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

**Analytical Chemistry**

**For**

**First Year Student**

**Lecture 10**

**By**

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**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  $\text{Cl}_2$  is to be precipitated as  $\text{AgCl}$ , then we can write a stoichiometric factor reading as follows: one mole of  $\text{Cl}_2$  gives 2 moles of  $\text{AgCl}$ . 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
  - $\text{GF for } \text{Cl}_2 = (1 \text{ mol } \text{Cl}_2 / 2 \text{ mol } \text{AgCl}) * (\text{FW } \text{Cl}_2 / \text{FW } \text{AgCl})$

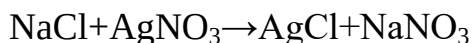
### calculations involving mass (Solids).

- 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 ( $\text{NaCl}$ ) was dissolved, and all the chloride ions were precipitated as silver chloride ( $\text{AgCl}$ ). The mass of  $\text{AgCl}$  obtained was 3.25 g. What is the percentage purity of  $\text{NaCl}$  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,  $\text{Fe}_2\text{O}_3$  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 .  $\text{Fe}_3\text{O}_4$  is sought,  $\text{Fe}_2\text{O}_3$  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  $\text{Ag}_3\text{PO}_4$  (m.wt = 711.22),  $\text{Bi}_2\text{S}_3$  m.wt 514.15) in  $\text{BaSO}_4$  (m.wt = 233.40)

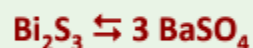
**Solution**



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

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

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



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

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

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

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

**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  $\text{P}_2\text{O}_5$  (m.wt = 141.95) in the sample.

### Solution



Stoichiometric ratio: 1 : 1

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

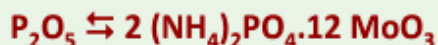
wt  $P$ /at wt  $P$  = wt  $(NH_4)_2PO_4 \cdot 12 MoO_3$  /  $m.wt (NH_4)_2PO_4 \cdot 12 MoO_3$

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  $\text{CaC}_2\text{O}_4$ . 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

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

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