

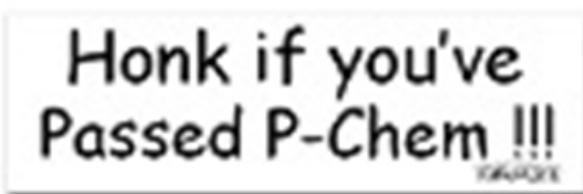
Physical Chemistry Courses at CU

Chem 4511/4531: Physical Chemistry I and II.

Chem 4411/4431: Physical Chemistry with Biological Applications I and II.

Chem 4521: Physical Chemistry for Engineers

Fall 2008: Focus on 4511 and 4411. Approximately 2/3 common course content, similar student populations.



Perceived difficulties (as reported by students and faculty):

Very abstract, disconnected from other courses in the major.

Very mathematical (compared to other chemistry courses.)

Students solve problems by grasping for equations.

Summer/Fall 2008: Planning for P Chem I

1. Discussed learning goals (developed by Amy for 4411.)
2. Revised a P. Chem. Concept Survey (originally developed by Linda Koch) to focus on common course content. Administered to both classes in Fall 2008, pre and post
3. Implemented two different interactive strategies:
 - 4411 (AP): Daily breakouts (already used in Fall 2007)
Do this every class period.
Break students into groups of 4-6.
15-20 min to work on a series of questions.
 - 4511 (RP): Clicker questions and JITT

CHEM 4411: Motivation for breakouts

1. Engage students.
2. Learn how students think about concepts (identify misconceptions).
3. Develop problem solving skills.
4. Give students an opportunity to learn from each other.
5. Make class more interesting.

Student testimonials

“They were very useful because they gave me the opportunity to hear from other students who might explain things differently and to explain concepts by teaching others.”

“While I honestly sometimes dreaded the break out sessions, they were actually very helpful.”

“The hands on activities were super useful because they allowed us to see that the principles we were learning are actually true and aren't just made up.”

What worked

Breakouts were designed to be challenging.

Breakouts emphasized conceptual understanding and problem solving.

Breakouts were strongly integrated with assessment (i.e. exams).

Biggest challenges

Need more people in the classroom to interface with groups.

Room not conducive to group interaction.

Some groups “work better” than others.

Sample break out

Name: _____

Break-out 1^q : Bioenergetics

The hydrolysis of ATP is given by the reaction below:



In cell biology this reaction is commonly coupled to unfavorable reactions in order to enable these unfavorable reactions to occur.

(a) In living cells the amount of energy produced by ATP hydrolysis (i.e. $\Delta G'_{rxn}$) can vary from 25 to 40 kJ/mol. Explain why this is so (i.e. what factors might influence this value).

Difference between standard Gibbs energy and Gibbs energy for a particular rxn.

Sample break out (continued)

(b) Explain why hydrolysis of ATP is such a favorable reaction. You should be able to come up with three reasons.

What determines favorability (think about ΔG , ΔH , ΔS)?

Recognize that they need to consider the chemical nature of products and reactants.

Recognize that what matters is the difference between products and reactants.

(c) Your roommate is an MCDB major and has not had the good fortune of taking Physical Chemistry. Your poor ill-informed roommate tells you that ATP hydrolysis is characterized by a large negative Gibbs energy because “it involves breaking a high energy phosphate bond”. What is wrong with this statement?

Dispelling myths (“ATP bond is special”)

Teaching students the importance of being precise in scientific explanation.

Chem 4511 Fall 2008

MWF Lectures (with Clicker questions)

Conventional Textbook (Atkins)

Traditional Weekly Homework problems (via WebAssign)

Extended written homework assignments

Evening Exams (three midterms)

“Just in Time Teaching”: (Novak et al. 1999).

“Warmup”: Pose questions online before each class

“Mindful/Insightful Lecture”: Instructor reads responses before class, adapts lecture accordingly.

“*Puzzle*”: follow up with a challenging problem

“Just in Time Teaching” (JITT)

Sample JITT Warmup Questions:

One popular metaphorical expression of the Second Law of Thermodynamics is "You cannot unscramble an egg." But is this really true? What if you feed the scrambled egg to a chicken and then wait for it to lay another egg?

