What's in That Bottle?  Lab 7

**CENTRAL CHALLENGE**

You will determine the type of bonding in unlabeled chemicals using physical and chemical properties of substances containing ionic, molecular (polar and nonpolar covalent), and metallic bonds.

**CONTEXT FOR THIS INVESTIGATION**

There is a problem in the chemical storeroom. The high humidity in the storeroom caused the labels on some of the chemical bottles to fall off. The labels are lying all over the shelves and it is your job, as a chemistry intern, to design a method that will help identify the chemicals so the labels can be put onto the correct bottles. The unlabeled chemicals are all solids but may be ionic compounds, nonpolar or polar covalent compounds, or metals. There are at least four unlabeled bottles that represent at least one of each type of bond. If the type of substance, or, even better, the identity can be determined, disposal will be less costly to the school. Once the properties of the unknown substances are determined, you will be given information that can help identify the name of each chemical within the unlabeled bottles.

**PRELAB GUIDING QUESTIONS/SIMULATIONS**

Answer Questions 1–2 using Table 1.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Observations</th>
<th>MP (°C)</th>
<th>Solubility in 25°C Water</th>
<th>Types of Elements Metal (M), Nonmetal(NM)</th>
<th>Type of Bond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium chloride (KCl)</td>
<td>White solid</td>
<td>993</td>
<td>Yes</td>
<td>M/NM</td>
<td>Ionic</td>
</tr>
<tr>
<td>Sucrose (C₁₂H₂₂O₁₁)</td>
<td>White solid</td>
<td>186</td>
<td>Yes</td>
<td>NM/NM</td>
<td>Polar covalent</td>
</tr>
<tr>
<td>Iodine (I₂)</td>
<td>Dark gray solid</td>
<td>114</td>
<td>Slightly soluble</td>
<td>NM/NM</td>
<td>Nonpolar covalent</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Gray, shiny metal</td>
<td>420</td>
<td>No</td>
<td>M</td>
<td>Metallic</td>
</tr>
</tbody>
</table>
Pre-lab Questions

1. Compare the type of bond with regard to the properties below using Table 1 and explain any relationships. HINT: Think of what is happening between the bonded atoms as well as what occurs between the particles.
   a. melting point
   b. solubility in 25°C water

2. Predict the properties of each substance below based on Table 1.

<table>
<thead>
<tr>
<th>Substances</th>
<th>Bond Type: Nonpolar Covalent, Polar Covalent, Metallic, Ionic</th>
<th>Relative Melting Point (High or Low)</th>
<th>Solubility in Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexane (C₆H₁₄)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bromobenzene (C₆H₅Br)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium chloride (NaCl)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EXPLANATION TO STRENGTHEN STUDENT UNDERSTANDING

There are few greater potential hazards around the laboratory than that of unmarked or improperly labeled chemicals. Many schools house unused, unlabeled, and improperly stored chemicals. These chemicals can pose a risk to humans and the environment. All chemicals must have complete identification securely fastened to their containers. Chemicals of unknown stability and those that deteriorate over time should have a preparation date clearly indicated on the label.

The chemistry storerooms in schools need to be cleaned out periodically and chemicals properly disposed of. Most chemicals should not be flushed down the drain or thrown into the garbage. Proper disposal of chemicals is costly. If the identity of a substance is not known due to poor labeling or lack of a label, the cost of proper chemical disposal can increase. There are many accidents associated with chemicals that are thrown out and inadvertently mix.

Disposal of unlabeled bottles is dangerous and therefore very expensive and closely regulated by law. The purpose of proper labels is to indicate the source, supplier or manufacturer of the chemicals, the production date, CAS (Chemical Abstract Service) number of the chemical, and to warn of possible hazards. The MSDS (Material Safety Data Sheet) provides personnel with procedures for handling and cleaning up each substance in a safe manner along with details on their physical and chemical properties and toxicity.
# PREPARATION

## Materials

<table>
<thead>
<tr>
<th>Potential unknown solids</th>
<th>Magnesium oxide (MgO)</th>
<th>Benzoic acid (C₆H₅COOH)</th>
<th>Aluminium</th>
<th>Wax/paraffin</th>
<th>Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium chloride (NH₄Cl)</td>
<td>Potassium nitrate (KNO₃)</td>
<td>Urea ((NH₄)₂CO)</td>
<td>Calcium</td>
<td>Iodine (I₂)</td>
<td>Zinc</td>
</tr>
<tr>
<td>Calcium carbonate (CaCO₃)</td>
<td>Sodium carbonate (Na₂CO₃)</td>
<td>Sucrose (C₁₂H₂₂O₁₁)</td>
<td>Copper</td>
<td>Sodium acetate (NaC₂H₃O₂)</td>
<td>Sodium hydrogen carbonate (NaHCO₃)</td>
</tr>
<tr>
<td>Copper (II) sulfate, anhydrous (CuSO₄)</td>
<td>Sodium chloride (NaCl)</td>
<td>Salicylic acid (C₆H₅(OH)COOH)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Materials for testing:

| 95% Ethanol, (C₆H₁₂O₆) 30 mL dropper bottle | Ice | Magnifying lens | Capillary tube | Beaker, 100 mL | Small test tubes and rack |
| Hexanes, 30 mL dropper bottle | Phenolphthalein (dropper bottle) | Ring stand | Thermometer clamp | Thermometer | Conductivity meter or tester (metals and aqueous only) |
| Distilled Water, 30 mL dropper bottle | pH paper and glass rod | Wooden splints | Orthodontic rubber band | Canned food lid | Relevant MSDS for all knowns and unknowns used |
| 0.1 M sodium hydroxide (NaOH) 30 mL dropper bottle | Corks for test tubes | Magnet | Cotton swabs | Well plate or micro well plate | Tongs |
| 0.1 M hydrochloric acid (HCl) 30 mL dropper bottle | Hot plate | Disposable gloves | Wire gauze | Sandpaper | Toothpicks |

