Fundamentals of Chemistry and Matter

Chapter 5: Acids, Bases, and Salts

Acids, bases, and salts are fundamental categories of chemical compounds that are essential to understanding countless chemical reactions and processes, from digestion in our bodies to industrial production.

5.1 Acids

Acids are substances that produce hydrogen ions (H^+) when dissolved in water. These H^+ ions are highly reactive and immediately combine with water molecules to form hydronium ions (H3O^+).

- **Acids in Solution:** When an acid dissolves in water, it undergoes **dissociation** or **ionization**, releasing H^+ ions (or H_3O^+ ions).
    - Example: HCl(aq) \rightarrow H^+(aq) + Cl^-(aq) or HCl(aq) + H2O(l) ➡️ 3O^+(aq) + Cl^-(aq)
    - **Strong Acids:** Acids that completely ionize in solution (e.g., HCl, H2SO4, HNO3).
    - **Weak Acids:** Acids that only partially ionize in solution (e.g., CH3COOH (ethanoic acid), H2CO3 (carbonic acid)).
- **Basicity of an Acid:** The basicity of an acid refers to the **number of replaceable hydrogen ions (H^+) per molecule** of the acid when it ionizes in water.
    - **Monobasic Acid:** Contains one replaceable H^+ ion (e.g., HCl, HNO3, CH3COOH).
    - **Dibasic Acid:** Contains two replaceable H^+ ions (e.g., H2SO4, H2CO3).
    - **Tribasic Acid:** Contains three replaceable H^+ ions (e.g., H3PO4).
- **Physical Properties of Acids:**
    - **Taste:** Sour (e.g., lemon juice, vinegar). *Never taste acids in the lab!*
    - **State:** Can be liquid (e.g., HCl) or solid (e.g., citric acid).
    - **Effect on Litmus Paper:** Turn blue litmus paper **red**.
    - **Electrical Conductivity:** Conduct electricity in aqueous solution (due to the presence of mobile ions).
    - **Corrosive:** Concentrated strong acids are highly corrosive, causing severe burns.
- **Chemical Properties of Acids:**
    - **Reaction with Metals:** Acids react with active metals (metals above hydrogen in the reactivity series) to produce **salt and hydrogen gas**.
        - Acid + Metal ➡️ Salt + Hydrogen gas
        - Example: 2HCl(aq) + Zn(s) ➡️ ZnCl2(aq) + H2(g)

    - **Reaction with Bases (Neutralization):** Acids react with bases to form **salt and water**. This reaction is called neutralization.
        - Acid + Base ➡️ Salt + Water
        - Example: HCl(aq) + NaOH(aq) ➡️ NaCl(aq) + H2O(l)
    - **Reaction with Carbonates and Hydrogen Carbonates:** Acids react with carbonates and hydrogen carbonates to produce **salt, water, and carbon dioxide gas**.
        - Acid + Carbonate ➡️ Salt + Water + Carbon Dioxide
        - Example: 2HNO3(aq) + CaCO3(s) ➡️ Ca(NO3)2(aq) + H2O(l) + CO2(g)
    - **Reaction with Sulphites:** Acids react with sulphites to produce **salt, water, and sulphur dioxide gas**.
        - Acid + Sulphite \rightarrow Salt + Water + Sulphur Dioxide
        - Example: H2SO4(aq) + Na2SO3(s) ➡️ Na2SO4(aq) + H2O(l) + SO2(g)
- **Preparation of Acids:**
    1. **From Non-metal Oxides (Acidic Oxides):** Non-metal oxides react with water to form acids.
        - SO3(g) + H2O(l) ➡️ H2SO4(aq) (Sulphuric acid)
        - CO2(g) + H2O(l) ➡️ H2CO_l3(aq) (Carbonic acid)
    2. **By Direct Combination (for certain acids):**
        - H2(g) + Cl2(g) ➡️ 2HCl(g) (Hydrogen chloride gas, then dissolved in water to make hydrochloric acid)
    3. **From Salt and a More Volatile Acid:** A less volatile (higher boiling point) acid can displace a more volatile (lower boiling point) acid from its salt.
        - 2NaCl(s) + H2SO4(l) ➡️ Na2SO4(s) + 2HCl(g) (to prepare HCl gas)
    4. **Specific Industrial Methods:**
        - **Contact Process:** For Sulphuric acid (H2SO4).
        - **Ostwald Process:** For Nitric acid (HNO3).
- **Uses of Acids:**
    - **Sulphuric Acid (H2SO4):** Most widely used industrial chemical ("King of Chemicals"). Used in car batteries, fertilizers, detergents, paints, etc.
    - **Hydrochloric Acid (HCl):** Used in cleaning metals, removing rust, and in the stomach as gastric acid.
    - **Nitric Acid (HNO3):** Used in fertilizers, explosives, and dyes.
    - **Ethanoic Acid (CH3COOH):** Found in vinegar, used as a food preservative and in plastics.
    - **Citric Acid:** Found in citrus fruits, used as a food additive and preservative.

