe the behavior of all electrical components and circuits in real-world situations.

Ohm's law is a fundamental principle in electronics that states: "The current flowing through a conductor between two points is directly proportional to the voltage across the two points, and inversely proportional to the resistance of the conductor."

FACTORS AFFECT THE RESISTANCE:



Several factors affect the resistance of a conductor:

1. Length: Resistance is directly proportional to the length of the conductor. Longer conductors offer more opposition to the flow of electrons, increasing resistance.

2. Cross-sectional area: Resistance is inversely proportional to the cross-sectional area of the conductor. A larger cross-sectional area allows more electrons to flow through, reducing resistance.

3. Material: Different materials have different resistivities, which determine their resistance. Materials with higher resistivity offer more resistance to the flow of electrons.

4. Temperature: In most materials, resistance increases with temperature. As temperature rises, atoms and molecules in the material vibrate more, impeding the flow of electrons and increasing resistance.

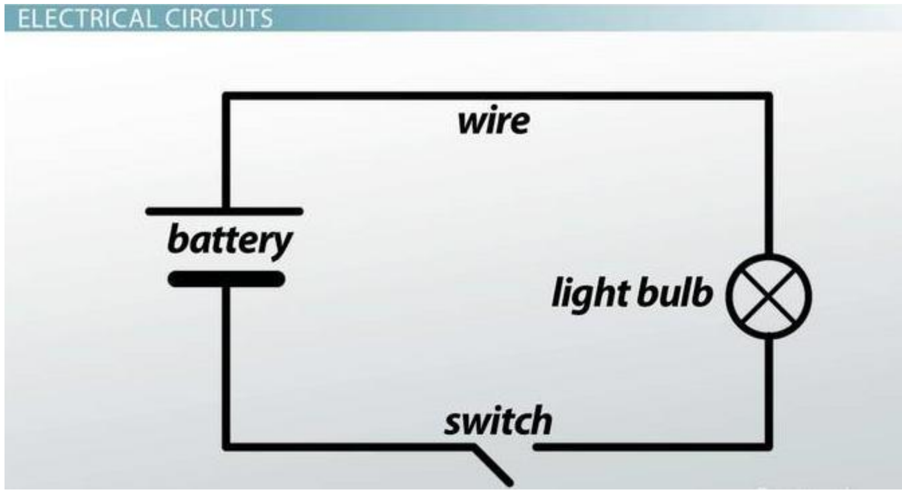
5. Temperature coefficient: Some materials have a temperature coefficient of resistance, which quantifies how much resistance changes with temperature. Materials with a positive temperature coefficient increase in resistance with temperature, while those with a negative coefficient decrease in resistance.

6. Type of material: Different materials have different inherent resistances. For example, conductors like copper have low resistance, while insulators like rubber have high resistance.

These factors collectively determine the overall resistance of a conductor.

ELECTRIC CIRCUIT:

An electric circuit is a closed loop through which electric current can flow. It typically consists of components such as voltage sources (like batteries), conductors (wires), and various electrical devices (such as resistors, capacitors, and lightbulbs) connected. Here's a simple diagram illustrating the components of a basic electric circuit:



ELECTRIC POWER

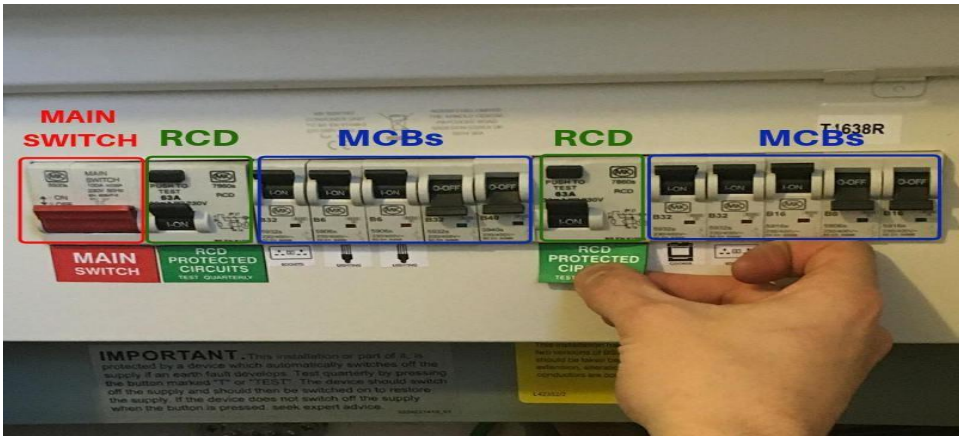
- Electric power is the rate at which electrical energy is transferred or consumed. It is measured in watts (W) and represents the amount of energy converted per unit of time.

Safety devices used in electric circuits:

1. Circuit Breakers: These are automatic switches designed to interrupt electrical flow when it exceeds a safe level, preventing overheating and potential fires caused by electrical faults or overloads.

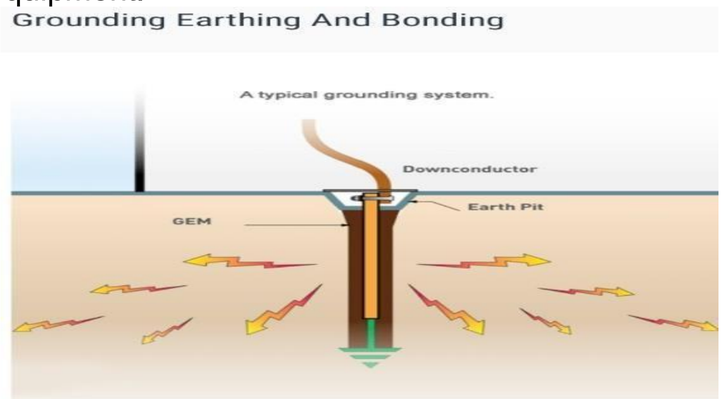
2. Fuses: Fuses are devices that contain a thin wire that melts when excessive current flows through it. This interrupts the circuit, protecting devices downstream from damage due to overcurrent.

3. Residual Current Devices (RCDs): Also known as ground fault circuit interrupters (GFCIs) or earth leakage circuit breakers (ELCBs), RCDs monitor the flow of current in a circuit and quickly disconnect power if they detect leakage of current to ground, thus preventing electric shock.



4. Isolation Switches: These switches are used to completely isolate a circuit or appliance from the power supply for maintenance or repair purposes, ensuring the safety of personnel working on the circuit.

5. Earthing or Grounding Systems: Grounding systems provide a safe path for fault currents to flow into the ground, reducing the risk of electric shock and preventing electrical equipment from becoming energized in the event of a fault.
These safety devices help protect against electrical hazards such as electric shock, fires, and damage to electrical equipment.

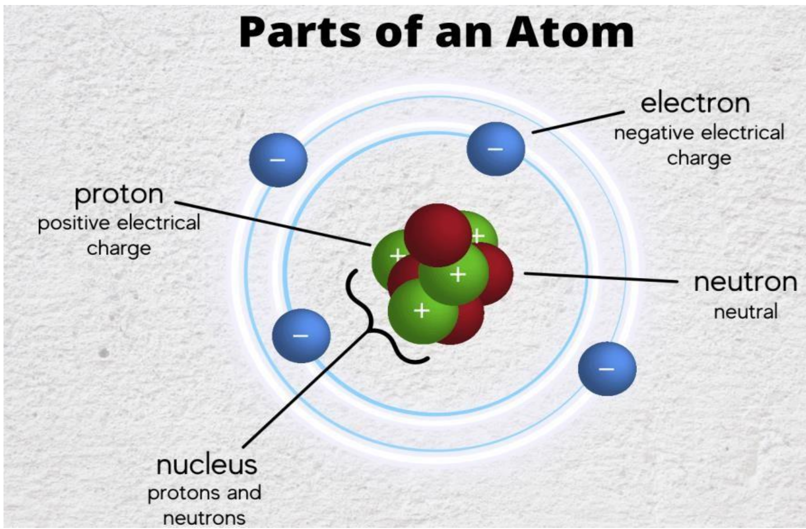


7 – ATOMIC STRUCTURE

INTRODUCTION:

Atomic structure is the foundation of chemistry, describing the composition and behaviour of atoms, the basic building blocks of matter. Atoms consist of a nucleus containing protons and neutrons, surrounded by electrons orbiting at energy levels called shells. The number of protons determines the element's identity, while the arrangement of electrons influences its chemical properties. Quantum mechanics provides a theoretical framework for understanding atomic behaviour, explaining phenomena such as electron orbitals and the wave-particle duality of electrons.

Atom: The atom is the smallest indivisible part of matter that retains its identity.
Ex: O oxygen atom



Element: An element is a pure substance that is made up of only one kind of atom.
Ex: aluminium (Al).

Molecules: A molecule is a pure substance that is either made up of only one kind or more than one kind of atom.
Ex: oxygen (O_2) molecule.

Compounds: when different types of atoms are combined to form a molecule, the pure substance formed by these molecules will be called a compound.
Ex: water (H_2O) molecule.

Atomic number: The total number of protons in the nucleus of an atom (which is the same as the number of electrons in the neutral atom) is called the atomic number. The atomic number is denoted with the symbol (Z).

Atomic mass: atomic mass is the total mass of particles of matter in an atom, i.e., the masses of protons, neutrons, and electrons in an atom added together. However, electrons are so small that they are negligible in finding the mass of an atom.

