Experiment #9: Liquids, Liquid Mixtures and Solutions

Objectives: This experiment is a broad survey of the physical properties of liquids. We will investigate solvent/solute mixtures. We will study and try to distinguish between polar and non-polar substances, miscible and immiscible mixtures that produce a two-phase system. We will examine the difference between true solutions and colloidal suspensions. We will examine the difference in physical properties, such as melting point and boiling point, between pure water and a solution of salt in water. We will examine dialysis and investigate which classes of materials will dialyze.

Safety glasses are required for this experiment
Textbook Reference: pp 411-414, 421-432

Discussion:
Solutions are mixtures of as solute in a solvent. The *solute* is the substance that is dissolved or goes into solutions, while the *solvent* is the medium that does the dissolving.
Suspensions are mixtures of finely divided substances in a suspending medium. *Colloidal dispersions* lie in the range between true solutions and suspensions in terms of size of the particle being dissolved. Colloids do not settle out on standing.

A common solubility rule is sometimes summarized "like dissolves like", which means that ionic or polar substances dissolve in polar solvents and nonpolar covalent substances dissolve in nonpolar solvents. Water and alcohol are examples of polar solvents, whereas toluene and benzene are nonpolar.

The presence of a solute affects the boiling point and freezing point of the solvent. Solutions boil at a temperature that is higher than the normal boiling point of the pure solvent, and freeze at a temperature that is lower than the freezing point of the pure solvent. In this experiment you will examine the effect of salt on the boiling point and freezing point of water.

In the dialysis process solution particles are separated from colloidal particles by means of a selectively permeable membrane. You will recall that colloidal particles do not pass through a membrane. The principal of dialysis is very important in hemodialysis in an artificial kidney machine, where certain body wastes that are dissolved in the blood are removed.

PROCEDURE
Part 1: Demonstrations – Write down all your observations!
Properties of Colloids Compared with Solutions
A. 1% colloidal solution of starch.

B. Iodine indicator can be used to test for the presence of starch. The solution will be filtered and the filtrate will also be tested for starch. This type of test is known as a destructive test since the molecule is not destroyed.

C. Tyndall Effect – The instructor will shine a strong light through two test tubes (one which contains 1% starch solution and the other with 5% sugar solution). This will demonstrate the Tyndall Effect which is the phenomenon by which colloidal particles, which are larger than solution particles, reflect and scatter a light beam so that it becomes visible. Compare the passage of light through the two. This type of test is considered non-destructive since the molecules are not destroyed.

Dialysis

Before the dialysis, three samples of pure water will be tested for barium and chloride ions and the starch molecule.

Barium Ions: 5 drops of dilute sulfuric acid is added to 5 mL of water. The development of a white ppt of $BaSO_4$ indicates the presence of barium ions in the water.

Chloride Ions: 5 drops of silver nitrate solution is added to 5 mL of water. A while ppt of AgCl indicates the presence of chloride ions.

Starch: A few drops of iodine solutions is added to 5 mL water. The development of a blue or blue-black color indicates the presence of starch in the water.

A dialysis setup has been prepared in which a semi-permeable membrane casing will be filled with 2 mL of starch solution and another solution of barium chloride in boiling water. The filled and tied membrane casing is placed in a large beaker almost full of water, so that the top level of the water covers the suspended and tied casing.

After heating for 30 minutes, three potions of water from the beaker (dialysate) will be removed and tested for barium ions, chloride ions and starch using the same procedure as before.

Barium Ions:

Chloride Ions:

Starch:

Dialysis of Iodine

In the previous part of the experiment, it was shown that only small ions (barium and chloride) could migrate through the semipermeable membrane, but the large starch molecule did not dialyze.

A solution of iodine in a beaker has been placed in a bag made of semipermeable membrane containing starch. The purpose of this part of the experiment is to determine whether small molecules can migrate like small ions and if something could dialyze from the outside into the bag. Include all observations in the space below.

At the start, what is the color inside the bag?

How can you tell where the iodine is and where the starch is?

After 30 minutes, observe the colors again:

What substance dialyzed? Starch or iodine?

Based on this result, does dialysis occur only from inside the semipermeable membrane or can it take place from the outside as well?

What are some applications of dialysis?

Part 2: You will now split up into six groups. Each group will perform one of the following experiments and then present their findings to the rest of the class.

Group 1: Filtration

You will have two samples, water with powdered chalk as an insoluble impurity and water with cupric sulfate, $CuSO_4$ (aq), as a dissolved impurity. You will perform a filtration on each of these samples to determine which impurity can be removed by filtration. Name the physical phenomenon that aids you in this type of filtration.

Group 2: Comparing the solubility of various solutes in water

Set up 5 test tubes in your test tube rack and place 5 mL of water in each test tube. Add the following substances to the test tubes and gently shake the tubes to dissolve the soluble substances. Those substances that do not dissolve in cold water are to be placed in a hot water bath and re-evaluated for solubility in hot water.

A) pinch of sodium chloride – ionic substance
B) pinch of sucrose (sugar) – polar substance
C) 2 drops vegetable oil – covalent substance
D) pinch of gelatin – protein with some polar groups
E) a few iodine crystals – nonpolar covalent substance.

	Observations	
	Cold	**Hot**
NaCl and water		
Sucrose and water		
Oil and water		
Gelatin and water		
Iodine and water		

Group 3: Comparison of the solubility of iodine in various solvents

Set up 4 dry test tubes in your rack. Add 5 mL of one of the following solvents to each test tube: water, ethyl alcohol, chloroform, and toluene. Water and alcohol are polar, chloroform is very slightly polar and toluene is non-polar. Add one or two crystals of iodine to each test tube. Stopper the tube and shake. Record your observations.

	Observations
Iodine and water	
Iodine and ethyl Alcohol	
Iodine and chloroform	
Iodine and toluene	

Group 4: Comparison of solubility of liquids in liquids

Set up six dry test tubes and place them in a test tube rack. Add 2 mL of each of the following liquids to the tubes. Put a stopper over each test tube and shake vigorously for at least 10 seconds. Decide if the substances are miscible, partly miscible or immiscible, homogenous or heterogeneous. What effects might the polarity have on miscibility?

	Observations
Water and alcohol	
Water and chloroform	
Water and toluene	
Alcohol and chloroform	
Alcohol and toluene	
Chloroform and toluene	

Group 5: Preparation of a saturated solution

Place 10 mL of water in a large test tube. Add sugar (Sucrose) in small portions of about 2 grams each. (Each portion is about 1 inch in the test tube). Stopper and shake after each addition. Keep adding sugar until no more dissolves. Estimate and record the total amount of sugar that you added.
Approximate solubility of sugar per 10 mL of water is _____
What factors affect the solubility?

** The instructor will show you a supersaturated solution.

Group 6: Determination of boiling point and freezing point of a solution

A. Boiling point: Pour 100 mL of distilled water into a 250 mL beaker and heat it to boiling. Record the temperature at which it boils. Then add 10 grams NaCl to the hot water. Reheat the salt solution and record the temperature at which it boils.

Pure water: _____ Salt Solution:_____

B. Freezing Point: Fill a clean 250 mL beaker with crushed ice up to the 100 mL mark. Add to the ice about 50 mL distilled water. Stir the solution with a thermometer. Record the temperature, making sure the thermometer bulb is in the iced area and ice and water are both present in the mixture. This is the freezing point of pure water. Pour 50 mL of the hot salt solution from the previous part into the ice-water mixture. Add more ice if necessary. Record the lowest temperature obtained.

Pure water: _____ Salt Solution:_____

What affect does NaCl have on the boiling and freezing points? What are some practical applications of this?