PRELIM 2001 QUESTIONS
Compiled by Ana O'Neill

Patty Cheung

Transport: Radke and Balsara
Flow through a square pipe. I set up the Navier Stokes equation, and boundary conditions. Then I had no clue how to solve the equation...so they asked me which method I would use to do it so I said separation of variables. I started working it out, then they stopped me and didn't ask me to go on. Can't remember what else they might have asked me. I had this exam really early in the morning and I was also pretty nervous - I thought I totally screwed up...but Radke reassured me as I was leaving that I didn't do that badly...and they passed me.

Process: Wallman and Cairns
After telling them I was from MIT and didn't have a controls class, Wallman told me to talk about my sr. design project. This part was kind of easy because they didn't have too many questions. Guess our design project wasn't too complicated since we had to do all our calcs. on excel...which they were surprised and unhappy to hear. Then Cairns asked me how to make nickel. What ore? (Ni2O3) Which acid would you throw it in? (H2SO4 - either this or HCl, but sulfuric acid is cheaper) What could I do with the spent acid? (Make CaSO4 - used in making dry wall) How would I separate out the Ni? (galvanic cell) Which reactions?...Basically I knew the general way to make Ni, but not the details...who would?!! They let me out 10 min early and I thought I did fine, but they failed me anyway.

Kinetics/Thermo.: Arup and Graves
They asked me to find the maximum temperature of a CSTR for the given reaction (methane combustion, maybe?...I forget) then I thought it would be fun to ask Arup to give me an energy vs. entrope questions (he promised that if any of us had him for the prelim, he would ask us one)...so he said that he'd think of one: Why do oil and water not mix? I talked about minimizing the helmholtz energy (max entropy, min energy - especially surface energy, blah, blah, blah). Then Arup asked me to draw the G-V diagram for water – how would it change with temperature and pressure and at the critical point - stuff he taught in 240. I finished this one 15 min. early... Finishing early doesn't always mean that you did well - as I learned in the process test.

Jessica Defreese

Process Design and Control (Prausnitz/Keasling)

1. How do you get O_2? A series of questions from that, how do you cool the streams, what is O_2 used for, how does a JT expansion work, can you do the same thing for hydrogen, etc.

2. Do you know what trichloroethylene is? (apparently used for dry-cleaning, pollutes the groundwater) How would you get it out of the groundwater? (I said adsorbing to activated carbon…Keasling said that was an excellent method but not the main one because of economics….I mentioned distillation and absorption into another organic solvent as bad methods on my way to being like "oh yeah, duh, strip it into an air stream") Keasling then drew me a graph of the TCE concentration going down as you treat the groundwater, but after you turn the pumps off, the concentration of TCE in the groundwater starts going back up. Why? (It took a little prodding to get me through this, because I didn't quite understand what they were looking for….I ended up realizing that it must desorb from the rocks/soil surrounding the groundwater which got me a fatherly smile and a "see, I knew you could figure it out" from Prausnitz)

3. Prausnitz then asked me about depreciation. I struggled through it more than I should of, because I was like "ah! Economics?!" The IRS came up. Sheesh.

4. My last question was a control one from Keasling. If you have a hot tub and you leave the temperature turned down during the day but want to turn it up at night, what types of control methods could you use. I

drew response curves for P, PI, and PID controller. He then asked me which one would you want to use and why. I said some decently intelligent stuff, but never quite got to what he was looking for (using the PID allows you to turn the gain up and reach your setpoint temperature faster)

<u>Transport (Schaffer, Goren)</u>

1. The infamous “rod up the turkey’s butt” problem. Took me at least 15 minutes to flounder my way to a faltering “4?” to which Dave just cocked his head and so I was like “one-fourth?” and we finally got to move on.

2. The siphon problem. I did well on this because I had just worked it out a few days before. Don’t remember exactly what was asked, but obviously it’s buried somewhere in the available prelim questions.

3. I also got a question from Goren about flow in pipes, friction factors, roughness, etc. If I remember correctly, he wanted me to try and explain some stuff about boundary layers.

