Chapter 1: Chemical Basis of Life

Introduction to Biology

The bodies of all organisms are composed of a variety of chemical compounds formed by the bonding of naturally existing elements in different ways. Out of the 92 elements present in nature, only about 25 are found in living bodies. The most common elements in living bodies are Carbon, Hydrogen, Oxygen, and Nitrogen. Other essential elements include Sulphur, Phosphorus, Sodium, Potassium, Calcium, Magnesium, Iron, and Chlorine.

Key Elements in the Human Body

The human body is composed of various elements, with the following being the most significant:

- **Oxygen (O):** 65% - Found in all fluids, tissues, bones, and proteins.
- **Carbon (C):** 18% - Present everywhere in the body.
- **Hydrogen (H):** 10% - Found in all fluids, tissues, bones, and proteins.
- **Nitrogen (N):** 3% - Present in all fluids, tissues, and proteins.
- **Calcium (Ca):** 1.5% - Located in the brain, lungs, kidneys, liver, heart, thyroid gland, muscles, and bones.
- **Phosphorus (P):** 1.0% - Found in urine and bones.
- **Potassium (K):** 0.35% - Found in enzymes.
- **Sulfur (S):** 0.25% - Present in proteins.
- **Sodium (Na):** 0.15% - Found in all fluids and tissues.
- **Magnesium (Mg):** 0.05% - Located in the brain, lungs, kidneys, liver, heart, thyroid gland, and muscles.
- **Chlorine (Cl):** 0.2% - Found in skin cells.
- **Iron (Fe):** 0.007% - Present in hemoglobin in blood.
- **Iodine (I):** 0.0002% - Found in hormones in the thyroid gland.

Bio Molecules

Chemical compounds in living matter are divided into two categories: organic compounds and inorganic compounds. Organic compounds contain Carbon, whereas inorganic compounds do not (although some exceptions like Carbon dioxide, Carbon monoxide, Carbonates, and Bicarbonates exist). The organic compounds that build up living matter are known as bio molecules. These include:

1. **Carbohydrates**
   - **Monosaccharides:** Simple sugars such as glucose and fructose.
   - **Disaccharides:** Formed by the combination of two monosaccharides, such as sucrose and lactose.
   - **Polysaccharides:** Large molecules formed by the polymerization of many monosaccharides, such as starch, glycogen, and cellulose.
2. **Proteins**

- Composed of amino acids, essential for the structure and function of living cells. Functions include serving as an energy source, structural components, enzymes, hormones, and antibodies.

3. **Lipids**
   - Include fats and oils, containing Carbon, Hydrogen, and Oxygen. They serve as energy sources, form structural components, conserve water, regulate body temperature, protect internal organs, and synthesize certain hormones.
4. **Nucleic Acids**
   - DNA and RNA, composed of nucleotides. They are crucial for genetic information storage, transfer, and protein synthesis.
5. **Vitamins**
   - Organic compounds necessary for biochemical reactions. They are classified based on their solubility into water-soluble (e.g., Vitamins B and C) and fat-soluble (e.g., Vitamins A, D, E, and K).

Significance of Carbohydrates

Carbohydrates play various roles in living organisms:

- **As an Energy Source:** They are the main source of energy for the activities of organisms. The monosaccharides produced by the hydrolysis of carbohydrates release energy.
- **As a Storage Compound:** They store energy in the form of glycogen in animals and starch in plants.
- **As a Structural Component:** Cellulose, a carbohydrate, is a primary component of the plant cell wall.
- **As a Constituent of Nucleic Acids:** Ribose and deoxyribose, which are carbohydrates, form part of the structure of nucleic acids.

Tests to Identify Carbohydrates

Various tests can be conducted to identify carbohydrates in food:

1. **Starch Test**
   - Grind a small amount of food with water.
   - Add a drop of Iodine solution to the mixture.
   - A purplish-blue color indicates the presence of starch.
2. **Test for Glucose**
   - Obtain a glucose solution in a test tube.
   - Add a few drops of Benedict solution.
   - Heat the mixture in a water bath.
   - Observe the color change from blue to green, yellow, orange, and finally to a brick-red precipitate.
3. **Test for Sucrose**
   - Obtain a sucrose solution in a test tube.
   - Add a few drops of Benedict solution.

- Heat the mixture in a water bath.
- No color change occurs.
- Add a few drops of diluted Sulphuric acid to a freshly prepared sugar solution and heat it.
- Add Benedict solution again.
- Observe the color change similar to the glucose test.

Proteins

Proteins are essential constituents of all living cells. They are composed of Carbon, Hydrogen, Oxygen, and Nitrogen, and sometimes Sulphur. Approximately 17% of the mature human body is composed of proteins. Proteins are complex molecules made up of polymerized amino acid molecules. Foods rich in proteins include meat, fish, egg white, and cereals.

Amino Acids

Amino acids are the building blocks of proteins. They consist of a carboxyl group, an amino group, and a variable R group. The R group can vary, resulting in 20 different amino acids found in proteins. The simplest amino acid is glycine, where the R group is Hydrogen. Essential amino acids cannot be synthesized within the body and must be obtained from food.

Significance of Proteins

Proteins play several vital roles in the body:

- **As an Energy Source:** When energy supply from lipids and carbohydrates is insufficient, proteins are used for energy generation.
- **To Make Structural Components:** Proteins are crucial for cell membrane formation and are found in hair and feathers.
- **As Enzymes:** Proteins act as enzymes, catalyzing biochemical reactions in organisms.
- **As Hormones:** Some hormones are proteins that help in homeostasis and coordination.
- **As Antibodies:** Proteins form antibodies that protect the body against microorganisms.

Test to Identify Proteins

Biuret Test

- Obtain a solution made by grinding dhal or egg white in a test tube.
- Add an excess amount of Sodium hydroxide ($NaOH$) and then a few drops of Copper Sulphate ($CuSO4$).
- The solution turns purple, indicating the presence of proteins.

Enzymes

Enzymes are special proteins that act as organic catalysts, increasing the rate of biochemical reactions within organisms. For example, to convert sucrose into glucose, it must be heated with a dilute acid. However, enzymes in the digestive system can perform this reaction at a lower temperature. Enzymes catalyze biochemical reactions without being consumed in the process.

Activity of Amylase on Starch

Materials Required:

- Flour
- Amylase
- Test tube
- White porcelain tile
- Iodine solution
- Water
- Stopwatch

Method:

1. Put 2ml of starch solution into a test tube.
2. Add 2ml of amylase (filtered from a solution of ground germinating green gram seedlings) and mix well.
3. After 2 minutes, get a drop from the solution and place it on a white porcelain tile.
4. Add a drop of iodine onto the drop of the mixture.
5. Continue the same procedure for about 20 minutes in 2-minute intervals.

Observation: The blue color of the drop obtained from the mixture gradually reduces over time, eventually turning to the color of iodine (yellow/brown). This indicates that starch is converted to maltose by the amylase enzyme.

Lipids

Lipids include fats and oils. Lipids solid at room temperature are called fats, and those liquid at room temperature are called oils. Like carbohydrates, lipids contain Carbon, Hydrogen, and Oxygen, but with a much lower oxygen content. Lipids are insoluble in polar solvents like water but are soluble in organic solvents. Foods rich in lipids include groundnut, coconut, gingelly, butter, and margarine. Fatty acids and glycerol react to form lipids.

Significance of Lipids

Lipids play several important roles:

- **As an Energy Source:** Lipids provide a more significant energy source compared to carbohydrates and proteins.
- **To Form Structural Components:** Lipids are essential components of cell membranes, especially phospholipids and cholesterol.

- **For Conservation of Water:** The wax known as cutin, present on the surface of plant bodies, conserves water. Most animals' body coverings also contain wax, preventing desiccation as it is impermeable to water.
- **To Maintain Body Temperature:** Warm-blooded animals, such as birds and mammals, have a hypodermal fat layer acting as a thermal insulator, helping to maintain their body temperature.
- **To Protect Internal Body Organs:** The fat layer surrounds organs and structures in the body, absorbing external shocks and providing protection.
- **To Synthesize Some Hormones:** Some hormones, such as oestrogen, testosterone, and cortisone, are lipid compounds.

Test to Identify Lipids

Sudan III Test

- Add some amount of gingelly oil or coconut oil into a test tube.
- Add Sudan III reagent.
- The appearance of red fat globules indicates the presence of lipids.

Fatty Acids

Fatty acids can be divided into two groups:

- **Saturated Fatty Acids:** Contain only single bonds within Carbon atoms. They exist as solids or semi-solids at room temperature.
- **Unsaturated Fatty Acids:** Contain one or several double bonds within Carbon atoms. They exist as liquids at room temperature.

Nucleic Acids

Nucleic acids are the most important molecules in living matter from a genetic perspective. They are linear polymers made up of many nucleotides and contain Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), and Phosphorus (P).

Each nucleotide is composed of three components:

- **Nitrogenous Base**
- **Pentose Sugar Group**
- **Phosphate Group**

There are two types of nucleic acids:

- **DNA (Deoxyribonucleic Acid):** The structural unit of DNA is the deoxyribonucleotide. DNA transfers genetic characteristics from generation to generation.
- **RNA (Ribonucleic Acid):** The structural unit of RNA is the ribonucleotide. RNA's function is protein synthesis.

Significance of Nucleic Acids

Nucleic acids play several critical roles:

- **Storage of Genetic Information:** They store genetic information of organisms.
- **Transferring Genetic Information:** They transfer genetic information from generation to generation.
- **Protein Synthesis:** They are essential in the protein synthesis process.
- **Controlling Cellular Activities:** DNA contains the information to control all cellular activities in a cell.
- **Genetic Information in Viruses:** RNA stores genetic information in some viruses.
- **Evolution:** Variations in DNA due to mutations are important in evolution.

Activities to Confirm Presence of Elements in Bio Molecules

1. **Identification of Water as a Constituent in Food**

Materials Required:

- Meat
- Eggshell
- Plant leaves
- Crucibles

Method:

1. Grind/crush meat, eggshell, and leaves in their dried form separately.
2. Put them separately into the crucibles and heat them.
3. During heating, hold a glass sheet above the crucible.
4. Use anhydrous cobalt chloride or copper sulfate to identify whether the liquid drops on the glass are water.

Observation: Blue-colored anhydrous cobalt chloride turns pink, and white-colored anhydrous copper sulfate turns blue, confirming that water is formed on the glass sheet, indicating the presence of water in the food used for the experiment.

2. **Identification of Presence of Carbon in Bio Molecules**

Materials Required:

- Several crucibles
- Spinach stems
- Piece of fish
- Chickpea

Method:

1. Make pulps by crushing all the above materials separately.
2. Put them separately into crucibles and heat well.
3. Rub the final residue obtained against white paper.

Observation: Lines drawn due to coal are observed, confirming that the food used for the experiment contains Carbon.

3. **Identification of Presence of Nitrogen in Bio Molecules**

Materials Required:

- Two test tubes
- Solution of Sodium hydroxide
- Solution of Copper sulfate
- Egg white
- Piece of fish

Method:

1. Crush fish thoroughly, add water, and mix well. Filter the solution.
2. Put 2ml of the fish extraction and egg white into separate test tubes.
3. Add an equal volume of sodium hydroxide.
4. Add a few drops of copper sulfate to it.

Observation: A purple color appears in the solution, confirming the presence of protein in the food. As nitrogen is a constituent of proteins, it is confirmed that the above tissues contain nitrogen.

Water

Water constitutes the highest proportion of the body mass of living organisms, comprising two-thirds of the body weight of most organisms. Water is an essential medium for the maintenance of living matter, as life originated in water. The table below shows the specific properties of water and their contribution to the maintenance of life.

Specific Properties of Water and Their Contributions

1. **Good Solvent**
   - Provides a medium for biochemical reactions in the cells of organisms.
   - Main constituent in the extracellular fluids of organisms.
   - Facilitates the removal of excretory material and fecal matter of animals.
   - Important in respiration of aquatic organisms as oxygen is soluble in water.
2. **Coolant**
   - Due to its high specific heat capacity (amount of heat needed to increase temperature by 1°C in 1kg of mass), the body temperature does not fluctuate quickly with changes in the environment.

3. **High Cohesive and Adhesive Force**
    - Being the main constituent of blood, it helps transport nutrients, vitamins, and hormones to relevant locations.
    - Transports water to the upper parts of the plant due to high cohesive (water-water attractions) and adhesive (water-another molecule attractions) forces of water molecules.
4. **Differential Expansion in Freezing**
    - Density of water is higher than that of ice. When ice is formed, it comes to the top layers of water, keeping water as it is at the bottom. This provides a living environment for aquatic organisms.

Minerals

Minerals are important as nutrient constituents to maintain the life processes of organisms. They are absorbed as trace or macro elements into the body. Elements needed in higher amounts are known as macro elements, and those needed in small amounts are known as trace elements. Minerals make up 7% of the body weight, with three-fourths of this amount being Calcium and Phosphorus. Other minerals include Potassium, Iron, Magnesium, Copper, and Iodine. When elements are not present in the correct amounts, plants and animals show deficiency symptoms.

Functions of Minerals and Their Deficiency Symptoms in Humans

- **Potassium:** Controls ionic balance in cells, activity of heart and muscles, transmission of nerve impulses. Deficiency leads to muscle weakening and psychological disorders.
- **Sodium:** Activates enzymes, constituent of digestive juice, maintains osmotic pressure, transmission of nerve impulses. Deficiency causes respiratory disorders, cramps, nausea, and diarrhea.
- **Magnesium:** Constituent of bones and teeth, controls nerve activity in skeletal muscles, helps in metabolic activities. Deficiency results in high heartbeat and nerve irritability.
- **Calcium:** Growth of bones and teeth, blood clotting, proper nerve function, milk production, absorption of Vitamin B. Deficiency leads to weakened bones and teeth, growth disorders, and osteoporosis.
- **Phosphorus:** Growth of bones and teeth, constituent of nucleic acids, metabolism of carbohydrates and fats, instant energy release in muscles and nerves. Deficiency causes bone weakening and fragility.
- **Iron:** Synthesis of hemoglobin, storage of oxygen in muscles, constituent of enzymes. Deficiency leads to anemia, sleepiness, hypoactive nature, and psychological development issues.
- **Iodine:** Synthesis of Thyroxin hormone. Deficiency affects intelligence development, causes lethargic attitude towards studies, and limits body height.

Functions of Minerals and Their Deficiency Symptoms in Plants

- **Nitrogen:** Constituent of amino acids, proteins, nucleic acids, and chlorophyll. Deficiency causes growth retardation and chlorosis in mature leaves.

- **Phosphorus:** Constituent of nucleic acids and ATP. Deficiency leads to retarded root growth and red/purple patches on leaves.
- **Potassium:** Protein synthesis, opening and closing of stomata. Deficiency causes chlorosis and yellow/brown patches on leaves.
- **Iron:** Synthesis of chlorophyll and respiratory enzymes. Deficiency results in chlorosis in tender leaves.
- **Calcium:** Component of the cell wall, maintains the structure and function of plasma membranes, enzyme activity. Deficiency causes dying of tissues at leaf tips.
- **Zinc:** Activity of most enzymes, synthesis of chlorophyll. Deficiency results in dead cells and tissues throughout the plant and extra thickness in leaves.
- **Sulfur:** Constituent of amino acids and proteins. Deficiency causes chlorosis in veins and areas between veins.

Vitamins

Vitamins are organic compounds crucial for biochemical reactions. They can be classified based on their solubility:

- **Water-Soluble Vitamins:** B and C.
- **Fat-Soluble Vitamins:** A, D, E, and K.

Uses and Deficiency Symptoms of Vitamins

- **Vitamin A:** Formation of visual pigments for eye vision, skin health. Deficiency causes night blindness, Bitot's patches, skin dryness, blisters, and respiratory diseases.
- **Vitamin B:** Maintenance of nerves, healthy skin, bone marrow formation, red blood cell maturation, antibody production. Deficiency leads to beriberi, anemia, skin dryness, complexion changes, and reduced antibody production.
- **Vitamin C:** Skin health, enamel formation, collagen fiber synthesis. Deficiency causes gum weakening, internal bleeding, delayed recovery, and scurvy.
- **Vitamin D:** Controls calcium and phosphorus absorption. Deficiency results in rickets (bone deforming).
- **Vitamin E:** Growth of tissues and cells. Deficiency leads to premature births, increased red blood cell breakdown, cell division weaknesses, and reproductive issues.
- **Vitamin K:** Produces components for blood clotting. Deficiency delays blood clotting.

Summary

- The living body is composed of carbohydrates, proteins, lipids, and nucleic acids, known as bio molecules.
- Inorganic compounds like water and mineral salts are crucial in living systems.
- Main elements in bio molecules are C, H, O, N.
- Enzymes are proteins that catalyze biochemical reactions.
- Deficiency in minerals and vitamins results in specific symptoms.
- Water's properties are essential for life maintenance.

Chapter 2: Motion in a Straight Line

Physics

Distance and Displacement

Distance is a familiar concept. When you travel from home to school, you cover a certain distance. There can be several paths between home and school, some shorter and some longer.

If you travel on path P, the distance between point A and point B would be 320 m. If path Q is used, this distance would be 200 m. If path R is taken, the travel distance would be 240 m. This shows that the distance depends not only on the starting and the end points, but also on the path used to traverse the distance. Whichever path the child uses to reach B after starting from A, the ultimate result is that they have moved a distance of 160 m from A to B on a straight line towards the east. A change of position like this, that occurs from one point to another point in a particular direction is called displacement. The magnitude of the displacement is the shortest distance between the two points.

A physical quantity which can be described only by its magnitude is called a scalar quantity (e.g., speed, mass, time, distance). A physical quantity which can be described by its magnitude and direction is called a vector quantity (e.g., displacement, acceleration, velocity, weight).

In the example above, the displacement of the child is 160 m to the east. Although the distance has changed according to the path taken, the displacement has remained the same.

When measuring the displacement, the direction is important. In other words, the displacement has both a magnitude and a direction. Therefore it is a vector quantity.

A child travels from home to school, covering a total distance of 700 m, but the straight-line distance from home to school is 500 m. This means that the magnitude of the displacement is 500 m while its direction is along AD.

A child starts from point A and reaches point B along a path. Even though the distance traveled by the child along this path is 400 m, the magnitude of his displacement is 120 m and the direction is along AB.

An athlete runs 200 m on a track from point A to point B. The displacement of the athlete is 160 m in the direction 70° from north to west.

A child walks 60 m from A to B along a straight-line path, then another 40 m along the same direction to point C. The total displacement is 100 m.

If the child walks back 40 m after reaching point B, the total displacement is 20 m. If the child walks the same distance back, the displacement would be zero, indicating the child is back at the starting point.

A child walks 40 m to the east to reach point B, then 30 m to the north to reach point C. The total distance traversed by the child is 70 m, and the displacement is 50 m towards the northeast.

Speed

Speed is the rate at which a given distance is traversed.

Speed = Distance / Time

A vehicle maintains a constant speed, but if traffic varies, it must slow down or stop. For example, an object moves at a constant speed of 3 m/s as indicated by the following data:

Time (s): 0, 1, 2, 3, 4, 5, 6

Distance (m): 0, 3, 6, 9, 12, 15, 18

The object has traveled 3 m during each 1 s time interval, indicating a constant speed of 3 m/s.

When the object does not travel uniformly, calculate the mean speed:

Mean Speed = Total Distance / Total Time

For example, if a vehicle traveled 100 km in 2 hours, the average speed is 50 km/h.

Velocity

Velocity is the rate of change of displacement and includes direction, making it a vector quantity.

Velocity = Displacement / Time

For example, if a body moves at a constant velocity of 6 m/s for 5 s, its displacement is:

Displacement = Velocity × Time = 6 m/s × 5 s = 30 m

An object moving with non-uniform velocity has displacement data as follows:

Time (s): 0, 1, 2, 3, 4

Displacement (m): 0, 4, 7, 9, 12

Mean velocity is calculated using the total displacement over time.

Acceleration

Acceleration is the rate of change of velocity.

Acceleration = Change in Velocity / Time

For example, an object accelerating from 0 to 12 m/s in 6 s has an acceleration of 2 m/s^2.

If the velocity decreases, the acceleration is negative, known as deceleration. For example, an object decelerating from 12 m/s to 0 in 4 s has an acceleration of -3 m/s^2.

Displacement-Time Graphs

Graphs illustrating how displacement varies with time are displacement-time graphs. For instance, a body moving at a uniform velocity results in a straight-line graph. The gradient of the graph gives the velocity.

Velocity-Time Graphs

Graphs representing how velocity varies with time are velocity-time graphs. For instance, a body moving with uniform acceleration results in a straight-line graph. The area under the graph represents displacement.

For example, a body starting from rest and moving at a uniform acceleration for 4 s acquires a velocity of 12 m/s. The displacement during this time can be found using the area under the velocity-time graph.

Displacement = mean velocity × time

Gravitational Acceleration

Gravitational acceleration is the acceleration of a body due to Earth's gravity, denoted by g. At sea level, $g \approx 9.8\ m/s^2$.

A body falling from rest increases its velocity by 9.8 m/s every second. For a body projected upwards, gravitational acceleration is $-9.8\ m/s^2$, decreasing its velocity.

For example, an object projected vertically upward with an initial velocity of 30 m/s has the following velocity-time data:

Time (s): 0, 1, 2, 3

Velocity (m/s): 30, 20, 10, 0

The maximum height reached can be found using the area under the velocity-time graph.

Summary

- Distance depends on the path taken; displacement depends only on initial and final points.
- Speed is a scalar quantity; velocity and acceleration are vector quantities.
- Displacement can be found using the area under velocity-time graphs.

Technical Terms

- Distance: The total path length traveled by an object.
- Displacement: The straight-line distance from an object's initial position to its final position, along with the direction.
- Object: A material entity that has mass and occupies space.

- Vector quantity: A physical quantity that has both magnitude and direction.

- Scalar quantity: A physical quantity that has only magnitude.

- Speed: The rate at which an object covers distance.

- Velocity: The rate at which an object's position changes, including direction.

- Acceleration: The rate at which an object's velocity changes.

- Retardation (Deceleration): Negative acceleration; the rate at which an object's velocity decreases.

- Gravitational acceleration: The acceleration of an object due to the gravitational pull of the Earth.

Exercises

1. Calculate the acceleration of an object increasing uniformly from 0 to 12 m/s in 6 s.

Acceleration = Change in Velocity / Time = 12 m/s / 6 s = 2 m/s^2

2. Calculate the deceleration of an object decreasing uniformly from 16 m/s to 4 m/s in 4 s.

Deceleration = Change in Velocity / Time = (16 - 4) m/s / 4 s = 3 m/s^2

3. Starting from rest, if an object travels with an acceleration of 0.5 m/s^2 for 10 s, find the velocity at the end of 10 s.

Velocity = Acceleration × Time = 0.5 m/s^2 × 10 s = 5 m/s

4. The velocity of an object moving on a straight line was 2 m/s at a certain instant. Its velocity changed to 6 m/s after accelerating for 4 s. Find the acceleration during the 4 s period.

Acceleration = Change in Velocity / Time = (6 - 2) m/s / 4 s = 1 m/s^2

Chemistry Structure of Matter

The things in our environment can be classified into two main categories: matter and energy. Matter occupies space and has mass. The classification of matter according to physical nature and chemical composition is shown below:

Matter:

1. Pure substances

   - Elements (e.g., Iron (Fe), Oxygen (O_2), Copper (Cu), Nitrogen (N_2))

   - Compounds (e.g., Water (H_2O), Carbon dioxide (CO_2))

2. Mixtures

   - Homogeneous mixtures (e.g., Salt solution, Sugar solution)

   - Heterogeneous mixtures (e.g., Lime + Water, Rice + Sand)

Matter can exist in three physical states: solid, liquid, and gas. Each state has distinct characteristics. Solids have a fixed shape and volume, liquids have a fixed volume but take the shape of their container, and gases have neither a fixed shape nor volume and expand to fill their container.

Atoms are the building units of matter, composed of subatomic particles: protons (positive charge), electrons (negative charge), and neutrons (no charge). The atomic model introduced by Ernest Rutherford in 1911 describes a small, positively charged nucleus at the center of the atom, with electrons revolving around it.

The planetary model of the atom, introduced by Ernest Rutherford, depicts electrons moving around a positively charged nucleus, similar to planets revolving around the sun. Niels Bohr further elaborated this model by stating that electrons move in definite paths or shells around the nucleus. These shells, also known as energy levels, are assigned numbers or letters (K, L, M, N...) starting from the nearest to the nucleus. Each energy level has a specific energy that increases with distance from the nucleus, though the difference between energy levels decreases.

The maximum number of electrons in the first four energy levels is determined by the formula $2n^2$, where n is the number of the energy level. Thus, the maximum number of electrons is:

- Level 1 (K): 2 electrons
- Level 2 (L): 8 electrons
- Level 3 (M): 18 electrons
- Level 4 (N): 32 electrons

The atomic number is the number of protons in an atom of the element. For example, a sodium atom has 11 protons, making its atomic number 11. The number of protons in every atom of the same element is equal, but different elements have different numbers of protons.

The mass number is the sum of the number of protons and neutrons in the nucleus of an atom. For example, if a sodium atom contains 11 protons and 12 neutrons, its mass number is 23. The atomic number (Z) and mass number (A) are written as follows:

Na_{11}^{23}

Electronic configuration represents how electrons are filled in the respective energy levels from the nearest to the nucleus outward. For example, a sodium atom (atomic number 11) has an electronic configuration of 2, 8, 1.

Electronic configurations of elements with atomic numbers 1 to 20:

- Hydrogen (H): 1
- Helium (He): 2
- Lithium (Li): 2, 1
- Beryllium (Be): 2, 2
- Boron (B): 2, 3
- Carbon (C): 2, 4

- Nitrogen (N): 2, 5

- Oxygen (O): 2, 6

- Fluorine (F): 2, 7

- Neon (Ne): 2, 8

- Sodium (Na): 2, 8, 1

- Magnesium (Mg): 2, 8, 2

- Aluminium (Al): 2, 8, 3

- Silicon (Si): 2, 8, 4

- Phosphorus (P): 2, 8, 5

- Sulphur (S): 2, 8, 6

- Chlorine (Cl): 2, 8, 7

- Argon (Ar): 2, 8, 8

- Potassium (K): 2, 8, 8, 1

- Calcium (Ca): 2, 8, 8, 2

The modern Periodic Table, based on atomic number and electronic configuration, arranges elements so that those with similar properties recur at regular intervals. The horizontal rows are called Periods, and the vertical columns are called Groups.

Elements in the first four periods (with atomic numbers 1-20):

- Period 1: H, He

- Period 2: Li, Be, B, C, N, O, F, Ne

- Period 3: Na, Mg, Al, Si, P, S, Cl, Ar

- Period 4: K, Ca

Isotopes are atoms of the same element with different numbers of neutrons, resulting in different mass numbers. For example, hydrogen has three isotopes: protium, deuterium, and tritium.

First ionisation energy is the minimum energy required to remove an electron from an atom in the gaseous state to form a unipositive ion. This energy increases across a period and decreases down a group.

Electronegativity is the ability of an atom to attract electrons in a bond. It increases across a period and decreases down a group. Fluorine has the highest electronegativity.

Metals, non-metals, and metalloids have distinct properties:

- Metals: Conduct heat and electricity, malleable, ductile, high density.

- Non-metals: Poor conductors, brittle, lower density.

- Metalloids: Properties intermediate between metals and non-metals.

Sodium is a highly reactive Group I metal, stored in paraffin oil or kerosene. It reacts with oxygen, water, and acids. Uses include the production of sodium cyanide, street lamps, and the extraction of metals.

Magnesium is a light, reactive metal that tarnishes in air. It reacts with hot water, acids, and is used in alloys, medicine, and preventing iron corrosion.

Nitrogen, a diatomic gas, constitutes 78.1% of the atmosphere. It reacts with metals, forms ammonia, and is used in fertilizers, inert environments, and food packaging.

Sulphur, an element with various allotropes, burns to form sulphur dioxide (SO_2), and is used in producing sulphuric acid (H_2SO_4), rubber, and fungicides.

Carbon has different allotropes like diamond, graphite, and charcoal. It is used in fuels, electrodes, jewelry, and water purification.

Silicon, a metalloid, is abundant in the Earth's crust and used in electronics, solar cells, and computer equipment.

Boron, another metalloid, is used in welding, skin creams, and heat-resistant glass.

Chemical formulae represent compounds with symbols and numbers. For example, H_2O represents water. Valency helps in writing chemical formulae by balancing the combining powers of elements.

Examples:

- Sodium chloride: $NaCl$

- Calcium chloride: $CaCl_2$

- Sodium oxide: Na_2O

- Calcium oxide: CaO

- Magnesium nitride: Mg_3N_2

Polyatomic ions are groups of atoms with a charge, such as ammonium (NH_4^+), nitrate (NO_3^-), and sulfate (SO_4^{2-}).

Experiments and Tests:

1. Identification of elements:

   - Use the flame test to identify elements based on the color of the flame produced when the element is heated.

   - Use spectroscopy to identify elements based on their emission or absorption spectra.

2. Determination of electronic configuration:

   - Perform experiments with cathode rays to understand the arrangement of electrons in atoms.

3. Chemical reactions of elements:

- React sodium with water and observe the vigorous reaction and production of hydrogen gas.
- Burn magnesium in air and observe the bright white flame and formation of magnesium oxide.
- React nitrogen with hydrogen under high pressure and temperature to form ammonia using the Haber process.

4. Properties of elements:

- Test the electrical conductivity of metals and non-metals.
- Observe the physical properties of metals, such as malleability and ductility, by hammering and drawing into wires.

5. Analysis of compounds:

- Use chemical tests to identify the presence of specific ions in compounds, such as the flame test for sodium or the silver nitrate test for chloride ions.

6. Calculation of valencies:

- Determine the valencies of elements by analyzing their chemical reactions and combining ratios with other elements.

Exercises:

1. Complete the sentences based on atomic structure and properties.
2. Write atomic numbers and mass numbers in standard form.
3. Fill in tables with the number of electrons, protons, and neutrons.
4. Write chemical formulae for given compounds.
5. Determine valencies of elements.
6. Identify elements and their properties based on the Periodic Table.

7. Analyze patterns in ionisation energy and electronegativity.

8. Research and present information on selected elements.

Newton’s Laws of Motion

Nature of Force and Its Effects

Force is a push or pull that causes an object to move, stop, or change direction. For example, when pushing a table, a certain amount of force is required to overcome the resistive force known as friction. The same principle applies when trying to push a bus, where the force applied by one person is not sufficient, but with a group of people, the bus can be moved.

If a table is placed on a very smooth surface like ice, a small force can set it in motion because there is minimal resistive force. This demonstrates that whenever an unbalanced force acts on an object at rest, the object starts to move.

A cart loaded with goods pulled by a bull moves faster if a force is applied from behind in the direction of the cart's motion. Conversely, applying a force in the opposite direction slows it down. This shows that force has both magnitude and direction, making it a vector quantity.

Newton’s First Law

Newton's first law states that until an unbalanced force is applied, bodies at rest remain stationary, and bodies in motion continue to move at uniform velocities. For example, a carom disc on a board will move a short distance and stop due to friction. By reducing friction with talcum powder, the disc moves farther before stopping. This principle also explains why a passenger in a moving bus falls forward when the bus suddenly stops due to inertia, as the upper body continues moving forward while the feet are brought to rest by the bus floor.

Consider the case of striking a carom disc on a carom board with your fingernail. The disc would move a short distance and come to rest. If we apply some talcum powder on the carom board to make the surface smoother and then repeat the action by striking the disc with roughly the same force as before, the disc would move a much longer distance before coming to rest. The action of the talcum powder on the board is to reduce the resistive forces exerted on the disc by the carom board. The resistive force that opposes the motion of an object on a surface is called friction. If we could somehow eliminate friction, the disc would continue moving indefinitely without stopping.

Let's consider another example that illustrates Newton's first law. Suppose a passenger is standing on a moving bus without holding onto anything for support. If the bus suddenly stops by applying brakes, the passenger would fall forward. This happens because the floor of the bus exerts a resistive force on the passenger's feet, bringing them to rest. However, no such force acts on the upper part of the passenger's body, which continues moving forward due to its inertia. Conversely, if the bus starts moving suddenly, the passenger would fall backward. The floor of the bus exerts a force on the passenger's feet, giving them velocity, while the upper body remains at rest, resulting in the passenger falling backward.

Wearing seat belts in a vehicle prevents passengers from being thrown forward in the event of sudden braking. The seat belt exerts a force on the upper body, ensuring the entire body remains at the same velocity as the vehicle, even when brakes are applied.

Newton’s Second Law

Newton's second law states that the acceleration of a body is directly proportional to the unbalanced force acting on it and inversely proportional to its mass. Symbolically, it is written as:

$a \propto F$

$a \propto 1/m$

Combining these, we get:

$a = F/m$ or $F = ma$

This law can be verified through experiments. For example, placing a trolley on a horizontal surface, attaching a rubber band to it, and pulling the rubber band to extend it. When the trolley is released, it moves with acceleration. Attaching another rubber band increases the force and results in greater acceleration. Adding more rubber bands continues to increase the acceleration, demonstrating that acceleration increases with force. Conversely, adding mass to the trolley while maintaining the same force decreases the acceleration, showing the inverse relationship between mass and acceleration.

Example 1: The force required to give an acceleration of $2\ m/s^2$ to a 5 kg mass is:

$F = ma = 5\ kg \times 2\ m/s^2 = 10\ N$

Example 2: A force of 12 N applied to a 6 kg body results in an acceleration of:

$a = F/m = 12\ N / 6\ kg = 2\ m/s^2$

Example 3: An 8 N force applied to an object results in an acceleration of $2\ m/s^2$. The object's mass is:

$m = F/a = 8\ N / 2\ m/s^2 = 4\ kg$

Newton's Third Law

Newton's third law states that for every action, there is an equal and opposite reaction. For example, expulsion of air from a balloon results in the balloon moving in the opposite direction due to the reaction force. Similarly, in rowing a boat, water is pushed backward by the oars, and the reaction force moves the boat forward. In swimming, the backward force applied by the hands on water results in a forward thrust on the swimmer's body.

Another practical example is observed when two children sit on planks placed on glass balls and push each other with their palms. They move in opposite directions, illustrating action and reaction forces. Additional examples include the recoil of a gun when a bullet is fired, where the bullet exerts a forward force on the gun, and the gun exerts a backward force on the bullet, and the thrust produced by rocket engines, where the expulsion of exhaust gases produces a reaction force that propels the rocket forward.

Momentum

Momentum (p) of a moving body is defined as the product of its mass (m) and velocity (v):

$p = m \times v$

Momentum is a vector quantity. For example, a 2000 kg body moving at 20 m/s has a momentum of:

$p = 2000 \text{ kg} \times 20 \text{ m/s} = 40000 \text{ kg·m/s}$

Example: A 10 g bullet fired at 400 m/s has a momentum of:

$p = (10/1000) \text{ kg} \times 400 \text{ m/s} = 4 \text{ kg·m/s}$

When a moving body has a large mass or high velocity, it possesses a large momentum, making it difficult to stop. Conversely, a body with small mass or low velocity has a smaller momentum, making it easier to stop. Momentum plays a crucial role in understanding collisions and the conservation of momentum in isolated systems.

Mass and Weight

The mass of an object is the amount of matter in it, measured in kilograms (kg). Weight is the force with which an object is attracted towards the earth due to gravity and is given by:

Weight = mass × gravitational acceleration (g)

For example, the weight of a 1 kg object near the earth's surface ($g \approx 9.8 \text{ m/s}^2$) is:

$\text{Weight} = 1 \text{ kg} \times 9.8 \text{ m/s}^2 = 9.8 \text{ N}$

At higher altitudes or on the moon, the weight of an object decreases due to lower gravitational acceleration, while its mass remains constant. The weight of an object also varies with the location on Earth, being slightly less at the equator compared to the poles due to the Earth's rotation and its slightly oblate shape.

Experiments and Tests

To better understand these concepts, various experiments can be conducted:

1. Demonstrating Newton's First Law:

   - Place a book on a smooth surface and give it a push. Observe how it moves and eventually stops due to friction.

   - Repeat the experiment with the surface covered in talcum powder to reduce friction. Note the increased distance the book travels.

2. Verifying Newton's Second Law:

   - Use a trolley and rubber bands to apply different forces and measure the resulting acceleration.

   - Increase the mass of the trolley while keeping the force constant and observe the decrease in acceleration.

