Class Web Site: http://www.uwosh.edu/facstaff/gutow/physical-chemistry-1 contains some publicly available class content (syllabus) and useful links. Most class content will be in CANVAS: https://uws.instructure.com/courses/346485.

Course Overview: Physical chemists and physicists make extensive use of mathematical models to describe natural phenomena. The underlying assumption is that the universe has an organization that can be expressed as a function of certain parameters. This semester we will concentrate on developing the models that describe the bulk thermodynamic and equilibrium properties of matter. We will make the connection between the microscopic (molecular level) properties of substances and these bulk properties using results from quantum mechanics.

You should be able to use these models to predict the behavior of matter. This means both estimating the range in which a measurement will fall and solving mathematical story problems, using approximations where valid. A summary list of the models and the types of systems to which you should be able to apply them is at the end of this syllabus.

Laboratory experiments will illustrate concepts being discussed in lecture and familiarize you with many of the tools used by physical chemists. The tools you will learn to apply include the chemical literature; written and oral communication; mathematical functions; error analysis; and mechanical and electronic equipment such as vacuum pumps and computers.

Required texts: Cooksy, *Physical Chemistry: Thermodynamics, Statistical Mechanics, & Kinetics.*

Chemistry 370 Lab Manual available at the University Bookstore.

Required Equipment: bound duplicating laboratory notebook, pen (for writing in lab notebook), scientific calculator and goggles.

Prerequisites: three semesters of calculus (Calc III may be concurrent), two semesters of calculus based physics (second semester may be concurrent).

Class times: Lectures: MWF 9:10 – 10:10 (HS 266); Lab (HS 428): M 1:50 – 5:10.

Instructor:

Name (Office)	E-mail	Class Sections	Online Office Hours (link)
Dr. Gutow (HS 412)	gutow@uwosh.edu	Lecture & Lab	MF 11 – 12, T 9:35 – 10:15, W 10:20 – 11:20, Th 8 – 9, *or by appointment*.

Assessment of learning: Homework, in-class exercises and exams will be used to assess your chemical knowledge and document your ability to:

- describe the structure and composition of matter;
- apply theoretical and mechanistic principles to the study of chemical systems employing both qualitative and quantitative approaches;
- use theories of microscopic properties to explain macroscopic behavior;
- explain the role of energy in determining the structure and reactivity of molecules;
- use mathematical representations of physical phenomena.

Reading Assignments and Homework will cover a week or two and _will have parts due before the beginning of each class meeting_. Assignments will not be accepted late, but some of your lowest scores will be dropped.

You are encouraged to discuss the homework with your classmates and instructor. The important thing is to understand the problems and exercises. Doing all the homework is the best way to understand the material and prepare for exams.

> **Reading Assignments** will come primarily from the textbook. Other sources will be used as necessary.

> **Homework** will be _due before each class_ and consist of up to three sections. The first two sections will focus on material we will be discussing during the class meeting for which the assignment is completed.

>> **Critical Thinking Exercises/Discussion Questions:** These are designed to help you learn how to use the textbook and other reference sources to prepare for class, as well as help you figure out what you need to ask about during class. These exercises might ask you to find definitions, compare two models and explain when it is appropriate to use each or work through some 'what if' calculations.

>> **Practice Exercises:** These will come primarily from the exercises section at the end of the chapter. The goal is to help you figure out what you need to ask about during class.

>> **Problems:** These problems will be a little more challenging and based on material discussed in previous class meetings.

In Class Exercises will typically be worksheets/group exercises. You will receive 100% credit for putting in honest effort on the exercise during class.

Exams: There will be 220 available points on each exam. However, exams will be scored out of 200 points (20 pts of extra credit distributed throughout the exam). The material requires that exams be cumulative, but primary emphasis will be on the chapters covered since the previous exam. The goal of this course is not to memorize formulas, but to learn how to use models to make predictions. You will be provided with an equation sheet for each exam consisting of the fundamental equations of each model. Additionally, you will be allowed to bring a 3" x 5" card of handwritten notes to the exam.

Grading:

Homework & in class worksheets:		25%
Exams:	3 x 200 pts	50%
Lab:		<u>25%</u>
Total:		100%

Grade Cutoffs: A/A- > 87%, B+/B/B- > 77%, C+/C/C- > 67%, D+/D > 60%, F $\leq$ 60%. The cutoffs will not be adjusted upwards, but the instructor reserves the right to lower them.

