

## 15 • Chemical Kinetics

## RATE LAWS

1. Consider the reaction:
- $2 \text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{NO}_2(\text{g})$

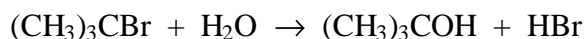
The following data were obtained from three experiments using the method of initial rates:

	Initial [NO] mol L <sup>-1</sup>	Initial [O <sub>2</sub> ] mol L <sup>-1</sup>	Initial rate NO mol L <sup>-1</sup> s <sup>-1</sup>
Experiment 1	0.010	0.010	$2.5 \times 10^{-5}$
Experiment 2	0.020	0.010	$1.0 \times 10^{-4}$
Experiment 3	0.010	0.020	$5.0 \times 10^{-5}$

- Determine the order of the reaction for each reactant.
  - Write the rate equation for the reaction.
  - Calculate the rate constant.
  - Calculate the rate (in mol L<sup>-1</sup>s<sup>-1</sup>) at the instant when [NO] = 0.015 mol L<sup>-1</sup> and [O<sub>2</sub>] = 0.0050 mol L<sup>-1</sup>
  - At the instant when NO is reacting at the rate  $1.0 \times 10^{-4}$  mol L<sup>-1</sup>s<sup>-1</sup>, what is the rate at which O<sub>2</sub> is reactant and NO<sub>2</sub> is forming?
2. The reaction  $2 \text{NO}(\text{g}) + 2 \text{H}_2(\text{g}) \rightarrow \text{N}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g})$  was studied at 904 °C, and the data in the table were collected.

	Initial [NO] mol L <sup>-1</sup>	Initial [H <sub>2</sub> ] mol L <sup>-1</sup>	Initial rate N <sub>2</sub> mol L <sup>-1</sup> s <sup>-1</sup>
Experiment 1	0.420	0.122	0.136
Experiment 2	0.210	0.122	0.0339
Experiment 3	0.210	0.244	0.0678
Experiment 4	0.105	0.488	0.0339

- Determine the order of the reaction for each reactant.
  - Write the rate equation for the reaction.
  - Calculate the rate constant at 904 °C.
  - Find the rate of appearance of N<sub>2</sub> at the instant when [NO] = 0.350 M and [H<sub>2</sub>] = 0.205 M.
3. The reaction of <sup>1</sup>butyl-bromide (CH<sub>3</sub>)<sub>3</sub>CBr with water is represented by the equation:

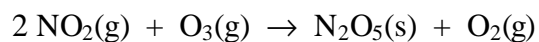


The following data were obtained from three experiments using the method of initial rates:

	Initial [(CH <sub>3</sub> ) <sub>3</sub> CBr] mol L <sup>-1</sup>	Initial [H <sub>2</sub> O] mol L <sup>-1</sup>	Initial rate mol L <sup>-1</sup> min <sup>-1</sup>
Experiment 1	$5.0 \times 10^{-2}$	$2.0 \times 10^{-2}$	$2.0 \times 10^{-6}$
Experiment 2	$5.0 \times 10^{-2}$	$4.0 \times 10^{-2}$	$2.0 \times 10^{-6}$
Experiment 3	$1.0 \times 10^{-1}$	$4.0 \times 10^{-2}$	$4.0 \times 10^{-6}$

- What is the order with respect to (CH<sub>3</sub>)<sub>3</sub>CBr?
- What is the order with respect to H<sub>2</sub>O?
- What is the overall order of the reaction?
- Write the rate equation.
- Calculate the rate constant, k, for the reaction.

4. The reaction:



$$\text{Rate Law: Rate} = k [\text{NO}_2]^a [\text{O}_3]^b$$

**ON ANOTHER SHEET OF PAPER:** Write your values for “a” (0, 1, 2), “b” (0, 1, 2), and “k”

The following data were obtained from three experiments using the method of initial rates:

	Initial $[(\text{CH}_3)_3\text{CBr}]$ $\text{mol L}^{-1}$	Initial $[\text{H}_2\text{O}]$ $\text{mol L}^{-1}$	Initial rate $\text{mol L}^{-1}\text{min}^{-1}$
Experiment 1	0.100	0.200	
Experiment 2	0.100	0.100	
Experiment 3	0.200	0.400	

- What is the order with respect to  $\text{NO}_2$ ?
- What is the order with respect to  $\text{O}_3$ ?
- Write the rate equation.
- Calculate the rate constant,  $k$ , for the reaction.