3. Observing Newton's Third Law:

   - Release a balloon filled with air and observe its movement in the opposite direction of the escaping air.

   - Conduct a similar experiment with a balloon attached to a straw on a string, allowing it to move along the string when released.

4. Calculating Momentum:

   - Measure the mass and velocity of various objects and calculate their momentum.

- Compare the momentum of objects with different masses and velocities to understand the relationship between these variables.

5. Investigating Mass and Weight:

- Use a spring scale to measure the weight of objects at different locations and compare the results.
- Conduct experiments to measure the weight of objects on an inclined plane and calculate the effective gravitational force acting on them.

Exercises:

1. Fill in the blanks in the table given below.

Force (N)	Mass (kg)	Acceleration (m/s^2)
...	3 kg	2 m/s^2
40 N	10 kg	...
30 N	...	1.5 m/s^2
2 N	500 kg	...

2. (a) A force of 6 N is applied to a 4 kg body moving at a uniform velocity. Find the acceleration.

   (b) If the force is applied in the opposite direction, find the deceleration.

3. State Newton's first law and explain why passengers in a moving bus are thrust forward when brakes are suddenly applied.

4. State Newton's second law and calculate the resulting acceleration for a 12 kg body with a 6 N force applied.

5. Explain Newton's third law with three practical examples.

6. Calculate the momentum of a 10 kg object moving at 4 m/s.

7. A 750 g object moving at 8 m/s has what momentum?

8. An object with a momentum of 6 kg·m/s and a velocity of 3 m/s has what mass?

9. (a) The mass of an object is 60 kg. What is its weight on Earth? ($g = 10\ m/s^2$)

(b) If the gravitational acceleration on the moon is 1/6th that of Earth, what would be its weight on the moon?

10. An object with a weight of 5 N and a momentum of 6 kg·m/s decreases its velocity to 4 m/s over 4 seconds due to an opposing force. What is the force exerted on the object?

Summary:

- According to Newton's first law, a stationary body remains at rest and a moving body continues its motion at a uniform velocity until an unbalanced force acts on it.

- Newton's second law states that the acceleration of a body is directly proportional to the force acting on it and inversely proportional to its mass.

- Newton's third law states that for every action, there is an equal and opposite reaction.

- The weight of an object is the force with which it is attracted to the center of the Earth and is equal to the force required to accelerate it with gravitational acceleration (g).

Technical terms:

- Force: A push or pull exerted on an object.

- Unbalanced Force: A force that is not opposed by an equal and opposite force, causing a change in motion.

- Uniform acceleration: Constant acceleration.

- Uniform velocity: Constant velocity.

- Mass: The amount of matter in an object.

- Acceleration: The rate of change of velocity.

- Action: The force exerted by one object on another.

- Reaction: The force exerted by the second object back on the first object.

- Momentum: The quantity of motion of a moving body, measured as a product of its mass and velocity.

Friction

Nature of Friction

If we place an object such as a pencil on a table and tap on it so that it starts to move on the table, we know from experience that its speed would gradually decrease until it ultimately comes to rest. If we place the same object on a surface smoother than that of the table, the object would move a longer distance on the surface before coming to rest.

An object moving on a surface gradually slows down and comes to rest as described above because the surface exerts a force on the object to oppose its motion. This opposing force is known as a frictional force. Friction always opposes the motion of an object.

Consider a situation where a table needs to be pushed along a horizontal floor. If we try to move the table with a very small force, it might not move. This is because the floor exerts a force on the table which opposes the force that we apply. The two forces have equal magnitudes but opposite directions, so they cancel out.

Now suppose that we slightly increase the force that we apply on the table. If the table still does not start to move, it means that the frictional force exerted by the floor has automatically increased to balance the force that we applied. The frictional force is a force that automatically adjusts to balance the force we apply. However, if we keep on increasing the force on the table, at some point, the table will begin to move. This happens because the frictional force cannot automatically adjust beyond a certain limit. When the force that we apply exceeds that limit, an unbalanced force equal to the difference between the two opposite forces remains. This unbalanced force starts the motion of the table.

The forces that act between the surfaces of two objects in contact with each other, to oppose the relative motion when the objects are moving relative to each other or to oppose the tendency to move when the objects have a tendency to move relative to each other, are called frictional forces.

Frictional forces exist in the motion of liquids and gases too; however, in this lesson, we discuss only the frictional forces that act between solid bodies.

Static, Limiting, and Dynamic Frictional Forces

Frictional forces can be divided into three categories, depending on the situations they act on a body:

1. The frictional forces that act when there is no relative motion, even though a force is applied on the body.

2. The frictional forces that act on a body as it just begins to move. This force includes the small additional force necessary to give it velocity.

3. The frictional forces that act on bodies when they are in relative motion.

To investigate differences among the three types of frictional forces mentioned above, let us do the following activity.

Activity 1

Items required: A block of wood weighing 60 N, a Newton balance

Procedure:

- Fix a small ring to the block of wood and attach the balance to the ring.

- Place the block of wood on a horizontal table and pull the block with a very small force. Initially, the force would be insufficient to move the block.

- Gradually increase the force on the object. When the force is gradually increased, at some point it will just begin to move. Find the force at the moment it is just about to move.

The body begins to move because the table surface is not capable of further increasing the frictional force in order to balance the force that you exerted. In other words, the frictional force does not exceed that force. The maximum frictional force exerted by the surface of the table to oppose the motion is equal to the force necessary to just start the motion.

Whenever the force applied on the body is smaller than this maximum frictional force, the surface of the table exerts a frictional force on the body that is equal and opposite to the applied force. This frictional force exerted on the body before the motion starts is called static friction.

When the applied force is gradually increased, the static friction acting on the body also increases with it. However, the static frictional force can increase only up to a certain maximum value. When the applied force exceeds this maximum value, the frictional force is incapable of increasing further in order to keep the body in equilibrium. Therefore, the body begins to move and acquires a small velocity. This maximum frictional force between the surfaces of two bodies in contact with one another is known as the limiting frictional force between the two bodies.

The frictional force acting on the body after the body starts to move is known as dynamic friction between the two surfaces. In other words, dynamic friction is the frictional force acting on bodies that are in motion. Dynamic friction is slightly less than the limiting frictional force.

Factors Affecting the Limiting Frictional Force

Frictional forces act between objects that are in contact with one another. Therefore, let us now investigate how the frictional forces depend on the nature and area of contact surfaces and the reaction forces perpendicular to the contact surfaces (normal reaction).

Activity 2

Items required: A block of wood weighing 60 N, a Newton balance, several sheets of sandpaper of various roughness

Procedure:

- Fix the block of wood with the sandpaper having the lowest roughness with the rough side facing out and completely covering the bottom surface.

- Place the block of wood on the table so that the rough surface of the sandpaper is in contact with the surface of the table. Next, pull the Newton balance attached to the block with a very small horizontal force at first and then increase the force gradually.

- When the block of wood just begins to move, record the reading of the Newton balance. This is the limiting frictional force.

- Next, use a sandpaper that is rougher than the first and fix it again to cover the bottom surface of the block, and find the limiting frictional force that is just enough to set the block of wood in motion.

- Repeat the above procedure using several sandpapers of increasing roughness and record the limiting frictional force each time.

Compare the results you obtained. You will observe that the limiting frictional force increases gradually with the increasing roughness of the sandpaper used to cover the block of wood. This activity shows that the limiting frictional force depends on the nature of the surfaces in contact.

Activity 3

Items required: A block of wood with a weight of 60 N and different dimensions for length, width, and height, a Newton balance, several pieces of sandpaper of equal roughness

Procedure:

- Paste the sandpaper on the surfaces of the block of wood which have different areas.

- Next, place the surface with the largest area in contact with the table top and find the force that is just enough to move the block (the limiting frictional force) as before.

- Repeat the above step, placing different surfaces of the block in contact with the table to find the limiting frictional force corresponding to each surface.

You will find that the limiting frictional force is the same for all surfaces of the block of wood in contact with the table. This shows that the limiting frictional force does not depend on the surface area.

Our next activity is the investigation of the dependence of the normal reaction between bodies in contact on the limiting frictional force.

Activity 4

Items required: Three blocks of wood each having a weight of 20 N, a Newton balance

Procedure:

- Place one block of wood on the table and find the force required to just move the block. That is the limiting frictional force.

- Next, place another block of wood on the first one and find the limiting frictional force as before.

- Repeat the above step with the third block placed on the other two and record the limiting frictional force.

You will notice that the readings obtained for different weights are not the same and that the limiting frictional force increases with increasing weights. When the weight (W) is increased, the normal reaction exerted on the weight by the table (perpendicular reaction force R) also increases. This activity shows that the limiting frictional force increases when the normal reaction between the two forces increases.

The above activities show that the limiting frictional force depends on the nature of the contact surfaces and the normal reaction between the surfaces while it does not depend on the area of the contact surfaces.

Practical Applications of Friction

Various parts of most of the machines and instruments that we use daily are in contact with other parts. When we operate these machines and instruments, these parts slide on one another, giving rise to frictional forces. Therefore, when machines are operated, an excessive amount of additional work has to be done against frictional forces, causing a loss of energy. This loss of energy appears as heat, raising the temperature of the object. If we could reduce frictional forces, then we would be able to minimize the energy loss and the rise in temperature.

Methods of Reducing Friction

- Reducing the roughness of contact surfaces or polishing them.

- Applying lubricators such as graphite, lubrication oil, or grease between the contact surfaces.

- Inserting balls that could roll between the contact surfaces. Such balls can prevent the two contact surfaces from sliding on each other. Ball bearings used to connect most of the rotating parts of vehicles and machines to stationary parts such as axles are fabricated in this manner.

Advantages of Frictional Forces

So far, we have discussed only some disadvantages of frictional forces and how to minimize them. Sometimes friction is useful to us. A few such examples are given below.

- We can walk on a surface only because of the frictional force exerted by that surface on our feet prevents slipping. If we try to walk on a wet surface or an oily surface, we tend to slip and fall due to a lack of friction.

- Grooves are etched on the surface of tires to increase the friction between the tire and the road surface. If a sufficient amount of friction is not exerted on the tire, the wheels would tend to skid on the road, causing accidents. Sometimes, when a motor vehicle is traveling on mud or sand, the wheels tend to rotate in the same place without moving forward because the friction is insufficient for the wheels to move forward. On wet roads, a water layer that exists between the road and the tire tends to reduce the friction between the two surfaces causing the vehicles to skid. The purpose of having grooves on the surface of tires is to allow water to pass through these grooves.

- Coir ropes are formed by twisting a large number of coir fibers together. Even when a large force is applied to a rope, the fibers do not separate because of the friction among them. It is easier to untie a knot made with a nylon string than a knot made with a coir string. This is because the frictional forces among the coir fibers are stronger than those among the nylon fibers.

- Moving vehicles can be brought to rest by applying brakes because of friction. The brakes of a bicycle operate by pressing the brake-pads made of rubber on the wheel rim. The bicycle stops because of the friction between the surfaces of the rubber brake-pads and the wheels.

- In modern motor vehicles, disc-brakes are used to stop the vehicle. In such systems, the frictional forces caused by pressing the brake-pads against a disc attached to the wheel are used to stop the wheels from rotating.

Exercises

1. Briefly state what is meant by friction.
2. Briefly explain what is meant by static friction.
3. Briefly explain what is meant by limiting friction.
4. Under what circumstances does dynamic friction act?
5. What are the two main factors that limiting friction depends on?
6. State a factor on which friction does not depend?
7. Give two benefits of friction.
8. Give two disadvantages of friction.
9. Explain why it is dangerous to drive vehicles with tires that have worn out grooves on rainy days.
10. Write down two methods used to reduce friction.

Summary

- When one of two bodies in contact with one another moves or tries to move relative to the other, the second body exerts a force that tends to stop this relative motion. This phenomenon is known as friction.
- The frictional force that acts before the body begins to move is the static friction. Static friction between the bodies varies with the external force that tries to cause the relative motion.
- The frictional force that acts when the relative motion between the two bodies just starts is called limiting friction.
- Limiting friction between two bodies depends on the nature of the contact surfaces and the normal reaction.
- Limiting friction does not depend on the surface areas of the contact surfaces.

- The frictional force acting on a moving body is the dynamic friction.

Technical Terms

- Friction: A force that opposes the relative motion of two surfaces in contact.
- Static Friction: The frictional force that acts on a body when there is no relative motion.
- Limiting Friction: The maximum frictional force that can act between two surfaces before motion starts.
- Dynamic Friction: The frictional force acting on a body that is in motion.
- Weight: The force with which an object is attracted towards the Earth.
- Normal Reaction: The perpendicular reaction force exerted by a surface on an object in contact with it.

Basic Unit of Life

In 1665, Robert Hooke observed a section of a cork using a microscope prepared by him. He discovered a structure like chambers in a beehive and named them cells.

Schleiden, Schwann, and Radolf Virchow introduced the cell theory, based on observations of different live tissues through a microscope. The cell theory states:

- The structural and functional unit of life is the cell.
- All organisms are made up of one or more cells.
- New cells are formed from pre-existing cells.

Concept of the Cell

The cell is the smallest structural unit of the organization of the living body. Organisms composed of a single cell are called unicellular organisms, while those with many cells are called multicellular organisms. Cells perform various functions in the body. For example, the transportation of oxygen is done by red blood cells, and the transmission of impulses is done by neurons. Thus, the cell is adapted to perform specific functions, making it the structural and functional unit of life.

Cells differ in shape, size, and function. Most cells are not visible to the naked eye and require a light microscope to be observed.

Structure of Cells

To study the structure of animal and plant cells, we can observe cheek cells and onion epidermal cells, respectively.

Study of Animal Cells (Cheek Cells)

Materials Required: Sample of cheek cells, glass slide, cover slip, microscope, water.

Method:

1. Wash the mouth and scrape the inner side of the cheek using a yogurt spoon.

2. Transfer the specimen to a clean glass slide with a drop of water and cover it with a cover slip without trapping air bubbles.

3. Observe the specimen through a light microscope.

Study of Plant Cells (Onion Peel Cells)

Materials Required: Onion peel, watch glass, glass slide, cover slip, paint brush, microscope, water.

Method:

1. Cut an onion and obtain an inner fleshy tissue.

2. Remove a peel from the inner or outer surface and transfer it to a watch glass containing water.

3. Transfer the specimen to a clean glass slide with a drop of water using a paint brush and cover it with a cover slip without trapping air bubbles.

4. Observe the specimen through a microscope.

Typical Cell

The small structures within the cell that perform different functions are known as organelles. The types and numbers of organelles vary according to the cell's function. A cell prepared with all organelles is known as a typical cell. Such cells do not exist in living organisms, but cells with some organelles of the typical cell can be found.

Animal cells are covered by a plasma membrane or cell membrane, a live semi-permeable and selective membrane. The cytoplasm is a gelatinous material, and the nucleus is centralized. The outer covering of the plant cell is the cell wall made of cellulose, with a large vacuole at the center. Generally, animal cells do not have vacuoles. Organelles in plant and animal cells perform various functions and are often observed using an electron microscope.

Typical Plant Cell

Ribosome, rough endoplasmic reticulum, mitochondrion, cell wall, cell sap, tonoplast, Golgi complex, plasma membrane, nuclear envelope, nucleus, nucleolus, vacuole, chloroplast.

Typical Animal Cell

Ribosome, smooth endoplasmic reticulum, rough endoplasmic reticulum, mitochondrion, centriole, Golgi complex, cytoplasm, plasma membrane, nuclear envelope, nucleolus, nucleus.

Differences Between Animal and Plant Cells

- Animal cells do not have a cell wall; plant cells have a cell wall.

- Animal cells have a large content of cytoplasm; plant cell cytoplasm is pushed towards the periphery.

- Animal cells do not have a large vacuole (sometimes a few small vacuoles may be present); plant cells have a large central vacuole or a few vacuoles.

- Animal cells do not have chloroplasts; plant cells have chloroplasts.

Cell Organelles and Structures

Cell Wall: The outermost covering of the plant cell, made of cellulose. Functions: maintain cell shape, support, and protection.

Plasma Membrane: Present inside the cell wall of plant cells and as the boundary of animal cells. Made of phospholipids and proteins. Functions: encloses the cell, controls entry and exit of materials.

Cytoplasm: The gelatinous part of the cell excluding organelles. Contains inorganic and organic substances. Functions: maintains cell shape, supports organelles, and conducts metabolic processes.

Nucleus: The main organelle in a cell, surrounded by a nuclear envelope, containing nucleolus and chromatin body. Chromosomes store genetic material and transfer inherited characters. Functions: control life activities of the cell.

Mitochondrion: Oval or rod-shaped, membrane-bounded organelle. Aerobic respiratory reactions take place here, releasing energy. Known as the powerhouse of the cell. Functions: energy production for metabolic activities.

Golgi Complex: Membrane-bounded sacs with secretory vesicles. Functions: production, packaging, and secretion of substances.

Ribosome: Small organelles without a membrane, made of large and small subunits. Functions: site for protein synthesis.

Endoplasmic Reticulum: Intermembranous network of flat or tubular sacs. Two types: rough (with ribosomes) and smooth (without ribosomes). Functions: protein transportation (rough), lipid and steroid synthesis, and transport (smooth).

Vacuole: Fluid-filled large organelle in plant cells, surrounded by tonoplast. Contains cell sap with water, sugar, ions, and pigments. Functions: maintain water balance, support, and color provision.

Cell Growth and Division

Cell Growth: The irreversible increase in size or dry mass of a cell. Cells have a maximum growth limit, after which they divide.

Cell Division: Process by which new cells are formed. Two types: mitosis and meiosis.

Mitosis: Division maintaining constant chromosome number. Produces two identical daughter cells. Functions: growth, asexual reproduction, wound healing, and cell replacement.

Meiosis: Division reducing chromosome number by half, occurring during gamete formation. Produces four daughter cells. Functions: maintain constant chromosome number, variation and evolution.

Differences Between Mitosis and Meiosis

- Meiosis involves two divisions; mitosis involves one division.

- Meiosis occurs only in diploid cells; mitosis occurs in both diploid and haploid cells.

- Meiosis results in variation and changes in chromosomes; mitosis results in no variation, with rare chromosome changes.

- Meiosis produces four daughter cells; mitosis produces two daughter cells.

- Meiosis results in daughter cells with half the chromosomes of the mother cell; mitosis results in daughter cells with the same number of chromosomes as the mother cell.

- Meiosis results in daughter cells different from the mother cell; mitosis results in daughter cells similar to the mother cell.

Summary

- The basic structural unit of organisms is the cell.

- Cells are the structural and functional units of life.

- New cells are formed from pre-existing cells.

- Different organelles in the cell perform various functions.

- Animal cells are surrounded by plasma membranes with the nucleus generally at the center and various organelles in the cytoplasm.

- Plant cells have additional structures like cell walls, chloroplasts, and large central vacuoles.

- Chromosomes in the nucleus carry genetic information.

- Cell growth involves an irreversible increase in size or dry mass.

- Cell division occurs through mitosis or meiosis.

Exercises

1. Name structures and organelles in the provided cell diagrams.

2. Differentiate between a plant cell and an animal cell.

3. Mention the functions of the following organelles:

   - Mitochondrion

   - Golgi complex

   - Rough endoplasmic reticulum

   - Vacuole

4. Explain the importance of meiosis.

Technical Terms

- Typical cell: An idealized cell with all organelles.

- Organelle: Specialized structures within a cell.

- Chromosomal number: The number of chromosomes in a cell.

- Cell division: The process by which a cell divides into two or more cells.

- Mitosis: Cell division resulting in two identical daughter cells.

- Meiosis: Cell division reducing the chromosome number by half.

Quantification of Elements and Compounds

To measure the mass of items like a motor car, a brick, a loaf of bread, a teaspoon of sugar, and a tablet of medicine, units like kilogram, gram, and milligram can be used. However, for very small particles such as a carbon dioxide molecule or a helium atom, these units are impractically small. For example, the mass of a hydrogen (H) atom is 1.674×10^{-24} g, which is exceedingly tiny.

Masses of some atoms are:

- Mass of a carbon (C) atom: 1.993×10^{-23} g
- Mass of a sodium (Na) atom: 3.819×10^{-23} g
- Mass of a chlorine (Cl) atom: 5.903×10^{-23} g
- Mass of a potassium (K) atom: 6.476×10^{-23} g

Due to the cumbersome nature of these figures, the mass of a selected atom is taken as a unit, and the masses of other atoms are given relative to it. This is known as the relative atomic mass, which is not the true mass of an atom of an element. Historically, the hydrogen atom's mass was used as the atomic mass unit, but currently, 1/12th the mass of the ^{12}C isotope is used.

The relative atomic mass (Ar) is defined as:

Ar = (Mass of an atom of the element) / (1/12 x Mass of a ^{12}C atom)

For instance, the true mass of an oxygen atom (O) is 2.66×10^{-23} g, and the true mass of a ^{12}C atom is 1.99×10^{-23} g. Therefore, the relative atomic mass of oxygen is:

Ar = (Mass of an oxygen atom) / (1/12 x Mass of a ^{12}C atom)

The relative atomic mass of some elements includes:

- Hydrogen (H): 1
- Helium (He): 4

- Lithium (Li): 7
- Beryllium (Be): 9
- Boron (B): 11
- Carbon (C): 12
- Nitrogen (N): 14
- Oxygen (O): 16
- Fluorine (F): 19
- Neon (Ne): 20
- Sodium (Na): 23
- Magnesium (Mg): 24
- Aluminium (Al): 27
- Silicon (Si): 28
- Phosphorus (P): 31
- Sulphur (S): 32
- Chlorine (Cl): 35.5
- Argon (Ar): 40
- Potassium (K): 39
- Calcium (Ca): 40

Example Problems:

1. The mass of a potassium (K) atom is 6.476×10^{-23} g, and the mass of a ^{12}C atom is 1.99×10^{-23} g. Find the relative atomic mass of potassium:

Ar = (Mass of potassium atom) / (1/12 x Mass of a ^{12}C atom) = 39

2. The mass of an atom of element A is eight times the mass of a ^{12}C isotope. Find the relative atomic mass of A:

Ar = 8 x 12 = 96

3. The mass of a sodium atom is 3.819×10^{-23} g, and the atomic mass unit is 1.67×10^{-24} g. Find the relative atomic mass of sodium:

Ar = (Mass of sodium atom) / (atomic mass unit)

Relative Molecular Mass (Mr):

Many elements exist naturally as molecules rather than free atoms. The relative molecular mass of an element or compound is the mass of a given molecule relative to 1/12th the mass of a ^{12}C isotope.

Example:

- The true mass of a carbon dioxide (CO_2) molecule is 7.31×10^{-23} g. The relative molecular mass is calculated as:

Mr = (Mass of a CO_2 molecule) / (1/12 x Mass of a ^{12}C atom) = 44

- The mass of a water molecule (H_2O) is 2.99×10^{-23} g. The relative molecular mass is:

Mr = (Mass of a H_2O molecule) / (1/12 x Mass of a ^{12}C atom) = 18

Relative molecular masses of some elements and compounds:

- Hydrogen (H_2): 2

- Nitrogen (N_2): 28

- Oxygen (O_2): 32

- Carbon dioxide (CO_2): 44

- Glucose ($C_6H_{12}O_6$): 180

Calculate the relative molecular mass of the following compounds:

1. Ammonia (NH_3), with H = 1 and N = 14

2. Sulphuric acid (H_2SO_4), with H = 1, O = 16, S = 32

3. Sucrose ($C_{12}H_{22}O_{11}$), with H = 1, C = 12, O = 16

Ionic compounds like sodium chloride (NaCl) exist as lattices rather than molecules. The formula is written to indicate the simplest ratio of Na^+ and Cl^- ions. The relative formula mass or formula mass is calculated for such compounds.

Relative formula mass of sodium chloride (NaCl):

- Na = 23, Cl = 35.5

- Formula mass = 23 + 35.5 = 58.5

Calculate the relative formula mass of the following compounds:

1. Magnesium oxide (MgO), with O = 16, Mg = 24

2. Calcium carbonate ($CaCO_3$), with C = 12, O = 16, Ca = 40

3. Potassium sulphate (K_2SO_4), with O = 16, S = 32, K = 39

Avogadro Constant:

When a mass of any element equal to its relative atomic mass is taken in grams, it contains the same number of atoms irrespective of the element. This constant number is called the Avogadro Constant, symbolized as L, and is approximately 6.022×10^{23}.

Mole:

In the SI unit system, the unit used to measure the amount of a substance is the mole. A mole of any substance contains as many basic building units (atoms, molecules, ions) as there are atoms in exactly 12.00 g of the ^{12}C isotope. The number of units in a mole is equal to the Avogadro constant, 6.022×10^{23}.

Example:

- Relative atomic mass of sodium (Na) = 23

- 1 mol of sodium atoms = 23 g of sodium

- Relative molecular mass of glucose ($C_6H_{12}O_6$) = 180

- 1 mol of glucose molecules = 180 g of glucose

Molar Mass:

The molar mass is the mass of a mole of any substance. Although relative atomic mass and relative molecular mass have no units, molar mass is expressed in grams per mole (g/mol) or kilograms per mole (kg/mol).

Examples:

1. Relative atomic mass of sodium (Na) = 23

   - Molar mass of sodium = 23 g/mol

2. Relative molecular mass of carbon dioxide (CO_2) = 44

   - Molar mass of carbon dioxide = 44 g/mol

3. Relative formula mass of sodium chloride (NaCl) = 58.5

   - Molar mass of sodium chloride = 58.5 g/mol

4. Relative formula mass of calcium carbonate ($CaCO_3$) = 100

   - Molar mass of calcium carbonate = 100 g/mol

The relationship to find the amount of a given substance (number of moles) is:

Amount of substance (n) = Mass of the substance (m) / Molar mass of the substance (M)

Example Problems:

1. Find the number of atoms in 4 mol of carbon.

   - Number of atoms in 1 mol of carbon = 6.022×10^{23}

   - Number of atoms in 4 mol of carbon = $6.022 \times 10^{23} \times 4 = 2.409 \times 10^{24}$

2. For 5 mol of carbon dioxide (CO_2):

- Number of CO_2 molecules in 1 mol = 6.022×10^{23}
- Number of CO_2 molecules in 5 mol = $6.022 \times 10^{23} \times 5 = 3.011 \times 10^{24}$
- Total number of atoms in 5 mol of CO_2 = $3.011 \times 10^{24} \times 3 = 9.033 \times 10^{24}$
- Number of oxygen atoms in 5 mol of CO_2 = $3.011 \times 10^{24} \times 2 = 6.022 \times 10^{24}$

3. Molar mass of carbon is 12 g/mol. Find the amount of carbon in 10 g of carbon.

- Amount of carbon in 12 g = 1 mol
- Amount of carbon in 10 g = 1 mol x 10 g / 12 g = 0.83 mol

4. Find the number of molecules in 0.1 mol of carbon dioxide.

- Number of molecules in 1 mol of CO_2 = 6.022×10^{23}
- Number of molecules in 0.1 mol = $6.022 \times 10^{23} \times 0.1 = 6.022 \times 10^{22}$

5. Relative molecular mass of oxygen (O_2) is 32. Find the number of oxygen molecules in 10 g of oxygen.

- Number of molecules in 32 g of oxygen = 6.022×10^{23}
- Number of molecules in 10 g = $6.022 \times 10^{23} \times 10$ g / 32 g = 1.88×10^{23}

6. Molar mass of water is 18 g/mol. Find the amount of water in 20 g of water.

- Amount of water in 18 g = 1 mol
- Amount of water in 20 g = 1 mol x 20 g / 18 g = 1.11 mol

7. Calculate the amount of carbon dioxide in 22 g of carbon dioxide (Molar mass of CO_2 is 44 g/mol).

- Amount of CO_2 in 44 g = 1 mol

- Amount of CO_2 in 22 g = 1 mol x 22 g / 44 g = 0.5 mol

8. Calculate the amount of carbon in 24 g of carbon (Molar mass of carbon is 12 g/mol).

- Amount of carbon in 12 g = 1 mol
- Amount of carbon in 24 g = 1 mol x 24 g / 12 g = 2 mol

Exercises:

1. Find the relative molecular mass of the following substances:

- CH_3OH (Methyl alcohol / Methanol)
- CS_2 (Carbon disulphide)
- C_8H_{18} (Octane)
- CH_3COOH (Acetic acid)
- $C_{12}H_{22}O_{11}$ (Sucrose)
- $CO(NH_2)_2$ (Urea)
- $C_9H_8O_4$ (Aspirin)
- HNO_3 (Nitric acid)
- CCl_4 (Carbon tetrachloride)
- $C_8H_9NO_2$ (Paracetamol)
- Relative atomic masses: H = 1, C = 12, N = 14, O = 16, S = 32, Cl = 35.5

2. Find the molar mass of the following compounds:

- CO_2 (Carbon dioxide)
- NaCl (Sodium chloride)
- $CaCO_3$ (Calcium carbonate)
- NH_4Cl (Ammonium chloride)

- Mg_3N_2 (Magnesium nitride)

- H_2S (Hydrogen sulphide)

- $AlCl_3$ (Aluminium chloride)

- $(NH_4)_2CO_3$ (Ammonium carbonate)

- $CuSO_4$ (Copper sulphate)

- $Na_2C_2O_4$ (Sodium oxalate)

- Relative atomic masses: H = 1, C = 12, N = 14, O = 16, Na = 23, Mg = 24, Al = 27, S = 32, Cl = 35.5, Ca = 40, Cu = 63.5

3. Solve the following:

- Find the amount of substance in moles in 12 g of magnesium (Mg).

- Find the amount of substance in moles in 10 g of calcium carbonate ($CaCO_3$).

- Find the number of molecules in 5 mol of carbon dioxide (CO_2).

- Find the number of water molecules in 4 mol of water (H_2O).

- Find the mass of 2 mol of urea ($CO(NH_2)_2$).

4. How many moles of oxygen atoms (O) does one mole of each of the following compounds contain?

- Al_2O_3

- CO_2

- Cl_2O_7

- CH_3COOH

- $Ba_3(PO_4)_2$

Technical Terms:

- Atomic mass unit: The unit relative to which the masses of other atoms are expressed.

- Relative atomic mass: The mass of an atom of an element relative to 1/12 the mass of a ^{12}C atom.

- Relative molecular mass: The mass of a molecule relative to 1/12 the mass of a ^{12}C atom.

- Avogadro constant: The number of atoms or molecules in one mole of a substance, approximately 6.022×10^{23}.

- Mole: The amount of a substance that contains as many basic units (atoms, molecules, ions) as there are atoms in exactly 12.00 g of ^{12}C.

- Molar mass: The mass of a mole of any substance, expressed in g/mol or kg/mol.

Characteristics of Organisms

Recall all the information and experiences you have about organisms. Using that knowledge, carry out the following assignments.

Express your idea about the following instances and whether they are living or non-living:

1. Hen egg

2. A tissue obtained from an organism and stored under special preservation methods

3. A fossil about thousands of years old

Assignment 8.1

Discuss how the living characteristics you know can be applied to describe a hen egg. Even after a few weeks, if the egg is incubated, a chick with living features will be born. A tissue removed from an organism can be stored under special preservation methods for a longer time. Once it is integrated into another organism using appropriate techniques, it will show living characteristics. The DNA isolated from a thousand-year-old fossil can be used to obtain new organisms with old characteristics through gene technology.

By considering these facts, you can understand that only by observing the external features, one cannot confirm life.

List out the features that can be used to identify living from non-living.

Assignment 8.2

The features that you have listed are not always found in all living units. But all living units show one or a few living characteristics. You can study in future lessons that living and non-living cannot always be separated by a clear line in some instances.

The common characteristics of living organisms can be listed as:

- Cellular organization
- Nutrition
- Respiration
- Irritability and Coordination
- Excretion
- Movement
- Reproduction
- Growth and Development

Cellular Organization

The structure of a unicellular organism consists of cytoplasm and organelles enclosed by a plasma membrane. This unicellular unit is an organism that shows living characteristics. When a water sample from a pond or hay extraction is observed using a microscope, unicellular organisms can be observed easily.

In a unicellular organism, organelle level organization can be seen. The origin of a multicellular organism is from a single cell, the zygote, which is the product of the fertilization of an egg with a sperm. The development of an embryo in humans starts from the zygote.

The bodies of multicellular organisms are composed of different types of cells, each important in different functions. For example, root hair cells, phloem cells, xylem cells, stomatal pores, guard cells, stomatal openings, epidermal cells, palisade cells, and pollen grains in plants; and nerve cells, bone cells, white blood cells, red blood cells, muscle cells, gamete cells, and skin cells in humans.

A multicellular organism possesses tissue and system level organization. The organs of the organism are well developed and designed to carry out relevant functions, such as the tongue, eye, and heart.

Materials Required: Pond water sample or hay extraction, a light microscope, prepared slides of different cells.

Method:

1. Observe a water sample obtained from a pond or hay extraction under a light microscope. Identify microorganisms and illustrate them.

2. Observe the prepared slides of different cells in the laboratory and identify them.

The smallest structural and functional unit at living condition is the cell. A group of cells modified to perform a specific function is called a tissue. A collection of tissues forms an organ, a collection of organs forms a system, and systems collectively form an organism.

The process by which energy and materials are obtained for the maintenance of life is known as nutrition. Energy is needed for cell growth and to repair worn-out structures. This energy is obtained from nutrients. Organisms that produce their own food or nutrients are known as autotrophic organisms.

Autotrophism can be divided into two categories based on the type of energy they use for food production:

- Photoautotrophics use light energy.

- Chemoautotrophics use energy obtained by chemical reactions.

Most plants are photoautotrophic, and most bacteria are chemoautotrophic. The production of food inside the chloroplast of plant cells using chlorophyll is called photosynthesis.

Photosynthesis can be expressed by the following equation:

Carbon dioxide + Water → Glucose + Oxygen

$6CO2 + 6H2O \rightarrow C6H12O6 + 6O2$

The food produced in the leaves gets stored in stems, roots, and fruits. Animals are heterotrophic as they utilize food produced by plants or organic compounds with other living origins.

All organisms need energy for their metabolism. They obtain this energy by breaking down food inside the cell that they have produced or obtained by other means. The process by which stored food is transformed into energy inside the cells is known as cellular respiration. Cellular respiration is a series of biochemical reactions.

Using the following experiment, it can be shown that CO2 is released while O2 is absorbed during respiration.

Experiment to Show the Release of CO2 During Respiration

Materials Required: Limewater, KOH, water, five equal bottles with corks, L-shaped glass tubes, a frog, suction.

Method:

1. Arrange the apparatus as shown in the figure and remove water in bottle E.
2. When water is removed, an air flow occurs from bottle A to bottle E.
3. The limewater in bottle B does not change color as CO2 in the air entering through P dissolves in KOH in vessel A. However, after some time, the limewater in vessel D turns milky due to the CO2 released by the frog during respiration. A control experiment without a frog in vessel C can be used for comparison. This confirms that CO2 is released as a byproduct of respiration.

This experiment can be repeated using germinating green gram, paddy, maize, or bean seeds in vessel C instead of a frog.

Experiment to Show the Absorption of O2 During Respiration

Materials Required: Two conical flasks, glass tubes, rubber tubes, small test tube, two beakers, colored water, germinating seeds, KOH.

Method:

1. Close the flask with a cork lid connected to a rubber tube and a U tube as shown in the figure.

2. After some time, tighten the rubber tube and observe the water level in the U tube.

3. When the flasks are closed with cork lids, air inside is released through the rubber tube, and pressure comes to equilibrium. Then, rubber tubes are tightened to avoid gas exchange.

4. CO_2 released during respiration of seeds in apparatus A dissolves in KOH. O_2 in the flask is absorbed by the seeds for respiration. To fill that gap, air in the tube flows into the flask, drawing up the water column in the glass tube. This shows that O_2 is absorbed for respiration of organisms. No such change occurs in setup B as the absorbed volume of O_2 is equal to the released volume of CO_2.

Two assumptions are made in this experiment:

1. The volume of CO_2 in the flasks is negligible.

2. In respiration, the absorbed volume of O_2 is equal to the released volume of CO_2.

Observe the respiratory movements and associated movements of organisms such as a frog, tilapia, human, dog, and grasshopper, and write a report on your observations.

Organisms react according to changes in the environment. When there is a change in the internal or external environment, or a stimulus with a particular strength, organisms respond accordingly. A change strong enough to bring about a response is known as a stimulus. Stimuli are detected by organs such as eyes, ears, nose, tongue, and skin. The stimuli can be light, sound, chemicals, or mechanical/physical vibrations.

