MSE 480/CHEM 488 Fall 2017

SURFACE AND COLLOIDS

Instructor: Prof. Qian Chen
Fall Semester 2017
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Course Web Page: compass2g.illinois.edu

Look around you: everything you see is a surface! Surfaces, interfaces, and the distinctive behavior owing to them, pervade most of daily life, including life itself. Processes at surfaces pervade technology. They pervade environmental issues (rain and smog, soils, aerosols). They are even the basis for much of bioengineering (milk and cheese, proteins -- and even we ourselves, who consist of a dynamic collection of biocolloids contained in about 75% water). In this course we will seek to understand the general principles which unify these seemingly disparate phenomena. To understand this subject is interesting for its own sake. Since you are also likely to encounter surface and colloid phenomena in whatever work you undertake in the real world, understanding will help you to do a better job.

Textbook: This class is mostly organized around class notes. The subject is too young to have one comprehensive textbook. All the following suggested references are reserved in Grainger.

(1) 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.*
(2) Gabor A. Somorjai, **Introduction to Surface Chemistry and Catalysis, 2 Ed**, Wiley, New York, 2010. *Clearly written, comprehensive.*
(3) 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.*
(4) 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. *Beautifully written, this is the best single text for the second half of the class. The 1st edition (1985) was shortest and even easier to read than the 2nd and 3rd editions. Also available on Amazon as a Kindle book.*

Assignments: There will be homework over the course of the semester. Late HW receives 1/2 credit. Graduate students taking the class for 4 credit hours will write a term paper, due on **Nov 30th, 2017**

Exams: There will be one in-class midterm and one final.

Tentative midterm date: Oct. 31, 2017. **Final date:** TBA

Grading: 3 credit hours:

Midterm (35%) + Final (45%) + Homework (20%)

4 credit hours:

Midterm (30%) + Final (40%) + Homework (15%) + Term Paper (15%)

Teaching Assistant (TA):

Office hours:

Prof. Qian Chen, Thursdays 9:30-10:30 am, MRL 102

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} - Hamaker constant - competititive van der Waals attractions -implications

4. 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

5. *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

Policy on conflicts or emergencies:

(1) For time conflicts with other events (e.g. another scheduled exam), or an official UIUC activity (e.g. varsity athletics, band concert),
Regarding HW, please show official documentation about the conflict at least **two weeks** before the homework due date. The HW due date will be extended.
Regarding the exam, please show official documentation about the conflict at least **three weeks** before our exam date. A make-up exam will be scheduled.

(2) If you will not be able to make it to the exam or submit HW on time due to serious illness or other emergent personal crisis (e.g. car accident) that are not described in (1), you must send email to the TA (bluo6@illinois.edu) and the instructor (qchen20@illinois.edu) at the earliest possible opportunity, and submit a statement from the professionals that are authorized to evaluate your situations (e.g. doctors, police). The statement needs to clearly explain that you are not physically capable of attending the exam or submitting HW on time. The HW due date will be extended for HW, and a make-up exam will be scheduled for exam.