Solving Differential Material Balances

Procedure

1. Draw a diagram of the system, labeling all flow directions and boundary conditions.
2. Select a representative differential volume element.
3. Perform a material balance around that volume element, resulting in an equation for flux in terms of system geometric parameters.
4. Write an appropriate flux equation, resulting in a differential equation for concentration.
5. Solve

Steady-state systems

Flux and concentration are not functions of time.

If flux can be expressed in one spatial dimension (preferred!), then an ordinary differential equation results.

If flux must be expressed in 2-3 spatial dimensions, then a partial differential equation results.

Unsteady-state systems

Flux and concentration are functions of time.

A partial differential equation always results (with spatial and time dimensions).