# A First Course on Kinetics and Reaction Engineering
# Unit 32. Ideal Semi-Batch Reactors

### Definitions

semi-batch operation - while reaction is occurring, at least one, but not all, reagent flows into or out of the reactor.

### Nomenclature

$\Delta H_j$ heat of reaction $j$

$\Delta H_{latent,i}$ latent heat associated with any phase change that occurs when species $i$ is added to or removed from a semi-batch reactor

$v_{i,j}$ stoichiometric coefficient of species $i$ in reaction $j$; value is positive for products and negative for reactants

$\rho_i$ density of pure species $i$

$C_i$ concentration of species $i$

$\hat{C}_{p,i}$ constant pressure specific molar heat capacity of species $i$

$M_i$ molecular weight of species $i$

$P$ pressure, a subscript denotes a partial pressure of that species and an additional asterisk denotes the saturation vapor pressure of that species

$\dot{Q}$ net heat input into a reactor through its walls or the walls of a submerged cooling coil

$T$ temperature; a subscripted $e$ denotes the (external) temperature of the heat transfer media

$V$ volume within which reaction takes place, not necessarily the volume of the entire reactor; a superscripted zero denotes the volume at the start of processing

$\dot{V}$ inlet volumetric flow rate

$\dot{W}$ net rate at which mechanical work is done by a reactor system on its surroundings through shafts and moving boundaries

$h_i$ Henry's law constant for species $i$

$\hat{h}_i$ specific enthalpy of species $i$ at the instantaneously prevailing conditions within the reactor, the additional subscript "stream" denotes the specific enthalpy of species $i$ at the instantaneously prevailing input or outlet stream conditions

$n_i$ moles of species $i$

$\dot{n}_i$ molar flow rate of species $i$

$r_j$ the generalized rate of reaction $j$

$t$ time

$x_i$ liquid phase mole fraction of species $i$

**Equations**

$$\frac{dn_i}{dt} = \dot{n}_i + V \sum_{\substack{j=all \\ reactions}} \nu_{i,j} r_j \tag{32.1}$$

$$\dot{Q} - \dot{W} = \sum_{\substack{i=all \\ species}} \dot{n}_i \left( \hat{h}_i - \hat{h}_{i,stream} \right) + \frac{dT}{dt} \sum_{\substack{i=all \\ species}} \left( n_i \hat{C}_{pi} \right) + V \sum_{\substack{j=all \\ reactions}} \left( r_j \Delta H_j \right) - \frac{dP}{dt} V - P \frac{dV}{dt} \tag{32.2}$$

$$\dot{n}_i \left( \hat{h}_i - \hat{h}_{i,stream} \right) = \dot{n}_i \left( \int_{T_{stream}}^{T} \hat{C}_{p,i} \, dT + \Delta H_{latent,i} \right) \tag{32.3}$$

$$P_i = x_i P_i^* \tag{32.4}$$

$$P_i h_i = C_i \tag{32.5}$$

$$V(t) = \sum_{\substack{i=all \\ species}} \frac{n_i(t) M_i}{\rho_i} \tag{32.6}$$

$$V(t) = V^0 + \dot{V} t \tag{32.7}$$