Goodie bag #3: Ionic solids

Handed out on 9.19.18 | Quiz #3 on 9.27.18

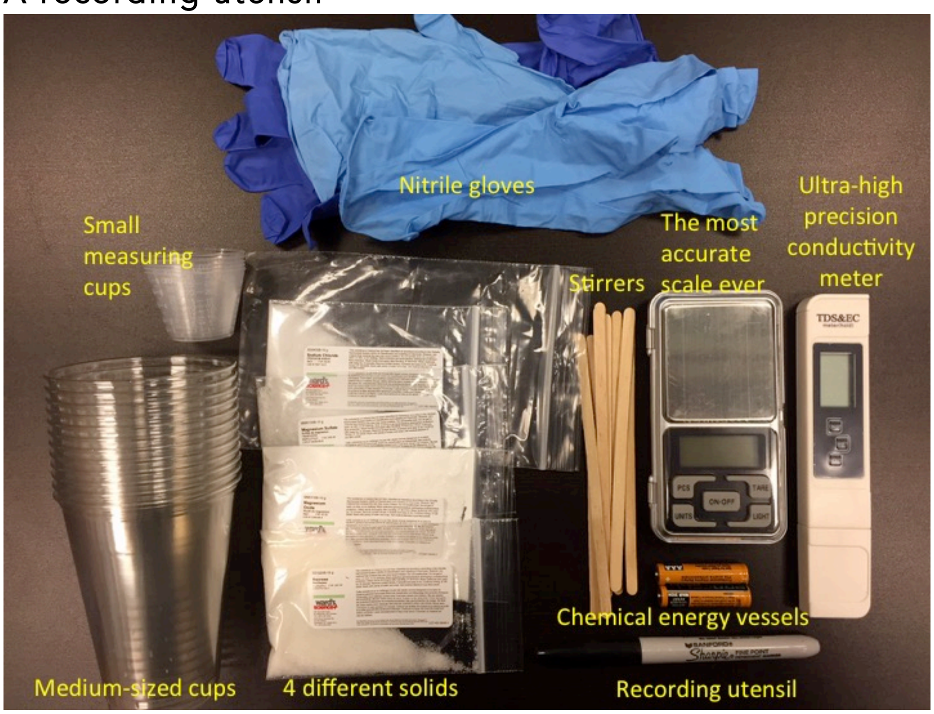
3.091

Do yourself a solid.

Please treat all contents of every Goodie Bag with care; remember that any item may be dangerous if improperly used. You are responsible for your own actions. Make sure to carry out any activities with items in this bag in an appropriate environment.

This bag contains:

- 4 solids in individual bags:
  - Sodium chloride
  - Magnesium sulfate
  - Magnesium oxide
  - Sucrose
- 12 medium-size cups
- 5 small measuring cups
- Stirrers
- The most accurate scale ever (which you should keep for use with GB8!!!)
- 2 chemical energy vessels for use with the scale
- An ultra-high-precision conductivity meter (which is so technically advanced that it also serves as a thermometer! But we won't use that.)
- 2 pairs of nitrile gloves
- A recording utensil



What to bring to the quiz: your conductivity meter

Introduction

Today in class we did something incredible. We bonded. Not only that, but we bonded into a full-on solid. We learned that some atoms don't mind losing an electron, or two or three, while other atoms like to gain electrons. When such atoms come together, one can "take" an electron from the other, making one atom effectively positively charged and the other negatively charged. These atoms are held together by a simple Coulombic attraction, the case of the ionic bond. The next several lectures cover a way to think about these valence electrons (yes, that would be Lewis dots), how they participate in bonds, and how they can be shared across atoms to form another type of bond, the covalent bond. This goodie bag will explore different types of solids by comparing some of their properties using incredible measurement technologies. The core knowledge and practice covered included: ionic solids, covalent solids, lattice energy, Lewis structures.

Instructions & Questions

Preparation:

- Make sure you have a fair bit of space available, away from any food or drink. Next to a source of running water would be ideal, or you can fill a bottle/bucket ahead of time.
- Set aside 2 medium cups and 1 measuring cup for each solid (8 medium cups and 4 measuring cups total).
- Using your leftover measuring cup, pour 1 measuring cup's worth of water into each of the 8 medium cups.

Experiment 1: Solubility.

- For each solid:
  - Place the measuring cup on the scale and press "tare" to zero out the weight.
  - Weigh 1g of solid on your scale, using a measuring cup as a container.
  - Pour into the water.
  - Mix with a stirrer for a few seconds (if the solid dissolves right away) or 1-2min (if it doesn't).
  - Using the marker, label the cup with the name of the chemical in it.
- When you are done with all the solids, look at each cup and record whether the solid entirely dissolved or not (some solids which hadn't dissolved right after mixing may have dissolved now). See table in the Questions for record-keeping.

Experiment 2: Conductivity.

- Take out the conductivity meter, remove the protective cap from the probe.
- Prepare 2 or 3 cups full of water, which will be used as reference/cleaning baths.
- Turn on the conductivity meter, press the "Units" button until it displays the conductivity in µS/cm.
- Dip the end of the conductimeter into a cup of water and record the conductivity value. You can then dip it into another cup of water, to see how reliable the measurement is. This is our baseline – the value in the absence of any reaction.
- Dip the conductimeter into each solution you previously made and record the conductivity value (XXXX means the conductivity exceeds 10,000 µS/cm). See table in the Questions for record-keeping. *NOTE: Be sure to clean the probe between each measurement! Either by passing it under running water for a few seconds (ideally), or by dipping and agitating it in a cup of water (whose water may need to be changed after a few measurements…). Make sure to verify the baseline before each new*

measurement by dipping the probe in water and verifying that the value isn't too much higher than the original measurement for water.

Experiment 3: Solubility again.

- For each solid that had dissolved the first time, redo the same experiment adding 1 more gram: weigh 1g, pour into the same cup, and mix with a stirrer.
- Look at each cup and record whether the solid entirely dissolved or not. See table in the Questions for record-keeping.

Questions.

- Fill out the following table with your results and by calculating the necessary quantities. For chemicals that had a conductivity over 10,000μS/cm, you can write 10,000.

Chemical	Solubility (yes/no)		Conductivity (after baseline subtraction)	Molar mass
	1g	2g		
Sodium chloride				
Magnesium oxide				
Magnesium sulfate				
Sucrose				

- Looking at the solubility and conductivity data and using your knowledge of common properties of ionic and covalent solids, make predictions about which of the solids are likely to be ionic or covalent.

- Use the relationship given in class (Coulomb's law) to rank the lattice energies of sodium chloride, magnesium sulfate and magnesium oxide. Here are the interatomic distances in the solids under consideration:
  r($NaCl$) = 2.8 A
  r($MgSO_4$) = 3.2 A
  r(MgO) = 1.7 A
  You will also need to write down each solid's ionic Lewis formula to deduce the number of charges on each ion.
  How does this ranking help rationalize the difference in the measured properties?

- How many moles of charge are there in the $MgSO_4$ solution with 1 gram dissolved? If 1 g of MgO could fully dissolve, how many moles of charge would there be in solution?