Syllabus for CHEN 4521: Physical Chemistry for Engineers

Instructors

Prof. Michael Shirts, JSCBB C123, michael.shirts@colorado.edu. (mailto:michael.shirts@colorado.edu) Office Hours: Th 1-2:30PM, JSCBB C124

(Use Zoom here when campus is closed: https://cuboulder.zoom.us/j/99836016706 (https://cuboulder.zoom.us/j/99836016706))

Class Meeting Times

T/Th 11:30AM-12:45PM, JSCBB A115

We will hold extra office hours and recitations near exam times. All office hours will begin Week 2 (Week of 1/20).

Teaching Assistants

Head TA: Rafael Ferreira de Menezes: rafael.ferreirademenezes@colorado.edu (mailto:rafael.ferreirademenezes@colorado.edu) , Office Hours: Friday 12-1:30, JSCBB E1B25 (except Feb 7, then E225)

TA: Joe Laforet: joe.laforet@colorado.edu (mailto:joe.laforet@colorado.edu) , Office Hours: Wed 1-2:30 (JSCBB B1B90, except on Feb 12, then JSCBB E125).

TA: Anne Marie McCombs: anne.mccombs@colorado.edu (mailto:anne.mccombs@colorado.edu) , Office Hours: Thurs 2:30-4 (JSCBB B1B90, except on Feb 13, then JSCBB E225)

CA: Vlad Denisenkov (helping with grading)

Textbook (Required): Peter Atkins, Julio de Paula, and James Keeler. Physical Chemistry. 12th edition. Available via RedShelf. Assigned readings are given in **Current Class Schedule** (https://canvas.colorado.edu/courses/115049/pages/current-class-schedule) .

Screencasts are heavily recommended for reading, and can be found **here** (https://learncheme.com/screencasts/p-chem/physical-chemistry-textbook-screencasts-atkins-11th-ed/) and are organized by chapter in Atkins, as found in the **Current Class Schedule** (https://canvas.colorado.edu/courses/115049/pages/current-class-schedule) .

Prerequisites

APPM 2350: Calculus 3 for Engineers
CHEM 1211: General Chemistry for Engineers (grade of C- or better)

We recommend that you review the following:

- Materials and Energy Balances: (Chapters 5-8 in Felder):
  - compression factor energy, enthalpy, work, First Law of Thermodynamics, partial pressure, vapor pressure, phase transitions, phase diagrams
- Mathematics:
  - multivariable calculus, partial derivatives, multiple derivatives, Taylor series, logarithms, rules of differentiation and integration
- Physics:
  - phases, physical properties, mass, energy, electromagnetic waves
- Chemistry:
  - atoms, molecules, molecular structure, electrons, orbitals

Communication

Announcements, homework assignments, quizzes, and other communication will be run through Canvas at canvas.colorado.edu. Please feel free to email your instructor or TA but be sure to include “CHEN 4521” at the beginning of your subject line so we can find it! We have set up a Discord instance for discussions (**https://discord.gg/xwen47Ck (https://discord.gg/xwen47Ck)**), which will be monitored by TA's and Prof. Shirts approximately daily Email is **not** a good way to clarify questions on the material; those questions should be answered in office hours. If you have questions on any administrative topic (typos in materials, scheduling questions, etc.), email works very well. I will make every effort to return emails within 24 hours.

Grading

Class attendance	10% (2 drops allowed)
Homework	20% (1 drop allowed)
Midterms	30% (= 2x 15%)
Final Exams	40% (= 2x 20%)

Note that since exams count for the largest part of your grade, you must be sure that you are learning the material sufficiently! Do not simply rely on your classmates for help!

Class Attendance

Class attendance is mandatory and will be recorded through answering in-class Clicker questions (using the iClicker Cloud app on your phone).

Homework

Due **every Friday at 11:59 pm,** starting next Friday, January 24th. Homework will be posted 1 week before the due date. Homework must be submitted via Gradescope **as a single PDF file**, usually from a scanned or photographed from a handwritten page. The Gradescope Mobile App has a PDF conversion feature, or you can use another program. You may work together, but you must submit separate work! The lateness policy is 10 pts off per hour late, up to 50 pts off. HW will not be accepted after 24 h.

Exams

See class schedule for exam dates (https://canvas.colorado.edu/courses/115049/pages/current-class-schedule) . You must work separately on the exams, with only allowed resources.

Classroom Behavior

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the policies on classroom behavior (http://www.colorado.edu/policies/student-classroom-and-course-related-behavior) and the Student Conduct & Conflict Resolution policies (https://www.colorado.edu/sccr/student-conduct) .

Requirements for Infectious Diseases

For those who feel ill and think you might have COVID-19 or other respiratory diseas if you have tested positive for COVID-19, please stay home and follow the further guidance of the Public Health Office (https://www.colorado.edu/healthcenter/coronavirus-updates/symptoms-and-what-do-if-you-feel-sick) . The CDC no longer recommends isolation for those who have been exposed to a respiratory illness such as COVID-19 but do not have symptoms and have not tested positive.

