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PART A: BIOLOGY



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Introduction to Biology

Introduction to Biology

1. **Biology** is the scientific study of life.
2. The word Biology is derived from the Greek words '*bios*' (life) and '*logos*' (study or reasoning).
3. **Carl Linnaeus** first used the term "Biology" in 1736.
4. **Lamarck and Treviranus** made the term "Biology" common in 1800.
5. The Holy Quran instructs humanity to reveal the study of life and its origins.
6. The Quranic verse "We made every living thing from water" (Sura: Al-Ambia) hints at the common aquatic origin of life.
7. Theophrastus is known as the **Father of Botany**.
8. **Aristotle** is known as the **Father of Zoology**.
9. **Jabir Bin Hayan** introduced experimental investigation in chemistry and wrote books on plants and animals.
10. **Abdul Malik Asmai** was the first Muslim scientist to study animals in detail; his famous book is "Al-Abil".
11. **Bu Ali Sina (Avicenna)** is known as the founder of medicine; his famous book "Al-Qanun-fi-al-Tib" is known as the canon of medicine in the West.

Major Divisions/Branches of Biology

12. The three major divisions of biology are **Zoology**, **Botany**, and **Microbiology**.
13. **Zoology** is the study of animals.
14. **Botany** is the study of plants.
15. **Microbiology** is the study of microorganisms like bacteria and viruses.
16. **Morphology** is the study of the form and structure of organisms.
17. **Anatomy** is the study of the internal structure of organisms.
18. **Physiology** is the study of the functions of different parts of living organisms.
19. **Histology** is the microscopic study of tissues.



Practice MCQs

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1. The word 'Biology' is derived from which language?

- A) Latin
- B) Arabic
- C) Greek
- D) English

Answer: Greek

2. The study of internal structure of organisms is called:

- A) Morphology
- B) Physiology
- C) Anatomy
- D) Histology

Answer: Anatomy

3. Which branch of biology deals with the study of fossils?

- A) Paleontology
- B) Entomology
- C) Taxonomy
- D) Embryology

Answer: Paleontology

4. The most abundant bioelement in the human body by mass is:

- A) Carbon
- B) Hydrogen
- C) Oxygen
- D) Nitrogen

Answer: Oxygen

5. A group of organisms of the same species living in a specific area at the same time is called a:

- A) Community
- B) Population
- C) Biome
- D) Ecosystem

Answer: Population

6. Which of the following is a colonial organism?

- A) Amoeba
- B) Paramecium
- C) Volvox
- D) Euglena

Answer: Volvox

7. The scientific name of the frog is:

- A) Rana tagrina
- B) Rana tigrina
- C) Rosa indica
- D) Brassica campestris

Answer: Rana tigrina

8. The branch of biology that studies the relationships between organisms and their environment is:

- A) Genetics
- B) Ecology
- C) Physiology
- D) Morphology

Answer: Ecology

9. Which mosquito is the primary vector for the transmission of malaria in humans?

- A) Culex
- B) Aedes
- C) Anopheles
- D) Tabanus

Answer: Anopheles

10. Who is known as the Father of Medicine?

- A) Theophrastus
- B) Aristotle
- C) Jabir Bin Hayan
- D) Bu Ali Sina

Answer: Bu Ali Sina



Biodiversity & Classification

1. Introduction to Biodiversity

1. **Biodiversity** means the variety of organisms in a particular area or on Earth.
2. It is measured by the number of different kinds of organisms and the variation within each kind.
3. Biologists have discovered, classified, and catalogued almost **two million** kinds of organisms.
4. The total number of species on Earth is estimated to be much higher than the number currently known.
5. Biodiversity is **not evenly distributed** across the globe.
6. **Tropical regions** have the highest biodiversity, while **polar regions** have the lowest.
7. The biodiversity of an area depends on factors like **climate, altitude, and soil type**.
8. Biodiversity is the result of **billions of years of evolution**.
9. **International Biodiversity Day** is celebrated on **May 22** to promote the protection of biodiversity.
10. Biodiversity provides essential **ecosystem services** like climate regulation and nutrient cycling.
11. It is a source of **food, medicine, building materials, fibres, and fuel**.
12. Biodiversity has significant **economic benefits**, supporting agriculture, tourism, and the pharmaceutical industry.

2. Aims, Principles, and Basis of Classification

13. **Classification** is the process of dividing organisms into groups and subgroups based on their similarities and differences.
14. The main aims of classification are to determine similarities/differences and to find **evolutionary relationships**.



Practice MCQs

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1. What does the term "biodiversity" refer to?

- A) The number of animals in a forest
- B) The variety of life in a particular ecosystem
- C) The study of biological classification
- D) The process of species evolution

Answer: The variety of life in a particular ecosystem

2. Approximately how many species have biologists identified and classified?

- A) 1 million
- B) 2 million
- C) 5 million
- D) 10 million

Answer: 2 million

3. Which region of the world typically has the highest biodiversity?

- A) Polar regions
- B) Deserts
- C) Temperate grasslands
- D) Tropical regions

Answer: Tropical regions

4. International Biodiversity Day is celebrated on which date?

- A) April 22
- B) May 22
- C) June 5
- D) December 10

Answer: May 22

5. What is the primary goal of biological classification?

- A) To give common names to organisms
- B) To understand evolutionary relationships and group organisms systematically
- C) To increase the number of known species

D) To focus only on plant and animal differences

Answer: To understand evolutionary relationships and group organisms systematically

6. The branch of biology that deals with classification is called?

- A) Ecology
- B) Physiology
- C) Taxonomy
- D) Genetics

Answer: Taxonomy

7. Who is credited with devising the Linnaean system of classification?

- A) Aristotle
- B) Charles Darwin
- C) Robert Whittaker
- D) Carolus Linnaeus

Answer: Carolus Linnaeus

8. Which of the following is the highest taxonomic rank in modern classification?

- A) Kingdom
- B) Domain
- C) Phylum
- D) Class

Answer: Domain

9. The correct order of taxonomic categories from most broad to most specific is:

- A) Kingdom, Order, Class, Phylum, Family, Genus, Species
- B) Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species
- C) Species, Genus, Family, Order, Class, Phylum, Kingdom
- D) Phylum, Kingdom, Class, Order, Family, Genus, Species



Biological Molecules

Introduction to Biochemistry

1. **Biochemistry** is the study of the chemical components and chemical processes in living organisms.
2. All structures of living organisms have a specific **biochemical organization**.
3. Life processes like photosynthesis, respiration, and digestion can be described in **biochemical terms**.
4. **Molecular Biology** is a specialized branch of biochemistry.
5. The sum of all chemical reactions taking place within a cell is called **metabolism**.
6. **Anabolism** involves reactions where simpler substances combine to form complex substances, requiring energy.
7. **Catabolism** involves the breakdown of complex molecules into simpler ones, releasing energy.
8. All living things are made of **organic** and **inorganic** compounds.
9. The most important organic compounds are **carbohydrates, proteins, lipids, and nucleic acids**.
10. Major inorganic substances include **water, carbon dioxide, acids, bases, and salts**.

Chemical Bonds in Biological Molecules

11. A **covalent bond** is formed by the mutual sharing of electrons between two atoms.
12. **Carbon** is tetravalent and can form stable covalent bonds with many elements.
13. Examples of covalent bonds in biomolecules include **peptide bonds, glycosidic bonds, and phosphodiester bonds**.
14. An **ionic bond** is formed when one atom donates an electron to another, creating positively and negatively charged ions.
15. A **hydrogen bond** is a weak attraction between a hydrogen atom and an electronegative atom like oxygen or nitrogen.



Enzymes

Introduction & Metabolism

1. The sum of all chemical reactions within a living organism is called **metabolism**.
2. The concept of metabolism was first given by **Ibn-e-Nafees**.
3. **Anabolism** involves the synthesis of complex molecules from simpler ones, consuming energy (e.g., photosynthesis, protein synthesis).
4. **Catabolism** involves the breakdown of complex molecules into simpler ones, releasing energy (e.g., cellular respiration, lipolysis).
5. **Enzymes** are biological catalysts that speed up biochemical reactions without being consumed.
6. Enzymes regulate **metabolic pathways**, where the product of one reaction becomes the substrate for the next.

Characteristics of Enzymes

7. Enzymes are primarily **globular proteins** in nature.
 8. The only non-protein enzymes are **ribozymes**, which are made of RNA.
 9. Enzymes **lower the activation energy** of a reaction, speeding it up.
 10. Enzymes are highly **specific** for their substrates and the type of reaction they catalyze.
 11. Enzymes are not used up in the reactions they catalyze and can be **reused**.
 12. Enzymes work efficiently in **small amounts**.
 13. Enzyme activity is sensitive to factors like **temperature, pH, and substrate concentration**.
 14. The catalytic activity of an enzyme is confined to a small region called the **active site**.
 15. Many enzymes require non-protein components called **cofactors** for their activity.
1. **Cofactors, Coenzymes, and Prosthetic Groups**
 16. **Cofactors** are non-protein components required for the proper functioning of many enzymes.



Cell Structure and Function

Cell Theory

1. **Robert Hooke** in 1665 first discovered and named "cells" while examining cork.
2. **Anton van Leeuwenhoek** was the first to observe living cells ("animalcules") in pond water.
3. **Robert Brown** discovered the nucleus in the cell in 1831.
4. **Schleiden (1838)** and **Schwann (1839)** formulated the cell theory.
5. **Rudolf Virchow** proposed that all cells arise from pre-existing cells ("omnis cellula e cellula").
6. **Louis Pasteur** provided experimental proof for Virchow's hypothesis.
7. The three tenets of the **Cell Theory** are: all organisms are composed of cells, the cell is the basic unit of life, and all cells come from pre-existing cells.
8. **Exceptions to Cell Theory** include viruses, viroids, prions, coenocytic hyphae, and striated muscle fibers.
9. Viruses are considered **acellular** and are an exception to the cell theory.
10. The cell is the structural, functional, and fundamental unit of all living organisms.