5.2 Bases and Alkalis

- **Bases:** Substances that can neutralize acids. They are typically metal oxides or hydroxides. A common definition is that bases are proton (H^+) acceptors.
- **Alkalis:** Are a specific type of base. They are **soluble bases** that produce hydroxide ions (OH^-) when dissolved in water.
    - Example: NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)
    - **Strong Alkalis:** Alkalis that completely dissociate in solution (e.g., NaOH, KOH).
    - **Weak Alkalis:** Alkalis that only partially dissociate in solution (e.g., NH3 (ammonia) forming NH4OH in water).

- **Physical Properties of Alkalis:**
  - **Taste:** Bitter (e.g., soap). *Never taste alkalis in the lab!*
  - **Feel:** Soapy or slippery.
  - **Effect on Litmus Paper:** Turn red litmus paper **blue**.
  - **Electrical Conductivity:** Conduct electricity in aqueous solution (due to mobile ions).
  - **Corrosive:** Concentrated alkalis are corrosive (e.g., caustic soda).
- **Chemical Properties of Bases/Alkalis:**
  - **Reaction with Acids (Neutralization):** Bases react with acids to form **salt and water**.
    - Base + Acid ➡️ Salt + Water
    - Example: KOH(aq) + HNO3(aq) ➡️ KNO3(aq) + H2O(l)
  - **Reaction with Ammonium Salts (for alkalis):** Alkalis react with ammonium salts to produce **salt, water, and ammonia gas**.
    - Alkali + Ammonium Salt ➡️ Salt + Water + Ammonia gas
    - Example: NaOH(aq) + NH4Cl(aq) ➡️ NaCl(aq) + H2O(l) + NH3(g)
  - **Reaction with Metal Salts (Precipitation):** Insoluble bases are often formed when an alkali reacts with a soluble metal salt.
    - 2NaOH(aq) + FeCl2(aq) ➡️ Fe(OH)2(s) + 2NaCl(aq) (Iron(II) hydroxide, a precipitate)
- **Uses of Alkalis:**
  - **Sodium Hydroxide (NaOH):** "Caustic soda." Used in soap making, paper manufacturing, textiles, and as a drain cleaner.
  - **Potassium Hydroxide (KOH):** "Caustic potash." Used in liquid soaps and detergents.
  - **Calcium Hydroxide (Ca(OH)2):** "Slaked lime." Used to neutralize acidic soil, in plaster, and to test for carbon dioxide.
  - **Ammonia Solution (NH3(aq)):** Used in fertilizers, cleaning agents, and rayon manufacturing.

5.3 Measurement of Acidity and Alkalinity: pH Scale, Acid-Base Indicators

- **pH Scale:** The pH scale is a measure of the **acidity or alkalinity** of a solution. It ranges from 0 to 14.
  - **pH < 7:** Acidic solution (higher H^+ concentration). Lower pH means stronger acid.
  - **pH = 7:** Neutral solution (equal H^+ and OH^- concentration, e.g., pure water at 25 {°C}).
  - **pH > 7:** Alkaline (basic) solution (higher OH^- concentration). Higher pH means stronger alkali.
  - The pH is inversely related to the concentration of H^+ ions. A change of 1 pH unit represents a tenfold change in H^+ concentration.
  - pH = -log{10}[H^+] (For secondary level, focus on the qualitative understanding).
- **Acid-Base Indicators:** Indicators are substances that change color depending on the pH of the solution. They are used to determine if a solution is acidic, basic, or neutral, and to find the endpoint of a titration.
  - **Litmus Paper:**
    - Blue litmus ➡️ Red (Acid)
    - Red litmus ➡️ Blue (Alkali)

        - No change (Neutral)
    - **Methyl Orange:**
        - Red (Acidic, pH < 3.1)
        - Yellow (Alkaline, pH > 4.4)
        - Orange (Neutral/Transition)
    - **Phenolphthalein:**
        - Colorless (Acidic/Neutral, pH < 8.2)
        - Pink (Alkaline, pH > 10)
    - **Universal Indicator:** A mixture of several indicators that shows a range of colors across the entire pH scale, allowing for a more precise estimation of pH.
    - **pH Meter:** An electronic device that provides a precise numerical reading of the pH.

