Name: Emily Dong Quiz Section: AG
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CHEM 142 Experiment #5: Kinetics I (Integrated Rate Law)

Goals of this lab:

- Create and use a calibration curve for the absorbance/concentration relationship for crystal violet
- Evaluate absorbance versus time measurements to determine the order of a reaction
- Analyze graphs of data to determine best linear fit
- Calculate rate constants from best-fit lines and values
- Assemble a complete kinetic description of the reaction from data gathered

Your lab report will be grade on the following criteria using a poor/good/excellent rating system (see the Self-Assessment on the "Reporting Your Results for Exp #5" page of the lab website for more details):

- Calculations are accurate and complete based on data gathered; proper significant figures and units are used
- Data collected is reasonable; outliers are identified and possible explanations are reasonable
- Interpretations of graphs and data are reasonable
- Reaction orders are determined accurately from data gathered; reasonable conclusions are reached
- All graphs and tables and clearly and accurately labeled; entire report is typed

By signing below, you certify that you have not falsified data, that you have not plagiarized any part of this lab report, and that all calculations and responses other than the reporting of raw data are your own independent work. Failure to sign this declaration will result in 5 points being deducted from your lab score.

Signature: Emily Dong

This lab is worth 60 points: 10 points for notebook pages, 50 points for the lab report
(Do NOT include your notebook pages when you scan your report for upload into Gradescope.)

READ THIS BEFORE PROCEEDING WITH THE DATA ANALYSIS FOR THIS EXPERIMENT:
For this lab, you will first evaluate the data for the CV^+ standards to obtain a value for molar absorptivity (ε) that you will then use to convert Absorbance data to $[CV^+]$ (Remember: $A=\varepsilon \ell c$; if the calibration curve does not go through 0,0 then you need to include the y-interecept in your calculation of the concentration). You will then evaluate the concentration data as a function of time using the integrated rate law method of determining the orders with respect to each reactant and the rate contant for the reaction at this temperature.

You will plot all of the data for the calibration curve and for Run 1. However, for the data in Runs 2-4 and the determination of the order with respect to OH^-, INSTEAD OF CREATING ADDITIONAL PLOTS, WE WILL USE A SHORTCUT THAT EMPLOYS FUNCTIONS WITHIN EXCEL TO DETERMINE THE SLOPE AND Y-INTERCEPT FOR A SET OF DATA. For example, to use these functions, click on the cell in which you want the result to appear and enter the following:

=SLOPE(A10:A15,B10:B15)

=INTERCEPT(A10:A15:B10:B15)

In this example, **A10:A15** represent an the cells that contain data for the y-axis and **B10:B15** represent data for the x-axis. This is a shortcut for generating the slope and y-intercept values without actually creating a plot of the data and generating the trendline equation of $y = mx + b$.

You will create three plots on page 4, using the data from Run 1, to determine the order of the reaction with respect to CV^+. Once you know the order of the reaction with respect to CV^+, you will perform the necessary "slope" functions for the other three runs to determine k' for each run. When you get to the section for determining the order of the reaction with respect to OH-, you will also need to use the "intercept" function mentioned above.

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Note: All sections of this report must be typed

