Adit Shah

Rebecca Cebula

Chemistry

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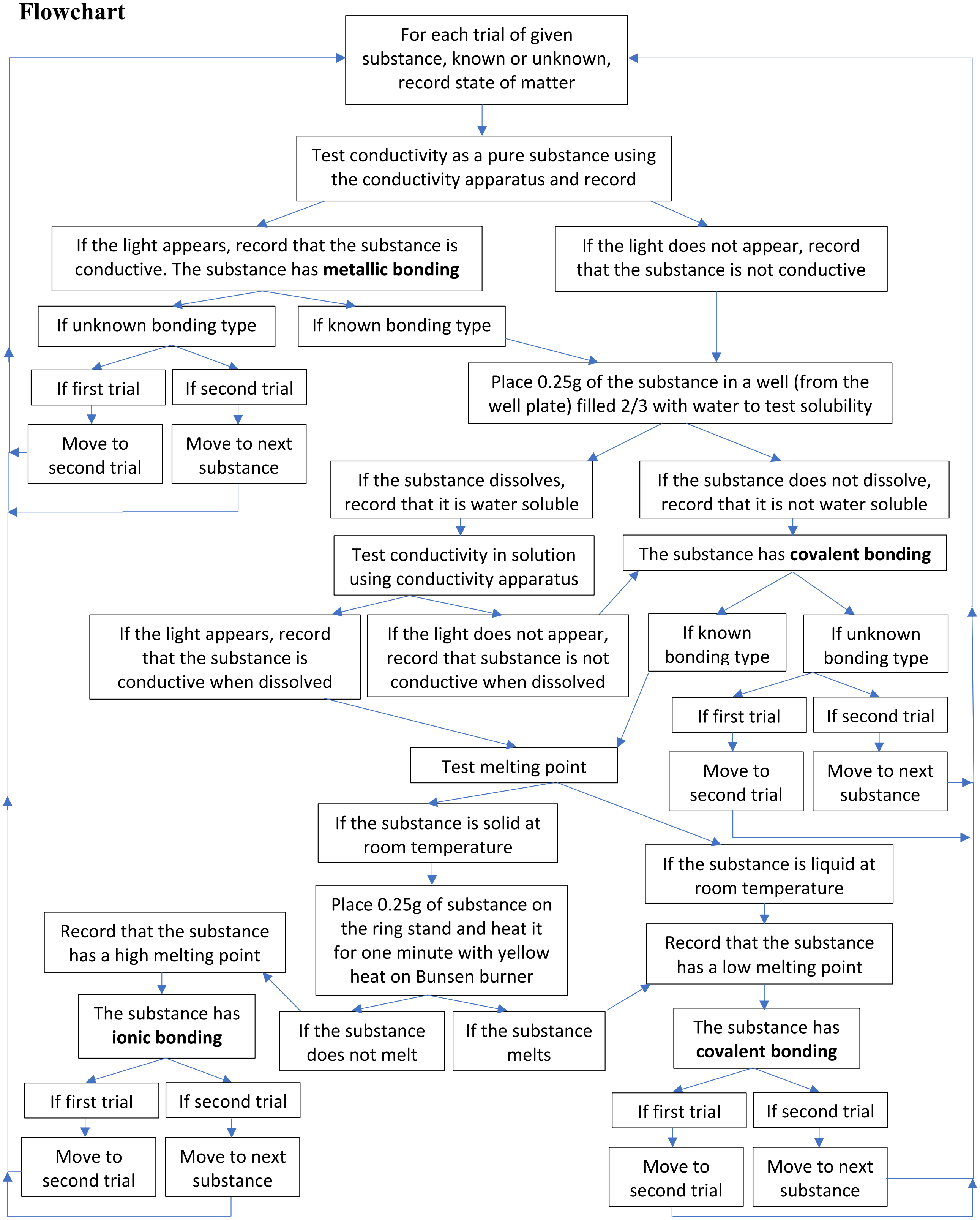
Determining the Bonding Types of Unknown Substances By Observing Macroscopic Properties

