Chemistry Essentials Cheatsheet

A quick reference guide covering fundamental concepts in chemistry, including atomic structure, chemical reactions, stoichiometry, and thermodynamics. Ideal for students and professionals needing a concise overview of key chemical principles and equations.

Atomic Structure & Periodic Table

Basic Atomic Structure

Protons	Positively charged particles in the nucleus. Number defines the element.
Neutrons	Neutral particles in the nucleus. Contribute to atomic mass, isotopes.
Electrons	Negatively charged particles orbiting the nucleus. Involved in chemical bonding.
Atomic Number (Z)	Number of protons in the nucleus of an atom.
Mass Number (A)	Total number of protons and neutrons in the nucleus.
Isotopes	Atoms of the same element with different numbers of neutrons.

Periodic Table Trends

Electronegativity	Increases across a period, decreases down a group.
Ionization Energy	Increases across a period, decreases down a group.
Atomic Radius	Decreases across a period, increases down a group.
Metallic Character	Decreases across a period, increases down a group.
Reactivity (Metals)	Increases down a group (Group 1 & 2).
Reactivity (Nonmetals)	Decreases down a group (Group 17).

Quantum Numbers

Principal Quantum Number (n)	Energy level of electron (n = 1, 2, 3...).
Azimuthal Quantum Number (l)	Shape of orbital (l = 0 to n-1; 0=s, 1=p, 2=d, 3=f).
Magnetic Quantum Number (ml)	Orientation of orbital in space (ml = -l to +l).
Spin Quantum Number (ms)	Spin of electron (+1/2 or -1/2).

Chemical Reactions & Stoichiometry

Types of Chemical Reactions

- **Combination (Synthesis):** $A + B \rightarrow AB$
- **Decomposition:** $AB \rightarrow A + B$
- **Single Displacement:** $A + BC \rightarrow AC + B$
- **Double Displacement:** $AB + CD \rightarrow AD + CB$
- **Combustion:** Fuel + $O_2 \rightarrow CO_2 + H_2O$
- **Acid-Base Neutralization:** Acid + Base → Salt + Water

Stoichiometry Essentials

Mole (mol)	Amount of substance containing Avogadro's number of particles (6.022×10^{23}).
Molar Mass (M)	Mass of one mole of a substance (g/mol).
Molarity (M)	Concentration of a solution in moles per liter (mol/L).
Percent Yield	`((Actual Yield) / (Theoretical Yield)) * 100%`
Limiting Reactant	The reactant that is completely consumed in a reaction and determines the amount of product formed.
Theoretical Yield	The maximum amount of product that can be formed from the given amounts of reactants.

Balancing Chemical Equations

1. Write the unbalanced equation.
2. Identify the most complex compound and start balancing with it.
3. Balance elements that appear in only one reactant and one product first.
4. Balance polyatomic ions as a single unit if they appear on both sides of the equation.
5. If necessary, multiply all coefficients by the smallest whole number to obtain integer coefficients.

Gases, Liquids, and Solids

Gas Laws

Boyle's Law	$P_1V_1 = P_2V_2$ (Constant temperature and number of moles)
Charles's Law	$V_1/T_1 = V_2/T_2$ (Constant pressure and number of moles)
Avogadro's Law	$V_1/n_1 = V_2/n_2$ (Constant temperature and pressure)
Ideal Gas Law	$PV = nRT$ (R = 0.0821 L atm / (mol K) or 8.314 J / (mol K))
Combined Gas Law	$(P_1V_1) / T_1 = (P_2V_2) / T_2$ (Constant number of moles)
Dalton's Law of Partial Pressures	$P_{total} = P_1 + P_2 + P_3 + ...$

Intermolecular Forces

- **London Dispersion Forces (LDF)**: Weakest, present in all molecules.
- **Dipole-Dipole Forces**: Between polar molecules.
- **Hydrogen Bonding**: Strongest, between molecules with H bonded to N, O, or F.

Phase Transitions

Melting (Fusion)	Solid to liquid
Freezing	Liquid to solid
Vaporization (Boiling)	Liquid to gas
Condensation	Gas to liquid
Sublimation	Solid to gas
Deposition	Gas to solid

Thermodynamics & Equilibrium

Thermodynamic Functions

Enthalpy (H)	Heat content of a system at constant pressure. `ΔH = ΔU + PΔV`
Entropy (S)	Measure of disorder or randomness in a system. `ΔS = q_rev / T`
Gibbs Free Energy (G)	Predicts spontaneity of a reaction. `ΔG = ΔH - TΔS`
Internal Energy (U)	Total energy of a system. `ΔU = q + w` (q = heat, w = work)
Heat (q)	Transfer of thermal energy. `q = mcΔT` (m = mass, c = specific heat, ΔT = change in temperature)

Equilibrium Constant

Equilibrium Constant (K)	Ratio of products to reactants at equilibrium. For `aA + bB ⇌ cC + dD`, `K = ([C]^c[D]^d) / ([A]^a[B]^b)`
Kp	Equilibrium constant in terms of partial pressures.
Kc	Equilibrium constant in terms of molar concentrations.
Relationship between Kp and Kc	`Kp = Kc(RT)^Δn`, where Δn is the change in the number of moles of gas.

Le Chatelier's Principle

If a change of condition (stress) is applied to a system in equilibrium, the system will shift in a direction that relieves the stress.

Stressors: Change in concentration, pressure, volume, or temperature.

Effect of adding heat: favors endothermic reaction

Effect of removing heat: favors exothermic reaction