



Republic of Iraq
Ministry of Higher Education & Scientific research
Al-Mustaqbal University
Science College
Medical physics Department

Analytical Chemistry

For

First Year Student

Lecture 6

By

Dr. Karrar M. Obaid

2024-2025

Gravimetric Calculations

- **The aim:** is to find the weight of analyte from the weight of precipitate.
- We can use the concepts discussed previously in stoichiometric calculations but let us learn something else.
- **Example :** Assume Cl_2 is to be precipitated as AgCl , then we can write a stoichiometric factor reading as follows: one mole of Cl_2 gives 2 moles of AgCl . We can define a quantity called the gravimetric factor (GF) where:
 - $\text{GF}(\text{analyte}) = (a/b) * (\text{FW analyte} / \text{FW ppt})$
 - a,b are stoichiometric coefficients
 - $\text{GF for } \text{Cl}_2 = (1 \text{ mol } \text{Cl}_2 / 2 \text{ mol } \text{AgCl}) * (\text{FW } \text{Cl}_2 / \text{FW } \text{AgCl})$

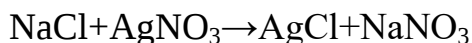
calculations involving mass (Solids).

- Write out the balanced equation
- Write out the known information under the equation, including mass, molecular weight of the species
- Calculation of number of moles of known chemicals
- Calculation of the number of moles of unknown using the ration *unknown/ known*
- Convert moles to mass *unknown known*

Problem: A 1.50 g sample of an impure sodium chloride (NaCl) was dissolved, and all the chloride ions were precipitated as silver chloride (AgCl). The mass of AgCl obtained was 3.25 g. What is the percentage purity of NaCl in the sample?

Solution:

1. Reaction:



2. Molar Mass:

$$\text{NaCl} = 58.44 \text{ g/mol}$$

$$\text{AgCl} = 143.32 \text{ g/mol}$$

3. Calculate Moles of AgCl

$$\text{Moles of AgCl} = 3.25 \text{ g} / 143.32 \text{ g/mol} = 0.02268 \text{ mol}$$

4. Relate to NaCl:

From the balanced equation, 1 mole of AgCl corresponds to 1 mole of NaCl.

$$\text{Moles of NaCl} = 0.02268 \text{ mol}$$

5. Calculate Mass of NaCl:

$$\text{Mass of NaCl} = 0.02268 \text{ mol} \times 58.44 \text{ g/mol} = 1.325 \text{ g}$$

6. Percentage Purity:

$$\text{Percentage Purity} = 1.325 \text{ g} / 1.50 \text{ g} \times 100 = 88.33\%$$

Gravimetric factor: is an algebraic expression that converts grams of a compound into grams of a single element. It is the ratio of the formula weight (FW) of the substance being sought to that of the substance weighed.

Example 1 . Fe is sought, Fe_2O_3 is weighed:

$$\text{gravimetric factor} = \frac{1 \text{ mol } \text{Fe}_2\text{O}_3}{159.69 \text{ g } \text{Fe}_2\text{O}_3} \times \frac{2 \text{ mol Fe}}{\text{mol } \text{Fe}_2\text{O}_3} \times \frac{55.847 \text{ g Fe}}{\text{mol Fe}} = 0.69944 \frac{\text{g Fe}}{\text{g } \text{Fe}_2\text{O}_3}$$

Example 2 . Fe_3O_4 is sought, Fe_2O_3 is weighed:

$$\begin{aligned}\text{gravimetric factor} &= \frac{1 \text{ mol } \cancel{\text{Fe}_2\text{O}_3}}{159.69 \text{ g } \text{Fe}_2\text{O}_3} \times \frac{2 \text{ mol } \cancel{\text{Fe}_3\text{O}_4}}{3 \text{ mol } \cancel{\text{Fe}_2\text{O}_3}} \times \frac{231.54 \text{ g } \text{Fe}_3\text{O}_4}{\text{mol } \cancel{\text{Fe}_3\text{O}_4}} \\ &= 0.96662 \frac{\text{g } \text{Fe}_3\text{O}_4}{\text{g } \text{Fe}_2\text{O}_3}\end{aligned}$$

