Lecture Contact Hours: 48-54; Homework Hours: 96-108; Total Student Learning Hours: 144-162
Laboratory Contact Hours: 96-108; Homework Hours: 0; Total Student Learning Hours: 96-108

CUYAMACA COLLEGE
COURSE OUTLINE OF RECORD

CHEMISTRY 142 – GENERAL CHEMISTRY II

3 hours lecture, 6 hours laboratory, 5 units

Catalog Description
Basic principles and calculations of chemistry with emphasis in the areas of chemical and acid-base equilibrium, thermodynamics, descriptive chemistry of the periodic table, intermolecular forces, properties of liquids, solids and solutions, kinetics, electrochemistry, coordination compounds. The laboratory is a continuation of CHEM 141 with the quantitative analysis of matter and also includes qualitative analysis.

Prerequisite
"C" grade or higher or "Pass" in CHEM 141 or equivalent

Entrance Skills
Without the following skills, competencies and/or knowledge, students entering this course will be highly unlikely to succeed:
1) Solve word problems involving heat transfer.
2) Use thermodynamic data to calculate enthalpy changes for chemical reactions, phase changes and solution processes.
3) Calculate bond energies from thermodynamic data.
4) Use Bohr's equation to calculate transition energies and ionization energies.
5) Interpret Schrodinger's theory of the atom including the concepts of orbitals, quantum numbers and electronic configurations.
6) Predict periodic trends in ionization energy, atomic size, electron affinity and acid-base properties.
7) Use molecular orbital theory to make predictions about the nature of the bonding in diatomic molecules.
8) Predict electron dot structures, formal charges, geometry, hybridization and orbital descriptions of molecules with three or more atoms including the concept of delocalized bonding.
9) Classify bonds into their various types–nonpolar, polar, ionic–and predict the polarity of molecules.
10) Predict trends in the lattice energies of ionic compounds.
11) Predict trends in bond length as a function of bond order and atomic radii.
12) Estimate enthalpies of reaction using average bond energies.
13) Describe the three types of cubic unit cells.
14) Solve word problems involving gases; perform calculations involving two or more variables including use of the ideal gas law.
15) For graphs of linear functions, determine the slope and intercept of the line.
16) For graphs of nonlinear functions, interpolate values from the curve.
17) Solve complex word problems including problems with two unknowns.
18) Use the technique of dimensional analysis to solve stoichiometric problems.

Course Content
1) Thermochemistry
2) Liquids, Solids and Solutions
3) Kinetics
4) Chemical Equilibrium
5) Acid/base and Equilibrium
6) Electrochemistry

Course Objectives

Students will be able to:

1) Interpret energy functions including enthalpy, entropy and free energy by the following:
   a. Calculate changes in enthalpy, entropy, and free energy for chemical reactions, phase changes, solution processes, and elementary molecular processes using tables of thermodynamic data.
   b. Calculate bond energies using tables of thermodynamic data as well as use bond energies to estimate enthalpies of reaction.
   c. Use the mathematical relationship among enthalpy, entropy, and free energy to calculate free energy changes at nonstandard temperatures.
   d. Predict qualitative entropy changes for chemical processes as well as qualitative changes in free energy as the temperature is varied.
2) Distinguish the different kinds of intermolecular forces between atoms, ions and molecules and predict their effect on physical properties.
3) Distinguish between the three states of matter by:
   a. Analyzing a phase diagram.
   b. Describing the structure of various solids: metallic, ionic, molecular, network solids.
   c. Applying kinetic molecular theory to describe the properties of solids, liquids and gases.
4) Explain solution properties including colligative properties and vapor pressure in terms of intermolecular forces.
5) Make determinations and predictions about reactions and their rates in the following ways:
   a. Calculate rates, reaction orders and/or rate constants from both graphical and tabular data of concentration vs. time.
   b. Use integrated rate equations to calculate concentrations, times, or half lives at any stage of a reaction.
   c. Calculate rates or activation energies of a reaction from rate vs. temperature data.
   d. Write the rate law for an elementary step in a chemical reaction.
6) Examine a chemical system at equilibrium and draw conclusions in the following ways:
   a. Calculate the equilibrium constant for a reaction from equilibrium composition data or vice-versa.
   b. Solve quadratic equations as well as employ approximation methods in the calculation of equilibrium compositions.
   c. Use the principle of Le Chatelier and also reaction quotients to predict the effect of changes in reaction conditions on the equilibrium composition of a reaction.
   d. Apply chemical equilibrium concepts to the solubility of ionic compounds and calculate K_{sp} values or solubility limits for salts
7) Perform calculations involving the equilibria of weak acids, weak bases, buffers and complex ions.
   a. Analyze titration curves of weak, strong, and polyprotic acids and bases to determine concentrations and equilibrium constant values.
   b. Solve solution inventory problems for acid-base reactions.
   c. Identify various reactions acids and/or bases; write and balance equations.
   d. Understand the formation of complex ions
8) Identify chemical reactions that are oxidation-reduction, determine and write the corresponding oxidation and reduction half reactions, and predict the spontaneity of the reaction by the use of tables of standard reduction potentials.
   a. Systematically balance equations for complex oxidation-reduction reactions.
9) Solve problems using the mathematical relationships between voltage, free energy change, and the equilibrium constant in the determination of the following:
   a. Knowing any one variable (voltage, free energy, equilibrium constant), calculate the other two.
   b. Predict the identity and quantity of products formed in the passage of an electric current through a pure substance or a solution.
10) Perform the following operations for any nuclear process:
   a. Write balanced equations for radioactive decay, particle bombardment, fission and fusion.
   b. Calculate the associated energy changes for each of the above processes.
   c. Calculate the binding energy of a nucleus.

