AP CHEMISTRY

TOPIC 8: KINETICS, PART A, EXAMPLES, PART III

Day 100:

- Reaction Order
- Rates Laws

Example # 1: The reaction

$$NH_4^{+1} + NO_2^{-1} \rightarrow N_2 + 2\,H_2O$$

was studied at 25^0C. The following results were obtained where:

Experiment	$[\ NH_4^{+1}\ ]$	$[\ NO_2^{-1}\ ]$	Initial Rate ($M\ \text{sec}^{-1}$)
1	0.100	0.0050	1.35×10^{-7}
2	0.100	0.010	2.70×10^{-7}
3	0.200	0.010	5.40×10^{-7}

a) What is the rate law?

$$\text{Rate} = k\,[\ NH_4^{+1}\ ]^m\,[\ NO_2^{-1}\ ]^n$$

$$\frac{Rate_{Exp\ 2}}{Rate_{Exp\ 1}} = \frac{2.70\times10^{-7}}{1.35\times10^{-7}} = 2$$

$$\frac{Rate_{Exp\ 2}}{Rate_{Exp\ 1}} = \frac{k\,[\ 0.100\ M\ ]^m\,[\ 0.010\ M\ ]^n}{k\,[\ 0.100\ M\ ]^m\,[\ 0.0050\ M\ ]^n} = 2 \ ; \ \frac{[\ 0.010\ M\ ]^n}{[\ 0.0050\ M\ ]^n} = 2 \ ; \ 2^n = 2$$

$$n = 1$$

$$\frac{Rate_{Exp\ 3}}{Rate_{Exp\ 2}} = \frac{5.40\times10^{-7}}{2.70\times10^{-7}} = 2$$

$$\frac{Rate_{Exp\ 3}}{Rate_{Exp\ 2}} = \frac{k\,[\ 0.200\ M\ ]^m\,[\ 0.010\ M\ ]^n}{k\,[\ 0.100\ M\ ]^m\,[\ 0.010\ M\ ]^n} = 2 \ ; \ \frac{[\ 0.200\ M\ ]^m}{[\ 0.100\ M\ ]^m} = 2 \ ; \ 2^m = 2$$

$$m = 1$$

The Rate Law is = **$\text{Rate} = k\,[\ NH_4^{+1}\ ]\,[\ NO_2^{-1}\ ]$**

$\text{Rate} = k\,[\ NH_4^{+1}\ ]\,[\ NO_2^{-1}\ ]$, both reactants are First Order !

b) What is the value of the rate constant?

To Determine the rate constant, k, pick "any" row of data and enter the values.

$$k = \frac{Rate\left(\frac{M}{\text{sec}}\right)}{[\ NH_4^{+1}\ ]\,[\ NO_2^{-1}\ ]} = \frac{5.40\times10^{-7}\ M}{(0.200\ M)(0.010\ M)(\text{sec})} = 2.7\times10^{-4}\ M^{-1}\ \text{sec}^{-1}$$

Example # 2: The reaction

$$2\ NO\ +\ Br_2\ \rightarrow\ 2\ NOBr$$

was studied at a constant temperature. The following results were obtained where:

Experiment	[NO]	[Br_2]	Initial Rate ($M\ sec^{-1}$)
1	0.10	0.20	24
2	0.25	0.20	150
3	0.10	0.50	60
4	0.35	0.50	735

a) What is the rate law?

$$Rate = k\ [\ NO\ ]^m\ [\ Br_2\ ]^n$$

$$\frac{Rate_{Exp\ 2}}{Rate_{Exp\ 1}} = \frac{150}{24} = 6.25$$

$$\frac{Rate_{Exp\ 2}}{Rate_{Exp\ 1}} = \frac{k\ [\ 0.25\ M\ ]^m\ [\ 0.20\ M\ ]^n}{k\ [\ 0.10\ M\ ]^m\ [\ 0.20\ M\ ]^n} = 6.25\ ;\ \frac{[\ 0.25\ M\ ]^n}{[\ 0.10\ M\ ]^n} = 6.25\ ;\ 2.5^m = 6.25$$

$$m = 2$$

$$\frac{Rate_{Exp\ 3}}{Rate_{Exp\ 1}} = \frac{60}{24} = 2.5$$

$$\frac{Rate_{Exp\ 3}}{Rate_{Exp\ 1}} = \frac{k\ [\ 0.10\ M\ ]^m\ [\ 0.50\ M\ ]^n}{k\ [\ 0.10\ M\ ]^m\ [\ 0.20\ M\ ]^n} = 2.5\ ;\ \frac{[\ 0.50\ M\ ]^m}{[\ 0.20\ M\ ]^m} = 2.5\ ;\ 2.5^n = 2.5$$

$$n = 1$$

The Rate Law is = **$Rate = k\ [\ NO\ ]^2\ [\ Br_2\ ]$**

$Rate = k\ [\ NO\ ]^2\ [\ Br_2\ ]$, "NO" is Second Order and "Br_2" is First Order !

b) What is the value of the rate constant?

To Determine the rate constant, k, pick "any" row of data and enter the values.

$$k = \frac{Rate\left(\frac{M}{\sec}\right)}{[\ NO\ ]^2\ [\ Br_2\ ]} = \frac{735\ M}{(0.35\ M)(0.50\ M)(\sec)} = 1.2\times10^4\ M^{-1}\ \sec^{-1}$$