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CHEM 145 Section AC

Reaction rate is central to understanding reaction kinetics, and has applications in many fields. Understanding how quickly a reaction might occur and how is important, and can be determined experimentally by a variety of methods. In this lab, reaction rate was measured using a colorimeter, following the absorbance that occurs as crystal violet (D^+), reacts with OH^- and forms DOH. Since D^+ is a colorful dye and DOH is colorless, the rate can be determined based on the absorbance over time. The rate law for this reaction is $rate = k[D^+]^n[OH^-]^m$. k is determined from the equation $k' = k[OH^-]^m$, where m is the reaction order of OH^-, and k' is the rate of formation. k' can be determined by plotting the concentration of D^+ (5.3827×10^4 times absorbance) against time, the natural log of $[D^+]$ against time, and the inverse of $[D^+]$ against time. The slope of whichever graph is linear is equivalent to the value of k'. m is then found using the equation $ln(k') = (m)ln[OH^-] + ln(k)$, which can be graphed and the slope found to equal m.

The procedure mostly involved obtaining enough data to find the values needed to calculate the rate. The first step was to obtain a calibration curve for D^+. This was done by taking the absorbance of a range of concentrations of D^+, obtained by doing a serial dilution of 2.0×10^{-5} M D^+ with water, and taking the absorbance with a colorimeter set to 565 nm. The data was then plotted, and the slope of the line of best fit for this plot was the value used to convert absorbance values to concentration in the main experiment. Three concentrations (0.5, 0.25, and 0.125 