Master Course Syllabus

For additional course information, including prerequisites, corequisites, and course fees, please refer to the Catalog: https://catalog.uvu.edu/

Semester: Spring
Year: 2025
Course Prefix: CHEM
Course and Section #: 1220-004
Course Title: Principles of Chemistry II
Credits: 4

Course Description

Continuation of Chemistry 1210. Primarily for students in the physical and biological sciences and engineering. Covers intermolecular interactions, properties of solutions, kinetics, equilibria, thermodynamics, and electrochemistry.

Course Attributes

This course has the following attributes:

☒ General Education Requirements

☐ Global/Intercultural Graduation Requirements

☐ Writing Enriched Graduation Requirements

☒ Discipline Core Requirements in Program

☐ Elective Core Requirements in Program

☐ Open Elective

Other: *Click here to enter text.*

Instructor Information

Instructor Name: Bruce Wilson, Ph.D.

Student Learning Outcomes

1. Relate the properties of solids, liquids and gases to the principles of intermolecular forces:
2. Characterization of the properties of various solutions.
3. Explain concepts of chemical kinetics and interpret chemical reactions from kinetic data.
4. Explain the concept of chemical equilibrium and the effect of Le Chatelier's Principle on equilibrium.
5. Apply chemical equilibrium concepts to acid-base equilibria.
6. Apply equilibrium concepts to solubility.
7. Apply the principles of chemical thermodynamics to processes of chemical or physical change.
8. Apply oxidation-reduction reactions in relation to electrochemistry.
9. Recognize, name, and describe the reactions of organic compounds.
10. Describe processes of nuclear reactions and their applications.
11. Apply critical thinking skills to solve problems in chemistry.

Course Materials and Texts

Textbook

Textbook

Chemistry 2e, https://openstax.org/details/books/chemistry-2e. This is a free textbook if you want the PDF only. The hardback book cost about $60. You can read the text online (with highlighting and links to online resources), download a free PDF, or get the OpenStax app on your device. If you have the PDF, you will likely want to print several appendices and important tables & figures for reference while you work homework problems. It's a pretty good text, but there are a few places where they assume you aren't as smart as you are and take unneeded shortcuts. I don't take those shortcuts; they gimp your ability to demonstrate you are intelligent.

Calculator

You will need a calculator capable of scientific calculation. Here are some recommendations. most are under $10: Victor 920, Mr. Pen Scientific, Casio fx-260SolarII, Casio fx-991EX, Casio fx-115, TI-30Xa. These are not recommended: TI-30XIIS, TI-30SX, TI-36Xpro, TI-34, Casio fx-300. Graphing calculators will not be allowed on the Final Exam.

Course Requirements

Course Assignments, Assessments, and Grading Policy

*Click here to enter text.***Course**

This is a 1000-level general chemistry course intended for students majoring in the sciences. It is assumed that you are conversant with the principles of algebra (including quadratics and logarithms) and you can remember all you learned in CHEM 1210. It is our intention to study the fundamental principles of chemistry in some detail, concentrating on your ability to work problems in chemistry, thus demonstrating that you can use the theories which underpin our understanding of the properties of matter and its reactions. This course is accompanied by a required laboratory course, which will greatly supplement your hands-on understanding of chemicals as our in-class descriptions of matter and reactions can be somewhat abstract.

Class times

We are assigned a 50 minute block each day, Monday through Thursday. During our 50-minutes together I can answer questions, I will lecture, and we will do problem solving together. If you must miss a lecture for some reason, speak with your classmates and get their notes. I don't record lectures; during the shutdown they destroyed both learning and skill in working with others, both vital for a successful career.

Office hours are listed in the information above. USE MY OFFICE HOURS! If someone is camped in there, stand at the door and ask your questions. Don't camp in there; camp in the hall if you like and work problems there. I'm happy to look over your work in my office. If you want more problems to work I have other textbooks you can photograph to work those problems at home.

Grades

	A	94%	A-	90%
B+	87%	B	84%	B- 80%

C+	75%	C	70%	C-	65%
D+	60%	D	55%	D-	50%
		E	<50%		

The grade cutoffs are hard cutoffs, and I do not move them around nor “bump” anyone up because they provide a story more pitiful that the rest.

