

# Physical Chemistry II: Chemistry 384

Spring 2020

## Instructor:

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**Lecture:** MWF 9:00 – 9:50 a.m.; Jepson Science Center 217B

## Office Hours:

MWF 10:00 – 11:00 am  
MW 1:00 – 2:00 pm  
or by appointment

## Required Course Materials:

**Text:** Engel and Reid, *Thermodynamics, Statistical Thermodynamics & Kinetics*, 3<sup>rd</sup> edition

Engel, *Quantum Chemistry and Spectroscopy*, 3<sup>rd</sup> edition

**CHEM 384 Course Pack**

**Calculator:** with scientific notation and logarithmic/exponential functions; you will use the department's Casio FX260 solar or TI-30X IIS for ALL examinations or an equivalent approved by the instructor. Cellular phones are not permitted on exam days.

## Recommended Course Materials:

**Mathematics Review:** Mortimer, *Mathematics for Physical Chemistry*, 3<sup>rd</sup> Edition

**Course Description and Objectives:** This course is designed to provide the fundamental concepts of physical chemistry. Two main areas will be stressed: Chemical Kinetics (rate expressions and reaction mechanisms) and Quantum Mechanics. This course expands upon the elementary notions of atomic structure, bonding, reaction rates, and spectroscopy introduced in earlier coursework. Physical chemistry uses extensive mathematical tools to probe the intricate interactions involved in chemical systems. Thus, in order to succeed, problem-solving skills must be practiced and developed. Physical chemists are employed in such disparate fields as financial consultants, corporation executives, professors, etc. due to their well-developed problem solving skills. After completing this course, a student should be able to

- describe chemical kinetics for zeroth, first and second order reactions and compare to reaction mechanisms
- evaluate Schrodinger's equation for chemically significant problems

- use quantum mechanical principles to describe chemically important motions and systems, including translation, vibration, rotation and atoms and molecules

**Grading:**

3 Hourly Exams at 200 points each	600 points
Graded Team Activities	50
Online PreP's	50
Graded Problems	50
Cumulative Final Exam at 250 points	250

Students with an exam average of C- or less will receive a midsemester report.

Grades will be determined on the following point scale

<b>Points accumulated</b>	<b>Letter Grade</b>	<b>Points accumulated</b>	<b>Letter Grade</b>
≥ 930 points	A	769 – 730 points	C
929 – 900 points	A-	729 – 700 points	C-
899 – 870 points	B+	699 – 650 points	D+
869 – 830 points	B	649 – 600 points	D
829 – 800 points	B-	below 600 points	F
799 – 770 points	C+		

**Honor System:** All graded work (hourly exams, online exercises, extra credit assignments, *graded* assignments, final exam) must be **your own** and pledged as such:  
*I hereby declare upon my word of honor that I have neither given nor received any unauthorized help on this work.*

*Signed*

Online PreP's (general chemistry and mathematics reviews) are deemed pledged by your submission. It is recommended that the *suggested* problems (i.e. not submitted for a grade) be done individually and then as a group when questions arise. **No late assignments will be accepted.** Please, discuss difficulties with the homework problems or lecture material with me.

**Class Attendance:** Class attendance is highly recommended. The material discussed in lecture frequently has a different emphasis than that provided by the textbook. Also, time has been set aside in the course schedule to discuss example problems. Students are responsible for all covered materials during a missed class. Missed exams cannot be made up. Exams will be rescheduled in the event of an excused absence due to an emergency. (Immediate notification of the instructor is mandatory). Lateness to lecture is distracting, and students should attempt to be on time. Lateness to an exam will result in less time allowed for completion of the exam.

**Team Activities:** Team activities in this course will take two different formats: First, at the end of each chapter (or topic), there will be between 5 and 10 assigned problems to be completed by students in teams of 3 or 4. Teams will be chosen at the beginning of the semester for the entire term. Individual students are strongly encouraged to attempt the

problems alone and then meet with the team to discuss a final solution. (This also enables you to check each other's work.) These problems are due to the instructor for a grade 2 lectures after the lecture material on that topic has been completed (e.g. if chapter 1 is completed on Monday, then the problems are due on Friday of the same week). No late assignments will be accepted. Only one submission is required per team; however, all members of the team must sign the submission in order to receive a grade. (A student who does not sign the handed-in work will receive a grade of zero.) You must also individually complete an evaluation of teamwork for you and your teammates. Failure to do so (or complete the assignment as a team) will result in a grade reduction of up to 3 points per assignment.

