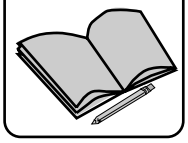
Includes
Teacher's Notes
and
Typical
Experiment Results



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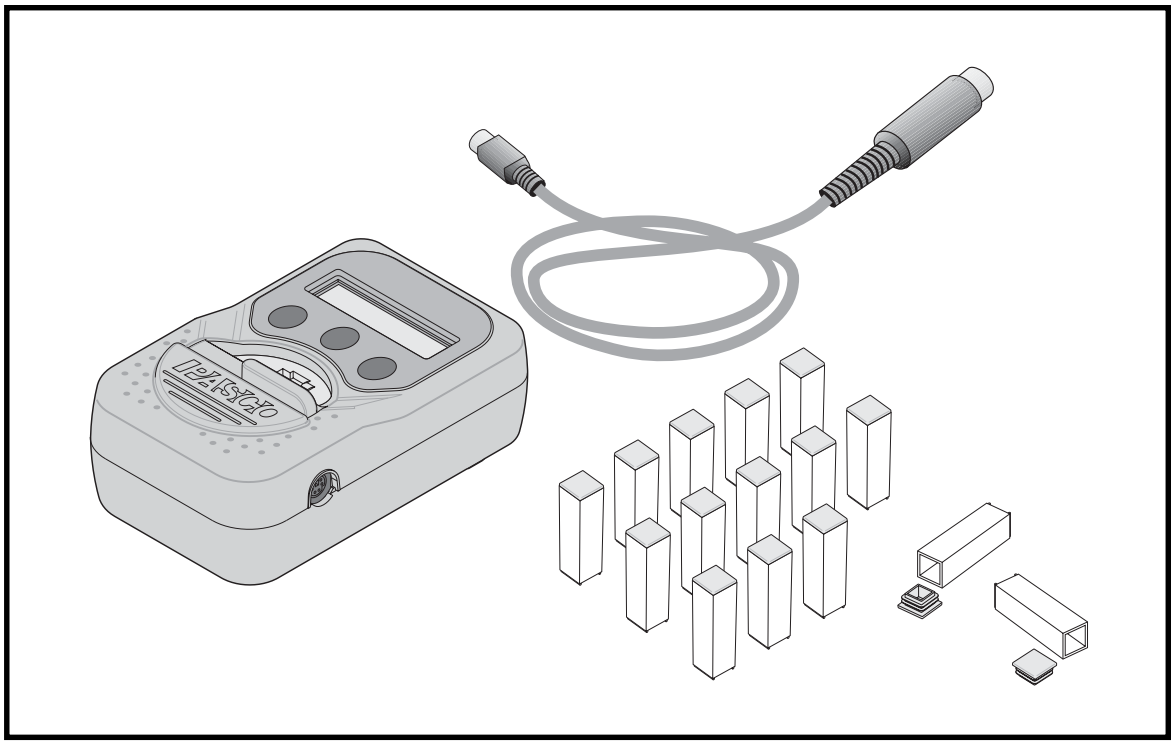
Instruction Manual and Experiment Guide for the PASCO scientific Model CI-6747

COLORIMETER



PASCO scientific

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The exclamation point within an equilateral triangle is intended to alert the user of the presence of important operating and maintenance (servicing) instructions in the literature accompanying the device.

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① The packing carton must be strong enough for the item shipped.

② Make certain there are at least two inches of packing material between any point on the apparatus and the inside walls of the carton.

③ Make certain that the packing material cannot shift in the box or become compressed, allowing the instrument come in contact with the packing carton.

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Introduction

The PASCO CI-6747 Colorimeter measures the amount of light that is transmitted through a liquid. The intensity of the light passing through the liquid can often be used to determine properties of the liquid such as the concentration of chemicals in the liquid. Substances absorb different amounts of certain colors of light and transmit other colors. Some substances absorb red but not blue, or green but not orange. The Colorimeter can shine the following colors of light through a liquid: orange (630 nm), green (565 nm), blue (460 nm), and red (697 nm). The Colorimeter uses a small container called a cuvette that holds a small amount of liquid. When you want to measure how much colored light can pass through the liquid, put some of the liquid in a cuvette and place it inside the Colorimeter.

Equipment

Included:

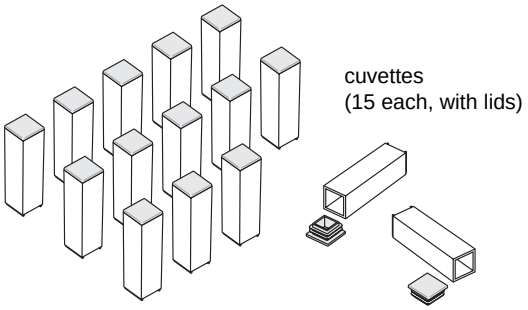
- PASCO CI-6747 Colorimeter
- cable with DIN and mini-DIN connectors (2 meters)
- cuvettes (15 each, with lids)

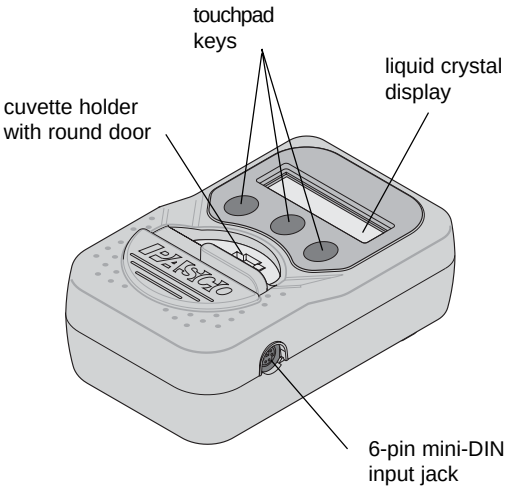
Also Required:

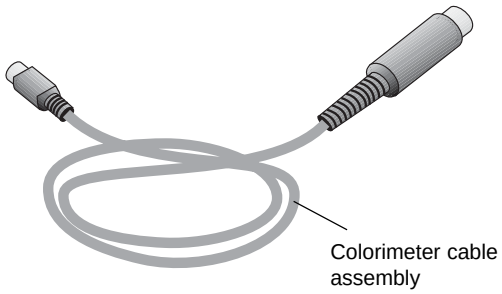
- solutions for calibration and analysis

Additional Recommended:

- *ScienceWorkshop*® Computer Interface, Series 500 or 700







Setup

Set up the sensor with the interface.

- The sensor's connector cable has a mini-DIN plug at one end and a regular DIN plug at the other. Plug the mini-DIN end of the cable into the sensor and then connect the other end of the cable into **Analog Channel A** on the interface. See Figure 1.

Set up the sensor in the software.

1. In *DataStudio*, double-click the name of the sensor in the Sensors list in the Experiment Setup window.
2. The sensor icon will appear below Channel A of the interface. The sensor's parameters (e.g., Transmittance, Absorbance) will appear in the Data list.
3. In ScienceWorkshop, click-and-drag the 'analog sensor plug' icon to the Channel A icon in the Experiment Setup window, select the name of the sensor from the list of sensors and click 'OK' to return to the Experiment Setup window. The sensor's icon will appear below Channel A of the interface.

➤ **Note:** This instruction sheet was written assuming that the user is familiar with *ScienceWorkshop* or DataStudio. Users can gain familiarity by working through the tutorials provided with *ScienceWorkshop* or from DataStudio's Online Help.

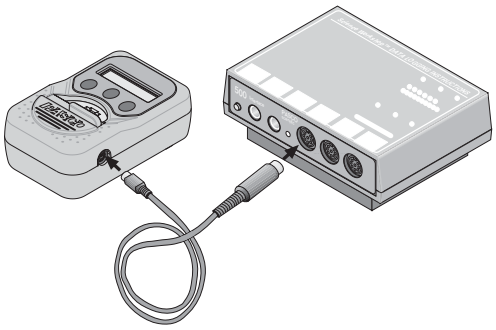


Figure 1
Connecting the Colorimeter to an interface box

➤ **Note:** The Colorimeter turns on automatically when it is connected to the interface. The sensor's liquid crystal display (LCD) shows "Please calibrate" on the second row.

