Spectrum Microprocessor (Visual and UV) Spectrophotometer

#FOT-10715

Introduction:

Thank you for your purchase of our spectrum analysis instrument. The spectrum 2000 series spectrophotometers are a single beam system. The instruments are compact, lightweight, easy-to-use, and rugged. A sleek, new design houses up-to-date electronics and the latest optical components for improved performance capability. A 2-line, 20-character liquid crystal display readout displays data. A large sample compartment accepts from 5mm to 10mm path length curvettes. 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 new spectrum SP 2000UV spectrophotometer will allow for ultraviolet and visible wavelength ranging from 190-1000nm. The nominal 5 nm spectral bandpass is constant over the entire wavelength range.

The spectrum SP 2000 series spectrophotometers are ideal for use in a clinical laboratory, biochemistry laboratory, or a petrochemistry laboratory, 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-2000UV
Optical system	Littrow type, single beam, grating system 1000 line/mm
Spectral Slit width	5 nm
Wavelength range	200-1000 nm
Wavelength Accuracy	± 2 nm
Repeatability	1 nm
Stray Radiant Energy	≤ 0.5% T @220nm and 340nm
Photometric Range	0% T to 125.0%T, 0A to 2.5A, 0C to 1999C(0-1999F)
Stability	± 0.002 A/hr
Photometric Accuracy	± 0.008A @ 0.5 A
Power Requirement	115/230 volt, ± 10%, 60/50 Hz adjustable
Size: (mm)	465 (18.3”) W x 365 (14.3”) D x 175 (6.9”) H
Weight	11.5 kg

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Packing List:

1	Spectrophotometer
1	Dust cover
2	Quartz cuvettes (needed for UV readings)
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.

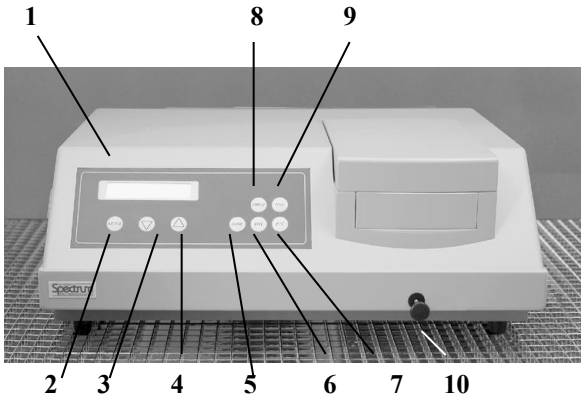
Turning on the unit:

When you turn on the unit, it will run through a set of self-diagnostics that will take a minute or two. When the unit is finished running its systems checks, it will display the following message: **546 nm 100.0%T**.

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. It should then begin running through its diagnostics.

Operating Features:

1. **Digital Readout**
2. **Mode key:** Selects Transmittance, Absorbance, Concentration mode.
3. & 4. **Arrow keys:** used to select wavelength and to select special functions such as concentration value or factor, light source exchange selection, lamp on/off, etc.
5. **Function:** selects the function (similar to a main menu)
6. **Enter Key:** used in confirming that a function is selected
7. **P/C key:** used to clear out the wrong parameter.
8. **100%T:** used to set the display to **100%T** or **0Abs**. It must be reset whenever the analytical wavelength is changed.
9. **0% T:** used to set the display to 0% before setting 0Abs.
10. **Cuvette Pull-out Rod**



Select Light Source (for UV only)

The **FUNC** key will allow you to select a light source.

1. Press the **FUNC** key until the display shows **LAMP EXCHANGE? 340nm**
2. Press up and down arrow buttons to select wavelength point of light source
3. Press **ENT** to store the wavelength selected.

Turning On/Off the Lamps

You may select the lamps of the SP2100UV spectrophotometer as needed.

1. Press the **FUNC** key until display shows **W lamp on?/ W lamp off?,** or **D2 lamp on?/D2 lamp off?**

Note: W is the UV source. Set W lamp On for wavelengths below approximately 340 nm. D2 is the visible light source. Set D2 lamp On for wavelengths above approximately 340 nm.

