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SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course Title: PRINCIPLES OF CHEMISTRY II THEORY & LAB

Code No.: CHM 218-5

Program: WATER RESOURCES II, PULP & PAPER II & ENV. ENG. II

Semester: II(WINTER) or III(FALL)

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Date: DECEMBER 1991 Previous Outline Dated: MAY 1988

APPROVED: _____ Jan 2/92
Dean, School of Sciences & Natural Resouces — Date

PRINCIPLES OF CHEMISTRY II — Course Name

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PREREQUISITE(S): CHM104

CREDIT HOURS: 80

I. PHILOSOPHY/GOALS:

CHM 218-5 is a continuation of CHM 104-4 from semester 1. The major emphasis in the lab is on Quantitative Analysis; the student is expected to analyze a variety of samples and arrive at satisfactory results. The theory component of the course deals with the following concepts: solution chemistry, chemical calculations, K_{sp}, K_{eq}, K_a, K_b, K_w, acid-base chemistry, pH, H^+, pOH, OH^-, % ionization of weak acids and bases.

CHM 218 serves as a prerequisite for CHM 230-33 (Water Chemistry) and Pulp and Paper - PPE 220-4 (Pulp Testing II).

II. STUDENT PERFORMANCE OBJECTIVES:

Unit I: "Solution Chemistry & Reactions in Aqueous Solution"
Ref: Ebbing - General Chemistry, Chapters 4, 12, 13

Upon completion of this unit, the student should be able to:

1. Make calculations for preparation of solutions having concentration expressed in M, N, ppm, and be able to convert from one concenration to another ex. N ---> M, M ---> ppm.

2. Using solubility rules, decide whether two soluble ionic compounds will or will not react to form a precipitate. If they will, write the net ionic equation.

3. Write the moleculous equation, and then the net ionic equation for the neutralization of an acid and a base.

4. Write a skeleton equation given as balanced oxidation-reduction equation. Label the oxidizing and reducing agents, the oxidized and reduced species, and the oxidation and reduction parts of the equation. Comment on the reaction by referring to the commonly observed oxidation states.

5. Given an oxidation-reduction equation (an unbalanced or a skeleton equation), complete and balance it by the half-reaction method and/or the oxidation number method.

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II. STUDENT PERFORMANCE OBJECTIVES: (cont'd)

Unit II: Chemical Equilibrium
Ref: Chapter 15 - Ebbing - General Chemistry

After completion of this unit, the student should be able to :

1. Given the starting amounts of reactants and the amount of one substance at equilibrium, find the equilibrium composition.
2. Given the chemical equation, write the equilibrium-constant expression.
3. Given the equilibrium composition, find K_c.
4. Given the concentrations of substances in a reaction mixture, predict the direction of reaction.
5. Given K_c and all concentrations of substances but one in an equilibrium mixture, calculate the concentration of this one substance.
6. Given the starting composition and K_c of a reaction mixture, calculate the equilibrium composition.
7. Given a reaction, use LeChatelier's principle to decide the effect of adding or removing a substance, changing the pressure, or changing the temperature.

Unit III: Solubility Equilibria
Ref: Chapter 17 - Ebbing

After completion of this unit, the student should be able to:

1. Write the solubility product expression for a given ionic compound.
2. Given the solubility of a slightly soluble ionic compound, calculate K_{sp}. Given K_{sp}, calculate the solubility of an ionic compound.
3. Given the solubility product constant, calculate the molar solubility of a slightly soluble ionic compound in a solution containing a common ion.
4. Given the concentrations of ions originally in solution, determine if a precipitate is expected to form. Determine if a precipitate is expected to form when two solutions of known volume and molarity are mixed. For both problems, you will need the solubility product constant.
5. Calculate the concentration and percentage of an ion remaining after the corresponding ionic compound precipitates from a solution of known concentrations of ions. K_{sp} is required.

