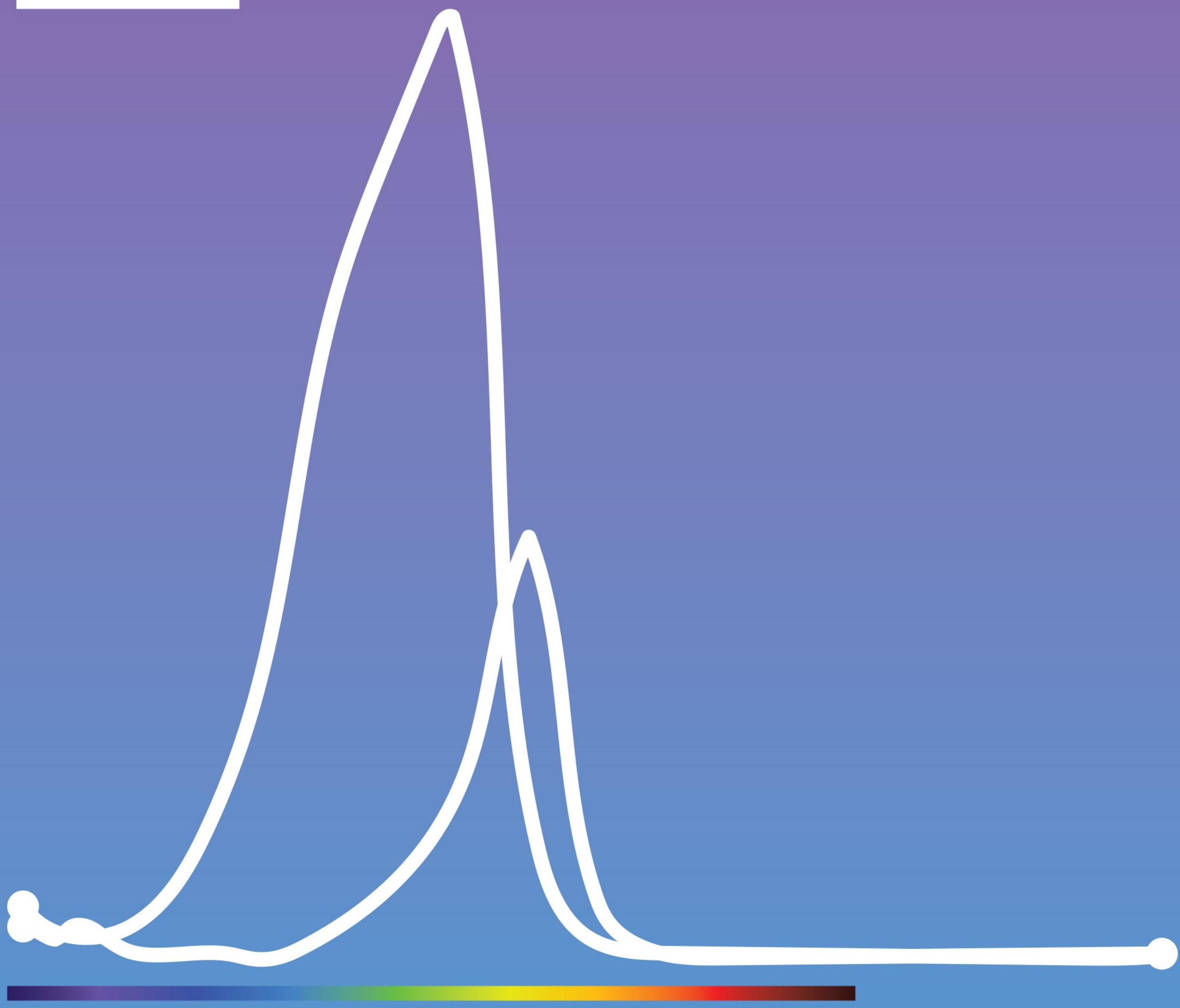
Vernier Chemistry Investigations

for Use with AP* Chemistry

4th Edition



Vernier

APCHEM

Contents

Equipment Used in Experiments

KEY
X = Sensor is required
O = Sensor is optional

		pH Sensor	Conductivity Probe	Drop Counter	SpectroVis Plus	Gas Pressure Sensor	ORP Sensor	Temperature Probe	Melt Station
1	Investigating Food Dyes in Sports Beverages				X				
2	Determining the Copper Content in Brass				X				
3	Investigating Water Hardness		X	O					
4	The Acidity of Juices and Soft Drinks	X		O					
5	Separating Molecules				X				
6	Investigating the Contents of an Unlabeled Container	O	X						X
7	Investigating the Purity of a Mixture		X			X			
8	Determining the Percent Hydrogen Peroxide in a Commercial Product			O			X		
9	Investigating the Components of a Commercial Tablet								X
10	The Effect of Acid Rain on Marble Structures					X			
11	Investigating the Kinetics of a Crystal Violet Reaction				X				
12	Investigating Commercial Hand Warmers							X	
13	Investigating LeChatelier's Principle				X				
14	Investigating Acid-Base Titrations	X		O					
15	The Buffering Ability of Commercial Products	X		O					
16	Testing the Effectiveness of a Buffer	X		O					

Investigating Food Dyes in Sports Beverages

There are many different brands of beverages that fall under the general category of "sports drinks." Most of these beverages contain an FD&C food dye to color the beverage. There are a few options available to determine how much food dye is contained in a sports drink. A common, and very accurate, test method involves using an instrument called a spectrophotometer.

In brief, a spectrophotometer projects light through a small sample of a colored solution. The molecules in the solution allow some, but not all, of the wavelengths of light to pass through the sample and reach the spectrophotometer's detector. By carefully analyzing what happens to light as it passes through a sample of liquid, a great deal can be learned about some of the molecules in the liquid.

In this investigation, you will determine the concentration of an FD&C food dye in a sports beverage. You will use a Vernier SpectroVis Plus Spectrophotometer to conduct your tests.

PRE-LAB ACTIVITY

To prepare for the investigation, you will make a series of dilutions of FD&C Blue #1 food dye. You will be given distilled water and a stock solution of Blue #1 of known molar concentration, from which to make your dilute solutions. Prepare 10 mL of each dilution and calculate the molar concentration of each solution. Use Table 1 to record the information about the solutions you prepare. You will measure the % Transmittance of each solution in the Initial Investigation.

