Dept. of Chemical Engineering: CH 2013

Assignment 2 on Aspen Plus

1. Liquid-liquid extraction

Acetone has to be extracted from a 100 kmol/hr acetone water mixture containing 90 mole % water using MIBK (methyl iso-butyl ketone) as solvent. The extraction is carried out at 30 deg C and 3 atm pressure using 100 kmol/hr of MIBK.

(a) Construct the liquid-liquid equilibrium diagram for the acetone-water-MIBK system. Using this determine the equilibrium concentration of acetone in MIBK (extract phase) and the concentration of acetone in the aqueous phase (raffinate) for the above feed-solvent mixture

(b) Set up a flowsheet for the extractor and determine the flow rates and compositions of raffinate and extract streams and compute the fraction of acetone in feed that is extracted.

(c) Set up the flowsheet for two cross current extractors in series where equal amount of solvent is used in each stage. Assume that equilibrium is attained in each stage. If the total amount of solvent used is same as in (b) determine the flow rates and concentrations of extract and raffinate streams from each stage and the fraction of acetone in feed that is extracted in the two stage process.

(d) Determine whether the single stage or two-stage process is more efficient and why? Provide theoretical reason for your observation (Qualitative discuss what happens in the limit as the number of stages goes to infinity and infinitesimal amount of solvent is used in each stage?).

Choose the NRTL model for modeling the liquid mixture behavior.

2. The formation of ammonia from nitrogen and hydrogen is a reversible reaction. Determine the equilibrium composition of ammonia reaction conducted at 150 atm pressure and 5000C using an equimolar mixture of hydrogen and nitrogen.

(a) Determine the equilibrium conversion of nitrogen for different temperatures in the range of 400 to 600 deg C (in steps of 500C) for a pressure of 150 atm. How does the equilibrium conversion vary with increase in temperature and why?

(b) Determine the equilibrium conversion of nitrogen for different pressures in the range 50atm – 200atm (in steps of 50atm) for a temperature of 5000C. How does the equilibrium conversion of nitrogen vary with increase in pressure and why?

Use Peng-Robinson equation of state for modelling the gas mixture.

3. A feed mixture at 300C and 1 atm pressure containing 25 mole % n-hexane, 40 mole % ethanol, 20 mole % methylcyclopentane is flashed to obtain a liquid and vapour stream (in equilibrium with each other). Determine the vapour and liquid compositions and the vapour fraction for the following two cases using Wilson equation to model the non-ideal liquid mixture and Redlich-Kwong (RK) equation of state for the vapour mixture.

(a) The flash drum is operated at 1 atm pressure and 610C. Note that this requires energy to be supplied to flash drum (this is known as isothermal flash). Also determine the energy supplied per kmol of the feed.

(b) Assume that the feed is at 30 atm pressure and 1000C. This is expanded through an isenthalpic valve to 1 atm pressure and then separated in a drum where the liquid and vapour fractions are separated (this is known as adiabatic flash).