

# AP CHEMISTRY

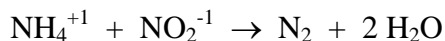
## TOPIC 8: KINETICS, PART A,

## EXAMPLES, PART III

Day 100:

- Reaction Order
- Rates Laws

Example # 1: The reaction



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

| Experiment | [ NH <sub>4</sub> <sup>+1</sup> ] | [ NO <sub>2</sub> <sup>-1</sup> ] | Initial Rate ( M sec <sup>-1</sup> ) |
|------------|-----------------------------------|-----------------------------------|--------------------------------------|
| 1          | 0.100                             | 0.0050                            | 1.35 x 10 <sup>-7</sup>              |
| 2          | 0.100                             | 0.010                             | 2.70 x 10 <sup>-7</sup>              |
| 3          | 0.200                             | 0.010                             | 5.40 x 10 <sup>-7</sup>              |

a) What is the rate law?

$$\text{Rate} = k [\text{NH}_4^{+1}]^m [\text{NO}_2^{-1}]^n$$

$$\frac{\text{Rate}_{\text{Exp 2}}}{\text{Rate}_{\text{Exp 1}}} = \frac{2.70 \times 10^{-7}}{1.35 \times 10^{-7}} = 2$$

$$\frac{\text{Rate}_{\text{Exp 2}}}{\text{Rate}_{\text{Exp 1}}} = \frac{k [ \cancel{0.100 M} ]^m [ 0.010 M ]^n}{k [ \cancel{0.100 M} ]^m [ 0.0050 M ]^n} = 2 ; \frac{[ 0.010 M ]^n}{[ 0.0050 M ]^n} = 2 ; 2^n = 2$$

$$n = 1$$

$$\frac{\text{Rate}_{\text{Exp 3}}}{\text{Rate}_{\text{Exp 2}}} = \frac{5.40 \times 10^{-7}}{2.70 \times 10^{-7}} = 2$$

$$\frac{\text{Rate}_{\text{Exp 3}}}{\text{Rate}_{\text{Exp 2}}} = \frac{k [ 0.200 M ]^m [ \cancel{0.010 M} ]^n}{k [ 0.100 M ]^m [ \cancel{0.010 M} ]^n} = 2 ; \frac{[ 0.200 M ]^m}{[ 0.100 M ]^m} = 2 ; 2^m = 2$$

$$m = 1$$

The Rate Law is = **Rate = k [ NH<sub>4</sub><sup>+1</sup> ] [ NO<sub>2</sub><sup>-1</sup> ]**

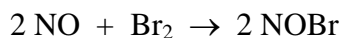
**Rate = k [ NH<sub>4</sub><sup>+1</sup> ] [ NO<sub>2</sub><sup>-1</sup> ], both reactants are First Order !**

b) What is the value of the rate constant?

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

$$k = \frac{\text{Rate} \left( \frac{M}{\text{sec}} \right)}{[\text{NH}_4^{+1}] [\text{NO}_2^{-1}]} = \frac{5.40 \times 10^{-7} M}{(0.200 M)(0.010 M)(\text{sec})} = 2.7 \times 10^{-4} M^{-1} \text{ sec}^{-1}$$

Example # 2: The reaction



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

| Experiment | [ NO ] | [ Br <sub>2</sub> ] | Initial Rate ( M sec <sup>-1</sup> ) |
|------------|--------|---------------------|--------------------------------------|
| 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?

$$\text{Rate} = k [\text{ NO }]^m [\text{ Br}_2 ]^n$$

$$\frac{\text{Rate}_{\text{Exp 2}}}{\text{Rate}_{\text{Exp 1}}} = \frac{150}{24} = 6.25$$

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

$$m = 2$$

$$\frac{\text{Rate}_{\text{Exp 3}}}{\text{Rate}_{\text{Exp 1}}} = \frac{60}{24} = 2.5$$

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

$$n = 1$$

The Rate Law is = **Rate = k [ NO ]<sup>2</sup> [ Br<sub>2</sub> ]**

**Rate = k [ NO ]<sup>2</sup> [ Br<sub>2</sub> ], “NO” is Second Order and “Br<sub>2</sub>” 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.*

$$k = \frac{\text{Rate} \left( \frac{\text{M}}{\text{sec}} \right)}{[\text{ NO }]^2 [\text{ Br}_2 ]} = \frac{735 \text{ M}}{(0.35 \text{ M})(0.50 \text{ M})(\text{sec})} = 1.2 \times 10^4 \text{ M}^{-1} \text{ sec}^{-1}$$