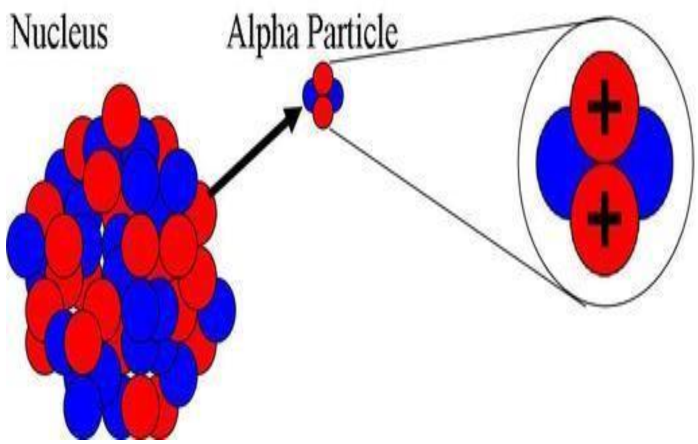
Valency of atom: Valency is defined as combining the power of an element with another atom to form a chemical bond. Valency refers to the electron in the outer shell of an atom.

Monovalent: Monovalent atoms are those atoms that show a value of 1.

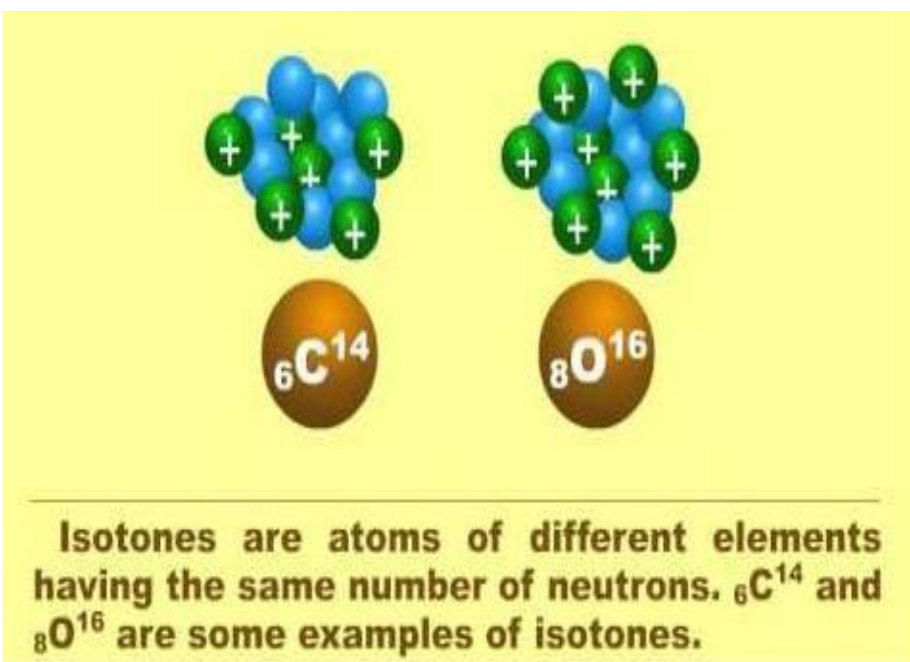
Bivalent: bivalent atoms are those atoms that show a value of 2.

Trivalent: private items are those atoms that show a value of 3.

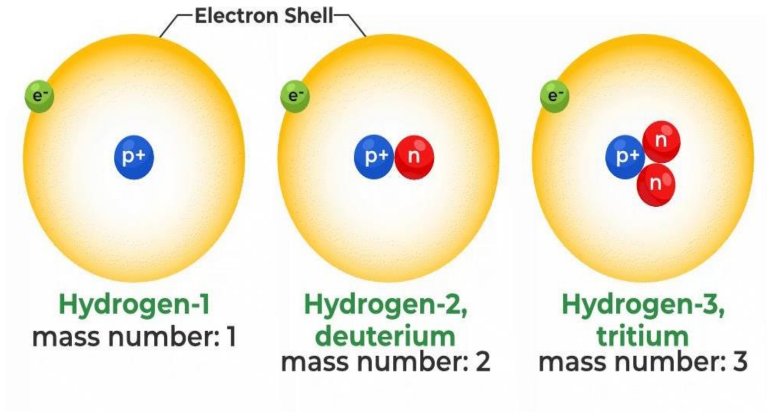
Alpha particle: Alpha particles are composite particles consisting of two; they are emitted from the nucleus of some radionuclides during a form of radioactive decay called alpha decay.



Isotones: isotones can be defined as two or more nuclei of atoms consisting of the same number of neutrons.



<u>Isotopes:</u> Those elements that have the same atomic number but a different mass number are referred to as isotopes.

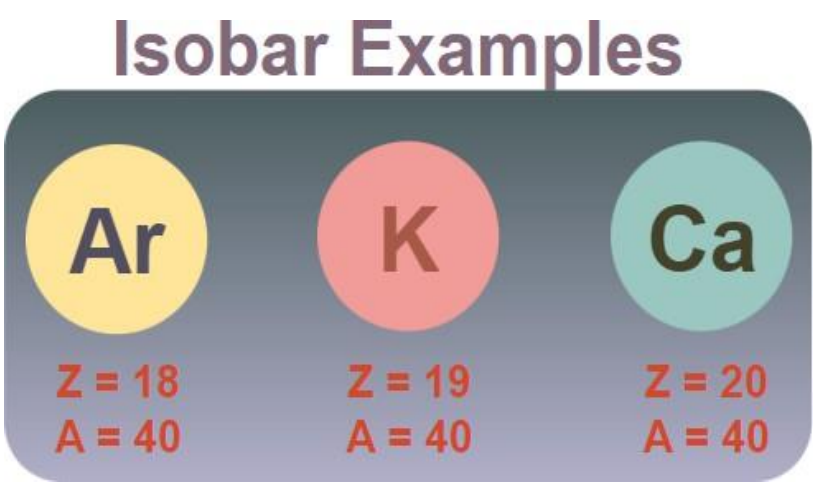


<u>Applications of isotopes:</u>

The following are the applications of isotopes:

1. One of the isotopes of Uranium, U-235, is used as fuel in nuclear reactors.
2. One of the isotopes of cobalt-60 is used in the treatment of cancer.
3. One of the isotopes of iodine, iodine-131, is used in the treatment of goitre.

<u>Isobars:</u> isobars, on the other hand, are atoms having the same mass number but a different atomic number.



<u>An isobar and its importance</u>:

An isobar is a line on a map that shows a meteorologist what the pressure is at the surface of the earth. They are lines that connect equal points of pressure.

8 – MATTER AROUND US

INTRODUCTION:

Matter is everything that has mass and occupies space. It's composed of atoms, which are made up of protons, neutrons, and electrons. Matter exists in various states, including solids, liquids, gases, and plasma. These states depend on factors like temperature and pressure. Matter is all around us, from the air we breathe to the food we eat and the buildings we inhabit.

Matter: anything that occupies space and has mass is considered matter.

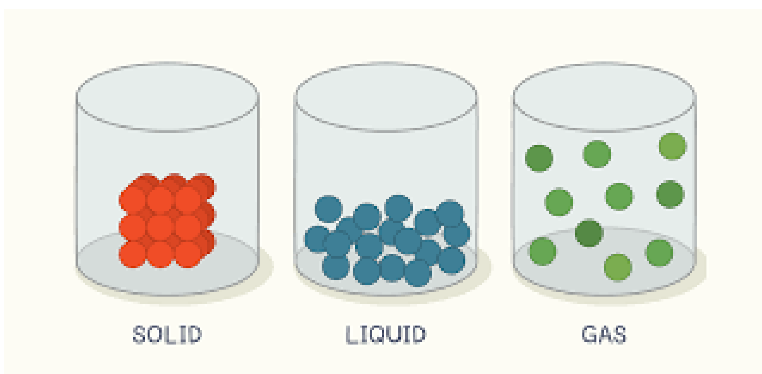
Mass: the measure of the amount of matter in a body.

States of matter:

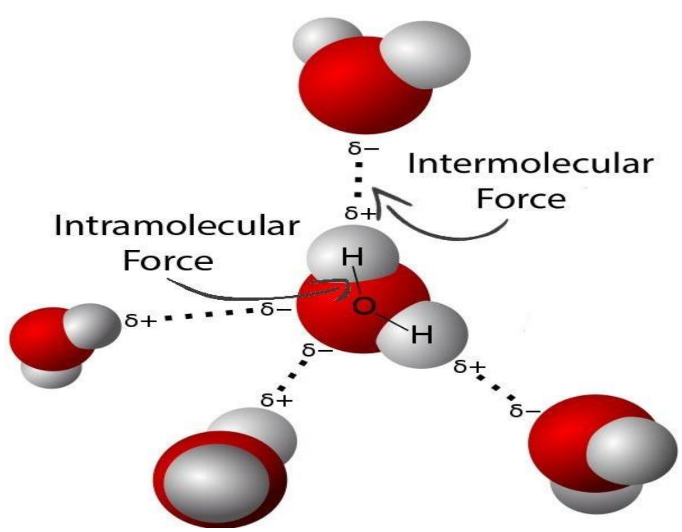
Solid

Liquid

Gas



Intermolecular forces: the forces holding together are called intermolecular forces.



Factors affecting the change of state of matter:

Melting point: the particular temperature at which a solid can be converted into liquid is called the "melting point".

Boiling point: when a liquid boils and gets converted into gas, a particular temperature is known as the "boiling point".

Freezing point: when a liquid cools down to a certain temperature under a given pressure. This particular temperature is called the "freezing point".