Part I. Determining the Molar Absorptivity for Crystal Violet

Concentration of stock solutions

CV^+	1.0E-04	**M**
OH^-	0.10	**M**

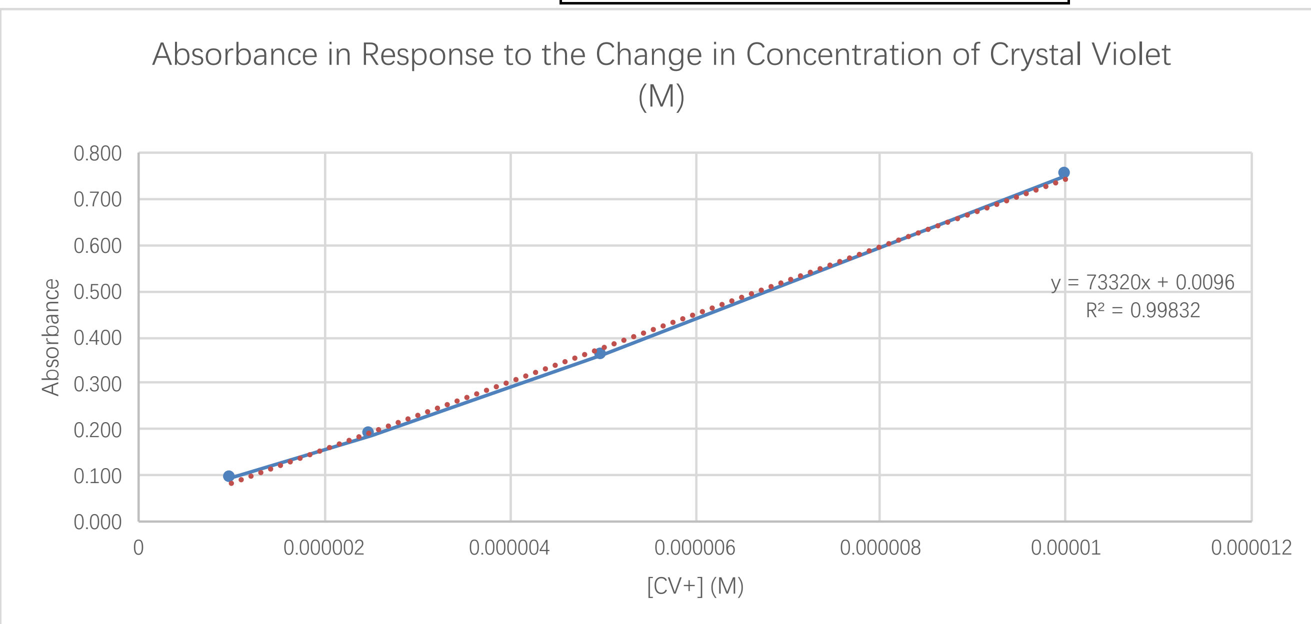
Volume of CV^+ stock solution needed to make 25 mL of 1.0×10^{-5} M CV^+ is

CV^+	2.5	**mL**

Calibration Curve Data

λ max, CV^+	757.8	**nm**

Dilution Factor	$[CV^+]$ (M)	Absorbance
10.0	1.0E-06	0.095
4.0	2.5E-06	0.188
2.0	5.0E-06	0.362
1.0	1.0E-05	0.750



Slope of Absorbance versus concentration graph

73320	M^{-1}

y-intercept of Absorbance versus concentration graph

0.0096

Detailed calibration equations:

FROM THIS REPORT: Absorbance = 73320 * [CV+] + 0.0096

FROM THE LQ2 SYSTEM IN LAB: Absorbance = 73327 * [CV+] + 0.010141

If the slope = εl, what is the molar absorptivity for the CV^+ at this wavelength?

molar absorptivity, ε	73320	**$M^{-1}cm^{-1}$**

(Note: if you have two different values based on two different calibration curves, use the equation that is based on your data analysis here in the Excel template, not the one from lab.)

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Part II. Determining the Rate Law for the $CV^+ + OH^-$ Reaction

Table of Volumes and Final Concentrations During Solution Preparation for Runs 1-4

Run #	mL of 0.1 M NaOH	mL of DI H_2O	mL of 3.0 x 10^{-5} M CV^+	mL Total	$[CV^+]_{final}$, M	$[NaOH]_{final}$, M
1	2	0.5	0.5	3	5.00E-06	0.0667
2	1.5	1	0.5	3	5.00E-06	0.0500
3	1	1.5	0.5	3	5.00E-06	0.0333
4	0.5	2	0.5	3	5.00E-06	0.0167

*$[CV+]_{final}$ and $[NaOH]_{final}$ are the final concentrations after all reagents are mixed and the initial concentration for the start of the reactions

	slope	units for slope	y-intercept
Student- specific data from pg 2 used in calculations autofill here:	73320	M^{-1}	0.0096

Show your calculation of the $[CV^+]$ at the **first timepoint in Run #1**:

Absorbance = 73320 * [CV+] + 0.0096

0.422 = 73320 * [CV+] + 0.0096

[CV+] = 5.63E-06M

Reaction Order Determination for CV+

READ THIS BEFORE PROCEEDING

For evaluating the data for Run 1, enter your time and absorbance values, as recorded in your lab notebook during lab, in columns A and B, respectively. In column C, convert the absorbance values to concentration according to the example you provided at the top of this page. In column D, convert the $[CV^+]$ values from column C to ln $[CV^+]$. In column E, convert the $[CV^+]$ values from column C to $1/[CV^+]$. Insert the plots used to determine the order with respect to $[CV^+]$ on