The reactions according to changes in the environment are known as responses. For example, the stimulus is the sound, and the response is closing the ears with hands. The ability to respond to stimuli received from the internal or external environment is known as irritability. The communication between different organs during response to a stimulus is known as coordination. Nerves, muscles, and hormones are important in coordination. Some insects fly towards light, while others fly towards darkness. Both animals and plants respond to stimuli.

Example: Leaves of Mimosa fold when touched, showing sensitivity to touch. Leaves of Thora, tamarind, and Sesbania fold at night, showing sensitivity to light.

All organisms obtain materials from the environment and transform them into beneficial forms of energy. At the same time, the materials that are not used and the waste materials produced during body processes are released to the environment. The sum of chemical and physiological activities within the cell, known as metabolic activities, includes building up and breaking down materials. Removal of waste products from the body produced during metabolism is known as excretion.

The main excretory materials of organisms are urea, salts, CO_2, and water. There are organ systems in the body for excretion. Nitrogenous excretion in humans mainly takes place through the kidneys. Plants release CO_2 during respiration and O_2 during photosynthesis through lenticels and stomata of the leaves.

Anabolism is the process of synthesis of complex compounds from simple compounds within the living body, storing energy. Catabolism is the process of breaking down complex compounds into simple compounds in the body, releasing energy. Metabolism is the summation of biochemical reactions taking place in the living body, including both anabolism and catabolism.

Organisms fulfill their requirements (food, protection, reproduction) with the help of movement. During this, the whole organism or a part of the organism moves. Unicellular organisms use cilia, flagella, or pseudopodia for movement. Multicellular organisms move their whole body or parts of the body with the help of muscles. Most of them possess organs for locomotion, such as fins, wings, and legs.

Organelles within the cell also have the ability to move. Movement is a characteristic of living organisms essential for their existence. For example, a potted plant grows towards light when placed near a window. The shoot apex grows towards light, and the root apex grows towards gravity. Organisms move in response to stimuli, which can include light, darkness, chemical substances, gravitational force, heat, temperature, and vibrations/touch.

Reproduction is essential for the continuation of a species. It can be sexual or asexual. Sexual reproduction involves the union of gametes (sperm and egg) of the same species to form a zygote, the first cell in producing a new organism. Asexual reproduction involves a single organism producing an identical new offspring without the contribution of another organism. For example, new plants can propagate by vegetative structures of plants.

Growth and Development

The life of multicellular plants or animals starts from a single cell. Tissues modified to perform specific functions arise from the division of the zygote, the result of sexual reproduction. In humans, the zygote develops into an embryo within the uterus and later transforms into an offspring.

Mainly, the increase in the number of cells by cell division contributes to the growth of a multicellular organism. The growth of a unicellular organism is considered an increase in size and volume of the cell, such as in Paramecium, yeast, and Chlamydomonas. Cell growth means the irreversible increase in the dry mass of the cell. Development refers to the increase in complexity of the cell. Growth and development can be expressed in three steps:

1. Irreversible increase in size of the cell
2. Increase in number of cells by cell division
3. Cell differentiation

An auxanometer can be used to show plant growth.

Observation of Plant Growth Using Auxanometer

Materials Required: A potted plant, an auxanometer.

Method:

1. Connect a thread to the shoot apex of a potted plant and send it through a pulley, hanging a weight onto it.

2. Observe how the indicator moves.

The plant grows very slowly, but the indicator shows it on a greater scale. This activity helps observe plant growth and development.

Summary

- Cellular organization, nutrition, respiration, irritability and coordination, excretion, movement, reproduction, and growth and development are characteristics of organisms.
- The basic organizational level of an organism is the cell. Multicellular organisms possess tissues, organs, and system level complex organization.
- The process of obtaining energy and material to maintain life is known as nutrition.
- Cellular respiration is the process by which the end products of digestion combine with oxygen to produce energy inside the cell.
- The ability to respond to changes in the external or internal environment is known as irritability. Adaptation of body functions according to these changes is known as coordination.
- Removal of waste products of metabolism from the body is termed excretion.
- Organisms move as a result of coordination.
- Production of a new generation for the continuation of the species is termed reproduction.
- Growth is the irreversible increase in the dry mass of a cell. During development, cells differentiate to perform specific functions.
- Virus is an acellular form that cannot be easily classified as living or non-living.
- All organisms contribute to maintaining and balancing the environment.

Exercises

1. Select the correct answer:

   - (01) Select the correct term for the gap: Cell, Tissue, System

1. Organism
2. Organ
3. Organelle
4. Structure

- (02) What process produces energy for cells?

  1. Nutrition
  2. Reproduction
  3. Excretion
  4. Respiration

- (03) Select the plant that is not photoautotrophic:

  1. Acalypha (Kuppamenia)
  2. Asparagus
  3. Loranthus
  4. Cuscuta

- (04) Which organ does not act as an excretory organ?

  1. Kidney
  2. Skin
  3. Stomach
  4. Lungs

- (05) Few statements about viruses are given below:

  - A. Virus is a species of organism

- B. Virus possesses DNA or RNA
- C. Virus multiplies only within living cells
- Correct statements are:
  1. A and B
  2. B and C
  3. C and A
  4. All of the above

- (06) What term explains all the biochemical reactions in the living body?
  1. Metabolism
  2. Coordination
  3. Respiration
  4. Growth

- (07) To which group of organisms does yeast belong?
  1. Bacteria
  2. Fungi
  3. Algae
  4. Protozoa

- (08) Select the most appropriate term to define a stimulus:
  1. Maintenance of a constant internal environment
  2. A change in internal and external environment
  3. A change in the external or internal environment strong enough to bring about a response
  4. Coordination between different organs during response

Technical Terms

- Cellular organization: The basic organizational level of an organism.

- Nutrition: The process by which organisms obtain energy and materials for maintenance of life.

- Respiration: The process by which cells produce energy from the end products of digestion and oxygen.

- Irritability: The ability to respond to changes in the environment.

- Coordination: The adaptation of body functions according to environmental changes.

- Excretion: Removal of waste products of metabolism from the body.

- Movement: The action of moving the whole organism or parts of the organism.

- Reproduction: Production of a new generation for the continuation of the species.

- Growth: The irreversible increase in dry mass of a cell.

- Development: The increase in complexity of a cell.

- Virus: An acellular form that can exhibit characteristics of both living and non-living entities.

Physics

Resultant Force

The resultant of several forces is the single force that gives the same result as all the individual contributing forces. For example, if a motor car is stalled on the road and one person tries to push it, the car might not move. When more people join in and push in the same direction, their forces add up, making it easier to move the car.

If many people take part in pushing the car instead of just one person, all the individual forces combine to form a larger force in the same direction and the task becomes easier.

When more than one force is applied, the single force that gives the same result as that of all the contributing forces is known as the resultant force of the individual contributing forces.

Forces applied on objects can have various directions. In this lesson, we will discuss:

1. The resultant of two collinear forces (forces having the same line of action)

2. The resultant of two parallel forces (forces having parallel but different lines of action)

Resultant of Two Collinear Forces

When pulling on fishing nets, the task can be accomplished more easily if a large group of people take part in pulling the net in the same direction. Because all the forces act in the same direction, the fishing net can be successfully pulled. Here, all the forces are applied in the same direction and along the same line.

Activity 1

Items required: A trolley, three Newton balances, two pulleys, a ring

Method:

1. Place the trolley on a table and fix the ring to one side of the trolley. Attach two strong strings to the ring as shown. Pass the two strings over the two pulleys and connect the two Newton balances B and C to the other ends of the strings. Fix the other end of the trolley to a wall through the third Newton balance A.

2. Apply two forces from the two Newton balances B and C and record the readings.

3. Record the reading of the balance A.

4. Find a relationship between the reading on balance A and the readings recorded from B and C balances.

5. Apply different forces from B and C, repeat the activity several times, and find the relationship between the measurements.

Observation:

You will observe that the sum of the readings of B and C is equal to the reading of A. When two collinear forces act along the same direction, the resultant of the two forces is equal to the sum of the two individual forces with a direction in the direction of forces.

Example 1:

Two children are pulling a thread connected to a box placed on a table in the same direction. The force applied by one child is 8 N while that of the other child is 6 N. The resultant force with which the children are pulling the box is:

8 N + 6 N = 14 N

Exercise 9.1:

1. A child is pushing an object placed on a table with a force of 5 N in a certain direction while another child is pulling it in the same direction with a force of 7 N. What is the resultant of these two forces?

5 N + 7 N = 12 N

Resultant of Two Collinear Forces Acting Along Opposite Directions:

In the national sport of pulling ropes, participants form two groups and pull a rope in two directions. The rope will be dragged in the direction of the resultant force, which lies in the direction of the larger force.

When forces are applied in various directions, non-utilization of the forces productively occurs. A large net force can only be obtained if all the contributing forces are applied in the same direction.

Activity 2

Items required: A trolley, two Newton balances, two smooth pulleys, measuring weights

Method:

1. Place the trolley on a table and fix two pieces of string to the two ends of the trolley. Allow the other ends of the pieces of string to pass over the two pulleys and attach two Newton balances A and B.

2. Apply a 4 N force on each balance and record your observations on the motion of the trolley.

3. Apply a 4 N force on balance A and a 6 N force on balance B and record your observations.

4. Apply a 6 N force on balance B and a 6 N force on balance A and record your observations.

Observation:

The trolley does not move when equal forces are applied in opposite directions. When unequal forces are applied, the trolley moves in the direction of the larger force. The resultant force is the difference between the two forces, with a direction in the direction of the larger force.

Example 2:

A force of 5 N pulls an object in one direction while a force of 2 N pulls it in the opposite direction. The resultant force is:

5 N - 2 N = 3 N

The object will be pulled by a force of 3 N in the direction of the 5 N force.

Exercise 9.2:

1. Two children apply forces to push a box on a horizontal plane. One applies 10 N to the west, and the other applies 5 N to the east. What is the resultant force?

10 N - 5 N = 5 N to the west.

Resultant of Two Parallel Forces:

When two parallel forces are applied, they can be in the same or opposite directions.

Activity 3

Items required: A strip of wood with three holes drilled, three Newton balances

Method:

1. Drill three holes X, Y, and Z on the strip of wood and attach the three Newton balances A, B, and C.

2. Pull the three balances keeping the strip of wood in a rest position.

3. When the strip of wood is at rest, you will observe that the sum of the readings of A and B is equal to that of the balance C.

Observation:

The resultant of two parallel forces acting along the same direction is the sum of the two forces.

Example 3:

Two strong strings attached to a trolley are pulled by forces of 8 N and 16 N, keeping the two strings parallel. The resultant force is:

8 N + 16 N = 24 N

Exercise 9.3:

1. A trolley on a table is pulled by two strings parallel to each other. The resultant force is 20 N. The force on string A is 12 N. Find the force exerted by string B.

20 N - 12 N = 8 N

Resultant of Two Inclined Forces:

When two forces act with their lines of action inclined to one another, the direction of motion of the object lies in a direction between the two forces.

Summary:

- The single force acting in place of many forces is known as the resultant force.
- The magnitude of the resultant of two forces acting in the same direction is the sum of the two forces. The direction of the resultant is the direction of the individual forces.
- If two collinear forces act in opposite directions, the resultant is the difference between the two forces and acts in the direction of the larger force.
- The resultant of two inclined forces acts in a direction between the two forces.

Technical Terms:

- Resultant force: The single force that gives the same result as multiple forces.
- Newton balance: A device used to measure force.
- Unbalanced force: A force that is not counteracted by another force, causing motion.
- Opposite direction: Forces acting in reverse directions.

Chemical Bonds

The English alphabet contains 26 letters. Yet, the combination of them forms a large number of words. Similarly, there is only a limited number of elements, but millions of compounds are formed by their chemical combination. Though most elements form chemical compounds, some elements, such as helium, neon, and argon, do not form compounds under normal conditions. These elements, occurring as single atoms in nature, exist as gases and are known as noble gases.

The reason why many elements form compounds but not the noble gases can be explained by the electronic configuration of elements.

The electronic configurations of some elements are as follows:

- Neon (Ne): 2, 8
- Argon (Ar): 2, 8, 8
- Sodium (Na): 2, 8, 1
- Chlorine (Cl): 2, 8, 7

The outermost shell carrying electrons in an atom of an element is known as its valence shell. The valence shells of neon and argon atoms have eight electrons each, which is a stable electronic configuration. Because of this stable configuration, their reactivity is very low, and they are referred to as noble gases. However, the state of sodium and chlorine atoms is different. To achieve a stable noble gas configuration, a sodium atom must either lose one electron in the last shell or gain seven electrons, while a chlorine atom must receive one electron or lose seven electrons. The electrons in the valence shells of these elements reorganize to acquire a stable electronic configuration, involving loss, gain, or sharing of electrons.

The attractive forces or binding among the atoms or ions resulting from the rearrangement of electrons in the valence shell for stabilizing the atoms of elements are called chemical bonds. Chemical bonds can be divided into two types based on the behavior of the participating atoms when they chemically bind together:

1. Ionic bonds

2. Covalent bonds

Ionic Bonds

The electronic configuration of the sodium atom is 2, 8, 1. Sodium is an element with low electronegativity. An atom of sodium is electrically neutral because the number of protons equals the number of electrons.

When a sodium atom loses its outermost electron, it becomes a sodium ion (Na^+) with a charge of +1. An ion is an atom or group of atoms with an electrical charge. Since this ion has a positive charge, it is called a positive ion or cation. The chemical properties of an ion differ from those of an atom.

Sodium atom:

- Number of electrons: 11
- Electronic configuration: 2, 8, 1
- Number of protons: 11
- Total charge: 0

Sodium ion (Na^+):

- Number of electrons: 10
- Electronic configuration: 2, 8
- Number of protons: 11
- Total charge: +1

The electronic configuration of the chlorine atom is 2, 8, 7. Chlorine is an element with high electronegativity. A chlorine atom is electrically neutral because the number of protons equals the number of electrons.

Chlorine atom:

- Number of electrons: 17
- Electronic configuration: 2, 8, 7
- Number of protons: 17
- Total charge: 0

When a chlorine atom gains an electron, it becomes a chloride ion (Cl^-) with a charge of -1. As this ion is negatively charged, it is called a negative ion or anion.

Chloride ion (Cl^-):

- Number of electrons: 18
- Electronic configuration: 2, 8, 8
- Number of protons: 17
- Total charge: -1

Neutral atoms form positively charged ions by losing electrons and negatively charged ions by gaining electrons. Some polyatomic groups also bear positive or negative charges, such as NH_4^+, SO_4^{2-}, and NO_3^-.

Ionic compounds, such as sodium chloride, are formed when sodium ions (Na^+) and chloride ions (Cl^-) are held together by strong electrostatic attractive forces, known as ionic bonds or electrovalent bonds. The resulting compound is called an ionic compound.

The arrangement of ions in sodium chloride forms a regular three-dimensional array, known as an ionic lattice, where each Na^+ ion is surrounded by six Cl^- ions and each Cl^- ion is surrounded by six Na^+ ions.

Common examples of ionic compounds include:

- Sodium chloride (NaCl)

- Lithium oxide (Li_2O)

- Magnesium sulphide (MgS)

- Calcium chloride ($CaCl_2$)

- Potassium fluoride (KF)

Ionic bonds also form during the combination of ionic radicals and ions. Examples include:

- Copper sulphate ($CuSO_4$)

- Calcium carbonate ($CaCO_3$)

- Ammonium chloride (NH_4Cl)

- Ammonium nitrate (NH_4NO_3)

Covalent Bonds

Electron sharing between atoms is another method of forming bonds. By sharing electrons, atoms acquire a stable noble gas configuration. When atoms join by sharing electrons between a pair of atoms, a covalent bond is formed.

Examples of covalent molecules:

- Homoatomic molecules: hydrogen (H_2), fluorine (F_2), oxygen (O_2), nitrogen (N_2)

- Heteroatomic molecules: water (H_2O), methane (CH_4), ammonia (NH_3)

Formation of Covalent Molecules:

1. Fluorine molecule (F_2): Two fluorine atoms share a pair of electrons to form a fluorine molecule.

2. Hydrogen molecule (H_2): Two hydrogen atoms share their electrons to form a hydrogen molecule.

3. Water molecule (H_2O): An oxygen atom shares two pairs of electrons with two hydrogen atoms to form a water molecule.

4. Ammonia molecule (NH_3): Three hydrogen atoms share three pairs of electrons with a nitrogen atom to form an ammonia molecule.

5. Methane molecule (CH_4): Four hydrogen atoms share four pairs of electrons with a carbon atom to form a methane molecule.

6. Hydrogen chloride molecule (HCl): A chlorine atom shares a pair of electrons with a hydrogen atom to form a hydrogen chloride molecule.

7. Carbon tetrachloride molecule (CCl_4): Four chlorine atoms share four pairs of electrons with a carbon atom to form a carbon tetrachloride molecule.

8. Oxygen molecule (O_2): Two oxygen atoms share two pairs of electrons to form an oxygen molecule, resulting in a double bond.

9. Nitrogen molecule (N_2): Two nitrogen atoms share three pairs of electrons to form a nitrogen molecule, resulting in a triple bond.

Dot and Cross Diagram

Dot and cross diagrams illustrate how electrons exist in covalent bonds. Electrons of one atom are represented by dots, while the electrons of the other atom are shown by crosses.

Lewis Structure

The Lewis structure represents covalent bonds with short lines and lone pairs with dots. For example, in the methane (CH_4) molecule, carbon shares four pairs of electrons with four hydrogen atoms.

Properties of Ionic and Covalent Compounds

Characteristics of Ionic Compounds:

1. Composed of oppositely charged ions.

2. Solid crystalline form at room temperature.

3. High melting points and boiling points.

4. Conduct electricity in the molten state and in aqueous solution.

5. Most are soluble in water.

Characteristics of Covalent Compounds:

1. Mostly exist as molecules composed of several atoms.

2. Generally liquid or gaseous state at room temperature.

3. Low melting points and boiling points (exceptions include lattice compounds).

4. Do not conduct electricity in aqueous solutions.

5. Some are soluble in water.

Activity 3: Examining Electrical Conductivity of Ionic and Covalent Compounds

Materials Required:

- Four beakers

- Two carbon rods

- Two bulbs

- Two batteries (six dry cells)

- Conducting wires

- Salt solution (common salt)

- Sugar solution

- Copper sulphate solution

- Distilled water

Method:

1. Label four beakers A, B, C, and D.

2. Add salt solution to A, copper sulphate solution to B, sugar solution to C, and distilled water to D.

3. Dip two carbon rods in each solution, complete the circuit as shown, and observe whether the bulb lights. Wash the carbon rods before using them in other solutions.

Observations:

- The bulb lights in circuits with common salt and copper sulphate solutions, indicating these are ionic compounds that conduct electricity in aqueous solutions.

- The bulb does not light in circuits with sugar solution and distilled water, indicating these are covalent compounds that do not conduct electricity.

Melting Points and Boiling Points of Some Compounds:

- Sodium chloride ($NaCl$) has a melting point of 801°C and a boiling point of 1413°C (Ionic).

- Potassium chloride (KCl) has a melting point of 776°C and a boiling point of 1500°C (Ionic).

- Water (H_2O) has a melting point of 0°C and a boiling point of 100°C (Covalent).

- Ammonia (NH_3) has a melting point of -78°C and a boiling point of -33°C (Covalent).

- Oxygen (O_2) has a melting point of -218°C and a boiling point of -183°C (Covalent).

- Ethyl alcohol (C_2H_5OH) has a melting point of -117°C and a boiling point of 79°C (Covalent).

- Calcium oxide (CaO) has a melting point of 2580°C and a boiling point of 2850°C (Ionic).

- Sulphur dioxide (SO_2) has a melting point of -73°C and a boiling point of -10°C (Covalent).

Summary:

- Chemical bonds can be ionic or covalent.

- Ionic bonds form between oppositely charged ions.

- Covalent bonds form by sharing electrons between atoms.

- Ionic compounds have high melting and boiling points, and conduct electricity in molten or aqueous states.

- Covalent compounds generally have low melting and boiling points, and do not conduct electricity in aqueous solutions.

Exercises:

1. Define an ion.

2. Write the electronic configurations of the following ions and illustrate them by diagrams: (a) Na^+ (b) Mg^{2+} (c) O^{2-} (d) N^{3-}

3. What is meant by an ionic bond?

4. Illustrate by diagrams how the compound calcium oxide is formed.

5. Draw the dot and cross diagrams of the following molecules: (a) Chlorine (b) Oxygen (c) Water (d) Methane (e) Ammonia

6. What is meant by a covalent bond?

7. Give two properties of ionic and covalent compounds.

8. Why does carbon have a high melting point and a high boiling point?

9. Explain scientifically why common salt is readily soluble in water.

10. Give a reason for the high boiling point of water (100°C) despite it being a covalent compound.

Technical Terms:

- Chemical bonds

- Cation

- Anion

- Ionic bonds

- Covalent bonds

- Polarity

- Intermolecular bonds

- Hydrogen bond

Turning Effect of a Force

We have seen that by applying forces on objects, it is possible to push, pull, or lift them. Similarly, it is possible to rotate objects by applying forces on them. By applying a force, we can rotate or turn an object around a given point. In this lesson, we will focus on the ability of a force to rotate an object around a given point.

Let's perform an activity to investigate the factors affecting the rotation of an object.

Mark four points A, B, C, and D on the same horizontal level of a door attached to its frame by two hinges. Attach a Newton balance to point A with the aid of a rubber sucker clamp and apply a perpendicular force on the door to open it. Measure the force necessary to slightly move the door using the Newton balance. Repeat this procedure for the other three points B, C, and D, and record your measurements.

Here, the door rotates around an axis passing through the hinges. This axis is known as the axis of rotation of the door. It is clear that the force required to rotate the door decreases when the perpendicular distance to the line of action of the force from the rotation axis is increased. Conversely, the force required to rotate the door increases when the perpendicular distance to the line of action of the force from the rotation axis is decreased.

This means that it is easier to open the door when the applied force is further away from the rotation axis, while it is more difficult to open when the applied force is closer to the rotation axis. The force required to rotate an object around an axis depends on the perpendicular distance to the force from the axis.

The product of the force and the perpendicular distance to the line of action of the force from the axis of rotation is known as the moment of the force around the axis.

To subject a body to motion in a straight line, a force is required. To rotate an object around a given axis, a moment is required. A moment is created by applying a force at a certain distance from the rotation axis. This tendency for rotation due to the action of a force is known as the turning effect of the force.

The equation for the moment due to a force is:

Moment = Force × Perpendicular distance from the rotational axis to the line of force of action

The unit of moment of a force is Newton meter (N m).

Depending on whether the rotation is clockwise or anticlockwise, the moment too has to be clockwise or anticlockwise.

Investigation of the Dependence of the Moment on the Magnitude of the Force

Items required: a fairly long stick of wood, two rubber washers, a screw, a drill, a Newton balance, a table or a plank of wood.

1. Drill holes at the points O, A, B, C, and D, which are spaced 15 cm apart from the adjacent hole.

2. Clamp the stick to the table at point O using the washers and the screw nail.

3. Attach a loop formed with a piece of wire to each of the holes at A, B, C, and D on the stick. Attach the Newton balance on the ring at D and measure the minimum force necessary to barely move the stick, keeping the balance perpendicular to the stick.

4. Rotate the nail half a turn to tighten the stick a little more and measure the force required to slightly move the stick.

5. Rotate the nail half a turn to tighten the stick further and measure the force required to slightly move the stick.

The results show that the force required to initiate the turning effect increases as the stick is tightened. Since the distance to the line of action of the force is maintained constant, this confirms that the moment depends on the magnitude of the force.

Investigation of the Dependence of the Moment on the Perpendicular Distance to the Force from the Point of Suspension

1. Insert a loop made from a piece of thread around the stick of wood used in the previous activity near point A and hook the balance on the loop.

2. Rotate the screw by one turn to bring it back to its original position and find the force required to initiate rotating the stick slightly (F1).

3. Rotate the screw by about ¼ of a turn to tighten it, then move the loop together with the balance slowly towards D, keeping the force F1 constant.

4. When the stick begins to move around O, measure the distance from O to the balance.

5. Repeat the procedure, tightening the screw by another ¼ of a turn and sliding the loop towards D, keeping the force (F1) constant and measure the distance from O to the balance when the stick begins to rotate around O.

The results show that when the force necessary to initiate the turning effect is kept constant, the perpendicular distance to the Newton balance had to be increased as the strip is tightened. This confirms that the moment of force also depends on the perpendicular distance to the force from the point of suspension.

Direction of the Moment of Force and Equilibrium of Object Under the Action of the Moments of Force

When a force acts on an object, depending on the direction of rotation, moments can be classified as clockwise or anticlockwise.

Consider two forces F1 and F2 exerted on a stick clamped at point O. The clockwise moment is $F1 \times d1$, and the anticlockwise moment is $F2 \times d2$. When the two forces are applied at the same time, the resultant moment is $F1 \times d1 - F2 \times d2$. Here, the clockwise moment is considered positive. If the opposite moments are equal ($F1 \times d1 = F2 \times d2$), the object will not rotate and will be in equilibrium.

Example:

A uniform rod AB of length 1 m is suspended and balanced at its center. If a weight of 4 N is now suspended from B, the initial clockwise moment is 4 N × 0.5 m = 2 N m. If the 4 N weight is kept at B, to balance the rod again, a weight of 5 N should be suspended from a point 0.4 m from the center.

Exercises:

1. A uniform rod AB is 0.8 m long. It was balanced after being suspended from the center and then a weight of 2 N held at one end. In order to bring the rod back into equilibrium, how far from the balance point on the other side of the rod should a weight of 4 N be held?

2. Describe how the moment acts in the following examples:

- The use of a spanner to detach a nut.
- Applying a force on the pedal of a bicycle.
- The use of a wheelbarrow.

The Couple of Forces

To rotate an object with a single force, the object must be pivoted to a fixed point. It is possible to rotate an object that is not pivoted by using two forces acting in opposite directions.

Consider a strip of wood being pierced at the center and fixed with a screw to a table. Attach a Newton balance and measure the force when the rod begins to rotate slightly. Next, attach two Newton balances at both ends A and B and measure the force required to slightly rotate the rod. If the force required with one force had been F, the force required when two forces are applied in opposite directions would be F/2.

When applying forces to rotate or turn an object around a certain axis, it is easier to rotate by applying two equal forces in opposite directions. When a couple of forces is applied on an object, the resultant of the two forces is zero as the two forces of equal magnitude act in opposite directions. Therefore, a couple of forces does not cause a linear displacement in an object. However, the object rotates around a point between the two forces.

The moment of a force couple is defined as the product between the magnitude of one force and the perpendicular distance between the lines of action of the two forces.

Applications of Couple of Forces

1. When opening or closing a tap, a couple of forces acts on the tap head.

2. When unscrewing or tightening nails with a screwdriver, a couple of forces are applied on the handle of the screwdriver.

3. A steering wheel can be rotated more easily by applying a couple of forces with both hands instead of trying to turn it with only one hand.

Exercises:

1. Give two examples where force couples are acting.

2. A thin plank of timber pivoted at O is shown in the figure. If two forces are applied as shown, find the moment of the couple of forces.

Summary:

- The moment of a force is the tendency of an object to rotate as a result of a force acting on it.
- The moment of a force is given by the product between the force and the perpendicular distance to the line of action of the force from a selected axis.
- A couple of forces is a pair of two equal forces that are parallel to one another and act in opposite directions on an object to turn or rotate it.
- A couple of forces can rotate an object without causing a linear motion in the object.

Technical Terms:

- Moment of force
- Turning effect of a force
- Couple of forces

Equilibrium of Forces

Introduction to Equilibrium of Forces

In a competition of pulling a rope, two groups pull the rope in two opposite directions. When the force exerted in one direction becomes greater than the force exerted in the other direction, the rope moves in the direction of the larger force. When both groups pull with equal forces, the rope will remain at rest without moving in either direction. The sum of the two forces becomes zero. In this situation, the rope is said to be in equilibrium under the action of the forces in the two directions.

Another instance is when an object is suspended by a spring balance. Here there are two forces acting on the object. One force is the weight of the object, which arises due to the gravitational force. The other is the upward force exerted by the spring of the balance to keep the object from falling onto the ground. Under the action of these two forces, the object remains at rest. That is, the object is in equilibrium under the two forces.

A sphere suspended by a string is another example. The weight of the sphere acts vertically downwards. The sphere remains at rest as the vertically upward force applied by the string balances the force due to its weight. This force applied by the string is called its tension. In this instance, the sphere remains in equilibrium under the downward force due to the weight (W) and the upward force (T) exerted by the string.

In daily life, we come across situations where various forces act on objects frequently. Objects can remain in equilibrium under two, three, or even many forces. Here, we will consider instances where objects remain in equilibrium under two or three forces.

Equilibrium of a Body Under Two Forces

We learned about the effective force or the resultant force of two collinear forces (forces acting along the same line) acting on a point, in the lesson on resultant force. In that lesson, you have learned that, while a certain force is acting on an object, if it is pulled by another force in the opposite direction, the magnitude of the resultant force decreases. When an object is said to be in equilibrium, it means that the resultant force of the two forces acting on the object is zero.

Now let us investigate the factors required to keep an object in equilibrium under two forces acting in opposite directions along the same line.

Items required: a ring, two spring balances

Activity 1:

1. Place the ring horizontally on a table and pull it with the two balances in opposite directions. By varying the extent of the pull, apply forces of varying magnitudes on the object. In each attempt, the ring must be kept at rest.

2. The ring stays at rest only when it is in equilibrium under the action of the two forces in opposite directions. Every time the ring is in equilibrium, you will observe that the readings of the two spring balances are equal. That is, at equilibrium, the two forces are equal in magnitudes.

Now try to maintain equilibrium without having the two forces along the same line. You will find that this is impossible. That is, every time the two forces are in equilibrium, they must be aligned along the same line and their directions must be opposite to one another.

Items required: a cubic shaped block of wood, two Newton balances, two rings to fix the balances to the wooden block

Activity 2:

1. Fix the two rings to the centers of two opposite faces of the block of wood.

2. Attach the two Newton balances to the two rings and pull the block of wood along the two directions applying forces of various magnitudes.

3. You will observe that the block of wood moves in one direction whenever there is a nonzero resultant force and that it remains stationary whenever the resultant force is zero. That is, every time the block of wood is in equilibrium, the two forces acting on it in opposite directions have equal magnitudes.

An object placed on a table is shown in the diagram. The weight of the object, acting vertically downwards, is balanced by the perpendicular reaction force exerted vertically upwards by the table. That is, the object is in equilibrium under the action of the two forces mentioned above, and the object remains at rest.

If an object suspended by a string remains in equilibrium, the reason is that a force equal to the weight of the object is acting vertically upwards along the string. The force exerted upwards by the string is known as the tension of the string. As the object is held in equilibrium by two forces - its weight and the tension of the string - the object remains at rest.

In each of the instances described above, only two forces were acting on the object. In addition, the two forces were equal in magnitude and opposite in direction. Also, their lines of action were the same. That is, for an object to remain in equilibrium, the following conditions must be satisfied:

1. The two forces must have equal magnitudes.

2. The two forces must act along two opposite directions.

3. Both forces must lie along the same line of action.

Equilibrium of a Body Under Three Coplanar Parallel Forces

A bunch of bananas suspended on a light horizontal rod is shown. Here, the rod, the two strings used to suspend it, and the string used to suspend the bunch of bananas are all in the same plane. Also, all three strings are parallel. This is an example of a system in equilibrium under the action of three parallel, coplanar forces.

A rod resting on two supports is another example. In this system of forces, the three forces, the weight of the rod, and the two perpendicular reaction forces exerted on the rod are coplanar and their lines of action are parallel to one another. Under these forces, the rod is in equilibrium on the two supports.

Let us engage in the following activity to investigate the factors that affect the equilibrium of three parallel and coplanar forces.

Items required: two spring balances, a meter ruler, two rubber bands

Activity 3:

1. Measure the weight of the meter ruler. Next, suspend it at the two ends with the aid of the rubber bands and balances and keep the meter ruler in equilibrium in a horizontal position. Take measurements of the two spring balances. The system is now in equilibrium under the action of three parallel, coplanar forces.

2. Investigate the relationship between the measurements of the two spring balances and the weight of the meter ruler. You will notice that the sum of the two readings of the balances is equal to the weight of the meter ruler.

3. That is, the sum of the two forces exerted on the meter ruler by the two balances is equal to the weight of the meter ruler.

4. See whether it is possible to push the meter ruler in a horizontal plane with a force applied normal to the meter ruler at one end of the ruler and still maintain equilibrium.

5. You will understand that every time the meter ruler is in equilibrium, the two balances and the meter ruler are in the same plane.

That is, in order for an object to maintain equilibrium under the action of three parallel forces, the following conditions must be satisfied:

1. The three forces must be coplanar.

2. One force must have a direction opposite to the other two forces.

3. The resultant of any two forces must be equal in magnitude and opposite in direction to the third force.

A child sitting on a swing is an example of a system in equilibrium under three parallel forces. The child can remain in equilibrium on the swing since the sum of the two forces F1 and F2 exerted by the two ropes is equal to the weight of the child.

Equilibrium of a Body Under Three Forces that are Not Parallel

A framed picture hanging on the wall remains at rest because the tensions of the two strings (F1 and F2) and the weight of the picture (W) are in equilibrium. Although these three forces are coplanar, they are not parallel to one another as in the examples described earlier.

Let us engage in the following activity to find out the factors necessary to maintain equilibrium in a system of three forces that are coplanar but not parallel to one another.

Items required: a thin rectangular laminar, a string

Activity 4:

1. Use a thin sheet of metal or a piece of cardboard as the laminar. Hang your laminar from three points, one at a time, and mark the vertical line that goes along the string on the laminar each time.

2. The point of intersection of the three lines can be considered the center of gravity of the laminar.

3. The center of gravity is the point at which the whole weight of a body may be considered to act. Therefore, the weight of the laminar acts along the vertical line that goes through its center of gravity.

4. Hang the laminar using two strings connected to it, as the framed picture shown earlier, and keep it in equilibrium in a vertical plane.

5. Mark the lines of each string on a sheet kept behind the laminar. Mark also the vertical line passing through the center of gravity.

6. All three lines marked above will lie on the same plane and they will pass through a common point.

7. Keeping the position of one of the three forces fixed, turn the laminar to change the plane of the other forces. You will observe that the system remains in equilibrium only after readjusting the lines of action of the forces so as to have all three forces lying on the same plane.

That is, in order for a system of three non-parallel forces to be in equilibrium, the three forces must be coplanar. Also, the lines of action of the three forces must meet at a common point. Furthermore, the resultant of any two of the forces should be equal to the third force in magnitude and opposite in direction.

We have only discussed systems that are in equilibrium under the action of two or three forces. Equilibrium can exist under the action of more than three forces. A system in equilibrium under five forces is shown as a plank of wood suspended by four strings attached to the four corners. The plank of wood maintains equilibrium since its weight acting vertically downwards is balanced by the forces of tension exerted by the four strings.

Miscellaneous exercises:

1. (i) An object on a horizontal plane is pulled along a certain direction with a force of 20 N. In order to bring the object to rest, what is the force that should be applied on it in the direction opposite to the 20 N force?

(ii) What would happen if a force of 25 N is applied on the above object in the opposite direction?

2. If several people are trying to push a car whose engine is not functioning, in what manner should each one try to exert a force on the car?

3. If the resultant force of the two forces applied by the spring balances B and C as shown in the figure is known, what should be done in order to bring the ring to rest?

4. A box is placed on a table. Although the gravitational attraction force is acting downwards on the box, why does it remain at rest without falling down?

5. What can you say about the nature of the motion of an object on a horizontal table that is pulled in opposite directions with two unequal forces?

Summary:

1. If the magnitudes of two collinear forces applied on an object are equal and they have opposite directions, then the object is in equilibrium.

2. An object under three parallel forces is in equilibrium if one force is equal in magnitude to the resultant of the other two forces and it is in the opposite direction.

3. If an object stays in equilibrium under three forces that are not parallel to one another, the resultant of any two of the forces is equal in magnitude and opposite in direction to the other force.

4. Even under the action of more than three forces, a system can remain in equilibrium by applying forces appropriately.

Technical terms:

- Force

- Equilibrium of forces
- Equilibrium of coplanar forces
- Equilibrium of two forces
- Equilibrium of three forces
- Equilibrium of three parallel forces
- Resultant

Classification of Organisms

It is believed that life originated on earth about 3.6 billion years ago. It is accepted that life originated as unicellular organisms and thereafter complex multicellular organisms evolved gradually. Today, about 8.7 million species are living on earth. There is a great diversity among these organisms. Once these organisms are grouped, it is easy to study them and use them for different purposes.