Lab Partner: Patrick Macilwaine

Purpose

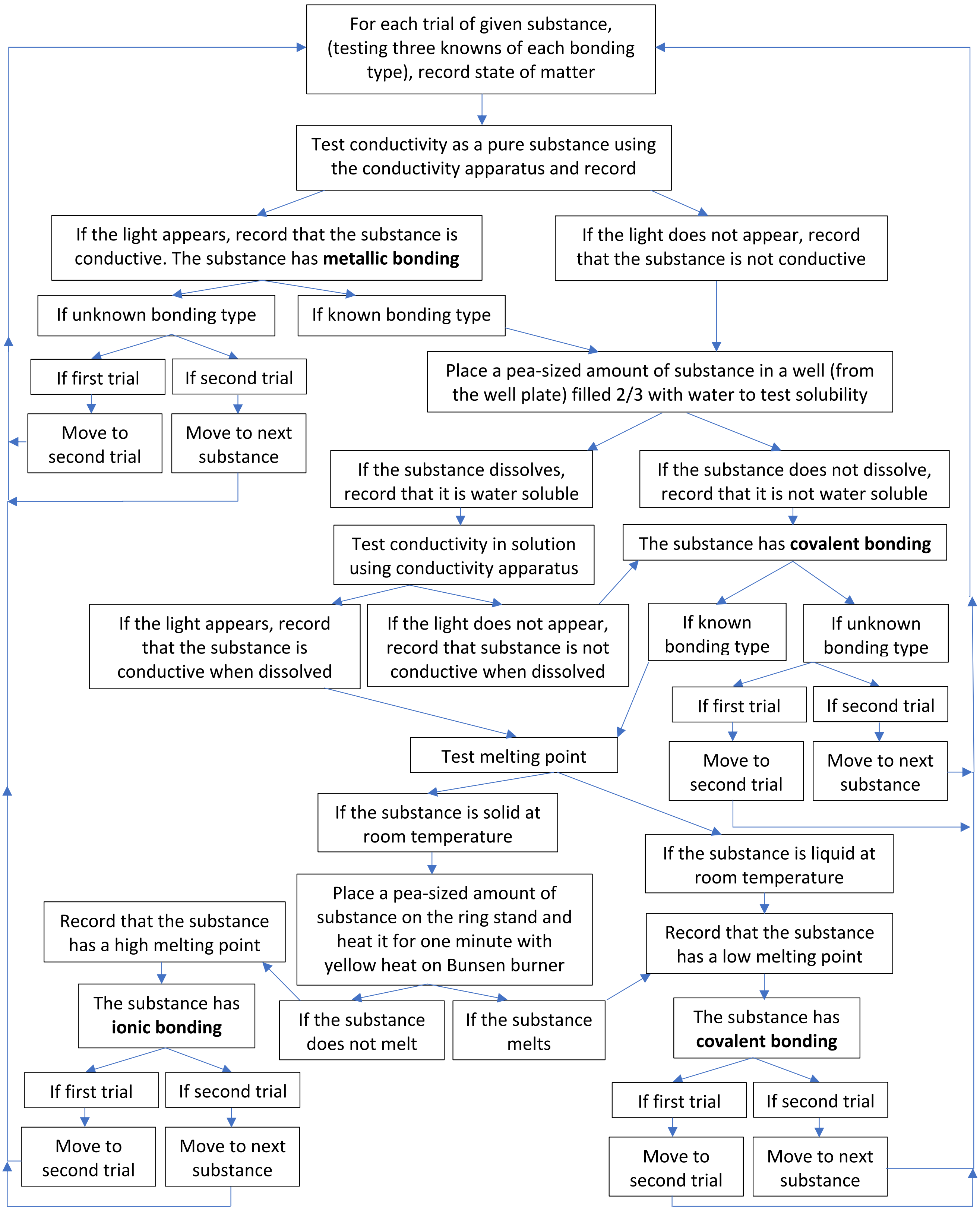
The purpose of this experiment is to determine the bonding types of 2 unknown substances. The bonding type will be determined by observing the macroscopic properties of the substances with various experiments and comparing these properties to the properties of substances with a known bonding type (Cebula, What the Heck is that Stuff 2018).

Flowchart



Flowchart Summary: This flowchart provides a basis to determine the type of bonding present in an unknown substance, both by observing macroscopic properties and comparing them to the known substances to confirm their identity.

