Colloid Chemistry **CHEM685** **Fall 2013**

Updated 8/1/13 .

COURSE DESCRIPTION: Introduction of the principles of colloid chemistry and discussion of applications including; surface and interfacial tension, capillarity, interfacial adsorption, adsorption isotherms, adhesion, contact angles, surface wetting and dewetting, emulsification, foaming and defoaming, interfacial thermodynamics and electrostatics, etc.

- **Instructor**:
  - Dr. J. A. Wingrave; Office (204 BRL); Phone (831-1676); e-mail (wingrave@udel.edu)
- **CHEM685 Lecture** T,R, from 10:10-11:00 am in 116BRL
- **Required Course Supplies** (Available at University Bookstore - sometimes!)
  - **Textbook**: "Physical Chemistry of Surfaces", 6th Ed., Arthur W. Adamson and Alice P. Gast, John Wiley & Sons, NY (1997). ISBN: 0-471-14873-3
  - **Lecture Manual** Lecture Manual for CHEM685, Wingrave 2013
  - **Syllabus** On SAKAI website

OFFICE HOUR - Problem Solving (204BRL/308QDH)

Tuesday,	11:00am - 12:00pm (noon)
Wednesday,	11:00am - 12:00pm (noon)
Monday, Thursday, Friday	NO PROBLEM SOLVING OFFICE HOURS

OFFICE HOUR - General Questions (204BRL)

Thursday,	11:00am - 12:00pm (noon)
Monday-Wednesday, Friday	NO GENERAL QUESTIONS OFFICE HOURS

- **Exams**
  - Exam Dates: October 10 (Exam #1) and November 14 (Exam #2)
  - Two (2) in-class exams of 100 points each will be given.
  - One (1) final exam of 100 points will be given.
  - No make-up exams
    - 1 EXCUSED missed exam and score of other exam will replace missed exam.
    - 1 UNEXCUSED missed exam and exam score will be zero.
    - 2 missed exams and exam score will be zero.
  - Exams Cover: textbook, lecture, and Lecture Manual material.

* Exam corrections must be made prior to the next exam date.

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• Grading Schedule for CHEM685

- **Examinations** **(200 points, 40%) = 2 x 100 points**
- **Final Examination** **(100 points, 20%)**
- **White Paper** **(100 points, 20%)**
- **Presentation** **(100 points, 20%)**

TTL POINTS (%)	GRADE	TTL POINTS (%)	GRADE	TTL POINTS (%)	GRADE
500-450 (90)	A	380-360 (72)	B -	290-280 (56)	D +
450-430 (86)	A -	360-340 (68)	C +	280-260 (52)	D
430-410 (82)	B +	340-300 (60)	C	260-250 (50)	D -
410-380 (76)	B	300-290 (58)	C -	250-0	F

Lecture Topics LIST

Chap	Lecture Number & Topics
II-9, III-3,4, XIII-5	0. Introduction and Syllabus
III-5	1. Integral and Differential Calculus
III-5	2. Mathematics of Thermodynamics
II-1, III-1,2,3,4,5,6	3. Gibbs Interfacial Thermodynamics
II-2,3,4,5,6,7,8,9, III-1	4. Single Component $\ell - v$ Interfacial Behavior
IV-2, XIV-7,8	5. Multicomponent $\ell - v$ Interfacial Behavior
XII-8, XIII-6, XIV-3,4,5,6	6. Emulsification and Detergency
II, X-7, XIV-3-8	7. $\ell - \ell$ Interfacial Behavior
IV-1, X-4,5,6, XIII-1,2,3,4	8. $s - \ell - v$ Interfacial Behavior
XVII	9. S-V Interfacial Behavior
XI	10. $s - \ell$ Interfacial Behavior
IV, V	11. $s - \ell$ Interfacial Electrostatics - **WHITE PAPER DUE**
	12 $s - \ell$ Interfacial Thermochemistry
Handout	13. Polymers
	14. Triglycerides/Fatty Acids
	15. Environmental Chemistry - **PRESENTATIONS**
	Semester Wrap-Up

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Lecture Number & Topics

0. Introduction & Syllabus

1. Integral and Differential Calculus
   Total Differential Equations, Partial Derivatives, Line Integrals, Derivatives of Explicit and Implicit Equations, Evaluation of Partial Derivatives, State and Non-State Functions, Exact and Inexact Differentials, Operations with Total Differentials, The Maxwell Equations,

2. Mathematics of Thermodynamics
   Thermodynamics for Homogeneous Systems, Thermodynamics for Interfacial Systems, The Gibbs-Duhem Equation Derivation, Applications and Manipulations of Thermodynamic Total Differentials

3. Gibbs Interfacial Thermodynamics
   Composition of Real Interfaces, Gibbs Dividing Surface Defined, Interfacial Dividing Surface Location, Surface Excess Energy, Surface Excess Variables (surface tension, interfacial curvature), Gibbs Phase Rule for Interfacial Systems

4. Single Component $\ell - v$ Interfacial Behavior
   Surface Tension, Young-LaPlace Equation, Kelvin Equation, Water Repellency, Capillary Rise, Pendular Liquids, Bosanquet-Lucas-Washburn Equation.