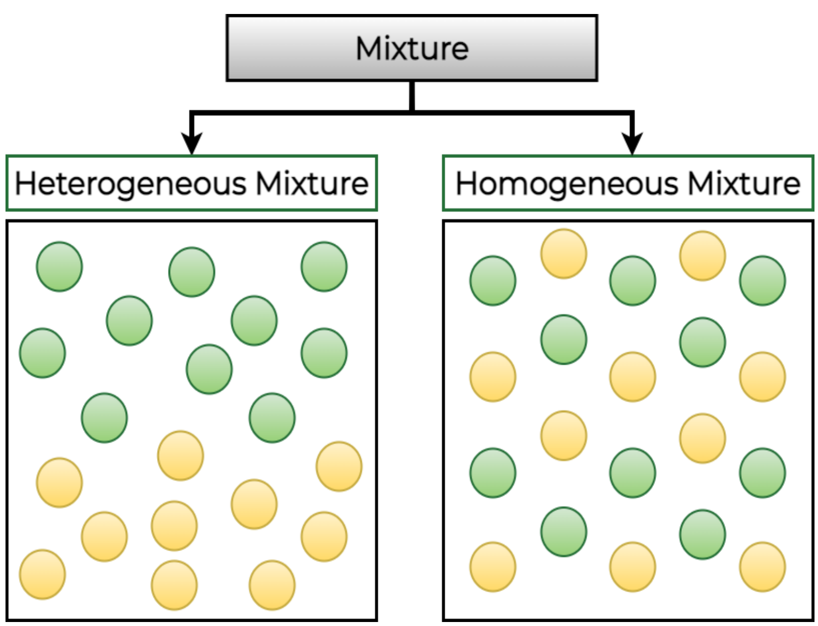
Mixture: A combination of two or more substances that are not chemically bonded and can be separated by physical means.

Types of mixtures

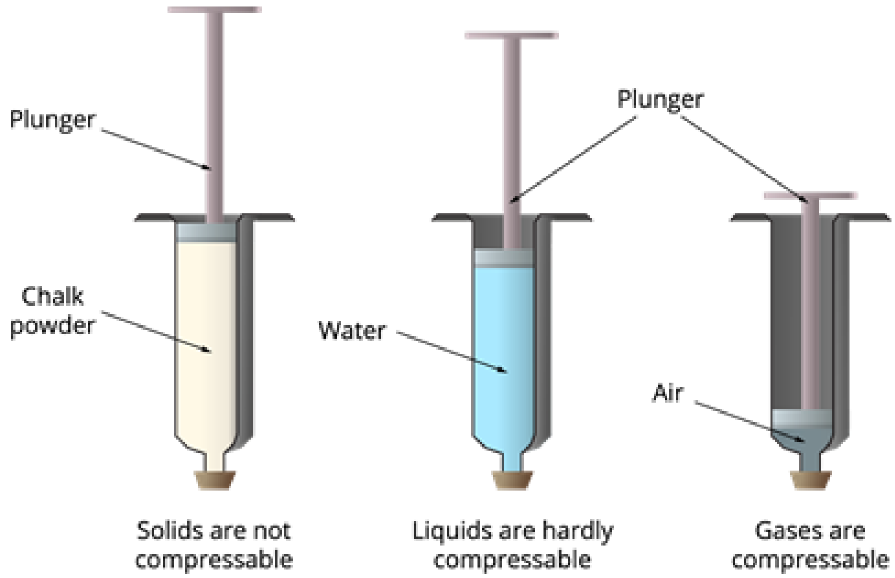
1. Homogeneous mixture
2. Heterogeneous mixture

1. Homogeneous mixture: in a homogeneous mixture, the components of the mixture are uniformly distributed throughout it.
Ex: Air is a homogeneous mixture of small gases.

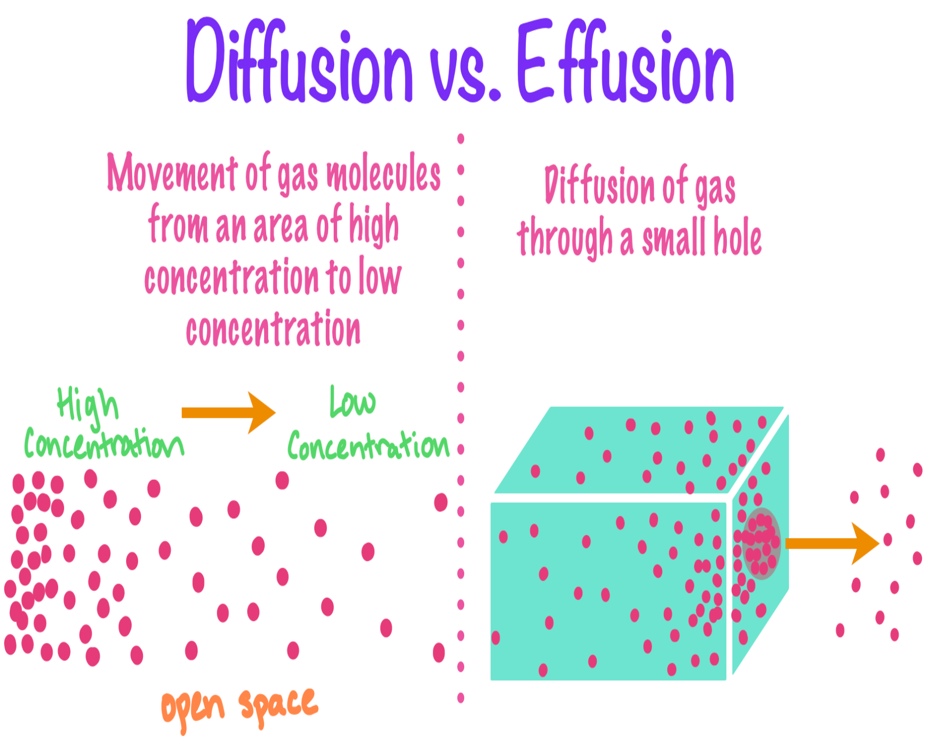
2. Heterogeneous mixture: a mixture is said to be homogeneous if it is uniform throughout it. The components of the mixture are not easily visible.
Ex: sugar, solution, alloys, air etc.



Compressibility: is the property of a substance that describes how much of its volume can be reduced under pressure.

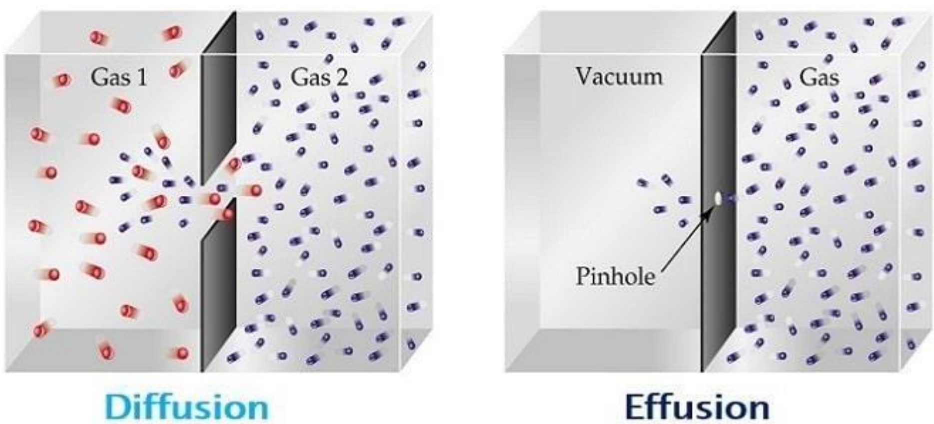


Diffusion is the process: by which molecules or particles spread from regions of higher concentration to regions of lower concentration, resulting in a uniform distribution. It's a fundamental mechanism for mixing substances and is vital in various natural and artificial processes, such as chemical reactions, heat transfer, and the movement of gases in the atmosphere.



Diffusion of liquids: refers to the gradual mixing of different liquids due to the random motion of their molecules. This process occurs when liquids of different compositions come into contact with each other, and the molecules move from regions of higher concentration to regions of lower concentration until they are uniformly distributed.

Diffusion of gases: the process by which gas molecules spread from an area of high concentration to an area of low concentration until they are evenly distributed. This movement occurs due to the random motion of gas molecules and is influenced by factors such as concentration gradients, temperature, and pressure.



Sublimation: is the process in which a substance transitions directly from the solid phase to the gas phase without passing through the intermediate liquid phase. This occurs when the substance's vapour pressure exceeds the atmospheric pressure at a certain temperature.

9 – METALS AND NON-METALS

Introduction:

Elements are classified into two basic categories: metals and non-metals. There are about 90 elements, up to uranium, that are found naturally. Another 20 elements beyond uranium, called trans-uranium elements, have been produced artificially in laboratories by nuclear reactions. Two elements, technetium (Tc) and promethium (Pm), that occur below uranium are unstable in nature. Elements can be classified by the physical and chemical properties that they display.

Metals are defined as those elements that possess lusture, are malleable and ductile, and are good conductors of heat and electricity.

Or

Metals are the elements that form positive ions by losing electrons, i.e., they are electropositive elements.
For example: sodium, magnesium, potassium, aluminum, copper, silver, gold, etc.

Non-metals are defined as those elements that do not possess lustre and are neither good conductors of heat and electricity nor malleable. They are not ductile, but they are brittle.

Or

Non-metals are the elements that form negative ions by gaining electrons, i.e., they are electronegative elements.
For example: carbon, hydrogen, oxygen, nitrogen, Sulphur, bromine etc.

Physical properties of metal

Some physical properties of metals are mentioned below.

- Metals can be hammered into thin sheets. This means that they have the property of malleability.
- Metals are ductile. They can be drawn into wires.
- Metals are the best conductors of electricity and heat.
- Metals are lustrous, meaning they have a shiny appearance.
- Metals have high tensile strength. This means they can hold heavy weights.
- Metals are sonorous. This means that when we hit them, they make a ringing sound.
- Metals are hard. This means that they cannot be cut easily.

