The goal of the following exercises is to be able to solve systems of ordinary differential equations without knowledge of the chemical and engineering context.

Problem 1

The hydrolysis of sucrose (S) into glucose (G) and fructose (F) is carried out on a large scale for the production of inverted sugar. The reaction can be described as follows:

$$S \rightarrow G + F$$

Inverted sugars find widespread use in the food industry. The hydrolysis is catalyzed by the enzyme Invertase, which is subject to substrate inhibition (here, inhibition by sucrose). The kinetics can be well described by a modified Michaelis-Menten model to account for substrate inhibition.

The rate of the hydrolysis reaction r (mol/L·min) is given by the following relationship:

$$r = \frac{V_m \cdot C_S}{K_M + C_S + \frac{C_S^2}{K_{iS}}}$$

V_m, K_m et K_{iS} are constants given below:

$V_m = 2.97 \cdot 10^{-2}$ (mol/L·min)

$K_m = 0.342$ (mol/L)

$K_{iS} = 0.379$ (mol/L)

The initial concentration of saccharose C_{SO} is 2 mol/L.

(a) Calculate the residence time needed to reach a conversion of 80 % in :

- A PFR reactor of 100 L
- A CSTR reactor of 100 L

(b) Calculate the residence time needed to reach a conversion of 99 % in :

- A PFR reactor of 100 L
- A CSTR reactor of 100 L

(c) Explain the differences

Problem 2

We consider the following elementary gas-phase reaction:

$$2A + B \rightarrow C$$

We consider the following elementary gas-phase reaction. The rate constant of this reaction is 10 $L^2/mol^2 \cdot s$. You want to carry out this reaction in an industrial isothermal tubular reactor of 250 L. The reactor is maintained at a temperature of 500 K and a pressure of 16.4 atm. There are no pressure drops along the reactor, and the molar fractions of A and B in the reaction mixture are both 0.5. The volumetric flow rate is 4 L/s.

a) Draw the profiles of concentration for each chemical species in the PFR reactor.
b) What volumes are needed to reach conversions of 80 % and 99 % in such a reactor ?