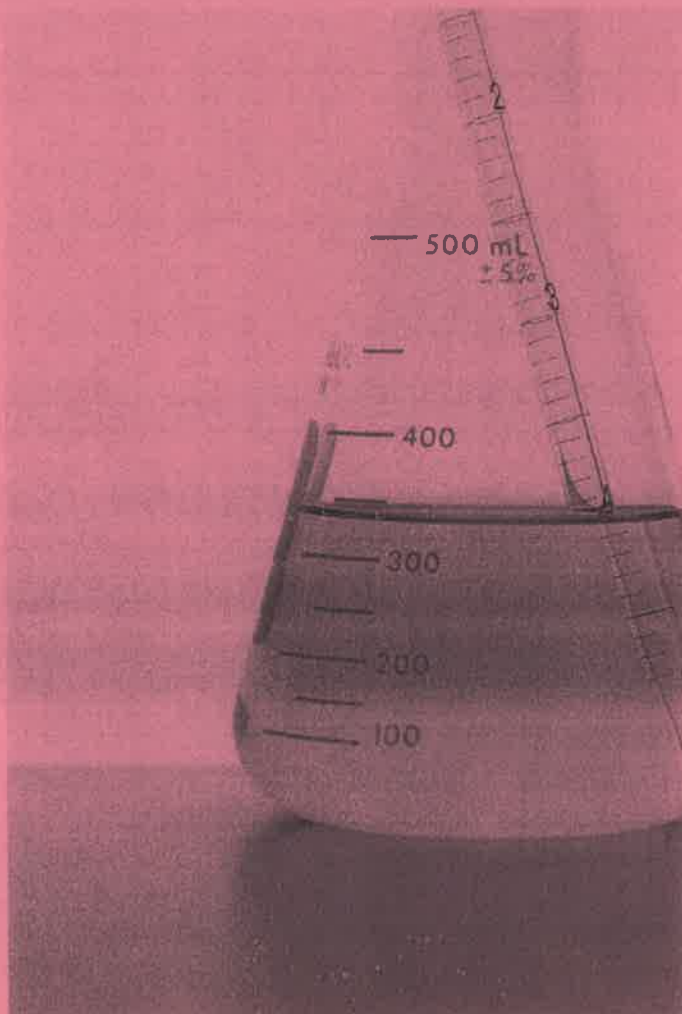
UNIT EIGHT:



Solution Chemistry

Name:_______________________________ Date: __________

DISTILLATION OF COPPER SULFATE

PURPOSE:

INTRODUCTION:

Distillation is the process of heating a liquid until it boils, capturing and cooling the resultant hot vapors, and the collecting of the condensed vapors. Mankind has applied the principles of distillation for thousands of years.

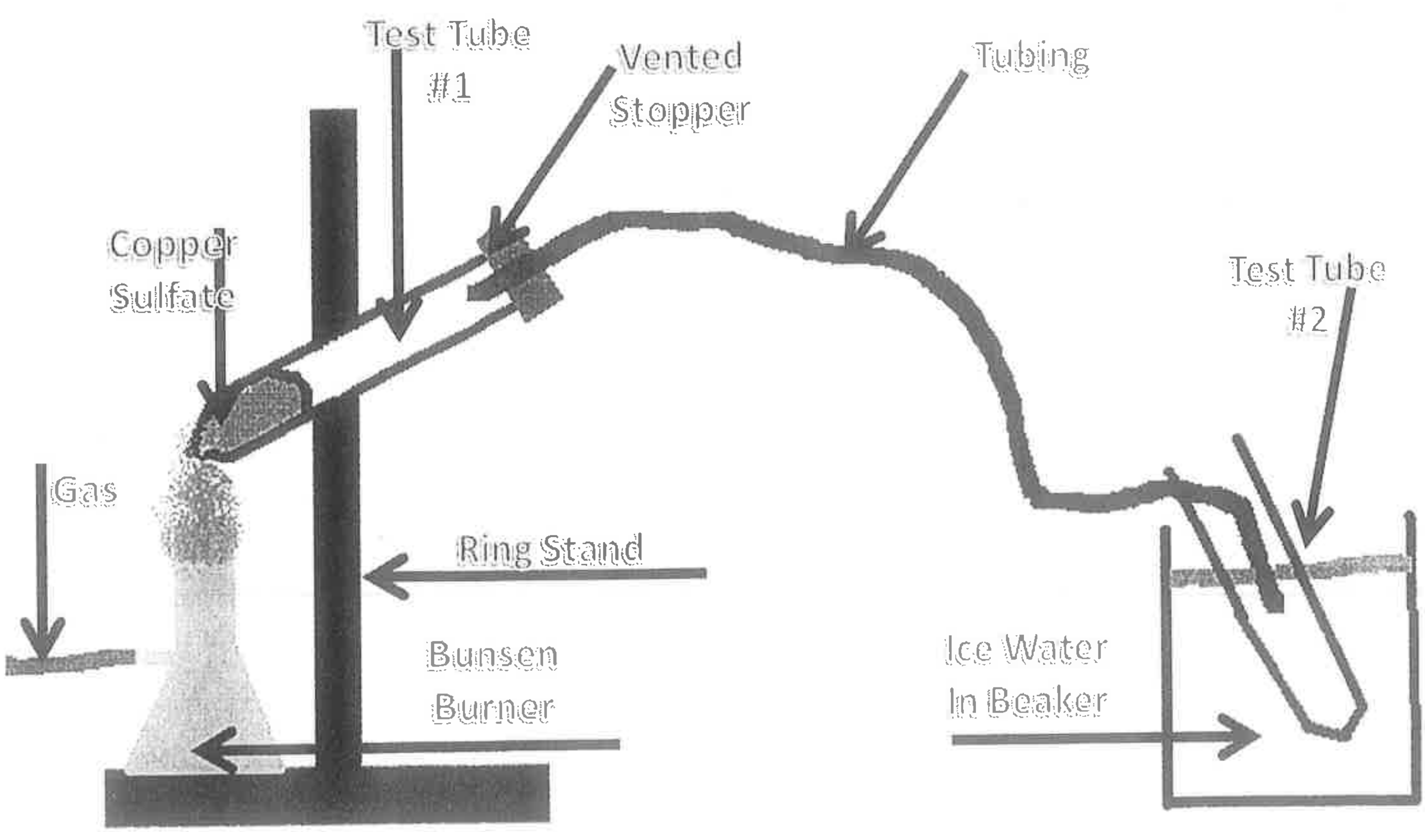
In the modern chemistry laboratory, distillation is a powerful tool, both for the identification and the purification of chemical compounds. Distillation is used to purify a substance by separating it from other substances with different boiling points. When different substances in a mixture have different boiling points, they separate into individual components when the mixture is carefully distilled.

SAFETY:

MATERIALS:

Bunsen Burner	Striker	Ring Stand	Test Tube Clamp	Two test tube
Vented Stopper	Tubing	Beaker	Ice Water	Copper Sulfate

ISTILLATION APPARATUS SET UP:



PROCEDURE:

1. Make sure the distillation apparatus is correctly set up as shown in the diagram.
2. Pour 6ml of $CuSO_4$ in the first test tube.
3. Stopper the test tube with the vented rubber stopper.
4. Place the open end of the rubber tubing in a test tube that is submerged in ice water.
5. Heat the $CuSO_4$ gently for 10 minutes.

OBSERVATIONS:

1. What is the color of the solution in the first test tube?

2. What happens to the solution in the first test tube when it is heated?

3. What is the color of the solution in the second test tube?

4. Is there a solid in the first test tube? If yes, what is the solid?

QUESTIONS:

1. What is evaporation? Where does it occur in this experiment?

2. What is condensation? Where does it occur in this experiment?

3. What is distillation?

Name:__________________________ Date: __________

MICRO-REACTIONS: PREDICTING THE PRODUCTS OF DOUBLE REPLACEMENT REACTIONS

PURPOSE:

INTRODUCTION:

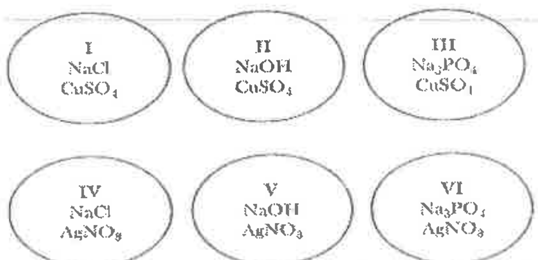
When two aqueous solutions react, the resulting products can be predicted by completing the double replacement reaction. These products can then be assessed using Table H to determine their phases of matter. Reactions where the products remain soluble are considered "no reaction" because the ions are free to dissociate again. Products that are solid are considered to have "precipitated" out of solution and the reaction has come to completion.

