CBE 450 Chemical Reactor Fundamentals
Midterm Exam 2
November 7, 2011
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Consider the two simultaneous reactions

A + B → C
A + D → E

with elementary mechanism such that the rate of the first reaction is

$$r_1 = k_1 C_A C_B$$

and the second reaction is

$$r_2 = k_2 C_A C_D$$

where the rate constants are given by

$$k_1 = k_{o,1} \exp\left(-\frac{E_{a,1}}{RT} \right)$$

and

$$k_2 = k_{o,2} \exp\left(-\frac{E_{a,2}}{RT} \right)$$

The activation energy for the first reaction is different for each individual. See the table on the following page for your specific value of the activation energy. The rate constant prefactor for the first reaction is 0.01 liter/mole/s. The activation energy for the second reaction is 10000 J/mol. The rate constant prefactor for the second reaction is 0.1 liter/mole/s. The heat capacities of A, B, C, D, E and S are respectively 80, 100, 160, 60, 120, and 60 J/mol/K. The heats of formation of A, B, C D and Eat a reference temperature of 298.15 K are respectively -1, -10, -15, -8 and -100 kJ/mol.

This reaction takes place in a jacketed PFR. The inlet temperature is 500 K. The inlet concentrations of A, B, C, D, E and S are 10.0, 6.0, 0.0, 5.0, 0.0, and 30.0 mol/liter respectively. The inlet flowrate is 1 liter/s. The reactor is circular with diameter 0.1 m. The reactor is 5 m in length.

The jacket is a cylindrical shell of diameter 0.2 m around the reactor. It is of the same length as the reactor. The overall heat transfer coefficient from the reactor to the jacket is 1500.0 J/s/m^2/K. The heat capacity of the coolant is 75.3 J/mol/K and the concentration is 55.6

mol/liter. The flowrate of coolant is 10 liters/s. The inlet temperature of the coolant is 273.15. The initial temperature of the coolant is the same as the inlet temperature.

Task 1. Assume the flow of coolant is co-current. Compute the concentrations of A, B, C, D and E at the end of the reactor. Provide the outlet temperatures of the reactor and the jacket. Provide a plot of the steady state profiles of the concentrations of A, B, C, D, E and S and the temperatures. Explain the features.

Task 2. Assume the flow of coolant is counter-current. Compute the concentrations of A, B, C, D and E at the end of the reactor. Provide the outlet temperature of the reactor (at z = L) and the outlet temperature of the fluid in the jacket (at z = 0). Provide a plot of the steady state profiles of the concentrations of A, B, C, D, E and S and the temperatures. Explain the features.

The activation for the first reaction can be obtained from this table

	name	activation energy (J/mol)
1	Agahan, Erika Lei	1000
2	Bowman, Alex	1100
3	Bright, Michael	1200
4	Broomsbank, Jeremy	1300
5	Caldwell, Daniel	1400
6	Churchill, Robert	1500
7	Clarke, Cassandra	1600
8	Cox, Aaron	1700
9	Crabtree, Sarah	1800
10	Cruise, Sarah	1900
11	Dossey, Patricia	2000
12	Edgar, Natalie	2100
13	Fawaz, Samar	2200
14	Gordon, Scott	2300
15	Hall, Jerrika	2400
16	Hay, Jack	2500
17	Hipp, Abigail	2600
18	Howell, Daniel	2700
19	Kidd, Rachel	2800
20	Kinsey, Michael	2900
21	Le, Lephan	3000
22	Long, Allan	3100
23	Lumley, Robert	3200
24	Martin, John	3300
25	Melton, Matthew	3400
26	Moll, Brett	3500
27	Nuri, Mussa	3600
28	Oswald, Aaron	3700
29	Park, Jeremy	3800
30	Parsons, justin	3900
31	Ponzio, Nicholas	4000
32	Shedd, Daniel	4100
33	Tabors, Tia	4200
34	Whitener, Ricky	4300
35	Wilson, David	4400
36	Yount, Brian	4500