Table 1

Blue #1 solution	Blue #1 stock solution (mL)	Distilled H_2O (mL)	Concentration (M)	% Transmittance
1	10	0		
2	8	2		
3	6	4		
4	4	6		
5	3	7		
6	2	8		
7	1	9		
8	0	10		

INITIAL INVESTIGATION

1. Obtain and wear goggles.
2. Launch Spectral Analysis. Connect the Go Direct SpectroVis Plus Spectrophotometer to your Chromebook, computer, or mobile device.
3. Select % Transmittance and then select vs. Concentration.
4. Prepare a *blank* by filling a cuvette 3/4 full with distilled water. To correctly use cuvettes, remember:
   - Wipe the outside of each cuvette with a lint-free tissue.
   - Handle cuvettes only by the top edge of the ribbed sides.
   - Dislodge any bubbles by gently tapping the cuvette on a hard surface.
   - Always position the cuvette so the light passes through the clear sides.
5. Calibrate the spectrophotometer.
   a. Place the blank cuvette in the spectrophotometer.
   b. Select Finish Calibration. **Note**: If necessary, wait for the spectrophotometer to warm up before selecting Finish Calibration.
6. Select the optimal wavelength for the food dye (630 nm).
   a. Remove the blank cuvette from the spectrophotometer. Refill the cuvette with the stock solution of Blue #1 food dye.
   b. The live graph will update with the spectrum of the sample. Click or tap the desired wavelength or enter **630** as the Wavelength. Click or tap Done.
7. Collect data for the Blue #1 food dye solutions.
   a. Leave the cuvette of stock Blue #1 solution in the spectrophotometer.
   b. Start data collection.
   c. After the value displayed in the meter has stabilized, select Keep and enter the concentration in mol/L. Select Keep Point. The % Transmittance and concentration values have now been stored.
   d. Repeat the necessary steps to test the remaining Blue #1 dilute solutions.
   e. After you have finished testing all the food dye solutions, stop data collection.
   f. To save the file, click or tap File, , and choose Save.
   g. Record the % Transmittance readings in Table 1.

PLANNING FOR THE FINAL INVESTIGATION

For the Final Investigation, obtain a sports drink containing FD&C Blue #1 food dye. Discuss the results of the Initial Investigation, and based on the data, develop a plan that uses a spectrophotometer to determine the molar concentration of FD&C Blue #1 food dye in the sports drink. Prepare a procedure in sufficient detail that another group could follow it and achieve similar results. Consider the following issues during planning:

1. What is the relationship between % Transmittance and concentration of the Blue #1 food dye solutions tested in the Initial Investigation?

