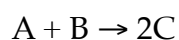


Chemical Reaction Engineering—Homework #7Due: Online submission on Canvas, [Wednesday, March 25, 2020, at 11:59pm.](#)

No late submissions will be accepted.

*Problems that require a numeric answer should have 3 significant figures.**Units, where required, are shown in blue. Please use these units.***Problem 1: Multiple steady states**

Calculate the steady states for the following elementary liquid-phase reaction and data below carried out in a CSTR.



$$V = 1 \text{ L}$$

$$k = 33\text{E}+9 \exp(-20000(\text{cal/mol})/(RT))$$

k has units of : (L/(mol*min))

$$-\Delta H_R = 20 \text{ kcal/mol}$$

$$C_{B0} = 3 \text{ mol/L}$$

$$T_0 = 17 \text{ deg C}$$

$$A = 250 \text{ cm}^2$$

$$\sum \Theta_i C_{p,i} * C_{B0} = 650 \text{ cal/(L*K)}$$

$$C_{A0} = 20 \text{ mol/L}$$

$$v = 100 \text{ cm}^3/\text{min}$$

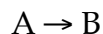
$$U = 0.1 \text{ cal/(cm}^2 * \text{min} * \text{K)}$$

$$T_a = 87 \text{ deg C}$$

- What are the steady state temperatures and conversions for this reactor? Hint: The temperatures will fall between 310K and 375K.
- Are there unstable steady state values, if so which one(s)?

Problem 2: CSTR with multiple steady states

The elementary liquid phase reaction:



occurs in a jacketed CSTR. Species A and inert I are fed to the reactor in equimolar amounts. The molar feed rate of A is 80 mol/min.

Information:

$$c_{P,I} = 30 \text{ cal}/(\text{mol } ^\circ\text{C})$$

$$UA = 8000 \text{ cal}/(\text{min } ^\circ\text{C})$$

$$k = 6.6 \times 10^{-3} \text{ min}^{-1} \text{ at } 350 \text{ K}$$

$$E_a = 40,000 \text{ cal}/(\text{mol K})$$

$$c_{P,A} = c_{P,B} = 20 \text{ cal}/(\text{mol } ^\circ\text{C})$$

$$\Delta H_R = -7500 \text{ cal/mol}$$

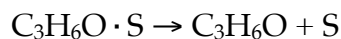
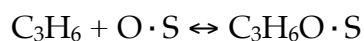
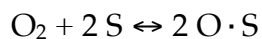
$$T_a = 300 \text{ K}$$

$$\tau = 100 \text{ min}$$

- What is the reactor temperature at a feed temperature of 450K?
- Plot the reactor temperature as a function of the feed temperature.
- Suppose that you begin with a feed temperature of 250K, which you slowly increase. What inlet temperature must the reactor be heated before the reactor operates at a high conversion? What are the corresponding temperature and conversion of the fluid in the CSTR just above this inlet temperature?
- Suppose that the inlet fluid is now heated 5°C above the temperature in part c and is cooled by 20°C where it remains. What will be the conversion?
- What is the feed temperature which will cause extinction for this reaction system?

Problem 3: Propylene oxidation

Propylene oxidation to acetone is believed to proceed via the following elementary steps.



with rate constants k_1, k_{-1}

with rate constants k_2, k_{-2}

with rate constant k_3

- Find the overall rate expression if step 1 is QE.
- Find the overall rate expression if step 1 and step 2 are QE.
- Write the apparent rate constant (k_{app}) and the apparent activation energy (E_{app}) for the mechanism in part b if $\text{O} \cdot \text{ S}$ is the MASI.