Prelim questions 2005

CCh

Design (Prausnitz, Segalman, and Alexander)

- Senior Design Project
- During the intro, I mentioned that I had done a senior design project, but that was a long time ago. However, I spent the past few years trying to make H2 before coming back to school. So please ask me about the H2 business. That led to the discussion of steam reforming. I discussed methanol steam reforming, microchannel steam reformer for military application.
- What to do with CO2 from conventional reforming? (separations with amine i.e. ethyl-amine/ethanol-amine) Design a CO2 absorber: equilibrium stage, HTU, equilibrium diagram, mass transfer coefficient, flow rate (qualitative).
- Ammonia Synthesis: limited by equilibrium, examining the reaction stoichoimetry, as a result the reactor operate at high P.
- After NH3 synthesis (from N2 and H2), of course, I was asked how to make N2. Air separation process, Linde column. I know all about the Linde column, as soon as I started talking, they realized I studied this part and did not want to hear about with the column. Instead, they want to know the location of throttle valve (this is the tricky part). Refer to Van Ness compression-throttle session.
- PFR with extremely exothermic reaction, ways to avoid runaway: diluted catalyst, diluted feed, feed one of the two reactants, and introduce small amount of the 2nd reactant through out the PFR
- After this, they almost let me go, but Prausnitz wanted to ask another question: Depreciation of equipment (e.g. distillation column). Definition (value increases or decrease?), I told them only piano appreciate in value. Fast depreciation or slow depreciation, in term of time period), which one is desirable?

Kinetics & Thermo (Balsara and Keasling)

- First, Michellis Mentin kinetic 1/r vs. 1/[S] plot. Need to derive the rate then use slope to get kinetic parameter. If add an inhibitor to the system, how would the plot change? Of course, the rate expression can be re-derived. Slope is not the same in this case. I didn't re-derive the expression, but it took me a while to figure this out. After that Keasling told me that if I have re-derived everything, the time for me to figure this out is just going to be the same.
- Bubble in the air, everything is in equilibrium, find P as a function of r. Use first law, dE=TdS-PdV+SdA solve for P in term of dA/dV

Transport (Newman and Radke)

- First, a viscometer, derive expression to relate flow rate with viscosity. Discussion of friction factor with Reynold number. Perform force balance (with friction factor), then substitute Re number to get v. Discussion on how to obtain the viscosity from the viscometer, if we are given a stop watch. Get the time, and then derive expression from the time to the velocity and the viscosity.

- Is the instrument primary or secondary instrument, basically, do we need calibration? How to calibrate the viscometer.
- Put a spherical shape ice in the bottom of a semi-infinite tube filled with water. Qualitative discussion on the velocity, melting, heat transfer etc. Then I was off to perform force balance to solve the terminal velocity assuming pseudo steady state. Ultimately we need to solve the rate of melting. But time ran out.

JCo:

Transport (Muller and Graves):
They both seemed a little stiff-looking when I walked in, so I decided to try and lighten things up a bit by making a joke about the friction factor in the door. Bad idea. Muller then asked me this question about a substance A diffusing between two flat plates. Infinitely long flat plates?, I asked. No. I had to find the concentration profile between them, when A reacted in a first order reaction to form P at one of the plates. It helps to draw the shell balance in the right direction, which is that A diffuses towards the plate, and you then have to use the reaction at the plate as a boundary condition. After getting the final equation dragged out of me, Muller asked what method I would use to solve it. I had no idea, so I said the common answer of a similarity solution. After questioning whether I could recollect anything from Newman's math class, she said 'separation of variables.' Graves then gave me a problem about heat conduction though insulation caused by heat generation in a wire. Time was running out, and he wanted to know how to find h in the air. Graves got a little exasperated at this point and sighed, saying all he wanted was a number. As I found out yesterday in Transport, you calculate the Re and Pr in the fluid, and use a correlation to get Nu, which will give you h. Graves couldn't wait to get out of there, and Muller wouldn't even tell me why we perceive sunsets as being beautiful.