Calibration

The general method for calibrating the Colorimeter is a two-step process, as follows:

- Calibrate the Colorimeter with a clear cuvette containing distilled water.
- Calibrate the software (either DataStudio or ScienceWorkshop) for one of the four colors of light that can be selected in the Colorimeter. (You can select RED, GREEN, BLUE, or ORANGE.)

Working with Cuvettes

You should exercise some general guidelines when handling cuvettes and preparing solutions for use with the Colorimeter.

These guidelines are as follows:

- All cuvettes should be wiped clean and dry on the outside with a tissue.
- Handle cuvettes only by the top edge of the ridged sides. See Figure 2.
- Cuvettes should be filled with the proper amount of solution as shown in Figure 3. Over-filling cuvettes may result in spillage of solution.
- All solutions should be free of bubbles.
- Always position the cuvette so the light beam will pass through the clear sides, as illustrated in Figure 4. The Colorimeter door will not close properly if the cuvette is in the wrong position.

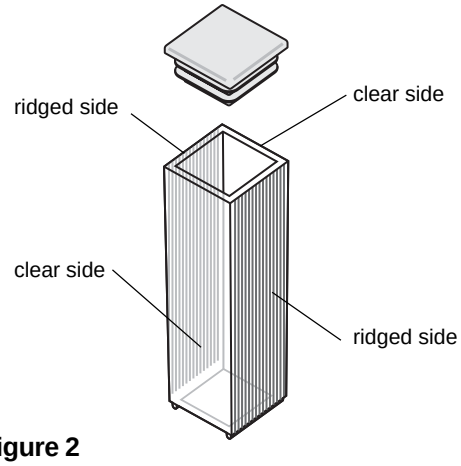


Figure 2
Cuvette Features

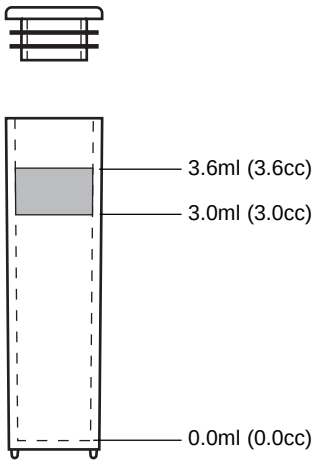


Figure 3
Cuvette Solution Levels

Calibrate the Colorimeter

1. When the Colorimeter comes on, the liquid crystal display (LCD) shows “Please calibrate” on the second row.
2. Fill a clean cuvette with distilled water and cap the cuvette. (The clear cuvette is a control or ‘reference’ that accounts for the small amount of light scattered or reflected by the walls of the cuvette.)
3. On the Colorimeter, press the ‘Select’ button and the ‘Start/ Stop’ button at the same time.

- **Result:** The Colorimeter’s LCD will show “Insert reference then push SELECT”.

5. Place the capped cuvette inside the Colorimeter. Make sure that the clear sides of the cuvette (without ridges) are lined up with the light path in the Colorimeter. Close the lid on the Colorimeter.
6. On the Colorimeter, press the ‘Select’ button.

- **Result:** The Colorimeter will automatically calibrate itself for all four wavelengths assuming that the light passing through the clear cuvette represents “100% Transmittance”. (The automatic calibration takes only a few seconds.)

The Colorimeter’s LCD will show “CAL done, push SELECT or START”.

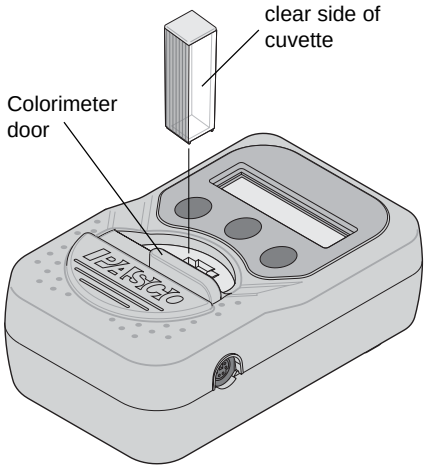


Figure 3
Cuvette Solution Levels

Calibrate the Software

Follow these steps to calibrate the software for one of the four colors of light:

Calibration Setup

1. Leave the cuvette with distilled water inside the Colorimeter.
2. In the Experiment Setup window, double-click the Colorimeter icon.

• **Result:** In DataStudio, the Sensor Properties window will open. Click the 'Calibration' tab. In ScienceWorkshop, the Sensor Setup window will open.

3. Select the color of light. The default color is RED.

To change to a different color, press the 'Select' button. The LCD shows the color and wavelength.

Calibrate the Software.

1. Leave the color selection unchanged and the cuvette filled with distilled water in the unit.
2. Connect the colorimeter to a Science Workshop interface.
3. Press the 'Start/Stop' button on the colorimeter to start it. (The LCD shows the color and wavelength, the percent transmittance, and "RUN".)
4. Click the **Setup** button in the top toolbar to access the Experiment setup window.
5. In the Experiment Setup window, click **Calibrate Sensors**.
6. Under Calibration Type, select "1 Point (Adjust Slope Only)".
7. When the voltage stabilizes, click the "Read from Sensor" button in the **Calibration Point 2** section of the window.
8. Press the **Start/Stop** button on the Colorimeter. (The LCD changes to "STOP".)
9. Click 'OK' to return to the Experiment Setup window.

Set up a Digits display of 'Transmittance'

1. In DataStudio, click-and-drag the 'Digits' icon from the Displays list and drop it on 'Transmittance' in the Data list.
2. In ScienceWorkshop, click-and-drag the 'Digits' display icon to the sensor's icon in the Experiment Setup window.
3. Start recording data.
4. Remove the cuvette and empty it. Fill the cuvette with a liquid (e.g., coffee), put a cap on the cuvette, place the cuvette inside the Colorimeter, and close the lid.
5. Press the 'Start/Stop' button to start the Colorimeter. (The LCD shows the color and wavelength, the percent transmittance, and "RUN".)
6. In DataStudio, click the 'Start' button. In ScienceWorkshop, click the 'REC' button.
7. Note the transmittance in the Digits display.
8. Stop recording data.
9. Click 'Stop' to end data recording. Press the 'Start/Stop' button to stop the Colorimeter.

Activity One: Rate of a Chemical Reaction 1

EQUIPMENT AND MATERIALS REQUIRED

- Colorimeter (CI-6747)
- Cuvette (with cap)
- Graduated cylinder, 10 mL, 2 ea.
- Protective gear
- Hydrochloric acid, 6 molar, 10 mL
- Sodium thiosulfate, 0.2 molar, 10 mL
- Water, distilled, 100 mL

Hypothesis

How will changing the concentrations of the reactants in a chemical reaction affect the rate of the reaction?

Theory

All chemical reactions occur at specific rates. The rate of a chemical reaction depends on several physical and chemical factors. These factors include:

- The concentration of the reactants
- The temperature of the reaction
- The pressure on the reaction
- The presence of a catalyst

In this activity you will determine the effect of changes in concentration of the reactants on the rate of the chemical reaction. The reaction for this activity is the acidic reduction of the thiosulfate ion to sulfur and sulfur dioxide.

The equation for the reaction is:

$$S_2O_3^{2-}(aq) + 2H^+(aq) \Rightarrow SO_{2(g)} + S(s) + H_2O$$

One way to determine the effect of concentration on the rate of the reaction is to use a Colorimeter to measure the formation of the solid sulfur generated. The solid sulfur will block the light in the Colorimeter and the amount of blockage is directly proportional to the amount of sulfur in suspension.

