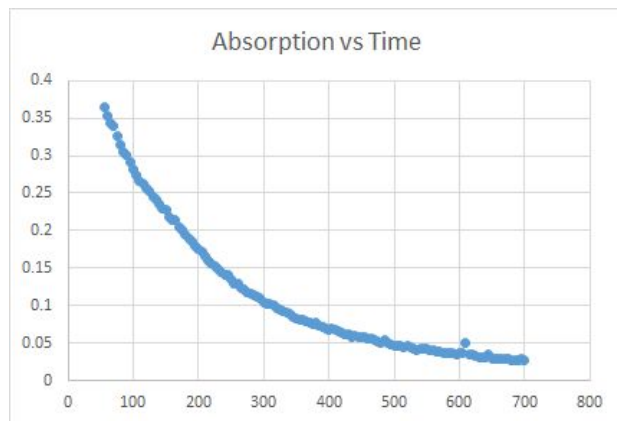
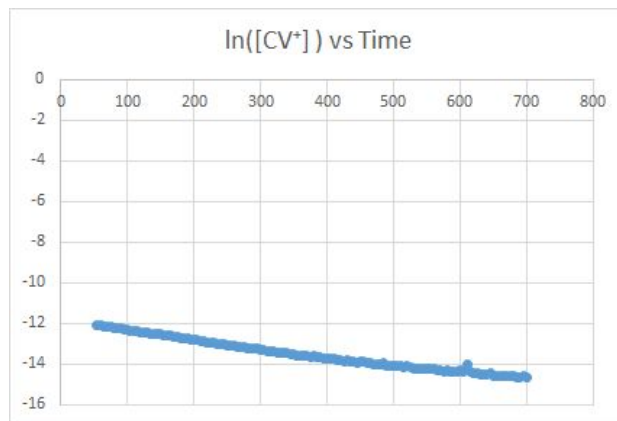


## Results

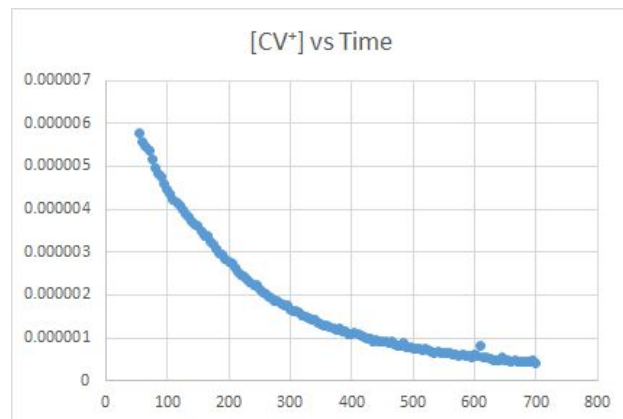
### Absorption



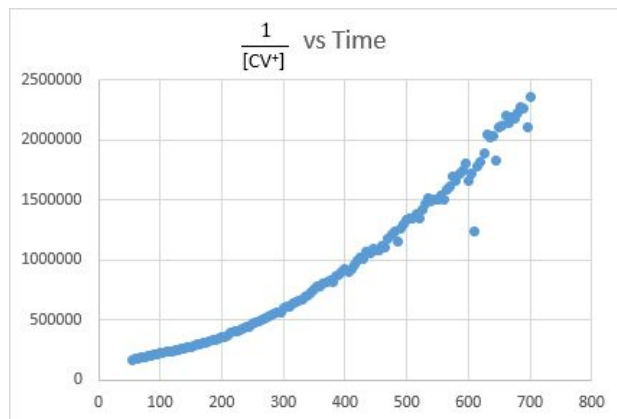
### First Order Reaction



### Zero order reaction



### Second Order Reaction



1. We know that this is a first order reaction because the graph of  $\ln([CV^+])$  vs time is the most linear. If it were some other order, then that corresponding graph would be most linear. We can prove that it will most linear at  $\ln([CV^+])$  if it is first order, by taking the derivative of the equation:  $[CV^+] = [CV^+]_0(e^{-kt})$ , and getting  $\ln([CV^+]) = -kt + \ln([CV^+]_0)$ , which is the equation of a line.
2. Using desmos, we find that the rate constant,  $k$ , is  $0.00541516 \ln([mol]) \cdot s^{-1}$ . Desmos arrived at this conclusion by minimizing the  $R^2$  value of the equation:  $[CV^+] = [CV^+]_0(e^{-kt})$ , and I know the units by plugging them into the equation, and making sure they cancel.
3. Specific rate law:

