Experiment 19
Determination of Chloride

Overview

In this experiment, you will determine the percent by mass chloride in a sample that is a mixture of NaCl (FW: 58.44 g/mol) and $MgCl_2$ (FW: 95.21 g/mol). You will also be able to determine the percent NaCl by mass of your sample. Your determination will be based on the mass of AgCl (FW: 143.32 g/mol) you collect as a precipitate from a portion of your sample which you dissolve in water. The **net ionic reaction** for the precipitation reaction is

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

Experimental Description

Oftentimes, it is necessary to determine the mass of one component in a mixture. This experiment will illustrate a possible approach to this problem. Specifically, you will determine the percent by mass NaCl in a mixture of NaCl and $MgCl_2$.

You will do this by precipitating all of the chloride in the sample as AgCl. You will then take advantage of the fact that NaCl has one Cl^- ion per formula unit, whereas $MgCl_2$ has two. This approach requires setting up two equations with two unknowns. It will be convenient to define the unknowns as the number of moles of NaCl and $MgCl_2$ in the sample respectively.

If *x* represents the number of moles of NaCl, and *y* represents the number of moles of $MgCl_2$ in the sample, the total mass of the sample is given by

$$m_{sample} = x(FW_{NaCl}) + y\left(FW_{MgCl_2}\right)$$

The second equation comes from the number of moles of chloride in the sample. This will be equal to the number of moles of AgCl precipitated, so long as sufficient $AgNO_3$ is used. Expressed in terms of the number of moles of NaCl and $MgCl_2$ as expressed above, this becomes

$$n_{AgCl} = x + 2y$$

Thus, the mass of AgCl obtained should be given by

$$m_{AgCl} = (x + 2y)\left(FW_{AgCl}\right)$$

Solving these two equations will provide all of the information needed to complete the calculations for this experiment.

Example: Cristobol dissolves 0.1192 g of unknown mixture of NaCl and $MgCl_2$ in 50 mL of water in a 100 mL beaker. He adds 25.5 mL of 0.100 M $AgNO_3$ to precipitate the Cl^-. He then filters and dries the precipitate. The mass of precipitate he acquires is 0.3283 g. What is the percent by mass NaCl in his unknown?

Solution: Let *x* represent the number of moles of NaCl in the unknown, and *y* represent the number of moles of $MgCl_2$. The mass of silver chloride obtained is given by

$$m_{AgCl} = 0.3283\ g = (x + 2y)\left(143.32\frac{g}{mol}\right)$$

Solving this for *y* yields

$$y = \frac{1}{2}\left(\frac{0.3283\ g}{143.32\frac{g}{mol}} - x\right) = 0.0011453\ mol - \frac{x}{2}$$

We still need a second equation in order to find both *x* and *y*. That second equation can come from the mass of the initial sample:

$$m_{sample} = 0.1192\ g = x\left(\frac{58.44\ g}{mol}\right) + y\left(\frac{95.21\ \text{g}}{mol}\right)$$

Inserting the results from the first equation into the second yields

$$0.1192\ g = x\left(\frac{58.44\ g}{mol}\right) + \left[0.0011453\ mol - \frac{x}{2}\right]\left(\frac{95.21\ \text{g}}{mol}\right)$$

Solving this expression for *x* reveals

$$x = 0.001107\ mol$$

The mass of NaCl in the original sample is then given by

$$\%_{NaCl} = \frac{(0.001107\ mol)\left(\frac{58.44\ g}{mol}\right)}{0.1192\ g} \cdot 100\% = 54.27\%$$

Equipment

The equipment list is forthcoming.

Procedure

1. Dissolve approximately 0.1 g of your unknown sample in about 50 mL water in a 100 mL beaker.
2. Add enough 0.1 M AgCl to ensure that you will precipitate all of the Cl^- in your sample. (You calculated this amount in your prelaboratory assignment.)
3. Filter and dry the AgCl(s) which you obtain in step 2.

Vocabulary and Concepts

net ionic reaction..... 1

Pre-Laboratory Assignment – Determination of Chloride

Name _____ Section _____

Consider Sam's experiment in which they use 1.2852 g of unknown.

1. Assuming all 1.2852 g of the unknown is NaCl, perform the following calculations.

    a. Calculate the number of moles of Cl^- in the sample.
    b. Calculate the minimum volume of 0.100 M $AgNO_3$ needed to precipitate all of the chloride.

2. Assuming all of the 1.2852 g of the sample are $MgCl_2$, perform the following calculations.

    a. Calculate the number of moles of Cl^- in the sample.
    b. Calculate the minimum volume of 0.100 M $AgNO_3$ needed to precipitate all of the chloride.

3. In order to ensure that you precipitate all of the chloride in the 1.2852 g sample which is a mixture of NaCl and $MgCl_2$, how many mL of 0.100 M $AgNO_3$ solution should you use?

Report Sheet – Determination of Chloride

Name _____ Date _____

Lab Partner(s) _____

Data	
Chlorine	35.45 g/mol
NaCl	58.44 g/mol
$MgCl_2$	95.21 g/mol
AgCl	143.32 g/mol
Volume 0.100 M $AgNO_3$ Used	
Mass of sample of unknown	
Mass of AgCl recovered	
Moles of Cl^-	
Mass of Cl^-	
% by mass Cl^- in unknown	
Moles of NaCl in sample	
Mass NaCl in sample	
% by mass NaCl in unknown	

Sample Calculations: