CIEE Global Institute – Monteverde

Course name: General Chemistry I (Lab course)
Course number: (GI) CHEM 1401 MOCR
Programs offering course: Monteverde Open Campus Block: STEM and Society
Open Campus track: STEM and Society
Language of instruction: English
U.S. semester credits: 4
Contact hours: 45 lecture and 45 laboratory
Term: Spring 2020

Course Description

Students will learn basic concepts of chemistry, including chemical equations, stoichiometry, gases, thermochemistry, equilibrium, electronic structure of atoms, periodic trends, molecular bonding and structure, intermolecular forces, and modern materials. Students will connect a variety of chemistry-related applications to contemporary social, technological, and scientific issues. Each student will improve their knowledge of chemistry, through qualitative and quantitative problem-solving skills. Hands-on experience with laboratory experiments will enable students to learn proper procedures, gather meaningful data, and draw and communicate appropriate scientific conclusions. Students will explore how chemistry is changing their lives as well as lives of local people. This course exceeds the first semester general chemistry standards of the American Chemical Society for university science majors.

Learning Objectives

By the end of this course, students will be able to:

- Make proper measurements, understand units and their conversions, and how to quantify uncertainty in measurements.
- Describe and work comfortably with fundamentals of general chemistry: Dimensional analysis, Problem-solving, Atomic Theory, Chemical Formulas, Masses, Moles, Chemical Equations (Balancing, Stoichiometry, Net Ionic Equations).
- Explain basic Thermochemistry: Enthalpy, Hess's Law, Enthalpy of Formation, Calorimetry, Laws of Thermodynamics.
- Evaluate Chemical Structures and Bonding, including Light and Spectroscopy, Bohr vs. Quantum models, Orbitals, Quantum Numbers and the Period Table, Periodic Trends, Electronegativity with ionic vs. covalent compounds, Lewis structures, hybridization, molecular orbital theory.
- Characterize States of Matter: Gas Laws, Kinetic Molecular Theory, Real Gases, Intermolecular Forces, Liquids and Solids, Phase Changes.

- Practice sound laboratory techniques: Use of volumetric glassware, electronic balance, Bunsen Burner, Spectrophotometer, pH meter and other basic chemical laboratory equipment.

- Know and follow proper laboratory safety practices.

- Collect and report data effectively: Use correct laboratory notebook skills, spreadsheets, graphing software and regression analysis.

- Master essential chemical laboratory procedures: Including preparation of solutions, titrations and chemical separations.

- Assess how chemistry impacts their lives and the lives of local people.

Course Prerequisites

High School General Chemistry and High School Algebra or equivalents

Methods of Instruction

The course will be taught using lectures, class discussions, lecture activities, reading assignments, problem sets, presentations, laboratory activities and experiments. In addition, students will tour government universities and industrial chemical facilities, conducting interviews with local chemists and Mexican chemistry students. Students will work individually and in groups in laboratory and on assigned problem sets. Students are expected to read portions of the textbook before lectures and review laboratory manual instructions before labs. Students will work in groups to present current applications of chemistry in their lives and in the lives of those in the local community. Students should take full advantage of generous online resources associated with the texts.

Assessment and Final Grade

Weekly Exams (Five)	25 %
Problem Sets	10 %
Laboratory	30 %
Group Presentation	10 %
Participation	5 %
Final Exam (Comprehensive)	20 %

Course Requirements

Participation

Participation is valued as meaningful contribution in the digital and tangible classroom, utilizing the resources and materials presented to students as part of the course. Meaningful contribution requires students to be prepared in advance of each class session and to have regular attendance. Students must clearly demonstrate they have engaged with the materials as directed, for example, through classroom discussions, online discussion boards, peer-to- peer feedback (after presentations), interaction with guest speakers, and attentiveness on co-curricular and outside-of-classroom activities.

Weekly Exams

Each week, students will take an exam based upon the previous week's material. These exams will include standard exam formats of True/False, Multiple Choice, Short Answer and Problem Solving. Each exam will take approximately 30 minutes and comprise 5% of the final course evaluation.

