EXPERIMENT 2

DETERMINATION OF SOLUBILITY CLASS

Each functional group has a particular set of chemical properties that it to be identified.

Some of these properties can be demonstrated by observing solubility behavior, while others can be in chemical reactions that are accompanied by color changes, precipitation formation, or other visible affects.

According to the presence of their functional group, organic compounds can be classified in different families and class. The types of compounds soluble in a particular solvent are summarized on the following pages:

1. Water Soluble Compounds
2. 5% Sodium Hydroxide Soluble Compounds.
3. 5% Sodium Bicarbonate Soluble Compounds
4. 5% Hydrochloric Acid Soluble Compounds.
5. 96% Sulfuric Acid Soluble Compounds.
6. Solubility of Amphoteric Compounds.

Much information can be obtained about an unknown substance by performing simple solubility and chemical tests.

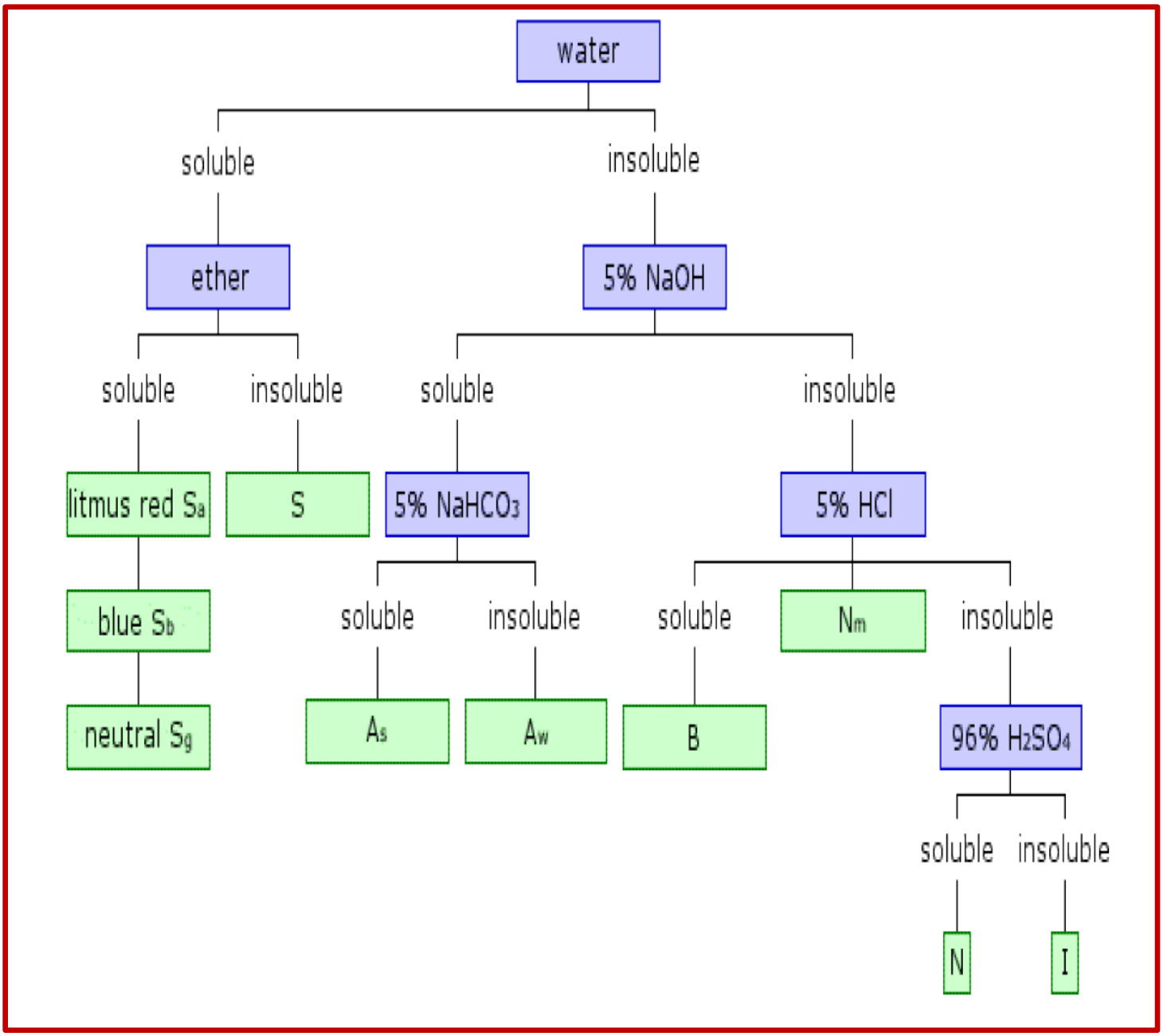
Determining the solubility behavior of an unknown in water, 5% sodium hydroxide solution, 5% sodium bicarbonate solution, 5% hydrochloric acid solution, and cold concentrated sulfuric acid will yield three kinds of information.

