CHEM 1BH: HONORS GENERAL CHEMISTRY

Foothill College Course Outline of Record

Heading	Value
Effective Term:	Fall 2020
Units:	5
Hours:	3 lecture, 6 laboratory per week (108 total per quarter)
Prerequisite:	CHEM 1AH.
Advisory:	MATH 48B or equivalent Precalculus II course; not open to students with credit in CHEM 1B.
Degree & Credit Status:	Degree-Applicable Credit Course
Foothill GE:	Non-GE
Transferable:	CSU/UC
Grade Type:	Letter Grade (Request for Pass/No Pass)
Repeatability:	Not Repeatable

Student Learning Outcomes

- A student who successfully masters the material in Chemistry 1BH at Foothill College will demonstrate the ability to think critically and employ critical thinking skills.
- A student who successfully masters the material in Chemistry 1BH at Foothill College will demonstrate the quantitative skills needed to succeed in General Chemistry. These will include the minimal use of calculus.
- A student who successfully masters the material in Chemistry 1BH at Foothill College will be able to read and interpret graphs, data and functions, including analysis of the first derivative and the integral of several functions.

Description

Designed for physical science majors, the fundamental chemical principles are explored with an emphasis on physical properties and their mathematical modeling and interpretation. As an honors course, the treatment of the chemical topics will be at a higher level mathematically and conceptually. Students are expected to have a high degree of competency in mathematics and advanced reasoning skills. Topics include: chemical equilibrium with a mass action and thermodynamic description; solutions, including acid-base titrations, oxidation reduction titrations, nonvolatile and volatile solutes; advanced acid-base equilibrium, including strengths, weak acid/base reactions, and polyprotic acids; introduction to quantum mechanics, including the wave nature of light, Bohr model, wave-particle duality and particle in a box models; quantum mechanics and atomic structure, including the hydrogen atom, the shell model, Aufbau principle, periodic table interpretation and periodic properties; valence bond theory and orbital hybridization; chemical kinetics, including mechanisms Arrhenius equation, catalysts and solution kinetics.

Course Objectives

The student will be able to:

A. Identify, calculate and relate composition in the equilibrium state to the equilibrium constant.
B. Given an equilibrium constant and initial state, calculate composition in equilibrium state from the equilibrium constant.
C. Adequately describe and model the influence of temperature on the equilibrium constant.
D. Use the concepts and mathematics of thermodynamics to explain equilibrium and how to maximize reaction yield.
E. Understand the components of a solution and how solution composition is expressed in molarity, molality and mole fraction.
F. Prepare a solution quantitatively, and understand net ionic-reactions.
G. Master acid-base and oxidation-reduction titration stoichiometry.
H. Apply the colligative properties of a solution to a system, including Raoult's Law, Henry's Law, and distillation.
I. Classify acids and bases on type, strength, and properties.
J. Determine the pH of any acid/base solution using appropriate equilibrium constants.
K. Compare and contrast acid strength based on molecular structure.
L. Understand the chemistry and behavior of polyprotic acids.
M. Understand the wave nature of light and evidence for energy quantization in atoms.
N. Use the Bohr model to calculate energy levels and energy transitions.
O. Give evidence for wave-particle duality and use the Schrodinger equation to solve quantum mechanical systems.
P. Understand the quantum mechanics of a particle in a box system.
Q. Apply quantum mechanics to the hydrogen atom and understand the meaning of the three quantum numbers for a single electron atom.
R. Use the shell model for many-electron atoms to write electron configurations and predict relative energy levels.
S. Understand the periodic properties of the elements in terms of electron configuration of the atoms.
T. Use the valence bond method to construct wave functions for localized electron pair bonds.
U. Understand hybridization theory and relate hybridization to the observed molecular geometry for polyatomic molecules.
V. Describe experimental methods for measuring average and instantaneous rates.
W. Deduce rate laws and reaction orders from experimental measurements.
X. Understand reaction mechanisms in terms of elementary reactions and deduce the rate law from a mechanism characterized by a single rate-determining step.
Y. Calculate Arrhenius factors and activation energy from measurements of the temperature dependence of rate constants.
Z. Describe several types of catalysts and their effects on chemical reactions.

