

## Spectrophotometer SP-1105

### #FOT-10711

#### Introduction:

Thank you for your purchase of our spectrum analysis instrument. The spectrum 1100 series spectrophotometers are a single beam system. The large LCD digital display, easy operation and wide wavelength range make these instruments ideal for spectrophotometric experiments in the visible wavelength region of the electromagnetic spectrum. A large sample compartment accepts from 5mm to 10mm path length cuvettes. The built-in RS-232 serial interface enables the instrument to be connected to a computer. Windows® 98 (or higher) based application software is provided.

The spectrum SP 1100 series spectrophotometers are general purpose instruments, designed for use in conventional laboratories. The instruments are ideal for various applications such as clinical chemistry, biochemistry, and petro chemistry, as well as in environmental protection and other fields of quality control.

After carefully unpacking the contents, please check the materials against the packing list to ensure that you have received everything in good condition. If you find some part is missing, damaged, or in any way defective, please contact your dealer or sales representative immediately.

However, to keep pace with technological advances, the specifications and operating instructions may be modified or changed as needed. We reserve the right to make design modifications and changes.

#### Specifications:

##### Model SP-1105

Spectral Slit width	6 nm
Wavelength range	325-1000 nm
Wavelength Accuracy	± 2 nm
Repeatability	± 1 nm
Stray Radiant Energy	≤ 0.5% T @ 340nm
Photometric Range	0% T to 125.0%T, 0A to 2.5A, 0C to 1999C(0-1999F)
Photometric Accuracy	± 1% T
Power Requirement	115/230 VAC, 50-60 Hz
Size: (mm)	400 (15.7") W x 285 (11.2") D x 155 (6.1") H
Weight	4.5 kg

## Packing List:

- 1 Spectrophotometer
- 1 Dust cover
- 1 Black cuvette (occluder)
- 4 Glass cuvettes
- 1 RS-232 cable
- 1 Data-collection software
- 1 User's instructions



## Unpacking instructions:

Carefully unpack the contents and check the materials against the above packing list to ensure that you have received everything in good order.

Place the instrument in a suitable location. In order for this unit to perform at its best, keep it as far as possible from any strong magnetic or electric fields, or any electrical device that may generate high frequency fields. Set the unit up in an area that is free of dust, corrosive gases, and strong vibrations. Remove any obstructions or materials that could hinder the flow of air under and around the instrument.

Plug the cord into a grounded outlet. Turn on the instrument and allow it to warm up for at least 20 minutes before taking any readings.

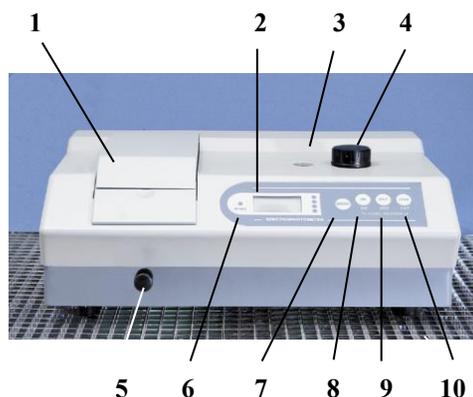
## Turning on the unit:

When you turn on the unit, the display will read 1.---

If the power indicator lamp indicates that there is power, but the liquid crystal display remains blank, turn the switch off, unplug the unit and wait 60 seconds. At this point, the unit will have reset. Then, plug the unit back in and turn the unit on.