Physical Properties of Non-Metal

- **Non-metals are not malleable or brittle.** Non-metals cannot be hammered or beaten into thin sheets without breaking. Non-metals break into pieces when hammered or stretched. Sulfur and phosphorous are powders that cannot be made into sheets. Brittleness is a characteristic property of non-metals.
- **Non-metals are not ductile.** Non-metals cannot be melted and drawn into thin wires. Non-metals do not have free electrons. Thus, the bonds between atoms in the elements are weak, and they snap when stretched. The non-ductility property follows from the non-malleability or brittleness property.
- **Non-metals are bad conductors of heat and electricity.** In non-metals, the bonds formed are weak as there are no free electrons to share. Other than graphite, which is an allotropic form of carbon, none of the non-metals are good conductors of heat and electricity. Graphite can conduct electricity because of its special crystalline arrangement.
- **Non-metals have no lustre.** Non-metals are in the form of powder or are gaseous. Hence, they cannot be polished, and they do not have any lustre. Most of the powders are dull in colour. Only graphite can be polished to some degree. Iodine shows some lustre as it has more electrons.
- **Non-metals are not strong.** Due to their non-ductile and non-malleable properties, non-metals are not strong at all. Their bonds break easily, as the electrons are not shared.
- **Physical state:** Non-metals may exist in a solid, liquid, or gaseous state at room temperature. For example, sulfur and carbon are solid at room temperature, bromine is liquid, and nitrogen and oxygen are gaseous non-metals.
- **Melting and boiling points:** All non-metals have low melting and boiling points. The melting point of Sulphur (S) is 115°C. Graphite and diamonds have high melting points, but these are exceptions in the non-metals.
- **Solubility of non-metals:** Non-metals are soluble in some chemical or organic solvents. For example, iodine (I) is soluble in alcohol.
- **Density of non-metals:** Non-metals have low densities as compared to metals, which have high densities. This means that in non-metals, the atoms are not strongly bound. The crystalline volume of non-metals is small.
- **Non-metals are not sonorous:** Non-metals do not make any characteristic sound when hit with an object. Thus, non-metals are not sonorous.

Difference between Metal and Non-Metal

Properties	Metals	Non-metals
State	Metals are solids at ordinary temperatures except mercury, which is a liquid.	Non-metals exist in all three states, that is, solid, liquid, and gas.
Luster	They possess lustre or shine.	They possess no lustre except iodine and graphite.
Malleability and Ductility	Metals are generally malleable and ductile.	Non-metals are neither malleable nor ductile.
Hardness	Metals are generally hard. Alkali metals are the exception.	Non-metals possess varying hardness. Diamond is an exception. It is the hardest substance known to occur in nature.
Density	They have high densities.	They generally possess low densities.
Conductivity	Metals are good conductors of heat and electricity.	Non-metals are poor conductors of heat and electricity. The only exception is graphite which is a good conductor of electricity.
Melting and boiling points	They usually have high melting and boiling points.	Their melting and boiling points are usually low. The exceptions are boron, carbon and silicon.

Chemical Properties of Metal and Non-Metal:

Metallic elements usually have 1, 2, or 3 electrons in their outer shell. The smaller the number of valence electrons, the more active the metal. They form cations by losing electrons. The metal molecule in the vapour state is generally monoatomic. They generally form basic oxides. They ionize by losing electrons, which is why they are called reducing agents.

Non-metallic elements usually have 5, 6, or 7 electrons in their outer shell. They form anions (negative ions) by gaining electrons to complete their octet. Their molecules are mostly polyatomic in the gaseous state. They generally form acidic oxides. Nonmetals ionize by gaining electrons, which is why they are known as oxidizing agents.

ALLOYS:

A homogeneous mixture of two or more molten metals (or non-metal) is called an alloy. Pure metals generally do not have all the properties of a good metal, such as malleability, ductility, tensile strength, hardness, resistance to corrosion, conduction of heat and electricity, etc. However, one or more of these properties can be improved by melting two or more metals (or non-metals) in some fixed proportion and then allowing the molten product to cool to room temperature. Such a product is called an alloy.

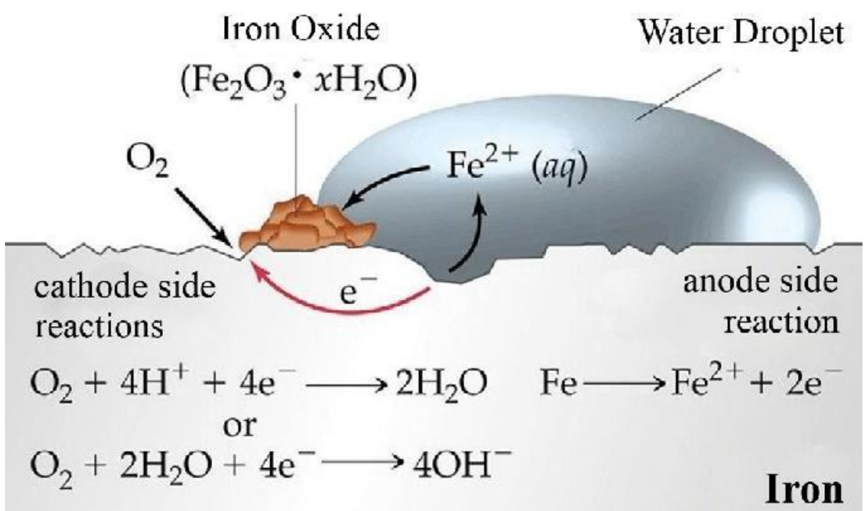
The objective of Alloy Making:

Alloys are generally prepared to have certain specific properties that are not possessed by the constituent metals. The main objects of alloy-making are:

- To increase chemical reactivity.
- To modify chemical reactivity.
- To increase the hardness.
- To increase tensile strength.
- To produce good casting.
- To lower the melting point.

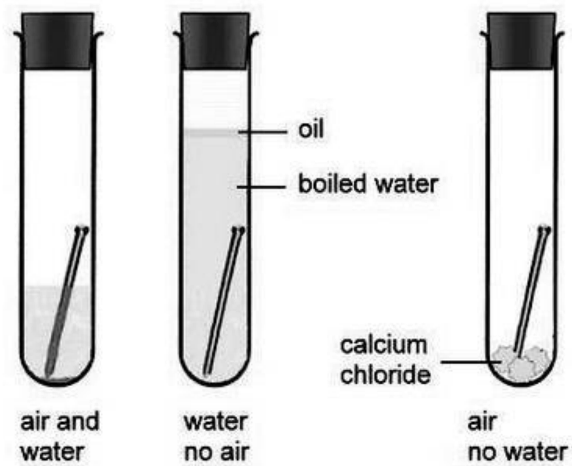
CORROSION OF METALS:

Corrosion is the process of deterioration of a metal as a result of its reaction with air or water (present in the environment) surrounding it.



RUSTING OF IRON:

The slow conversion of iron into its hydrated oxide in the presence of moisture and air is called rusting, whereas the hydrated oxide of iron is called rust.



$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Iron + Oxygen→ Ferric oxide

$Fe_2O_3 + xH_2O \rightarrow Fe2O_3.xH_2O$

Ferric Oxide Water Hydrated Ferric Oxide

The brownish residue ($Fe_2O_3.xH_2O$) is commonly called rust, and the phenomenon is called rusting. The rust so formed is flaky and easily crumbles from the surface of the metal. Thus, fresh iron is exposed to the attack of moist air to form more rust.

PREVENTION OF RUSTING:

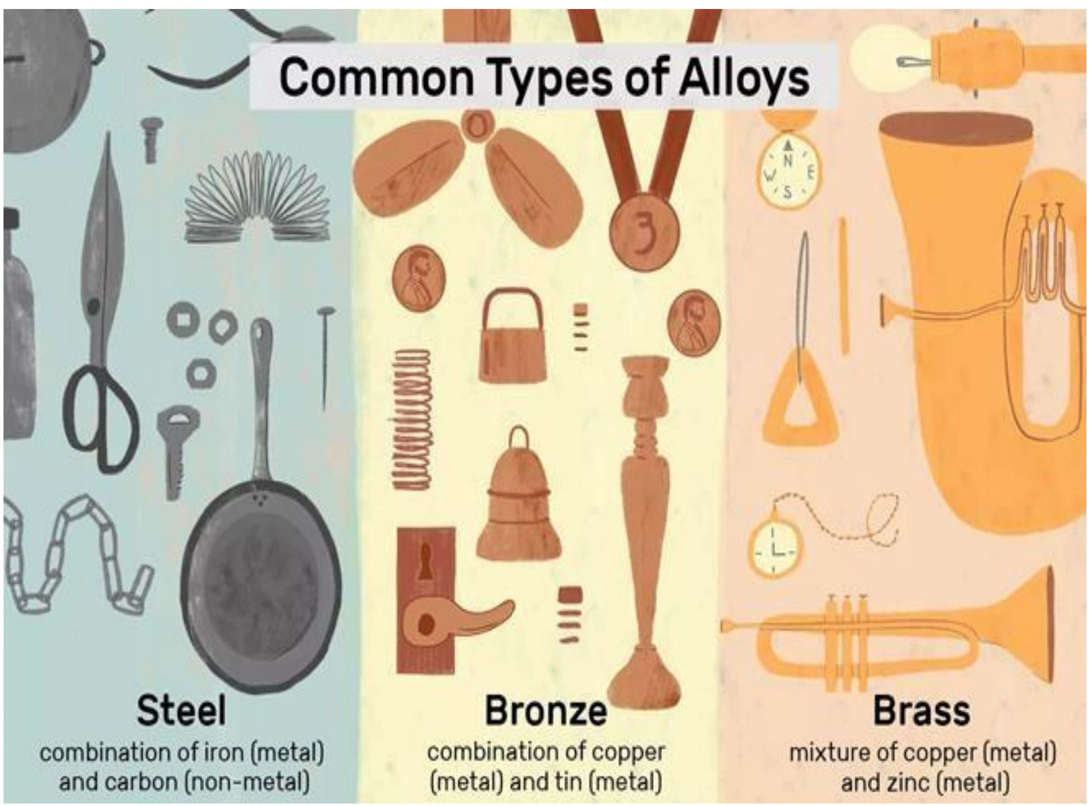
The wasting of iron objects due to rusting causes a big loss to the country's economy, so it must be prevented. The various common methods of preventing the rusting of iron (or corrosion of iron) are given below:

1. **By painting:** The most common method of preventing the rusting of iron (or corrosion of iron) is to coat its surface with paint. When a coat of paint is applied to the surface of an iron object, air and moisture cannot come into contact with the object, and hence no rusting takes place. The iron articles, such as window grills, railings, steel furniture, iron bridges, railway coaches, ships, and bodies of cars, buses, trucks, etc., are all painted to protect them from rusting.
2. **By applying grease or oil:** When some grease or oil is applied to the surface of an iron object, air and moisture cannot come into contact with it, and hence rusting is prevented. For example, the tools and machine parts made of iron and steel are smeared with grease or oil to prevent their rusting.

