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“IF IT WERE DONE...THEN ‘TWERE WELL IT WERE DONE  
QUICKLY”

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Experiment 4: Chemical Kinetics



NOVEMBER 15, 2016

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ID: \*\*\*\*\*

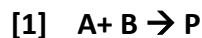
Lab Partner: \*\*\*\*\*

Demonstrator: \*\*\*\*\*

Tuesday, Even, 2:30pm

## Introduction:

A chemical reaction rearranges the ionic structure of a substance, this process can happen at different rates. It could either be a fast reaction that takes seconds or a slow reaction that can take years. To see the rate reaction we can look at the *order of the reaction*, which is the exponent in the following equation with respect to its concentration.



$$[2] \quad \text{Rate} = k [A]^n [B]^m$$

The *rate of a reaction* is proportional to the product of the concentrations of the reactants [1] raised to a power [2]. The  $k$  is the rate constant relates the reaction at a specific temperature to the concentration of reactants measured in  $L^{-1}$  or mol/L. By graphing this relation (concentration with respect to time) we can see an *instantaneous rate* by calculating the reaction at a specific time.

*The order of a reaction* is determined by the  $n$  and  $m$  exponents in equation [2] with respect to the concentration of the products. Unlike the rate constant, the order of a reaction can only be figured out experimentally.

*Spectrophotometry* is the study of the interaction of electromagnetic radiation with matter. Two terms commonly used is *transmittance* and *absorbance*. Transmittance is defined by this equation

$$[3] \quad T = I/I_0$$

$$[4] \quad \%T = T \times 100$$

From equation [3] we can define transmittance as a ratio where  $I$  is the intensity of light after it passes through the medium to ( $I_0$ ) the intensity of the light before passing through the medium. Turning this relationship into a percentage to see how much light is actually transmitted is described by equation [4] which is linear. Equation [4] is used rather than equation [3] on the spectrophotometer.

$$[5] \quad A = -\log T = -\log(I/I_0)$$

From equation [5] the relationship between absorbance and transmittance (not percentage transmittance). Absorbance follows a logarithmic scale, in order to calculate the absorbance, the transmittance value is needed.

*Beer- Lambert Law* describes the relationship between absorbance and the concentration with the following equation:

$$[6] A = \epsilon b c$$

This equation [6] illustrates that absorbance is equal to the molar absorptivity coefficient which is a constant for a given light multiplied by the path length and the concentration of the absorbing species.

### **Procedure:**

As described in the lab manual (“What in the world ISN’T Chemistry?”, Dr. Rashmi Venkateswaran, General Chemistry Laboratory Manual, 2016, Exp. 4, p. 50).

