Introduction:

The reaction of EDTA and Cr(III) is one that can be observed through colour change. As the reaction's ratio between reactants and products become product favoured, the solution becomes a darker shade of purple. This change in the colour is the reason why the spectrophotometer is able to detect the change in transmittance. Since the percent transmittance is measured at a consistent time interval, the graph should have a negative slope due to a decrease in the number of reactants.

The Changing pH value in the EDTA is what's causing the different percent transmissions. The EDTA solution. The EDTA with the lowest pH (4.0) value will have the highest concentration of hydrogen ions, while the change in pH values should cause each a unique reaction.

Spectrophotometry is the measurement of the transmission properties of a material with respect to its wavelength. The first measurements that will be made are of the percent transmittance. This value is gained by spectrophotometry using photometers measure a light beam's intensity as a function of its wavelength. Furthermore, after measuring the percent transmittance of the solution, it compares this result with the initial wavelength it was calibrated to. Overall the process of the spectrophotometry can be observed through this equation:

$$T=I/I_o$$

Where T is how much light is transmission, I is the intensity, or the current function, of the colour's wavelength, and I_o is the initial calibrated desired wavelength. If multiplied by 100%, then the T variable will give off the percent transmittance which is read off of the spectrophotometer.

The Absorbance from the spectrophotometer is equal to the negative base 10 logarithm of the transmittance. This can be Observed in this calculation:

$$A=-\log T \text{ or } A=-\log(I/I_o)$$

Furthermore, the reaction order depends on the reaction, the temperature, and the presence of a catalyst if there is one present. The unit of rate depends on the overall order of the reaction which is the sum of all of the exponents in the rate law. While the value of k is the slope of the graph, If rate=0 (zero order reaction), then the graph of the reaction with respect to time should be a straight line, with a negative slope as mentioned previously. If rate=1(First order reaction), Then the graph of the reaction with respect to time should be a mono exponential curve with a negative slope compared to the Zero Order reaction. In order to get a straight line and convert it to a first order reaction, the result is determined by taking the log of both sides of the equation of the line in order to get a straight line, if rate =2(Second order reaction), then the graph of the reaction with respect to time is a bi-exponential curve, where in order to get a straight line, the equation has to be logged and inverted in order for the graph to be a straight line. Moreover, when the reaction starts it has to move over the activation barrier in order to begin reacting to produce products. If the equilibrium reaction is heavily product favoured, then an increase in temperature(kinetic energy), should increase the reaction rate, which should change the reaction from heavily product favours to a specific equilibrium ratio.

Raw Data:

	Solution 1(PH=4.0)	Solution 2 (PH=4.5)	Solution 3 (PH=5.0)
Volume of EDTA solution	50	50	50
PH of EDTA Solution	4	4.5	5
Temperature of Water bath (°C)	21.0	23.2	23.3

Table 1: The Data recorded before the reaction proceeded

Percent Transmittance value after (minutes)	Solution 1 (%) PH=4.0	Solution 2 (%) PH=4.5	Solution 3 (%) PH=5.0
5	81.5	78.0	69.0
10	80.6	69.0	55.0
15	77.0	60.0	39.0
20	75.0	54.0	32.2
25	74.0	47.5	32.0
30	70.0	48.0	25.0
35	67.0	41.0	23.0
40	64.5	37.0	21.8
45	66.0	37.0	20.0
50	61.0	35.0	19.0
55	58.9	33.5	19.0
60	57.0	32.0	18.0
65	57.0	32.0	18.0
70	55.0	30.5	17.0
75	52.9	30.0	17.0
80	52.0	29.0	17.0
85	52.0	28.0	17.0
90	51.0	27.0	16.0
Percent Transmittance value after 10 minutes in the hot water bath	5.0	6.0	14.0

Table 2: The Percent transmittance recorded for the reaction at the times Stated.

