CIEE Global Institute – Monteverde

Course name: General Chemistry II (Lab course)
Course number: (GI) CHEM 1402 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 add to their basic concepts of chemistry, including fundamentals of chemical equilibria, acid-base dynamics, thermodynamics, electrochemistry, structure and general properties of metals and nonmetals, transition metals and coordination chemistry and an introduction to organic and nuclear chemistry. 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 people around the world. This course exceeds the second 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:

- Describe key fundamentals of general chemistry: chemical equilibria, acid-base dynamics, thermodynamics, electrochemistry, structure and general properties of metals and nonmetals, transition metals and coordination chemistry, and an introduction to organic and nuclear chemistry.
- Use mathematics and stoichiometry to characterize fundamental chemical relations, including chemical equilibria and acid-base dynamics.
- Represent organic and inorganic molecular structures using drawings and models to relate how molecular structure impacts their chemical properties.
- Detail the basics of electrochemistry and how they influence thermodynamic and stoichiometric parameters.
- 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 more advanced essential chemical laboratory procedures, including: acid/base titrations, buffer behavior.
- Apply thermodynamics to determine how much and how soon products are formed.
- Assess how chemistry covered in the course impacts their lives and the lives of people around the world.

Course Prerequisites

General Chemistry 1 or its equivalent, High School Algebra or equivalent

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 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 (5)	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 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 that 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 principles of chemistry presented in class impact 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.

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 Review: Lecture and Lab Concepts

Session 1.1: Review of General Chemistry 1 Foundational Concepts and Chemical Equilibrium. Students will review basic chemical definitions, terms and the scientific method, numbers and significant figures, density, dimensional analysis and key concepts from General Chemistry 1 that will be important building blocks for General Chemistry 2. Students will explore chemical equilibrium in many contexts. They will write reaction quotient expressions, evaluate reaction quotients, predict the direction of a reaction, convert K_c to K_p, describe shifting equilibria using Le Châtelier's Principle, determine relative changes in concentration, calculate the equilibrium constant and concentration changes as a reaction goes to equilibrium.

Laboratory 1: Lab Check in, Basic Lab Safety, use of Lab Equipment review. There will be a sample Pre-Lab Quiz (not graded). The instructor will take students on a walking tour of the historic district to explore chemistry in local people's lives. Students will consider pasteurization, fermentation, dry cleaning, rusting metal,

combustion, batteries, soaps, photosynthesis, and the chemistry of baking, among others. Students will follow strict laboratory procedures to prepare a local baked food and report on the chemical processes involved.

Readings: Chapter 13 Fundamental Equilibrium Concepts and assigned problems, Saini, R.D., 2015. Green chemistry in everyday life. *International Journal for Science, Management and Technology (IJSMT)*, *3*(3): 97-99, and Matlin, S.A., Mehta, G., Hopf, H. and Krief, A., 2016. One-world chemistry and systems thinking. *Nature chemistry*, *8*(5), p.393. https://www.thoughtco.com/examples-of-chemical-reactions-in-everyday-life-604049

Week 2 Chemical Equilibrium

Session 2.1: Acid-Base Equilibria. Students will identify acids, bases and conjugate acid-base pairs according to the Brønsted-Lowry definition, write equations for acid and base ionization reactions, use the ion-product constant for water to calculate hydronium and hydroxide ion concentrations and describe the acid-base behavior of amphiprotic substances. They will characterize aqueous solutions as acidic, basic or neutral, express hydronium and hydroxide ion concentrations as pH and pOH and use these in calculations. Students will then assess the relative strengths of acids and basis, relate this to molecular structure and carry out equilibrium calculations for weak acid-base systems. Students will also predict whether a salt solution is acidic, basic or neutral, calculate concentrations of various components of a salt solution and describe the process that causes solutions of certain metal ions to be acidic. They will describe compositions and calculate pH for buffer solutions, interpret titration curves and explain the function of acid-base indicators.

Readings and Problem Sets: Chapter 14 Acid-Base Equilibria and assigned problems

Laboratory 2: La Châtelier's Principle (Experiment 16 in Lab Manual). Students will study the effects of concentration and temperature change on the position of equilibrium in a chemical system. They will study the effect of strong acids and bases on the pH of buffered and unbuffered solutions. Students will observe the common-ion effect on a dynamic equilibrium. There will be a Pre-Lab Quiz and Post-Lab Notebook check (graded).