Problem Sets

Problems located at the end of each chapter of the textbook will be assigned to individuals or groups by the instructor. Student solutions to these problems will be collected and discussed in review sessions. The instructor will work through or give solutions to all problems. Similar problems will appear on weekly quizzes and the final exam. Assessment for problem sets will include timely and correct completion of problems.

Laboratory

Each lab will begin with a short quiz assessing the student preparedness. This will cover material in the laboratory manual related to the lab assigned for that day. Each lab will end with a report sheet which must be turned in at the end of the lab period. All lab report sheets must be completed in ink. Report protocol will be covered in the first lab period. Points will be deducted for failing to follow these procedures or if the lab sheet is not neatly presented. A laboratory notebook will be kept, in addition to the manual, and will contain all changes to protocols, data collected and interpretation of data. Some labs will require written lab reports. The style and content of written lab reports will be given in the first lab period.

Group Presentations

Students will investigate how chemistry impacts their daily lives and the lives of local people. This will be done in groups using information from various sources, including interviewing each other and local people. A 15-minute presentation with a demonstration using chemicals and chemical techniques will be graded on the overall presentation as well as each student's part in it.

Final Exam
The final exam is comprehensive. As with quizzes, this exam will include standard exam formats of True/False, Multiple Choice, Short Answer and Problem Solving. It will include material from both lecture and laboratory.

Class Attendance
Regular class attendance is required throughout the program, and all unexcused absences will result in a lower participation grade for any affected CIEE course. Due to the intensive schedules for Open Campus programs, unexcused absences that constitute more than 10% of the total course will result in a written warning.

Students who transfer from one CIEE class to another during the add/drop period will not be considered absent from the first session(s) of their new class, provided they were marked present for the first session(s) of their original class. Otherwise, the absence(s) from the original class carry over to the new class and count against the grade in that class.

For CIEE classes, excessively tardy (over 15 minutes late) students must be marked absent. Attendance policies also apply to any required co-curricular class excursion or event, as well as to Internship, Service Learning, or required field placement. Students who miss class for personal travel, including unforeseen delays that arise as a result of personal travel, will be marked as absent and unexcused. No make-up or re-sit opportunity will be provided.

Attendance policies also apply to any required class excursion, with the exception that some class excursions cannot accommodate any tardiness, and students risk being marked as absent if they fail to be present at the appointed time.

Unexcused absences will lead to the following penalties:

Percentage of Total Course Hours Missed	*Equivalent Number of Open Campus Semester classes*	*Minimum Penalty*
Up to 10%	1 content classes, or up to 2 language classes	Participation graded as per class requirements
10 – 20%	2 content classes, or 3-4 language classes	Participation graded as per class requirements; **written warning**
More than 20%	3 content classes, or 5 language classes	Automatic **course failure**, and possible expulsion

Weekly Schedule

NOTE: this schedule is subject to change at the discretion of the instructor to take advantage of current experiential learning opportunities.

Week 1 Foundational Concepts, Matter and Measurement

Session 1.1: Review of General Chemistry Foundational Concepts and components of matter. Students will review basic chemical definitions, terms and the scientific method, numbers and significant figures, density, dimensional analysis. Using internet resources, students will explore chemistry in everyday life and present their most amazing findings with one another. Students will cover atomic theory, law of multiple proportions, compounds vs. elements, conservation of mass, Bohr models, notation, ions, isotopes and atomic mass.

Watch: Chemistry Life Hacks https://www.youtube.com/watch?v=mAqJmEjCy4E https://www.youtube.com/watch?v=ReGfd_s9gXA

Reading: Chapter 1 Essential Ideas, plus assigned problems (at end of chapter): 2, 7, 9, 11, 14, 18, 20, 36, 40,58, 59,60, 62, 71,77,79, 83,87,89,93 and Roy, S. 2016. Chemistry in our daily lives: preliminary information. International Journal of Home Science 2(3): 361-366, Chapter 2 Atoms, Molecules and Ions and problems 1,9, 20, 22, 23, 27, 37,39,41, 43, 47,50,55, 56, 58.

