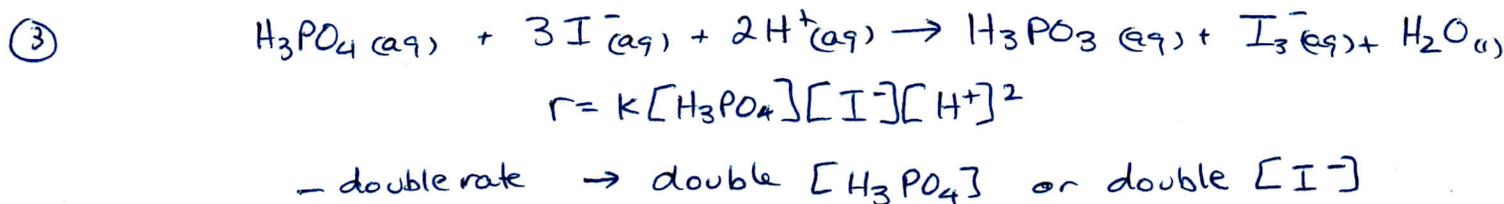
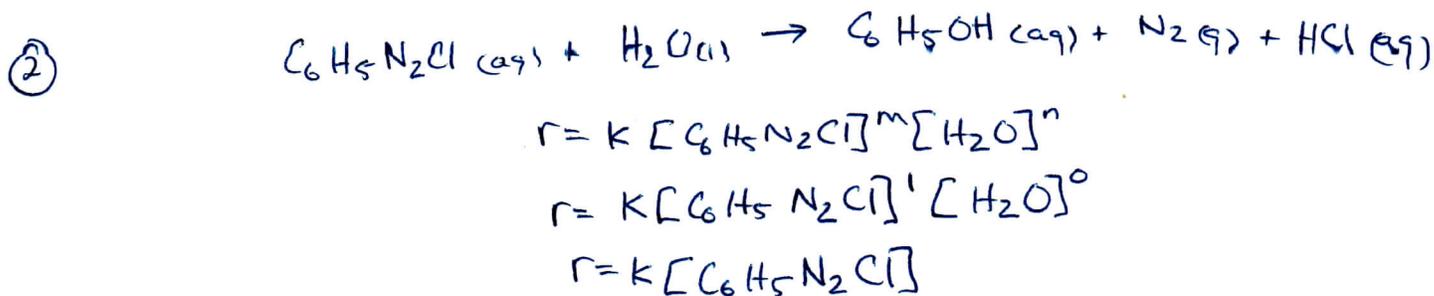
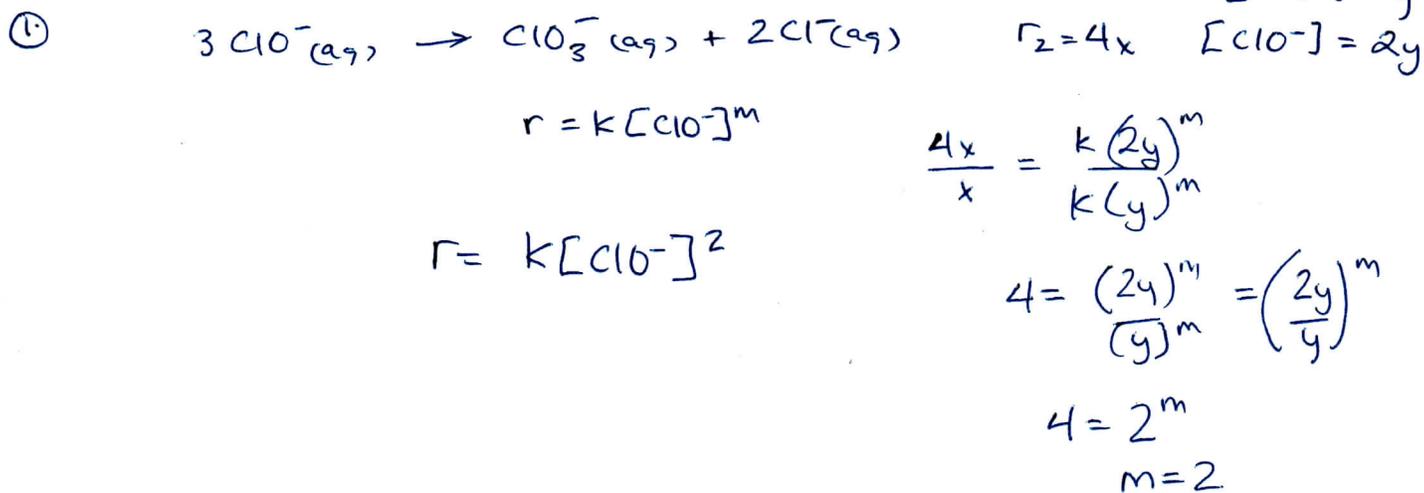