5.4 Salts

Salts are ionic compounds formed when the hydrogen ions (H^+) of an acid are replaced by a metal ion or ammonium ion (NH4^+). They are typically formed during the neutralization reaction between an acid and a base.

- **Types of Salts:**
    - **Normal Salts:** Formed when all replaceable hydrogen ions of an acid are completely replaced by metal ions (e.g., NaCl, K2SO4).
    - **Acid Salts:** Formed when only part of the replaceable hydrogen ions of a polybasic acid are replaced, so it still contains acidic hydrogen atoms (e.g., NaHCO3 (sodium hydrogencarbonate), NaHSO4). They can further react with bases.
    - **Basic Salts:** Formed when there is incomplete neutralization of a polyacidic base (a base that can accept more than one proton), leaving hydroxide ions remaining (e.g., Mg(OH)Cl).
    - **Mixed Salts:** Contains more than one type of cation or anion (e.g., Bleaching powder, CaOCl2).
- **Uses of Salts:**
    - **Sodium Chloride (NaCl):** Common table salt, food preservative, used in chemical industries to produce NaOH, Cl_2, H_2.
    - **Calcium Carbonate (CaCO3):** Limestone, marble, chalk. Used in construction, cement production, and as an antacid.
    - **Sodium Bicarbonate (NaHCO3):** Baking soda. Used in baking, antacids, and fire extinguishers.
    - **Potassium Nitrate (KNO3):** Used in fertilizers, gunpowder, and fireworks.
    - **Ammonium Sulphate ((NH4)2SO4):** Used as a fertilizer.
- **Preparation of Salts:** The method used depends on whether the salt is soluble or insoluble in water.
    - **Preparation of Soluble Salts:** Generally involves reactions that produce a soluble product which can then be crystallized.
        1. **Acid + Active Metal:** (for less reactive metals like Zn, Fe, Mg).
            - Zn(s) + H2SO4(aq) ➡️ ZnSO4(aq) + H2(g)
        2. **Acid + Insoluble Base/Metal Oxide:** (for insoluble metal oxides/hydroxides).
            - CuO(s) + H2SO4(aq) ➡️ CuSO4(aq) + H2O(l)
        3. **Acid + Carbonate/Hydrogencarbonate:** (for soluble or insoluble carbonates).
            - Na2CO3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H2O(l) + CO2(g)

4. **Titration (Acid-Base Neutralization):** For salts of strong acid and strong base.
    - HCl(aq) + NaOH(aq) ➡️ NaCl(aq) + H2O(l)
    - Requires careful measurement of volumes using indicators to ensure complete neutralization, then evaporation.
- **General Steps for Soluble Salt Preparation:** React reactants, filter off any excess insoluble reactant, evaporate the filtrate to concentrate, then cool to crystallize the salt.

- **Preparation of Insoluble Salts:** Usually done by **precipitation**, which involves mixing two soluble salt solutions whose ions will combine to form an insoluble salt.
    1. **Precipitation (Double Decomposition):**
        - AgNO3(aq) + NaCl(aq) ➡️ AgCl(s) + NaNO3(aq) (Silver chloride is insoluble)
        - BaCl2(aq) + Na2SO4(aq) ➡️ BaSO4(s) + 2NaCl(aq) (Barium sulphate is insoluble)
    - **General Steps for Insoluble Salt Preparation:** Mix solutions, filter the precipitate, wash the precipitate with distilled water to remove impurities, dry the precipitate.

