CH 3300 – Introduction to Physical Chemistry
MWF 10:10 – 11:00
Hendrix 206 (David Peebles Room)

Dr. Brian N. Dominy
Office: 367 Hunter Labs
Email: dominy@clemson.edu

Syllabus for CH-3300 Introduction to Physical Chemistry

Course Overview: This class will introduce concepts of physical chemistry particularly relevant to the medicinal and life sciences. The 3 modules of this course will address Thermodynamics, Chemical Kinetics, and Quantum Mechanics. While developing the tools to solve quantitative problems in the physical sciences is an integral part of this class, an emphasis will be placed on developing a deeper conceptual understanding of the physics that forms the foundation of chemistry.

Textbook: Physical Chemistry for the Life Sciences; 2nd Edition; Atkins and de Paula; ISBN: 9781429231145

Planned modality: Blended

Course Prerequisites: MATH 1060 – Calculus of One Variable I

Quantitative Learning Objectives: At the conclusion of this course, students will be able to: 1) Calculate changes in thermodynamic properties associated with both phase transitions and chemical reactions. 2) Calculate changes in thermodynamic properties as a result of changes in the environment (e.g. temperature and pressure). 3) Mathematically derive thermodynamic equations. 4) Mathematically derive chemical reaction kinetics equations for reactions of varying complexity. 5) Calculate changes in chemical reaction rates as a result of changes in the environment. 6) Apply quantum mechanical operators to wavefunctions and determine observable properties

CT^2 Learning Objectives: 1) Qualitatively explain the quantitative relationships (equations) between thermodynamic properties. 2) Explain the assumptions underlying fundamental thermodynamic and kinetic models. 3) Deduce the appropriate kinetic model for a broad range of chemical reactions. 4) Describe these typical spontaneous processes using thermodynamic equations. 5) Evaluate different *mechanisms* proposed for quantum mechanical phenomena. 6) Refine definitions of energy, entropy, heat, and work. 7) Reflect on common misconceptions regarding how the universe works.

Late Policy: Students may leave after 15 minutes if the professor or a guest lecturer does not arrive in that time.

Attendance Policy: Attendance will not be taken, but is highly recommended. Occasional, unannounced, in-class, group exercises (In-class Challenge Problems) will contribute to your final grade. Tentative test dates are listed in this syllabus.

Academic Integrity: Official Clemson statement: "As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning.' Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form.

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Our Class Integrity Statement: Academic dishonesty can be a very harmful habit both inside and particularly outside of the university setting. It will benefit everyone, most importantly yourselves, to avoid this destructive habit. As a result, academic dishonesty, including but not limited to cheating and plagiarism, will not be tolerated in this class.

Accessibility Statement: Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to a class should let the professor know, and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848or by emailing studentaccess@lists.clemson.edu. Students who receive Academic Access Letters are strongly encouraged to request, obtain and present these to their professors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. You can access further information here: http://www.clemson.edu/campus-life/campus-services/sds/.

Title IX Statement: Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. The University is committed to combatting sexual harassment and sexual violence. As a result, you should know that University faculty and staff members who work directly with students are required to report any instances of sexual harassment and sexual violence, to the University's Title IX Coordinator. What this means is that as your professor, I am required to report any incidents of sexual harassment, sexual violence or misconduct, stalking, domestic and/or relationship violence that are directly reported to me, or of which I am somehow made aware. There are two important exceptions to this requirement about which you should be aware: Confidential Resources and facilitators of sexual awareness programs such as "Take Back the Night and Aspire to be Well" when acting in those capacities, are not required to report incidents of sexual discrimination. Another important exception to the reporting requirement exists for academic work. Disclosures about sexual harassment, sexual violence, stalking, domestic and/or relationship violence that are shared as part of an academic project, a research project, classroom discussion, or course assignment, are not required to be disclosed to the University's Title IX Coordinator. This policy is located at http://www.clemson.edu/campus-life/campus-services/access/title-ix/. Ms. Alesia Smith is the Executive Director for Equity Compliance and the Title IX Coordinator. Her office is located at 223 Holtzendorff Hall, phone number is 864.656.3181, and email address is alesias@clemson.edu.