Sample Calculations:

1.-log(T/100%)

2.A_{infnity} -A_t

3.-log($A_{Cr(III)}$)

4.y/Δx=2

5.-log(RATE)

6. Slope of the line of best fit on the data for the pH of 4.5, on the thrid graph log(RATE) as a Function of log($A_{Cr(III)}$)

Results:

Values after (mins)	PH =4.0		
	-log(T/100%)	$A_{infinity}$-A_t	Log($A_{cr(III)}$)
5	0.09	0.77	0.12
10	0.09	0.76	0.12
15	0.11	0.72	0.14
20	0.12	0.70	0.15
25	0.13	0.69	0.16
30	0.15	0.65	0.19
35	0.17	0.62	0.21
40	0.19	0.60	0.23
45	0.18	0.61	0.21
50	0.21	0.56	0.25
55	0.23	0.54	0.27
60	0.24	0.52	0.28
65	0.24	0.52	0.28
70	0.26	0.50	0.30
75	0.28	0.48	0.32
80	0.28	0.47	0.33
85	0.28	0.47	0.33
90	0.29	0.46	0.34
10 minutes of boiling to bring the reaction to completion	1.30	Irrelevant	Irrelevant

Table 3: The Calculated data from the reaction with the EDTA at a PH of 4.0

Values after (Minutes)	PH=4.5					
	-log(t/100%)	$A_{infinity}-A_t$	-log($A_{Cr(III)}$)	Y	Y/Δx	-log(RATE)
5	0.11	0.72	0.14	0.72	0.36	0.44
10	0.16	0.63	0.20	0.63	0.32	0.50
15	0.22	0.54	0.27	0.54	0.27	0.57
20	0.27	0.48	0.32	0.48	0.24	0.62
25	0.32	0.41	0.38	0.41	0.21	0.68
30	0.32	0.42	0.38	0.42	0.21	0.67
35	0.39	0.35	0.46	0.35	0.18	0.76
40	0.43	0.31	0.51	0.31	0.16	0.81
45	0.43	0.31	0.51	0.31	0.16	0.81
50	0.46	0.29	0.54	0.29	0.15	0.84
55	0.47	0.27	0.56	0.27	0.14	0.86
60	0.49	0.26	0.59	0.26	0.13	0.89
65	0.49	0.26	0.59	0.26	0.13	0.89
70	0.69	0.14	0.84	0.14	0.07	1.14
75	0.52	0.24	0.62	0.24	0.12	0.92
80	0.54	0.23	0.64	0.23	0.12	0.94
85	0.55	0.22	0.66	0.22	0.11	0.96
90	0.57	0.21	0.68	0.21	0.11	0.98
10 minutes of boiling to bring the reaction to completion	1.22	Irrelevant	Irrelevant	Irrelevant	Irrelevant	Irrelevant

Table 4: The calculated data from the reaction with the EDTA at a PH of 4.5

Values after (Minutes)	PH=5.0					
	-log(t/100%)	$A_{infinity}$-A_t	-log($A_{Cr(III)}$)	Y	Y/Δx	-log(RATE)
5.0	0.16	0.55	0.26	0.55	0.28	0.56
10	0.26	0.41	0.26	0.41	0.21	0.69
15	0.41	0.25	0.41	0.25	0.13	0.90
20	0.49	0.18	0.49	0.18	0.09	1.04
25	0.49	0.18	0.49	0.18	0.09	1.05
30	0.60	0.11	0.60	0.11	0.06	1.26
35	0.64	0.09	0.64	0.09	0.05	1.35
40	0.66	0.08	0.66	0.08	0.04	1.41
45	0.70	0.06	0.70	0.06	0.03	1.52
50	0.72	0.05	0.72	0.05	0.03	1.60
55	0.72	0.05	0.72	0.05	0.03	1.70
60	0.74	0.04	0.74	0.04	0.02	1.70
65	0.74	0.04	0.74	0.04	0.02	1.82
70	0.77	0.03	0.77	0.03	0.02	1.82
75	0.77	0.03	0.77	0.03	0.02	1.82
80	0.77	0.03	0.77	0.03	0.02	1.82
85	0.77	0.03	0.77	0.03	0.02	1.82
90	0.80	0.02	0.80	0.02	0.01	2.00
10 minutes of boiling to bring the reaction to completion	0.85	Irrelevant	Irrelevant	Irrelevant	Irrelevant	Irrelevant

