Chmy 361
Elements of Physical Chemistry,

website: http://www.chemistry.montana.edu/callis/courses/chmy361

Instructor: **Pat Callis**

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Textbook: Tinoco, et al. in Bookstore, **5th EDITION*****

***This edition is substantially revised** **(4th Ed. does not work)**

***Lab: CHMY 362 or 372:** Everyone who wants to take the lab, whether registered or not yet, should attend class **at 2:10 pm in Gaines Hall room 343**.
on **this Wednesday (362) or Tuesday (372)**
The TA (David Chen) asks that you bring a **thumb drive** to class.
The professor is Prof. Tim Minton <tminton@montana.edu>

Homework

Graded homework assignments will be given for each chapter. The total homework and midterms are worth 100 points each and the final is worth 200 points, giving a total of 700 points.

The first homework assignment will be posted on the website by tomorrow and will be due Tue. September 12.

More on that tomorrow.

Why Physical Chemistry?

Some quotes from your textbook:

"The POWER of Physical Chemistry lies in its *generality*."

"Physical chemistry has been especially powerful in understanding fundamental biological [, geological, and climate] processes."

"There is a deep sense of *pleasure* to be experienced when the patterns and symmetry of nature are revealed"

Physical chemistry is *everywhere*. "Its principles are basic to the methods used to sequence the human genome, obtain atomic resolution structures of proteins and nucleic acids, and learn how biochemicals (+ water, salts, phosphate) interact to make a cell function."

Working Hypothesis: Living matter obeys the *same* physical principles as non-living matter.

THE WHOLE OF SCIENCE IS NOTHING MORE THAN A *REFINEMENT OF EVERYDAY THINKING.*

-- A. EINSTEIN

Thinking does not necessarily mean understanding. Many crucially important facts about our reality are not possible to “understand” at present.

Today we focus on these facts!

Remarks on Knowledge and Learning:

Quantum Mechanics and why chemistry is difficult to teach

You cannot learn — ***if your knowledge is not organized!***

History is not boring — ***if it organizes your knowledge.***

Thermodynamics was developed ***much*** before quantum mechanics (1800-1900) — ***when nobody had a clue about the structure of atoms.***

Quantum ideas—*essential for understanding chemistry*—developed slowly over 25 years (1905-1930 — ***beginning while there was still no picture of the atom in 1905 !!***

Only from Rutherford's experiment in **1912**—was it revealed that ***electrons do not fall to the nucleus* despite enormous electrostatic attraction!!!**

All students of chemistry can easily see—***that Newton's Laws fail for electrons.***

The two most powerful facts for Chemistry ***cannot be "understood" in the usual sense of the word:***

1. 1926: Schrodinger equation—***contains Newton's Laws of Motion and predicts orbitals of electrons, and has NEVER FAILED!***

2. THERE ARE ONLY ***TWO CLASSES*** of PARTICLES KNOWN!
Fermions (***electrons*, protons*,*** neutrons, ^{3}He)—which obey **Pauli Exclusion**;

Bosons (deuteron, photons, ^{4}He) –- which obey "**INCLUSION"**, (identical bosons all want to have the ***same*** quantum numbers, leading to phenomena such as lasers, superconductivity, superfluidity, etc.

REALIZE: that these profound facts ***describe*** nature perfectly as we now know it.

But no person ***"understands"*** ***why*** they work.

Therefore your job is **NOT to "understand"** these incredible facts.
Just KNOW them, marvel at them, and enjoy them.

All of chemistry can be computed (in principle) from these two principles, given enough computer power.

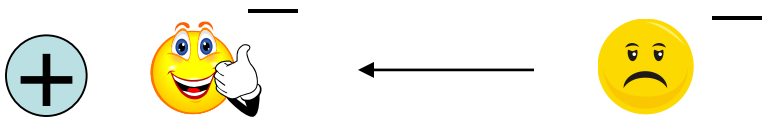
The Working Theory of Chemistry, Biology, and Geology— is simple:

Matter? **Nuclei (+) and electrons (-)**

Potential Energy? **Electromagnetic --> Coulomb's Law**

= constant * charge1 * charge2 /distance

Atoms: **electrons seeking a more positive environment**



Chemical Energy: **electrons getting to a more positive environment by pulling nuclei together**

Mechanics: **Quantum (describes everything; it contains Newtonian mechanics, and "becomes" Newtonian mechanics as the masses and energies become large)**

What is Physical Chemistry?

Applies fundamental principles of physics to chemistry—and therefore to biology, medicine, geology, materials, new energy sources,.....

Three Realms of Physical Chemistry:

1. Micro: electrons, nuclei, and their forces (only Coulomb's Law)
+ quantum mechanics (chapters 11-14)

2. Statistical Mechanics: the bridge from micro to macro using quantum properties + statistics and probability principles
(chapter 5)

3. Macro: Equilibrium: 3 laws of thermodynamics (chapters 2-7)

Non-Equilibrium: Transport, e.g., diffusion (chap. 8)
Chemical reaction rates (chaps. 9-10)

We will study these in the reverse order, the order in which human beings discovered them

Einstein on Thermodynamics:

"A theory is the more impressive the greater the simplicity of its premises, the more different kinds of things it relates, and the more extended its area of applicability. Hence the deep impression that classical thermodynamics made upon me."

"It is the only physical theory of universal content concerning which I am convinced that, within the framework of the applicability of its basic concepts, *it will never be overthrown.*"

--Albert Einstein

We will focus on learning and applying the Three Laws of Thermodynamics for the first half of this course.

Please Read pages 13-15, (at least), for tomorrow

Physical chemistry is everywhere. Some questions you *may (or may not)* have:

Why are temperatures usually colder at higher elevations?

What is the difference between temperature and heat?

Can a ship use the vast HEAT ENERGY in the ocean water to propel itself??? (freezing cold water at 273 K is only 20% less energy than burning hot 330 K.)

What is "vapor pressure of a liquid"?

What is relative humidity?

What do x-rays and microwaves do?

Why is the sky blue, but sunsets are often red?

Why doesn't the electron fall into the nucleus in a hydrogen atom, even though there is an *enormous* force of attraction?

What is the natural logarithm of e^{-3}?