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Specific COVID-19 related information for in-person classes: While on campus, face coverings are required in all buildings and classrooms. Face coverings are also required in outdoor spaces where physical distance cannot be guaranteed. Please be familiar with the additional information on the Healthy Clemson website, such as the use of wipes for in-person classes. If an instructor does not have a face covering or refuses to wear an approved face covering without valid accommodation, students should notify the department chair. If a student does not have a face covering or refuses to wear an approved face covering without valid accommodation, the instructor will ask the student to leave the academic space and may report the student's actions to the Office of Community & Ethical Standards as a violation of the Student Code of Conduct. If the student's actions disrupt the class to the extent that an immediate response is needed, the instructor may call the Clemson University Police Department at 656-2222.

Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency: A. Ensure you are signed up for emergency alerts (https://www.getrave.com/login/clemson), B. Download the Rave Guardian app to your phone (https://www.clemson.edu/cusafety/cupd/rave-guardian/) C. Learn what you can do to prepare yourself in the event of an active threat (http://www.clemson.edu/cusafety/EmergencyManagement/)

Grades: Grades will be based on homeworks, In class challenge problems, packback, and 4 exams (including the final exam).

Homeworks: 10%
In class challenge problems: 10%
Packback questions/answers: 20%
Exams: 40%
Final Exam: 20%

Homework and In-class challenge problems may be completed by working collaboratively with other current students of this class, but you are required to submit your own individual assignments. Packback questions/answers, Regular exams, and the final exam must be completed independently and **will not** involve any collaboration.

If your final exam grade is higher than your lowest regular exam grade, the lowest regular exam grade will be dropped and replaced with your final exam grade. Your lowest homework grade, and lowest In-Class challenge problem grade, will be dropped. If you have an overall A average (based on the Homework, In-Class Challenge Problems, Packback, and 3 regular exams) AND an A average on the 3 regular exams directly prior to the final exam, you will not be required to take the final exam.

Grade Scale for the Course:

90 – 100 A
80 – 89 B
70 – 79 C
60 – 69 D
0 – 59 F

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Assessments: (This includes Packback, Homeworks, In-Class Challenge Problems, and Exams including the Final exam). What kinds of questions should you expect in the assessments of this course? First, you should expect similar TYPES of questions in each of the 4 formats (Packback, Homeworks, In-Class challenge problems, and Exams). Approximately 75% of these questions will be conceptual questions and 25% will involve applying mathematical tools to solve a practical/applied problem.

Packback: See information at the end of this syllabus.

Homeworks: Homework questions will include both conceptual and quantitative questions similar in type to those you will encounter on the exams. The quantitative questions, in particular, will also closely resemble those you find at the end of each chapter in the textbook. In some cases, homework questions will be taken directly from the textbook.

Late Homeworks: Homeworks will be due by 11:59pm on the day specified. 20% will be deducted from the homework grade after 11:59pm. An additional 20% will be deducted for each 24-hour period thereafter.

In-Class Challenge Problems: In-Class Challenges will be group exercises performed in groups of ~5 students. They will focus on conceptual and quantitative questions similar in type to those you will encounter on the exams.

Exams: Exams will be multiple-choice exams containing approximately 75% conceptual questions and 25% quantitative questions.

Make-ups: Make-up exams, In-class challenge problems, and/or homeworks are possible ONLY with a written medical or university excuse. It is the student's responsibility to give the professor the written excuse and to arrange for any makeup work to be done BEFORE the exam for that section is taken. All makeup exams will be given on the last day of the semester unless an alternative date is agreed upon.

Inclement Weather: Any exam that was scheduled at the time of a class cancellation due to inclement weather will be given at the next class meeting unless contacted by the instructor. Any assignments due at the time of a class cancellation due to inclement weather will be due at the next class meeting unless contacted by the instructor. Any extension or postponement of assignments or exams must be granted by the instructor via email or Canvas within 24 hours of the weather-related cancellation.

