Chemical Reaction Engineering, CHE331A (2020-21-I)

Assignment 2

1. Consider a cylindrical variable-volume batch reactor that has one end fitted with a frictionless piston attached to a spring. The reaction A + B → 8 C with rate expression $-r_A = k\ C_A^2\ C_B$ is taking place in this reactor. Initially equal volumes of A and B are present in the reactor. Initial volume of reactor is 0.45 m^3. Value of ***k*** is $1.3*10^{-12}$ $(m^3/mol)^2 s^{-1}$. Relation between volume of reactor and pressure within reactor is $V = 0.11P$ were P is in atm and V is in m^3. Reaction takes place isothermally at 35°C. Write rate law solely as a function of conversion. What is the conversion and rate when volume of reactor is $0.6 m^3$?

2. The isothermal isobaric catalytic gas phase reaction A + 2 B → C, is carried out in a PBR at 4 atm and 150°C. Feed entering the reactor is a stoichiometric mixture. Assume reaction follows elementary rate law. Express concentration of each species as a function of conversion. What weight of catalyst is required to reach 95% conversion in a fluidized CSTR at 150°C? Volumetric flow is 4.3 dm^3/min and activation energy is 65 kJ/mol. Rate constant with respect to A is given as: $k_A = 92$ mol/(kg cat min atm^3) at 330K.

3. It is desired to carry out the gaseous reaction A → B in an existing tubular reactor consisting of 60 parallel tubes each of 30 ft long with a 0.5-inch inside-diameter. Bench-scale experiments have given the reaction rate constant for this first-order reaction as 0.00152 s^{-1}at 200°F and 0.080 s^{-1} at 340°F. At what temperature should the reactor be operated to give a conversion of A of 80% with a feed rate of 600 lb/h of pure A and an operating pressure of 100 psig? A has a molecular weight of 73. Deviation from perfect gas behavior may be neglected, and the reverse reaction is insignificant at these conditions.

4. The gaseous reaction A → B has a unimolecular reaction rate constant of 0.001 min^{-1} at 60°F. This reaction is to be carried out in parallel tubes 15 ft long and 1.5 inch inside diameter under a pressure of 132 psig at 240°F. A production rate of 500 lb/h of B is required. Assuming an activation energy of 20,000 cal/mol. How many tubes are needed if the conversion of A is to be 95%? Assume ideal gas law is applicable. A and B each have molecular weights of 58.