1. A liquid-phase reaction \( A + 2B \rightarrow C \) is taking place in a semi-batch reactor. The reaction is begun with 84 moles of A in the reactor. The initial reactor volume is 50 liters. B is added at a volumetric rate of 2 lit/min and a concentration of 10 mol/lit. The reaction is assumed to be zero order with respect to both A and B. The rate constant \( k \) is 0.125 \( \text{mol/} \text{lit-min} \). How much time does it take to reach a conversion of 50% A? What is the concentration of B at this time? 

20 points
2. A series reaction $A \xrightarrow{1st \text{ order}} B \xrightarrow{Zero \text{ order}} C$ is taking place in a CSTR. Derive the concentrations of A and B as functions of residence time $\tau$, the rate constants ($k_1$ and $k_2$) and the initial concentration of A ($C_{A0}$). Assume that the concentrations of B and C in the reactor entrance stream are zero.

20 points
3. Determine the composite rates of reaction for all of the species in the following reaction sequence.

\[ A \xleftrightarrow[k_1]{\text{First order}} B \xrightarrow[k_3]{\text{First order}} C \]

\[ 2A \xrightarrow[k_4]{\text{Second order}} D \]
4. Measured concentrations in a constant-volume batch reactor are tabulated. Determine the order of the reaction and the rate constant.

<table>
<thead>
<tr>
<th>t (mins)</th>
<th>0</th>
<th>5</th>
<th>13</th>
<th>20</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca (mol/lit)</td>
<td>5</td>
<td>0.93</td>
<td>0.41</td>
<td>0.27</td>
<td>0.18</td>
</tr>
</tbody>
</table>

22 points
5. The following first-order reaction is taking place in a PBR.

\[ A \rightarrow B \]

The reaction rate and the rate constant are given by:

\[-r_A^\cdot = k p_A \quad \text{mol kg cat-h} \]

\[ k = 0.75 \quad \text{mol atm-kg cat-h} \]

A is fed to the reactor with 50% inerts at 327°C and 1 atmosphere. Feed rate of A is 37.5 moles/h. The pressure drop parameter \( \alpha = 0.0045 \text{kg}^{-1} \). Obtain an expression that relates the conversion in the reactor to the weight of the catalyst used. What conversion can you obtain with 100 kg of the catalyst?

22 points