Session 2.2: Equilibria of other Reaction Classes. Students will write chemical equations and equilibrium expressions representing solubility equilibria and will carry out related computations of solubility, equilibrium expression and solute concentration. They will explain the Lewis model of acid-base chemistry, write equations for the formation of adducts and complex ions and perform equilibrium calculations involving formation constants. Students will also give examples of systems involving two (or more) simultaneous chemical equilibria, calculate reactant and

product concentrations for multiple equilibria systems and compare dissolution and weak electrolyte formation. Session will include a review and discussion, including a problem-solving workshop

Readings and Problem Sets: Chapter 15. Equilibria and other Reaction Classes and assigned problems

Laboratory 3: Alkalinity of a Water Resource (Experiment 19) and Hard Water Analysis (Experiment 20). Students will study local tap water and determine its alkalinity and hardness. They will use titrations of methyl orange to determine pH. Students will also articulate the causes and harm of hard water, as well as what farmers, municipalities and households can do to lessen negative effects of hard water. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Week 3 Thermodynamics and Electrochemistry

Session 3.1: Thermodynamics. Students will distinguish spontaneous and nonspontaneous processes and describe the dispersal of matter that accompanies certain spontaneous processes. They will define entropy, explain the relationship between entropy and the number of microstates and predict the sign of the entropy change for chemical and physical processes. Students will then state and explain the second and third laws of thermodynamics, using them to calculate entropy changes for phase transitions and chemical reactions under standard conditions. Finally, students will define Gibbs free energy and describe its relation to spontaneity, calculate free energy changes and explain how temperature, spontaneity, standard free energy and equilibrium constants are related.

Readings and Problem Sets: Chapter 16 Thermodynamics and assigned problems

Laboratory 4: Thermodynamics of the Dissolution of Borax (Experiment 26 in Lab Manual). Students will standardize a hydrochloric acid solution, determine the solubility product of borax as a function of temperature, determine the standard free energy, standard enthalpy and standard entropy changes for the dissolution of borax in an aqueous solution. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Session 3.2: Electrochemistry. Students will define electrochemistry and associated terms, split oxidation-reduction reactions into their half reactions, produce balance redox equations for acidic and basic solutions and identify oxidizing and reducing agents. They will use cell notation to describe galvanic cells and describe basic components of galvanic cells. Students will determine standard cell potentials for redox reactions and use standard reduction potentials to determine the better oxidizing and reducing agents from several options. They will relate cell

potentials to free energy changers, use the Nernst equation to determine cell potentials at nonstandard conditions and perform calculations to convert cell potentials, free energy changes and equilibrium constants. Students will then classify batteries as primary or secondary, list characteristics and limitations of battery types and provide a general description of a fuel cell. They will define corrosion and give examples of how to stop or slow it. They will then describe electrolytic cells and their relation to galvanic cells.

Readings and Problem Sets: Chapter 17 and assigned problems

Laboratory 5: Site Visit to local Chemistry Department of university. Students will tour facilities, interview faculty and local graduate students, and participate in Thermodynamics and Electrochemistry demonstrations. A written report of the trip will be due the next lab period.

Session 3.3: The instructor will lead students in an exploration of the application of thermodynamics and electrochemistry to our lives, including the lives of local people, there will be a conceptual review and discussion of major concepts with a problem-solving workshop.

Readings: Aneke, M. and Wang, M., 2016. Energy storage technologies and real-life applications–A state of the art review. *Applied Energy*, *179*, pp.350-377.

Week 4 Representative Metals, Metalloids and Nonmetals

Lecture 4.1: Representative Metals, Non-Metals and Metalloids. Students will classify elements and make predictions about their periodicity, reviewing and using the periodic table of the elements. The will identify natural sources of representative metals and describe electrolytic and chemical reduction processes used to prepare these elements from natural sources. Students will describe the general preparation, properties and uses of metalloids, as well as describe the preparation, properties and compounds of boron and silicon. Students will also describe the structure and properties of nonmetals.

Readings and Problem Sets: Chapter 18.1 – 18.4 Representative Metals, Metalloids and NonMetals: Structure and General Properties, and assigned problems

Laboratory 6: Oxidation-Reduction Reactions (Experiment 27 in Lab Manual). Students will observe and predict products of oxidation-reduction reactions. They will also determine the relative reactivity of a series of metallic elements. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Lecture 4.2: Occurrence, Preparation and Properties of Important Chemicals. Students will describe the properties, preparation and compounds of hydrogen. They will go onto describe the preparation, properties and important uses of some representative metal carbonates, nitrogen and the nitrogen cycle in ecosystems, phosphorus, sulfur, halogens and noble gases.

Readings and Problem Sets: Chapter 18.5 – 18.12 Occurrence, Preparation and Properties of Important Chemicals, and assigned problems.

Laboratory 7: Electrolytic Cells and Avogadro's Number (Experiment 33). Students will identify the reactions occurring at the anode and cathode during the electrolysis of various aqueous salt solutions and determine Avogadro's number and the Faraday constant. A prelab quiz and post-lab notebook check will be graded. A written laboratory report from this lab will be due the following lab period.

