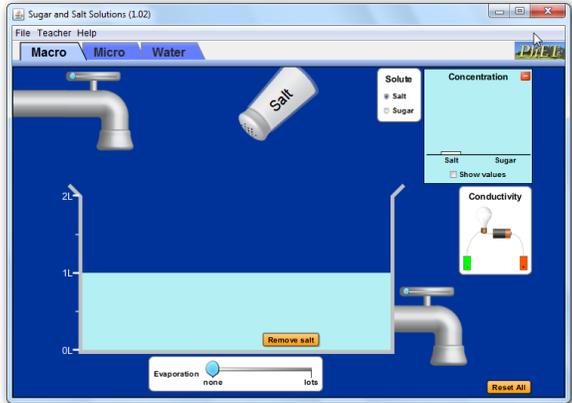


## Sample Unit Plans – Homogenous Solutions (90 minute periods)

Day 1: [Sugar and Salts PhET](#) (pages 2-3)



Homework - textbook reading and note taking

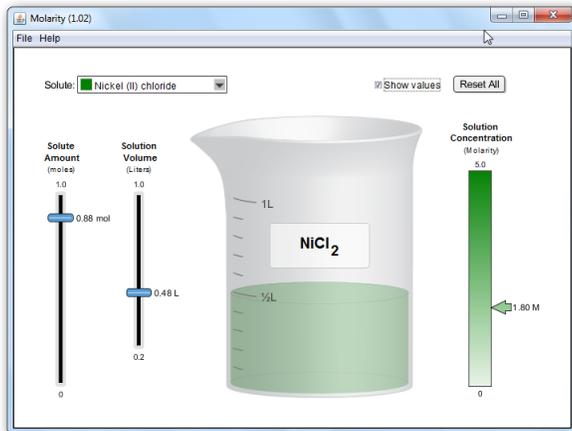
Day 2: Lecture - Polar vs non-polar solvents, sample text concept questions

Class discussion - clicker questions Sugar and Salts PhET (pages 4-5)

Lab - Solubility of salt and sugar (page 6)

Homework - textbook reading, note taking, and problems

Day 3: [PhET Molarity](#) (pages 7 – 8)



Day 4: Lecture- Concentrations of solutions calculations: molarity, dilutions, percent by mass

Lab - Small scale molarity lab (page 9)

Homework - textbook reading, note taking, and problems

Day 5: Class discussion, Clicker questions Molarity (10-11)

Homework - Review worksheet or textbook problems

Day 6: TEST

## Lesson plan for *Sugar and Salts*:

<http://phet.colorado.edu>

**Learning Goals:** Students will be able to:

- Identify if a compound is a salt or sugar by macroscopic observations or microscopic representations.
- Explain how using combinations of solutes changes solution characteristics or not.
- Use observations to explain ways concentration of a solute can change.
- Describe ways the formula, macroscopic observations, or microscopic representations of a compound indicates if the bonding is ionic or covalent.

### **Background:**

Most of the college prep chemistry students will have experience with molecular representations of moving particles in physics, but not all of the students took physics. In honors chemistry, students will have used molecular representations in their text book, physics and chemistry lessons using PhET. In regular chemistry, during a lab about salts, I put out some sugar, salt, and acid solutions and provided a conductivity tester. The honors students should have experience with conductivity from physics. At this point in the course, we will not have talked about anhydrides, so the students would not predict molecular compounds like  $\text{CO}_2$  to conduct in water. I have avoided the issue in the clicker questions.

### ***Sugar and Salt* Introduction:**

Students may have difficulty with the scale of the Micro tab since the water is not depicted. The number of water particles is really quite small, so the representation is an over simplification of the actual hydration process. The third tab is meant to help with this, but there is no way to exclude the water particles, so during the post-lab or during class, I plan to demonstrate that the third tab is a “super microscopic” version of the second tab. [Tips for Teachers](#) are provided by the PhET team.

**Lesson:** In college prep chemistry, the students will work in pairs during class. I noticed that students did not realize that there were 5 different solutes and many only were answering the questions for “salt” and “sugar”; I began checking groups and guiding them to use the other salt and sugars. I changed the directions to include the number of chemicals available hoping this helps. My honors chemistry students will do this activity for homework because they have already had an introduction to molecular representations of solutes using Salts and Solubility [Activity 1](#).

**Post-Lesson:** I plan to use clicker questions included in this activity. For some of the questions, if I saw that the distribution of answers was great, I demonstrated the sim to help students after the first clicker response before I made any comments. Then I would have a “revote”. This stimulated lots of discussion between votes.