Second, specific topics in lecture will be flipped: outside of the classroom, students will watch a video, read the textbook material, and complete recommended practice problems (posted on Canvas). If a student needs more information on a given topic, they can either re-view the lecture or view other online lectures and/or re-read the material in the textbook. Students will be encouraged to practice the concepts with problems but will not be completing graded individual homework; however, students must bring their practiced problems with them to class. During class, students' knowledge will be assessed with in-class team activities. These exercises are designed to prompt critical thinking (and potentially discussion) about the key concepts learned outside of the classroom in the lectures and textbook. I will move around the classroom during this problem solving process and address any misconceptions or challenges students experience. The assigned class problems will be completed by the team and submitted by the end of the period. Students are still expected to complete a team evaluation assessing the contributions of their peers to this process and completion of the in class assigned work. (The evaluation form is posted on Canvas.)

**Online PreP's:** At the beginning of each chapter, approximately 5 questions (generally, multiple choice or fill-in-the-blank format) will be posted on Canvas. These questions review topics that were covered in prerequisite courses, such as Calculus I and II, Physics, and General Chemistry. The answers must be submitted through Canvas by the assigned date and time (usually, before the next lecture). You may use textbooks and notes from these courses or others to complete the quizzes; however, you may not consult with anyone other than your instructor about them. Electronic submission constitutes your abiding by the Mary Washington Honor Code.

**Graded Problems:** At the end of each chapter or section of material, approximately 5 questions (numerical answer/fill-in) will be assigned from your textbook. Answers must be submitted through Canvas by the due date and time; in addition, you must submit your written out work for full credit. Students who do not submit the written out work leading to a solution will only receive half credit. You may use your textbook and notes to complete the problems; however, you may not consult with anyone other than your instructor, including on-line personas, about them. Electronic submission constitutes your abiding by the Mary Washington Honor Code.

**Extra Credit:** What is physical chemistry good for? Why is physical chemistry fun? Students may earn extra points for summarizing a topic we have discussed in lecture and finding an interesting application of the topic on the internet and then posting about it on the course blog ([physchem.umwblogs.org](http://physchem.umwblogs.org)). A maximum of 2.5 points will be awarded per blog or 1 point for a comment with one submission per chapter.

**Disability Services:** The Office of Disability Services has been designated by the University as the primary office to guide, counsel, and assist students with disabilities. You will need to request appropriate accommodations through this office as soon as possible and then make an appointment with me to discuss your approved accommodation needs. I will hold any information you share with me in the strictest confidence unless you give me permission otherwise.

**Title IX:** University of Mary Washington faculty are committed to supporting students and upholding the University's *Policy on Sexual and Gender Based Harassment and Other Forms of Interpersonal Violence*. Under Title IX and this Policy, discrimination based upon sex or gender is prohibited. If you experience an incident of sex or gender based discrimination, we encourage you to report it. ***While you may talk to me, understand that as a "Responsible Employee" of the University, I MUST report to UMW's Title IX Coordinator what you share.*** If you wish to speak to someone confidentially, please contact the below confidential resources. They can connect you with support services and help you explore your options. You may also seek assistance from UMW's Title IX Coordinator. Please visit <http://diversity.umw.edu/title-ix/> to view UMW's *Policy on Sexual and Gender Based Harassment and Other Forms of Interpersonal Violence* and to find further information on support and resources.

**Class Recordings:** Video and/or audio recording of class lectures and review sessions without the advance consent of the instructor is prohibited. On request, the instructor may grant permission for students to record course lectures, on the condition that these recordings are only used as a study aid by the individual making the recording. Unless explicit permission is obtained from the instructor, recordings of lectures and review sessions may not be modified and must not be transferred or transmitted to any other person, whether or not that individual is enrolled in the course. Students with approved accommodations from the Office of Disability Resources permitting the recording class meetings must present the accommodation letter to the instructor in advance of any recording being done. On any days when classes will be recorded, the instructor will notify all students in advance. Distribution or sale of class recordings is prohibited without the written permission of the instructor and other students who are recorded. Distribution without permission is a violation of educational law. This policy is consistent with UMW's Policy on Recording Class and Distribution of Course Materials.