Practice Rate Law Problems - Chp 17



- 4 a) $r = k [\text{NO}_2]^2$ overall order = 2
- b) $r = k$ overall order = 0
- c) $r = k [\text{H}_2] [\text{Br}_2]^{1/2}$ overall order = 1.5
- d) $r = k [\text{NO}]^2 [\text{O}_2]$ overall order = 3



$$r = k[\text{NO}]^m [\text{Cl}_2]^n$$

$$x = k(y)^m (z)^n$$

$$9x = k(3y)^m (z)^n$$

$$0.5x = k(y)^m (0.5z)^n$$

r	$[\text{NO}]$	$[\text{Cl}_2]$
x	y	z
$9x$	$3y$	z
$0.5x$	y	$0.5z$

$$\frac{9x}{x} = \frac{k(3y)^m (z)^n}{k(y)^m (z)^n}$$

$$9 = \frac{(3y)^m}{(y)^m} = \left(\frac{3y}{y}\right)^m = 3^m$$

$$9 = 3^m$$

$m = 2$

$$r = k[\text{NO}]^2 [\text{Cl}_2]$$

$$\frac{x}{0.5x} = \frac{k(y)^m (z)^n}{k(y)^m (0.5z)^n}$$

$$\frac{1}{1/2} = \frac{(z)^n}{(0.5z)^n} = \left(\frac{z}{0.5z}\right)^n$$

$$\frac{1}{1/2} = \left(\frac{1}{1/2}\right)^n$$

$n = 1$

$$2 = 2^n$$



$$r = k[\text{NH}_3]^m \quad m = 0$$

$$r = k$$

⑦ a)

$$r = k[A]^2$$

$$r = k[3y]^2$$

$$r = 9ky$$

$$r_1 = ky \quad [A] = y$$

$$[A] = 3y$$

$$r_2 = 9ky$$

rate increase
by a factor
of 9

7b)

$$r = k[A]^2$$

$$r = k \left(\frac{1}{3}x\right)^2$$

$$r = \frac{1}{9}xk$$

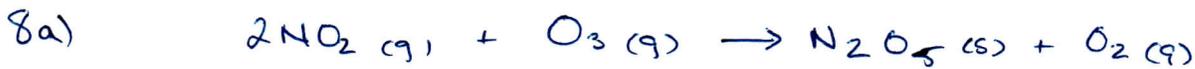
$$[A] = x$$

$$[A] = \frac{1}{3}x$$

$$r = kx^2$$

$$r = \frac{1}{9}kx^2$$

∴ rate decrease by a factor of 9



$$r = k[NO_2][O_3]$$

b)

trial 1
 $[NO_2] = x$

$$[O_3] = y$$

trial 2

$$[NO_2] = 2x$$

$$[O_3] = y$$

trial 1

$$r = k(x)(y)$$

$$r_1 = xyk$$

trial 2

$$r = k(2x)(y)$$

$$r_2 = 2xyk$$

rate doubled

$$\frac{r_2}{r_1} = \frac{2xyk}{xyk} = 2$$

$$r_2 = 2r_1$$

c)

trial 1
 $[NO_2] = x$

$$[O_3] = y$$

trial 2

$$[NO_2] = x$$

$$[O_3] = 3y$$

trial 1

$$r = k(x)(y)$$

$$r = xyk$$

trial 2

$$r = k(x)(3y)$$

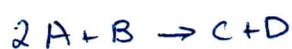
$$r = 3xyk$$

rate tripled

$$\frac{r_2}{r_1} = \frac{3xyk}{xyk} = 3$$

$$r_2 = 3r_1$$

9.



