Student Name:

Student Number:

Partner's Name and Student #:
Demonstrator's Name:

PLEASE NOTE: If ANY of the above information is UNCLEAR or not provided, your grade will NOT be recorded!!

Lab Day (circle): *Tues aft* *Tues night* *Wed* *Thurs aft* *Thurs night* *Fri*

Lab Week (circle): *1* *2*

Laboratory Report Form

Experiment 4

Checklist:

- **Raw Data Sheet written in pen, signed by TA AND Raw data from LabQuest attached**
- **Data tables and graphs (12 minimum!) made in Logger Pro attached**
- **Report Form attached**

Student's Initials _

"IF IT WERE DONE… THEN `TWERE WELL IT WERE DONE QUICKLY"

CHEMICAL KINETICS

Introduction:

This experiment focuses on chemical kinetics by studying the following principles; instantaneous reaction rate, the order of a reaction, complexation, absorbance, and spectrophotometry.

The following techniques were also used throughout the experiment; rate measurement, order determination from graphs, graphing, complex formation, and the use of spectrometers.
More specifically, this experiment studies the above topics, using the above techniques on the reaction between sodium EDTA ($Na_2C_{10}H_{14}N_2O_8 \cdot 2H_2O_{(aq)}$) with chromium nitrate ($Cr(NO_3)_3 \cdot 9H_2O_{(aq)}$).
Every chemical reaction has a unique rate. Some reactions can happen so quickly that they can be almost instantaneous while others can take up to 45 minutes (or longer) to complete. The rate of a reaction depends on several factors. Some of these factors are concentration of the reactants, heat, volume or pressure of a container (gas), and many more.
When we talk about rates of reactions, we are essentially talking about the number of successful collisions that take place between two molecules over a period of time. In order for a collision to be deemed successful it must meet certain criteria. The collision must happen with enough energy and it must occur in the correct spot on the molecules (reaction site).
Every reaction has an activation energy which must be reached each successful collision. Increasing the heat of a system, as was done during this experiment, will make this happen more frequently by allowing collisions to occur more often and with greater kinetic energy, thus increasing the rate of the reaction.
The rate of a reaction can be expressed or written as a rate law
For example: for the reaction,

$$\mathbf{A+B \rightarrow C}$$

$$\mathbf{RATE = K[A]^a[B]^b}$$

where K is the rate constant (proportionality constant) and the concentrations of the reactants are expressed in units of mol/L.
The exponents a and b are the order of the reaction. The order refers to the magnitude of which the rate of reaction will be altered based on changes in the concentrations or heats of the reactants. The following reaction

$$\mathbf{Rate= K[A]}$$

is a first order reaction and the graph of the rate vs the concentration of A will be a linear function.
The rate law of a second order reaction looks like this:

$$\mathbf{Rate=K[A]^2}$$

These examples were over simplified as most reactions have more than one reactant. The order of an individual reactant in a rate law is referred to as a partial order with respect to the reactant.

Moreover, in some special cases of second order reactions where one reactant is in high excess, it can cause the reaction to appear to be first order. These reactions are called pseudo first order reactions.

Sometimes chemical reactions for a complex which is when a central (usually metal) atom bonds to non-metals called ligands. When a complex forms in a solution it usually causes a drastic change is colour. This is why spectrometry can be used to determine when a reaction has gone to completion.

Two very important measurements in spectrometry are transmittance (the ratio of light intensity before and after it passes through the medium) and absorbance.

Transmittance can be expressed by the following equation:

$$\mathbf{T=I/I_0}$$

Where T is transmittance, I is final intensity of light and I_0 is initial intensity of light.

Percent transmittance can be expressed as:

$$\mathbf{\%T = T \times 100\%}$$

Absorbance can be expressed as follows:

$$\mathbf{A = -\log T}$$

Procedure:

As described in the lab manual (Note that steps 10 and 11 were omitted during the procedure of this experiment.) (Dr. R. Venkateswaran, "What In The World Isn't Chemistry?", General Chemistry Laboratory Manual, 2016, Experiment 3, p (79-83)

Observations:

The EDTA was colourless and transparent to begin with. Once the chromium nitrate was added it became a pale purple but was still transparent. After being heated, the solution became bright and opaque purple.

