5.6.3

$$\xrightarrow{V_0} S \xrightarrow{V_1} \qquad C^J_{e0} + C^J_{e1} = 1$$

$$C^J_{e0}\varepsilon^0_s + C^J_{e1}\varepsilon^1_s = 0$$

(a)

$$C^J_{e0} = 1 - C^J_{e1} \qquad C^J_{e0}\varepsilon^0_s = -C^J_{e1}\varepsilon^1_s$$

$$C^J_{e1} = -\frac{C^J_{e0}\varepsilon^0_s}{\varepsilon^1_s} \qquad 1 - C^J_{e0} = -\frac{C^J_{e0}\varepsilon^0_s}{\varepsilon^1_s}$$

$$1 = \frac{C^J_{e0}\varepsilon^1_s - C^J_{e0}\varepsilon^0_s}{\varepsilon^1_s} \Rightarrow C^J_{e0} = \frac{\varepsilon^1_s}{\varepsilon^1_s - \varepsilon^0_s}$$

#

$$\frac{\varepsilon^1_s}{\varepsilon^1_s - \varepsilon^0_s} = 1 - C^J_{e1} \Rightarrow C^J_{e1} = \frac{-\varepsilon^0_s}{\varepsilon^1_s - \varepsilon^0_s}$$

#

(b) $V_0 \Rightarrow$ supply rate $V_1 \Rightarrow$ demand rate

V_0's perturbation > V_1's perturbation

for perturbation, the bigger coefficient of sensitivity, the bigger perturbation

$$C^{J}_{e_0} > C^{J}_{e_1}$$

$$\frac{\varepsilon^1_s}{\varepsilon^1_s - \varepsilon^0_s} > \frac{-\varepsilon^0_s}{\varepsilon^1_s - \varepsilon^0_s}$$

$\Rightarrow$ suppose $\varepsilon^1_s - \varepsilon^0_s > 0$ $\quad \varepsilon^1_s > -\varepsilon^0_s$

$\varepsilon^1_s + \varepsilon^0_s > 0$

suppose $\varepsilon^1_s - \varepsilon^0_s < 0$ $\quad \varepsilon^1_s < -\varepsilon^0_s$

$\varepsilon^1_s + \varepsilon^0_s < 0$

(c)

$V_0 = e_0(k_0 X - k_{-1}[S])$, $V_1 = e_1 k_1 [S]$

$\varepsilon_S^0 = \frac{k_{-1}[S]}{k_0 X - k_{-1}[S]}$ $\varepsilon_S^1 = 1$

at steady state $k_0 X - k_{-1} s = e_1 k_1 s / e_0$

$$\varepsilon_S^0 = \frac{s}{V_0}\frac{\partial V_0}{\partial s} = \frac{[S]}{e_0(k_0 X - k_{-1}[S])}\left(\frac{\partial V_0}{\partial s}\right)$$

$$\frac{\partial V_0}{\partial s} = -e_0 k_{-1} \quad \hookrightarrow \frac{[S]\cdot(-e_0 k_{-1})}{e_0(k_0 X - k_{-1}[S])}$$

$$= \frac{-k_{-1}[S]}{k_0 X - k_{-1}[S]}$$

$$\varepsilon_S^1 = \frac{s}{V_1}\frac{\partial V_1}{\partial s} = \frac{[S]}{e_1 k_1 [S]} \times e_1 k_1 = 1$$

for V_0's effect > V_1's effect $\Rightarrow \varepsilon_S^1 > -\varepsilon_S^0$

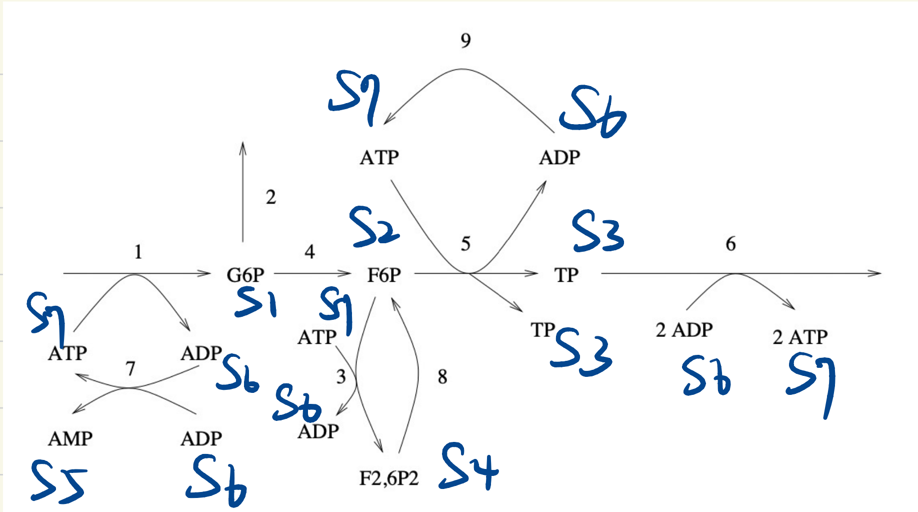
$$1 > \frac{k_{-1}[S]}{k_0 X - k_{-1}[S]} \quad k_0 X - k_{-1}[S] > k_{-1}[S]$$

$$e_1 k_1 \cancel{s} / e_0 > k_{-1}[\cancel{s}]$$

$$k_{-1} < \frac{e_1 k_1}{e_0}$$

5.6.9 (a)