Thermo and Kinetics (Shafer and Iglesia)
Shafer started it off with (by I think) asking me how to find the maximum amount of work that could be obtained from a hot object. I attempted to explain this in terms of the carnot cycle, but got all messed with the efficiency. I found out the efficiency is never 1, even for a carnot cycle, and the cycle is not completely adiabatic. It would also help to know how you calculate Cp. Shafer was really nice about this problem though, and we eventually worked through it. I thought Iglesia would also be un poco simpatico, but not so much. His qualitative questions were pretty easy, mostly about conversions in PFRs and CSTRs. His main problem was also pretty easy, and was about an absorption reaction. We talked about what conversion really means, and you can only assume $C_a=C_{ao}(1-X)$ if the volumetric flow rates are the same, otherwise, you have to use Fa.

Process and Design (Carins and Blanch)
This was by far my most pleasurable experience, I think because of who it was and that it was my last exam. Blanch asked how to design a tower to remove dilute HCl from an air stream, using water. This was a learning experience for me, and I had to draw the concentration profile of HCl from the bubble to the liquid phase. It would be good not to show an HCl concentration in the water, because it dissociates. Interesting. Carins then broke out a fuel cell problem, asked

me to design one (which I had luckily done 2 hours earlier) and then asked me where to get the pure H2 from. I went as far as I could on this one, at which point Carins literally (he actually came up to the board!) walked me though the rest of the problem. After talking about this for awhile, Carins and I finished the problem off with an oxidizing (or "cold fire" as Carins said) black box to get rid of excess CO to from CO2. We were all laughing at this point, and Blanch asked what we should give Professor Carins for this exam. We also had a few minutes left, so Blanch and I talked about psychedelic drugs for a bit.

HGu
Kinetics and Thermo (Keasling and Balsara)
Keas: Given *draws chart with a slanted line. y and x axis are 1/r and 1/s respectively*, how do you get out relevant parameters? What happens if you have an inhibitor?
Bal: You have a droplet in 1atm surroundings; how do you get internal pressure? (← we couldn't believe he asked a surface tension question again. I didn't make any progress on it though since I had figured he wouldn't ask the same thing two years in a row.)
<u>About these two:</u>
Balsara was very solemn and quiet. Keasling was slightly more talkative but brisk and thus neither were helpful. Now, it was true that it was my first exam and I tried to work everything out myself. I heard from others that if you directed questions at them, then they would lead you a little bit so you might try striking up a conversation.

Process (Prausnitz, Segalman, Alexander)
Note: I've never had a process course nor worked in industry. I did have a lead-in which worked well considering they asked the exact processes I'd memorized thus leaving less time to ask me practical questions.
Seg: What did you do for your senior design class?
Me: We didn't have a process class. I only knew about Monsanto because I took law classes and they were involved with several hallmark trade secret cases. As of last week, I found out they make sulfuric acid =P .
Prau: How do you make sulfuric acid?
Seg: What's the pressure of the water that you use?
(oh geez, practical. I started throwing out complicated eqns and fugacity in hopes of showing I knew other things. Prau laughed, "for some reason, people see me and talk about fugacity…")
Prau: do you need pure oxygen for that? why not air? How would you get oxygen from air? Why not leave the argon? what do you do with the nitrogen? (Haber! this is working better than expected)
Prau: How do you get hydrogen? How do you get out the carbon dioxide? How does an absorber work (oh oh, again with practical questions. I had no clue. they told me to draw a picture, I don't think they understood the extent to which I really didn't know. *draws up a square* "Because that's what everything looks like according to the books" and they chuckled).
Prau: How do I size it? What's the airspeed? (oh geez. "Well…slower than my car." Seg: ok, that's a good start…) Answer: apparently 0.5 m/s
Alexander: you mentioned that you can use interstage cooling for sulfuric acid. how else could you have cooled it? Answer: delayed addition
<u>About these three:</u>

They were all fairly cordial though Prausnitz and Segalman did most of the talking. The more I talked, the more they had to help me with so I would *highly* recommend verbalizing your thoughts. One of them mentioned that they're interested in seeing what I knew rather than what I didn't. Another reason to showcase what you know.