Microscopy

11. The **resolution** is the ability of a microscope to distinguish two close points as separate.
12. The resolution of the naked human eye is approximately **0.1 mm**.
13. A **compound light microscope** uses visible light as an illuminating source.
14. The maximum magnification of a light microscope is about **1500X**.
15. The resolving power of a light microscope is about **0.2 μm**.
16. The source of illumination in an electron microscope is a **beam of electrons**.
17. An **Electron Microscope** has a much higher resolution (up to 0.2 nm) than a light microscope.
18. **Transmission Electron Microscope (TEM)** is used to view internal cell structures.
19. **Scanning Electron Microscope (SEM)** is used to study the surface details of cells.



Cell Cycle

Introduction to Cell Cycle

1. The **cell cycle** is the series of events from the formation of a cell until it divides into two daughter cells.
2. Rudolf Virchow proposed the principle that **all cells come from pre-existing cells**.
3. The two main phases of the cell cycle are **Interphase** and the **M phase (Mitotic phase)**.

Interphase

4. **Interphase** is the period between two consecutive cell divisions and is a phase of high metabolic activity, not a resting phase.
5. Interphase lasts for about **90%** of the total cell cycle time.
6. Interphase is divided into three sub-phases: **G1, S, and G2**.
7. During the **G1 phase (First Gap Phase)**, the cell grows in size, synthesizes proteins and organelles, and produces enzymes required for DNA replication.
8. The **S phase (Synthesis Phase)** is when **DNA replication** occurs, resulting in each chromosome consisting of two identical **sister chromatids**.
9. During the **G2 phase (Second Gap Phase)**, the cell continues to grow, produces proteins essential for division (like tubulin for spindle fibres), and checks for DNA damage.
10. Cells that temporarily or permanently stop dividing enter a state called the **G0 phase** (quiescence).
11. Examples of cells that enter **G0** permanently include **neurons** and cells of the **eye lens**.

Mitosis

12. **Mitosis** is a type of cell division where a parent cell divides to produce two daughter cells with the **same number of chromosomes** as the parent cell.
13. Mitosis occurs in the **somatic cells** (body cells) of eukaryotes.



Chromosomes and DNA

Discovery and Basic Concepts of Chromosomes

1. **Chromosomes** are thread-like structures that appear inside the nucleus at the time of **cell division**.
2. They were first observed in 1882 by the German embryologist **Walther Fleming** in the rapidly dividing cells of **salamander larvae**.
3. The term "chromosome" was proposed by **Waldeyer**, which literally means coloured bodies.
4. The number of chromosomes varies from species to species and is a characteristic feature.
5. **Penicillium**, a fungus, has only **one pair** of chromosomes, while some ferns have more than **500 pairs**.
6. A mosquito has **6**, honeybee **32**, corn **20**, sugarcane **80**, frog **26**, and a mouse has **40** chromosomes.
7. Human cells have **46** chromosomes, consisting of **23 pairs**.
8. The particular array of chromosomes that an individual possesses is called its **karyotype**.
9. The possession of all chromosomes is essential for survival, and missing a part or whole chromosome leads to serious consequences or death.
10. In an interphase cell, chromosomes become uncondensed and form a fine network called the **chromatin network**.

Morphology and Types of Chromosomes

11. A typical chromosome is made of two **chromatids**, a **centromere (primary constriction)**, and sometimes a **secondary constriction**.
12. Chromatids are attached to each other at the **centromere**, which divides the chromosome into two arms.



Variation and Genetics

Fundamental Concepts

1. A **gene** is the basic unit of biological information and a segment of DNA that codes for a polypeptide.
2. The position of a gene on a chromosome is called its **locus**.
3. Partners of a gene pair occupying the same locus on homologous chromosomes are called **alleles**.
4. The genetic complement of an individual is called its **genotype**.
5. The measurable or observable trait or characteristic of an individual is called its **phenotype**.
6. When both alleles of a gene pair are identical, the individual is said to be **homozygous**.
7. When the two alleles of a gene pair are different, the individual is said to be **heterozygous**.
8. A **gene pool** is the sum total of all genes and their alleles in a breeding population at a given time.
9. A sudden, permanent change in the cell's DNA is called a **mutation**.
10. **Jumping genes** are genes that do not settle at one locus and keep hopping on the same or different chromosomes.

Mendel's Laws of Inheritance

11. **Gregor Johann Mendel** is known as the father of genetics for his work on pea plants.
12. Mendel established **true-breeding** lines for his experiments, which always produced offspring identical to parents upon self-fertilization.
13. A cross between two individuals differing in a single trait is called a **monohybrid cross**.
14. In a monohybrid cross, the F1 generation exhibits only the **dominant** phenotype.
15. The phenotypic ratio in the F2 generation of a monohybrid cross is **3:1**.
16. The genotypic ratio in the F2 generation of a monohybrid cross is **1:2:1** (Homozygous Dominant: Heterozygous: Homozygous Recessive).



Biotechnology

Introduction to Biotechnology

1. **Biotechnology** is defined as the use of living organisms in processes for the manufacture of useful products or for services.
2. Traditional biotechnology includes ancient practices like fermentation, cheese and yogurt making, and animal breeding.
3. **Genetic engineering**, the artificial manipulation of DNA, is considered modern biotechnology.
4. The proof that DNA carries genetic information in 1944 was a pivotal starting point for genetic engineering.
5. In 1978, scientists prepared **human insulin** by inserting the insulin gene into bacteria.
6. The **Human Genome Project** was launched in 1990 to map all human genes, with a complete map published in 2002.
7. Biotechnology has applications in diverse fields including medicine, agriculture, and environmental science.
8. **Gene therapy** involves the insertion of genetic material into human cells to treat disorders.
9. **Fermentation** is the process of incomplete oxidation-reduction of glucose.
10. Louis Pasteur, in 1857, convinced the scientific community that all fermentations are the results of **microbial activity**.

Fermentation & Fermenters

11. In biotechnology, the term "**fermentation**" means the production of any product by the mass culture of microorganisms.
12. **Alcoholic fermentation** is carried out by yeast (*Saccharomyces cerevisiae*) and produces ethanol and CO₂.
13. **Lactic acid fermentation** is carried out by bacteria (e.g., *Streptococcus*, *Lactobacillus*) and produces lactic acid.



Pharmacology

Introduction to Pharmacology

1. **Pharmacology** is the scientific study of **drugs**, including their composition, properties, and medical applications.
2. The term pharmacology is derived from the **Greek** word "*pharmakon*," which means **drug**.
3. Pharmacology is distinct from **pharmacy**, which is the name used for a profession.
4. Until 1890, the subject of pharmacology was known as **Materia Medica**.
5. A **drug** is any chemical substance that, when absorbed into a living organism, **alters normal body function**.
6. A **pharmaceutical drug** or **medicinal drug** is a chemical substance used in the **diagnosis, cure, treatment, or prevention of disease**.
7. **Drug therapy** or **pharmacotherapy** is an important part of the medical field that relies on pharmacology.
8. **Prescription drugs** are sold only on a physician's order and include barbiturates, tranquilizers, and antibiotics.
9. **Non-prescription drugs** or **over-the-counter (OTC)** drugs are considered safe enough to be sold without a prescription, e.g., aspirin.

Sources of Drugs

10. Drugs are obtained from various sources: **synthetic, plants, fungi, animals, minerals, and bacteria**.
11. **Synthetic drugs** are manufactured artificially in laboratories and do not occur naturally, e.g., **Aspirin**.
12. Many drugs are derived from **plants and fungi**, e.g., **Penicillin** from fungus and **Digitalis** from the foxglove plant.
13. **Morphine**, a powerful painkiller, is extracted from the **opium poppy** plant.
14. **Quinine**, used to treat malaria, is extracted from the bark of the **Cinchona tree**.

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10. Pharmacology



Bioenergetics

Introduction to Bioenergetics

1. **Bioenergetics** is the quantitative study of energy relationships and conversions in living systems.
2. It explores how cells acquire, convert, store, and utilize energy.
3. All life on Earth is powered, directly or indirectly, by **solar energy**.
4. Biological energy transformations obey the **laws of thermodynamics**.
5. The two fundamental processes studied in bioenergetics are **photosynthesis** (energy-capturing) and **respiration** (energy-releasing).

ATP – The Energy Currency

6. **ATP (Adenosine Triphosphate)** is the chief energy currency of the cell.
7. ATP is a nucleotide composed of **adenine, ribose, and three phosphate groups**.
8. The covalent bonds between the phosphate groups are **high-energy bonds**.
9. The hydrolysis of ATP to **ADP (Adenosine Diphosphate)** and inorganic phosphate (Pi) releases about **7.3 kcal/mol** of energy.
10. ATP is synthesized from ADP and Pi during energy-releasing processes like respiration.
11. ATP is broken down during energy-consuming processes like active transport and muscle contraction.
12. Fritz Lipmann proposed that ATP is the main energy-transfer molecule in the cell.

Photosynthesis - An Overview

13. **Photosynthesis** is the process by which plants, algae, and some bacteria convert light energy into chemical energy, stored in glucose.
14. The overall equation for photosynthesis is: $6\text{CO}_2 + 12\text{H}_2\text{O} + \text{Light Energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}$.
15. Photosynthesis is a **redox (oxidation-reduction) process**; water is oxidized, and carbon dioxide is reduced.
16. It occurs in the **chloroplasts** of plant cells.
17. Photosynthesis is divided into two main phases: the **light-dependent reactions** and the **light-independent reactions (Calvin Cycle)**.



Evolution

Introduction to Evolutionary Concepts

1. **Evolution** refers to the processes that have transformed life on Earth from its earliest forms to the vast diversity observed today.

M 2. The idea that organisms evolve was first suggested by ancient philosophers like **Aristotle**.

K 3. **Creationism** is the concept that each species was specially created by God in its present form and is incapable of change.

P 4. **Evolutionists** believe that life is the result of much stable change from lower to higher forms over time.

R 5. **Charles Darwin** was the first to argue from evidence that species evolved from ancestral species and proposed **Natural Selection** as the mechanism.

Historical Background of Evolutionary Thought

A 1. **Carolus Linnaeus** introduced binomial nomenclature and sought order in the diversity of life, though he believed in the permanence of species.

R 2. **Jean-Baptiste Lamarck** was the first to propose a comprehensive theory of evolution in his 1809 book *Philosophie Zoologique*.

T 3. **George Cuvier**, a proponent of **Catastrophism**, explained Earth's history by a series of sudden, catastrophic events.