## Operating Features:

1. **Sample Compartment**
2. **Digital Readout**
3. **Wavelength Readout**
4. **Wavelength Control Knob**
5. **Cuvette Pull-out Rod**
6. **Power On/Off Indicator**
7. **Mode Selector Key:** Selects Transmittance, Absorbance, Concentration or Factor
8. **100% T/OA Control key:** used to set the display to OA or 100% T. It must be reset whenever the analytical wavelength is changed.
9. **0% T:** used to set the display to 0% before setting 0Abs
10. **Print button:** to send displayed data to a printer or a computer connected to the R-232C serial port



## Operating Instructions:

### Measuring Transmittance or Absorbance

1. Plug the instrument into a grounded outlet.
2. Turn the instrument on and allow the instrument to warm up for at least 20 minutes.
3. Set the unit to the desired wavelength with wavelength control knob.
4. Select the desired operating mode as **TRANSMITTANCE**, **ABSORBANCE**, **CONCENTRATION** or **FACTOR** by pressing the **MODE** key. Indicator lights next to the digital readout will indicate **A**, **T**, **C**, or **F**.
5. Choose matched cuvettes of appropriate path length for the analytical method you are using. You have to use the same path length cuvette for all blanks, standards, and samples.

**Note:** All four glass cuvettes supplied with this instrument have 10mm path lengths and have been matched. Glass cuvettes are useable only above 325nm.

6. Fill one of the matched cuvettes with a blank solution (distilled water), wipe the sides of the cuvette with a lint-free tissue, and place the cuvette in position one of the cuvette holder. Cuvettes are placed in the far right hand positions of the cuvette holder. Position one is the position closest to the front of the unit. The solution to be measured is then placed in the next position in the cuvette holder. The cuvette holder can accommodate one blank along with as many as three samples.

**Note:** Cuvette must be filled at least 25mm high with solution (approximately half full) in a standard square cuvette.

7. Close the sample compartment cover. With the rod controlling the cuvette holder pushed all the way in, you then have the blank solution lined up. With the blank solution in the light path, calibrate the instrument by pressing the **0A** key. The LCD will initially display **BLA** and blink but after a few seconds will read **100.0** (if in Transmittance mode) or **.000** (if in Absorbance mode).
8. To take readings of your sample, pull rod towards you until the first sample is lined up with the light path. [One click forward places the light path between two cuvettes and should give you a reading of 0% T (or 1. — — if measuring absorbance). Two clicks forward moves the first sample into position. Each subsequent click forward will move another sample into position.]

### Measuring Concentration using the C/Standard mode

**Note:** This mode is used only when the linearity of the standard curve has been verified.

1. Plug the instrument into a grounded outlet.
2. Turn the instrument on and allow the instrument to warm up for at least 20 minutes.
3. Set the unit to the desired wavelength with the wavelength control knob.
4. Press the **MODE** key until the LED under the **A** is lit.

5. Choose matched cuvettes of appropriate path length for analytical method you are using. You have to use the same path length cuvette for all blanks, standards, and samples.
6. Place the blank solution in the sample compartment, then close the sample compartment cover.
7. Press the **0A** control key to zero the blank solution.
8. Once a reading of **.000** appears, remove the blank solution from the sample compartment.
9. Press the **MODE** selector key until the LED under the **C** is lit.
10. Using the **INC** or **DEC** of the **CONC/FACTOR** keys to set the concentration of the standard solution on the digital display, then press the **ENT** key.
11. Place the standard solution in position one of the cuvette holder. Press the **ENT** key. The LCD will now display that concentration.
12. Place the solution of unknown concentration in position two of the cuvette holder. Pull the unknown sample into the light path and its concentration will be displayed.

### **Measuring Concentration using the C/Factor mode**

If the Concentration factor is known, the unit will display the concentration of unknown samples.

1. Plug the instrument into a grounded outlet.
2. Turn the instrument on and allow the instrument to warm up for at least 20 minutes.
3. Set the unit to the desired wavelength with the up and down arrow keys.
4. Press the **MODE** key until the LED under the **A** is lit.
5. Choose matched cuvettes of appropriate path length for analytical method you are using. You have to use the same path length cuvette for all blanks, standards, and samples.
6. Place the blank solution in the sample compartment, then close the sample compartment cover.
7. Press the **0A** control key to zero the blank solution.
8. Once a reading of **.000** appears, remove the blank solution from the sample compartment.
9. Press the **MODE** selector key until the led under the **F** is displayed.
10. Press the **FUNC** selector key until the **F** is lit.
11. Using the up and down arrow keys, set the factor of the standard on the digital display, then press the **ENT** key.
12. Insert the sample solution to be measured into the cuvette holder. Close the sample compartment cover; read the results directly in concentration units on the digital display.