Transport (Mueller, Radke)
Muller: Draws up question about how thick of a coating you'll have on a wire if you pull it out of a polymer reservoir.
Radke: You release a ball of ice in the bottom of a bath. How long will it rise before it completely disappears?
<u>About these two:</u>
Both were nice but also the most interruptive of the profs. Muller kept interrupting me as I was writing just the basic equations since I omitted the dot of grad DOT tau, "is that a scaler? is that a vector?" etc; she was one for detail as I could guess from the overly thorough description of the wire coating problem. If you have Radke, the odds of finishing an entire sentence are slim. He is a very big proponent of oral exams since it allows him to probe your thought process so he will do exactly that. By this point in the day, I was joking around, "well now, let's see what I've got up my sleeve" and Radke seemed quite pleased with the comfortable demeanor.

<u>Overall thoughts on prelims:</u> It seemed less an exam on knowledge (everyone is quite capable), and more a look at how you carried yourself as a potential colleague (confidence under fire). I'd include my results to give you an idea of what responses can get you what grade (esp design), but considering I have yet to open the envelope with the results nor intend to until next winter break, it's not quite possible =) . Just saying, how seriously are you to take the conclusions drawn in a highly artificial setting? Do their opinions (vs your beliefs) cause some huge difference in the course of your career? Maybe, but they sure haven't for me =) .

LMi
Design (Segalman, Alexander, and Cairns)
S-What was your design project? (making acrylic acid from propylene and oxygen)
S-What is acrylic acid used for?
S-How did you separate the water from the acrylic acid? (water was a by-product)
C-How do you make lithium (starting from lithium ore)?
C-How do you get the lithium out of the cell?
C-The electrodes will short out because of the layer of Li at the top, how do you get around this problem? (put a cover around the electrode, at least through the Li layer)
S-How does a hydrogen fuel cell work?
S-What reactions are going on in the cell?
C-How do you get the highest reaction rate possible?
S-How do you get rid of the water accumulating in the cell?
C-How efficient is a fuel cell? (I said 40%; they said that was a little high).
C-Where does the heat go that is produced in the cell?
S-Where can you get the H_2 that is needed for the cell?

Transport (Graves and Muller)

G-You have a tube with a plasma in the middle that can be turned on and off. The plasma heats up the gas flowing through the tube. What are the pressure and velocity profiles when the plasma is off and when it is on? (Plasma off is easy: decreasing pressure and laminar velocity profile i.e. Hagan-Poiseuille flow; Plasma on is harder. The velocity profile is the same as with the plasma off before and after the plasma though in the plasma the density has changed since the temperature has increased…I don't think I ever got to the pressure profile in that case.)

M-A gas is flowing between two infinite parallel plates. A rxn takes place at the two inside surfaces to get a product P. Obtain the concentration profile as a function of position and time. (Set up a mass balance with accumulation. Input the flux into the balance. Set up boundary conditions such as Ca=bulk concentration in the middle and flux = rxn at the surfaces.)

G-You have a wire that is being heating. It has insulation around it. How do you solve the problem of heat transfer from the wire to the air? (set up conduction and convection equations) Where do you get h? (correlations!)

Kinetics and Thermo (Iglesia and Balsara)

I-You have a PBR with the rxn A→2B (both in liquid state). Derive a mass balance for this system. (I assumed no dispersion and treated it as a PFR with no temperature gradient and no concentration gradient in the radial direction and did the shell balance to get the normal PFR equation.)

I-What happens if you have a concentration gradient in the radial direction? (You do a shell balance on an annular piece)

I-What happens if B diffuses through the walls instantaneously? (The concentration of A is constant so the rxn rate is in terms of Ca0).

B-You have a drop. Find the pressure inside if you know the pressure outside. (This is based on surface tension so write dE with the surface tension in there. You can cancel some terms and dE=0 because you are at equilibrium….energy minimization).

B-Using this relation how do you find the height a liquid rises in a capillary? (Do a force balance with gravity and surface tension being the important forces…Fox and McDonald (fluids book) has a good example of this problem).

PSh

Transport (Newman/Radke)

Radke: Do you know what a capillary viscometer looks like?

PSh: *drawing what I think it is*

Radke: No. *takes chalk from my hand* A Ubbedubedold (I have no idea how to spell it) viscometer.