I included an alcohol in the lab and it seemed that most students made appropriate predictions because “it was made up of the same elements as sugar that it would not dissociate”. I included a clicker question to help them see the difference between acids and alcohols because my texts both integrate acids and alcohols early in the sequence, but just as classification introduction, not function. I also specifically included aluminum because some students think it is a metalloid; the texts both mention this irregularity on the periodic table, so I wanted to reinforce the metal nature of Al. Having HCl in the questions also provides an opportunity to remind students that Hydrogen is not a metal even though it is on the metal side of the periodic table in the versions that they use.

**Following Activities:** Real lab with Salt and sugar (see activity for file) and Molarity: Quantitative Relationship's.

## Student directions: *Sugar and Salts* activity

**Learning Goals:** Students will be able to:

- Identify if a compound is a salt or sugar by macroscopic observations or microscopic representations.
- Explain how using combinations of solutes changes solution characteristics or not.
- Use observations to explain ways concentration of a solute can change.
- Describe ways the formula, macroscopic observations, or microscopic representations of a compound indicates if the bonding is ionic or covalent.

**Directions:**

1. Describe:
  - a. Solute, solvent, and solution.
  - b. What solvent is used in the sim? Why do you think it was chosen? What types of solutes are used? What representations or tools did you use to help you decide the “type of solute”?
  - c. List each of the 5 chemicals in the simulation and identify the “type of solute” to which each belongs. Give at least one piece of evidence for each.
  - d. Which the *Micro* tab solute combinations are more complex than others? Explain.
2. What is the “concentration” specifically indicating for each “type of solute”? Make sure to include the differences between the Macro and Micro tabs.
3. Find all the ways you can change the concentration of a solute. Describe what you would do in a real lab to increase or decrease the concentration of a solution.
4. Using your text or cite other resources to describe the difference between an “ionic” and a “covalent” compound. Why is the periodic table given as an optional display? How could you use your periodic table to predict conductivity of a solution?
5. Draw pictures that would show what the following chemicals would look like on a microscopic scale if dissolved in water-
  - a. LiF
  - b. KNO<sub>3</sub>
  - c. C<sub>2</sub>H<sub>5</sub>OH
  - d. MgF<sub>2</sub>

# Clicker Questions

1. Which would you predict to be a salt?

- A.  $\text{CO}_2$
- B.  $\text{CaCl}_2$
- C.  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
- D.  $\text{HCl}$

1. Ans Which would you predict to be a salt?

- A.  $\text{CO}_2$
- B.  $\text{CaCl}_2$
- C.  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
- D.  $\text{HCl}$

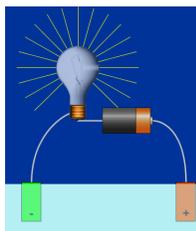
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn						

Legend:  Metal       Non-metal

A metal combined with a non-metal make a "salt".

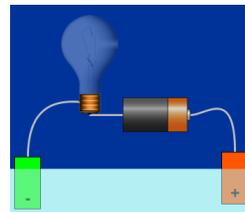
2. If a compound conducts electricity when in solution with water, you might categorize the compound as a

- A. salt
- B. sugar
- C. Both conduct
- D. Neither conduct



3. Which would not conduct electricity very well in solution with pure water?

- A.  $\text{O}_2$
- B.  $\text{CaCl}_2$
- C.  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
- D.  $\text{HCl}$
- E. More than one of these

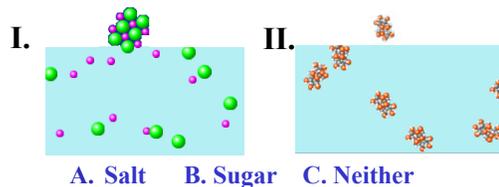


3ans. Which would not conduct electricity very well in solution with pure water?

- A.  $\text{O}_2$
- B.  $\text{CaCl}_2$
- C.  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
- D.  $\text{HCl}$
- E. More than one of these

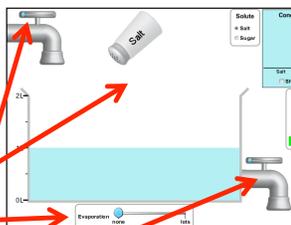
Non-metals combined with each other don't break into ions in solution. Ions are needed to conduct. Acids are an exception (compounds that begin with H); usually they break into ions.