Laboratory 1: Lab Check in, Basic Lab Safety, and Lab Equipment, including measurements and density (Dry Lab 1) and Basic Lab Operations (Experiment 1). Students will check into the laboratory, become familiar with the laboratory and the laboratory manual and put into practice rules of lab safety. Students will also learn to organize and record data. Using International SI units, students will organize and record data. Lab Notebook protocol will be explained with a post lab check. There will be a Pre-Lab Quiz and Lab Notebook check (graded) on: Safety, Technique, Procedure, Clean Up, Observations and Data, Proper Format for Calculations and Results, Discussion

Readings: Ball, Philip. 2005. Lessons from early chemists – Where is the wisdom to be found in ancient materials chemistry? Chemistry International 27:13.

Week 2 Stoichiometry and Chemical Reactions

Session 2.1: Chemical Composition of Solids, Gases and Liquids. Students will explore the mole, molar mass, empirical formula, percent composition, balancing chemical equations, mole ratio, stoichiometry, limiting reagents and percent yield.

Readings and Problem Sets: Chapter 3 Composition of Substances and Solutions, and problems 2, 7, 9, 11, 14, 18, 20, 36, 40,58, 59,60, 62, 71,77,79

Laboratory 2: Inorganic Nomenclature: Oxidation Numbers (Dry Lab 2A); Acids, Bases and Salts (Experiment 6). Oxidation numbers of various elements will be explored and explained. Students will identify oxidation numbers of elements in compounds and ions. Students will also become familiar with the chemical properties of acids, bases and salts, develop the concept of pH and measure the pH of common acids, bases and salts, observe the relative solubility of salts and

write equations accounting for observed chemical reactions. There will be a Pre-Lab Quiz and Post-Lab Notebook check (graded).

Session 2.2: Three Major Classes of Chemical Reactions. Students will study solubility, precipitation reactions, double replacement reactions, acid-base reactions, net ionic equations, single replacement reactions, redox reactions, combustion reactions and concentration and dilution of solutions. Application of stoichiometry and chemical reactions to our lives, including local people, review and discussion of stoichiometry and chemical reaction concepts, problem solving workshop

Readings and Problem Sets: Chapter 4 Stoichiometry of Chemical Reactions and problems 3,6,16,20,22,23,24,28,33, 37,39, 41,43,47,53,55,63a,71,86,90,95; Tucker, J.L. and Faul, M.M., 2016. Drug companies must adopt green chemistry. *Nat. News*, *534*, pp.27-28.

Laboratory 3: Inorganic Nomenclature: Binary (Dry Lab 2B) and Ternary (Dry Lab 2C) Compounds, Vitamin C Analysis (Experiment 30). Students will name and write formulas for binary and ternary compounds, including metal, nonmetal, acids, hydrated compounds, acid salts and polyatomic anions. Using a Vitamin C tablet, as well as fruits and vegetables purchased at the Central Market, students will determine the amount of Vitamin C in local foods. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Week 3 Gases and Thermochemistry

Session 3.1: Gases and Kinetic-Molecular Theory. Students will learn about pressure; the macroscopic description of gases P,V,T, mass relations; density; gas mixtures; mole fraction and partial pressures; the ideal gas law and reaction stoichiometry; kinetic molecular theory; Dalton's Law, effusion and diffusion; real gases.

Readings and Problem Sets: Chapter 5 Thermochemistry and problems 8,10,20,22,24,30,41,45, 47,51,58,61,68,71,74,75,77,78,79,82

Laboratory 4: A Carbonate Analysis; Molar Volume of Carbon Dioxide (Experiment 13) and Calorimetry (Experiment 25). Much of the Yucatan is limestone, chemically known as Calcium Carbonate. Students will determine the percent Calcium Carbonate in a heterogeneous mixture and from local soil. Students will also determine the molar volume of carbon dioxide gas at 273 K and 760 Torr, using calorimetry, students will define an determine the specific heat of a metal, determine the enthalpy of neutralization for a strong acid-base reaction and the enthalpy of solution for the dissolution of a salt. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Session 3.2: Thermochemistry, Energy Flow and Chemical Change. Students will cover concepts of energy: Kinetic, potential, and internal; heat and work; the first law of thermodynamics; enthalpy; specific heat; calorimetry; changes in state; Hess' Law; reaction enthalpy and standard enthalpy of formation.