3. **Galvanization:** The process of depositing a thin layer of zinc metal on iron objects is called galvanization. Galvanization is done by dipping an iron object in molten zinc metal. A thin layer of zinc metal is then formed all over the iron object. This thin layer of zinc metal on the surface of iron objects protects them from rusting because zinc metal does not corrode on exposure to damp air. The iron sheets used for making buckets, drums, dustbins, and sheds (roofs) are galvanized to prevent their rusting. The iron pipes used for the water supply are also galvanized to prevent rusting.

4. **By tin-plating and chromium-plating:** Tin and chromium metals are resistant to corrosion. So, when a thin layer of tin metal (or chromium metal) is deposited on iron and steel objects by electroplating, then the iron and steel objects are protected from rusting. For example, tiffin boxes made of steel are nickel-plated on the inside and outside to protect them from rusting. Tin is used for plating tiffin boxes because it is non-poisonous and hence does not contaminate the food kept in them. Chromium-plating is done on bicycle handlebars and car bumpers made of iron and steel to protect them from rusting and give them a shiny appearance.

5. **By alloying it to make stainless steel:** When iron is alloyed with chromium and nickel, then stainless steel is obtained. Stainless steel does not rust at all. Cooking utensils, knives, scissors, surgical instruments, etc., are made of stainless steel. However stainless steel is too expensive to be used in large amounts.



10 – PERIODIC CLASSIFICATION OF ELEMENTS

Introduction: "The periodic table, a cornerstone of chemistry, is not just a list of elements but a roadmap to understanding the fundamental building blocks of our universe. Developed over centuries of scientific inquiry and discovery, the modern periodic table arranges the elements in a systematic manner based on their atomic structure and properties. This organization not only provides a framework for predicting the behaviour of elements but also unveils profound insights into the nature of matter itself. From Mendeleev's initial sketches to the latest advancements in atomic theory, let's embark on a journey through the modern periodic classification of elements, where order emerges from the chaos of the atomic realm."

This introduction sets the stage by highlighting the significance of the periodic table, its historical context, and the systematic approach used in organizing the elements.

- **Topics in the chapter**
  Dobereiner's Triads
  → Limitations of Dobereiner's Triads
  • Newland's Law of Octaves
  → Limitations of Newland's Law of Octaves
  • Mendeleev's Periodic Table
  → Merits of Mendeleev's Periodic Table
  → Limitations of Mendeleev's Classification
  → Explanation of the Anomalies of Mendeleev's Periodic Table
  • Modern Periodic Table
  → Explanation of the Anomalies by the Modern Periodic Table
  → Trends in the Modern Periodic Table
  • Metallic Character
  • Non-metallic Character
  • Atomic size, metallic character, and non-metallic according to the periodic table

Dobereiner's Triads:

→ When elements were arranged in the order of increasing atomic masses, groups of three elements (known as triads) with similar chemical properties were obtained.
The atomic mass of the middle element of the triad was roughly the average of the atomic masses of the other two elements.

Elements	Atomic Mass
Ca	40.1
Sr	87.6
Ba	137.3

Limitations of Dobereiner's Triads:

→ Only three triads were recognized from the elements known at that time.
(i) Li, Na, and K
(ii) Ca, Sr, Ba
(iii) Cl, Br, and I

Newland's Law of Octaves:

→ Newland arranged the then-known elements in order of increasing atomic masses and found that the properties of every 8th element are similar to those of the 1st element.

→ He compared this to the octaves found in music and called it the 'Law of Octaves'. For example, the properties of lithium (Li) and sodium (Na) were found to be the same.

→ To fit elements into his table, Newlands put even two elements together in one slot, and that too in the column of unlike elements having very different properties.

• Limitations of Newland's Law of Octaves:

→ It is applied to calcium (for lighter elements only).
→ The properties of newly discovered elements did not fit into the law of the octave.

Mendeleev's Periodic Table:

Mendeleev used atomic masses as the basis for the arrangement of elements. According to him, elements were arranged in increasing order of their atomic masses. It believes that there was a periodic reappearance in their physical and chemical properties.

Group	I	II	III	IV	V	VI	VII	VIII
Oxide Hydride	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4
Periods	A B	A B	A B	A B	A B	A B	A B	
1	H 1.008							
2	Li 6.93	Be 9.01	B 10.81	C 12.01	N 14.00	O 15.99	F 18.99	
3	Na 22.99	Mg 24.31	Al 26.98	Si 28.09	P 30.97	S 32.06	Cl 35.45	
4 1st Series	K 39.10	Ca 40.08	— 44	Ti 47.90	V 50.94	Cr 52.10	Mn 54.9	Fe Co Ni 55.85 58.93 58.71
2nd Series	Cu 63.5	Zn 65.4	— 68	— 72	As 74.9	Se 79.0	Br 79.9	
5 1st Series	Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.91	Mo 95.94	Tc 99.0	Ru Rh Pd 101.0 102.9 106.4
2nd Series	Ag 107.9	Cd 112.4	In 114.82	Sn 118.69	Sb 121.75	Te 127.60	I 126.9	
6 1st Series	Cs 132.9	Ba 137.3						
2nd Series	Au 196.97	Hg 200.59						

Advantages of the Mendeleev Periodic Table:

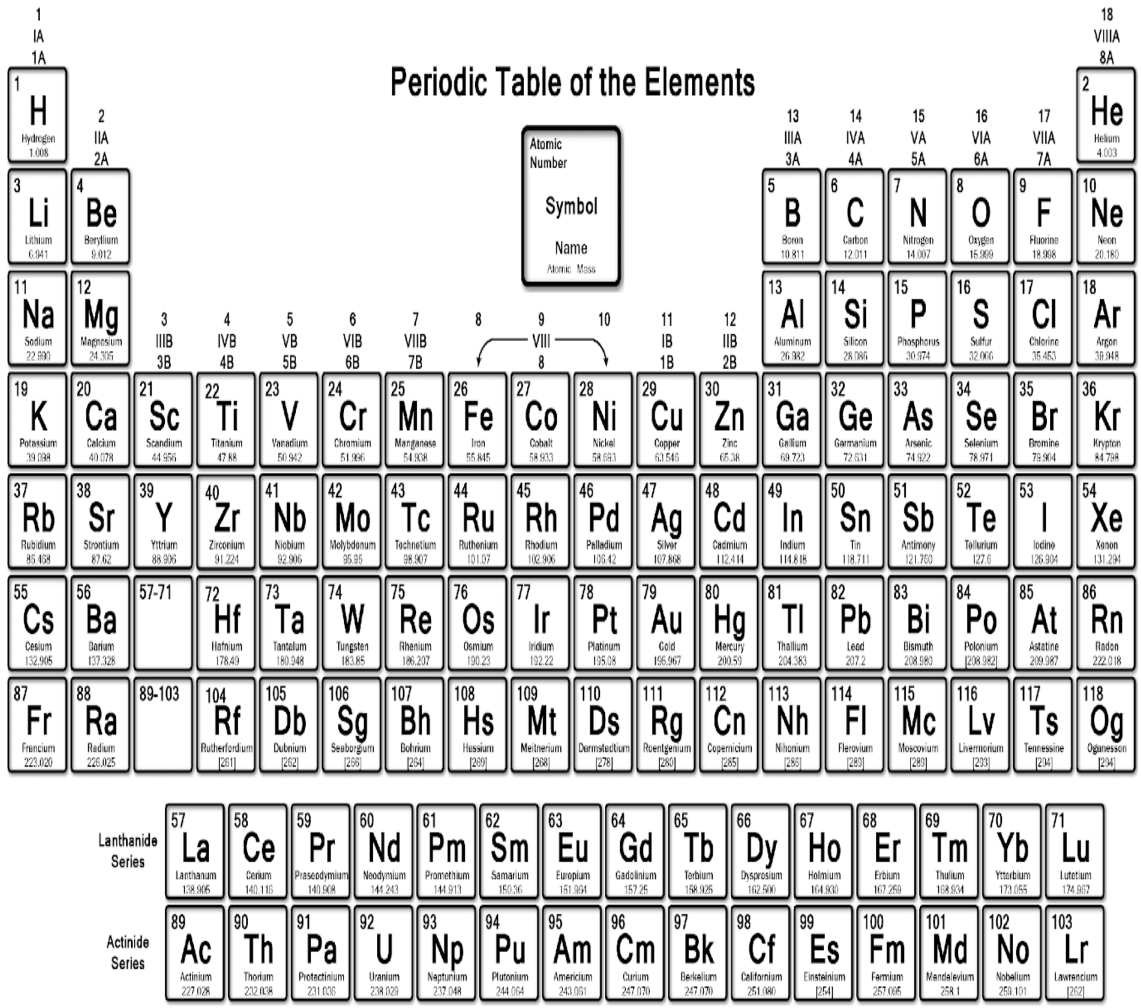
- He left a gap for some undiscovered elements.
  For example, Eka Boron, etc.
- This table also accommodates the noble gases.
- Also corrected the atomic masses of certain elements.

Limitations of the Mendeleev Periodic Table:

- The position of isotopes cannot be explained.
- The position of hydrogen is not fixed. It is placed in Group 1A, though some of its properties match those of halogens.

Modern Periodic Table:

D. Mendeleev discovered the modern periodic table in the year 1869. According to modern periodic law, “properties of an element are the periodic function of their increasing atomic number”.



