CHEM 103: Structure and Bonding
FALL 2005
MWF 12:40-1:30 pm 2122 CHEM

Syllabus

Surveying the Molecular World - Course Plans and Expectations

Instructor: **John P. Fackler, Jr., Ph.D.,**
Distinguished Professor of Chemistry and Toxicology
1428 Chemistry Bldg. 845-0648 or -2835
Office Hours: 2:00-3:00 (Mon. & Thurs.) or by appointment
Email: fackler@mail.chem.tamu.edu
Homepage: http://www.chem.tamu.edu/rgroup/fackler/

Textbook: **"Chemical Principles: The Quest for Insight,"** 3rd Edition, Peter Atkins and Loretta Jones; W.H. Freeman and Company, New York (2004).

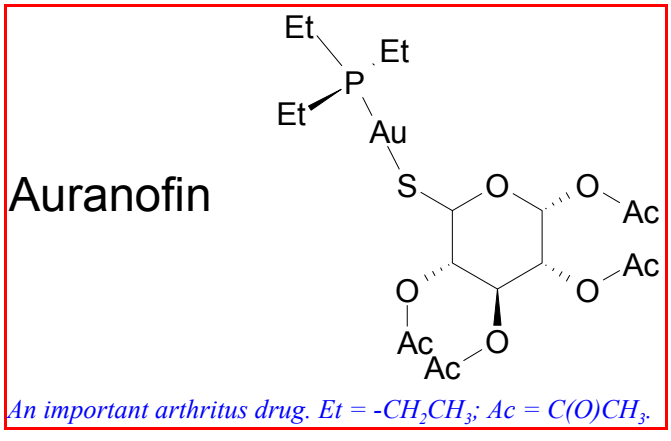
Grading:

Hour Exams (2 at 100 pts each)	200
Short Quizzes and Homework Assignments	50 (But must exceed 80% correct)
Written paper	50
Final Exam	200
Total:	500

Exam Schedule: **Hour Exams:** October 7, November 4
Final Exam: Monday, December 12, 10:30 AM
Paper Due: Monday, December 5

Course Description: Basic chemical principles and their applications for chemistry majors and other students who have an aptitude for science and a desire to learn about the molecular world.

Prerequisites: For entering students with satisfactory aptitudes in mathematics and chemistry, with one or two years of high school chemistry background and a strong interest. The language and symbolism of chemistry includes the known elements and small units of elements. Common ones should be known already by the student.



An important arthritus drug. Et = -CH_2CH_3; Ac = $C(O)CH_3$.

Course Description: The chemistry 103/104 sequence is intended for chemistry majors and others with a strong interest in chemistry. It provides a rigorous introduction to important theories and concepts in the broad area of general chemistry which is preparatory to organic chemistry and inorganic chemistry taken by

students in the second college year. The course materials in CHEM 103 is parallel to material offered in CHEM 101H with the expectation that satisfactory performance in either course enables the student to enter CHEM 104 or CHEM 102H.

After a brief one week review of fundamentals, CHEM 103 covers these topics: atomic and molecular structure in the quantum world, chemical bonding, molecular shape and structure, the properties of gases liquids and solids, the first law of thermodynamics and descriptive inorganic chemistry of the transition elements.

CHEM 104 covers the second and third laws of thermodynamics, physical and chemical equilibria including equilibria in solutions, electrochemistry, kinetics of chemical reactions, and nuclear chemistry. Successful completion of these courses will provide you with an excellent foundation for further study in the various areas of chemistry, as well as in related disciplines such as biochemistry, molecular biology, materials science and chemical engineering.

Learning outcomes: In order to be prepared for further study in the chemical sciences, the student must demonstrate a knowledge of fundamentals that are universally applicable, and be able to use this knowledge to analyze physical observations and problems encountered while working with molecular substances. For example, what is the origin of the blue color of clean water swimming pools? Why do copper pipes used for plumbing in many places in Texas decay so fast? Although this is a first course in chemical principles, these principles are universal and unexpected to change as further knowledge develops of the molecular world.

In general, achievement of success in CHEM 103 will be determined by the students ability to solve problems related to the material of the course which builds upon previously obtained chemical knowledge. The student should review the fundamentals of what has been learned in previous study of chemistry. Some of these fundamentals will be reviewed during the first few class periods and are contained in the section of the text listed as fundamentals. In order to effectively grasp the molecular world, some of these fundamentals must be committed to memory. Au, for example refers to the element gold in English but comes from the Latin Aurum. Similarly the symbol for tungsten, W, comes from the German word Wolfram.