11) In a lab setting, collect data using a data acquisition system on the computer; analyze and draw inferences from the graphical data.

Method of Evaluation

A grading system will be established by the instructor and implemented uniformly. Grades will be based on demonstrated proficiency in subject matter determined by multiple measurements for evaluation, one of which must be essay exams, skills demonstration or, where appropriate, the symbol system.

1) Exams consisting of the following question types–definitions, short essay, qualitative problems, quantitative problems–that measure students' ability to explain and apply the basic chemical concepts.
2) Laboratory activities that evaluate students' ability to observe the properties of a wide range of chemical substances, to apply competent observational skills, and to demonstrate proper collection and recording of data.
3) Written laboratory reports that measure students' ability to interpret and analyze both qualitative and quantitative data.
4) Problem sets including group problem sets that enable students to apply basic chemical principles and communicate those principles.

Special Materials Required of Student

Safety glasses, scientific calculator, laboratory notebook, combination lock, lab apron

Minimum Instructional Facilities

1) Smart classroom with writing board, wall-sized periodic table, overhead projector/screen, demonstration table with sink and gas tap
2) Chemistry laboratory facility including lockers for lab equipment
3) Computer network connections for Internet access and performance of computer interfaced laboratory experiments including access to laptops with Vernier interfaces and miscellaneous probes

Method of Instruction

1) Lectures are designed to explain basic concepts. Lecture demonstrations are used liberally. Applications to the real world are incorporated as much as possible.
2) Laboratory experiments (correlated with lectures) are designed to allow students to make observations of chemical phenomena. Lab reports and class discussions require students to explain and analyze their laboratory observations employing theories discussed in lectures.
3) Textbook and laboratory manual are required reading and are essential to successful solution of homework problems, performance of laboratory experiments and performance on exams.
4) Students are strongly encouraged to form study groups as well as seek help through peer tutoring and instructor's office hours.

Out-of-Class Assignments

1) Reading and homework problems, as assigned
2) Formal lab reports
3) Specialized project involving selected topics in chemistry, as required; this project may require the use of research on the internet, at the library, or other resources

Texts and References

1) Required (representative examples):
   a. Kotz, et al. *Chemistry & Chemical Reactivity*. 10th edition. Cengage, 2018.
   b. Leblanc & Villarreal. *Chemistry 142 Lab Manual*. Morton, 2018.
2) Supplemental: None

Exit Skills

Students having successfully completed this course exit with the following skills, competencies and/or knowledge:

1) Solve word problems involving heat transfer.
2) Calculate changes in enthalpy, entropy, and free energy for chemical reactions, phase changes, solution processes, and elementary molecular processes using tables of thermodynamic data.
3) Calculate bond energies using tables of thermodynamic data as well as use bond energies to estimate enthalpies of reaction.
4) Use the mathematical relationship among enthalpy, entropy, and free energy to calculate free energy changes at nonstandard temperatures.
5) Predict qualitative entropy changes for chemical processes as well as qualitative changes in free energy as the temperature is varied.
6) Analyze phase diagrams.
7) Distinguish the different kinds of intermolecular forces and predict their effect on physical properties.
8) Demonstrate an understanding of the structure of solids including the three types of cubic unit cells.
9) Predict physical properties of substances, e.g., solubility and boiling point, based on polarity.
10) Perform calculations involving colligative properties such as freezing point, boiling point and osmotic pressure.
11) Calculate rates, reaction orders and rate constants from both graphical and tabular data of concentration vs. time.
12) Use integrated rate equations to calculate concentrations, times, or half lives at any stage of a reaction.
13) Calculate rates or activation energies of a reaction from rate vs. temperature data.
14) Write the rate law for an elementary step of a reaction.
15) Calculate the equilibrium constant (K_c, K_p, K_{sp}, K_a, K_b) for reactions from equilibrium composition data or vice-versa.
16) Solve quadratic equations as well as employ approximation methods in the calculation of equilibrium compositions.
17) Use the principle of Le Chatelier and also reaction quotients to qualitatively predict the effect of changes in reaction conditions on equilibrium composition.
18) Identify redox chemical reactions, write the corresponding oxidation and reduction half reactions and predict spontaneity of the reaction by employing tables of standard reduction potentials.
19) Use the mathematical relationships involving voltage, free energy change and equilibrium constant to calculate any two of these quantities from a third.
20) Predict the identity and quantity of products formed in the passage of an electric current through a pure substance or a solution.
21) Systematically balance equations for complex oxidation-reduction reactions in both acidic and basic solutions.
22) In a lab setting, collect data using a data acquisition system on the computer; plot data graphically and analyze.
23) Perform the qualitative analysis scheme and use observations of known cations to identify unknown cations.

Student Learning Outcomes

Upon successful completion of this course, students will be able to:

1) Solve a wide variety of problems including those involving the topics of electrochemistry, kinetics, equilibrium, heat transfer, entropy and free energy, and lattice energy, among others. Analyze results to make predictions.
2) Apply knowledge of the bonding and intermolecular forces in solids, liquids and gases.
3) Perform a variety of experimental analytical techniques and qualitative analysis in a laboratory setting to collect data/observations, analyze data/observations and make predictions about the nature of matter.