Answer Key: As Easy as Pie

Background
It’s Thanksgiving morning and you answer a frantic phone call from your grandma. She tells you she spent all day yesterday baking her famous pies for Thanksgiving dinner and left them on the counter to cool overnight. When she woke up this morning, they were gone. She doesn’t have time to make more pie, and Thanksgiving dinner won’t be the same without them. She suspects the thief is someone she knows, so she has already collected some evidence. She is depending on you and your chemistry skills to help her track down the thief and confirm her suspicions.

When you arrive at her house, you notice some white powder that has been tracked across her kitchen floor. You ask her what it is, but she used so many white powders in the creation of her masterpieces, she’s not sure which one it is. You head to her pantry and discover the following:
- Salt, NaCl, an ionic compound used for flavoring
- Baking soda, NaHCO₃, an ionic compound that is used as a leavening agent in baked goods
- Corn starch, C₆H₁₁O₅, a covalent compound used as a thickening agent
- Powdered sugar, C₁₂H₂₂O₁₁, a covalent compound used as a sweetener

You take some notes then ask her about her preliminary investigation. She hands you the following profiles:

**Suspect #1**
Name: Betty Crump
Occupation: Grandma’s best friend & nosy neighbor
Evidence: White powdery substance collected from the stairs of the back door to her house
Back-story: Betty has extended family coming to town for Thanksgiving dinner and is a terrible cook

**Suspect #2**
Name: Gladys Smith
Occupation: Retired teacher & vocal city councilwoman
Evidence: White powdery substance collected near her kitchen sink, right next to where she keeps her dentures
Back-story: Gladys is Grandma’s biggest Bingo rival, and she is jealous of Grandma’s recent winnings

**Suspect #3**
Name: George Jones
Occupation: Works for the city’s transportation department
Evidence: White powdery substance collected from his work boot soles
Back-story: George is a big fan of Grandma’s pies and has been begging her to make him one for him to take to his own family’s Thanksgiving

**Suspect #4**
Name: Millie Malone
Occupation: Retired lunch lady & county fair blue ribbon contender
Evidence: White powdery substance collected from the door handle leading into her kitchen
Back-story: Millie’s pies placed second in the last county fair behind Grandma’s, and she still hasn’t gotten over it
You collect the white powder from the kitchen floor, the white powders from the pantry, the evidence collected at the homes of the suspects, vinegar from the pantry, iodine from the medicine cabinet, a hot plate, beakers, a spot plate, a conductivity tester, and pH paper from your chemistry lab, and get to work.

Procedure
Design a series of tests to determine what the unknown substance on the kitchen floor is. Write out the steps you take in the space below – make sure your instructions are clear and could be easily repeated by another scientist.

Answers may vary, but possible tests include:

1. Add a small amount of water to a small amount of the powder sample in a small beaker or cup and mix them together. Record your observations.
2. Use the conductivity tester in the powder-water mixture to see if it conducts electricity.
3. Add a small amount of the powder to a spot plate. Pour a small amount of vinegar into the same spot. Record your observations.
4. Add a small amount of the powder to another spot on the spot plate. Add a few drops of iodine. Record your observations.
5. Repeat for each sample.

Other notes: Students may choose to use pH paper instead of a reaction with vinegar (identifies baking soda, which is basic). Ionic compounds (baking soda, salt) will conduct electricity when dissolved in water, but covalent compounds (cornstarch, powdered sugar) will not. Only cornstarch should react with the iodine, and it forms a non-Newtonian fluid when it is mixed with water.

Data
Create a data table to clearly organize the information you gather from your tests.

<table>
<thead>
<tr>
<th></th>
<th>Grandma’s Kitchen</th>
<th>Betty’s door</th>
<th>Gladys’s sink</th>
<th>George’s boots</th>
<th>Millie’s door</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mix with Water</strong></td>
<td>Results for the unknown will vary depending on which one you choose but will match one of the other 4</td>
<td>Gooey mixture</td>
<td>Dissolved</td>
<td>Dissolved</td>
<td>Dissolved</td>
</tr>
<tr>
<td><strong>Conductivity test in water</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td><strong>Add vinegar</strong></td>
<td>No reaction</td>
<td>Bubbles</td>
<td>No reaction</td>
<td>No reaction</td>
<td></td>
</tr>
<tr>
<td><strong>Add iodine</strong></td>
<td>Turns dark purple</td>
<td>No reaction</td>
<td>No reaction</td>
<td>No reaction</td>
<td></td>
</tr>
</tbody>
</table>

Conclusion
Who stole Grandma’s pies?! Explain how your tests led you to this conclusion.

Answers will vary depending on which substance you choose as the one found in the kitchen.

**If it is cornstarch:** The unknown substance formed agooey mixture when mixed with water and turned dark purple when iodine was added, and the powder from Betty’s stairs is the only one that reacted this way, so the pie thief must have been Betty.

**If it is baking soda:** The unknown substance formed bubbles when it was mixed with vinegar (or showed as basic on pH paper if they used that instead), and the powder from Gladys’s sink was the only one that reacted this way, so it must have been Gladys.

**If it is salt:** The unknown substance dissolved in water and conducted electricity when dissolved, but did not react with vinegar or iodine, and the powder from George’s boots was the only one that behaved this way, so it must have been George.

**If it is powdered sugar:** The unknown substance dissolved in water and did not conduct electricity or react with vinegar or iodine, and the powder from Millie’s door was the only one that behaved this way, so it must have been Millie.