

Investigation 6

What's in That Bottle?

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, non-polar 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 compounds are determined, you will be given information that can help identify the name of each chemical within the unlabeled bottles. You will determine the type of bonding in unlabeled chemicals using physical and chemical properties of substances containing ionic, molecular (polar and non-polar covalent), and metallic bonds.

Prelab Guiding Questions

Answer Questions 1–2 using Table 1.

Table 1. Properties and Bond Types of Solid Substances

Compound	Observations	MP (°C)	Solubility in 25°C Water	Types of Elements Metal (M), Nonmetal(NM)	Type of Bond
Potassium chloride (KCl)	White solid	993	Yes	M/NM	Ionic
Sucrose (C ₁₂ H ₂₂ O ₁₁)	White solid	186	Yes	NM/NM	Polar covalent
Iodine (I ₂)	Dark gray solid	114	Slightly soluble	NM/NM	Nonpolar covalent
Zinc (Zn)	Gray, shiny metal	420	No	M	Metallic

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.

Compound	Bond Type: Nonpolar Covalent, Polar Covalent, Metallic, Ionic	Relative Melting Point (High or Low)	Solubility in Water
Hexane (C ₆ H ₆)			
Bromobenzene (C ₆ H ₅ Br)			
Sodium chloride (NaCl)			
Iron (Fe)			

3. How do the melting points of ionic compounds compare to those of covalent compounds?
4. What types of solids conduct electricity in water? Why?
5. How could you determine each unknown as being an ionic, metallic, or covalent (polar or nonpolar) compound?

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. Use small amounts of all chemicals to minimize solvent and chemical exposure. Hexanes and iodine should be used in the hood. Exercise appropriate safety precautions

Part 1: 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 compounds, 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), 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.

Materials

Potential unknown solids:					
Ammonium chloride (NH ₄ Cl)	Magnesium oxide (MgO)	Benzoic acid (C ₆ H ₅ COOH)	Aluminum	Wax/paraffin	Magnesium
Calcium carbonate (CaCO ₃)	Potassium nitrate (KNO ₃)	Urea ((NH ₂) ₂ CO)	Calcium	Iodine (I ₂)	Zinc
Copper (II) sulfate, anhydrous (CuSO ₄)	Sodium carbonate (Na ₂ CO ₃)	Sucrose (C ₁₂ H ₂₂ O ₁₁)	Copper	Sodium acetate (NaC ₂ H ₃ O ₂)	Sodium hydrogen carbonate (NaHCO ₃)
Copper (II) sulfate pentahydrate (CuSO ₄ •5H ₂ O)	Sodium chloride (NaCl)	Salicylic acid (C ₆ H ₄ (OH)COOH)			
Materials for testing:					
95% Ethanol, (C ₂ H ₅ OH) 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)					

Lab Questions Part 1

After you complete the first part of the lab, answer the questions that follow.

1. Based on the Practice 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.

Part 2: Investigation

Procedure

Using what you have learned, apply the same four tests and detailed procedure developed in the 'Practice with Instrumentation and Procedure' section to identify at least 4 unknown solids. Include any changes to your previous procedure here.

Data Collection and Computation

After you have completed your procedure, identify the bond type in each unknown.

Obtain a list of all of the unlabeled bottles (the unknowns) from your instructor. Using your results and the MSDS for the unknowns, identify the unknown chemicals you tested. Check your results with your teacher.