5. Multicomponent $\ell - v$ Interfacial Behavior
   Surfactants, Surface Excess Adsorption, Gibbs-Duhem Equation, Foam, Defoamers, Wedge Theory of Adsorption,

6. Emulsification and Detergency, $\ell - \ell$ Interfacial Behavior
   HLB, Emulsion stability,

7. Interfacial Energetics - $\ell - \ell$ Interfacial Behavior
   Interfacial tension, Work of Adhesion, Work of Cohesion, Spreading Coefficient, Girifalco-Good Equation, Girifalco-Good-Fowkes Equation

Lecture Number & Topics (continued)

8. Triple Phase Point Behavior - s – ℓ – v Interfacial Behavior
   Contact angle, film pressure, adhesion tension, Spreading Coefficient, Zisman Plots, Young-Dupré Equation, Girifalco-Good-Young Equation, s – ℓ interfacial tension, solid surface tension,

9. Adsorption at the s-v Interface – s-v Interfacial Behavior
   Adsorption Kinetics, Adsorption Energies, Langmuir Adsorrtion, BET Adsorption, Other Adsorption Models, BET Adsorption Apparatus/Method

10. Adsorption at the s – ℓ Interface – s – ℓ Interfacial Behavior
    Surface site chemistry, Proton Adsorption, Zeta Potential, Zero Point of Charge (ZPC), Acid/Base effects on surface site chemistry, Cation Adsorption, Anion Adsorption, Nonionic Adsorption, Activity Effects on Adsorption, Adsorption Plotting Methods,

11. Electrostatics of the s – ℓ Interface - s – ℓ Interfacial Electrostatics
    DLVO Theory, Primitive Interfacial Model, Gouy-Chapman Model, Oscillating Surface Forces,

12. Thermochemistry of the s – ℓ Interface
    Optional

13. Polymers and Biopolymers
    Addition Polymers, Condensation Polymers, EO/PO polymers, Natural Polymers

14. Lipids - Triglycerides, Phospholipids, Steroids
    Structure and Surface Activity of Triglycerides, Phospholipids, Steroids

15. Environmental Chemistry – Chemical Causes and Solutions
    Air Pollution, Water Pollution, Green Energy

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WHITE PAPER

1. Project Total Score: 100 points

2. Find a personal care product that has at least THREE (3) identifiable colloidal ingredients listed on the container. Suggested types of products: hair shampoos or conditioners, liquid dishwashing detergents (light duty liquids), hard surface cleaners (i.e., 409), body washes, laundry products, etc.

3. List the following information, IN YOUR OWN WORDS, for each of the 3 colloidal ingredients you choose to identify;

   1. (10 pts) Photocopy of product label
   2. (3x5= 15 pts) Chemical name as listed on the label
   3. (3x5= 15 pts) Chemical or chemical composition
   4. (3x10=30 pts) Function of component in the product + Other applications.
   5. (3x5= 15 pts) Manufacturer
   6. (3x5= 15 pts) MSD Sheet if available (1 page max length for MSDS)

   (3x30=100 pts) TOTAL

4. Submit the project results to Professor Wingrave (Wingrave@udel.edu) by deadline: **NOVEMBER 4, 2011**.

5. Project will be graded by professor.

6. Criteria for grading include:
   - Thoroughness of chemical description
   - Completeness of description of component function
   - List of other applications

7. Helpful References:
   - McCutcheons, "Emulsifiers and Detergents".
   - "Polymer Handbook", Brandrup & Immergut, Wiley-Interscience.
   - Textbook, "Physical Chemistry of Surfaces", Adamson & Gast.

8. Some Possibly Useful Website(s)

   - http://householdproducts.nlm.nih.gov/index.htm

http://www.ewg.org/reports/skindeep2/report.php?type=INGREDIENT&id=1750

http://www.answers.com/topic/sodium-pareth-sulfate

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PRESENTATION

1. From the list below, pick a named equation or effect.

2. Research your chosen topic and prepare a 10-15 minute POWERPOINT presentation that covers the following: Project Total Score: 100 points

   (5 pts) History.
   (10 pts) Equation Derivation
   (Important parts of equation discussion & its derivation)
   - o applications,
   - o approximations,
   - o assumptions,
   - o boundary conditions / limitations,
   - o etc.

