# Virginia Western Community College
# CHM 112
# General Chemistry II

## Prerequisites

Successful completion of CHM 111 with a grade of "C" or higher

## Course Description

Explores the fundamental laws, theories, and mathematical concepts of chemistry. Designed primarily for science and engineering majors. Requires a strong background in mathematics. Students must earn a grade of C or higher in the lecture portion of the course to earn an overall grade of C or higher. Part II of II.

**Semester Credits: 4** **Lecture Hours: 3** **Laboratory Hours: 3**

## Required Materials

**Textbook:**
General Chemistry: Atoms First. Young, Vining, Day, and Botch. 1st Edition. Cengage Unlimited. ISBN: 9780357700006

Chemical Principles in the Laboratory – Customized. Slowinski, Wolsey, Masterton. 11th edition. Cengage. ISBN: 9781337051057

Safety Goggles

## Course Objectives

Upon completing the course, the student will be able to:

Liquids and Intermolecular Forces

- Explain and apply the principles of Intermolecular Forces. Describe and predict the properties of liquids. Perform phase change calculations. Draw and interpret phase diagrams and perform vapor pressure calculations. Identify the types of solids.

Solutions

- Explain and predict the properties of solutions, including: solubility of gases in liquids, solubility of liquids in liquids and solids in liquids. Perform calculations using different units of concentration. Explain colligative properties and apply the equations for colligative properties.

Kinetics

- Apply concepts in Kinetics: explain and do calculations using the rate law, the integrated rate laws and the Arrhenius equation. Understand reaction orders, collision theory, reaction mechanisms and catalysis.

Chemical Equilibrium

- Recognize dynamic Chemical Equilibrium: Apply the law of mass action to homogeneous and heterogeneous equilibria. Perform equilibria calculations. Apply Le Chatelier's Principle.

Acids/bases and solubility

- Recognize and predict properties of aqueous solutions. Write reactions for acid/base hydrolysis reactions. Identify Bronsted and Lewis acids and bases. Identify strong and weak acids, strong and weak bases and salts. Perform calculations (especially pH calculations) for: strong and weak acids, strong and weak bases, salts and buffers.
- Perform titration calculations for the addition of strong acids or bases to both strong and weak acids or bases.
- Perform solubility calculations for slightly soluble ionic compounds and predict precipitation reactions.

Thermodynamics

- Apply the laws of thermodynamics. Explain entropy and spontaneity. Perform entropy calculations. Employ the idea of maximum work and be able to perform Gibbs free energy calculations both at standard state and nonstandard state.

Electrochemistry

- Explain and employ the concepts in Redox and Electrochemistry. Explain and write balanced Redox reactions. Describe and label electrochemical cells. Be able to calculate the EMF for an electrochemical cell both at standard state and nonstandard state. Be able to use standard reduction potentials to predict the spontaneity of reactions. Be able to perform electrolysis calculations. Describe batteries and corrosion.

Laboratory Skills

- Perform a minimum of 8 “wet” supervised hands-on labs per semester.
- Work in the lab safely. Wear Splash resistant goggles, proper clothing and closed toed shoes.
- Properly handle and dispose of chemicals.
- Read and analyze an SDS.
- Properly collect hazardous waste.
- Recognize basic laboratory equipment.
- Make measurements using the correct number of significant figures.
- Utilize notebook skills (especially data acquisition, data handling and data analysis).
- Required student deliverable: Students will perform a minimum of 2 wet labs using a lab notebook. The notebook needs to include an introduction, procedure, data table and conclusion.
- Utilize spreadsheets to graph (plot) and analyze data and do basic error analysis. Required student deliverable: Students will write 1 formal lab report using proper scientific analytical writing. The formal lab report must include good data analysis.
- Use volumetric glassware, including a buret.
- Perform accurate titrations.
- Use basic lab equipment including: balance, hot plate and thermometer.
- Use of spectrometer or colorimeter.
- Connect topics discussed in lecture and lab observations.