## Connecting to a PC

The Spectrum 1100 series spectrophotometer has a built-in RS-232C interface. It enables you to connect a personal computer and use PC running Windows® 98 to collect and store data. It will then allow a report to be printed. The program requires Windows® 98 or above.

If you wish to use the software provided in order to produce a report, you need to install the program on your computer and connect the spectrophotometer, via the RS-232 cable, to a serial port of your computer. You should turn on the spectrophotometer and allow it to warm up for at least 20 minutes. However, do not bother to adjust wavelength or even to select transmittance versus absorbance versus concentration since all modes must be set through the computer once the program is loaded.

To connect to a PC,

1. Connect the RS-232 cable that is supplied to both the spectrophotometer and to your computer.
2. Start program.
3. Select **CONNECT**. At this point, all control of the spectrophotometer must now be made through the computer. You will note buttons and arrows that will allow you to change the mode settings, change wavelengths, zero the absorbance, etc.
4. You will now be instructed to insert occluder into cell holder, and set 0%T by pressing **0%T** button. (The occluder is the black cell that was supplied.)
5. Select the test mode you want by selecting it on the computer screen.
6. If you want to change wavelength, arrow up/down or type in desired wavelength on screen and select **OK**.
7. Whether measuring transmittance, absorbance, or concentration, press the **0A/100% T** button **on the computer screen** to zero the blank.
8. When you are ready to take readings, hit **CONFIRM** button **on the computer screen**. Then select **TEST** **on the computer screen**. Move the next sample into the path way and select **TEST** again.
9. When you are finished collecting data, you can type in your name and other pertinent information and either save the file or print it, using the icons on the program screen.

## Maintenance:

### To Replace the Halogen Bulb:

Unit uses a 6V, 10W Halogen bulb

To replace bulb:

1. Shut off unit and unplug it.
2. Remove knob/rod (that allows movement of cuvette holder) from front of unit by turning it counter clockwise.
3. Remove black screws from lower sides of unit.
4. Slide a small screwdriver into the cap on the wavelength control knob and pop the cap off. Remove brass nut from top of the knob. Slip knob off.
5. Lift entire top casing off of unit, being careful not to disconnect the three cables. Carefully set lid aside.

6. Locate flat black horizontal plate at back right side of unit just behind the wavelength dial. Loosen two screws at forward position on the plate and slide plate off.
  7. Locate halogen bulb. It is protected by a guard that is attached with springs. You will need to pull the guard straight out from bulb and move it to the side, while you remove old bulb.
- Note: Do not handle the halogen lamp with bare fingers. Use a piece of tissue paper or cloth when handling the lamp. The oil from your fingers can cause the lamp to burn out prematurely.**
8. Replace the old bulb with a new one. The bulbs have 2-pin connections so they simply pull out and plug in.
  9. Carefully replace spring guard.
  10. Slide black plate back into position and tighten the screws that hold it.
  11. Place unit casing back into position and reattach the two screws on each side.
  12. Position knob back onto the post aligning the slot in the fitting to the plastic tab on the knob. Attach the brass nut, tightening it snugly. Replace cap on knob.
  13. Screw back in the cuvette pull. It will help to over flip-top cover to line up rod with cuvette holder.

### **Wavelength Calibration:**

As usual, the spectrum SP-1105 spectrophotometer retains its wavelength calibration indefinitely. However, if the instrument receives a severe shock or abuse, use the following methods to check wavelength calibration.

