Rate Law Worksheet

1.

$r = K[A][B]$

$r_1 = k(1)(1)$

$r_1 = k$

$r_2 = k(4)(4)$

$r_2 = 16k$

∴ rate increase 16 x's

initial $[A] = 1\ mol/L$

$[B] = 1\ mol/L$

final

$[A] = \frac{[A]_1 V_1}{V_2}$

$= \frac{(1\ mol/L)(1\ L)}{0.5\ L}$

$= 4\ mol/L$

$[B]_2 = \frac{[B]_1 V_1}{V_2}$

$= \frac{(1\ mol/L)(1\ L)}{(0.5\ L)}$

$= 4\ mol/L$

2. $r = K[A]^m[B]^n[C]^p$

① $10 = k(0.1)^m(0.02)^n(0.04)^p$

② $15 = k(0.1)^m(0.03)^n(0.04)^p$

③ $80 = k(0.2)^m(0.02)^n(0.08)^p$

④ $160 = k(0.2)^m(0.02)^n(0.16)^p$

$\frac{②}{①}$ $\frac{15}{10} = \frac{k(0.1)^m(0.3)^n(0.04)^p}{k(0.1)^m(0.2)^n(0.04)^p}$

$1.5 = \frac{0.3^n}{0.2^n}$

$1.5 = \left(\frac{0.3}{0.2}\right)^n = 1.5^n$

$\boxed{n = 1}$

$\frac{③}{①}$ $\frac{80}{10} = \frac{k(0.2)^m(0.02)^n(0.08)^p}{k(0.1)^m(0.02)^n(0.04)^p}$

$8 = \left(\frac{0.2}{0.1}\right)^m\left(\frac{0.08}{0.04}\right)^p$

$8 = 2^m 2^p$ $\boxed{m = 2}$

$8 = 2^m(2)^1$

$4 = 2^m$

$\frac{④}{③}$ $\frac{160}{80} = \frac{k(0.2)^m(0.02)^n(0.16)^p}{k(0.2)^m(0.02)^n(0.08)^p}$

$2 = \left(\frac{0.16}{0.08}\right)^p$

$2 = 2^p$ $\boxed{p = 1}$

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

$$10 \frac{mol}{L \cdot s} = k\left(0.1 \frac{mol}{L}\right)^2 \left(0.02 \frac{mol}{L}\right)\left(0.04 \frac{mol}{L}\right)$$

$$\left(10 \frac{mol}{L \cdot s}\right) = \left(8 \times 10^{-6} \frac{mol^4}{L^4}\right) k$$

$$k = 1.25 \times 10^6 \frac{L^3}{mol^3 \cdot s}$$

2a) $r = 1.3 \times 10^6 \cdot [A]^2[B][C]$

if [B] doubles rate doubles

b) $r_z = r_y \times$ mol ratio

$$= 80 \frac{mol\ Y}{L \cdot s} \times \frac{1\ mol\ Z}{2\ mol\ Y}$$

$$\boxed{r = 40 \frac{mol\ Z}{L \cdot s}}$$

c) $r_c = -r_y \times$ mol ratio

$$= -15 \frac{mol\ Y}{L \cdot s} \times \frac{3\ mol\ C}{2\ mol\ Y}$$

$$= -22.5 \frac{mol}{L \cdot s}$$

d) $$r = 1.3 \times 10^6 \frac{L^3}{mol^3 \cdot s} [A]^2[B][C]$$

e) $$r = 1.3 \times 10^6 \frac{L^3}{mol^3 \cdot s} \left(0.05 \frac{mol}{L}\right)^2 \left(0.01 \frac{mol}{L}\right)\left(0.08 \frac{mol}{L}\right)$$

