The Integrated Rate Law

The integrated rate law describes how concentration varies with time. For each differential rate law there is a corresponding integrated rate law. To find the integrated rate law from experimental data we graph time v. concentration and look for linear relationships. Integrated rate laws are determined for one reactant at a time. It is significantly easier to do for single reactant reactions, but can be done with more complex reactions.

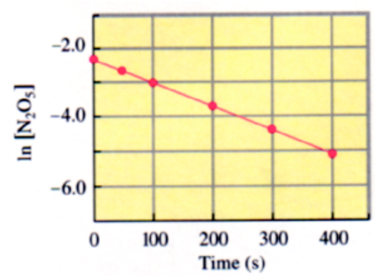
$$2N_2O_5 \rightarrow 4NO_2 + O_2$$

$$\text{Rate} = -\frac{\Delta[N_2O_5]}{\Delta t} = k[N_2O_5]$$

$$ln[N_2O_5] = -kt + ln[N_2O_5]_o$$

$$ln[A] = -kt + ln[A]_o$$

$[N_2O_5]$ (mol/L)	Time (s)
0.1000	0
0.0707	50
0.0500	100
0.0250	200
0.0125	300
0.00625	400



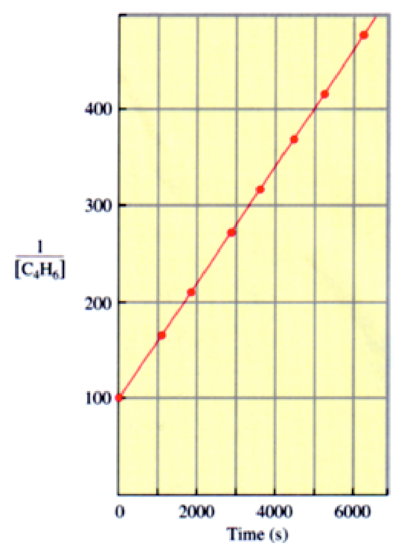
Second Order IRL

$$2C_4H_{6(g)} \rightarrow C_8H_{12(g)}$$

$$\text{Rate} = -\frac{\Delta[C_4H_6]}{\Delta t} = k[C_4H_6]^2$$

$$\frac{1}{[C_4H_6]} = kt + \frac{1}{[C_4H_6]_o}$$

t (s)	$\frac{1}{[C_4H_6]}$	$ln[C_4H_6]$
0	100	−4.605
1000	160	−5.075
1800	210	−5.348
2800	270	−5.599
3600	320	−5.767
4400	370	−5.915
5200	415	−6.028
6200	481	−6.175



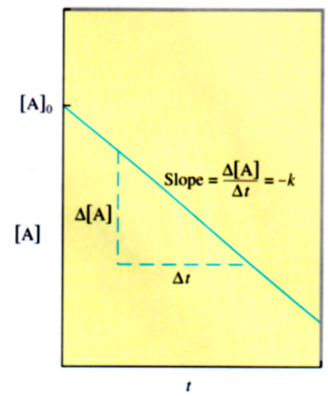
Zero Order IRL

$$2N_2O_{(g)} \rightarrow 2N_{2(g)} + O_{2(g)}$$

$$\text{Rate} = -\frac{\Delta[N_2O]}{\Delta t} = k[N_2O]^0 = k$$

$$[N_2O] = -kt + [N_2O]_o$$

$$[A] = -kt + [A]_o$$



Ex:

Rate Law Summary

	Order		
	Zero	First	Second
Rate law	Rate = k	Rate = k[A]	Rate = $k[A]^2$
Integrated rate law	$[A] = -kt + [A]_0$	$\ln[A] = -kt + \ln[A]_0$	$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$
Plot needed to give a straight line	[A] versus t	ln[A] versus t	$\frac{1}{[A]}$ versus t
Relationship of rate constant to the slope of straight line	Slope = $-k$	Slope = $-k$	Slope = k
Half-life	$t_{1/2} = \frac{[A]_0}{2k}$	$t_{1/2} = \frac{0.693}{k}$	$t_{1/2} = \frac{1}{k[A]_0}$