2/18/2019

last time ... $2H_2(g) + 2NO(g) \longrightarrow N_2(g) + 2H_2O(g)$

$$\text{rate} = K[H_2]^1[NO]^2$$

determined via XPTs!

RATE LAW

Q: if $[H_2] = 0.010M$
and $[NO] = 0.0025M$
and experimentally, rate $= 3.5 \times 10^{-6} M \cdot s^{-1}$

- What is the rate constant? K

$$K = \frac{\text{rate}}{[H_2][NO]^2} = \frac{3.5 \times 10^{-6} M \cdot s^{-1}}{[0.010M][0.0025M]^2}$$

$$= 56 \frac{M \cdot s^{-1}}{M^3} \text{ OR } \frac{s^{-1}}{M^2} \text{ OR } M^{-2}s^{-1}$$

$$\text{OR } \frac{1}{M^2 s} \text{ OR } \frac{1}{\left(\frac{mol}{L}\right)^2 \cdot s}$$

$$\text{OR } \frac{L^2}{mol^2 \cdot s} \text{ OR } L^2 \cdot mol^{-2} \cdot s^{-1}$$

ex: What would rate be if $[H_2] = [NO] = 0.50M$?

$$\text{rate} = K[H_2][NO]^2 = 56 M^{-2}s^{-1} \times (0.50M) \times (0.50M)^2$$

$$= 7 \underbrace{M^{-2}s^{-1}M^3}$$

$$= 7.0 \, M s^{-1}$$

How do we determine a rate law?

Do XPTS! - Common to use method of initial rates.

- need to know init concs.
- mix reactants.
- measure init. rate of rxn!

- we will run multiple trials + try to figure out orders and K from our data!

ex: $NO_2(g) + CO(g) \longrightarrow NO(g) + (O_2(g)$

assume rate law is: $\text{rate} = K[NO_2]^m[CO]^n$

XPT#	$[NO_2]_0$ (M) (time=0)	$[CO]_0$ (M)	Init rate ($M \cdot s^{-1}$)
1	0.10	0.10	0.0021
2	0.20 (×2)	0.10 (same)	0.0082 (×4)
3	0.20 (same)	0.20 (doubles)	0.0083 (same)

$\text{rate} \propto [NO_2]^m$ → if $m = 0$, $\text{rate} \propto [NO_2]^0$ should stay same? ✗

$\Rightarrow [CO]^0$ 0-order!

→ if $m = 1$, $\text{rate} \propto [NO_2]^1$: double NO_2 conc → double rate ✗

→ if $m = 2$, $\text{rate} \propto [NO_2]^2$: double NO_2 conc → quadruples rate ✓

$\Rightarrow$ 2nd order wrt NO_2!

$\text{rate} \propto [NO_2]^2$ (why? $\times 2\,[NO_2]$, $\times 4$ rate)

$\text{rate} \propto [CO]^0$ (why? $\times 2\,[CO]$, $\times 1$ rate)

$\Rightarrow \quad \text{rate} = K[NO_2]^2[CO]^0$

2nd order overall!

$$\boxed{\text{rate} = K[NO_2]^2}$$ K?

$$K = \frac{\text{rate}}{[NO_2]^2} \overset{\text{trial 1}}{=} \frac{0.0021\ M \cdot s^{-1}}{[0.10\ M]^2} = 0.21\ M^{-1}s^{-1}$$

always for 2nd order!

We'll do a bunch of these calcs in lab!
- we'll also need to use logarithms (see p633)

The integrated rate law: dependence of [ ] on time!

- useful to know how [ ] varies w/ time