Experimental No. (3) Solubility and solution

Solubility and solution

Purpose of experimental

1) Preparation of different solutions in concentrate and to show how temperature affects solubility.
2) To show how the nature of the solute and the solvent affects solubility.

Theory part of experimental

The solubility of a solute is the maximum quantity of solute that can dissolve in a certain quantity of solvent or quantity of solution at a specified temperature. The substance to be dissolved is called as **solute** and the dissolving fluid in which the solute dissolve is called as **solvent**, which together form a solution. The process of dissolving solute into solvent is called as **solution** or hydration if the solvent is water. Solubility definitions are; The process of **solubilisation** involves the breaking of inter-ionic or intermolecular bonds in the solute, the separation of the molecules of the solvent to provide space in the solvent for the solute, interaction between the solvent and the solute molecule .

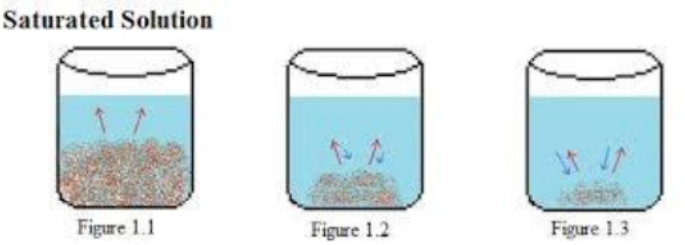
One generalization which can be used for determining solubility is **"like dissolves like."** This means that the more similar the polarity of a solute is to the polarity of the solvent, the more likely the two will form a homogeneous solution. A polar solvent, such as water, will dissolve a polar compound. Nonpolar solvents such as naphtha or turpentine will dissolve nonpolar material, such as grease or oil. On the other hand, oil and water do not mix because of their different polar, If it will not mix

it is **immiscible**. The rate at which it can dissolve can be influenced by three methods: **heating**, **stirring**, and **grinding**. Each of these will increase the rate at which a solute will dissolve.

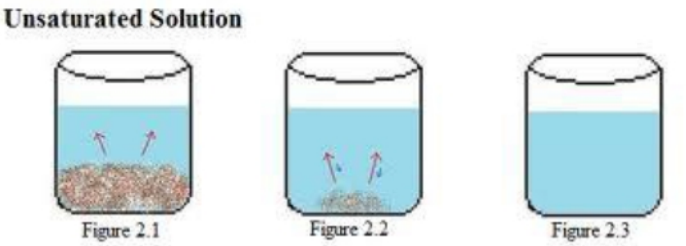
Molarity is a way of expressing how concentrated a solution is. This molarity is expressed in moles of solute per liter of solution (solution being solute plus solvent). It is give the symbol, **M**.

Type of solutions

Saturated solution: A solution with solute that dissolves until it is unable to dissolve anymore, leaving the un dissolved substances at the bottom.



Unsaturated Solution: A solution (with less solute than the saturated solution) that completely dissolves, leaving no remaining substances.



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Supersaturated Solution : A solution (with more solute than the saturated solution) that contains more undissolved solute than the saturated solution because of its tendency to crystallize and precipitate.

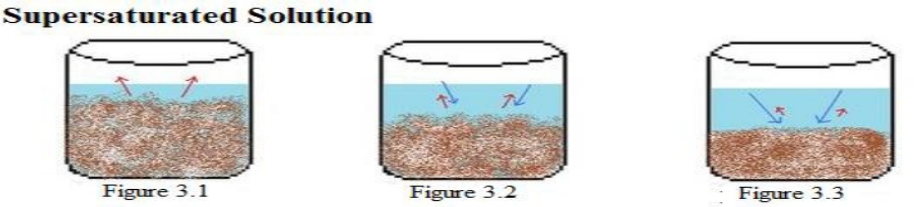

Figure 3.1 Figure 3.2 Figure 3.3

Chemical and Apparatus

$KMnO_4$, NaCl , Naphthalene, Iodine, Ethanol (ethyl alcohol), Acetone, hexane, Hot plate, Wash bottle, test tubes

Procedure of Experimental (preparation of solutions)

1. Place 10 mL of distilled water into a 50-mL beaker, while stirring with a glass rod, add NaCl salt to the water in 2-g portions; keep
2. adding until no more NaCl dissolves. The solution should be saturated.
3. Heat the solution on a hot plate to 50 ^oC; maintain this temperature. Again add to the solution, while stirring, salt in 2-g portions until no more NaCl dissolves.
4. Heat the solution above 50 C until all of the solid dissolves. With beaker tongs, remove the beaker from the hot plate and set it on the bench top.
5. Observe what happened to the solution when it cooled to room temperature. Offer an explanation for what has taken place (5).

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Procedure of Experimental (Solubility – Solids in Liquids)

1- Clean and dry 12 test tubes.

2. Place approximately 0.1 g of the following solids into test tubes numbered as indicated (your instructor will weigh exactly 0.1 g of solid as a demonstration; use your spatula to estimate the 0.1g sample):

a. No. 1: table salt, NaCl

b. No. 3: naphthalene, $C_{10}H_8$

c. No. 4: iodine, I_2

d. No. 4: potassium permanganate , $KMnO_4$

3. Add 3 mL of distilled water to each test tube and shake the mixture (simply tapping the test tube with your fingers will agitate the contents enough).

