## Quiz Module 3

Due: 11:59pm on Friday, April 28, 2017

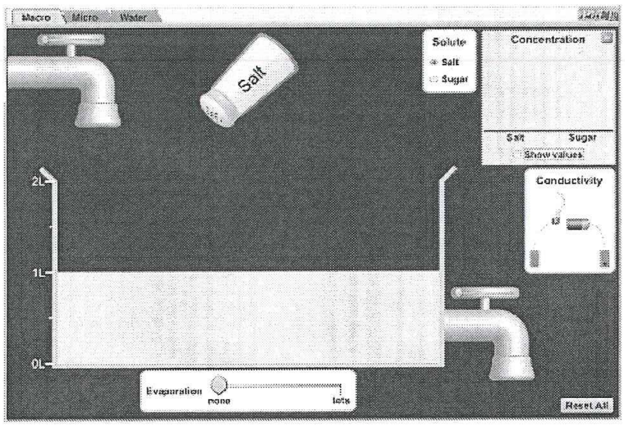
You will receive no credit for items you complete after the assignment is due. Grading Policy

### PhET Simulation - Sugar and Salt Solutions

NOTE: These activities use Java, and are therefore not screen-reader accessible and may not work on a mobile device. If the browser you're using no longer supports Java, try a different browser and download the Java plugin for this content.

Molecules are atoms that are bonded together; these bonds can be either ionic or covalent. Ionic bonds occur between two atoms that do not share electrons. Although ionic bonds are the strongest type of interaction (between a positive charge and a negative charge), they can be easily dissociated in water because water has stronger interactions with the ions when it is significantly more abundant. Covalent bonds do not dissociate in water, the electrons can be unevenly shared between atoms such that the atoms participating in those bonds can have partial charges. In fact, water is one such molecule, where the oxygen has a partial negative charge because oxygen is more electronegative than the hydrogens, and the hydrogens have partial positive charges. Molecules with significant partial charges can interact with each other and ions in a similar manner to ion-ion interactions.

Click on the image below to explore this simulation, which allows you to explore the dissolution of various ionic and covalent species at three levels as they dissolve in water. When you click the simulation link, you may be asked whether to run, open, or save the file. Choose to run or open it.




The **Macro** menu reflects what we observe on the human observational level when either salt or sugar is dissolved. The **Micro** menu depicts what occurs on a molecular level for various salts and different types of sugars. The **Water** menu shows how the partial charges interact with each other and with ions.

### Part A

In the PhET simulation window, click the **Macro** menu in the top left corner of the screen. This view gives a view of the beaker at a macroscopic level (as your naked eye would see it). The **Micro** menu shows what happens to sugars and salts at the molecular level when they dissolve in water (note that you can use the arrows to switch to other type of solutes). Use both the **Macro** and **Micro** menus in the PhET simulation to help complete the following statements regarding solutions.

**Match the words in the left column to the appropriate blanks in the sentences on the right. Make certain each sentence is complete before submitting your answer.**

ANSWER:

Electrolytes and Nonelectrolytes

Electrolytes, typically known as salts, dissolve in water to form ions in solution. For some of these salts, the ion can be a polyatomic ion, which is a charged particle that consists of more than one element, e.g., $NO_3^-$ .

Salts are not the only ionizable compounds. Acid and base compounds, where $H^+$ serves as the cation, can dissociate in water. The molecular formulas for organic acids are commonly written with a $-COOH$ ending or with the acidic hydrogen first to distinguish them from nonacidic isomers, e.g., $C_2H_5COOH$ or $HC_3H_5O_2$ for propanoic acid.

Some molecules dissolve in water without forming ions, thus they would be considered nonelectrolytes. These molecules are formed by covalent bonds and are able to dissolve due to interactions between their partial charges and the partial charges on water. In the case of water, this type of interaction is known as hydrogen bonding. Hydrogen bonding can occur between molecules in which hydrogen is covalently bonded to an electronegative element (oxygen, nitrogen, fluorine), and partially positive hydrogen will interact with an electronegative atom on another molecule.

### Part B

Sort the following compounds based on whether or not they will behave as electrolytes that dissolve via ionization or as soluble nonelectrolytes that dissolve via hydrogen bonding.

**Drag the appropriate formulas to their respective bins.**

ANSWER:

Reset Help

- partial charges
- ions
- opposite
- NaCl
- solute
- sugar
- negatively
- positively
- $CaCl_2$

1. Pure water contains only water molecules that interact strongly with each other due to their ____, which are graphically depicted as $\delta^+$ and $\delta^-$ .

2. Solutions are formed when a ____ like a salt or sugar becomes homogeneously distributed in a solvent like water, and this distribution can be viewed in the **Micro** view.