Exams

During the semester I will assess your progress with **seven biweekly exams,** and a **final exam** at the end of the semester. All exams will be administered in our classroom on Thursdays.

Your final grade will be 70% exams, 30% final.

Exams will have between 14 and 20 multiple-choice questions. The lowest exam is dropped from your score. Since a C grade is 70%, I want all exams to have a 70% average, +/- 5%. When a class underscores significantly, I'll grade the exam out of fewer questions than I ask on the exam. It's not really curving the exam. For example, on a 20-question exam, if the class averages 11 correct (55%) I'll grade out of 14 (70%). This means that top students will score above 100%. They can thank those who don't study.

NOTE: If you miss an exam for *any* reason other than university-excused absences, you forfeit the points. The University expects you to be in class on schedule, just as Dr. Wilson is expected to be there and ready to teach.

ACS Standardized Final

The Final Exam will be the ACS Standardized Exam which covers the same material we do in this course. You must take the final to pass the course. This is a standardized final, which means your percentile score reflects where you stand out of 100 average university students taking general chemistry. Very informative. For the grade-book I add 100 to your percentile standing, and grade out of 200, compressing the class distribution to the top half.

Homework

This is a professional course, and I consider each of you a pre-professional of some sort. One of the great demarcations of a professional is that they don't have a boss telling them what to do and if they did it correctly. We train university students to find, on their own, the right and best solution, and to know it is right when they have found it. Each of you has a completely unique mind and set of experiences which have brought you here. Your variety of experience is far beyond my ability to judge what problems you need to work to discover the ideas and problem-solving skills you haven't yet mastered. Thus I do not assign homework problems for you to work. At the back of each chapter are about a hundred problems, half of which have answers in the back of the book. Your job (and it is a job) is to spend 3 hours each school-day finding problems you cannot solve, and work to solve them. It will be difficult, and frustrating, because my expectation is that you will here discover how to do things you never imagined yourself capable of doing.

When you sit down to an exam, you need to already know that you can do the problems. If you sat in class and took notes *but nothing more*, it is likely you can complete 25% of the problems you will see on the exam. A failing grade, because you haven't learned to *do* anything new. Chemistry is a very engaged discipline which will change the way you think; this change happens as you work problems. You will need to work a broad selection of problems. *Pay attention to how you do on each type of problem*; some will seem easy, others will seem difficult, or puzzling. A variety of difficult problems must be seen repeatedly, until you master the thinking and information involved. Work problems above and below the difficult problem until you gain enough exposure to master the topic. Monitor your own progress in solving problems. Repeat the ones that were difficult. You also have the privilege to skip any problem that now seems trivial or easily solved.

Required or Recommended Reading Assignments

Chemistry, 2e, OpenStax, chapters 10-18, 21.

General Description of the Subject Matter of Each Lecture or Discussion

Cover at least two topics each lecture.

1. Relate the properties of solids, liquids and gases to the principles of intermolecular forces:

A. Employ the kinetic molecular model to explain the differences between the gas, liquid, & solid phases.

B. Explain the origins and relative strengths of covalent bonding, ionic bonding, metallic bonding, dipole-dipole forces, hydrogen bonding and London dispersion forces in pure substances and mixtures and use these to explain the trends in phase change and other properties of solids, liquids and gases.

C. Draw a phase diagram of a substance given proper data and use a phase diagram to predict the phases present at a given temperature and pressure.

D. Given heating/cooling curves, calculate the heat associated when a given substance changes from one condition to another.

E. Compare and contrast crystalline and amorphous solids.

F. Categorize crystalline solids as ionic, molecular, covalent network and metallic solids.

2. Characterization of the properties of various solutions:

A. Describe the energetics by which solutes and solvents interact in forming solutions. Include terms about the nature of particles, the various forces and energy involved.

B. Solve concentration problems with molarity, mass percent, mole fraction, molality and ppm.

C. Solve problems with Henry's law.

D. Describe temperature effects on solubility.

E. Explain qualitatively-the colligative properties, vapor pressure lowering, boiling point elevation and freezing point depression, and work quantitative problems.

