MSE 480 Surfaces and Colloids

Course Summary

Chemistry and physics of surfaces and interfaces, with emphasis on behavior in liquid media. Surface composition; surface and interfacial forces; colloidal stability and flocculation; amphiphilic molecules. For a detailed list of topics see Course Coverage.

Prerequisites

MSE 401 – Thermodynamics of Materials

Class

Location: MSEB 119

Time: 12:30 – 1:50 pm on Tuesdays and Thursdays.

Sections: Undergaduate/Grad, 3 or 4 credit hours

This class utilizes Canvas for communications and assignments. The course is divided by weeks and there are assignments and activities to be completed each week, including homework, lectures, quizzes, and discussions. The class is designed to be interactive and your active participation is required.

All class communications and interactions with other students, TAs, Graders, and me should follow common social standards for respect and courtesy; rude, abusive, or discriminatory language will not be tolerated. I will communicate with students using Canvas and your Illinois email account; please check both regularly. Students can expect graded work to be returned within 10 days and questions will be answered as quickly as possible. Canvas is the best way to communicate, but I am also available via email and Zoom (during office hours/class time or a 1:1 meeting scheduled in advance).

Textbooks

This class is mostly organized around class notes.

Suggested references:

- Arthur W. Adamson and Alice P. Gast, Physical Chemistry of Surfaces, 6 edition, Wiley, New York, 1997. A good reference book, but it's hard to read an encyclopedia.
- Gabor A. Somorjai, Introduction to Surface Chemistry and Catalysis, 2 Ed, Wiley, New York, 2010. Clearly written, comprehensive.
- Andrew Zangwill, Physics at Surfaces, Cambridge University Press, Cambridge,1988 This is the physics point of view (electronic structure, phase transitions, epitaxy ...) and complements the chemistry point of view in the book by Somorjai.
- The recommended textbook for the second half of the class is: Jacob N. Israelachvili, Intermolecular and Surface Forces, 3rd ed., Academic Press, New York, 2011.

Course Coverage

PART I: BASICS ABOUT SURFACES

1. Introduction

2. Distinctive features of interfaces
   what is an interface? – how to describe an interface?
   what are typical behavior patterns? real versus apparent area – surface to volume ratio -surface
   energy – surface structure and composition versus that of the bulk.
3. Surface energy
   typical values — how to measure it? — reconstruction, relaxation, molecular orientation, melting,
   roughening — how to evaluate surface structure?
4. Surface thermodynamics
   origin of surface energy — Gibbs dividing surface — surface excess functions
   Gibbs adsorption equation — other implications
5. Adsorption isotherms
   physisorption versus chemisorptions — adsorption isotherms: Langmuir, BET, etc. — internal interfaces: critical micelle concentration
6. Monomolecular films
   pressure-area diagrams — Langmuir-Blodgett films — self-assembled monolayers, SAMs — layer-by-layer self-assembly
7. Curved surfaces
   capillary pressure: the Young-Laplace equation — vapor pressure: the Kelvin equation —
   implications: nanoparticles, adhesion, etc.

PART II: THE FORCES BETWEEN SURFACES

1. Introduction
   Uses of colloids in technology – how to measure surface forces? Characterization of colloids.
2. Varieties of inter-particle forces
   Scale-up from molecules to larger particles – van der Waals, electrostatic," structured liquids"
3. Van der Waals interactions
   origin of r-6
4. Hamaker constant – competititive van der Waals attractions -implications
5. Electrostatic interactions
   why all interfaces are charged or polarized – the electric double layer – the screened Coulomb
   potential – examples of calculations – Stern layer – typical
   DLVO behavior – zeta potential – examples
6. Non-equilibrium and time-dependent interactions
   diffusion; hydrodynamics; flocculation kinetics.

