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Identifying ionic versus covalent compounds based on physical and chemical properties

Introduction:

The purpose of this lab was to identify unknown materials as ionic or covalent compounds based on their physical and chemical properties by observing their structure, as well as their behavior when exposed to thermal and electrical energy.

An ionic compound is a bond formed between a metal and a non-metal when the separate atoms, attempting to reach a more stable state (full outer shell), gain (non-metals) or lose (metals) electrons. Metals are more likely to lose electrons in order to reach a stable state because they have a larger atomic radius than non-metals, and thus require less energy to strip electrons from. These positively- and negatively-charged atoms are now ions, and the oppositely charged ions are attracted to each other to form a bond. Once the ions bond, they have filled the outer electron shell and are thus in the most stable state possible. Ionic compounds are crystalline in structure because each negatively-charged ion must be bonded to a positively-charged ion. Though not electrically conductive when solid, ionic compounds will conduct electricity when dissolved in a solvent because the ions are separated and able to pass the electrical charge between atoms. The high stability of ionic compounds gives them a high melting point, as the attraction between the ions are very strong, and thus require more energy to separate. Ionic compounds have a very low reactivity due to their full octet; they behave similarly to the noble gases, which also have a full octet. The ionic compounds have no desire to gain or lose electrons, and will not react. Ceramics are examples of ionic bonds as they are the chemical combination of metals and non-metals. Ceramics have a high melting point, as well as having a crystalline structure.

Covalent bonds are formed when two non-metal atoms share electrons. The nuclei of both atoms are attracted to the electrons of the other atom, trapping the electrons between the two nuclei. As atoms move closer together, the potential energy decreases. Each nucleus is attracting the other atom's electrons more strongly until the positively-charged nuclei begin to repel each other. Intramolecular bonds are the strongest bonds in a covalent molecule. The bonds between individual atoms in the molecules are stronger than the bonds between molecules, making the covalent molecules easy to separate from each other, and thus very easy to break. The weak bond between molecules in a covalent bond also explains the low melting point of covalent compounds, as less energy is required to separate the molecules. There is no bonding pattern that covalent compounds must follow, unlike ionic compounds; thus they have irregular crystal shapes in their structure. Covalent compounds are not electrically conductive in any state because the molecules have no electrical charge. Polymers are typically covalent bonds, as they have very low melting points and are not crystalline in structure.

Results:

Table 1: Melting point, physical appearance, relative conductivity, and observed structure of Unknowns A-F

Unknown	Melting point/Physical appearance	Conductivity	Structure
A	Medium; ~60 seconds; liquidy & brown	Low-medium; red only	Crystalline
B	High; None after 2 minutes; some sticking	High; red & green	Crystalline
C	Low; ~30 seconds; gray & oxidizing	High; red & green	Not crystalline
D	High; None after 2 minutes	High; red & green	Crystalline
E	Low; ~30 seconds; brown coloring	Low; red only	Not crystalline
F	High; None after 2 minutes	Medium; red only	Not crystalline

Discussion:

The purpose of this lab was to develop the skills necessary in identifying ionic versus covalent bonds based on physical and chemical properties of unknown materials. Unknown A was identified as ionic, as it was crystalline in structure, conducted electricity when dissolved in water, and had a higher relative melting point. Unknown B was classified as being an ionic compound because of its crystalline structure, high electrical conductivity, and high melting point. Unknown C was classified as a covalent compound because, although it conducted electricity like an ionic compound, it was not crystalline in structure and had a very low melting point. Unknown D was determined to be an ionic compound, as it exhibited a high melting point, high electrical conductivity, and a crystalline structure. Unknown E was shown to be a covalent compound based on its low melting point, non-crystalline structure, and very low electrical conductivity. Unknown F was determined to be an ionic compound based on its electrical conductivity and high melting point.

I am confident in my findings for Unknowns A, B, and D, because their physical and chemical properties were identical to the properties of ionic compounds. I am less certain about C, E, and F because the materials had properties of both ionic and covalent compounds. Unknown C had a low melting point and was not crystalline like a covalent compound, but exhibited very high electrical conductivity like an ionic compound. Unknown E, like Unknown C, had the low melting point and non-crystalline structure of a covalent compound, but conducted electricity like an ionic compound. Unknown F had a high melting point and conducted electricity, much like an ionic compound, but it was not crystalline in structure as an ionic compound should have been. These discrepancies in data made identification of Unknowns C, E, and F difficult.

As our data should not have reflected that each sample conducted electricity because not all of the samples were ionically bonded, contamination of either the samples or of the conductivity probe are highly likely. Even a small amount of an ionic compound, either mixed in with the covalent unknown or left behind on the wires of the conductivity probe, would skew our results. If this experiment were ever repeated, I would be sure to obtain each sample with a clean scoopula, free of any residue from any other unknown, and dry the wires of the conductivity probes before testing a new sample. These changes would help to prevent the contamination of the data collection concerned with electrical conductivity of unknown samples.