Run 1

Time (s)	Absorbance	$[CV+]_t$	$ln[CV+]_t$	$1/[CV+]_t$
0	0.422	5.63E-06	-12.087	1.78E+05
10	0.365	4.85E-06	-12.237	2.06E+05
20	0.383	5.09E-06	-12.188	1.96E+05
30	0.356	4.72E-06	-12.264	2.12E+05
40	0.328	4.34E-06	-12.348	2.30E+05
50	0.288	3.80E-06	-12.481	2.63E+05
60	0.282	3.72E-06	-12.502	2.69E+05
70	0.264	3.47E-06	-12.571	2.88E+05
80	0.243	3.18E-06	-12.659	3.14E+05
90	0.223	2.91E-06	-12.747	3.44E+05
100	0.210	2.73E-06	-12.811	3.66E+05
110	0.197	2.56E-06	-12.876	3.91E+05
120	0.184	2.38E-06	-12.948	4.20E+05
130	0.175	2.26E-06	-13.000	4.43E+05
140	0.166	2.13E-06	-13.059	4.69E+05
150	0.157	2.01E-06	-13.117	4.98E+05
160	0.143	1.82E-06	-13.217	5.49E+05
170	0.129	1.63E-06	-13.327	6.13E+05
180	0.116	1.45E-06	-13.444	6.90E+05

ORDER WITH RESPECT TO CV^+

Which plot (on the next page) is the most linear?

ln[CV+]t v.s Time

Based on the plots you created on the next page, what is the order of this reaction with respect to CV^+?

1

RUN #1

What is the value of the slope for the most linear plot?

-0.00720

What is the psuedo-rate constant (k') for this reaction?

7.20E-03

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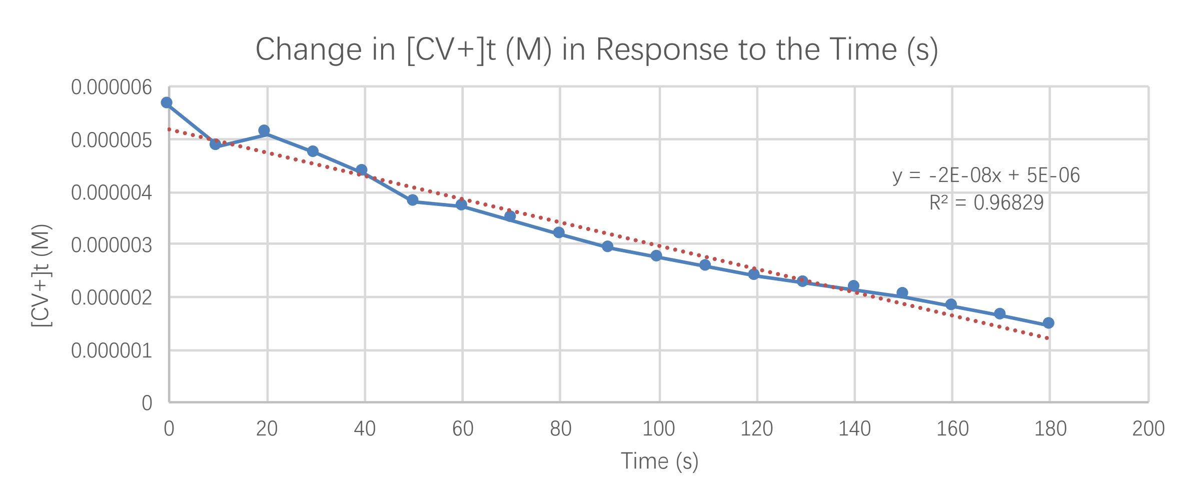