2. You measured transmittance of light through the Blue #1 solutions. There is another measurement you could have made, called *absorbance*, which relates to concentration in a linear fashion. How does % Transmittance relate to absorbance? To help you establish the relationship between % Transmittance and absorbance, complete Table 2. Next, prepare a graph of one of the columns as the y-values and the molar concentrations of the food dye as the x-values. Identify the graph that is the most linear *and* has a positive slope. **Note**: In Table 2, *T* represents transmittance, which is percent transmittance written in decimal form.

Table 2					
Blue #1 solution	%*T*	*T*	1/*T*	log *T*	–log *T*
1					
2					
3					
4					
5					
6					
7					
8					

3. The Blue #1 food dye solutions tested in the Initial Investigation were pure in that the samples contained only the food dye and water. A sports drink contains a long list of ingredients. How does this difference play a role in determining how much food dye is contained in the beverage?

FINAL INVESTIGATION

As you carry out your approved plan, consider the following questions:

- Is there an optimum number of data-collection runs to achieve the best data?
- What is the best way to sample the sports drink to ensure that your sampling is the most reliable representation of the product?
- Is there a method of testing that provides more accurate data than the other methods?

ANALYZING RESULTS

When preparing your report, include

- A statement of the results: What was the concentration of Blue #1 food dye in the sports beverage chosen by your group?
- A description of the procedure that you used in the investigation, including any changes that were made to the method that was used during the Initial Investigation
- An analysis of the graphs and supporting calculations

Additional items to consider including in your report

- A comparison of your results with the results from other groups
- Recommended modifications to the procedure that would increase accuracy, save time, or ensure that liquids are handled more efficiently and safely

Investigating the Contents of an Unlabeled Container

Occasionally, despite the best efforts of the most meticulous workers in a chemistry lab, containers with no labels are discovered. When this happens, there are two major concerns: making sure all the workers in the lab are safe and identifying the contents of the container.

In the scenario presented in this investigation, several unlabeled bottles have been found in your laboratory stockroom. Each unlabeled bottle contains a solid substance. The lab director, through some very careful research, has narrowed the list of possible substances in the bottles to those in Table 1.

Table 1

Substance	Chemical formula	Substance	Chemical formula
Ammonium chloride	NH_4Cl	Calcium	Ca
Calcium carbonate	$CaCO_3$	Zinc	Zn
Magnesium oxide	MgO	Wax/paraffin	
Potassium nitrate	KNO_3	Iodine	I_2
Benzoic acid	C_6H_5COOH	Sodium acetate	CH_3COONa
Salicylic acid	$C_6H_4(OH)COOH$	Copper (II) sulfate	$CuSO_4$
Aluminum	Al	Sodium carbonate	Na_2CO_3
Magnesium	Mg	Sucrose	$C_6H_{12}O_6$
Copper	Cu	Sodium hydrogen carbonate	$NaHCO_3$
Sodium chloride	NaCl	Urea	$CO(NH_2)_2$

The objective of this investigation is to identify the contents of a bottle assigned to you, knowing only that it is one of the 20 substances in Table 1. **DANGER**: *Some of the substances in Table 1 can cause irritation if they come in contact with skin and eyes. They can also cause respiratory irritation if dust is inhaled. Do not eat or drink when using these substances—harmful if swallowed. Handle all solids with care.*

PRE-LAB ACTIVITY

Because this investigation is primarily involved with the physical properties of substances, it is helpful to review different types of bonds, as well as bonding behavior.

1. One test that can help identify a substance is melting temperature. Use the resources available, text, or online references, to find the melting temperatures of the twenty substances in Table 1.
2. When describing whether or not a substance will dissolve in a particular liquid, the phrase "like dissolves like" is often used. Explain the meaning of "like dissolves like" and offer a few examples.
3. An unknown solid is tested to determine its identity. The first test performed is to add a small amount of the unknown to water. The solid does not appear to dissolve in water. What type, or types, of bonding can you eliminate as possible properties of the solid? What might be a good second test to perform on the solid?

INITIAL INVESTIGATION

In the Initial Investigation, you will conduct three tests on the unknown solid substance that has been assigned to your group.

