EXPERIMENT

Electrolytes and insoluble compounds

Goal

The goal of this experiment is to familiarize with *insoluble compounds and electrolytes*. You will identify compounds based on its soluble and electrolyte character.

Background

On one hand, electrolytes are compounds that conduct the electricity once dissolved in water. Differently, nonelectrolytes are compounds that do not conduct the electricity once dissolved in water. On the other hand, insoluble compounds are not soluble in water, whereas soluble compounds can be dissolved in water. This section covers the properties of electrolytes and insoluble (and soluble) compounds. At the end of this section, you should be able to classify a chemical in terms of its electrolyte type and solubility character.

Soluble and insoluble salts

Learn more about *the solubility rules.*

Visual

Soluble compounds dissolve in water, whereas insoluble compounds do not. For example, barium chromate ($BaCrO_{4\,(s)}$) is an insoluble salt. How do we know that? Table 1 will help you predict the solubility of a salt. In order to do this, you need to start by assess the right ion (the anion, $CrO_4{}^{2-}$) located on the left column of Table 1. After that you need to assess the left ion (the cation, Ba^{2+}) located on the right column. If you follow this, you will see that chromate is insoluble and barium is not part of any exception. Let us predict for example the soluble/insoluble nature of $CaSO_4$, calcium sulfate. We start by looking for $SO_4{}^{2-}$ in the left column to find out is soluble. Next we continue in the same line as $SO_4{}^{2-}$ and look for the ion in the left Ca^{2+}. In conclusion, even when $SO_4{}^{2-}$ is soluble, when combined with Ca^{2+}, we have that $CaSO_4$ is insoluble, and overall $CaSO_{4\,(s)}$ is insoluble.

Strong electrolytes

Strong electrolytes completely dissociate in water. Hence, in a solution of a strong electrolyte you will only have ions and never molecules. Strong electrolytes are typically ionic compounds such as $MgCl_2$ or NaCl (table salt). We represent the dissociation of a strong electrolyte with a single arrow, meaning that the reaction proceeds to completion and for the example below, in the solution we will only have ions ($Mg^{2+}_{(aq)} + 2\,Cl^{-}_{(aq)}$) and not molecules ($MgCl_{2\,(s)}$):

$$MgCl_{2\,(s)} \xrightarrow{H_2O} Mg^{2+}_{(aq)} + 2\,Cl^{-}_{(aq)}$$

Weak electrolytes

Weak electrolytes partially dissociate in water, and this is indicated by means of a chemical reaction with a double arrow. Hence in a solution of a weak electrolyte you will have ions as well as molecules at the same time. Examples of weak electrolytes are hydrofluoric acid, water, ammonia or acetic acid. The dissociation of hydrochloric acid (HF) proceeds as:

$$HF_{(g)} \xrightleftharpoons{H_2O} H^{+}_{(aq)} + F^{-}_{(aq)}$$

Acetic acid (CH_3COOH) is an important weak electrolyte and its dissociation proceeds somehow in a peculiar way:

$$CH_3COOH_{(l)} \xrightleftharpoons{H_2O} CH_3COO^{-}_{(aq)} + H^{+}_{(aq)}$$

Table 1 Soluble and insoluble compounds	
Ions that form *soluble* compounds...	... **except** when combined with
Group I ions (Na^+, Li^+, K^+, etc)	no exceptions
Ammonium (NH_4^+)	no exceptions
Nitrate (NO_3^-)	no exceptions
Acetate (CH_3COO^-)	no exceptions
Hydrogen carbonate (HCO_3^-)	no exceptions
Chlorate (ClO_3^-)	no exceptions
Halide (F^-, Cl^-, Br^-)	Pb^{2+}, Ag^+ and Hg_2^{2+}
Sulfate (SO_4^{2-})	Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Hg_2^{2+} and Pb^{2+}
Ions that form *insoluble* compounds...	... **except** when combined with
Carbonates (CO_3^{2-})	group I ions (Na^+, Li^+, K^+, etc) or ammonium (NH_4^+)
Chromates (CrO_4^{2-})	group I ions (Na^+, Li^+, K^+, etc) or Ca^{2+}, Mg^{2+}or ammonium (NH_4^+)
Phosphates (PO_4^{3-})	group I ions (Na^+, Li^+, K^+, etc) or ammonium (NH_4^+)
Sulfides (S^{2-})	group I ions (Na^+, Li^+, K^+, etc) or ammonium (NH_4^+)
Hydroxides (OH^-)	group I ions (Na^+, Li^+, K^+, etc) or Ca^{2+}, Mg^{2+}, Sr^{2+}or ammonium (NH_4^+)

Nonelectrolytes

Nonelectrolytes do not dissociate in water. Hence a solution of a nonelectrolyte will only contains molecules and not ions. Examples of nonelectrolytes are carbon-based chemicals such as methanol, ethanol, urea or sucrose. The dissociation of urea for example CH_4N_2O proceeds as:

$$CH_4N_2O\,(s) \xrightarrow{H_2O} CH_4N_2O_{(aq)}$$

Identify the electrolyte character of a chemical

You can use Table 2 to identify the electrolyte character of a chemical. Ionic compounds are in general strong electrolytes, and most acids as well. There is four important weak electrolytes: water, acetic acid, ammonia and hydrofluoric acid. Covalent compounds are in general nonelectrolytes. Organic compounds, compounds based on carbon atoms (e.g. $C_{12}H_{22}O_{11}$) are in general nonelectrolytes.

Table 2 Different types of electrolytess			
Electrolyte Type	Dissociation	Particles in solution	Examples
Strong	Fully	Mostly ions	Ionic Compounds and most acids and bases: NaCl, NaOH, HCl, $MgCl_2$, H_2SO_4, etc·
Weak	Partially	Ions & molecules	NH_3, CH_3COOH (acetic acid), HF, H_2O
Nonelectrolytes	No	molecules	Most covalent compounds: CH_3OH(methanol), CH_3CH_2OH(ethanol), $C_{12}H_{22}O_{11}$ (sucrose), CH_4NO_2(urea)

STUDENT INFO

Name: _____ Date: _____

Worksheet

Electrolytes and insoluble compounds

1. Classify the following compounds in terms of their electrolyte character.

Compound	Strong electrolyte	Weak electrolyte	Nonelectrolyte
KCl			
KOH			
CO_2			
HF			
Li_3N			

2. Classify the following compounds in terms of their soluble character.

Compound	Soluble	Insoluble
KCl		
Ag_2S		
$Be(OH)_2$		
$NaHCO_3$		
$NaCO_2$		

3. Name and dissociate the following compounds into ions.

Compound	Ions	Chemical Name
$NaHCO_3$		
$Be(OH)_2$		
Li_3N		
$Ca_3(PO_4)_2$		
KNO_3		