CHEM 1AH: 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:	Satisfactory score on the chemistry placement test or CHEM 25; MATH 105 or equivalent.
Advisory:	MATH 48A or equivalent Precalculus I course; not open to students with credit in CHEM 1A.
Degree & Credit Status:	Degree-Applicable Credit Course
Foothill GE:	Area III: Natural Sciences
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 1AH at Foothill College will demonstrate the ability to think critically and employ critical thinking skills.
- A student who successfully masters the material in Chemistry 1AH 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.
- A student who successfully masters the material in Chemistry 1A at Foothill College will demonstrate the quantitative skills needed to succeed in General Chemistry. These will include the minimal use of calculus.

Description

Fundamental chemical principles 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: The atom in modern chemistry; chemical formulas, equations, stoichiometry and theoretical yields; classical models of atomic bonding, electron shells, and molecular shapes; the behavior of gases, gas laws, kinetic molecular theory, molecular collisions; solids, liquids and phase transitions, intermolecular forces, phase diagrams; thermodynamic processes and thermochemistry, heat capacity and colorimetry, reversible processes in ideal gases; spontaneous processes and thermodynamic systems.

Course Objectives

The student will be able to:
A. Describe the key experiments and the underlying physical models that justify the central role of the atom in modern chemistry.
B. Understand the chemical evidence for the existence and properties of atoms and molecules.
C. Cite and compare the physical evidence for the existence and properties of atoms and molecules.
D. Describe the modern planetary model of the atom.
E. Use the mole concept that relates weighing and counting of molecules and atoms.
F. Balance chemical equations and relate moles of reactants to moles of products.
G. Master qualitatively and quantitatively the established procedures that describe chemical reactions as rearrangements of atoms forming products from reactants.
H. Describe the classical theory of chemical bonding.
I. Apply Valence Bond theory to organic molecules.
J. Describe the structure and shapes of simple and organic molecules using Lewis structures.
K. Reliably determine the three-dimensional shapes of molecules using VSEPR theory and name simple compounds.
L. Define the central physical properties of gases and apply the gas laws conceptually and quantitatively.
M. Use kinetic molecular theory to describe micro and macroscopic gas behavior for both ideal and real gases.
N. Describe and interpret the bulk properties of gases liquids and solids.
O. Describe, identify and apply the four types of intermolecular forces, especially forces between organic molecules.
P. Identify the six common phase transitions and interpret a phase diagram.
Q. Learn the vocabulary of thermochemistry and use calorimetry as a basis for understanding heat flow.
R. Master the concepts and mathematics of thermochemistry using standard state enthalpies and Hess's Law.
S. Describe a spontaneous process and use the second law of thermodynamics to understand the behavior of a chemical system in terms of entropy.
T. Use the third law of thermodynamics as a basis for defining standard-state enthalpies and apply them to find the Gibbs free energy of a system.

Course Content

A. Describe the key experiments and the underlying physical models that justify the central role of the atom in modern chemistry
1. Conservation of matter and energy
2. Macroscopic methods and nanoscopic models
3. Substances and mixtures
4. Elements
B. Understand the chemical evidence for the existence and properties of atoms and molecules
1. Law of conservation of mass
2. Law of definite proportions
3. Dalton's atomic theory
4. Law of multiple proportions
5. Law of combining volumes
6. Avogadro's hypothesis
C. Cite and compare the physical evidence for the existence and properties of atoms and molecules
1. Electrolysis and the existence of ions
2. Glow discharges and cathode rays
3. Negative charge in the atom: electrons
4. Charge to mass ratio of the electron
5. Charge of the electron
6. Positive charge in the atom: the nucleus
7. Discovery of the atomic nucleus