M) of NaOH were then obtained through serial dilution. To measure the reaction rate, equal amounts of 2.0×10^{-5} M D^+ and NaOH were mixed and a sample was placed in a colorimeter, which took approximately 20 measurements over the course of 90 seconds. The same procedure was repeated for each concentration of NaOH. This data was used to determine the reaction order of D^+ (n) and the reaction rate of D^+ (k').
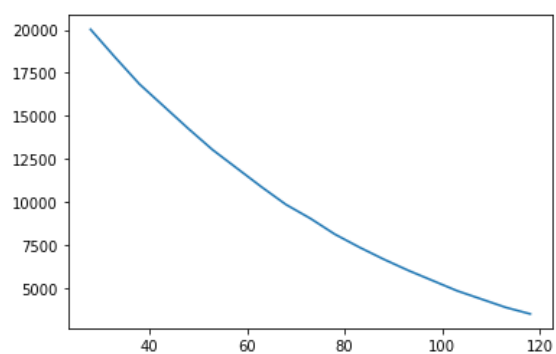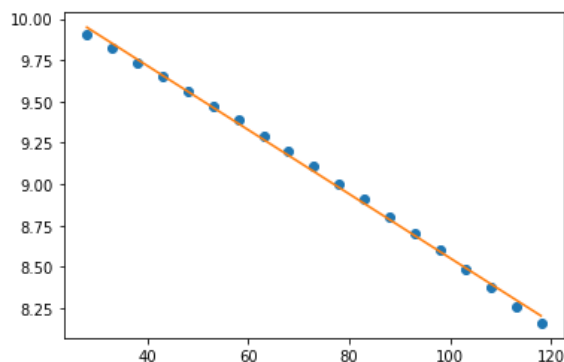
T vs. [D⁺] (0.5 M NaOH)
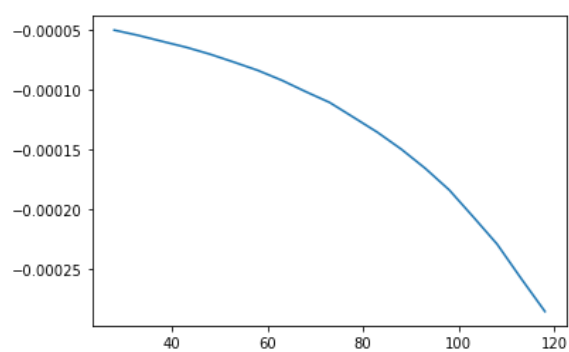
T vs. ln[D⁺] (0.5 M NaOH)
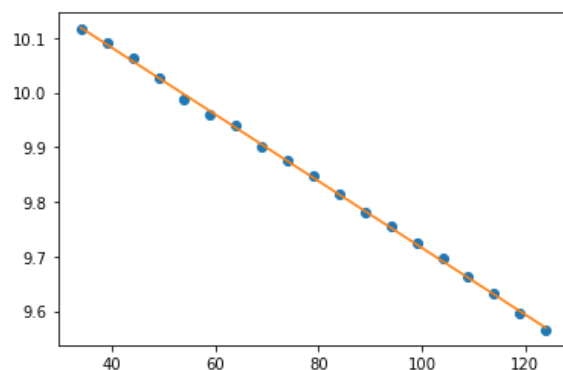## (slope = 0.019385426608660564)
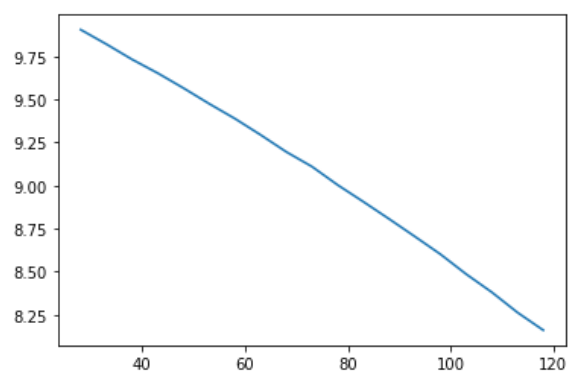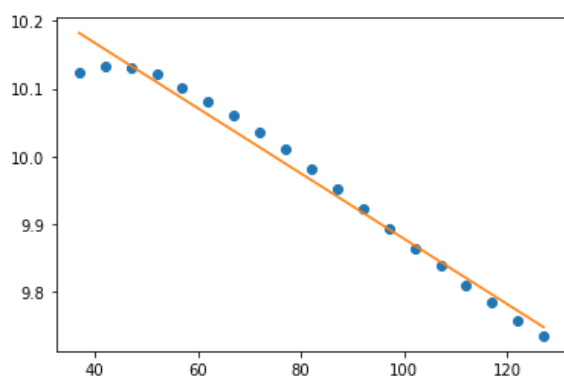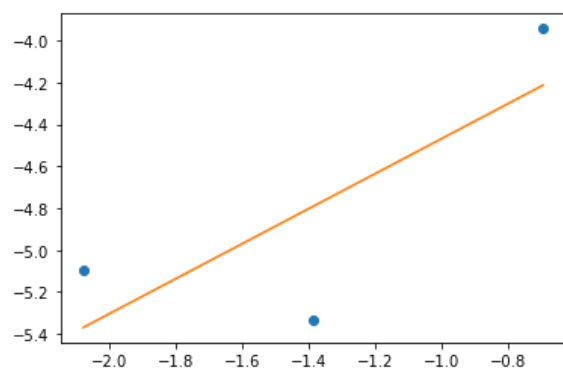

T vs. 1/ [D⁺] (0.5 M NaOH)

T vs. 0.5 M NaOH (n=1)

T vs. 0.125 M NaOH (n=1)

T vs. 0.25 M NaOH (n=1)

$\ln(k')$ vs. $\ln[OH^-]$

$$rate \; = \; 4.379 \times 10^{-2}[D^+]^1[OH^-]^1$$

The reaction rate obtained from this experiment was relatively simple because the reaction order for both reactants was one. If the reaction was second order for one of the species, the rate will change exponentially, and if both concentrations were doubled, the rate would be double what it would be if both were in first order. If it's the first species specifically that's in second order, it would affect k, because k is dependent on k', and k' is dependent on the reaction order of the first species. Not much about the reaction mechanism can be determined by the rate law found in this experiment. It appears to be a single-step, bimolecular reaction, and gives no information about any potential intermediates or sequential steps.

