1. The elementary reversible gas phase reaction

$$2A \leftrightarrow C$$

is performed in a packed bed reactor with pressure drop. Pure A enters the reactor at 450 K with a flow rate of 8 mol/s and a concentration of $.8\ mol/dm^3$. The PBR contains 35 kg of catalyst and is surrounded by a heat exchanger with a cooling fluid at 525 K.

Data: $\alpha = .018 \frac{1}{kg*cat}$; $\frac{Ua}{\rho} = 100 \frac{J}{kg*cat*s*K}$; $\Delta H^o_{rxn} = -21000 \frac{J}{mol*K}$; $C_{p_A} = 20 \frac{J}{mol*K}$; $C_{p_C} = 40 \frac{J}{mol*K}$;

$$C_{p_{coolant}} = 20 \frac{J}{mol*K};\ m_{coolant} = 90 \frac{mol}{s}$$

$$k = 0.6\ @450\ K;\ E = 7500 \frac{J}{mol*K};\ Kc = 95\ @\ 450\ K$$

Plot the conversion, pressure ratio and temperatures as a function of catalyst weight for counter-current flow of the cooling fluid.

2. The elementary irreversible liquid-phase reaction

$$A + 2B \rightarrow 3C$$

Is performed adiabatically in a 25 L CSTR. The feed enters at $40\ {}^oC$, with volumetric flow rate of $2 \frac{dm^3}{s}$ with $C_{A0} = 0.5 \frac{kmol}{m^3}$ and $C_{B0} = 2.0 \frac{kmol}{m^3}$

Additional information:

$$H_A(273\ K) = -20 \frac{kcal}{mol};\ H_B(273\ K) = -15 \frac{kcal}{mol};\ H_C(273\ K) = -21 \frac{kcal}{mol}$$

$$C_{p_A} = C_{p_B} = 15 \frac{cal}{mol*K};\ C_{p_C} = 30 \frac{cal}{mol*K};\ k = .01 \frac{dm^3}{mol*s} @\ 300K;\ E = 10{,}000 \frac{cal}{mol}$$

Determine the temperature and conversion in the reactor.

3. Consider the following gas phase reactions taking place in a plug flow reactor. The gas stream entering the reactor is equimolar in A and B, and is at 16.4 atm and 500 K, with a volumetric flow rate of 20 $\frac{dm^3}{min}$.

$$A + 2B \rightarrow C + D; \quad r_{1D} = k_{1D} C_A C_B{}^2$$

$$2D + 3A \rightarrow C + E; \quad r_{2E} = k_{2E}\, C_A C_D$$

$$B + 2C \rightarrow D + E; \quad r_{3E} = k_{3E} C_B C_c{}^2$$

$$k_{1D} = 1.4 \ \frac{dm^6}{mol^2 * min}$$

$$k_{2E} = .18 \ \frac{dm^3}{mol * min}$$

$$k_{3E} = 1.2 \ \frac{dm^6}{mol^2 * min}$$

Plot the conversion of A, the molar flow rates of each species as a function of reactor volume and determine the reactor volume required to achieve a conversion of 80%.

4. The elementary liquid phase reaction

$$A + B \ \leftrightarrow C$$

Takes place in a 30 dm^3 adiabatic plug flow reactor. The molar flow rate of the feed is 4 mol/s, with a composition 25% A and 75% B and a volumetric flow rate of 2.3 $\frac{dm^3}{s}$. The inlet is fed at 350K. The heat of reaction at 298K is -20,000 cal/mol. The reaction constant is k = .0005 1/s at 298 K with $E = 12500 \ \frac{cal}{mol} K_c = 645 \ @ \ 315\ K$. The heat capacities are: $C_{pA} = 15$, $C_{pB} = 25$, $C_{pc} = 35$.

Determine the adiabatic equilibrium conversion and plot conversion and equilibrium conversion as a function of reactor volume. Plot the temperature with respect to reactor volume.