Example 3: Calculate the ratio of weight (mg) of analyte to weight of precipitate for the following: P (at wt = 30.97) in Ag_3PO_4 (m.wt = 711.22), Bi_2S_3 m.wt 514.15) in BaSO_4 (m.wt = 233.40)

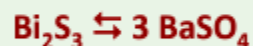
Solution



$$\text{mmol P} = \text{mmol Ag}_3\text{PO}_4$$

$$\text{mg P}/30.97 = \text{mg Ag}_3\text{PO}_4/711.22$$

$$\text{mg P}/\text{mg Ag}_3\text{PO}_4 = 30.97/711.22 = 0.04354$$



$$\text{mmol Bi}_2\text{S}_3 = 1/3 \text{ mmol BaSO}_4$$

$$\text{mg Bi}_2\text{S}_3/\text{m.wt Bi}_2\text{S}_3 = 1/3 \text{ mg BaSO}_4/\text{m.wt BaSO}_4$$

$$\text{mg Bi}_2\text{S}_3/514.15 = 1/3 \text{ mg BaSO}_4/233.40$$

$$\text{mg Bi}_2\text{S}_3/\text{BaSO}_4 = 1/3 (514.15/233.40) = 0.73429$$

Example 4: Phosphate in a 0.2711 g sample was precipitated giving 1.1682 g of $(\text{NH}_4)_2\text{P}_2\text{O}_7 \cdot 12 \text{MoO}_3$ (m.wt = 1876.5). Find percentage P (at wt = 30.97) and percentage P_2O_5 (m.wt = 141.95) in the sample.

Solution



Stoichiometric ratio: 1 : 1

So, mole P = mole $(NH_4)_2PO_4 \cdot 12 MoO_3$

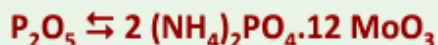
wt P /at wt P = wt $(NH_4)_2PO_4 \cdot 12 MoO_3$ / $m.wt (NH_4)_2PO_4 \cdot 12 MoO_3$

wt P = at wt P x (wt $(NH_4)_2PO_4 \cdot 12 MoO_3$ / $m.wt (NH_4)_2PO_4 \cdot 12 MoO_3$)

wt P = 30.97 (1.1682 / 1876.5) = 0.0192 mg

% P = (0.0192/0.2711) x 100 = 7.1%

The same procedure is applied for finding the percentage of P_2O_5



Stoichiometric ratio: 2 : 1

so, mole P_2O_5 = 1/2 mole $(NH_4)_2PO_4 \cdot 12 MoO_3$

wt P_2O_5 /m.wt P_2O_5 = 1/2 (wt $(NH_4)_2PO_4 \cdot 12 MoO_3$ / $m.wt (NH_4)_2PO_4 \cdot 12 MoO_3$)

wt P_2O_5 = 1/2 x $m.wt P_2O_5$ x (wt $(NH_4)_2PO_4 \cdot 12 MoO_3$ / $m.wt (NH_4)_2PO_4 \cdot 12 MoO_3$)

wt P_2O_5 = 1/2 x 141.95 (1.1682/1876.5) = 0.0442 g

% P_2O_5 = (0.0442/0.2711) x 100 = 16.30%

EXAMPLE 12-1

The calcium in a 200.0-mL sample of a natural water was determined by precipitating the cation as CaC_2O_4 . The precipitate was filtered, washed, and ignited in a crucible with an empty mass of 26.6002 g. The mass of the crucible plus CaO (56.077 g/mol) was 26.7134 g. Calculate the concentration of Ca (40.078 g/mol) in water in units of grams per 100 mL of the water.

Solution

The mass of CaO is

$$26.7134\text{g} - 26.6002 = 0.1132\text{g}$$

The number of moles of Ca in the sample is equal to the number of moles of CaO, or

$$\begin{aligned}\text{amount of Ca} &= 0.1132\text{gCaO} \times \frac{1\text{molCaO}}{56.077\text{gCaO}} \times \frac{1\text{molCa}}{1\text{molCaO}} \\ &= 2.0186 \times 10^{-3}\text{molCa}\end{aligned}$$

$$\begin{aligned}\text{conc. Ca} &= \frac{2.0186 \times 10^{-3}\text{molCa} \times 40.078\text{gCa/molCa}}{200\text{ mL sample}} \times \frac{100}{100} \\ &= 0.04045\text{ g/100 mL sample}\end{aligned}$$