Anomalies of the Modern Periodic Table:

- Isotopes are placed in the same group.
- There is no element between hydrogen and helium, as atomic masses always come in whole numbers.
- The atomic number is represented by Z, and it is equal to the number of protons in the nucleus of the atom.
- It also consists of 18 vertical columns known as **groups and** 7 horizontal rows known as **periods**.
- Elements having the same number of valence electrons are placed in the same group.
- As we go down in a group, the number of shells increases.
- Elements having the same number of occupied shells are placed in the same period.
- Each period has a new electronic shell getting filled.
- The number of elements placed in a particular period depends on the point at which electrons are filled into various shells.
- To find out the number of electrons in a shell, 2n2 formulas can be used, where n is the shell number.

K Shell n = 1 or $2n^2 = 2(1)^2 = 2$

L shell n = 2 or $2n^2 = 2(2)^2 = 8$

- The valence electron also determines the number of bonds that are formed by an element.

Trends in the Modern Periodic Table:

1. **Valency and Valence Electrons:** On moving left to right in a period, valency increases, and then it decreases. But it remains the same in a group. As we move from left to right in a period, the valence electron increases and remains the same as we go down the group.

2. **Atomic Size:** It decreases from left to right in a period as the nuclear charge increases due to large positive charges on the nucleus. Atomic size decreases in a group due to a decrease in nuclear charges and the addition of a new shell.

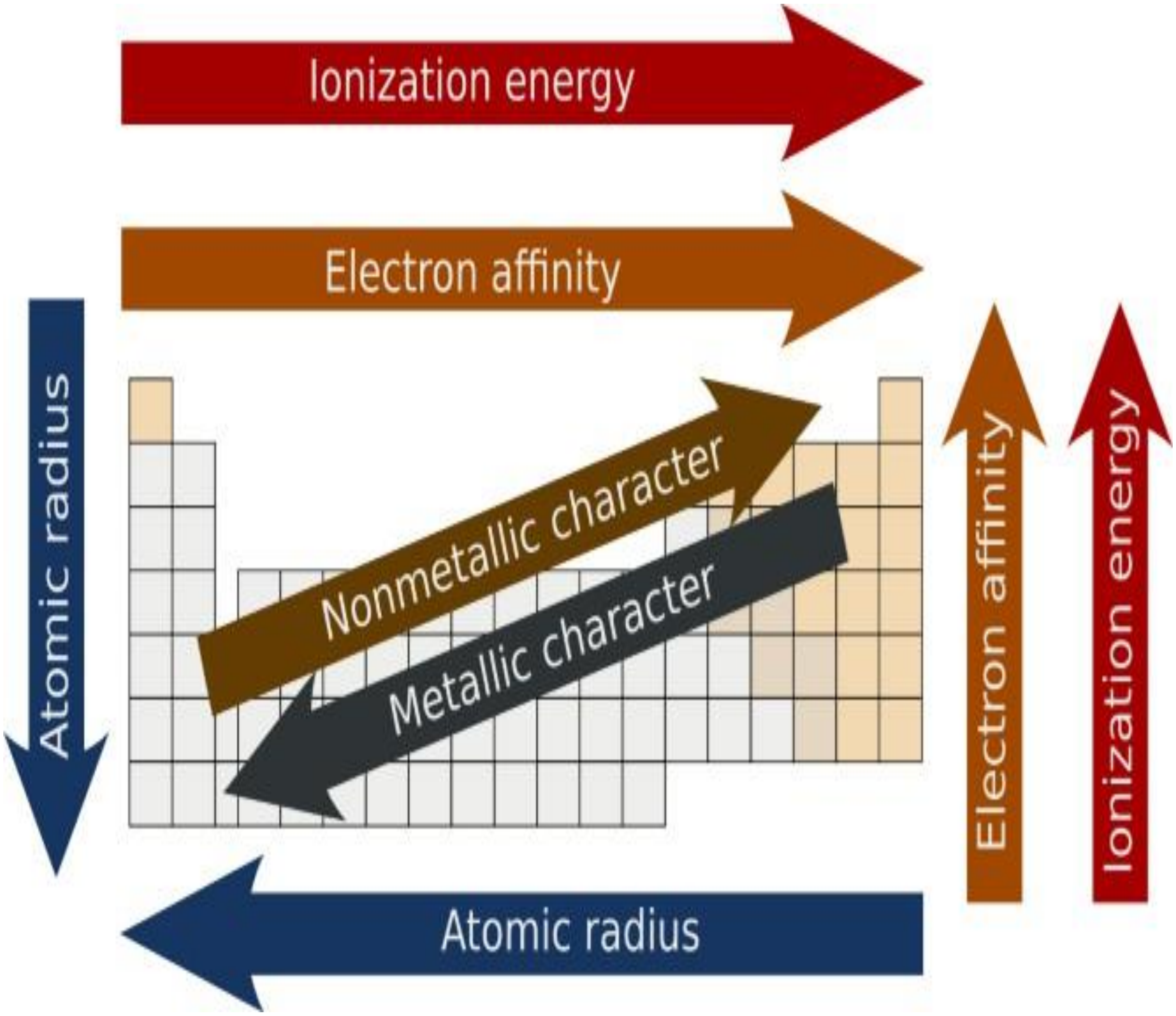
3. **Metallic Character:** The ability of an atom to lose the electron is known as metallic character decreases from left to right in a period. This is due to an increase in nuclear charge. But non-metallic character increases from left to right in a period. And metallic character increases down the group as the size increases; it can easily lose electrons.

4. **Ionization energy is** the energy required to remove an electron from an isolated gaseous atom. Ionization energy increases as we move left to right in a period. This is due to an increase in nuclear charge as we move left to right in a period. However down in a group, ionization energy decreases due to a decrease in nuclear charge, but there are some exceptional cases.

5. **Electropositive Character decreases** from left to right in a periodic table and increases down the group. This is due to a decrease in metallic character from left to right in a period.

6. **<u>The basic character of oxides</u>** increases down the group as the atomic radius increases and ionization energy decreases. This is due to an increase in the metallic character or electropositive nature of elements. The acidic character of oxides decreases as the non-metallic character of elements decreases from top to bottom.

Trends in Periodic Table



11 – CHEMICAL REACTIONS

INTRODUCTION:

Chemical reactions are fundamental processes in chemistry that involve the transformation of substances through the breaking and forming of chemical bonds. During a chemical reaction, the reactants, which are the initial substances, undergo a reorganization of atoms to form new substances known as products. These reactions are governed by the principles of chemical kinetics, thermodynamics, and the conservation of mass.

Chemical reactions can be classified into several types, including synthesis, decomposition, single replacement, double replacement, and combustion. Each type involves different processes and outcomes, reflecting the diverse nature of chemical interactions.

Understanding chemical reactions is crucial for various fields such as medicine, engineering, environmental science, and everyday life. They underpin the mechanisms of biological processes, the development of new materials, and the production of energy. By studying chemical reactions, scientists can predict how substances will behave, design new compounds with desired properties, and develop technologies that benefit society.

Writing a Chemical Equation:

While writing a chemical reaction, we should keep some rules in mind, and those rules are as follows:

- The reactants are written on the left side of the equation.
- The products are written on the right side of the equation.
- For solids, we write (s).
- For liquids, we write (l).
- For gas, we write (g).
- For an aqueous solution, we write (aq).
- If gas is produced in a reaction, we represent it by (↑).
- If a precipitate is produced in a reaction, we represent it by (↓).

Balanced Chemical Equation:

A chemical equation is said to be balanced when the number of atoms of the elements on the reactant side is equal to the number of atoms of the elements on the product side. There are certain steps that you can follow to balance a chemical equation, and they are:

- Make a list of each element involved in the equation.
- Then identify the number of atoms present in each element on both the reactant and product sides.
- Multiply the number of atoms to make both reactants and the product side equal.
- Place the coefficient in front of the reactants and product elements, as obtained from the multiplication.
- Check the equation to ensure that it is balanced.

Unbalanced Chemical Equation: $CaCo_3 + H_3PO_4 \rightarrow Ca_3(PO_4)_2 + H_2Co_3$
Balanced Chemical Equation: $3CaCo_3 + 2H_3Po_4 \rightarrow Ca_3(Po_4)_2 + 3H_2Co_3$

Types of chemical reactions:

1. **Chemical combination.**
2. **Chemical decomposition.**
3. **Chemical displacement.**
4. **Chemical double displacement.**
5. **Oxidation reaction.**
6. **Reduction reaction.**
7. **Redox reaction.**

1. **Chemical combination:** when two or more substances react chemically to form only one new product. These types of reactions are known as combination reactions.

Example: $S + O_2 \rightarrow SO_2$

Sulphur Oxygen Sulphur dioxide

2. **Chemical decomposition:** When a chemical compound decomposes into two or more compounds or substances, these types of reactions are known as chemical decomposition.

Example: $CaCO_3(s) \rightarrow CaO(s) + CO_2(s)$

Calcium carbonate Calcium oxide Carbon dioxide

3. **Chemical displacement:** In a displacement reaction, one element displaces another element from its compound and takes its place therein.

Example: $Zn\ (s) + 2HCl \rightarrow Zncl_2\,(aq) + H_2\,(g)$

Zinc Hydrochloric acid Zinc chloride and hydrogen

4. **Chemical double displacement:** In a double displacement reaction, two compounds react through an exchange of ions to form new compounds.

Example: $Pb\ (NO_3)_2\ (aq) + 2KI \rightarrow 2KNO_3\,(s) + PbI_2\,(g)$

Lead iodide Potassium iodide and lead nitrate

5. **Oxidation reaction:** the addition of oxygen to an atom or a group or the removal of hydrogen is known as oxidation.

In other terms, the loss of electrons is also called oxidation.
All combustion reactions are oxidation reactions.

Example1: $S + O_2 \rightarrow SO_2$

Sulphur Oxygen Sulphur dioxide

Example2: $C + O_2 \rightarrow CO_2$

Carbon Oxygen Carbon dioxide

6. **Reduction reaction:** the addition of hydrogen to an atom or a group or the removal of oxygen is known as reduction.

