Rate Laws

① Trial 1 → Trial 2

[HI] doubles $\left(\frac{0.2}{0.1} = 2\right)$

Rate doubles $\left(\frac{0.0152}{0.0076} = 2\right)$

∴ 1st order in HI

Trial 1 → Trial 3

$[H_2O_2]$ doubles $\left(\frac{0.2}{0.1} = 2\right)$

Rate doubles $\left(\frac{0.0152}{0.0076} = 2\right)$

∴ 1st order in H_2O_2

$\text{Rate} = k[H_2O_2][HI]$

$0.0152 = k(0.2)(0.1)$

$0.0152 = 0.02k$

$k = \frac{0.0152}{0.02} = 0.76$

$$\boxed{\text{Rate} = 0.76[H_2O_2][HI]}$$

③ Trial 1 → Trial 2

$[I_2]$ doubles, Rate doubles

∴ 1st order in I_2

Trial 2 → Trial 3

$[H_2]$ doubles, Rate doubles

∴ 1st order in H_2

$$\text{Rate} = K[H_2][I_2]$$

$$0.8 = K(2)(2)$$

$$0.8 = 4K$$

$$K = \frac{0.8}{4} = 0.2$$

$$\boxed{\text{Rate} = 0.2[H_2][I_2]}$$

③ Trial 1 → Trial 2

$[NO_2]$ doubles, Rate doubles

∴ 1st order in NO_2

Trial 1 → Trial 3

$[F_2]$ doubles, Rate doubles

∴ 1st order in F_2

$$\text{Rate} = k[NO_2][F_2]$$

$$2\times10^{-4} = k(1)(2)$$

$$2\times10^{-4} = 2k$$

$$k = \frac{2\times10^{-4}}{2} = 1\times10^{-4}$$

$$\boxed{\text{Rate} = 1\times10^{-4}[NO_2][F_2]}$$

④ Trial 1 → Trial 2

[NO] doubles $\left(\frac{2}{1} = 2\right)$

Rate x4 $\left(\frac{5.20 \times 10^{-3}}{1.30 \times 10^{-3}} = 4\right)$

∴ 2nd order (since $2^2 = 4$) ← order

Trial 1 → Trial 3

$[Br_2]$ doubles $\left(\frac{2}{1} = 2\right)$

Rate x32 $\left(\frac{4.16 \times 10^{-2}}{1.30 \times 10^{-3}} = 32\right)$

∴ 5th order (since $2^5 = 32$)

$$\text{Rate} = k[NO]^2[Br_2]^5$$

$$4.16 \times 10^{-2} = k(1)^2(2)^5$$

$$4.16 \times 10^{-2} = 32k$$

$$k = \frac{4.16 \times 10^{-2}}{32} = 1.3 \times 10^{-3}$$

$$\boxed{\text{Rate} = 1.3 \times 10^{-3}[NO]^2[Br_2]^5}$$

⑤ Trial 2 → Trial 3

$[ClO_3^-]$ doubles $\left(\frac{0.2}{0.1} = 2\right)$

Rate doubles $\left(\frac{4x}{2x} = 2\right)$

∴ 1st order in ClO_3^-

Trial 1 → Trial 2

$[I^-]$ doubles $\left(\frac{0.2}{0.1} = 2\right)$

Rate doubles $\left(\frac{2x}{x} = 2\right)$

∴ 1st order in I^-

Trial 3 → Trial 4

$[H^+]$ doubles $\left(\frac{0.2}{0.1} = 2\right)$

Rate x 4 $\left(\frac{16x}{4x} = 4\right)$

∴ 2nd order (since $2^2 = 4$)

$\text{Rate} = K[ClO_3^-][I^-][H^+]^2$

$16x = K(0.2)(0.2)(0.2)^2$

$16x = K(0.0016)$

$K = \frac{16x}{0.0016} = 10\,000\,x$

⑤ continued

$$\text{Rate} = 10\,000 \times [ClO^-][I^-][H^+]^2$$

⑥ a) H_2 is 1st order

∴ $[H_2] \times 2 \rightarrow$ Rate $\times 2$

b) NO is 2nd order

∴ $[NO] \times 2 \rightarrow$ Rate $\times 2^2$ or $\times 4$

c) H_2 is 1st order

∴ $[H_2] \times 0.5 \rightarrow$ Rate $\times 0.5$

d) half the volume → double the concentration

∴ $[NO] \times 2$ and $[H_2] \times 2$

↓ ↓

Rate $\times (2)^2$ Rate $\times 2$

$\times 4$ $\times 2$

Total $= (4)(2) = 8$

∴ Rate $\times 8$

h) $[H_2] \times 2 \rightarrow$ Rate $\times 2$

$[NO] \times 0.5 \rightarrow$ Rate $\times (0.5)^2 = \times 0.25$

Total $(2)(0.25) = 0.5$

$\therefore$ **Rate $\times 0.5$**

⑦ a) X is 0 order (does not affect rate)

$\therefore$ **no effect**

b) $[Y] \times 3 \rightarrow$ Rate $\times (3)^2 = \times 9$

(since y is 2nd order)

$\therefore$ **Rate $\times 9$**

c) Z is 1st order.

$[Z] \times 4 \rightarrow$ Rate $\times 4$

$\therefore$ **Rate $\times 4$**

d) $V_0 l \times 0.5 \rightarrow$ Conc. $\times 2$ (of all gases)

$[Y] \times 2$ ↓ Rate $\times 4$

$[Z] \times 2$ ↓ Rate $\times 2$

$(4)(2) = 8$ $\therefore$ **Rate $\times 8$**

e) vol x 2 → [ ] x 0.5

∴ $[NO]$ x 0.5 and $[H_2]$ x 0.5

↓ ↓

Rate x $(0.5)^2$ Rate x 0.5

x 0.25 x 0.5

Total = (0.25)(0.5)

= 0.125

∴ **Rate x 0.125**

f) Temp increase → increases the value of k

Increasing k will increase the reaction rate.

∴ **rate increases**

g) $[NO]$ x2 → Rate x 2^2 = x4

$[H_2]$ x 0.5 → Rate x 0.5

Total (4)(0.5) = x2

∴ **Rate x2**

e) Vol x 2 → Conc x 0.5 (For all gases)

[Y] x 0.5

↓

Rate x $(0.5)^2$

Rate x 0.25

[Z] x 0.5

↓

Rate x 0.5

Total (0.25)(0.5) = 0.125

∴ Rate x 0.125

f) temp. increase → K increases

∴ Rate increases

g) [X] x 4 → no effect

[Y] x 2 → Rate x 4

[Z] x 2 → Rate x 2

Total (4)(2) = 8

∴ Rate x 8

h) $[Z] \times 0.5 \rightarrow$ Rate $\times 0.5$

$[Y] \times 2 \rightarrow$ Rate $\times 4$

Total $(0.5)(4) = 2$

$\therefore$ **Rate $\times 2$**

i) $[Y] \times 3 \rightarrow$ Rate $\times 3^2 = \times 9$

$[Z] \times 3 \rightarrow$ Rate $\times 3$

$[X] \times \frac{1}{3} \rightarrow$ no effect

Total $(9)(3) = 27$

$\therefore$ **Rate $\times 27$**