PART III: FORCES DUE TO STRUCTURE IN LIQUIDS

1. Polymers
   types of polymers – general features of polymers in solution – examples
2. Structured liquids (small molecules)
   liquid structure at surfaces – forces that result – examples

3. Tribology and adhesion

PART IV: OUTLOOK

1. Review of the course
2. Frontier areas
   selected depending on interests of the class

Office Hours

Prof. Statt: TBD

TA office hours: TBD

Homework

Homework assignments for this class will be issued via PrarieLearn. Students will have one or two weeks to complete the assignment and they are to be submitted on PrarieLearn.

Late homework up to 24 hrs will be generally be accepted for a maximum of 50% credit. Late homework after 24 hrs will receive 0% credit. The lowest score for homework and quiz will be dropped. *Students with valid reasons precluding on-time submission that should contact Prof. Statt well in advance of the deadline.* Students are strongly encouraged to complete all assignments to assess their own understanding of the course material. It is acceptable to work with fellow students on homework problems, and to ask as well as answer questions pertaining homework online on Canvas. Provision will be made for office hours during which to discuss the problems and solutions. Exam questions will be loosely based on assigned homework problems.

Quizzes

Short online multiple-choice quizzes will be issued via PrarieLearn, to gauge elementary understanding and mastery of the course material. Each quiz has a time limit of 30 minutes and can only be taken once.

Exams

There will be one (1) midterm exam, and one (1) final exam. Exams are held at CBTF via PrarieLearn. Specific details will be made available a week before each exam. Both exams will be closed book.

Paper (4-credit option only)

Students in the 4-credit option will write a term paper on a student-selected topic in colloidal science. This paper can be written either alone or in small teams of two-three students. The term paper should be written in the style of a literature review or summary of a relevant research topic. *Students with valid reasons precluding on-time submission should contact Prof. Statt well in advance of the deadline*. The due dates are listed in the Class Schedule.

Topic: Term paper topic selections are due via Canvas. Submissions should include all authors on the team and take the form of a one-sentence topic title and short (≤250 word) abstract summarizing the topic and projected thrusts of the paper. Prof. Statt will be available to discuss and advise topic choice and general direction of the paper, overlap with relevant research projects of the student in the area of polymers are encouraged. Early topic identification and submission is also encouraged.

Paper: Both first draft and final version of the term papers are due via Canvas. Papers should be 5-6 pages in length (excl. figures and bibliography; 12-pt font, 1-inch margins, single-spaced). Students will research and summarize the state of the field, reference classic texts and papers, and identify the principal challenges, important questions, and current research

directions in the field. Prof. Statt will be available to discuss and advise paper research and production. Papers will be graded on: (i) topic definition and motivation (10%), (ii) summary of status of field (20%), (iii) identification and motivation of open challenges (25%), (iv) analysis of current research into identified challenge (20%), (v) clarity of report (10%), (vi) appropriate citations and formatted bibliography (5%).

Content: Give the reader something beyond what one can obtain directly from the source materials.

• Research and investigate. Seek out relevant materials, and unify them into a clear presentation.

• Synthesize. Draw together diverse things to show patterns and relations.

• Organize. Give logical continuity and structure to diverse materials.

• Analyze. Provide your own critical analysis in which arguments are examined for evidence, validity, logic, and flaws.

• Examine in a broader context. Show how your topic fits into a broader context, relates to another field, or relates to historic precedents.

• Outlook. Going beyond what is known, discuss what is not known and why.

Peer review: Reviews are due via Canvas. Each submitted paper will be assigned to two other randomly selected students in the class for peer review. Each student will write a *short* (≤1 page) *constructive* review on their assigned papers, summarizing the content of the paper very briefly, and giving feedback on (i) topic, (ii) summary of the field, (iii) open challenges, (iv) analysis, (v) clarity of the term paper, as well as formatting/style. The remaining 10% of the grade will be the quality of the given peer review. Each student will receive the peer reviews on their paper, will incorporate the feedback and submit a final version via Canvas.

