Case File 7

Drug Tests: Identifying an unknown chemical

Use quantitative and qualitative analyses to identify the powder in Mr. Orlow's car.

Police Report

Patrol officers pulled over Mr. Yuri Orlow for reckless driving last night at 8:50 p.m. A preliminary Breathalyzer test showed that Mr. Orlow was intoxicated. Mr. Orlow consented to a search of the vehicle, in which the officers found traces of a white powder that seemed to have leaked across the leather of the passenger seat. The officers think that Mr. Orlow might have thrown a bag of the unknown substance out the open passenger-side window before pulling over. A search of the snowy road has revealed nothing. The powder has been sent to the lab for testing.

Mr. Orlow has been charged with driving recklessly and awaits a second charge pending the results of the tests on the white powder.

Enclosed are two photographs of Mr. Orlow's car and an evidence vial containing a sample of the powder.

Forensics Objective

- identify an unknown powder using physical and chemical properties

Science and Mathematics Objectives

- distinguish between physical and chemical properties
- distinguish between qualitative and quantitative observation

Materials (for each group)

- TI-83/TI-84 Plus™ Family
- Vernier® EasyData™ application
- Vernier® EasyLink™
- pH Sensor
- Conductivity Probe
- vinegar
- 5 known and 1 unknown "drug" samples (4 g of each)
- distilled or deionized water
- spoons and/or weighing paper (one per sample)
- filter paper
- six 50 mL beakers
- stirring rod
- disposable pipettes or droppers
- wash bottle (with deionized water)
- magnifying glass
- balance
- lint-free tissues
- goggles (1 pair per student)

Procedure

Caution: Obtain and wear goggles during this experiment. Avoid inhaling the powders. Do not taste or smell any of the powders. If you get any powder or liquid on your skin, wash it with water immediately. Tell your teacher right away if any spills or accidents occur.

Part I: Appearance

1. Label five 50 mL beakers with numbers 1 through 5. Label one beaker "Unknown" for the powder taken from Mr. Orlow's car. Using the balance, measure 2 g of each sample and place it in the proper beaker. (To avoid cross-contamination of the other samples, use a different weighing paper or spoon for each sample. Save the spoons or weighing papers for use in Part V.)

2. Observe the samples through the magnifying glass, and record your observations in the Evidence Record.

Part II: Preparing the Solutions

3. Prepare powder-and-water mixtures of the six samples.
   a) Add 20 mL distilled or deionized water to each beaker prepared in step 1. Stir the mixtures thoroughly with the stirring rod. (Note: After stirring one sample, rinse the stirring rod with deionized water and dry it with a lint-free tissue before using it to mix another sample.)
   b) Stir each mixture once every 3 minutes for 15 minutes. After the final stir, let the mixtures settle for about 5 minutes.

c) Write any observations that you can make about the water mixtures into the Evidence Record. (Did they fizz? Were the powders very soluble, or not soluble at all?)

Part III: Testing the pH of the Samples

4. Connect the EasyLink to the USB port in your calculator. Then connect a pH Sensor to the port on the EasyLink. (Note: For this experiment, your teacher already has the pH Sensor in a pH soaking solution in a beaker. Be careful not to tip over the beaker when you connect the sensor to the interface.)

5. Set up the EasyData App for data collection.
   a) Select [File] from the Main screen.
   b) Select option **1: New** to reset the application. The Main screen should be displayed. The Main screen displays the current reading from the pH probe.

> At the bottom of the Main screen are five options ([File], [Setup], [Start], [Graph], and [Quit]). Each of these options can be selected by pressing the calculator key located below it ([Y=], [WINDOW], [ZOOM], [TRACE], or [GRAPH]).
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> 
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6. Use the pH Sensor to determine the pH of the solution in each sample beaker.
   a) Rinse the tip of the pH Sensor with deionized water from the wash bottle and place it into the liquid in the beaker containing sample 1. Be careful not to let the tip of the sensor touch any solid material at the bottom of the beaker.
   b) When the pH reading on the Main screen has stabilized, record it in the Evidence Record.
   c) Repeat steps 6a and 6b for each of the remaining samples.