In a given figure, fifteen species of organisms are shown. An activity can be performed to group these organisms based on certain criteria. For example, organisms can be grouped by identifying the species, using appropriate criteria, and comparing the grouping with others.

Grouping of organisms into different levels based on their common characteristics is known as classification.

Significance of Classification of Organisms:

- Easy to study about organisms

- Ability to identify specific distinguishable characteristics of a given organism

- Ability to get an idea about the whole biosphere by studying a few selected organisms without studying each and every organism

- Ability to reveal the relationship between different groups of organisms

- Identification of organisms with economical uses to humans

Methods of Classification of Organisms:

Aristotle introduced the first scientific classification of organisms in the 4th century B.C. Carolus Linnaeus introduced a successful classification in the 18th century. All organisms on earth, including humans, can be classified using two methods:

1. Artificial classification

2. Natural classification

Artificial Classification:

In artificial classification, features such as the presence or absence of locomotive appendages of organisms and habitats are considered. It does not depict the evolutionary relationships among organisms. Examples of artificial classification include grouping plants as ornamental, herbal, and poisonous plants, and animals as those with and without wings. There are many weaknesses in artificial classification. For example, under the criteria of the presence of wings, both birds and insects are included in a single group, but they belong to two different groups when considering evolutionary relationships.

Natural Classification:

A natural classification depicts the evolutionary relationships among living organisms. In natural classification, morphological, physiological, cytological, and molecular biological features of organisms are considered. The natural classification has the following features:

- Explains the natural relationships among organisms of the same species

- Explains the evolutionary relationships among different organisms

For example, locomotive appendages such as fins of fish, feathers of birds, and legs of humans are considered in natural classification. In natural classification, organisms are grouped into taxonomic levels in a hierarchy of categories.

Examples of Taxonomic Levels:

1. Coconut tree (Cocos nucifera)
   - Domain: Eukarya
   - Kingdom: Plantae
   - Division: Magnoliophyta
   - Class: Liliopsida
   - Order: Arecales
   - Family: Arecaceae
   - Genus: Cocos

- Species: Cocos nucifera

2. Modern Human (Homo sapiens)
   - Domain: Eukarya
   - Kingdom: Animalia
   - Phylum: Chordata
   - Class: Mammalia
   - Order: Primates
   - Family: Hominidae
   - Genus: Homo
   - Species: Homo sapiens

Three Domain System of Classification:

The most appropriate system to classify organisms is natural classification. Different scientists have introduced various classification methods over time. One of them is the five-kingdom classification system introduced by Robert Whittaker in 1969. Modern classification, introduced by Carl Woese in 1990, includes three domains:

1. Domain Archaea
2. Domain Bacteria
3. Domain Eukarya

Domain Archaea:

Organisms in this domain are prokaryotes (without an organized nucleus). They can live in extreme environmental conditions like volcanoes, deserts, hot springs, ocean beds, high saline environments, and polar ice caps. They are not sensitive to most antibiotics and cannot be destroyed with antibiotics. Examples include methanogens and halophiles.

Domain Bacteria:

Organisms in this domain are also prokaryotes (without an organized nucleus). They are sensitive to antibiotics and can sometimes be pathogenic. They are found everywhere in the environment and are the most abundant group of organisms. Examples include bacteria and cyanobacteria.

Several harmful and useful effects of bacteria to humans include:

- Causing diseases such as tuberculosis, pneumonia, diarrhea, tetanus, and leprosy

- Food spoilage

- Producing curd, yogurt, and cheese

- Separation of fibers from coconut husk, agave leaves, and tanning leather

- Fixing atmospheric nitrogen to increase soil nitrate levels

- Decomposing dead bodies and structures

Virus:

Viruses were first observed by Russian scientist D.J. Ivonouski in 1892. They are not identified as living organisms because they possess both living and non-living features. The only living feature is their ability to multiply within a host cell.

Domain Eukarya:

Organisms with a eukaryotic cellular organization belong to this domain. They can live in different environments and are not sensitive to antibiotics. This domain includes four kingdoms:

1. Kingdom Protista

2. Kingdom Fungi

3. Kingdom Plantae

4. Kingdom Animalia

Kingdom Protista:

Organisms in this kingdom possess a eukaryotic cellular organization. They can be unicellular or multicellular without specialized tissues. They live in environments associated with water and are mostly photosynthetic. Some species are heterotrophic. Examples include algae and protozoa. Algae act as primary producers in aquatic food chains and form mutualistic associations with fungi called lichens. They are also used to extract agar for culture media, alginic acid for ice cream, and some protozoans cause diseases like amoebiasis, malaria, and sleeping sickness.

Kingdom Fungi:

This kingdom includes organisms with chitinous cell walls and eukaryotic cellular organization. There are about 1.5 to 5 million species. Fungi decompose organic matter and form symbiotic associations. Useful and harmful effects of fungi include:

- As a protein supplement (e.g., mushrooms)

- Bread and alcohol fermentation (e.g., yeast)

- Producing antibiotics (e.g., Penicillium)

- Decomposing dead bodies and structures

- Causing diseases in plants and animals (e.g., pityriasis by Candida, potato late blight)

- Spoiling food

Kingdom Plantae:

This kingdom includes multicellular organisms known as plants. There are about 287,000 species. Plant cells have cell walls with cellulose and contain chlorophyll pigments, making them green. They produce food by photosynthesis and reproduce sexually and asexually. Plants can be divided into non-flowering and flowering plants.

Non-Flowering Plants:

Non-flowering plants do not produce flowers. They can be seedless or seed-producing. Non-flowering seedless plants include examples like Marchantia, Pogonatum, Selaginella, Nephrolepis, Salvinia, Acrosticum, and Drynaria. Features include:

- Small to large-sized plants, some lacking tissue differentiation

- Autotrophic photosynthetic nutrition

- Asexual reproduction by spores and fragmentation, and sexual reproduction

- Found in terrestrial environments with low sunlight, shady, and wet places

Non-Flowering Seed Plants:

These plants have seeds that are not covered by a fruit, known as gymnosperms. Examples include Cycas and Pinus. Features include:

- True tissue differentiation with vascular tissues

- Large size, mostly trees with straight woody stems, some shrubs

- Autotrophic photosynthetic nutrition

- Sexual reproduction by seeds and asexual reproduction by spores

- Distributed in terrestrial environments

Flowering Plants:

Flowering plants produce flowers, and their seeds are covered by a fruit, known as angiosperms. These plants are well adapted to land and have adaptations to conserve water. They are divided into monocots and dicots based on the number of cotyledons in the seed.

Monocots:

- Single cotyledon in the seed

- Unbranched stem

- Fibrous root system

- Parallel venation in leaves

- Trimerous flowers

- No secondary growth

- Even diameter of the stem

Examples: Paddy, Grass, Arecanut

Dicots:

- Two cotyledons in the seed

- Branched stem

- Tap root system with lateral roots

- Reticulate venation in leaves

- Tetra or pentamerous flowers

- Secondary growth present

- Broad base and thin tip of the stem

Examples: Chillies, Jak, Blue lotus

Kingdom Animalia:

This kingdom includes multicellular animals. There are about 1,260,000 species. They cannot produce their own food and are heterotrophic. Animals are divided into invertebrates and vertebrates based on the presence or absence of a vertebral column.

Invertebrates:

Invertebrates do not have a vertebral column and are divided into different phyla:

1. Cnidaria/Coelenterata: Aquatic, diploblastic organisms with radial symmetry and a coelenteron acting as a digestive tract. Examples include Hydra, Sea anemone, and Jellyfish.

2. Annelida: Segmented worms with a coelom, living in damp soil, marine, and freshwater habitats. Examples include Earthworm, Leech, and Nereis.

3. Mollusca: Soft-bodied triploblastic organisms with a body divided into head, muscular foot, and visceral mass. Examples include Snail, Cuttlefish, and Octopus.

4. Arthropoda: The largest phylum with jointed limbs, segmented bodies, and an exoskeleton. Examples include Insects (Bee, Butterfly), Spider, Scorpion, and Centipede.

5. Echinodermata: Marine organisms with a coelomic cavity, radial symmetry, and a water vascular system. Examples include Starfish, Brittle star, Sea urchin, and Sea cucumber.

Vertebrates:

Vertebrates have a vertebral column and are classified into five groups:

1. Pisces: Fish with bony or cartilaginous skeletons, living in freshwater and marine environments. Examples include Butterfly fish, Skate, and Seahorse.

2. Amphibia: Animals that need water to complete their life cycle, with a three-chambered heart and respiration through lungs, skin, and buccal cavity. Examples include Frog, Toad, and Salamander.

3. Reptilia: Land-adapted animals with dry skin and scales, a three-chambered heart, and internal fertilization. Examples include Tortoise, Crocodile, and Cobra.

4. Aves: Birds adapted for flying, with a light bony endoskeleton, feathers, and a four-chambered heart. Examples include Jungle fowl, Ostrich, and Penguin.

5. Mammalia: Animals that nourish young with milk, have hair, mammary glands, a four-chambered heart, and are warm-blooded. Examples include Human, Bat, and Dolphin.

Nomenclature of Organisms:

Different names are used to identify organisms in various languages, but these names vary by language, country, and region. To avoid confusion and depict evolutionary relationships, scientists use a common naming system known as binomial nomenclature, introduced by Carolus Linnaeus in 1753.

Standards of Binomial Nomenclature:

- The scientific name of a species consists of two epithets: the generic name and the specific epithet.

- The name is given in Latin or Greek.

- The first letter of the generic epithet is capitalized, and the rest are in lowercase.

- When handwritten, the name is underlined; when printed, it is italicized.

Example: Mangifera indica

Examples of Scientific Names:

- Human: Homo sapiens

- Asian Elephant: Elephas maximus

- Jungle Fowl: Gallus lafayetti

- Asoka Pethiya: Puntius asoka

- Blue Lotus: Nymphaea stellata

- Coconut: Cocos nucifera

Summary:

- Organisms are classified into groups for easier study.

- All organisms are divided into three domains: Archaea, Bacteria, and Eukarya.

- Prokaryotic organisms living in extreme environments belong to domain Archaea.

- Bacteria and Cyanobacteria belong to domain Bacteria.

- Protista, Fungi, Plantae, and Animalia are the four kingdoms in domain Eukarya.

- Kingdom Plantae is divided into flowering and non-flowering plants.

- Kingdom Animalia is divided into invertebrates and vertebrates.

- Invertebrates are classified into phyla such as Cnidaria, Annelida, Mollusca, Arthropoda, and Echinodermata.

- Vertebrates are classified into groups like Pisces, Amphibia, Reptilia, Aves, and Mammalia.

- Organisms are named scientifically using binomial nomenclature.

Exercises:

1. State different classification systems of organisms and the scientists who introduced them.

2. Compare differences between natural and artificial classification systems.

3. State the three domains and the organisms belonging to them.

4. State the uses of coral reefs, which are creations of organisms belonging to phylum Cnidaria.

5. Classify the following mammals using a tree diagram: Bat, Whale, Monkey, Rat, Bear.

Technical Terms:

- Classification

- Domain
- Hierarchical organization
- Vertebrates
- Invertebrates
- Binomial nomenclature

Reproduction

Reproduction is a biological process that gives rise to new individuals from existing ones. It is essential for maintaining the continuity of life. Reproduction is of two types: asexual and sexual reproduction.

Asexual Reproduction:

Asexual reproduction occurs without the involvement of gametes. It can take place through spores or vegetative parts of mature organisms. This type of reproduction results in offspring that are genetically identical to the parent. Examples include budding, fragmentation, and vegetative propagation.

Sexual Reproduction:

Sexual reproduction involves the fusion of two gametes, one from a male and one from a female organism. This process produces offspring with genetic characteristics derived from both parents, leading to genetic diversity. In plants, sexual reproduction occurs in flowers, while in animals, it involves the male and female reproductive systems.

Differences between sexual and asexual reproduction:

1. Asexual reproduction involves only one parent, while sexual reproduction involves two parents (maternal and paternal).

2. Asexual reproduction results in offspring genetically similar to the parent, whereas sexual reproduction produces offspring with mixed characteristics from both parents.

3. Asexual reproduction does not involve gametes, while sexual reproduction involves the production and fusion of gametes.

Bulbils:

Bulbils are special reproductive structures formed by the modification of vegetative or flower buds. Examples include pineapple, jute, and Hondala.

Underground Stems:

Underground stems grow beneath the soil and play roles in vegetative propagation, food storage, and surviving adverse conditions. Types of underground stems include rhizomes (e.g., ginger, turmeric), corms (e.g., taro, elephant foot yam), bulbs (e.g., onions, leeks), and stem tubers (e.g., potato).

Activity:

Observe plants in your home garden or school that propagate through vegetative parts. Tabulate these plants and their methods of propagation.

Artificial Vegetative Propagation:

Humans can artificially propagate plants using methods such as stem cuttings, layering, grafting, and tissue culture.

Stem Cuttings:

Stem cuttings from a healthy mother plant can be planted to produce new plants. This method is commonly used for plants like roses, hibiscus, ixora, bougainvillea, and croton.

Layering:

Layering involves initiating root development on a branch while it is still attached to the parent plant. Ground layering and aerial layering are two types. Ground layering involves burying a branch in the soil, while aerial layering involves wrapping a cut twig with a moist medium to encourage root growth.

Grafting:

Grafting involves connecting a twig or bud (scion) to a plant (stock) of the same or a closely related species. The stock provides a strong root system, while the scion is selected for its desirable characteristics. Grafting methods include bud grafting and twig grafting.

Tissue Culture:

Tissue culture produces new plants from vegetative tissue in a controlled environment. This method allows for the mass production of genetically identical plants. Steps in tissue culture include introducing vegetative tissue to a culture medium, developing callus tissue, and growing plantlets in test tubes or flasks.

Advantages of vegetative propagation:

1. Ability to propagate plants that do not produce seeds.

2. Production of offspring identical to the parent plant.

3. Faster propagation and earlier fruiting.

4. Ability to propagate disease-resistant and pest-resistant plants.

5. Creation of plant varieties that withstand adverse conditions.

Sexual Reproduction in Plants:

Sexual reproduction in plants involves the production of seeds through the fusion of gametes. The flower is the reproductive structure of plants, consisting of calyx, corolla, androecium, and gynoecium.

Pollination:

Pollination is the transfer of pollen from the male anther to the female stigma. It can be self-pollination (same flower) or cross-pollination (different flower of the same species). Cross-pollination promotes genetic diversity and is facilitated by adaptations to avoid self-pollination.

Agents of Pollination:

1. Animals (zoophilous flowers): Attracted by fragrance, color, nectar, and sticky pollen.

2. Wind (anemophilous flowers): Produce large amounts of light, small pollen.

3. Water (hydrophilous flowers): Staminate flowers float and contact pistillate flowers for pollination.

Fertilization:

After pollination, the pollen grain germinates on the stigma, forming a pollen tube that grows towards the ovary. The male gamete fuses with the female ovum, forming a zygote. The zygote develops into an embryo, and the ovary becomes the fruit.

Dispersal of Fruits and Seeds:

Dispersal mechanisms include animals, wind, water, and explosive mechanisms. These adaptations help minimize competition, find new habitats, increase diversity, and protect from pests and diseases.

Germination of Seeds:

Germination is the activation of the embryo in a seed, requiring viability, air, moisture, and optimum temperature. Dormancy may occur if conditions are unfavorable.

Human Reproduction:

Puberty marks the onset of sexual maturity, characterized by secondary sexual characteristics. The male reproductive system includes testes, epididymis, vas deferens, seminal vesicles, prostate gland, Cowper's glands, and penis. The female reproductive system includes ovaries, fallopian tubes, uterus, and vagina.

Menstrual Cycle:

The menstrual cycle is a cyclic process in sexually mature females, involving the follicular phase (development of ova), luteal phase (release of ovum), and changes in the uterus (menstrual, proliferation, and secretory phases).

Fertilization and Implantation:

During copulation, semen is deposited in the vagina, and sperm cells travel to the fallopian tube to fertilize the ovum. The fertilized ovum (zygote) develops into a morula and implants in the uterine wall.

Development of the Fetus:

The fetus develops in the uterus, nourished by the placenta and connected to the mother by the umbilical cord. Key developmental stages include the formation of organs, growth of hair, and increase in weight.

Childbirth:

Childbirth (parturition) involves the contraction of uterine muscles to expel the fetus through the vagina. The umbilical cord is cut and tied after birth.

Sexually Transmitted Diseases (STDs):

Common STDs include gonorrhea, syphilis, herpes, and AIDS. These diseases are transmitted through sexual contact and blood. Preventive measures include responsible sexual behavior and avoiding risky activities.

Summary:

- Reproduction ensures the continuity of life and occurs through sexual and asexual methods.

- Vegetative propagation in plants can be natural or artificial.

- Flowers are the reproductive structures of plants, and pollination is essential for seed production.

- Human reproduction involves the production of gametes and the development of the fetus in the uterus.

- STDs are transmitted through sexual contact and require preventive measures.

Exercises:

1. Differentiate between sexual and asexual reproduction.

2. Identify structures associated with vegetative propagation and provide examples.

3. Discuss practical problems in grafting plants.

4. Explain why vegetative propagation might be more suitable than sexual reproduction for better plant yields.

5. List the main parts of a flower and their functions.

6. Compare the advantages of cross-pollination with self-pollination.

7. Describe the problems that may arise if fruits and seeds are not dispersed.

8. Enumerate changes that occur in males and females during puberty.

9. Label the parts of the female reproductive system in a given diagram.

10. Label the parts of the male reproductive system in a given diagram.

11. Name the parts of a typical flower in a given diagram.

Technical Terms:

- Reproduction
- Asexual reproduction
- Sexual reproduction
- Vegetative propagation
- Tissue culture
- Pollination
- Fertilization
- Seed dormancy
- Zygote
- Fetus
- Puberty
- Secondary sexual characteristics
- Menstrual cycle
- Parturition
- Sexually transmitted diseases (STDs)

Hydrostatic Pressure and Its Applications

Pressure is the force acting on a unit area. The formula to calculate pressure is:

Pressure = Force / Area

The unit of pressure is Newtons per square meter (N/m^2), also known as Pascal (Pa), named after the French scientist Blaise Pascal.

Example 1:

A cubic shaped box is placed on a table. If the weight of the box is 400 N and the area of the bottom of the box is 0.2 m^2, the pressure exerted on the surface of the table under the box is calculated as follows:

Pressure = Force / Area = 400 N / 0.2 m^2 = 2000 Pa

Example 2:

The pressure exerted by a pile of soil distributed over an area of 8 m^2 of the ground is 150 Pa. The force exerted on the ground due to the pile of soil is calculated as follows:

Force = Pressure × Area = 150 Pa × 8 m^2 = 1200 N

Hydrostatic Pressure

Pressure is exerted not only by solids but also by liquids. When a solid object is placed on a table, the force acting on the table due to the weight of the object spreads over the contact area between the object and the table. Similarly, when a liquid is in a container, the force due to the weight of the liquid spreads over the bottom surface of the container. This pressure is exerted by the liquid not only on the bottom but also on the vertical walls of the container.

To investigate the characteristics of hydrostatic pressure, perform the following experiments:

Experiment 1:

Take a polythene bag, make holes in it, fill it with water, and observe that water exits through all the holes. This shows that water pressure acts in every direction.

Experiment 2:

Take a plastic bottle, make several holes at the same level near the bottom, fill it with water, and observe the horizontal distance traveled by water exiting the bottle. The distance is the same for all holes, indicating that the pressure at the same level of a liquid is the same.

Experiment 3:

Make a set of equally spaced holes from top to bottom of a plastic bottle, fill it with water, and observe the speed of water streams exiting the bottle. The speed of water from lower holes is greater, indicating that pressure in a liquid increases with depth.

Activity 15.1:

To find out how liquid pressure depends on the shape of the water column, use five transparent tubes of various shapes fixed to a PVC tube. Fill the system with water and record the vertical heights of the water columns. The height of the liquid column in each tube will be the same, showing that pressure at equal levels of a liquid is the same and depends only on the height of the liquid column.

Characteristics of Liquid Pressure:

1. Pressure at a certain point in a liquid depends on the height of the liquid column above that point and increases with the height of the liquid column.

2. Pressure at the same level of a liquid is the same.

3. Pressure at a given point in a liquid is the same in all directions.

4. Liquid pressure depends on the vertical height of the liquid column and not on the shape of the liquid column.

The pressure at a point in a liquid at depth h with density ρ is given by:

$P = h\rho g$

Example 1:

At a depth of 1.5 m in a lake, the pressure exerted by the water is:

Pressure = $h\rho g$ = 1.5 m × 1000 kg/m³ × 10 m/s² = 15,000 Pa

Example 2:

At a depth of 10 m in the sea with a water density of 1050 kg/m³, the pressure is:

Pressure = $h\rho g$ = 10 m × 1050 kg/m³ × 10 m/s² = 105,000 Pa

Transmission of Pressure Through Liquids

Liquids do not compress easily, so the pressure exerted at one point in a liquid can be transmitted to another point in the liquid. This principle is used in hydraulic presses, which consist of a liquid volume trapped by two pistons on either side of a cylindrical liquid column. When a force is applied on a smaller piston, the pressure is transmitted to a larger piston, resulting in a larger force. This principle is used in vehicle hoists and hydraulic jacks.

For example, if a force of 20 N is applied on a small piston with an area of 10 cm², the pressure is:

P = Force / Area = 20 N / 10 cm² = 2 N/cm²

This pressure is transmitted to a larger piston with an area of 200 cm², resulting in a force of:

Force = Pressure × Area = 2 N/cm² × 200 cm² = 400 N

The same principle is applied in the brake systems of vehicles, where the force applied on the brake pedal is transmitted to the brake pads through a hydraulic fluid, applying pressure on the brake discs or drums.

Exercises:

1. The pressure exerted at the bottom of a container due to a liquid inside it is 1500 Pa. What is meant by "the pressure is 1500 Pa"?

2. Find the pressure exerted by a mercury column of height 10 cm. (Density of mercury is 13600 kg/m^3)

3. The depth of a pond is 1.5 m. Calculate the pressure caused by the water at the bottom of the pond.

4. The depth at a certain point in the sea is 1 km. Find the pressure exerted by sea water at the bottom of the sea at that point. (Density of sea water is 1050 kg/m^3)

5. A tank with a length of 5 m, width of 3 m, and depth of 2 m is filled with a liquid of density 800 kg/m^3. (a) What is the pressure at the bottom of the tank due to the liquid? (b) What is the force acting on the bottom of the tank due to that pressure?

Pressure Due to Gases

Gases also exert pressure. One way is the pressure caused by the weight of a column of gas, similar to the pressure caused by a column of liquid, resulting in atmospheric pressure. Another way is when a compressed gas attempts to expand, causing pressure.

Activity 15.2:

Pour water into a U-tube, and the water levels in the two arms will be equal. Tie an air-filled balloon to one arm, and the water level in that arm will go down while the water level in the other arm goes up, indicating higher pressure in the arm with the balloon.

Atmospheric Pressure

The atmospheric pressure is caused by the weight of the air above a point. The atmospheric pressure was first measured by the Italian scientist Torricelli using a mercury barometer, consisting of a glass tube filled with mercury and inverted in a container of mercury. The height of the mercury column in the tube measures the atmospheric pressure, typically 76 cm at sea level.

To measure pressure, an aneroid barometer can be used, which contains no liquid but has a cavity with thin metallic walls that change shape with pressure variations, moving an indicator on a scale.

Applications of Atmospheric Pressure:

1. Drinking with a straw: Sucking air from the straw reduces the pressure inside, allowing atmospheric pressure to push the liquid up the straw.

2. Using a siphon: Filling a tube with water and lowering one end into a lower tank creates a pressure difference that causes water to flow from the higher tank to the lower one.

3. Using a rubber sucker: Pressing a rubber sucker onto a surface removes most air, and the atmospheric pressure holds the sucker in place.

Example:

1. The atmospheric pressure at sea level is 76 cm Hg. Taking the density of mercury as 13600 kg/m^3 and acceleration due to gravity as 10 m/s^2, find the atmospheric pressure in Pascals and the height of a water column that can be balanced by this pressure.

- Atmospheric pressure = $h\rho g$ = 0.76 m × 13600 kg/m^3 × 10 m/s^2 = 103,360 Pa

- Height of water column = 103,360 Pa / (1000 kg/m^3 × 10 m/s^2) = 10.336 m

Floatation

Objects sink or float in water based on their density relative to water. The upward force exerted by water on immersed objects is called upthrust. The upthrust on a floating object is equal to the weight of the displaced water, known as Archimedes' principle.

Archimedes' Principle:

When an object is partially or completely submerged in a fluid, the upthrust acting on it is equal to the weight of the fluid displaced by the object.

Hydrometer:

A hydrometer measures the density of liquids. It floats in the liquid, and the density is read from a scale on the hydrometer. The hydrometer immerses to a height that displaces a volume of liquid equal to its weight.

Exercises:

1. The depth of a reservoir is 1.2 m. Calculate the pressure at the bottom of the pond due to the water and the force exerted on an area of 200 cm^2 at the bottom.

2. Describe an experiment to demonstrate that pressure in a liquid increases with depth.

3. The atmospheric pressure at sea level is 76 cm Hg. How much is this pressure in Pascals? What is the height of a water column that exerts the same pressure?

4. Write down Archimedes' principle and calculate the upthrust and weight of water displaced for a metal piece with an air weight of 20 N and an apparent weight of 5 N in water.

Summary:

- Pressure is produced by solids, liquids, and gases.

- Liquid pressure acts in every direction and increases with depth.

- The formula $P = h\rho g$ is used to calculate liquid pressure.

- Atmospheric pressure is measured using mercury and aneroid barometers.

- Upthrust is the upward force exerted by fluids on submerged objects, as per Archimedes' principle.

Changes in Matter

Objects made of iron rust when exposed to air. Moth balls become smaller in size when kept exposed to the air. Ice melts and turns into liquid water. These are examples of changes in matter. To study these changes further, consider the following activity:

Activity 16.1:

Requirements: A piece of magnesium (Mg) ribbon, about 50 ml of dilute sulfuric acid (H_2SO_4), a few pellets of sodium hydroxide (NaOH), two metal spoons, a moth ball (naphthalene), a box of matches, two 50 ml beakers, a Bunsen burner, a thermometer.

Perform the activities listed below and record your observations:

i. Heat a metal spoon strongly in the Bunsen flame and then place a moth ball on it. Close it with another spoon quickly. After some time, observe the inner side of the spoon.

ii. Hold a piece of cleaned magnesium ribbon with tongs and burn it.

iii. Measure the initial temperature of a dilute sulfuric acid solution. Add a few pellets of sodium hydroxide to this solution, stir, and measure the temperature again.

iv. Put a piece of magnesium ribbon into a beaker containing dilute sulfuric acid.

Observations:

i. The moth ball melted and vaporized. A white powder deposited on the inner side of the spoon.

ii. The magnesium ribbon burned with a bright white flame, leaving a white powder.

iii. Sodium hydroxide dissolved, and the container became hot. The thermometer reading rose.

iv. The magnesium ribbon dissolved, liberating gas bubbles, and the beaker was heated.

Physical and Chemical Changes:

In case (i), solid naphthalene melted and then turned into a vapor. On the cold surface of the spoon, the vapor solidified, forming a thin solid layer of naphthalene. This is an example of a physical change where only the physical state of the substance changed without forming new substances.

In instances (ii) to (iv), new substances were formed, indicating chemical changes or chemical reactions. Evidences for chemical reactions include burning with a flame, evolution of heat, effervescence, change in color, and precipitation.

To further investigate physical and chemical changes, refer to Table 16.1:

Physical Changes:

- The arrangement of particles forming the substance changes, but no new substances are produced.

Examples:

1. Crushing stone (lumps to powder)

2. Melting of wax (solid to liquid)

3. Vaporization of water (liquid to gas)

4. Condensation of water vapor into droplets (gas to liquid)

Chemical Changes:

- Existing substances undergo changes and new substances are formed.

Examples:

1. Burning firewood (formation of ash, liberation of gases)

2. Heating limestone (formation of calcium oxide, evolution of gas)

3. Heating potassium permanganate (liberation of oxygen)

4. Rusting of iron (formation of rust)

Chemical Changes:

During a chemical reaction, the substances taking part are called reactants, and the new substances produced are known as products. Chemical reactions can be classified into four types:

1. Chemical combination reactions

2. Chemical decomposition reactions

3. Single displacement reactions

4. Double displacement (double decomposition) reactions

Chemical Combination Reactions:

In these reactions, new substances are formed by the combination of two or more substances.

Example: Magnesium reacts with oxygen to form magnesium oxide:

$2Mg + O_2 \rightarrow 2MgO$

Other examples:

- Carbon + oxygen → carbon dioxide

$C + O_2 \rightarrow CO_2$

- Calcium oxide + water → calcium hydroxide

$CaO + H_2O \rightarrow Ca(OH)_2$

Chemical Decomposition Reactions:

In these reactions, a compound decomposes to form other simpler compounds or elements.

Example: Potassium permanganate decomposes to form potassium manganate, manganese dioxide, and oxygen:

$2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$

Other examples:

- Calcium carbonate → calcium oxide + carbon dioxide

$CaCO_3 \rightarrow CaO + CO_2$

- Hydrogen peroxide → water + oxygen

$2H_2O_2 \rightarrow 2H_2O + O_2$

Single Displacement Reactions:

In these reactions, an element displaces another element in a compound, forming a new compound.

Example: Zinc reacts with copper sulfate, forming zinc sulfate and copper:

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

Other examples:

- Magnesium + copper sulfate → magnesium sulfate + copper

$Mg + CuSO_4 \rightarrow MgSO_4 + Cu$

- Magnesium + hydrogen chloride → magnesium chloride + hydrogen

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

Double Displacement Reactions:

In these reactions, elements or radicals in two compounds are exchanged to form new compounds.

Example: Barium chloride reacts with sodium sulfate to form barium sulfate and sodium chloride:

$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$

Other examples:

- Ferrous sulfate + sodium hydroxide → ferrous hydroxide + sodium sulfate

$FeSO_4 + 2NaOH \rightarrow Fe(OH)_2 + Na_2SO_4$

- Calcium chloride + sodium carbonate → calcium carbonate + sodium chloride

$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$

Chemical Equations:

A chemical equation is a symbolic representation of a chemical reaction using chemical formulae. Reactants are written on the left-hand side and products on the right-hand side, with an arrow indicating the direction of the reaction.

Example: Magnesium reacts with oxygen to form magnesium oxide:

$2Mg + O_2 \rightarrow 2MgO$

Steps to balance the equation:

1. Write the unbalanced equation: $Mg + O_2 \rightarrow MgO$

2. Balance oxygen atoms: $Mg + O_2 \rightarrow 2MgO$

3. Balance magnesium atoms: $2Mg + O_2 \rightarrow 2MgO$

Another example:

Aluminum reacts with dilute hydrochloric acid to form aluminum chloride and hydrogen:

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

Reactivity of Metals:

Metals react differently with air, water, and dilute acids. The activity series ranks metals in descending order of reactivity.

Reactions of Metals with Air:

- Sodium reacts fast with air, forming sodium oxide:

$4Na + O_2 \rightarrow 2Na_2O$

- Magnesium reacts with air, forming magnesium oxide:

$2Mg + O_2 \rightarrow 2MgO$

Reactions of Metals with Water:

- Sodium reacts violently with water, forming sodium hydroxide and hydrogen:

$2Na + 2H_2O \rightarrow 2NaOH + H_2$

- Magnesium reacts with hot water, forming magnesium hydroxide and hydrogen:

$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$

- Zinc reacts with steam, forming zinc oxide and hydrogen:

$Zn + H_2O \rightarrow ZnO + H_2$

- Iron reacts with steam, forming iron(II,III) oxide and hydrogen:

$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

Reactions of Metals with Dilute Acids:

- Magnesium reacts with hydrochloric acid, forming magnesium chloride and hydrogen:

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

- Aluminum reacts with hydrochloric acid, forming aluminum chloride and hydrogen:

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

Reactions of Metals with Solutions of Other Metallic Salts:

- Zinc reacts with copper sulfate, forming zinc sulfate and copper:

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

Activity Series:

The activity series ranks metals by their reactivity, helping to identify methods of metal extraction, prevent corrosion, and select metals for electrochemical cells.

Extraction of Iron:

Iron is extracted from haematite (Fe_2O_3) in a blast furnace using coke and limestone. Reactions in the furnace include:

- Coke burns in air, forming carbon dioxide:

$C + O_2 \rightarrow CO_2$

- Carbon dioxide reacts with coke, forming carbon monoxide:

$CO_2 + C \rightarrow 2CO$

- Carbon monoxide reduces haematite, forming iron:

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Extraction of Gold:

Gold is extracted by sifting ore and using solvents to dissolve impurities. The metal is then precipitated by another metal.

Gases - Their Preparation, Properties, and Uses

Hydrogen (H_2):

- Physical properties: Lightest gas, combustible, slightly soluble in water, colorless, odorless.

- Preparation: Zinc reacts with dilute hydrochloric acid:

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

Oxygen (O_2):

- Physical properties: Higher density than air, supporter of combustion, slightly soluble in water, colorless, odorless.

- Preparation: Heating potassium permanganate:

$2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$

Carbon Dioxide (CO_2):

- Physical properties: Higher density than air, does not support combustion, slightly soluble in water, colorless, odorless.

- Preparation: Calcium carbonate reacts with dilute hydrochloric acid:

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Summary:

- Changes in matter can be physical (state changes) or chemical (new substances formed).

- Chemical reactions include combination, decomposition, single displacement, and double displacement.

- Chemical equations represent reactions and must be balanced.

- The activity series helps in understanding metal reactivity and extraction methods.

- Gases have specific preparation methods, properties, and uses.

Exercises:

1. Classify the following reactions: combination, decomposition, single displacement, or double displacement.

2. Write balanced chemical equations for the given reactions.

3. Explain the reactivity of metals with air, water, and dilute acids.

4. Describe methods of gas preparation and their properties.

5. Discuss the uses of hydrogen, oxygen, and carbon dioxide.

Rate of Reaction

Introduction:

The rate of reaction refers to how quickly a chemical reaction occurs. Various factors influence the rate of chemical reactions, including surface area, concentration, pressure, and the presence of catalysts. Understanding these factors can help control the speed of reactions for desired outcomes in various applications.

Surface Area of Reactants:

A large log of wood can burn more easily when it is split into smaller splints. Similarly, physicians advise chewing food well for easier digestion. This is because reactions between solids and liquids or gases occur on the surface of the solid. When a solid is broken into smaller pieces, the surface area increases, leading to more collisions between reactant particles.

Assignment - 17.2:

Consider a marble cube with a side length of 2 cm. If it is cut into 8 small cubes, each with a side length of 1 cm, the total surface area changes significantly.

- Surface area of one side of the large cube: 2 cm × 2 cm = 4 cm^2

- Total surface area of the large cube: 4 cm^2 × 6 = 24 cm^2

- Surface area of one side of a small cube: 1 cm × 1 cm = 1 cm^2

- Total surface area of one small cube: 1 cm^2 × 6 = 6 cm^2

- Total surface area of 8 small cubes: 6 cm^2 × 8 = 48 cm^2

This demonstrates that the surface area increases when a large cube is divided into smaller cubes. This increased surface area allows for more effective collisions between reactant particles, thus increasing the rate of reaction.

Activity 17.1:

To find out how the surface area of reactants affects the rate of a reaction, conduct the following experiment:

Requirements:

- Marble cube
- Dilute hydrochloric acid (HCl)
- Beaker
- Balance

Procedure:

1. Measure the surface area of a marble cube with a side length of 2 cm.
2. Calculate the total surface area when the cube is cut into smaller pieces.
3. Immerse both the large cube and the small cubes in dilute HCl and observe the reaction rate by the speed of gas bubbles evolution.

Observation:

The reaction rate is higher with the small cubes due to the increased surface area, confirming that a larger surface area leads to a faster reaction rate.

Concentration of Reactants:

The concentration of reactants also affects the rate of reactions. Conduct the following activity to investigate this effect:

Activity 17.3:

Requirements:

- Three pieces of cleaned magnesium ribbon of equal surface area
- Three test tubes

- Dilute hydrochloric acid (HCl)
- Water

Procedure:

1. Add 15 ml of water to each test tube and mark the water level with a rubber band.
2. Add 2.5 ml, 5.0 ml, and 7.5 ml of dilute HCl to the three test tubes, respectively, and fill each tube with water up to the marked level.
3. Introduce a piece of magnesium ribbon to each test tube and observe the speed of fizzing.

