

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: $\text{Fuel} + O_2 \rightarrow CO_2 + H_2O$                                      |
| Acid-Base Neutralization: $\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}$ |

Stoichiometry Essentials

|                   |                                                                                                     |
|-------------------|-----------------------------------------------------------------------------------------------------|
| Mole (mol)        | Amount of substance containing Avogadro's number of particles ( $6.022 \times 10^{23}$ ).           |
| 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     | $((\text{Actual Yield}) / (\text{Theoretical Yield})) * 100\%$                                      |
| 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 | $P_{\text{total}} = P_1 + P_2 + P_3 + \dots$ |
|-----------------------------------|----------------------------------------------|

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. $\Delta H = \Delta U + P\Delta V$                               |
| Entropy (S)           | Measure of disorder or randomness in a system. $\Delta S = \frac{q_{rev}}{T}$                                  |
| Gibbs Free Energy (G) | Predicts spontaneity of a reaction. $\Delta G = \Delta H - T\Delta S$                                          |
| Internal Energy (U)   | Total energy of a system. $\Delta U = q + w$ (q = heat, w = work)                                              |
| Heat (q)              | Transfer of thermal energy. $q = mc\Delta T$ (m = mass, c = specific heat, $\Delta T$ = change in temperature) |

## Equilibrium Constant

|                                |                                                                                                                                    |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Equilibrium Constant (K)       | Ratio of products to reactants at equilibrium.<br>For $aA + bB \rightleftharpoons cC + dD$ , $K = \frac{[C]^c [D]^d}{[A]^a [B]^b}$ |
| Kp                             | Equilibrium constant in terms of partial pressures.                                                                                |
| Kc                             | Equilibrium constant in terms of molar concentrations.                                                                             |
| Relationship between Kp and Kc | $K_p = K_c (RT)^{\Delta n}$ , where $\Delta n$ 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. |
| <b>Stressors:</b> Change in concentration, pressure, volume, or temperature.                                                            |
| <b>Effect of adding heat:</b> favors endothermic reaction                                                                               |
| <b>Effect of removing heat:</b> favors exothermic reaction                                                                              |