7. When you are finished, rinse the pH Sensor with deionized water and return it to its storage container.

Part IV: Testing the Conductivity of the Samples

8. Disconnect the pH Sensor from the EasyLink.

9. Connect the Conductivity Probe to the EasyLink. Set the switch on the probe to the 0–20,000 µS setting.

10. Select [File] from the Main screen, and then select option **1: New** to reset the application.

11. Zero the Conductivity Probe.
    a) Place the probe in a beaker of deionized water. Select [Setup].
    b) Select option **7: Zero**. On the resulting screen, select [Zero].

12. Collect conductivity data for each sample.
    a) Place the tip of the probe into the liquid in the beaker containing sample 1. The hole near the tip of the probe should be completely covered by the liquid.
    b) When the conductivity reading on the Main screen has stabilized, record it in your Evidence Record.
    c) Rinse the Conductivity Probe thoroughly with deionized water from the wash bottle before collecting data for the next sample.
    d) Repeat steps 12a–12c for each of the remaining samples.

13. Empty the remaining liquid from the beakers as directed by your teacher. Rinse and dry the beakers.

Part V: Reaction of the Samples with Vinegar

14. In the next test, you will observe the reaction of each of the samples with vinegar, an acid.
    a) Using the balance, measure 2 g of each sample and put it in the proper beaker. (To avoid cross-contamination of the samples, use the measuring papers or spoons that you used in step 1 or use a new paper or clean spoon for each sample.)
    b) Add 10 mL of vinegar to each sample. Observe what reaction takes place (if any). Record your observations in the Evidence Record.

15. When you have observed and recorded the reactions of all of the samples with vinegar, then empty, rinse, and dry the beakers as directed by your teacher.

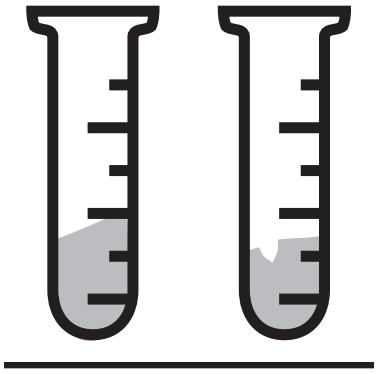
Name: _____
Date: _____

Evidence Record

Sample	General Appearance	Observations of Water Mixture	pH	Conductivity (µS/cm)	Reaction with Vinegar
1					
2					
3					
4					
5					
Unknown					

Case Analysis

1. Based on your observations, which known sample do you think was most similar to the unknown powder found in Mr. Orlow's car? Do you think the unknown was an exact match to that known sample? Explain your answer.
2. Why was it important to measure the amounts of the substances that you used in the lab?
3. Explain the difference between physical and chemical properties. Give two examples of physical properties and one example of a chemical property that you measured in the lab.
4. Explain the difference between qualitative and quantitative observations. Give one example of a qualitative observation and one example of a quantitative observation that you made in the lab.
5. Identify two tests, other than those that you carried out in this investigation, that forensic scientists can use to identify a suspected drug.



Case File 7
Drug Tests: Identifying an unknown chemical

Teacher Notes

Teaching time: one or two class periods

This lab uses the identification of an unknown "drug" to demonstrate the differences between chemical and physical properties and between qualitative and quantitative observations.

Tips

If pH or conductivity readings do not stabilize, have students collect data in Single Point mode (from the Main screen, select Setup and then option **5: Single Point**). When the students select Start, the probe or sensor will collect data for 10 seconds and then display an average reading on the screen.

Lab Preparation

- The following powders work well as samples and unknowns: flour, powdered (ground) salt (NaCl), powdered sugar ($C_6H_{12}O_6$), baking powder ($NaAl(SO_4)_2$ or $NaHCO_3$ + $KHC_4H_4O_6$), baking soda ($NaHCO_3$), talcum powder, baby formula, plaster of paris ($CaSO_4 \cdot \frac{1}{2}H_2O$), cornstarch ($C_6H_{10}O_5$), chalk ($CaCO_3$), and Epsom salts ($MgSO_4 \cdot 7H_2O$).
- You can use empty 35 mm film canisters or other small containers to distribute the unknowns. The lab will go faster if the correct amount of each sample is measured beforehand and given to each group.