$$r = k[A]^m[B]^n$$

$$x = k(y)^m(z)^n$$

$$2x = k(2y)^m(z)^n$$

$$x = k(y)(0.5z)^n$$

$$\frac{2x}{x} = \frac{k(2y)^m(z)^n}{k(y)^m(z)^n} \quad 2 = \left(\frac{2y}{y}\right)^m$$

$$\frac{x}{x} = \frac{k(y)^m(z)^n}{k(y)^m(0.5z)^n}$$

$$2 = 2^m$$

$$m = 1$$

$$1 = \frac{(2)^n}{(0.5z)^n}$$

$$1 = (2)^n$$

$$n = 0$$

$$r = k[A]^1[B]^0$$

11.

$$r = k[A]^m[B]^n$$

$$\textcircled{1} \quad 0.470 = k(0.72)^m(0.18)^n$$

$$\textcircled{2} \quad 1.888 = k(0.72)^m(0.72)^n$$

$$\textcircled{3} \quad 0.117 = k(0.36)^m(0.18)^n$$

trial 2
trial 1

$$\frac{1.888}{0.470} = \frac{k(0.72)^m(0.72)^n}{k(0.72)^m(0.18)^n}$$

$$4 = \frac{(0.72)^n}{(0.18)^n} = \left(\frac{0.72}{0.18}\right)^n = 4^n$$

$$\boxed{n=1}$$

trial 1
trial 3

$$\frac{0.470}{0.117} = \frac{k(0.72)^m(0.18)^n}{k(0.36)^m(0.18)^n}$$

$$4 = \left(\frac{0.72}{0.36}\right)^m = 2^m$$

$$\boxed{m=2}$$

$$0.470 \frac{\text{mol}}{\text{L}\cdot\text{s}} = k \left(0.720 \frac{\text{mol}}{\text{L}}\right)^2 \left(0.180 \frac{\text{mol}}{\text{L}}\right)^1$$

$$0.470 \frac{\text{mol}}{\text{L}\cdot\text{s}} = k \left(0.093312 \frac{\text{mol}^3}{\text{L}^3}\right)$$

$$k = 5.04 \frac{\text{L}^2}{\text{mol}^2\cdot\text{s}}$$

$$r = 5.04 \frac{\text{L}^2}{\text{mol}^2\cdot\text{s}} [A]^2[B]$$

12.

$$r = k [A]^m [B]^n$$

$$\textcircled{1} \quad 0.42 = k (0.42)^m (0.53)^n$$

$$\textcircled{2} \quad 3.78 = k (0.42)^m (1.59)^n$$

$$\textcircled{3} \quad 0.14 = k (0.14)^m (0.53)^n$$

$$\frac{\text{trial 2}}{\text{trial 1}} \quad \frac{3.78}{0.42} = \frac{k (0.42)^m (1.59)^n}{k (0.42)^m (0.53)^n}$$

$$9 = \frac{(1.59)^n}{(0.53)^n} = \left(\frac{1.59}{0.53}\right)^n = 3^n \quad \boxed{n=2}$$

$$\frac{\text{trial 1}}{\text{trial 3}} \quad \frac{0.42}{0.14} = \frac{k (0.42)^m (0.53)^n}{k (0.14)^m (0.53)^n}$$

$$3 = \frac{(0.42)^m}{(0.14)^m} = \left(\frac{0.42}{0.14}\right)^m = 3^m \quad \boxed{m=1}$$

$$r = 3.56 \frac{\text{L}^2}{\text{mol}^2 \cdot \text{s}} [A][B]^2 \quad 0.42 \frac{\text{mol}}{\text{L} \cdot \text{s}} = k \left(0.42 \frac{\text{mol}}{\text{L}}\right) \left(0.53 \frac{\text{mol}}{\text{L}}\right)^2$$

$$k = 3.56 \frac{\text{L}^2}{\text{mol}^2 \cdot \text{s}}$$

13.

