Lab: Comparing Physical Properties of Ionic and Covalent Compounds

Introduction

A compound is defined as the chemical combination of two or more elements.
Solid crystals consist of a regular array of particles located at the lattice points in a three-dimensional lattice work.
A chemical bond is the "glue" that holds atoms of different elements together.
Bonds can be classified into two general types: ionic and covalent.

The units which occupy the lattice points in an ionic crystal are alternately spaced positive and negative ions. The force of attraction between the oppositely charged ions constitutes an ionic bond.

Some substances are composed of molecules rather than ions.
Molecules are neutral species composed of atoms which are held together by covalent bonds. Covalent bonds are the result of an attraction between the positive nuclei of two atoms and the negative electrons shared by the two atoms.
When molecules of gases condense, they form molecular liquids and molecular crystals.
In these crystals the lattice points are occupied by molecules.
The molecules in a molecular crystal are composed of atoms which are held together by covalent bonds.
However these strong covalent bonds within the molecules are held by weak intermolecular forces of attraction, called intermolecular forces of attraction, (IMFA).

Properties such as melting point, boiling point, solubility, electrical conductivity, and colour are some of the properties that can be used to distinguish between the different bond types.

This experiment investigates some physical properties of two solids – one a typical ionic compound and the other a typical covalent compound.

Materials

naphthalene, $C_{10}H_8$, sodium chloride, NaCl, test tubes, trichlorotrifluoroethane, TTE, $C_2Cl_3F_3$, (or another organic solvent)

Procedure

1. Test the hardness of each compound by rubbing a small sample between your fingers. Record the hardness as either soft and waxy, or brittle and granular. Record your observations in the Data Table. Wash your hands after testing.

2. Put a small sample (~ 0.1 g) of naphthalene in a test tube and a small sample of sodium chloride in another test tube. Observe their appearance. Note the odour of each. If you detect an odour, assume that the substance is volatile, if there is no odour, assume that it is nonvolatile. What deduction can you make about the type of forces between each type of substance?

3. **Demo in Fume Hood (Teacher)**:
Heat each test tube from procedure 2 in turn, and record the time it takes for any change to occur. How is "melting time" related to the melting point of substances? Which type of compound seems to have the higher melting point?
4. Place a small amount (~ 0.1 g) of naphthalene in a clean test tube containing 5 mL of water. Place an equal amount of sodium chloride in another test tube containing 5 mL of water. Shake each test tube vigorously and describe the solubility of each compound in water.

5. **Demo in Fume Hood (Teacher)**:
Place a small amount of naphthalene in a clean test tube containing 2 mL of TTE in the fume hood. Shake the test tube and describe the solubility of naphthalene in TTE. When finished dispose of the contents of the test tube in the organic waste container in the fume hood.

6. Repeat procedure 5 above using sodium chloride instead of naphthalene. Record the relative solubilities of the two compounds in TTE.

7. **Demo: Teacher**: Observe the conductivity of each compound in the solid state and in solution.

Data Table

Physical property	**Sodium Chloride, NaCl**	**Naphthalene, $C_{10}H_8$**
Hardness, texture		
Odour, Volatility (high, or low)		
Melting point (high, or low)		
Solubility in Water (soluble or insoluble)		
Solubility in TTE (soluble or insoluble)		
Electrical conductivity in the solid state		
Electrical conductivity in aqueous solution		

Data Analysis

1. Use your knowledge of the periodic table, bond types and electronegativities to classify NaCl and $C_{10}H_8$ as either covalent or ionic.

Electronegativity difference of Na and Cl:
.: Ionic or Covalent: _____
Electronegativity difference of C and H:
.: Ionic or Covalent _____

2. Explain in terms of type and relative strengths of attractive forces, the presence or absence of odours of naphthalene and sodium chloride.

Explanation of odour of sodium chloride in terms of type and relative strengths of attractive forces in sodium Chloride, NaCl:

Explanation of odour of naphthalene in terms of type and relative strengths of attractive forces in naphthalene, $C_{10}H_8$:

3. Explain in terms of type and relative strengths of attractive forces the difference in melting point of the two substances.

Explanation of melting point in terms of type and relative strength of attractive forces:
sodium Chloride, NaCl:

naphthalene, $C_{10}H_8$:

4. a. Are you comparing the relative strengths of covalent and ionic bonds when you are comparing relative melting points of NaCl and $C_{10}H_8$?

b. Explain

5. a. Did either of the crystals appear to be soft or waxy?

b. How do you account for any observed differences in hardness of the crystals?

6. How do you explain the conductivity of the substance observed in procedure 7?

Conclusion

Write a conclusion to summarize the physical properties of a substance as related to bond type.

Extension

Use the results of your experiment to predict the properties of the following two compounds: CH_4 and KF.