The rate of this chemical reaction is given by the equation:

$$\text{Rate} = k[\text{thiosulfate}]^a[\text{acid}]^b$$

The letters a and b seen as exponents are numerals which can only be determined experimentally. Each reactant must be varied separately while the other is kept constant. The effect on the rate of the reaction is noted and the value of the exponent is determined in this way:

- If a change in concentration of one of the reactants has no effect, the exponent is 0.
- If doubling the concentration doubles the rate, the exponent is 1.
- If doubling the concentration quadruples the rate, the exponent is 2.

The over all order of the reaction is determined by adding a + b.

Safety Reminders

- Wear protective gear.
- Follow directions for using the equipment.
- Handle and dispose of all chemicals and solutions properly.

> ➤ ***CAUTION: Never pipette by mouth. Always use a pipette bulb or a pipette pump. Be careful when handling any acid or base solutions.***

For You To Do

Use the Colorimeter to measure the change in absorbance of light by a solution of sodium thiosulfate and hydrochloric acid as the two components react. Begin with a mixture with specific concentrations of the two components, and then test mixtures with different concentrations of one component or the other. Use DataStudio or ScienceWorkshop to record and display the data. Use the data to determine the overall order of the rate of reaction.

Computer Setup

If using the Colorimeter with a ScienceWorkshop interface, open the file titled as follows:

Software	**File Name**
DataStudio	C14 Reaction Rate 1.DS
ScienceWorkshop (Mac)	C14 Reaction Rate 1
ScienceWorkshop (Win)	C14_REA1.SWS

- The DataStudio file has a Graph display. Read the Workbook display for more information.
- The ScienceWorkshop document has a Graph display with absorbance of light versus time.
- Data recording is set at ten measurements per second (10 Hz).

Calibration

The general method for calibrating the Colorimeter is as follows:

- First, calibrate the Colorimeter with a clear cuvette containing distilled water.
- Second, calibrate the software (either DataStudio or ScienceWorkshop) for one of the four colors of light that can be selected in the Colorimeter. (For this activity you will use the RED wavelength.)

> ➧ ***Note: The cuvette has two clear sides and two ridged sides.***

- All cuvettes should be wiped clean and dry on the outside with a tissue.
- Handle cuvettes only by the top edge of the ridged sides.

- All solutions should be free of bubbles.
- Always position the cuvette so the light beam will pass through the clear sides.

Equipment Setup

When sodium thiosulfate and hydrochloric acid are mixed, the solution gradually becomes darker. The solution absorbs more and more light (its absorbance increases).

You will test four solutions made up of different amounts of two reactants as follows:

Table 1.1: Solution Parameters for Activity One

Solution	Component A	Component B
#1	1.6 ml of 0.2 M sodium thiosulfate	1.6 mL of 6 M hydrochloric acid
#2	1.6 ml of 0.2 M sodium thiosulfate	0.8 mL of 6 M hydrochloric acid and 0.8 mL of distilled water
#3	0.8 mL of 0.2 M sodium thiosulfate and 0.8 mL of distilled water	1.6 mL of 6 M hydrochloric acid
#4	0.4 ml of 0.2 M sodium thiosulfate and 1.2 mL of distilled water	1.6 mL of 6 M hydrochloric acid

The general procedure is as follows:

1. Measure the liquids needed for Component A into one graduated cylinder.
2. Measure the liquids needed for Component B into a second graduated cylinder.
3. Put Component B into a cuvette.
4. Add Component A to the same cuvette and put a cap on the cuvette.
5. Quickly invert the cuvette to mix the components.
6. Quickly put the cuvette into the Colorimeter.
7. Start the Colorimeter. Record data. Stop the Colorimeter

Data Recording Using A ScienceWorkshop Interface

1. When you are ready to begin data recording, place Component B for the first solution in the cuvette. Add Component A for the first solution to the cuvette. Cap the cuvette, invert it to mix the components, and quickly put the cuvette into the Colorimeter. Close the Colorimeter lid.
2. Press the ‘Start/Stop’ button to start the Colorimeter.
3. Start recording data. (Hint: Click ‘Start’ in DataStudio or click ‘REC’ in

ScienceWorkshop.)

4. Record data for 3 minutes and then stop the data recording.

5. Press the ‘Start/Stop’ button to stop the Colorimeter.

6. Remove the cuvette from the Colorimeter and dispose of the solution as instructed.

7. Repeat the procedure for solutions 2, 3, and 4. There will be four runs of data at the end of the data recording.

Analyzing the Data in DataStudio or ScienceWorkshop

Find the slope using the slope tool in DataStudio or by using the linear curve fit function in ScienceWorkshop.

Questions

1. How will changing the concentrations of the reactants affect the rate of a chemical reaction?

Table 1.2: Data Table

Solution	Rate
#1 (1.6 mL thiosulfate, 1.6 mL HCl)	
#2 (1.6 mL thiosulfate, 0.8 mL HCl + 0.8 mL water)	
#3 (0.8 mL thiosulfate + 0.8 mL water, 1.6 mL HCl)	
#4 (0.4 mL thiosulfate + 1.2 mL water, 1.6 mL HCl)	

2. What is the effect on the rate of the reaction by halving the concentration of thiosulfate?

3. What is the order of the reaction due to thiosulfate?

4. What was the effect on the rate of reaction by halving the concentration of acid?

5. What is the order of the reaction due to acid?

6. What is the over all order of the reaction?

ActivityTwo: Rate of a Chemical Reaction 2

EQUIPMENT AND MATERIALS REQUIRED

- Colorimeter (CI-6747)
- Cuvette (with cap)
- Pipette, 1 mL
- Protective gear
- 2-butanol, 2 molar, 10 mL
- Potassium permanganate, 0.2 molar, 10 mL
- Sulfuric acid, 1 molar, 10 mL
- Water, distilled, 10 mL

Hypothesis

How will changing the concentration of the reactants affect the rate of a chemical reaction?

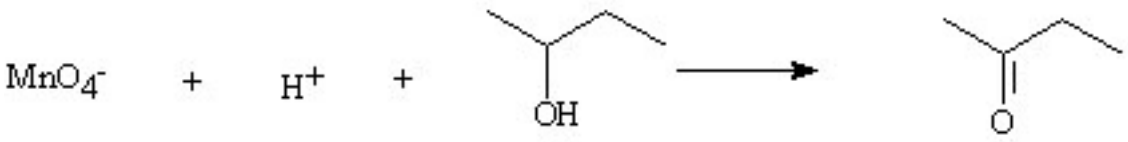
Theory

All chemical reactions occur at specific rates. The rate of a chemical reaction depends on several physical and chemical factors. These factors include:

- The concentration of the reactants
- The temperature of the reaction
- The pressure on the reaction
- The presence of a catalyst

In this activity you will determine the effect of changes in concentration on the rate of a chemical reaction. The chemical reaction under investigation is the conversion of 2-butanol to methyl ethyl ketone or 2-butanone. The reaction will be monitored by using a Colorimeter to measure the change in optical density (absorbance) at 635 nm (wavelength of red light).

The equation for the reaction is:



or

permanganate ion + hydrogen ion + 2 butanol ⇒ 2 butanone

or

$$2\ MnO_4 + 6\ H^+ + 5\ C_4H_{10}O \Rightarrow 5\ C_4H_8O + 8\ H_2O + Mn^{2+}$$

In order to determine the effect of concentration on the rate of the reaction, you will follow the reaction by using the Colorimeter to monitor the absorption of the manganese ion. As the reaction produces the Mn^{2+} the light from the Colorimeter will be absorbed. The amount of absorption is directly related to the concentration of the manganous ion in the solution.

The rate of this chemical reaction is given by the equation:

$$\text{Rate} = k\ [\text{reactant}]^a\ [\text{reactant}]^b\ [\text{reactant}]^c$$

The letters a, b and c seen as exponents are numerals which can only be determined experimentally. Each reactant must be varied separately while the other is kept constant. The effect on the rate of the reaction is noted and the value of the exponent is determined in this way:

- If a change in concentration of one of the reactants has no effect, the exponent is 0.
- If doubling the concentration doubles the rate, the exponent is 1.
- If doubling the concentration quadruples the rate, the exponent is 2.

The over all order of the reaction is determined by adding a + b + c.

Safety Reminders

- Wear protective gear.
- Follow directions for using the equipment.
- Handle and dispose of all chemicals and solutions properly.

> ➤ ***CAUTION: Never pipette by mouth. Always use a pipette bulb or a pipette pump. Be careful when handling any acid or base solutions.***

For You To Do

Use the Colorimeter to measure the change in absorbance of light by a solution of 2-butanol, potassium permangante, and sulfuric acid as the three components react. Begin with a mixture with specific concentrations of the three components, and then test mixtures with different concentrations of one component or the other. Use DataStudio or ScienceWorkshop to record and display the data. Use the data to determine the overall order of the rate of reaction.

Computer Setup

If using the Colorimeter with a ScienceWorkshop interface, open the file titled as follows:

Software	**File Name**
DataStudio	C15 Reaction Rate 2.DS
ScienceWorkshop (Mac)	C15 Reaction Rate 1
ScienceWorkshop (Win)	C15_REA2.SWS

- The DataStudio file has a Graph display. Read the Workbook display for more information.
- The ScienceWorkshop document has a Graph display with absorbance of light versus time.
- Data recording is set at ten measurements per second (10 Hz).

Calibration

The general method for calibrating the Colorimeter is as follows:

- First, calibrate the Colorimeter with a clear cuvette containing distilled water.
- Second, calibrate the software (either DataStudio or ScienceWorkshop) for one of the four colors of light that can be selected in the Colorimeter. (For this activity you will use the RED wavelength.)

➤ ***Note: The cuvette has two clear sides and two ridged sides.***

- All cuvettes should be wiped clean and dry on the outside with a tissue.
- Handle cuvettes only by the top edge of the ridged sides.
- All solutions should be free of bubbles.
- Always position the cuvette so the light beam will pass through the clear sides.

Equipment Setup

When the reactants are mixed, the solution gradually becomes darker. In other words, the solution absorbs more and more light (absorbance goes up).

You will test how each of the three substances (sulfuric acid (2 Molar), 2-butanol (1 Molar), and potassium permanganate (0.02 Molar)) effect the rate of reaction. You will vary the concentration of one reactant at a time by diluting it with distilled water.

Use the following protocol in each test:

1. Add the specified amount of distilled water to the cuvette.

2. Add the specified amount of 2-butanol to the cuvette.

3. Add the specified amount of sulfuric acid to the cuvette.

4. Add the specified amount of potassium permanganate to the cuvette LAST and quickly cap the cuvette.

5. Quickly invert the cuvette to mix the components.

6. Quickly put the cuvette into the Colorimeter.

7. Start the Colorimeter, record data, then stop the Colorimeter

8. Remove the cuvette, discard the solution, and rinse the cuvette thoroughly.

Part A: Data Recording - Vary the Concentration of Permanganate Ion

You will test three solutions made up of different amounts of the reactants as follows:

Table 2.1: Vary the Concentration of Permanganate Ion

Trial	Water	2-butanol, 2 M	sulfuric acid, 1 M	potassium permanganate, 0.2 M
#1	0.8 mL	0.8 mL	0.8 mL	0.8 mL
#2	1.2 mL	0.8 mL	0.8 mL	0.4 mL
#3	1.4 mL	0.8 mL	0.8 mL	0.2 mL

1. When you are ready to begin data recording, place distilled water, 2-butanol, and sulfuric acid in the cuvette in the amounts specified.

2. Add the specified amount of potassium permanganate LAST. Quickly cap the cuvette, mix, and put the cuvette into the Colorimeter. Close the Colorimeter lid.

3. Press the 'Start/Stop' button to start the Colorimeter.

4. Start recording data. (Hint: Click 'Start' in DataStudio or click 'REC' in ScienceWorkshop.)

5. Record data for about 135 seconds and then stop recording data.

6. Press the 'Start/Stop' button to stop the Colorimeter. Empty and rinse the cuvette with distilled water.

7. Repeat the procedure for trials 2 and 3 using the amounts of reactants shown above. Remember to add the $KMnO_4$ last.

- You will have three runs of data at the end of the data recording for Part A.

Part B: Data Recording - Vary the Concentration of 2-Butanol

You will test three solutions made up of different amounts of the reactants as follows:

Table 2.2: Vary the Concentration of 2-Butanol

Trial	Water	2-butanol, 2 M	sulfuric acid, 1 M	potassium permanganate, 0.2 M
#4	0.8 mL	0.8 mL	0.8 mL	0.8 mL
#5	1.2 mL	0.4 mL	0.8 mL	0.8 mL
#6	1.4 mL	0.2 mL	0.8 mL	0.8 mL

1. When you are ready to begin data recording, place distilled water, 2-butanol, and sulfuric acid in the cuvette in the amounts specified.

2. Add the specified amount of potassium permanganate LAST. Quickly cap the cuvette, mix, and put the cuvette into the Colorimeter. Close the Colorimeter lid.

3. Press the 'Start/Stop' button to start the Colorimeter.

4. Start recording data. (Hint: Click 'Start' in DataStudio or click 'REC' in ScienceWorkshop.)

5. Record data for about 135 seconds and then stop recording data.

6. Press the 'Start/Stop' button to stop the Colorimeter. Empty and rinse the cuvette with distilled water.

7. Repeat the procedure for trials 5 and 6 using the amounts of reactants shown above. Remember to add the $KMnO_4$ last.

- You will have three more runs of data at the end of the data recording for Part B.

Part C: Data Recording - Vary the Concentration of Sulfuric Acid

You will test three solutions made up of different amounts of the reactants as follows:

Table 2.3: Vary the Concentration of Sulfuric Acid

Trial	Water	2-butanol, 2 M	sulfuric acid, 1 M	potassium permanganate, 0.2 M
#7	0.8 mL	0.8 mL	0.8 mL	0.8 mL
#8	1.2 mL	0.8 mL	0.4 mL	0.8 mL
#9	1.4 mL	0.8 mL	0.2 mL	0.8 mL

1. When you are ready to begin data recording, place distilled water, 2-butanol, and sulfuric acid in the cuvette in the amounts specified.
2. Add the specified amount of potassium permanganate LAST. Quickly cap the cuvette, mix, and put the cuvette into the Colorimeter. Close the Colorimeter lid.
3. Press the ‘Start/Stop’ button to start the Colorimeter.
4. Start recording data. (Hint: Click ‘Start’ in DataStudio or click ‘REC’ in ScienceWorkshop.)
5. Record data for about 135 seconds and then stop recording data.
6. Press the ‘Start/Stop’ button to stop the Colorimeter. Empty and rinse the cuvette with distilled water.
7. Repeat the procedure for trials 5 and 6 using the amounts of reactants shown above. Remember to add the $KMnO_4$ last.

- You will have three more runs of data at the end of the data recording for Part C.

Analyzing the Data in DataStudio or ScienceWorkshop

Find the slope using the slope tool in DataStudio or by using the linear curve fit function in ScienceWorkshop.

Questions

1. How will changing the concentrations of the reactants affect the rate of a chemical reaction?

Table 2.4: Data Table

Trial	Variable	Amount (mL)	Rate
#1	potassium permanganate ($KMnO_4$)	0.8	
#2	potassium permanganate ($KMnO_4$)	0.4	
#3	potassium permanganate ($KMnO_4$)	0.2	
#4	2-butanol	0.8	
#5	2-butanol	0.4	
#6	2-butanol	0.2	
#7	sulfuric acid (H_2SO_4)	0.8	
#8	sulfuric acid (H_2SO_4)	0.4	
#9	sulfuric acid (H_2SO_4)	0.2	

2. What is the effect of varying the concentration of each of the reactants?

3. Which of the reactants effected the rate of reaction the most?

4. Use the information in the Data Table to determine the order of each reactant and then determine the overall rate of the reaction.