$$r = k [A]^m [B]^n$$

$$0.350 = k (0.48)^m (0.19)^n$$

$$0.35 = k (0.48)^m (0.38)^n$$

$$0.087 = k (0.24)^m (0.19)^n$$

$$\frac{\text{trial 2}}{\text{trial 1}} \quad \frac{0.35}{0.35} = \frac{k (0.48)^m (0.38)^n}{k (0.48)^m (0.19)^n}$$

$$1 = \frac{(0.38)^n}{(0.19)^n} = \left(\frac{0.38}{0.19}\right)^n = 2^n \quad n=0$$

$$\frac{\text{trial 1}}{\text{trial 3}} \quad \frac{0.35}{0.087} = \frac{k (0.48)^m (0.19)^n}{k (0.24)^m (0.19)^n}$$

$$4 = \frac{(0.48)^m}{(0.24)^m} = \left(\frac{0.48}{0.24}\right)^m = 2^m \quad m=2$$

~~m=2~~

$$0.35 \frac{\text{mol}}{\text{L} \cdot \text{s}} = k \left(0.48 \frac{\text{mol}}{\text{L}}\right)^2$$

$$k = 1.52 \frac{\text{L}}{\text{mol} \cdot \text{s}}$$

$$r = 1.52 \frac{\text{L}}{\text{mol} \cdot \text{s}} [A]^2$$

14.

$$r = k[A]^m[B]^n$$

$$0.370 = k(0.66)^m(0.47)^n$$

$$1.48 = k(0.66)^m(0.94)^n$$

$$0.123 = k(0.22)^m(0.47)^n$$

trial 2
trial 1

$$\frac{1.48 = k(0.66)^m(0.94)^n}{0.37 = k(0.66)^m(0.47)^n}$$

$$4 = \frac{(0.94)^n}{(0.47)^n} = \left(\frac{0.94}{0.47}\right)^n = 2^n \quad \boxed{n=2}$$

trial 1
trial 3

$$\frac{0.370}{0.123} = \frac{k(0.66)^m(0.47)^n}{k(0.22)^m(0.47)^n}$$

$$3 = \frac{(0.66)^m}{(0.22)^m} = \left(\frac{0.66}{0.22}\right)^m = 3^m \quad \boxed{m=1}$$

$$0.370 \frac{\text{mol}}{\text{L}\cdot\text{s}} = k(0.660 \frac{\text{mol}}{\text{L}})^1(0.47 \frac{\text{mol}}{\text{L}})^2$$

$$k = 2.54 \frac{\text{L}^2}{\text{mol}^2\cdot\text{s}}$$

$$r = 2.54 \frac{\text{L}^2}{\text{mol}^2\cdot\text{s}} [A][B]^2$$

15.

$$r = k[A]^m[B]^n$$

$$0.34 = k(0.3)^m(0.43)^n$$

$$1.36 = k(0.3)^m(1.72)^n$$

$$0.34 = k(0.15)^m(0.43)^n$$

trial 2
trial 1

$$\frac{1.36}{0.34} = \frac{k(0.3)^m(1.72)^n}{k(0.3)^m(0.43)^n}$$

$$4 = \frac{(1.72)^n}{(0.43)^n} = \left(\frac{1.72}{0.43}\right)^n = 4^n \quad \boxed{n=2}$$

trial 1
trial 3

$$\frac{0.34}{0.34} = \frac{k(0.3)^m(0.43)^n}{k(0.15)^m(0.43)^n}$$

$$1 = \frac{(0.3)^m}{(0.15)^m} = \left(\frac{0.3}{0.15}\right)^m = 2^m \quad \boxed{m=0}$$

$$\left(0.43 \frac{\text{mol}}{\text{L}}\right)^2 k = 0.34 \frac{\text{mol}}{\text{L}\cdot\text{s}}$$

$$k = 1.84 \frac{\text{L}}{\text{mol}\cdot\text{s}}$$

$$r = 1.84 \frac{\text{L}}{\text{mol}\cdot\text{s}} [B]^2$$

16.