The Calculated Observations of Part 1

Time (min)	% Transmittence @569.1	Absourbence	A(CrIII)	Log (A(CrIII)	Rate	Log(Rate)
0	83.87665092	0.076358919	1.934941	0.286667745	0.015461124	-1.810758938
2	76.14602482	0.118352764	1.892947	0.277138509	0.009111934	-2.040389456
4	75.76753749	0.120516827	1.890783	0.276641729	0.003453483	-2.461742693
6	75.41521148	0.122541047	1.888759	0.276176536	0.001877627	-2.726390588
8	74.8803844	0.125631935	1.885668	0.275465246	0.001634156	-2.786706446
10	74.30649393	0.12897323	1.882327	0.274695019	0.002010298	-2.696739659
12	73.51048244	0.133650727	1.877649	0.273614473	0.002401625	-2.619494867
14	72.65731422	0.13872066	1.872579	0.272440228	0.002733963	-2.563207431
16	71.68853726	0.144550281	1.86675	0.271086095	0.003065285	-2.513529102
18	70.63564032	0.150976114	1.860324	0.269588562	0.003383106	-2.47068436
20	69.44282724	0.158372606	1.852927	0.267858402	0.003578834	-2.446258473
22	68.35825229	0.165209049	1.846091	0.266253093	0.003788973	-2.42147846
24	67.08597182	0.173368285	1.837932	0.264329372	0.00404312	-2.393283333
26	65.78906919	0.181846258	1.829454	0.262321433	0.00409193	-2.388071788
28	64.59742193	0.189784814	1.821515	0.260432796	0.004104864	-2.386701202
30	63.37102422	0.198109274	1.813191	0.258443489	0.004169732	-2.379891875
32	62.15239422	0.206542137	1.804758	0.256418943	0.004210116	-2.375705891
34	60.97185695	0.214870578	1.796429	0.254410159	0.004293533	-2.367185185
36	59.74476911	0.223700113	1.7876	0.252270319	0.028835965	-1.540065505
38	58.56295624	0.232377008	1.778923	0.250157148	0.107178893	-0.969890735
40	57.31994842	0.241694209	1.769606	0.247876531	0.359099009	-0.444785794
42	0.974350718	2.01128469	1.53E-05	-4.815034615	0.640295054	-0.193619853

Figure 1. A Plot of the Absorbance of CrIII as a Function of Time and The Log of Rate as a Function of Time in Part 1