2. Then press the **ENT** key to toggle from on to off at this point.

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 the up and down arrow keys.
4. Select the desired operating mode as **TRANSMITTANCE** or **ABSORBANCE** by pressing the **MODE** key.
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, as well as the two quartz cuvettes, supplied with this instrument have 10mm path lengths and have been matched. Glass cuvettes are useable only above 325nm. Quart cuvettes must be used at wavelengths below 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. 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 **100% T** key. The LCD will initially display **BLANK** but after a few seconds

will read **100.0%T** (if in Transmittance mode) or **–0.000A** (if in Absorbance mode). Pull the rod one click forward. The light is now directed between cuvettes. Press the **0% T** key. The LCD will initially display **ZERO** but, after a few seconds, it will display **000.0% T** (if in Transmittance mode) or **2.500A** (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. 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 up and down arrow keys.
4. Select the desired operating mode as **ABSORBANCE** by pressing the **MODE** key.
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 **100%T** control key to zero the blank solution.
8. Once a reading of **–0.000A** appears, remove the blank solution from the sample compartment.
9. Press the **MODE** selector key until concentration is displayed.
10. Press the **FUNC** selector key until the **CONC/STD=1000** is lit.
11. Using the up and down arrow, set the concentration of the standard solution you will be using on the digital display (any value from 0 to 1999).
12. Place the standard solution in position one of the cuvette holder. Press the **ENT** key. The LCD will now display that concentration.
13. 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. Select the desired operating mode as **ABSORBANCE** by pressing the **MODE** key.
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.

6. Place the blank solution in the sample compartment, then close the sample compartment cover.
7. Press the **100%T** control key to zero the blank solution.
8. Once a reading of **–0.000A** appears, remove the blank solution from the sample compartment.
9. Press the **MODE** selector key until concentration is displayed.
10. Press the **FUNC** selector key until the **C/FACTOR=1000** 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 2000 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. (If an hourglass cursor appears, ignore it and click on gray icon above EXIT button.
3. Select appropriate serial port.
4. On spectrophotometer, press the **FUNC** key until the display shows **CONNECT PC?**

When the instrument is connecting to the PC, the display shows **CONNECTING PC.**
When the instrument has connected to the PC, the display shows **PC CONNECTED.**
When the instrument is not connected to the PC, the display shows **CONNECT PC?**

5. The instructions on computer will have you press the **ENT** key **on spectrophotometer**.
6. 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 turn on and off the D2 and W lights, change the mode settings, change wavelengths, zero the absorbance, etc.
7. If you want to measure transmittance, select mode setup **%Trans**.

8. If you want to change wavelength, arrow up/down or type in desired wavelength on screen and select **GO.** Wait a few seconds for change to register; grayscale will disappear.
9. Select light source to either UV (D2) or visible (W).
10. Whether measuring transmittance, absorbance, or concentration, press the **0A** button **on the computer screen** to zero the blank.
11. When you are ready to take readings, hit **enter** button **on the computer screen.** Then select **TEST on the computer screen**. Move the next sample into the path way and select **TEST** again.
12. 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 (Cynmar #021-00392)
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. Lift entire top casing off of unit, being careful not to rip out the IEEE cable. (This cable can be disconnected from either end by pushing tabs at top of connector.)
5. Locate flat black horizontal plate at back left side of unit. Loose two screws at forward position on the plate and slide plate off.
6. 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.

7. Replace the old bulb with a new one. The bulbs have 2-pin connections so they simply pull out and plug in.
8. Carefully replace spring guard.
9. Slide black plate back into position and tighten the screws that hold it.
10. Reconnect IEEE cable.
11. Place unit casing back into position and reattach the two screws on each side.
12. Screw back in the cuvette pull. It will help to over flip-top cover to line up rod with cuvette holder.