PSh: Oh.

Radke: Tell me how to measure the viscosity of a fluid.

After spending some time solving for the velocity profile (because I didn't memorize HP-flow eqns) I related the flow rate to the volume of the ubbedubedold and the time required to empty the viscometer

Radke: What assumptions must we make, other than the obvious Newtonian fluid assumption?

PSh: *After a bit of thinking and leading from Radke* The timescale of momentum transfer (I made up a momentum Fourier number) must be much faster than the timescale of the experiment such that the change in the velocity profile due to a constantly changing driving force (the head

of water) is negligible.
Radke: Now suppose I have a sphere of ice that is rising in an bath of water. Will it melt before it reaches the top?
PSh: *Do mass balance and energy balance, then overcomplicate problem by asking if the temperature profile in the ice matters*
We ran out of time before I was done. Overall, Radke did most of the talking, Newman basically spoke in order to keep Radke from giving away the answer. These guys are RGG (real good guys).

Kinetics/Thermo (Keasling/Balsara)
Keasling: Let's start with an easy kinetics question. Suppose I have an enzymatic reaction that takes a substrate and converts it to a product. The reaction kinetics look like this. *draws a Lineweaver-Burk plot*. How do I find the relavant constants?
PSh: *I try not to smile too much and think to myself CMM (cash money millionaire), does Keasling realize that I'm actually just a biologist that happens to know some math?* I derive MM kinetics and explain the rate constants.
Keasling: How does this change if I add a competitive inhibitor?
This changes affinity constant, slope and x-intercept changes. I refrained from doing a touch down dance or fist-pumping, but I was very tempted to spike the chalk.
Balsara: Suppose I have a drop of liquid in a gas of P=1 atm. How do I find the pressure inside the drop.
This has to do with surface tension. I started with a force balance as that's the way I've seen this done before, but I got flustered with units somehow. At this point I rethought the problem and Balsara helped me with an energy minimization to solve for P_inside.
Balsara: now consider a capillary tube, find the height of the liquid using the same fluid.
PSh: *getting flustered again* Relate h (height of fluid) to P_in, P_atm and surface tension. The contact angle was 0. Thankfully we ran out of time since I spent so much time dazzling them with MM-kinetics.

Process/Controls: (Alexander/Segalman/Prauznitz)
Segalman: Did you take process?
PSh: *thank God Penny went before me, go Techers!* Well sort of. We had a baby design project.
Segalman: Tell us about your design project.
PSh: We had to analyze aqueous scrubbing of flue gas to sequester CO2.
Segalman: Draw out the block flow chart.
Papa Prau: How would you design a scrubber? How would you size it?
PSh: *shit*. Diameter depends on flow rate.
Segalman: How do you determine that?
PSh: Usually it's specified by how much you're producing.
Segalman: What's a normal flow rate?
Apparently this is 1 m/s. I had no idea.
Papa Prau: What about the height? And how could I increase my transfer?
PSh: Well increase contact surface area with baffles to mix the flow (the didn't want impellers). The height is found from a McCabe-Theile type diagram. Equate the number of theoretical stages with a height and then add some more for good measure.

Segalman: Why is it 2 ft/stage?
PSh: *after getting lots of help* you need enough time at each stage to acheive eqlb.
Alexander: Did you design the inside of the scrubber?
PSh: *holy shit, he actually said something* Well, MIT students don't really do practical things like that...we had enough trouble learning how to work Aspen...
Segalman: Design a hydrogen fuel cell.
This requires an anode, cathode, and some membrane to keep the electrons from taking the path of least resistance. I had to write the rxns at the anode and the cathode. I think I actually wrote leo and ger on the board (I hadn't done any electrochemistry in 4.5 years). The membrane has to be permeable to protons but not hydrogen or oxygen (commbustion risk). The membrane should have water to help the protons dissolve.
Segalman: Where does the excess water go?
PSh: It'll be hot (exothermic rxn), so vent water as steam.
Alexander: How would I cool this?
PSh: *damnit, again with the practical questions.* With baffles and a heat exchanger. (I didn't really get the point of his question, he was looking for something else, but we moved on).
Segalman: Where does the hydrogen come from, and please don't say from Sigma?
PSh: *did someone actually say Sigma?* Well it could come from steam-reforming of methane, followed by a WGS rxn. *writing rxns on board*
Then we ran out of time.