Members of the campus community should follow CDC guidelines for physical distancing, masking, and/or staying home if they are sick or test positive for all respiratory illnesses (https://www.cdc.gov/respiratory-viruses/prevention/precautions-when-sick.html) . Stay home and away from others (including people you live with who are not sick) if you have respiratory virus symptoms that aren't better explained by another cause. These symptoms can include fever, chills, fatigue, cough, runny nose, and headache, among others. You can go back to your normal activities when, for at least 24 hours, both are true 1) Your symptoms are getting better overall, **and** 2) You have not had a fever (and are not using fever-reducing medication). When you go back to your normal activities, take added precaution over the next 5 days, such as masking and avoiding crowded spaces. Masking with symptoms of respiratory disease is courteous to others in the class.

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code (https://www.colorado.edu/sccr/honor-code) and the academic integrity policy. Violations of the Honor Code may include, but are not limited to: plagiarism (including use of paper writing services or technology such as essay bots), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all

course instructors involved, and aiding academic dishonesty. Understanding the course's syllabus is a vital part in adhering to the Honor Code.

All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu (mailto:honor@colorado.edu)); 303-492-5550). Students found responsible for violating the academic integrity policy will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member and the department. Visit the Honor Code website (https://www.colorado.edu/sccr/media/229) for more information on the academic integrity policy.

Any discovered incidents of academic dishonesty will be reported to the departmental disciplinary committee who will recommend an academic sanction. Sanctions can range from an F for the particular assignment and a lowering of your grade at least a full letter grade to an F for the course. In addition, all confirmed incidents will be reported to the University Honor Code where further nonacademic disciplinary action can be taken. The following list includes some of the examples of dishonest acts (not comprehensive) for which a hearing will result:

1. Talking to each other during a class individual exam or bringing any information into the exam.
2. Possessing or searching for any unallowed information during an exam.
3. Any alteration, forgery, or falsification of official records (such as modification of graded homework problems or exams for which you are seeking additional credit).
4. Allowing another person to take an exam for you (false identification).
5. Knowingly providing material of your own or of others to a fellow student.
6. Possession of or observation of examinations or solutions to examinations prior to the date and time of the exam.
7. Allowing another person to answer clicker questions for you, or answering clicker questions for someone else.
8. Attempting to bribe, threaten or otherwise influence an instructor or TA, or having another person attempt to do this for you.

Acceptable Use of AI

Generative AI (sites like ChatGPT, Claude, etc) is only allowed in very specific cases, such as grammar or spelling checks, or revising text. Finding solutions to mathematical and physical problems using generative AI is not allowed. In most cases, since generative AI was trained on online sources, it is nearly equivalent to just copying solution manuals. Using generative AI in this course will not enhance student learning. The largest number of points are from exams, in which you will not be able to use AI tools. Keep in mind that the goal of generative AI tools is to reproduce content that seems to have been produced by a human, not to produce accurate or reliable content; therefore, relying on a generative AI tool may result in your submission containing inaccurate content. If generative AI use is suspected on an assignment, I will consult with you and ask that you redo the assignment using no generative AI within a week of notification.

Mental Health and Wellness

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS) (https://www.colorado.edu/counseling/) located in C4C or call (303) 492-2277, open 24/7.

Free and unlimited telehealth is also available through **Academic Live Care (https://www.colorado.edu/health/academiclivecare)**. The **Academic Live Care (https://www.colorado.edu/health/academiclivecare)** site also provides information about additional wellness services on campus that are available to students.

Religious Holidays and Observances

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. See the **campus policy regarding religious observances (http://www.colorado.edu/policies/observance-religious-holidays-and-absences-classes-andor-exams)** for full details. Please notify the instructors **as soon as possible** before any conflict, **a minimum of one week prior** so we can arrange proper accommodation.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

Disability Services (https://www.colorado.edu/disabilityservices/) determines accommodations based on documented disabilities in the academic environment. If you qualify for accommodations because of a disability, submit your accommodation letter from Disability Services to your faculty member in a timely manner so your needs can be addressed. Contact Disability Services at 303-492-8671 or **dsinfo@colorado.edu (mailto:dsinfo@colorado.edu)** for further assistance.

If you have a temporary medical condition, please notify the instructors before missed class, so we can arrange the appropriate accommodations. Also see **Temporary Medical Conditions (http://www.colorado.edu/disabilityservices/students/temporary-medical-conditions)** on the Disability Services website.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits **protected-class (https://www.colorado.edu/oiec/policies/discrimination-harassment-policy/protected-class-definitions)** discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community.

The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email **cureport@colorado.edu (mailto:cureport@colorado.edu)**. Information about university policies, **reporting options (https://www.colorado.edu/oiec/reporting-resolutions/making-report)**, and support resources can be found on the **OIEC website (http://www.colorado.edu/institutionalequity/)**.

Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive an outreach from OIEC about their options for addressing a concern and the support resources available. To learn more about reporting and support resources for a variety of issues, visit the **Don't Ignore It page (https://www.colorado.edu/dontignoreit/)**.

Current Class Schedule

Date	Topic	Readings
1/14	The First Law, Properties of Gases, Heat and Work	Prologue, Topics 1A.1: Variables of State, 2A: Internal Energy (notes (https://canvas.colorado.edu/courses/115049/files/78042242?wrap=1) (https://canvas.colorado.edu/courses/115049/files/78042242/download?download_frd=1))
1/16	Equations of State and Intermolecular Forces	Topics 1A: The Perfect Gas, 1C: Real gases (notes (https://canvas.colorado.edu/courses/115049/files/78074365?wrap=1) (https://canvas.colorado.edu/courses/115049/files/78074365/download?download_frd=1))
1/21	First Law and Working with State Functions	Topics 2A: Internal Energy. 2B: Enthalpy, 2D: State Functions and Exact Differentials (notes (https://canvas.colorado.edu/courses/115049/files/78117659?wrap=1) (https://canvas.colorado.edu/courses/115049/files/78117659/download?download_frd=1))
1/23	Process Paths, Adiabatic Processes, Second Law	Topic 2D: State Functions and Exact Differentials. 2E: Adiabatic Processes Carnot engine efficiency derivation (link (https://phys.libretexts.org/Bookshelves/University_Physics/University_Physics_(OpenStax)/University_Physics_II_-_Thermodynamics_Electricity_and_Magnetism_(OpenStax)/04%3A_The_Second_Law_of_Thermodynamics/4.06%3A_The_Carnot_C)) (notes (https://canvas.colorado.edu/courses/115049/files/78148203?wrap=1) (https://canvas.colorado.edu/courses/115049/files/78148203/download?download_frd=1))
1/28	Entropy, Second Law, Process Cycles, Efficiency	Topics 3A: Entropy, 3B: Entropy changes accompanying specific processes. (notes (https://canvas.colorado.edu/courses/115049/files/78241692?wrap=1) (https://canvas.colorado.edu/courses/115049/files/78241692/download?download_frd=1))
1/30	Process Cycles, Efficiency, Spontaneity, Free Energy	Topics 3B: Entropy changes, 3C: Measurement of Entropy, 3D: Concentrating on the System (notes (https://canvas.colorado.edu/courses/115049/files/78276566?wrap=1) (https://canvas.colorado.edu/courses/115049/files/78276566/download?download_frd=1))
2/4	Spontaneity, Free Energy, Maxwell's Relations*	3E: Combining the First and Second Laws Review
2/6	**MIDTERM IN CLASS**	
2/11	Maxwell's Relations and Chemical Potential	Topics 3E: Combining the First and Second Laws, 4A: Phase Diagrams of Pure Substances
2/13	Phase Diagrams and Phase Transitions	Topics 4A: Phase Diagrams of Pure Substances, 4B: Thermodynamic Aspects of Phase Transitions

2/18	Thermodynamics of Mixtures	Topic 5A: Thermodynamic description of mixtures
2/20	Ideal and Regular Solutions, Activity Coefficients	Topics 5B: Properties of solutions, 5F: Activities
2/25	Binary Systems	Topic 5C: Phase Diagrams of Binary Systems: Liquids
2/27	**REVIEW**	
3/4	**MID-FINAL IN CLASS**	
3/6	QM and quantized energy, Particle-Wave Duality	Topic 7A: The Origins of Quantum Mechanics
3/11	Schrödinger's Equation and Wavefunctions	Topics 7B: Wavefunctions
3/13	Operators and QM Postulates	Topics 7C: Operators and Observables
3/18	Quantized translation and confinement (1D)	Topic 7D: Translational Motion
3/20	2D and 3D translation / confinement	Topic 7D: Translational Motion
3/25-3/27	**Spring Break**	
4/1	Tunnelling and Quantized vibration	Topic 7E: Vibrational Motion
4/3	Quantized rotation	Topic 7F: Rotational Motion
4/8	Catch up/ review	
4/10	**MIDTERM IN CLASS**	
4/15	Schrödinger's equation for atoms	Topic 8A: The Schrödinger equations, atoms, and molecules

4/17	The Boltzmann distribution and energy levels	Topic 13A: The Boltzmann Distribution (start reading 13B)
4/22	Molecular partition functions	13B: Molecular Partition Functions, 13C: Molecular Energies
4/24	The canonical ensemble, internal energy and entropy	Topic 13D: The Canonical Ensemble, Topic 13E: Internal Energy and Entropy
4/29	Derived functions (enthalpy, free energy)	Topic 13F: Derived Functions
5/1	**REVIEW**	
5/7	**Final exam**	4:30-7 pm