Miami Dade College
CHM 1046 - Second Semester General Chemistry

<u>Course Description</u>**:** CHM 1046 is the second semester of a two-semester general chemistry course for science, premedical science and engineering majors. CHM 1046 topics include: solids and liquids, thermochemistry, thermodynamics, kinetics, gas phase equilibria, ionic equilibria of soluble substances (including acids and bases, buffers, and hydrolysis), titration curves, equilibria of slightly soluble salts, and electrochemistry.

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3 Credits Each

<u>Prerequisites for CHM 1046:</u> CHM 1045 with a grade of "C" or better.
<u>Corequisites for CHM 1046:</u> CHM 1046L

Competency 1: The student will demonstrate knowledge of thermodynamics by:

a. Distinguishing among state functions, system, surroundings, and universe.
b. Using the First Law of Thermodynamics to relate heat, work, and energy changes.
c. Relating work done on or by the system to changes in its volume.
d. Comparing and contrasting the concept of changes in internal energy and enthalpy.
e. Carrying out calorimetry calculations.
f. Demonstrating the ability to convert between changes in internal energy and enthalpy.
g. Using bond energies to estimate the heat of reaction for gas phase reactions.
j. Using the Born-Haber cycle to find the crystal lattice energy of ionic solids. [OPTIONAL]

Competency 2: The student will demonstrate knowledge of liquids and solids by:

a. Describing the properties of liquids and solids and how they differ from the properties of gases.
b. Using the kinetic-molecular description of liquids and solids, and showing how this description is different from that of gases.
c. Using correct terminology to describe phase changes.
d. Recognizing the various kinds of intermolecular attractions that exist in substances.
e. Relating the various kinds of intermolecular attractions that exist in substances to physical properties such as vapor pressure, melting point, boiling point, and viscosity.

f. Applying the Clasius-Claperyon equation to relate changes in temperature and vapor pressure to a substance's molar heat of vaporization. [OPTIONAL]

f. Calculating the heat transfer involved during phase transitions.

g. Interpreting Pressure versus Temperature phase diagrams.

h. Describing the various types of solids and their properties.

i. Visualizing some common simple arrangements of atoms in solids. [OPTIONAL]

j. Describing the bonding that occurs in metals. [OPTIONAL]

k. Explaining why some substances are conductors, semiconductors, or insulators. [OPTIONAL]

Competency 3: The student will demonstrate knowledge of solutions by:

a. Identifying the components in a solution.

b. Identifying the different types of solutions that can form [e.g., 1) dilute and concentrated, 2) saturated, unsaturated, and super saturated, 3) miscible and immiscible].

c. Describing the factors that favor the dissolution process.

d. Describing the dissolution of solids in liquids, liquids in liquids, and gases in liquids.

e. Expressing concentrations of solutions in molarity, mass percent, molality, and mole fraction.

f. Interconversion of molarity, mass percent, molality and mole fraction concentration units.

g. Carrying out calculations involving the four colligative properties of solutions: lowering of vapor pressure (Raoult's Law), boiling point elevation, freezing point depression, and osmotic pressure.

h. Describing the associated effects on the colligative properties of compounds that undergo dissociation and ionization.

i. Recognizing and describing colloids: the Tyndall effect, the adsorption phenomenon, hydrophilic, and hydrophobic colloids. [OPTIONAL]

Competency 4: The student will demonstrate knowledge of chemical thermodynamics by:

a. Understanding the terminology of thermodynamics (e.g., system, surroundings, universe, open system, closed system, isolated system, state functions, enthalpy, internal energy, entropy, free energy) and the meaning of the sign conventions that are employed (e.g., endothermic or exothermic, work done or by the system, spontaneous or non-spontaneous, more or less entropy).

b. Understanding the relationship between entropy and the order or disorder of a system.

c. Summarizing the three Laws of Thermodynamics.

d. Determining the spontaneity and entropy changes of a process or chemical reaction.

a. Using tabulated values of absolute entropies and standard molar free energy of formation to calculate entropy changes (ΔS) and free energy changes (ΔG), respectively.

f. Working out problems that involve the relationship between: free energy changes, enthalpy changes, entropy changes, and temperature.

g. Predicting the temperature range of spontaneity of a chemical or physical process.