Advice: go in relaxed, make jokes if possible. they see this as a sign of confidence in yourself and in your knowledge about chemical engineering. and when faced with things you've never seen, just act like you've been there before. that's the best advice i've been given and it applies to everything in life, but most definitely here.

MSt
Thermo/Kinetics (Schaffer & Iglesia)

Schaffer: You have a block of material in infinite surroundings. It is hotter than its surroundings. What is the maximum amount of work you can get from it? Answer: use Carnot stuff but do it in differential form and then integrate.

Iglesia: What is PSSA? Answer: study this from his class. He also had me do a surface reaction. Also some easy question about a CSTR. For Iglesia the important thing is to be able to talk about why you make what assumptions.

Process (Blanch Cairns)

Cairns: talk about your undergrad project. Softball questions. nice.

Blanch: Talk about how you would design a tower packed with ice. Water vapor flows down the tower and melts a specified amount of water per time. How would you determine the diameter of the column and the flow rate of ice? I struggled through this but Blanch was very helpful. I don’t remember the answer but I’m pretty sure it had to do with mass transfer etc.

Cairns: describe a fuel cell. Where does hydrogen come from?

Transport (Graves and Newman)

Graves: He wanted to try out a problem that Muller had told him that morning. Bad idea because he did a terrible job explaining the problem. Newman noticed this also and spent a lot of the test making faces at Graves and arguing about details of the problem. You are pulling a string out of an orifice at the end of a cylinder. The cylinder is filled with a polymer solution. At a distance far away from the orifice the solvent has evaporated and the string is coated with polymer. What is the thickness of this polymer layer? Really all you have to do is solve for the velocity profile in the cylinder (I didn't actually do this but eventually Newman convinced me to set it up). Then integrate to find the mass flow rate. By mass balance this must equal the total solution leaving through the orifice. If you know the concentration then use some equations to solve the problem.

Newman: An ice cube is at the bottom of a container of water. What happens? The ice cube floats up b/c it is less dense. Use Stokes law to describe. Oops, Newman pointed out that I forgot that the cube will be melting. Well now we have a problem because everything is inter-related and I got really lost. Newman didn't seem to care because they gave me a good grade despite my lack of doing anything right.

JSt

Process Design: Blanch and Prausnitz

The exam started by us talking about where I went to school, what classes I took, and what my senior design project was (CO2 Capture and Sequestration). After briefly discussing my design project, Prausnitz started asking me questions about the Hydrogen economy (What is it? How is it useful? How would I store the hydrogen? If I would compress it, then how? Keep in mind the Joule-Thomson Effect on hydrogen if you plan on cooling it). After a few minutes of rapid-fire questions from Prausnitz, it was Blanch's turn to ask the questions. Blanch asked how I would determine the height of a HCl absorber that would remove HCl from a gas stream to a liquid (in this case, water) stream. I really didn't remember how to do this at all, and so they tried to lead me along to find the way to do it, but to no avail. Blanch actually asked this same question the year before too, so those with Blanch for Process Design would be wise to read up on absorber design.

Transport: Graves and Newman

The exam started by us talking about where I went to school, what transport classes I took, and my undergrad texts. I don't think either professor had seen or even heard of the books that I used (de Nevers, Cussler, and Holman), so Graves started off with an easy mass transfer problem: You have a fluid flowing past a metal sheet, and species A in the fluid reacts when in contact with the sheet. He wanted to know the reaction rate and profile for the limiting cases of mass transport (ie, for the transport and reaction limited cases). Then he wanted to know how I would find the mass transfer coefficient. He then asked about the parallels that could be drawn to heat transfer. Newman also threw in a few questions about how I could acquire the some of the data being discussed (how would you find Kg? The reaction constant?). After that, Newman asked a question about a ball of ice placed in the bottom of a very tall water container. The idea is that, when released, the ice will float towards the surface, but will also melt, shrinking in size. Newman wanted the height at which the ball would be completely melted. I went to work on the problem, but got tripped up trying to find the drag on the ball of ice. After a few moments of cryptic Newmanesque hints, I ran out of time.