$$\text{rate} = k[CV^+] = -0.00541516[CV^+]$$

Integrated rate law:

$$[CV^+] = [CV^+]_0 (e^{-kt}) = 7.48539 \times 10^{-6} (e^{-0.00541516t})$$

### Analysis

4. Evaluating error:

a. Experimentally-determined value of  $[CV^+]_0$  is 7.48539, as given by Desmos to best fit the data.

b. Percent Error:

$$\left(1 - \frac{[CV^+]_{\text{experimental}}}{[CV^+]_{\text{theoretical}}}\right) \times 100\% = \left(1 - \frac{7.48539}{8}\right) \times 100\% = 6.432625\%$$

5. Inspecting concentration vs time graph:

a. Looking at the graph, the half life is roughly 137.5 seconds. I estimated by looking at our first data point at 55 seconds, and finding where on the graph is roughly half of that. I found that at around 192.5, the data point is at roughly half the concentration. So, the half life would be the time in between or 137.5 seconds

b.  $e^{-0.00541516t} = \frac{1}{2}$

$$-0.00541516t = \ln\left(\frac{1}{2}\right)$$

$$t = 128.001$$

I got to this answer because I knew that the only thing that changes in the integrated rate equation is  $e^{-0.00541516t}$ . And so, it must be equal to one-half. Setting it equal to one-half, I then solved.

6. Examining rate of the concentration vs time graph:

a. instantaneous rate = instantaneous slope  $\sim \frac{[CV^+]_{365} - [CV^+]_{355}}{10}$   
 $= \frac{1.24635 \times 10^{-6} - 1.28283 \times 10^{-6}}{10} = -3.648 \times 10^{-9}$

I estimated the rate at time = 360 by taking the average slope between time = 355 and time = 365.

b. rate =  $k[CV^+] = k[CV^+]_0 (e^{-kt}) = -0.00541516 (7.48539 \times 10^{-6} (e^{-0.00541516t}))$   
 $= -0.00541516 (7.48539 \times 10^{-6} (e^{-0.00541516(360)})) = -4.382 \times 10^{-9}$

These two values are very close to each other, being only  $-1.2 \times 10^{-9}$  apart from each other, especially given how small the values are.

### Thought Questions

7. Concentration of  $[OH^-]$ :

a. Given that  $[OH^-]$  is more than 3000 times more concentrated than  $[CV^+]$ , the relative change for  $[CV^+]$  will be much higher than that of  $[OH^-]$ . This is because the number of molecules of  $[OH^-]$  that react will be a much smaller percentage of the total number of molecules will be much smaller than that of  $[CV^+]$ .

b. It is essential to the success of the experiment that the relative change of  $[OH^-]$  be much smaller than that of  $[CV^+]$ , because the rate equation would be in the form of:

$$\text{rate} = k[OH^-]^a [CV^+]$$

So, if  $[OH^-]$  only changes a tiny bit percentagewise, it won't affect the rate that much.

8. Analysing the wavelength of maximum absorbance:

a. This value 588.5nm represents yellow.

b. The crystal-violet solution is violet, but specifically, the complementary color to the wavelength of maximum absorbance.

- c. We used the wavelength of maximum absorbance to measure absorbance. The reason the maximum absorbance corresponds to yellow is because the crystal-violet solution absorbs the most yellow-wavelength light. A material will absorb the most of its complementary color's wavelength, which makes sense because it reflects the most of its own color, and so we see it as that color. So, by using the wavelength of maximum absorbance, the crystal-violet solution will absorb more, making our absorbance values higher, and our data more accurate as a result.
9. Crystal Violet is only slightly soluble in water, because it only has four places where it can hydrogen bond with water: twice off each N, and once on the COOH. However, given the large size of the crystal violet molecule, the chance that a water molecule will collide with the crystal violet in the perfect orientation and exactly in one of those four places is much smaller. This makes the amount of collisions that result in hydrogen bonding much less, making crystal violet only slightly soluble in water.