Lecture 4.3: Transition Metals and Coordination Chemistry. Students will outline the general approach for isolation of transition metals from natural sources, describe typical physical and chemical properties of transition metals and identify simple compound classes for transition metals, describing their chemical properties. They will list defining traits of coordination compounds, describe the structures of complexes containing monodentate and polydentate ligands, use standard nomenclature rules to name coordination compounds, explain and provide examples of geometric and optical isomerism and identify several natural and technological occurrences of coordination compounds. Students will outline the basic premise of crystal field theory (CFT), identify molecular geometries associated with various d-orbital splitting patterns, predict electron configurations of split d orbitals for selected transition metal atoms or ions and explain spectral and magnetic properties using CFT concepts.

Readings: Chapter 19 Transition Metals and Coordination Chemistry, and assigned problems

Week 5 Introduction to Organic and Nuclear Chemistry

Lecture 5.1: Introduction to Organic Chemistry. Students will explain the importance of hydrocarbons and the reason for their diversity. They will name saturated and unsaturated hydrocarbons, and molecules derived from them. They will describe reactions characteristic of saturated and unsaturated hydrocarbons. Students will also describe the structure and properties of alcohols and ethers, naming and drawing basic structures for each. They will describe the structure and property of amines and amides, as well.

Readings: Chapter 20 Organic Chemistry and assigned problems

Laboratory 8: Transition Metal Complexes (Experiment 36). Students will observe the various colors associate with transition metal ions. They will determine the relative

strengths of ligands and compare stability of complexes. They will also synthesize a coordination compound. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Lecture 5.2: Introduction to Nuclear Chemistry. Students will explore nuclear structure and stability, nuclear equations, radioactive decay, transmutation, uses of radioisotopes and the biological effects of radiation. Specifically, students will describe nuclear structure using protons, neutrons and electrons. They will calculate mass defect and binding energy for nuclei and explain trends in the relative stability of nuclei. They will identify common particles and energies involved in nuclear reactions, as well as write and balance nuclear equations. Students will recognize common modes of radioactive decay, calculate kinetic parameters for decay processes and describe radiometric dating techniques. They will describe the synthesis of transuranium nuclides, explain nuclear fission and nuclear chain reactions. Students will list common uses for radioactive isotopes, describe the biological impact of ionizing radiation and list common sources of radiation exposure in the U.S. and the host location.

Readings and Problem Sets: Chapter 21 Introduction to Nuclear Chemistry and assigned problems

Laboratory 9: Aspirin Synthesis and Analysis (Experiment 19). Students will synthesize aspirin and determine the purity of the synthesized product vs. a commercial tablet. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Session 5.3: The instructor will lead students in an investigation of the application of organic and nuclear chemistry to our lives, including local people, conceptual review and discussion of major concepts with a problem-solving workshop

Readings: Antonio, A.L et al. 2017. Ionizing radiation for food preservation processing: less or in excess?. In *NUTECH'2017-International Conference on Developments and Applications of Nuclear Technologies*.

Week 6 Applications of Chemistry and Review

Session 6.1: Student group workshop. In this session, groups of students will investigate how different chemical concepts covered in the course impact their lives and the lives of local people. They will use internet sources, as well as laboratory resources, to explain and eventually demonstrate three chemical principles covered in the course and how they relate to real life situations.

Laboratory 10: Radioactivity and the Geiger Counter. Students will explore which everyday products are radioactive. They will determine which materials are most effective at restricting passage of radiation. A prelab quiz and post-lab notebook check will be graded. 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.

Readings: Milvenan, R.D. and Hayes, R.B., 2016. Contributions of various radiological sources to background in a suburban environment. *Health physics*, *111*(5), pp. S193-S199.

Lecture 6.2: Comprehensive Review, Problem Set Workshop and Final Exam Preparation, including taking the American Chemical Society (ACS) General Chemistry Exam (Part 2) for second semester General Chemistry.

Presentations: 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.

Session 6.3: Final Review, Final Thoughts and 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

Aneke, M. and Wang, M., 2016. Energy storage technologies and real-life applications–A state of the art review. *Applied Energy*, *179*, pp.350-377.

Antonio, A.L., Ferreira, I.C., Santos, P.M. and Cabo Verde, S., 2017. Ionizing radiation for food preservation processing: less or in excess?. In *NUTECH'2017-International Conference on Developments and Applications of Nuclear Technologies*.

Matlin, S.A., Mehta, G., Hopf, H. and Krief, A., 2016. One-world chemistry and systems thinking. *Nature chemistry*, *8*(5), p.393.

Milvenan, R.D. and Hayes, R.B., 2016. Contributions of various radiological sources to background in a suburban environment. *Health physics*, *111*(5), pp. S193-S199.

Saini, R.D., 2015. Green chemistry in everyday life. *International Journal for Science, Management and Technology (IJSMT)*, *3*(3): 97-99.

Online Resources

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

Thought, Co. 10 Examples of Chemical Reactions in Daily Life. 2018.
https://www.thoughtco.com/examples-of-chemical-reactions-in-everyday-life-604049