Kinetics and Thermodynamics: Balsara and Iglesia
The exam started with question of what books I used in undergrad for both subjects. Then Iglesia started with questions about kinetics. He kept jumping all over the place, asking new questions every time I tried to answer his last question. First I did a shell balance for a PFR. Then I did one that included dispersion. Then I talked about what would change if there were gradients in the r-direction. Then, using the balance equation that I had obtained for a first order reaction in a PFR, I had to talk about the case where a reactant A goes to B in a reactor where B is immediately removed from the reactor ("perhaps it quickly diffuses through a membrane at the wall of the PFR"). After finally figuring this last part out, Balsara started asking about thermodynamics. First he asked for the pressure inside a drop of radius R. (To solve this, you write the energy equation, and cancel out the terms that can be neglected. You will get an equation for pressure in terms of surface tension and radius). Once I had found this equation, he asked me to determine how high a liquid (such as water) would climb in a capillary tube of radius R. (Using the assumption that the meniscus can be approximated as half a sphere, you then use the result of the first problem to determine the final height). Before I had even written the answer, they told me I was finished and could go.

MTi

Transport – Newman & Radke
First they asked me to sit down and tell them my transport background. I mentioned that I had 3 semesters, at which point Radke was utterly amazed. Newman then points out that they used to have 3 semesters worth as well, but had since cut back. Radke retorts with, those must have been 3 quarters and not semesters. Newman, fires back with the fact that they only had the quarter system for 3 years, and those years were prior to Radke being hired. Finally, they got around to the questions. Note – Radke did most of the talking.
Question 1: Given a bulb-glass apparatus (I don't remember what it's called) used frequently in polymers to measure the viscosity of a fluid, how would I calculate the viscosity if I've measured the time it takes for the bulb, of known volume, to drain? The solution – figure out that you have collected, or rather, obtained the volumetric flow rate from the experiment and thus need the Hagen-Poiseuille equation. This equation can be used to obtain the kinematic viscosity. The follow-up question was, would you want to use this instrument as a primary or secondary source of measurement, i.e. do you want this instrument to be calibrated or not? The answer – calibrated because we can't trust the glass blower to give us the correct volume. …those were Radke's words.

Question 2: A sphere of ice is held at the bottom of an infinitely large cup. What will happen to the ice once it is released? The ice will gradually melt as it rises through the liquid water. At what height does the sphere of ice completely disappear? I was supposed to do an energy balance and I proceeded with a shell balance. I ran out of time, however.

Thermo and Kinetics – Balsara & Iglesia

Question 1 (Balsara): Given a drop of water, either falling or on a surface, calculate the pressure on the inside of the droplet. I struggled through this for 20 minutes and not one word of help from Balsara. I figured out that energy had to be minimized and there was something to do with surface tension. Supposedly, the solution was to write the equation for internal energy, cancel out terms to get a relation for surface tension/area and pressure/volume.

Question 2 (Iglesia): Given a flow reactor, packed with a catalyst, find the conversion of A to B for the liquid phase reaction: 2A à B. I was to do a mole balance, using a shell method. I was asked why a differential volume was looked at. Then, I was asked what additional term would be necessary for axial dispersion.

Design – Prausnitz, Segalman & Alexander

Question 1 (Prausnitz): Say you have dilute acetic acid in water, how would you separate the two. First I said that I'd look at the relative volatilities and separate via distillation. Acetic acid happened to be less volatile, so the alternative I suggested was extraction with some organic. What was the organic?? Oh, something like decanol, which is insoluble in water. The acetic acid prefers the organic phase, but what about the dissociated ions? How do we pull that into the organic phase? Modify the decanol such that there is some sort of amine (base). Now, say that the organic phase is separated from the aqueous phase, now, how do we separate the alcohol, acid, and amine? Distillation! How do you determine reactor height? Use McCabe Thiele to find the number of stages, then heuristics (2ft/stage) to determine height. Why 2 feet? Liquid/Vapor contact time and area. How do you determine diameter? Flow rates.