4. I also got some question about the earth and gravity and stuff, but I can’t remember it anymore.

<u>Thermo and Kinetics (Clark/Bell)</u>

Bell asked all the questions (Clark didn’t even open his mouth). The first question was about a CVD reactor. I think the gas was reacting on the walls of the reactor or something. The problem wasn’t that difficult, and I got the right answer, but I think I took longer than Bell would have liked.

Then I got pinned to the wall by fugacity. Bell wanted me to prove one of the basic equations (like delta G = -RTlnK) from ground zero. Since I suck at fugacity stuff (and since we had Arup for thermo…..) I was in serious trouble (especially when I got “this is not going in a fruitful direction”). I think Bell thought it was an easy question, because the last time he gave a prelim was when Prausnitz used to teach the grad level thermo class.

Anyway, I failed this one, so I’ve blocked most of it out of my mind.

Kai Wang

<u>Thermo and Kinetics: Prof. Reimer and Bell</u>
Reimer:
Draw and explain, T-xy P-xy diagram of mixture of propane and butane
How to calculate exit mole fraction and flow rate in the flash drum from the T-xy chart?
Rxn A+B=C+D
How to calculate the concentration of component in the rxn?
How to calculate fugacity coefficient?
What’s fugacity? How do you define it?
How to calculate entropy? Integral of (Cv/T)dT
Bell:
Rxn: AB=A+B
How to describe the rxn rate? I wrote out first order rate law and drew Ea vs. rxn coordinate diagram and had the energy of products lower than energy of reactant. They grew mad because dissociation rxn should be endothermic not exothermic.
What’s the mechanism like if the rxn takes place on a surface?
Bell said that Tuesday Vice Chair will discuss our prelim results, and I thought I had failed this one.

<u>Process Design and Control: (Prof. Lynn and Wallman)</u>
As it was said, I was first asked about my senior design project. It was hands-on work on a fermentor not a traditional paper design of the whole process for a chemical. They did ask me about the chemical structure of my chemicals, i.e. citric acid and sucrose. After I talked for almost half an hour about the fermentation

reaction, they said it wasn't what they want to test me on , so they asked me about a flash unit to separate ethanol and water at constant pressure (remember this VLE has an azeotrope). The pressure is controlled by feedback control loop on a valve on the vapor stream. They asked me to calculated V, L, x and y with two material balances, one energy balance, and one vapor liquid equilibrium relationship (4 equations and 4 unknowns!). We ran out of time to test me more on process control.

Both of them were very helpful and provided good hints. Wallman asked most of the questions. Lynn asked one, and I wasn't sure what he meant. It felt that Lynn was really interested in teaching me something about design and not necessarily just giving me a hard time.

<u>Transport: (Porf. Goren and Schaffer)</u>
Prof. Goren:
*Calculate light bulb filament temperature and glass temperature, heat transfer problem, how to find h (use Nu number Nu=C*Re^n*Pr^m. calculate Re and Pr)
Prof. Schaffer:
*Ice in water problem
*Heat lose of sphere in flowing air

Hany Eitouni

<u>Transport</u> with Newman and Shaffer.
I think I had the same questions as everyone. The main problem was to calulate how the cooking time of a turkey decreased if a metal nail was inserted to the center. Along with this I had to define all the dimensionless groups that I could think of. Another problem was to calculate the weight of the atmosphere. There was another problem I don't remember well about a sphere in a moving fluid...something about real fluids and inviscous fluids and how shear and skin and form friction come about. This was a difficult problem, but Newman answered most of his own questions.

<u>Kinetics</u> with Graves and Clark.
Clark was difficult. I basically derived Lanmuir's isotherm problem and discussed exothermic and endothermic reactions that could be reversible or irreversible (temperature profiles of reactors and best operating conditions...)