$$r = k[A]^m[B]^n$$

$$0.46 = k(0.6)^m(0.36)^n$$

$$1.38 = k(0.6)^m(1.08)^n$$

$$0.051 = k(0.2)^m(0.36)^n$$

trial 2
trial 1

$$\frac{1.38}{0.46} = \frac{k(0.6)^m(1.08)^n}{k(0.6)^m(0.36)^n}$$

$$3 = \frac{(1.08)^n}{(0.36)^n} = \left(\frac{1.08}{0.36}\right)^n = 3^n \quad \boxed{n=1}$$

trial 1
trial 3

$$\frac{0.46}{0.051} = \frac{k(0.6)^m(0.36)^n}{k(0.2)^m(0.36)^n}$$

$$9 = \frac{(0.6)^m}{(0.2)^m} = \left(\frac{0.6}{0.2}\right)^m = 3^m \quad \boxed{m=1}$$

$$1.38 \frac{\text{mol}}{\text{L}\cdot\text{h}} = k \left(0.6 \frac{\text{mol}}{\text{L}}\right) \left(1.08 \frac{\text{mol}}{\text{L}}\right)$$

$$k = 2.13 \frac{\text{L}}{\text{mol}\cdot\text{h}}$$

$$r = 2.13 \frac{\text{L}}{\text{mol}\cdot\text{h}} [A][B]$$

17.

$$r = [A][B]^2$$

trial 1 $[B] = 0.1 \text{ mol/L}$

trial 2 $[B] = 0.3 \text{ mol/L}$

$$r_1 = (A)(0.1)^2$$

$$r_2 = (A)(0.3)^2$$

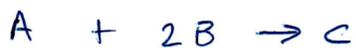
$$r_1 = 0.01 A$$

$$r_2 = 0.09 A$$

$$\frac{r_2}{r_1} = \frac{0.09 A}{0.01 A}$$

$$r_2 = 9r_1 \quad \therefore \text{rate } \uparrow \text{ by a factor of } 9$$

18.



$$[A] = 0.27 \frac{\text{mol}}{\text{L}}$$

$$[B] = 0.32 \frac{\text{mol}}{\text{L}}$$

$$r = 1.25 \times 10^{-2} \frac{\text{L}^3}{\text{mol}^3 \cdot \text{s}} [A]^2 [B]^2$$

$$r = 1.25 \times 10^{-2} \frac{\text{L}^3}{\text{mol}^3 \cdot \text{s}} \left(0.27 \frac{\text{mol}}{\text{L}}\right)^2 \left(0.32 \frac{\text{mol}}{\text{L}}\right)^2$$

$$r = 9.3 \times 10^{-5} \frac{\text{mol}}{\text{L} \cdot \text{s}}$$

19.



$$[A] = 0.68 \frac{\text{mol}}{\text{L}}$$

$$[B] = 0.14 \frac{\text{mol}}{\text{L}}$$

$$r = 1.94 \times 10^2 \frac{\text{L}}{\text{mol} \cdot \text{s}} [A] [B]$$

$$= 1.94 \times 10^2 \frac{\text{L}}{\text{mol} \cdot \text{s}} \left(0.68 \frac{\text{mol}}{\text{L}}\right) \left(0.14 \frac{\text{mol}}{\text{L}}\right)$$

$$r = 18 \frac{\text{mol}}{\text{L} \cdot \text{s}}$$

20.



$$[A] = 0.47 \frac{\text{mol}}{\text{L}}$$

$$[B] = 0.79 \frac{\text{mol}}{\text{L}}$$

$$r = 3.01 \times 10^2 \frac{\text{L}}{\text{mol} \cdot \text{s}} [A] [B]$$

$$= 3.01 \times 10^2 \frac{\text{L}}{\text{mol} \cdot \text{s}} \left(0.47 \frac{\text{mol}}{\text{L}}\right) \left(0.79 \frac{\text{mol}}{\text{L}}\right)$$

$$r = 1.1 \times 10^2 \frac{\text{mol}}{\text{L} \cdot \text{s}}$$