#### Use of a Didymium filter

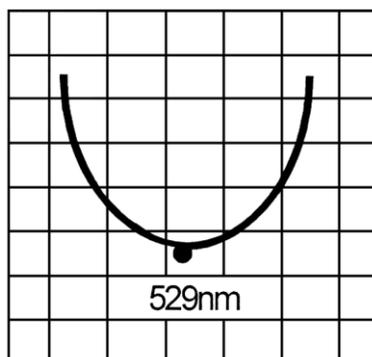
The didymium filter has two special absorbance peaks at 529nm and at 808nm. When the instrument is calibrated properly, you will find minimum Transmittance (maximum absorbance) at the range of 529nm (or 808nm)  $\pm 2$ nm.

Note that the specific transmittance values are not important, you are only looking for the wavelength where minimum transmittance (maximum absorbance) occurs.

1. Turn on your unit and allow it to warm up for 20 minutes.
2. Select the % Transmittance operating mode by pressing the **MODE** key.
3. Set the wavelength to 519nm.
4. Insert the cuvette filled with distilled water in position one of the cuvette holder.
5. Press the **0A/100%T** key until the display reads 100.0% T or 0.000A, then remove the cuvette from the unit.
6. Insert the didymium filter in the well of the cuvette holder, record the %T reading on the digital display.
7. Repeat steps 3 through 6 to measure the wavelength at 2nm intervals between 519 and 539nm.
8. The minimum % Transmittance should be obtained between 526nm and 532nm.

The wavelength accuracy of the SP-1105 spectrophotometers is  $\pm 2\text{nm}$ .

**Wavelength Calibration Curve**



### Troubleshooting:

Problem	Remedy
Nothing at all appears on the display.	Check that the power indicator lamp is lit. <ol style="list-style-type: none"> <li>1. If it is not, check that the cord is connected properly.</li> <li>2. If it is lit and you still have no display, turn off the unit. Unplug it. Wait 10 seconds, and plug it back in and turn on the switch again. This will allow the unit to reset itself.</li> </ol> If you still get no display, call our service department (1-800-223-3517)
Display shows "125.0" or "125" in %Transmittance mode and shows a "0.097" or "0.1" in absorbance mode.	<ol style="list-style-type: none"> <li>1. Make sure that the sample compartment lid is closed.</li> <li>2. Press <b>100%T/0A</b> key until display is on scale.</li> <li>3. Turn the wavelength to low energy region, then check the bulb. If it is not down from bright to dark when you press the <b>100%T/0A</b> key, call Cynmar's service department.</li> </ol>
T% cannot be set to 0.00% T	<ol style="list-style-type: none"> <li>1. Check to see if the tube is fully inserted in the sample compartment. If not, insert it.</li> <li>2. Contact our service department (1-800-223-3517)</li> </ol>
Digital display does not change regardless of sample concentration.	<ol style="list-style-type: none"> <li>1. Wrong wavelength setting. Check your application, procedure, and sampling technique.</li> <li>2. Insufficient sample volume. Fill the cuvette with more sample.</li> <li>3. Stray sample preparation vapors.</li> </ol>

	<p>Prepare sample away from instruments. Use proper ventilation.</p>
<p>Display shows “00.0” or “000.0” in %T mode or “1.XX” in Absorbance mode (where “XX” are two blank digits.)</p>	<ol style="list-style-type: none"> <li>1. Check the bulb. If it is not lit, replace the bulb.</li> <li>2. Check to see if the tube is fully inserted in the sample compartment. If not, insert it.</li> <li>3. Open the lid of the sample compartment and make sure that nothing is blocking the light path.</li> <li>4. Check the display to see if it changes when you open and close the lid. <ol style="list-style-type: none"> <li>a. If the display doesn’t change, either the detector or the main PC board needs to be replaced. Contact our service department.</li> <li>b. If the display does change, check the light beam with the following steps. <ol style="list-style-type: none"> <li>1. Set the wavelength to 580nm.</li> <li>2. Insert a long thin piece of paper into a cuvette and place the cuvette into a compartment. Partially close the lid and peer in. You should see a yellowish light at the bottom of the paper. If you don’t see any light at all, the internal optical path is blocked in some way. If you see light and still have a problem, contact our service department. (1-800-223-3517)</li> </ol> </li> </ol> </li> </ol>
<p>Readings drift.</p>	<ol style="list-style-type: none"> <li>1. Check your application, procedure, and sampling technique.</li> <li>2. Check that you are using the correct lamp appropriate to the wavelength you are using.</li> <li>3. Fumes from sample are affecting the optics of the instrument.</li> <li>4. Power in the line is fluctuating.</li> <li>5. Bulb is defective.</li> <li>6. Instrument is not grounded properly.</li> </ol>
<p>Other problems</p>	<p>Call our service department (1-800-223-3517)</p>