F. Describe the process of osmosis and some applications and solve quantitative problems.

G. Describe how the colligative properties of solutions of electrolytes differ from those of solutions of non-electrolytes. Explain the role of the activity of a species in solution.

H. Use colligative properties to determine molar mass and predict atomic scale solution behavior.

I. Describe the characteristics of colloids.

3. Explain concepts of chemical kinetics & interpret chemical reactions from kinetic data:

A. Discuss the effect of concentration, temperature, catalysis and physical state upon rate of reaction.

B. Distinguish between average rate and instantaneous rate.

C. Determine the rate law and overall order of a reaction using initial rate data, concentration v. time graphs, and concentration interval data.

D. Calculate the rate constant from rate data.

E. Describe and use quantitatively the two types of rate laws (differential and integrated).

F. Distinguish between zero, first and second order reactions using integrated rate laws.

G. Determine the relationship between half-life equations and reaction order.

H. Draw a reaction profile to explain the progress of a reaction.
I. Describe the collision model and discuss the temperature dependence of reaction rates.
J. Define and calculate activation energy.
K. Discuss reaction mechanisms and identify the rate-determining step using reaction rate data.
L. Explain the effect of a catalyst on a chemical reaction.

4. Explain the concept of chemical equilibrium and the effect of Le Chatelier's Principle on equilibrium

A. Explain how the terms reversible reaction and dynamic equilibrium are related by deriving equilibrium constants from forward and reverse rate laws.
B. Write the general equilibrium constant expression and explain its significance.
C. Explain why the concentrations of pure liquids and solids are never used in equilibrium constant expressions.
D. Show how the numerical value of the equilibrium constant changes when the stoichiometric coefficients are changed or the reaction is reversed.
E. Explain the differences between the terms *Keq*, *Kc* and *Kp* and calculate one given the other.
F. Calculate the value of a reaction quotient and use it to predict the direction of a reaction.
G. Given *Keq* and initial concentrations/pressures of reactants and/or products, calculate the final concentrations/pressures of reactants and/or products or calculate *Keq* when given initial and one final concentrations/pressures.
H. List the external factors that can affect equilibria.

- I. Explain how changes in pressure, volume or concentration affect the equilibrium position for a chemical reaction. Explain how changes in temperature change the value of *K*.
- J. Describe the effect of a catalyst on a system as it approaches equilibrium.

5. Apply chemical equilibrium concepts to acid-base equilibria.

A. Explain the similarities and differences between terms such as: *Ka* and *Kb*, pH and pOH, and *pKa* and *pKb*.
B. Apply Arrhenius and Broasted-Lowry acid/base theory to understand reactions.
C. Apply Brønsted-Lowry acid-base concepts to determine the relative strength of acids and their conjugate bases.
D. Name and list the common strong acids and strong bases.
E. Relate [H+] and [OH-], pH and pOH. Calculate the pH for solutions of strong acids and bases.
F. Identify a weak acid or base and write a chemical equation to represent its ionization. Set up an equation for determining its ionization constant expression (*Ka* and *Kb*).
G. Calculate from appropriate data, ionization constants (*Ka* or *Kb*), concentration of the non-ionized acid or base, the concentration of ions in aqueous solution, the pH ~~and the percent dissociation~~.
H. Relate acid strength to *Ka* and base strength to *Kb*.
I. Explain why certain salts give acidic, basic or neutral solutions and show how to calculate the pH of these solutions.
J. Describe the ionization of a polyprotic acid in aqueous solution.
K. Explain how bond strength and polarity affect acid-base properties.
L. Identify the Lewis acid and base in a chemical reaction.
M. Describe the effect of common ions on the ionization of weak acids or bases and calculate the concentration of species present in solutions of weak acids or bases with their common ion.
N. Explain the principles of a buffered solution.
O. Calculate the pH of a buffer solution from concentrations of the buffer components and a value of *Ka* and *Kb*, and describe how to prepare a buffer having a specific pH from weak acid/conjugate base, weak acid/strong base, and weak base/strong acid combinations.
P. Determine the changes in pH of a buffer solution that result from addition of acids or bases. Determine the buffer capacity of a buffered solution.
Q. Determine the volume of a solution of known concentration required to titrate another solution of known volume and concentration.
R. Determine the concentration of a solute in a solution by titrating it against a known amount of another substance.
S. Sketch a titration curve for and carry out calculations associated with the titration of:

1. Strong acid with a strong base
2. Weak acid with a strong base
3. Weak base with a strong acid
4. Polyprotic acid or base

T. Know what the half-neutralization pH reveals of the species involved in a titration.

6. Apply equilibrium concepts to solubility.

A. Write an equation to express the relationship between a solid solute and its constituent ions in a saturated solution.