D. Describe the modern planetary model of the atom
1. Rutherford's planetary model of the atom
2. Structure of the nucleus: protons, neutrons, and isotopes
E. Use the mole concept that relates weighing and counting of molecules and atoms
1. Relation between atomic and macroscopic masses: Avogadro's number
2. The mole
3. Density and molecular size
F. Balance chemical equations and relate models of reactants to moles of products
1. Empirical formula and percentage composition
2. Determination of empirical formula from mass composition
3. Empirical formula determined from elemental analysis by combustion
4. Connection between empirical court and molecular formulas
5. Writing balanced chemical equations
G. Master qualitatively and quantitatively the established procedures that describe chemical reactions as rearrangements of atoms forming products from reactants
1. Mass relationships in chemical reactions
2. Limiting reactant
3. Theoretical yield
4. Percentage yield
H. Describe the classical theory of chemical bonding
1. Representations of molecules
2. The periodic table
3. Survey of the physical and chemical properties: the representative elements
4. Forces and potential energy in atoms
5. Ionization energies
6. The shell model of the atom
7. Periodic behavior in chemical bonding
8. Electron affinity
9. Electronegativity
10. Formation of chemical bonds
11. Ionic bonding
12. Covalent and polar covalent bonding
13. Bond lengths
14. Bond energies
15. Polar covalent bonding: electronegativity and dipole moments
16. Dipole moments and percent ionic character
I. Describe the structure and shapes of organic molecules using Lewis structures
1. Electron pair bonds Lewis diagrams for simple molecules
2. Bond order
3. Formal charges
4. Drawing Lewis diagrams
5. Resonance forms of organic molecules
6. Breakdown of the octet rule
J. Determine the three dimension shapes of molecules using VSEPR theory
1. The valence shell electron pair repulsion theory
2. Dipole moments of polyatomic molecules
3. Oxidation numbers
4. Names and formulas of ionic compounds
5. Naming binary covalent compounds
6. Naming of simple organic compounds
K. Define the central physical properties of gases and apply the gas laws conceptually and quantitatively
1. The chemistry of gases
2. Pressure and Boyle's Law
3. Temperature and Charles's Law
4. The ideal gas law
5. Chemical calculations for gases
6. Mixtures of gases
L. Use kinetic molecular theory to describe micro and macroscopic gas behavior for both ideal and real gases
1. The meaning of temperature
2. Distribution of molecular speeds
3. The van der Waals equation of state
4. Intermolecular forces
5. Molecule-wall collisions: effusion
6. Molecule molecule collisions
7. Mean free path and diffusion
M. Bulk properties of gases liquids and solids
1. Molar volume
2. Compressibility
3. Thermal expansion
4. Fluidity and rigidity
5. Diffusion
6. Surface tension
N. Describe, identify and apply the four types of intermolecular forces
1. Ion-ion forces
2. Dipole-dipole forces
3. Ion-dipole forces
4. Charged induced dipole forces: polarizability
5. Induce induced dipole forces: London dispersion forces
6. Repulsive forces
7. Comparison of potential energy curves
8. The shapes of molecules and electrostatic forces
9. Hydrogen bonds
10. Special properties of water
11. Intermolecular forces in organic molecules
O. Identify the six common phase transitions and interpret a phase diagram
1. The six common phase transitions
2. Vapor pressure curves
3. Normal melting and boiling points
4. Triple points critical points and super critical fluids
P. Learn the vocabulary of thermochemistry and use calorimetry as a basis for understanding heat flow
1. The definitions of systems states and processes
2. The first law of thermodynamics
3. Work
4. Internal energy
5. Heat
6. Heat capacity and specific heat capacity
7. Heat transfer at constant volume
8. Heat transfer at constant pressure: enthalpy
9. Heat capacities of ideal gases
10. Heat and work for ideal gases
11. Molecular contributions to internal energy and heat capacity
Q. Master the concepts and mathematics of thermochemistry using standard state enthalpies and Hess's Law
1. Enthalpies of reaction
2. Hess's Law
3. Standard state enthalpies
4. Bond enthalpies
5. Isothermal processes
6. Adiabatic processes
7. The Boltzman energy distribution
8. Vibrational energy distribution

R. Describe a spontaneous process and use the second law of thermodynamics to understand the behavior of a chemical system in terms of entropy
1. Spontaneity and molecular motions
2. Entropy and molecular motions
3. Entropy and heat: the definition of entropy
4. *d*Ssys for isothermal processes
5. *d*Ssys for processes with changing temperature
6. *d*Ssurr and *d*Suniv
S. Use the third law of thermodynamics as a basis for defining standard-state enthalpies and apply them to find the Gibbs free energy of a system
1. The third law of thermodynamics and the concept of zero entropy
2. Standard-state enthalpies
3. Gibbs free energy and its properties
4. The Gibbs free energy and phase transitions
5. The Gibbs free energy and chemical reactions

Lab Content

A. Determining and comparing the densities of a soda and a diet soda
1. Become familiar with the scientific method of investigation
2. Formulate and test a hypothesis
3. Gain experience in the proper use of electronic balances, graduated cylinders, volumetric pipets, and burets
4. Experimentally determine the density of an assigned soda using three different volume measuring devices
5. Organize the pooled density results in a scatter graph to visualize the precision and range of the three different volume measuring devices
6. Effectively communicate within a group to determine which density results should be retained in the calculated average result
7. Use extended statistical analysis do find outliers and confidence limits for a data set
B. The determination of a chemical formula and the percent water in a compound
1. Determine the water of hydration in a copper chloride hydrate sample
2. Conduct a reaction between a solution of copper chloride and solid aluminum
3. Use the results of the reaction to determine the mass and moles of copper and chlorine in the reaction
4. Calculate the empirical formula of the copper chloride compound
5. Carefully heat a measured sample of hygroscopic ionic compound
6. Determine the water of hydration of the compound
7. Complete the chemical formula of the compound
C. Determining the mole ratios in a chemical reaction
1. Measure the enthalpy change of a series of reactions
2. Determine the stoichiometry of an oxidation reduction reaction in which the reactants are known but the products are unknown
D. Standardizing a sodium hydroxide solution and determining the molar mass of an unknown solid acid
1. Become familiar with the principles and techniques involved in titrations
2. Use a primary standard to determine the molarity of a sodium hydroxide solution to be used in a subsequent procedure
3. Perform at least three trials to ensure precise results
4. Gain experience in writing an experimental procedure and organizing data and results
5. Use a standardized sodium hydroxide solution to determine the molar mass of an unknown solid acid
6. Refine the proper use of a buret and the application of solution stoichiometry
7. Deduce the impact of several theoretical procedural errors on the experimentally determined molar mass
E. Beers Law and the synthesis and analysis of aspirin
1. Prepare and test the absorbance of five standard copper (II) sulfate solutions
2. Calculate a standard curve from the test results of the standard solutions
3. Test the absorbance of a copper to sulfate solution of unknown molar concentration
4. Calculate the Moller concentration of the unknown solution
5. Synthesize a simple organic molecule, aspirin
6. Calculate the percent yield of your synthesis
7. Measure the melting temperature of your aspirin sample
8. Conduct a spectroscopic analysis of your aspirin sample
F. The molar mass of a volatile liquid and the molar volume of a gas
1. Evaporate a sample of a liquid substance and measure certain physical properties of the substance as it condenses
2. Determine the molar mass of the unknown liquid
3. Measure the gas production of a chemical reaction by a pressure change
4. Determine the Moller volume of the gas produced in the reaction
5. Calculate the molar volume of a gas at STP
G. Determining the enthalpy of a chemical reaction using calorimetry
1. Use Hess's Law to determine the enthalpy change for the reaction between aqueous ammonia and aqueous HCl
2. Compare your experimental results with the theoretical results
H. The enthalpy of neutralization of phosphoric acid
1. Measure the temperature change of the reaction between solutions of sodium hydroxide and phosphoric acid
2. Calculate the entropy of neutralization of phosphoric acid
3. Compare your calculated enthalpy with the theoretical value

Special Facilities and/or Equipment

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

Method(s) of Evaluation

A. Class participation in lecture and lab
B. Written laboratory assignments/projects/presentations
C. Laboratory quizzes and exams
D. Lecture exams/quizzes
F. Online homework
G. 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.

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