## Experiments

### Experiment 1

### Absorption Spectrum

#### Materials needed:

Spectrophotometer  
0.0500 M Cr<sup>+3</sup> solution  
graph paper

#### Theory

In this experiment, the absorption spectrum of chromium (III) ion solution will be examined in the range of 350nm to 650nm. You will note two absorption peaks in the visible region, corresponding to the energy level splitting of the 3d electrons in the aqueous complex of the ion. After plotting the spectrum, you can calculate the molar absorptivity from Beer's law at two different wavelengths.

#### Procedure:

1. Plug the instrument into a grounded outlet.
2. Turn the instrument on and allow the instrument to warm up for at least 20 min.
3. Choose matched cuvettes of appropriate path length for analytical method you are using. You have to use the same path length cuvette for all blanks, standards, and samples.
4. Rinse and then fill a cuvette with distilled water.
5. Rinse a second cuvette with distilled water, followed by rinsing the cuvette twice with your Cr<sup>+3</sup> solution. Pour rinsings into a waste beaker for later disposal. Fill the cuvette with the Cr<sup>+3</sup> solution.
6. Wipe the sides of the cuvette filled with distilled water with a lint-free tissue, and place the cuvette in position one of the cuvette holder. Position one is the position closest to the front of the unit. The cuvette with the Cr<sup>+3</sup> solution to be measured is then placed in the next position in the cuvette holder.
7. Select the desired operating mode as **ABSORBANCE** by pressing the **MODE** key.
8. Set the unit to a wavelength of 350nm.
9. Close the sample compartment cover. With the rod controlling the cuvette holder pushed all the way in, you then have the blank solution lined up. With the blank solution in the light path, calibrate the instrument by pressing the 100% T key. The LCD will initially display BLA but after a few seconds will read .000A.
10. To take an absorbance reading on your sample, pull rod towards you until the chromium (III) ion sample is lined up with the light path. [One click forward from the starting position places the light path between two cuvettes and should give you a reading. Two clicks forward moves the first sample into position.] Measure the absorbance of the solution and record the result.
11. Repeat steps 8 to 10 for wavelengths from 360nm to 650nm in 10nm intervals. Make sure the unit is calibrated with the 100%T/0A key at each new wavelength.

**Calculations:**

1. On a sheet of graph paper, label the x-axis wavelength, and mark it from 350 to 650nm in 10nm intervals. Label the y-axis absorbance and mark it in equal intervals from 0 to a convenient whole number above your highest data point.
2. Plot the absorbance for each wavelength measured.
3. Connect the data points with a smooth curve.
4. Determine the wavelengths at which the chromium (III) solution absorbs the most and the least. From the graph, determine the absorbance at each of these wavelengths.