I 4. **James Hutton** and **Charles Lyell** proposed **Uniformitarianism**, which states that geological changes are slow and continuous, indicating a very old Earth.

O 5. **Thomas Malthus**, in his *Essay on the Principle of Population*, noted that populations can grow exponentially while food supply grows only arithmetically, leading to a struggle for existence.

S 6. **Alfred Russel Wallace** independently developed a theory of natural selection nearly identical to Darwin's, which prompted Darwin to publish his work.

7. The joint papers of Darwin and Wallace were presented to the **Linnaean Society of London** on July 1, 1858.



Ecology & Environment

Introduction to Ecology & Ecosystem

1. **Ecology** is the study of the interrelationship between organisms and their environment.
2. The term ecology was originally coined by the German zoologist **Ernst Haeckel** in 1866.
3. The environment includes both **physical (abiotic)** and **biological (biotic)** conditions.
4. The major unit of ecology is the **ecosystem**.
5. An **ecosystem** is a self-sufficient unit formed by interactions between a biotic community and abiotic components.
6. **Biotic components** consist of all living organisms like plants, animals, fungi, and microorganisms.
7. **Abiotic components** include non-living factors like air, water, soil, light, and temperature.
8. A **population** is a group of interbreeding individuals of the same species occurring together in space and time.
9. A **community** is formed by all the populations that live in a habitat and interact with one another.
10. Major types of ecosystems that occupy broad geographical regions are called **biomes**.
11. The **biosphere** is a thin layer of Earth where all life exists, extending from the ocean depths to the upper atmosphere.
12. The **habitat** is the actual location or place where an organism lives.
13. The **niche** is the role a species plays in a community, including its behavior and influence.
14. **Autecology** is the study of a single population's relationship to its environment.
15. **Synecology** is the study of the relationship of different communities to their environment.

Components and Processes in an Ecosystem

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13. Ecology & Environment



Viruses & Bacteria

Introduction To Prokaryotes & Taxonomy

1. Prokaryotes are unicellular organisms that lack a membrane-bound nucleus and other membrane-bound organelles.
2. Robert H. Whittaker's **Five-Kingdom system** placed all prokaryotes in the kingdom **Monera**.
3. The **Three-Domain system**, based on molecular studies, classifies life into **Bacteria**, **Archaea**, and **Eukarya**.
4. **Carl Woese** discovered that Archaea have a separate evolutionary lineage from Bacteria.
5. The most recent common ancestor of Bacteria and Archaea was likely a **hyperthermophile**.
6. The study of bacteria is called **Bacteriology**, a branch of microbiology.
7. **Anton van Leeuwenhoek** first discovered bacteria in 1674 and called them "animalcules".
8. The term "bacterium" was introduced by **Christian Gottfried Ehrenberg**.

Domain Archaea

9. Archaea are prokaryotic cells often found in **extreme environments**.
10. Archaea were previously known as **Archaeobacteria**.
11. The lipids in the plasma membranes of Archaea contain **glycerol linked to branched-chain hydrocarbons**.
12. The cell walls of Archaea **do not contain peptidoglycan**.
13. **Methanogenesis** (the production of methane) is a type of metabolism unique to some Archaea.
14. There are no known photosynthetic Archaea.

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14. Viruses & Bacteria



Protists and Fungi

Introduction to Protists

1. **Protists** are a diverse group of primarily **aquatic eukaryotic** organisms.
2. They are defined by **exclusion**, meaning they are eukaryotes that are not plants, animals, or fungi.
3. The kingdom Protista is considered a **polyphyletic** group, meaning its members do not share a single common ancestor.
4. Protists were the **first eukaryotes** to evolve.
5. They can be **unicellular, colonial, or simple multicellular** organisms.
6. Unlike plants and animals, protists do not develop from a **blastula or embryo**.
7. They exhibit extreme diversity in **size, structure, nutrition, locomotion, habitat, and reproduction**.

Major Groups of Protists

8. The four major groups of protists are **Protozoa, Algae, Myxomycota (slime molds), and Oomycota (water molds)**.

Protozoa: The Animal-like Protists

9. **Protozoa** are mostly **unicellular, heterotrophic** protists that ingest their food.
10. They inhabit **aquatic environments, soil, and can be parasitic**.
11. Their body is a single mass of **cytoplasm** containing all typical cell structures.
12. They perform all life functions like nutrition, respiration, locomotion, and reproduction.
13. **Vacuoles** perform specialized functions; **food vacuoles** aid in digestion, and **contractile vacuoles** regulate water content in freshwater species.
14. Locomotion is via **pseudopodia** (e.g., *Amoeba*), **cilia** (e.g., *Paramecium*), or **flagella** (e.g., *Trypanosoma*).
15. Parasitic protozoa like *Plasmodium* often lack specific locomotory structures.



Plant Systems, Reproduction, and Physiology

Plant Root System

1. The **root system** is primarily responsible for **anchoring** the plant and **absorbing water and minerals**.
2. The root system originates from the **radicle** of the embryo.
3. The **taproot system** has a single dominant primary root and is found in **dicots** like mustard and mango.
4. The **fibrous root system** has numerous thin, thread-like roots and is found in **monocots** like grasses and wheat.
5. The **root cap** is a protective covering at the root tip that shields the meristem.
6. The **region of meristematic activity** contains cells that are constantly dividing.
7. The **region of elongation** is where cells elongate, leading to root growth.
8. The **region of maturation** contains **root hairs** for absorption.
9. **Root hairs** are unicellular extensions of epidermal cells that increase surface area for absorption.
10. The internal structure of a root consists of the **epidermis, cortex, endodermis, and vascular system**.
11. The **endodermis** contains the **Casparian strip**, a waxy band that regulates water and solute entry into the vascular cylinder.
12. **Xylem** conducts water and minerals **upwards** from roots to shoots.
13. **Phloem** transports food via **translocation** in **all directions**.

Plant Shoot System & Leaf Structure

14. The **shoot system** comprises the aerial parts: stem, branches, leaves, flowers, and fruits.
15. The **stem** provides support, bears leaves and flowers, and contains vascular bundles.
16. The **leaf** is the primary site for **photosynthesis** and **transpiration**.
17. The **petiole** is the stalk that attaches the leaf to the stem.
18. The **lamina** is the flat, green, expanded part of the leaf.



Kingdom Plantae

Evolutionary Origin & Diagnostic Features

1. Plants are thought to have evolved from a common protistan ancestor, specifically **freshwater green algae (Charophyceae)**.
2. Plants and Charophycean algae share key characteristics like **chlorophyll a and b**, storing **starch** in chloroplasts, and having **cellulose** in their cell walls.
3. The **diagnostic features** of plants include being multicellular, eukaryotic, autotrophic organisms with well-developed tissues.
4. A key adaptation to terrestrial life is the **waxy cuticle**, which reduces water loss.
5. Plants have a **heteromorphic alternation of generations**, alternating between a diploid **sporophyte** and a haploid **gametophyte** generation.
6. Plants are **oogamous**, producing large, non-motile eggs and small, motile sperm.
7. The four major groups of plants living today are **Bryophytes, Seedless Vascular Plants, Gymnosperms, and Angiosperms**.

Non-Vascular Plants (Bryophytes)

8. **Bryophytes** include liverworts (Hepaticopsida), mosses (Bryopsida), and hornworts (Anthoceropsida).
9. They are **non-vascular plants**, lacking specialized xylem and phloem tissues.
10. Bryophytes are called "**amphibians of the plant kingdom**" because they require water for fertilization.
11. The dominant, independent generation in their life cycle is the **gametophyte**.
12. The sporophyte in bryophytes is **dependent on the gametophyte** for nutrition and protection.
13. They lack true roots, stems, and leaves, instead having **root-like rhizoids**, stem-like structures, and leaf-like appendages.
14. Male sex organs are called **antheridia**, which produce biflagellated **sperms (antherozoids)**.

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17. Kingdom Plantae



Kingdom Animalia

Introduction to Animalia

1. The name **Animalia** is derived from the Latin word *anima*, meaning breath or soul.
2. All animals are **eukaryotic, multicellular, and heterotrophic** organisms.
3. A key characteristic that distinguishes animals from plants, algae, and fungi is that they **lack cell walls**.
4. Most animals are **diploid** and develop from two dissimilar haploid gametes, a large egg and a smaller sperm.
5. Animals evolved from **protoctists** (protists), specifically from ancestors similar to **choanoflagellates**.

Criteria for Animal Classification

6. Animals are primarily classified based on the **presence or absence of tissues**, the **number of tissue layers**, **type of symmetry**, and the **type of body cavity (coelom)**.
7. The animal kingdom is divided into two subkingdoms: **Parazoa** (without true tissues) and **Eumetazoa** (with true tissues).
8. **Parazoa** includes the phylum **Porifera** (sponges), which have a cellular level of organization and are mostly asymmetrical.
9. **Eumetazoa** is divided into two grades: **Radiata** (diploblastic, radially symmetrical) and **Bilateria** (triploblastic, bilaterally symmetrical).
10. **Diploblastic** animals have two germ layers: **ectoderm** and **endoderm**, with a non-cellular **mesoglea** in between.
11. **Triploblastic** animals have three germ layers: **ectoderm, mesoderm, and endoderm**.
12. **Radial symmetry** is an adaptation for a **sessile** or floating lifestyle (e.g., cnidarians).
13. **Bilateral symmetry** is an adaptation for **motility** and is associated with cephalization (e.g., worms, insects, vertebrates).
14. Based on the body cavity, animals are classified as **acoelomates, pseudocoelomates, or coelomates**.



Human Digestive System

Introduction to the Digestive System

1. The **digestive system** breaks down food into absorbable forms to deliver nutrients to body cells.
2. It consists of the **gastrointestinal tract (GIT)** and **accessory digestive organs**.
3. The GIT is a continuous tube from the **mouth** to the **anus**.
4. The four major layers of the GIT wall, from innermost to outermost, are: **mucosa, submucosa, muscularis, and serosa**.
5. **Viscera** is a general term for abdominal organs, including those of digestion.
6. The term **gut** generally refers to the developing stomach and intestine.

