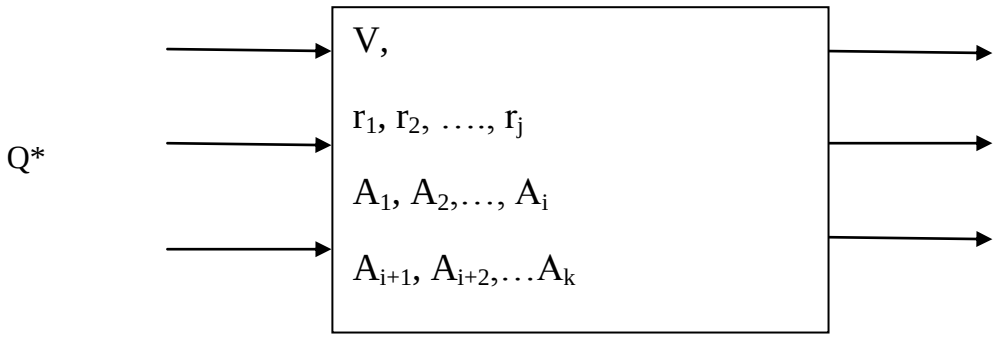
MASS BALANCE ANALYSIS OF REACTIONS AND REACTORS

1. **General mass balance concept**

$Mass_i$ inflow – $Mass_i$ outflow + $Mass_i$ generation = $Mass_i$ accumulation

2. **Multiple mass balances required for process that have coupled reactions, with overlapping reactants and products**
    a. Oxidation of organic matter and oxygen uptake
    b. Heterotrophic cell synthesis uptake of organic matter
    c. Cell synthesis uptake of nitrogen
    d. Oxidation of ammonia and autotrophic cell synthesis
    e. Reduction of nitrate and simultaneous consumption of organic matter
    f. Lysis of cells and generation of degradable organic matter
    g. And others…

Mass balance schematic for reactor volume, V, with multiple reactions r_j, with inflow/outflow rate, Q, multiple reactants A_i, and multiple products A_k is appropriate for biological wastewater treatment reactor, where we will keep track of COD, N, O_2, cells, etc.



3. **Two elements of mass balances:**
    h. **Components (products and reactants)**
    i. **Rates (kinetics)**

For component A_1, mass balance on mixed volume with a single reaction rate, r_1:

$$\mathbf{Q^*A_{1,0} - Q^*A_{1,e} + V^*r_1 = V} \quad \text{——}$$

Where V = reactor volume (m^3), Q = volumetric flow rate (m^3/d), $A_{1,0}$ = influent concentration of A_1, $A_{1,e}$ = effluent concentration of A_1, and A_1 = reactor concentration (g/m^3).

NOTE: one mass balance per component. For the system above, could write k mass balances each with 1 → j reaction terms.

4. **Stoichiometric analysis and coefficients** enables us to express consumption and production of a reactant or product in terms of other components in the reactor system which is necessary to evaluate multiple reactions
    a. For example, calculating the oxygen requirement for consumption of inflows of COD and ammonia nitrogen require the stoichiometric coefficients for oxygen in both reactions

5. **Kinetic (rate) expressions** are second element of mass balances required to predict effluent and reactor component concentrations.