Observation:

The speed of gas bubble evolution is higher when the concentration of HCl is higher. This indicates that the rate of reaction increases with an increase in the concentration of hydrochloric acid. Higher concentration leads to more reactant particles in a unit volume, resulting in more collisions per unit time and a higher reaction rate.

Pressure of Gaseous Reactants:

The pressure of gaseous reactants can also affect the reaction rate. Higher pressure means a higher concentration of gas molecules in a given volume, leading to more frequent collisions and a faster reaction rate.

Example:

Consider two containers, A and B, with equal masses of gaseous reactants. The volume of container B is reduced compared to A, resulting in higher pressure in B. As a result, the rate of reaction in B is higher due to the increased number of collisions per unit time.

Catalysts:

Catalysts are substances that increase the rate of a reaction without being consumed during the reaction. They provide an alternative pathway with a lower activation energy for the reaction to occur.

Activity 17.4:

Requirements:

- Two test tubes
- Solution of fresh hydrogen peroxide (H_2O_2)
- 0.2 g of manganese dioxide (MnO_2)

Procedure:

1. Add equal volumes of fresh hydrogen peroxide solution to two test tubes.
2. Add 0.2 g of manganese dioxide to one of the test tubes.
3. Observe the speed of gas bubble evolution in both test tubes.

Observation:

The test tube with manganese dioxide shows a higher rate of gas bubble evolution. Manganese dioxide acts as a catalyst, increasing the rate of decomposition of hydrogen peroxide:

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

After the reaction, filter the solution, dry the residue, and weigh it to confirm that the mass of manganese dioxide remains unchanged, demonstrating that it has not been consumed during the reaction. Inhibitors are substances that reduce the rate of reactions.

Factors Affecting Rate of Reaction:

1. Temperature: Increasing the temperature increases the kinetic energy of the particles, leading to more frequent and energetic collisions, thus increasing the rate of reaction.

2. Nature of Reactants: Different substances react at different rates depending on their chemical nature. For example, sodium reacts faster with water than iron.

3. Surface Area: As demonstrated earlier, increasing the surface area of a solid reactant increases the rate of reaction.

4. Concentration: Higher concentration of reactants increases the rate of reaction due to more frequent collisions.

5. Pressure: In gaseous reactions, higher pressure increases the rate of reaction by increasing the concentration of gas molecules.

6. Catalysts: Catalysts increase the rate of reaction by providing an alternative pathway with lower activation energy.

Temperature and Rate of Reaction:

Conduct the following experiment to observe the effect of temperature on the rate of reaction:

Activity:

Requirements:

- Three beakers
- Sodium thiosulfate solution
- Hydrochloric acid (HCl)
- Water bath
- Thermometer

Procedure:

1. Place one beaker in a cold water bath, one at room temperature, and one in a hot water bath.
2. Add equal volumes of sodium thiosulfate solution and hydrochloric acid to each beaker.
3. Observe the time taken for the reaction to complete in each beaker.

Observation:

The reaction occurs faster in the hot water bath and slower in the cold water bath, demonstrating that increasing the temperature increases the rate of reaction.

Nature of Reactants:

Different reactants have different reaction rates. For example, sodium reacts rapidly with water, while iron reacts slowly. The nature of the reactants influences the energy required to break bonds and form new ones.

Example:

Sodium reacts vigorously with water:

$2Na + 2H_2O \rightarrow 2NaOH + H_2$

Iron reacts slowly with water:

$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

Importance of Reaction Rate:

Understanding reaction rates is crucial in various fields such as chemical manufacturing, pharmaceuticals, and environmental science. Controlling reaction rates can optimize production processes, enhance safety, and reduce environmental impact.

Exercises:

1. Explain the effect of surface area on the rate of reaction with a practical example.

2. Describe how the concentration of reactants influences the rate of reaction with an experiment.

3. Discuss the role of pressure in the rate of gaseous reactions.

4. Explain how catalysts affect the rate of chemical reactions with an example.

5. Differentiate between catalysts and inhibitors.

6. Describe an experiment to demonstrate the effect of temperature on the rate of reaction.

7. Explain why different reactants have different reaction rates with examples.

8. Discuss the importance of understanding reaction rates in industrial applications.

Summary:

- The rate of reaction is influenced by surface area, concentration, pressure, temperature, and catalysts.

- Increasing the surface area of reactants increases the reaction rate by allowing more collisions.

- Higher concentrations of reactants lead to more frequent collisions and faster reactions.

- Higher pressure increases the concentration of gas molecules, resulting in a higher reaction rate.

- Catalysts increase the reaction rate without being consumed by providing a lower activation energy pathway.

- Temperature increases the kinetic energy of particles, leading to more frequent and energetic collisions.

- Different reactants have different reaction rates depending on their chemical nature.

- Understanding these factors is essential for optimizing chemical processes and industrial applications.

Work, Energy, and Power

Work:

You have learned that an object is said to have done work if its position or shape changes under the action of a force applied on it. To investigate further about work, consider the following examples:

Example 1:

If we place an object on a horizontal plane and apply a constant force of 1 N on it until it moves a distance of 1 m along the direction of the force, the work done by the force is defined as one Joule (1 J).

Work done by a force = Magnitude of the force × Distance moved in the direction of the force.

Example 2:

If a constant force of 2 N acts on the object until it moves by 1 m in the direction of the force, then the work done on the object is 2 J.

Work done = Force × Distance = 2 N × 1 m = 2 J

Example 3:

The weight of an object is 40 N. What is the work done in lifting the object by a vertical distance of 2 m?

Work done = Force × Distance = 40 N × 2 m = 80 J

Energy:

Energy is the ability to do work. The unit for measuring energy is the same as the unit for measuring work, which is the Joule (J). We need energy to perform various tasks. Different forms of energy help us do work, including heat energy, electric energy, magnetic energy, mechanical energy, light energy, and sound energy.

Mechanical Energy:

Mechanical energy is of two types: potential energy and kinetic energy.

Kinetic Energy:

The energy possessed by an object due to its motion is known as kinetic energy. To demonstrate this, consider the following experiment:

Project an object (A) with a certain velocity along a horizontal floor so that it collides with a light trolley (B). After the collision, the trolley moves some distance before coming to rest. Project the object with a higher velocity and observe that the trolley moves a longer distance before coming to rest. The kinetic energy of the moving object is transferred to the trolley, setting it in motion. Kinetic energy depends on velocity and mass, and can be calculated using the equation:

Kinetic energy (E_k) = $1/2\ mv^2$

where m = mass of the object and v = velocity of the object.

Example 1:

The mass of an object is 6 kg. Calculate its kinetic energy when it is moving at a velocity of 4 m/s.

Kinetic energy = $1/2\ mv^2 = 1/2 \times 6 \times 4^2 = 48$ J

Example 2:

Calculate the kinetic energy of an object of mass 4 kg at an instant when it is moving with a velocity of 2 m/s.

Kinetic energy = $1/2\ mv^2 = 1/2 \times 4 \times 2^2 = 8$ J

Potential Energy:

The energy stored in an object due to its position or a change in its form is known as potential energy. When an object is lifted upwards by a certain distance, work is done on the object, and energy is stored as potential energy. This can be calculated using the equation:

Potential energy (E_p) = mgh

where m = mass of the object, g = gravitational acceleration, and h = vertical distance.

Example:

Find the gravitational potential energy of an object of mass 7.5 kg at a vertical height of 4 m.

Potential energy = mgh = 7.5 kg × 10 m/s^2 × 4 m = 300 J

Transformation of Energy:

Kinetic energy can transform into potential energy and vice versa. For example, when a child on a swing moves from the lowest point to the highest point, the kinetic energy decreases while the potential energy increases. At the highest point, all kinetic energy has transformed into potential energy. As the swing moves back, potential energy transforms back into kinetic energy.

Power:

Power is the amount of work done in a unit of time or the rate of doing work. It is calculated using the equation:

Power (P) = Work done (W) / Time taken (t)

Example 1:

The time taken to lift a mass of 5 kg to a height of 8 m is 10 s. Calculate the power.

Work done = Force × Distance = Weight × Height = 50 N × 8 m = 400 J

Power = Work done / Time = 400 J / 10 s = 40 W

Example 2:

What is the work done in a minute by a machine operating with a power output of 100 W?

Power = 100 W = 100 J/s

Time = 1 minute = 60 s

Work done = Power × Time = 100 J/s × 60 s = 6000 J

Summary:

- The work done by a force is equal to the product of the magnitude of the force and the displacement along the direction of the force.

- Energy is the ability to do work, and it is measured in Joules (J).

- Mechanical energy includes kinetic energy and potential energy.

- Kinetic energy depends on the mass and velocity of an object.

- Potential energy depends on the mass, gravitational acceleration, and height of an object.

- Power is the rate of doing work and is measured in Watts (W).

Exercises:

1. A child lifts a bag of mass 4 kg to a height of 1.5 m. What is the work done? ($g = 10\ m/s^2$)

2. If the child took 3 seconds to do the work above, what is the power?

3. A mass of 800 g is projected vertically upwards at a velocity of 20 m/s. Calculate the kinetic energy, time to reach maximum height, maximum height, and potential energy at maximum height.

4. A child of mass 35 kg climbs up a staircase to a vertical height of 4 m. Calculate the work done and the power if it took 1 minute to climb the stairs.

Energy and Its Forms:

Energy is a fundamental concept in physics and is essential for doing work. There are various forms of energy, each with unique properties and applications.

Heat Energy:

Heat energy is the energy transferred between objects due to a temperature difference. It can be harnessed for various purposes, such as heating homes, cooking food, and generating electricity in thermal power plants.

Electric Energy:

Electric energy is the energy carried by electric charges moving through a conductor. It is widely used for powering appliances, lighting, and industrial machinery.

Magnetic Energy:

Magnetic energy is the energy associated with magnetic fields. It is used in various applications, including electric motors, generators, and magnetic storage devices.

Light Energy:

Light energy is the energy carried by electromagnetic waves in the visible spectrum. It is essential for vision and is harnessed in technologies such as solar panels and lasers.

Sound Energy:

Sound energy is the energy carried by sound waves. It is used in communication, music, and medical imaging technologies like ultrasound.

Mechanical Energy:

Mechanical energy is the sum of kinetic and potential energy in an object. It is used in various mechanical systems, such as engines, turbines, and simple machines.

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Sound energy is the energy carried by sound waves. It is used in communication, music, and medical imaging technologies like ultrasound.

Mechanical Energy:

Mechanical energy is the sum of kinetic and potential energy in an object. It is used in various mechanical systems, such as engines, turbines, and simple machines.

Experiments and Activities:

1. Investigate the effect of surface area on the rate of reaction by comparing the reaction rate of a large marble cube and smaller cubes of the same material in dilute hydrochloric acid.

2. Study the effect of concentration on the rate of reaction by observing the speed of gas bubble evolution in different concentrations of hydrochloric acid with magnesium ribbon.

3. Explore the effect of temperature on the rate of reaction by conducting an experiment with sodium thiosulfate solution and hydrochloric acid at different temperatures.

4. Demonstrate the role of catalysts in increasing the rate of reaction by comparing the decomposition rate of hydrogen peroxide with and without manganese dioxide.

Applications of Energy:

1. Water stored in high reservoirs is allowed to fall to a lower level, transforming potential energy into kinetic energy, which is used to rotate turbines and generate electricity.

2. In construction, piles are lifted and released to compact the soil, transforming potential energy into kinetic energy.

3. Sledgehammers are used to break stones and cut firewood, with potential energy transforming into kinetic energy upon impact.

Understanding the various forms of energy and their applications is essential for harnessing and optimizing energy use in daily life and industrial processes.

Exercises:

1. Explain the effect of surface area on the rate of reaction with a practical example.

2. Describe how the concentration of reactants influences the rate of reaction with an experiment.

3. Discuss the role of pressure in the rate of gaseous reactions.

4. Explain how catalysts affect the rate of chemical reactions with an example.

5. Differentiate between catalysts and inhibitors.

6. Describe an experiment to demonstrate the effect of temperature on the rate of reaction.

7. Explain why different reactants have different reaction rates with examples.

8. Discuss the importance of understanding reaction rates in industrial applications.

Summary:

- The rate of reaction is influenced by surface area, concentration, pressure, temperature, and catalysts.

- Increasing the surface area of reactants increases the reaction rate by allowing more collisions.

- Higher concentrations of reactants lead to more frequent collisions and faster reactions.

- Higher pressure increases the concentration of gas molecules, resulting in a higher reaction rate.

- Catalysts increase the reaction rate without being consumed by providing a lower activation energy pathway.

- Temperature increases the kinetic energy of particles, leading to more frequent and energetic collisions.

- Different reactants have different reaction rates depending on their chemical nature.

- Understanding these factors is essential for optimizing chemical processes and industrial applications.

Current Electricity

Static electricity and current electricity:

Electricity is a very important form of energy to us. In the modern world, many instruments are manufactured in a way that they could be operated using electricity. Household equipment such as electric bulbs, electric irons, and electric fans are some examples. Electricity basically has two forms: static electricity and current electricity.

You have learned in grades 7 and 9 that static electricity consists of charges that are deposited on the surfaces of insulators and that they do not flow. Now let us investigate the behavior of static electricity.

Rub a drinking straw well with a piece of cotton material and bring it close to tiny bits of paper. You will observe that the bits of paper get attracted to the straw rubbed with the piece of cotton cloth. Also, bring another straw that was not rubbed with a cotton cloth close to tiny pieces of paper. You will notice that the bits of paper would not be attracted to the straw.

When some objects are rubbed, they acquire a force to attract little pieces of paper, dust, and other light materials. Such objects acquire this attractive power through the static electric charges generated by rubbing.

You have observed that objects such as a drinking straw or a comb attract tiny bits of paper only after rubbing them and if the objects are not rubbed, they cannot attract bits of paper.

How are static electric charges that give certain objects an attractive power generated? All materials are composed of atoms. Atoms consist of tiny particles known as electrons, protons, and neutrons. Protons are positively charged particles while electrons are negatively charged particles. Neutrons do not have a charge. They are neutral.

Protons and neutrons are found in the center of an atom known as the nucleus. Electrons are found rotating around the nucleus. Only electrons can be removed from an atom easily. If electrons are removed from the atoms on the surface of an object after rubbing it with a piece of cloth, positive charges are generated on the surface of the object. That is, the surface is positively charged. If the object receives electrons from the piece of cloth after being rubbed with the cloth, then the surface of the object acquires a negative charge. That is, the surface gets negatively charged.

Charges that are found stationary on an object in this manner are known as electrostatic charges. When such accumulated electrostatic charges begin to move, they give rise to an electric current.

Activity 19.1:

Items required: A piece of PVC tube, a piece of polythene, a neon bulb, conducting wires, a stand.

1. Arrange the set-up by connecting the conducting wires to the neon bulb. Connect one terminal of the neon bulb to the earth.

2. Charge the PVC rod by rubbing it with polythene.

3. Touch the terminal of the neon bulb with the charged rod.

4. Repeat the above steps several times and observe the lighting of the neon bulb.

Electrostatic charges are stored on the surface of the PVC rod rubbed by polythene. When it touches the conducting wires, the stored static charges begin to flow out via the conducting wires. When these charges flow through the neon bulb, it lights up. When static electric charges begin to flow in this manner, it is known as an electric current.

A current of electric charges flowing through a conductor is known as an electric current.

Electricity flowing through conductors:

Conductors are materials that allow a current of electrons to pass easily through them. All metals conduct electricity easily. All metals such as copper, aluminum, and iron are electric conductors. The electrons in the outermost shell of metallic atoms can be easily detached from the atom. A large number of such detached electrons from the outermost shell of metal atoms are in random motion in the regions between metal atoms. These electrons are known as free electrons.

The reason for electricity to flow easily through metals is the existence of free electrons. Let us consider the process that takes place when the ends of such a metallic conductor are connected to a dry cell.

The negative terminal of a cell has the ability to repel electrons. Its positive terminal has the ability to attract electrons. Therefore, whenever the positive and negative terminals of a cell are connected by a conductor, electrons begin to flow from the negative terminal of the cell to the positive terminal via the conductor. This flow of electrons is possible because of the presence of free electrons in metals. That is, the free electrons that are in random motion in a metal begin to move from the negative terminal of the cell to the positive terminal along the same direction as a result of connecting the electric cell.

The actual flow of electrons takes place from the negative to the positive terminals of the cell via the conductor. However, conventionally the direction of the electric current is considered to be in the opposite direction to that of the electron flow. That is, when an electron current flows from the negative to the positive terminal, a conventional electric current is said to flow from the positive to the negative terminal. The directions of the electric current flow and the electron flow are illustrated.

The SI unit used to measure the electric current is known as the Ampere (A) and the instrument used to measure electric current is known as the ammeter.

If we need to measure the current flowing through a conductor, it is necessary to connect the ammeter to the circuit in such a way that the entire current passing through the conductor passes through the ammeter as well.

Potential difference and electromotive force:

It is a well-known fact that the speed of water flow through pipelines is larger for water tanks positioned at higher locations. The reason for the higher flow speeds with higher positions of the tank is the larger pressure difference between the water tank and the place where the water is utilized.

The current flowing in an electric circuit is analogous to the water flow from a water tank. Here, the source of electricity acts like the water tank and the pressure difference between the two ends of a water-carrying tube corresponds to the electric pressure difference arising due to the electrons being pushed by the negative terminal of the source of electricity through the conductor.

This electric pressure difference is known as the potential difference. The unit used to measure the potential difference is the Volt (V). The force by which the negative terminal of the electric source releases electrons to the external circuit is known as the electromotive force (EMF).

The electromotive force of a cell is equal to the potential difference between the terminals of the cell when electricity is not drawn from the cell.

When an electric current is drawn from a cell, the current also passes through the cell itself. The cell too has an electric resistance. Then a potential difference arises across the resistance of the cell. When this potential difference is subtracted from the electromotive force of the cell, the potential difference that provides an electric current to the external circuit can be obtained.

Since the potential difference between two points in a circuit is measured in Volts, it is also known as the voltage.

The instrument used to measure the voltage is the voltmeter. In order to measure the potential difference between two points in a circuit, the two terminals of the voltmeter should be connected across the two points.

In order to verify that there should be a potential difference between the terminals of a cell for a current to flow, let us engage in the following activity.

Activity 19.2:

Items required: two dry cells, conducting wires, a voltmeter, an ammeter, a bulb.

1. There are three different ways to connect the two dry cells to the bulb. In all three ways, the voltmeter is used to measure the voltage across the bulb. The ammeter is connected to the circuit to measure the current passing through the bulb.

2. Connect the circuits as shown in each of the three circuit diagrams and observe the lighting of the bulb.

3. Record the potential difference across the bulb and the current passing through it for each circuit.

In the first instance, the positive terminals of the two cells are connected to the two terminals of the bulb. Therefore there is no potential difference across the bulb. As there is no potential difference, there won't be a current flow through the bulb. This will be evident from your observations.

In the second connection, the negative terminals of the two cells are connected to the terminals of the bulb. Here also there does not exist a potential difference across the battery and there won't be a current flow through the bulb.

In the third connection, the positive terminal of one cell and the negative terminal of the other cell are connected to the terminals of the bulb. Here, there will be a potential difference across the bulb and a current flow through the bulb only in the third connection.

From this activity, we can conclude that in order for a current to flow through a conductor, it is necessary for a potential difference to exist across it.

Relationship between the current flowing through a conductor and the potential difference across the conductor:

When a potential difference is applied across a conductor, a current flows through it. Let us now investigate whether there is a relationship between the current passing through a conductor and the potential difference across the conductor.

Activity 19.3:

Items required: a nichrome wire coil, a voltmeter, an ammeter, a rheostat, two dry cells, connecting wires, a switch.

1. The voltmeter is used to measure the voltage affecting the conductor (nichrome coil).

2. The ammeter is used to measure the current passing through the conductor (nichrome coil).

3. The rheostat is used to vary the current and the potential difference across the nichrome coil.

Connect the circuit using the items above.

1. Close the switch and quickly obtain the readings of the voltmeter and the ammeter and turn off the switch. The reason for quickly turning off the switch is to prevent the temperature of the nichrome coil from rising. It is essential to maintain a constant temperature throughout the activity.

2. After some time, adjust the rheostat, close the switch and take another set of readings.

3. Repeat the above steps to take at least five sets of readings.

By changing the current through the circuit using the rheostat, obtain readings for the potential difference across the nichrome coil and the current and tabulate the results.

Find the ratio Voltage (V)/Current (I) for each data set. You will observe a constant value for the above ratio if the temperature of the coil was maintained at a constant value.

This relationship was first discovered by the German scientist George Simon Ohm. This law is known as Ohm's law.

Ohm's Law:

When the temperature of a conductor remains constant, the current (I) passing through the conductor is directly proportional to the potential difference (V) across it. That is, at constant temperature, $I \propto V$. Therefore, V/I = constant. This constant is known as the electrical resistance of the conductor. The unit for measuring the resistance is the Ohm (Ω). That is, $V = IR$, where R is the resistance of the conductor.

The instrument used to measure the resistance is known as the Ohm meter.

If a graph is plotted using your data, with the voltage difference on the y-axis and the current on the x-axis, it will take the form shown.

Example 1:

A current of 1.5 A is flowing through a bulb which has a resistance of 6Ω. Find the potential difference across the bulb.

By applying V = IR for the bulb:

$V = 1.5 \times 6$

Voltage difference across the bulb = 9 V

1. When a bulb is connected to a 12 V power supply, a current of 0.5 A flows. What is the resistance of the filament of the bulb at that instance?

2. A nichrome wire coil has a resistance of 10 Ω. When it is connected to a power supply, a current of 0.6 A flows. What is the potential difference between the terminals of the power supply?

3. The resistance of a nichrome wire coil is 6 Ω. When it is connected to a power supply of 3 V, what is the current flowing through it?

Factors affecting the resistance of a conductor:

The resistance of a segment of a conductor depends on the following factors:

(i) Area of cross-section of the segment of the conductor.

(ii) Length of the segment of the conductor.

(iii) Material composition of the conductor.

Activity 19.4:

Items required: three segments of nichrome wire of length 1 m having different cross-sectional areas, a copper wire segment and several segments of iron wires with the same length as the nichrome wires and having a cross-sectional area equal to the nichrome wire with the lowest cross-sectional area, two dry cells, an ammeter, a switch, a board of wood with a length of about 1 m and a breadth of about 20 cm.

Connect the circuit using the items above. Connect the terminal X to the end of each conductor and record the current passing through each conductor.

In the above figure, the numbers indicate the following segments:

1 – nichrome wire with the largest cross-sectional area.

2 – nichrome wire with the medium cross-sectional area.

3 – nichrome wire with the smallest cross-sectional area.

4 – thin copper wire.

5 – thin iron wire.

6 and 7 – iron wires with unequal lengths.

(a) What conclusion can you draw from the readings obtained for the wires 1, 2, and 3?

(b) What can you conclude from the readings for the wires 3, 4, and 5?

(c) What can you say from the readings for the wires 5, 6, and 7?

According to Activity 4, it will be clear that the current flowing in each of the above instances is different. The reason for this is the differences in the resistances in each instance. According to this activity, three main factors that affect the resistance of a conductor can be stated:

(i) Area of cross-section of the conductor.

(ii) Length of the conductor.

(iii) Material of the conductor.

How each of them affects the resistance is mentioned below:

- The resistance decreases when the cross-sectional area is increased.

- The resistance increases when the length is increased.

- For wires having the same length and cross-sectional areas but made of different metals, the currents flowing for the same potential difference are different. The reason for this is the difference in the factor known as the “resistivity” which depends on the material.

Resistors:

In order to control the water flow through a tube, a tap can be used. What is done here is the use of an obstacle to control the water flow. The electric current flowing through a conductor can also be controlled in a similar manner. By increasing the resistance of a circuit, the current flow through the circuit can be decreased. In order to change the resistance of a circuit, many circuit components with various resistances that could be connected to the circuit have been found. They are known as resistors.

Activity 19.5:

Items required: A small torch bulb, a switch, resistors having resistances 5 Ω, 10 Ω, 20 Ω, connecting wires, two dry cells, an ammeter.

1. Connect the circuit shown.

2. Observe the brightness of the bulb by connecting each of the resistors between A and B. Record your observations.

In this activity, you will observe that the brightness of the bulb decreases as the resistor value increases. It will be clear that the current through a circuit decreases with the increase of resistance.

Types of resistors:

Various types of resistors with various values for the resistances have been invented. Let us consider a few such varieties:

1. Fixed value resistors.

2. Variable resistors.

3. Light-dependent resistors.

Fixed value resistors:

By depositing thin films of carbon on insulators or by winding a material with high resistance materials like nichrome, resistors having various values for the resistance are fabricated. Their resistances cannot be changed.

E.g.: fixed value resistors with resistances 10 Ω, 100 Ω, 1.2 kΩ.

Resistor color code:

Often, the value of a resistor is indicated in coded form by color bands marked on its body. The coding system of marking the resistor value using colored bands is known as the color code method.

Resistors with four color bands:

In this method, four color bands are marked on the resistor. Three of them are marked close together while the fourth one is marked slightly away from them. When the three closely spaced bands are placed to the left, the first two bands from the left indicate respectively the first and second digit of the value of the resistor.

The value assigned to each color is given in a table. In order to find the coded value of the resistor, the number given by the first two color bands should be multiplied by a power of ten. The power to which ten should be raised (index of the tenth power) is given by the value of the third band. The fourth band marked apart from the other three indicates the range that the resistor value can vary (tolerance interval).

Example:

A resistor with color bands brown, black, and red indicates a value of 1,000 Ω. The tolerance value of the resistor is 10%, meaning the true value of the resistor could range from 900 Ω to 1,100 Ω.

Variable resistors:

Resistors fabricated so as to allow a variation in the resistance as desired are known as variable resistors. The resistor value can be varied manually by turning a screw in the appropriate direction. There are many types of variable resistors such as pre-adjustment resistors, rheostats, and volume control resistors.

Light Dependent Resistors:

Light-dependent resistors (LDR) are fabricated using chemicals such as cadmium sulfide. The value of the resistance depends on the intensity of light. In the dark when the light intensity is low, these resistors have a high resistance. In the presence of light, their resistance decreases. Light-dependent resistors are used in control circuits of instruments that need to operate based on the amount of light falling on them.

Combination of resistors:

Resistors are used to control the current passing through a circuit as desired. When it is difficult to find a resistor with the required resistance, it is possible to use many resistors to obtain the required value. There are two basic methods of combining resistors:

1. Series combination of resistors.

2. Parallel combination of resistors.

Series combination of resistors:

When the resistors are connected in such a way that the same current flows through each of the resistors, it is known as a series combination of resistors. The equivalent resistance is the resistance of a single resistor that could be used in place of all the resistors in series. The equivalent resistance is equal to the sum of all the resistors.

Example:

A 10 Ω resistor and a 2 Ω resistor connected to a 6 V power supply have an equivalent resistance of 12 Ω. The current passing through the circuit is 0.5 A.

Parallel combination of resistors:

A combination of resistors in which the total current is divided among the resistors is known as a parallel combination of resistors. The reciprocal of the equivalent resistance of a parallel combination of resistors is equal to the sum of the reciprocals of each of the constituent resistors.

Example:

A 12 Ω resistor and a 6 Ω resistor connected in parallel have an equivalent resistance of 4 Ω. The current flowing through the circuit is 1.5 A.

Electric Shock:

Electric shock occurs when the human body becomes part of a path through which electrons can flow. A complete circuit and a voltage difference are necessary for current to flow.

Without two contact points on the body for current to enter and exit, there is no hazard of shock. These two points should also be of different voltages. This is why birds can safely rest on high-voltage power lines without getting shocked: they make contact with the circuit but the two points they touch have the same voltage.

A person standing on the ground and touching a live wire makes contact between two points in the circuit, the wire and the earth ground.

Ohm's Law and Electrical Safety:

"It's not voltage that kills, it's current!" is a common phrase heard in reference to electrical safety. However, electric current doesn't just occur on its own; there must be voltage available to motivate electrons to flow through a victim. A person's body also presents resistance to current, which must be taken into account. The amount of current through a body is equal to the amount of voltage applied between two points on that body, divided by the electrical resistance offered by the body between those two points.

Current = Voltage / Resistance ($I = V / R$)

More voltage difference between two points makes it easier for current to flow through any given amount of resistance. Hence, high voltage implies high potential for a large amount of current to flow through your body, which will injure or kill you.

Body resistance varies depending on how contact is made with the skin and other factors. Therefore, just how much voltage is dangerous depends on how much total resistance is in the circuit to oppose the flow of electrons.

Summary:

- By rubbing certain materials on one another, electrons are exchanged between them.

- An electric current is a flow of electric charges.

- The direction of the conventional current is from the positive terminal to the negative terminal.

- The potential difference between the two terminals of a cell when a current is not passing through it is known as the electromotive force of the cell.

- Ohm's law states that the current passing through a conductor is proportional to the potential difference across it when the temperature of the conductor is constant.

- The property that obstructs the flow of current through a circuit is its electrical resistance.

- There are two main methods of connecting resistors in a circuit: series connection and parallel connection.

- A single resistance equal to the total resistance of a system of resistors is known as the equivalent resistance.

Diversity Among Organisms

You know that there are large numbers of plant and animal species in the biosphere. One species can be identified separately from another species by observing their external features. This ability is due to inherited features. Inherited characters are the features that transmit from generation to generation. Although there are common characteristics for a species, all organisms belonging to a single species are not identical. For example, the body features of every human are not similar. There are many differences among them.

One can observe differences within species like cats and parrots. For example, rose and orchid plants in your home garden produce flowers of different colors and sizes. Tomato and brinjal plants also have fruits of different shapes.

Common Inherited Characteristics in Humans

Different common inherited characteristics observed in humans include skin color (complexion) – white, fair, dark, curly and straight hair, fused or free earlobes, the ability to fold the tongue, the position of the thumb when fingers are crossed, and dimpled and normal cheeks. Prepare a table using these inherited characteristics of your parents' relatives and identify characteristics and skills transmitted from generation to generation. Study whether you or any relative has a new characteristic not found in any previous generation.

It is revealed that most of the parents' characteristics pass to the next generations. However, new characteristics may appear, which may have been present in previous generations but were not expressed. Inherited characteristics can skip generations.

Some rare inherited characteristics include a straight and curved thumb, widow's peak on the forehead, syndactyly, polydactyly, albinism, and brown or blue eyes.

Transmission of inherited characteristics is common to all organisms. Other plants and animals also possess inherited characteristics.

Mendel’s Experiments on Inheritance

The first person to study the transmission of inherited characteristics was Gregor Mendel, an Austrian priest and a science graduate, honored as the father of genetics. Mendel used the garden pea (Pisum sativum) plant for his experiments in 1865 due to its special features: easy to grow, yields within a short time, pure breeding plants, presence of easily observable contrasting characters, naturally self-pollinating, and the ability to cross-pollinate.

Mendel observed seven contrasting characters and tested one character at a time. For example, he cultivated pure breeding tall and short plants. The tall plants were cross-pollinated with short plants, resulting in all tall plants in the F1 generation. Upon self-pollination of the F1 generation, the F2 generation showed a 3:1 ratio of tall to short plants. This indicated that the tall character was dominant and the short was recessive. Mendel's experiments showed that the recessive feature reappeared in the F2 generation.

Mendel’s Monohybrid Cross

Mendel used symbols to denote factors responsible for inherited characteristics. The dominant factor is denoted by a capital letter (T for tall) and the recessive by a simple letter (t for short). Pure breeding tall plants are denoted as TT, short plants as tt, and tall plants with a recessive short feature as Tt. Homozygous refers to similar factors (TT, tt), while heterozygous refers to different factors (Tt).

Mendel’s monohybrid cross of the pea plant for tall and short characters can be expressed using symbols and a Punnett square to show the occurrence of the F2 generation.

Probability in Inheritance

The inheritance pattern can be explained using probability. For example, the probability of getting heads or tails when tossing a coin is 1/2. The bead experiment can demonstrate probabilities using two coins at a time to find out Head – Head, Head – Tail, Tail – Head, Tail – Tail probabilities.

Activity

Divide the class into groups. Provide each group with two vessels containing a mixture of 50 white beads (W) and 50 red beads (R). Take out a bead from each vessel simultaneously and note the color of the beads using tally marks. Continue for 50 times and tabulate results. Calculate the probability of each combination (RR, RW, WR, WW) and find the ratio.

Gene Concepts in Inheritance

Mendel's experiments led to the understanding that features are determined by genes. If two genes are similar for a feature, the organism is homozygous (RR, rr). If different, the organism is heterozygous (Rr). The combination of a gene pair for a character is known as gene expression (Rr, rr, RR).

Phenotype and Genotype

The externally expressed feature is the phenotype, while the gene composition determining that feature is the genotype. For example, the phenotype of a round seed heterozygote is round (genotype Rr), a round seed homozygote is round (genotype RR), and a wrinkled seed homozygote is wrinkled (genotype rr).

Nature of Genetic Material and Genes

DNA in chromosomes acts as the genetic material transmitting features from generation to generation. Watson and Crick discovered the double helical structure of DNA in 1953. A gene is a specific base sequence in a DNA molecule responsible for a character.

Gene Linkage

A pair of chromosomes arranged in the same sequence are homologous chromosomes. An organism receives homologous chromosomes from its parents. A pair of genes determining a character are present in complementary locations of homologous chromosomes. Morgan discovered that genes in the same chromosome, which do not segregate independently, are linked genes.

Heredity in Humans

Transmission of inherited characters to the next generation is known as heredity. The process is inheritance. The behavior of genes and chromosomes during inheritance includes gene linkage and meiosis. Humans have 46 chromosomes, including 22 pairs of autosomal chromosomes and one pair of sex chromosomes. The sex chromosomes determine gender. Females have two X chromosomes, while males have one X and one Y chromosome.

Sex Determination in Humans

Sex determination involves the association of sex chromosomes during fertilization. A zygote with two X chromosomes produces a girl, while a zygote with X and Y chromosomes produces a boy. The factor determining a boy is received from the father.

Human Inherited Disorders

Genetic disorders due to sex-linked inheritance include haemophilia and red-green color blindness. Haemophilia, caused by a recessive gene on the X chromosome, results in blood that does not clot. Females can be carriers. Red-green color blindness is due to a recessive gene on the X chromosome, making it more common in males.

Gene Mutations and Related Disorders

Gene mutations, changes in the DNA of a chromosome, can result from various causes, including spontaneous occurrences, radiation, and chemicals. Disorders due to gene mutations include albinism and thalassemia. Albinism, caused by a mutation in a gene responsible for melanin production, results in white skin, hair, and eyelashes. Thalassemia, due to a mutation in a gene responsible for hemoglobin production, results in anemia.

Application of Inheritance Knowledge

Genetic principles have been applied to improve the quality of plants and animals. Examples include cows producing more milk, pest-resistant crops, and seedless fruits.

Genetic Engineering

Genetic engineering involves producing recombinant DNA by combining DNA fragments from different sources. Applications include weedicide-resistant crops, pest-resistant crops, vitamin A-enriched rice, cold-resistant tomatoes, and high-productivity cattle.

Industrial and Medical Applications

Gene technology is used in industrial applications, such as enzyme and amino acid production, and in medical fields, including insulin production, protein synthesis, antibiotic production, and gene therapy. DNA technology is also used in forensic medicine to confirm identity.

Summary

- Diversity among organisms is due to inherited features.
- Inherited features transmit from generation to generation.
- Within the same species, organisms possess differences.
- Genetics is the study of inherited character transmission.
- Gregor Mendel's experiments established the principles of inheritance.
- Characters are determined by genes, with one being dominant and the other recessive.
- Gene expression determines phenotype and genotype.

- DNA transmits features from generation to generation.

- The number of chromosomes is constant for a species.

- Homologous chromosomes have similar lengths, widths, and centromere locations.

- Linked genes do not segregate independently.

- Sex is determined by sex chromosomes during fertilization.

- Genetic disorders occur due to recessive sex-linked genes and DNA mutations.

- Genetic engineering has led to improvements in agriculture, industry, and medicine.

Exercise

1. Identify the correct genotype of a carrier female for red-green color blindness.
2. Determine the percentage of parental genotypes received by progeny in a BB x bb cross.
3. Explain how a child with a normal-complexion couple can have white skin using genetics knowledge.
4. Explain the impact of recombinant DNA technology on an organism's genotype and phenotype.
5. Describe how to determine the genotype of a green seed plant given a homozygous yellow seed plant.
6. Discuss the harmful effects of the human genome project on insurance firms.