Activity Three: A Pseudo First Order Reaction

EQUIPMENT AND MATERIALS REQUIRED

- Colorimeter (CI-6747)
- Cuvette (with cap)
- Pipette, 1 mL, 4 ea.
- Protective gear
- ethanol, 20 mL
- Hydrochloric acid, 1 molar, 20 mL
- Potassium permanganate, 0.02 molar, 20 mL
- Water, distilled, 20 mL

Hypothesis

How will changing the concentrations of the reactants affect the rate of a chemical reaction?

Theory

The rate of a chemical reaction depends on the temperature, pressure and other physical characteristics of the reaction surroundings. The first consideration a chemist gives to a chemical reaction however, is the concentration of the reactants. High concentrations of chemical reactants insure that molecules have the greatest opportunity to for successful collisions.

Chemists often change the concentration of reactants so that they can study the effect the change has on the rate of the reaction. For example, consider the reaction of permanganate ion (MnO_{4^-}), in an acidic solution with ethyl alcohol (C_2H_6O) to form the acetate ion ($C_2H_3O_{2^-}$). The balanced equation for this reaction is given below.

$$\mathbf{5\ C_2H_6O + 4\ MnO_4^- + 7\ H^+ \Rightarrow 5\ C_2H_3O_2^- + 4\ Mn^{2+} + 11\ H_2O}$$

Five moles of ethyl alcohol are needed to react with four moles of permanganate ion to form five moles of acetate ion and four moles of the manganous (Mn^{2+}) ion. If the concentration of ethyl alcohol and acid are raised to a high level relative to the permanganate concentration, the kinetics of the appearance of the Mn^{2+} ion can be studied. In a similar manner, if the concentration of the hydrogen ion is raised above the stoichiometric requirement of the reaction, then the interaction of the other two reactants can be studied. Each participant in the reaction can be studied in turn using this technique. The method is a pseudo first order reaction because the kinetics of the single reactant can be studied as if the concentration were first order while the other reactants are held almost constant because their concentration is so large relative to the species being studied.

Remember that the Colorimeter measures the change in absorbance due to the manganous ion in the reaction solution.

Safety Reminders

- Wear protective gear.
- Follow directions for using the equipment.
- Handle and dispose of all chemicals and solutions properly.

> ➤ ***CAUTION: Never pipette by mouth. Always use a pipette bulb or a pipette pump. Be careful when handling any acid or base solutions.***

For You To Do

Use the Colorimeter to measure the change in absorbance of light by a solution of ethanol, hydrochloric acid and potassium permangante as the three components react. Begin with a mixture with specific concentrations of the three components, and then test mixtures with different concentrations of one component or the other. Use DataStudio or ScienceWorkshop to record and display the data. Use the data to determine the overall order of the rate of reaction.

Computer Setup

If using the Colorimeter with a ScienceWorkshop interface, open the file titled as follows:

Software	**File Name**
DataStudio	C16 Pseudo 1.DS
ScienceWorkshop (Mac)	C17 Pseudo 1
ScienceWorkshop (Win)	C17_PSE1.SWS

- The DataStudio file has a Graph display. Read the Workbook display for more information.
- The ScienceWorkshop document has a Graph display with absorbance of light versus time.
- Data recording is set at two measurements per second (2 Hz).

Calibration

The general method for calibrating the Colorimeter is as follows:

- First, calibrate the Colorimeter with a clear cuvette containing distilled water.
- Second, calibrate the software (either DataStudio or ScienceWorkshop) for one of the four colors of light that can be selected in the Colorimeter. (For this activity you will use the RED wavelength.)

> ➤ ***Note: The cuvette has two clear sides and two ridged sides.***

- All cuvettes should be wiped clean and dry on the outside with a tissue.
- Handle cuvettes only by the top edge of the ridged sides.
- All solutions should be free of bubbles.
- Always position the cuvette so the light beam will pass through the clear sides.

Equipment Setup

When the reactants are mixed, the solution gradually becomes darker. In other words, the solution absorbs more and more light (absorbance goes up).

You will test how each of the three substances (hydrochloric acid (1 Molar), ethyl alcohol, and potassium permanganate (0.02 Molar)) effect the rate of reaction. You will vary the concentration of one reactant at a time by diluting it with distilled water.

Use the following protocol in each test:

1. Add the specified amount of distilled water to the cuvette.
2. Add the specified amount of ethanol to the cuvette.
3. Add the specified amount of hydrochloric acid to the cuvette.
4. Add the specified amount of potassium permanganate to the cuvette LAST and quickly cap the cuvette.
5. Quickly invert the cuvette to mix the components.
6. Quickly put the cuvette into the Colorimeter.
7. Start the Colorimeter, record data, then stop the Colorimeter
8. Remove the cuvette, discard the solution, and rinse the cuvette thoroughly.

Part A: Data Recording - Vary the Concentration of Permanganate Ion

You will test three solutions made up of different amounts of the reactants as follows:

Table 3.1: Vary the Concentration of Permanganate Ion

Trial	Water	Ethanol	Hydrochloric acid, 1 M	potassium permanganate, 0.2 M
#1	0.8 mL	0.8 mL	0.8 mL	0.8 mL
#2	1.2 mL	0.8 mL	0.8 mL	0.4 mL
#3	1.4 mL	0.8 mL	0.8 mL	0.2 mL

1. When you are ready to begin data recording, place distilled water, ethanol, and hydrochloric acid in the cuvette in the amounts specified.
2. Add the specified amount of potassium permanganate LAST. Quickly cap the cuvette, mix, and put the cuvette into the Colorimeter. Close the Colorimeter lid.
3. Press the ‘Start/Stop’ button to start the Colorimeter.
4. Start recording data. (Hint: Click ‘Start’ in DataStudio or click ‘REC’ in ScienceWorkshop.)
5. Record data for about 120 seconds and then stop recording data.
6. Press the ‘Start/Stop’ button to stop the Colorimeter. Empty and rinse the cuvette with distilled water.

7. Repeat the procedure for trials 2 and 3 using the amounts of reactants shown above. Remember to add the $KMnO_4$ last.

- You will have three runs of data at the end of the data recording for Part A.

Part B: Data Recording - Vary the Concentration of Ethyl Alcohol

You will test three solutions made up of different amounts of the reactants as follows:

Table 3.2: Vary the Concentration of Ethanol

Trial	Water	Ethanol	Hydrochloric acid, 1 M	potassium permanganate, 0.2 M
#4	0.8 mL	0.8 mL	0.8 mL	0.8 mL
#5	1.2 mL	0.4 mL	0.8 mL	0.8 mL
#6	1.4 mL	0.2 mL	0.8 mL	0.8 mL

1. When you are ready to begin data recording, place distilled water, ethanol, and hydrochloric acid in the cuvette in the amounts specified.

2. Add the specified amount of potassium permanganate LAST. Quickly cap the cuvette, mix, and put the cuvette into the Colorimeter. Close the Colorimeter lid.

3. Press the ‘Start/Stop’ button to start the Colorimeter.

4. Start recording data. (Hint: Click ‘Start’ in DataStudio or click ‘REC’ in ScienceWorkshop.)

5. Record data for about 120 seconds and then stop recording data.

6. Press the ‘Start/Stop’ button to stop the Colorimeter. Empty and rinse the cuvette with distilled water.

7. Repeat the procedure for trials 5 and 6 using the amounts of reactants shown above. Remember to add the $KMnO_4$ last.

