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Course: FVS Chemistry AB 19.3

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Question: Based on a substance's properties, how can you determine whether its bonds are ionic or covalent?

Claim: If a substance is solid at room temperature, has a crystalline structure, dissolves easily in water, and conducts electricity well, then it likely contains ionic bonds. Otherwise, it likely contains covalent bonds.

Evidence:

Property	Oil	Cornstarch	Sodium Chloride	Sodium Bicarbonate
State of Matter	Liquid	Solid	Solid	Solid
Appearance and Texture	Pale Yellow and Viscous, Amorphous	Powdery and White	Granular and White	Powdery and White
Crystalline Structure (Yes/No)	No (not solid)	No (non-crystalline solid)	Yes	Yes
Solubility in Water	None	None	All	Most
Conductivity when in Water (Yes/No)	No	No	Yes	Yes
Ionic or Covalent Bonds	Covalent	Covalent	Ionic	Ionic

I know this because all examined substances follow most trends as expected. Starting with the covalent substances, oil is liquid at room temperature, leading us to think it is covalent in line with the claim; cornstarch is solid, contradicting the trend, showing that these trends for ionic and covalent bonds aren't hard and fast. The more "strict" properties such as solubility in water, crystalline structure, and conductivity while in solution are, respectively none, none, and none—exactly as one would expect for covalent substances.

The ionic substances, in turn, satisfy the predictions much more readily. They are both solid at room temperature and have a crystalline structure visible macroscopically as grains or powder. Also, they mostly or completely dissolve in water and allow it to conduct electricity in solution—precisely as predicted by the claim.

Justification (Reasoning) of the Evidence:

The properties listed occur in these examples and in general because of core structural differences in ionic and covalent bonds. The most important of these differences is the strong polarisation of ionic compounds. Such a polarisation is generated from the cations losing their outer valence shell to the anions.

The strongly polar nature of ionic compounds manifests in high (compared to covalent compounds) boiling and melting points because of the resultant high intermolecular forces. Covalent bonds have low boiling and melting points because they have lower intermolecular forces. Even if a given covalent bond is polar, ionic bonds are generally stronger because they contain strongly charged ions instead of generally uncharged atoms of which one more strongly attracts electrons. This can also explain why ionic compounds dissolve in water more readily than a typical covalent compound (generally nonpolar or weakly polar). The strong polarity of these ionic compounds allows the water, a weakly polar compound and a polar solvent, to dissolve the solute and dissociate the ions.

These dissociated ions are precisely why a solution of an ionic compound and water is extremely conductive—the electrons flow through the ions sliding around inside the liquid to generate an electric current. The crystals that ionic compounds form occur for a loosely related reason: the ions can associate very readily into 3-dimensional crystals (the bonds are just the strong attraction between the ions, which works the same with 20 pairs or with 200). These crystals also have low potential energy, making them one of the most stable forms for ionic compounds to be in.