Experiment #12. Solutions

Goals

To explore several properties of solutions.

Background

A **solution** is a homogeneous mixture of two or more substances. A **solvent** is the dissolving agent (often water) and is usually the substance there is the most of in the solution. A **solute** is a substance that is dissolved in a solution, the part of the solution there is less of. Solutions can come in many forms, as illustrated in the table below. In chemistry class we will mostly deal with liquid-solid and liquid-liquid solutions.

Types of Solutions		
Solvent	**Solute**	**Example**
gas	gas	air
liquid	gas	carbonated beverages
liquid	liquid	rubbing alcohol (isopropanol in water)
liquid	solid	saltwater
solid	solid	brass (copper and zinc)

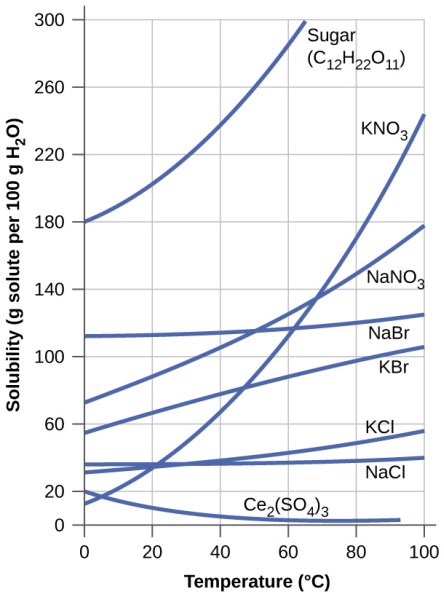
Like Dissolves Like

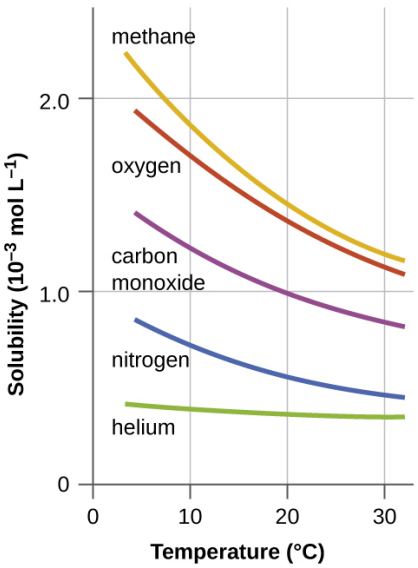
The basic principle of solubility is "like dissolves like". Water is a polar molecule. It has a positive end and a negative end. Water will dissolve polar molecules and some ionic compounds. Nonpolar solvents will dissolve nonpolar solutes. There are some compounds (like soap) that can dissolve in both polar and nonpolar compounds. Soaps or surfactants are able to dissolve in both types of solvents because they have a polar end and a nonpolar end.

Solubility and Saturation

Solutions can be saturated, unsaturated or supersaturated. A **saturated** solution contains the maximum amount of solute that can dissolve. The amount of solute needed to make a saturated solution depends on the identity of the solute, the solvent and the temperature of the solution. An **unsaturated** solution can dissolve more solute. **Supersaturated** solutions are unstable – they contain more solute than should be soluble at that temperature. Disturbing the supersaturated solution in any way causes the excess solute to precipitate out.

The graph to the left below shows the maximum grams of different solids that will dissolve in 100 g of water at different temperatures. Note that for most solids, solubility increases as the temperature increases. For any temperature, the amount of solid on the line is the saturation point. Adding any amount below the saturation like leads to an unsaturated solution. If the solution contains more grams than indicated by the line it is supersaturated.





Gases are soluble in water. Unlike solids, as the temperature of the solution increases, the solubility of the gas in water decreases. You may have observed that warm soda becomes flat faster than cold soda. Notice the downward trend in solubility of gases as temperature increases in the graph above to the right.

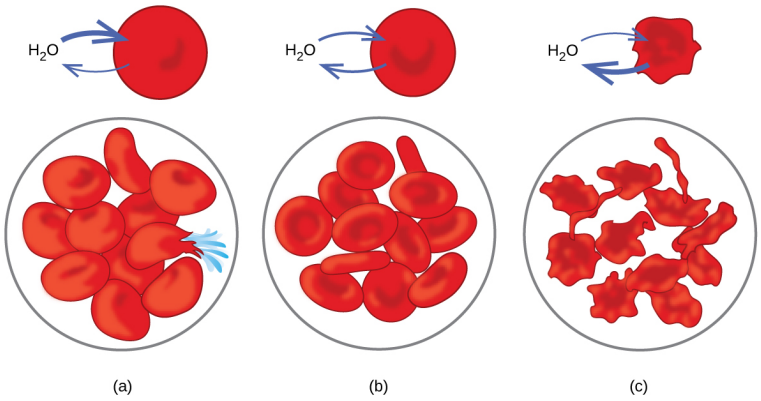
Colligative Properties

Colligative properties are properties of solutions that only depend only on the amount of solute particles present, not on the properties of the solute itself. Colligative properties include freezing point depression, boiling point elevation, and osmosis.

When solutes such as salt are added to water, the solution will freeze at a lower temperature than pure water. This is known as freezing point depression. This property of solutions is useful in winter for treating ice-covered roads and preventing radiator fluid from freezing. It was also used in old-fashioned ice cream makers. Ice cream is a solution and therefore freezes below 0°C. The churner was surrounded by ice, water, and rock salt so the mixture would be cool enough to freeze the ice cream.

Osmosis is the flow of solvent through a semipermeable membrane. The solvent flows from the side with more solvent (dilute) to the side with less solvent (concentrated).

Osmosis is very important when delivering intravenous solutions. To prevent damage to cells, the solutions should **isotonic** with body fluids – that is they should have the same concentration of ions. When concentration of ions are the same on both sides of a cell membrane, there is no net change in volume of cells. This isotonic solution and is shown below in (b). **Hypertonic** solutions have higher ion concentrations than body fluids. In hypertonic solutions, water will migrate out of the cell, decreasing its volume giving a withered appearance, such as in (c). **Hypotonic** solutions have a lower concentration of ions than cells. Water will migrate into the cell swelling it and the cell could potentially explode, see (a). Thus you would never inject someone with pure water. Typical saline solutions are 0.9% (m/m) NaCl which is isotonic with body fluids.



Laboratory Activity

Materials:	sodium acetate trihydrate	small test tubes	test tube rack	glucose
	sodium chloride	naphthalene	hexane	soda
	string	potato slices	concentrated sugar solution	

Procedure

A. Saturated Solutions

1. Add 0.5 g of sodium acetate trihydrate and 1.0 mL of deionized water to a dry test tube and shake for two minutes. (You may want to use your gloved thumb as a stopper to prevent spills.) Record observations under solution A.
2. Add an additional 1.5 g of sodium acetate trihydrate to the test tube from step 1. Shake the solution for two minutes. Record observations under solution B.

3. Obtain a clean, **dry!** test tube. **First**, add 5.0 g of sodium acetate trihydrate to the test tube. **Second**, add 1.0 mL of water to the test tube. Add in this order so that solids do not stick to the sides.
4. Heat the mixture in a hot water bath until the solid completely dissolves. Gently shake the test tube from time to time to help it dissolve and to dislodge air bubbles. When no solid remains, move the test tube to a rack and leave undisturbed for 15 minutes. Record observations of this cooling solution under solution C.
5. After 15 minutes add one crystal of sodium acetate to your solution. Record observations under solution D.
6. Pour contents of both test tubes in the sink. Thoroughly rinse the test tubes with water before putting them back. (warm water or reheating may help)