The Oral Cavity

7. The **oral cavity** is bounded by lips anteriorly, cheeks laterally, palate superiorly, and a muscular floor inferiorly.
8. It is lined with **stratified squamous epithelium** for protection against abrasion.
9. The **palate** consists of the anterior **hard palate** and the posterior **soft palate**.
10. The **uvula** is a projection from the soft palate that helps prevent food from entering the nasal cavity during swallowing.
11. **Palatine tonsils** are located in the lateral walls of the fauces.
12. **Mechanical digestion** in the mouth is called **mastication** (chewing), performed by the teeth.
13. **Chemical digestion** in the mouth is initiated by **salivary amylase** on starch.
14. Three pairs of major salivary glands are: **parotid, submandibular, and sublingual**.
15. **Saliva** contains water, mucus, salivary amylase, bicarbonate ions, lysozyme, and immune globulins.
16. Saliva has a pH of 6.0-7.0, which is favorable for salivary amylase activity.
17. **Lingual lipase**, secreted by Ebner's glands, begins fat digestion in the mouth.
18. Chewing increases the **surface area** of food for enzymatic action.
19. The mass of chewed and moistened food is called a **bolus**.



Human Respiratory System

Introduction to Respiration

1. **External respiration** involves the exchange of gases between the environment and the blood at the body system level.
2. **Internal respiration** refers to cellular catabolic processes that use oxygen and produce carbon dioxide.
3. The main organs providing the **respiratory surface** for gaseous exchange are the **lungs**.

Properties of the Respiratory Surface

4. The **respiratory surface** must be **moist and permeable** for gases to diffuse.
5. It must be **thin** to minimize the diffusion distance for gases.
6. A **large surface area** is essential for sufficient gas exchange.
7. A **good blood supply** is required for efficient transport of gases.
8. A **good ventilation mechanism** maintains a steep diffusion gradient.
9. It is **located internally** to prevent water loss from its moist surface.
10. **Structural support** prevents it from collapsing.
11. Air reaches it via a **branched tubular way**, becoming saturated with water vapor.

Components of the Human Respiratory System

12. The respiratory system is divided into the **upper and lower respiratory tract**.
13. The **upper respiratory tract** includes the **nasal cavity, pharynx, and larynx**.
14. The **lower respiratory tract** includes the **trachea, bronchi, bronchioles, and lungs**.

Upper Respiratory Tract

15. The **nasal cavity** warms, humidifies, and filters inhaled air.
16. **Hairs, mucus, and cilia** in the nose trap foreign particles.
17. The **pharynx** is a common passage for both air and food.
18. The **larynx**, or voice box, contains the **vocal cords**.



Circulatory System

Introduction to the Circulatory System

1. The human body has two transport systems: the **blood circulatory system** and the **lymphatic system**.
2. The **cardiovascular system** consists of the heart, blood vessels (arteries, capillaries, veins), and blood.
3. The primary need for a circulatory system is to transport oxygen, nutrients, and remove waste for cells that are not in direct contact with the environment.

The Human Heart: Location and Pericardium

4. The human heart is located in the **mediastinum** of the thoracic cavity, between the lungs.
5. The heart is roughly the size of a clenched fist, with its **base** beneath the second rib and its **apex** at the level of the fifth intercostal space.
6. The heart is enclosed and protected by a double-layered sac called the **pericardium**.
7. The **fibrous pericardium** is the outer, inelastic layer that prevents overstretching.
8. The **serous pericardium** consists of an outer **parietal layer** and an inner **visceral layer (epicardium)**.
9. The **pericardial cavity** between these layers contains **pericardial fluid** which lubricates the heart and reduces friction.
10. **Pericarditis** is a painful inflammation of the serous pericardium.

Structure of the Heart Wall and Chambers

11. The heart wall has three layers: the **epicardium** (outer), **myocardium** (middle, muscular), and **endocardium** (inner, lining of chambers).
12. The heart has four chambers: two upper **atria** (receiving chambers) and two lower **ventricles** (pumping chambers).
13. The atria are separated by the **interatrial septum**, and the ventricles are separated by the **interventricular septum**.



Skeletal & Muscular System

Bones and Cartilage

1. The **skeleton** is an internal framework of bones and cartilage that provides support, protects organs, and enables movement.
2. The broad ends of a long bone are called the **epiphysis**.
3. The middle shaft of a long bone is called the **diaphysis**.
4. The outer connective tissue membrane covering the bone is the **periosteum**.
5. The dense, hard layer of bone found under the periosteum is the **compact bone**.
6. The basic structural unit of compact bone is the **Haversian system (Osteon)**.
7. A Haversian system consists of concentric layers of mineralized matrix called **lamellae**.
8. Small spaces within the lamellae that house mature bone cells are called **lacunae**.
9. Mature bone cells that maintain bone tissue are called **osteocytes**.
10. The central canal in a Haversian system that contains blood vessels and nerves is the **Haversian canal**.
11. Small channels connecting lacunae to each other and to the Haversian canal are **canaliculi**.
12. The lattice-like, light, and strong bone found beneath the compact bone is **spongy (cancellous) bone**.
13. **Red bone marrow**, found in spongy bone, is responsible for the production of blood cells.
14. **Yellow bone marrow**, found in the shafts of long bones, consists mostly of fat cells and serves as an energy reserve.
15. **Osteoblasts** are bone-forming cells that synthesize and secrete the unmineralized bone matrix.

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22. Skeletal & Muscular System



Nervous Coordination & Chemical Coordination

Introduction to Coordination

1. The system that provides coordination through electric signals among body parts is the **nervous system**.
2. The study of the structure and functions of the nervous system is called **neurology**.
3. **Nervous coordination** involves three basic steps: reception of stimulus, processing of information, and response to stimulus.
4. **Chemical coordination** is managed by the endocrine system through hormones.
5. A **receptor** acts as a **transducer**, converting energy from one form (e.g., light, sound) into an electrical impulse.

Neurons: Structure and Types

6. The basic structural and functional unit of the nervous system is the **neuron**.
7. The three main parts of a neuron are the **cell body**, **dendrites**, and **axon**.
8. The cell body contains **Nissl's granules**, which are groups of ribosomes and rough ER for protein synthesis.
9. **Dendrites** are short, branched extensions that receive stimuli and conduct impulses toward the cell body.
10. The **axon** is a long nerve fiber that conducts signals away from the cell body to the **presynaptic terminals**.
11. **Schwann cells** are neuroglial cells in the PNS that wrap around axons to form the **myelin sheath**.
12. The gaps between Schwann cells are called **Nodes of Ranvier**.
13. Based on function, the three types of neurons are **sensory neurons**, **motor neurons**, and **interneurons**.
14. **Sensory neurons** (afferent) transmit impulses from receptors to the CNS and are typically unipolar.
15. **Motor neurons** (efferent) transmit impulses from the CNS to effectors and are multipolar.



Homeostasis & Thermoregulation

Introduction to Homeostasis

1. **Homeostasis** is the tendency of an organism to regulate its internal conditions to maintain health and functioning.

M 2. The **internal environment** consists of interstitial fluid, lymph, and plasma.

K 3. The **external environment** is the atmosphere or water in which the organism lives.

4. A homeostatic system consists of three components: **receptors, control center (integrator), and effectors.**

P 5. The primary feedback mechanism for maintaining homeostasis is **negative feedback**, which reverses a stimulus.

R 6. **Positive feedback** amplifies a stimulus and can be harmful; examples include childbirth and blood clotting.

P 7. The **hypothalamus** in the brain acts as the body's thermostat for temperature regulation.

Thermoregulation

R 8. **Thermoregulation** is the maintenance of internal temperature within a range that allows cells to function efficiently.

T 9. The main purpose of thermoregulation is to keep the **enzyme systems** of the body working properly.

10. Animals classified on the basis of their ability to thermoregulate are **poikilotherms** (variable temperature) and **homeotherms** (constant temperature).

N 11. Animals classified on the basis of their source of body heat are **ectotherms** (external heat source) and **endotherms** (internal heat production).

12. Birds and mammals are **endothermic homeotherms.**

13. Physiological responses to heat, controlled by the hypothalamus, include **vasodilation** and **sweating.**

14. **Vasodilation** increases blood flow to the skin surface, promoting heat loss via radiation.



Reproduction

Introduction to Reproduction

1. **Reproduction** is the ability of an organism to produce new offspring of its own kind.
2. It is essential for the **survival of the species**, not the individual.
3. Human reproduction involves **internal fertilization**.

Male Reproductive System

4. The **male reproductive system** functions to produce and maintain **sperms**.
5. It includes **gonads (testes)**, accessory ducts, glands, and the **copulatory organ (penis)**.
6. **Testes** are located outside the abdomen in a skin pouch called the **scrotum**.
7. The **scrotum** maintains a temperature **2–3°C lower** than body temperature for optimal spermatogenesis.
8. Each testis contains **250–300 lobules**, each with **1–4 seminiferous tubules**.
9. **Seminiferous tubules** are the site of **sperm production**.
10. **Sertoli cells** are found in the seminiferous tubules and nourish developing sperms.
11. **Leydig (interstitial) cells** are located between seminiferous tubules and produce **testosterone**.
12. **Epididymis** stores and transports sperms.
13. **Vas deferens** carries sperms from the epididymis to the **ejaculatory duct**.
14. **Ejaculatory duct** is formed by the union of the vas deferens and the duct of the **seminal vesicle**.
15. **Urethra** serves as a common passage for urine and semen.
16. **Seminal vesicles** produce a fluid rich in **fructose** that provides energy to sperms.
17. The **prostate gland** secretes an alkaline fluid that neutralizes vaginal acidity.



Immunity

Introduction to Immunity

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1. The study of immunity and the body's defense mechanisms is called **Immunology**.
 2. **Immunity** is the body's ability to resist damage from foreign substances like microorganisms and harmful chemicals.
 3. The Greek historian **Thucydides** observed over 2000 years ago that people who recovered from a disease often became immune to it.
 4. In 1796, **Edward Jenner** hypothesized that cowpox infection provided protection against smallpox.
 5. An **immune response** is the body's reaction to foreign molecules, such as the production of antibodies against a specific antigen.
 6. The term "immune" is derived from the Latin word *immunis*, meaning "safe" or "free from burden."

Lines of Defense

7. The human body has **three lines of defense** against microbial attack.
8. The **first line of defense** consists of external barriers like the skin and mucous membranes.
9. The **second line of defense** is the **nonspecific internal defense** (innate immunity) that combats all invading microbes.
10. The **third line of defense** is the **specific internal defense** (adaptive/acquired immunity) that targets specific invaders.
11. The first and second lines of defense together constitute **innate immunity**.
12. The third line of defense is also known as **adaptive or acquired immunity**.

