321 هكم تصميم العمليات الكيميائية باستخدام الحاسب
CHE 321 Computer Aided Design for Chemical Processes
Spring Semester (1428 / 2007)

Final Exam

Note: use the simulation software to answer the following problems. Assign your student number as the file name. Your answers in the exam sheet must match the results in the simulator.

Problem No. 1
(Use any simulator to solve this problem)

A distillation column is needed to separate benzene from styrene. The feed is 60 mol% benzene and 40 mol% styrene which enters at 30 ^{o}C and 2 atm. The distillate should contain 99% benzene and 95% of the benzene fed to the column. Determine the followings:

a. The dew and bubble temperatures of the feed stream at 2 atm.
b. The dew and bubble pressures at 30 ^{o}C.
c. The minimum number of trays (N_{min}) at total reflux, the minimum reflux ratio (R_{min}), and the theoretical number of trays at equilibrium when $R = 1.2\ R_{min}$.

Problem No. 2
(Use ASPEN PLUS to solve this problem)

A hydrocarbon mixture (1000 mole/hr) containing 65% propane, 35% butane (all in mole %) at 60 ^{o}C and 3 atm is burned in a combustion chamber with 10% excess air. Air enters at 25 ^{o}C and 3 atm. All butane and 90% of the propane are consumed and no CO is found in the product gas. Determine the heat duty and the stack gas temperature, (T_{out}).

Problem No. 3
(Use any simulator to solve this problem)

Toluene **(C_7H_8)** is to be thermally converted to benzene in a reactor and be subsequently separated. The main reaction is

$$C_7H_8 + H_2 \xrightarrow{\quad} C_6H_6 + CH_4$$

with 75% conversion of the toluene. An unavoidable side-reaction occurs in which 2% of benzene is converted to biphenyl via the reaction,

$$2C_6H_6 \quad ========\rightarrow \quad C_{12}H_{10} + H_2$$

Using a basis of 1000 lb-mole for toluene, the two feed streams enter a mixer in stoichiometric amounts at 75 ºF and 570 psia. They are then heated to 1200 ºF. The adiabatic reaction effluent is then cooled to 120 ºF before being fed into distillation columns. In the first distillation column, all H_2 and CH_4 are removed in the distillate and then hydrogen is separated and recycled back to the reactor. The bottom stream from the first distillation column is fed to the second distillation column where benzene is removed in the distillate. The third distillation column separates toluene from diphenyl and toluene is recycled back to the reactor.

a. Determine the dew point of the feed stream before entering the reactor.
b. Determine the adiabatic reaction temperature and the heat duty.
c. Using a shortcut column with partial condenser, determine the number of stages and the feed stage location of the three distillation columns when R/R_{min} is 1.3.
d. What are the reboiler and condenser loads in each distillation column?
e. If the utility liquid for cooling the reactor effluent enters at 75ºF and leaves at 100ºF, calculate the ΔT_{LM} and estimate the amount of water required for the cooling.