Approximate Lecture Schedule(F20):

Topic (text chapter)	Lectures
I. Statistical Mechanics of Gases	
Intro/Historical Background (1)	9/9
Intro to quantum and statistical mechanics (2)	9/11, 9/14, 9/16, 9/18
Partitioning energy (3)	9/21, 9/23, 9/25, 9/28
Molecular Interactions (4)	9/30, 10/2, 10/5
Review	10/7
Exam 1 (Unit I)	**October 8 or 9, 2020 (Th or F)**
II. Thermodynamics & Statistical Mechanics	
Heat Capacities (7)	10/12, 10/14, 10/16, 10/19
First Law (8)	10/21, 10/23, 10/26, 10/28
Second Law, Third Law and Mixing (9)	10/30, 11/2, 11/4, 11/6
Review	11/9
Exam 2 (Unit II)	**November 10 or 11, 2020 (T or W)**
III. Thermodynamics of Equilibria, Mixtures and Reactions	
Phase Transitions (10)	11/13, 11/16, 11/18, 11/20
Solutions (11)	11/23, 11/30, 12/2, 12/4
Reactions (12)	12/7, 12/9, 12/11, 12/14
Review	12/16
Exam 3 (Unit III)	**December 17 or 18, 2020 (Th or F)**

Laboratory: This laboratory emphasizes the use of tools to study properties of chemicals. We will begin the semester by collecting a number of different kinds of experimental data and put off the analysis of that data until later in the semester. *This organization requires you to keep very good lab notes, as it will be a minimum of 3 weeks from when you collect the data to when you analyze it*. This better reflects the timeframe encountered in a research environment.

The laboratory will be used to assess your chemical knowledge and document your ability to:
- read and follow experimental protocols;
- properly set up and safely manipulate laboratory equipment;
- plan and execute experiments, including the use of the chemical literature;
- maintain accurate records of experimental work;
- analyze data statistically and assess reliability of results;
- prepare effective written scientific reports;
- use mathematical representations of physical phenomena;
- use and understand modern instrumentation;
- use computers for chemical applications;
- retrieve specific information from the chemical literature;
- work cooperatively in problem solving situations.

We will do experiments to illustrate principles studied in lecture related to thermodynamics and the properties of mixtures.

The laboratory schedule and grading specifications are included in the lab manual. In addition to in lab performance you will be evaluated on (see the lab manual for details):

- *Laboratory Notebooks*: These will include pre-lab, during the experiment and analysis notes.
- *Lab Reports*: You will be preparing formal reports (or parts of some), posters, a news article, and an oral report. You will have a chance to rewrite some of these to improve your grade.
- *Peer Reviews*: You will get credit for reviewing some of your peers' work in a timely manner so that your input can be used by your peers to rewrite their work.
- *SciFinder Searches*: You will do a number of literature searches to find articles related to the experiments you do.
- *Final Lab Quiz*: This will focus on your understanding of concepts from lab, and some simple data analysis including error propagation.

Additional Resources:

WEB RESOURCE: Class content will be in CANVAS: https://uws.instructure.com/courses/346485. Additionally, a copy of this syllabus and some of the useful links will be available on a public webpage at: https://www.uwosh.edu/facstaff/gutow/physical-chemistry-1. Dr. Gutow also maintains useful information such as study hints and useful links for chemists on his website at: https://uwosh.edu/facstaff/gutow.

COMPUTER AIDES TO HELP WITH P-CHEM PROBLEM SOLVING: In this class you are encouraged to use computer assistance for algebra, calculus and numerical computations. There are lots of options (e.g. Maple™, MathCAD™, Mathematica™, SageMath, and others), but the *Python* programming language plus a web interface called *Jupyter* has recently been widely adopted for scientific computing and mathematics, so we will learn to use that.

The software is available on a server at: https://math.gutow.uwosh.edu. You will be provided with server log-in information during the first meeting of class. This software is open-source and could also be installed on your own computer. Dr. Gutow will provide instructions for installation, if requested.

