Rate Law Expression

$NH_4^+ + NO_2^- \rightarrow N_2 + 2H_2O$

Trial	$[NH_4^+]$	$[NO_2^-]$	Initial Rate (mol L^{-1} s^{-1})
1	0.100 *M*	0.0500 *M*	1.50×10^{-3}
2	0.100 *M*	0.100 *M*	3.00×10^{-3}
3	0.200 *M*	0.100 *M*	1.20×10^{-2}

$$\text{rate} = k\,[NH_4^+]^x[NO_2^-]^y$$

Trials 1 & 2 hold $[NH_4^+]$ constant but change $[NO_2^-]$

Trial	$[NO_2^-]$	Initial Rate (mol L^{-1} s^{-1})
1	0.0500 *M*	1.50×10^{-3}
2	0.100 *M* (0.0500 **×2**)	3.00×10^{-3} (1.50×10^{-3} **×2**)

First order with respect to ammonium concentration

$$\text{rate} = k\,[[NO_2^-]^{\mathbf{1}}$$
$$1.50 \times 10^{-3}\,M\,s^{-1} = k\,[0.0500\,M]^{\mathbf{1}}$$
$$3.00 \times 10^{-3}\,M\,s^{-1} = k\,[0.100\,M]^{\mathbf{1}}$$

Trials 2 & 3 hold $[NO_2^-]$ constant but change $[NH_4^+]$

Trial	$[NH_4^+]$	Initial Rate (mol L^{-1} s^{-1})
2	0.100 *M*	3.00×10^{-3}
3	0.200 *M* (0.100 **×2**)	1.20×10^{-2} (3.00×10^{-3} **×4**)

Change in $[NH_4^+]$ changes the Initial Rate by the square of the change in $[NH_4^+]$

Second order with respect to ammonium concentration

$$\text{rate} = k\,[NH_4^+]^{\mathbf{2}}$$
$$3.00 \times 10^{-3}\,M\,s^{-1} = k\,[0.100\,M]^{\mathbf{2}}$$
$$20 \times 10^{-2}\,M\,s^{-1} = k\,[0.200\,M]^{\mathbf{2}}$$

Overall reaction is third order (**2 +1**)

$$\text{rate} = k\,[NH_4^+]^{\mathbf{2}}[NO_2^-]^{\mathbf{1}}$$