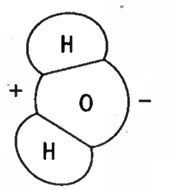
10A Polar and Non-Polar Solutes and Solvents

Chemists have studied the differences between ionic and covalent compounds by investigating such characteristics as melting points and solubilities of the solids and electrical conductivities of their solutions. As a result, they discovered that ionic compounds have higher melting points than covalent compounds. They also found that solutions of ionic compounds are good conductors of electricity, whereas solutions of covalent compounds are poor conductors. Finally, they learned that ionic compounds tend to be more soluble in water, while covalent compounds tend to be more soluble in methanol. In the case of solubility, chemists also noted one obvious exception to this trend: sucrose (table sugar), a covalent compound, is highly soluble in water but only slightly soluble in methanol. From these results, it appears that not all covalent compounds are soluble in the same type of solvent.

People engaged in the drycleaning industry have learned that different stains on garments sometimes require different approaches to cleaning. A drycleaner will often ask a customer for information about a given stain and then make a cleaning decision based on that information. In many cases, the nature of the stain (solute) will determine the drycleaning solvent to be used.

Figure 10A-1 *A polar water molecule*



Covalent compounds can be further classified as polar or non-polar. Although, as a result of the sharing of electrons between component atoms, all covalent compounds are bonded, this sharing is not necessarily an *equal* sharing of electrons. As a result, one side of a neutral molecule can end up with a net negative charge, while the other side is left with a net positive charge. (See Figure 10A-1.) It is this type of covalent compound which is said to be polar. It is more common than the non-polar type.

The classification of a covalent compound as polar or non-polar requires information about electron-sharing tendencies and molecular shapes. Since such a detailed study of compounds is beyond the scope of this experiment, you will simply be informed as to the classification of the compounds you will be using. It is important to remember that both the solute and the solvent have characteristics that can affect solubility. Therefore, in this experiment you will test the solubilities of a variety of solutes in a variety of solvents. The solutes to be tested are ionic, polar covalent, and non-polar covalent, while the solvents to be tested are polar covalent and non-polar covalent. (There are no typical ionic solvents.) In Part I, you will be doing solubility tests on known solutes and in Part II, you will be testing the solubility of unknown solutes. In Part III, you will be mixing liquids to study their solubilities.

OBJECTIVES

1. to determine the type of solvent that generally dissolves ionic compounds
2. to determine the type of solvent that generally dissolves polar covalent compounds
3. to determine the type of solvent that generally dissolves non-polar covalent compounds
4. to investigate the effect of adding a polar liquid solute to a non-polar liquid solvent

SUPPLIES

Equipment
6 test tubes (13 mm × 100 mm)
6 stoppers to fit test tubes
test-tube rack
tweezers
lab apron
safety goggles

Chemical Reagents
sodium chloride (table salt) crystals
sucrose (table sugar) crystals
iodine crystals
3 unknown solid solutes
paint thinner (or varsol)
glycerin

PROCEDURE

Part I: Solubility Tests on Known Solutes

1. Put on your lab apron and safety goggles.
2. Obtain 6 clean, dry test tubes and place them in a test-tube rack so that you have two rows of test tubes with three test tubes in each row.
3. Half fill one set of three test tubes with water at room temperature and half fill the other set of three test tubes with paint thinner. Your test tubes should now form a grid that is similar to the grid in Table 1 in Experimental Results.
4. In the first pair of test tubes (one containing water, the other containing paint thinner), add enough crystals of salt with a pair of tweezers to cover the bottom of the test tubes.
5. Stopper one of these test tubes, then invert it to agitate the mixture. Turn the test tube over several times until you are convinced that no further change will take place. Carefully examine the inside of the test tube for crystals that may get trapped on the walls. Repeat this agitation process for the second test tube, then record your observations for both test tubes in your copy of Table 1 in your notebook. (Record whether or not the solute dissolves.)
6. Repeat Steps 3 and 4 with crystals of sugar in the second pair of test tubes.
7. Repeat Steps 3 and 4 with an iodine crystal in the remaining pair of test tubes. (Note: One iodine crystal gives better results than several crystals.)
8. Clean up your apparatus according to the reagent disposal instructions.