- You will have three more runs of data at the end of the data recording for Part B.

Part C: Data Recording - Vary the Concentration of Hydrochloric Acid

You will test three solutions made up of different amounts of the reactants as follows:

Table 3.3: Vary the Concentration of Hydrochloric Acid

Trial	Water	Ethanol	Hydrochloric acid, 1 M	potassium permanganate, 0.2 M
#7	0.8 mL	0.8 mL	0.8 mL	0.8 mL
#8	1.2 mL	0.8 mL	0.4 mL	0.8 mL
#9	1.4 mL	0.8 mL	0.2 mL	0.8 mL

1. When you are ready to begin data recording, place distilled water, ethanol, and hydrochloric acid in the cuvette in the amounts specified.
2. Add the specified amount of potassium permanganate LAST. Quickly cap the cuvette, mix, and put the cuvette into the Colorimeter. Close the Colorimeter lid.
3. Press the ‘Start/Stop’ button to start the Colorimeter.
4. Start recording data. (Hint: Click ‘Start’ in DataStudio or click ‘REC’ in ScienceWorkshop.)
5. Record data for about 135 seconds and then stop recording data.
6. Press the ‘Start/Stop’ button to stop the Colorimeter. Empty and rinse the cuvette with distilled water.
7. Repeat the procedure for trials 5 and 6 using the amounts of reactants shown above. Remember to add the $KMnO_4$ last.

- You will have three more runs of data at the end of the data recording for Part C.

Analyzing the Data in DataStudio or ScienceWorkshop

Find the slope using the slope tool in DataStudio or by using the linear curve fit function in ScienceWorkshop.

Record your results in Table 3.4.

Questions

1. How will changing the concentrations of the reactants affect the rate of a chemical reaction?

Table 3.4: Data Table

Trial	Variable	Amount (mL)	Rate
#1	potassium permanganate ($KMnO_4$)	0.8	
#2	potassium permanganate ($KMnO_4$)	0.4	
#3	potassium permanganate ($KMnO_4$)	0.2	
#4	ethanol	0.8	
#5	ethanol	0.4	
#6	ethanol	0.2	
#7	hydrochloric acid (HCl)	0.8	
#8	hydrochloric acid (HCl)	0.4	
#9	hydrochloric acid (HCl)	0.2	

2. What is the effect of varying the concentration of each of the reactants?

3. Which of the reactants effected the rate of reaction the most?

4. Using the information in the Data Table determine the order of each reactant and then determine the overall rate of the reaction.

Activity Four: Another Pseudo First Order Reaction

EQUIPMENT AND MATERIALS REQUIRED

- Colorimeter (CI-6747)
- Cuvette (with cap)
- Graduated cylinder, 10 mL
- Pipette, 1 mL, 4 ea.
- Protective gear
- Hydrochloric acid, 3 molar, 20 mL
- Potassium permanganate, 0.001 molar, 20 mL
- Sodium oxalate, 0.1 molar, 20 mL
- Water, distilled, 200 mL

Hypothesis

How will changing the concentrations of the reactants affect the rate of a chemical reaction?

Theory

The rate of a chemical reaction depends on the temperature, pressure and other physical characteristics of the reaction surroundings. The first consideration a chemist gives to a chemical reaction however, is the concentration of the reactants. High concentrations of chemical reactants insure that molecules have the greatest opportunity to for successful collisions.

Chemists often change the concentration of reactants so that they can study the effect the change has on the rate of the reaction. For example, consider the reaction of permanganate ion (MnO_4^-), in an acidic solution with oxalate ion to form carbon dioxide. The balanced equation for this reaction is given below.

$$5\ C_2O_4^{2-} + 2\ MnO_4^- + 16\ H^+ \Rightarrow 10\ CO_2 + 2\ Mn^{2+} + 8\ H_2O$$

Five moles of oxalate ion are needed to react with two moles of permanganate ion to form ten moles of carbon dioxide and two moles of the manganous ion (Mn^{2+}). If the concentration of oxalate ion and acid are raised to a high level relative to the permanganate concentration, the kinetics of the disappearance of the permanganate ion can be studied. In a similar manner, if the concentration of the hydrogen ion is raised above the stoichiometric requirement of the reaction, then the interaction of the other two reactants can be studied. Each participant in the reaction can be studied in turn using this technique. The method is a pseudo first order reaction because the kinetics of the single reactant can be studied as if the concentration were first order while the other reactants are held almost constant because their concentration is so large relative to the species being studied.

The Colorimeter measures the change in absorbance of light caused by the disappearance of the permanganate ion as it is consumed by the reaction.

Safety Reminders

- Wear protective gear.
- Follow directions for using the equipment.
- Handle and dispose of all chemicals and solutions properly.

> ➤ ***CAUTION: Never pipette by mouth. Always use a pipette bulb or a pipette pump. Be careful when handling any acid or base solutions.***

For You To Do

Use the Colorimeter to measure the change in absorbance of light by a solution of hydrochloric acid, sodium oxalate, and potassium permangante as the three components react. Begin with a mixture with specific concentrations of the three components, and then test mixtures with different concentrations of one component or the other. Use DataStudio or ScienceWorkshop to record and display the data. Use the data to determine the overall order of the rate of reaction.

Computer Setup

If using the Colorimeter with a ScienceWorkshop interface, open the file titled as follows:

Software	**File Name**
DataStudio	C17 Pseudo 2.DS
ScienceWorkshop (Mac)	C18 Pseudo
ScienceWorkshop (Win)	C18_PSE2.SWS

- The DataStudio file has a Graph display. Read the Workbook display for more information.
- The ScienceWorkshop document has a Graph display with absorbance of light versus time.
- Data recording is set at two measurements per second (2 Hz).

Calibration

The general method for calibrating the Colorimeter is as follows:

- First, calibrate the Colorimeter with a clear cuvette containing distilled water.
- Second, calibrate the software (either DataStudio or ScienceWorkshop) for one of the four colors of light that can be selected in the Colorimeter. (For this activity you will use the RED wavelength.)

> ➤ ***Note: The cuvette has two clear sides and two ridged sides.***

- All cuvettes should be wiped clean and dry on the outside with a tissue.
- Handle cuvettes only by the top edge of the ridged sides.
- All solutions should be free of bubbles.
- Always position the cuvette so the light beam will pass through the clear sides.

Equipment Setup

When the reactants are mixed, the solution gradually becomes light. In other words, the solution absorbs less and less light so absorbance goes down.

You will test how each of the three substances effects the rate of reaction. You will vary the concentration of one reactant at a time by diluting it with distilled water.

Use the following protocol in each test:

1. Add the specified amount of distilled water to the cuvette.
2. Add the specified amount of sodium oxalate to the cuvette.
3. Add the specified amount of hydrochloric acid to the cuvette.
4. Add the specified amount of potassium permanganate to the cuvette LAST and quickly cap the cuvette.
5. Quickly invert the cuvette to mix the components.
6. Quickly put the cuvette into the Colorimeter.
7. Start the Colorimeter, record data, and then stop the Colorimeter
8. Remove the cuvette, discard the solution, and rinse the cuvette thoroughly.

Part A: Data Recording - Vary the Concentration of Permanganate Ion

You will test three solutions made up of different amounts of the reactants as follows:

Table 4.1: Vary the Concentration of Permanganate Ion

Trial	Water	Sodium oxalate, 0.1 M	Hydrochloric acid, 3 M	Potassium permanganate, 0.001 M
#1	1.0 mL	1.0 mL	1.0 mL	1.0 mL
#2	1.5 mL	1.0 mL	1.0 mL	0.5 mL

1. When you are ready to begin data recording, place distilled water, sodium oxalate, and hydrochloric acid in the cuvette in the amounts specified.
2. Add the specified amount of potassium permanganate LAST. Quickly cap the cuvette, mix, and put the cuvette into the Colorimeter. Close the Colorimeter lid.
3. Press the ‘Start/Stop’ button to start the Colorimeter.
4. Start recording data. (Hint: Click ‘Start’ in DataStudio or click ‘REC’ in ScienceWorkshop.)
5. Record data for about 4 minutes (240 seconds) and then stop recording data.
6. Press the ‘Start/Stop’ button to stop the Colorimeter. Empty and rinse the cuvette with distilled water.

