Chapter 6 – Review of Salts	NAME:	
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Chapter 6 – Review of Salts

Salts are solid crystalline substances at room temperature that contains the cation of a base and the anion of an acid, e.g.:

NaCl	LiBr	KNO_3	NaOCl	$Mg_3(PO_4)_2$	$Al_2(SO_4)_3$

 Some common salts are summarized in the table, below:

Salt	Name	Salt	Name
$CaSO_4 \cdot \frac{1}{2} H_2O$	Plaster of Paris	$NaHCO_3$	Baking soda
$MgSO_4 \cdot 7H_2O$	Epsom salts	$NaNO_2$	Preservative
$Na_2B_4O_7 \cdot 10H_2O$	Borax	$AgNO_3$	Antiseptic/germicide

The formation of salts necessarily depends on their solubility -- or the lack thereof -- in water. Solubility rules that actually help make chemical reactions make sense are tabulated, below:

Rule	Exceptions
Alkali metal and NH_4^+ salts are all soluble.	Some cations in analytical group 5 are moderately insoluble
Nitrates and acetates are all soluble.	AgOAc is moderately insoluble
Chlorides, bromides and iodides are all soluble.	Those salts of Pb^{2+}, Ag^+, Hg_2^{2+} ; BiOCl and SbOCl
Sulfates are soluble.	Those salts of Ca^{2+}, Sr^{2+}, Ba^{2+}, Ag^+, Pb^{2+}, Hg_2^{2+}
Carbonate and sulfite salts are generally insoluble.	Those of the alkali metals and NH_4^+
Sulfides are generally insoluble.	Those of the alkali metals and NH_4^+; alkaline earth sulfides and Cr_2S_3 and Al_2S_3 are decomposed by water
Hydroxides are generally insoluble.	Alkali metals and NH_4^+; Barium, strontium and calcium hydroxides are moderately soluble.
All other salts are insoluble.	

As a general rule, solubility is defined as the solute being dissolved in aqueous solution to about 3-5%.

Soluble salts are electrolytes, i.e., they will conduct an electrical current. The rules of electrolytes are summarized in the table, below, as well:

Summary of Strong and Weak Electrolytes	
Rule	Exception
Most acids are weak electrolytes.	The common strong acids: hydrochloric, hydrobromic, hydroiodic, nitric, sulfuric, chloric and perchloric
Most bases are weak electrolytes.	The strong basic hydroxides of Li, Na, K, Rb, Cs, Ca, Sr, Ba hydroxides
Most salts are strong electrolytes	The most importantly weakly ionized salt is $HgCl_2$; occasionally, the following are listed without general agreement: $Hg(CN)_2$, $CdCl_2$, $CdBr_2$, CdI_2 and $Pb(OAc)_2$

Preparation of Salts

There are at least 5 mechanisms for the preparation of salts. They are summarized with representative reactions in the table, below:

Mechanism	Representative Reactions
Direct union of their elements.	$2Na + Cl_2 \rightarrow 2NaCl$ $Fe + S \rightarrow FeS$
Reactions of acids with metals, metal hydroxides or metal oxides.	$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ $Fe(OH)_3 + 3HCl \rightarrow FeCl_3 + 3H_2O$ $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$
Reactions of basic anhydrides with acid anhydrides.	$BaO + SO_3 \rightarrow BaSO_4$ $CaO + CO_2 \rightarrow CaCO_3$
Reaction of acids with salts.	$BaCO_3 + 2HCl \rightarrow BaCl_2 + H_2O + CO_2$ $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$
Reaction of salts with other salts.	$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$ $ZnCl_2 + Na_2S \rightarrow ZnS + 2NaCl$

Chapter 7 -- Freezing Point Depression: A Colligative Property	NAME:	
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<mark>Chapter 7 -- Freezing Point Depression: A Colligative Property</mark>

Introduction

Various properties of chemicals in solution depend on the number of solutes per volume of solution, i.e., concentration, but NOT upon the identity of the solute. These properties include vapor pressure lowering, freezing point depression, boiling point elevation and osmotic pressure. These properties are called **colligative properties**.

The colligative property to be studied in this experiment is the property of freezing point depression. When a solute is added to a pure solvent, the freezing point of the new solution will be less than that for the pure solvent. (Conversely, when a solute is added to a pure solvent, the boiling point is elevated.)

Arithmetically, this is represented by the following equation:

$$\Delta T_f = K_f \, m$$

The depression in freezing point is ΔT_f; K_f is the freezing point constant and is in units of $^\circ$C/m; m is the **molality** of the solution in units of moles of sol**ute** per kilogram of sol**vent**.

To determine what the new freezing temperature (T_{fo}) is, all one needs to do is subtract ΔT_f from the T_f of the pure solvent:

$$T_{f_o} - \Delta T_f = T_f$$

T_{fo} is the freezing point of the pure solvent; ΔT_f is as defined previously; T_f is the new freezing temperature of the solution.

Freezing point determinations have been utilized in the past by such scientists as protein biochemists to determine the molecular mass of unknown proteins. This idea is also applicable to other substances including electrolytes. Electrolyte solutions will not be examined in this laboratory experiment.

In order to make use of freezing point depressions to determine molecular masses, the original equation must be rearranged as follows:

$$\Delta T_f = K_f \, m$$

$$\Delta T_f = K_f \frac{mol\ solute}{kilogram\ solvent} \qquad mol = \frac{gram\ solute}{Molecular\ weight\ solute}$$

$$\Delta T_f = K_f \frac{gram\ solute}{M\ W\ solute} * \frac{1}{kilogram\ solvent}$$

The K_f is experimentally determined prior to determining the ΔT_f with the unknown. Both values are then "plugged into" the previous equation along with the mass of the unknown and the solvent. The molecular weight (MW) follows as a simple calculation and is equal to:

$$M\ W_{solute} = \frac{K_f}{\Delta T_f} * \frac{gram\ solute}{kilogram\ solvent}$$

<u>Experimental</u>

CAUTION!!!!!!