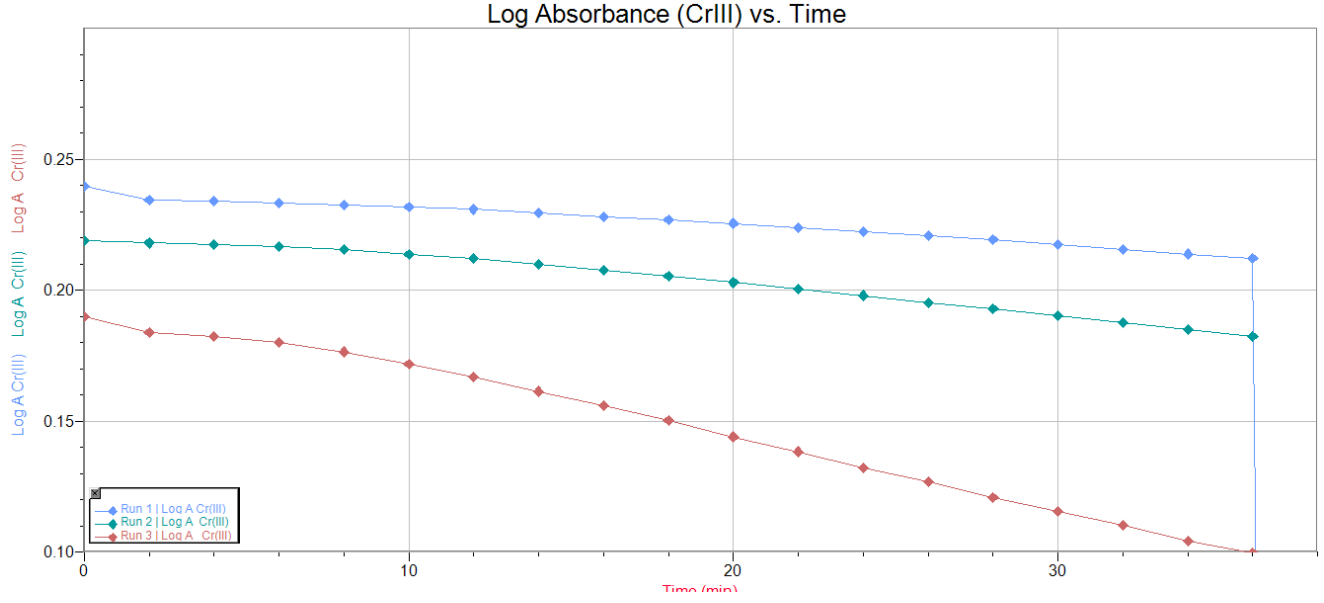
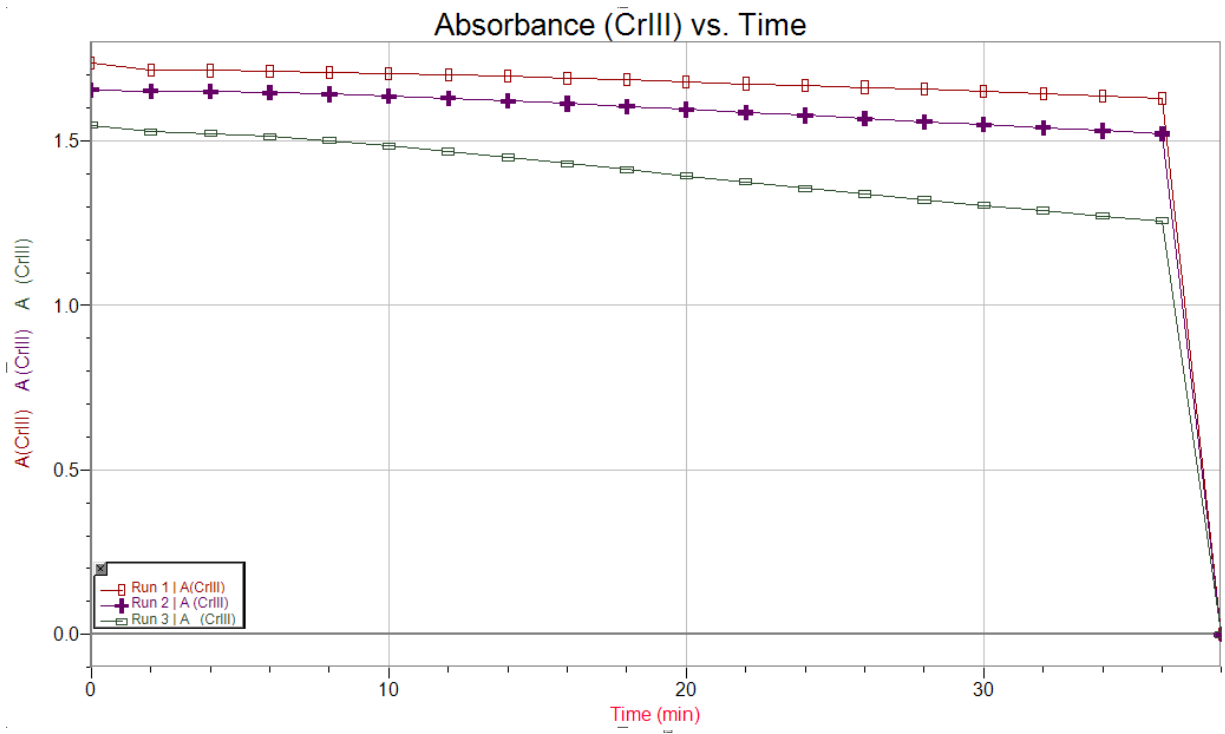
### **Observations/Data/Results:**

All three solutions of EDTA solution (4.0pH, 4.5pH, 5.0pH) and Cr(III) turned a dark purple when heated ( $T_{\infty}$ ). However initially all the solutions were clear and odorless. Once the Cr(III) solution was added each of the solutions had a very slight grey tinge.

