Today, Jan. 24 Section 13.3 - 13.6

lab tomorrow

$CH_3CHO \rightarrow CH_4 + CO$

expt	time	$[CH_3CHO]_0$	initial rate
1	0	1.65 M	5.46 mmol/L·s
2	0	4.11 M	33.78 mmol/L·s
3	0	6.60 M	87.1 mmol/L·s

$rate = k[CH_3CHO]^{0,1,2}$

$5.45 = k[1.65]^{0,1,2}$

$33.78 = k[4.11]^{0,1,2}$

$$\frac{5.45}{33.78} = \frac{k(1.65)^{0,1,2}}{k(4.11)^{0,1,2}}$$

$$0.161 = (0.401)^{0,1,2}$$

$$0.161 = (0.401)^2$$

$rate = k[CH_3CHO]^2$

$33.78 \text{ mmol/L·s} = k\left(4.11 \frac{\text{mol}}{L}\right)^2$

$33.78 \times 10^{-3} \frac{\text{mol}}{L \cdot s} = k\left(4.11 \frac{\text{mol}}{L}\right)^2$

$$k = \frac{3.378 \times 10^{-2} \text{ mol} \mid L^2}{L \cdot s \mid 4.11^2 \text{ mol}^2} = 0.00200 \frac{L}{\text{mol·s}}$$

2nd order	1st order	0 order
$rate = k[A]^2$	$rate = k[A]^1$	$rate = k[A]^0$
$\frac{\text{mol}}{L \cdot \text{time}} = \left(\frac{L}{\text{mol·time}}\right)\frac{\text{mol}^2}{L^2}$	$\frac{\text{mol}}{L \cdot \text{time}} = \left(\frac{1}{\text{time}}\right)\frac{\text{mol}}{L}$	$\frac{\text{mol}}{L \cdot \text{time}} = \left(\frac{\text{mol}}{L \cdot \text{time}}\right)$

the units for k can change

rate = $k[A]^{0,1,\text{or }2} \times [B]^{0,1,\text{or }2}$

$2NO + H_2 \rightarrow N_2O + H_2O$

expt	$[NO]_0$	$[H_2]_0$	initial rate
1	0.60	0.37	0.181
2	1.00	0.37	0.503
3	0.60	0.94	0.181

rate = $k(NO)^{0,1,2}(H_2)^{0,1,2}$

$\frac{0.181}{0.506} = \frac{k\left(\frac{0.60}{1.00}\right)^{0,1,2} \times \left(\frac{0.37}{0.37}\right)^{0,1,2}}{k}$

$0.358 = (0.6)^{0,1,2}$

$0.36 = (0.6)^2$

2nd order

rate = $k(NO)^{0,1,2}(H_2)^{0,1,2}$

$\frac{0.181}{0.181} = \frac{k\left(\frac{0.60}{0.60}\right)^2 \times \left(\frac{0.37}{0.94}\right)^{0,1,2}}{k}$

$1 = (0.39)^{0,1,2}$

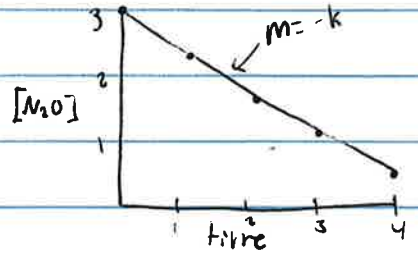
$1 = (0.39)^0$

zero order

Rate law: rate = $k[NO]^2$ (since H_2 is to zero order you don't have to write it)

$2N_2O \rightarrow 2N_2 + O_2$

time	$[N_2O]$
→ 0 hrs	3.00 mol/L
1 hr	2.37
→ 2 hrs	1.74
3 hrs	1.11
4 hrs	0.48



$y = mx + b$

$[N_2O]_t = -k(t) + [N_2O]_0$

↑ negative

k = always positive

$k = -m$

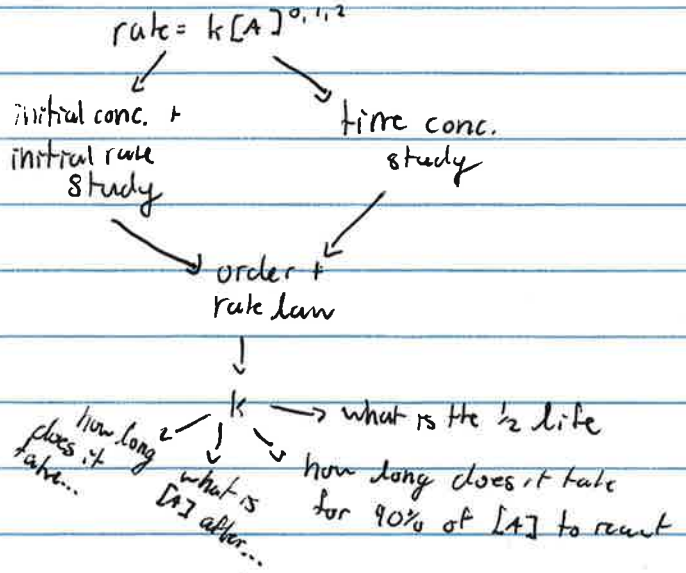
time concentration expression for zero order:

$[A]_t = -k(t) + [A]_0$

to find slope pick 2 times (usually $t = 0$ and then pick another where the concentration is about half the initial concentration)

$1.74 \text{ mol/L} = -k(2\text{hr}) + 3.00 \frac{\text{mol}}{\text{L}}$

$k = 0.63 \frac{\text{mol}}{\text{L·hr}}$



How long does it take until $[N_2O] = 1.50 \frac{mol}{L}$

$1.50 \frac{mol}{L} = -0.63 \frac{mol}{L \cdot hr}(t) + 3.00 \frac{mol}{L}$

$t = 2.38$ hrs.

What is $[N_2O]$ after 45 min?

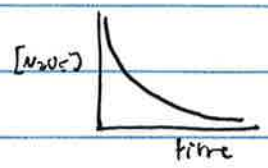
$\frac{45 min \mid 1 hr}{60 min} = 0.75 hr$

$[N_2O]_{0.75hr} = -0.63 \frac{mol}{L \cdot hr}(0.75 hr) + 3.00 \frac{mol}{L}$

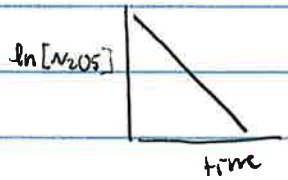
$[N_2O]_{0.75hr} = 2.53 \frac{mol}{L}$

$2N_2O_5 \rightarrow 4NO_2 + O_2$

time	$[N_2O_5]$	$\ln[N_2O_5]$
0s	2.330 mol/L	0.846
1000s	1.260 mol/L	0.231
2000s	0.681 mol/L	-0.384
3000s	0.369 mol/L	-0.997



zero order ✗



first order ✓

$y = mx + b$

$\ln[N_2O_5]_t = m(t) + \ln[N_2O_5]_0$

$y = mx + b$

$\ln [N_2O_5]_t = mt + \ln [N_2O_5]_0$

$-mt = \ln [N_2O_5]_0 - \ln [N_2O_5]_t$

$kt = \ln\left(\frac{[N_2O_5]_0}{[N_2O_5]_t}\right)$

$\ln\left(\frac{[A]_0}{[A]_t}\right) = kt = \ln\left(\frac{[A]_t}{[A]_0}\right) = -kt$ } time-conc expression for 1st order

how long does it take for $[N_2O_5]$ to decrease to 1.50 mol/L?

$\ln\left(\frac{[A_0]_0}{[A]_t}\right) = kt$

$\ln\left(\frac{2.330 \text{ mol/L}}{0.681 \text{ mol/L}}\right) = k(2000\text{s})$

$k = 0.00062 = 6.15 \times 10^{-4}\ \text{s}^{-1}$

$\ln\left(\frac{2.330 \text{ mol/L}}{1.50 \text{ mol/L}}\right) = (6.15 \times 10^{-4}\ \text{s}^{-1})\, t$

$t = 716\text{s}$

What is $[N_2O_5]$ after 2500s?

$\ln\left(\frac{2.330 \text{ mol/L}}{[N_2O_5]_{2500\text{s}}}\right) = (6.15 \times 10^{-4}\ \text{s}^{-1})(2500\text{s})$

$[N_2O_5]_{2500\text{s}} = 0.501 \text{ mol/L}$

How long does it take for 32% of the $[N_2O_5]$ to react?

$\ln\left(\frac{100\%}{68\%}\right) = kt$

$t = 627\text{s}$

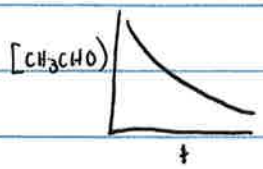
How long does it take until $[N_2O_5]$ falls to 75% of its original value?

$\ln\left(\frac{100\%}{74\%}\right) = kt$

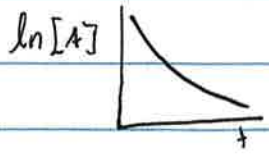
$t = 490\text{s}$

$CH_3CHO \rightarrow CH_4 + CO$

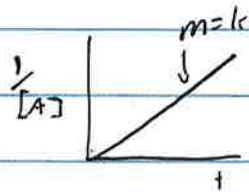
time	$[CH_3CHO]$
0 hr	0.400 mol/L
3 hr	0.118
6 hr	0.069
9 hr	0.049
12 hr	0.038



not zero order



not first order



second order

time conc expression for second order:

$$\frac{1}{[A]_t} = kx + \frac{1}{[A]_0}$$