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II. STUDENT PERFORMANCE OBJECTIVES: (cont'd)

Unit IV: Acid-Base Concepts
Ref: Chapter 13 - Ebbing

After completing this unit, the student should be able to:

1. Given the concentration of hydroxide ion (or concentration of strong base), calculate the hydrogen-ion concentration.
2. Given the hydrogen-ion concentration (or concentration of strong acid), calculate the pH; given the pH, calculate the hydrogen-ion concentration.
3. Given a proton-transfer reaction, label the Brønsted-Lowry acids and bases, and name the conjugate acid-base pairs.
4. Given a Brønstead-Lowry acid-base reaction and the relative strengths of acids (or bases), decide whether reactants or products are favored at equilibrium.
5. Decide whether an aqueous solution of a given salt will be acidic, basic, or neutral.
6. Given a reaction involving the donation of an electron pair, identify the Lewis acid and Lewis base.

Unit V: Acid-Base Equilibria
Ref: Chapter 16 - Ebbing

After completion of this chapter, the student should be able to:

1. Given the molarity and pH of a solution of a weak acid, calculate the acid ionization constant, K_a (Example 18.1). Given K_a, calculate the hydrogen-ion concentration and pH of a solution of a weak acid of known molarity.
2. Given the molarity and pH of a solution of a weak base, calculate the base ionization constant, K_b (similar to Example 18.1). Given K_b, calculate the hydrogen-ion concentration and pH of a solution of a weak base of known molarity.
3. Calculate the K_a for a cation or the K_b for an anion from the ionization constant of the conjugate base or acid.
4. Given the concentrations of weak acid and strong acid in a solution, calculate the degree of ionization and concentration of the anion of the weak acid.

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II. STUDENT PERFORMANCE OBJECTIVES: (cont'd)

Unit V: Acid-Base Equilibria
Ref: Chapter 16 - Ebbing

After completion of this chapter, the student should be able to:

5. Given the K_a and the concentrations of weak acid and its salt in a solution, calculate the pH. Given the K_b and the concentrations of weak base and its salt in a solution, calculate the pH.

6. Calculate the pH of a given volume of buffer solution (given the concentrations of conjugate acid and base in the buffer) to which a specified amount of strong acid or base is added.

7. Calculate the pH during the titration of a strong acid and strong base, given the volumes and concentrations of the acid and base.

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III. TOPICS TO BE COVERED:

UNIT I: SOLUTIONS - 40% of total time

1 Types of Solutions
Gaseous Solutions
Liquid Solutions
Solid Solutions

2 Ways of Expressing Concentration
Mass
Percentage of Solute
Conversion of Concentration Units

3 Equivalents and Normality

IONS IN SOLUTION; IONIC EQUATIONS

Continuation of solution chemistry problems.

4-1 Electrolytes
A note about the Hydrogen Ion
Introduction to Chemical Equilibrium
Strong and Weak Electrolytes

4-2 Ionic Equations

4-3 Types of Reactions

METATHESIS REACTIONS

4-4 Solubility and Precipitation
Solubility Rules
Precipitation Reactions

5 Reactions of Acids, Bases and Salts
Neutralization
Reactions of Salts
Formation of a Gas

6 Introduction to Oxidation-Reduction Reactions
Terminology
Understanding oxidation-Reduction Equations

7-1 Properties of Water
Hydrogen Bonding and the Physical
Properties of Water
Chemical Properties of Water

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III. TOPICS TO BE COVERED: (cont'd)

UNIT II: CHEMICAL EQUILIBRIUM - 20% of total time

DESCRIBING CHEMICAL EQUILIBRIUM

1 Chemical Equilibrium - A Dynamic Equilibrium

2 The Equilibrium Constant
Definition of the Equilibrium Constant K_c
Obtaining Equilibrium Constants for Reactions
The Equilibrium Constant K_p

3 Heterogeneous Equilibria

USING AN EQUILIBRIUM CONSTANT

4 Qualitatively Interpreting an Equilibrium Constant

5 Predicting the Direction of Reaction

6 Calculating Equilibrium Concentrations

CHANGING THE REACTION CONDITIONS AND THE APPLICATION OF LeCHATELIER'S PRINCIPLE

7 Adding a Catalyst

8 Removing or Adding Reactants or Products

9 Changing the Pressure and Temperature
Effect of Pressure Change
Effect of Temperature Change
Choosing the Optimum Conditions for Reaction