Resources

Although the powders being tested in this lab are not illegal drugs, the procedures used by the students are similar to some used by professional forensic chemists. The sites listed below provide information about procedures and techniques for the identification of real drugs.

http://www.swgdrug.org/approved.htm
This site of the Scientific Working Group for the Analysis of Seized Drugs provides information about processes and procedures that are used in the analysis and identification of unknown (presumably illegal) drugs.

http://chrom.tutms.tut.ac.jp/JINNO/DRUGDATA/00database.html
This extensive database of prescription and nonprescription drugs, organized alphabetically or by drug classification (such as analgesic or antipsychotic), provides chemical composition and structure, physical properties, and analytical results.

http://www.streetdrugs.org/index.htm
This comprehensive Web site discusses characteristics, sources, and effects of various street drugs.

Modifications

If you wish, you can use this activity to introduce or explain heats of reaction to your students. Several of the possible "drugs" will show measurable temperature changes when they react with or dissolve in water or vinegar. Have the students measure the temperatures of the water and the vinegar before they are added to the solids in steps 3 and 14. Have them continue to measure the temperatures as the various powders are added and dissolve in and/or react with the liquids. You can have the students use the Vernier EasyTemp™ temperature probe to monitor the temperatures. This

will require *either* that you provide one calculator and temperature probe for each mixture (six per group) *or* that you have the students mix the solutions and measure the temperatures one at a time (requiring more than 90 minutes if the temperature of each mixture is recorded for 15 minutes). If you have a limited number of calculators or time is short, it may be better to have the students use traditional thermometers to monitor the temperatures.

Sample Data

Sample	General Appearance	Observations of Water Mixture	pH	Conductivity (µS/cm)	Reaction with Vinegar
1 (Flour)	Fine, white powder	Did not dissolve	6.5	345	Did not react
2 (Baking Soda)	Fine, white powder	Partially dissolved	8.0	1.39E4	Fizzed vigorously
3 (Baking Powder)	Fine, white powder	Fizzed vigorously	6.9	9049	Fizzed vigorously
4 (Salt)	Fine, white powder	Dissolved	6.7	1.76E4	Nearly dissolved
5 (Sugar)	Fine, white powder	Dissolved	7.2	0	Nearly dissolved
Unknown	Fine, white powder	Fizzed vigorously	6.5	9263	Fizzed vigorously

Case Analysis Answers

1. Based on your observations, which known sample do you think was most similar to the unknown powder found in Mr. Orlow's car? Do you think the unknown was an exact match to that known sample? Explain your answer.
   Answers will vary. Students should describe what properties led to the choice for the unknown. For the sample data, Mr. Orlow's powder appears to be baking powder (with similar pH, conductivity, and reactions with water and vinegar).
2. Why was it important to measure the amounts of the substances that you used in the lab?
   When making comparisons, you must keep all untested variables constant.
3. Explain the difference between physical and chemical properties. Give two examples of physical properties and one example of a chemical property that you measured in the lab.
   Physical properties are properties that you can measure without changing the substance. When chemical properties are measured, the substance is destroyed. The physical properties measured here included solubility, pH, and conductivity. The chemical properties measured were the reactions with water and vinegar.
4. Explain the difference between qualitative and quantitative observations. Give one example of a qualitative observation and one example of a quantitative observation that you made in the lab.
   In a qualitative observation of a substance, you use one of the five senses without taking a measurement. A quantitative observation requires a numerical measurement of some property of the substance. Qualitative observations included dissolution or no dissolution in water and reactions with water and vinegar. Quantitative observations included pH and conductivity.
5. Identify two tests, other than those that you carried out in this investigation, that forensic scientists can use to identify a suspected drug.
   Forensic scientists can use gas chromatography (GC), mass spectroscopy (MS), infrared spectroscopy (FTIR), column chromatography, electrophoresis, titration, precipitation reactions, redox reactions, and other chemical reactions.