This problem is adapted from Text Exercise 4.8. It considers a different initial condition for the constant mass case.

Propylene glycol is produced by the hydrolysis of propylene oxide according to the following reaction

$$\mathrm{C_3H_6O + H_2O \rightarrow C_3H_8O_2}$$

In the presence of excess water, the reaction has been found to be first-order in propylene oxide

$$r = kc_{\mathrm{PO}}$$

and the rate constant is

$$k = k_0 e^{-E_a/RT} \qquad k_0 = 4.71 \times 10^9 \ \mathrm{s}^{-1} \qquad E_a = 18.0 \ \mathrm{kcal/mol}$$

Methanol is added as a solvent, and the reaction is performed in a 1000 L CSTR operating at 60 °C. The feed conditions and physical properties are as follows

Component	Density ($\mathrm{g/cm^3}$)	Mol. wt. (g/mol)	Inlet feedrate (L/hr)
propylene oxide	0.859	58.08	1300
water	1.000	18.02	6600
propylene glycol	1.0361	76.11	0
methanol	0.7914	32.04	1300

Assume the mixture is ideal so that

$$1 = \sum_j c_j V_j^\circ$$

in which $V_j^\circ = M_j/\rho_j^\circ$ are the pure component specific molar volumes. Neglect any change in the pure component densities with temperature in the temperature range 25–60 °C.

(a) Compute the steady-state concentrations of all components, Q, and V_R for the following two situations.

1. A float in the top of the tank is used to adjust Q to maintain reactor volume constant at 1000 L.
2. The reactor is initially charged with unreacted feed in proportion to the feedrates listed above, and a differential pressure measurement is used to adjust Q to maintain constant reactor mass.

(b) Explore what happens if you assume constant density, which leads to constant volume and constant volumetric flow.