4. Record on the Report Sheet whether the solid dissolved completely (soluble), partially (slightly soluble), or not at all (insoluble).

5. With new sets of labeled test tubes containing the solids listed above, repeat the solubility tests using the solvents ethanol (ethyl alcohol), C_2H_5OH, and hexane. Record your observations.

6. Discard your solutions in waste containers provided. *Do not discard into the sink*

Solute	**Solvent**		
	water	**hexane**	**ethanol**
NaCl			
$KMnO_4$			
I_2			
Naphthalene			

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Procedure of Experimental (Miscibility – Liquids in Liquids)

Set up three test tubes in your test tube rack. Put 20 drops of water into each of them. Add 20 drops of acetone, C_3H_6O, to the first test tube, 20 drops of hexane, C_6H_{14}, to the second test tube, and 20 drops of ethanol, CH_3CH_2OH, to the third test tube. Shake gently and note whether the liquids are miscible or immiscible.

Solvent (liquid)	**Solvent (liquid)**		
	Acetone	**Hexane**	**Ethanol**
Water			

Questions for discussion

1) What is meant by the following terms?

Soluble, Miscible, Undersaturated, saturated, and supersaturated, Molarity,"like dissolves like"

2) Indicate whether each of these solute/solvent pairs is soluble or insoluble:

Solute	**Solvent**	
	Water	**Hexane**
Ionic Solid		
Polar Solid		
Nonpolar Solid		
Sugar		
KCl		

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3) Indicate which of the liquid pairs is miscible or immiscible:

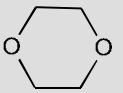
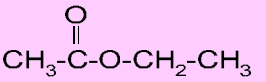
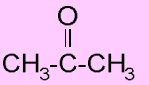
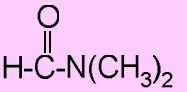
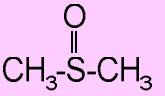
1st Liquid	2nd Liquid	Miscible/Immiscible
Water	Alcohol	
Hexane	Alcohol	
Water	Oil	
Oil	Gasoline	

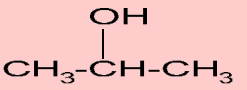
4) What are the three ways to increase the rate of dissolving?

Which appears to affect the rate the most?

Table of polar and non polar solvents

Dip-olar	Dens-ity	Diele-ctric const-ant	Bioling	Chemical formula	Solvent
Non-polar solvents					
0.00 D	0.626 g/ml	1.84	36 °C	CH_3-CH_2-CH_2-CH_2-CH_3	Pentane
0.00 D	0.751 g/ml	1.97	40 °C	C_5H_{10}	Cyclopentane
0.00 D	0.655 g/ml	1.88	69 °C	CH_3-CH_2-CH_2-CH_2-CH_2-CH_3	Hexane
0.00 D	0.779 g/ml	2.02	81 °C	C_6H_{12}	Cyclohexane

0.00 D	0.879 g/ml	2.3	80 °C	C_6H_6	Benzene
0.36 D	0.867 g/ml	2.38	111 °C	C_6H_5-CH_3	Toluene
0.45 D	1.033 g/ml	2.3	101 °C		1,4 - Dioxane
1.04 D	1.498 g/ml	4.81	61 °C	$CHCl_3$	Chloroform
1.15 D	0.713 g/ml	4.3	35 °C	CH_3CH_2-O-CH_2-CH_3	Diethyl ether
Polar aprotic solvents					
1.60 D	1.3266 g/ml	9.1	40 °C	CH_2Cl_2	Dichloromethane (DCM)
1.75 D	0.886 g/ml	7.5	66 °C		Tetrahydrofuran (THF)
1.78 D	0.894 g/ml	6.02	77 °C		Ethyl acetate
2.88 D	0.786 g/ml	21	56 °C		Acetone
3.82 D	0.944 g/ml	38	153 °C		Dimethylform-amide (DMF)
3.92 D	0.786 g/ml	37.5	82 °C	CH_3-C≡N	Acetonitrile (MeCN)
3.96 D	1.092 g/ml	46.7	189 °C		Dimethyl sulfoxide (DMSO)

Polar protic solvents					
1.41 D	1.21 g/ml	58	101 °C	H-COOH	Formic acid
1.63 D	0.810 g/ml	18	118 °C	CH_3-CH_2-CH_2-CH_2-OH	*n*-Butanol
1.66 D	0.785 g/ml	18	82 °C		Isopropanol (IPA)
1.68 D	0.803 g/ml	20	97 °C	CH_3-CH_2-CH_2-OH	*n*-Propanol
1.69 D	0.789 g/ml	24.55	79 °C	CH_3-CH_2-OH	Ethanol
1.70 D	0.791 g/ml	33	65 °C	CH_3-OH	Methanol
1.74 D	1.049 g/ml	6.2	118 °C	CH_3-COOH	Acetic acid
1.85 D	1.000 g/ml	80	100 °C	H_2O	Water