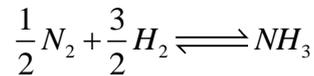

CL-402: Chemical Process Technology

July-November Session, 2018

7th semester, Department of Chemical Engineering
Indian Institute of Technology Guwahati, Guwahati

Tutorial-2**Problem-1: Ammonia Production**

Nitrogen and hydrogen react to form ammonia in the presence of a catalyst,



The reactor in which this reaction is to be run is maintained at 450 K.

- What will be the mole fractions of nitrogen, hydrogen, and ammonia exiting the reactor if stoichiometric amounts of nitrogen and hydrogen enter the reactor, which is kept at 4 bar?
- What will be the exit mole fractions if the reactor operates at 4 bar and the feed consists of 0.5 kmol/hr of nitrogen, 1.5 kmol/hr of hydrogen and 2.0 kmol/hr argon?
- For a feed consisting of stoichiometric amounts of nitrogen and hydrogen, study the effect of reaction temperature on ammonia production in the range 200-700 °C and also the effect of reaction pressure on ammonia production in the range of 100-1000 bar.

Problem-2: Isomerization of Normal Butane

Normal butane, C₄H₁₀, is to be isomerized to isobutane in a plug-flow reactor. This elementary reversible reaction is to be carried out adiabatically in the liquid phase under high pressure using a liquid catalyst. The feed enters at 330 K.

Isomerization reaction:



Both forward and reverse reactions are 1st order with respect to reactants.

$$Rate_{forward} = k_f C_{C_4H_{10}} \quad \text{and} \quad Rate_{reverse} = k_b C_{iC_4H_{10}}$$

where,

$$k_f = 0.008639 \times \text{Exp} \left[\frac{65700000}{R} \left(\frac{1}{360} - \frac{1}{T} \right) \right] \quad \text{and} \quad k_b = 0.003442 \times \text{Exp} \left[\frac{72600000}{R} \left(\frac{1}{360} - \frac{1}{T} \right) \right]$$

where, k_f and k_b are in sec^{-1} , Temperature in K, reactant concentration in terms of molarity (kmol/m^3) and activation energy in J/kmol.

- Calculate the PFR volume for 70% conversion (feed rate=160 kmol/h, 90 mol% n-butane and 10 mol% of i-pentane (which is considered an inert)).
- Plot the molar composition of all the components along the length of the reactor. Also plot the temperature profile along the length of the reactor.
- Calculate the CSTR volume for the same conditions as the PFR.