<u>Process</u> Prausnitz and Cairns.
It was kind of fun because Prausnitz sat with his eyes closed almost the entire time (he was awake and listening though). Cairns asked about how to make many metals and about my design project. Prausnitz asked how to make a few chemicals industrially like $CaSO_4$ and about plant economics. He also asked about how to purify oxygen, nitrogen and helium. I was a little sketchy on my finacial terms but they let me go early.

Jon Eide

<u>Thermo and Kinetics</u> with Graves and Clark:
They asked a bunch of small questions. Nothing really big. They were actually looking through thermo and kinetics books as I walked in to think of questions. Some of the questions they went over were about some reaction rate questions (like what you do at beginning of 244), energy changes in the reactions, possible ways to speed up reactions or slow them down (ie, how to make the catalysts to do this), and then they ended with a question about how a fridge works (i.e.. write down the cycle and explain).

<u>Transport</u> with Balsara and Radke:
I don't think Balara said one word because he had just flown in from somewhere east and had not slept in a long time. He may have slept during this one. This was one large question about a flow in a square pipe. First I had present the proper equations and then show how I would solve them (but I did not have to). Just explain how I would have. Then we went into how I would measure the pressure drop and friction factors.

AS you should know they are related and can be determined by know the geometries, flow rates etc. (it is all in Bird,Stewart and lightfoot). Then we talked about how to measure the Re numbers in the case of turbulent flow in this square pipe. What should be used as the length scale etc.

Design with Keasling and Blanch:
Keasling took a small nap during this one. I think I did as well. I know nothing about design or process yes somehow they passed me. Basically they just asked me a bunch of question on one would make this or purify this. I knew what reactors/process to use (because I studied a design book several minutes earlier before the test) but for some reason they though this was a organic Chemistry PhD and asked me exactly what acids and other crap to use. I had Organic chemistry as an undergrad with all the pre-meds and forced my self to rid my mind of such worthless knowledge long ago so I had no idea. I basically raddled off organic compounds until they said that one was right. Hey, a B- is a pass so that is all that counts.

Brian Frushour

Transport - Newman and Schaffer

Schaffer started off by asking me what the units length squared per time meant to me. Although I was tempted to give some smart ass answer, I said diffusivity. That led into a discussion about the analogies between mass, momentum and heat transfer and Newman asked me when they do not hold (radiation, high rates of m.t.,etc.). Then I got a question about an ice cube melting in a glass of water (the level doesn't change). Schaffer asked me to calculate how much time you save by cooking a turkey with a metal rod in the middle, but he only wanted me to use characteristic values. He also asked what the controlling resistance was. This was a pretty easy committee; Newman will help you out if you get stuck.

Thermo and Kinetics - Arup and Graves

Graves started out by saying "I think this is a fair question." That's when I knew I was in trouble. He asked me about gas ionization in a light bulb and I had no clue how to answer it. He helped me through it a little and it involved collision theory, mean free paths and other things that I hadn't studied. I can't remember the specifics - its kind of a blur. He only left Arup with about 5 minutes and he asked me about 1st and 2nd order phase transitions and something about orange juice in a bag surrounded by water. I did alright on Arup's questions, but still failed this one.

Design - Cairns and Prausnitz

Prausnitz started out by asking about my design project which was the production of ethylene oxide from ethylene and oxygen. He asked where I could get oxygen from and I said air and talked about that process for a little bit. Then he asked what I could do with the leftover nitrogen and I said "make ammonia" and we talked about the Haber process. Then Cairns asked me how to make lithium and I stumbled through that, but eventually got it. While Cairns and I were talking, Prausnitz began reading a paper. I looked over a couple of minutes later and he was asleep! He woke up in time to ask me why you can't depreciate the full value of something in the first year. I said that the government has depreciation plans that you have to follow. Prausnitz said "But who in the government is it? - its not the police that say you can't depreciate something all in the first year" So I said the IRS and he said "Good, a lot of people don't know that" and that was that.