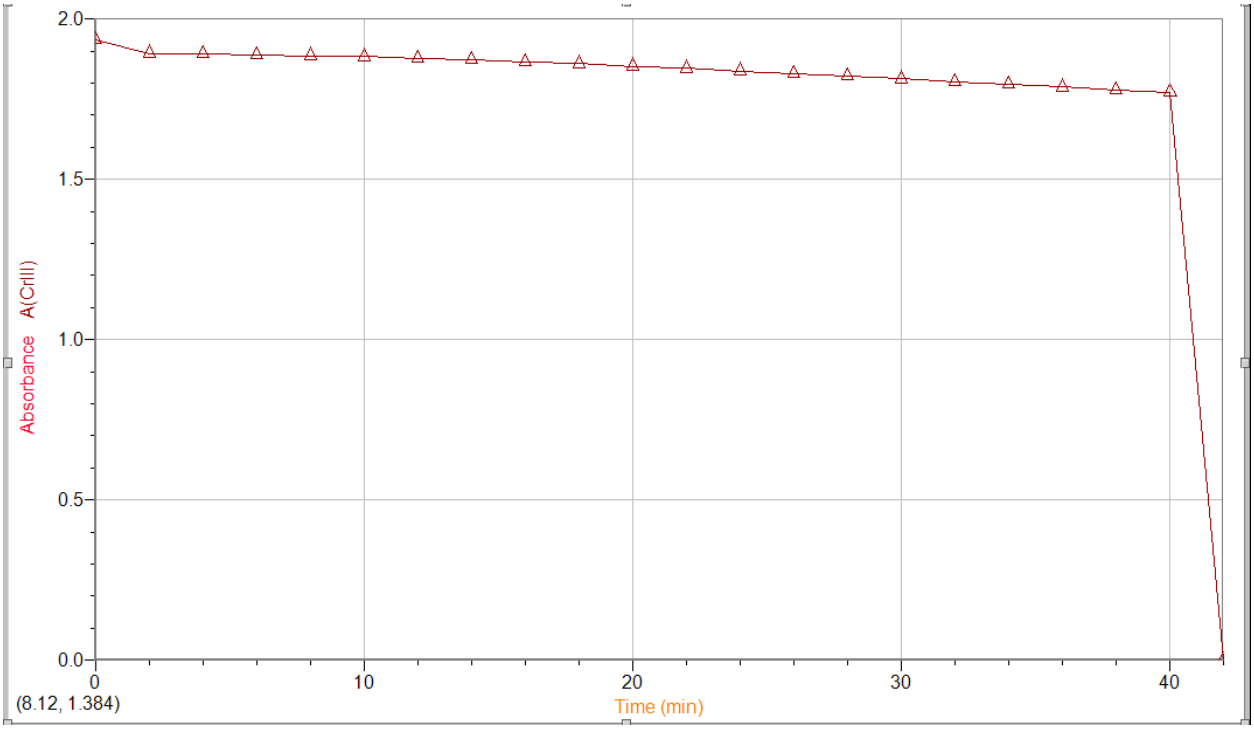
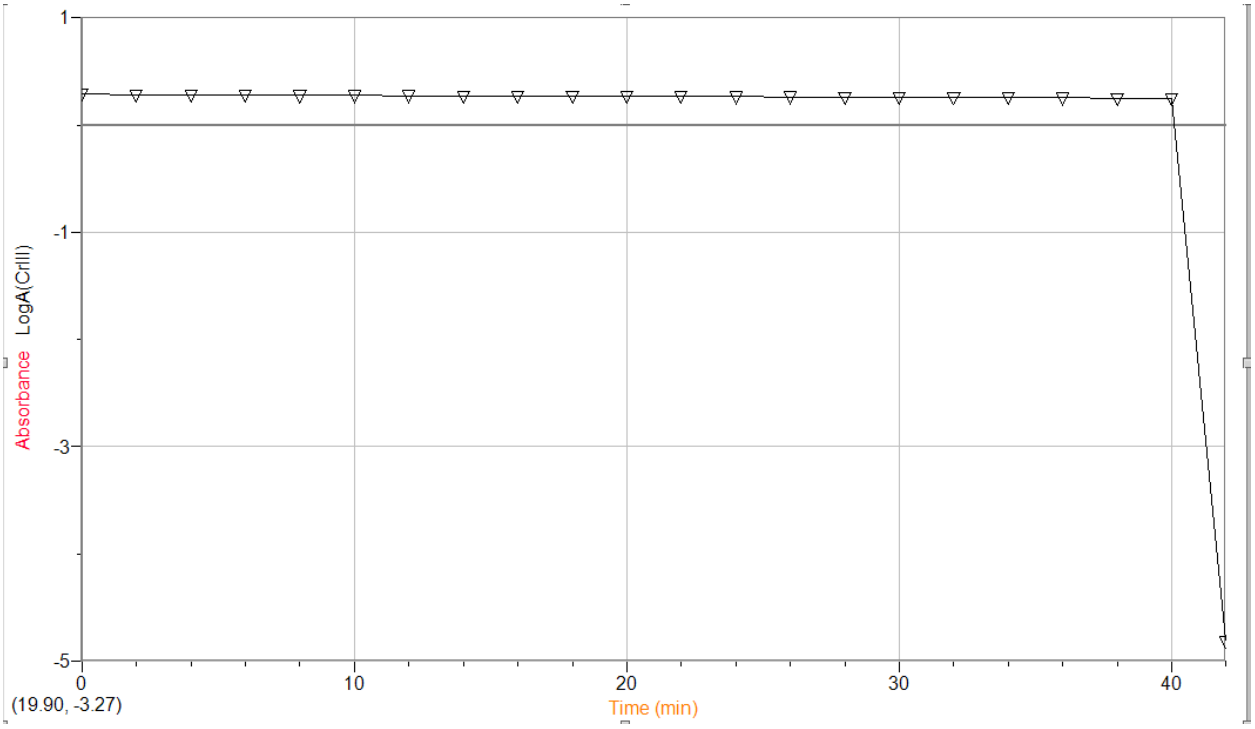


Figure 2. A Plot of the Log of the Rate as a Function of the Log of CrIII in Part 1



The Calculated Observations of Part 2

Time (min)	% Transmittence @569.1	Absourbence	A(CrIII)	Log (A(CrIII)	Rate	Log(Rate)
0	83.83362622	0.076581748	1.457518	0.163614002	0.009394888	-2.027108414
2	79.17523883	0.101410618	1.432689	0.156152042	0.006055551	-2.217846301
4	78.7108849	0.103965205	1.430135	0.155376973	0.003425047	-2.465333459
6	77.77007194	0.109187499	1.424913	0.153788197	0.003313153	-2.479758516
8	76.55987118	0.115998806	1.418101	0.151707223	0.00394695	-2.403738369
10	74.95225174	0.125215315	1.408885	0.148875448	0.004780175	-2.32055618
12	73.2129221	0.135412259	1.398688	0.145720768	0.005453655	-2.263312322
14	71.28538258	0.146999515	1.3871	0.142107924	0.00611298	-2.21374701
16	69.1861719	0.159980698	1.374119	0.13802444	0.006682991	-2.175029125
18	67.0120341	0.173847199	1.360253	0.133619629	0.007155024	-2.145388905
20	64.69611826	0.189121776	1.344978	0.128715253	0.00736658	-2.132734115
22	62.5701275	0.20363296	1.330467	0.12400412	0.007410535	-2.130150464
24	60.47780849	0.218403955	1.315696	0.119155569	0.007577013	-2.120501958
26	58.33757485	0.234051629	1.300048	0.113959511	0.007677124	-2.114801425
28	56.31365439	0.249386289	1.284714	0.108806359	0.007635895	-2.11714006
30	54.34622856	0.264830589	1.269269	0.103553814	0.007462707	-2.127103613
32	52.54836004	0.279440833	1.254659	0.098525764	0.007199884	-2.142674485
34	50.89837157	0.293296112	1.240804	0.093703146	0.007079196	-2.150016076
36	49.26125763	0.307494505	1.226605	0.088704906	0.023535601	-1.6282747
38	47.65089476	0.32192894	1.212171	0.083563911	0.076087542	-1.118686446
40	46.20507849	0.335310288	1.19879	0.078743007	0.245514214	-0.609923359
42	2.923545972	1.534090073	9.93E-06	-5.003167957	0.434780473	-0.361729969

Figure 3. A Plot of the Absorbance of CrIII as a Function of Time and The Log of Rate as a Function of Time in Part 2

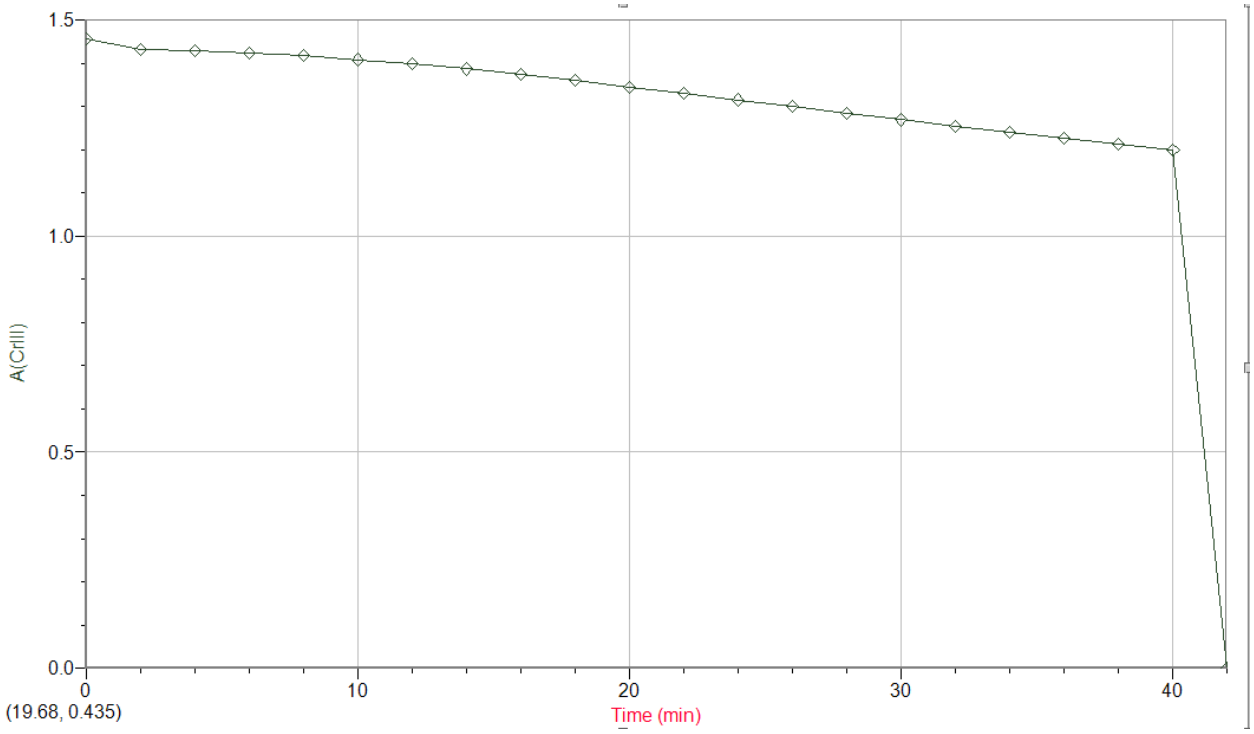
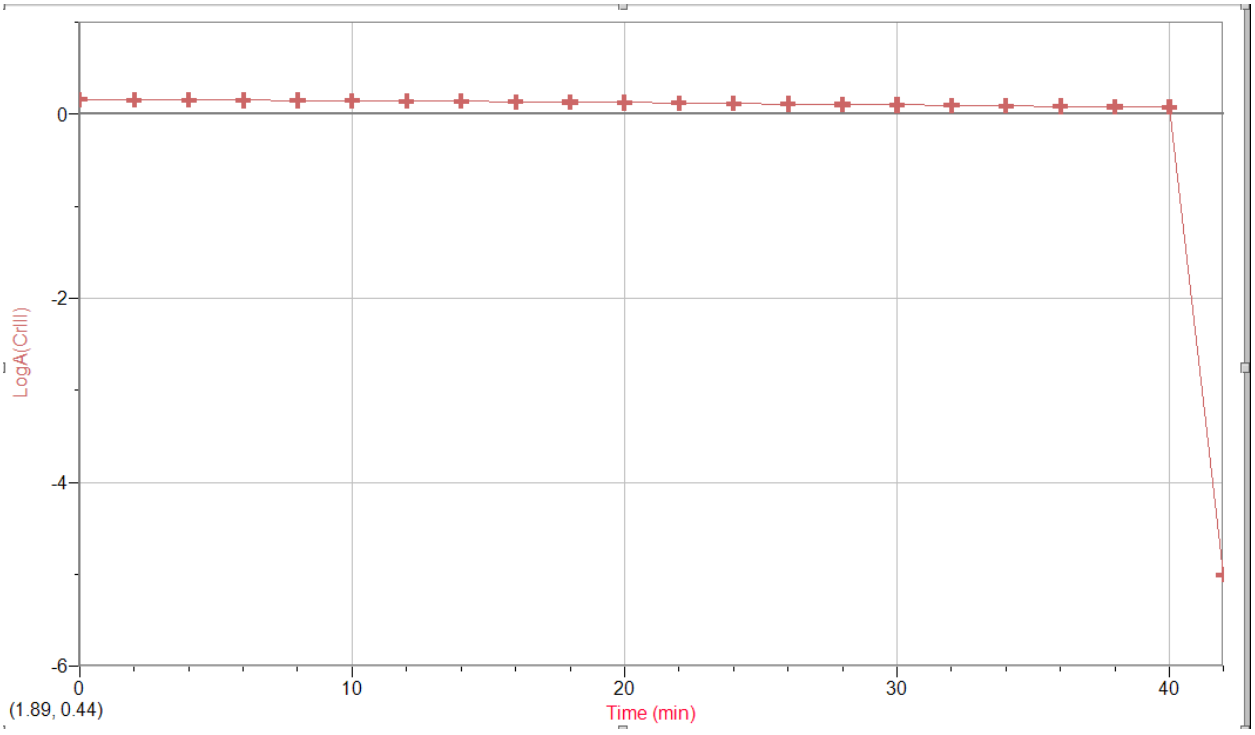


Figure 4. A Plot of the Log of the Rate as a Function of the Log of CrIII in Part 2



