A First Course on Kinetics and Reaction Engineering

Unit 3. Lesson Plan

Before Class

- Provide the redacted slides to the students and tell them to bring them to class
- Decide whether students will work alone or in groups for each of the two activities

During Class

- Introduce today's topic and where it fits in the course (Slides 1 and 2)
- Review of Unit 3 (5 to 10 minutes)
  - Slide 3: Describe the typical process
    - Calculate ΔG(298 K)
    - Calculate K(298 K)
    - Calculate ΔH(298 K)
      - Use it and heat capacities to generate an expression for $\Delta H(T)$
    - Calculate K(T)
    - Write equilibrium expressions for independent reactions
    - Use relations at bottom to convert activities to mole fractions
    - Use mole table to convert mole fractions to extents of reaction
      - Gives n equations in n unknown extents of reaction
    - Solve for equilibrium extents of reaction
      - Use those to calculate whatever equilibrium compositions variables you need
- Ask whether the students have any questions from their pre-class preparation
  - Slide 4
- Learning Activity (~20 minutes)
  - The students can use the worksheet as they progress through this activity
  - Slide 5: Go over the problem statement and answer any questions
  - Slide 6
    - Give them some time to work on calculating the equilibrium constant at 298 K.
    - Tell them to set things up, not make calculations
    - Circulate among them as they work
      - Stop and observe
      - Answer questions
      - If a common misconception is observed, stop them and discuss it
    - After a reasonable time, move on to slide 7
  - Slide 7
    - Ask if anyone had a different answer; and answer any questions they have
    - Then tell them to use that result to show how to calculate the equilibrium constant at one of the requested temperatures.

      - Circulate, etc. as for slide 6; after a reasonable time, move on to slide 8
  - Slide 8
    - Show them the result and answer any questions
    - Show them that to a first approximation the T dependence of the equilibrium constant has the same form as the Arrhenius expression
    - Show how increasing T decreases K for exothermic reactions
    - Point out that heat and entropy of reaction are actually variable with T, but result is generally valid that K decreases as T increases for exothermic reactions
  - Slide 9
    - Circulate, etc. as they work
  - Slide 10
    - Answer questions
    - Circulate, etc.
  - Slide 11
    - Answer questions and go over the remaining steps in the solution
- Learning Activity (~20 minutes)
  - Slide 12
    - Tell them that this is more challenging in two ways: first there are multiple reactions and second a solid forms
    - Remind them that for gases and liquids, the thermodynamic activity is related to the mole fraction, but point out that for a solid, it is equal to 1, and this adds a little complication to the calculations
    - Challenge them to see if they can set up the solution and let them get started
    - Circulate as they work, depending on their previous experience there may be a lot more questions as they work, tell them to do as much as they can
    - When you feel they are no longer making progress, use the following slides to walk them through the solution
  - Slide 13 - point out that in these problems you make an assumption regarding the formation of the solid and then check that assumption
    - Go through the steps you will be showing them
  - Slide 14 - This is like the first activity, there shouldn't be any questions
  - Slide 15 - Also like the first activity except two things to point out
    - First, the activity of carbon was set equal to 1
    - Second, the y's are gas phase mole fractions, and therefore the n_{total} refers to the total gas phase moles, not overall total moles
  - Slide 16, Like examples and first activity problems
    - Point out the total moles expression is gas phase moles; it does not include solid C; if necessary, use a mole table to show them
  - Slide 17, Go through bullet items

- Slide 18 (Optional)
  - Tell them this is an equivalent way to solve, it starts with the opposite assumption; then go through the steps
  - Point out that calculations are easier If the assumption that carbon does not form proves to be correct, otherwise they will have to go back and go through the other procedure where it was assumed carbon does form if they need to find the composition (if all they need is whether carbon forms, won't need to)
- Slide 19: Put what they just worked on in context, and tell them what's coming next class

After Class

- Provide the complete slides to the students.
- Optionally assign them to perform the calculations in either or both of the problems; in the latter, you'll need to specify a temperature and pressure.