NAME ______________________________ **SECTION** ________________

PARTNER(S)_________________________ **DATE** ___________________

INVESTIGATING SOLUTIONS

The objective of this activity is to uncover characteristics of a variety of solutions and factors that affect the making of solutions.

Pre-Lab Queries

Based on the work you have done in the laboratory (or course) so far this semester, explain how you could tell if a liquid you were given was a solution or pure substance.

Procedure

A **solution** is a homogeneous mixture of two or more substances that can be mixed in variable proportions. Any combination of phases may result in a solution but most commonly solids or liquids are mixed with liquids. The material that serves as the dissolving medium is called the **solvent**. The component that is dissolved is called the **solute**. Some solutions are called true solutions. **Salty water**, also known as brine (NaCl in H_2O), is a **true solution.** Solutions that have water as the solvent are called **aqueous solutions**.

1. Make a sample of salty water by placing a small amount of salt in a test tube about half full of distilled water and shaking the tube. For the second mixture place a very small amount of powdered coffee creamer in the same amount of water, and for the third mixture place sand in water.

   How could you recover the NaCl and determine the % salt in the water?

   Make the series of observations as suggested in the table below. Perform whatever procedure will help you make the observation. For each mixture and observation, insert a descriptor which best fits.

Observations	**NaCl + H_2O**	**creamer + H_2O**	**sand + H_2O**
Homogeneous or heterogeneous			
Clear or cloudy? (while being shaken)			
Settles on standing? (yes or no)			
Can be separated by gravity filtration? (yes or no)			
Scatters a laser beam (is the beam visible within the mixture if it is aimed at the side of the container?)			
Which has smallest, medium, and largest particles of the three samples?			

Based on your observations, summarize the properties of a true solution.

List two other examples of true solutions from your experience.

Why do you think some countries that are arid and border on oceans do not process ocean water to obtain water for drinking water and for irrigation?

The sand/water is a **heterogeneous mixture**. A suspension settles over time but will scatter light while the particles are suspended. List an example of a mixture that has similar properties to the sand/water mixture (another suspension).

The creamer/water combination formed a **colloid.** A **colloid** has suspended particles that do not settle out but do scatter light. If the suspended particles come from a liquid solute and are dispersed in a liquid the resulting mixture is called an **emulsion**. Provide an example of a mixture that has similar properties to the cornstarch and water.

2. Is a tea a true solution? Explain.

Using one tea bag and 3 small beakers of hot water, make very weak, medium strength, and strong tea.

Thinking back to the *Separation I* activity, what separation process is used in the preparation of the tea?

Describe in your own words the difference between the three mixtures with respect to both composition and appearance.

Are the descriptors *weak, medium, and strong* precise enough that someone else could make another cup of tea that exactly matches the tea you made? Explain

How could someone else make a cup of tea just like your cup of medium tea, if they had your tea in front of them?

The amount of solute in a given amount of solution is called the **concentration**. Devise and explain a method of describing the concentration of a cup of tea that would allow another person to match exactly what you made without seeing your tea.

Would your method work if the tea had no color? ________

Would it work if you used any kind of tea? ________

Hypothetically speaking, how would you make the world's most dilute cup of tea?

Do you think it is possible to make infinitely more concentrated cups of tea? Why or why not?

Note: In chemistry, we avoid the use of the terms strong and weak to describe solution concentrations because these terms have a different meaning which relates to the behavior of certain compounds in water.

3. If you added ½ teaspoon of sugar, $C_{12}H_{22}O_{11}$, to your most concentrated tea and stirred, would your mixture still have the properties of a true solution? Explain.

If you added 12 or more teaspoons full of sugar to your beaker of tea would you still have a true solution? Explain.

If you had a liter of tea instead of the amount in the small beaker, would your answer about adding 12 teaspoons of sugar be the same? Explain.

If you had a liter of iced tea instead of hot tea, would your answer about adding 12 teaspoons of sugar be the same. Explain.

Is there a limit to the amount of sugar that can be added to hot tea and iced tea? Explain.

Summarize what you know about the concentration of a solution. Think in terms of solute (what is dissolved) and solvent (what does the dissolving).

