Advanced Chemistry Syllabus

1. INTRODUCTION TO CHEMISTRY

- A) Why study Chemistry?
- B) Chemistry is…
- C) Scientific Method
- D) Measurement
  1. SI Units
  2. Prefixes
- E) Uncertainty
- F) Significant figures:
  1. Determining
  2. Rules
- G) Accuracy/Precision
- H) Mathematics and Scientific Notation Dimensional analysis
- I) Basic Concepts
  1. Element/Compound
  2. Fundamental Laws
  3. Substance/Mixture (Homogeneous/heterogeneous)

2. STRUCTURE AND NATURE OF MATTER

- A) Atomic structure and Atomic theory
  1. Historical development of the Periodic Table
  2. The organization of the Periodic Table
  3. The development of the atomic model
     a. Historical development
     b. The Electromagnetic Spectrum
     c. Emission spectra and the Modern quantum atomic theory, orbital theory,
  4. Electron configurations
  5. The Periodic Table: Trends in affinities, electronegativities, ionization energies, Valence electrons
- B) Descriptive chemistry of groups of elements

3. NUCLEAR CHEMISTRY

- A) Nuclear binding forces
- B) Natural radioactivity:
- C) Artificial radioactivity
  1. Fission reactions/ reactors
  2. Fusion reactions
- D) Effects of radiation

4. STOICHIOMETRY

- A) Formulas/Nomenclature
  1. Oxidation numbers
  2. Solubility Rules
  3. Common Ions
  4. Chemical symbols, formulas and names
- B) Mass Relationships/Mathematical skills
  1. Calculating average atomic mass
  2. Molar mass and Avogadro's number
  3. Conversion Map
  4. Determining Percent composition
  5. Determining empirical formula from percent composition
  6. Determining a molecular formula from the empirical formula
- C) Balancing equations
- D) Stoichiometry
  1. The "Mole Method"
  2. Limiting Reactants
  3. Percent Yield

5. STOICHIOMETRY II: REACTIONS IN AQUEOUS SOLUTIONS

- A) Concentrations
- B) Precipitation reactions
  1. Complete molecular equations
  2. Complete ionic equations
  3. Net ionic equations
  4. Spectator ions
- C) Oxidation-reduction (redox)
  1. Types of redox reactions
  2. Metal activity series
  3. Balancing redox reactions
  4. The ion-electron method of balancing redox reactions
- D) Acid-base reactions
- E) Gravimetric analysis/ titrations
- F) Dilutions

6. STATES OF MATTER

- A) Gases; Kinetic - Molecular Theory of Ideal Gases
  1. Pressure and pressure units
  2. Ideal gas laws
     a. Boyle's Law
     b. Charles' Law
     c. Gay-Lussac's Law
     d. Avogadro's Law and STP
     e. Combined Gas Law

f. Ideal Gas Law
g. Dalton's Law of partial pressure
h. Grahams' Law of Effusion

3. Molecular speeds and root mean square velocities
4. Real gases: van der Waal's equation
5. Gas Stoichiometry

B) Liquids and Solids

1. Kinetic-Molecular Theory and Intermolecular Forces of Attraction
   a. Temporary dipoles: London Dispersion Forces
   b. Permanent Dipoles
   c. Hydrogen Bonding
   d. Properties of Liquids and colligative properties
2. Vaporization and Vapor Pressure. Raoults Law
3. Phase diagrams: triple points and critical points
4. Structures of liquids and selected solids (crystals)
   a. Ionic solids
   b. Metallic Solids
   c. Network Solids
   d. Molecular Solids
      i. Polar
      ii. Non-polar

7. CHEMICAL BONDING

A) Types of bonding:

1. Lewis Dot Structures and the octet rule
2. Ionic
3. Covalent
4. Formal Charge

B) Modeling

1. Resonance
2. Exceptions to the octet rule
3. Molecular Geometries and VSEPR
4. Molecular Polarity
5. Orbital hybridization, σ- and π- bonds

8. THERMODYNAMICS

A) The Nature of Energy
B) The 1st Law of Thermodynamics
   1. Internal Energy, work and heat
   2. Enthalpy
   3. Calorimetry
   4. Hess's Law

5. Heats of formation and determining heats of reaction

C) The 2nd Law of Thermodynamics: Entropy

D) Entropy, Free energy and spontaneity

E) Bond enthalpies

9. KINETICS AND EQUILIBRIA

A) Kinetics

1. Collision Theory
2. The Driving Forces behind reactions
3. Reaction Rates
4. Factors affecting Reaction Rates
5. The Rate Law
    a. Determining the rate law: Method of Initial rates
    b. Graphical transformations of the Rate Law and the Order of reaction
6. Energy of activation and the temperature dependence of the rate constant
7. Reaction mechanisms and intermediates
8. Catalysts

B) Equilibria

1. The Law of Mass Action and the Equilibrium constant (K_{eq})
2. Quantitative Equilibrium
    a) Determining K_{eq}
    b) Determining the reaction quotient Q
    c) Determining Equilibrium concentrations

2. Qualitative Equilibrium: LeChâtelier's Principle

10. EQUILIBRIUM REACTIONS

A) General Types of reactions (synthesis, decomposition, replacement, addition, subtraction)

B) Acids and Bases

1) Arhennius, Brönsted-Lowry, Lewis definitions
    a. The autoionization of water and the Hydronium ion
    b. The pH scale and indicators
    c. Conjugate acid-base pairs
2) Acid-Base equilibria
3) Calculating pH
4) Polyprotic acids
5) Acid-Base properties of salts
6) Structural Considerations of Acids
7) Common ion effect
8) Buffers
9) Titrations

C) Solubility Equilibria
   1) The common ion effect
   2) Precipitation and Quantitative analysis
   3) Classical qualitative analysis for metals by selective precipitation

11. REDOX AND ELECTROCHEMISTRY

A) Oxidation number
B) Voltaic cells,
C) Electrochemistry
   1. Determining ξ^0_{cell}
   2. Determining ΔG^o_{cell}
D) The Nernst equation
E) Electrolysis

12. ORGANIC CHEMISTRY

A) General physical and chemical characteristics
B) Hydrocarbons and Functional Groups
C) IUPAC nomenclature
D) Isomerism
E) Organic reactions
F) Biochemistry: Basic groups