Table 5: the calculated data from the reaction with the EDTA at a PH of 5.0

	PH = 4.5	PH=5.0
Slope of the data on Graph 3	-1.50	-1.90

Table 6: The partial order with respect to the Cr(III) ion for the two different pH's graphed

Discussion:

The first graph is the representation of the Absorbance as a function of time. The reason that the curve for the pH of 4.0 is steep because that there was enough OH^- to cause the reaction to go to completion without the presence of a catalyst. This resulted in the liquid solution to turn purple, which is the colour of the products, but at a slow to a moderate pace. While in the other two reactions, it is observed that as the concentration of OH^- increase when the pH increases, the graph of the reactions tend to become stepper and tend to have a higher concentration of products.

The second graph is the logarithm of the absorbance as a function of time. This shows the rate of change in graph 1. The graph of the pH 4.5 has a more linear curve because it is not subject to as great of a change in concentration of reactants when compared to that of the pH 5.0. This is due to the collision theory requiring the reactants to have the correct orientation, energy and concentration in this case. The reaction with the solution of pH 5.0 has a higher rate of loss of reactants because there are more molecules of OH^- ions colliding, thus meaning a higher chance of collision.

The Third graph represents the logarithm of the rate as a function of the logarithm of the absorbance. Overall this graph depicts the partial order of the reaction as the slope is that of the linear equation log(RATE)= alog(RATE) + log(K). This 'a' value is close to one in 4.5 and close to 5.0 as observed in table 6. Thus making the reaction with a pH of 4.5 a first order reaction and the reaction with the pH 5.0 a second order reaction.

In this lab there were quite few errors including the fact that the timing was always precise or exact as recorded. Even though the data was recorded every 5 minutes, this may differ up to 1 minute and 30 seconds due to a huge line up on the spectrophotometer and more then 1 way trips in order to get the values for all 3 solutions. This should cause the graph to have a horizontal translate by one, shouldn't affect the results to the nearest mm. Moreover, this still causes an error, because this could have potentially changed the shape of the graph to make it either more linear or more exponential. This error could be resolved in the near future by having more equipment ready to use. Moreover, it also could have been resolved by having an additional partner to decrease the time used spending walking back and forth to get the other vials.

A second error that could have been prevented is that thermometer would give odd reading occasionally, this error effected the rate of how the solution reacted, because the desired temperature for the reaction to be stable is between twenty Celsius to twenty five Celsius. In some, reading the thermometer would give accurate readings and sometimes it wouldn't, due to that error, there were huge spikes in the reading as observed in graph 1 and 2. This error could have been resolved, if the room was at twenty four degree's Celsius, which should help stabilize the water's temperature roughly between the desired range of twenty to twenty five Celsius.

In conclusion, the partial orders for the solution with a concentration of pH 4.5 with respect to Cr(III) was close enough to one. While the solution with a concentration of pH 5.0 with respect to Cr(III) was close enough to two. Due to this, the solution with the pH 4.5 is considered as a first order solution, while the solution with a pH 5.0 is considered as a second order solution. The order for the reaction of the EDTA with the pH 4.5 order was 1.5 and for the reaction pH 5.0 the order was 1.9. This is evident because the data for the reaction of the solution with a concentration of pH 4.5 is a first order reaction and the graph of the data in graph 3 is close to becoming a linear graph. While the reaction of the solution with a concentration of pH 5.0 is a second order reaction because the graph of the data in graph 3 is closer to an exponential graph than a linear graph.

References:

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