SAFETY:

MATERIALS:

.1 M NaCl	.1M NaOH	5 Droppers
.1 M $AgNO_3$	.1 $CuSO_4$	Spot Plate
.1 M Na_3PO_4		

REACTION SET UP:



PROCEDURE:

1. Using a spot plate, place 10 drops of NaCl solution into wells I and IV, 10 drops of NaOH into wells II and V and 10 drops of Na_3PO_4 into wells III and VI.
2. Using the Diagrams above, add 10 drops of $CuSO_4$ to wells I, II, and III and 10 drops of $AgNO_3$ to wells IV, V and VI.
3. Note any color changes or precipitates formed.

DATA AND OBSERVATIONS:

I. ____

II. ____

III. ____

IV ____

V. ____

VI. ____

QUESTIONS:

1. What does soluble mean?

2. What does insoluble mean?

3. What does the symbol (aq) mean when it is placed next to an ionic compound?

4. What is a precipitate?

5. How can you identify a precipitate when it is written in a reaction? How can you identify a precipitate in a reaction?

6. Write a balance equation for each of the reactions that occur. Include physical state symbols for the reactants and products. If no precipitate occurs, write NO REACTION occurred.

   a. $NaCl\ (aq) + CuSO_4\ (aq) \rightarrow$ ______________________________

   b. $NaOH\ (aq) + CuSO_4\ (aq) \rightarrow$ ______________________________

   c. $Na_3PO_4\ (aq) + CuSO_4\ (aq) \rightarrow$ ______________________________

   d. $NaCl\ (aq) + AgNO_3(aq) \rightarrow$ ______________________________

   e. $NaOH\ (aq) + AgNO_3(aq) \rightarrow$ ______________________________

   f. $Na_3PO_4\ (aq) + AgNO_3(aq) \rightarrow$ ______________________________

DISPOSAL: Only Aqueous solutions may be flushed down the back sinks. Solids should be collected and placed into a labeled, solid waste container provided by the instructor.

NAME:________________ DATE:______________

SOLUBILITY CURVE OF POTASSIUM NITRATE IN WATER

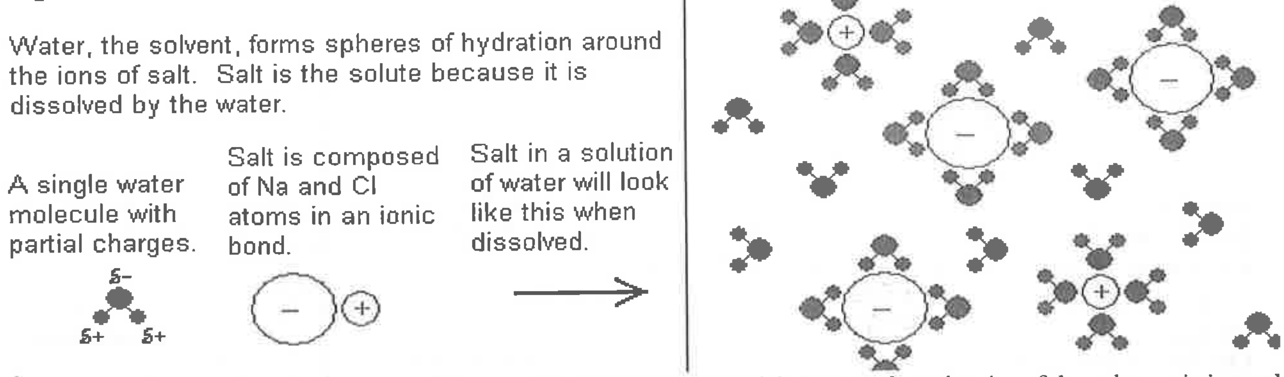
I ?OSE:

BACKGROUND:

Solutions are homogeneous mixture of **solvents** (the larger volume of the mixture) and **solutes** (the smaller volume of the mixture). For example, a hot chocolate is a solution, in which the solute (the hot chocolate powder) is dissolved in the solvent (the milk or the water). The solute and solven can be either a solid, liquid or a gas. A solution forms when the attractive forces between the solute and the solvent are similar. For example, the ionic or polar solute, NaCl, dissolves in water, a polar solvent. The phrase "like dissolves like" has often been used to explain this.

As the water molecules collide with the ionic compound NaCl, the charged ends of the water molecule becomes attracted to the positive sodium ions and negative chloride ions. The water molecules surround the ions and the ions move into solution. This process of attraction between the water molecules (the solvent) and the ionic compound (NaCl, the solute) is called **solvation**. Solvation continues until the entire crystal has dissolved and all ions are distributed throughout the solvent.

Figure 2: Salt dissolved in Water.



S e solutions form quickly and others form slowly. The rate depends upon several factors, such as the size of the solute, stirring or heating. When making hot chocolate, we stir chocolate powder into hot milk or water. When a solution holds a maximum amount of solute at a certain temperature, it is said to be **saturated**. If we add too much chocolate powder to the hot mild, the excess solute will settle to the bottom of the container. Generally, the chocolate powder dissolves better in hot milk than cold milk. Thus, heating the solution can increase the amount of solute that dissolves. Most solids are more soluble in water (solvents) at higher temperatures.

Solubility is the quantity of solute that dissolves in a given amount of solvent. The solubility depends of the nature of the solute and solvent, the amount of solute, the temperature and pressure (for a gas) of the solvent. Solubility is often expressed as the quantity of solute per 100 g of solvent at a specific temperature.

MATERIALS:

Balance	Potassium nitrate, KNO_3	Iron ring
Burner	Distilled water	Utility clamp
Spatula	Thermometer	Wire gauze
Test tubes	10 ml graduated cylinder	Marking pen
Test tube holder	Stirring rod	
400 ml beaker	Ring stand	

SAFETY:

- Test tube holders should always be used to remove test tubes from the hot water bath.
- Long hair should be tied back.
- The gas valve for the Bunsen burner should only be turned on when needed and to the lowest flame (blue flame).
- Make sure to place the beaker in the middle of the gauze to prevent it from falling.
- Make sure to either hold on to the thermometer or have it hanging from a clamp. Do not let it touch the bottom of the beaker for accurate measurements.
- Make sure to pick up the hot-water bath with tongs when moving it, or let it cool down first before moving it.

PRE LAB QUESTIONS

1. Why does an oil and vinegar salad dressing have two separate layers?

2. When making hot chocolate, how does stirring affect the rate of solvation?

3. How is the solubility of sugar in water affected by increasing the temperature?

4. What does the phrase "like dissolves like" mean?

5. How is solubility expressed?

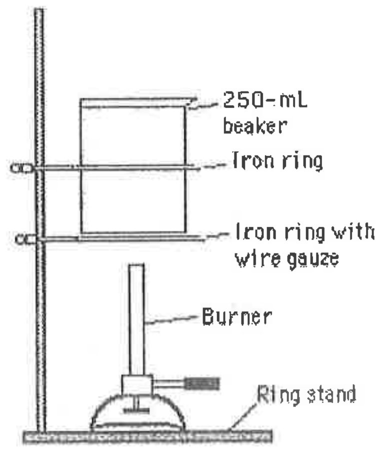
6. What is the difference between a saturated and an unsaturated solution?

PROCEDURES:

1. Divide the lab up so that one lab partner completes steps 2-3, while the other partner begins on step 4.
2. Using a marking pencil, number four test tubes and place them into a test tube rack.
3. Using a balance to measure the KNO_3, prepare the test tubes as indicated below.