First Line of Defense: External Barriers

13. The **skin** and **mucous membranes** of the digestive and respiratory tracts are the primary physical barriers.



Development and Aging

Introduction to Development and Aging

1. **Development** is a period of extensive growth in size and mass and ongoing differentiation of organ systems.
2. **Aging** is defined as the progressive negative physiological changes over time, leading to loss of function and eventually death.
3. The study of aging is called **gerontology**.

Embryonic Development

4. **Embryonic development** begins with a series of mitotic divisions in the zygote, forming a multicellular embryo.
5. The stages of embryonic development are **cleavage, gastrulation, organogenesis, and growth**.
6. The study of an organism at the embryonic stage is called **embryology**.

Cleavage

7. **Cleavage** is the repeated mitotic division of the zygote following fertilization.
8. Cleavage results in cells called **blastomeres**.
9. Repeated divisions form a solid ball of cells called the **morula**.
10. A fluid-filled cavity called the **blastocoel** forms, leading to a hollow sphere stage called the **blastula**.
11. In mammals, the blastula stage is called a **blastocyst**.
12. A **blastocyst** consists of an outer layer of **trophoblast cells** and an inner cluster called the **inner cell mass**.
13. The amount and distribution of **yolk** in an egg affect the pattern of cleavage.



Behavior

Nature of Behaviour

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1. **Behaviour** is defined as the entire pattern of responses made by an organism to the stimuli of its environment.
2. A **stimulus** is any form of energy from the environment that is detected by an organism's sensors.
3. The response to a stimulus can be **positive** (attraction), **negative** (avoidance), or **ignored**.
4. Genes play a role in behaviour by directing the development of the nervous and endocrine systems.
5. The capacity to **learn** is itself an inherited trait.
6. **Biological rhythms** are cyclic patterns of physiological changes or activity in response to periodic environmental changes.
7. The internal mechanism controlling biological rhythms is called the **biological clock**.
8. **Circadian rhythms** are 24-hour cycles shown by physiological processes like body temperature and sleep-wake cycles.
9. **Diurnal** animals are behaviorally active during the day.
10. **Nocturnal** animals are behaviorally active during the night.
11. **Crepuscular** animals are most active during dawn and dusk.
12. **Exogenous** rhythms are directly driven by external environmental stimuli, like bird migration.
13. **Endogenous** rhythms are driven by an internal biological clock, like the sleep-wake cycle.

Innate Behaviour

14. **Innate behaviour** results from genetically determined neural programmes and is performed completely the first time it is exhibited.



Biostatistics & Structural Biology

Biostatistics and Data Handling

Introduction & Uses

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1. **Biostatistics** is the application of statistical principles to biological, medical, and health sciences data.
2. It is used for designing experiments, analyzing data, interpreting results, and predicting outcomes.
3. Biostatistics helps in assessing agricultural and cattle farming needs for a growing population.
4. It is crucial for evaluating the efficacy and safety of medical instruments and pharmacological drugs.
5. Biostatistics aids in monitoring epidemiological studies and public health policy development.
6. It is used to analyze inheritance patterns and risk factors for genetic diseases.
7. Biostatistics helps in analyzing pollution levels and their impact on population health.
8. **Survival analysis** in biostatistics predicts patient survival rates after specific treatments.
9. A **data set** is a collection of related data values organized for analysis.
10. The main components of a biostatistics study are problem identification, data collection, experiment design, result interpretation, and tool development.

Measures of Central Tendency & Dispersion

11. The **Mean** is the sum of all values in a data set divided by the number of values.
12. The formula for the mean of ungrouped data is $\bar{X} = \frac{\sum x}{n}$.
13. The formula for the mean of grouped data is $\bar{X} = \frac{\sum fx}{\sum f}$.
14. The **Median** is the middle value in an ordered data set.



PART B: CHEMISTRY



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Fundamentals of Chemistry

Introduction to Chemistry

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1. Chemistry is the branch of physical science that deals with the composition, structure, properties of matter, the changes it undergoes, and the laws governing those changes.
2. The modern world is a world of chemicals, and chemistry has wide applications serving humanity and nature.
3. The development of chemistry has provided facilities like petrochemicals, medicines, plastics, and detergents.
4. During the Muslim period (600-1600 AD), chemistry grew significantly and was known as "Al-Chemy."
5. The principal goals of Muslim chemists were to prolong life, transmute base metals into gold, and find physical evidence for religious beliefs.
6. Muslim scientists laid the foundation of modern laboratory methods like filtration, fermentation, and distillation.
7. Jabber Ibn Haiyan (721-803 AD), known as the father of chemistry, invented experimental methods like distillation and sublimation.
8. Al-Razi (864-930) classified chemical compounds into four types and prepared alcohol by fermentation.
9. Al-Beruni (973-1048) determined the densities of different substances.
10. Ibne-Sina (980-1037), known as the Aristotle of the Muslim world, rejected the idea of converting base metals into gold.

Branches of Chemistry

11. **Physical Chemistry** deals with the relationship between the physical properties of substances and their chemical changes.



Experimental Techniques, Chromatography & Materials

Analytical Chemistry

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1. **Analytical chemistry** is the science of chemical characterization.
 2. **Qualitative analysis** involves the identification of elements present in a compound.
 3. **Quantitative analysis** involves determining the relative amounts of the elements in a compound.
 4. A complete quantitative analysis involves obtaining a sample, separation, measurement, and drawing conclusions.

Filtration

5. Filtration is the process used to separate insoluble particles from liquids.
6. Filtration can be performed using a filter paper or a filter crucible.
7. For smooth filtration, the stem of the funnel should remain continuously full of liquid.
8. The funnel's tip should touch the side of the beaker to prevent splashing.
9. A fluted filter paper increases the rate of filtration.
10. A Gooch crucible is made of porcelain with a perforated bottom, often covered with asbestos mat or paper pulp.
11. A sintered glass crucible has a porous glass disc sealed into its bottom and requires no preparation.

Crystallization

12. Crystallization is the removal of a solid from a solution by increasing its concentration above the saturation point.
13. An ideal solvent should dissolve a large amount of the solute at its boiling point and only a small amount at room temperature.



Atomic Structure

Historical Development

1. Democritus, a Greek philosopher, first proposed that matter is composed of tiny, indivisible particles called atoms.
2. John Dalton presented his atomic theory in 1808, stating that matter is composed of indivisible atoms.
3. Dalton's theory postulated that atoms of a given element are identical in size, mass, and properties.
4. A key drawback of Dalton's theory was that it considered the atom to be the ultimate, indivisible particle.

Discovery of Fundamental Particles

5. Cathode rays were discovered in a gas discharge tube at low pressure and high voltage, producing fluorescence on the glass wall.
6. J.J. Thomson determined that cathode rays are streams of negatively charged particles (electrons).
7. The charge to mass ratio (e/m) for an electron was determined by J.J. Thomson to be 1.7588×10^{11} C/kg.
8. Eugen Goldstein discovered canal rays (positive rays) using a perforated cathode in a discharge tube.
9. The positive particle obtained from hydrogen gas in the discharge tube is the lightest and is called a proton.
10. James Chadwick discovered the neutron in 1932 by bombarding beryllium with alpha particles.
11. Millikan's oil drop experiment determined the charge on an electron to be 1.6022×10^{-19} Coulombs.
12. The mass of an electron, calculated from its charge and e/m ratio, is 9.1095×10^{-31} kg.

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Stoichiometry

Introduction to Stoichiometry

1. **Stoichiometry** is the branch of chemistry that deals with the quantitative relationship between reactants and products in a chemical reaction.
2. The word stoichiometry is derived from the Greek words 'stoicheion' (element) and 'metron' (measurement).
3. A **balanced chemical equation** is essential for all stoichiometric calculations as it indicates the number of moles of reactants and products.

The Mole and Avogadro's Number

1. A **mole** is the amount of a substance that contains 6.023×10^{23} representative particles (atoms, molecules, ions, or formula units).
2. The number 6.023×10^{23} is known as **Avogadro's number** (N_A).
3. One mole of any substance is its **atomic mass, molecular mass, or formula mass** expressed in grams.
4. One mole of any element contains the same number of atoms.
5. The **molar mass** of a substance is the mass in grams of one mole of that substance.
6. The number of moles (n) can be calculated as: $n = \frac{\text{mass in grams}}{\text{molar mass}}$.
7. The number of particles can be calculated from moles using: $n = \frac{\text{Number of particles}}{N_A}$.
8. **3. Chemical Equations and Stoichiometric Calculations**
9. A balanced chemical equation can be interpreted in terms of moles, masses, representative particles, and volumes of gases at STP.
10. The **law of conservation of mass** states that mass is neither created nor destroyed in a chemical reaction.
11. Stoichiometric calculations often involve **mole-mole, mass-mole, mass-mass, and volume-volume** conversions.



Physical States of Matter

Gaseous State

1. The **gaseous state** is characterized by molecules that are far apart with very weak intermolecular forces.
2. Gases have **no definite shape or volume** and occupy the entire volume of their container.
3. **Diffusion** is the spontaneous mixing of gas molecules from a region of higher concentration to a region of lower concentration.
4. **Effusion** is the escape of gas molecules one by one through a tiny hole without collision.
5. According to **Graham's Law of Diffusion**, the rate of diffusion of a gas is inversely proportional to the square root of its density or molar mass.
6. **Gas Pressure (P)** is defined as the force (F) exerted by the gas per unit area (A) of the container wall ($P = F/A$).
7. The SI unit of pressure is **Pascal (Pa)**, where $1 \text{ Pa} = 1 \text{ N/m}^2$.
8. **Standard Atmospheric Pressure** at sea level is 760 mm Hg, 760 torr, 1 atm, or 101.325 kPa.
9. Gases are **highly compressible** due to the large empty spaces between their molecules.
10. **Boyle's Law** states that the volume of a given mass of a gas is inversely proportional to its pressure at constant temperature ($P_1V_1 = P_2V_2$).
11. **Charles's Law** states that the volume of a given mass of a gas is directly proportional to its absolute temperature at constant pressure ($V_1/T_1 = V_2/T_2$).
12. The **Absolute Temperature (Kelvin) scale** is related to the Celsius scale by the formula:
 $K = ^\circ\text{C} + 273$.
13. **Absolute Zero (0 K or -273 °C)** is the temperature at which the volume of an ideal gas becomes zero.
14. **Avogadro's Law** states that equal volumes of all gases at the same temperature and pressure contain an equal number of molecules.