General Information

OFFICIAL BULLETIN COURSE DESCRIPTION: Physical Chemistry I: Fundamental principles of physical chemistry. Lecture topics include ideal and real gases, kinetic theory, thermodynamics, equilibria, properties of solutions, surface and colloid chemistry. Laboratory includes experiments that are designed to illustrate the lecture material. Prerequisites: Mathematics 273 (may be taken concurrently), Chemistry 235, and Physics 110 and declared chemistry major or consent of instructor. Special fees may apply. 370/570 (3+3)

ACADEMIC MISCONDUCT: Representing the work of another as your own is considered academic misconduct. Any assignment (exams) which you are required to do individually should contain only your own work. Using ideas and writing from the work of others without proper attribution is considered plagiarism and could result in expulsion. See the Dean of Students office website for more information.

ABSENCES: You are responsible for informing your instructor of absences and making arrangements to make up any missed work. If an emergency (medical or exceptional personal circumstances) will cause you to miss more than three (3) days of class or prevents you from contacting individual

instructors you should request an out-of-class letter from the Dean of Students office, which will go to all your instructors and provide you with one initial contact point.

ACCOMMODATIONS: The University of Wisconsin Oshkosh supports the right of all enrolled students to a full and equal educational opportunity. It is the University's policy to provide reasonable accommodations to students who have documented disabilities that may affect their ability to participate in course activities or to meet course requirements.

Students are expected to inform Instructors of the need for accommodations as soon as possible by presenting an Accommodation Plan from either the Accessibility Center, Project Success, or both. Reasonable accommodations for students with disabilities is a shared Instructor and student responsibility.

The Accessibility Center is part of the Dean of Students Office and is located in 125 Dempsey Hall. For more information, email accessibilitycenter@uwosh.edu, call 920-424-3100, or visit the Accessibility Center Website.

RESPECTING THE DIVERSITY OF OUR COMMUNITY: Diversity drives innovation, creativity, and progress. At the University of Wisconsin Oshkosh, the culture, identities, life experiences, unique abilities, and talents of every individual contribute to the foundation of our success. Creating and maintaining an inclusive and equitable environment is of paramount importance to us. This pursuit prepares all of us to be global citizens who will contribute to the betterment of the world. We are committed to a university culture that provides everyone with the opportunity to thrive. Therefore, all members of our community are expected to treat each other with respect and apply intellectually rigorous critical analysis to all their interactions with others (e.g. activities, discussions, arguments, etc...).

STUDENTS RIGHT TO KNOW ACT OF 1990: Students are advised to see the following URL for disclosures about essential consumer protection items required by the Students Right to Know Act of 1990: https://uwosh.edu/financialaid/consumer-information/.

Why this is a Liberal Arts Course: As part of a good liberal arts curriculum this course has a number of goals. The primary goal, as described in the course overview, is to introduce you to quantitative chemical models. This topic fits well into the liberal arts curriculum because it teaches skills which are generally useful and specific models that are widely applicable. Learning to use these models is extremely good practice at solving difficult and unfamiliar problems as well as thinking analytically, critically and creatively. The models discussed in this class are fundamental to understanding much of what happens to matter in the universe. In lecture and lab you will practice using these widely applicable models and consider their limitations (more critical thinking). In many cases simpler models or direct experimentation can provide high accuracy results with significantly less effort. A secondary, but very important goal of the course, is to help you develop effective communication skills. You will work on communication skills primarily in lab where you will produce reports on your work.

Models you will learn to apply:

Models	Be able to apply to
Gas Laws -Ideal -van der Waals -Virial Expansion	Pure Gases Gas Mixtures To simplify thermodynamic models
Kinetic Molecular Theory	Gases (molecular speeds and energies)
Quantum Mechanics	Particle-on-a-line, Particle-in-a-box Allowed energies (Translation, Rotation, Vibration, Electronic) Boltzmann Distribution (most random distribution)
Classical Thermodynamics -fugacity/activity -Maxwell Relations -Colligative Properties	Reaction enthalpies, entropies and free energies ($\Delta H, \Delta S, \Delta G$) Constant pressure (isobaric) phenomena Constant temperature (isothermal) phenomena Heat engines (adiabatic versus isothermal processes) Equilibria (Phase, Electrochemical, Chemical) Physical changes (phase) Mixtures (Fp, Bp, vapor pressure and Osmotic pressure changes)
Statistical Thermodynamics	Heat capacities (C_p versus C_v) Entropy of matter Equilibria Chemical reactions Physical changes Classical thermodynamics