Test tube #	grams of KNO_3	mL of distilled water
1	2.00	5
2	4.00	5
3	6.00	5
4	8.00	5

4. Fill a 400 mL beaker about ¾ full of tap water. This will be used as a hot water bath. Place the water bath and test tube #1 on the stand, firmly attached. Heat the water to 90°C and adjust the flame to maintain this temperature. Stir the KNO_3 water mixture with a glass stirring rod, until the KNP_3 is completely dissolved. Loosen the clamp and, using a test tube holder, remove the tube.
5. One lab partner repeats steps 5 for test tube # 2. The other lab partner holds a warm thermometer into the solution in the test tube #1. Hold the test tube up to the light and water for the first signs of **crystallization** in the solution. Record the temperature immediately as crystallization begins in the data table.
6. Repeat steps 5 and 6 for all four test tubes. One partner should do step 5 and the other step 6. Record all temperatures in the data table.



DATA TABLE

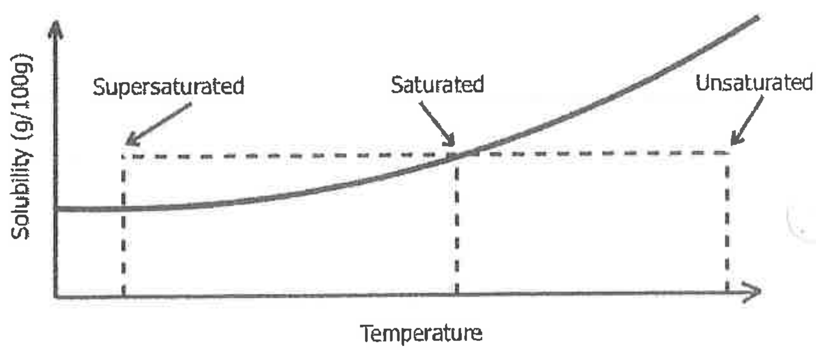
Test tube #	Grams of KNO_3 + mL of H_2O	Crystallization temp (°C)
1	2.00 g / 5.0 mL	
2	4.00 g / 5.0 mL	
3	6.00 g / 5.0 mL	
4	8.00 g / 5.0 mL	

CALCULATIONS:

1. Convert mass / 5.0 mL ratio to mass /100 mL ratios.
2. Plot your data. Note: plot the mass of solute per 100 mL of water on the y-axis and the temperature of crystallization on the x-axis.
3. Construct a solubility curve by connection the plotted points on your graph.

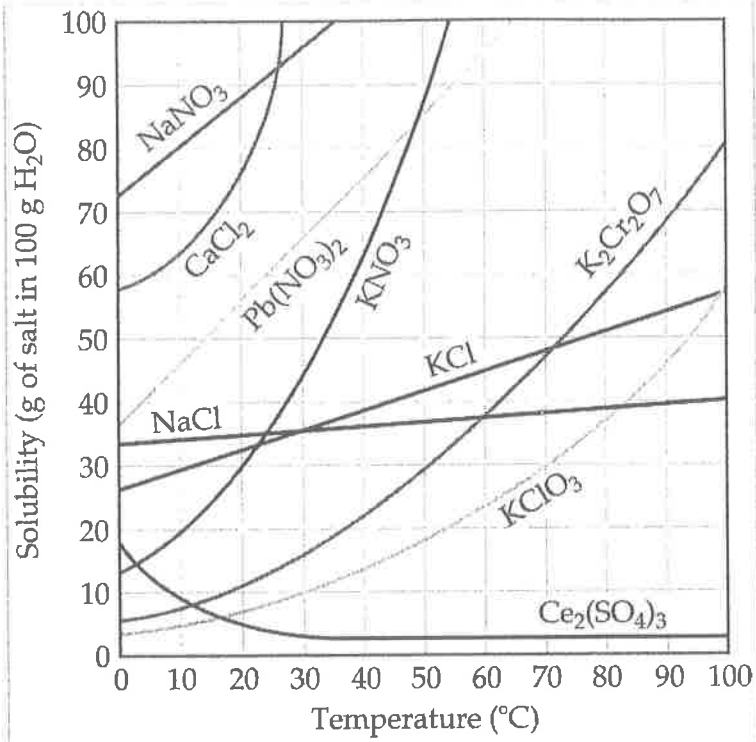
CONCLUSION AND QUESTIONS:

1. According to your graph, how does the solubility of KNO_3 change as the temperature rises.
2. Explain at the molecular level why this relationship exists between temperature and solubility.
3. Using your graph, how many grams of KNO_3 can be dissolved in 100 ml of water at the following temperatures?
   a. 40°C b. 55°C c. 65°C



4. On your solubility curve, what is the change in solubility from 30°C to 60°C?
5. Using your graph, how much KNO_3 must be added to make a saturated solution at 55°C.
6. Define the terms saturated, unsaturated and supersaturated. Use the diagram below to explain the terms.

Use the solubility curves to determine the answers to the following questions:

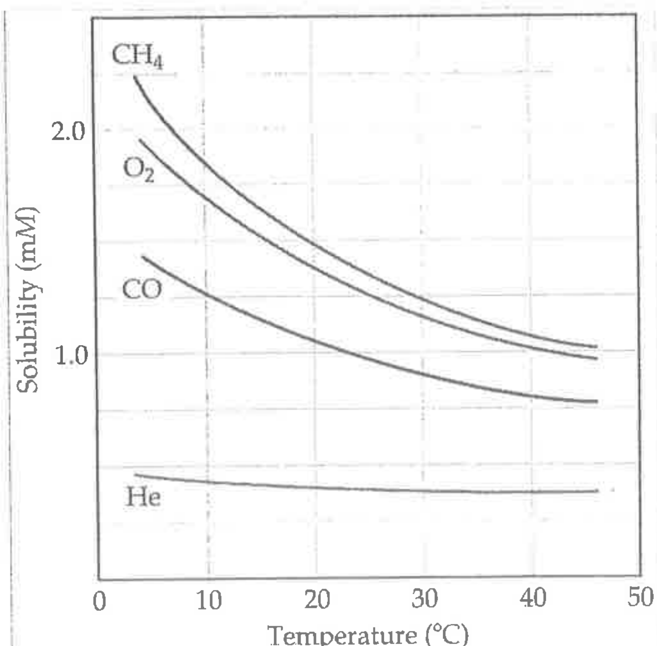


7. How many grams of solute are required to saturate 100 g of water in each of the following solutions?
   a. KCl at 80°C
   b. $NaNO_3$ at 10°C
   c. $K_2Cr_2O_7$ at 50°C
   d. $KClO_3$ at 90°C
   e. KNO_3 at 30°C

8. What is each of the solutions below: saturated, unsaturated or supersaturated ? All of the solutes are mixed with 100 g of water.
   a. 40 g of NaCl at 50°C
   b. 30 g of $NaNO_3$ at 30°C
   c. 70 g of KCl at 20°C
   d. 80 g of KNO_3 at 60°C
   e. 80 g of $Pb(NO_3)_2$ at 80°C

9. How many grams of KNO_3 per 100 g of water would be crystallized from a saturated solution as the temperature drops from
   a. 54°C to 20°C
   b. 50°C to 30°C
   c. 50°C to 10°C
   d. 54°C to 40°C
   e. 40°C to 0°C

10. How many additional grams of $K_2Cr_2O_7$ are required to keep each of the following $K_2Cr_2O_7$ solutions saturated during the temperature changes indicated ?
    a. 100 g of water with a temperature change of 10°C to 30°C ?
    b. 200 g of water with a temperature change of 10°C to 30°C ?
    c. 100 g of water with a temperature change of 40°C to 90°C ?
    d. 1000 g of water with a temperature change of 40°C to 90°C ?
    e. 100 mL of water with a temperature change of 10°C to 60°C ?
    f. 1 L of water with a temperature change of 10°C to 60°C ?



11. At what temperature are the following solutes equally soluble in 100 g of water ?
    a. NaCl and KNO_3
    b. $K_2Cr_2O_7$ and $Ce_2(SO_4)_3$
    c. KCl and KNO_3
    d. $KClO_3$ and NaCl
    e. O_2 and CO

12. Which solute is least affected by the temperature changes ?

13. Which solutes show a decrease in solubility with increasing temperature ?

14. How does the solubility of all "ionic solids" change with an increase in temperature ? Explain.

15. How does the solubility of all "gases" (CH_4, O_2, CO and He) change with increased temperatures ? Explain at the particle level the cause of the change in solubility.