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5. Physical States of Matter



Acids, Bases & Salts

Introduction to Acids and Bases

1. **Acids** were originally identified by their sour taste.
2. **Bases** were originally identified by their slippery, soapy feel.
3. Acids change the colour of blue litmus to red.
4. Bases change the colour of red litmus to blue.
5. Acids react with active metals to produce hydrogen gas.
6. Acids react with carbonates and bicarbonates to produce carbon dioxide gas.
7. The reaction between an acid and a base produces a salt and water, a process called **neutralization**.
8. A substance that can behave as both an acid and a base is called an **amphoteric** substance.
9. **Water** is the most common amphoteric substance.
10. The **autoionization** of water involves the transfer of a proton between two water molecules to produce a hydronium ion and a hydroxide ion.

Acid-Base Theories

11. According to the **Arrhenius theory**, an acid is a substance that produces H^+ ions in aqueous solution.
12. According to the **Arrhenius theory**, a base is a substance that produces OH^- ions in aqueous solution.
13. According to the **Bronsted-Lowry theory**, an acid is a proton (H^+) donor.
14. According to the **Bronsted-Lowry theory**, a base is a proton (H^+) acceptor.
15. The Bronsted-Lowry theory is not restricted to aqueous solutions.
16. A **Lewis acid** is an electron-pair acceptor.



Chemical Bonding

Introduction to Chemical Bonds

1. A **chemical bond** is the attractive force that holds atoms together in a substance.
2. Atoms form bonds to **decrease their energy** and attain stability.
3. Except for noble gases, most elements exist in a combined state through chemical bonds.
4. The **Lewis and Kossel electronic theory of valence** states atoms bond by losing, gaining, or sharing electrons to achieve a noble gas configuration.
5. The tendency of atoms to have **eight electrons** in their valence shell is called the **octet rule**.
6. The tendency of atoms to have **two electrons** in their valence shell is called the **duplet rule**.
7. Noble gases are stable due to their **completely filled** outermost electron shells.
8. The **orbital concept** of bonding is based on the combination of atomic orbitals to form molecular orbitals.

Types of Chemical Bonds

9. The four main types of bonds are **Ionic, Covalent, Coordinate Covalent, and Metallic bonds**.
10. An **ionic bond** is formed by the complete transfer of electron(s) from a metal to a non-metal.
11. A **cation** is a positively charged ion formed when an atom loses electron(s).
12. An **anion** is a negatively charged ion formed when an atom gains electron(s).
13. Ionic bonds are held together by strong **electrostatic forces** of attraction between oppositely charged ions.
14. A **covalent bond** is formed by the mutual sharing of electron pairs between two non-metal atoms.
15. A **single covalent bond** involves the sharing of one pair of electrons.

Chemical Equilibrium

Reversible and Irreversible Reactions

1. A **reversible reaction** can proceed in both the forward and reverse directions.
2. An **irreversible reaction** proceeds predominantly in one direction and goes to completion.
3. In a reversible reaction, the reactants are not completely converted into products.
4. Examples of irreversible reactions include the reaction of sodium with water and the combustion of hydrogen.
5. The Haber process ($N_2 + 3H_2 \rightleftharpoons 2NH_3$) is a classic example of a reversible reaction.

State of Chemical Equilibrium

6. **Chemical equilibrium** is achieved when the rate of the forward reaction equals the rate of the reverse reaction.
7. At equilibrium, the **concentrations of reactants and products remain constant** over time.
8. Equilibrium is a **dynamic state** where molecular activity continues, but with no net change.
9. The same equilibrium state can be reached starting from either the reactants or the products.
10. The point of equilibrium is recognized when properties like concentration, pressure, or color become constant.

Law of Mass Action and Equilibrium Constant (K_c)

11. The **Law of Mass Action** states that the rate of a reaction is proportional to the product of the active masses of the reactants.
12. **Active mass** is represented by the molar concentration in mol dm^{-3} .
13. For a general reaction $aA + bB \rightleftharpoons cC + dD$, the **equilibrium constant K_c** is $K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$.
14. The **K_c** is the ratio of the rate constant of the forward reaction (k_f) to the rate constant of the reverse reaction (k_r), i.e., $K_c = k_f/k_r$.

Chemical Kinetics

Introduction to Chemical Kinetics

1. **Chemical kinetics** is the branch of chemistry that deals with the rates of chemical reactions, the factors affecting these rates, and the reaction mechanisms.
2. Reaction rates vary greatly, from instantaneous (e.g., $\text{AgNO}_3 + \text{NaCl}$) to very slow (e.g., rusting of iron).
3. The **rate of a reaction** is never constant; it decreases as the concentration of reactants decreases.
4. Knowledge of kinetics is crucial in industry to determine the most economical conditions for a reaction.

Rate of Reaction

5. The **rate of a reaction** is defined as the change in concentration of a reactant or product per unit time.
6. Its units are typically $\text{mol dm}^{-3} \text{ s}^{-1}$.
7. The **average rate** is the rate of reaction over a specific, finite time interval.
8. The **instantaneous rate** is the rate at a particular instant, given by dx/dt or the slope of the tangent on a concentration-time graph.
9. For a reaction, $a\text{A} \rightarrow b\text{B}$, the rate can be expressed as $\text{Rate} = - (1/a) d[\text{A}]/dt = + (1/b) d[\text{B}]/dt$.
10. The negative sign indicates a decrease in reactant concentration, while the positive sign indicates an increase in product concentration.

Rate Law, Rate Constant, and Order of Reaction

11. The **rate law** or **rate equation** is an experimental expression showing the relationship between the reaction rate and the concentrations of reactants.
12. The **rate law** cannot be deduced from the stoichiometry of the balanced equation.



Chemical Energetics & Thermochemistry

Introduction to Energetics & Thermochemistry

1. The study of energy changes accompanying physical and chemical changes is called **Energetics** or **Thermochemistry**.
2. The SI unit of heat or thermal energy is the **Joule (J)**.
3. Another common unit of heat is the **calorie**, where 1 calorie = 4.18 Joules.
4. A chemical reaction that proceeds with the evolution of heat is called an **exothermic reaction**.
5. A chemical reaction that proceeds with the absorption of heat is called an **endothermic reaction**.
6. In an exothermic reaction, the **enthalpy change (ΔH)** is negative.
7. In an endothermic reaction, the **enthalpy change (ΔH)** is positive.
8. The **First Law of Thermodynamics** states that energy can neither be created nor destroyed, only converted from one form to another.
9. The **First Law of Thermodynamics** is also known as the **Law of Conservation of Energy**.

System, Surroundings, and State Functions

10. The specific part of the universe under study is called the **system**.
11. The rest of the universe outside the system is called the **surroundings**.
12. The real or imaginary surface separating the system from the surroundings is called the **boundary**.
13. A **state function** is a property whose value depends only on the current state of the system, not on the path taken to reach that state.
14. Examples of state functions include **Pressure (P), Volume (V), Temperature (T), Internal Energy (E), and Enthalpy (H)**.



Electrochemistry

Introduction to Electrochemistry

1. **Electrochemistry** deals with the interconversion of electrical energy and chemical energy.
2. An **electrolytic cell** converts electrical energy into chemical energy.
3. A **galvanic** or **voltaic cell** converts chemical energy into electrical energy.
4. **Electrolysis** is a non-spontaneous process driven by electrical energy.
5. A spontaneous redox reaction produces electricity in a **galvanic cell**.

Oxidation and Reduction

6. **Oxidation** is the loss of electrons or an increase in oxidation number.
7. **Reduction** is the gain of electrons or a decrease in oxidation number.
8. A **redox reaction** involves simultaneous oxidation and reduction.
9. An **oxidizing agent** accepts electrons and gets reduced.
10. A **reducing agent** donates electrons and gets oxidized.
11. According to the classical concept, oxidation is the addition of oxygen or removal of hydrogen.
12. According to the classical concept, reduction is the removal of oxygen or addition of hydrogen.

Oxidation State (Oxidation Number)

13. The **oxidation number** is the apparent charge on an atom in a molecule or ion.
14. The oxidation number of a free element (e.g., Na, O₂, H₂) is zero.
15. The oxidation number of a monatomic ion equals its charge (e.g., Na⁺ is +1, S²⁻ is -2).
16. The oxidation number of hydrogen is +1, except in metal hydrides (e.g., NaH) where it is -1.



Solutions

Introduction & Basic Definitions

1. A **solution** is a homogeneous mixture of two or more substances.
2. An **aqueous solution** is formed when the solvent is water.
3. The component present in a smaller amount is called the **solute**.
4. The component present in a larger amount is called the **solvent**.
5. A solution with only two components is called a **binary solution**.
6. Water is called a **universal solvent** due to its ability to dissolve a wide variety of substances.
7. The **concentration** of a solution is the amount of solute present in a given amount of solvent or solution.
8. A **dilute solution** contains a relatively small amount of dissolved solute.
9. A **concentrated solution** contains a relatively large amount of dissolved solute.
10. A **standard solution** is a solution of known concentration.

Types of Solutions (Based on Solute-Solvent States)

11. **Gaseous Solutions:** Solute and solvent are gases (e.g., Air - Oxygen in Nitrogen).
12. **Liquid Solutions:** Solvent is a liquid; solute can be gas, liquid, or solid (e.g., CO₂ in water, alcohol in water, salt in water).
13. **Solid Solutions:** Solvent is a solid; solute can be gas, liquid, or solid (e.g., Hydrogen in Palladium, Amalgams, Alloys like Brass).
14. There are **nine possible types** of solutions based on the physical states of solute and solvent.