7. Repeat the procedure for trial 2 using the amounts of reactants shown above. Remember to add the KMnO4 last.

- You will have two runs of data at the end of the data recording for Part A.

Part B: Data Recording - Vary the Concentration of Oxalate Ion

Dilute a small amount of the sodium oxalate from 0.1 molar to 0.001 molar. Use the pipette to put 1 mL of 0.1 M sodium oxalate into a 100-mL graduated cylinder. Add distilled water to the cylinder until the volume is 100 mL.

Table 4.2: Vary the Concentration of Oxalate Ion

Trial	Water	Sodium oxalate, 0.1 M	Hydrochloric acid, 3 M	Potassium permanganate, 0.001 M
#3	none	2.0 mL	1.0 mL	1.0 mL
#4	1.0 mL	1.0 mL	1.0 mL	1.0 mL

1. When you are ready to begin data recording for Part B, place distilled water, sodium oxalate (0.001 M), and hydrochloric acid in the cuvette in the amounts specified.
2. Add the specified amount of potassium permanganate LAST. Quickly cap the cuvette, mix, and put the cuvette into the Colorimeter. Close the Colorimeter lid.
3. Press the 'Start/Stop' button to start the Colorimeter.
4. Start recording data.
5. Record data for about 4 minutes (240 seconds) and then stop recording data.
6. Press the 'Start/Stop' button to stop the Colorimeter. Empty and rinse the cuvette with distilled water.
7. Repeat the procedure for trial 4 using the amounts of reactants shown above. Remember to add the KMnO4 last.

- You will have four runs of data at the end of the data recording for Part B.

Part C: Data Recording - Vary the Concentration of Hydrochloric Acid

Dilute a small amount of the hydrochloric acid from 3 molar to 0.3 molar. Put 9 mL of distilled water into a graduated cylinder. Use a pipette to add 1 mL of 3 M hydrochloric acid into the water. Add distilled water to bring the total volume to 10 mL.

Table 4.3: Vary the Concentration of Oxalate Ion

Trial	Water	Sodium oxalate, 0.1 M	Hydrochloric acid, 0.3 M	Potassium permanganate, 0.001 M
#5	none	1.0 mL	2.0 mL	1.0 mL
#6	1.0 mL	1.0 mL	1.0 mL	1.0 mL

1. When you are ready to begin data recording for Part C, place distilled water, sodium oxalate (0.1 M), and hydrochloric acid (0.3 M) in the cuvette in the amounts specified.
2. Add the specified amount of potassium permanganate LAST. Quickly cap the cuvette, mix, and put the cuvette into the Colorimeter. Close the Colorimeter lid.
3. Press the 'Start/Stop' button to start the Colorimeter.
4. Start recording data.
5. Record data for about 4 minutes (240 seconds) and then stop recording data.
6. Press the 'Start/Stop' button to stop the Colorimeter. Empty and rinse the cuvette with distilled water.
7. Repeat the procedure for trial 6 using the amounts of reactants shown above. Remember to add the KMnO4 last.

Analyzing the Data in DataStudio or ScienceWorkshop

Find the slope using the slope tool in DataStudio or by using the linear curve fit function in ScienceWorkshop.

Record your results in Table 4.4.

Questions

1. How will changing the concentrations of the reactants affect the rate of a chemical reaction?

Table 4.4: Data Table

Trial	Variable	Amount (mL)	Rate
#1	potassium permanganate (0.001)	1.0	
#2	potassium permanganate (0.001)	0.5	
#3	sodium oxalate (0.1 M)	2.0	
#4	sodium oxalate (0.1 M)	1.0	
#5	hydrochloric acid (0.3 M)	0.5	
#6	hydrochloric acid (0.3 M)	2.0	

2. What is the effect of varying the concentration of each of the reactants?
3. Which of the reactants effected the rate of reaction the most?
4. Using the information in the Data Table determine the order of each reactant and then determine the overall rate of the reaction.

Activity Five: Determine the Concentration of a Solution – Beer's Law

EQUIPMENT AND MATERIALS REQUIRED

- Colorimeter (CI-6747)
- Cuvette (with cap)
- Beaker, 100 mL, 2 ea.
- Graduated cylinder, 10 mL
- Pipette, 10 mL, 2 ea.
- Test tube, 25 by 150 mm, 6 ea.
- Test tube rack
- Protective gear
- Copper sulfate, 0.4 molar, 30 mL
- Copper sulfate, unknown, 5 mL
- Water, distilled, 100 mL
- Label, 6 ea.
- Tissue, 6 ea.

Hypothesis

The German astronomer Wilhem Beer discovered that the absorbance of light by a solution has a linear relationship to the concentration of a substance in the solution. Can you use the relationship between absorbance and concentration to determine the concentration on an unknown solution?

Theory

A Colorimeter sends light from a light emitting diode (LED) through a solution placed in a cuvette inside the Colorimeter. The light that passes through the solution strikes a photodiode. A higher concentration of the colored solution absorbs more light and transmits less light than a solution of lower concentration. The Colorimeter monitors the light received by the photodiode as either an absorbance or a percent transmittance value.

You can use the amount of light that penetrates the solution and strikes the photodiode to compute the absorbance of each solution. A graph of absorbance versus concentration for a series of standard solutions shows a linear relationship (see the figure). The direct relationship between absorbance and concentration for a solution is known as Beer's law.

In Beer's law, A is the absorbance, c is the concentration, I0 is the intensity of radiation before passage through the solution, and I is the intensity of radiation transmitted through the solution.

Safety Reminders

- Wear protective gear.
- Follow directions for using the equipment.
- Handle and dispose of all chemicals and solutions properly.

> ➤ ***CAUTION: Never pipette by mouth. Always use a pipette bulb or a pipette pump. Be careful when handling any acid or base solutions.***

For You To Do

Use the Colorimeter to generate a graph of absorbance versus concentration using solutions of known concentration. Then use the Colorimeter to measure the absorbance of the unknown solution. Use DataStudio or ScienceWorkshop to record and display the data. Use the graph of absorbance versus concentration that you plotted for the standard solutions to determine the concentration of the unknown solution.

Computer Setup

If using the Colorimeter with a ScienceWorkshop interface, open the file titled as follows:

Software	File Name
DataStudio	C27 Beer's Law.DS
ScienceWorkshop (Mac)	C27 Beer's Law
ScienceWorkshop (Win)	C27_BEER.SWS

- The DataStudio file has a Graph display. Read the Workbook display for more information.
- The ScienceWorkshop document has a Graph display with absorbance of light versus time.
- Data recording is set at one measurements per second (1 Hz).

Calibration

The general method for calibrating the Colorimeter is as follows:

- First, calibrate the Colorimeter with a clear cuvette containing distilled water.
- Second, calibrate the software (either DataStudio or ScienceWorkshop) for one of the four colors of light that can be selected in the Colorimeter. (For this activity you will use the RED wavelength.)

➤ ***Note: The cuvette has two clear sides and two ridged sides.***

- All cuvettes should be wiped clean and dry on the outside with a tissue.
- Handle cuvettes only by the top edge of the ridged sides.
- All solutions should be free of bubbles.
- Always position the cuvette so the light beam will pass through the clear sides.

Equipment Setup

1. Add about 30 mL of 0.40 Molar copper sulfate ($CuSO_4$) stock solution to a 100-mL beaker. Add about 30 mL of distilled water to another 100-mL beaker.