5.5 Water of Crystallization

- **Definition:** Many salts, when crystallized from aqueous solutions, incorporate a definite number of water molecules into their crystal structure. This associated water is called **water of crystallization**.
- **Hydrated Salts:** Salts that contain water of crystallization (e.g., copper(II) sulphate pentahydrate, CuSO4 … 5H2O).
- **Anhydrous Salts:** Salts that have lost their water of crystallization (e.g., anhydrous copper(II) sulphate, CuSO4).
- **Properties related to Water of Crystallization:**
    - **Efflorescence:** The process where a hydrated salt **loses its water of crystallization** to the atmosphere upon exposure to dry air, typically changing to a powder (e.g., Na2CO_3 … 10H2O loses water to become Na2CO3 … H2O or anhydrous Na2CO3).
    - **Deliquescence:** The process where a substance **absorbs so much moisture from the atmosphere** that it dissolves in the absorbed water to form a solution (e.g., NaOH, CaCl2). These are typically very soluble.
    - **Hygroscopy:** The process where a substance **absorbs moisture from the atmosphere** but does not dissolve to form a solution (e.g., concentrated H2SO4, anhydrous CaCl2 as a drying agent). The absorbed water is simply adsorbed onto the surface or held within its structure.

5.6 Ionic Reactions and Equations

- **Ionic Equations:** Chemical equations that show only the particles (ions, atoms, molecules) that participate in a chemical reaction. They are particularly useful for reactions in aqueous solution where ionic compounds dissociate.
- **Spectator Ions:** Ions that are present in the solution but do not participate in the actual chemical reaction (they remain unchanged on both sides of the equation).

- **Steps to Write an Ionic Equation:**
    1. Write the balanced molecular equation.
    2. Break down all soluble ionic compounds into their respective ions. Leave insoluble solids, liquids, and gases as whole molecules.
    3. Cancel out spectator ions (ions that appear identically on both sides of the equation).
    4. Write the remaining ions and molecules as the net ionic equation.
- **Example: Reaction of Silver Nitrate with Sodium Chloride**
    - Molecular Equation: AgNO3(aq) + NaCl(aq) ➡️ AgCl(s) + NaNO3(aq)
    - Total Ionic Equation: Ag^+(aq) + NO3^-(aq) + Na^+(aq) + Cl^-(aq) ➡️ AgCl(s) + Na^+(aq) + NO3^-(aq)
    - Spectator Ions: Na^+(aq) and NO3^-(aq)
    - Net Ionic Equation: Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)

5.7 Conductance of Acids, Bases, and Salts

- **Electrical Conductivity:** The ability of a substance to conduct electric current. This requires the presence of mobile charged particles (ions or electrons).
- **Acids, Bases, and Salts in Solution:**
    - **Acids:** Conduct electricity in aqueous solution because they ionize to produce mobile H^+ (or H3O^+) ions and corresponding anions. Strong acids are good conductors; weak acids are poor conductors.
    - **Bases/Alkalis:** Conduct electricity in aqueous solution because soluble bases (alkalis) dissociate to produce mobile OH^- ions and corresponding cations. Strong alkalis are good conductors; weak alkalis are poor conductors.
    - **Salts:** Conduct electricity when dissolved in water (aqueous solution) or when molten (melted). This is because in both states, their ions become mobile and can carry charge. Solid salts do not conduct electricity because their ions are held in fixed positions in the crystal lattice.

Chapter 6: Carbon and Its Compounds

Carbon is an incredibly versatile element, forming the basis of all organic life and numerous inorganic compounds. Its unique ability to form strong bonds with itself and other elements leads to a vast array of structures and properties.

6.1 Carbon

- **General Properties of Carbon:**
    - **Group 14 element:** Located in Group 14 of the periodic table, it has 4 valence electrons.
    - **Valency of 4:** It can form four covalent bonds.
    - **Catenation:** The unique ability of carbon atoms to form strong covalent bonds with other carbon atoms, creating long chains, branched chains, and rings. This property is responsible for the enormous number of organic compounds.
    - **Multiple Bonding:** Can form single, double, and triple bonds with other carbon atoms and other elements (e.g., C=C, C≡C, C=O, C≡N).

- **Allotropy:** Exists in different physical forms (allotropes) with different structures and properties, but composed of the same element.