4. If the microscopic view of a compound in water looks like the picture on the left (I.), you might categorize the compound as a



5. To increase the concentration of a solution, you could

- A. Add more water
- B. Add more salt
- C. Evaporate
- D. Drain out solution
- E. More than one of these



6. Which would you predict to be ionic?

- A. NO
- B.  $MgF_2$
- C.  $Al_2O_3$
- D.  $I_2$
- E. More than one of these

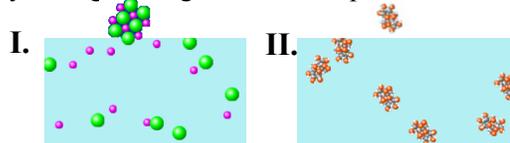
6ans. Which would you predict to be ionic?

- A. NO
- B.  $MgF_2$
- C.  $Al_2O_3$
- D.  $I_2$
- E. More than one of these

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn						

Legend: Metal (grey box), Non-metal (pink box)

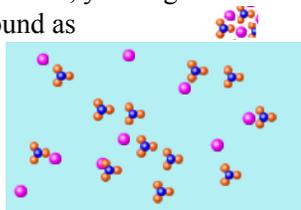
7. If the microscopic view of a compound in water looks like the picture on the left (I.), you might categorize the compound as a



- A. Ionic
- B. Covalent
- C. Neither

7b What is the compound on the right (II.)?

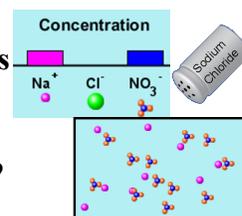
8. If the microscopic view of a compound in water looks like the picture, you might categorize the compound as



- A. Ionic
- B. Covalent

7b How are the particles bonded?

9. If Sodium Chloride is added to this solution, how will the concentrations change?



- A. Only the  $Na^+$  will increase
- B.  $Na^+$  and  $Cl^-$  will increase
- C.  $NO_3^-$  will decrease
- D. More than one of these

## Laboratory: Solubility of Table Salt and Table Sugar in Water

**Purpose:** Determine the solubility of table salt and table sugar in room temperature water using varying amounts of water.

**Data:** Read the experiment directions and the calculations. Then design a data table that will serve to show your data and allow required predictions.

### Directions:

Part A: Table salt

1. Mass a clean cup or beaker, then put about 150 grams of table salt in it and record the amount of salt.
2. Measure 20 ml of water into a 150 ml beaker.
3. Carefully add salt and while stirring until the solution appears to be barely over saturation.
4. Record the amount of salt that dissolved.
5. Add another 10 ml of water to your salt solution and then find out how much will dissolve.
6. Continue adding 10ml of water and then salt until you reach a total of 80 ml of solution.

Part A: Table sugar

Repeat 1-6 procedure with table sugar and water.

### Graph and Calculations:

1. Graph your results and include a trendline. (use graph paper or Excel). Consider these ideas before you finalize your graph.
  - a. How did you decide what to put on the x- axis?
  - b. How did you decide what type of trendline to use?
  - c. Do you have any outliers that should be excluded in a trendline?
2. Describe how to use your graph to predict how much of each substance in grams will dissolve in 100 ml of water at room temperature using each trial. State your prediction.
3. Research to find the accepted value for solubility of each substance in g/100ml. Then calculate your percent error.
4. Show how to calculate how much of each substance in moles will dissolve in 100 ml of water using each trial.

### Questions:

1. Explain why your results might have some variation and also a percent error. (ie. your precision and accuracy errors) Make sure to explain experimental errors that are not just “mistakes”, but design issues.
2. What ideas do you have that might explain why the solubility of salt is not the same as sugar?

# Lesson plan for *Molarity: Quantitative Relationships*

<http://phet.colorado.edu>

Time for activity

**Learning Goals:** Students will be able to

- A. Determine the solubility for some solutes and explain why the solubility cannot be determined for others given experimental constraints.
- B. Identify the relationships for measurable variables by designing quantitative experiments, collecting data, graphing, and using appropriate trend lines.

**Background:** My students will have used [Salts and Solutions](#) and [Sugar and Salts](#), so they are familiar with macroscopic and microscopic views of solutions. Additionally, we have used many PhET sims like [States of Matter](#) and [Gas Properties](#). In our Gas Laws unit, I discovered that the students needed more practice selecting appropriate curves for fit. We use Excel and TI graphing calculators pervasively in our school, so I was surprised that the seniors were poor at selecting appropriate curves when data had reasonable variations. So I had them do a lab with sugar and salts (file attached in this activity). We had more discussion about curve choice and then did this activity.

## ***Molarity* Introduction:**

I did not show anything about the sim. The [Tips](#) have good information about the assumptions made in this sim.

