Complete Formula Sheet: Electrochemistry and Redox Reactions

Oxidation Numbers and Redox Reactions

Rules for Assigning Oxidation Numbers

1. Free elements = 0
2. Monatomic ions = charge on the ion
3. H = +1 (except in metal hydrides = -1)
4. O = -2 (except in peroxides = -1)
5. F = -1 always
6. Sum of oxidation numbers = 0 (for neutral molecules)
7. Sum of oxidation numbers = net charge (for ions)

Redox Reactions Balancing

For acidic medium:

1. Overall change in oxidation number = Number of electrons transferred
2. Net ionic equation: n_1 × (oxidation half) + n_2 × (reduction half) where n_1 and n_2 balance electrons

For basic medium: Add OH^- to both sides equal to H^+ ions $H^+ + OH^- \rightarrow H_2O$

Conductance and Conductivity

Basic Relations

1. Conductivity (κ) = 1/Resistance × (l/A) where l = length, A = area of cross-section
2. Molar Conductivity (Λ□) = κ × (1000/c) where c = concentration in mol/m³
3. Relation between Λ□ and α (degree of dissociation): α = Λ□/Λ°□

Kohlrausch's Law

1. Limiting molar conductivity: Λ°□ = $v_+\lambda°_+ + v_-\lambda°_-$ where v = number of ions, λ° = ionic conductivity
2. For weak electrolytes: Λ°□(HA) = $\lambda°(H^+) + \lambda°(A^-)$
3. Transport number: $t_+ = \lambda_+/(\lambda_+ + \lambda_-)$ $t_- = \lambda_-/(\lambda_+ + \lambda_-)$ $t_+ + t_- = 1$

Electrochemical Cells

Cell EMF Calculations

1. Standard Cell Potential: E°cell = E°cathode - E°anode E°cell = E°reduction(right) - E°reduction(left)
2. Nernst Equation: E = E° - (RT/nF)ln Q At 298K: E = E° - (0.0591/n)log Q
3. Concentration Cells: For concentration cell without transference: Ecell = (RT/nF)ln(C_2/C_1) At 298K: Ecell = (0.0591/n)log(C_2/C_1)

Relation with Thermodynamic Parameters

1. Gibbs Free Energy: ΔG° = -nFE°cell ΔG = -nFE
2. Equilibrium Constant: At 298K: log K = nE°/0.0591
3. Temperature Coefficient: dE°/dT = ΔS°/nF

Electrolysis

Faraday's Laws

1. First Law: m = (M × It)/(n × F) where m = mass deposited M = molar mass I = current t = time n = number of electrons F = Faraday constant (96,500 C/mol)
2. Second Law: m_1/m_2 = (M_1/n_1)/(M_2/n_2)

Electrolysis Calculations

1. Current Efficiency: Current Efficiency = (Actual yield/Theoretical yield) × 100
2. Time of electrolysis: t = (m × n × F)/(M × I)

Special Cases and Important Relations

pH Dependence

1. For hydrogen electrode: E = E° - (0.0591)pH
2. For oxygen electrode: E = E° - (0.0591)pH

Gas Electrodes

1. Gas concentration cell: E = (0.0591/n)log(P_2/P_1)

Corrosion

1. Corrosion rate: Rate = K × (ΔG°/RT)exp(-Ea/RT)

Battery and Fuel Cell Equations

Battery Capacity

1. Capacity = Current × Time (in ampere-hours)

Fuel Cell Efficiency

1. Thermodynamic efficiency: $\eta = \Delta G/\Delta H = -nFE/\Delta H$
2. Actual efficiency: η(actual) = (Actual voltage/Theoretical voltage) × 100

Important Constants and Conversion Factors

1. Faraday constant (F) = 96,500 C/mol
2. R = 8.314 J/mol·K
3. At 298K, RT/F = 0.0257 V
4. 1 Faraday = 1 mol of electrons = 96,500 coulombs

Cell Representation Conventions

1. Oxidation (anode): $A \rightarrow A^{+} + e^{-}$
2. Reduction (cathode): $B^{+} + e^{-} \rightarrow B$
3. Cell notation: Anode | Anode solution ‖ Cathode solution | Cathode
4. Salt bridge represented by ‖
5. Phase boundary represented by |