B. Solubility of Solids

7. Fill in the first table on the data sheet based on the structures provided.
8. Clean and dry 3 test tubes and put them in a test tube rack.
9. Put 2.0 mL of deionized water in each test tube.
10. Add small amount of solid sodium chloride (about the volume of a peppercorn) to test tube 1. Add a small amount of glucose to test tube 2. Add a small amount of naphthalene to test tube 3. Shake each tube to aid dissolving. Record if the substances soluble or not. Explain the results based on the principle of "like dissolves like."
11. Dispose of test tube 3 (with naphthalene) in the waste hood. The water/NaCl and water/glucose tubes can be poured down the drain.

C. Freezing Point of Solutions

12. Get two 100 mL beakers (A & B) and fill each half way with ice. Add water to just below the ice line.
13. Stir each beaker for 1 minute then record the initial temperature of each.
14. Add nothing to beaker A. Add 10 grams of sodium chloride to beaker B. Stir each for an addition two minutes and record the final temperature of each.

D. Solubility of Gases

15. Your instructor will set up a demonstration where three test tubes of soda are inverted in beakers of hot, room temperature and cold water respectively. Observe what is happening to the gas in each of these circumstances. Think about how temperature affects the solubility of gases in water.

E. Osmosis

16. Your instructor will set up a demonstration where slices of potato are placed in a hypertonic solution (saturated sugar solution) and a hypotonic solution (deionized water).
17. Remove the slices from the solutions and observe their properties. Explain the differences between the slices based on what you know about osmosis.
18. Place the slices back into the same beakers you took them from.

Waste: All solutions containing hexane or naphthalene should be disposed of in the waste hood. All other solutions may be poured down the sink.

Name_____

Team Name _____

CHM101 Lab - Solutions – Grading Rubric

To participate in this lab you must have splash-proof goggles, proper shoes and attire.

Criteria	Points possible	Points earned
Lab Performance		
Printed lab handout and rubric was brought to lab	3	
Safety and proper waste disposal procedures observed	2	
Followed procedure correctly without depending too much on instructor or lab partner	3	
Work space and glassware was cleaned up	1	
Lab Report		
Part A (detailed observations recorded, solutions correctly classified)	2	
Part B - Properties table (correct classification and IMFs)	2	
Part B (detailed observations recorded and explained with solubility principles)	2	
Part C (detailed observations recorded, explaination)	2	
Part D (detailed observations recorded, solubility Q correct)	1	
Part E (detailed observations recorded, table correct)	2	
Total	20	

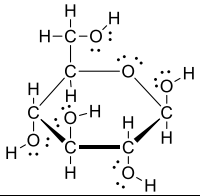
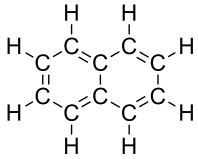
Subject to additional penalties at the discretion of the instructor.

Solutions: Data Sheet **Name _____**

A. Saturated Solutions

	Observations	Saturated, Unsaturated or Supersaturated?
Solution A		
Solution B		
Solution C		
Solution D		

B. Solubility of Solids

Substance	**nonpolar, polar or ionic?**	**list all attractive forces present** (dispersion, dipole-dipole, hydrogen bonding, ionic bonding)
water (draw Lewis structure)		
NaCl		
glucose 		
naphthalene 		

solute	dissolves? (Y/N)	Explain why or why not
NaCl		
glucose		
naphthalene		

C. Freezing Point of Solutions

	Beaker A (no salt)	**Beaker B (salt)**
initial temperature		
lowest temperature reached		

Which beaker reached a lower temperature? Explain your results.

D. Solubility of Gases

Observations:

Hot	Room temp	Cold

At which temperature was the gas most soluble? _____

E. Osmosis

	Hypertonic (saturated sugar solution)	Hypotonic (deionized water)
Observations of potato (look at size and flexibility)		
Lower or higher concentration than potato cells?		
Direction of water flow (into or out of potato)		