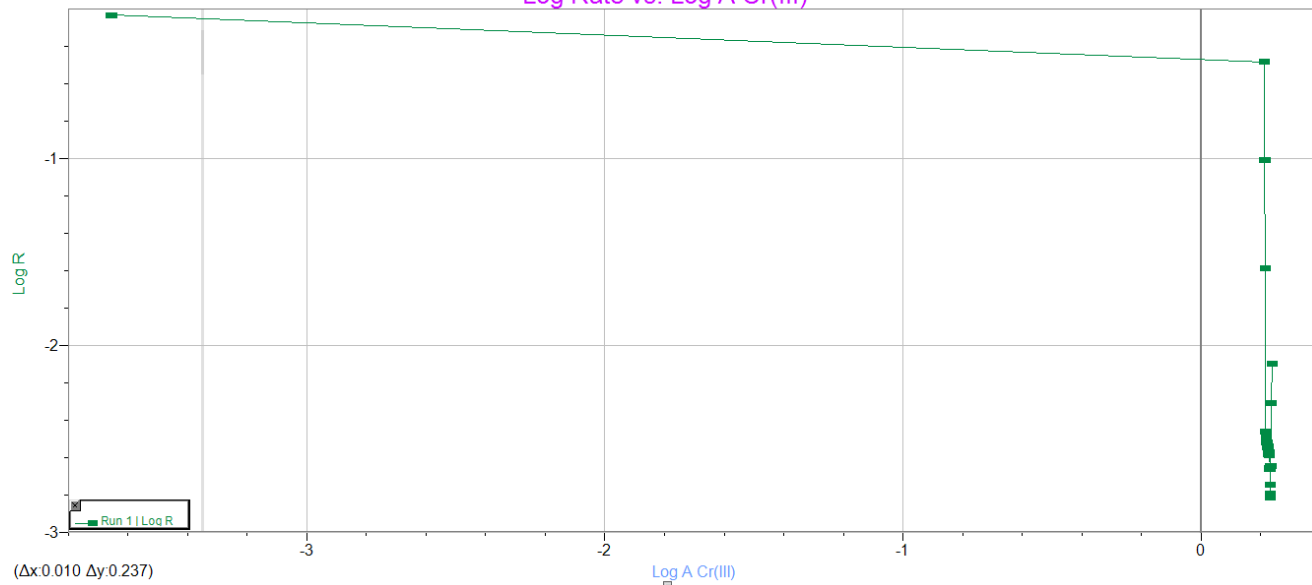
### **Data Table:**

Data	Trial 1	Trial 2	Trial 3
pH(EDTA)	4.0	4.5	5
Volume (ml)	10	10	10
Molarity (M)	0.1	0.1	0.1
Initial % Transparency (T)	80.976%	80.763%	80.633%
Wavelength	571.2nm	571.2nm	571.2nm

