Fractional Precipitation

A. Objectives

Students are expected to separate a mixture of substances based on their different solubilities

B. Theory

There is no definite dividing lines between insoluble salts, sparingly soluble, and soluble salts, but concentrations of their saturated solutions are small, medium, and large. The solubility process reaches a dynamic equilibrium described by an equilibrium constant. This equilibrium constant is called the solubility product constant, and is given the symbol K_{sp}.

The *solubility product constant* K_{sp} is just one more version of the standard equilibrium constant expression. Here, it's applied to the equilibrium between a solid and the corresponding ions in solution. For example, if there is an equilibrium:

$$A_2B(s) \rightleftharpoons 2A^+(aq) + B^{2-}(aq)$$

the corresponding solubility product constant expression will be:

$$\mathbf{K_{sp} = [A^+]^2[B^-]}$$

The solubility product can be calculated given a compound's solubility. The solubility constant can be used to calculate whether a precipitate will form given the concentrations of ionic species. Compounds having a common ion but different solubility constants can be separated by fractional precipitation. The K_{sp} values for various salts are valuable information, and some data are given in the table 1.

Table 1. Ksp measured in 25^0C

Compound	Ksp
$Al(OH)_3$	$1{,}3 \times 10^{-23}$
$AgCl$	$1{,}8 \times 10^{-10}$
$CaCO_3$	$4{,}8 \times 10^{-9}$
$Cu(OH)_2$	$2{,}2 \times 10^{-20}$
$Fe(OH)_3$	$6{,}3 \times 10^{-38}$
$Fe(OH)_2$	$1{,}6 \times 10^{-16}$
$Mg(OH)_2$	$1{,}8 \times 10^{-11}$
$Mn(OH)_2$	$1{,}9 \times 10^{-13}$
$PbCl_2$	$1{,}7 \times 10^{-5}$

The reaction quotient, Q, can be used to determine whether a precipitate will form with a given concentration of ions. (The reaction quotient is also called the ion product when it is calculated using concentrations of species involved in solubility equilibria). One first calculates Q, then compares it with K_{sp}.

If $Q < K_{sp}$, no precipitate will form.

If $Q = K_{sp}$, a precipitate will form.

If $Q > K_{sp}$, a precipitate will form.

Note that precipitation may not happen immediately if Q is equal to or greater than K_{sp}. A solution could be supersaturated for some time until precipitation occurs. It can be used as a rule when separate mixture by using fractional precipitation.

Fractional precipitation is a method for separating elements or compounds with similar solubilities by means of their gradual precipitation from the solution. It is a series of analytical precipitations, each one improving the purity of the desired element. The possibility of quantitative separation of a mixture depends on the ratio of the original concentrations of compounds being precipitated and on the values of their solubility product (McGraw-Hill Dictionary of Scientific & Technical Terms, 6E, 2003). Fractional precipitation can be done in many ways, like ordering acidity, precipitating by sulfide reagent or other anorganic reagent like phosphate, carbonate, chloride, and sulphate. Such organic reagent like dimethylglyoxime (DMG), and oxyn can also be used as precipitant. Besides that, by using electrical current, the substances in a solution can be separated each others, known as electrodeposition.

C. Equipments

1. Beaker glass
2. Volumetric glass
3. Filter paper
4. Centrifuge
5. pHmeter
6. Heater

D. Materials

1. NaCl

2.K_2CrO_4

3. $AgNO_3$

4. Fe(III)

5. Zn(II)

6. buffer acetate

7. NH_3

E.Procedures

1. Experiment 1

1. 100 ml solution containing 0,001 mole NaCl and K_2CrO_4 add in a beaker glass
2. Dropwise adding $AgNO_3$ into the glass slowly
3. When precipitation begin, observe your volume of $AgNO_3$ adding
4. Separate precipitate by filter paper
5. Dropwise adding $AgNO_3$ again into the glass
6. Separate the second precipitate form from solution

2. Experiment 2

1. 100 ml solution containing 0.1 mole Fe (III) and 0,1 mole Zn(II) ions add in a beaker glass
2. Measure pH at 1 with an acid reagent
3. Dropwise buffer acetate until pH 6, while observe your solution. Let your precipitate .
4. Add water and let it be slightly warm by a heater, then filtered
5. Add NH_3 solution until pH 9.
6. Filter the occurred precipitate

F. Table of Observation Data

Write down your observation on the table below:

No	Treatment	Quantitative factor of treatment	Observation
1			
Etc			

F. Task

1. The experiment is a kind of fractional precipitation. What the way is done?

2. In the first experiment, what compounds made in the first and second precipitate? Why?

3. When the first precipitate has separated, what percentage of ion that precipitated remain?