

CHAPTER 1: INTRODUCTION TO ANALYTICAL CHEMISTRY

ASSESSMENT:

I. Select the letter of the correct answer.

1. A. Defining the Problem
2. C. Qualitative
3. D. Statistics
4. A. Accuracy
5. A. Qualitative Analysis

II. Compare and Contrast.

1. QUALITATIVE CHEMISTRY AND QUANTITATIVE CHEMISTRY

QUALITATIVE CHEMISTRY	QUANTITATIVE CHEMISTRY
<ul style="list-style-type: none">• Gives the presence or absence of different chemical components in a sample• Example:<ul style="list-style-type: none">✓ Elemental Analysis✓ Identification of sample structure to be analyzed	<ul style="list-style-type: none">• Gives the amount of different chemical components present in a given sample.• Example:<ul style="list-style-type: none">✓ Chemical Analysis $y + x = p$✓ Instrumental analysis

2. ACCURACY AND PRECISION

ACCURACY	PRECISION
<ul style="list-style-type: none">• Refers to how closely the measured value of a quantity corresponds to its "true" value.	<ul style="list-style-type: none">• Refers to how close measurements of the same item are to each other. Precision is independent of accuracy.

3. PHYSICAL PROPERTIES AND CHEMICAL PROPERTIES

PHYSICAL PROPERTIES	CHEMICAL PROPERTIES
<ul style="list-style-type: none">• A characteristic of a substance that can be observed or measured without changing the identity of the substance. Physical properties include color, density, hardness, and melting and boiling points.	<ul style="list-style-type: none">• Describes the ability of a substance to undergo a specific chemical change.

4. ANALYTICAL PERSPECTIVE AND THE SCIENTIFIC METHOD

ANALYTICAL PERSPECTIVE	THE SCIENTIFIC METHOD
<ul style="list-style-type: none">• An approach that use of analysis to break a problem down into the elements necessary to solve it. There are five-step process in analytical perspective:<ol style="list-style-type: none">1. Identify and define the problem.2. Design the experimental procedure.3. Conduct an experiment, and gather data.4. Analyze the experimental data.5. Propose a solution to the problem.	<ul style="list-style-type: none">• Experiments (often with controls and variables) are devised to test hypotheses. In the scientific method, analysis of the results of an experiment will lead to the hypothesis being accepted or rejected. The basic steps of the scientific method are:<ol style="list-style-type: none">1. Make an observation that describes a problem.2. Create a hypothesis.3. Test the hypothesis.4. Draw conclusions and refine the hypothesis.

CHAPTER 2: BASIC TOOLS OF ANALYTICAL CHEMISTRY

ASSESSMENTS:

I. Solve for the following chemical problems. Show your solutions.

1. Calculate the number of grams of HCl needed to produce 150 mL of 2 M HCl solution.

SOLUTION:

Given data:

Volume of solution = 150 mL

Molarity of HCl solution = 2 mole/Liter

Number of grams = ?

Molar mass of HCl = (1 + 35.5) gram/mole
= 36.5 gram/mole

$$1000 \text{ mL} = 1 \text{ liter}$$

$$150 \text{ mL} = \frac{150}{1000} \text{ liter}$$

$$\therefore 0.30 \text{ mole}$$

Formula:

Mass \therefore Number of mole \times Molar mass

$$\therefore 0.30 \text{ mole} \times 36.5 \text{ gram/mole}$$

$$\therefore 10.95 \text{ gram}$$

Hence, number of gram = 10.95 gram

2. How many grams of table sugar ($H_{12}C_{22}O_{11}$) is needed to produce 1.5 M of 1 L sugar solution.

ANSWER:

- **Molarity (mol/1):** Number of moles of solute dissolve in one liter of solution is known as molarity (mol/L)

$$\text{molarity (mol/L)} = \frac{\text{no. of moles of solute}}{\text{volume of solution (L)}}$$

$$\text{no. of moles} = \frac{\text{mass of solute (g)}}{\text{molar mass of solute (g/mol)}}$$

- **Given:** Sugar Solution
Concentration of sugar solution = 1.5M
Volume of sugar solution = 1 Liter
- **Formula:** $C_{12}H_{22}O_{11}$ (molar mass = 342.3 g/mol)

$$\begin{aligned} \text{no. of moles } C_{12}H_{22}O_{11} &= \text{molarity (mol/L)} \times \text{volume (L)} \\ &\hat{=} 1.5(\text{mol/L}) \times 1 \text{ L} \\ &\hat{=} 1.5 \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{mass of } C_{12}H_{22}O_{11} \text{ needed (g)} &= 1.5 \text{ mol} \times 342.3 \text{ g/mol} \\ &\hat{=} 513.45 \text{ g} \end{aligned}$$

3. What would be the percent by volume and proof of an ethanol solution containing 70 mL alcohol in 250 mL alcohol solution?