Late submission of abstract first draft, peer review, and final draft is not permitted. *Students with valid reasons precluding on-time submission should contact Prof. Statt well in advance of the deadline*. The due dates are listed in the Class Schedule.

In class presentations: At the end of the semester, each student team will give a short 5 min presentation about their topic of choice for their term paper.

Plagiarism

Each student is responsible for submitting their own original quiz responses, homework assignments, and (if applicable) term paper. Collaborative interaction online and in-person is permissible and encouraged via Canvas, but each student must perform all calculations themselves, and submit their own work. **Plagiarism will not be tolerated, and verified incidents will result in all parties receiving a zero on their project and formal academic sanctions.** Students are responsible for familiarizing themselves with the definition and penalties for plagiarism detailed in Section I-401 of the UIUC Student Code. Ignorance of these policies is not an excuse for any academic dishonesty. As a student it is your responsibility to refrain from infractions of academic integrity and from conduct that aids others in such infractions. A short guide to academic integrity issues may be found here. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity. Note that the code's definition of plagiarism includes "copying another student's paper or working with another

person when both submit similar papers without authorization to satisfy an individual assignment".

Please note that all course materials are protected by copyright and are considered intellectual property. Course materials should only be used for this course and should not be shared with anyone not in the course, including uploading to a study site, social media, or other online sharing mechanism.

Certain assignments in this course will permit the use of generative artificial intelligence (GAI) tools such as ChatGPT. The default is that such use is **disallowed**, especially for the term paper 4-credit assignment; the students bear the final responsibility of checking that their term paper is valid and correct and not generated by GAI. **Violations of this policy will be considered academic misconduct.**

Grading

A3/A4 (3-credits):		A4 (4-credits):	
Quizzes:	10%	Quizzes:	10%
Participation:	5%	Participation:	5%
Homework:	25%	Homework:	25%
Midterm:	30%	Midterm:	20%
Final:	30%	Final:	20%
		Term paper:	20%

Participation includes participation via Google Forms, participating in discussions & questions during class, as well as posting content questions on Canvas, and answering content questions on Canvas. If a student participated actively in 75% of all weeks, the student will receive the full 5% credit. ONLY Verified Absences will be accepted.

Letter grades will be based on final aggregate student scores, with numerical cutoffs specified by the instructor. However, students with aggregate scores >95% are guaranteed *at least* an A, >85% *at least* a B, and >75% *at least* a C (i.e. cutoffs will not be higher than these values).

Covid-19 Policies

We will follow University Policies, for more details please review: https://covid19.illinois.edu/. *If you feel ill or are unable to come to class or complete class assignments due to issues related to COVID-19, including but not limited to testing positive yourself, feeling ill, caring for a family member with COVID-19, or having unexpected child-care obligations, you should contact your instructor immediately, and you are encouraged to copy your academic advisor.*

Face coverings are strongly encouraged to create a safe and welcoming learning environment for everyone. To be effective, masks/face coverings need to cover both the nose and mouth and stay in place at all times. Please refrain from eating/drinking during class. We will take a 10 min break halfway through the class. Verified Absences will be accepted.

Anti-Racism and Inclusivity Statement

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (https://bart.illinois.edu/**).** Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Mental Health

Diminished mental health, including significant stress, isolation, mood changes, excessive worry, substance/alcohol abuse, or problems with eating and/or sleeping can interfere with optimal academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings at no additional cost. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do — for yourself and for those who care about you.

Counseling Center: 217-333-3704, 610 East John Street Champaign, IL 61820

McKinley Health Center: 217-333-2700, 1109 South Lincoln Avenue, Urbana, Illinois 61801

Disability-Related Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu or go to https://www.disability.illinois.edu. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnosis a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at https://odos.illinois.edu/community-of-care/resources/students/religious-observances/ to request appropriate accommodations. This should be done in the first two weeks of classes.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.