Yoshie Kimura

Transport – Balsara and Newman

For a flow through a square tube, they wanted me to setup a complete momentum balance with boundary conditions and then to simplify the balance by making assumptions that might be appropriate such as Newtonian fluid, no frictional loss, laminar flow and infinitely long tube. When I forgot to include a term in my original balance Newman opened up his BSL to help me. Newman asked me how to solve the simplified equation.

The second question was about a spherical turkey with a well conducting rod up its butt. I needed to figure out how the rod will change the cooking time. After some prodding and Newman's tragic story about his Thanksgiving turkey experiences, I came up with the Fourier number that predicts that the turkey will cook 4x faster with the rod.

<u>Thermo and Kinetics – Chakraborty and Katz</u>

Arup asked me to draw the PT diagram for water. Based on the negative slope of the solid-liquid line, I explained why the solid had a lower density than liquid using the Maxwellian relationship from the Hemholtz equation. Then I drew two graphs of Gibbs free energy versus density curves: Graph 1) I plotted lines at constant pressure but varying temperature with one line at liquid-solid equilibrium; and Graph 2) I showed a 2^{nd} order phase transition and related the transition in the PT diagram. Needless to say, I learned this stuff in Arup's class and not in my undergrad classes.

Alex asked me the kinetics problem on mothballs. I failed the Thermo and Kinetics prelim because of this problem. I blocked it from my memory so read other peoples descriptions.

<u>Process Design and Control –Lynn and (winking) Blanch ;)</u>

Lynn asked me to explain my senior project that made propylene glycol from lactic acid. Harvey informed me that lactic acid eats the stainless steel recommended in my design so I should have used rubber or glass. Fortunately Lynn didn't know either so I was saved. While asking me questions, Lynn forgot and asked me one question twice, 15 minutes apart. I repeated the same answer twice.

In the remaining time they asked me about producing sulfuric acid. They asked me why oleum was made and I said "for dehydrant," but they wanted to hear that transportation is cheaper for oleum than for sulfuric acid because you don't move water.

Adam Weber

<u>thermo and kinetics with Graves and Clark,</u>

They were running a little late so we didn't have that much time. After talking a bit, Clark asked me some questions about basic first law and second law type stuff. Then he came out with how much energy is needed to be converted from fuel to breach the earth's atmosphere with a rocket. He was pretty nice and framed his questions well. He wanted the definition of enthalpy, the physics equation for gravitation between two masses, the how to change enthalpy at various temperatures, definition of heat capacities, etc. I wasn't quite on the same wavelength as he was but he helped me out. Before I knew it, it was over. Graves had just nodded and smiled and the only kinetics question we got to was how do you spell kinetics, which I am happy to say I answered correctly.

<u>transport with Muller and Radke,</u>

This was actually the best prelim of the day. If you don't mind Radke waving his hands and telling you what to write before you can finish then you are fine. I would say to just go with the flow and don't get too worried about the interruptions, it can be fun. The question was the same as that asked to other people. First, it was about flow through a pipe by gravity and how high you can loop it before you get to a low enough pressure that cavitation starts. Next was an example from BSL which involved the movement of fluid down an inclined plane. I had to draw velocity profiles and boundary layers and put down the relevant equations. I also had to say how I would solve them (similarity transform) and what the solution would look like near the plane. Susan was very helpful when I got stuck, and Clay was Clay.

Design with Keasling and Blanch,

They both were pretty tired of listening to people (I was the last of the day) and their senior design projects. I sat down and talked to them for a little bit about random design questions. The wanted to know how to treat various hazardous wastes (incineration, etc.) Next, they said they wanted to remove Cadmium from a discharge stream. I said that since it was a heavy metal and in water, you shouldn't incinerator it because of cost, etc. They said it was in low quantities and I told Harvey to let his designer bugs to do it. They wanted a traditional answer so I thought and came up with fixing it and settling it out by a chemical reaction. They wanted to know what to use. (Sodium sulfide since cadmium sulfide is insoluble.) Next, I went to the board and I asked if they wanted to see my design project "SCWO". They said no, I said it was really cool, they still said no, I said but its SCWO, again they said no. Jay asked his spa questions and had me draw the controller profiles which I didn't get quite right. Then Harvey wanted me to draw basically a scrubber. I had to put down all of the relevant equations and discuss various effects (like a reactive cooling tower, I had to mention the enthalpy balances, the mole balances, the chemical reaction, the evaporation and heat transfer equations, what would happen with recycle, how would the high heat of reaction and mixing effect recycle and the system, how do you get high conversion, etc.) It kind of been brutal but it was Harvey and Jay and they were nice. I asked if this was a 250 question and they said no, it was 251, but that wasn't going to be taught anymore if Harvey had to do it, we all laughed and I was done.