First, the presence of a functional group is often indicated. For instance, because hydrocarbons are insoluble in water, the mere fact that an unknown is partially soluble in water indicates that a polar functional group is present.

Second, solubility in certain solvents often leads to more specific information about the functional group present. For example, an unknown may be insoluble in water, but soluble in 5% sodium hydroxide solution. In this case, the solubility of a water insoluble unknown in basic solution is a strong indication that an acidic functional group (like a carboxylic acid) is present.

Third, information about molecular size and shape can often be obtained. For example, in homologous series of compounds, the members with fewer than five carbon atoms are water soluble, whereas the higher homologs are not. Additionally, in homologous series of compounds, chain branching and positioning of functional groups toward the center of the molecule increases water solubility.

Flow Chart for Classes of Organic Compounds



Class	Functional Group Possibilities
Sa	monofunctional carboxylic acids (≤5C), arylsulfonic acids
Sb	monofunctional amines (≤6C)
Sg	monofunctional alcohols, aldehydes, ketones, esters, nitriles, and amides (all ≤5C)
S	salts of organic acids, amine hydrochlorides, amino acids, polyfunctional compounds with hydrophilic functional groups
As	strong organic acids: carboxylic acids (>6C), phenols with electron-withdrawing groups in the ortho and/or para position(s),□□-diketones
Aw	weak organic acids: phenols, enols, oximes, imides, sulfonamides, thiophenols (all >5C),□□-diketones, nitro compounds with□□-hydrogens
B	aliphatic amines (≥8C), anilines (only one phenyl group attached to N), some ethers
Nm	miscellaneous neutral compounds containing N or S (>5C)
N	alcohols, aldehydes, ketones, monofunctional esters (>5C but <9C), ethers, epoxides, alkenes, alkynes, some aromatic compounds (with activating groups)
I	saturated hydrocarbons, haloalkanes, aryl halides, other deactivated aromatic compounds, diaryl ethers

Procedure:

1. Water Solubility. Place 0.05 mL or 25 mg of compound in a small test tube, and add 0.75 mL of water in small portions. Shake test tube vigorously after the addition of each portion of solvent. If water soluble, go on to step 2; otherwise proceed to step 3.

2. Ether Solubility. Place 0.05 mL or 25 mg of compound in a small test tube, and add 0.75 mL of diethyl ether in small portions. Shake test tube vigorously after the addition of each portion of solvent. If the compound is both water and ether soluble, the acid-base properties of the compound should be determined with litmus.

- ❖ litmus turns red - water soluble acidic compound (class Sa)
- ❖ litmus turns blue - water soluble basic compound (class Sb)
- ❖ litmus neutral - water soluble general compound (class Sg)

If the compound is not ether soluble it is a salt, amino acid, or contains many hydrophilic functionalities (class S)

3. 5% NaOH Solubility. Place 0.05 mL or 25 mg of compound in a small test tube, and add 0.75 mL of NaOH solution in small portions. Shake test tube vigorously after the addition of each portion of solvent. If NaOH soluble, go on to step 4; otherwise proceed to step 5.

4. 5% $NaHCO_3$ Solubility. Place 0.05 mL or 25 mg of compound in a small test tube, and add 0.75 mL of $NaHCO_3$ solution in small portions. Shake test tube vigorously after the addition of each portion of solvent. If

NaHCO3 soluble, then it is a strong organic acid (class As). If not NaHCO3 soluble, then it is a weak organic acid (class Aw).

5. 5% HCl Solubility. Place 0.05 mL or 25 mg of compound in a small test tube, and add 0.75 mL of HCl solution in small portions. Shake test tube vigorously after the addition of each portion of solvent. If HCl soluble, then it is an organic base (class B). If not HCl soluble and (from elemental analysis) is found to contain nitrogen or sulfur, then it is a miscellaneous neutral compound (class Nm). If not HCl soluble, then go on to step 6.

6. 96% H_2SO_4 Solubility. Place 0.6 mL of H_2SO_4 in a small test tube, and add 0.05 mL or 25 mg of compound. Shake test tube vigorously. If H_2SO_4 soluble, then it is a neutral compound (class N). If not H2SO4 soluble, then it is an inert compound (class I).