## **Lesson:**

The students took about 2 -40 minute periods to complete this activity.

**Post-Lesson:** I have not written any clicker questions. We did a lab I wrote called Molarity and Dilution. I chose the nickel salt because I had a large supply and it has a nice color. I did not worry that it might not totally dissolve, but just wanted to make sure it was colored and that dilution would look very different. You could use any number of chemical and perhaps one that is more soluble. My jar was full and had not been used in 15 years, so it seemed a good use. We have chemical traps, so I don't have to worry about disposal.

## Student directions Molarity activity

**Learning Goals:** Students will be able to

- Determine the solubility for some solutes and explain why the solubility cannot be determined for others given experimental constraints.
- Identify the relationships for measurable variables by designing quantitative experiments, collecting data, graphing, and using appropriate trend lines.

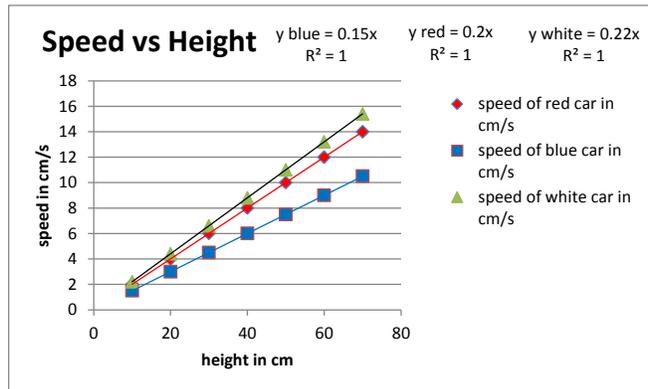
**Prelab:**

- When you were dissolving salt or sugar in a beaker of water, how did you know it was a saturated solution?
- If you designed an experiment for another student for them to see some saturated solutions and some unsaturated solutions, what might you have them do?

**Directions:**

- Make a list of all the solutes and determine the solubility if possible.
  - Explain how you know you have identified the solubility.
  - Explain why you couldn't determine the solubility for some substances. How does this explanation match your experimental ideas for Prelab #2?
- What are the variables for solutions in this simulation? Which are independent and which are dependent?
- Design an experiment to determine the relationship between one of the independent variables and the dependent one. Collect data for more than one solute so that you will have more than one trend line to support your conclusion about the relationship.
  - Excel hint: To graph more than one set of data and make multiple trendlines. First make sure that the independent variable values are consistent; put them in the A column. Then, you can put the dependent results in other columns. For example, a student may design an experiment to determine the speed of three toy cars at the bottom of a ramp released from a variety of heights. Their data table and graph might look like this:

Height in cm	speed of red car in cm/s	speed of blue car in cm/s	speed of white car in cm/s
10	2	1.5	2.2
20	4	3	4.4
30	6	4.5	6.6
40	8	6	8.8
50	10	7.5	11
60	12	9	13.2
70	14	10.5	15.4



- Design an experiment to determine the relationship between the other independent variable and the dependent one. Collect data for more than one solute so that you will have more than one trend line to support your conclusion about the relationship

## Molarity and Dilution

### Students will be able to:

- Determine the amount of grams of solute to make a given volume of specified molarity.
- After dilution, determine the molarity of a solution.

### Directions:

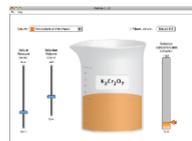
Part A: Make 100 ml of a 0.08 M solution of  $\text{NiNH}_4\text{SO}_4$

1. Calculate how many grams of  $\text{NiNH}_4\text{SO}_4$  you will need.
2. Show your calculation to your teacher for approval.
3. Get a clean 150 ml beaker and put in about 25 ml distilled water.
4. Use a small piece of wax paper to measure your  $\text{NiNH}_4\text{SO}_4$ .
5. Carefully add your  $\text{NiNH}_4\text{SO}_4$  to the beaker and use the wash bottle to get all of the particles off the paper. Then stir.
6. Pour your solution into a 100ml volumetric flask. Wash all of the solution out of the beaker into the flask using your wash bottle.
7. Fill the flask to the line using the wash bottle.

Part B: Dilute your solution

1. Pour your solution back into your 150 ml beaker.
2. Measure 10ml of the solution and put it in the 100ml flask.
3. Carefully fill the flask to the 100 ml mark. Put on the lid and gently rotate to stir.
4. Show your calculation to determine the concentration of the Part B solution.
5. Show your teacher both of the solutions and the work for PartB #4 for credit.