Course Content

A. Identify, calculate and relate composition in the equilibrium state to the equilibrium constant
1. Characteristics of the equilibrium state
2. The empirical law of mass action
3. Reactions among ideal gases
4. Relationships among equilibrium expressions
B. Given an equilibrium constant and initial state, calculate composition in equilibrium state from the equilibrium constant
1. Evaluating equilibrium constant from reaction data
2. Calculating equilibrium compositions when K is known
3. The reaction quotient
4. The principal of Le Chatalier

C. Adequately describe and model the influence of temperature on the equilibrium constant
1. The effects of changing the temperature on the equilibrium constant and reaction yield
D. Use the concepts and mathematics of thermodynamics to explain equilibrium and how to maximize reaction yield
1. The magnitude of the equilibrium constant in relation to *d*G-std
2. Free energy changes in the reaction quotient
3. Temperature dependence of equilibrium constants
4. Temperature dependence of vapor pressure
5. Extraction and separation processes in organic chemistry
E. Understand the components of solution and how solution composition is expressed in various ways
1. Composition of solutions: mass percentage mole fraction molarity canned molality
2. Aqueous solutions of molecular species and aqueous solutions of ionic species
F. Prepare a solution quantitatively, and understand net ionic-reactions
1. Quantitative preparation of solutions using volumetric glassware
2. Net ionic equations: precipitation
G. Master acid-base and oxidation-reduction titration stoichiometry
1. Reactions types in solution including titrations
2. Acid-base reactions
3. Oxidation reduction reactions
H. Apply the colligative properties of a solution to a system, including Raoult's Law, Henry's Law, and distillation
1. Raoult's Law and vapor pressure lowering
2. Boiling point elevation, freezing point depression and osmotic pressure
3. Henry's Law and distillation
I. Classify acids and bases on type, strength and properties
1. Arrhenius acids and bases
2. Bronsted-Lowry acids and bases and conjugate pairs
3. Lewis acids and bases
4. Auto ionization of water
5. Strong acids and bases
J. Determine the pH of any acid/base solution using appropriate equilibrium constants
1. The pH function
2. Acid ionization constants and calculations
K. Compare and contrast acid strength based on molecular structure
1. The effective resonance on conjugate base strength
2. Inductive effects and conjugate base strength
3. Bond strength and bond electronegativity on conjugate base strength
4. Organic acids and bases: structure and reactivity
5. Weak acid and weak base pH calculations
L. Understand the chemistry and behavior of polyprotic acids and amphoteric species
1. Weak polyprotic acids
2. The effect of pH on solution composition
3. Exact treatment of acid-base equilibria
4. Amphoteric equilibria
M. Understand the wave nature of light and evidence for energy quantization in atoms
1. Electromagnetic radiation
2. Blackbody radiation and Planck's quantum hypothesis
3. Atomic specter and transitions between discrete energy states
4. The Franck-Hertz experiment
N. Use the Bohr model to calculate energy levels and energy transitions
1. Quantized anger momentum the border radius and ionization energy
2. Atomic spectra interpretation by the Bohr model
O. Give evidence for wave particle duality and use the Schrodinger equation to solve quantum mechanical systems
1. The photoelectric affect
2. De Broglie waves
3. Electron diffraction
4. The Heisenberg uncertainty principle
5. Origins of the Schrodinger equation
6. Interpretation of the energy in the Schrodinger equation
7. Interpretation of the wave function in the Schrodinger equation
P. Understand the quantum mechanics of particle in a box systems
1. Particle and a one-dimensional box, wave functions and energy levels
2. Energy levels and wave functions for particles in two and three dimensional boxes
Q. Apply quantum mechanics to the hydrogen atom and understand the meaning of the three quantum numbers for a single electron atom
1. The hydrogen atom energy levels, wave functions and quantum numbers
2. Sizes and shapes of orbitals: s, p, d and f orbitals
3. The radial distribution function
4. Electron spin quantum number
R. Use the shell model for many electron atoms to write electron configurations and predict relative energy levels
1. Hartree orbitals: sizes and shapes
2. Shielding effects and effective nuclear charge
3. Slaters rules
S. Understand the periodic properties of the elements in terms of electron configuration of the atoms
1. The Aufbau principle
2. Building up from helium to argon
3. Transition metal elements and beyond
4. Photoelectron spectroscopy and shells
5. Periodic properties: sizes of atoms and ions
6. Periodic trends in ionization energy
7. Periodic trends in electron affinity
T. Use the valence bond method to construct wave functions for localized electron pair bonds
1. Valence bond theory and single bonds
2. Valence bond and multiple bonds
3. Valence bond and polyatomic molecules
U. Understand hybridization theory and relate hybridization to the observed molecular geometry for polyatomic molecules
1. sp hybridization
2. sp2 hybridization
3. sp3 hybridization
4. Summary of hybridization results
5. Hybridization and loan pairs
6. Hybridization and multiple bonds
7. Predicting molecular structure and shapes
8. The shapes of molecules and electrostatic forces
9. Shapes of simple organic molecules
V. Describe experimental methods for measuring average and instantaneous rates
1. Measuring reaction rates
2. Average instantaneous and initial rates
W. Deduce rate laws and reaction orders from experimental measurements
1. Order of a reaction
2. The integrated rate laws
X. Understand reaction mechanisms in terms of elementary reactions and deduce the rate law from a mechanism characterized by a single rate determining step
1. Elementary reactions
2. Reaction mechanisms
3. Kinetics and chemical equilibrium