Living Tissues

You have studied tissues as one of the organizational levels of multicellular organisms in grade 10. In this chapter, you will learn more about tissues.

1.1 Plant Tissues

Activity 1.1: Study of Plant Tissues

Materials required: Thin peel of the lower epidermis of a betel leaf, thin section of a potato tuber, thin cross-section of a stem of a plant like Balsam.

Method:

1. Prepare temporary slides using the above plant materials.
2. Observe them under a microscope.
3. Identify tissues formed by cells with the help of your teacher.

You may observe that plant tissues are of different forms. Animal tissues are also of different forms. It is observable that different cell types are present in living beings and similar cells are arranged together. A group of cells with a common origin that has been modified to perform particular functions in the body is known as a tissue.

Classification of Plant Tissues

Activity 1.2: Study of Tissue Organization in Plant Organs

Materials required: Prop root of Banion, Stilt root of Pandanus, Stilt root of Rampe.

Method:

1. Observe the external view of the growing tips of the above roots.

2. Use a hand lens to observe them.

From the above observation, we can identify the nature of a growing root. The growing part is soft and light-colored, while the mature part is rough and dark-colored. This is due to the nature of the tissues.

Plant tissues can be categorized using different criteria and can be divided into two groups based on the ability of cell division:

1. Meristematic Tissues

2. Permanent Tissues

Permanent tissues are found in mature regions and meristematic tissues in growing regions.

1.1.1 Meristematic Tissues

Meristematic tissues are tissues with cells that actively divide by mitosis to produce new cells. These cells are undifferentiated. The growth of plants takes place due to the activity of meristematic tissues.

Features of Meristematic Tissues:

- Consists of small-sized living cells

- No or minimal intercellular spaces

- Distinct nucleus in each cell

- Absence of large central vacuole but small vacuoles may be present

- Absence of chloroplasts

- Large number of mitochondria present

Types of Meristematic Tissues:

- Apical Meristems: Found in the shoot apex, root apex, and axillary buds, responsible for the increase in plant height.

- Intercalary Meristems: Found at nodes, responsible for the lengthening of internodes, common in grass family plants.

- Lateral Meristems: Present laterally in the stem and roots, responsible for the increase in plant diameter. Examples include cambium tissue in dicots.

1.1.2 Permanent Tissues

Activity 1.3: Identification of Different Types of Tissues in Plant Stems

Materials required: Pumpkin or Tridex plant stem, glass slide, microscope.

Method:

1. Observe the cross-section of the plant stem using a microscope.

2. Identify the different tissue types present in them.

Permanent tissues are those that have lost the ability to divide and have specialized to perform a particular function. Permanent tissues can be grouped into two categories:

- Simple Permanent Tissues: Consist of one type of cell.

- Complex Permanent Tissues: Consist of different types of cells.

Types of Simple Permanent Tissues:

- Parenchyma: Forms the soft parts of the plant body, most abundant tissue, living cells, isodiametric, large central vacuole, thin cell wall made of cellulose, intercellular spaces present.

- Collenchyma: Provides mechanical strength and support, modified parenchyma cells, living cells, elongated and polygonal in cross-section, thickened cell wall corners, may or may not have intercellular spaces.

- Sclerenchyma: Provides mechanical strength and support, dead cells, lignified cell wall, tightly packed cells, no intercellular spaces, evenly thickened cell wall forming a central lumen.

Locations and Functions of Simple Permanent Tissues:

- Parenchyma: Found in the cortex and pith of stems, fleshy parts of fruits, seeds, leaves. Functions include photosynthesis, food storage, water storage, and support.

- Collenchyma: Found in herbaceous stems and dicot leaves, providing mechanical support and carrying out photosynthesis in immature dicot stems.

- Sclerenchyma: Found in xylem (xylem fibers), phloem (phloem fibers), coconut fibers, and various fruit pericarps. Provides support.

Complex Permanent Tissues:

- Xylem: Composed of vessel elements, tracheids, fibers, and parenchyma cells. Functions include transportation of water and minerals, and mechanical support.

- Phloem: Composed of sieve tube elements, companion cells, phloem fibers, and phloem parenchyma. Functions include transportation of food throughout the plant body (translocation).

1.2 Animal Tissues

The animal body is also made up of different types of cells. For example, the human body is composed of about 210 different types of cells. Groups of cells with a common origin perform particular functions in multicellular animals. Main types of animal tissues include:

- Epithelial Tissue

- Connective Tissue

- Muscle Tissue

- Nervous Tissue

1.2.1 Epithelial Tissue

Epithelial tissue lines up the free surfaces (internal and external) of the vertebrate body. Some epithelial tissues are composed of a single layer of cells, while others have several cell layers.

Features of Epithelial Tissues:

- Cells placed on a basement membrane
- Tightly packed cells
- Nerve supply present within the tissue but no blood supply

Functions of Epithelial Tissue:

- Lining and protection of internal organs from pressure, friction, and microbes
- Absorption of digestive end products
- Perception of stimuli (taste and smell)
- Secretion of mucus in the respiratory tract
- Filtration in the nephrons

Examples of Locations of Epithelial Tissues:

- Wall of blood capillaries
- Thyroid gland
- Lining of nasal cavity
- Wall of the urinary bladder
- Skin (epidermis)

1.2.2 Connective Tissue

Connective tissue provides a connection between tissues and organs and offers support. It is composed of different types of cells and fibers embedded in a large matrix. Most connective tissues possess nerve and blood supply.

Examples of Connective Tissues:

- Blood Tissue: Special connective tissue with a fluid matrix (plasma) containing red blood cells (erythrocytes), white blood cells (leucocytes), and platelets. Functions include transportation of materials, protection through phagocytosis and antibody production, and maintenance of homeostasis.

- Bone Tissue

- Cartilage

1.2.3 Muscle Tissue

Muscle tissue is made up of muscle cells or fibers that possess contraction and relaxation abilities. Muscle tissue has a good blood supply, receiving oxygen and nutrients at a high rate. Muscle tissue acts as an effector in coordination responses.

Types of Muscle Tissue:

- Smooth Muscle Tissue: Found in the walls of organs with cavities (digestive tract, uterus, blood vessels, bladder). Features include spindle-shaped, unbranched cells with a central nucleus, no striations, and involuntary control.

- Skeletal Muscle Tissue: Associated with the skeletal system (biceps, triceps, leg muscles, facial muscles). Features include long, cylindrical, unbranched, multinucleate cells with striations, peripheral nuclei, and voluntary control.

- Cardiac Muscle Tissue: Exclusively found in the vertebrate heart. Features include uninucleate, striated, short cells with intercalated discs, rhythmic contractions, and involuntary control.

1.2.4 Nervous Tissue

Nervous tissue is essential in chordate bodies. The structural unit is the neuron, specialized for transmitting impulses.

Features of Neurons:

- Composed of cell body and nerve fibers
- Cell body contains the nucleus, mitochondria, Golgi body, and endoplasmic reticulum
- Axon transmits impulses away from the cell body
- Dendrites receive stimuli and transmit impulses to the cell body
- Myelinated axons increase the speed of impulse transmission

Functions of Neurons:

- Receiving information from receptors (eyes, ears, nose, tongue, skin) or another neuron and transmitting it to effectors (muscles) or another neuron

Types of Neurons:

- Sensory Neuron: Transmits impulses from sensory organs to the central nervous system
- Motor Neuron: Transmits impulses from the central nervous system to effectors (muscles)
- Interneuron: Connects sensory neurons with motor neurons

Summary

- Plant and animal tissues have different forms and functions.
- Plant tissues are categorized into meristematic and permanent tissues.
- Meristematic tissues are responsible for plant growth, while permanent tissues perform specialized functions.
- Animal tissues include epithelial, connective, muscle, and nervous tissues.
- Each type of tissue has specific features and functions crucial for the organism's survival and function.

Photosynthesis

Food is essential for the survival of all organisms. Food is obtained in many ways. Using knowledge about the modes of nutrition of living beings, we can classify organisms based on their nutritional methods. For example, cows and storks depend on other organisms for food, known as heterotrophic nutrition. Green plants, however, produce their food through autotrophic nutrition by synthesizing food within them. All living organisms depend on this food directly or indirectly for their existence.

Photosynthesis is the process through which green plants synthesize food using light energy, carbon dioxide, and water. This process occurs in chloroplasts, which contain the green pigment chlorophyll. Chlorophyll absorbs light energy, which drives the synthesis of glucose from carbon dioxide and water. The overall balanced chemical equation for photosynthesis is:

$6CO_2 + 6H_2O$ + Light energy, Chlorophyll $\rightarrow C_6H_{12}O_6 + 6O_2$

Factors that affect photosynthesis include chlorophyll, light energy, water, and carbon dioxide. Let us study how these factors influence the process.

Activity 2.1: Study of Chloroplasts in Plant Cells

Materials required: Hydrilla or Vallisneria leaves, a glass slide, a microscope

Method:

1. Observe a small section of a Hydrilla or Vallisneria plant leaf under the microscope.

2. Note how chloroplasts with chlorophyll move towards the direction of sunlight for photosynthesis.

Products of Photosynthesis:

The glucose produced during photosynthesis is temporarily stored in leaves as starch. Later, part of this starch is converted into sucrose and transported to other tissues via phloem. The sucrose transported to storage organs is again stored as starch. Examples of storage organs include fruits, vegetables, yams, leaves, and roots. The byproduct of photosynthesis, oxygen, is diffused into the atmosphere through stomata.

Activity 2.2: Test for Starch in Leaves

Materials required: Beaker, test tube, tripod, Bunsen burner, water, alcohol, plant leaf

Method:

1. Pluck a leaf from a plant exposed to sunlight and boil it in water.

2. Place the leaf in a boiling tube with alcohol and boil it in a water bath for a few minutes.

3. Wash the leaf and add a few drops of iodine solution to observe any color change.

Observation:

If the leaf turns blue or dark purple upon adding iodine, it indicates the presence of starch, confirming that photosynthesis has taken place.

Testing for Factors Required for Photosynthesis:

To demonstrate that light energy and carbon dioxide are necessary for photosynthesis, plants must be kept in the dark for 48 hours before the experiment to deplete stored starch from the leaves.

Activity 2.3: Light Energy Requirement for Photosynthesis

Materials required: Potted plant kept in the dark for 48 hours, black and colorless polythene strips, materials for starch test

Method:

1. Select two leaves (A and B) of the plant kept in the dark.

2. Cover part of leaf A with black polythene and part of leaf B with colorless polythene.

3. Place the plant in sunlight for 3-5 hours.

4. Conduct a starch test on the leaves as described in Activity 2.2.

Observation:

The covered area of leaf A shows no color change, while the covered area of leaf B turns dark purple or blue, indicating the presence of starch.

Conclusion:

Light energy is necessary for photosynthesis.

Activity 2.4: Carbon Dioxide Requirement for Photosynthesis

Materials required: Potted plant, materials for starch test, two polythene bags, KOH solution, water

Method:

1. Select two similar leaves (C and D) of the plant.

2. Add KOH solution to one polythene bag and water to the other. Insert leaf D into the bag with KOH and leaf C into the bag with water. Seal both bags.

3. Place the plant in sunlight for 3-5 hours.

4. Conduct a starch test on the leaves.

Observation:

Leaf D shows no color change, while leaf C turns dark purple or blue.

Conclusion:

Carbon dioxide is necessary for photosynthesis, as KOH absorbs CO_2, preventing photosynthesis in leaf D.

Activity 2.5: Chlorophyll Requirement for Photosynthesis

Materials required: Mosaic plant leaf (e.g., Hibiscus, Croton), white paper, materials for starch test

Method:

1. Pluck a mosaic leaf and draw a sketch of its pattern.

2. Conduct a starch test on the leaf.

Observation:

Green areas of the leaf turn dark purple or blue, while white areas show no color change.

Conclusion:

Chlorophyll is necessary for photosynthesis, as white areas lack chlorophyll and do not perform photosynthesis.

Experiment to Show Oxygen Production During Photosynthesis:

Materials required: Trough, boiling tube, glass funnel, aquatic plant (Hydrilla or Vallisneria), water

Method:

1. Add water to the trough and place the aquatic plant inside the funnel.

2. Fill a boiling tube with water and invert it over the funnel.

3. Place the setup in sunlight.

Observation:

Gas bubbles release from the aquatic plant and collect at the top of the boiling tube. A glowing splinter inserted into the tube burns with a bright flame, confirming the gas is oxygen.

Importance of Photosynthesis:

1. Photosynthesis converts light energy into chemical energy, producing food essential for all organisms.

2. Oxygen, necessary for aerobic organisms and combustion, is released during photosynthesis.

3. Photosynthesis removes excess carbon dioxide from the environment, maintaining the balance of oxygen and carbon dioxide in the atmosphere.

4. Photosynthesis supports the carbon cycle.

Summary:

- Light energy, water, carbon dioxide, and chlorophyll are required for photosynthesis.

- The main product of photosynthesis is glucose, with oxygen as a byproduct.

- Photosynthesis can be expressed by the balanced chemical equation:

$6CO_2 + 6H_2O + \text{Light energy, Chlorophyll} \rightarrow C_6H_{12}O_6 + 6O_2$

- Photosynthesis provides food for all organisms directly or indirectly, maintains atmospheric oxygen and carbon dioxide balance, and supports the carbon cycle.

Exercise:

1. Identify the main product of photosynthesis.

2. Determine the tissue involved in transporting photosynthesis products to storage organs.

3. Identify the type of food that translocates to storage organs.

4. Identify the gas emitted during photosynthesis.

5. Explain the energy conversion during photosynthesis.

Technical Terms:

- Photosynthesis: Process of converting light energy into chemical energy to produce food in plants.

- Chloroplasts: Organelles containing chlorophyll where photosynthesis occurs.

- Chlorophyll: Green pigment in chloroplasts that absorbs light energy for photosynthesis.

- Aquatic plants: Plants that grow in water and perform photosynthesis.

Mixtures

Understanding the different types of mixtures and their properties is crucial in chemistry. Mixtures are composed of two or more substances that are not chemically combined and can be separated by physical methods. Natural environments mostly contain mixtures rather than pure substances. Examples include air, soil, sea water, river water, and rocks. Additionally, many everyday items like drinks, ice cream, yoghurt, and fruit salad are mixtures.

Activity 3.1.1:

Materials required: Hydrated copper sulphate, naphthalene (moth balls), mortar, and pestle.

Method: Grind hydrated copper sulphate and naphthalene together in a mortar, mix well, and observe the resulting powder. This activity demonstrates that a blend of two or more pure substances forms a mixture, and the individual substances are known as components.

Activity 3.1.2:

Materials required: Two beakers, a glass rod, a funnel, filter paper, hand lens.

Method: Transfer the mixture made in Activity 3.1.1 into a beaker, add water, and stir. Filter the solution using a funnel and filter paper. Observe the residue and filtrate. The residue on the filter paper is naphthalene, and the filtrate is a blue copper sulphate solution, showing that the components of a mixture retain their chemical nature and can be separated by physical methods.

A mixture can be defined as matter consisting of two or more components not chemically combined and separable by physical methods.

Types of Mixtures:

- Homogeneous Mixtures: The composition of components is uniform throughout (e.g., salt solution).

- Heterogeneous Mixtures: The composition of components is not uniform throughout (e.g., clay in water).

Activity 3.1.3:

Materials required: A beaker, clay, water, a piece of cloth.

Method: Mix clay with water in a beaker, stir, and filter using a cloth. Observe the uniformity of the muddy water. The activity demonstrates the non-uniform distribution of components in heterogeneous mixtures.

Activity 3.1.4:

Materials required: A beaker, water, common salt, a piece of cloth.

Method: Dissolve salt in water, stir, and filter using a cloth. Observe the uniformity of the solution. This activity shows that homogeneous mixtures have uniform composition and properties throughout.

Classification of Mixtures:

- Homogeneous mixtures (solutions) have identical physical properties throughout.

- Heterogeneous mixtures have varying physical properties and components that can be distinguished.

Activity 3.1.5:

Materials required: Common salt, washing powder, laundry blue, copper sulphate, potassium permanganate, wheat flour, ethyl alcohol.

Method: Dissolve each substance in water and classify the resulting mixtures as homogeneous or heterogeneous.

Factors Affecting Solubility:

1. Temperature

2. Nature of the solute

3. Nature of the solvent

Activity 3.1.6:

Materials required: A beaker, salt, a glass rod.

Method: Dissolve salt in water until no more dissolves, and measure the remaining salt. This activity demonstrates the solubility of a solute in a solvent.

Activity 3.1.7:

Materials required: A beaker, calcium hydroxide, a glass rod.

Method: Dissolve calcium hydroxide in water and measure the remaining solid. Compare the solubility of calcium hydroxide with that of salt. The activity shows that different substances have different solubilities in the same solvent.

Homogeneous mixtures can also be classified based on the physical state of the components:

- Solid-liquid mixtures (e.g., salt in water)

- Liquid-liquid mixtures (e.g., alcohol in water)

- Solid-solid mixtures (e.g., brass)

- Gas-liquid mixtures (e.g., carbon dioxide in water)

Solubility of a Gas:

Factors affecting the solubility of a gas in water include temperature and pressure. The solubility of a gas decreases with an increase in temperature and increases with an increase in pressure.

Separation Techniques:

1. Mechanical Separation: Using physical properties like density, particle size, and magnetic properties.

2. Filtration: Using filters to separate suspended particles from liquids.

3. Crystallization: Separating solid substances from solutions by increasing concentration.

4. Recrystallization: Obtaining pure crystals from a solution by dissolving and re-forming crystals.

5. Solvent Extraction: Using solvents to extract substances based on their solubility.

6. Simple Distillation: Separating volatile components from non-volatile ones by vaporization and condensation.

7. Fractional Distillation: Separating components with different boiling points using controlled cooling.

8. Steam Distillation: Extracting volatile compounds from plant materials using steam.

Paper Chromatography:

Used to separate and identify components in a mixture. Components move at different rates based on their attraction to the stationary phase (paper) and the mobile phase (solvent).

Applications of Separation Techniques:

- Extracting salt from sea water using evaporation and crystallization.

- Obtaining essential oils from plants using steam distillation and solvent extraction.

- Identifying components in mixtures using chromatography.

Summary:

- Mixtures consist of two or more components not chemically combined.

- Homogeneous mixtures have uniform composition; heterogeneous mixtures do not.

- Solubility depends on temperature, nature of the solute, and nature of the solvent.

- Various methods are used to separate components of mixtures based on their physical and chemical properties.

Exercises:

1. Explain the meaning of mixture, homogeneous mixture, solvent, solute, solution, and solubility.

2. List two properties of a homogeneous mixture.

3. Explain the polarity of solvents and solutes.

4. Explain why jak latex cannot be washed away with water and why styrofoam dissolves in petrol.

5. Identify the physical property used to separate stones from rice.

6. Compare vaporization and distillation.

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- Fractional Distillation: Separating components with different boiling points using controlled cooling.

- Steam Distillation: Extracting volatile compounds from plant materials using steam.

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Waves and their Applications

You have seen the ripples formed when you drop a pebble onto a still water surface. The disturbance caused by the pebble spreads over the water surface in the form of circles centered around the point where the pebble hit the water surface. If you hold a rope horizontally and shake it up and down, you will observe ripples forming in the rope. Here, the disturbance caused by the hand travels along the rope. Such a disturbance propagating through a medium or space is known as a wave.

If you place an object like a plastic ball on the water surface and then disturb the water surface, you will observe that the plastic ball moves up and down perpendicular to the water surface. Energy must be transmitted to the ball for it to move up and down. Here, energy was transmitted to the ball through the water waves. An important property of waves is that they carry energy from one point to another without transmitting the substance of the medium between the points.

When a water wave travels on a water surface, the water particles at each point move up and down, but the water particles do not travel along with the wave.

Wave Motion

Waves propagate through a certain medium. The medium in the case of water waves is water, and the medium in the case of waves propagating along a rope is the material of the rope. The motion of the particles in each medium transmits energy in the form of waves through the medium even though the particles themselves do not travel along with the wave. Waves propagate through many other media as well.

Sound waves propagate through air, liquids, and solids. Light is an example of a wave that travels without a material medium. Light and heat from the sun arrive at the earth as electromagnetic waves, and a material medium is not required for their propagation. Radio waves are also electromagnetic waves, transmitting radio programs through air without requiring air for transmission.

Mechanical Waves

Wave motion can be studied using a slinky, a coil formed with steel wire. By placing a slinky on a table and shaking it left and right on the plane of the table, you will see a wave propagating through the slinky. This wave is an example of a wave that needs a medium for propagation, known as mechanical waves. Waves formed on water surfaces, sound waves that travel in air, and waves formed on a guitar string when plucked are examples of mechanical waves.

Mechanical waves require the participation of the particles in the medium. Based on the direction of motion of the particles of the medium and the direction of wave propagation, mechanical waves can be divided into two categories:

1. Transverse waves

2. Longitudinal waves

Transverse Waves

In transverse waves, the wave propagates in a direction perpendicular to the direction the particles of the medium move. Water waves are an example of transverse waves. When you disturb a water surface with a floating object, the object moves up and down, indicating that the water particles move vertically while the waves spread horizontally.

Longitudinal Waves

In longitudinal waves, the particles of the medium oscillate parallel to the direction of wave propagation. An example is sound waves generated in air by a tuning fork. When the fork vibrates, it creates compressions and rarefactions in the air, which propagate as sound waves. Longitudinal waves can propagate through solids, liquids, and gases.

Physical Quantities Associated with Wave Motion

Waves are disturbances that spread from one point to another. These disturbances have variations that depend on both time and distance. Simple forms of waves, known as sinusoidal waves, can be analyzed using graphs.

The maximum displacement shown by the particles taking part in wave motion is known as the amplitude of the wave. The distance between two particles in the same state of motion, such as two consecutive crests or troughs, is known as the wavelength (λ). The time taken by a particle for a complete oscillation is known as the period (T). The number of oscillations carried out by a particle in a unit time is known as the frequency (f), measured in Hertz (Hz). The speed of a wave is given by $v = f\lambda$.

Electromagnetic Waves

Electromagnetic waves consist of electric fields and magnetic fields that oscillate in directions perpendicular to each other, propagating in a direction perpendicular to both fields. They travel at the speed of 3×10^8 m/s in a vacuum. The electromagnetic spectrum includes various types of waves, such as gamma rays, X-rays, ultraviolet rays, visible light, infrared rays, microwaves, and radio waves.

Applications of Electromagnetic Waves

Visible light allows us to see. Gamma rays, emitted by radioactive elements, are used to destroy cancer cells and sterilize surgical instruments. X-rays are used for imaging internal organs and examining luggage at airports. Ultraviolet rays, present in sunlight, help produce vitamin D in the human body but can cause skin cancer with overexposure. Infrared radiation, emitted by heated bodies, is used in remote controls, heat photography, and physiotherapy. Microwaves are used in RADAR systems, mobile phones, and microwave ovens. Radio waves are used for long-distance communication.

Sound

Sound waves propagate through air, water, and solids. They are longitudinal waves that require a medium for propagation. The speed of sound in air at 0°C is about 330 m/s, increasing with temperature. The speed of sound in water is about 1400 m/s, and in steel, it is about 5000 m/s.

Characteristics of Sound

The main characteristics of sound are pitch, loudness, and quality. Pitch depends on the frequency of the wave, with higher frequencies producing higher pitches. Loudness depends on the amplitude of the wave, with larger amplitudes producing louder sounds. The quality of sound, or timbre, depends on the wave form and allows us to distinguish between different musical instruments playing the same note.

Musical Instruments

Musical instruments are classified into string instruments, percussion instruments, and wind instruments. String instruments produce sound through the vibration of strings, with pitch depending on the length, tension, and mass of the strings. Percussion instruments produce sound through the vibration of membranes, rods, or metal plates. Wind instruments produce sound through the vibration of air columns, with pitch depending on the length of the air column.

Hearing Range

The human ear can hear sounds with frequencies from 20 Hz to 20,000 Hz. Sounds below 20 Hz are called infra-sound, and sounds above 20,000 Hz are called ultrasound. Animals such as elephants can hear infra-sound, while bats and dolphins use ultrasound for communication and navigation.

Applications of Ultrasound

Ultrasound waves are used to measure the depth of the sea, investigate schools of fish, detect remnants of capsized ships, and examine internal organs of the human body through ultrasound scanning. Ultrasound is also used in medical treatments such as lithotripsy to blast bladder stones.

Summary

- Waves are disturbances that travel through a medium or space.
- Mechanical waves require a medium for propagation, while electromagnetic waves do not.

- Transverse waves propagate perpendicular to the direction of particle motion, while longitudinal waves propagate parallel to the direction of particle motion.

- The amplitude, wavelength, period, frequency, and speed are important physical quantities associated with waves.

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- Musical instruments generate sound through vibrations of strings, membranes, rods, metal plates, or air columns.

- The human ear can hear sounds with frequencies from 20 Hz to 20,000 Hz.

- Ultrasound waves have various applications, including medical imaging and treatment.

Exercises

1. Explain the meaning of mixture, homogeneous mixture, solvent, solute, solution, and solubility.

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

- Homogeneous mixture: A mixture with a uniform composition throughout.

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- Solution: A homogeneous mixture of two or more substances.

- Solubility: The ability of a solute to dissolve in a solvent.

2. List two properties of a homogeneous mixture.

- Uniform composition throughout.

- No visible boundaries between the components.

3. Explain the polarity of solvents and solutes.

- Polarity refers to the distribution of electrical charges within a molecule. Polar solvents, like water, have molecules with positive and negative ends (dipoles), which can dissolve polar solutes. Nonpolar solvents, like hexane, dissolve nonpolar solutes.

4. Explain why jak latex cannot be washed away with water and why styrofoam dissolves in petrol.

- Jak latex is nonpolar and does not dissolve in polar solvents like water. Styrofoam, a nonpolar substance, dissolves in nonpolar solvents like petrol.

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- The physical property used is size or density. Stones are denser and larger than rice grains, allowing separation by sieving or handpicking.

6. Compare vaporization and distillation.

- Vaporization is the process of converting a liquid into vapor. Distillation is a method of separating mixtures based on differences in boiling points, involving vaporization and subsequent condensation.

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- Concentration (c) = Amount of solute (n) / Volume of solution (V). The calculation depends on the given amounts of solute and solvent.

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- Essential oils like cinnamon oil, citronella oil, and eucalyptus oil are produced by steam distillation in Sri Lanka.

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Physics: Geometrical Optics

Light plays a crucial role in enabling us to see objects. We can only see an object if light from it reaches our eyes. Objects that emit light, like a candle flame or a light bulb, are called luminous objects. Our eyes receive light from these objects, making them visible to us. On the other hand, non-luminous objects do not emit light. We can see these objects when light from the Sun or an artificial source reflects off them and reaches our eyes.

Light interacts with objects in various ways. It passes through some objects, known as transparent objects (e.g., glass, polythene). Other objects, through which light does not pass at all, are called opaque objects (e.g., stones, bricks). Some materials allow light to pass through but scatter it in different directions, making it impossible to see through them clearly. These are known as translucent materials (e.g., tissue paper, oil paper).

A light ray is represented by a straight line with an arrow indicating its direction. A collection of light rays is called a light beam. There are different types of light beams:

- Parallel light beams: A bundle of parallel rays.

- Convergent light beams: A bundle of rays meeting at a point.

- Divergent light beams: A bundle of rays spreading out from a point.

Reflection of Light

Reflection occurs when light rays hit a surface and change direction. Plane mirrors, such as those on dressing tables, are familiar examples. When light rays strike a plane mirror perpendicularly, they reflect back along the same path. If a light ray hits the mirror at an angle, it reflects off the mirror at an equal angle. The line perpendicular to the mirror's surface at the point of incidence is called the normal.

There are two laws of reflection:

1. The incident ray, the reflected ray, and the normal all lie in the same plane.

2. The angle of incidence is equal to the angle of reflection ($i = r$).

When a point object is placed in front of a plane mirror, its image forms behind the mirror. This image is virtual, meaning no light rays actually pass through the image's location. Plane mirror images are virtual, identical to the objects, and laterally inverted (the right side of the object appears as the left side in the image).

Curved Mirrors

Curved mirrors, or spherical mirrors, have surfaces that are parts of spheres. There are two types of curved mirrors:

- Concave mirrors: The reflecting surface curves inward.

- Convex mirrors: The reflecting surface curves outward.

Key terms related to curved mirrors:

- Pole (P): The center point of the mirror.

- Center of Curvature (C): The center of the hypothetical sphere to which the mirror's surface belongs.

- Principal Axis: The line joining the pole and the center of curvature.

Focal Point of a Curved Mirror

For concave mirrors, parallel light rays converge at a point on the principal axis after reflection. This point is called the focal point (F). The distance between the pole and the focal point is the focal length (f). The distance between the pole and the center of curvature is the radius of curvature (r), which is twice the focal length.

Reflection from Concave Mirrors

1. Rays coming along the principal axis reflect back along the same path.

2. Rays parallel to the principal axis pass through the focal point after reflection.

3. Rays passing through the focal point reflect parallel to the principal axis.

4. Rays passing through the center of curvature reflect back along the same path.

5. Rays hitting the mirror at an angle reflect at an equal angle.

Images Formed by Concave Mirrors

The position, size, and nature of images formed by concave mirrors depend on the object's distance from the mirror:

- Object between the mirror and the focal point: The image is upright, virtual, and larger than the object.

- Object on the focal point: The image forms at infinity and is highly magnified and inverted.

- Object between the focal point and center of curvature: The image is real, inverted, and larger than the object, forming beyond the center of curvature.

- Object on the center of curvature: The image is real, inverted, and the same size as the object, forming at the center of curvature.

- Object beyond the center of curvature: The image is real, inverted, and smaller than the object, forming between the focal point and center of curvature.

- Object very far from the mirror: The image forms at the focal point, is real, inverted, and much smaller than the object.

Reflection from Convex Mirrors

Convex mirrors reflect light rays in a divergent manner, making the rays appear to come from a focal point behind the mirror. Images formed by convex mirrors are always virtual, upright, and smaller than the object.

Refraction of Light

Refraction occurs when light rays pass from one medium to another with different optical properties, causing the rays to bend. This happens because light travels at different speeds in different media. When light passes from a less dense medium (e.g., air) to a denser medium (e.g., water), it bends towards the normal. Conversely, when light passes from a denser medium to a less dense medium, it bends away from the normal.

Laws of Refraction

1. The incident ray, the refracted ray, and the normal lie in the same plane.

2. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant, known as the refractive index (n) of the second medium with respect to the first.

Total Internal Reflection and Critical Angle

When light travels from a denser medium to a less dense medium and the angle of incidence exceeds a certain value called the critical angle, the light reflects entirely back into the denser medium. This phenomenon is called total internal reflection. Optical fibers and prisms use total internal reflection to guide light effectively.

Lenses

Lenses are optical devices with curved surfaces that refract light to form images. There are two main types of lenses:

- Convex lenses (converging lenses): Thicker in the middle and thinner at the edges. They converge parallel light rays to a focal point.

- Concave lenses (diverging lenses): Thinner in the middle and thicker at the edges. They diverge parallel light rays away from a focal point.

Convex Lenses

Convex lenses have two focal points, one on each side. The focal length is the distance from the optical center to the focal point. The nature and position of images formed by convex lenses depend on the object's distance from the lens:

- Object between the lens and its focal point: The image is virtual, upright, and larger than the object.

- Object on the focal point: The image forms at infinity and is highly magnified.

- Object between the focal point and twice the focal length: The image is real, inverted, and larger than the object, forming beyond twice the focal length.

- Object at twice the focal length: The image is real, inverted, and the same size as the object, forming at twice the focal length.

- Object beyond twice the focal length: The image is real, inverted, and smaller than the object, forming between the focal length and twice the focal length.

- Object very far from the lens: The image forms at the focal point, is real, inverted, and much smaller than the object.

Concave Lenses

Concave lenses always form virtual, upright, and smaller images irrespective of the object's distance from the lens.

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Biological Processes in the Human Body

Various biological processes take place in the human body, each supported by specialized systems. This text provides a comprehensive explanation of these processes and the systems involved.

Food Digestion

Energy required for biological processes is obtained from food containing nutrients like carbohydrates, lipids, and proteins. These complex organic molecules must be broken down into smaller particles to be absorbed by the body. Digestion converts complex organic compounds into simple organic products.

Digestion occurs through mechanical and chemical processes. Mechanical processes alter the physical nature of food, such as breaking it down into smaller pieces using teeth. Chemical processes involve enzymes breaking down insoluble complex compounds into simpler molecules. For example, salivary amylase (ptyalin) converts starch into maltose in the mouth. Some nutrients, like mineral salts, certain vitamins, glucose, fructose, and galactose, are directly usable by the body without digestion.

The human digestive system, a continuous tube running from mouth to anus, includes various structures and glands (salivary glands, pancreas, liver) that supply enzymes and substances like bile. Functions of the digestive system include food digestion, absorption of digested end products, and elimination of undigested materials.

Human Digestive System

The digestive system begins at the buccal cavity, which includes structures like the lips, jaws, teeth, cheeks, and tongue. Three salivary glands in the buccal cavity secrete saliva, aiding in taste identification, food mixing, and swallowing. Salivary amylase in saliva partially digests starch into maltose, giving a sweet taste when chewing rice or bread.

Food then moves to the pharynx, a common area for the respiratory and digestive systems. The epiglottis, a movable organ above the trachea, closes off the trachea during swallowing, preventing food from entering it. The bolus (chewed food) is propelled through the oesophagus by peristaltic movements to the stomach.

In the stomach, the bolus is broken down into chyme through muscular contractions. Gastric juice, containing hydrochloric acid (HCl) and pepsin, facilitates protein digestion into polypeptides. In infants, renin coagulates milk. Digestion products like water, glucose, and certain drugs are absorbed in the stomach, while chyme, containing partially digested proteins, digested and undigested carbohydrates, undigested lipids, water, minerals, and vitamins, moves to the small intestine's duodenum.

The small intestine, about 7 meters long, is where most chemical digestion occurs, involving pancreatic and intestinal enzymes. Pancreatic juice, secreted into the duodenum, contains trypsin, amylase, and lipase. Bile from the liver, stored in the gall bladder, emulsifies lipids, increasing the surface area for enzyme action. Intestinal juice contains enzymes like maltase, sucrase, lactase, and peptidase, aiding further digestion.

Enzymes in Food Digestion in the Small Intestine

- Pancreas:
  - Trypsin: Proteins → Polypeptides
  - Amylase: Starch → Maltose
  - Lipase: Lipids → Fatty acids and glycerol
- Small Intestine:
  - Maltase: Maltose → Glucose
  - Sucrase: Sucrose → Glucose and Fructose
  - Lactase: Lactose → Glucose and Galactose
  - Peptidase: Polypeptides → Amino acids

Digestion products are absorbed in the small intestine, facilitated by its length, circular folds, villi, and microvilli. Thin epithelial lining and high vascularization enhance absorption efficiency. Monosaccharides, amino acids, vitamins, and mineral salts are absorbed into blood capillaries in the villi, while fatty acids and glycerol are absorbed into lacteals, entering the blood circulatory system. Unabsorbed materials move to the large intestine.

The large intestine, about 1.5 meters long, absorbs water from the material received from the ileum, forming semi-solid fecal matter. It consists of the caecum, appendix, colon, rectum, and anus. The appendix, a small tubular structure at the caecum's end, can become infected (appendicitis). The rectum stores fecal matter until it is expelled through the anus.

Digestive System Disorders

Common disorders include gastritis, constipation, typhoid, and diarrhea. Gastritis, or stomach lining inflammation, causes symptoms like acid regurgitation, burning sensation, and stomach pain. Constipation results from hard fecal matter due to low dietary fiber, inadequate water intake, or delaying defecation. Typhoid, caused by bacteria, leads to symptoms like headache, fever, and stomachache. Diarrhea, caused by infections, results in watery feces and dehydration.

Respiration

Respiration involves gas exchange between the external environment and the lungs, gas exchange in alveoli, and cellular respiration. The respiratory system facilitates oxygen intake and carbon dioxide expulsion.

Gas exchange between the environment and lungs is demonstrated by a bell jar model, where volume changes cause air to enter or exit balloons (representing lungs). The human respiratory system includes the nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles, and alveoli. The nasal cavity filters, warms, and humidifies inhaled air.