### Universal indicator (dropper bottle)

## Safety and Disposal

Safety goggles should be worn at all times in the laboratory. Be cautious of acidic and basic solutions since they can cause skin burns and eye damage. Liquids and solids are to be disposed of in properly labeled waste containers per MSDS guidelines. It is recommended that the lab be done on a small scale to minimize solvent and chemical exposure. If hexanes and iodine are used, it is advisable for the teacher to leave these substances in the hood for student use and to use and exercise appropriate safety precautions. A recommended site for MSDS information is [http://www.ehso.com/msds.php](http://www.ehso.com/msds.php)
**Practice with Instrumentation and Procedure**

The purpose of this portion of the lab is to identify properties that allow one to determine the type of bonding in a substance and to carry out tests that allow one to characterize these properties.

**Procedure**

Given four to six known substances, you will choose at least four different tests, qualitative or quantitative, to study the physical and chemical properties of each of the given substances. Based on your results you will develop a system that will help determine whether an unknown solid is ionic, covalent (polar or nonpolar), or metallic using these tests. Characteristics to consider testing include: color, solubility in water, conductivity of the solid, conductivity in water, pH of the solution in water, solubility in ethanol, solubility in hexanes, high/low melting point (order of melting if qualitative, or quantitative value), reaction with 0.1 M HCl, reaction with 0.1 M NaOH, and magnetism.

Select at least four tests and write a detailed procedure to carry out the tests. Refer to the Materials section for guidance on available materials. Create a data table to record results.

**Pre-Lab Continued**

**Practice Questions**

1. Based on the Practice Instrumentation and Procedure data, list the general properties associated with each bond type (metallic, ionic, polar covalent, nonpolar covalent).

2. Go to two other groups and compare your answers. Write a brief statement about what you learned from discussing results with other groups or as a class.

3. How can your experimental procedure be improved? List what your team/group would do differently. If any additional materials are needed, please inform the teacher.

4. Design a flowchart using your experimental procedure that can help you identify unknown substances.

5. You are given a blue crystalline solid. Using your flowchart, explain how the type of bond can be determined, and what you might observe in the lab.

**Investigation**

**Procedure**

The knowledge acquired in the Practice section for known compounds will now be applied in order to determine the type of bond for four to six unknown solids. Given four to six unknown compounds, you will choose at least four different tests to study physical and chemical properties of the substances. Based on your results, you will develop a system that will help determine whether an unknown solid is ionic, covalent (polar or nonpolar), or metallic using these tests. Characteristics to consider testing include: color, solubility in water, conductivity of the solid, conductivity in water, pH of the solution in water, solubility in ethanol, solubility...
in hexanes, high/low melting point (order of melting if qualitative, or quantitative value), reaction with 0.1 M HCl, reaction with 0.1 M NaOH, and magnetism.

Select at least four tests, quantitative and qualitative, and write a detailed procedure to carry out the tests. Refer to the Materials section for guidance on available materials. Create a data table to record results.

Data Collection and Computation
After you have completed your procedure, identify the bond type in each unknown.

Obtain a list of all of the unlabelled bottles (the unknowns) from your instructor. Using your results and the MSDS for the unknowns, identify the four to six chemicals you tested. Check your results with your instructor.

Post-lab Questions
1. To what extent do you believe the classification of your unknown is reliable? Justify your claim with evidence.
2. Discuss in your group the two most significant tests done to identify each of the types of bonds.
3. Go to another group and compare your answers for Questions 1 and 2. Do you need to revise the answers?
4. Obtain the MSDS of your substances to summarize the toxicity and method of disposal for each of your “unlabeled bottles.”

POSTLAB ASSESSMENT
You may find it necessary to talk to other groups to compare findings as you complete these questions.

6. How do the melting points of ionic compounds compare to those of covalent compounds? What evidence from the investigation supports your conclusion?

6. When the solids were placed in water were all the results the same? What types of solids conduct electricity in water? Use your investigations to explain what happened.

7. Explain how you were able to determine each unknown as being an ionic, metallic, or covalent (polar or nonpolar) compound.

8. If the solid is ionic, explain why you cannot make the general statement that “all ionic compounds are soluble in water.” What evidence from the investigation supports your conclusions?

9. Why was it necessary to use distilled water and not tap water?

10. Metal oxides dissolved in water show a pH in what range? In contrast to these metal oxides, do nonmetal oxides produce the same pH range?

11. Wax is a saturated hydrocarbon, a covalent compound. Wax is not soluble in water yet sugar is also a covalent compound and is soluble in water. Look at the structure of both compounds and explain what could justify these results.
SUPPLEMENTAL RESOURCES

Links
http://bcs.whfreeman.com/thelifewire/content/chp02/02020.html