# Chemistry 342

# Physical Chemistry I

## *Course Outline*

**1.** Empirical Properties of Gases

**1.1** The Ideal Gas

**1.2** Real Gases

**2.** The First Law of Thermodynamics; Thermochemistry

**2.1** Definitions (system, surroundings, isolated system, open system, state of a system, change in state, path, process, state variable)

**2.2** Work ($w$) and Heat ($q$)

**2.3** Work of expansion, work of compression, maximum and minimum quantities of work

**2.4** Reversible and Irreversible Transformations, a cyclical transformation

**2.5** Energy, **U** ; First Law of Thermodynamics

**2.6** Exact and Inexact Differentials

**2.7** Examples of Changes in State (at Constant Volume, at Constant Pressure); Definition of **H**

**2.8** Relation between $C_p$ and $C_V$

**2.9** The Measurement of $(\partial \mathbf{U}/\partial V)_T$ - Joule's Expt.; the Measurement of $(\partial \mathbf{H}/\partial p)_T$ - Joule-Thomson Expt.

**2.10** Adiabatic Changes in State

**2.11** Application of the First Law of Thermodynamics to Chemical Reactions, Standard Enthalpy Changes

**2.12** Temperature Dependence of Enthalpy

**3.** Introduction to the Second Law of Thermodynamics

**3.1** The Carnot Cycle

**3.2** The Thermodynamic Definition of Entropy, $d\mathbf{S} \equiv dq_{rev}/T$

**3.3** The Clausius Inequality

**4.** Entropy Changes Accompanying Specific Processes, the Third Law of Thermodynamics

**4.1** Entropy Changes in Isothermal Transformations, Trouton's rule

**4.2** Entropy as a Function of Temperature and Volume

**4.3** Entropy as a Function of Temperature and Pressure

**4.4** The Third Law of Thermodynamics

**4.5** Standard Entropy Values ("Third Law Entropies), $\mathbf{S}^{\ominus}(T)$

**5.** Spontaneity and Equilibrium

**5.1** The General Conditions for Equilibrium and Spontaneity

**5.2** Define Helmholtz Free Energy, **A** ; Define Gibbs Free Energy, **G**

**5.3** The Maxwell Relations

**5.4** The Properties of **A**, the Properties of **G**, The Gibbs Helmholtz Eqn.

**5.5** The Chemical Potential, $\mu$ of a Pure Substance, fugacity

**6.** Phase Equilibrium in Simple Systems; The Phase Rule

**6.1** The Equilibrium Condition

**6.2** The Clapeyron Equation; solid-liquid, liquid gas, solid-gas equilibria

**6.3** The Phase Diagram, the Phase Rule

**7.** Solutions

**7.1** The Ideal Solution, Raoult's law

**7.2** The Gibbs-Duhem Equation, Gibbs Energy of Mixing, Chemical Potential in Ideal Solutions

**7.3** Vapor Pressure of Binary Solutions

**7.4** The Chemical Potential in the Ideal Dilute Solution, Henry's law

**7.5** Colligative Properties, Freezing Point Depression, Boiling Point Elevation, Osmotic Pressure

**7.6** Equilibria in Non-Ideal Systems: The Concept of Activity $a_i$, the Rational System, or the Practical System, or in terms of Molalities

**8.** Phase Diagrams of Two-Component Systems

**8.1** Vapor Pressure Diagrams; the Lever Rule

**8.2** Temperature Composition Diagrams; Fractional Distillation, Azeotropes

**8.3** Liquid-Liquid Equilibria, Partially Miscible Liquids, Critical Solution Temperature

**8.4** Solid-Liquid Equilibria, Eutectics, Incongruent Melting

**9.** Chemical Equilibrium

**9.1** Chemical Equilibrium in a Mixture of Ideal Gases

**9.2** Chemical Equilibrium in a Mixture of Real Gases

**9.3** The Temperature Dependence of an Equilibrium Constant

**9.4** LeChatelier's Principle

**9.5** Activities in Solutions of Electrolytes, Mean Activity Coefficients

**9.6** Equilibria in ionic solutions

**9.7** Debye Hückel limiting law

**10.** Equilibria in Electrochemical Cells

**10.1** Definitions (electrochemical cell, electrical potential, electrical potential difference, electrode potential, electromotive force of the cell)

**10.2** Gibbs Free Energy of Formation of an Ion in Solution

**10.3** Thermodynamic Functions from Cell Measurements: $\Delta \mathbf{G}^{\ominus}$, Equilibrium Constants, $\Delta \mathbf{S}^{\ominus}$, Activities and Activity Coefficients