Chemistry

A comprehensive cheat sheet covering advanced chemical concepts, including atomic structure, reaction kinetics, enzymes, and practical skills related to data analysis and environmental issues.

Chemical Foundations & Reactions

Atomic Structure Fundamentals

Element: A substance that cannot be broken down into simpler substances by chemical means.

Atom: The smallest unit of an element that retains the chemical properties of that element.

Matter: Anything that has mass and takes up space.

Proton: Positively charged particle located in the nucleus; mass ≈ 1 amu.

Neutron: Neutral particle located in the nucleus; mass ≈ 1 amu.

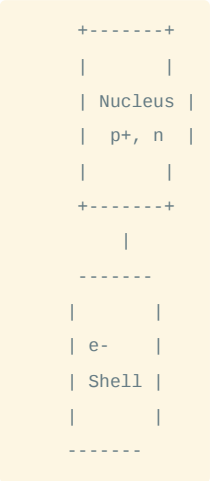
Electron: Negatively charged particle orbiting the nucleus; negligible mass.

Nucleus: The central core of an atom, containing protons and neutrons.

Atomic Structure (Bohr-Rutherford)

The Bohr-Rutherford model illustrates the atom as a central nucleus containing protons and neutrons, surrounded by electrons orbiting in specific shells or energy levels.

Sketch:



Subatomic Particles

Particle	Mass, Charge, Location
Proton	≈ 1 amu, +1, Nucleus
Neutron	≈ 1 amu, 0, Nucleus
Electron	≈ 0 amu, -1, Orbitals

Physical vs. Chemical Reactions

Physical Reaction	Alters form or appearance, but not chemical composition (e.g., melting ice).
Chemical Reaction	Involves the rearrangement of atoms and formation of new substances (e.g., burning wood).

Law of Conservation of Mass

Mass is neither created nor destroyed in a chemical reaction. The total mass of the reactants equals the total mass of the products.

Example:

$2H_2 + O_2 \rightarrow 2H_2O$

If 4g of H_2 reacts with 32g of O_2, 36g of H_2O will be produced.

Balancing Chemical Equations

Ensure the number of atoms of each element is the same on both sides of the equation by adjusting coefficients.

Example:

Unbalanced: $H_2 + O_2 \rightarrow H_2O$

Balanced: $2H_2 + O_2 \rightarrow 2H_2O$

Collision Theory & Reaction Rates

Collision Theory Overview

For a reaction to occur, reactant particles must collide with sufficient energy (activation energy) and proper orientation.

Temperature: A measure of the average kinetic energy of particles in a substance.

Particles must possess energy equal to or greater than the activation energy (Ea) to overcome the energy barrier and react.

Reaction Rate: The speed at which a chemical reaction proceeds.

Reaction Rate Factors

Temperature: Higher temperature increases kinetic energy, leading to more effective collisions.

Concentration: Higher concentration increases the frequency of collisions.

Surface Area: Increased surface area (e.g., using powders instead of chunks) allows for more collisions.

Catalysts: Lower the activation energy, enabling more particles to react.

Pressure (for gases): Higher pressure increases the frequency of collisions.

Maxwell-Boltzmann Distribution

Illustrates the distribution of kinetic energies among particles at a given temperature. Higher temperatures shift the curve to the right, increasing the fraction of particles with sufficient energy to react.

Catalysts effectively lower the activation energy barrier.

graphs demonstrating how temperature and catalysts can influence rate of reaction.

Reaction Rate Calculations

Reaction rate can be calculated as the change in concentration of reactants or products over time.

$\text{Rate} = -\Delta[\text{Reactant}]/\Delta t = \Delta[\text{Product}]/\Delta t$

Example:

If the concentration of a reactant decreases by 0.1 M in 10 seconds, the rate is 0.01 M/s.

Enzymes & Catalysis

Catalysis and Reaction Rate

Catalysts (including enzymes) increase reaction rate by lowering the activation energy without being consumed in the reaction.

They provide an alternative reaction pathway with a lower energy barrier.

Enzymes: Biological Catalysts

Enzymes are essential for life because they catalyze biochemical reactions at physiological conditions (temperature, pH) at a high rate.

Without enzymes, many reactions would occur too slowly to sustain life.

'Induced Fit' Model

The active site of an enzyme is not perfectly complementary to the substrate. Upon binding, the enzyme changes shape to better fit the substrate, facilitating the reaction.

This conformational change stresses substrate bonds, lowering the activation energy.

Factors Affecting Enzyme Activity

Temperature: Enzymes have an optimal temperature range. High temperatures can denature the enzyme.

pH: Enzymes have an optimal pH range. Extremes can alter enzyme shape and activity.

Substrate Concentration: Increased substrate concentration generally increases the reaction rate until the enzyme is saturated.

Inhibitors: Competitive inhibitors bind to the active site, while non-competitive inhibitors bind elsewhere, altering enzyme shape.

ATP Synthase

ATP synthase is an enzyme complex that synthesizes ATP from ADP and inorganic phosphate using the energy from a proton gradient across a membrane (e.g., in mitochondria and chloroplasts).

It's a crucial enzyme for energy production in cells.

Practical Skills & Environmental Chemistry

Data Collection and Presentation

Collect data systematically, organize it in tables (with proper headings and units), and present it graphically (scatter plots, bar graphs, etc.) to visualize trends.

Data Interpretation

Analyze data to identify patterns, relationships, and draw conclusions. Use statistical tools to determine significance.

Hypothesis Validity

Evaluate whether experimental data supports or refutes the hypothesis. Consider limitations of the method and potential sources of error.

Method Improvement

Suggest modifications to improve accuracy, precision, or scope of the experiment. Consider controls, sample size, and measurement techniques.

Plastic Pollution

Plastic pollution poses a significant threat to ecosystems due to its persistence, accumulation in the environment, and potential harm to wildlife (ingestion, entanglement).

Microbial Plastic Recycling

Microbes can break down certain plastics through enzymatic degradation. This offers a potential solution for recycling plastics that are difficult to recycle through conventional methods.

Enzymatic Plastic Recycling

Enzymes are required for efficient and specific breakdown of plastics into monomers, which can then be used to create new plastics or other valuable products. This can be faster and more energy-efficient than traditional methods.

PLA (Polylactic Acid)

Positives: Biodegradable under specific conditions, made from renewable resources.
Negatives: Requires industrial composting facilities, can release methane if not composted properly.
Issues: Widespread adoption limited by infrastructure and consumer awareness.

Plastic Chemical Composition

plastics are mainly composed of carbon and hydrogen and sometimes oxygen, nitrogen, chlorine, sulphur, phosphorus, silicon and fluorine. Different plastics have different composition.