Jake Christensen

Thermo/Kinetics (Arup Chakraborty and Alex Katz)

Thermo question (Arup):
Draw a PV diagram with isotherms (above T_{cr}, below T_{cr}, and at T_{cr}).
[I drew a binodal curve with isotherms--incorrectly drawing an inflection point for the isotherm at $T>T_{cr}$. Arup pointed out my mistake.]
You've drawn a binodal curve for the system. How would you draw the spinodal curve?
[It took a long time for him to lead me to the definition of the spinodal.]
Starting with a liquid, can you travel along an isotherm and decrease the pressure below the saturation pressure without forming vapor? What is required for vapor to form? How low can you go in pressure? What happens if P increases with V?
Now draw the Gibb's Free Energy vs. volume. What would the spinodal region look like there?
Katz asked: From where would you get that isotherm you drew? [An equation of state]

Kinetics question (Alex):
What are two continuous reactors? Why is the PFR so prevalent in industry while the CSTR is preferred for biological processes?
[It ultimately has to do with reaction order. For Michaelis Menton kinetics, the reactor is operated in a regime in which the rate is independent of substrate concentration. Industrial processes have reaction order greater than or equal to 1.]
What are the residence time distributions for a PFR and CSTR? What is the material balance for a tracer experiment in the CSTR? How would you find the fraction of dye remaining in the reactor as a function of time?
[Alex was very helpful in leading me through all of this.]

Transport (Dave Schaeffer and Simon Goren)

Simon:
I have a 100W lightbulb in my garage [shows me a lightbulb taken from, presumably, his garage], and I want to know the temperature at the surface of the glass and of the filament. How would I find them?

Dave:

Imagine a very long can of beer that's just been taken out of the cooler and is now surrounded by air. What is the temperature profile of the can? What thermal resistances are important? What dimensionless number relates the thermal resistance outside the can and inside the can? Draw the temperature profiles for very large and very small Biot number? How does the can's temperature change over time if the Biot number is very low?

Simon:
[Draws a vat of water with a syphon coming down from the top]
Given the height of the tube (from the end to the surface of the water), calculate the volumetric flow rate through the tube. What limits the volumetric flow rate as the length of the tube is increased? What about cavitation at the top of the tube?

Design (Lynn and Wallman)

I talked for a good ten minutes about my senior design project (an ethylene plant) before they started grilling me on specifics and asking why the furnace pressure was kept so low. They asked me how a flash vessel worked and had me design one with controllers. They also asked how I would use controllers in my ethylene plant.

Ian Drake

Transport: Balsara and Radke

My question involved a complete analysis of axial flow in a square conduit. Slightly opened ended but there was direction. First I had to write out the governing equations, both navier stokes and continuity. I also had to set up B.C. and explain the method of the solution (Poisson's Equation, Sep of Var. Sturm. Loveuille). Wanted me to rationalize why the flow didn't vary on the axial direction. (Continuity). Also, they wanted the Hagen-Pouiselle analog. They then spun me in the direction of analyzing turbulent flow in this pipe. They wanted a discussion of the mean hydraulic radius. The final question was to explain why the mean hydraulic radius should not be used for laminar flow (check out BSL, pg. 204, 6.L)

Design: Lynn and Blanch

Talk about your Design Project. What is the origin of your raw material. What is the relation between Yield and conversion. Are the results typical of what is expected, explain.