3. When salts dissolve, they separate into individual ____ that strongly interact with the water molecules.

4. Binary salts are made up of two elements at varying ratios, where one element is a ____ charged cation, and the other is a ____ charged anion.

5. In the **Micro** view, each shake of the container releases 6 molecules of its respective solute, but 6 molecules of the salt ____ actually produce more ions in solution than 6 molecules of the salt ____.

6. Not all soluble molecules are salts, e.g., a covalent species like ____ readily dissolves in water without forming ions.

7. The reason they dissolve is because their partially charged atoms are able to associate with the partially charged atoms of water molecules, and these attractive forces occur as long as they are between atoms with ____ charges.

Electrostatic Interactions

Solutes are constantly in motion when dissolved in a solvent. While in motion, similar charges on atoms will repel each other (+/+, +/$\delta^+$ , $\delta^+$ /$\delta^+$ , –/–, –/$\delta^-$ , $\delta^-$ /$\delta^-$ ), whereas opposite charges will attract atoms to each other (+/–, +/$\delta^-$ , –/$\delta^+$ , $\delta^+$ /$\delta^-$ ). The oppositely charged interactions require the least amount of energy, thus molecules will predominantly orient in a manner that benefits electrostatic attraction.

### Part C

Move each water molecule (each has a unique orientation) to the most ideal locations in the depicted scenario such that the strongest combination of electrostatic attractions are occurring.

**Drag the appropriate water molecule orientations to their respective targets.**

ANSWER:

Reset Help

$H_2CO_3$ | $K_2SO_4$ | $C_3H_8O_3$ | $PH_3$ | $C_{12}H_{22}O_{11}$ | $Co(ClO)_2$ | $NaNO_3$ | $CaCl_2$ | $C_6H_{12}O_6$

| Electrolytes that dissolve via ionization | Nonelectrolytes that dissolve via hydrogen bonding |
|---|---|
| | |

## Electrolytes, Conductivity, and Resistance

Conductivity is the ability for materials to allow the flow of electrons, ions, or both. This movement of charged species is generally known as current, and the prevention or inhibition of current is known as resistance. Even when there are ions in solution, resistance still exists, and there are limitations to the amount of current that can flow. This resistance causes the charged species to separate over some distance and creates a potential (also known as voltage). Increasing the concentration of ions reduces resistance. Conductive metals like silver, copper, and gold have negligible resistance to the flow of electrons; therefore resistors are always included in circuits to control the voltage.

$$V = IR$$

where $V$ represents voltage (in volts, $\mathrm{V}$ ), $I$ represents current (in amperes, $\mathrm{A}$ ), and $R$ represents resistance (in ohms, $\Omega$ ).

Batteries are constructed to have an internal resistance that produces a known potential, which is why consumer batteries are rated at 1.5 $\mathrm{V}$ , 9 $\mathrm{V}$ , 12 $\mathrm{V}$ , etc. The following describes what happens when a circuit is shorted: a lower resistance pathway is introduced to a designed circuit, and electric current would flow through that new pathway instead since electrons and ions always travel the path of least resistance, and both the resistance and voltage would be considerably reduced (they can even approach values of zero).

### Part D

In the PhET simulation, click the Macro menu in the top left corner of the screen. Notice the circuit available in the Conductivity tab on the right side of the screen. This circuit contains a negative electrode (green bar), positive electrode (red bar), battery, and light bulb. Drag this circuit to the beaker. Notice that you can change the length of the wire for both the electrodes by dragging them up or down (provide images with wire lengths changed). Sort the following the submersion scenarios according to whether they will result in a short circuit, a completed circuit that conducts electricity, or an incomplete circuit that does not conduct electricity.

**Drag the appropriate items into the respective bins.**

ANSWER:

## Sample Exercise 4.1 Practice Exercise 1 with feedback

**Part A -** Relating Relative Numbers of Anions and Cations to Chemical Formulas

If you have an aqueous solution that contains 1.5 $\mathrm{mol}$ of $HCl$, how many moles of ions are in the solution?

ANSWER:

Reset Help

battery in $CaCl_2$ solution | both electrodes in $CaCl_2$ solution | both electrodes in glucose solution | positive electrode in glucose solution

both electrodes in pure water | both electrodes in $NaCl$ solution | battery in $NaCl$ solution | negative electrode in pure water

negative electrode in $NaCl$ solution | battery in pure water

| Does not complete the circuit | Completes the circuit | A short circuit exists |
|---|---|---|
| | | |

Correct

$HCl$ is a strong electrolyte that completely ionizes in water, thus 1.5 $\mathrm{mol}$ of hydrogen ions are formed and 1.5 $\mathrm{mol}$ of chloride ions are formed to give a total of 3.0 $\mathrm{mol}$ of ions when in aqueous solution.