Name:______________________________ Date: __________

MAKING ICE CREAM: A STUDY OF FREEZING POINT DEPRESSION

PURPOSE:

INTRODUCTION:

Adding solute to a solvent affects the boiling point, freezing point and vapor pressure of the solution. The more particles there are present per amount of solution, the greater the effect will be. This property is called a colligative property. Because of this, solutions exhibit boiling point elevation, freezing point depression and vapor pressure depression. Solutes with ionic bonding are more effective than solutes with covalent bonding.

SAFETY:

MATERIALS:

lk	Vanilla	Small Ziploc	Papertowels
Sugar	Ice	Large Ziploc	Salt

PROCEDURE:

1. You will work with a partner to complete this activity-
   a. Partner One- Prepare the large Ziploc with ice and salt.
      i. 2-3 cups of ice with liberal amount of salt- pour generously for about 3 seconds.
   b. Partner Two- Prepare the smaller ziplock back with the milk-sugar recipe
      i. 2/3 cup of milk
      ii. ¼ cup of sugar (or less)
      iii. ¼ teaspoon of vanilla

2. Remove any air from the bags, place the smaller back into the larger one and seal
3. Shake vigorously for up to 10 minutes- do this until the milk coagulates.
4. Partner One- remove and rinse the inner bag, transfer ice cream to cup/bowl.
5. Partner Two- empty larger bag into sink and discard bag.
6. Enjoy! Be sure to clean up- wipe all counters, spills and throw out any dirty materials.

QUESTIONS

1. How does adding a solute to the ice help you make ice cream in the classroom?
   Explain why an ionic salt was used as the solute in this experiment rather than sugar?
3. A solution of water has a concentration of 3.0 M $C_6H_{12}O_6$(non-electrolyte), what is the freezing point of this water solution?
4. A solution of water has a concentration of 3.0 M NaCl, what is the freezing point of this water?
5. Sodium chloride was used in this experiment as a means to depress the freezing point. Identify two other ionic salts that would have been BETTER. Explain why.

Name:______________________________ Date: __________

SUPERSATURATED SOLUTIONS

PURPOSE:

SAFETY:

MATERIALS:

Test Tube	Striker	Water	Test Tube Rack	Two Beakers
Spatula	Bunsen Burner	Test Tube Holder	Sodium Thiosulfate	

SET-UP

PROCEDURE:

1. Before starting, fill a beaker half way with water and heat at medium high heat.
2. Put ½ inch of water in the test tube,
3. Fill 2/3 of the test tube with Sodium Thiosulfate.
4. Feel the test tube as the Sodium Thiosulfate is dissolving in the water. Record your observations below.
5. Heat the test tube in the water bath beaker until all the Sodium Thiosulfate dissolves in the water.
6. Cool the test tube in the ice bath. Record your observations below.
7. Add one crystal of Sodium Thiosulfate. Record your observations below.
8. Give your test tube to your teacher when completed for disposal.

OBSERVATIONS

1. Describe the temperature as the Sodium Thiosulfate dissolves in the water BEFORE heating.

2. After cooling in the ice bath, describe the appearance of the solution before adding the seed crystal.

3. Describe the change that occurs once the seed crystal is added to the solution.

4. Describe the temperature of the test tube after the seed crystal is added.

QUESTIONS

1. Explain the differences between saturated, unsaturated and supersaturated solutions in terms of solute and solvents.
2. When too many resturants open in the same neighborhood, you may hear the market for restaurants is now saturated. Explain what this statements means and how it relates to solutions being saturated. Be descriptive!!

   Characterize each of the following situations as saturated, unsaturated or supersaturated.
   a. A solution that will produce large amounts of crystalline solid when you add just a small additional amount of solute crystal to it.
   b. A solution that will remain dissolved even when you add additional solute to it.
   c. A solution in which, if you add a small additional solute, that small amount of solute will remain undissolved at the bottom of the container.