Design a system for lactic acid. What is the chemical formula? What is the relationship between pKa and pH, please derive. Name an acid that would precipitate in solution. Make sure it is economical (H2SO4). How do you produce H2SO4?

Thermodynamics: Graves and Chakraborty

Graves: Internal energy of an ideal gas. Complete discussion of first law applied to open system. Thermal energy verse convective energy.

Chak: What type of reactor would you use for a biological/ Enzymatic reaction (assume Michellous Menton-Kinetics). What does a plot of conversion vs. time look like. Compare this to industrial chemical reactions (assume first order rxn.)

Brian Pfleger

Design: Wallman and Cairns

What was your senior Design Problem? Mine was an ethanol from biomass plant. The questions then went into specifics of my plant. How would you design a multi stage evaporator, point being , not to waste all of your energy in the first shot. How would you design a flash drum, and then how would you control the inlet T, outlet T, P and Level control, meaning what streams would you alter, not specifics on control theory. I thought I did pretty well, considering Cairns didn't get to his metal questions, and that they helped me through some unclear parts, but I got my worst grade on this one.

Kinetics and Thermo: Bell and Clark

A --> B, what is the rate, how does it work, and what could be the possible mechanism. Now the reaction is taking place at the wall, what does the conc. Profile look like, what are the differential eqns for the problem, I flubbed this one and they allowed me to move on. What is the equilibrium concentration for a 2NO --> O2 + N2. How would you get Keq? I nailed this one and they stopped me before I finished, they then tried to ask me some wierd question about the dominoes pizza bag, that was basically some poor analog to the ice cube placed H2O calculate the final temperature problem. I think I got started on the right path and then time ran out.

Transport: Muller and Radke

Siphon problem:
Set it up, how would you solve it. Bernouli's eqn. What is cavitation and what is its impact on the problem. (Don't automatically throw out the viscous losses term) including viscous losses, how would you do the problem? I did well on this one and they went real easy on me the rest of the way.

Falling film:

What is the situation, set up the eqns, what will the profile look like. What are the BC's and the dif Eqn's, Solve them (they helped a lot), and then the last question which Radke basically told me, Why does the Nu scale with the 1/3 power of Pr. (from the dif eqn's)

Josh Leonard

TRANSPORT - Radke, Balsara
After the expected pre-exam jokes, Clay signaled for Nitash to read me the first question. It was very impressive - I could not even see Clay's lips moving - they wanted me analyze a flow through a square pipe. After this point, Nitash did not make a peep. We started off by looking at the situation via a Bernoulli balance, and eventually, I was asked to find the velocity profile near the walls. Somehow Clay worked me into setting up an eigen-value problem with a series solution. Why is this solution guaranteed to be complete? because you have the full set of eigen-functions and eigen-values. Also, he had me say something about the hydraulic pressure, but I sort of missed that. Nitash smiled a lot.

PROCESS DESIGN AND CONTROL - Wallman, Lynn
After introducing themselves, Dr. Wallman asked me to discuss my senior design project. I mentioned that we had designed a brewery, at which point Dr. Wallman became interested, since his family had owned a brewery in Europe a few generations back. By now, Dr. Lynn was fast asleep. I talked about my project, and Dr. Wallman asked me a few questions here and there. Towards the end of this, Dr. Lynn stirred and asked, "So, let's say you wanted to make some scotch…", at which point he paused noticeably and slowly rolled his eyes back into his head as if fantasizing, "mmm… scotch. I wish I had some scotch right now….". It wasn't bad at all.

For the second part of the exam, they had me design a flash drum. They asked the usual questions - for what do you use this? What parameters are important (temperature, pressure, flow rate, etc.)? What would be the best way/ place to measure temperature? pressure? What would you control if you wanted to achieve a desired pressure? a desired flow rate? What kind of control would you use, and why (feed forward vs. feed back)? All in all, rather qualitative.