Inspiration and Expiration

During inspiration, inter-costal muscles contract, ribs move up, and the diaphragm contracts, increasing thoracic cavity volume and allowing air into the lungs. During expiration, inter-costal muscles relax, ribs return to position, and the diaphragm relaxes, decreasing thoracic cavity volume and expelling air from the lungs.

Gas Exchange in Alveoli

Inhaled air reaches alveoli, where oxygen diffuses into blood capillaries, and carbon dioxide and water vapor diffuse from blood into alveoli. This process occurs at the respiratory surface (alveolar walls), adapted for efficient gas exchange with thin, moist walls, a large surface area, and high vascularization.

Cellular Respiration

In cells, oxygen reacts with glucose, producing carbon dioxide, water, and energy (ATP). Aerobic respiration requires oxygen, while anaerobic respiration does not. Anaerobic respiration in yeast (alcohol fermentation) produces carbon dioxide and ethyl alcohol. In animals, it produces lactic acid, causing muscle pain during intense activity.

Excretion

Excretion removes metabolic waste products from the body. The urinary system, including kidneys, ureters, bladder, and urethra, filters blood to produce urine. Nephrons, the functional units of kidneys, perform ultrafiltration, selective reabsorption, and secretion.

Ultrafiltration occurs in the glomerulus, where high blood pressure forces fluid through capillary walls into Bowman's capsule. Selective reabsorption reclaims water, glucose, amino acids, vitamins, and some ions from the filtrate. Secretion adds waste materials to the filtrate, forming urine, which is stored in the bladder before excretion.

Kidney Disorders

Renal failure, nephritis, and kidney stones are common disorders. Renal failure impairs kidney function, requiring dialysis or transplantation. Nephritis, kidney inflammation, affects glomerular filtration, causing waste accumulation. Kidney stones, crystallized minerals, cause pain and may require surgical removal or lithotripsy.

Blood Circulation

Blood circulates oxygen, nutrients, and waste products throughout the body. Blood consists of plasma and corpuscles (RBCs, WBCs, and platelets). RBCs transport oxygen via hemoglobin. WBCs defend against infections. Platelets aid in blood clotting. Plasma contains water, proteins, nutrients, waste products, hormones, and gases.

The heart pumps blood through the pulmonary and systemic circulations. The cardiac cycle includes atrial and ventricular contractions and relaxation. Blood pressure is the force of blood against artery walls, measured as systolic and diastolic pressures.

Lymphatic System

The lymphatic system transports lymph, a fluid containing WBCs, and filters out harmful substances. Lymph nodes, scattered throughout the body, swell during infections. The lymphatic system aids in immune defense and maintains fluid balance.

Coordination and Homeostasis

Coordination involves the nervous and endocrine systems. The nervous system uses neurons to transmit impulses, while the endocrine system uses hormones. Neurons include sensory, motor, and inter-neurons. The central nervous system (brain and spinal cord) and peripheral nervous system (cranial and spinal nerves) coordinate responses.

The brain consists of the cerebrum, cerebellum, and medulla oblongata. The spinal cord transmits signals between the brain and body. Reflex arcs involve sensory neurons, inter-neurons, and motor neurons in quick responses.

The autonomic nervous system controls involuntary actions through the sympathetic (fight or flight) and parasympathetic systems.

Hormones regulate bodily functions, maintaining homeostasis (constant internal environment). Key processes include regulating blood glucose levels (insulin and glucagon), body temperature (hypothalamus), and water balance (ADH).

Summary

- Digestion converts complex food into absorbable products using enzymes.

- Respiration involves oxygen intake, carbon dioxide expulsion, and energy production.

- Excretion removes metabolic waste through organs like kidneys, skin, and lungs.

- Blood circulation distributes essential substances and protects against infections.

- The lymphatic system aids immune defense and fluid balance.

- Coordination and homeostasis are maintained by the nervous and endocrine systems, regulating internal conditions for optimal cellular function.

Chemistry: Acids, Bases, and Salts

Acids, bases, and salts are integral to various activities in our daily lives. To explore your prior knowledge about acids, bases, and salts, consider the following substances we frequently use: lime juice, Jeewani solution, antacid tablets, milk of magnesia, toothpaste, vinegar, salt, lime, soap, vitamin C tablets, and saline solution. Classify these as acids, bases, and salts.

Acids

In the classification exercise, lime juice, vinegar, and vitamin C are acids. Laboratory experiments often involve acids like hydrochloric acid (HCl), nitric acid (HNO_3), and sulfuric acid (H_2SO_4). The common characteristic of acids is that they release hydrogen ions (H^+) in an aqueous medium. For instance, hydrochloric acid ionizes in water as follows:

$HCl (aq) \rightarrow H^+ (aq) + Cl^- (aq)$

Acids are classified as strong or weak based on their ionization in water. Strong acids completely ionize, meaning all acid molecules dissociate into H^+ ions and corresponding negative ions. Examples include:

- Hydrochloric acid (HCl): $HCl (aq) \rightarrow H^+ (aq) + Cl^- (aq)$
- Sulfuric acid (H_2SO_4): $H_2SO_4 (aq) \rightarrow 2H^+ (aq) + SO_4^{2-} (aq)$
- Nitric acid (HNO_3): $HNO_3 (aq) \rightarrow H^+ (aq) + NO_3^- (aq)$

Weak acids partially ionize in water, leaving many unionized molecules. Examples include acetic acid (CH_3COOH), carbonic acid (H_2CO_3), and phosphoric acid (H_3PO_4).

Properties of Acids

Acids are corrosive, sour-tasting, and react with metals to produce hydrogen gas. For example, magnesium reacts with hydrochloric acid to form magnesium chloride and hydrogen gas:

$Mg (s) + 2HCl (aq) \rightarrow MgCl_2 (aq) + H_2 (g)$

Acids also react with carbonates to produce carbon dioxide, such as in the reaction between hydrochloric acid and calcium carbonate:

$CaCO_3 (s) + 2HCl (aq) \rightarrow CaCl_2 (aq) + H_2O (l) + CO_2 (g)$

Additionally, acids react with bases to form salts and water, turning blue litmus paper red. Examples of uses for common acids include hydrochloric acid for rust removal and gelatin production, sulfuric acid for fertilizer and battery acid production, and acetic acid for food processing and rubber coagulation.

Bases

Common bases include milk of magnesia, toothpaste, soap, and lime. Bases increase the hydroxyl ion (OH^-) concentration in aqueous solutions. Strong bases like sodium hydroxide ($NaOH$) and potassium hydroxide (KOH) completely ionize in water, while weak bases like ammonia (NH_4OH) partially ionize.

Properties of Bases

Bases are slimy to touch, react with acids to form salts and water, and turn red litmus paper blue. Examples of uses for bases include sodium hydroxide for soap and paper production, and magnesium hydroxide for antacids and molasses purification.

Identification of Acids and Bases by Indicators

Using indicators like litmus, methyl orange, and phenolphthalein, acids and bases can be identified. For example, hydrochloric acid turns blue litmus red, while sodium hydroxide turns red litmus blue. The pH scale, ranging from 0 to 14, indicates acidity or basicity, with 7 being neutral, values below 7 acidic, and above 7 basic.

Salts

Salts are products of acid-base reactions, such as sodium chloride ($NaCl$) from hydrochloric acid and sodium hydroxide:

$NaOH (aq) + HCl (aq) \rightarrow NaCl (aq) + H_2O (l)$

Salts can be acidic, basic, or neutral depending on the strength of the reacting acid and base. Most salts are crystalline solids, soluble in water, with high melting and boiling points. Examples include sodium chloride for food flavoring and preservation, and copper sulfate for fungicides and electroplating.

Neutralization

Neutralization is the reaction of H^+ ions from an acid with OH^- ions from a base to form water. This reaction eliminates the acidic and basic properties of the reactants, forming salt and water. Applications of neutralization include antacids for stomach acidity, lime to reduce soil acidity, and baking soda for bee stings.

Summary

- Acids release H^+ ions in aqueous solutions.
- Bases increase OH^- ion concentration in aqueous solutions.
- Acids react with bases to form salts and water.
- Strong acids and bases completely ionize in water, while weak ones partially ionize.
- Indicators help identify acids and bases, and the pH scale measures their strength.
- Neutralization reactions produce salts and water, with various practical applications.

Exercises

1. Complete the following sentences.

   i. Sodium hydroxide and hydrochloric acid react to form sodium chloride and water.

   ii. Calcium carbonate and hydrochloric acid react liberating carbon dioxide gas.

   iii. Potassium hydroxide and sulfuric acid react to form potassium sulfate and water.

iv. Nitric acid and magnesium hydroxide react giving magnesium nitrate.

v. Hydrochloric acid reacts with magnesium liberating hydrogen gas and forming the salt magnesium chloride.

2. You are provided with three unlabelled solutions of sodium hydroxide, dilute hydrochloric acid, and sodium chloride. You are given only blue litmus papers. Using only them, how do you identify the above three solutions?

- Sodium hydroxide will turn red litmus blue.
- Hydrochloric acid will turn blue litmus red.
- Sodium chloride will not change the color of either litmus paper.

3. Fill in the blanks with the solutions selected from the following list: H_2SO_4(aq), HCl (aq), NH_3(aq), H_2O(l), $Ca(OH)_2$(aq), CH_3COOH(aq)

i. $Ca(OH)_2$(aq) and NaOH turn red litmus blue.

ii. H_2SO_4(aq) and HCl(aq) act as strong acids.

iii. In NH_3(aq) and $Ca(OH)_2$(aq), pH is greater than 7.

iv. Vinegar used at home is diluted CH_3COOH(aq).

v. H_2SO_4(aq) causes severe burns on the skin when spilled.

vi. Calcium sulfate salt is formed by the reaction between H_2SO_4(aq) and $Ca(OH)_2$(aq).

4. Arrange the following solutions in ascending order of pH: sodium hydroxide, sulfuric acid, water, vinegar.

- Sulfuric acid, vinegar, water, sodium hydroxide.

5. Of the solutions dilute hydrochloric acid, dilute sodium hydroxide, and acetic acid, which does not react with sodium carbonate?

- Acetic acid.

6. When somebody comes into contact with the plant (kahambiliya), it causes itching and a severe burning sensation due to formic acid it contains. Suggest a suitable substance to apply on the skin to relieve that sensation.

- Apply a weak base like baking soda ($NaHCO_3$) to neutralize the formic acid.

Glossary

- Mixtures: Matter consisting of two or more components not chemically combined.

- Homogeneous Mixtures: Mixtures with uniform composition.

- Heterogeneous Mixtures: Mixtures with non-uniform composition.

- Solvent: The component in a solution present in a greater proportion.

- Solute: The component in a solution present in a lesser proportion.

- Solubility: The ability of a solute to dissolve in a solvent.

- Distillation: A process of separating components by boiling and condensing vapors.

- Fractional Distillation: Separating components with different boiling points using controlled cooling.

- Steam Distillation: Extracting volatile compounds from plant materials using steam.

- Chromatography: Separating and identifying components in a mixture using a stationary and mobile phase.

Chemistry: Heat Changes Associated with Chemical Reactions

Chemical reactions often involve changes in temperature, indicating the absorption or release of heat. This section explores the heat changes that accompany chemical reactions through various activities and explanations.

Activity 8.1: Dissolution of Sodium Hydroxide and Ammonium Chloride in Water

Materials required: Two small beakers (100 cm^3 each), a thermometer, a glass rod, solid sodium hydroxide ($NaOH$), and solid ammonium chloride (NH_4Cl).

Method:

1. Fill half a beaker with water and measure its temperature.

2. Add a small amount of solid sodium hydroxide to the water, stir with the glass rod, and measure the temperature again.

3. Repeat the process with another beaker, water, and solid ammonium chloride.

Observations:

- When solid sodium hydroxide dissolves in water, the temperature rises due to the release of heat.

- When solid ammonium chloride dissolves in water, the temperature falls due to the absorption of heat.

Explanation: The temperature change measures the heat evolved or absorbed. When sodium hydroxide dissolves, it releases heat into the water, making the reaction exothermic. Conversely, when ammonium chloride dissolves, it absorbs heat from the water, making the reaction endothermic.

Activity 8.2: Reaction Between Magnesium and Hydrochloric Acid

Materials required: A small beaker, a piece of magnesium strip, dilute hydrochloric acid, and a thermometer.

Method:

1. Add 10 cm^3 of dilute hydrochloric acid to a beaker and measure its temperature.

2. Add a 2 cm piece of magnesium ribbon to the acid and measure the temperature at the end of the reaction.

Observations:

- The temperature increases, indicating an exothermic reaction.

Explanation: Chemical reactions with heat evolution are exothermic. The reaction can be represented as:

$Mg (s) + 2HCl (aq) \rightarrow MgCl_2 (aq) + H_2 (g) + Heat$

In exothermic reactions, the energy content of products is less than that of reactants, as shown in an energy level diagram where energy is released.

Activity 8.3: Reaction Between Citric Acid and Sodium Bicarbonate

Materials required: A small beaker, citric acid solution, and sodium bicarbonate solution.

Method:

1. Add 10 cm^3 of citric acid solution to a beaker and record its temperature.

2. Record the temperature of the sodium bicarbonate solution.

3. Mix the solutions, stir, and note the temperature.

Observations:

- The temperature decreases, indicating an endothermic reaction.

Explanation: Endothermic reactions absorb heat. This can be represented by the equation:

Reactants + Heat → Products

In endothermic reactions, the energy content of products is greater than that of reactants, as illustrated in an energy level diagram where energy is absorbed.

Activity 8.4: Heat Change in the Reaction Between Sodium Hydroxide and Hydrochloric Acid

Materials required: 50 cm^3 of 2 mol/dm^3 sodium hydroxide solution, 50 cm^3 of 2 mol/dm^3 hydrochloric acid solution, two 100 cm^3 beakers, a thermometer (0-100°C range), a polystyrene cup, and a glass rod.

Method:

1. Measure 50 cm^3 of each solution into separate beakers.

2. Record the initial temperatures.

3. Mix the solutions in a polystyrene cup, stir with a glass rod, and record the maximum temperature.

Calculation:

The heat change (Q) is calculated using the equation:

$Q = mc\theta$

Where:

- m is the mass of the substance (100 g, assuming the density of water).

- c is the specific heat capacity (4200 J/kg°C).

- θ is the temperature change (10°C).

Thus,

$Q = 0.1 \times 4200 \times 10 = 4200$ J

Explanation: This experiment determines the heat evolved when 50 cm^3 of 2 mol/dm^3 NaOH reacts with 50 cm^3 of 2 mol/dm^3 HCl. The amount of heat evolved per mole can be calculated:

Heat per mole = 4200 J / 0.1 mol = 42,000 J/mol = 42 kJ/mol

This is the heat of the reaction between NaOH and HCl.

Exothermic reactions release heat (e.g., burning fuels, neutralization, cellular respiration). Endothermic reactions absorb heat (e.g., photosynthesis, thermal decomposition).

Summary

- Every chemical reaction involves a heat change.

- Exothermic reactions release heat to the surroundings.

- Endothermic reactions absorb heat from the surroundings.

- The amount of heat change can be calculated using $Q = mc\theta$.

Exercises

1. (a) Define exothermic and endothermic reactions.

   - Exothermic reactions release heat. Examples include burning of fuels and neutralization reactions.

   - Endothermic reactions absorb heat. Examples include photosynthesis and thermal decomposition.

   (b) Identify the type of reaction:

      1. Burning of a candle: Exothermic

      2. Putting a piece of sodium into water: Exothermic

      3. Dissolving urea in water: Endothermic

      4. Adding glucose to water: Endothermic

      5. Adding water to quicklime: Exothermic

   (c) Represent the reaction:

      $2\,Na\,(s) + Cl_2\,(g) \rightarrow 2\,NaCl\,(s)$

      using an energy level diagram indicating heat release.

      - In this reaction, the reactants (sodium and chlorine) have higher energy levels than the products (sodium chloride), and energy is released as heat.

2. A reaction between vinegar and lime water:

   - Given: 40 cm^3 vinegar, 60 cm^3 lime water, temperature increase by 10°C.

   - Calculate the heat change using:

     $Q = mc\theta$

     Where m = 100 g (assuming density of water), c = 4200 J/kg°C, θ = 10°C.

     $Q = 0.1 \times 4200 \times 10 = 4200$ J

   - Assumptions: No heat loss to surroundings, equal density and specific heat capacity as water.

- Reaction type: Exothermic. The increase in temperature indicates that the reaction releases heat to the surroundings.

Glossary

- Exothermic reaction: Reaction releasing heat.

- Endothermic reaction: Reaction absorbing heat.

Physics: Heat

Temperature

Daily weather reports often mention the lowest temperature reported from Nuwaraeliya and the highest from Trincomalee on a particular day. This highlights the importance of temperature, a fundamental property of any material object. For instance, an ice cube has a very low temperature, while warm water has a higher temperature than cold water. Our bodies also have a temperature, which allows us to perceive if an object's temperature is higher or lower than our body temperature by touch. Temperature is a measure of the mean kinetic energy possessed by the particles that form an object.

Measuring Temperature

Touching objects gives a rough idea of their temperature, but it is not accurate. Therefore, scientists developed devices to measure temperature accurately, known as thermometers. The first thermometer was invented by Galileo Galilei around 1600 A.D.

Glass-Mercury Thermometer

A glass-mercury thermometer consists of a narrow glass tube connected to a bulb containing mercury. As the temperature rises, mercury expands and moves up the tube, indicating the temperature on a marked scale. Mercury is commonly used due to its uniform expansion over a broad range of temperatures, good thermal conductivity, and liquid state over a wide temperature range (-39°C to 357°C). However, due to mercury's toxicity, its use is declining.

Glass-Alcohol Thermometer

A glass-alcohol thermometer is similar to a glass-mercury thermometer but uses ethyl alcohol (ethanol) instead of mercury. Ethanol's low melting point (-115°C) makes it suitable for measuring very low temperatures. It expands uniformly with temperature and is colored for visibility.

Digital Thermometer

Digital thermometers are widely used today. They utilize electrical properties such as resistance, which depends on temperature, instead of thermal expansion.

Temperature Scales

Three temperature scales are widely used: Celsius, Fahrenheit, and Kelvin.

Celsius Scale

The Celsius scale sets the melting point of ice (0°C) and the boiling point of water (100°C) as its fixed points, divided into 100 divisions.

Fahrenheit Scale

The Fahrenheit scale uses the melting point of ice (32°F) and the boiling point of water (212°F) as fixed points, divided into 180 divisions.

Kelvin Scale

The Kelvin scale is based on absolute zero (-273.15°C), the lowest temperature possible, where particles have zero kinetic energy. The Kelvin scale's zero point (0 K) is set at absolute zero, with each Kelvin unit equal to one degree Celsius.

Relationship between Celsius and Kelvin Scales

To convert Celsius to Kelvin, add 273 to the Celsius value. To convert Kelvin to Celsius, subtract 273 from the Kelvin value.

Example:

(i) How many divisions in the Kelvin scale equal one division in the Celsius scale?

- 1 Celsius division = 1 Kelvin division

(ii) To convert a temperature from Celsius to Kelvin, add 273.

- Example: 50°C = 50 + 273 = 323 K

(iii) To convert a temperature from Kelvin to Celsius, subtract 273.

- Example: 373 K = 373 - 273 = 100°C

Exercises

1. Convert the following Celsius temperatures to Kelvin:

   (i) 10°C → 283 K

   (ii) 27°C → 300 K

   (iii) 87°C → 360 K

   (iv) 127°C → 400 K

   (v) 100°C → 373 K

2. Convert the following Kelvin temperatures to Celsius:

   (i) 0 K → -273°C

   (ii) 100 K → -173°C

   (iii) 273 K → 0°C

   (iv) 373 K → 100°C

   (v) 400 K → 127°C

Heat

Heat is the energy transferred from one object to another due to temperature differences.

Activity 9.1: Heat Transfer

Materials: A heated iron block, a thermometer, a stirrer, a vessel with water at room temperature.

Method: Place a heated iron block in cold water and observe the temperature change.

Observation: The water temperature rises as heat transfers from the iron block, and the iron's temperature decreases until thermal equilibrium is reached.

Heat Capacity of an Object

Heat capacity is the amount of heat required to raise an object's temperature by one unit. It depends on the substance and its mass. Specific heat capacity is the amount of heat needed to raise the temperature of one kilogram of a substance by one degree.

Finding the Quantity of Heat

The quantity of heat (Q) required to change the temperature of a mass (m) by a certain amount (θ) can be calculated using the formula:

$Q = mc\theta$

Where c is the specific heat capacity.

Examples:

1. Calculate the heat required to increase the temperature of 2 kg of water by 10 K. Specific heat capacity of water is 4200 J/kg·K.

   $Q = 2 \times 4200 \times 10 = 84,000$ J

2. A 500 g aluminum block requires heating from 30°C to 50°C. Specific heat capacity of aluminum is 900 J/kg·°C.

   $Q = 0.5 \times 900 \times (50 - 30) = 9000$ J

3. If 20,000 J of heat is transferred to 2 kg of copper at 30°C, what is the final temperature? Specific heat capacity of copper is 400 J/kg·K.

   $20,000 = 2 \times 400 \times \theta$

   $\theta = 25°C$

   Final temperature = 30°C + 25°C = 55°C

Change of State of Matter

Matter changes state when it absorbs or releases heat. Melting point is the temperature at which a solid turns into a liquid. Freezing point is the temperature at which a liquid solidifies. Boiling point is the temperature at which a liquid turns into vapor.

Latent Heat

Latent heat is the heat absorbed or released during a change of state without changing temperature. Specific latent heat of fusion is the heat required to convert 1 kg of a solid into a liquid at its melting point. Specific latent heat of vaporization is the heat required to convert 1 kg of a liquid into vapor at its boiling point.

Evaporation and Vaporization

Vaporization can occur through boiling or evaporation. Evaporation occurs at temperatures below the boiling point and is important in processes like drying clothes and perspiration.

Thermal Expansion

Thermal expansion is the increase in an object's dimensions due to temperature rise. Solids, liquids, and gases expand when heated.

Expansion of Solids

Activity: Heat a metal ball and observe if it can pass through a ring. It expands when heated and contracts when cooled.

Application: Fitting iron rims to wooden wheels, gaps in railways, and loosening tight metallic lids.

Expansion of Liquids

Activity: Heat colored water in a test tube and observe the liquid level rise due to expansion.

Application: Thermometers use the expansion of liquids like mercury or alcohol.

Expansion of Gases

Activity: Place an empty plastic bottle in ice, attach a balloon, and then place the bottle in hot water. The balloon inflates due to the expansion of air.

Observation: Air expands when heated and contracts when cooled.

Heat Transfer

Heat transfers from a higher temperature to a lower temperature through conduction, convection, or radiation.

Conduction

Heat transfer through solids, primarily metals, occurs via conduction. Good conductors include silver, copper, and aluminum, while insulators include wood and plastic.

Convection

Convection occurs in fluids (liquids and gases) where heated particles move upwards, creating convection currents.

Example: Sea breeze and land breeze formation due to temperature differences between land and sea.

Radiation

Heat transfer by radiation occurs without a medium, through electromagnetic waves. Examples include heat from the sun and warmth from a fire.

Summary

- Temperature measures the mean kinetic energy of particles.

- Thermometers measure temperature in Celsius, Fahrenheit, or Kelvin.

- Heat is the energy transferred due to temperature differences.

- Heat capacity and specific heat capacity are measures of the heat required to change an object's temperature.

- Latent heat is absorbed or released during state changes without temperature change.

- Thermal expansion occurs in solids, liquids, and gases when heated.

- Heat transfers by conduction, convection, and radiation.

Exercises

1. Fill in the blanks:

   (i) The international unit for temperature is Kelvin, and for heat is Joules.

   (ii) Absolute zero is -273°C.

   (iii) Temperature does not change when absorbing latent heat, but state changes.

   (iv) Heat transfer without a medium is radiation.

   (v) Bodies with low specific heat capacities increase temperature quickly, those with high capacities increase temperature slowly.

2. Cooling curves of two cups of tea:

   (i) Temperature of tea in cup A after five minutes.

   - Suppose the initial temperature of both cups is 80°C, and after five minutes, cup A is at 60°C, while cup B is at 70°C.

   (ii) Time taken for tea in cup B to drop by 30°C.

   - If it takes 20 minutes for cup B to drop by 30°C from 80°C to 50°C.

   (iii) Difference in temperatures of tea in both cups after 15 minutes.

   - If cup A is at 40°C and cup B is at 50°C after 15 minutes, the difference is 10°C.

   (iv) Cup with lower heat conductivity.

   - Cup B has lower heat conductivity as it retains heat longer.

   (v) Reason for above.

   - Lower heat conductivity in cup B means less heat is lost to the surroundings.

   (vi) Ultimate temperature of tea in both cups.

   - Both cups will eventually reach room temperature, say 25°C.

3. Thermos flask:

(i) Uses of a thermos flask.

- Keeps liquids hot or cold for extended periods.

(ii) Techniques to prevent heat loss in a flask with 500 ml of water at 100°C.

- Use of double-walled glass with vacuum, silver coating to reflect radiation, and tight stopper to prevent convection.

(iii) Calculate heat loss when water cools to 25°C. Specific heat capacity of water is 4200 J/kg·K.

- $Q = mc\theta = 0.5 \times 4200 \times (100 - 25) = 0.5 \times 4200 \times 75 = 157{,}500$ J

(iv) Reason for not switching hot water with cold water immediately.

- Sudden temperature change may cause the glass to crack due to thermal shock.

4. Heat calculations:

(i) Heat released when 10 g of water at 100°C cools to 25°C.

- $m = 0.01$ kg, $c = 4200$ J/kg·K, $\theta = 100 - 25 = 75$°C

- $Q = mc\theta = 0.01 \times 4200 \times 75 = 3150$ J

(ii) Explanation why steam burns are more harmful than boiling water burns.

- Steam contains more heat due to latent heat of vaporization, causing more severe burns than boiling water at the same temperature.

5. Paraffin experiment:

(i) Room temperature.

- Assume 25°C.

(ii) Melting point of paraffin.

- Assume 60°C.

(iii) Time for paraffin to begin melting.

- Suppose it begins melting at 2 minutes.

(iv) Reason for constant temperature between 2-3 minutes.

- The heat is used for the phase change from solid to liquid, maintaining a constant temperature.

(v) Sketch temperature variation if heating stopped at 4 minutes.

- The temperature will rise steadily until 60°C, remain constant between 2-3 minutes, then continue rising after 3 minutes if heating continues.

Physics: Power and Energy of Electric Appliances

We use electric energy to perform various tasks in our daily lives. On all these occasions, electric energy is converted into another form of energy to meet our needs. This energy conversion happens in various electric appliances. The instruments used for these energy conversions are known as electric appliances. The main forms of energy conversions that take place in some electric appliances used in daily life include:

- Induction cooker: Electric energy to heat
- Microwave oven: Electric energy to heat
- Electric motor: Electric energy to kinetic energy
- Electric heater: Electric energy to heat
- Electric oven: Electric energy to heat and light
- Fluorescent light: Electric energy to light
- Television set: Electric energy to light and sound
- Radio set: Electric energy to sound

In some electric appliances, after the first energy conversion, another energy conversion also takes place, and we use that energy. For example, in a filament bulb, electric energy is initially converted into heat, which increases the temperature of the filament, resulting in the emission of light. In fluorescent lights, electric energy is first converted into ultraviolet radiation, which is next converted into visible light.

Power Output of an Electric Appliance

Power is the work done in a unit time. It is the rate at which work is done or energy is consumed. The rate of energy consumption (P) by an electric appliance operated with a voltage (V) and drawing a current (I) is given by the equation:

Power = Voltage × Current

$P = VI$

When the voltage (V) is measured in volts (V) and the current (I) in amperes (A), the power (P) is given in watts (W).

Example 1

When a filament bulb is connected across a voltage difference of 12 V, a current of 2 A flows through it. The power of the bulb is calculated as:

$P = VI = 12 \times 2 = 24$ W

The power of the bulb is 24 W.

Example 2

An electric oven operates under a 230 V power supply. If it has a power output of 2000 W, the current drawn when the oven is working can be found as:

$P = VI$

$\therefore 2000 = 230 \times I$

$\therefore I = 2000 / 230 = 8.69$ A

The current drawn by the oven is 8.69 A.

In the heating coils (heating elements) of electric ovens, the energy consumed is converted only into heat. In some other appliances, part of the electric energy is converted into heat due to their internal resistance, while the remaining part is converted into other forms of energy.

Electric Energy Consumed by Electric Appliances

Power is the rate of consumption of energy or the energy consumed in a unit time by an electric appliance. Therefore, the total energy consumed by an electric appliance depends on the time duration that it operates. If the energy consumed during a unit time interval is P, the total amount of electric energy consumed in a time (t) is Pt. If the total energy consumed is E:

$E = Pt$

When P is measured in watts (W) and the time (t) in seconds (s), the electrical energy (E) is given in joules (J). Since P = VI, substituting VI for P:

$E = Pt = VIt$

Total Energy = Voltage × Current × Time

Example 1

The power of the headlight of a motor car is 50 W. Find the energy consumed when this lamp is operated for 1.5 hours:

$E = Pt = 50 \times 1.5 \times 60 \times 60 = 270{,}000$ J

The amount of energy consumed is 270,000 J.

Example 2

A 6 V bicycle electric bulb draws a current of 0.6 A. What is the power consumed in lighting this bulb for five minutes?

$E = VIt = 6 \times 0.6 \times 5 \times 60 = 1080$ J

The total electric energy consumed is 1080 J.

Efficiency of Electric Appliances and Conserving Power

In many instances, the same purpose can be achieved using various different appliances. Choosing a more efficient appliance helps save energy. For example, filament bulbs, LED bulbs, fluorescent light tubes, and CFL lights (compact fluorescent lights) can all be used for illumination. Table 10.1 compares the power output and life spans of various types of bulbs:

- Filament bulbs: 60 W, 1200 hours
- Fluorescent tubes: 22 W, 3000 hours
- CFL bulbs: 11-13 W, 8000 hours

- LED lights: 6-8 W, 50,000 hours

It is advantageous to use LED bulbs as light sources. However, the use of LED bulbs in some regions is limited due to their high initial cost. Similarly, the efficiencies of cookers used to prepare food vary. Old cookers that use heating coils are the least efficient, while emersion heaters are highly efficient for heating water. Microwave ovens and induction cookers are also efficient, with induction cookers generating heat only at the bottom of the cooking utensil.

Home Electric Circuits

Electric energy required to operate home electric appliances is obtained from the national electric grid. Electric energy generated by power stations is raised to high voltages (132 kV or 220 kV) using step-up transformers and distributed throughout the island. In distribution sub-centers, these high voltages are lowered to 33 kV or 11 kV and finally to 230 V before supplying to households. Electricity provided to houses is in the form of alternating current with a frequency of 50 Hz.

Electricity is supplied to houses using a service cable consisting of two wires: the live wire and the neutral wire. The current flowing through these wires is provided to the electric appliances through a circuit inside the house.

Components of a Domestic Electric Circuit

1. Overload Circuit Breaker (or Service Fuse): Disconnects power to the house when a current above the limit passes through it. Only the live wire is disconnected by the overload circuit breaker or service fuse.

2. Electricity Meter: Records electric energy consumption in kilowatt hours (kWh). Live and neutral wires are connected to the meter.

3. Isolator (or Main Switch with Main Fuse): Disconnects both live and neutral wires. Acts as a high-current circuit breaker, disconnecting the home circuit from power mains.

4. Residual Current Circuit Breaker (RCCB or Trip Switch): Protects residents from electric shocks by automatically disconnecting the circuit when there is a current leak.

5. Distribution Box: Distributes electricity inside the house through lighting circuits and plug circuits. Equipped with miniature circuit breakers (MCBs) that disconnect circuits when a current larger than the maximum allowable current flows.

6. Switches and Plug Sockets: Allow turning on/off power to electric bulbs and connecting appliances to the circuit. Plug sockets are connected to the live, neutral, and earth wires.

7. Connecting Wires: Copper wires with suitable cross-sectional areas are used to carry currents. Live wires are identified by brown covers, neutral wires by blue covers, and earth wires by green covers.

Domestic Electric Circuit

Bulbs and plugs in a domestic circuit are connected in parallel. All switches should be connected to the live wire to prevent electric shocks when the switch is off. Plug circuits are often connected as ring circuits, allowing current to flow through two wires.

Protective Measures in Domestic Circuits

1. Residual Current Circuit Breaker (RCCB): Disconnects power supply in case of current leakage or electric shock.

2. Fuses or MCBs: Prevent large currents from flowing through domestic circuits.

Safety Precautions:

- Use appropriate fuses for 6 A and 13 A currents.

- Avoid connecting multiple high-current appliances to a single plug socket.

- Use rubber slippers or carpets when using electric irons.

- Turn off the overload circuit breaker or main switch before changing bulbs in bathrooms.

- Disconnect plugs when appliances are not in use.

- Unplug electrical devices during strong lightning strikes.

- Avoid using electric devices with wet hands.

- During power failures, keep appliance switches off.

- Disconnect power supply during fires.

- Perform maintenance work by trained electricians.

- Test RCCB functionality regularly.

Measuring Electric Energy in Kilowatt Hours

Electric energy is measured in kilowatt hours (kWh) by the domestic electricity meter. One kilowatt hour is the amount of electric energy consumed during one hour by an appliance with a power consumption of 1 kW.

1 kWh = 1000 W × 1 × 60 × 60 s = 3,600,000 J

To calculate the energy consumed by domestic appliances:

Number of kWh = (number of Watts × number of hours) / 1000

Example 1:

If four 100 W bulbs are used for 3 hours and five 60 W bulbs are used for 4 hours daily, the monthly electricity consumption is:

Energy consumed by 4 bulbs of 100 W = 100 × 4 × 3 Wh

Energy consumed by 5 bulbs of 60 W = 60 × 5 × 4 Wh

Total energy consumed in a month = (100 × 12 + 60 × 20) × 30 Wh

= (1200 + 1200) × 30 Wh

= 2400 × 30 / 1000 kWh = 72 kWh

Exercises

1. The power of an electric water pump is 750 W.

(a) Calculate the current drawn by the motor if it is connected to a 230 V supply.

$P = VI \rightarrow 750 = 230 \times I \rightarrow I = 750 / 230 \approx 3.26$ A

(b) State one type of energy, other than kinetic energy, generated when the motor is operating.

Answer: Heat energy.

2. Specifications of a flashlight bulb are given as 2.5 V and 0.3 A.

(a) What is the power of this bulb?

$P = VI = 2.5 \times 0.3 = 0.75$ W

(b) If the efficiency of emitting light from this bulb is 42%, what happens to the remaining 58%?

Answer: The remaining 58% is converted to heat.

3. The power of the two headlamps of a motor vehicle is 50 W each. There are two other lamps in the rear with 10 W each. If all these bulbs are lighted up for 1/2 hour, calculate the quantity of electrical energy spent.

Total power = 2×50 W + 2×10 W = 100 W + 20 W = 120 W

Energy spent = Power × Time = 120 W × 0.5 h = 60 Wh

4. The current flowing through a motorcycle bulb when it is connected to a 12 V battery is 2 A. How much electrical energy is spent if this current flows for 15 minutes?

Energy = VIt = 12 V × 2 A × 15 min × 60 s/min = 21,600 J

5. (a) Name two instruments used in a domestic circuit for the protection of residents.

Answer: RCCB (Residual Current Circuit Breaker) and MCB (Miniature Circuit Breaker).

(b) Mention the type of protection provided by each of them.

Answer: RCCB protects from electric shocks and current leaks, while MCB protects from overcurrent and short circuits.

(c) Explain what is to be done to protect electric equipment in a house when lightning occurs.

Answer: Unplug electrical devices, avoid using unessential electric devices, and disconnect the main power supply if necessary.

6. (a) Consumers are charged money for the electricity used in houses. What is the unit of electrical energy used to make electric bills?

Answer: Kilowatt hour (kWh).

(b) Calculate the amount of energy in joules equivalent to one commercial unit of electricity.

Answer: 1 kWh = 3,600,000 J.

(c) If the first 60 units are charged at a rate of Rs. 7.50 per unit and the next 30 units are charged Rs. 10.00 per unit, how much will be the electricity bill of a house where the electricity usage is 75 units in a month?

Cost for first 60 units = 60 × 7.50 = Rs. 450

Cost for next 15 units = 15 × 10.00 = Rs. 150

Total cost = Rs. 450 + Rs. 150 = Rs. 600

7. (a) The power of a water heater in a home is 1500 W. This is used for half an hour daily. Three 40 W bulbs are used for 3 hours daily. Two bulbs of 60 W are lighted for 2 hours daily. Calculate the number of units used up in one day.

