

First-Order Reactions: (rate is directly proportional to the concentration)

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

using calculus, as the  $\Delta t$  approaches 0, the Rate equation becomes

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

which can be rearranged into the “y = mx + b” format

$$\ln[R]_t = -kt + \ln[R]_0$$

so... IF the reaction is first-order with respect to R,  
plotting  $\ln[R]_t$  versus time results in a straight line with **k = -slope**

**SUMMARY**

Order	Rate Equation	Integrated Rate Equation	Straight Line Plot	Slope	k Units
0	Rate = k[R] <sub>0</sub>	[R] <sub>t</sub> - [R] <sub>0</sub> = -kt	[R] <sub>t</sub> vs. t	-k	mol / L*s
1	Rate = k[R] <sub>1</sub>	Ln([R] <sub>t</sub> /[R] <sub>0</sub> ) = -kt or see below table	Ln[R] <sub>t</sub> vs t	-k	s <sup>-1</sup>
2	Rate = k[R] <sub>2</sub>	(1/[R] <sub>t</sub> - (1/[R] <sub>0</sub> ) = kt	1/[R] <sub>t</sub> vs t	k	L / mol*s
<b>Memorize this!!</b>					

Second-Order Reactions	Zero-Order Reactions	First-Order Reactions
Rate = $-\frac{\Delta[R]}{\Delta t} = k[R]^2$	Rate = $-\frac{\Delta[R]}{\Delta t} = k[R]^0$	Rate = $-\frac{\Delta[R]}{\Delta t} = k[R]^1$
$\frac{1}{[R]_t} - \frac{1}{[R]_0} = kt$	[R] <sub>t</sub> - [R] <sub>0</sub> = -kt	Ln[R] <sub>t</sub> - Ln[R] <sub>0</sub> = -kt
$\frac{1}{[R]_t} = kt + \frac{1}{[R]_0}$	[R] <sub>t</sub> = -kt + [R] <sub>0</sub>	Ln[R] <sub>t</sub> = -kt + Ln[R] <sub>0</sub>

Practice Problem: Show all work. Complete the following.

Data for the decomposition of N<sub>2</sub>O<sub>5</sub> in a particular solvent at 45°C are as follows:

[N <sub>2</sub> O <sub>5</sub> ] mol·L <sup>-1</sup>	t (min)
2.08	3.07
1.67	8.77
1.36	14.45
0.72	31.28

Ln[N <sub>2</sub> O <sub>5</sub> ]	$\frac{1}{[N_2O_5]}$

Plot [N<sub>2</sub>O<sub>5</sub>], ln[N<sub>2</sub>O<sub>5</sub>], and  $\frac{1}{[N_2O_5]}$  versus time, t.

What is the order of the reaction? What is the rate constant, k, for the reaction?