2. Label four clean, dry, test tubes 1 through 4 (the fifth solution is the beaker of 0.40 M $CuSO_4$).

3. Pipette 2, 4, 6, and 8 mL of 0.40 M $CuSO_4$ solution into Test Tubes 1 through 4, respectively.

4. With a second pipette, deliver 8, 6, 4, and 2 mL of distilled water into Test Tubes 1 through 4, respectively.

5. Thoroughly mix each solution with a stirring rod. Clean and dry the stirring rod between stirrings.

6. Keep the remaining 0.40 M CuSO4 in the 100-mL beaker to use in the fifth trial.

- Volumes and concentrations for the trials are summarized below:

Table 5.1: Summary of Solutions

Trial	Volume 0.40 M $CuSO_4$ (mL)	Volume H_2O (mL)	Concentration (M)
#1	2	8	0.08
#2	4	6	0.16
#3	6	4	0.24
#4	8	2	0.32
#5	~10	0	0.40

7. Empty the water from the cuvette used during calibration. Using the solution in Test Tube 1, rinse the cuvette twice with approximately 1 mL amounts of solution from the test tube, and then fill the cuvette with solution. Cap the cuvette.

8. Wipe the outside of the cuvette with a tissue and place the cuvette in the Colorimeter. Close the lid.

Part IA: Data Recording with DataStudio – Solutions with Known Concentrations

1. Arrange the Table display so you can see it clearly.

2. When everything is ready, press the 'Start/Stop' button on the Colorimeter and then start recording data. (Hint: Click 'Start' in DataStudio.)

- In DataStudio, the 'Start' button changes to a 'Keep' button. The Table display shows default values for Concentration.

3. When the Absorbance value stabilizes, click 'Keep' to record the Absorbance value in the Table display.

4. Press the 'Start/Stop' button on the Colorimeter to stop the Colorimeter. Remove the cuvette from the Colorimeter and empty the cuvette. Rinse the cuvette carefully with distilled water. Empty the water from the cuvette.

5. Using the solution in Test Tube 2, rinse the cuvette twice with approximately 1 mL amounts and then fill the cuvette with solution from Test Tube 2. Cap the cuvette. Wipe the outside with a tissue and place the cuvette in the Colorimeter. Close the Colorimeter lid.

6. Press the 'Start/Stop' button on the Colorimeter to start the Colorimeter. When the Absorbance value stabilizes, click 'Keep' in DataStudio to record the new Absorbance value.

7. Continue with each of your other samples (for concentrations of 0.24, 0.32, and 0.40 respectively for solutions 3, 4, and 5).

8. After you record the Absorbance for the last solution, stop recording data. Press the 'Start/Stop' button to stop the Colorimeter. Rinse the cuvette with distilled water.

Part IB: Data Recording with DataStudio - Solution of Unknown Concentration

1. Measure about 10 mL of the unknown $CuSO_4$ into a clean, dry, test tube. Rinse the cuvette twice with approximately 1 mL amounts of the unknown solution and then fill the cuvette with the unknown solution. Cap the cuvette. Wipe the outside with a tissue and place the cuvette in the Colorimeter. Close the Colorimeter lid.

- For this part of data recording, you will monitor the Absorbance of the unknown solution on the Digits display.

2. Press the 'Start/Stop' button to start the Colorimeter. In DataStudio, click the Experiment menu and select 'Monitor Data'.

3. When the Absorbance value displayed in the Digits display stabilizes, record the value of Absorbance in your Data Table as the value for the unknown solution.

4. Stop recording data. Press the 'Start/Stop' button to stop the Colorimeter.

5. Discard of the solutions as directed.

Part IIA: Data Recording with ScienceWorkshop – Solutions with Known Concentrations

1. Click on the Digits display to make it active. Arrange the display so you can see it while recording data.

2. When everything is ready, press the 'Start/Stop' button to start the Colorimeter and click the 'REC' button to begin recording data.

- The Keyboard Sampling window will appear.

3. Wait for the Absorbance value displayed in the Digits display to stabilize. Then enter '0.08' (the concentration of the solution in Test Tube 1) in the Concentration box for Entry # 1, and click the 'Enter' button.

- The concentration will appear in the list area of the Keyboard Sampling window and the data pair you just collected should appear on the Graph and in the Table display of Absorbance and Concentration.

4. Press the 'Start/Stop' button to stop the Colorimeter. Remove the cuvette from the Colorimeter and empty the cuvette. Rinse the cuvette carefully with distilled water. Empty the water from the cuvette.

5. Using the solution in Test Tube 2, rinse the cuvette twice with approximately 1 mL amounts and then fill the cuvette with solution from Test Tube 2. Cap the cuvette. Wipe the outside with a tissue and place the cuvette in the Colorimeter. Close the Colorimeter lid.

6. Press the 'Start/Stop' button to start the Colorimeter. When the Absorbance value displayed in the Digits display stabilizes, enter the new concentration, 0.16, as before.

7. Continue with each of your other samples entering concentrations of 0.24, 0.32, and 0.40 respectively for solutions 3, 4, and 5.

8. Click 'Stop Sampling' to end data recording for Part IIA. The Keyboard Sampling window will automatically close. Press the 'Start/Stop' button to stop the Colorimeter.

Part IIB: Data Recording with ScienceWorkshop - Solution of Unknown Concentration

1. Measure about 8 mL of the unknown $CuSO_4$ into a clean, dry, test tube. Rinse the cuvette twice with approximately 1 mL amounts of the unknown solution and then fill the cuvette with the unknown solution. Cap the cuvette. Wipe the outside with a tissue and place the cuvette in the Colorimeter. Close the Colorimeter lid.

- For this part of data recording, you will monitor the Absorbance on the Digits display.

2. Press the 'Start/Stop' button to start the Colorimeter. Click the 'MON' button to begin monitoring the data.

- The Keyboard Sampling window will open. Ignore it for this part of the experiment.

3. When the Absorbance value displayed in the Digits display stabilizes, record the value of Absorbance in your Data Table as the value for the unknown solution.

4. Click the 'STOP' button to end data monitoring. Press the 'Start/Stop' button to stop the Colorimeter.

5. Discard of the solutions as directed.

Analyzing the Data in DataStudio or ScienceWorkshop

Find the slope using the slope tool in DataStudio or by using the linear curve fit function in ScienceWorkshop.

Record your results in Table 5.2.

Questions

The German astronomer Wilhem Beer discovered that the absorbance of light by a solution has a linear relationship to the concentration of a substance in the solution.

1. Can you use the relationship between absorbance and concentration to determine the concentration on an unknown solution?

Table 5.2: Data Table, Beer's Law

Trial	Absorbance	Concentration $\left(\frac{\text{mol}}{\text{L}}\right)$
#1		
#2		
#3		
#4		
#5		
unknown		

Concentration of the Unknown	$\left(\frac{\text{mol}}{\text{L}}\right)$

2. What is the concentration of the unknown solution?

Technical Support

Feedback

If you have any comments about the product or manual, please let us know. If you have any suggestions on alternate experiments or find a problem in the manual, please tell us. PASCO appreciates any customer feedback. Your input helps us evaluate and improve our product.

To Reach PASCO

For technical support, call us at 1-800-772-8700 (toll-free within the U.S.) or (916) 786-3800.

fax: (916) 786-3292

e-mail: techsupp@pasco.com

web: www.pasco.com

Contacting Technical Support

Before you call the PASCO Technical Support staff, it would be helpful to prepare the following information:

➤ If your problem is with the PASCO apparatus, note:

- Title and model number (usually listed on the label);
- Approximate age of apparatus;
  - A detailed description of the problem/sequence of events (in case you can't call PASCO right away, you won't lose valuable data);
  - If possible, have the apparatus within reach when calling to facilitate description of individual parts.

➤ If your problem relates to the instruction manual, note:

- Part number and revision (listed by month and year on the front cover);
- Have the manual at hand to discuss your questions.