Competency 5: The student will demonstrate knowledge of chemical kinetics by:

a. Outlining the factors that affect the rate of a reaction (e.g., temperature, concentration, and catalysis).

b. Expressing the rate of a chemical reaction in terms of changes in concentration of reactants and products with time.

c. Applying the rate law-expression for a reaction to express the relationship between concentration and rate.

d. Applying the method of initial rates to find the rate-law expression for a reaction.

e. Determining the order of a reaction from the reaction rate law.

f. Using the integrated rate equation to determine the half-life of a reaction or to determine the concentration of substrate at some point in time.

g. Analyzing concentration versus time data to determine the order of a reaction. [OPTIONAL]

h. Pointing out the fundamental notions of collision theory and transition state theory.

i. Describing the main aspects of transition state theory and the role of activation energy in determining the rate of a reaction.

j. Using potential energy diagrams to identify where the transition state occurs, to find the energy of activation, and obtain the net amount of energy released or absorbed during a reaction.

k. Explaining how the mechanism of a reaction is related to its rate-law expression. [OPTIONAL]

l. Predicting the rate-law expression that would result from a proposed mechanism. [OPTIONAL]

m. Identifying reactants, products, intermediates, and catalysts in a multistep reaction mechanism. [OPTIONAL]

n. Using the Arrhenius equation to relate the energy of activation for a reaction to changes in its rate constant with changing temperature.

o. Explaining how catalyst changes the rate of a reaction.

Competency 6: The student will demonstrate knowledge of homogeneous and heterogeneous equilibria by:

a. Explaining the basic ideas of chemical equilibrium.

b. Writing down the equilibrium expression for a reaction.

c. Calculating the equilibrium constant from concentration data (or partial pressure data).

d. Relating the size of the equilibrium constant to the extent of a reaction.

e. Predicting the extent of a reaction by evaluating the reaction quotient (or mass action expression), Q.

f. Recognizing the factors that affect the equilibrium constant.

g. Applying the Le Chatelier's Principle to show how a variety of stresses applied affect the equilibrium system. (temperature, pressure, concentration)

h. Interconverting between K_p and K_c.

i. Finding equilibrium concentrations (or partial pressures) when initial concentrations (or partial pressures) and the equilibrium constant are supplied.

j. Determining the relationship between free energy and the equilibrium constant.

k. Evaluating an equilibrium constant at different temperatures.

Competency 7: The student will demonstrate knowledge of ionic equilibria involving soluble electrolytes by:

a. Identifying the type of electrolyte that a substance is.

b. Identifying strong acids and bases and soluble salts.

c. Calculating the concentration of each ion present, when a strong electrolyte is placed in water.

d. Evaluating the ion product for water to obtain the relationship between the molarity of the hydrogen ion and that of the hydroxide ion.

e. Describing the relationship between pH and pOH.

f. Interconverting between pH, pOH, $[H^+]$, and $[OH^-]$.

g. Writing equilibrium expressions for weak acids and bases.

h. Calculating K_a (or pK_a) or K_b (or pK_b) from: 1) initial and equilibrium concentrations, 2) initial concentrations and pH, $[H^+]$, or $[OH^-]$ values, and 3) initial concentrations and percent ionization data and vice-versa.

i. Calculating equilibrium concentrations, pH, pOH, $[H^+]$, and $[OH^-]$, and percent ionization when given the K_a (or pK_a) or K_b and (or pK_b) and the initial concentration.

j. Relating the strength of acids and bases to their equilibrium constants.

k. Describing the effect of adding a “common ion” on the equilibrium.

l. Recognizing a buffer solution and giving illustrations of its operation.

m. Predicting the effect upon the pH when adding a strong acid or a strong base to 1) distilled water, 2) a strong acid, 3) a strong base, and 4) a buffer.

n. Writing equations for the action of buffers with H^+ ions and with OH^- ions.

o. Calculating the ratio of components of a buffer, given the pH of the buffer.

p. Calculating the pH of a buffer, when strong acids or bases are added.

q. Predicting whether an aqueous salt solution is acidic, basic, or neutral.

r. Illustrating the ionization of a soluble salt solution and subsequent hydrolysis of the ion derived from a weak acid or base.

s. Interconverting between K_a and K_b of conjugate acid-base pairs.

t. Writing the equilibrium expression and solving problems involving hydrolysis of a salt.