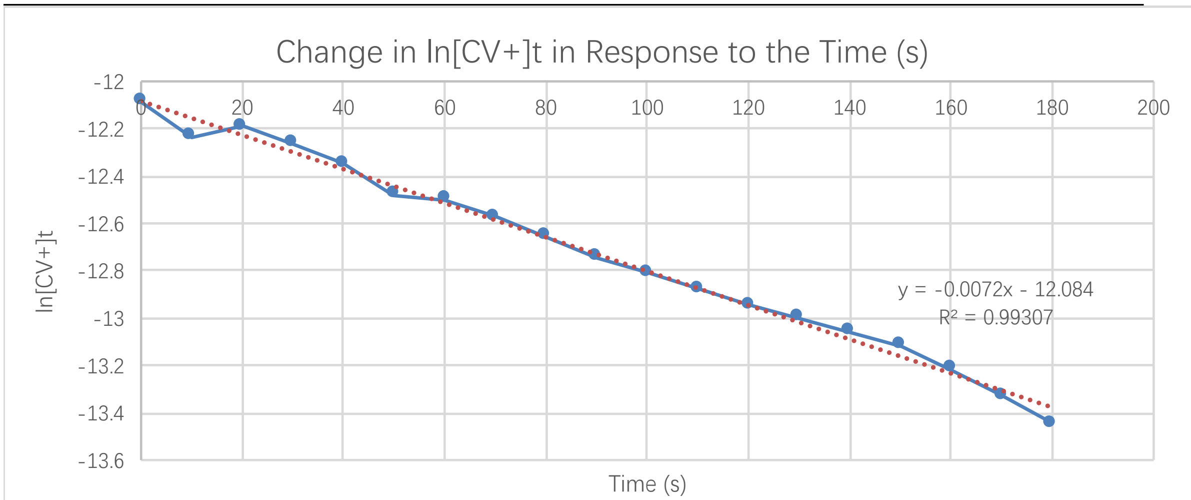

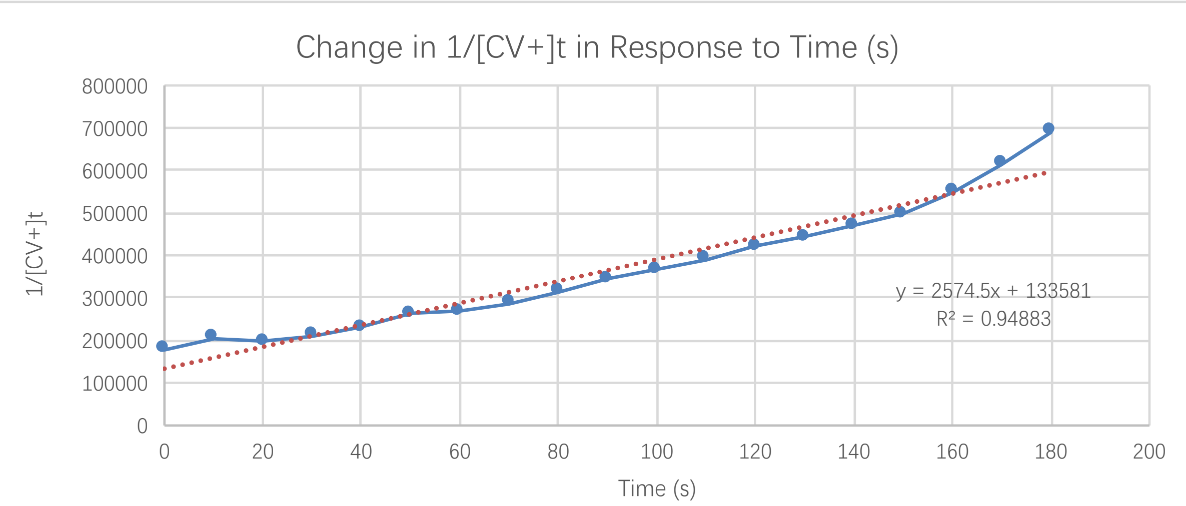

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Run 2			
Time (s)	Absorbance	$[CV+]_t$	$f([CV^+]_t)$
0	0.345	4.57E-06	-12.295
10	0.298	3.93E-06	-12.446
20	0.247	3.24E-06	-12.641
30	0.252	3.31E-06	-12.620
40	0.252	3.31E-06	-12.620
50	0.231	3.02E-06	-12.710
60	0.224	2.92E-06	-12.743
70	0.215	2.80E-06	-12.785
80	0.192	2.49E-06	-12.904
90	0.181	2.34E-06	-12.966
100	0.172	2.21E-06	-13.020
110	0.175	2.26E-06	-13.002
120	0.153	1.96E-06	-13.145
130	0.137	1.74E-06	-13.263
140	0.126	1.59E-06	-13.353
150	0.118	1.48E-06	-13.425
160	0.107	1.33E-06	-13.532
170	0.096	1.18E-06	-13.651

Run 3			
Time (s)	Absorbance	$[CV+]_t$	$f([CV^+]_t)$
0	0.306	4.04E-06	-12.419
10	0.290	3.82E-06	-12.474
20	0.273	3.59E-06	-12.537
30	0.288	3.80E-06	-12.481
40	0.286	3.77E-06	-12.488
50	0.260	3.42E-06	-12.587
60	0.245	3.21E-06	-12.649
70	0.238	2.80E-06	-12.785
80	0.235	3.07E-06	-12.692
90	0.220	2.87E-06	-12.761
100	0.214	2.79E-06	-12.790
110	0.203	2.64E-06	-12.846
120	0.183	2.36E-06	-12.955
130	0.173	2.23E-06	-13.014
140	0.166	2.13E-06	-13.058
150	0.159	2.04E-06	-13.104
160	0.150	1.91E-06	-13.166
170	0.139	1.76E-06	-13.247
180	0.130	1.64E-06	-13.320
190	0.122	1.53E-06	-13.388
200	0.112	1.40E-06	-13.481
210	0.102	1.26E-06	-13.584
220	0.096	1.18E-06	-13.651
230	0.089	1.08E-06	-13.736

RUN #2

What is the value of the slope for the most linear plot?