## Molarity PhET



**Learning Goals:** Students will be able to

- Determine the solubility for some solutes and explain why the solubility cannot be determined for others given experimental constraints.
- Identify the relationships for measurable variables by designing quantitative experiments, collecting data, graphing, and using appropriate trend lines.

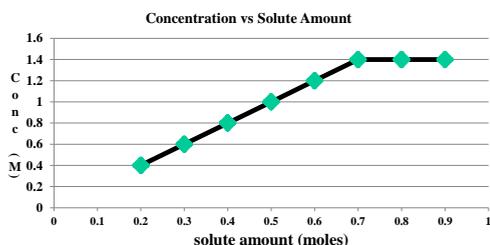
Trish Loeblein March 2013 [Molarity](#)

1. Which of these solutions look like they are saturated?



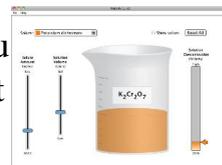
- A.                      B.                      C.  
D. none of these    E. two of these

2. What do you think the solubility of this solution is?



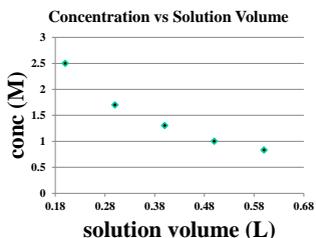
- A. 0.7 moles    B. 1.4 M  
C. 2.0M/moles    D. Can't be determined

3. Which could help you identify the independent variables?



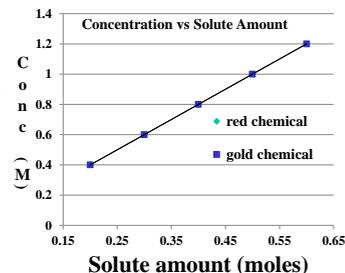
- A. Move a slider and see if another measurement changes  
B. Assume that there is only one independent variable  
C. Move a slider and anything that changes is an independent variable  
D. More than one of these

4. Given this graph, what can you say about the experiment?



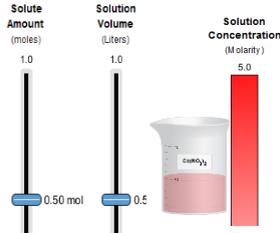
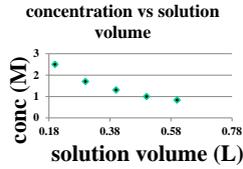
- A. Amount of solute was the independent variable  
B. Amount of solution was the independent variable  
C. Concentration was the independent variable  
D. More than one of these

5. Given this graph, what can you say about the relationship between amount of solute and concentration?



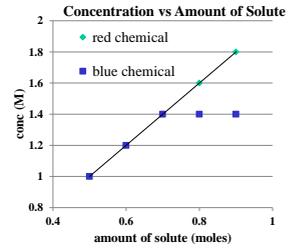
- A. The amount and concentration are directly related  
B. Some chemicals are not as soluble as others  
C. The relationship is the same for the chemicals used  
D. More than one of these

6. What was held constant in the experiment that gives this graph? (Assume good experimental design)



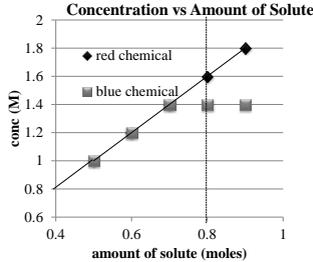
- A. The amount of solute
- B. The solution volume
- C. The concentration
- D. More than one of these

7. Given this graph, what can you say about the relationship between amount of solution and concentration?



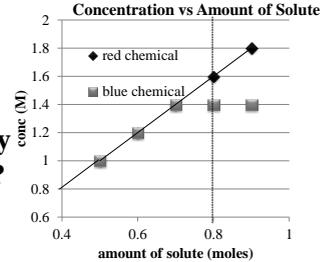
- A. The amount and concentration are directly related
- B. Some chemicals are not as soluble as others
- C. The relationship is the same for the chemicals used
- D. More than one of these

8. Given this graph, what would you predict for the concentration at 0.8 moles of solute for each chemical?



- A. Red(♦) is 1.6M and Blue (■) is 1.4 M
- B. They are both 0.4M
- C. They are both 1.6 M

9. Given this graph, what would you predict the solubility of the red chemical?



- A. Red(♦) solubility is 1.6M
- B. Red(♦) solubility is 1.4M
- C. Red(♦) solubility is 0.8M
- D. Cannot be determined by this experiment