Competency 8: The student will demonstrate knowledge of acid-base titrations by:

a. Recognizing the shape of a titration curve and describing what species are present at various stages of titration curves for a strong acid vs. a strong base, a weak acid vs. a strong base, and a weak base vs. a strong acid.

b. Carrying out calculations based on titration curves.

c. Selecting an appropriate indicator for titrations. [OPTIONAL]

Competency 9: The student will demonstrate knowledge of equilibria of slightly soluble substances by:

a. Writing the equilibrium expression for the saturated solution of a slightly soluble substance.

b. Calculating the value of the solubility product, K_{sp}, when given the solubility of the substance.

c. Calculating the solubility of a substance from its K_{sp} value.

d. Calculating the solubility of a substance when dissolved in a solution containing a common ion.

e. Calculating the concentration of ions needed to initiate precipitation.

f. Predicting if precipitation will occur if solutions of known ionic concentration are mixed.

g. Listing several ways to dissolve "insoluble" substances. [OPTIONAL]

h. Solving appropriate problems involving complex ion equilibria. [OPTIONAL]

Competency 10: The student will demonstrate knowledge of electrochemistry by:

a. Understanding and applying the terminology of electrochemistry (e.g., cell, electrode, cathode, anode, electrolysis, electromotive force, reduction, oxidation).

b. Comparing and contrasting electrolytic cells and voltaic (galvanic) cells.

c. Recognizing oxidation and reduction half-reactions, and knowing at which electrode each occurs.

d. Writing half-reactions and overall cell reactions for electrolysis.

e. Applying Faraday's Law of Electrolysis to calculate amounts of products formed, amounts of current passed, time elapsed, and oxidation state.

f. Describing the refining and plating of metals by electrolytic methods. [OPTIONAL]

g. Describing the construction of simple voltaic cells from half-cells and a salt bridge, and showing an understanding of the function of each component.

h. Writing half-reactions and overall reactions for voltaic cells.

i. Comparing various voltaic cells to determine the relative strength of oxidizing and reducing agents.

j. Interpreting standard reduction potentials.

k. Using standard reduction potentials, E°, to calculate the potential of a standard voltaic cell, $E°_{cell}$.

l. Appropriately applying standard reduction potentials to identify the cathode and anode in a standard cell.

m. Writing the shorthand notation for a voltaic cell.

n. Predicting the spontaneity of a redox reaction by using standard reduction potentials.

o. Applying the Nernst equation to relating electrode potentials and cell potentials to different concentrations and partial pressures.

p. Relating the standard cell potential to the standard Gibbs free energy change and the equilibrium constant.

Competency 11: The student will demonstrate an understanding of nuclear chemistry by:

OPTIONAL

a. Describing the makeup of the nucleus.

b. Describing the relationship between neutron-proton ratio and nuclear stability.

c. Describing the common types of radiation emitted when nuclei undergo radioactive decay.

d. Writing and balancing equations that describe nuclear reactions.

e. Carrying out calculations involved with radioactive decay.

f. Comparing and contrasting nuclear fusion and nuclear fission.

Competency 12: The student will demonstrate an understanding of coordination compounds by:

OPTIONAL

a. Using the terminology that describes coordination compounds (e.g., complex species, coordination sphere, coordination number, chelate, ligand).

b. Writing the name of a coordination compound given its formula and vice versa.

c. Describing the geometry and hybridization of typical coordination compounds with coordination numbers 2, 4, and 6 using the valence bond approach.

d. Defining and illustrating geometric and optical isomers of some coordination compounds.

e.. Comparing and contrasting Valence Bond Theory with Crystal Field Theory and with Ligand Field Theory with regard to bonding, magnetic behavior, and spectral properties.