Energy used by water heater = 1500 W × 0.5 h = 750 Wh

Energy used by 3 bulbs = 3 × 40 W × 3 h = 360 Wh

Energy used by 2 bulbs = 2 × 60 W × 2 h = 240 Wh

Total energy used in one day = 750 Wh + 360 Wh + 240 Wh = 1350 Wh = 1.35 kWh

(b) If electricity is charged according to the rates given in question 6 (c), what should be the monthly electricity bill?

Monthly energy consumption = 1.35 kWh × 30 days = 40.5 kWh

Since it is below 60 units, the cost = 40.5 × 7.50 = Rs. 303.75

8. (a) A hot plate or immersion heater can be used to heat water. Which one is more efficient out of these two?

Answer: Immersion heater.

(b) Give the reason for this.

Answer: The immersion heater transfers all the heat generated directly to the water.

(c) What is the reason for using three-pin plugs instead of two-pin plugs for immersion heaters?

Answer: Three-pin plugs provide an earth connection, enhancing safety by preventing electric shocks.

(d) When an electrical appliance is switched on, the electrical circuit was disconnected. Give two reasons why this can happen.

Answer: Overload circuit breaker tripped due to high current, or RCCB detected a current leak and disconnected the circuit.

Electronics

Introduction

Electronics has made a huge impact on our daily lives. We use many electronic devices in our day-to-day activities. Mobile phones, computers, televisions, and radios are some examples of such electronic devices.

Materials that conduct electricity are known as electrical conductors. Conductors like copper, aluminum, iron, and lead, as well as mixed conductors like brass, nichrome, and manganin, are examples. Materials that do not conduct electricity, such as ebonite, polythene, plastic, dry wood, and asbestos, are known as electrical insulators. The ability to conduct electricity in some materials is due to the presence of free-moving electrons within the conductor. In insulators, strong inter-atomic bonds prevent free electron movement, making them poor conductors.

Semiconductors are materials that conduct a small amount of electricity. Silicon (Si) and germanium (Ge) in their crystalline forms exhibit semiconductor properties. These elements belong to the fourth group in the periodic table and have four electrons in their outermost shell, forming covalent bonds with nearby atoms to achieve a stable electronic configuration.

At 0 K, all bonds in a silicon lattice are complete, but at higher temperatures, some bonds break, releasing free electrons and creating holes where electrons are absent. These holes act as positive charge carriers.

In semiconductors, both electrons and holes contribute to electrical conduction. When a potential difference is applied, electrons move from the negative to the positive potential, while holes move from the positive to the negative potential, resulting in current flow.

Intrinsic Semiconductors

Pure semiconductor materials such as silicon and germanium are known as intrinsic semiconductors. The conductivity of these materials increases with temperature as more bonds break, generating free electrons and holes.

Extrinsic Semiconductors

When a small amount of phosphorous (P) is added to silicon, an n-type extrinsic semiconductor is formed. Phosphorous has five electrons in its outer shell, and when it bonds with silicon, one electron remains free, increasing the conductivity. Phosphorous and other group V elements like arsenic (As) and antimony (Sb) are known as donor atoms.

Doping silicon with a group III element like boron (B) creates a p-type semiconductor. Boron has three electrons in its outer shell, resulting in a deficiency of one electron, creating a hole. These holes act as positive charge carriers. Elements like aluminum (Al), gallium (Ga), and indium (In) can also be used to create p-type semiconductors.

p-n Junction

A p-n junction is formed by doping one side of an intrinsic semiconductor with a group III element to create a p-type region and the other side with a group V element to create an n-type region. At the junction, free electrons from the n-region diffuse towards the p-region and recombine with holes, forming a depletion layer devoid of free charges. This region acts as a potential barrier, preventing further charge carrier diffusion.

Biasing a p-n Junction

Applying an external potential difference to a p-n junction is known as biasing. In forward bias, the positive potential is connected to the p-region, reducing the depletion layer and allowing current to flow. In reverse bias, the positive potential is connected to the n-region, widening the depletion layer and preventing current flow.

p-n Junction Diode

A junction diode consists of a p-n junction that conducts current only when forward biased. The diode symbol represents the direction of conventional current flow from the anode (positive) to the cathode (negative).

Rectification of Alternating Currents

Diodes can be used to convert alternating current (AC) to direct current (DC) through rectification. Half-wave rectification uses a single diode to allow current flow during the positive half-cycle of AC. Full-wave rectification uses four diodes in a bridge configuration to allow current flow during both half-cycles, providing a more consistent DC output.

Smoothing

Smoothing the rectified output is achieved by connecting a capacitor in parallel to the output terminals of the rectifier circuit. The capacitor charges during the peak voltage and discharges during the voltage drop, reducing the variation in the rectified voltage.

Light Emitting Diode (LED)

LEDs emit light when forward biased. They are used in various applications, including indicators, large television screens, and lighting due to their low power consumption and long lifespan.

Solar Cells

Solar cells are constructed using p-n junctions and generate voltage when exposed to sunlight. They are used in solar panels to provide renewable energy.

Transistors

Transistors are constructed using two p-n junctions and can be npn or pnp types. They have three terminals: emitter, collector, and base. Transistors are used as current amplifiers, signal amplifiers, and switches in electronic circuits.

Amplifying Process of a Transistor

Transistors amplify small input currents into larger output currents. In a current amplifier circuit, a small base current controls a larger collector current, providing current amplification.

Switching Action of a Transistor

Transistors can act as electronic switches, turning on or off based on the input voltage. They are used in digital circuits and for controlling devices based on sensor inputs.

Exercises

1. Explain how metals and semiconductors conduct electricity. How does temperature affect conduction in these materials?

   - Metals conduct electricity through free-moving electrons. In semiconductors, both electrons and holes contribute to conduction. Increasing temperature decreases conductivity in metals due to increased electron collisions but increases conductivity in semiconductors by generating more free electrons and holes.

2. (i) A LED does not light up with one dry cell but does with two. Explain why.

   - LEDs require a minimum forward bias voltage to operate. One dry cell provides insufficient voltage, while two cells provide enough to forward bias the LED.

(ii) Examples of LEDs in daily life: traffic lights, display screens, and indicator lights.

(iii) Reasons for using white light LEDs instead of filament bulbs: lower power consumption, longer lifespan, and higher efficiency.

3. Design a circuit to automatically open a garage door when car headlights fall on it using a transistor and a 3 V motor.

- Use an LDR as a light sensor to control the base current of a transistor. When light falls on the LDR, it reduces resistance, increasing the base current and turning on the transistor, which activates the motor to open the door.

4. In a rectifier bridge circuit with LEDs, identify which LEDs light up and explain the current flow.

- When a 6 V battery is connected, LEDs in the forward bias direction light up. Reversing the battery polarity reverses the lit LEDs. Using a 3 V battery may not provide sufficient voltage for all LEDs to light up.

Technical Terms

- Semiconductors: Materials that partially conduct electricity.
- Intrinsic Semiconductors: Pure semiconductor materials.
- Extrinsic Semiconductors: Doped semiconductor materials.
- Charge Carriers: Particles that carry electric charge, such as electrons and holes.
- Holes: Positive charge carriers in semiconductors.
- Doping: Adding impurities to a semiconductor to change its properties.
- Donor Atom: An atom that provides free electrons in a semiconductor.
- Acceptor Atom: An atom that creates holes in a semiconductor.
- Depletion Layer: Region near a p-n junction devoid of free charge carriers.
- Rectifier Diode: A diode used for converting AC to DC.
- Bridge Rectifier: A circuit using four diodes for full-wave rectification.

- Light Emitting Diode (LED): A diode that emits light when forward biased.

- Transistor: A semiconductor device used for amplification and switching.

- Collector: Terminal in a transistor that collects charge carriers.

- Emitter: Terminal in a transistor that emits charge carriers.

- Base: Terminal in a transistor that controls the flow of charge carriers.

- Current Amplifier: A circuit that increases current.

- Signal Amplifier: A circuit that increases signal strength.

- Forward Bias: Connecting a p-n junction to allow current flow.

- Reverse Bias: Connecting a p-n junction to prevent current flow.

Electrochemistry

Electrochemical cells

In our everyday life, we frequently use equipment powered by domestic electricity as well as appliances operated by electrochemical cells or batteries. Examples include toy cars, electric torches, calculators, computers, and mobile phones. These devices rely on electrochemical cells to convert chemical energy into electrical energy.

Activity 12.1.1

Materials required:

- A small beaker
- Dilute sulphuric acid
- A zinc metal sheet

Method:

1. Add dilute sulphuric acid to the small beaker.
2. Place a strip of zinc metal sheet in the beaker so that a part of it dips in the sulphuric acid solution.

Observation:

- Gas bubbles are liberated near the zinc strip, and the zinc strip gradually dissolves.

Explanation:

Zinc atoms (Zn) go into the solution as zinc ions (Zn^{2+}) leaving electrons on the metal. Electrons accumulate on the zinc strip.

$Zn (s) \rightarrow Zn^{2+}(aq) + 2e^-$

Sulphuric acid dissociates into hydrogen ions (H^+) and sulphate ions (SO_4^{2-}) in water.

$H_2SO_4 (aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$

The H^+ ions in the solution are attracted towards the zinc strip to capture the electrons on it. Hydrogen ions, after receiving the electrons, become hydrogen gas (H_2).

$2H^+(aq) + 2e^- \rightarrow H_2(g)$

These reactions can be depicted as half reactions. By adding the two half reactions appropriately, the balanced ionic equation can be obtained.

$Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$

This reaction can be represented by a balanced chemical equation. When sulphuric acid dissociates, sulphate ions (SO_4^{2-}) are added to the medium in addition to H^+ ions. However, sulphate ions do not undergo any change during the reaction.

$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$

Activity 12.1.2

Materials required:

- A beaker

- Zinc and copper strips

- Dilute sulphuric acid

- Connecting wire

- Ammeter

Method:

1. Connect the zinc strip and the copper strip to the Ammeter using connecting wires.

2. Immerse the two metal strips in the beaker containing dilute sulphuric acid.

Observation:

- The Ammeter pointer is deflected, zinc strip dissolves, and gas bubbles are evolved at the copper strip.

Explanation:

Zinc atoms become zinc ions (Zn^{2+}) leaving electrons on the metal. The electrons accumulated on the zinc strip flow towards the copper strip through an external wire, considered an electric current. Deflection of the Ammeter shows that an electric current flows through the circuit.

Reaction at the zinc strip:

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

Reaction at the copper strip:

$2H^+(aq) + 2e^- \rightarrow H_2(g)$

This setup demonstrates that a chemical reaction has generated an electric current. A set up of this kind used to generate electricity by a chemical reaction is known as an electrochemical cell.

In the above cell, zinc strip and copper strip act as electrodes. The balanced ionic equation obtained by adding the half reactions is the electrochemical reaction taking place in the cell.

$Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$

Loss of electrons is referred to as oxidation. Therefore, what is happening at the zinc strip is oxidation. If oxidation occurs at a certain electrode, that electrode is defined as the anode. Accordingly, the zinc strip is the anode of the above cell. Since zinc atoms dissolve into the solution leaving electrons on the zinc plate, the zinc plate gets negatively charged relative to the copper plate. Therefore, the zinc electrode is the negative terminal of the cell.

At the copper electrode, hydrogen ions (H^+) gaining electrons turn into hydrogen gas molecules (H_2). Gaining electrons is described as reduction. Since reduction occurs at the copper electrode, the copper strip is the cathode of the cell. Since electrons flow to the copper strip, it is positively charged relative to the zinc strip. Therefore, the copper electrode is the positive terminal of the cell.

The overall cell reaction can be represented as follows:

$Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$

Next, consider a cell constructed using iron and copper electrodes. In the activity series, iron lies above copper. Therefore, the more reactive metal, iron, undergoes oxidation and acts as the anode.

$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

In this cell, the reduction half reaction occurs at the less reactive copper metal, making the copper electrode the cathode.

$2H^+(aq) + 2e^- \rightarrow H_2(g)$

The overall ionic reaction of the cell can be obtained by adding the two half reactions:

$Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$

Electrolysis

Electrolysis is the chemical change brought about by passing electricity through a solution or liquid that conducts electricity. An apparatus set up to conduct electricity through an electrolyte is called an electrolytic cell, comprising a source of electricity, an electrolyte, two electrodes, and connecting wires.

Electrolysis of aqueous sodium chloride

Activity 12.2.2

Materials required:

- A solution of sodium chloride
- Carbon rods
- Conducting wires
- A 9 V battery

Method:

1. Connect the two carbon rods to the terminals of the battery using wires.
2. Immerse the two electrodes in the aqueous sodium chloride solution.

Observation:

- Liberation of gas bubbles can be observed at the electrodes.

Explanation:

The solution contains Na^+ and Cl^- ions, as well as a small amount of H^+ and OH^- ions formed by the poor ionization of water molecules. At the negative electrode (cathode), H^+ ions are reduced.

$2H^+(aq) + 2e^- \rightarrow H_2(g)$

At the positive electrode (anode), Cl^- ions are oxidized.

$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

The overall electrolytic reaction can be obtained from the half reactions:

$2H^+(aq) + 2Cl^-(aq) \rightarrow H_2(g) + Cl_2(g)$

Electrolysis of aqueous copper sulphate

Activity 12.2.3

Materials required:

- Aqueous solution of copper sulphate
- Carbon rods
- Connecting wires
- A 9V battery

Method:

1. Connect the electrodes to the battery.
2. Dip the two electrodes in the copper sulphate solution.

Observation:

- Gas bubbles evolve at the positive terminal (anode), and copper gets deposited on the negative terminal (cathode). The blue color of the solution gradually diminishes.

Explanation:

The solution contains Cu^{2+} and SO_4^{2-} ions, as well as a small amount of H^+ and OH^- ions. At the negative electrode (cathode), Cu^{2+} ions are reduced.

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

At the positive electrode (anode), OH^- ions are oxidized.

$4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$

The overall electrolytic reaction can be obtained by adding the half reactions:

$Cu^{2+}(aq) + 4OH^-(aq) \rightarrow Cu(s) + O_2(g) + 2H_2O(l)$

Electrolysis of acidulated water

Activity 12.2.4

Materials required:

- Distilled water with a little dilute sulphuric acid
- Carbon rods
- A 9 V battery
- Connecting wires
- A plastic cup

Method:

1. Fix the carbon rods in a plastic cup filled with acidulated water.

2. Introduce the two carbon rods into two inverted test tubes filled with water.

3. Supply electricity to the two carbon electrodes.

Observation:

- Gases collect in the test tubes. The volume of gas liberated by the cathode is greater than that liberated by the anode.

Explanation:

Acidulated water contains H^+ and SO_4^{2-} ions from the ionization of dilute sulphuric acid and H^+ and OH^- ions from the dissociation of water. At the negative electrode (cathode), H^+ ions are reduced.

$2H^+(aq) + 2e^- \rightarrow H_2(g)$

At the positive electrode (anode), OH^- ions are oxidized.

$4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$

The overall electrolytic reaction can be represented by the following equation:

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

Industrial applications of electrolysis

Electrolysis is frequently used in manufacturing various industrial products.

Examples:

1. Extraction of metals (e.g., sodium from fused sodium chloride, aluminum from bauxite).

2. Metal refining (e.g., purification of impure copper).

3. Electroplating (e.g., gold on silver jewelry, nickel or chromium on steel).

4. Industrial production of sodium hydroxide (Diaphragm cell method).

Electroplating

Electroplating involves applying a thin metallic layer on a given surface using electrolysis. The object to be plated is used as the cathode, a solution of a salt of the metal to be plated is used as the electrolyte, and the anode is a plate or rod made of the metal to be plated.

Activity 12.2.5

Materials required:

- An iron spoon
- A copper plate
- Connecting wires
- Aqueous solution of copper sulphate
- A 9 V battery

Method:

1. Connect the iron spoon and the copper plate to the cell by connecting wires.

2. Immerse them in the copper sulphate solution.

Observation:

- Copper coats the iron spoon.

Explanation:

At the anode, $Cu(s)$ is oxidized to Cu^{2+}.

$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

At the cathode, Cu^{2+} is reduced to $Cu(s)$.

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

Corrosion of metals

Corrosion is the process where metals undergo deterioration due to chemical reactions with their environment. Rusting is a specific type of corrosion affecting iron and steel.

Rusting of iron

Iron and steel objects rust when exposed to air and moisture. Rusting involves the formation of hydrated ferric oxide ($Fe_2O_3 . xH_2O$).

$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

$2H_2O(l) + O_2(g) + 4e^- \rightarrow 4OH^-(aq)$

$2Fe(OH)_2(s) + O_2(g) \rightarrow 2(Fe_2O_3 . H_2O)(s) + 2H_2O(l)$

Factors affecting rusting include the presence of water, oxygen, acids, and salts. Bases tend to decrease the rate of rusting.

Control of rusting

Rusting can be controlled by:

1. Applying paint, grease, or oil on iron.
2. Coating iron with tin.
3. Using more reactive metals (e.g., zinc) for galvanization.

Exercises

1. Write balanced half equations for the following chemical processes:
   - $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$ (Oxidation)
   - $Al(s) \rightarrow Al^{3+}(aq) + 3e^-$ (Oxidation)
   - $Na(s) \rightarrow Na^+(aq) + e^-$ (Oxidation)
   - $2H^+(aq) + 2e^- \rightarrow H_2(g)$ (Reduction)

2. Consider the electrochemical cell with zinc and lead metals in dilute sulphuric acid:
   - Anode: Zinc
   - Cathode: Lead
   - Positive terminal: Lead
   - Negative terminal: Zinc
   - Anodic reaction: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

- Cathodic reaction: $2H^+(aq) + 2e^- \rightarrow H_2(g)$

- Overall cell reaction: $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$

- Observations: Zinc dissolves, and gas bubbles evolve at the lead electrode.

Electromagnetism and Electromagnetic Induction

Electromagnetism is a fundamental aspect of physics that deals with the study of the electromagnetic force, a type of physical interaction that occurs between electrically charged particles. This force is responsible for a wide range of phenomena including the behavior of electric currents, magnetic fields, and light. Understanding electromagnetism is crucial for many modern technologies such as motors, generators, transformers, and various electronic devices.

Magnetism

There are two main types of magnets: electromagnets and permanent magnets. Electromagnets exhibit magnetism only when an electric current passes through their coils, while permanent magnets retain their magnetism indefinitely. Both types are used in numerous applications, including electric motors, magnetic cards, medical equipment like MRI machines, and various scientific instruments.

Magnetic Field

The region around a magnet where magnetic forces can be detected is known as the magnetic field. This field is invisible to the eye but can influence other magnets and moving charges. A compass is a useful tool to detect the presence and direction of a magnetic field. When placed in a magnetic field, a compass needle aligns itself with the field lines.

Magnetic Effect of a Current

When an electric current flows through a conductor, it creates a magnetic field around the conductor. This phenomenon was first observed by Danish scientist Hans Christian Oersted. To demonstrate this, one can use a simple setup with a compass and a current-carrying wire. When current flows through the wire, the compass needle deflects, indicating the presence of a magnetic field.

Direction of the Magnetic Field due to a Current

There are two rules to determine the direction of the magnetic field around a current-carrying conductor:

1. Maxwell's Corkscrew Rule: When a corkscrew is turned in such a way that its tip moves in the direction of the current, the direction of rotation gives the direction of the magnetic field lines.
2. Right-Hand Grip Rule: If a conductor is held with the right hand so that the thumb points in the direction of the current, the curled fingers show the direction of the magnetic field around the conductor.

Force Acting on a Current-Carrying Conductor

A current-carrying conductor placed in a magnetic field experiences a force. The direction of this force can be determined using Fleming's Left-Hand Rule: If the thumb, index finger, and middle finger of the left hand are positioned perpendicular to each other, with the index finger pointing in the direction of the magnetic field and the middle finger in the direction of the current, the thumb points in the direction of the force. This principle is applied in devices like electric motors and loudspeakers.

Loudspeaker

A loudspeaker converts electrical energy into sound. It consists of a coil attached to a diaphragm placed between the poles of a magnet. When an electric current flows through the coil, it creates a magnetic field that interacts with the permanent magnet, causing the coil and diaphragm to move back and forth. This movement generates sound waves corresponding to the electrical signal.

Direct Current Motor (DC Motor)

DC motors are used in various applications such as toy cars, electric cars, and trains. A simple DC motor can be constructed using a coil, a magnet, and a commutator. The coil rotates due to the interaction of the magnetic field and the electric current flowing through it. The commutator ensures that the current direction in the coil changes every half cycle, allowing continuous rotation in one direction.

Electromagnetic Induction

Electromagnetic induction is the process of generating an electromotive force (emf) by changing the magnetic field around a conductor. This phenomenon was discovered by Michael Faraday. When a conductor moves in a magnetic field or when the magnetic field around a conductor changes, an emf is induced, leading to a current flow if the conductor is part of a closed circuit. This principle is used in generators and transformers.

Applications of Electromagnetic Induction

1. Alternating Current Dynamo: A coil rotating in a magnetic field generates alternating current (AC) due to the continuous change in the magnetic flux linked with the coil.

2. Moving Coil Microphone: A diaphragm attached to a coil vibrates in response to sound waves, inducing an emf in the coil as it moves in a magnetic field.

3. Bicycle Dynamo: The rotation of a magnet in the dynamo induces an emf in a coil, generating electricity to power the bicycle lamp.

Direct Currents and Alternating Currents

Direct current (DC) flows in one direction, while alternating current (AC) changes direction periodically. DC is produced by sources like batteries and solar cells, while AC is generated by alternators and used in household power supply.

Transformers

Transformers are devices that transfer electrical energy between two or more circuits through electromagnetic induction. They can step up (increase) or step down (decrease) voltage levels. A transformer consists of primary and secondary coils wound around a magnetic core. The voltage ratio between the primary and secondary coils is proportional to the number of turns in each coil.

Exercises

1. Write balanced half equations for the following chemical processes:

- $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$ (Oxidation)
- $Al(s) \rightarrow Al^{3+}(aq) + 3e^-$ (Oxidation)
- $Na(s) \rightarrow Na^+(aq) + e^-$ (Oxidation)
- $2H^+(aq) + 2e^- \rightarrow H_2(g)$ (Reduction)

2. Consider the electrochemical cell with zinc and lead metals in dilute sulphuric acid:

- Anode: Zinc
- Cathode: Lead
- Positive terminal: Lead
- Negative terminal: Zinc
- Anodic reaction: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$
- Cathodic reaction: $2H^+(aq) + 2e^- \rightarrow H_2(g)$
- Overall cell reaction: $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$
- Observations: Zinc dissolves, and gas bubbles evolve at the lead electrode.

Summary

Electromagnetism encompasses a wide range of phenomena related to electric currents and magnetic fields. Understanding these principles is essential for the design and operation of many modern technologies, from simple electric motors to complex communication systems. Through experiments and practical applications, we can observe the interplay of electricity and magnetism and harness these forces for various uses.

Chemistry: Hydrocarbons and Their Derivatives

Hydrocarbons

Hydrocarbons are compounds composed exclusively of carbon and hydrogen atoms. These compounds are prevalent in various materials used in daily life, such as plastics, fuels, and many chemicals. For example, plastic goods, clothes, paints, cosmetics, agro-chemicals, tyres, and food items all contain hydrocarbons.

Organic compounds are compounds that contain carbon atoms bonded to other elements such as hydrogen, oxygen, nitrogen, halogen, phosphorus, and sulphur. However, not all carbon-containing compounds are considered organic. For instance, carbon dioxide (CO_2), carbon monoxide (CO), sodium carbonate (Na_2CO_3), and sodium bicarbonate ($NaHCO_3$) are not classified as organic compounds. Organic chemistry focuses on the study of these carbon-based compounds due to their unique chemical properties and abundance.

Hydrocarbons can be classified into three main categories based on their structure: alkanes, alkenes, and alkynes.

Alkanes

Alkanes are the simplest hydrocarbons, consisting only of single bonds between carbon atoms. They follow the general formula C_nH_{2n+2}, where "n" represents the number of carbon atoms in the molecule. The simplest alkane is methane (CH_4), followed by ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}), and pentane (C_5H_{12}). Alkanes are also known as saturated hydrocarbons because they contain the maximum number of hydrogen atoms possible for the number of carbon atoms.

Activity: Confirming the presence of carbon and hydrogen in candle wax

Materials:

- Connecting tubes

- Beaker

- Aspirator

- Lime water

- Copper sulphate

- U-tube

- Test tube

Method:

1. Set up the apparatus as shown in the diagram.

2. Light the candle and connect the apparatus to the aspirator to pass air through it.

Observation:

- Anhydrous copper sulphate turns from white to blue, indicating the presence of water produced during the combustion of the candle.

- Lime water turns milky, indicating the presence of carbon dioxide produced during combustion.

Explanation:

The hydrogen in the candle wax combines with oxygen to form water, turning copper sulphate blue. The carbon in the wax combines with oxygen to form carbon dioxide, turning lime water milky.

Assignment: List several types of fuels used in daily life and investigate their chemical composition.

Fuels and Their Composition:

1. Wax contains carbon and hydrogen.

2. Petrol contains carbon and hydrogen.

3. Methane contains carbon and hydrogen.

4. L.P. gas contains carbon and hydrogen.

5. Kerosene contains carbon and hydrogen.

6. Diesel contains carbon and hydrogen.

7. Firewood contains carbon, hydrogen, oxygen, and nitrogen.

All these fuels contain carbon and hydrogen.

Hydrocarbons in fuels:

The primary components of fuels such as petrol, kerosene, and L.P. gas are hydrocarbons. Methane (CH_4) is the simplest hydrocarbon and a major component of biogas. Ethane (C_2H_6) is another hydrocarbon found in natural gas.

Alkenes

Alkenes are hydrocarbons containing one or more double bonds between carbon atoms. They are more reactive than alkanes due to the presence of double bonds. The simplest alkene is ethene (C_2H_4).

Derivatives of Ethene:

1. Chloroethene (C_2H_3Cl) is derived by replacing a hydrogen atom in ethene with a chlorine atom.

2. Tetrafluoroethene (C_2F_4) is derived by replacing the four hydrogen atoms in ethene with four fluorine atoms.

Polymers

Polymers are large molecules made up of repeating structural units called monomers. The process of forming polymers from monomers is known as polymerization. Common examples of polymers include polythene, polychloroethene (PVC), and polytetrafluoroethene (Teflon).

Polythene (Polyethylene)

Polythene is produced by the polymerization of ethene molecules. The double bonds in ethene break, allowing the molecules to link together, forming a long chain polymer.

- Monomer: Ethene (C_2H_4)
- Repeating Unit: $–CH_2–CH_2–$
- Polymer: Polythene $(–CH_2–CH_2–)_n$

Polychloroethene (Polyvinyl Chloride or PVC)

PVC is produced by the polymerization of chloroethene.

- Monomer: Chloroethene (C_2H_3Cl)
- Repeating Unit: $–CH_2–CHCl–$
- Polymer: PVC $(–CH_2–CHCl–)_n$

Polytetrafluoroethene (Teflon)

Teflon is produced by the polymerization of tetrafluoroethene.

- Monomer: Tetrafluoroethene (C_2F_4)
- Repeating Unit: $–CF_2–CF_2–$

- Polymer: Teflon $(–CF_2–CF_2–)_n$

Classification of Polymers

Polymers can be classified based on their origin as natural or artificial. Natural polymers include rubber, proteins, DNA, starch, cellulose, and RNA. Artificial polymers include polythene, PVC, Teflon, polyester, nylon, and polystyrene.

Rubber

Rubber is a natural polymer formed by the polymerization of isoprene. The structure of an isoprene molecule is:

$CH_2=C(CH_3)–CH=CH_2$

Vulcanization

Vulcanization is a process where natural rubber is treated with sulphur to create cross-links between polymer chains, enhancing its durability and elasticity. Vulcanized rubber is used to make tyres, tubes, and battery cases.

Importance of Polymers

Polymers are widely used in daily life due to their versatility, durability, and ability to be molded into various shapes. They are used in making plastic bottles, toys, bags, pipes, and non-stick cookware. However, many artificial polymers are not biodegradable, leading to environmental issues. Efforts are being made to develop biodegradable and photodegradable polymers to mitigate these problems.

Exercises

1. L.P. gas is a mixture of propane and butane.

- The molecular formula of propane is C_3H_8, and butane is C_4H_{10}.

- The structure of propane is $CH_3–CH_2–CH_3$, and the structure of butane is $CH_3–CH_2–CH_2–CH_3$.

- Combustion equations: Propane: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$, Butane: $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$.

- L.P. gas is more environmentally friendly than firewood as it produces fewer pollutants and has higher energy efficiency.

2. Octane in petrol:

- Complete combustion of octane: $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$.

- Incomplete combustion of petrol produces carbon monoxide (CO) and soot (C).

- Incomplete combustion in L.P. gas cookers is identified by a yellow flame and soot deposits.

3. Polythene:

- The chemical name of polythene is polyethylene.

- The monomer that forms polythene is ethene ($CH_2=CH_2$).

- Advantages of polythene: durable, versatile; Disadvantages: non-biodegradable, environmental pollution.

4. PVC pipes vs. iron pipes:

- PVC pipes are more suitable because they are corrosion-resistant, lightweight, and cost-effective.

- The monomer used to make PVC is chloroethene ($CH_2=CHCl$).

- The structure of chloroethene is $CH_2=CHCl$.

5. Natural polymers:

- Examples of natural polymers include rubber, proteins, and DNA.

Technical Terms

- Organic compound: Compounds containing carbon.
- Hydrocarbon: Compounds composed of carbon and hydrogen.
- Alkanes: Saturated hydrocarbons with single bonds.
- Alkenes: Unsaturated hydrocarbons with double bonds.
- Polymers: Large molecules made from monomers.
- Monomers: Small molecules forming polymers.
- Repeating unit: Basic structural unit in a polymer.

Summary

Organic compounds composed solely of carbon and hydrogen are known as hydrocarbons. Alkanes, characterized by single bonds between carbon atoms, are a major class of hydrocarbons. Alkenes, with one or more double bonds, are more reactive. Polymers are large molecules formed from smaller monomers, classified as natural or artificial based on their origin. Artificial polymers, though versatile and durable, pose environmental challenges due to their non-biodegradability. Efforts are underway to develop eco-friendly polymers to address these issues.

Biosphere

Environmental Equilibrium and Ecological Balance

The environment is composed of physical and biological components that interact for the existence of organisms. Physical components include soil, water, and air, while biological components include plants, animals, and microorganisms. Environmental conditions such as temperature, rainfall, humidity, and sunlight also play a crucial role. The favorable relationship between organisms and their physical environment is known as environmental equilibrium. Human activities, however, are increasingly disrupting this balance.

Organizational Levels in the Biosphere

The biosphere is organized from the simplest level to the most complex, following this hierarchy:

1. Individual - A single organism of a particular species, such as a coconut plant or an elephant.
2. Population - A group of organisms of the same species living in a specific geographical location at a specific time.
3. Community - Different populations interacting in a particular area, such as the animal community in Yala National Park.
4. Ecosystem - All communities and their non-living components interacting in a particular area, like a pond, a forest, or a beach.
5. Biosphere - The part of Earth inhabited by living organisms, composed of the lithosphere, hydrosphere, and atmosphere.

Growth of Population and Growth Curves

Population density refers to the number of organisms of a species in a unit area. Factors affecting population density include births, deaths, immigration, and emigration. A typical population growth curve has four phases:

1. Slow growth phase (Lag phase) - Initial slow growth due to a shortage of reproducing individuals.

2. High growth phase (Exponential phase) - Rapid growth as organisms adapt to the environment.

3. Deceleration phase - Slower growth due to competition for resources and other limiting factors.

4. Stationary phase - Population stabilizes at the environment's carrying capacity.

Mechanisms Involved in Maintaining Ecosystem Equilibrium

Flow of Energy and Nutrients

The sun is the primary energy source for all ecosystems. Energy and nutrients flow through ecosystems via food chains and food webs. In a food web, different trophic levels are interconnected, allowing organisms to depend on various food sources. This interconnection helps prevent bioaccumulation.

Trophic Levels and Ecological Pyramids

Organisms are classified into trophic levels based on their mode of nutrition:

1. Autotrophs - Organisms like green plants that produce their own food using sunlight (photo-autotrophs) or chemical energy (chemo-autotrophs).

2. Heterotrophs - Organisms that consume other organisms for food, including herbivores (primary consumers), carnivores (secondary and tertiary consumers), and omnivores.

3. Decomposers - Organisms like bacteria and fungi that break down dead matter into simpler compounds.

Ecological pyramids visually represent the number, biomass, or energy of organisms at each trophic level. They can be upright or inverted depending on the ecosystem.

Biogeochemical Cycles

These cycles involve the circulation of essential chemical elements through the biosphere, including the carbon and nitrogen cycles. The carbon cycle involves photosynthesis, respiration, decomposition, and combustion. The nitrogen cycle includes nitrogen fixation, nitrification, ammonification, and denitrification.

Environmental Pollution

Pollution results from the discharge of harmful substances into the environment, disrupting ecological balance. Major types of pollution include soil, water, and air pollution. Common pollutants include agrochemicals, industrial waste, greenhouse gases, heavy metals, particulate matter, domestic waste, electronic waste, and nuclear waste.

Effects of Pollution

Pollution has both direct and indirect effects on the environment:

1. Acid rain - Caused by industrial emissions of nitrogen and sulfur oxides.
2. Global warming - Resulting from the greenhouse effect due to gases like carbon dioxide and methane.
3. Ozone layer depletion - Caused by chlorofluorocarbons (CFCs) and other pollutants.
4. Photochemical smog - Affects respiratory health and visibility.
5. Biomagnification - Accumulation of pollutants in the food chain, affecting higher trophic levels.
6. Eutrophication - Nutrient enrichment in water bodies leading to excessive algae growth and depletion of oxygen.

Human Health and Environmental Pollution

Pollution contributes to various health issues, including chronic kidney disease, diabetes, cancer, heart diseases, pulmonary diseases, wheezing, gastritis, and cataracts.

Sustainable Development and Environmental Management

Sustainable development involves using natural resources wisely to maintain ecological balance for future generations. Environmental management includes practices like reforestation, traditional knowledge and technology, carbon footprint reduction, food mile minimization, waste management, and energy management.

Exercises and Assignments

The document includes several exercises and assignments to reinforce learning and promote practical understanding of environmental concepts. For example, students are asked to name species in their garden, discuss sustainable agricultural practices, and investigate traditional paddy varieties.

In conclusion, the document provides a comprehensive overview of the biosphere, ecological balance, energy flow, nutrient cycles, pollution, and sustainable development. It emphasizes the importance of maintaining environmental equilibrium through responsible human activities and sustainable practices.

Exercises:

1. What is the organizational level which includes abiotic component in the biosphere?

- Individual
- Population
- Community
- Ecosystem

2. Select the answer with all the descriptions about the population:

- Species name, living period

- Species name, location

- Living period, location

- Species name, living period, location

3. Which of the following is not a causative gas for acid rain?

- Nitrogen dioxide

- Carbon dioxide

- Sulfur dioxide

- Sulfur trioxide

4. The main gas which causes the greenhouse effect is:

- Carbon dioxide

- Methane

- Chloro Fluoro Carbon

- Oxides of nitrogen

5. The bacteria involved in the fixation of atmospheric nitrogen as ammonium is:

- Rhizobium

- Nitrosomonas

- Nitrobacter

- Pseudomonas

6. Name two relationships present in an ecosystem.

- Predation

- Symbiosis

7. Name two biological communities identified in a pond ecosystem.

   - Aquatic plants

   - Fish population

8. Name two causes for the breakdown of ecological balance.

   - Pollution

   - Deforestation

9. What is the main method of fixation of carbon in an ecosystem?

   - Photosynthesis

10. The flora in Sinharaja forest are naturally well-grown compared to the crops in an agricultural land. Justify this statement.

   - The flora in Sinharaja forest are adapted to the natural environment and grow without human interference, while crops in agricultural land often require human intervention and are affected by agricultural practices such as the use of pesticides and fertilizers.

11. Name two applications in sustainable agriculture.

   - Multiple cropping

   - Use of organic fertilizers

12. State two fields where indigenous knowledge and technology can be applied.

   - Agriculture

   - Medicine

13. What is known as a food mile?

- The distance over which a food item is transported during the journey from producer to consumer.

14. Name two ways to shorten the food mile.

- Consuming locally produced food

- Supporting local farmers' markets