### Absorption Spectrum Report

Wavelength	Absorbance	Wavelength	Absorbance
350	_____	510	_____
360	_____	520	_____
370	_____	530	_____
380	_____	540	_____
390	_____	550	_____
400	_____	560	_____
410	_____	570	_____
420	_____	580	_____
430	_____	590	_____
440	_____	600	_____
450	_____	610	_____
460	_____	620	_____
470	_____	630	_____
480	_____	640	_____
490	_____	650	_____
500	_____		

**Calculations:**

Absorption maximum wavelength: \_\_\_\_\_ nm      Absorbance: \_\_\_\_\_

\_\_\_\_\_

Absorption minimum wavelength: \_\_\_\_\_ nm      Absorbance: \_\_\_\_\_

\_\_\_\_\_

## Experiment 2

## Beer's Law

### Materials Needed:

0.100 M Cr<sup>+3</sup> solution  
unknown solution  
spectrophotometer  
graph paper

4 Erlenmeyer flasks  
100 mL volumetric flask  
50 mL buret

### Theory:

We can study the quantitative relationships between the amount of light absorbed by chromium (III) ion and its concentration. The relationship between absorbance and concentration is given by Beer's law  $A = a b c$ , where  $A$  is absorbance,  $a$  is absorptivity,  $b$  is path width, and  $c$  is concentration. We will need to measure the absorbance of several samples of varying but known concentrations of chromium (III), as well as one sample of unknown concentration. We can then plot concentration versus absorbance. From the graph, we can then determine the concentration of the unknown solution.

### Procedure:

1. Rinse the buret twice with small volumes of the stock 0.100 M Cr<sup>+3</sup> solution. Collect the rinsings in a waste container for disposal later. Fill the buret with the chromium (III) solution.
2. Add 5.0 mL of the stock solution from the buret into a 100 ml volumetric flask. Add distilled water to the mark and stopper the flask. Mix this diluted solution thoroughly.
3. Season one of the Erlenmeyer flasks with small portion of this diluted standard, discarding the rinsings into the waste container. Pour the diluted standard from the volumetric flask into this Erlenmeyer flask and stopper the flask. Calculate the concentration of this first standard and label it appropriately. Record the result on the report sheet.
4. Rinse the volumetric flask with distilled water and repeat step 3 using 10.0mL of the stock from the buret. Repeat step three twice more, once using 15.0mL, and once using 20.0mL.
5. After the four standard solutions have been prepared, rinse the volumetric flask with water.
6. Obtain the unknown solution from your instructor.
7. Refer to an absorption spectrum of chromium (III) and choose a wavelength at which the ion absorbs most strongly. [You can refer to the results from Experiment 1 or can refer to a reference work to determine this wavelength.] Set your spectrophotometer to the chosen wavelength. Fill a clean cuvette with distilled water, wipe the cuvette clean, and place it in position 1 of the cuvette holder. Set the **MODE** to absorbance.
8. Close the sample compartment cover. With the rod controlling the cuvette holder pushed all the way in, you then have the blank solution lined up. With the blank solution in the light path, calibrate the instrument by pressing the 100% T/0A key. The LCD will initially display BLA but after a few seconds will read .000A.

9. Fill a second cuvette with the first standard (or empty the cuvette of distilled water, rinse twice with the first standard to keep from diluting your standard). Insert the cell into a sample compartment. Align the cell with the light beam and read the absorbance of this first standard. Record the result.
10. Repeat the process with the other three standards and with the unknown solution.

### Report Sheet

**Data:**

<b>Solution</b>	<b>Concentration</b>	<b>Absorbance</b>
Standard 1		
Standard 2		
Standard 3		
Standard 4		
Unknown solution		

**Calculations:**

1. Graph concentration versus absorbance, graphing concentration on the x-axis and absorbance on the y-axis.
2. Plot absorbance versus concentration for the four standard solutions. Draw the best straight line through the four points and the origin of the graph. This is the standard curve for Beer's law.
3. From the measured absorbance of the unknown sample, read the graph to determine the concentration of chromium (III) ion in the unknown. Record this on your report sheet.