Covid-19 Related Information: For a student who reports testing positive or is being asked to quarantine/isolate because of exposure to the virus, it will be up to the student to inform the instructor that they will be moving to online only instruction for at least the next two weeks. Students are directed to use the Notification of Absence link in Canvas to initiate this notification, which can be found under the "Help" button on the left navigation. (For courses where Canvas is not used, the direct link to the Notification of Absence form can be found through the Division of Student Affairs site.) Additional communication via email is encouraged; students should follow up with their instructor to develop a continued plan of study for each course. Students cannot be penalized in their grade for needing to move to online instruction.

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Academic Continuity Plan: Clemson has developed an Academic Continuity Plan for academic operations. Should university administration officially determine that the physical classroom facility is not available to conduct classes in, class will be conducted in a virtual (online) format. The University issues official disruption notifications through email /www /text notification/Social Media.

When notified, use one of the following links to navigate to Clemson Canvas where you will find important information about how we will conduct class:

Primary access link: www.clemson.edu/canva
Secondary access link, if needed: https://clemson.instructure.com/
You can also use the Canvas Student App.

Our activities for teaching and learning will occur through our Canvas course.

Class Preparation: It is recommended that you read the relevant sections in your textbook prior to coming to class.

Office hours: I will hold office hours through Zoom each Friday from 5-6pm:
https://clemson.zoom.us/j/95293672301?pwd=Mk1KNnJkM2tDc243VzdlWlAwYjNxZz09

During weeks when we have an exam, I will do my best to hold an additional office hour prior to the exam. If you are unable to attend the Friday office hours and have questions, please feel free to email me and set up a time to meet.

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Tentative Weekly Topical Schedule:

Week 1: Introduction, What does it mean to think critically? What is the difference between training and education? Kinetic theory of gasses, Microscopic basis of macroscopic properties (ex. P and T), *Critical thinking assessment (Pre-"test")*.

- **Reading**: Fundamentals (Chapter 0) – Atoms, Ions, and Molecules; Bulk Matter; Energy

Week 2: 1st law of thermodynamics (energy conservation), Internal energy and enthalpy, Mechanisms of energy transfer (heat and work), Why are heat and work NOT state variables? Reversibility. Gasses as both a relevant application and a model system, What is energy? What are variables of state? Systems vs. environment.

- **Reading**: The First Law (Chapter 1)

Week 3: 2nd law of thermodynamics (entropy isn't conserved), 3rd law of thermodynamics (Under what conditions is entropy smallest?), Micro and macroscopic descriptions of entropy

- **Reading**: The Second Law (Chapter 2) – Sections 2.1, 2.2, 2.3, 2.4

Week 4: Spontaneity and Equilibrium, Gibbs and Helmholtz energies as useful tools, The relationship between Gibbs energy and work

- **Reading**: The Second Law (Chapter 2) – Sections 2.5, 2.6, 2.7, 2.8

Week 5: ***Exam 1***, Physical applications of equilibria (Phase equilibria),

- **Reading**: Phase Equilibria (Chapter 3) – Sections 3.1, 3.2, 3.3, 3.4, 3.5, 3.6

Week 6: Thermodynamics of mixtures, Chemical potential (Equilibrium between gas and solution phases), Ideal solutions (Why is it "ideal"? Relationship to entropy, ideal gases), Activity and Real solutions, Colligative properties (Relationship to entropy)

- **Reading**: Phase Equilibria (Chapter 3) – Sections 3.7, 3.8, 3.9, 3.10

Week 7: Chemical applications of equilibria, Gibbs energy of reactions as a function of composition, Standard Gibbs energy of reaction, Equilibrium constant, The Effects of catalysts/pressure/temperature on Equilibrium

- **Reading**: Chemical Equilibrium (Chapter 4) – Sections 4.1, 4.2, 4.3, 4.4, 4.5, 4.6