Serial dilution is the process of taking a stock solution and procedurally generating solutions of lower concentration by mixing one part of the solution with one part of water, and doing the same with the solution created continually. It is an easy and efficient way to make a range of solutions without having to measure the concentration of each. The range of solutions can be used for a variety of experiments and other applications, as demonstrated by this experiment's use of it.

A calibration curve is, most generally, used to determine concentration of a substance from another known value. It is obtained by taking a large enough range of measurements to find an approximate relationship between concentration and the other variable, and that relationship is used to convert to concentration from the same variable when it is involved in a more complicated operation.

The most glaring potential error in this experiment was the data for the first two concentrations of NaOH. 0.5 M NaOH displayed a clear linear relationship for n=1, and the expected curves for n=0 and n=2, but 0.125 and 0.25 M did not. A *k'* value was still obtained for each, and while that of 0.125 M seemed consistent, the value for 0.25 M seemed far too low. This could easily be due to any range of errors, as the procedure for measuring the absorbance was delicate and depended on quick movement, which could have resulted in inaccuracies in solution measurements or colorimeter use. These *k'* values were used to determine the overall rate, so it may be slightly inaccurate as a result of these errors. The process of serial dilution could also have resulted in inaccurate results, as the measurements had about 1 mL of potential inaccuracy and therefore the concentrations may not have been exactly what they were expected to be. Nonetheless, these errors would have been minute and the overall rate is still close to accurate.

The overall reaction rate of crystal violet and OH⁻ was found to be $4.379 \times 10^{-2}[D^+]^1[OH^-]^1$. Both reactants were first order, and the molecularity was bimolecular. Reaction rate was demonstrated to be possible to obtain experimentally.

Exp. No.	Experiment/Subject		Date		
5	Reaction Rate				
Name Eddie Hunt	Lab Partner		Locker/Desk No.	Course & Section No.	

$$\frac{2 \times 10^{-5}}{1\,L} \times .250\,L = 5 \times 10^{-6}\,mol \times \frac{1\,L}{1 \times 10^{-4}} = .05\,L$$

$$50\,mL$$

Solution #	Concentration	A
5	6.25×10^{-7}	0.032
4	1.25×10^{-6}	0.105
3	$2.5 \times 10^{-6}\,M$	0.127
2	$5 \times 10^{-6}\,M$	0.243
1	$1 \times 10^{-5}\,M$	.470
Stock	$2 \times 10^{-5}\,M$	1.1

$[D^+] = 5.3827 \times 10^4\,abs$

$n = 1$

$-k' = -0.01939$

C(OH⁻)	$C(OH^-)$	k'	K
	0.125	0.0061	4.88×10^{-2}
	0.25	0.00433	1.932×10^{-2}
	0.5	0.01939	3.878×10^{-2}

$.0061 = .125\,k$　　$k = 4.88 \times 10^{-2}$　　$m = 1$　　$\approx 4.374 \times 10^{-2}$

0.5 M

t	A
(+225) 0	.372
5	.342
10	.313
15	.289
20	.265
25	.242
30	.222
35	.202
40	.183
45	.168
50	.151
55	.137
60	.124
65	.112
70	.101
75	.090
80	.081
85	.072
90	.065

0.25 M

t	A
(+375) 0	.463
5	.467
10	.466
15	.462
20	.453
25	.444
30	.435
35	.424
40	.414
45	.402
50	.390
55	.379
60	.368
65	.357
70	.348
75	.338
80	.330
85	.321
90	.314

0.125 M

t	A
0	.460
5	.448
10	.436
15	.420
20	.404
25	.393
30	.385
35	.371
40	.361
45	.351
50	.340
55	.329
60	.320
65	.311
70	.302
75	.292
80	.283
85	.273
90	.265

(+34s)

$.00483 = .25\,k$

Signature	Date	Witness/TA	Date