**Major Topics to be Included**

Liquids and Intermolecular Forces
Solutions
Kinetics
Chemical Equilibrium
Acids/bases and solubility
Thermodynamics
Electrochemistry
Laboratory Skills

## Topical Description

Liquids, Solids, and Intermolecular Forces

- Water, No Gravity
- Solids, Liquids, and Gases: A Molecular Comparison
- Intermolecular Forces: The Forces That Hold Condensed States Together
- Intermolecular forces in Action: Surface Tension, Viscosity, and Capillary Action
- Vaporization and Vapor Pressure
- Sublimation and Fusion
- Heating Curve for Water
- Phase Diagrams
- Water; An Extraordinary Substance
- Crystalline Solids: Until Cells and Basic Structures
- Crystalline Solids: The Fundamental Types
- Crystalline Solids: Band Theory

Solutions

- Thirsty Solutions: Why You Should Not Drink Seawater
- Types of Solutions and Solubility
- Energetics of Solution Formation
- Solution Equilibrium and Factors Affect Solubility
- Expressing Solution Concentration
- Colligative Properties: Vapor Pressure Lowering, Freezing Point Depression, Boiling Point Elevation, and Osmotic Pressure
- Colligative Properties of Strong Electrolyte Solutions

Chemical Kinetics

- Catching Lizards
- The Rate of a ChemicalReaction
- The Rate Law: The Effect of Concentration on Reaction Rate
- The Integrated Rate Law: The Dependence of Concentration on Time
- The Effect of Temperature on ReactionRate
- Reaction Mechanisms
- Catalysis

Chemical Equilibrium

- Fetal Hemoglobin and Equilibrium
- The Concept of Dynamic Equilibrium
- The Equilibrium Constant (K)
- Expressing the Equilibrium Constant in Terms of Pressure
- Heterogeneous Equilibria: Reaction Involving Solids and Liquids
- Calculating the Equilibrium Constant from Measured Equilibrium Concentrations
- The Reaction Quotient: Predicted the Direction of Change
- Finding Equilibrium Concentrations
- Le Châtelier's Principle: How a System at Equilibrium Responds to Disturbances

Acids and Bases

- Heartburn
- The Nature of Acids and Bases
- Definitions of Acids and Bases
- Acid Strength and the Acid Ionization Constant ($K_a$)
- Autoionization of Water and pH
- Finding the $[H_3O^+]$ and pH of Strong and Weak Acid Solutions
- Base Solutions
- The Acid-Base Properties of Ions and Salts
- Acid Strength and Molecular Structure
- Lewis Acids and Bases

Aqueous Ionic Equilibrium

- The Danger of Antifreeze
- Buffers: Solutions That Resist pH Change
- Buffer Effectiveness: Buffer Range and Buffer Capacity
- Titrations and pH Curves
- Solubility Equilibria and the Solubility Product Constant
- Precipitation
- Complex Ion Equilibria

Free Energy and Thermodynamics

- Nature's Heat Tax: You Can't Win and You Can't BreakEven
- Spontaneous and Nonspontaneous Processes
- Entropy and the Second Law of Thermodynamics
- Heat Transfer and Changes in the Entropy of the Surroundings
- Gibbs Free Energy
- Entropy Changes in Chemical Reactions: Calculating $\Delta S^o_{rxn}$
- Free Energy Changes in Chemical Reactions: Calculating $\Delta G^o_{rxn}$

Electrochemistry

- Pulling the Plug on the Power Grid
- Balancing Oxidation-Reduction Equations
- Voltaic (or Galvanic) Cells: Generating Electricity from Spontaneous Chemical Reactions
- Standard Electrode Potentials
- Cell Potential, Free Energy, and the Equilibrium Constant
- Cell Potential and Concentration
- Batteries: Using Chemistry to Generate Electricity
- Electrolysis: Driving Nonspontaneous Chemical Reactions with Electricity
- Corrosion: Undesirable Redox Reactions

Radioactivity and Nuclear Chemistry

- Diagnosing Appendicitis
- Types of Radioactivity
- The Valley of Stability: Predicting the Type of Radioactivity
- The Kinetics of Radioactive Decay and Radiometric Dating
- The Discovery of Fission: The Atomic Bomb and NuclearPower

- Converting Mass to Energy: Mass Defect and Nuclear BindingEnergy
- Nuclear Fusion: The Power of the Sun
- The Effects of Radiation of Life
- Radioactivity in Medicine