### Experiment 3

### Reaction Kinetics

#### Materials Needed:

0.010 M Cr <sup>+3</sup> solution	Graduated cylinder
0.20 M Na <sub>2</sub> EDTA (EDTA disodium) (pH 6.15)	5 Erlenmeyer flasks
0.010 M Na <sub>2</sub> CO <sub>3</sub> (aq)	graph paper
	2 50mL burets
	hotplate

#### Theory

Chemical reactions occur as a result of collisions between atoms, molecules, or ions of the reactants. Kinetics deals with the rate of chemical reactions, with the factors that influence those rates, and the mechanism of the reaction. The rate of a reaction can be determined experimentally by measuring the change in concentration of the reacting species or the products as a function of time.

In this experiment, you will measure the effect of one reactant (Cr<sup>+3</sup>) on the formation of a colored complex ion formed between chromium (III) and ethylenediamine-tetraacetic acid (EDTA). You will measure the appearance of the complex with the spectrophotometer. You will also observe the effect of temperature on the rate of the reaction, and the effect of a catalyst (carbonate ion) on the rate.

The rate of a reaction is defined as the rate of disappearance of a reactant or appearance of a product. The rate is related to the concentration of the reactants through the rate law. For example, if we consider the following reaction:



Rate =  $k [A]^x [B]^y$  where  $k$  is the rate constant,  $[A]$  and  $[B]$  are the molar concentrations of the reactants, and  $x$  and  $y$  are the order of the reaction with respect to  $A$  and  $B$ .

#### Procedure:

1. Rinse five Erlenmeyer flask, six cuvettes, two burets and the graduated cylinder with distilled water.
2. Rinse one of the burets with a small amount of the stock Cr<sup>+3</sup> solution to remove water. Allow the rinse to drain through the stopcock into a waste container. Fill the buret with the stock chromium (III) solution.
3. Rinse and fill the second buret with distilled water.
4. From the burets, add the following volumes of each solution to five clean, dry Erlenmeyer flasks:

FLASK NUMBER	mL Cr <sup>+3</sup> (aq)	mL H <sub>2</sub> O
1	5.0	20.0
2	10.0	15.0
3	15.0	10.0
4	20.0	5.0
5	10.0	10.0

Calculate the concentrations of chromium (III) in flasks 1 through 4 and record the results on the report sheet.

5. To flask 5, add 5 mL of 0.010 M  $\text{Na}_2\text{CO}_3$  (aq) from a graduated cylinder.
6. Set the wavelength of the spectrophotometer to 545 nm. Adjust the **MODE** to read **Absorbance**. Fill a cuvette with distilled water and insert it into the cuvette holder. Calibrate the meter by pressing the 100% T key. After a few seconds it should read .000A. Remove the distilled water cuvette and set it aside.

**Note: The following steps require you to time all additions and measurements at two minute intervals. You need to read through the entire procedure and understand the entire procedure before starting.**

7. At time = 0.0 minutes, use a graduated cylinder to add 25 mL of the EDTA solution to flask 1. Swirl the contents, rinse a cuvette with the solution to season it, then fill the cuvette. Label the cell and set it aside. Place this flask on a hotplate with the setting at LOW. (Do not allow the solution to boil, as it will start to decompose.)
8. At time = 2.0 min, 4.0 min, 6.0 min, and 8.0 min repeat step 7 with flasks 2, 3, 4, and 5 and cuvettes 2, 3, 4, and 5. As you did with flask 1, place flasks 2, 3, and 4 on the hotplate but do **not** heat the solution in flask 5.
9. At time = 10.0 minutes, insert cuvette 1 into the sample holder and measure the absorbance. Record the results on the report sheet. Remove the cell and set it aside.
10. At time = 12.0 min, 14.0 min, 16.0 min, and 18.0 min, measure the absorbance of the remaining four solutions, in numerical order, at two minute intervals. Record the results on the report sheet. After removing cuvette 5 from the sample compartment, insert the cell containing distilled water. Adjust the meter by pressing the 100%T/0A key.
11. At time = 20.0 min until time = 110.0 min, repeat the measurements at two minute intervals, so that each solution is measured every ten minutes. Record the results on the report sheet. Adjust the 100%T/0A reading with distilled water cuvette after every cycle of the five solutions.
12. At the end of the measurements, remove the flasks from the hotplate, and allow them to cool to room temperature. Measure the absorbance of each of these solutions when they are cool.