Revised Flowchart



Revision Summary: The number of knowns tested was clarified, and the quantities of substances were changed from “0.25g” to “pea-sized amount” because their masses were not measured during the experiment. There were no major sources of human error.

Data Table

Substance	State of matter?	Conducts as Pure Substance?	Solubility in Water?	Conducts when Dissolved?	Melting point?
Covalent #1 Trial 1	Solid	No	No	N/A	Low
Covalent #1 Trial 2	Solid	No	No	N/A	Low
Covalent #2 Trial 1	Solid	No	Yes	No	Low
Covalent #2 Trial 2	Solid	No	Yes	No	Low
Covalent #3 Trial 1	Solid	No	Yes	Yes	Low
Covalent #3 Trial 2	Solid	No	Yes	Yes	Low
Ionic #1 Trial 1	Solid	No	Yes	Yes	High
Ionic #1 Trial 2	Solid	No	Yes	Yes	High
Ionic #2 Trial 1	Solid	No	Yes	Yes	Low
Ionic #2 Trial 2	Solid	No	Yes	Yes	Low
Ionic #3 Trial 1	Solid	No	Yes	Yes	High
Ionic #3 Trial 2	Solid	No	Yes	Yes	High
Metallic #1 Trial 1	Solid	Yes	No	N/A	High
Metallic #1 Trial 2	Solid	Yes	No	N/A	High
Metallic #2 Trial 1	Solid	Yes	No	N/A	High
Metallic #2 Trial 2	Solid	Yes	No	N/A	High
Metallic #3 Trial 1	Solid	Yes	No	N/A	High
Metallic #3 Trial 2	Solid	Yes	No	N/A	High
Unknown #5 Trial 1	Solid	No	No	N/A	N/A
Unknown #5 Trial 2	Solid	No	No	N/A	N/A
Unknown #10 Trial 1	Solid	No	Yes	Yes	High
Unknown #10 Trial 2	Solid	No	Yes	Yes	High

Analysis

Unknown substance #5 has covalent bonding, and unknown substance #10 has ionic bonding. Unknown #5 has the same properties as Covalent #1, and therefore is covalent. Unknown #10 has the same properties as Ionic #1 and Ionic #3, and therefore is ionic.

Discussion

Unknown substance #5 has covalent bonding, and unknown substance #10 has ionic bonding. A compound's macroscopic properties are determined by their bonding type. Hence, the bonding types were determined by testing if the substances were conductive, testing if they dissolved in water, testing their conductivity when dissolved, and determining whether the melting point was "low" or "high" with a Bunsen burner (Cebula, What the Heck is that Stuff 2018). Unknown #5 is not conductive as a pure substance, and not soluble in water, indicating that it is covalent. Unknown #10 is not conductive as a pure substance, is soluble in water, is conductive when dissolved, and has a high melting point, indicating that it is ionic.

Unknown #5 and Unknown #10 are not conductive as a pure substance, implying that they cannot be metallic. Metallic compounds are conductive because the electrons are not fixed to a particular atom, rather, they are free to move around within the compound as seen in Figure 1 because the electrons are delocalized. Ionic and covalent compounds are not conductive as a pure substance because the electrons are essential to the structure of the atom, and cannot be removed without changing its properties, as seen in Figures 2 and 3 (Cebula, Chemical Bonding 2018). Unknown substance #5 is not soluble in water, implying that it cannot have ionic bonding. Ionic compounds form in a lattice structure with alternating cations and anions to maximize electrostatic attraction and minimize repulsion as seen in Figure 2. Because water molecules are polar, when ionic compounds are mixed with water, the positive ends of the water molecules will attract the anions, and the negative

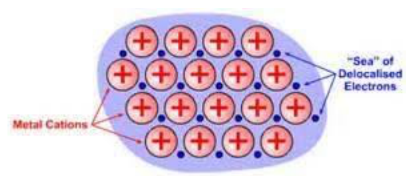


Figure 1: Metallic bond with delocalized elections Credit: https://www.meta-synthesis.com/web book/38_laing/metallic_x.jpg