This experiment utilizes phenol (caustic) as the solvent, p-dichlorobenzene (moth balls -- possible carcinogen) to determine the K_f and an unknown compound for MW determination.

Dispose of as instructed by your lab instructor.

Supplies	Supplies	Supplies
1-Clay triangle 1-Bronze stirrer Bunsen burner with tubing Rubber stopper	BIG test tube Thermometer Phenol Unknown sample p-dichlorobenzene (PDCB)	1-Ring stand 1-400 ml beaker 2-Rings 1-Utility clamp

Assemble the apparatus shown in the figure, right. Once you have accomplished this, add 10 grams phenol to your BIG test tube (record the mass -- this is important). Heat the sample of phenol in the water bath until the temperature is 10°C above the melting temperature for phenol (i.e., heat to between 51°C and 53°C), then stop heating and allow

the phenol to solidify while mixing it. At the first sign of solidification (looks a little like a spider web), record the temperature. This is the visual freezing point. While you are doing this, remember to record the temperature at the various times (every minute) in the data sheets, below, while you are reading the thermometer. Let the sample cool, then repeat the procedure. **This data will provide you with the T_f of phenol.**
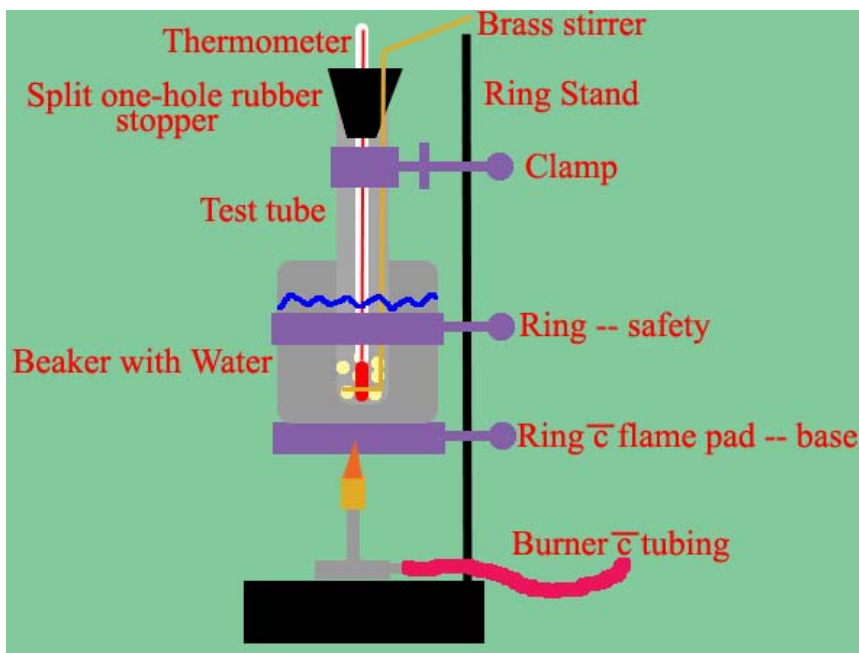
Once your sample has cooled, add 0.5 gram PDCB to the phenol and repeat the procedure as before. **This data will give you the necessary information to calculate the K_f of phenol.** Repeat the procedure and record your data from both trials, below.

To determine the molecular mass of your unknown, obtain a "clean" sample of phenol and add 1.0 gram of the unknown to it. Repeat the procedure as before in duplicate, recording your data from each trial, below.

Plot the results of your temperature drop *vs* time for all experiments using Excel, Quattro-Pro or Lotus. Where is the graphic freezing point of your pure solvent? the PDCB and solvent?; unknown and solvent? **Attach your graphs to this report.** Did you observe any super-cooling? How do you know if you did or not? Phenol has a literature melting point of between 41°C and 43°C. How does your melting temperature compare to this? Does altitude have any effect on the melting temperature? The K_f for phenol is 7.27°C/m [1]. How does this compare to your value for K_f? The molecular weight of naphthalene is 128.2 g/mol. How does the determined MW of your unknown compare to this value? Determine the per cent error for each of the three parameters you determined in this experiment.

Rinse the tubes with chloroform and dispose of the chloroform and contents of the test tube in the container directed by your instructor.

Pure Phenol			
Trial 1		Trial 2	
Time (min)	Temp (°C)	Time (min)	Temp (°C)
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	
11		11	
12		12	
13		13	
14		14	
15		15	
16		16	
17		17	
18		18	
19		19	
20		20	
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23		23	
24		24	
25		25	
26		26	
27		27	
28		28	
29		29	
30		30	
31		31	
32		32	
33		33	
34		34	
35		35	

Phenol plus PDCB			
Trial 1		Trial 2	
Time (min)	Temp (°C)	Time (min)	Temp (°C)
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	
11		11	
12		12	
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22		22	
23		23	
24		24	
25		25	
26		26	
27		27	
28		28	
29		29	
30		30	
31		31	
32		32	
33		33	
34		34	
35		35	

Phenol plus Unknown			
Trial 1		Trial 2	
Time (min)	Temp (°C)	Time (min)	Temp (°C)
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	
11		11	
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33		33	
34		34	
35		35	

References

1. Atkins, P.W. and Beran, J.A.: **General Chemistry, Second Edition**. (W.H. Freeman and Company: New York, ©1991) p. 429.