Practical Session 11

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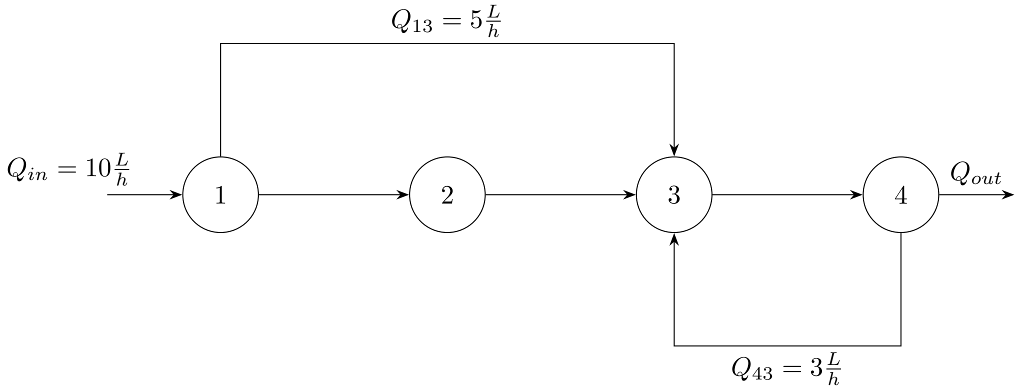
Exercise 1

Inside 4 perfectly mixed reactors, the following irreversible first-order reaction occurs: $A \to B$ with kinetic constant k.
The rate at which A is transformed into B is expressed as $R = kVc\left[\frac{mol}{h}\right]$ with $V[L]$ and $c\left[\frac{mol}{L}\right]$
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 $F\left[\frac{mol}{h}\right]$
$Q_{in} = 10\frac{L}{h}, \quad C_{A,in} = 1\frac{mol}{L}, \quad C_{B,in} = 0\frac{mol}{L}$



Exercise 2

Una parete è costituita da una serie di strati isolanti di diverso spessore e conducibilità termica $\mathbf{k}$. Se la temperatura dell'interfaccia tra ogni strato è indicata con $\mathbf{T_j}$, $j = 0, 1, ..., 4$ situata in posizione $\mathbf{z_j}$, il flusso di calore $\mathbf{q}$ attraverso ogni strato può essere approssimato dalla seguente equazione

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

Data $\mathbf{T_0} = 0\,°C$, $\mathbf{T_4} = 100\,°C$, $\mathbf{k_{1,2,3,4}} = [3, 1.5, 5, 2]\,\frac{W}{mK}$ e $\mathbf{z_{0,1,2,3,4}} = [0, 0.1, 0.2, 0.4, 0.45]\,m$. Risolvere il seguente sistema di equazioni lineari nelle $\mathbf{4}$ incognite $\mathbf{T_1}$, $\mathbf{T_2}$, $\mathbf{T_3}$ e $\mathbf{q}$, e diagrammare il valore della Temperatura nei punti corrispondenti di $\mathbf{z}$.

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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:

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