Question 2 (Segalman): How do you make hydrogen? Steam reformation. I went through the process and its details.

Question 3 (Alexander): Given a packed-bed reactor with two inlet streams, benzene and some misc. gas, which react highly exothermicly, how would you design the process to minimize heat? Design it so that the benzene is injected at different heights in the reactor.

NWa

Kinetics and Thermo

(Iglesia and Schaffer)

I spent so much time trying to put off engine cycles (I hate memorization, and that's not really thermodynamics... is it?) But SOMEHOW it managed to sneak its way into my test in the form of a metal block at some temperature T2, and an infinite space around it at temperature T1. "How would I extract work from the block?" (Q=CpdT)... but don't forget the 2nd law! Luckily I memorized every single variation of the second law (there's about 4 of them!)... including the Kelvin-Planck statement: "it is not possible to construct a cyclical device which can convert all heat into work." So there is some sort of efficiency which goes with the term (Carnot Engine --> W=(efficiency)*Q). The second question dealt with a huge magnifying glass orbiting the earth, and whether or not I would be able to heat a spot on the earth greater than the temperature of the sun. I managed to mutter another variation of the second law (Claussius Statement)... that it can't get hotter unless there is some sort of external force acting on it... but that's as far as I got, and eventually Schaffer told me the answer (and I was still confused... some force balance --is that really thermo??--... and yes it is possible).

Iglesia then wanted to move on to kinetics... and he kept complaining about how slowly I was erasing the board (so maybe, if you have him... erase quickly! he's an impatient man with many important things to do...) His questions involved a reaction A --> B, some sort of surface reaction... how would I go about getting the rate? Just set up a reaction rate equation, then determine the value for surface species. What assumptions would I make? What are the criteria for PSSH (2 of them: rate and time) and QE (1 of them: rate). Then a liquid phase CSTR problem... he asked me to do a mass balance (do exactly as he says... I started writing the design equation which is basically the mass balance... but he told me to start over and do a simple mass balance). Get the equation in terms of conversion... what would happen if the walls were permeable to only B (how would equation change). Overall, both were very nice.

Process Design

(Segalman, Cairns, and Alexander)

I had Cairns, so I was expecting a metals question... but of course, since I spent all my time memorizing those metals, it wasn't on my test (so mad!!! grrr....) And don't be fooled by others who had Alexander and said he didn't really speak... he asked LOTS of questions. The first question was "How do you concentrate fruit juice?" .... an evaporator of course. So I ended up setting up a system of evaporators in a line which each subsequent unit used the rejected steam and outlet flow of the previous. They asked me to determine how many evaporators I needed (I had no idea since I spent all my time memorizing how to make aluminum and silicon... they eventually talked me through it... it's all about economics.... grrrrr). Then they asked me about how to make hydrogen fuel cell... as Segalman said "this is what your lab [Newman's] does." Okay....grrrrr....

grrrrrr

Transport

(Muller and Radke)

A great duo. They were both very nice (a little intimidating). First we spent time trying to figure out what books I used... Radke started pulling out all of his transport books, and Muller commented on how many books he had and he started gushing about how people likes to buy him books. When it got down to the actual test... Muller went on the board and drew the problem out for me: She wants to coat a string by pulling it through (horizontally) a tube, at one end there is a large vat of a very viscous fluid (the coating) which is dragged through the tube by the string. In the beginning, for a length of L, the fluid fills the whole tube. After some time, the only fluid left is the one which coats the string. She defined the radius of the tube, radius of the coating, and radius of the string. First they wanted me to draw the profile and the boundary conditions. I had to solve the velocity profile for further down the end when it was coated, and then do the same for when it was not coated. Then, due to conservation of mass, the volumetric flow rates equate (note: volumetric flow rates uses average velocity). Radke asked me some question about how I could make the coating thicker without changing the velocity or geometry of the setup... then he

got like 3 phone calls in a row, and couldn't really talk to me (he spent that time picking up the phone and saying... I can't talk... then hanging up... then picking up the phone again and saying "I can't talk!") So Muller tried to help me out, thinking that I was supposed to change the speed, but after Radke muttered that's not what he wanted inbetween phone calls, Muller said she had no idea. Apparently you can apply pressure across tube.
The second questions dealt with an ice cube (spherical) at the bottom of room temperature water (very very tall glass of water). As soon as I let go of it, it starts floating to the top -- How long would it take for the ice to melt completely? I just had to set up the equations for the system (equate heat of melting to heat convection). Then I left... feeling unsure, frightened, but most of all relieved.