1. Obtain and wear goggles.
2. Obtain a 10 g sample of an unknown substance.

Test I Melting Temperature

3. Use a Melt Station to determine the melting temperature of the unknown sample.
   a. If your unknown solid is not a powder, use a mortar and pestle to grind a small portion of it into a powder. **Important**: If you cannot grind your unknown solid into a powder, skip this test and proceed to Test II.
   b. Check the control dial on the Melt Station to confirm that it is in the Off position. Connect the Melt Station power supply to a powered electrical outlet.
   c. Launch Graphical Analysis. Connect the Melt Station to your Chromebook, computer, or mobile device. The Melt Station is now ready to measure temperature for up to 20 minutes.
   d. Pack a capillary tube 2–3 mm deep with the unknown sample by inserting the open end of the capillary tube into a small pile of the powdered sample. A small amount will be pushed up into the tube. Wipe off any loose solid that is on the outside of the capillary tube.
   e. Tap the closed end of the capillary tube on a table top to compress the sample.
   f. Carefully insert the capillary tube of sample into one of the three slots in the heating block of the Melt Station.
   g. Click or tap Collect to start data collection. On the Melt Station, turn the control knob to a setting of 180ºC. The red light will turn on indicating active heating.
   h. Carefully observe the sample. If it begins to melt, record the temperature. When the entire solid has completely melted, record the temperature. The two values describe the estimated melting temperature range of the substance.

i. If the solid does not melt by the time the temperature reaches 150ºC, turn the control knob to the 220ºC setting. Continue observing the sample, and if the sample begins to melt, mark the temperatures on the graph as previously described.

j. If the sample has not melted by the time the temperature reaches 190ºC, turn the knob to the Rapid Heat setting. When the sample finally begins to melt, record the temperature.

k. If the sample has not melted by the time the temperature reaches 220ºC, then stop data collection and record the estimated melting temperature as >220ºC.

l. After you have determined the approximate melting temperature range for the sample, stop data collection. Discard the capillary tube and sample as directed by your instructor.

m. On the Melt Station, turn the control knob to the Fan/Cooling setting to prepare for the next trial. The blue light will turn on indicating that the fan is cooling the Melt Station. If the sample did not melt, there is no need to conduct a second trial. **Note**: If you collect additional sets of data, the previous data set is automatically stored.

4. To save the file, click or tap File, 🗋, and choose Save.

Test II Solubility in Water

5. Measure out 0.2–0.5 g of the unknown solid and add it to 100 mL of distilled water in a small beaker. Stir the mixture for a few moments. If the solid dissolves, proceed to Test III. If the solid does not dissolve, skip Test III.

Test III Conductivity of a Solution

If the sample is water soluble, use a Conductivity Probe to determine whether or not the sample contains dissolved ions. Note that this sensor does not identify the ions, it merely reports the electrical conductance of dissolved ions.

6. Set up the Conductivity Probe.
   a. Launch Graphical Analysis. Connect the Conductivity Probe to your Chromebook, computer, or mobile device.
   b. Immerse the Conductivity Probe in the beaker of solution prepared in Step 5 so the opening near the end of the probe is completely immersed.
   c. If the conductivity reading is significantly above 0, then the solution contains ions. If the reading is near 0, there are no ions present in the solution.

PLANNING FOR THE FINAL INVESTIGATION

Discuss the results of the Initial Investigation and plan for additional testing to help identify the unknown substance. The unknown will be one of the twenty substances listed in Table 1. Consider the following issues during your group discussion:

- Should any of the tests conducted in the Initial Investigation be done again to help confirm the identity of the unknown?
- Is it possible that the three tests could give false or misleading results?
- Is there additional testing, with or without sensors, that can be done to help identify the unknown or eliminate some of the twenty possibilities?
- Are there physical characteristics of the unknown that may provide the most convincing evidence of its identity?

- Are there chemical properties that could be easily and safely tested to help identify the unknown?

FINAL INVESTIGATION

As you carry out your approved plan, consider the following points:

- The information that provides convincing evidence to eliminate substances from the list of possibilities
- Saving a portion of the unknown in case extra testing is needed
- Handling the sample and taking measurements to acquire the best data

ANALYZING RESULTS

When preparing your report, include

- A statement of the results: What is the identity of the unknown substance assigned to your group?
- An evaluation of the process you followed to identify the unknown
- A description of the physical properties of the substance that helped identify the unknown

Additional items to consider including in your report

- A comparison of your results with the results from other groups
- Recommended modifications to the procedure that would increase accuracy, save time, or ensure that liquids are handled more efficiently and safely
- Recommendations of additional tests, physical or chemical, that would help improve the process of identifying an unknown substance