PHYSICAL CHEMISTRY CHEAT SHEET

1. Chemical Thermodynamics

First Law of Thermodynamics:

$$\Delta U = q + w$$

PV Work: $w = -\int P_{\text{ext}} dV$

Reversible Isothermal Work: $w = -nRT\ln(\frac{V_2}{V_1})$

Adiabatic Process: $PV^\gamma = \text{const}, \quad \gamma = \frac{C_p}{C_v}$

Enthalpy & Heat Capacity:

$$H = U + PV \implies \Delta H = \Delta U + \Delta(PV)$$

$$C_v = (\frac{\partial U}{\partial T})_V, \quad C_p = (\frac{\partial H}{\partial T})_P, \quad C_p - C_v = R$$

Entropy & Second Law:

$$dS = \frac{dq_{\text{rev}}}{T}, \quad \Delta S_{\text{univ}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}} \geq 0$$

Isothermal Expansion: $\Delta S = nR\ln(\frac{V_2}{V_1})$

Gibbs Free Energy:

$$G = H - TS \implies \Delta G = \Delta H - T\Delta S$$

$$\Delta G^\circ = -RT\ln K_{eq}$$

2. Chemical Kinetics

Rate Laws & Integrated Forms:

- **Zero Order:** $[A]_t = [A]_0 - kt, \quad t_{1/2} = \frac{[A]_0}{2k}$
- **First Order:** $[A]_t = [A]_0 e^{-kt}, \quad t_{1/2} = \frac{\ln 2}{k}$
- **Second Order:** $1\frac{}{[A]_t - \frac{1}{[A]_0} = kt, \quad t_{1/2} = \frac{1}{k[A]_0}}$

Arrhenius Equation:

$$k = Ae^{-\frac{E_a}{RT}} \implies \ln(\frac{k_2}{k_1}) = \frac{E_a}{R}(\frac{1}{T_1} - \frac{1}{T_2})$$

Eyring Equation (Transition State Theory):

$$k = \frac{k_B T}{h} e^{\frac{\Delta S^\ddagger}{R}} e^{-\frac{\Delta H^\ddagger}{RT}}$$

3. Chemical & Ionic Equilibrium

Equilibrium Constants:

$$K_p = K_c(RT)^{\Delta n_g}$$

van 't Hoff Equation: $\frac{d\ln K}{dT} = \frac{\Delta H^\circ}{RT^2}$

pH & Acid-Base Equilibria:

$\text{pH} = -\log[H^+], \quad K_w = [H^+][OH^-] = 10^{-14}$ at 25°C

Henderson-Hasselbalch (Acidic Buffer):

$$\text{pH} = pK_a + \log(\frac{[A^-]}{[HA]})$$

Solubility Product: $A_x B_y left harpoons x A^{y+} + y B^{x-} \implies K$

4. Electrochemistry

Nernst Equation:

$$E = E^\circ - \frac{RT}{nF}\ln Q = E^\circ - \frac{0.0591}{n}\log Q \quad (298\ \text{K})$$

$$\Delta G = -nFE_{\text{cell}}, \quad \Delta G^\circ = -nFE^\circ_{\text{cell}}$$

Conductance & Kohlrausch's Law:

$$\Lambda_m = \frac{\kappa \times 1000}{M}$$

$$\Lambda^0_m = \nu_+\lambda^0_+ + \nu_-\lambda^0_-$$

Faraday's Laws of Electrolysis:

$$m = Z \cdot I \cdot t = (\frac{M}{nF})Q$$

5. Quantum Chemistry & Atomic Structure

De Broglie & Heisenberg:

$$\lambda = \frac{h}{p} = \frac{h}{mv}, \quad \Delta x \Delta p \geq \frac{\hbar}{2}$$

Time-Independent Schrödinger Equation:

$$\hat{H}\Psi = E\Psi \implies -\frac{\hbar^2}{2m}\nabla^2\Psi + V\Psi = E\Psi$$

Particle in a 1D Box:

$$E_n = \frac{n^2h^2}{8mL^2}, \quad \Psi_n(x) = \sqrt{\frac{2}{L}}\sin(\frac{n\pi x}{L})$$

6. Solutions & Colligative Properties

Raoult's Law: $\mathrm{P}_A = X_A P^\circ_A$ **Henry's Law:** $P_A = K_H X_A$ **Colligative Properties** (i = **van 't Hoff factor):**

- **Relative Lowering of VP:** $\frac{P^\circ - P}{P^\circ} = iX_{\text{solute}}$
- **Elevation of Boiling Point:** $\Delta T_b = iK_b m$
- **Depression of Freezing Point:** $\Delta T_f = iK_f m$
- **Osmotic Pressure:** $\Pi = iCRT$