THERMO/KINETICS - Reimer, Katz

Jeff started off, and he asked me how I would go about teaching thermodynamics to high school students (probably seniors) in a way that would interest them. He had me start by explaining the first law and then providing an interesting example problem to demonstrate it (without bringing up any higher principles - i.e. ignore later laws). Same for the second and third laws. Took some on-the-fly thinking, but not too bad.

Alex asked me a rather convoluted question about moth balls. Basically, you are suspending moth balls with an air flow, and they are sublimating. The balls remain in the reactor until they are small enough to be carried out. He asked me how to design the reactor such that moth balls of the desired size exit the reactor. It was a bit unclear what he was shooting for, but essentially they were looking for mass balances, mass transport barriers, and reactor design principles (i.e. residence time distributions, etc.). I went down a few wrong paths for a while. Also, I was a bit distracted because I couldn't stop thinking about the reactor as a "corn popper"… (see picture at right)

Analeah O'Neill

Themo/Kinetics (Katz, Arup)

This was an amusing prelim. In retrospect.
Katz started by asking what my undergrad kinetics background was. My answer was "None. Except Michalis-Menten from P-chem." I majored in bio and never took reactor design/kinetics, so everything I knew I got from Alex Bell. He didn't miss a beat and gave me a bio-oriented question. Asked me to explain why the biotech industry prefers to use CSTR and the petrochemical industry prefers PFR. Some discussion got me to an RTD argument, so I derived them for CSTR and PFR. He also got me to discuss how reaction order (enzyme kinetics in bioreactors vs catalysis in PFR) affected the residence time requirements for the system. This required the derivation of Michalis-Menten.

Arup basically gave me another 240 final. He had me draw a P-V diagram and, based on that, sketch a Gibbs free energy vs density diagram for pressures above, below, and at the critical pressure. Then discuss, at length, the differences in first and second order phase transitions. Then he started asking me weird questions about my diagrams and I didn't know what he wanted. So I started asking him questions to find out what he was asking me. After much discussion, he made some comment about the energy/entropy trade-off. I still looked confused I guess, because he got mad and asked if I did not agree that A=E-TS. I said I did but I that still didn't understand what question he was asking. He said, "I just answered the question for you! A=E-TS!" Take home lesson: Don't overcomplicate. So I made some comment about my being a total idiot and apparently got visibly angry at myself. (Now, every time I see Arup, he chuckles and mentions how I'm the only student he ever saw get pissed at themselves during a prelim. Got a real kick out of me, I guess.)

So that I could redeam myself, Arup then let me talk about how I might calculate the delta S for putting a drop of ink into a beaker of water (lattice model stuff from 240). Alex chimed in and made me tell him why I couldn't take the drop back out without adding energy. Then I left…longest 40 minutes EVER. The funniest part was that they gave me an A.

Transport (Balsara, Newman)

Nitash asked me about flow in a square pipe: set up the equations to solve for velocity profile. Didn't have to solve, but I did have to talk about how I might try to solve it. Then Newman wanted to talk about the heat/mass/momentum analogy, when it holds and when it doesn't. He latched on when I mentioned friction and we spent some time discussing a sphere flowing through viscous fluid (form vs. friction drag). At one point, I was searching for key phase he wanted and he told me that I would feel stupid if he told it to me. I don't remember what the phrase was, but I remember that I did feel stupid when I finally came up with it. Finally, he told me he was satisfied with my knowledge, "So now let's have some fun." "Fun" apparently means "calculate the weight of the atmosphere". So I did and it was very fun.

<u>Process/Design (Lynn, Wallman)</u>

When I told them I never took controls or design they stared at me for a very long time. Several minutes. Finally Lynn goes, "Are you familiar with the concept of an azeotrope?"

