1. Thermodynamics

First Law:

$$\Delta U = q + w$$

For an ideal gas expansion ($isothermal, reversible$):

$$w = -nRT \ln\left(\frac{V_2}{V_1}\right)$$

Enthalpy and Heat Capacity:

$$H = U + PV, \quad \Delta H = \Delta U + \Delta(PV)$$

$$C_p - C_v = R$$

Second and Third Laws:

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

Gibbs Free Energy: $G = H - TS$

$$\Delta G = \Delta H - T\Delta S, \quad \Delta G^\circ = -RT \ln K$$

2. Chemical Kinetics

Rate Laws: For $aA \rightarrow$ Products, $\text{rate} = -\frac{1}{a}\frac{d[A]}{dt} = k[A]^n$

Integrated Rate Equations: * **Zero Order** ($n = 0$)**:**

$$[A]_t = -kt + [A]_0, \quad t_{1/2} = \frac{[A]_0}{2k}$$

* **First Order** ($n = 1$)**:**

$$\ln[A]_t = -kt + \ln[A]_0, \quad t_{1/2} = \frac{\ln 2}{k}$$

* **Second Order** ($n = 2$)**:**

$$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}, \quad t_{1/2} = \frac{1}{k[A]_0}$$

Arrhenius Equation:

$$k = Ae^{-E_a/RT}$$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{T_2 - T_1}{T_1 T_2}\right)$$

3. Quantum Chemistry Electrochemistry

Quantum Mechanics: * **Schrödinger Equation:** $\hat{H}\psi = E\psi$ * **Planck's Energy:** $E = h\nu = \frac{hc}{\lambda}$ * **De Broglie Wavelength:** $\lambda = \frac{h}{p} = \frac{h}{mv}$

Electrochemistry: * **Nernst Equation:**

$$E = E^\circ - \frac{RT}{nF} \ln Q$$

At 25°C:

$$E = E^\circ - \frac{0.0591}{n} \log Q$$

* **Cell Thermodynamics:**

$$\Delta G^\circ = -nFE^\circ$$

* **Kohlrausch's Law:**

$$\Lambda_m^\circ = \nu_+ \lambda_+^\circ + \nu_- \lambda_-^\circ$$