- **Allotropes of Carbon:**
  1. **Diamond:**
     - **Structure:** Each carbon atom is covalently bonded to four other carbon atoms in a rigid, tetrahedral 3D network structure.
     - **Properties:** Extremely hard (hardest natural substance), high melting point, does not conduct electricity (no free electrons), transparent, high refractive index.
     - **Uses:** Cutting tools (drills, saws), abrasives, jewelry.
  2. **Graphite:**
     - **Structure:** Each carbon atom is covalently bonded to three other carbon atoms in planar hexagonal rings, forming layers. The layers are held together by weak Van der Waals forces.
     - **Properties:** Soft and slippery (layers can slide past each other), good conductor of electricity (one delocalized electron per carbon atom), high melting point, opaque, greyish-black.
     - **Uses:** Lubricants, pencils ("lead"), electrodes, battery components.
  3. **Amorphous Carbon (Impure forms):** These are non-crystalline forms of carbon.
     - **Coal:** A complex mixture of carbon compounds, formed from the decomposition of plant matter over millions of years. Used as a fuel.
     - **Coke:** A solid carbonaceous residue derived from destructive distillation of coal. Used as a fuel and reducing agent in metallurgy (e.g., in blast furnaces).
     - **Carbon Black (Soot):** Fine black powder formed from the incomplete combustion of hydrocarbons.
       - **Uses:** Pigment in inks and paints, reinforcing filler in rubber products (e.g., tires).
     - **Charcoal:** Porous black solid residue obtained by heating wood (wood charcoal) or animal bones (animal charcoal) in the absence of air.
       - **Uses:** Adsorbent (removes impurities from water/gases due to its large surface area), fuel.
     - **Carbon Fibres:** Thin strands of carbon atoms arranged in long, parallel structures.
       - **Properties:** Extremely strong, lightweight, high tensile strength.
       - **Uses:** Reinforcing material in composites (e.g., aircraft parts, sports equipment, bulletproof vests).

6.2 Carbon(II) Oxide (Carbon Monoxide, CO)

- **Preparation:**
  1. **Incomplete Combustion of Carbon-containing fuels:** When carbon or carbon compounds burn with an insufficient supply of oxygen.
     - $2C(s) + O2(g) \rightarrow 2CO(g)$ (limited oxygen)
  2. **Passing steam over hot coke:**
     - $C(s) + H2O(g) \rightarrow CO(g) + H2(g)$ (Water gas)
  3. **Dehydration of Formic Acid with Concentrated Sulphuric Acid:**
     - $HCOOH(l) \xrightarrow{\text{Conc. } H2SO4} CO(g) + H2O(l)$

- **Physical Properties:**
  - Colorless, odorless, tasteless gas.
  - Slightly less dense than air.
  - Highly poisonous.
- **Chemical Properties:**
  - **Flammable:** Burns with a blue flame to form carbon dioxide.
    - 2CO(g) + O2(g) ➡️ 2CO2(g)
  - **Reducing Agent:** A strong reducing agent, especially at high temperatures. It can reduce metal oxides to metals.
    - Fe2O3(s) + 3CO(g) ➡️ 2Fe(s) + 3CO2(g) (Used in blast furnaces)
  - **Neutral Oxide:** It does not react with acids or bases.
  - **Toxic:** Highly poisonous because it binds irreversibly to hemoglobin in red blood cells, preventing oxygen transport.
- **Uses:**
  a. As a **reducing agent** in metallurgy (e.g., extraction of iron).
  b. As a component of **fuel gases** (e.g., water gas: CO + H_2; producer gas: CO + N_2).

6.3 Carbon(IV) Oxide (Carbon Dioxide, CO_2)

- **Preparation:**
  1. **Complete Combustion of Carbon-containing fuels:** When carbon or carbon compounds burn with sufficient oxygen.
     - C(s) + O2(g) ➡️ CO2(g)
     - CH4(g) + 2O2(g) ➡️ CO2(g) + 2H2O(l)
  2. **Decomposition of Carbonates (e.g., Limestone):**
     - CaCO3(s) ➡️ {{heat}} CaO(s) + CO2(g) (Industrial preparation)
  3. **Reaction of Carbonates/Hydrogencarbonates with Acids:** (Laboratory preparation)
     - CaCO3(s) + 2HCl(aq) ➡️ CaCl2(aq) + H2O(l) + CO2(g)
  4. **Respiration:** A biological process where organisms release CO_2.
  5. **Fermentation:** Biological process producing alcohol and CO_2.
- **Physical Properties:**
  - Colorless, odorless gas.
  - Denser than air (can be poured).
  - Slightly soluble in water (forms carbonic acid, H2CO3).
  - Sublimes at -78.5 {°C} (solid CO_2 is called "dry ice").
  - Non-flammable and does not support combustion.
- **Chemical Properties:**
  - **Acidic Oxide:** Reacts with water to form a weak acid (carbonic acid).
    - CO2(g) + H2O(l) ↔ H2CO3(aq)
  - Reacts with alkalis to form carbonates or hydrogen carbonates.
    - CO2(g) + 2NaOH(aq) ➡️ Na2CO3(aq) + H2O(l)
    - CO2(g) + NaOH(aq) ➡️ NaHCO3(aq) (with excess CO_2)
  - **Reaction with Magnesium:** Magnesium is active enough to burn in carbon dioxide, reducing it to carbon.
    - 2Mg(s) + CO2(g) ➡️ 2MgO(s) + C(s)
  - **Photosynthesis:** Essential for photosynthesis in plants (CO2 + H2O ➡️ {{light, chlorophyll}} {glucose} + O2).