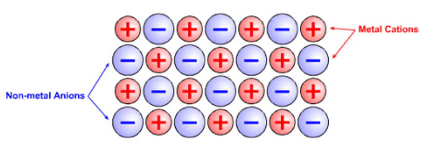


Figure 2: Ionic bond with lattice structure Credit: https://www.meta-synthesis.com/ webbook/38_laing/ionic_bonding.jpg

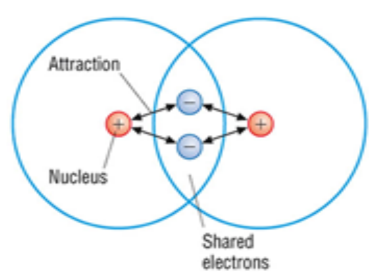


Figure 3: Covalent bond with shared electrons Credit: https://www.worldofchemicals.com/ Article/573/250x170/covalent%20bond.jpg

ends of water molecules will attract the cations. This causes the dissociation, or pulling apart, of the ionic compound, into cations and anions, and results in the ionic compound dissolving in the water, which is visualized in Figure 4 (Cebula, Chemical Bonding 2018). Hence, because

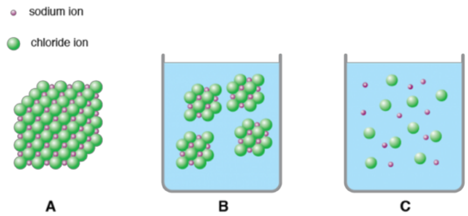


Figure 4: NaCl dissolving in water (dissociation) Credit: https://manoa.hawaii.edu/exploringourfluidearth/sites/default/files/styles/full-page-width/public/M2U2-Fig2.33%20Dissolve.png?itok=O3x8Z6hw

unknown substance #5 did not dissolve in water, and did not conduct electricity, it must be covalent, which aligns with the results from Covalent #1. Unknown #10 is soluble in water and conductive when dissolved, which implies that it could be ionic or covalent. Although covalent compounds are generally insoluble in water, and generally do not conduct even when dissolved, their properties vary widely based on the structure of the molecule and the strength of the intermolecular forces (Cebula, Chemical Bonding 2018). Hence, to determine whether Unknown #10 is ionic or covalent, the melting point must be considered. Ionic substances tend to have a high melting point because the strong electrostatic forces within the ionic bond require a high amount of energy to break as seen in Figure 2. Covalent substances tend to have a low melting point because although the covalent bond is very strong, the intermolecular forces are much weaker (Cebula, Chemical Bonding 2018). To melt a covalent compound, only the intermolecular bond needs to be broken. Because Unknown #10 has a high melting point, it is an ionic compound. This aligns with the properties of Ionic #1 and Ionic #3.

The most significant source of systematic error in this experiment is the procedure for measuring and classifying substances based on their melting points. The melting points were classified as “low” or “high” based on whether the substances melted when placed on a piece of aluminum foil on a ring stand above a Bunsen burner at yellow heat for one minute. This is a source of error because the temperature being tested is both inconsistent and arbitrary. The temperature could vary based on the distance between the flame and the aluminum foil, and the substances at the center of the foil could be at a higher temperature. Additionally, the boundary between “low” and “high” is arbitrary, and consequently there may be ionic substances with a “low” melting point (such as Ionic #2) or covalent substances with a “high” melting point. To minimize this error, the temperature of the substance when it melts would be measured rather than simply making a binary classification. A boundary between low and high could then be established based on the melting points of ionic and covalent knowns.

Unknown #5 is covalent, and unknown #10 is ionic. Because bonding type determines macroscopic properties, observations of these properties can be used to determine the bonding type. Unknown #5 is not conductive as a pure substance and not water soluble, indicating that it is covalent. Unknown #10 is not conductive as a pure substance, is water soluble, is conductive when dissolved, and has a high melting point, indicating that it is ionic. An area for further study would be to determine the strength of substances’ intermolecular forces based on their macroscopic properties.

Works Cited

Cebula, Rebecca, and Luca, Maria. “Lab: What the Heck is that Stuff?” Handout. The Athenian School. Danville, CA. Print.

Cebula, Rebecca, and Luca, Maria. “Unit 3: Chemical Bonding Part 1.” Packet. The Athenian School. Danville, CA. Print.