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# Midterm Exam

Student Name:
Student Number:
Computer Number:

Note: use the simulator (CHEM-CAD) to answer the following questions. Assign your student number as the file name. **Your answers in this sheet must match the results of the simulator.**

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 the benzene is converted to biphenyl via the reaction,

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

Using a basis of 1000 moles 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. 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.

**Hint**: Use (shortcut column) to simulate three distillation columns, and use (component separator) to simulate the separation of methane from hydrogen.

- Make your own Process Flow Diagram of the problem.
- Determine the adiabatic reaction temperature/s and the heat duty/ies.
- Determine the dew point of the feed stream before entering the reactor.
- 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.
- What are the reboiler and the condenser loads in your distillation columns?
- If the utility liquid for cooling the reactor effluent enters at 75ºF and leaves at 100ºF, calculate the $\Delta T_{LM}$ and estimate the amount of water required for the cooling.