**Other "helpful" information:**

The tentative schedule that follows is how I see the course arranged. It is not concrete. If there is material that you, as a class, find confusing, we will spend more time on that topic. The exam dates will remain set according to the schedule. If all of the

“scheduled” material has not been presented prior to the exam, the exam will include only what has been covered.

Success in physical chemistry requires considerable work on your part. Successful students typically spend a minimum of 1 hour per day on chemistry. This time is devoted to reviewing notes, attempting the suggested/assigned problems and reading ahead for the next lecture. Some of their "secrets" include (but are not limited to)

- reading the material prior to class.
- attending the lectures.
- taking good notes.
- utilizing the website that is supplemental to your textbook. (There are excellent graphics and animations for nearly all of the chapters. This should facilitate your understanding of the “big picture” by providing a visualization of the complicated mathematics associated with physical chemistry.)
- asking questions. (The only “stupid” question is the one that goes unasked.)
- solving the suggested problems for each chapter. (Attempting extra problems is also a great idea. As in all aspects of life, “practice makes perfect.”)
- consulting your peers when you are struggling with the solution to a suggested problem. (First, they may have a different slant or see the problem in a different light. Second, scientists typically work in teams. Each member of the team is responsible for a particular aspect of the problem; therefore, each scientist must understand what each of the other members of the team does and have requisite background knowledge.)
- enlisting the aid of the instructor (office hours or appointments, before or after class).
- reviewing the appropriate sections of the text and all notes after class.
- attempting all suggested and assigned (team activity) problems by yourself
- reviewing topics from prerequisite courses.

## Course Outline:

Topic	Chapters and/or Sections
Chemical Kinetics	Chapter 18
Review of Classical Physics	Chapter 19 in Engel and Reid
Fundamentals of Quantum Mechanics	Chapter 1
Applications of the Schrödinger Equation:	2.1 – 2.6, 3.1 – 3.4, 6.1, 6.3
Translational Motion (Particle in the box)	Chapter 4
Applications of the Schrödinger Equation:	5.3, 5.5 - 5.8
Vibration and Rotation (Harmonic Oscillator, Rigid Rotor)	7.1 – 7.5, 7.7
Vibrational, Rotational Spectroscopy	8.1 – 8.6, 8.8
Applications of the Schrödinger Equation:	Chapter 9
Hydrogen Atom	
Assumptions in Quantum Mechanics	
Many Electron Atoms	10.1, 10.2, 11.1 – 11.4
Molecules and Bonding	12.1 – 12.4, 12.6 – 12.9, 13.1 – 13.4
Electronic Spectroscopy	11.4 – 11.6; 14.1, 14.4 – 14.9

1/13 Chapters 18/19	1/15 Chapters 18/19	1/17 Chapters 18/19
1/20 NO CLASS	1/22 Chapters 18/19	1/24 Chapters 18/19
1/27 Chapters 18/19	1/29 Chapters 18/19	1/31 Chapter 1
2/3 Chapter 1	2/5 Chapters 2/3	2/7 Chapters 2/3
2/10 Chapters 2/3	2/12 Chapters 2/3	2/14 <b>EXAM 1</b>
2/17 Chapters 4/5	2/19 Chapter 4/5	2/21 Chapter 4/5
2/24 Chapter 7	2/26 Chapter 7	2/28 Chapter 7
3/2 SPRING BREAK	3/4 SPRING BREAK	3/6 SPRING BREAK
3/9 Chapter 7	3/11 Chapter 7	3/13 <b>EXAM 2</b>
3/16 Chapter 8	3/18 Chapter 8	3/20 Chapter 8
3/23 Chapters 9	3/25 Chapters 9	3/27 Chapters 9/10
3/30 Chapters 10/11	4/1 Chapters 10/11	4/3 Chapter 10/11
4/6 Chapters 12/13	4/8 Chapters 12/13	4/10 Chapters 12/13
4/13 Chapters 12/13	4/15 Chapters 11/14	4/17 <b>EXAM 3</b>
4/20 Chapters 11/14	4/22 Chapters 11/14	4/24 Research & Creativity Day

**American Chemical Society Cumulative Final Exam:  
Monday, April 27, 2020; 8:30 – 11:00 a.m.**