- **Uses:**
  - **Fire Extinguishers:** Being denser than air and non-combustible, it smothers fires.
  - **Refrigerant:** Dry ice is used for cooling and preservation.
  - **Carbonated Drinks:** Gives fizziness to soft drinks.
  - **Photosynthesis:** Crucial for plant life.
  - **Manufacture of Soda Ash and Baking Soda:** (Na2CO3 and NaHCO3).

6.4 Trioxocarbonates(IV) (Carbonates) and Hydrogentrioxocarbonates(IV) (Hydrogencarbonates)

These are salts of carbonic acid (H2CO3).

- **Trioxocarbonates(IV) (Carbonates, CO3^{2-}):**
  - **Properties:**
    - Most carbonates are insoluble in water, except those of Group 1 metals (e.g., Na2CO3, K2CO3) and ammonium carbonate ((NH4)2CO3).
    - React with acids to produce carbon dioxide gas, water, and salt.
      - Na2CO3(s) + 2HCl(aq) ➡️ 2NaCl(aq) + H2O(l) + CO2(g)
    - Most carbonates decompose on heating to form a metal oxide and carbon dioxide (Group 1 carbonates are very stable and require very high temperatures).
      - CaCO3(s) ➡️ {{heat}} CaO(s) + CO2(g)
  - **Preparation:**
    - From Carbon dioxide and a Metal oxide/hydroxide: CaO(s) + CO2(g) ➡️ CaCO3(s)
    - Precipitation: CaCl2(aq) + Na2CO3(aq) ➡️ CaCO3(s) + 2NaCl(aq)
  - **Uses:** Limestone (CaCO_3) for cement and building, washing soda (Na2CO3 …. 10H2O) as a detergent.
- **Hydrogentrioxocarbonates(IV) (Hydrogencarbonates, HCO3^-):**
  - **Properties:**
    - All hydrogen carbonates are soluble in water.
    - Decompose on heating to form a carbonate, water, and carbon dioxide.
      - 2NaHCO3(s) ➡️ {{heat}} Na2CO3(s) + H2O(l) + CO2(g) (This property is why baking soda makes cakes rise).
    - React with acids to produce carbon dioxide, water, and salt.
      - NaHCO3(s) + HCl(aq) ➡️ NaCl(aq) + H2O(l) + CO2(g)
  - **Preparation:**
    - Passing excess carbon dioxide through a carbonate solution:
      - Na2CO3(aq) + H2O(l) + CO2(g) ➡️ 2NaHCO3(aq)
  - **Uses:** Sodium hydrogencarbonate (NaHCO3, baking soda) in baking, antacids, and fire extinguishers.

6.5 Carbon Cycle

The carbon cycle is a biogeochemical cycle by which carbon is exchanged among the biosphere, pedosphere, geosphere, hydrosphere, and atmosphere of the Earth. It is crucial for maintaining life on Earth and regulating climate.