$$r = 2.5 \frac{mol}{L \cdot s}$$

f) $$k = 1.3 \times 10^6 \frac{L^3}{mol^3 \cdot s}$$

③

$r = k[S_2O_8^{2-}]^m[I^-]^n$

① $39 = k(0.04)^m(0.08)^n$

② $78 = k(0.04)^m(0.04)^n$

③ $156 = k(0.01)^m(0.08)^n$

trial ② / ① $\quad \frac{39}{78} = \frac{k(0.04)^m(0.04)^n}{k(0.04)^m(0.08)^n}$

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

$n = -1$

$\therefore n = 1$

↑ orders are

trial ③ / ① $\quad \frac{156}{39} = \frac{k(0.01)^m(0.08)^n}{k(0.04)^m(0.08)^n}$

$4 = \left(\frac{0.01}{0.04}\right)^m$

$4 = \left(\frac{1}{4}\right)^m \qquad m = -1$

$\therefore m = 1$

$$\boxed{r = k[S_2O_8^{2-}][I^-]}$$

$156\,s = k(0.01\ \frac{mol}{L})(0.08\ \frac{mol}{L})$

$$\boxed{K = 2.0 \times 10^5\ \frac{L^2 \cdot s}{mol^2}}$$

$$\boxed{r = 2 \times 10^5\ \frac{L^2 \cdot s}{mol^2}\ [S_2O_8^{2-}][I^-]}$$

trial 4

$r = 2 \times 10^5\ \frac{L^2 \cdot s}{mol^2}(0.02)(0.02)$

$$\boxed{r = 80\ s}$$

(4) $r = k[A]^m[B]^n$

using trials 1, 3, 4

(1) $0.26 \times 10^{-9} = k(1\times10^{-3})^m(0.25\times10^{-3})^n$

(3) $1.04 \times 10^{-9} = k(1\times10^{-3})^m(1\times10^{-3})^n$

(4) $4.16 \times 10^{-9} = k(2\times10^{-3})^m(1\times10^{-3})^n$

Trial 3 / Trial 1 $\quad \dfrac{1.04\times10^{-9}}{0.26\times10^{-9}} = \dfrac{k(1.00\times10^{-3})^m(1.0\times10^{-3})^n}{k(1.00\times10^{-3})^m(0.25\times10^{-3})^n}$

$4 = \left(\frac{1}{.25}\right)^n$

$4 = 4^n$

$\boxed{n = 1}$

Trial 4 / Trial 3 $\quad \dfrac{4.16\times10^{-9}}{1.04\times10^{-9}} = \dfrac{k(2\times10^{-3})^m(1\times10^{-3})^n}{k(1\times10^{-3})^m(1\times10^{-3})^n}$

$4 = \left(\frac{2}{1}\right)^m$

$4 = 2^m$

$\boxed{m = 2}$

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

$$1.04\times10^{-9}\ \frac{mol}{L\cdot s} = k\left(1\times10^{-3}\ \frac{mol}{L}\right)^2\left(1\times10^{-3}\ \frac{mol}{L}\right)$$

$$1.04\times10^{-9}\ \frac{mol}{L\cdot s} = k\left(1\times10^{-9}\ \frac{mol^3}{L^3}\right)$$

$$k = 1.04\ \frac{L^2}{mol^2\cdot s}$$

$$\boxed{r = 1.04\ \frac{L^2}{mol^2\cdot s}[A]^2[B]}$$

5. $r = k[X]^m[Y]^n$

① $6\times10^{-3} = k(1.0\times10^{-2})^m(4\times10^{-4})^n$

② $1.2\times10^{-2} = k(2\times10^{-2})^m(4\times10^{-4})^n$

③ $2.4\times10^{-2} = k(4\times10^{-2})^m(4\times10^{-4})^n$

④ $6.0\times10^{-3} = k(1\times10^{-2})^m(8\times10^{-4})^n$

trial 2 / trial 1

$$\frac{1.2\times10^{-2}}{6\times10^{-3}} = \frac{k(2\times10^{-2})^m(4\times10^{-4})^n}{k(1\times10^{-2})^m(4\times10^{-4})^n}$$

$$2 = \left(\frac{2}{1}\right)^m \qquad \boxed{m=1}$$

$$2 = 2^m$$

trial 4 / trial 1

$$\frac{6\times10^{-3}}{6\times10^{-3}} = \frac{k(1.0\times10^{-2})^m(8\times10^{-4})^n}{k(1\times10^{-2})^m(4\times10^{-4})^n}$$

$$1 = \left(\frac{8}{4}\right)^n \qquad \boxed{n=0}$$

$$1 = 2^n$$

$$r = k[X]$$

$$2.4\times10^{-2}\ \frac{mol}{L\cdot s} = k\left(4\times10^{-2}\ \frac{mol}{L}\right)$$

$$\boxed{k = 0.6\ s^{-1}}$$

$$\boxed{r = 0.6\ s^{-1}[X]}$$