Example: $CuO + H_2 \rightarrow Cu + H_2O$

Copper oxide Hydrogen Copper water

7. **Redox reaction:** Generally, oxidation and reduction occur in the same reaction. If one, the other gets reduced. Such reactions are called oxidation-reduction reactions or redox reactions.

Example: $CuO + H_2 \rightarrow Cu + H_2O$

Copper oxide   Hydrogen   Copper   water

In the CuO-H_2 reaction, CuO is reduced and H_2 is oxidized.

Effects of oxidation reaction in daily life:

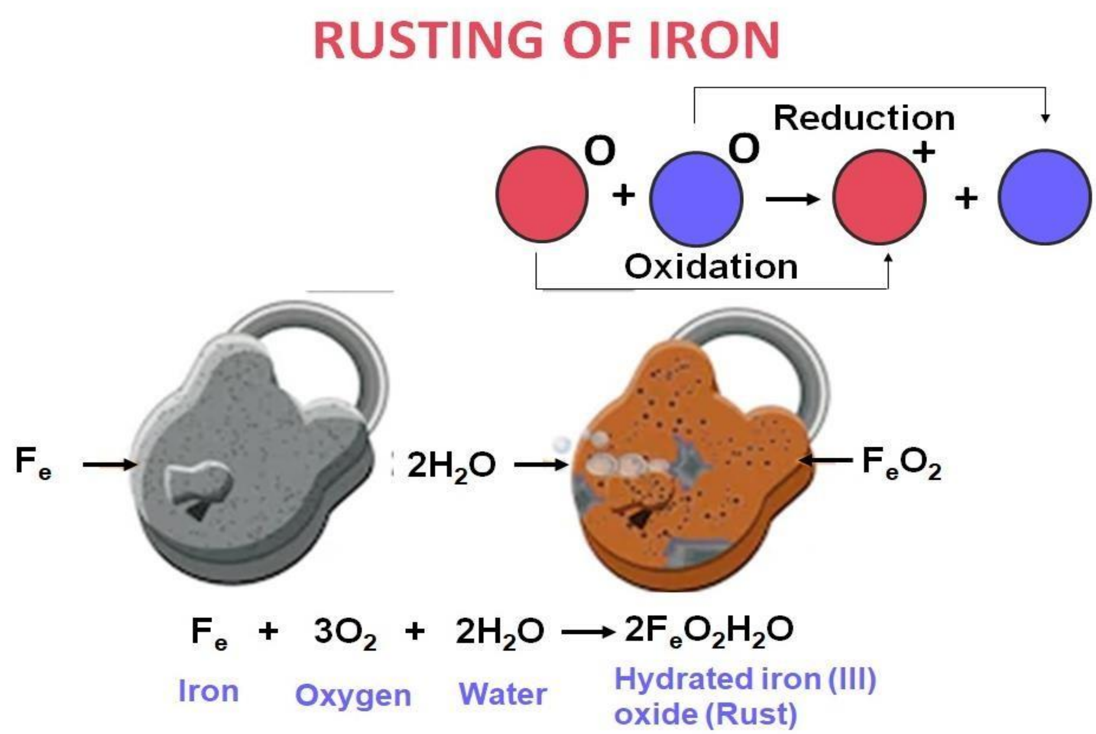
The two major oxidation reactions taking place in our day-to-day lives are the corrosion of metals and the rancidity of food items.

Corrosion:

When a metal is attacked by the substances around it, such as moisture, water, air, acids, etc., this process of degradation of the metal is known as **corrosion** of the metal.

Example: $Fe + O_2 \rightarrow Fe_2O_3$

Iron   Oxide   Iron oxide



Prevention of corrosion of metals:

- Corrosion can be prevented, or at least minimized, by shielding the metal surface from oxygen and moisture.
- It can be prevented by painting, oiling, greasing, galvanizing, chrome plating, or making alloys.
- Galvanizing is a method of protecting iron from rusting by coating it with a thin layer of zinc.
- Alloying is also a very good method of improving the properties of metal.

Rancidity:

- Rancidity is an oxidation reaction.
- The spoilage of food can be prevented by adding preservatives like Vitamin C and Vitamin E.
- Usually substances that prevent oxidation (antioxidants) are added to foods containing fats and oils. Keeping food in airtight containers helps slow down the oxidation process. Manufacturers of potato chips flush bags of chips with nitrogen gas to prevent the chips from getting oxidized.

Prevention of Rancidity of food items:

- By adding anti-oxidants to foods containing oils.
- Fat-containing food items Chips, kur kuray, and packets will be filled with nitrogen gas.
- Keeping food items in an airtight container.
- It can be restarted by storing foods away from light.

12 – ACIDS, BASES & SALTS

INTRODUCTION:

For generations, our elders have been using tamarind or lemon juice to give a shiny look to the copper vessels and never stored pickles in metal containers like brass or copper. Common salt and sugar have often been used as effective preservatives. How did our ancestors know that tamarind, lemon, vinegar, sugar, etc. work effectively? You have noticed that people suffering from a problem of acidity take an antacid tonic or chew tablets. Today, bleaching powder, baking soda, etc. are commonly used in our homes. You must have used various cleaners to open drains and pipes and window pane cleaners for sparkling glass. How do these chemicals work?

Acids and bases:

For thousands of years, people have known that vinegar, lemon juice, amla, tamarind, and many other food items taste sour. However, only a few hundred years ago, it was proposed that these things taste sour because they contain 'acids'.

- The term acid comes from the Latin term 'accre', which means sour.
- It was first used in the seventeenth century by Robert Boyle to label substances as acids and bases based on certain properties.
- He succeeded in defining acids and bases but could not explain their behaviour based on their chemical structure.

This was accomplished by Swedish scientist Svante Arrhenius in the late nineteenth century. He proposed that, on dissolving, mainly the properties of their form. Governed by this, he identified the ions furnished by acids and bases responsible for their characteristic behaviour and gave their definitions.

Some of the characteristics:

Acids	Bases
Taste sour	Taste bitter
Corrosive to metals	Feel slippery or soapy.
Change blue litmus into red.	Change red litmus into blue.
Become less acidic when mixing with bases.	Become less basic when mixing with acids.

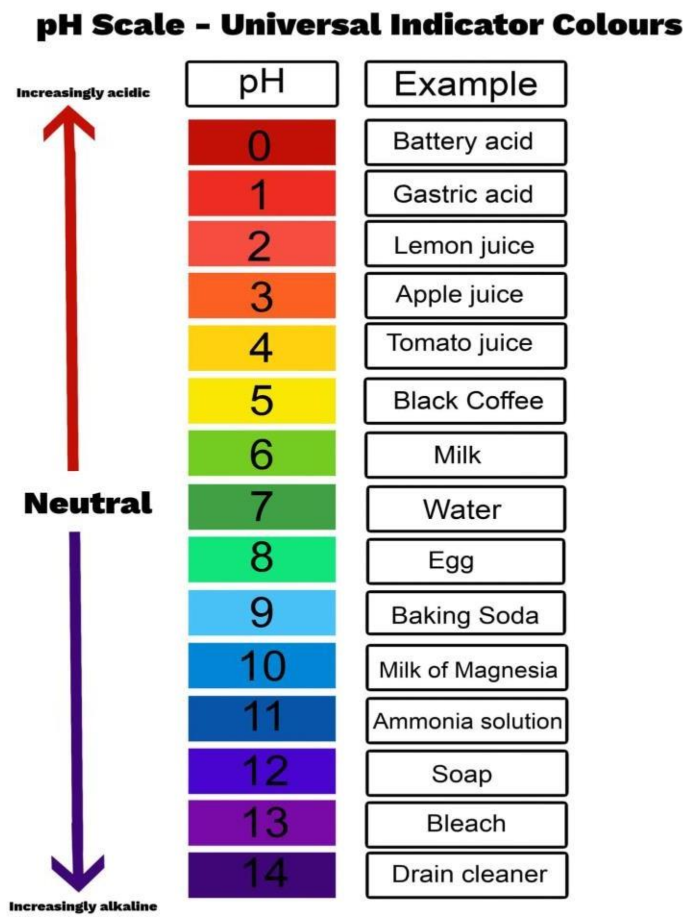
Indicators:

- Indicators are used to detect whether the product is acidic or basic.
- An acid-base indicator possesses one colour in an acidic medium and a different colour in an alkaline medium.

The colours of these indicators in acidic, neutral, and basic solutions are given below in the table:

Indicators	Colour in acid	Colour in neutral	Colour in basic
Litmus red	-	purple	blue
Litmus blue	red	purple	-
Phenolphthalein	colourless	colourless	pink
Methyl orange	red	orange	yellow

pH scale: The pH scale ranges from 0 to 14 on this scale. pH 7 is considered neutral, below 7 acidic, and above 7 basic. Farther from 7, more acidic towards zero and 14 basic the solution.



Determination of pH: The pH of a solution can be determined by using a proper indicator or with the help of a pH meter. The latter is a device that gives an accurate value of pH. We shall discuss here the use of indicators for finding out the pH of a solution.

Universal Indicator/PH Paper:

- It is a mixture of several indicators used to determine the strength of an acid or base.
- It shows a specific colour at a given pH.
- A colour guide is provided with the bottle of the indicator or the strips of paper impregnated with it, which are called pH paper strips.
- The test solution is tested with a drop of the universal indicator, or a drop of the test solution is put on pH paper.
- The colour of the solution on the pH paper is compared with the colour chart or guard, and the pH is read from it.
- The pH values thus obtained are only approximate.