Laboratory Topics

| Experiment Number | Experiment Title | Page |
|---|---|---|
| 1 | Determination of Iron by Reaction with Permanganate – A Redox Titration Spot Tests for Some Common Anions (exp. 30 in etext) | 245 |
| 2 | Spot Tests for Some Common Anions (35 in etext) | 281 |
| 3 | Crystal Structures and Unit Cells (online) | |
| 4 | Qualitative Analysis of Group III Cations (38 in etext) | 305 |
| 5 | Preparation of Aspirin (41 in etext) | 329 |
| 6 | Chemical Kinetics (handout) | |
| 7 | Determination of Solubility Product Constant (Two week lab) (handout) | |
| 7 | Determination of Solubility Product Constant (cont'd.) (handout) | |
| 8 | The Standardization of Basic Solution and the Determination of the Molar Mass of an Acid (24 in etext) | 195 |
| 9 | Properties of Systems in Equilibrium – LeChatelier's Principle (22 in etext) | 173 |
| 10 | pH, Buffers and Their Properties (25 in etext) | 203 |
| 11 | The Alkaline Earth and the Halogens – Two Families in the Periodic Chart (12 in etext) | 81 |
| 12 | Electrolysis (handout) | |
| 13 | Polymers (handout) | |
| 14 | Nuclear (online) | |

## ADA Statement

https://www.virginiawestern.edu/wp-content/uploads/2024/12/Syllabus-Statement_ADA.pdf

## Title IX Statement

https://www.virginiawestern.edu/wp-content/uploads/2024/12/Syllabus-Statement_Title-IX-2025.pdf

## Notes to Instructors

1. Please note that a three-hour time slot is allotted to the laboratory and the student should be aware that this time will be fully utilized. The laboratory time is used not only for experimentation, but may also be used for demonstrations, movies, and problem solving. Whenever time permits, homework problems will be worked out in the beginning of the laboratory and the student is expected to participate.

2. Attendance in the laboratory is mandatory at the scheduled time. In case of an unavoidable situation, the student should contact the instructor beforehand to be excused and to see if any arrangements can be made to make up the laboratory. It may or may not be possible. Approved safety goggles must be worn in the laboratory ***over the eyes*** as required by state law.

3. Laboratory reports are due at the beginning of the next lab period. The report consists of the data report sheets included in the lab manual or handout. To aid not only the instructor but also especially the students, reports will not be accepted two weeks after the lab was assigned. Completion of the lab experiment followed by turning in the data and calculations on the due date with appropriate write-up insures a good grade. Grading scales for laboratory reports are at the professor's discretion but will count towards the overall grade for the course.

**1.** There will be 1000 total points available that will come from 4 in class exams, 1 cumulative final exam, homework, and lab:
700 points exams, 200 points lab, and 100 points homework. Since exams and homework are part of the lecture, the requirement of a C or better in the course is as follows:
For an A, 900 points are required, with a minimum of 560 points coming from the lecture portion.
For a B, 800 – 899 points are required, with a minimum of 560 points coming from the lecture portion.
For a C, 700 – 799 points are required, with a minimum of 560 points coming from the lecture portion.
The 560 is 70% of the 800 points coming from exams and homework.

4. The following lab skill expectations have been established for successful transfer to 4-year colleges in Virginia:
   a. Perform a minimum of 8 "wet" supervised hands-on labs per semester.
   b. Work in the lab safely. Wear Splash resistant goggles, proper clothing and closed toed shoes.
   c. Properly handle and dispose of chemicals.
   d. Read and analyze an SDS.
   e. Properly collect hazardous waste.
   f. Recognize basic laboratory equipment.
   g. Make measurements using the correct number of significant figures.
   h. Utilize notebook skills (especially data acquisition, data handling and data analysis).
   i. Required student deliverable: Students will perform a minimum of 2 wet labs using a lab notebook. The notebook needs to include an introduction, procedure, data table and conclusion.
   j. Utilize spreadsheets to graph (plot) and analyze data and do basic error analysis.
      a. Required student deliverable: Students will write 1 formal lab report using proper scientific analytical writing. The formal lab report must include good data analysis.
   k. Use volumetric glassware, including a buret.
   l. Perform accurate titrations.
   m. Use basic lab equipment including: balance, hot plate and thermometer.
   n. Use of spectrometer or colorimeter.
   o. Use of pH meter.
   p. Use data from other lab groups as part of your data analysis (Google Sheets).

q. Connect topics discussed in lecture and lab observations.