B. Calculate the *Ksp* from molar solubility and molar solubility from *Ksp*.

C. Calculate the effect of a common ion on the molar solubility of a salt. Calculate the solubility of a salt in a buffered solution, in acid or base solution, or when complexing ions are present in solution.

D. Predict whether precipitation will occur when salt solutions are mixed and determine the concentration of ions remaining in solution after precipitation. Determine whether a selected anion could separate two or more metal ions in a precipitation titration, and calculate percent contamination of the precipitates.

E. Solve chemical equilibrium problems involving complex ions.

7. Apply the principles of chemical thermodynamics to processes of chemical or physical change.

A. Explain the similarities and differences between such terms as enthalpy, entropy and free energy.

B. Explain entropy changes in terms of changes in the number of accessible microstates.

C. Predict whether the entropy and enthalpy change in a given process is positive, negative or near zero.

D. Use standard molar entropies to calculate ΔS for a reaction.

E. Distinguish between spontaneous and non-spontaneous processes using the second law of thermodynamics.

F. Use Gibbs free energies of formation to calculate ΔG for a reaction.

G. Explain how ΔH, ΔS and ΔG are related to reaction spontaneity and allow one to predict the conditions under which a reaction will occur.

H. Describe the relationship between the standard free energy of reaction and the equilibrium constant. Calculate Keq for a chemical reaction from $\Delta H°$ and $S°$ or $\Delta G°$.

I. Calculate ΔG for a chemical reaction that occurs under non-standard conditions.

8. Apply oxidation-reduction reactions in relation to electrochemistry.

A. Describe oxidation-reduction reactions as electron loss and electron gain.

B. Balance oxidation-reduction equations using both the oxidation number method and the half-reaction method.

C. Describe the components and operation of voltaic/galvanic and electrolytic cells.

D. Using standard half-cell potential, calculate cell potentials for both voltaic and electrolytic cells and make predictions about reaction spontaneity.

E. Using a table of standard reduction potentials, predict whether a selected reaction will occur.

F. Explain the similarities and differences between terms such as anode and cathode, voltaic cell and electrolytic cell, electromotive force and voltage.

G. Understand the relationship between cell potential, free energy change and equilibrium constant and carry out appropriate calculations.

H. Use the Nernst equation to calculate the cell potential for reactions occurring under nonstandard conditions.

I. Predict products and solve stoichiometry problems involving electrolytic cells.

J. Describe practical applications for voltaic and electrolytic cells (batteries, corrosion and commercial electrolytic cells).

10. Describe processes of nuclear reactions and their applications.

A. Explain the similarities and differences between such terms as alpha, beta and gamma radiation; binding energy and mass defect; fission and fusion.

B. Review and describe the composition of the nucleus.

C. Name the five different types of radioactive decay (e.g., alpha decay) and describe the characteristics of each.

D. Write balanced equations for radioactive decay processes.

E. Calculate the rate of radioactive decay, the half-life or the number of atoms or moles in a sample of a

radioactive nuclide if two of the three terms are known.
F. Write balanced equations for nuclear transformation reactions.
G. Describe some of the practical and beneficial uses of radioisotopes.
H. Describe the processes of nuclear fission and fusion and discuss the problems with using either process as a source of energy.
I. Calculate binding energies and energies associated with nuclear reactions.
J. Describe the operation of a nuclear fission core, and of fission and fusion weapons.