Reaction of Acids with Metals

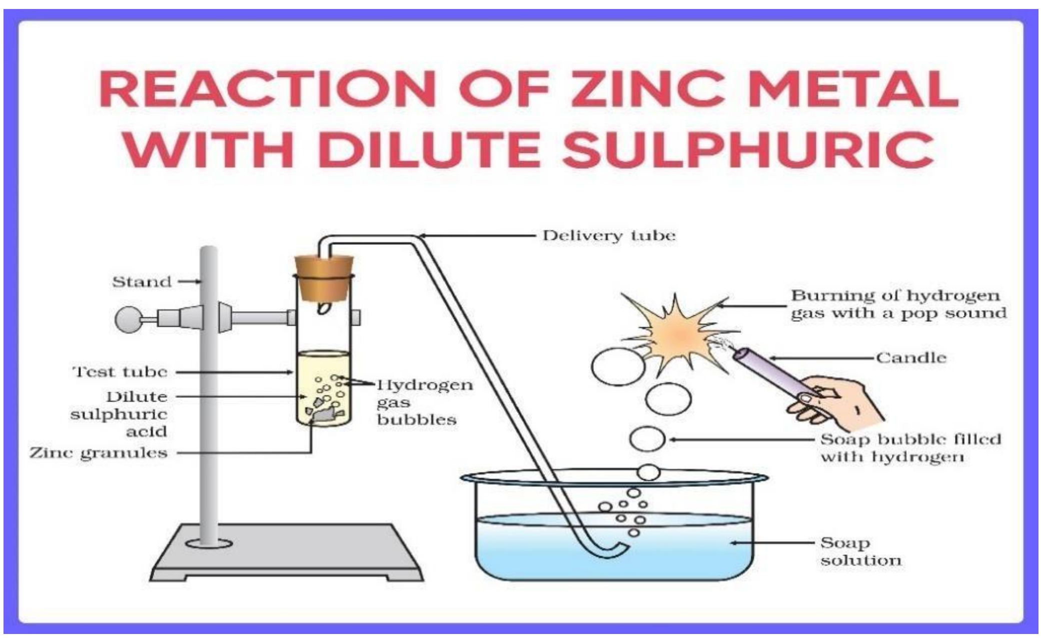
Lab Activity

Aim: To study the reaction of acids with metals.

Objective: An experiment to study the reaction of diluted sulfuric acid (H_2SO_4) with zinc (Zn).

Required material: a test tube, zinc (Zn) granules, a diluted sulfuric acid (H_2SO_4) stand, a matchbox, and a test tube holder.

Procedure: Drop a few zinc (Zn) granules in a test tube and add dilute sulphuric acid (H_2SO_4) carefully along the sides of the test tube. Set the apparatus as shown in Fig. Bring a burning match stick near the mouth of the test tube. The gas burns with a 'pop' sound when a burning match stick is brought near the mouth of the test tube.



Conclusion: From this experiment, it can be said that dilute sulphuric acid (H_2SO_4) reacts with zinc (Zn) to produce hydrogen (H_2) gas.

A similar reaction is observed when we use other metals like iron.

In general, it can be said that in such reactions metal displaces hydrogen (H_2) from acids and hydrogen (H_2) gas is released. The metal combines with the remaining part of the acid and forms a compound called a salt, thus,

Acid + Metal $\rightarrow$ Salt + Hydrogen gas

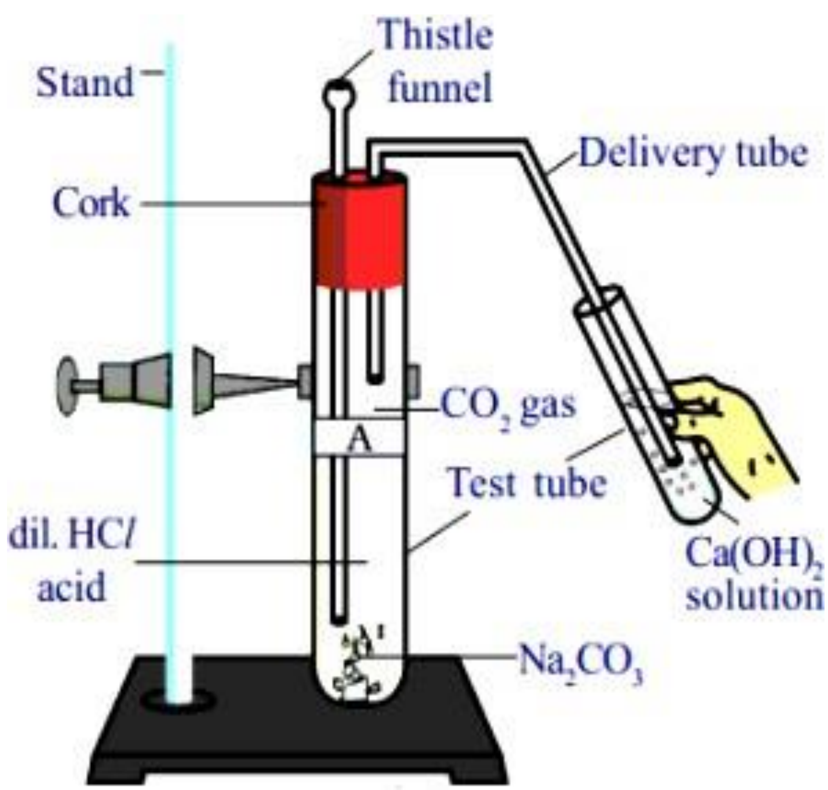
The reaction between zinc (Zn) and dil. sulphuric acid (H_2SO_4) can be written as:

Zn +	(H_2SO_4)	$\rightarrow$	ZnSO4 +	(H_2) ($\uparrow$)
Zinc metal	dil sulphuric acid		zinc sulphate salt	hydrogen gas

Reaction of acids with metal carbonates and hydrogen carbonates:

Activity - 2

Take the boiling tube and add about 0.5 g sodium carbonate (Na_2CO_3) and about 2 mL of freshly prepared lime water in another test tube. Add about 3 mL dilute hydrochloric (HCl) to the boiling tube containing sodium carbonate(Na_2CO_3) and immediately fix the cork filled with a delivery tube and set the apparatus as shown in the Fig. Dip the other end of the delivery tube in the lime water. Repeat the activity with sodium hydrogen carbonate. Observe the lime water, both times.



Passing CO_2 gas through $Ca(OH)_2$ solution

Conclusion:

From the above activity it can be concluded that if sodium carbonate or sodium hydrogen carbonate reacts with dilute hydrochloric acid, carbon dioxide gas is evolved

(Na_2CO_3) (s) + 2HCl(aq) → 2NaCl(aq) + H_2O(l) + CO_2 (g)↑

(Sodium carbonate) (dil. Hydrochloric) (Sodium chloride) (Water) (Carbon dioxide)

(Na_2CO_3) (s) + HCl (aq) → NaCl (aq) + H_2O (l) + CO_2 (g)↑

(Sodium hydrogen carbonate) (dil. Hydrochloric) (Sodium chloride) (Water) (Carbon dioxide)

On passing the evolved carbon dioxide CO_2 gas through lime water, $Ca(OH)_2$, the latter turns milky due to the formation of a white precipitate of calcium carbonate ($CaCO_3$)

$Ca(OH)_2$ (aq) + CO_2 (g) → $CaCO_3$ (s) + H_2O (l)

(Calcium hydroxide) (Carbon dioxide) (Calcium carbonate) (Water)

Metal carbonate + Acid →Salt + Water + Carbon dioxide

Metal hydrogen carbonate + Acid → Salt + Water + Carbon dioxide

Salts:

Salts are ionic compounds made of cations and anions Hydroxyl ion (OH–). Potassium sulphate (K_2SO_4), sodium sulphate (Na_2SO_4), calcium sulphate ($CaSO_4$), magnesium sulphate (Mg_2SO_4), copper sulphate ($CuSO_4$), sodium chloride (NaCl), sodium nitrate (NaNO3), sodium carbonate (Na_2CO_3) and ammonium chloride (NH_4Cl). Salts having the same positive and negative radicals belong to the same family. Sodium chloride (NaCl) and sodium sulphate (Na_2SO_4) belong to the sodium salt family, and sodium chloride (NaCl) and potassium chloride (KCl) belong to the chloride family.

Baking soda - sodium hydrogen carbonate (Na_2HCO_3) uses:

The chemical name of baking soda is sodium hydrogen carbonate ($NaHCO_3$).

1. It acts as a mild antiseptic.
2. For making baking powder, cakes and pastries are made fluffy and soft by using baking powder.
3. In medicines, a mild and non-corrosive base is used to neutralize the excessive acid in the stomach and provide relief. Mixed with solid edible acids such as citric or tartaric acid, it is used in effervescent drinks to cure indigestion.
4. Used in fire extinguishers as soda acid.

Washing soda (sodium carbonate decahydrate) (Na_2CO_3 .10H_2O)

Washing soda is used to wash clothes. It is mainly because of this chemical that the clothes washed by a washerman appear so white. Chemically, washing soda is sodium carbonate decahydrate (Na_2CO_3 .10H_2O).

Uses of washing soda (Na_2CO_3 .10H_2O).

1. It is used in the manufacture of caustic soda, glass, soap powders, and borax, and the paper industry.
2. As a cleansing agent for domestic purposes

Plaster of Paris ($CaSO_4$ .1/2H_2O)

You must have seen some beautiful designs made on the ceiling and walls of rooms in many houses. These are made of plaster of Paris, also called POP. Chemically, it is $2CaSO_4 .H_2O$ **or** $CaSO_4$ .1/2 H_2O (calcium sulphate hemi hydrate)

Uses of plaster of Paris (CaSO4 .1/2H_2O)

1. In making casts for the manufacture of toys and statues.
2. In medicine, plaster casts are used to hold fractured bones in place while they set. It is also used for making casts in dentistry.
3. For making the surfaces of walls and ceilings smooth.
4. For making decorative designs on ceilings, walls, and pillars.
5. For making 'chalk' for writing on the blackboard.

Uses of bleaching powder ($CaOCl_2$)

1. In the textile industry for the bleaching of cotton and linen.
2. In the paper industry for the bleaching of wood pulp.
3. In making wool unshrinkable.
4. Used as a disinfectant and germicide for the sterilization of water.
5. Used as an oxidizing agent in the chemical industry

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