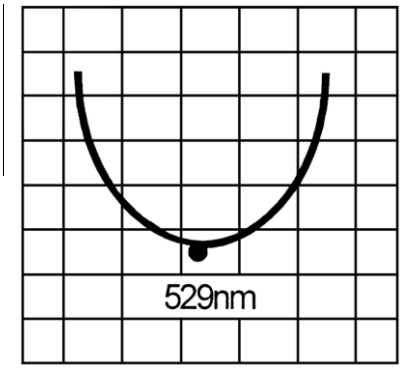
If you have any problems installing a new bulb, feel free to call the service department at Cynmar. (1-800-223-3517)

Wavelength Calibration:
As usual, the spectrum SP2000-UV 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) ±2nm.
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 **100%T** key until the display reads 100.0% T, 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 SP2000-UV spectrophotometers is ±2nm.

Wavelength Calibration Curve



Troubleshooting:

Problem		Remedy
Nothing at all appears on the display.		Check that the power indicator lamp is lit. 1. If it is not, check that the cord is connected properly. 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. If you still get no display, call our service department (1-800-223-3517)

Display shows "1XX.X" in %Transmittance mode and shows a negative reading in absorbance mode.		Make sure that the sample compartment lid is closed.
Display shows "000.0" in %T mode or "1.XXX" in absorbance mode (where XX are two blank digits.)		1. Check the bulb. If it is not lit, replace the bulb. 2. Check to see if the tube is fully inserted in the sample compartment. If not, insert it. 3. Open the lid of the sample compartment and make sure that nothing is blocking the light path. 4. Check the display to see if it changes when you open and close the lid. a. If the display doesn't change, either the detector or the main PC board needs to be replaced. Contact our service department. b. If the display does change, check the light beam with the following steps. 1. Set the wavelength to 580nm. 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)
Readings differ greatly from expected results.		1. Check wavelength calibration. 2. Check your application, procedure, and sampling technique.
Readings drift.		1. Check your application, procedure, and sampling technique. 2. Check that you are using the correct lamp appropriate to the wavelength you are using. 3. Fumes from sample are affecting the optics of the instrument. 4. Power in the line is fluctuating. 5. Bulb is defective. 6. Instrument is not grounded properly.
Other problems		Call our service department (1-800-223-3517)

Experiments

Experiment 1 Absorption Spectrum

Materials needed:
Spectrophotometer
0.0500 M Cr^{+3} 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^{+3} solution. Pour rinsings into a waste beaker for later disposal. Fill the cuvette with the Cr^{+3} 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^{+3} 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 BLANK but after a few seconds will read –0.000A. Pull the rod one click forward. The light is now directed between cuvettes. Press the 0% T key. The LCD will initially display ZERO but, after a few seconds, it will display 2.500A.
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 of 0% T. 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 and 0%T 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:** _____

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Experiment 2 **Beer's Law**

Materials Needed:

0.100 M Cr^{+3} 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^{+3} 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 key. The LCD will initially display BLANK but after a few seconds will read –0.000A. Pull the rod one click forward. The light is now directed between cuvettes. Press the 0% T key. The LCD will initially display ZERO but, after a few seconds, it will display 2.500A.

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:

Solution	Concentration	Absorbance
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^{+3} solution
0.20 M Na_2EDTA (EDTA disodium) (pH 6.15)
0.010 M Na_2CO_3 (aq)
Graduated cylinder
5 Erlenmeyer flasks
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^{+3}) 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:

$$a\,A + b\,B \rightarrow c\,C$$

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^{+3} 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^{+3} (aq)	mL H_2O
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 0l010 M Na_2CO_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 –0.000A. Pull the rod one click forward so that the light is now directed between cuvettes. Press the 0% T key. After a few seconds, it should read 2.500A. 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 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 reading with distilled water cuvette after every cycle of the five solutions.
12. At the end of the measurements, remove the flasks from 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 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 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 $Cr(NO_3)_3 \bullet 9\ H_2O$ 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 $Cr(NO_3)_3 \bullet 9\ H_2O$, 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 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 $Cr(NO_3)_3 \bullet 9\ H_2O$, 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 Na_2CO_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).

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