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Analytical Chemistry & Spectroscopy

Introduction to Analytical Chemistry

1. **Analytical Chemistry** deals with the identification and quantification of substances.
2. **Qualitative analysis** identifies what substances are present in a sample.
3. **Quantitative analysis** determines how much of a substance is present.
4. Classical methods include separations like precipitation, extraction, and distillation.
5. **Volumetric analysis (titrations)** and **gravimetric analysis** are classical quantitative methods.
6. Modern instrumental methods measure physical properties like light absorption or conductivity.
7. Modern methods are superior due to their speed, accuracy, and requirement of small sample amounts.

Classical Methods: Combustion Analysis & Formulas

8. **Combustion analysis** is used to find the percentage composition of Carbon and Hydrogen in an organic compound containing C, H, and O.
9. The organic compound is burned in oxygen, producing CO₂ and H₂O.
10. CO₂ is absorbed by KOH, and H₂O is absorbed by **Magnesium perchlorate** [Mg(ClO₄)₂].
11. Percentage of Carbon is calculated as: $\%C = (\text{mass of CO}_2 / \text{mass of compound}) \times (12/44) \times 100$.
12. Percentage of Hydrogen is calculated as: $\%H = (\text{mass of H}_2\text{O} / \text{mass of compound}) \times (2.02/18.02) \times 100$.
13. Percentage of Oxygen is found by difference: $\%O = 100 - (\%C + \%H)$.
14. The **Empirical Formula** gives the simplest whole-number ratio of atoms in a compound.
15. The **Molecular Formula** shows the actual number of atoms of each element in a molecule.

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13. Analytical Chemistry and Spectroscopy



Environmental Chemistry

Introduction to Environmental Chemistry & Atmosphere

1. The branch of chemistry dealing with the study of the environment and the changes occurring in it is called **Environmental Chemistry**.

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2. The environment is composed of four spheres: **Lithosphere, Hydrosphere, Biosphere, and Atmosphere**.

3. The **Atmosphere** is a protective blanket of air around the earth, composed mainly of **Nitrogen (78%)** and **Oxygen (21%)**.

P
4. The mass of the atmosphere is approximately **4.5 to 5 x 10¹⁵ metric tonnes**.

R
5. Atmospheric pressure **decreases** with an increase in altitude.

E
P
6. The atmosphere is divided into four main layers based on temperature: **Troposphere, Stratosphere, Mesosphere, and Thermosphere**.

Layers of the Atmosphere

A
R
7. The **Troposphere** is the lowest layer where all weather phenomena occur.

8. The average height of the troposphere is **10-11 km**.

T
9. The change in temperature with height is called the **Lapse Rate**.

I
10. The **Stratosphere** extends from 11 km to 50 km and contains the **Ozone Layer (Ozonosphere)**.

O
N
11. The temperature in the stratosphere **increases** with altitude due to the absorption of UV radiation by ozone.

S
12. The **Mesosphere** is the coldest layer, with temperatures dropping to **-92°C**.

13. The **Thermosphere** has very high temperatures (up to 1200°C) and is also called the **Ionosphere** due to the presence of ions.



Chemical Industries

Metallurgy (Copper)

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1. The art and science of making metals and alloys from their ores is called **metallurgy**.
2. An aggregate of mineral and other impurities is known as an **ore**.
3. The most important method for the concentration of copper ore is the **Froth Flootation** method.
4. In the Froth Flootation process, the ore particles are wetted by **oil** and float to the top.
5. In copper extraction, the concentrated ore is mixed with **silica** and **calcium carbonate** and heated in a blast furnace to form **matte**.
6. The chemical reaction for the reduction of copper in a Bessemer converter is: $\text{Cu}_2\text{S} + \text{O}_2 \rightarrow 2\text{Cu} + \text{SO}_2$.
7. The porous, impure copper obtained after reduction is called **blister copper**.
8. Blister copper is purified by the process of **electro-refining**.
9. In the electro-refining of copper, the impure blister copper is made the **anode**.
10. The impurities that settle at the bottom during electro-refining are called **anode mud**, which contains **silver** and **gold**.

Solvay's Process (Sodium Carbonate)

11. Sodium carbonate is commercially manufactured by **Solvay's process**.
12. The raw materials for Solvay's process are **sodium chloride (NaCl)**, **limestone (CaCO₃)**, and **ammonia (NH₃)**.



Periodic Table & Periodicity

Historical Development of the Periodic Table

1. The **modern periodic table** is based on the **atomic number** of elements, as established by **Henry Moseley**.
2. **Dobereiner** classified elements into groups of three called **triads**, where the atomic mass of the middle element was roughly the average of the other two.
3. **Newlands** proposed the **Law of Octaves**, noting that every eighth element had properties similar to the first.
4. **Mendeleev** created the most successful early periodic table based on **atomic mass** and left gaps for undiscovered elements.
5. Mendeleev's **Periodic Law** stated that properties of elements are a periodic function of their **atomic weights**.
6. The **Modern Periodic Law** states that properties of elements are a periodic function of their **atomic numbers**.
7. The confusion in Mendeleev's table regarding elements like Be, Mg, Ca, Sr, Ba, Zn, Cd, Hg was resolved in the modern table by creating **A and B subgroups**.

Structure of the Modern Periodic Table

8. The horizontal rows in the periodic table are called **periods**, and there are **7** of them.
9. The vertical columns in the periodic table are called **groups** or **families**.
10. **Group number** indicates the number of **valence electrons** in the outermost shell for representative elements.
11. **Period number** indicates the number of **electron shells** or the principal quantum number n of the valence shell.
12. The **1st period** is the shortest period, containing only **2** elements (H and He).
13. The **2nd and 3rd periods** are short periods, each containing **8** elements.



Chemical Reactivity

Introduction to Metals & Non-Metals

1. **Metals** are good conductors of heat and electricity, malleable, ductile, and form basic oxides.
2. **Non-metals** are generally poor conductors (except graphite), brittle, and form acidic oxides.
3. A **metal** is defined as an element that loses electrons to form a **cation**.
4. A **non-metal** is defined as an element that gains electrons to form an **anion**.
5. **Hydrogen** is an exception; it is a non-metal that usually acts as an electron donor.
6. The tendency of an element to lose electrons and form positive ions is called **electropositive** or **metallic character**.
7. Elements with lower **ionization energies** have a higher tendency to lose electrons and are more metallic.
8. **Metallic character** decreases across a period from left to right.
9. **Non-metallic character** increases across a period from left to right.

Alkali Metals (Group I)

10. The elements of **Group I** (except Hydrogen) are called **Alkali Metals**.
11. Alkali metals include **Lithium (Li), Sodium (Na), Potassium (K), Rubidium (Rb), Cesium (Cs), and Francium (Fr)**.
12. They have one electron in their valence shell with the configuration ns^1 .
13. Alkali metals are the **most highly electropositive** elements.
14. They have **low ionization energies**, which decrease down the group.
15. Due to high reactivity, alkali metals **do not occur free in nature**.



S & P Block Elements, Halogens & Noble Gases

s-Block Elements - Introduction

1. The **s-block** of the periodic table comprises **Group IA (Alkali Metals)** and **Group IIA (Alkaline Earth Metals)**.

M 2. Alkali metals have a general **electronic configuration** of ns^1 and form **M^+ ions**.

K 3. Alkaline earth metals have a general **electronic configuration** of ns^2 and form **M^{2+} ions**.

4. The name "**alkali**" comes from Arabic, meaning "the ashes," as ashes of plants are rich in sodium and potassium.

P 5. Due to **high reactivity**, s-block elements do not occur freely in nature and are found in **combined states**.

E **Group IA: Alkali Metals**

P 6. Alkali metals are **Lithium (Li), Sodium (Na), Potassium (K), Rubidium (Rb), Caesium (Cs), and Francium (Fr)**.

R 7. **Atomic and ionic radii increase** down the group from Li to Fr.

A 8. The **first ionization energy decreases** down the group.

T 9. They are **highly electropositive**, and their **electronegativity** values are very low, decreasing down the group.

I 10. They are **soft metals** with **low melting and boiling points** that decrease down the group.

O 11. **Density generally increases** down the group, but **potassium is lighter than sodium**.

N 12. They react **vigorously with water** to form hydroxides and hydrogen gas, and reactivity increases down the group.

S 13. They form **ionic hydrides (MH)** when reacted with hydrogen.

14. They burn in oxygen to form **oxides (Li), peroxides (Na), and superoxides (K, Rb, Cs)**.

15. **Lithium** is the only alkali metal that forms a **nitride (Li_3N)** with nitrogen.



Transition Elements

Introduction & Definition

1. **Transition elements** are defined as elements with a partially filled **d or f subshell** in their atomic state or in any common oxidation state.
2. They are located between the **s-block and p-block** elements in the periodic table.
3. **d-block elements** are also commonly referred to as transition elements.
4. Zinc (Zn), Cadmium (Cd), and Mercury (Hg) are included in the d-block, although their d-subshell is fully filled in the ground state.
5. Copper (Cu), Silver (Ag), and Gold (Au) are considered transition elements as they form ions (Cu^{2+} , Ag^{2+} , Au^{3+}) with partially filled d-orbitals.
6. **f-block elements** are called **inner transition elements** and comprise the Lanthanides and Actinides.
7. All **Actinides** are radioactive in nature.
8. Elements of group IIB (Zn, Cd, Hg) and group IIIB (Sc, Y, Lu) are termed **non-typical transition elements**.
9. Non-typical transition elements like Zn and Cd do not form coloured complexes and lack partially filled d-subshells in their common ions.
10. All d-block elements except group IIB and IIIB are called **typical transition elements**.

Electronic Configuration

11. The general valence shell electronic configuration for d-block elements is $(n-1)d^{1-10} ns^{0-2}$.
12. The electronic configuration of Chromium (Cr, Z=24) is $[\text{Ar}] 4s^1 3d^5$, an exception to the Aufbau principle for extra stability via **half-filled subshell**.
13. The electronic configuration of Copper (Cu, Z=29) is $[\text{Ar}] 4s^1 3d^{10}$, an exception for extra stability via a **fully filled d-subshell**.



Fundamentals of Organic Chemistry

Introduction & Historical Background

1. **Organic chemistry** is the study of **hydrocarbons and their derivatives**.
2. Initially, organic compounds were defined as those obtained from **living organisms (plants and animals)**.
3. Inorganic compounds were those obtained from **mineral or non-living sources**.
4. The **Vital Force Theory**, proposed by Berzelius, stated that organic compounds could only be synthesized by living organisms.
5. **Friedrich Wohler** synthesized **urea** from ammonium cyanate in 1828, disproving the Vital Force Theory.
6. Urea is an organic compound found in **urine**.
7. The modern definition of organic chemistry is the study of **carbon compounds**, with a few exceptions.
8. Compounds like **CO, CO₂, carbonates, bicarbonates, cyanides, and carbides** are considered inorganic.

