Name Mr. Shank Class AP 1, 2, 3

12 converted to 20

Quiz 3: *Rate Tables*

Consider the following reaction between fluorine and chlorine dioxide: $F_{2(g)} + 2ClO_{2(g)} \rightarrow 2FClO_{2(g)}$

Using the data in the table below:

Experiment	$[F_2]$ (M)	$[ClO_2]$ (M)	T (C)	Initial Rate (M/s)
1	0.1	0.01	25	1.2×10^{-3}
2	0.1	0.04	25	9.6×10^{-3}
3	0.2	0.01	25	1.2×10^{-3}
4	0.3	0.04	0	1.5×10^{-3}

1. Determine the rate law for the reaction above. Do NOT calculate the value of k yet (see question 2).

$r = k[F_2]^x[ClO_2]^y$

$\frac{r_2}{r_1} = \frac{k(298)[F_2]_2^x[ClO_2]_2^y}{k(298)[F_2]_1^x[ClO_2]_1^y}$

$[F_2]_2 = [F_2]_1$

$\ln\left(\frac{r_2}{r_1}\right) = y \ln\left(\frac{[ClO_2]_2}{[ClO_2]_1}\right)$

$y = 3/2$

$x = \frac{\ln(r_3/r_1)}{\ln([F_2]_3/[F_2]_1)} = \frac{\ln(1)}{\ln(2)} = 0$

+4

Rate Law: r = $k[ClO_2]^{3/2}$

2. Determine the value of the rate constant (k) at 25 C. Be sure to include the **correct units**.

$r = k[ClO_2]^{3/2}$

$r = k[ClO_2]^{3/2}$ +3

$\frac{M}{s} = k\, M^{3/2}$

$k = \frac{M^{1/2}}{s} M^{-3/2} = M^{-1/2} s^{-1}$

$r_1 = k(25°C)[ClO_2]_1^{3/2}$

$k(25°C) = \frac{r_1}{[ClO_2]_1^{3/2}} = \frac{1.2 \times 10^{-3}}{(0.01)^{3/2}} = 1.2$

k (25 C) = 1.2 $M^{-1/2} s^{-1}$

3. Determine the activation energy of the reaction. (R = 8.314 J/mol K.)

$\frac{r_4}{r_2} = \frac{k(273)[ClO_2]_4^{3/2}}{k(298)[ClO_2]_2^{3/2}}$

$[ClO_2]_4 = [ClO_2]_2$

$\frac{r_4}{r_2} = \frac{k(273)}{k(298)} = \frac{Ce^{\frac{-E_a}{273R}}}{Ce^{\frac{-E_a}{298R}}}$

$\ln\left(\frac{r_4}{r_2}\right) = -\frac{E_a}{R}\left(\frac{1}{273} - \frac{1}{298}\right)$

$E_a = \frac{-8.314 \times 10^{-3} \ln\left(\frac{1.5 \times 10^{-3}}{9.6 \times 10^{-3}}\right)}{\left(\frac{1}{273} - \frac{1}{298}\right)}$ +4

E_a = 50.22 kJ/mol

+11

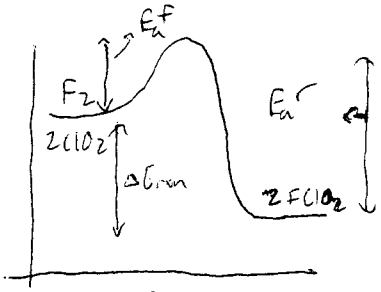
The rate constant for the reverse reaction

$$2FClO_2(g) \rightarrow F_2(g) + 2ClO_2(g)$$

Is 10^4 times **slower** than the forward reaction (at the top of the first page).

4. The formation of $FClO_2$ from F_2 and ClO_2 is is (circle one): (spontaneous) non-spontaneous

EC. Calculate ΔG_{rxn} for the formation of $FClO_2$ at 298 K.



$$E_a^r = E_a^f - \Delta G_{rxn}$$

$$\frac{k_f}{k_r} = \frac{Ce^{-\frac{E_a^f}{RT}}}{Ce^{-\frac{E_a^r}{RT}}} = \frac{e^{-\frac{(E_a^f)}{RT}}}{e^{-\frac{(E_a^f - \Delta G_{rxn})}{RT}}}$$

$$\ln\left(\frac{k_f}{k_r}\right) = -\frac{1}{RT}\left(E_a^f - E_a^f + \Delta G_{rxn}\right)$$

$$\ln\left(\frac{k_f}{k_r}\right) = -\frac{\Delta G_{rxn}}{RT}$$

$$\Delta G_{rxn} = -RT \ln\left(\frac{k_f}{k_r}\right)$$

$$= -\left(8.314 \times 10^{-3} \frac{kJ}{mol\,K}\right)(298\,K)\ln(10^4)$$

$$\Delta G_{rxn} = -22.82\ kJ/mol$$

+1