-0.00710

What is the psuedo-rate constant (k') for this reaction?

7.10E-03

RUN #3

What is the value of the slope for the most linear plot?

-0.00570

What is the psuedo-rate constant (k') for this reaction?

5.70E-03

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Run 4			
Time (s)	Absorbance	$[CV^+]_t$	*f* ($[CV^+]_t$)
0	0.367	4.87E-06	-12.231
10	0.340	4.51E-06	-12.310
20	0.351	4.66E-06	-12.277
30	0.332	4.40E-06	-12.335
40	0.320	4.23E-06	-12.372
50	0.318	4.21E-06	-12.379
60	0.301	3.97E-06	-12.436
70	0.301	3.97E-06	-12.436
80	0.290	3.82E-06	-12.474
90	0.294	3.88E-06	-12.460
100	0.289	3.81E-06	-12.478
110	0.283	3.73E-06	-12.499
120	0.272	3.58E-06	-12.540
130	0.267	3.51E-06	-12.560
140	0.263	3.46E-06	-12.575
150	0.255	3.35E-06	-12.607
160	0.239	3.13E-06	-12.675
170	0.228	2.98E-06	-12.724
180	0.224	2.92E-06	-12.743
190	0.221	2.88E-06	-12.757
200	0.217	2.83E-06	-12.776
210	0.211	2.75E-06	-12.805
220	0.206	2.68E-06	-12.830
230	0.201	2.61E-06	-12.856
240	0.194	2.52E-06	-12.893
250	0.186	2.41E-06	-12.938
260	0.178	2.30E-06	-12.984
270	0.173	2.23E-06	-13.014
280	0.169	2.17E-06	-13.039
290	0.164	2.11E-06	-13.071
300	0.160	2.05E-06	-13.097
310	0.156	2.00E-06	-13.124
320	0.151	1.93E-06	-13.159
330	0.146	1.86E-06	-13.195
340	0.140	1.78E-06	-13.240
350	0.135	1.71E-06	-13.279
360	0.131	1.66E-06	-13.309

RUN #4

What is the value of the slope for the most linear plot?

-0.00290

What is the psuedo-rate constant (k') for this reaction?

2.90E-03

Reaction Order Determination for OH^-

Consult the "Helpful Information" section in the introductory pages for this experiment in the lab manual for help with this last section of data analysis. As explained in the Instruction box on page 1 of the template, for the slope and y-intercept calculations you will use the functions in Excel rather than creating a plot.

Values for [OH] and k' autofill from earlier in report

Run #	$[OH^-]$	k'	$ln[OH^-]$	ln(k')
1	0.0667	7.20E-03	-2.708	-4.934
2	0.0500	7.10E-03	-2.996	-4.948
3	0.0333	5.70E-03	-3.401	-5.167
4	0.0167	2.90E-03	-4.094	-5.843

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

slope	0.684
y-int	-2.96

Show your calculation of the rate constant for the overall reaction.

rate = k[CV+][OH-]^x

ln(k) = y-intercept = -2.96

k = 0.0518 M^-1 s^-1

Order of the reaction with respect to $[OH^-]$:	1
Rate constant for the overall reaction, k:	0.052
Units for k:	M^-1 s^-1

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Results from earlier in the report autofill here:

Order wrt CV+	Order wrt OH-	Overall rate constant	Units for overall rate constant
1	1	0.052	M^-1 s^-1

Results and Discussion

1. Based on your data, write the complete rate law, including the value and units for the rate constant.

Rate = 0.052 * [CV+] * [OH-]

2. The literature values of the orders with respect to CV^+ are and OH^- are 1 and 1, respectively. Calculate your % error for the experimental value for the order with respect to $[OH^-]$. Discuss your largest sources of error.

[(1 - 0.684) / 1] * 100% = 31.6%

In our experiment, our largest error was that before putting the cuvvet into LQ2, we did not mix the crystal violate with NaOH fully. Therefore, our data fluctuate a little at the beginning of each run. This will influence the final result of all the graph, equations, and calculations that are based on the raw data.

Laboratory Waste Evaluation

Laboratory waste is considered *anything* generated during an experiment that is disposed of down the sewer drain, thrown in the garbage, collected in a container for disposal by the UW Environmental Health & Safety department, or released into the environment. Based on the written lab procedure *and* your actions during the lab, list the identity and approximate amount (mass or volume) of waste that you generated while performing this experiment.

We generated about 70 mL of waste in total. The substance in the waste bottle is a mixture of water, NaOH, and crystal violet.