What is Quantitative Gravimetric Analysis?

Gravimetric analysis is a method of quantitative chemical analysis in which the amount of an analyte (substance being measured) is determined by measuring the mass of a solid. This technique is based on the principle that the analyte or a compound related to it can be converted into a stable, pure, and easily measurable form (usually a precipitate). The mass of this solid is then used to calculate the

Steps in Gravimetric Analysis:

1. **Sample Preparation**: A precise amount of the sample is taken.
2. **Precipitation**: The analyte or a component of it is precipitated by adding a reagent that forms an insoluble compound.
3. **Filtration**: The precipitate is filtered to separate it from the liquid phase.
4. **Washing**: The precipitate is washed with a solvent (often distilled water) to remove impurities.
5. **Drying or Igniting**: The precipitate is then dried or heated (ignited) to remove any remaining moisture or volatile components, ensuring it is in a pure, stable form.
6. **Weighing**: The mass of the precipitate is measured accurately.

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7. **Calculation**: The amount of the analyte in the original calculated based on the mass of the precipitate, considering stoichiometric relationships.

Types of Gravimetric Analysis

Gravimetric analysis can be broadly classified into two main types based on the nature of the precipitate formed and the procedure used for its determination. These types include:

Precipitation gravimetry

- Precipitation Gravimetry uses a precipitation reaction to separate one or more parts of a solution by incorporating it into a solid.

Volatilization gravimetry

- Volatilization Gravimetry involves separating components of our mixture by heating or chemically decomposing the sample.

Electrogravimetry

- Electrogravimetry is a method used to separate and quantify ions of a substance, usually a metal.

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Advantages of Gravimetric Analysis

If the methods are followed carefully, it provides exceedingly precise analysis. It is used to determine the atomic masses of many elements to six-figure accuracy. It provides little room for instrumental error and does not require a series of standards for calculation of an unknown.

Disadvantages of Gravimetric Analysis

It usually provides only for the analysis of a single element, or a limited group of elements, at a time. Comparing modern dynamic flash combustion coupled with gas chromatography with traditional combustion analysis.

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Example1:

Determine the mass of oxygen required to completely burn 10.0 g of propane (C_3H_8) ?

$$C_3H_{8\,(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

C = 12

H = 1

O = 16

Sol:

M.wt (C_3 H_8)= (3×12) +(8×1) =44

M.wt ($O_{2)=}$(2×16) =32

	Known (C_3H_8)	unknown (O_2)
Wt. =	10.0 g	???
M.wt. =	44	32

Moles of (…….) $= \frac{wt.}{M.wt.}$

Moles of $C_3H_8 = \frac{10.00}{44} = 0.2272\ mole$, *stoichiometric ratio* $= \frac{unknown}{known} = \frac{5}{1}$

Moles of $O_2 = 0.2272 \times 5 = 1.136\ mol$

Wt. of O_2= *moles of* $O_2 \times$ *M. wt.* $\rightarrow$ *Wt. of* $O_2 = 1.136 \times 32 = 36.352\ g$

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Example 2:

If you decompose 1.00 g of malachite, or $Cu(OH)_2.CuCO_{3(s)}$, what mass of CuO would be formed and percent yield of the reaction using the following reaction:

$$Cu(OH)_2.CuCO_3 \rightarrow 2CuO + CO_2 + H_2O$$

$Cu = 64$

$O = 16$

$C = 12$

$H = 1$

Sol:

M.wt $(Cu(OH)_2.CuCO_3)$ = (2×64) +(5×16) +(2×1) +(1×12) =222

M.wt (CuO) = (1×64) +(1×16) =80

	Known ($Cu(OH)_2.CuCO_3$)	unknown (CuO)
Wt. =	*1.00 g*	*???*
M.wt =	*222*	*80*

Moles of (…….) = $\frac{wt.}{M.wt.}$

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Moles of $(Cu(OH)_2.CuCO_3) = \frac{1.00}{222} = 0.0045$ *mole*

, stoichiometric ratio $= \frac{unknown}{known} = \frac{2}{1}$

Moles of CuO = 0.0045 × 2 = 0.009 mole

Wt. of CuO = moles of CuO × M. wt.

Wt. of $O_2 = 0.009 \times 80 = 0.72$ *g*

Percent yield $= \frac{Wt.CuO}{Wt.Cu(OH)_2.CuCO_3} \times 100$

$= \frac{0.72}{1.00} \times 100 = 72\ \%$

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H.W /

- ***What mass of sodium hydroxide, NaOH, would be required to produce 16 g of the antacid milk of magnesia [magnesium hydroxide, $Mg(OH)_2$] by the following reaction?***

$$MgCl_{2(aq)} + 2NaOH_{(aq)} \rightarrow Mg(OH)_{2(s)} + 2NaCl_{(aq)}$$

Mg=24

O=16

H=1

Na=23

- ***Methyl tert-butyl ether (MTBE, $C_5H_{12}O$), a substance used as an octane booster in gasoline, can be made by reacting isobutylene (C_4H_8) with methanol (CH_3OH). What is the percent yield of the reaction if 32.8 g of methyl tert-butyl ether is obtained from reaction of 26.3 g of isobutylene (the purity of isobutylene 80%) with sufficient methanol?***

$$C_4H_{8(g)} + CH_3OH \rightarrow C_5H_{12}O$$

C=12
H=1
O=1

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