CAUTION

Paint thinner is poisonous. Wipe away any spills with paper towel.

CAUTION

Some of these unknown solutions can harm skin and clothing. Wash off spills and splashes with plenty of water. Call your instructor.

Part II: Solubility Tests on Unknown Solutes

1. Repeat Part I of this experiment, but refer to Table 2 and test the solub ities of unknown solutes A, B, and C.

Part III: Mixing Two Liquids

1. Fill a clean test tube one quarter full with water, then add twice as muc paint thinner as water to the same test tube.
2. Stopper the open end of the test tube and agitate the liquids as in Part
3. Examine what happens to the liquids after agitation and record yo observations in your copy of Table 3.
4. Add one iodine crystal to the test tube and agitate the contents. Make labeled sketch of your test tube and its contents. Include this sketch your observations.
5. Using a second test tube, repeat Steps 1 to 4, but use glycerin in place paint thinner. Glycerin is also known as glycerol, or, as you will learn organic chemistry, 1,2,3–propanetriol. It is a polar liquid.
6. Clean up all apparatus according to the reagent disposal instructions.
7. Before you leave the laboratory, wash your hands thoroughly with so and water.

REAGENT DISPOSAL

Pour the contents of all test tubes into the container designated by yc instructor. Wash out the test tubes with detergent and water, using a test tu brush if necessary. Be sure to thoroughly rinse out the detergent from the t tubes.

POST LAB CONSIDERATIONS

It is obvious from the results in Table 1 that certain types of solutes will solve only in certain types of solvents. Although there are exceptions to results obtained in this experiment, you should now be able to propose a g eral rule for the type of solvent that will dissolve each type of solute.

EXPERIMENTAL RESULTS

Part I: Solubility Tests on Known Solutes

Table 1 Known Solutes with Known Solvents

Solvents	Solutes		
	Salt (NaCl) (Ionic)	Sugar ($C_{12}H_{22}O_{11}$) (Polar Covalent)	Iodine (I_2) (Non-Polar Covalent)
Water (Polar covalent)	COMPLETE IN YOUR NOTEBOOK	COMPLETE IN YOUR NOTEBOOK	COMPLETE IN YOUR NOTEBOOK
Paint thinner (Non-polar covalent)			

Part II: Solubility Tests on Unknown Solutes

Table 2 Unknown Solutes with Known Solvents

Solvent	Solute		
	A	B	C
Water (Polar covalent)	COMPLETE IN YOUR NOTEBOOK	COMPLETE IN YOUR NOTEBOOK	COMPLETE IN YOUR NOTEBOOK
Paint thinner (Non-polar covalent)			

Part III: Mixing Two Liquids

Table 3

Combinations of Liquids	Covalent Types	Results
Water and paint thinner	COMPLETE IN YOUR NOTEBOOK	COMPLETE IN YOUR NOTEBOOK
Water and glycerin		

ANALYSIS OF RESULTS

1. a. What general trend appears in Table 1 with regard to which type of solute dissolves in which type of solvent?
   b. This general solubility trend is sometimes expressed as "Like dissolves like." Explain this expression.
2. Classifying the solutes:
   a. Attempt to classify each of the unknown solutes from Part II as ionic, polar covalent, or non-polar covalent.
   b. What problem do you encounter in making this classification?
   c. Explain what further tests you would perform to remove any doubts about your classification.
3. a. Compare the results from Part III with the general solubility trends observed in Part I.
   b. Using a reference, explain the meaning of the term "immiscible", then use this word to describe results from Part III.
4. How did the addition of iodine crystals help in identifying the layers of liquids in the water–paint thinner combination?
5. Explain how many layers you would expect to see if water, paint thinner, and glycerin were combined in one test tube.

FOLLOW-UP QUESTIONS

1. Explain which solvent from this experiment you would use to remove road salt stains from a pair of jeans.
2. Some people use gasoline (a non-polar covalent compound) to clean grease stains from clothing. Although it is an effective solvent for grease, explain why gasoline should never be used for this purpose. Suggest a suitable alternate solvent.

CONCLUSION

What general rule can be followed when choosing a type of solvent for a particular solute?