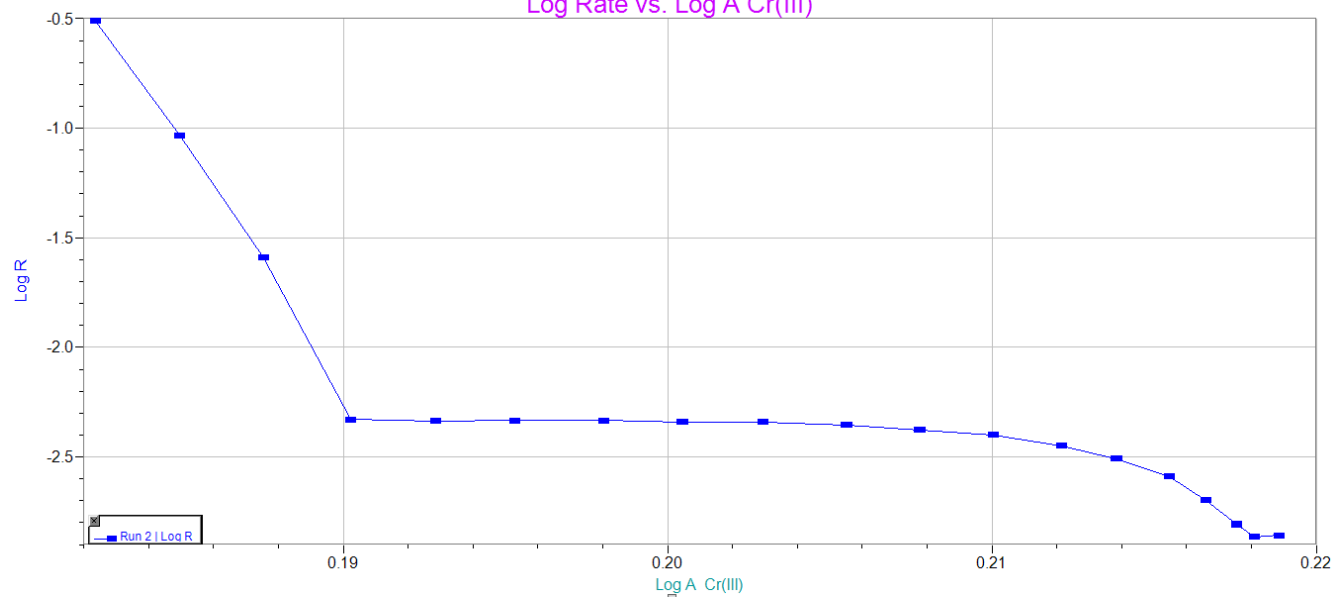
### **Graphs:**

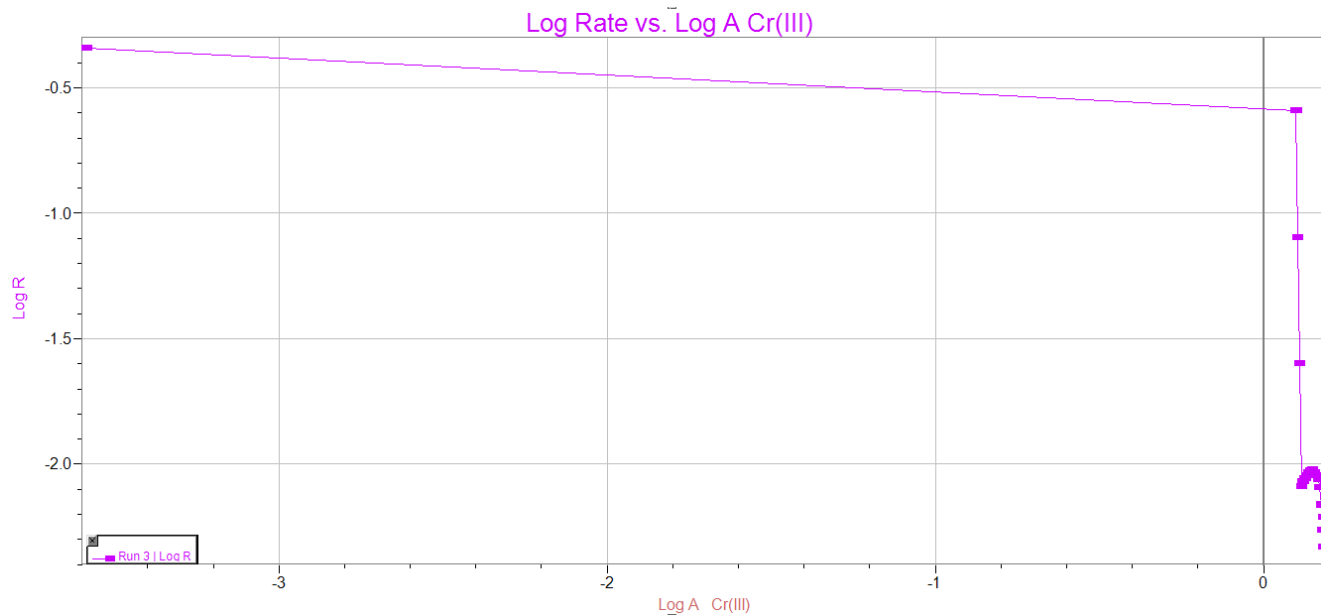


Log Rate vs. Log A Cr(III)



Log Rate vs. Log A Cr(III)





