FREE AP CHEMISTRY FORMULA SHEET

All the Essential Formulas You Need for Test Day

Fundamental Constants & Conversions

- **Avogadro's number NA** = 6.022×10^{23} mol^{-1}
- **Gas constant R** = 0.0821 $L\cdot atm\cdot mol^{-1}\cdot K^{-1}$ or 8.314 $J\cdot mol^{-1}\cdot K^{-1}$
- **Boltzmann constant k** = 1.38×10^{-23} $J\cdot K^{-1}$
- **Planck's constant h** = 6.626×10^{-34} J·s
- **Speed of light c** = 3.00×10^{8} m/s
- **1 atm** = 760 mmHg = 101.3 kPa
- **1 cal** = 4.184 J
- **STP** = 273 K, 1 atm, 22.4 L/mol (ideal gas)

Atomic & Electronic Formulas

- **Energy of a photon:** $E = h\nu = hc/\lambda$
- **Bohr model:** $E_n = -2.18\times10^{-18}\ (1/n^2)$ J
- **de Broglie wavelength:** $\lambda = h / (mv)$
- **Percent composition:** % element = (mass of element ÷ mass of compound) × 100
- **Empirical formula:** divide all moles by smallest value

Gas Laws

- **Boyle's:** $P_1V_1 = P_2V_2$ (constant T, n)
- **Charles':** $V_1/T_1 = V_2/T_2$ (constant P, n)
- **Gay-Lussac's**: $P_1/T_1 = P_2/T_2$
- **Combined:** $(P_1V_1)/T_1 = (P_2V_2)/T_2$
- **Ideal gas:** $PV = nRT$
- **Dalton's law:** $P_{total} = P_1 + P_2 + \dots$
- **Graham's law:** $r_1/r_2 = \sqrt{(M_2/M_1)}$

Thermodynamics

- **Heat:** $q = mC\Delta T$
- **Calorimetry:** $q_{lost} = q_{gained}$
- **Enthalpy**: $\Delta H = H_{products} - H_{reactants}$
- **Hess's Law:** total ΔH = sum of step ΔH values
- **Formation enthalpy:** $\Delta H°_{rxn} = \Sigma\Delta H°f(products) - \Sigma\Delta H°f(reactants)$
- **Gibbs free energy:** $\Delta G = \Delta H - T\Delta S$ (Good Horses Take Sugar)
- **At equilibrium:** $\Delta G° = -RT \ln K$
- **Work:** $w = -P\Delta V$

Phase Changes & Intermolecular Forces

- **Within a phase:** $q = mC\Delta T$
- **Phase change:** $q = n\Delta H_{fus}$ or $q = n\Delta H_{vap}$
- **Clausius–Clapeyron:** $\ln(P_1/P_2) = -(\Delta H_{vap}/R) \times (1/T_1 - 1/T_2)$
- **IMF strength:** H-bond > Dipole > LDF

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Equilibrium

- **Equilibrium constant:** $K = [products]^n / [reactants]^n$
- **Reaction quotient:** $Q = [products]/[reactants]$
- If $Q < K \rightarrow$ forward shift; $Q > K \rightarrow$ reverse shift
- **Le Chatelier's Principle:** system shifts to oppose stress
- **Relationship:** $\Delta G° = -RT \ln K$
- Use ICE table (Initial → Change → Equilibrium)

Electrochemistry

- **Cell potential:** $E°_{cell} = E°_{red} - E°_{ox}$
- **Free energy:** $\Delta G° = -nFE°_{cell}$
- **Nernst equation:** $E = E° - (RT/nF) \ln Q$
- Faraday's constant $F = 96485\ C\cdot mol^{-1}\ e^-$

Mnemonic: "Red Cat, An Ox" (Reduction at cathode, oxidation at anode)

Kinetics

- **Rate law:** $rate = k[A]^m[B]^n$
- **Integrated rate laws:**
  - 1st order → $\ln[A] = -kt + \ln[A]_0$
  - 2nd order → $1/[A] = kt + 1/[A]_0$
- **Half-life (1st order):** $t_{½} = 0.693/k$
- **Arrhenius equation:** $k = A\cdot e^{(-Ea/RT)}$
- Plot of ln k vs 1/T → slope = $-Ea/R$

Acids, Bases & Solutions

- $pH = -\log[H^+]$; $pOH = -\log[OH^-]$
- $[H^+][OH^-] = 1\times10^{-14}$; $pH + pOH = 14$
- $K_a = [H^+][A^-]/[HA]$; $K_b = [BH^+][OH^-]/[B]$; $K_a \times K_b = K_w$
- **Henderson–Hasselbalch:** $pH = pK_a + \log([A^-]/[HA])$
- **Dilution:** $M_1V_1 = M_2V_2$

Mnemonic: "pH high → base, pH low → acid"

Stoichiometry & Moles

- $n = m/M$; $M = m/n$; Molarity = mol/L
- **Percent yield** = (actual ÷ theoretical) × 100
- **Limiting reagent** = reactant that makes fewest moles of product
- **Conversion chain:** g → mol → mol → g

Always balance equations first