I wasn't going to be like, "Come on, I'm not *that* pathetic!" and volunteer that I had studied a ton of design stuff in prepation for the prelim. So instead I just said "Yes". I explained what an azeotrope was, and we had a nice discussion about the EtOH/water azeotrope and activity coefficients, which they were glad to know I had also heard of. Then Wallman wanted to know what I would do to get rid of methane waste from a factory. We talked for a while about steam reforming. Then it got funny. Wallman took a look at my reaction and asked what would happen if I pressurized the reactants. I told him and then he asked how I knew that (Le Chatlier's principle). Lynn heard my answer, but I guess Wallman did not because he said, "No..." and proceeded to spend five minutes promting me to say "Le Chatlier's priniple." Finally he says, "It's a principle. Named after a famous person. If you ask a chemist for a principle every chemist knows, they will says this person's name." I'm standing there trying to think of some other principle that applies to the situation I have that isn't Le Chat and is very famous. I couldn't. Wallman finally goes "Le Chatlier's principle". I laughed and told him I'd said that 5 minutes before. Lynn agreed with me and started cracking up. Then it was over. I think I passed because Wallman felt bad for torturing me over something I learned sophomore year in HS.

Boonchai

<u>Cairns and Wallman: (Process and Design)</u>
Both asked questions on these two main topics

What was your senior design project?
Lets look at the distillation of ethanol from water. How do we control the temperature of the feed steam? Where should we place the controllers and the sensors? How do we determine of the composition of the vapor and liquid phases? What additional heat is required for the vapor phase?

<u>Bell & Reimer: (Thermodynamics and Kinetics)</u>
Reimer started with thermo and Bell finished with kinetics

Imagine a flash drum with ethanol and water coming in. How do you determine the compositions of the vapor and liquid? How would you get the boiling points of pure ethanol and liquid from the diagram? Consider a generic reaction. How would you calculate the enthalpy generated by the reaction? How do you get the deltaH of reaction at STP? How would you get it at another temperature? What is Cp (specific heat) independent of and what is it equal to in thermodynamic variables? What is the rate equation for a generic reaction? What do each of the terms mean? How do you determine the rate constant?
Imagine a tube with reactants flowing through and the reaction occurring only at the walls of the tube. How do your determine the concentration along the length of the tube? What would be the units of rate constant? Draw the concentration profile along the length of the tube. How do we determine the diffusivity? What is the k in the Sherwood number from?

<u>Muller & Radke: (Transport)</u>
Both of them asked questions on these two problems

Imagine of tank of water with a siphon coming out of it. What is the velocity of the fluid coming out of the siphon? What is lost along the length of the tube? How do we determine the frictional factor? What determines how high the tube can above the level of the tank before it curves down?
Imagine a fluid flowing down a vertical wall and gas of concentration Ca diffusing into the liquid from the wall. Draw the concentration profile along the length of the wall. Set up the boundary conditions to solve the problem. In the mass balance equation, where do we get the velocity profile from? Solve the resulting equation?

Lily Cheng

Process Design (Prausnitz/Keasling):
I didn't write down their questions right after I took the prelim, so by the time I sat down to write them out, I forgot. :O This exam was a blur anyway. However, I can give you some practice questions that other grad students asked me.

- Ethanol/water azeotrope --> how to break it?
- How to separate O2 and N2

Thermo/Kinetics (Clark/Bell):
- Calculate adiabatic flame temperature
- Ideal Gas Law question
- Discuss multiple steady states (derive energy balance & mass balance, draw graphically, and discuss multiple steady states)

Transport (Newman/Balsara):
- Derive Navier Stokes equations for a rectangular duct, also write down boundary conditions (did not need to solve these differential equations)
- Transient heat conduction through a turkey: How long does it take to cook a turkey? What if you place a rod in the center of the turkey, does the turkey cook faster? Why or why not? Sketch the temperature profile of the turkey, assuming a rectangular slab.) I knew this stuff from my undergrad research, in which I studied simultaneous heat & mass transfer of foods cooked in a high-performance convection/microwave oven, so I liked this question a lot. :)

Julie Yu

Thermo/Kinetics (Reimer, Bell)

Reimer: If a meteor lands in the ocean, how much water will boil? Mixing rule stuff.