Readings and Problem Sets: Chapter 9 Gases and problems 11,19,21,26,28,34,35,37,41, 43,47,54,55,57,68,70,77,79,82,84

Laboratory 5: Site Visit to local chemical facility or chemistry department of local university: Facilities tour, interviews with faculty, chemical demonstration and chat with local students. A written report of the trip will be due the next lab period.

Session 3.3: Application of gases and thermochemistry to our lives, including local people, conceptual review and discussion of major concepts of gases and thermochemistry, problem solving workshop

Readings: Roy, S. 2016. Chemistry in our daily lives: preliminary information. International Journal of Home Science 2(3): 361-366.

Week 4 Atomic Structure, Quantum Theory, Periodic Table

Lecture 4.1: Quantum Theory and Atomic Structure. Students will explore the nature of light and electromagnetic radiation; wave-particle duality; the photon theory of light; atomic spectra; quantum structure of the hydrogen atom; electron orbital shapes and energies.

Readings and Problem Sets: Chapter 6 Electronic Structures and Period Properties of Elements, and problems 2,7,9,13,20,22,23,29,45,46,47, 48,49,50,54,57,59,64

Laboratory 6: Antacid Analysis (Experiment 17) and Aspirin Synthesis (Experiment 18). In this laboratory, students will explore acid-base equilibria using antacids as weak basis and aspirin as a weak acid. The neutralizing power of several antacids will be determined with acid-base titration. Next, students will synthesize and determine the purity of commercial aspirin, an organic acid. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Lecture 4.2: Electron Structure and Chemical Periodicity. Students will learn about multi-electron atoms; electron spin; electron configurations; quantum origins of the structure of the periodic table; groups and periods; trends in atomic properties and chemical reactivity.

Readings and Problem Sets: Chapter 7 Chemical Bonding and Molecular Geometry and problems 6,7,11,13,18,21,23,25,31,33,35, 44,50,53,55, 69,77,79,85

Laboratory 7: Atomic and Molecular Structure (Dry Lab 3), Periodic Table and Periodic Law (Experiment 11). Students will familiarize themselves with the periodic table, observe and generalize trends within groups and periods of elements, and experimentally observe trends of chemical properties with various atomic properties within the periodic table. Next, students will view and calibrate visible line spectra, identify an element and then a compound from its visible line spectrum and predict the three-dimensional structure of molecules and molecular ions. A prelab quiz and post-lab notebook check will be graded.

Lecture 4.3: Comprehensive Review and Discussion of Chemical Concepts. Question and answer review session with instructor. Groups will work together on sample problems with instructor oversight.

Readings: Wood, D.J., 2016. Beer Brewing as a Model for Improving Scientific Literacy in Higher Education. *HAPS Educator*, *20*(2), p.19.

Week 5 Molecular Bonds, Shapes of Molecules

Lecture 5.1: Models of Chemical Bonding. Students will examine atomic properties related to chemical bonds, including ionic bonds, properties of ionic compounds, covalent bonds and properties of compounds containing them, electronegativity, bond polarity and metallic bonding.

Laboratory 8: Kinetics and Activation Energy (Experiment 24) and Factors Affecting Reaction Rates (Experiment 23). Students will determine various factors impacting rates of chemical reactions, including the nature of the reactants, temperature, presence of a catalyst, concentration of reactants and the surface area of reactants. Students will measure the rate law for a chemical reaction, including graphical analysis, to determine the order of each reactant and the activation energy for the reaction. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Lecture 5.2: The Shapes of Molecules. Students will study Lewis structures, resonance; free radicals; formal charge; exceptions to the octet rule; valence-shell electron-pair repulsion theory and molecular shape; bond polarity, bond angle, dipole moment and molecular polarity. Students will use chemical models to illustrate these concepts to one another.