4. If you had one liter of water, and wanted to add exactly 6.02×10^{23} molecules of sugar, (sucrose - $C_{12}H_{22}O_{11}$), how much sugar would you add? Show your work.

If you added 10.0 grams of sucrose to one liter of water, how many molecules would be mixed in with the water molecules?

5. After you added Avogadro's number of sugar molecules to the one liter of water, do you think that the volume of the water with the sugar mixed in would still be one liter? Explain.

Describe how you could make a solution of sugar water that contained a known amount of sugar molecules, but that was exactly one liter in volume after the solute and solvent were mixed.

If you took the 1 liter of sugar solution that contains Avogadro's number of sugar molecules and poured 250 mL of it into a beaker and boiled away the water, the number of sugar molecules left in the beaker would be_________________________.

6. It is known that in order for a material to be a conductor of electricity (allow electrons to pass through it) it must contain **freely moving charged particles.** There is an apparatus which has a light bulb on top of two black electrodes and also has an electrical plug attached which can be used to determine the conductivity of anything placed between the electrodes. This apparatus is known as the **E**lectronic **C**onductivity **A**pparatus (**ECA**). ***Caution- your body will conduct electricity so do not touch the electrodes while the apparatus is plugged in.***

Plug in the ECA. Does anything happen? Why or why not?

Place the electrodes of the ECA in a solution of NaCl in water that is contained in a wide mouth jar. Does anything happen? Why?

Pull out the plug and rinse the electrodes with distilled water. You can raise a container of distilled water up around the electrodes or squirt the electrodes with distilled water from a wash bottle.

Plug in the ECA. Place a small container of sugar solution between the electrodes. Record the result and your conclusion about the solution.

Test other solutions that are available. Test pure distilled water. Place results here.

Make a general statement about the conductivity of solutions.

Think back to the chemistry concerned with bonding. Review what you know about salt and sugar and the other solutes that you tested and about the water molecule.

Form a hypothesis about what is happening when salt dissolves in water and sugar dissolves in water that leads to the results with the ECA.

7. Suppose you need to make a solution of sugar or salt in water quickly. What factors might affect the rate at which the solute dissolves in the solvent?

Obtain two test tubes. Place a small scoop of finely ground NaCl in one and a scoop of coarse NaCl in the second. Add 10 mL of distilled water to each. Stir each mixture and note the rate of dissolving.

Obtain two 150 mL beakers and fill each about half full of distilled water. Place the first one a hot plate and heat to about 80^{o}C. Carefully remove the beaker from the hot plate and place it along side the beaker of cooler water. Allow both beakers to sit for about 2 minutes. Place 1 crystal of potassium permanganate ($KMnO_4$) in each beaker. Observe the changes in the beakers over the next 10-15 minutes without disturbing the beakers. When you are finished, discard these solutions in the marked waste container.

Describe the effect of the following on the rate of dissolution or dissolving:

particle size

temperature

stirring or shaking

8. Recall the discussion on dissolving sugar in tea in this activity. Is there a limit to the amount of solute that can dissolve in a solute? Explain.

How can you tell that the limit has been reached?

What factors might control the maximum amount of solute that will dissolve in a given amount of solvent?

Temperature is a major factor in determining the solubility of a solute in a given amount of solvent for most substances. It is often useful to construct a "solubility curve", that is, a graph that shows how solubility changes with temperature. We will construct a solubility curve as a group.

a. You will be assigned an amount of solute (KNO_3) from the following table by the instructor. Mass out this exact amount of KNO_3 in a massing boat.

b. **Carefully** measure exactly 10.0 mL of distilled water with a 10 mL graduated cylinder or pipet and place it in a test tube. Add the KNO_3 to the test tube and mix well. All of the KNO_3 may not dissolve at room temperature.

c. Set up a water bath using a 250 mL beaker filled with water on a hot plate. Place your solution in the water bath and turn on the hot plate. Place your test tube in the beaker and heat the water in the bath until all of the KNO_3 has dissolved. You may need to raise the bath as high as 80^oC. Stir the solution as you heat it. Why?