- **Key Processes in the Carbon Cycle:**
    1. **Photosynthesis:** Plants absorb atmospheric carbon dioxide (CO_2) and convert it into organic compounds (glucose) using sunlight.
        - $CO_2 + H_2O$ ➡️ {{light}} {Glucose} + O_2
    2. **Respiration:** Living organisms (plants and animals) break down organic compounds for energy, releasing carbon dioxide back into the atmosphere.
        - {Glucose} + O_2 ➡️ $CO_2 + H_2O$ + {Energy}
    3. **Combustion:** The burning of carbon-containing fuels (fossil fuels like coal, oil, natural gas, and biomass like wood) releases large amounts of carbon dioxide into the atmosphere.
    4. **Decomposition:** Decomposers (bacteria and fungi) break down dead organic matter, releasing carbon dioxide (and methane) into the atmosphere.
    5. **Ocean Absorption/Release:** Oceans absorb a significant amount of atmospheric carbon dioxide, which dissolves to form carbonic acid. Marine organisms also use carbon to form shells (carbonates). Carbon is released back as the ocean warms.
    6. **Volcanic Activity:** Releases carbon dioxide from the Earth's interior.
- **Importance of the Carbon Cycle:**
    - Provides carbon for living organisms to build their bodies.
    - Regulates Earth's climate by influencing the concentration of carbon dioxide (a greenhouse gas) in the atmosphere.
    - Supports the flow of energy through ecosystems.
- **Human Impact on the Carbon Cycle:**
    - **Burning of Fossil Fuels:** Releases large amounts of stored carbon into the atmosphere, increasing atmospheric CO_2 levels.
    - **Deforestation:** Reduces the amount of CO_2 absorbed by plants through photosynthesis.
    - These human activities lead to an imbalance in the carbon cycle, contributing to increased greenhouse gas concentrations and global warming.

Glossary of Terms

- **Acid:** Substance that produces H^+ ions in solution.
- **Basicity of an Acid:** Number of replaceable H^+ ions per acid molecule.
- **Base:** Substance that neutralizes an acid; often metal oxide/hydroxide.
- **Alkali:** Soluble base that produces OH^- ions in solution.
- **Neutralization:** Reaction between an acid and a base to form salt and water.
- **pH Scale:** Measure of acidity/alkalinity (0-14).
- **Indicator:** Substance that changes color with pH.
- **Salt:** Ionic compound formed when H^+ of an acid is replaced by a metal or NH_4^+.
- **Water of Crystallization:** Water molecules incorporated into a salt's crystal structure.
- **Efflorescence:** Loss of water of crystallization by a hydrated salt.
- **Deliquescence:** Absorption of atmospheric moisture to dissolve and form a solution.
- **Hygroscopy:** Absorption of atmospheric moisture without dissolving.
- **Ionic Equation:** Equation showing only reacting ions.
- **Spectator Ions:** Ions that do not participate in a reaction.
- **Allotropes:** Different structural forms of the same element.
- **Catenation:** Ability of an element (like carbon) to form bonds with itself.
- **Carbon Cycle:** Biogeochemical cycle of carbon exchange on Earth.

Practice Questions

(Note: Answers are not provided here, but you would typically include them at the end of a physical ebook.)

Acid, Base and Salt Questions:

1. Define an acid and an alkali according to their behavior in water. Give one example of a strong acid and one example of a weak acid.
2. What is the basicity of sulphuric acid (H_2SO_4) and nitric acid (HNO_3)?
3. Describe two physical properties and two chemical properties of acids.
4. Write a balanced chemical equation for the reaction between magnesium and hydrochloric acid.
5. How would you prepare sodium chloride in the laboratory using an acid and a base?
6. Explain what happens when carbon dioxide gas is bubbled through limewater ($Ca(OH)_2$ solution) first in small amounts, then in excess. Write equations for both reactions.
7. Explain the terms efflorescence, deliquescence, and hygroscopy. Give one example for each.
8. Why does a solution of common salt ($NaCl$) conduct electricity, while solid common salt does not?
9. Write the net ionic equation for the reaction: $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$. Identify the spectator ions.
10. A solution turns red litmus blue and feels soapy. What type of substance is it? What pH range would you expect it to have?

Carbon and It Compounds Questions:

1. Name three allotropes of carbon and state one distinct property for each.
2. Explain the term "catenation" with reference to carbon. Why is it important for organic chemistry?
3. Compare and contrast the electrical conductivity of diamond and graphite, explaining the reason for the difference.
4. Describe how carbon monoxide is prepared in the laboratory or industrially. State two of its physical properties.
5. Why is carbon monoxide considered a poisonous gas?
6. Write a balanced chemical equation for the complete combustion of methane (CH_4).
7. State two industrial uses of carbon dioxide.
8. How can you distinguish between a carbonate and a hydrogencarbonate using a simple test? (Hint: Consider heating).
9. Describe the role of photosynthesis and respiration in the carbon cycle.
10. Discuss two ways human activities are impacting the natural carbon cycle.