Rate Law Expression Proof

$$2N_2O_5 \rightarrow 4NO_2 + O_2$$
$$\text{Rate} = k[N_2O_5]^x$$

What is the order of this reaction?

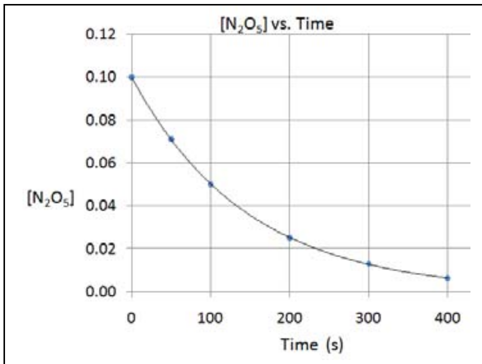
Data
Note that Rod Lederer had typo'd the first two concentration data points.

$[N_2O_5]$ (*M*)	Time (s)
0.100	0
0.071	50
0.050	100
0.025	200
0.013	300
0.0063	400

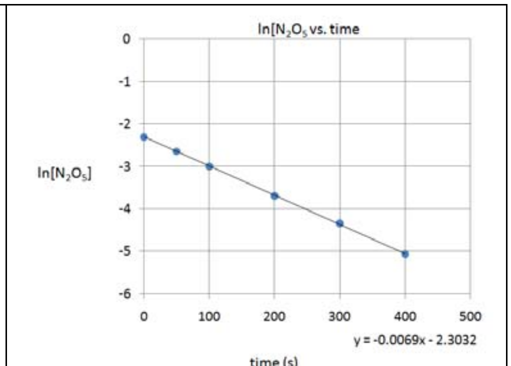
Equations for zero order reactions are not on the AP Exam Equations and Constants sheets.

Equation for first order reactions[1] $\ln[A]_t = -kt + \ln[A]_o$

Equations for second order reactions are on the AP Exam Equations and Constants sheets, but have never been used in any of the questions.



A zero order reaction would plot to a make straight line. Therefore this not a first order reaction.



$\ln[N_2O_5]$ vs. time produces a straight line therefore this a first order reaction.
-slope = k = 0.0069 s^{-1}

A faster easier method of proving that this is a first order reaction is noting that every 100 seconds the concentration is halved. Only a first order reaction has a constant half life time. Always be on the lookout for half concentrations.

Dividing the half life into 0.693, you will get rate constant for the reaction.

$$k = \frac{0.693}{t_{1/2}}$$
$$k = 0.0069\ s^{-1}$$

[1] $\ln[A]_t - \ln[A]_o = -kt$ is the form of the equation found on the AP Equations sheet.

<table>
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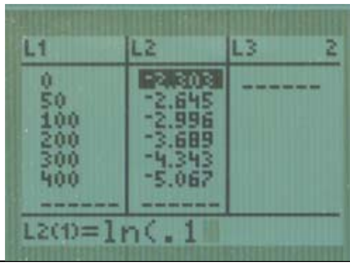
<td>
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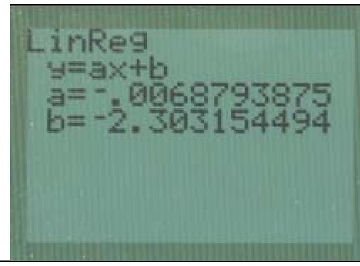
<td>
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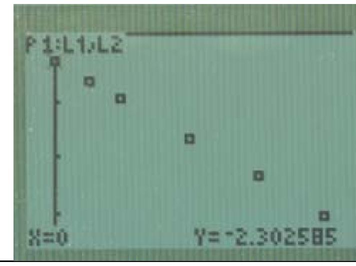
<td>
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<td>[STAT]

select EDIT [ENTER]

You can enter the data in L1 and L2 Calculations are accepted for data input i.e. you can enter ln(value) and the natural log will be calculated for you and be entered in that L location</td>
<td>[STAT]

right arrow [CALC]
down arrow [LinReg (ax+b)]

The L1 and L2 data will be analyzed for the best fit straight line. The negative of the slope, a, will be the rate constant.

$k = 0.0069\ s^{-1}$

Divided into ln(2), you will get the half life.

$t_{½} = \ln(2) \div 0.0069$

$t_{½} = 1.0 \times 10^{2}\ s$

The concentrations halve each 100 seconds. A constant half life is also proof of a 1^{st} order reaction.</td>
<td>With just PLOT 1 turned on

[ZOOM]
Scroll down to 9 Zoom Stat
press [ZOOM] [9]

You should see your L1 (x) L2(y) data plotted.

With [TRACE] you can jump form point to point to check your data.

the time vs. $\ln[N_2O_5]$ plots to a straight line which proves that this is a first order reaction with respect to the $[N_2O_5]$. Since this is the only reactant.

$rate = k\ [N_2O_5]^1$
$rate = (0.00689\ s^{-1})\ [N_2O_5]^1$

Given any concentration you could find the rate at that instant or given any rate you could find the concentration at that instant.</td>
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