BWe
Process + Design: Blanch and Prausnitz

This was my first of the day and I basically fell flat on my face. They started with my design project. I had luckily practiced it the night before so most of what I said made sense. Then, Blanch asks a question on how one should go about designing a reactor to melt ice using water vapor. Basically, he was looking for the word "residence time" but I didn't say them. I just stood there looking confused about why anyone would want to melt ice like that. Then Prausnitz asked a few questions about how to make ammonia and how to separate air. Unfortunately, my difficulties in this one set a nervous tone for the rest of the day. If possible, forget everything that happened in your committee the moment you exit.

Transport: Newman and Radke

If you can look past Radke's boyish excitement, feel blessed that you have this committee. With every question, Radke will invent some scheme that you just have to write the conservation equation for. If he goes too far, Newman will gently call him back. Both are quite responsive to what you write, essentially applauding or booing your every movement. The first question was to determine the height at which an ice cube released from the bottom of a deep bucket of water will disappear. The second question involved determining the salt concentration in a blinking eye. To study for this one, practice writing the balance equations and know a few analogies of dimensionless numbers.

Kinetics + Thermo: Keasling and Schaeffer

They asked standard questions. First, Schaeffer wants to know what is the maximum amount of work that you can extract from a hot object. (Answer: integrate work, $dW = h\, dQ_{in} = (1 - T_{atm}/T)\, m\, C_p\, dT$ from T_o to T_{atm}). Then, Schaeffer asks me to describe a non-ideal system with a solute dissolved in a volatile solvent. There are two components and two phases. Make sure you know the Lewis and Randall fugacity rule and call it by name. I think my grade was docked a full denomination for not knowing this one. Finally, Keasling asks about Michaelis-Menton kinetics and an enzyme inhibitor which I quickly derived with Langmuir-Hinselwood equations.
Nothing tricky, you just have to know your stuff.

MZb

Process Design:

Prausnitz/Blanch

I told them a little about my design porject. They stopped me when they felt there wasnt anything novel or interesting in how we produced ethylene from ethane. It was the standard industry process of ethane pyrolysis. First question was from Prausnitz about ion exchange separation. 2nd question from blanch on vitamin E production using uv light. I was asked how you design a reactor for this and what concentration profiles might look like in a PFR. Last question about how to separate O2 and N2 and what they are used for. Mentioned the Linde process but they wanted other processes that could be used.

Transport:

Newman/Radke

First question was about how a viscometer works (its the one you use in the polymers lab on intrinsic viscosity). Wanted to hear about hagan-poussueille flow and see some Navier-Stokes equations set up. What is the characteristic time for the profile to become well developed. Also, why do you have to measure the pure water going through the tube if you know R, delta P, etc.

2nd question was about a spherical piece of ice at the bottom of a tank of water. How do you determine how fast it will rise when released? Energy balance necessary here. Basically then how do you determine all the parameters needed in the equation. You must come up with some correlations. Finally how to relate this to the speed at which it is rising if the sphere is getting smaller. Must assume creeping flow and use stoke's law.

Thermo/Kinetics:

Schaffer/Keasling

Keasling draws the 1/rate vs 1/[S] plot for Michaelis-Menten. Derive it. What are your assumptions? What happens to the plot for a competitive inhibitor? Derive it.

Schaffer says you have a block of metal at temperature T, mass m. How much work can you obtain from this block with an ambient temperature of Ta? Must use a carnot engine with hot temp T and cold temp Ta. Need efficiency for this engine that is limited by the 2nd law. What is the appropriate formulation of the second law for this problem. Finally, since the temperature is changing with time so is your efficiency. You must integrate to find the total possible amount of work.

Last question, How would you estimate the weight (or mass) of the earth's atmosphere?