Assignment of oxidation numbers may seem entirely arbitrary, and physicists tend to ignore these numbers, but they are essential to the development of a meaningful understanding of chemical transformations. They are based upon the concept that the element in its natural state, uncombined with other atoms, has an oxidation state of zero. The rules, p. 75 of the text, are derived in part from electron loss or electron gain of the element in combination with other elements. For example, O in OF_2 is assigned the oxidation state of +2 but in the compound H_2O it becomes -2. Yet in both compounds there are 10 electrons strongly associated with each oxygen nucleus, eight from the O and two from each element to which O is bonded. The assumption is made that the ease of electron loss for these elements is H > O > F, which it is. Hence H loses its electrons to O and has a oxidation state of +I while the O become -II in water. In $OF_{2.}$, the F accepts two electrons from O and become -I whole the O atom becomes +II. Review the rules and commit them to memory.

One of the best ways to learn a subject is to explain or teach it to others. Therefore, all homework assignments (except the first one) will be performed in pre-assigned groups of three or four students. Each group will submit a single set of solutions for each assignment, signed by all group members, and each member of the group will receive the same grade for the assignment. Graded in-class exercises and short quizzes will occur approximately once per week. Don't miss them. Sometimes these will also be performed as group exercises by the same pre-assigned

groups as those for the homework problems, and again each member of a group will receive the same grade for the exercise. At other times individual performance will be graded. A satisfactory performance on these quizzes and homework assignments will be 80% correct. If you become ill or must miss class because of other important obligations, please let me know so that I can help you with what you have missed.

The problem assignments are minimal to the learning of the material in the course. Your study guide and solutions manual is available to help you practice with as many problems as you have time. Working through two to three times the number of problems assigned from a chapter each week is highly desireable. Asking questions regarding problems you have found difficult, either in class or during conference hours, is strongly recommended. I may not always have the answer immediately but will help you get it.

Most students will receive an A, B, or C. Failure to do the work so that answers to questions related to the textual materials cannot be determined by you will result in a grade of D or F. The research paper is to be graded according to readability, imagination and content. An example of a good paper is presented below.

Texas A&M Requirements

Course Materials and Copyright Issues

All documents used in this course are copyrighted. Here, "documents" means all materials generated for this class, including, but not limited to, syllabi, quizzes, exams, lab materials, problem sets, and all materials appearing on the class web site. Because these materials are copyrighted, you do not have the right to copy any of them for any purpose other than your own personal academic use unless expressly granted permission. In particular, course materials are not to be given or sold to any profit-seeking enterprise.

Plagiarism

As commonly defined, plagiarism consists of passing off as one's own the ideas, words, writings, *etc*., which belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and submit it as your own, even if you have the permission of that person. If you have any questions regarding plagiarism, please consult the latest issue of the Texas A&M University Student Rules, under the section "Scholastic Dishonesty."

Students with Disabilities

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Room 126 of the Koldus Building. Their phone number is 845-1637. The Student Services office is very busy, so please make an appointment with them immediately if you feel you require assistance.

Aggie Honor Code

"An Aggie does not lie, cheat, or steal, or tolerate those who do."

Upon accepting admission to Texas A&M University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning, and to follow the philosophy and rules of the Honor System. Students will be required to state their commitment on examinations, research papers, and other academic work. Ignorance of the rules does not exclude any member of the TAMU community from the requirements or the processes of the Honor System.

For additional information please visit: www.tamu.edu/aggiehonor/

Reading Assignments and Schedule:

Week	Date(s)	Text Sections	Chapter Title	Text Pages
1, 2	Aug. 29- Sept. 5	A1 - M2	"Fundamentals"	F1 - F93
2, 3	Sept. 7- 19	1.1 - 1.21	"Atoms: *The Quantum World*"	1 - 47
4, 5	Sept. 21- Oct 3	2.1 - 2.17	"Chemical Bonds"	52 - 78
6	Oct 5	Review		
.	**Oct 7**	.	**HOUR EXAM No. 1**	.
7, 8	Oct. 10 -17	3.1 - 3.14	"Molecular Shape and Structure"	86 - 118
8, 9	Oct. 19 - 26	16.5 - 16.7	"The Elements: *The d Block*"	620 - 630
10	Oct 31 - Nov 9	4.1 - 4.17	"The Properties of Gases"	126-154
.	**Nov 4**	.	**HOUR EXAM No. 2**	.
11, 12	Nov. 11- 18	5.1 - 5.15	"Liquids and Solids"	143 - 187
13 -15	Nov. 21 - Dec 5	6.1 - 6.22	"Thermodynamics: *The First Law*"	198 - 236
.	**Dec. 13 8:00 AM**	.	**FINAL EXAM**	.

