

AK

$$1^{\circ} = 1 \quad x^{\circ} = 1 \quad \left(\frac{\text{mol}}{\text{L}}\right)^{\circ} = 1$$

## Rate Law Problems

### problem 1

trial 1  $\rightarrow$  3  $[B]^y$  rate

$$\left(\frac{0.30}{0.10}\right)^y = \frac{3.0 \times 10^{-4}}{3.0 \times 10^{-4}}$$

$$3^y = 1 \quad y = 0 \quad \therefore [B]^0!$$

trial 2  $\rightarrow$  3  $[A]^x$  rate

$$\left(\frac{0.10}{0.30}\right)^x = \frac{3.0 \times 10^{-4}}{9.0 \times 10^{-4}}$$

$$\frac{1}{3}^x = \frac{1}{3} \quad x = 1$$

$$r = \frac{\cancel{[A]}^1}{\cancel{[A]}^1} = \frac{3.0 \times 10^{-4} \frac{\text{mol}}{\text{L min}}}{0.10 \frac{\text{mol}}{\text{L}}} = k$$

$$r = 3.0 \times 10^{-3} \text{ min}^{-1} [A] \quad 3.0 \times 10^{-3} \text{ min}^{-1} k$$

problem 2 \* find the rule for  $[A]^x$   
 then use with info for  $[B]^y$ .

trial 1  $\rightarrow$  2

$$\frac{[A]}{[A]} \quad \text{rate}$$

$$\left(\frac{1.50}{0.50}\right)^x = \frac{1.3 \times 10^{-2}}{4.2 \times 10^{-3}}$$

$$3^x = 3 \quad x = 1 \therefore [A]^1$$

trial 2  $\rightarrow$  3  $[A]^1 [B]^y = \text{rate}$

$$\left(\frac{3.00}{1.50}\right)^1 \cdot \left(\frac{3.00}{1.50}\right)^y = \frac{5.2 \times 10^{-2}}{1.3 \times 10^{-2}}$$

$$\cancel{2} \cdot 2^y = \frac{4}{2}$$

$$2^y = 2 \therefore y = 1$$

$$r = \frac{k [A]^1 [B]^1}{[A][B]}$$

$$4.2 \times 10^{-3} \frac{\text{mol}}{\text{L min}} = k = 5.6 \times 10^{-3} \frac{\text{L}}{\text{mol min}}$$

$$\frac{\left(\frac{0.5 \text{ mol}}{\text{L}}\right)^1 \left(\frac{1.5 \text{ mol}}{\text{L}}\right)^1}{\text{mol}^2 / \text{L}^2}$$

$$\frac{\frac{\text{mol}}{\text{L min}} \cdot \frac{\text{L}^2}{\text{mol}^2}}{\frac{\text{mol}^2}{\text{L}^2}} = \frac{\text{L}}{\text{mol min}}$$

### problem 3

trial 1 → 2

$$[A]^x = \text{rate}$$

$$\left(\frac{2.0}{4.0}\right)^x = \frac{0.80}{1.60}$$

$$\left(\frac{1}{2}\right)^x = \frac{1}{2} \quad \therefore x = 1$$

trial 1 → 3

$$[B]^y = \text{rate}$$

$$\left(\frac{3.0}{6.0}\right)^y = \frac{0.40}{1.60}$$

$$\left(\frac{1}{2}\right)^y = \frac{1}{4} \quad \therefore y = 2$$

$$\frac{r}{[A][B]^2} = \frac{k [A]^1 [B]^2}{[A][B]^2}$$

trial 1 info:

$$\frac{1.60 \text{ mmol}}{\text{L min}}$$

$$= k = 0.011 \text{ L}^2$$

$$\left(\frac{4.0 \text{ mol}}{\text{L}}\right) \left(\frac{6.0 \text{ mol}}{\text{L}}\right)^2$$

$$\frac{\text{mmol}^2}{\text{min}}$$

$$\therefore r = 0.011 \text{ L}^2 \frac{\text{mmol}^2}{\text{min}}$$

### problem 4

a) trial 1 → 2

$$[A]^x = \text{rate}$$

$$\left(\frac{0.080}{0.040}\right)^x = \frac{1.92 \times 10^{-5}}{9.6 \times 10^{-6}}$$

$$2^x = 2 \quad \therefore x = 1$$

trial 2 → 3

$$[B]^y = \text{rate}$$

$$\left(\frac{0.020}{0.040}\right)^y = \frac{9.6 \times 10^{-6}}{1.92 \times 10^{-5}}$$

$$\left(\frac{1}{2}\right)^y = \frac{1}{2} \quad \therefore y = 1$$

problem 4 cont.

