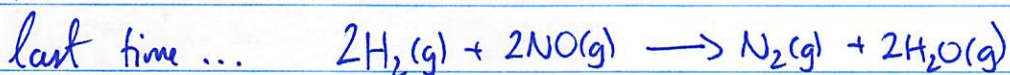


2/18/2019



$$\text{rate} = k [\text{H}_2]^1 [\text{NO}]^2$$

determined  
via XPTS!

RATE LAW

Q: if  $[\text{H}_2] = 0.010\text{M}$

and  $[\text{NO}] = 0.0025\text{M}$

and experimentally,  $\text{rate} = 3.5 \times 10^{-6} \text{M} \cdot \text{s}^{-1}$

- What is the rate constant?  $k$

$$k = \frac{\text{rate}}{[\text{H}_2] [\text{NO}]^2} = \frac{3.5 \times 10^{-6} \text{M} \cdot \text{s}^{-1}}{[0.010\text{M}] [0.0025\text{M}]^2}$$

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

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

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

ex: What would rate be if  $[\text{H}_2] = [\text{NO}] = 0.50\text{M}$ ?

$$\begin{aligned} \text{rate} &= k [\text{H}_2] [\text{NO}]^2 = 56 \text{M}^{-2} \cdot \text{s}^{-1} \times (0.50\text{M}) \times (0.50\text{M})^2 \\ &= 7 \text{M}^{-2} \cdot \text{s}^{-1} \cdot \text{M}^3 \end{aligned}$$

$$= 7.0 \text{M} \cdot \text{s}^{-1}$$



## How do we determine a rate law?

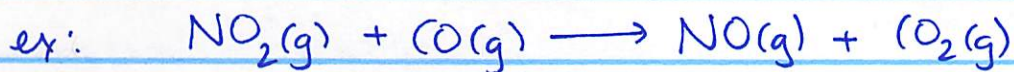
Do XPTS! - Common to use method of initial rates.

- 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!



assume rate law is:  $\text{rate} = k [\text{NO}_2]^m [\text{CO}]^n$

XPT#	$[\text{NO}_2]_0$ (M)	$[\text{CO}]_0$ (M)	Init (M·s <sup>-1</sup> ) rate
------	-----------------------	---------------------	--------------------------------

1	0.10	0.10	0.0021
2	0.20	0.10	0.0082
3	0.20	0.20	0.0083

$\text{rate} \propto [\text{NO}_2]^m \rightarrow$  if  $m=0$ ,  $\text{rate} \propto [\text{NO}_2]^0$  should stay same? (X)

$\Rightarrow [\text{CO}]^n$  0-order!  $\rightarrow$  if  $m=1$ ,  $\text{rate} \propto [\text{NO}_2]^1$ : double  $\text{NO}_2$  conc  $\rightarrow$  double rate (X)

$\rightarrow$  if  $m=2$ ,  $\text{rate} \propto [\text{NO}_2]^2$ : double  $\text{NO}_2$  conc  $\rightarrow$  quadruple's rate (✓)  
 $\Rightarrow$  2<sup>nd</sup> order wrt  $\text{NO}_2$ !



rate  $\propto [\text{NO}_2]^2$  (why?  $\times 2 [\text{NO}_2]$ ,  $\times 4$  rate)

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

$$\Rightarrow \text{rate} = k [\text{NO}_2]^2 [\text{CO}]^0$$

$$\boxed{\text{rate} = k [\text{NO}_2]^2}$$

k?

2<sup>nd</sup> order overall!

$$k = \frac{\text{rate}}{[\text{NO}_2]^2} \stackrel{\text{trial}}{=} \frac{0.0021 \text{ M}\cdot\text{s}^{-1}}{[0.10 \text{ M}]^2} = 0.21 \text{ M}^{-1}\text{s}^{-1}$$

always for 2<sup>nd</sup> order!

We'll do a bunch of these calcs in lab!

- we'll also need to use logarithms

(see p 633)

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

- useful to know how [ ] varies w/ time