The Calculated Observations of Part 3

Time (min)	% Transmittence @569.1	Absourbence	A(CrIII)	Log (A(CrIII)	Rate	Log(Rate)
0	83.65299474	0.077518507	1.133581	0.054452747	0.005674637	-2.246061904
2	81.45059285	0.08910575	1.121994	0.049990631	0.00574185	-2.240948166
4	79.62376439	0.098957294	1.112143	0.046160518	0.006317962	-2.199422966
6	77.05416307	0.113203892	1.097896	0.040561245	0.007402876	-2.130599547
8	74.24486968	0.129333551	1.081766	0.034133508	0.008235446	-2.084312883
10	71.39658287	0.146322574	1.064777	0.027258835	0.008934972	-2.048906818
12	68.31423798	0.165488772	1.045611	0.019370238	0.009367966	-2.028354682
14	65.40406054	0.184395288	1.026705	0.011445555	0.009487803	-2.022834348
16	62.61752799	0.203304081	1.007796	0.003372595	0.00960387	-2.017553718
18	59.82305128	0.22313144	0.987969	-0.005256875	0.009534535	-2.020700496
20	57.32037591	0.24169097	0.969409	-0.013492939	0.009332799	-2.029988104
22	54.88210097	0.260569272	0.950531	-0.022033839	0.00906227	-2.042763007
24	52.72646777	0.277971322	0.933129	-0.030058463	0.008758833	-2.057553772
26	50.65069622	0.295414581	0.915685	-0.038253701	0.008541548	-2.068463415
28	48.70629251	0.312414927	0.898685	-0.046392472	0.008213457	-2.085474026
30	46.9907378	0.327987736	0.883112	-0.053984084	0.007998882	-2.096970694
32	45.24446102	0.344434581	0.866665	-0.062148532	0.007763505	-2.109942153
34	43.71294031	0.35938998	0.85171	-0.069708244	0.007369353	-2.13257063
36	42.28752176	0.373787766	0.837312	-0.077112563	0.018106805	-1.742158165
38	40.95922765	0.387648241	0.823452	-0.084361839	0.053190627	-1.27416489
40	39.82463673	0.399848177	0.811252	-0.090844314	0.16719531	-0.776775908
42	6.150174096	1.21111259	-1.26E-05		0.294697155	-0.530624056

Figure 5. A Plot of the Absorbance of CrIII as a Function of Time and The Log of Rate as a Function of Time in Part 3

