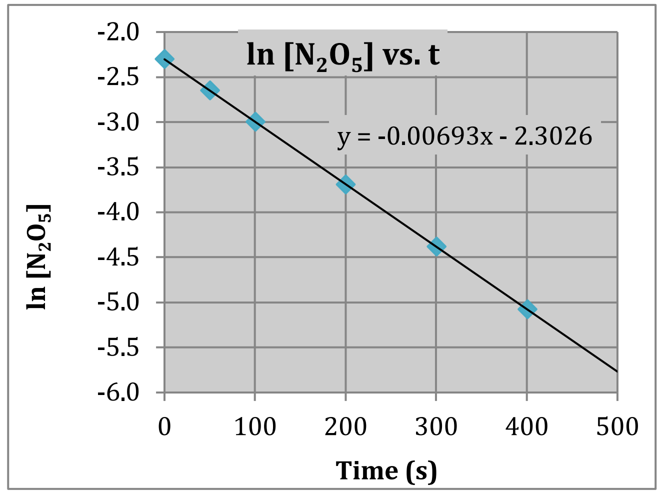
Notes (continued): Integrated Rate Law Example Data Sets (Reactant Concentration as a function of time)

1) The decomposition reaction, 2 N_2O_5 (g) → 4 NO_2 (g) + O_2 (g) was studied at constant temperature and the following kinetic data were collected:

Time (s)	$[N_2O_5]$ (M)	$\ln[N_2O_5]$	$[N_2O_5]^{-1}$, M^{-1}
0	0.1000	–2.3026	10.00
50	0.0707	–2.649	14.1
100	0.0500	–2.996	20.0
200	0.0250	–3.689	40.0
300	0.0125	–4.382	80.0
400	0.00625	–5.075	160.



Then the data was graphically analyzed. The results were as follows:

- Plot of $[N_2O_5]$ vs. time: not linear
- Plot of $\ln[N_2O_5]$ vs. time: linear as shown in graph→
- Plot of $[N_2O_5]^{-1}$ vs. time: not linear

a. What is the order with respect to N_2O_5? (The answer is also the order of the overall rxn b/c N_2O_5 is the only reactant.)

b. Write the general integrated rate law equation for this order of reaction. Then rearrange the equation so that it is in the form of "y= mx+b."

c. The specific equation of the line for the graph is shown on the graph. Use that equation of the line to determine the value of the rate constant for this reaction.

d. Determine the half-life of the reaction.

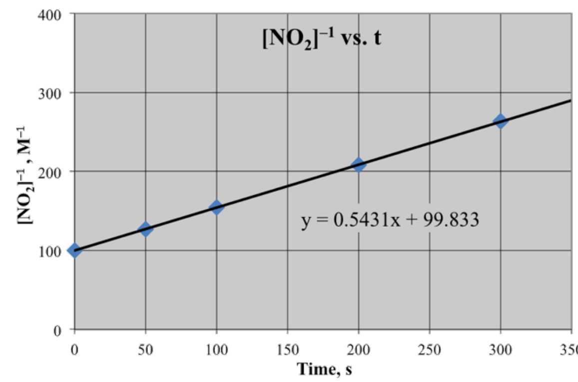
e. At what time will $[N_2O_5]$=0.0350 M? (Note: the initial N_2O_5 concentration is given in data chart.)

f. Determine the value of $[N_2O_5]$ at t = 1.00×10^3 s.

g. Suppose the same reaction is done at the same temperature, but one started with a different initial concentration of N_2O_5. How long would it take for 90% of the N_2O_5 to react? (Hint: If 90% of N_2O_5 reacts, then 10% is left unreacted. Thus, starting with 100%. Since concentrations are in a ratio, %'s can be used.)

2) The following data were obtained for the gas-phase decomposition of nitrogen dioxide, $NO_2(g) \rightarrow NO(g) + \frac{1}{2} O_2(g)$, at 300°C

Time (s)	$[NO_2]$, M	$\ln[NO_2]$	$[NO_2]^{-1}$, M^{-1}
0.0	0.01000	–4.6052	100.0
50.0	0.00787	–4.845	127
100.0	0.00649	–5.038	154
200.0	0.00481	–5.337	207
300.0	0.00380	–5.573	263



Then the data was graphically analyzed. The results were as follows:

- Plot of $[NO_2]$ vs. time: not linear
- Plot of $\ln[NO_2]$ vs. time: not linear
- Plot of $[NO_2]^{-1}$ vs. time: linear as shown in graph

a. What is the order with respect to NO_2? (The answer is also the order of the overall rxn b/c NO_2 is the only reactant.)

b. Write the general integrated rate law equation for this order of reaction. Then, rearrange the equation so that it is in the form of "y= mx+b."

c. The specific equation of the line for the graph is shown on the graph. Use that equation of the line to determine the value of the rate constant for this reaction.

d. Given the initial concentration of NO_2 above, what is the remaining concentration after 0.500 hours?

e. At what time, in s, will $[NO_2] = 2.50\times10^{-3}$ M?

Answers: 1c) 0.00693 s^{-1}; 1d) 100. S; 1e) 151 s; 1f) 9.8×10^{-5} M; 1g) 332 s; 2c) 0.543 M^{-1} s^{-1}; 2d) 9.29×10^{-4} M; 2e) 552 s