**Trial 1: 4.0 pH**

Run 1								
Time (min)	Trans @ 571.2 nm (%)	A(t)	A(CrIII)	Log A Cr(III)	Rate	Log R	A (CrIII)f	
0	80.976	0.092	1.737	0.240	0.008	-2.097	1.737	
2	77.085	0.113	1.716	0.235	0.005	-2.308	1.716	
4	76.767	0.115	1.714	0.234	0.002	-2.646	1.714	
6	76.328	0.117	1.712	0.233	0.002	-2.794	1.712	
8	75.805	0.120	1.709	0.233	0.002	-2.816	1.709	
10	75.283	0.123	1.706	0.232	0.002	-2.746	1.706	
12	74.616	0.127	1.702	0.231	0.002	-2.660	1.702	
14	73.791	0.132	1.697	0.230	0.003	-2.587	1.697	
16	72.731	0.138	1.691	0.228	0.003	-2.576	1.691	
18	71.981	0.143	1.686	0.227	0.003	-2.580	1.686	
20	71.117	0.148	1.681	0.226	0.003	-2.539	1.681	
22	69.991	0.155	1.674	0.224	0.003	-2.538	1.674	
24	69.217	0.160	1.669	0.223	0.003	-2.544	1.669	
26	68.255	0.166	1.663	0.221	0.003	-2.519	1.663	
28	67.324	0.172	1.657	0.219	0.003	-2.489	1.657	
30	66.246	0.179	1.650	0.218	0.003	-2.461	1.650	
32	65.134	0.186	1.643	0.216	0.026	-1.586	1.643	
34	64.179	0.193	1.636	0.214	0.098	-1.009	1.636	
36	63.201	0.199	1.630	0.212	0.330	-0.481	1.630	
38	1.483	1.829	0.000	-3.656	0.589	-0.230		

**Trial 2: 4.5pH**

Run 2								
Time (min)	Trans @ 571.2 nm (%)	A(t)	A (CrIII)	Log A Cr(III)	Rate	Log R	A (CrIII) f	
0	80.763	0.093	1.655	0.219	0.001	-2.859	1.655	
2	80.219	0.096	1.652	0.218	0.001	-2.865	1.652	
4	79.848	0.098	1.650	0.218	0.002	-2.807	1.650	
6	79.180	0.101	1.647	0.217	0.002	-2.697	1.647	
8	78.410	0.106	1.642	0.215	0.003	-2.589	1.642	
10	77.305	0.112	1.636	0.214	0.003	-2.508	1.636	
12	76.178	0.118	1.630	0.212	0.004	-2.448	1.630	
14	74.805	0.126	1.622	0.210	0.004	-2.400	1.622	
16	73.371	0.134	1.614	0.208	0.004	-2.376	1.614	
18	71.970	0.143	1.605	0.206	0.004	-2.354	1.605	
20	70.420	0.152	1.596	0.203	0.005	-2.340	1.596	
22	68.952	0.161	1.587	0.200	0.005	-2.341	1.587	
24	67.560	0.170	1.578	0.198	0.005	-2.333	1.578	
26	66.038	0.180	1.568	0.195	0.005	-2.333	1.568	
28	64.717	0.189	1.559	0.193	0.005	-2.336	1.559	
30	63.330	0.198	1.550	0.190	0.005	-2.330	1.550	
32	61.960	0.208	1.540	0.188	0.026	-1.591	1.540	
34	60.657	0.217	1.531	0.185	0.093	-1.032	1.531	
36	59.400	0.226	1.522	0.182	0.309	-0.510	1.522	
38	1.785	1.748	0.000		0.551	-0.259		

**Trial 3: 5.0 pH**

Run 3								
Time (min)	Trans @ 571.2 nm (%)	A(t)	A (CrIII)	Log A Cr(III)	Rate	Log R	A (CrIII) f	
0	80.633	0.093	1.549	0.190	0.008	-2.075	1.549	
2	76.818	0.115	1.527	0.184	0.006	-2.209	1.527	
4	75.903	0.120	1.522	0.182	0.005	-2.329	1.522	
6	74.479	0.128	1.514	0.180	0.005	-2.262	1.514	
8	72.346	0.141	1.501	0.177	0.007	-2.161	1.501	
10	69.728	0.157	1.485	0.172	0.008	-2.092	1.485	
12	67.009	0.174	1.468	0.167	0.009	-2.059	1.468	
14	64.268	0.192	1.450	0.161	0.009	-2.043	1.450	
16	61.631	0.210	1.432	0.156	0.009	-2.032	1.432	
18	59.012	0.229	1.413	0.150	0.010	-2.022	1.413	
20	56.383	0.249	1.393	0.144	0.009	-2.026	1.393	
22	54.098	0.267	1.375	0.138	0.009	-2.033	1.375	
24	51.763	0.286	1.356	0.132	0.009	-2.043	1.356	
26	49.754	0.303	1.339	0.127	0.009	-2.057	1.339	
28	47.764	0.321	1.321	0.121	0.009	-2.068	1.321	
30	45.956	0.338	1.304	0.115	0.008	-2.086	1.304	
32	44.343	0.353	1.289	0.110	0.025	-1.596	1.289	
34	42.610	0.370	1.272	0.104	0.080	-1.096	1.272	
36	41.269	0.384	1.258	0.100	0.258	-0.589	1.258	
38	2.282	1.642	0.000	-3.587	0.456	-0.341		

### Sample Calculations:

#### %T → A:

$$A = \log(100/T) = \log(100/77.085) = \mathbf{0.113030}$$

#### A → A Cr(III):

$$A \text{ Cr(III)} = A_{\infty} - A(2) = 1.829 - 0.113030 = \mathbf{1.71597}$$

#### A Cr(III) → log A Cr(III):

$$\text{Log A Cr(III)} = \text{Log}(1.716) = \mathbf{0.23452}$$

#### Rate → log Rate:

$$\text{Log Rate} = \log(0.005) = \mathbf{-2.301}$$

#### Slope:

$$m = y_2 - y_1 / x_2 - x_1 = [-2.336 - (-2.333)] \div [0.193 - 0.198] = \mathbf{0.6}$$

### Discussion:

The purpose of this lab was to determine the partial order of the substance. During this experiment there were many factors that determined how the reaction proceeded such as the volume of the solution as well as the temperature. Over the duration of the three trials these two things are expected to be constant in order to have similar data, however if they are not constant there is a high chance that we would not have accurate results. This could be one of the sources that caused error during this experiment. These inaccurate results could have altered the reaction order. If these two variables remained constant it would be easier to compare our data for each of the different pH solutions and would ensure that it is more accurate. One other way the data of this experiment could be altered would be if we did not wipe the cuvette thoroughly. This could lead to the spectrometer having inaccurate readings which would change the data slightly not giving us an accurate representation of what is actually happening.

By looking at the graphs we can see that the graph [ A (CrIII) vs time] shows the concentration of the chromium ions changing over a period of time. This means that the graph of Log A (CrIII) vs time will be able to tell us the order of the reaction with respect to Cr(III). In the calculations above the value of the slope was 0.6 which can be rounded to 1. Although this value is not accurate due to the possible errors through the experiment, we can assume that this is the value. The order of  $[H^+]$  is assumed to be zero because of the buffer used in the reaction. The order of the EDTA solution is also said to be zero since there was not much Cr (III) reacting with the solution. The new rate law equation for this reaction would be  $rate = k [Cr^{3+}]^1$ . This means that the order of the Cr (III) is in fact one.

### **Conclusion:**

By analyzing the results of the lab we can see that the reaction between Cr (III) and EDTA solution is a first order reaction. By looking at the log A (CrIII) vs time graph we can also say that the partial order for Cr(III) is 1. Through the entire process of the lab, there was a lot of room for error because of small things such as the volume of the solution, temperature and wiping the cuvette. These small things can accumulate and shift are data, because of this we must be aware that the results of the lab are not as accurate. Not only that but the duration of the lab was a short which could have changed our data since only part of the reaction was observed.

### **References:**

("What in the world ISN'T Chemistry?, Dr. Rashmi Venkateswaran, General Chemistry Laboratory Manual, 2016, Exp. 4, p. 50)

"Van, Kessel H. Nelson Chemistry 12. Toronto: Thomson Nelson, 2003. Pg 410-422."

Lab 4

~~MA 2018~~

Min<sup>o</sup> 23.803 (Min transference) @ 571.20

0.1M

step 24 / Volume  $\rightarrow$  10ml of 40 pH in grad cyl

$\rightarrow$  Solution purple (dark) after hot water bath

0.1M 10ml of 4.5 pH in ~~grad cyl~~

} clear with dark tinge  
} purple in hot bath

0.1M of 5.0 pH in grad cyl

} clear with dark tinge  
} dark purple in hot bath