d. After all of the KNO_3 has dissolved, carefully remove the test tube from the water bath and place it in a beaker or test tube rack. Allow the tube to cool as you stir it GENTLY with a thermometer.

e. Watch for the appearance of crystals in the tube and record the temperature at which the crystals first appear. The appearance of crystals means that the solution is **saturated** and the solvent cannot hold any more solute at that temperature. The process of formation of a solid from a saturated or supersaturated solution without a chemical reaction is called **crystallization**. Crystallization is a physical process that can be used as a separation method, especially as a means to purify a substance.

f. Reheat the solution and cool it again to verify the temperature at which crystallization first occurred.

g. Since solubility is usually expressed as g/100 mL, convert your data to these units. Record your data in the location specified by your instructor. DO not be concerned if more than one group has the same concentration of KNO_3. Be sure you have the data for all groups in the class when available.

h. Plot the solubility and temperature data to generate the solubility curve. You can do this by hand or using Excel. What is the independent variable? (Does temperature change solubility or does solubility change temperature?)

Grams KNO_3/10 mL	**Grams KNO_3/100 mL**	**Temperature (^oC)**
8.0		
10.0		
12.0		
14.0		
16.0		
18.0		

Post-Lab Questions

1. You need to quickly make a solution of solid potassium chloride in water. Explain what you would do to minimize the time it would take and why each step works.

2. You are handed a cloudy solution and asked to classify it as a true solution, colloid or suspension. Explain how you would determine its classification

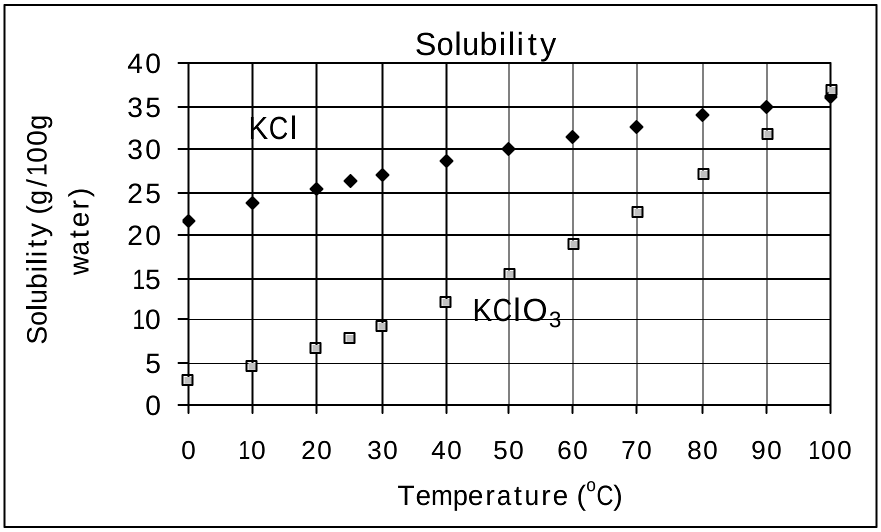
3. Using the solubility curve you generated for KNO_3 determine the solubility of KNO_3 at 30^oC and 50^oC. Explain how you determined the values.

4. In the beginning of the course you investigated some methods for separating mixtures. Based on your experience with solutions, explain the basis for the separation of a mixture of sand and salt (NaCl). Be sure to discuss the recovery of both components.

5. Based on what you have investigated about solutions and your experience from *Investigation of Chemical Reactions I and II*, explain the difference between crystallization and precipitation.

6. A student begins with 125 mL of a Na_2SO_4 solution and evaporates the water from the mixture. The resulting material has a mass of 7.56 g. What is the % concentration (g/mL) of the original solution?

7. Here are the solubility curves for potassium chloride and potassium chlorate.



At 25°C, which salt is more soluble?

At 80°C, 15 g of KCl and $KClO_3$ will dissolve in 100 g of water. Suppose you made a solution containing 15 g of KCl and 15 g of $KClO_3$ in 100 g of water and heated it to 80°C. If you slowly cooled this solution to 0°C, explain what would happen.

Why are data for temperatures below 0°C not included in this solubility graph?