Week 8: Chemical applications of equilibria: Proton transfer examples

- **Reading**: Chemical Equilibrium (Chapter 4) – Sections 4.7, 4.8, 4.9, 4.10, 4.11

Week 9: ***Exam 2***, Rates and Kinetics, Distinctions from thermodynamics, Using differential equations to describe rates, Discovering connections to thermodynamics (approaching equilibrium)

- **Reading**: The Rates of Reactions (Chapter 6) – Sections 6.1, 6.2
- **Reading**: Accounting for the Rate Laws (Chapter 7) – Section 7.1

Week 10: Orders of rate laws, Identifying/validating rate laws through experimental data, Integration of rate laws, Effect of temperature and pressure on reaction rates

- **Reading**: The Rates of Reactions (Chapter 6) – Sections 6.3, 6.4, 6.5, 6.6, 6.7

Week 11: Rate laws for complex (non-elementary) processes, Simplifying/"Idealizing" rate laws and their integration, *Critical thinking assessment (Post-"test")*.

- **Reading**: Accounting for the Rate Laws – Sections 7.2, 7.3, 7.4, 7.5, 7.6, 7.7

Week 12: Introduction to Quantum Mechanics, The loss of physical intuition and common logic, The reliance on mathematical intuition, How do we think critically about QM? Blackbody radiation and Planck's tiny (packet) idea. Why do chemists care? A: Electrons, Electrons, Electrons. Is light a particle or a wave? Are electrons particles or are they waves? Double slit experiment.

- **Reading**: Microscopic Systems and Quantization – Sections 9.1, 9.2

Week 13: Schrodinger, a cat, and a "wavefunction". The uncertainty of Heisenberg. A particle and a box

- **Reading**: Microscopic Systems and Quantization – Sections 9.3, 9.4

Week 14: Using QM to calculate things you can measure, The amazing accuracy of QM

- **Reading**: Microscopic Systems and Quantization – Sections 9.4, 9.5, 9.6

Week 15: Remaining challenges in QM: Entanglement, Collapse, Gravity, ***Exam 3***

Tentative Exam Dates (Details may change depending on the pace of the class):

Section 1 Exam (chap. 1, 2) – Sept. 25th
Section 2 Exam (chap. 3, 4, 5) – Oct. 23rd
Section 3 Exam (chap. 6, 7, 9) – Dec. 2nd

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Packback Information

Participation is a requirement for this course, and the Packback Questions platform will be used for online discussion about class topics. Packback Questions is an online community where you can be fearlessly curious and ask open-ended questions to build on top of what we are covering in class and relate topics to real-world applications. As it relates to *this specific course*, my goals for using Packback are to encourage critical thinking (this is a CT2 course), class discussions, and a deeper understanding of physical chemistry.

Packback Requirements:

Your participation on Packback will count toward **20%** of your overall course grade.

There will be a Weekly **Sunday at 11:59PM EST deadline** for submissions. In order to receive your points per week, you should submit the following per each deadline period:

- 1 open-ended Question per week each worth 33.33% of each assignment grade
- 2 Responses per week each worth 66.67% of each assignment grade

How to Register on Packback:

An email invitation will be sent to you from help@packback.co prompting you to finish registration. If you don't receive an email (be sure to check your spam), you may register by following the instructions below:

1. Create an account by navigating to https://questions.packback.co and clicking "Sign up for an Account"
   Note: If you already have an account on Packback you can log in with your credentials.

2. Then enter our class community's lookup key into the "Looking to join a community you don't see here?" section in Packback at the bottom of the homepage.
   Community Lookup Key: **10689bf2-4613-4b4e-80e5-73c6d43c1b78**

3. Follow the instructions on your screen to finish your registration.
   Packback may require a paid subscription. Refer to www.packback.co/product/pricing for more information.

How to Get Help from the Packback Team:

If you have any questions or concerns about Packback throughout the semester, please read their FAQ at help.packback.co. If you need more help, contact their customer support team directly at help@packback.co.

For a brief introduction to Packback Questions and why we are using it in class, watch this video: vimeo.com/packback/Welcome-to-Packback-Questions