$S_1 = G6P$
$S_2 = F6P$
$S_3 = TP$
$S_4 = F2,6P2$
$S_5 = AMP$
$S_6 = ADP$
$S_7 = ATP$



→

$$S = \begin{bmatrix} S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \\ S_7 \end{bmatrix} \qquad V = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \\ v_7 \\ v_8 \\ v_9 \end{bmatrix}$$

Suppose all reactions are reversible

$$N = \begin{array}{c c} \begin{array}{ccccccccc} V_1 & V_2 & V_3 & V_4 & V_5 & V_6 & V_7 & V_8 & V_9 \end{array} & \\ \begin{bmatrix} 1 & -1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & -1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & -1 & -1 & 0 & -1 \\ -1 & 0 & -1 & 0 & -1 & 1 & 0 & 0 & 1 \end{bmatrix} & \begin{array}{l} \leftarrow S_1 \\ \leftarrow S_2 \\ \leftarrow S_3 \\ \leftarrow S_4 \\ \leftarrow S_5 \\ \leftarrow S_6 \\ \leftarrow S_7 \end{array} \end{array}$$

$$
\frac{d}{dt}\begin{bmatrix} S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \\ S_7 \end{bmatrix}
=
\begin{bmatrix}
1 & -1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & -1 & 1 & -1 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & -1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
1 & 0 & 1 & 0 & 1 & -1 & -1 & 0 & -1 \\
-1 & 0 & -1 & 0 & -1 & 1 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \\ V_5 \\ V_6 \\ V_7 \\ V_8 \\ V_9 \end{bmatrix}
= 0
$$

$$
= \begin{bmatrix}
V_1 - V_2 - V_4 \\
V_4 + V_8 - V_3 - V_5 \\
V_5 - V_6 \\
V_3 - V_8 \\
V_7 \\
V_1 + V_3 + V_5 - V_6 - V_7 - V_9 \\
V_6 + V_9 - V_1 - V_3 - V_5
\end{bmatrix}
$$

$$
\begin{bmatrix}
1 & -1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & -1 & 1 & -1 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & -1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
1 & 0 & 1 & 0 & 1 & -1 & -1 & 0 & -1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix} +
$$

$$
S_5 + S_6 + S_7 = \text{constant}
$$

$$
\Rightarrow \begin{bmatrix}
1 & 0 & 0 & 0 & 0 & -\frac{3}{2} & 0 & 1 & -1 \\
0 & 1 & 0 & 0 & 0 & -1 & 0 & 1 & -1 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & -1 & 0 \\
0 & 0 & 0 & 1 & 0 & -\frac{1}{2} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & -\frac{1}{2} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
\begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \\ V_5 \\ V_6 \\ V_7 \\ V_8 \\ V_9 \end{bmatrix}
= 0
$$

$V_7 = 0$

$V_1 = \frac{3}{2} V_6 - V_8 + V_9 \quad V_3 = -V_8 \quad V_5 = -\frac{1}{2} V_6$

$V_2 = -V_6 + V_8 + V_9 \quad V_4 \; -\frac{1}{2} V_6 \quad V_7 = 0$

$\Rightarrow$ The kernel of N

$$\Rightarrow \begin{bmatrix} \frac{3}{2} \\ 1 \\ 0 \\ \frac{1}{2} \\ \frac{1}{2} \\ 1 \\ 0 \\ 0 \end{bmatrix} V_6 + \begin{bmatrix} -1 \\ -1 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix} V_8 + \begin{bmatrix} 1 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} V_9$$

5.6.9 (b)

$$N = \begin{array}{c c} & \begin{array}{ccccccccc} V_1 & V_2 & V_3 & V_4 & V_5 & V_6 & V_7 & V_8 & V_9 \end{array} \\ \begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \end{array} & \left[\begin{array}{ccccccccc} 1 & -1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & -1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & -1 & -1 & 0 & -1 \\ -1 & 0 & -1 & 0 & -1 & 1 & 0 & 0 & 1 \end{array}\right] \begin{array}{l} \leftarrow S_1 \\ \leftarrow S_2 \\ \leftarrow S_3 \\ \leftarrow S_4 \\ \leftarrow S_5 \\ \leftarrow S_6 \\ \leftarrow S_7 \end{array} \end{array}$$

$$\begin{bmatrix} \frac{3}{2} \\ 1 \\ 0 \\ \frac{1}{2} \\ \frac{1}{2} \\ 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 1 \\ 1 \\ -1 \\ 0 \\ 0 \\ 0 \\ 0 \\ -1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} \frac{1}{2} \\ 0 \\ 1 \\ \frac{1}{2} \\ \frac{1}{2} \\ 1 \\ 0 \\ 1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 1 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \end{bmatrix}$$

#

5.6.9.(c)

$$N^T = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 1 & -1 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 1 & -1 \\ -1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 1 & -1 \\ 0 & 0 & -1 & 0 & 0 & -1 & 1 \\ 0 & 0 & 0 & 0 & 1 & -1 & 0 \\ 0 & 1 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 \end{bmatrix}$$

化簡 reduced row echelon form

$$\Rightarrow \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \\ v_7 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$\Rightarrow$ The mass conservation is $\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \end{bmatrix}$