$$P_n(t+dt) = P_n(t)\,(1 - \text{term}_3) + \text{term}_1\,dt + \text{term}_2\,dt$$

$$\frac{P_n(t+dt) - P_n(t)}{dt} = -P_n\,\text{term}3 + \text{term}1 + \text{term}2.$$

For term3 we have the propensity function of any reaction occurs:

$$\underbrace{k_1(N-n)}_{\text{Reac. a)}} + \underbrace{k_1 n}_{\text{Reac. b)}} + \underbrace{\frac{k_2}{v} N(N-n)}_{\text{Reac. c)}} + \underbrace{\frac{k_2}{v} N(N-n)}_{\text{Reac. d)}} + \underbrace{\frac{k_3}{v^2} n(n-1)(N-n)}_{\text{Reac. e)}} + \underbrace{k_3 n(N-n)(N-n-1)}_{\text{Reac. f}}$$

$$= k_1 N + \frac{2k_2}{v} N(N-n) + \frac{k_3}{v^2} n(N-n)(n-1+N-n-1) =$$

$$k_1 N + \frac{2k_2}{v} N(N-n) + \frac{k_3}{v^2} n(N-n)(N-2) = \underline{\underline{\text{term}3}}$$

3. $M := \langle n \rangle$ (not)

$$\frac{\partial M}{\partial t} = \frac{\partial \sum_n P_n \cdot n}{\partial t} = \sum_{n=0}^{\infty} n P_{n-1}\left(k_1(N-n+1) + \frac{k_2}{v}(n-1)(N-n+1) + \frac{k_3}{v^2}(n-1)(n-2)(N-n+1)\right)$$

$$+ \sum_{n=0}^{\infty} n P_{n+1}\left(k_1(n+1) + \frac{k_2}{v}(n+1)(N-n-1) + \frac{k_3}{v^2}(n+1)(N-n-1)(N-n-2)\right)$$

$$- \sum_{n=0}^{\infty} n P_n\left(k_1 N + 2\frac{k_2}{v} n(N-n) + \frac{k_3}{v^2} n(N-n)(N-2)\right). \quad = *$$

— $n-1=k$ — $n+1=k$

$n=k+1$ $n=k-1$

$n=0 \Rightarrow k=-1$ $n=0 \Rightarrow k=1$

$$* = \sum_{k=0}^{\infty} (k+1)P_k\left(k_1(N-(k+1)+1) + \frac{k_2}{v}((k+1)-1)(N-(k+1)+1) + \frac{k_3}{v^2}((k+1)-1)((k+1)-2)(N-(k+1)+1)\right)$$

(term is 0 if $k=-1$)

$$+ \sum_{k=0}^{\infty} (k-1)P_k\left(k_1(k-1+1) + \frac{k_2}{v}(k-1+1)(N-(k-1)-1) + \frac{k_3}{v^2}((k-1)+1)(N-(k-1)-1)(N-(k-1)-2)\right).$$

($k=1$ vanishes)

$$- \sum_{k=0}^{\infty} k P_k\left(k_1 N + \frac{2k_2}{v^2} k(N-k) + \frac{k_3}{v^2} k(N-k)(N-2)\right)$$