ChE 4063

# EXAM II
## Open Books and Notes
SOLUTION

November 7, 2000

I. 50 points:

The reactions:

$$A \rightarrow V \qquad r_v = k_1 C_A$$

$$A \rightarrow W \qquad r_w = k_2 C_A^2$$

are studied at constant density and temperature in a laboratory CSTR. The following experiment has been observed:

| | | | |
|---|---|---|---|
| $v_o$ | = | 0.6 lt/min | |
| $V_R$ | = | 4 lt | |
| $C_{Ao}$ | = | 1.8 moles/lt | |
| $C_{vo}$ | = | 0 | |
| $C_{wo}$ | = | 0 | |
| $C_{v1}$ | = | 1.2 moles/lt | (exit condition) |
| $C_{w1}$ | = | 0.4 moles/lt | (exit condition) |

(a) 20 points:

Set up the design equation for the CSTR and find the rate constants $k_1$ and $k_2$. Include units!

(b) 20 points:

Set up the design equation and determine the product distribution ($C_{A1}$, $C_{v1}$, and $C_{w1}$) if a 4 lt. PFR was substituted for the CSTR and the entrance conditions remain identical. Use the values of the rate constants you determined in part (a) for this calculation.

(c) 10 points

Calculate and compare $Y_v$ (the yield of V) for the CSTR and PFR.

II. 50 points:

The gas phase reaction:

$$A \rightarrow \tfrac{1}{2} B$$

is first order in A and takes place in a CSTR operated adiabatically and at constant pressure of 1 atm. An inert material, I, is used to dilute the A that enters the reactor. Assume ideal gases but do not assume constant density. The following data applies:

| | | | |
|---|---|---|---|
| $T_o$ | = | 350°K | |
| $F_{Ao}$ | = | 10 moles/min | |
| $F_{Io}$ | = | 100 moles/min | |
| $F_{Bo}$ | = | 0 | |
| $\Delta H_R$ | = | -10 kcal/mole | (independent of T) |
| $C_{pA}$ | = | 15 cal/mol°K | (independent of T) |
| $C_{pI}$ | = | 17 cal/mol°K | (independent of T) |
| $C_{pB}$ | = | 19 cal/mol°K | (independent of T) |
| A | = | $8 \times 10^{16}\ \text{min}^{-1}$ | (pre-exponential factor) |
| E | = | 22 kcal/mol | (activation energy) |

(a) 20 points:

Set up the adiabatic energy balance and determine the exiting temperature for 70% conversion of A.

(b) 30 points:

Set up the design equation and determine the reactor volume required to convert 70% of the A.

Note: R= 1.987 cal/mole-K = 8.314 J/mole-K

1 cal = 8.314/1.987 J