Chemistry

A comprehensive cheat sheet covering fundamental chemistry concepts including atomic structure, chemical reactions, reaction rates, enzymes, and the chemistry of plastics with a focus on recycling and environmental impact.

Chemical Foundations

Atomic Structure Basics

Element: A pure substance consisting only of atoms that have the same number of protons in their atomic nuclei.

Atom: The basic unit of matter; consists of a nucleus containing protons and neutrons, surrounded by electrons.

Matter: Anything that has mass and takes up space.

Proton: A positively charged subatomic particle located in the nucleus of an atom.

Neutron: A neutral (no charge) subatomic particle located in the nucleus of an atom.

Electron: A negatively charged subatomic particle orbiting the nucleus of an atom.

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

Subatomic Particles

Proton	Mass: ~1 atomic mass unit (amu), Charge: +1, Location: Nucleus
Neutron	Mass: ~1 amu, Charge: 0, Location: Nucleus
Electron	Mass: ~0 amu (negligible), Charge: -1, Location: Orbitals around the nucleus

Reactions: Physical vs. Chemical

Physical Reaction: A change in the form or appearance of a substance, but not in its chemical composition. Examples: melting, boiling, dissolving.

Chemical Reaction: A process that involves rearrangement of atoms and molecules to form new substances. Examples: burning, rusting, cooking.

Observations of Physical Reactions: Change in state, size, or shape; no new substance is formed.

Observations of Chemical Reactions: Color change, gas production (bubbles), precipitate formation, heat absorption (endothermic) or release (exothermic).

Law of Conservation of Mass

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

Example:
`H2 + Cl2 -> 2HCl`

This law can be observed by ensuring that the total mass of reactants equals the total mass of products in a balanced chemical reaction.

Balancing Chemical Reactions

Balancing ensures the number of atoms of each element is the same on both sides of the equation.

Example:
`2H2 + O2 -> 2H2O` (Balanced)

Reaction Rates and Collision Theory

Collision Theory

Collision Theory: 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 the particles in a substance. Higher temperature means particles move faster and collide more frequently.

Only collisions with energy equal to or greater than the activation energy result in a reaction.

Reaction Rate Factors

Temperature	Increasing temperature increases the average kinetic energy of particles, leading to more frequent and energetic collisions, increasing reaction rate.
Concentration	Higher concentration means more reactant particles are present, leading to more frequent collisions, increasing reaction rate.
Surface Area	Increasing surface area (e.g., using powdered reactants) provides more contact points for collisions, increasing reaction rate.
Catalysts	Catalysts lower the activation energy of a reaction, making it easier for collisions to result in a reaction, increasing reaction rate.
Pressure (for gases)	Increasing pressure increases the concentration of gaseous reactants, leading to more frequent collisions and a higher reaction rate.

Maxwell-Boltzmann Distribution

The Maxwell-Boltzmann distribution shows the distribution of kinetic energies among particles at a given temperature. Higher temperatures shift the curve to the right, indicating more particles have sufficient energy to react.

Catalysts lower the activation energy, effectively increasing the number of particles with sufficient energy to react.

Energy Profile Graphs

Energy profile graphs show the energy changes during a reaction. The peak represents the activation energy. Catalysts lower the height of this peak.

Enzymes and Catalysis

Catalysts and Reaction Rate

Catalysts: Substances that increase the rate of a chemical reaction without being consumed in the process. They lower the activation energy required for the reaction.

Enzymes as Biological Catalysts

Enzymes: Biological catalysts, usually proteins, that speed up biochemical reactions in living organisms. They are essential for life because they enable reactions to occur at a rate compatible with life.

Induced Fit Model

Induced Fit Model: The enzyme's active site changes shape slightly to better fit the substrate, maximizing interaction and facilitating the reaction.

Factors Affecting Enzyme Activity

Temperature	Enzyme activity increases with temperature up to an optimal point; beyond this, activity decreases due to denaturation (loss of shape).
pH	Each enzyme has an optimal pH range. Deviations from this range can alter the enzyme's shape and reduce its activity.
Substrate Concentration	Increasing substrate concentration increases enzyme activity up to a point where all enzyme active sites are occupied (saturation).
Inhibitors	Inhibitors can bind to the enzyme and reduce its activity. Competitive inhibitors bind to the active site, while non-competitive inhibitors bind elsewhere, altering the enzyme's shape.

ATP Synthase

ATP Synthase: An enzyme that creates adenosine triphosphate (ATP), the main energy currency of the cell. It uses a proton gradient across a membrane to drive the synthesis of ATP from ADP and inorganic phosphate.

Plastics and Recycling

Plastic Composition

Plastics are polymers, large molecules made of repeating units (monomers). Common plastics include polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polyethylene terephthalate (PET), and polystyrene (PS).

Plastic Pollution

Plastic pollution poses a significant threat to the environment, especially marine ecosystems. Plastics do not easily degrade and can persist for hundreds of years, accumulating in landfills and oceans.

Microplastics (small plastic particles) can be ingested by marine life, leading to bioaccumulation of toxins in the food chain.

Microbial Involvement in Recycling

Microbes, such as bacteria and fungi, can be used to break down certain types of plastics into smaller, less harmful molecules.

Enzymes produced by these microbes are key to the degradation process.

Enzymatic Plastic Recycling

Enzymes offer a targeted and efficient way to break down plastics into their original monomers, which can then be used to create new plastics. This process reduces the need for virgin plastic production and minimizes waste.

PLA (Polylactic Acid)

Positives	PLA is biodegradable under specific conditions (e.g., industrial composting). It is derived from renewable resources like corn starch or sugarcane.
Negatives	PLA requires specific composting conditions to degrade. It is not suitable for all applications due to its lower heat resistance and mechanical properties compared to traditional plastics.
Issues	The infrastructure for composting PLA is not widely available. The production of PLA can compete with food crops for land and resources.