Readings and Problem Sets: Chapter 10 Liquids and Solids and problems 1,5,7,11,13,15,17,19,26,28, 30,34,36,40,55,57,64,70

Laboratory 9: Galvanic Cells (Experiment 32) Pre-Lab Quiz, Lab Notebook check (graded). Students will measure the relative reduction potentials for redox couples, study the movement of electrons, anions and cations in a galvanic cell, study factors affecting cell potentials, and estimate the concentration of ions in solution using the Nernst equation. A prelab quiz and post-lab notebook check will be graded.

Lecture 5.3: Theories of Covalent Bonding. Students will learn about Valence bond theory; orbital hybridization; single, double and triple bonds; σ and π bonds; rotation around bond axis; theoretical basis for predicting the shapes of organic molecules.

Readings and Problem Sets: Chapter 8 Advanced Theories of Covalent Bonding and problems 1, 2, 7,13,20,21,23,40,56,64,72

Week 6 Intermolecular Forces, Properties of Mixtures

Lecture 6.1: Liquids, Solids and Phase Changes. Students explore physical states and phase changes; equilibrium and phase changes; the nature of solids and liquids; X-ray diffraction; types of intermolecular forces: ionic, dipole-dipole forces, hydrogen bonding, and dispersion forces; the unique properties of water.

Readings and Problem Sets: Chapter 12 Kinetics and problems 3,12, 13, 18, 35,36, 37, 39, 41, 43, 47, 49, 63

Laboratory 10: Spectrophotometric Metal Ion Analysis (Experiment 35). Students will use a spectrophotometer to measure the concentration of a metal ion. This will include graphing a standard curve from solutions of known concentration. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period. The lab will conclude with a thorough laboratory clean up.

Lecture 6.2: Properties of Mixtures: Solutions and Colloids. Students study concentration units, solution energetics, factors affecting solubility, colligative properties, solution composition, vapor pressure of a solution, Raoult's Law, boiling point elevation, freezing point depression, gas solubility, Henry's Law, osmotic pressure, colligative properties of electrolyte solutions and van't Hoff i factor.

Readings and Problem Sets: Chapter 11 Solutions and Colloids and problems 3,9,11,12,14,26,32,36,38,39, 40,46,47,48,49,58,64,71,76,88

Laboratory: Group Presentations of Chemicals in Daily Life (with demonstration experiment). Using principles of chemistry, a thorough literature search online and personal interviews with local people, groups will present how chemistry impacts their lives and the lives of local people. This will include a chemical demonstration of some kind. Students will be given a group and individual grade on their presentation.

Lecture 6.3: Comprehensive Review, Problem Set Workshop and Final Exam Preparation, including taking the American Chemical Society (ACS) General Chemistry Exam (Part 1) for first semester General Chemistry. Final Exam (Comprehensive)

Course Materials

Textbooks

Chemistry, 2015 Edition by Flowers, P., K. Theopold and R. Langley, Open Stax College

Laboratory Manual for Principles of General Chemistry, Tenth Edition by Jo A. Beran, Wiley

Readings

Ball, P., 2005. Lessons from Early Chemists: Where is there Wisdom to be Found in Ancient Materials Chemistry?. *Chemistry international*, *27*(6), p.13.

Roy, S. 2016. Chemistry in our daily lives: preliminary information. International Journal of Home Science 2(3): 361-366.

Tucker, J.L. and Faul, M.M., 2016. Drug companies must adopt green chemistry. *Nat. News*, *534*, pp.27-28.

Wood, D.J., 2016. Beer Brewing as a Model for Improving Scientific Literacy in Higher Education. *HAPS Educator*, *20*(2), p.19.
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Online Resources

Chemistry Student Resources. 2018. Openstax. Rice University
https://openstax.org/details/books/chemistry#student-resources-section