UNIT III: SOLUBILITY AND COMPLEX-ION EQUILIBRIA - 20% of time

1 The Solubility Product Constant

2 Solubility and the Common-Ion Effect

3 Precipitation Calculations
Criterion for Precipitation
Completeness of Precipitation
Fractional Precipitation

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III. TOPICS TO BE COVERED: (cont'd)

UNIT IV: ACID-BASE CONCEPTS - 20% of time

1. Arrhenius Concept of Acids and Bases
2. Self-Ionization of Water
3. The pH of a Solution
4. Bronsted-Lowry Concept of Acids and Bases
5. Relative Strengths of Acids and Bases
6. Molecular Structure and Acid Strength
7. Acid-Base Properties of Salt Solutions
8. Lewis Concept of Acids and Bases

UNIT V: ACID-BASE EQUILIBRIA

SOLUTIONS OF A WEAK ACID OR BASE OR SALT

1. Acid Ionization Equilibria
   Experimental Determination of K_a
   Calculations from K_a
2. Polyprotic Acids
3. Base Ionization Equilibria
4. Hydrolysis
5. Acid-Base Titration Curves
   Titration of a Strong Acid by a Strong Base
   Titration of a Weak Acid by a Strong Base
   Titration of a Weak Base by a Strong Acid

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III. TOPICS TO BE COVERED: (cont'd)

LABORATORY WORK

The student will complete five of the experiments designated for this course in the allotted time. The following experiments are required: (#1 to 4 and 3 or 5)

1. Titration of Acids and Bases - standardization of NaOH, and determination of unknown KHP.
2. Gravimetric Cl^- - Cl^- in a known (NH_4Cl) plus Cl^- in an unknown.
3. Volumetric Cl^- - Cl^- in a known (NaCl) and in unknown (use same unknown as Exp. #2)
4. Gravimetric Ni - use organic precipitant DMG.
5. Determination of sulphate in a known (Na_2SO_4) and an unknown.
6. Hardness of water - Volumetric determination using ED7A.

In addition to the above the student will be able to subject his results to statistical analysis and determine:

1. Precision
2. Relative error
3. Average deviation
4. Standard deviation
5. Whether a result should be excluded by the 2.5d rule, 4.0d rule and by the Q test.

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IV. EVALUATION METHOD:

Grades: 90% > - A+
80% > - A
70% > - B
60% > - C

The final grade is arrived at by totalling the theory marks (50%) and the lab marks (50%).

The lab mark is the sum of all marks awarded for the analysis plus the written report for each of the five experiments. The analysis is graded on accuracy and precision. The report is graded on format, content, and neatness.

The theory mark is the sum of all tests, assignments, mid-term and final examinations.

Term Test/Quizzes/Assignments/Final Exam	50 marks
Lab Work	50 marks
	100 marks

Assignments are due on the date specified. Late assignments will not be accepted so it is critical that you submit as much of the assignment as possible on the due date. Lab reports are due one week from completion of the lab. Late labs will be downgraded 10% per week.

ATTENDANCE:

Your grade will be greatly affected by attendance at scheduled classes and labs. 85% is required at all theory classes while 100% is needed for all labs. Serious illness (doctor's care) is the only valid excuse.

EXEMPTION:

The theory grade is the sum of all test and assignments. Tests will include all work up to the time of each test. All students having 70% or more on term work and mid-term exam are exempt from the final exam which will cover the whole course and counts 50% of the theory grade. The final exam will be held during the exam week at the end of the semester.

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V. REQUIRED STUDENT RESOURCES:

Ebbing, Darrell D., General Chemistry, 3rd ed. Houghton Mifflin Co., 1990.

LAB MANUAL:

Lab Experiments for CHM 218 - Sault College, Heggart & Korrey. 2nd ed.

VI. SPECIAL NOTES:

Students with special needs (e.g. physical limitations, visual impairments, hearing impairments, learning disabilities) are encouraged to discuss required accommodations confidentially with the instructor.

Your instructor reserves the right to modify the course as he/she deems necessary to meet the needs of students.