$$b) \frac{r}{[A][B]} = k \frac{[A][B]}{[A][B]}$$

$$\frac{9.6 \times 10^{-6} \frac{\text{mol}}{\text{L s}}}{(0.040 \frac{\text{mol}}{\text{L}})(0.040 \frac{\text{mol}}{\text{L}})} = k = 0.006 \frac{\text{L}}{\text{mol s}}$$

$$c) r = 0.006 \frac{\text{L}}{\text{mol s}} [A][B]$$

$$= 0.006 \frac{\text{L}}{\text{mol s}} (0.12 \frac{\text{mol}}{\text{L}})(0.015 \frac{\text{mol}}{\text{L}})$$

$$\text{rate} = 1.08 \times 10^{-5} \frac{\text{mol}}{\text{L s}}$$

Problem 5

a) "determination"  $1 \rightarrow 2$

$$\frac{[\text{ClO}_2]^x}{\left(\frac{2.50 \times 10^{-2}}{1.25 \times 10^{-2}}\right)^x} = \frac{\text{rate}}{2.33 \times 10^{-4}}$$
$$\frac{9.34 \times 10^{-4}}{2.33 \times 10^{-4}} = 4$$

$$2^x = 4 \therefore x = 2$$

"determination"  $2 \rightarrow 3$

$$b) r = k [\text{ClO}_2]^2 [\text{OH}^-]^y$$

$$\frac{[\text{OH}^-]^y}{\left(\frac{2.60 \times 10^{-3}}{1.30 \times 10^{-3}}\right)^y} = \frac{\text{rate}}{9.34 \times 10^{-4}}$$
$$\frac{1.87 \times 10^{-3}}{9.34 \times 10^{-4}} = 2$$

$$2^y = 2 \therefore y = 1$$

$$k = 2.33 \times 10^{-4} \frac{\text{mol}}{\text{L s}}$$

$$\left(\frac{1.25 \times 10^{-2} \frac{\text{mol}}{\text{L}}}{1.30 \times 10^{-3} \frac{\text{mol}}{\text{L}}}\right)^2 \left(\frac{1.30 \times 10^{-3} \frac{\text{mol}}{\text{L}}}{1.30 \times 10^{-3} \frac{\text{mol}}{\text{L}}}\right)$$

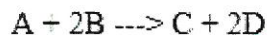
$$c) r = 1147 \frac{\text{L}^2}{\text{mol}^2 \text{s}} [\text{ClO}_2]^2 [\text{OH}^-]$$

$$\text{rate} = 4.18 \times 10^{-3} \frac{\text{mol}}{\text{L s}}$$

$$k = 1147 \frac{\text{L}^2}{\text{mol}^2 \text{s}}$$

## Rate Law Problems

**Problem #1:** Rate data were obtained for following reaction:



Exp.	Initial A (mol/L)	Initial B (mol/L)	Init. Rate of Formation of C ( $M \text{ min}^{-1}$ )
1	0.10	0.10	$3.0 \times 10^{-4}$
2	0.30	0.30	$9.0 \times 10^{-4}$
3	0.10	0.30	$3.0 \times 10^{-4}$
4	0.20	0.40	$6.0 \times 10^{-4}$

no change in rate!  
 $\therefore$  exponent is zero  
 $\therefore$  [B] is probably part of a very fast step

What is the rate law expression for this reaction?

**Problem #2:** For the reaction  $A + B \rightarrow$  products, the following initial rates were found. What is the rate law for this reaction?

- ↪ Trial 1: [A] = 0.50 M; [B] = 1.50 M; Initial rate =  $4.2 \times 10^{-3} M/\text{min}$
- ↪ Trial 2: [A] = 1.50 M; [B] = 1.50 M; Initial rate =  $1.3 \times 10^{-2} M/\text{min}$
- ↪ Trial 3: [A] = 3.00 M; [B] = 3.00 M; Initial rate =  $5.2 \times 10^{-2} M/\text{min}$

**Problem #3:** The following data were obtained for this chemical reaction:  $A + B \rightarrow$  products

Exp.	Initial A (mmol/L)	Initial B (mmol/L)	Init. Rate of Formation of products ( $mM \text{ min}^{-1}$ )
1	4.0	6.0	1.60
2	2.0	6.0	0.80
3	4.0	3.0	0.40

- (a) Determine the rate law for this reaction.
- (b) Find the rate constant.