Expanded detail:

Fundamentals

Sections A.2, A.3, B.4, B.5, C.2, C.3, E.1, E.2,H.1, I.1, I.4 (solubity rules) J.1, J.3, K.1, K.2, L.2, L.3, M.1, an M.3 are particularly important.

Homwork due September 7: **A.4; A.22; B.10; B.18; C.12; D.12; D.24; E.4; E.8; F.10; F.14; G.8; G.18; H.8, I.24, J.6; K.8; L.10; L.18; M.14**

Other assignments will be given approximately one week before they are due.

Example paper

JASON'S BLAST

Jason had just turned 21. His birthday celebration had been a real blast. It was the first time in his life that he could order a beer without permission or support of his parents, and he had drunk plenty. He should have know the consequences, but sometimes knowledge isn't enough. The problem was that he had little to eat earlier in the day.

Beer contains a few percent of ethyl alcohol, C_2H_5OH, a chemical[1] that quickly passes through various membranes in the stomach and intestines to enter the blood stream.[2] If the stomach and intestines are coated with foods, the alcohol penetrates into the blood stream more slowly, making it possible for the body to metabolize the alcohol before it can block various nerve receptors.
In effect the body "burns" the alcohol by combining it with oxygen. This reaction follows the equation:

$$C_2H_5OH(1) + 3O_2(g) = 2CO_2(g) + 3H_2O(1)$$

It is an exothermic reaction which gives off - 1367 kJ of thermal energy per mole of alcohol.

Jason had managed to drink 3 liters of beer during the evening. Therefore, Jason had consumed about 150 mL of ethyl alcohol assuming each bottle of the strong beer he had drunk contained 5% alcohol. Based on a density of 0.80g/mL and a calculated[3] formula weight of 46 $gmol^{-1}$ for ethyl alcohol, he drank 2.6 moles of the chemical. If he had taken this as absolute alcohol, without dilution, he probably would have passed out within minutes. The number of receptor sites that could be blocked by 2.6 moles of alcohol is 1.6×10^{24}, a number far to large to fathom. Accordingly, a protein weight of about 78 kg would be needed assuming that one receptor can be found for each 30,000 molecular weight of protein. This calculates out to be 175 lbs of protein, and Jason only weight 160 lbs total. Fortunately much of the alcohol got burned up before it could interfere with Jason's nervous system. Maybe that is why Jason started to get warm after a couple of beers.

After the party a friend got ready to drive Jason home. Unfortunately this friend was himself a little bit unsteady. The net result was that Jason and his friend were stopped by a patrolman before they got into the car. The patrolman asked them a few questions and realized that they should not drive. They were given a breath test which immediately determined that alcohol was being eliminated from the lungs. Unmetabolized alcohol vapor expelled from the lungs is usually present in very small amount after one or two beers, but these guys obviously had more than just one or two. The patrolman suggested that the parents of Jason be called, who came and took the lads home. The patrolman had been most understanding when Jason told him about how much fun he had at his 21st birthday celebration.

In the morning Jason's head felt terrible. He decided to find out why. Upon going to the library, he learned that alcohol is partly oxidized to an aldehyde on the way to the formation of carbon dioxide and water. Aldehydes also can combine with amines to form amides:

$$CH_3C(O)H + NH_2R = CH_3CH{=}NR + H_2O$$

These and other metabolic products can produce a toxic reaction from which it takes many hours to recover. The liver normally eliminates toxic products by hydroxylation. Food would have helped Jason, but now it was too late.

Jason also learned that the aldehydes, amides and related products of the metabolism chemistry of alcohol can coordinate to important metal ions in the liver, metal ions which are part of the enzymes. The net result is that some of the enzymes that would help prevent cell damage by oxygen radicals such as OH or O_2 become nonfunctional. Damaged cells contribute to the nausea and

uncomfortable feeling called a hangover. Vitamin C(L-Ascorbic acid) can help. Vitamin C, $C_6H_8O_6$, is an antioxidant[4] which helps remove the oxygen radicals. It has long been used in the preservation of foods, such as applesauce, from air oxidation. There is some evidence that the vitamin can protect against cancer causing oxygen radicals which damage DNA. Nobel Laureate Linus Pauling advocated vitamin C's use on a daily basis in gram quantities.