4. The rate determining step
Y. Calculate Arrhenius factors and activation energy from measurements of the temperature dependence of rate constants
1. Gas phase reaction rate constants
2. Activation energy and the pre-exponential factor
3. The reaction cornet and the activated complex
4. Collision theory
5. Transition state theory
6. Diffusion controlled reactions
Z. Describe several types of catalysts and their effects on chemical reactions
1. Homogeneous and heterogeneous catalysts
2. Enzyme catalysis

Lab Content

A. Determination of an equilibrium constant
1. Prepare and test standard solutions of FeSCN2+ in equilibrium
2. Test solutions of SCN- of unknown molar concentration
3. Determine the mower concentrations of the ions present in an equilibrium system
4. Determine the value of the equilibrium constant for the reaction
B. Determining the KSP of calcium hydroxide
1. Titrate a saturated calcium hydroxide solution with a standard hydrochloric acid solution
2. Determine the hydroxide concentration for the saturated calcium hydroxide solution
3. Calculate the KSP of calcium hydroxide
C. Using freezing point depression to find molecular weight
1. Determine the freezing temperature of the pure solvent
2. Determine the freezing temperature of a mixture of lauric acid and benzoic acid
3. Calculate the freezing point depression of the mixture
4. Calculate the molecular weight of benzoic acid
D. The potentiometric titration of hydrogen peroxide
1. Conduct the potentiometric titration of the reaction between commercially available hydrogen peroxide and potassium permanganate
2. Measure the potential change of the reaction
3. Determine the concentration of the hydrogen peroxide solution
E. Determining Ka by the half titration of a weak acid
1. Conduct a reaction between solutions of a weak acid and sodium hydroxide
2. Determine the half titration point of an acid base reaction
3. Calculate the pKa and the Ka for the weak acid
F. Exploring light, color, and emission spectroscopy
1. Understand the Bohr model of the hydrogen atom and its limitations
2. Understand the relationship between the energy, frequency, and wavelength of light
3. Investigate the light emitted by different light sources, including various element discharge tubes plus an incandescent light source, and draw corresponding emission spectra showcasing observed wavelengths of light
4. Match calculated wavelengths using Bohr’s equation with observed wavelengths
5. Observe the characteristic colors emitted by various elements when placed in a flame
G. The rate and order of a chemical reaction
1. Conduct the reaction of KI and FeCl3 using various concentrations of reactants
2. Determine the order of reaction in KI and FeCl3
3. Determine the rate law expression for the reaction
H. Rate determination and activation energy
1. Reacts solutions of crystal violet and sodium hydroxide at four different temperatures
2. Measure and record the effect of temperature on the reaction rate and rate constant
3. Calculate the activation energy for the reaction
Laboratory develops experimental techniques, critical thinking and data analysis skills, and introduces the use of a laboratory notebook. Extensive use of graphical techniques are employed for data analysis. Laboratory topics parallel lecture topics.

Special Facilities and/or Equipment

A. Chemistry laboratory, safety goggles or Visorgogs, a scientific calculator, a laptop or tablet computer with access to the internet, Loggerpro software by Vernier.

Method(s) of Evaluation

A. Class participation in lecture and lab
B. Laboratory notebook
C. Written laboratory assignments/projects/presentations
D. Laboratory quizzes and exams
E. Lecture exams
F. Final examination

Method(s) of Instruction

A. Lecture
B. Laboratory

Representative Text(s) and Other Materials

Petrucci, Herring, Madura, and Bissonnette. General Chemistry. 11th ed. Pearson, 2017.

Atkins, Jones, and Laverman. Chemical Principles: The Quest for Insight. 6th ed. W.H. Freeman, 2013.

Oxtoby, Gillis, and Butler. Principles of Modern Chemistry. 8th ed. Cengage Learning, 2016.

Types and/or Examples of Required Reading, Writing, and Outside of Class Assignments

A. Homework assignments:

1. There are 40-60 homework problems for each of the 12 chapters covered in this course

B. Laboratory assignments:

1. There are eight experiments administered in this course during the biweekly two-hour laboratory sessions, for which a pre-laboratory assignment, a data sheet, a calculations sheet, and a post-laboratory assignment are all collected and graded by the instructor

2. There are a few worksheets and assignments administered in the laboratory sessions that more richly cover some of the key course concepts, all of which are collected and graded by the instructor. These assignments will make use of graphical differentiation and integration of relevant mathematical functions covering energy, probability, and collision theory

C. Additional coursework:

1. The careful and regular reading and rereading of the text and lecture notes is essential to passing this course

2. There are several practice problems provided by the instructor that showcase more challenging problems and may be completed in-class or as additional homework

Discipline(s)

Chemistry