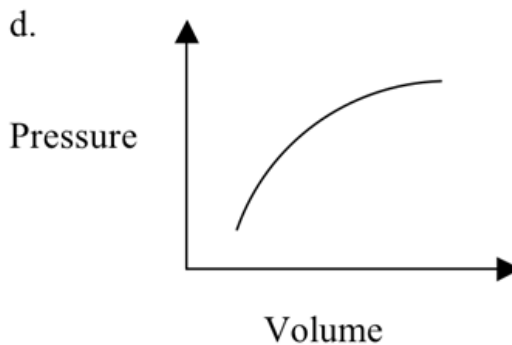
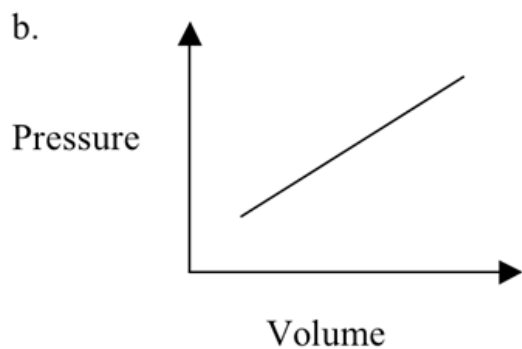
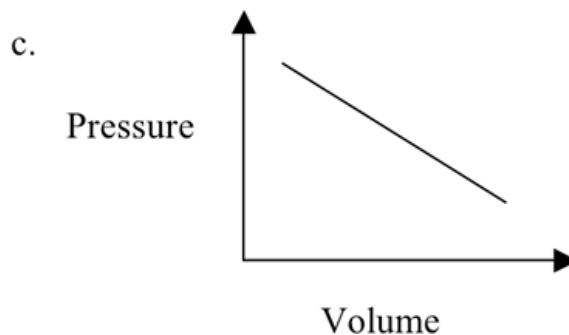
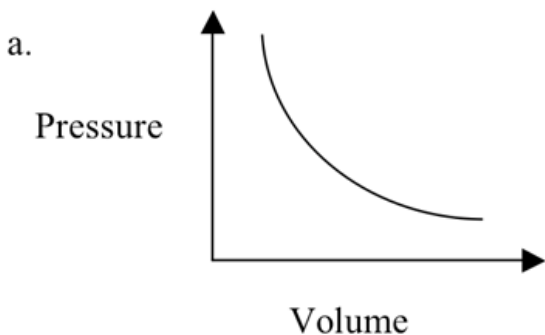
A flask partially full of liquid water is heated to boiling, and then promptly capped. Cold water is poured over the flask. The water inside then starts to boil more vigorously. What is going on here?

Thoughts on CT and JITT in upper division classes

- **Concept Tests:** harder to find or construct questions that effectively target areas of student difficulty than in lower division courses. But easy to implement and familiar to students. Recommend.
- **JITT:** extraordinarily useful, but time-consuming for instructors. Need to develop a database of good questions. Recommend with reservations (for now).

Concept Survey: striking differences between classes

Which graph best represents the relationship between Pressure and Volume for an ideal gas? Assume the temperature and number of moles of gas remain constant.



a.	4411	4511
Pre	31%	57%
Post	65%	52%

Diagnosis (Tom P.) and treatment (R.P.)

4411 Fall08: students constructed a PV curve as part of a breakout activity.

4511 Fall09: students did PV calculations but merely *saw* lots of curves.

4511 Spring 09: (Taught by Veronica Vaida). RP designed clicker questions that involved having students both calculate and draw curves. Huge improvement in post scores!

	4411 Fa08	4511 Fa08	4511 Sp09
Pre	31%	57%	44%
Post	65%	52%	74%

Quotes from Student Interviews

“ I feel like this class, you have to really know what you’re doing” (4411)

“That it is a lot of material. You need to be prepared to put some time into it. It’s not just a normal under-division kind of class. But at the same time, it’s really interesting material, and if you work at it, you can learn a lot and you can have a lot of fun in it. It’s not as scary as it sounds.” (4411)

“I like the problem sets. They’re—I—I mean, like, this one in particular tied together a lot of different things. One of the—I think it was, like, the second one that we did tied together things that I didn’t even realize could be tied together. It just kind of—it brings everything together for me, and that makes it helpful.” (4511)

“I’ve come across some scenarios in my life where I can look at something that’s happening in real life and actually understand the chemistry behind it. For me, I find that’s interesting, nice to know what’s going on.” (4511)

Thanks to:

- Linda Mayfield (*nee* Koch) and Jack Barbera
- Lynn Geiger, Veronica Bierbaum, Debbie Wuttke
- David Wren
- Stephanie Chasteen
- Veronica Vaida
- The Science Education Initiative (SEI)
- The Physics Education Research Group (PER)
- The Discipline-based Education Research Group (DBER)