### Calculations:

1. On a sheet of graph paper, label the x-axis as concentration and the y-axis as absorbance. Mark off intervals appropriate to the data you have collected.
2. Plot the absorbance vs. concentration for the heated solutions in flasks 1 through 4. Draw the best fit straight line through the four points and the origin.
3. On a second sheet of graph paper, label the x-axis time and the y-axis absorbance. Mark off intervals appropriate for all five of the timed runs.
4. For each of the five sample runs, plot, the absorbance value versus time. Time is measured from the time the EDTA is added to the solution. (0 to 100 minutes in 10 minute intervals) Draw a smooth curve through the data set for each of the five solutions.
5. Using the second graph, determine the order of the reaction with respect to  $\text{Cr}^{+3}$ .

## Report Sheet

### Data

Time (in min)	Absorbance Cuvette Number				
	1	2	3	4	5
10.0					
20.0					
30.0					
40.0					
50.0					
60.0					
70.0					
80.0					
90.0					
100.0					

Flask	Concentration	Absorbance
1		
2		
3		
4		

### Results:

1. Determine the order of the reaction with respect to  $\text{Cr}^{+3}$ .
2. Discuss the effect of the catalyst (flask 5).
3. Discuss the effect of temperature.
4. Discuss the effect of concentration.

## Instructors Notes for the Experiments

### Experiment 1.

#### Chromium (III) solution:

To make the 1 liter of the 0.0500 M stock solution, add 20.0 grams of  $\text{Cr}(\text{NO}_3)_3 \cdot 9 \text{H}_2\text{O}$  then fill to 1 liter mark. Each student group will need approximately 20 mL of the stock solution.

### Experiment 2.

#### Chromium (III) solution:

To make 1 liter of the 0.100 M stock solution, dissolve 40.0 grams of  $\text{Cr}(\text{NO}_3)_3 \cdot 9 \text{H}_2\text{O}$ , then fill to 1 liter mark. Each student group will need approximately 60 mL of the stock solution.

The Beer's law plot should be linear over the concentration range used in this experiment.

The 0.100 M  $\text{Cr}^{+3}$  stock solution can be used for the unknown solution by varying the volume given to each student group. The volumes should range between 5 mL and 10 mL so that the final concentrations, after dilution, are in the range of 0.0050 to 0.0200M.

### Experiment 3.

#### Chromium (III) solution:

To make 1 liter of the 0.0100 M stock solution, dissolve 4.0 grams of  $\text{Cr}(\text{NO}_3)_3 \cdot 9 \text{H}_2\text{O}$ , then fill to 1 liter mark. Each student group will need approximately 70 mL of the chromium (III) solution.

#### EDTA solution

To make 1 liter of the 0.200 M EDTA solution, dissolve 74.45 grams of EDTA disodium salt, then fill to 1 liter mark. Each student group will need approximately 135 mL of the EDTA solution.

#### Sodium carbonate solution

To make 1 liter of the 0.010 M  $\text{Na}_2\text{CO}_3$  solution, dissolve 1.06 grams, then fill to the 1 liter mark. Each student group will need approximately 5 mL of the sodium carbonate solution.

The reaction is first order ( $x = 1$ ) in chromium (III).

### **Limited Warranty**

Purchase of items branded Cynmar<sup>®</sup> are warranted against defects in workmanship and materials for 90 days from the original purchase date. Should there be a defect or malfunction of the product, Cynmar<sup>®</sup> will repair or replace the product (at its option) free of charge excluding shipping charges, which remain the responsibility of the Purchaser. This limited warranty is void if the product has been subjected to damage, unreasonable use, improper service, modification, or other causes not arising from defects in original materials or workmanship.

Cynmar, LLC reserves the right to make changes in instrument design in accordance with scientific and mechanical progress, without notice and without obligation



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