   (10 pts) Two example applications of and/or calculations with the equation
   (5 pts) Other noteworthy information.

   SCORING
   (30 pts) TOTAL – Average of ALL Student evaluations
   (60 pts) TOTAL – Professor
   (10 pts) Serving as grader for other Presenters

3. Give the presentation in Lecture: Dates TBD.

4. Project will be graded by class and professor. Four points for each presentation previewed.

PRESENTATION TOPICS

1 Eötvös equation for surface tension
2 Fowler-Guggenheim equation for lateral interaction
3 Frenkel kinetic adsorption equation
4 Girfalco-Good-Fowkes-Young interfacial tension equation
5 Hildebrand-Scott equation for surface tension of solutions
6 Darcy's Law for flow in porous media
7 Redhead equation for adsorption kinetics
8 Stern equation for electrolyte adsorption
9 Szyszkowski equation for surface tension of a solution
10 Washburn equation for capillary pressure liquid flow in a capillary tube
11 Zisman equation for work of adhesion
12 Griffin's HLB concept
13 Polanyi potential adsorption equation
14 BET adsorption equation
15 Langmuir adsorption equation
16 Freundlich adsorption equation
17 Tolman equation for curvature dependence of surface tension
18 Hydrophobic forces
19 Zsigmondy model for adsorption isotherm hysteresis

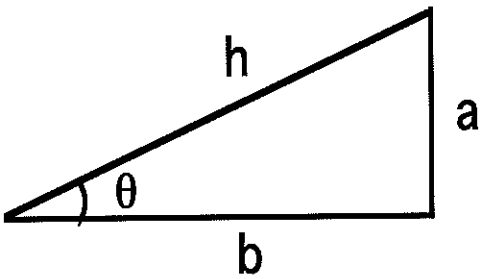
BASIC MATH FUNCTIONS

A. Exponents

1. $x^2 \bullet x^3 = x^{2+3} = x^5$
2. $x^5 \bullet y^5 = (xy)^5$
3. $x^3 \bullet y^4 = x^3 y^4 = y\left(x^3 y^3\right) = y(x\,y)^3$
4. $\left(x^2\right)^5 = x^{(2\bullet 5)} = x^{10}$
5. $\sqrt[3]{x^6} = \left(x^6\right)^{1/3} = x^{(6/3)} = x^2$
6. $\sqrt{x^6} = \left(x^6\right)^{1/2} = x^{(6/2)} = x^3$
7. $x^{-4} = \dfrac{1}{x^4}$
8. $\dfrac{x^5}{x^3} = x^{5-3} = x^2$

B. Logs

1. $\log 1000 = +3.0$ ⋮ $10^{+3} = 10^{\log 1000} = 1000$
2. $\ln 1000 = +6.91$ ⋮ $e^{+6.91} = e^{\ln 1000} = 1000$
3. $pH \equiv -\log\left[H^+\right]$ ⋮ $\left[H^+\right] = 10^{-pH}$
4. $\log x^7 = 7 \bullet \log x$
5. $\ln x^6 = 6 \bullet \ln x$
6. $\ln x = 2.303 \log x$
7. $\log xy = \log x + \log y$
8. $\log \dfrac{y}{x} = \log y - \log x$
9. $\log (x+y) = \log (x+y)$



10. $\sin\theta = \dfrac{\text{opposite}}{\text{hypotenuse}} = \dfrac{a}{h} = \dfrac{1}{\sec\theta}$
11. $\cos\theta = \dfrac{\text{adjacent}}{\text{hypotenuse}} = \dfrac{b}{h} = \dfrac{1}{\csc\theta}$
12. $\tan\theta = \dfrac{\text{opposite}}{\text{adjacent}} = \dfrac{a}{b} = \dfrac{1}{\cot\theta} = \dfrac{\sin\theta}{\cos\theta} = \left(\dfrac{a}{h}\right)\left(\dfrac{h}{b}\right) = \dfrac{a}{b}$
13. $1 = \sin^2\theta + \cos^2\theta$

D. Mensuration:

1. $C = \pi d = 2\pi r$ ⋮ Circumference of circle
2. $A = \pi r^2 = \dfrac{\pi}{4} d^2$ ⋮ Area of circle
3. $A = 2\pi r L$ ⋮ Area of cylinder
4. $A = 4\pi r^2$ ⋮ Area of sphere
5. $A = \dfrac{1}{2} bh$ ⋮ Area of RIGHT triangle
6. $A = 6L^2$ ⋮ Area of cube
7. $V = L^3$ ⋮ Volume of cube
8. $V = \dfrac{4}{3}\pi r^3$ ⋮ Volume of sphere
9. $V = \pi r^2 L$ ⋮ Volume of cylinder

E. Quadratic Equation

: $ax^2 + bx + c = 0$ ⋮ $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$