ChE 201 – Energy Balances – Spring 2003 – 100 points
Pink Sheets & Calculators Allowed – No Books or Notes – No Sharing
Use Only the 'A' Term in the Heat Capacity Equations

Problem 1 (50 points)
Propylene (C_3H_6) is converted to cyclohexane (C_6H_{12}) in a catalytic reactor at 100 °C. Pure propylene is fed to the reactor at 50 °C and 1 atm. In the reactor, 80 % of the propylene is converted to cyclohexane. The cyclohexane and unreacted propylene are then cooled to 30 °C to recover cyclohexane as a liquid. You may assume that the propylene is non-condensible. The heat capacity of liquid cyclohexane is 0.15 kJ/mol °C. The heat of formation of gas phase cyclohexane is misprinted in the text, and should be –123.1 kJ/mol. The utility streams available for this process are:

- Saturated steam at 5 bar converted to saturated liquid water at 5 bar.
- Saturated liquid water at 5 bar converted to saturated steam at 5 bar.
- Liquid water at 10 °C converted to liquid water at 20 °C.
- Liquid water at 20 °C converted to liquid water at 10 °C.

a. Select the appropriate utility stream for the reactor and calculate the amount of utility H_2O required per 100 moles of propylene fed to the process.

b. Select the appropriate utility stream for the condenser and calculate the amount of utility H_2O required per 100 moles of propylene fed to the process.

Problem 2 (30 points)
Aqueous sulfuric acid (50 mol %) at 25 °C is diluted with pure water at 25 °C to make 20 mol % sulfuric acid, also at 25 °C. The flow rate of the aqueous sulfuric acid mixture coming in is 10 mol/min. All pipes leading into and out of the mixer are 5 cm inner diameter, and are constructed of stainless steel. There is no significant change in altitude between the inlet and outlet of the mixture. The utility streams available for this process are:

- Saturated steam at 5 bar converted to saturated liquid water at 5 bar.
- Saturated liquid water at 5 bar converted to saturated steam at 5 bar.
- Liquid water at 10 °C converted to liquid water at 20 °C.
- Liquid water at 20 °C converted to liquid water at 10 °C.

a. Select the appropriate utility stream for the process and calculate the amount of utility H_2O required.

b. If the dilution took place adiabatically, would the temperature of the 20 mole % solution be greater than or less than 25 °C?

Problem 3 (20 points)
Air at 30 °C and 50 % relative humidity is fed to a partial condenser, where it is cooled to 20 °C. Calculate the compositions of the inlet and exit streams, in either mass fraction or mole fraction (your choice).