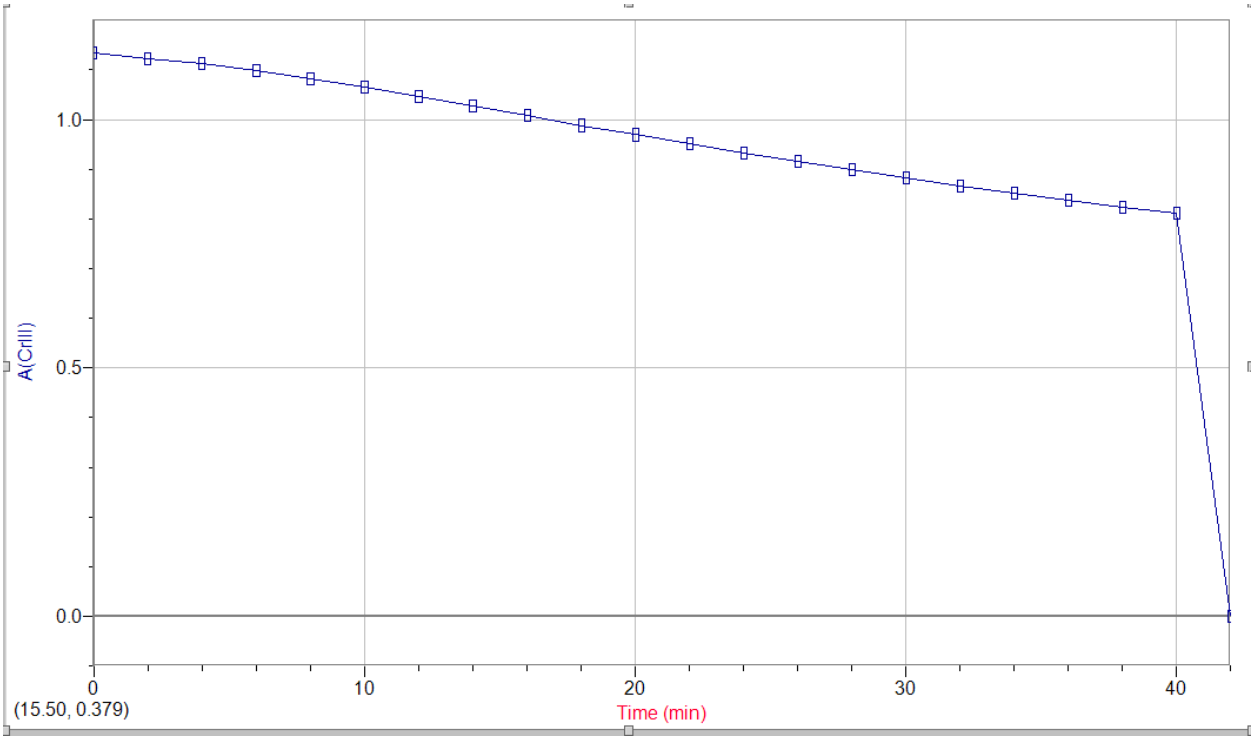
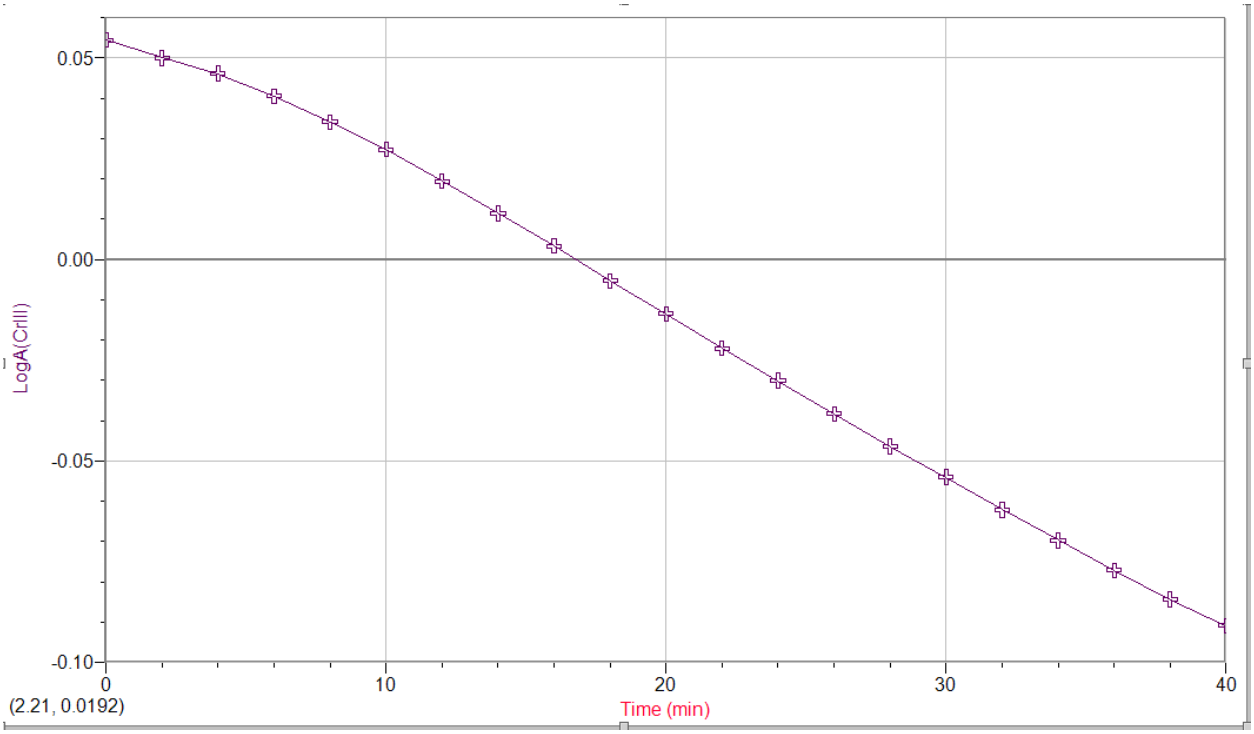


Figure 6. A Plot of the Log of the Rate as a Function of the Log of CrIII in Part 3



Sample Calculations:

Absorbance:

$A(t) = \log(100/T)$

$= \log(100/76.146)$

$= 0.1184$

A(CrIII):

$A(Cr(III)) = I - A(t)$

$= 2.924 - 0.076582$

$= 2.8474$

Log(Cr(III)):

$\log(A(Cr(III))) = \log(1.935) = 0.287$

Log of Rate:

$\log(0.015) = -1.811$

Discussion:

After analysing the data it is clear that, the results match the theory discussed in the introduction. As predicted the rate of reaction decreased as the pH increased, this is made evident by the graphs of Rate Vs Time. As the pH got larger, the slope of the corresponding graph became less steep than the one before it. It is however important to note that these graphs only represent a small portion of the reaction. This is due to lack of time during the lab period, normally this reaction would take up to four hours to complete, however we could only allow 42 minutes per trial.

This is important to note because the graphs appear to be almost linear, this would not be the case if the entire reaction was captured on the graph. This also means that the slopes on the graphs are inaccurate.

