# Practical Session 12

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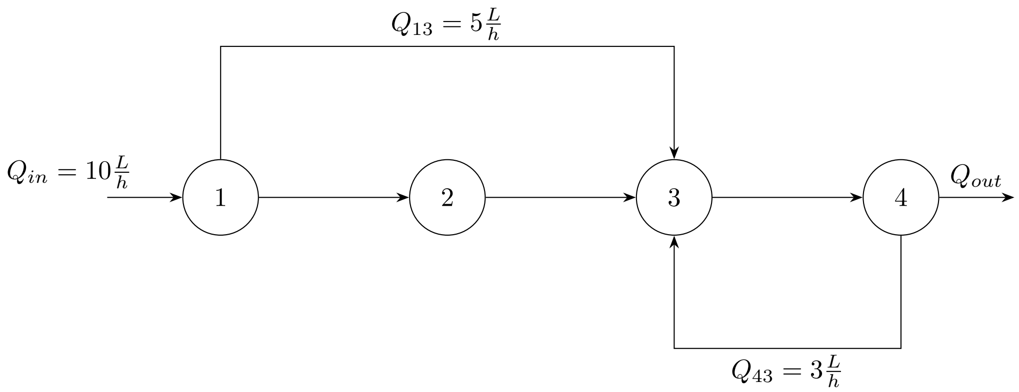
## Exercise 1

Inside 4 perfectly mixed reactors, the following irreversible first-order reaction occurs: $A \rightarrow B$ with kinetic constant $k$.
The rate at which A is transformed into B is expressed as $R = k\,V\,C_A \left[\frac{mol}{h}\right]$ with $V[L]$ and $C_A \left[\frac{mol}{L}\right]$
The reactors have different volumes and, since they operate at different temperatures, they have different reaction rates. Determine the concentration of A and B in each reactor under steady-state conditions.

| Reactor | V [L] | k [$h^{-1}$] |
|---|---|---|
| 1 | 25 | 0.05 |
| 2 | 75 | 0.1 |
| 3 | 100 | 0.5 |
| 4 | 25 | 0.1 |

Recall that the material balance is expressed as: Accumulation $= F_{in} - F_{out} \pm R$ with $F \left[\frac{mol}{h}\right]$ $Q_{in} = 10\frac{L}{h}$, $C_{A,in} = 1\frac{mol}{L}$, $\quad C_{B,in} = 0\frac{mol}{L}$




## Exercise 2

A wall is composed of a series of insulating layers of different thickness and thermal conductivity $\mathbf{k}$. If the temperature at the interface between each layer is denoted by $\mathbf{T_j}$, $j = 0, 1, ..., 4$ located at position $\mathbf{z_j}$, the heat flux $\mathbf{q}$ through each layer can be approximated by the following equation

$$q = k_j \frac{T_j - T_{j-1}}{z_j - z_{j-1}}$$

Given $\mathbf{T_0} = 0\,°C$, $\mathbf{T_4} = 100\,°C$, $\mathbf{k_{1,2,3,4}} = [3, 1.5, 5, 2]\,\frac{W}{mK}$ and $\mathbf{z_{0,1,2,3,4}} = [0, 0.1, 0.2, 0.4, 0.45]\,m$. Solve the following system of linear equations for the $\mathbf{4}$ unknowns $\mathbf{T_1}$, $\mathbf{T_2}$, $\mathbf{T_3}$ and $\mathbf{q}$, and plot the Temperature values at the corresponding points of $\mathbf{z}$.

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$$\begin{cases} q = k_1 \frac{T_1 - T_0}{z_1 - z_0} \\ q = k_2 \frac{T_2 - T_1}{z_2 - z_1} \\ q = k_3 \frac{T_3 - T_2}{z_3 - z_2} \\ q = k_4 \frac{T_4 - T_3}{z_4 - z_3} \end{cases}$$

## Exercise 3

Numerically determine the temperature extremes at the lunar surface between day and night by applying an energy balance (the sum of incoming thermal fluxes equals the sum of outgoing fluxes). Given the low thermal conductivity of the lunar soil (approximately $k = 0.005 \frac{W}{mK}$), at a depth of $d = 30$ cm the temperature remains constant at a value of $T0 = 253$ K. Consider 3 contributions: the incoming solar thermal flux, which varies between $1200 \frac{W}{m^2}$ and $0 \frac{W}{m^2}$; the outgoing radiative flux, which can be approximated as:

$$0.89 \cdot 5.67e^{-8} \cdot T^4 \quad (T \text{ in } K) \tag{1}$$

and an outgoing conduction contribution equal to:

$$(T - T0) \cdot \frac{k}{d} \tag{2}$$