Jason learned that copper[3] containing enzymes in the liver can react with oxygen radicals according to the following equation:

$$Cu^{+}+OH = Cu^{2+}+OH^{-}$$

This reaction effectively removes the hazardous OH radical from the cell before it does damage. The Cu^{2+} is reduced to CU^{+} by thiol containing amino acids (cysteine) in the cell, becoming available for further oxidation by the oxygen radicals. This reduction reaction by thiols can be described as follows:

$$2RS^{-} + 2Cu^{2+} = RSSR + 2Cu^{+}$$

Some persons lack the ability to synthesize alcohol decomposing enzymes because of genetic factors. Such persons, Jason read, should avoid alcohol completely because the chemical is not metabolized easily by liver enzymes. Intoxication occurs rapidly and cells develop a speeded up chemical function which causes a further craving for the chemical. These persons easily become "alcoholics", persons who cannot effectively control their alcohol intake. Not all alcoholics are deficient of the genetic material to produce alcohol controlling enzymes, however. Psychological factors can contribute to the development of the disease.

Jason found that the chemically and biochemistry of alcohol have many interesting facets. Alcohol is a natural product arising from the anaerobic (no air) breakdown of sugars such as sucrose, $C_{12}H_{22}O_{11}$. Yeast fermentation occurs according to the following reaction:

$$C_{12}H_{22}O_{11}(aq)+H_2O(1) = 4C_2H_5OH(aq)+4CO_2(g)$$

This reaction is exothermic, giving off many kJ of heat energy per mole of sugar fermented. Jason visited a brewery and learned that much heat energy and CO_2 are released from the brewing vats. Jason was told that the sugar containing substances undergoing fermentation of sugars. These sugars come from fruits such as grapes. Fermentation can occur naturally without the artificial introduction of yeasts grown for the special fermentation involved.

Jason found that there is a major chemical industry[1] devoted to fermentation and the production of alcohol. Many chemists are employed by this industry. Corn and cane sugar is fermented in ton quantities to produce alcohol for gasoline, so called "Gasohol". Jason thought he would apply for a summer job as a brewery chemist. He had learned a lot from his experience.

References.

1. Bernice G. Segal, “Chemistry Experimental Theory”, John Wiley and Sons, New York, 1989.
2. Susan Budavari, Ed., “The Merck Index”, Merck and Co., Rahway, New Jersey, 1989.
3. F. A. Cotton and G. Wilkinson, “ Advanced Inorganic Chemistry”, 5th Ed., John Wiley and Sons, New York, 1988.
4. D. R. Haynes and M.W. Whitehouse in “ New Developments in Antirheumatic Therapy”, K. D. Rainsford, Ed., Kluwer Acad. Pub., Lancaster, U.K., 1989, pp. 207-235.

T E X A S A&M U N I V E R S I T Y
DEPARTMENT OF CHEMISTRY
College Station, Texas 77843-3255

Tel: (979) 845-2835
(979) 845-0648
Fax:(979) 845-9351
E-Mail: FACKLER@MAIL.CHEM.TAMU.EDU
http://www.chem.tamu.edu/faculty/fackler

Dear Chemistry 103 student:

I look forward to working with you as you study and learn general chemistry. I have taught freshman chemistry often in my nearly 50 of teaching, starting at MIT, then UC Berkeley, Case Western Reserve University and now here. I have worked with students as a student advisor, as department head, a Dean and especially as a mentor of over 25 PhD graduates and 50 postdoctoral associates, most of whom have gone on into successful careers in academics or industry. Over 50 undergraduates have worked in my laboratory as research students and some have gone on to become award winning scientists and teachers. One Aggie who took 101H with me went on to become one of Governor Perry's assistants after graduation. Several have careers in medicine. It is exciting for me to see the progress made by talented young people who have been in my classes.

I am very active here at A&M helping the University evaluate and assess what it does as it progresses toward the desired achievements of Vision 2020. You probably can find my name on some University WEB pages unrelated to chemistry. You might even find an interview with me as to why I became an academic scientist with over 300 research publications, several books and several million dollars of research funding over the years. Much of that funding supported students who have studied with me. I hope that some of you obtain such opportunities in the future.

Unfortunately you cannot be expected to learn everything in general chemistry. At this time some material will simply be descriptive without your development of a full understanding. For example, the differential equation, (8a), on page 12 may be gibberish at this stage of you science career. In the future you probably will learn to solve such mathematical equations but at this stage of your career it is sufficient to learn what the solutions look like and their consequences. Their mathematical form (page 21) dictates for H atoms the energy levels and spacial features we will use in our discussion of chemical bonding.

Good luck with the course. You will get out of it what you put in. The more time you put into it now, the easier advanced courses in the chemical sciences will be for you in the future.

Sincerely yours,

Laboratory for Molecular Structure and Bonding

John P. Fackler, Jr.
Distinguished Professor of Chemistry