$$CO + Cl_2 \rightarrow COCl_2$$

Active intermediates : Cl^*, $COCl^*$

Reactions:

$$Cl_2 \xrightarrow{k_1} 2Cl^* \quad -(1)$$

$$2Cl^* \xrightarrow{k_2} Cl_2 \quad -(2)$$

$$CO + Cl^* \xrightarrow{k_3} COCl^* \quad -(3)$$

$$COCl^* \xrightarrow{k_4} CO + Cl^* \quad -(4)$$

$$COCl^* + Cl_2 \xrightarrow{k_5} COCl_2 + Cl^* \quad -(5)$$

Rates :

$$r_1 = k_1 [Cl_2]$$

$$r_2 = k_2 [Cl^*]^2$$

$$r_3 = k_3 [CO][Cl^*]$$

$$r_4 = k_4 [COCl^*]$$

$$r_5 = k_5 [COCl^*][Cl_2]$$

Rate of product formation

$$r_{COCl_2} = r_5 = k_5 [COCl^*][Cl^*]$$

Net rate of formation of active intermediates

$$r_{COCl^*} = r_3 - r_4 - r_5$$

$$r_{Cl^*} = \frac{r_1}{2} - r_2 - r_3 + r_4 + r_5$$

PSSH:

$$r_{COCl^*} = 0 = k_3 [CO][Cl^*] - k_4 [COCl^*] - k_5 [COCl^*][Cl_2]$$

$$\Rightarrow [COCl^*] = \frac{k_3 [CO][Cl^*]}{k_4 + k_5 [Cl_2]}$$

$$r_{Cl^*} = 0 \Rightarrow r_{Cl^*} + r_{COCl^*} = 0$$

$$\Rightarrow \cancel{r_3} - \cancel{r_4} - \cancel{r_5} + \frac{r_1}{2} - r_2 - \cancel{r_3} + \cancel{r_4} + \cancel{r_5} = 0$$

$$\Rightarrow \frac{r_1}{2} - r_2 = 0 \quad \frac{k_1}{2}[Cl_2] - k_2 [Cl^*]^2 = 0$$

$$[Cl^*] = \sqrt{\frac{k_1}{2k_2}[Cl_2]}$$

$$r_{COCl_2} = k_5 \left[\frac{k_3 [CO] \sqrt{\frac{k_1}{2k_2}} [Cl_2]^{1/2}}{k_4 + k_5 [Cl_2]} \right] [Cl_2]$$

$$r_{COCl_2} = \frac{k' [CO][Cl_2]^{3/2}}{k_4 + k_5 [Cl_2]}$$

$$k' = k_3 k_5 \sqrt{\frac{k_1}{2k_2}}$$

If $k_4 \gg k_5 [Cl_2]$

$$\boxed{r_{COCl_2} = k [CO][Cl_2]^{3/2}} \qquad k = \frac{k'}{k_4}$$