In order to determine whether the reaction was pseudo first order or not, the graph of log(A(Cr(III))) must be analysed. If these graphs were linear, then it would mean that the reaction was indeed pseudo first order, however since the graphs are not quite linear, the reaction is not pseudo first order. If more of the reaction had been completed and graphed the non-linear nature would be much more pronounced.

In order to find the instantaneous rate of reaction at a given time, the slope of the tangent to the graph of A(CrIII) at a specific point must be calculated. This is an important tool to have when measuring the effects of certain factors on the rate of a reaction. This shows that transmittance and absorbance can be used to calculate the rate constant K of a reaction.

The only significant error in this experiment was one in the procedure. Due to time constraints, the reaction could not be carried out to completion as each trial would have then taken 4-6 hours. This altered some of the data and the appearance of the graphs.

Conclusion:

In conclusion, the rate of reaction decreased as the pH of the EDTA increased which is shown by the slope od the graphs of Rate Vs Time. The shape of the graphs is rather inaccurate in this experiment due to the small amount of time that the reaction was observed.

References:

Kenneth A. Connors, "Chemical Kinetics The Study of Reaction Rates in Solution" Chapter 1, Wiley-VCH; Revised ed. edition, page 13, (Aug. 29 1990)

Dr. R. Venkateswaran, "What In The World
Isn't Chemistry?", General Chemistry Laboratory Manual, 2016, Experiment 3, p
(79-83)

Raw Data:

	Run 1			Run 2			Run 3		
	Time (min)	s @ 569.1 (%)	Abs	Time (min)	s @ 569.1 (%)	Abs	Time (min)	s @ 569.1 (%)	Abs
1	0	83.877	0.076359	0	83.834	0.076582	0	83.653	0.077519
2	2	76.146	0.11835	2	79.175	0.10141	2	81.451	0.089106
3	4	75.768	0.12052	4	78.711	0.10397	4	79.624	0.098957
4	6	75.415	0.12254	6	77.770	0.10919	6	77.054	0.11320
5	8	74.880	0.12563	8	76.560	0.11600	8	74.245	0.12933
6	10	74.306	0.12897	10	74.952	0.12522	10	71.397	0.14632
7	12	73.510	0.13365	12	73.213	0.13541	12	68.314	0.16549
8	14	72.657	0.13872	14	71.285	0.14700	14	65.404	0.18440
9	16	71.689	0.14455	16	69.186	0.15998	16	62.618	0.20330
10	18	70.636	0.15098	18	67.012	0.17385	18	59.823	0.22313
11	20	69.443	0.15837	20	64.696	0.18912	20	57.320	0.24169
12	22	68.358	0.16521	22	62.570	0.20363	22	54.882	0.26057
13	24	67.086	0.17337	24	60.478	0.21840	24	52.726	0.27797
14	26	65.789	0.18185	26	58.338	0.23405	26	50.651	0.29541
15	28	64.597	0.18978	28	56.314	0.24939	28	48.706	0.31241
16	30	63.371	0.19811	30	54.346	0.26483	30	46.991	0.32799
17	32	62.152	0.20654	32	52.548	0.27944	32	45.244	0.34443
18	34	60.972	0.21487	34	50.898	0.29330	34	43.713	0.35939
19	36	59.745	0.22370	36	49.261	0.30749	36	42.288	0.37379
20	38	58.563	0.23238	38	47.651	0.32193	38	40.959	0.38765
21	40	57.320	0.24169	40	46.205	0.33531	40	39.825	0.39985
22	42	0.074	2.0112	42	2.024	1.5241	42	6.150	1.2111

4.5 10mL

1 solutions were transparent & colourless.

→ when $CrCl_3$ was added it was pale purple & transparent

2) 78.711%

10 min 74.952

20 min 64.696%

40 16.205

Bright purple after heat.

5.0 10.0mL

Start 83.85

39.825

Final with extra purple...

6.150%

Kas ~~Theori Thamil~~chelvan
~~416~~ 520 1916
~~8599844~~

Come at 8
Next week

Lavena Aoun
8751460
(613)794-0990

min ~~26.744~~

wake length = 569.1

1) 10mL
4.0r

Test tube
bright purple once removed from boiling water....

1st) @569.1 nm 75.768%
2nd) 75.415%
3rd) 74.880%
4) 74.306%
5) 73.510%
6) 72.657%
7) 71.689%
8) 70.636%
9) 69.443
10) 68.358
11) 67.086%
12) 65.789
13) 64.597
14) 63.317
15) 62.152

40min 57.320%
42w/brightpurple 0.974%