Sources of Organic Compounds

9. The major sources of organic compounds are **coal, petroleum, and natural gas** (fossil fuels).
10. **Fossil fuels** are formed by the **anaerobic decomposition of buried plants and animals** over millions of years.
11. **Coal** is a solid fossil fuel formed from the decay of plant matter, first converting into **peat**.
12. Types of coal include **lignite, bituminous, and anthracite** (highest carbon content).
13. **Destructive distillation of coal** yields **coke, coal tar, ammoniacal liquor, and coal gas**.
14. **Coal tar** is a source of **aromatic compounds** like benzene, toluene, and naphthalene.



Hydrocarbons

Introduction & Classification

1. **Hydrocarbons** are organic compounds composed exclusively of **carbon and hydrogen**.
2. They are broadly classified into **Aliphatic Hydrocarbons** and **Aromatic Hydrocarbons**.
3. **Aliphatic hydrocarbons** include open-chain (acyclic) and cyclic compounds that are not aromatic.
4. **Aromatic hydrocarbons** contain at least one **benzene ring** and are also known as **arenes**.
5. Aliphatic hydrocarbons are further divided into **saturated** and **unsaturated** types.
6. **Saturated hydrocarbons** contain only **single covalent bonds** (C-C and C-H).
7. **Unsaturated hydrocarbons** contain **carbon-carbon multiple bonds** (double or triple).
8. The three main homologous series of aliphatic hydrocarbons are **Alkanes, Alkenes, and Alkynes**.
9. **Cyclic hydrocarbons** are closed chain compounds classified as **Alicyclic** (non-aromatic) and **Aromatic**.

Nomenclature and Carbon Types

10. Carbon atoms are classified as **Primary (1°), Secondary (2°), Tertiary (3°), and Quaternary (4°)** based on the number of carbon atoms attached to them.
11. The prefix '**n-**' denotes a straight-chain hydrocarbon.
12. The prefix '**iso-**' is often used for branched-chain alkanes with one **tertiary carbon**.
13. The prefix '**neo-**' is used for branched-chain alkanes with one **quaternary carbon**.
14. The **IUPAC system** provides a systematic set of rules for naming organic compounds.
15. The parent chain is the **longest continuous carbon chain**.
16. Numbering starts from the end **nearest to a substituent** in alkanes.



Alkyl Halides & Amines

Introduction & Classification of Alkyl Halides

1. **Alkyl halides** are halogen derivatives of alkanes with a hydrogen atom replaced by a halogen atom.

M 2. The general formula for a monohaloalkane is **R-X** or **C_nH_{2n+1}X**.

K 3. Alkyl halides are classified as **primary (1°)**, **secondary (2°)**, or **tertiary (3°)** based on the carbon atom to which the halogen is bonded.

P 4. In a **primary alkyl halide**, the halogen is attached to a carbon that is attached to only **one other carbon** atom.

R 5. In a **secondary alkyl halide**, the halogen is attached to a carbon that is attached to **two other carbon** atoms.

E 6. In a **tertiary alkyl halide**, the halogen is attached to a carbon that is attached to **three other carbon** atoms.

A Nomenclature of Alkyl Halides

R 7. In the **common naming system**, alkyl halides are named as two words: the alkyl group name followed by the halide name (e.g., Methyl chloride).

T 8. In the **IUPAC system**, the halogen is treated as a substituent (prefix: fluoro-, chloro-, bromo-, iodo-) on the parent alkane chain.

I 9. In IUPAC naming, the carbon chain is numbered to give the **halogen-bearing carbon the lowest possible number**.

N Physical Properties of Alkyl Halides

S 10. Lower members like **CH₃Cl**, **C₂H₅Cl**, and **CH₃F** are gases at room temperature.

11. Alkyl halides up to **C₁₈** are colorless liquids, and higher members are colorless solids.

12. Alkyl halides are generally **insoluble in water** due to their inability to form hydrogen bonds with water molecules.



Alcohols, Phenols, and Ethers

ALCOHOLS

Introduction & Classification

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1. **Alcohols** are organic compounds containing a hydroxyl (-OH) functional group attached to an aliphatic carbon atom.
2. The general formula for alcohols is $R-OH$ or $C_nH_{2n+1}OH$.
3. Alcohols containing one -OH group are called **monohydric alcohols**.
4. Alcohols containing two or more -OH groups are called **polyhydric alcohols**.
5. Monohydric alcohols are classified into **primary** (1°), **secondary** (2°), and **tertiary** (3°) alcohols.
6. In a **primary alcohol**, the carbon atom carrying the -OH group is attached to only **one** alkyl group.
7. In a **secondary alcohol**, the carbon atom carrying the -OH group is attached to **two** alkyl groups.
8. In a **tertiary alcohol**, the carbon atom carrying the -OH group is attached to **three** alkyl groups.
9. Examples of dihydric and trihydric alcohols are **1,2-ethanediol** (Glycol) and **1,2,3-propanetriol** (Glycerol).

Nomenclature

10. In the **common system**, alcohols are named as 'Alkyl Alcohols' (e.g., Methyl alcohol, Isopropyl alcohol).
11. In the **IUPAC system**, alcohols are named as 'alkanols' by replacing the 'e' of the parent alkane with '-ol'.
12. The carbon chain is numbered to give the carbon carrying the -OH group the **lowest possible number**.



Aldehydes and Ketones

Introduction to Carbonyl Compounds

1. The **carbonyl group** is a functional group composed of a carbon atom doubly bonded to an oxygen atom ($>C=O$).
2. Aldehydes, ketones, carboxylic acids, esters, amides, acid halides, and acid anhydrides are all **carbonyl compounds**.
3. In **aldehydes**, the carbonyl carbon is attached to at least one hydrogen atom.
4. The general formula for aldehydes is $R-CHO$, where R can be H or an alkyl group.
5. In **ketones**, the carbonyl carbon is attached to two alkyl or aryl groups.
6. The general formula for ketones is $R-COR'$, where R and R' can be the same or different alkyl/aryl groups.
7. The functional group of an aldehyde is the **formyl group** ($-CHO$).
8. The functional group of a ketone is the **keto group** ($-CO-$).

Nomenclature of Aldehydes

9. In the **common naming system**, aldehydes are named by replacing the "-ic acid" of the corresponding carboxylic acid with "-aldehyde" (e.g., Formic acid \rightarrow Formaldehyde).
10. In the **IUPAC system**, the ending "-e" of the parent alkane is replaced with "-al" for aldehydes.
11. In IUPAC naming, the carbonyl carbon of an aldehyde is always carbon number **1**.
12. The position of the aldehyde group is **not specified** in the name as it is always terminal.
13. In common names, the carbon adjacent to the formyl group is designated as the **α -carbon**.

Nomenclature of Ketones

14. In the **common naming system**, ketones are named by listing the alkyl groups attached to the carbonyl carbon followed by the word "ketone".

Carboxylic Acids

Introduction & Nomenclature

1. Organic compounds containing the **carboxyl functional group** (-COOH) are called **carboxylic acids**.

M 2. The carboxyl group is comprised of a **carbonyl group** (C=O) and a **hydroxyl group** (-OH).

K 3. Carboxylic acids where the -COOH group is attached to an alkyl group are **aliphatic acids** (R-COOH).

P 4. Carboxylic acids where the -COOH group is attached to an aryl group are **aromatic acids** (Ar-COOH).

R 5. Acids containing one -COOH group are **monocarboxylic acids**, while those with two are **dicarboxylic acids**.

P 6. In **IUPAC nomenclature**, aliphatic carboxylic acids are named as **alkanoic acids**.

A 7. The carbon of the carboxyl group is always assigned number **1** in the parent chain.

R 8. In common names, the positions of substituents are often indicated by Greek letters (α , β , γ), starting from the carbon adjacent to the -COOH group.

A 9. **Formic acid** (HCOOH) is derived from the Latin word *formica* (ant).

T 10. **Acetic acid** (CH₃COOH) is derived from the Latin word *acetum* (vinegar).

I 11. **Butyric acid** (C₃H₇COOH) is named after the Latin word *butyrum* (butter).

O 12. Pure, anhydrous acetic acid solidifies at **17°C** and is known as **glacial acetic acid**.

Acidity of Carboxylic Acids

S 13. Carboxylic acids are the **most acidic** simple organic compounds but are weaker than mineral acids.

14. The acidity of carboxylic acids is due to the **resonance stabilization** of the carboxylate ion (R-COO⁻).



Biochemistry

Introduction to Macromolecules

1. **Macromolecules** are large molecules built up from small repeating units called **monomers**.
2. The **macromolecular hypothesis** was significantly advanced by **Staudinger** in the 1920s.
3. Macromolecules are classified into **Inorganic** (e.g., Diamond, Graphite) and **Organic** types.
4. **Organic Macromolecules** are further divided into **Biopolymers** and **Synthetic polymers**.
5. **Polymers** can have **linear, branched, or cross-linked** structures.
6. The **Degree of Polymerization (DP)** is the number of repeating units in a polymer chain.
7. A **homopolymer** is formed from a single type of monomer, e.g., polyvinyl acetate.
8. A **copolymer** is formed from two different monomers, e.g., vinyl acetate and butyl maleate.
9. A **terpolymer** is formed from three different monomers.
10. **Thermoplastic polymers** can be softened repeatedly by heating and hardened by cooling, e.g., PVC.
11. **Thermosetting polymers** become hard on heating and cannot be softened again, e.g., epoxy resins.
12. **Addition polymerization** involves initiation, propagation, and termination steps, e.g., polystyrene.
13. **Condensation polymerization** involves the reaction of two functional groups with the removal of a small molecule like water, e.g., Nylon and Polyester.

Carbohydrates

14. **Carbohydrates** are defined as **polyhydroxy aldehydes or ketones**.
15. The general formula for many carbohydrates is $C_x(H_2O)_y$, but this is not universal.
16. Carbohydrates are primarily produced by plants through **photosynthesis**.

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