Required Course Syllabus Statements

Generative AI
Use ChatGPT (and all generative AI) as a learning assistant, not as a crutch, so use it for information, not as a substitute for thinking. You are responsible to make sure that any submitted content is cited properly, including generative AI results. Because AI can't think, don't accept anything AI generates at face value without checking it critically. AI is notorious for getting chemistry facts wrong (they "hallucinate" an answer because they know words, not numbers). Potential employers will expect you to know how to use tools like ChatGPT to generate content, so it is a skill you should learn. If it helps you learn some things faster, GREAT because you can spend more time doing hard things. Just remember: If you REALLY want to be good at thinking, you need to improve your brain, not find a new tool.

Using Remote Testing Software
☒ This course does not use remote testing software.

☐ This course uses remote testing software. Remote test-takers may choose their remote testing locations. Please note, however, that the testing software used for this may conduct a brief scan of remote test-takers' immediate surroundings, may require use of a webcam while taking an exam, may require the microphone be on while taking an exam, or may require other practices to confirm academic honesty. Test-takers therefore shall have no expectation of privacy in their test-taking location during, or immediately preceding, remote testing. If a student strongly objects to using test-taking software, the student should contact the instructor at the beginning of the semester to determine whether alternative testing arrangements are feasible. Alternatives are not guaranteed.

Required University Syllabus Statements

Accommodations/Students with Disabilities
Students needing accommodations due to a permanent or temporary disability, pregnancy or pregnancy-related conditions may contact UVU Accessibility Services at accessibilityservices@uvu.edu or 801-863-8747.

Accessibility Services is located on the Orem Campus in BA 110.

Deaf/Hard of Hearing students requesting ASL interpreters or transcribers can contact Accessibility Services to set up accommodations. Deaf/Hard of Hearing services can be contacted at DHHservices@uvu.edu

DHH is located on the Orem Campus in BA 112.

Academic Integrity

At Utah Valley University, faculty and students operate in an atmosphere of mutual trust. Maintaining an atmosphere of academic integrity allows for free exchange of ideas and enables all members of the community to achieve their highest potential. Our goal is to foster an intellectual atmosphere that produces scholars of integrity and imaginative thought. In all academic work, the ideas and contributions of others must be appropriately acknowledged and UVU students are expected to produce their own original academic work.

Faculty and students share the responsibility of ensuring the honesty and fairness of the intellectual environment at UVU. Students have a responsibility to promote academic integrity at the university by not participating in or facilitating others' participation in any act of academic dishonesty. As members of the academic community, students must become familiar with their rights and responsibilities. In each course, they are responsible for knowing the requirements and restrictions regarding research and writing, assessments, collaborative work, the use of study aids, the appropriateness of assistance, and other issues. Likewise, instructors are responsible to clearly state expectations and model best practices.

Further information on what constitutes academic dishonesty is detailed in UVU Policy 541: *Student Code of Conduct*.

Equity and Title IX

Utah Valley University does not discriminate on the basis of race, color, religion, national origin, sex, sexual orientation, gender identity, gender expression, age (40 and over), disability, veteran status, pregnancy, childbirth, or pregnancy-related conditions, citizenship, genetic information, or other basis protected by applicable law, including Title IX and 34 C.F.R. Part 106, in employment, treatment, admission, access to educational programs and activities, or other University benefits or services. Inquiries about nondiscrimination at UVU may be directed to the U.S. Department of Education's Office for Civil Rights or UVU's Title IX Coordinator at 801-863-7999 – TitleIX@uvu.edu – 800 W University Pkwy, Orem, 84058, Suite BA 203.

Religious Accommodation

UVU values and acknowledges the array of worldviews, faiths, and religions represented in our student body, and as such provides supportive accommodations for students. Religious belief or conscience broadly includes religious, non-religious, theistic, or non-theistic moral or ethical beliefs as well as participation in religious holidays, observances, or activities. Accommodations may include scheduling or due-date modifications or make-up assignments for missed class work.
To seek a religious accommodation, a student must provide written notice to the instructor and the Director of Accessibility Services at accessibilityservices@uvu.edu. If the accommodation relates to a scheduling conflict, the notice should include the date, time, and brief description of the difficulty posed by the conflict. Such requests should be made as soon as the student is aware of the prospective scheduling conflict.

While religious expression is welcome throughout campus, UVU also has a specially dedicated space for meditation, prayer, reflection, or other forms of religious expression.