Republic of Iraq
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Analytical Chemistry

For

First Year Student

Lecture 10

By

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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:
- GF(analyte) = (a/b)*(FW analyte/FW ppt)
- a,b are stoichiometric coefficients
- GF for Cl_2 = (1 mol Cl2/2 mol AgCl) * (FW Cl_2/FW 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:

$$NaCl+AgNO_3 \rightarrow AgCl+NaNO_3$$

2. Molar Mass:

NaCl=58.44 g/mol

AgCl=143.32 g/mol

3. Calculate Moles of AgCl

Moles of AgCl=3.25 g/143.32 g/mol=0.02268 mol

4. Relate to NaCl\text{NaCl}NaCl:

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

Moles of NaCl=0.02268 mol

5. **Calculate Mass of NaCl**:

Mass of NaCl=0.02268 mol×58.44 g/mol=1.325 g

6. Percentage Purity:

Percentage Purity=1.325/ g1.50 g×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:

$$\text{gravimetric factor} = \frac{1\ \cancel{\text{mol } Fe_2O_3}}{159.69\ \text{g } Fe_2O_3} \times \frac{2\ \cancel{\text{mol Fe}}}{\cancel{\text{mol } Fe_2O_3}} \times \frac{55.847\ \text{g Fe}}{\cancel{\text{mol Fe}}} = 0.69944\ \frac{\text{g Fe}}{\text{g } Fe_2O}$$

Example 2 . Fe_3O_4 is sought, Fe_2O_3 is weighed:

$$\text{gravimetric factor} = \frac{1\,\cancel{\text{mol Fe}_2\text{O}_3}}{159.69\,\text{g Fe}_2\text{O}_3} \times \frac{2\,\cancel{\text{mol Fe}_3\text{O}_4}}{3\,\cancel{\text{mol Fe}_2\text{O}_3}} \times \frac{231.54\,\text{g Fe}_3\text{O}_4}{\cancel{\text{mol Fe}_3\text{O}_4}}$$

$$= 0.96662\,\frac{\text{g Fe}_3\text{O}_4}{\text{g Fe}_2\text{O}_3}$$

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_2 S_3 m.wt 514.15) in $BaSO_4$ (m.wt = 233.40)

Solution

$P \leftrightarrows Ag_3PO_4$

mmol P = mmol Ag_3PO_4

mg P/30.97 = mg Ag_3PO_4/711.22

mg P/mg Ag_3PO_4 = 30.97/711.22 = 0.04354

$Bi_2S_3 \leftrightarrows 3\ BaSO_4$

mmol Bi_2S_3 = **1/3** mmol $BaSO_4$

mg Bi_2S_3/***m.wt*** Bi_2S_3 = **1/3** mg $BaSO_4$/***m.wt*** $BaSO_4$

mg Bi_2S_3/514.15 = **1/3** mg $BaSO_4$/233.40

mg Bi_2S_3/ $BaSO_4$ = **1/3** (514.15/ 233.40) = 0.73429

Example 4: Phosphate in a 0.2711 g sample was precipitated giving 1.1682 g of $(NH4)_2PO_4$ .12 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

$$P \leftrightarrows (NH_4)_2PO_4.12\ MoO_3$$

Stoichiometric ration: 1 : 1

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

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

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

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

$$P_2O_5 \leftrightarrows 2\ (NH_4)_2PO_4.12\ MoO_3$$

Stoichiometric ratio: 2 : 1

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

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

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

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

$$\text{amount of Ca} = 0.1132\,\cancel{\text{g CaO}} \times \frac{1\,\cancel{\text{mol CaO}}}{56.077\,\cancel{\text{g CaO}}} \times \frac{1\,\text{mol Ca}}{\cancel{\text{mol CaO}}}$$

$$= 2.0186 \times 10^{-3}\,\text{mol Ca}$$

$$\text{conc. Ca} = \frac{2.0186 \times 10^{-3}\,\cancel{\text{mol Ca}} \times 40.078\,\text{g Ca}/\cancel{\text{mol Ca}}}{200\text{ mL sample}} \times \frac{100}{100}$$

$$= 0.04045\text{ g}/100\text{ mL sample}$$