SOLUTION:

Given data:

Volume of ethanol = 70 mL

Volume of ethanol solution = 250 mL

Here, Solute of the ethanol solution is ethanol.

Percent by volume $\left(\% \frac{V}{V} \right)$

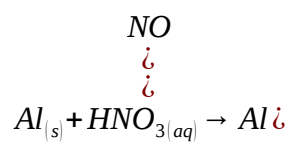
$$\hat{=} \left(\frac{\text{Volume of solute}}{\text{Volume of solution}} \right) \times 100 \%$$

$$\hat{=} \left(\frac{70 \text{ mL}}{250 \text{ mL}} \right) \times 100 \%$$

$$\hat{=} 28 \%$$

Therefore, percent by volume = **28%**

- II. Balance the chemical equation below, in the analysis below, the Aluminum present in the sample is 15.62 g which was extracted with suitable solvent. The complete oxidation of the Aluminum to Aluminum nitrate required 5.44 mL of 0.0150 M HNO_3 . What is the weight of oxalic acid in the sample?



CHAPTER 3: THE LANGUAGE OF ANALYTICAL CHEMISTRY

ASSESSMENT:

I. Calculate for the following problem. Show our solution.

1. A sample was analyzed for the concentration of two analytes, C and D, under two sets of conditions. Under condition 1 the calibration sensitive are

$$k_{c,1} = 23 \text{ ppm}^{-1} \quad k_{D,1} = 415 \text{ ppm}^{-1}$$

And for condition 2

$$k_{c,2} = 115 \text{ ppm}^{-1} \quad k_{D,2} = 45 \text{ ppm}^{-1}$$

The signals under the two sets of conditions are

$$S_{meas,1} = 78.6 \quad S_{meas,2} = 47.9$$

Determine the concentration of C and D. You may assume that S_{reag} is zero under both conditions.

ANSWER:

GIVEN:

Under condition 1 the calibration sensitivities are

$$k_{c,1} = 20 \text{ ppm}^{-1} \quad S_{reag,1} = 0 \quad k_{D,1} = 410 \text{ ppm}^{-1}$$

for condition 2

$$k_{c,2} = 110 \text{ ppm}^{-1} \quad S_{reag,2} = 0 \quad k_{D,2} = 40 \text{ ppm}^{-1}$$

The signals under the two sets of conditions are

$$S_{meas,1} = 78.1 \quad S_{meas,2} = 47.2$$

SOLUTION:

Equation:

$$S_{meas,1} = k_{c,1} C_c + k_{D,1} C_D + S_{reag,1}$$

$$S_{meas,2} = k_{c,2} C_c + k_{D,2} C_D + S_{reag,2}$$

Substitute the given value of the given equation:

$$78.1 = (20 \text{ ppm}^{-1}) C_c + \overset{\text{ppm}^{-1}}{410} C_D$$

$$\begin{array}{l}
 ppm^{-1} \\
 40 \text{ } \dot{C} \\
 \dot{C} \\
 47.2 = (110 ppm^{-1}) C_C + \dot{C}
 \end{array}$$

Multiplying the first equation by the ratio of 110/20 or 5.5 given the equation as:

$$\begin{array}{l}
 ppm^{-1} \\
 410 \text{ } \dot{C} \\
 \dot{C} \\
 78.1 = (20 ppm^{-1}) C_C + \dot{C} \\
 \\
 ppm^{-1} \\
 40 \text{ } \dot{C} \\
 \dot{C} \\
 47.2 = (110 ppm^{-1}) C_C + \dot{C}
 \end{array}$$

Subtracting the first equation from the second yields to:

$$\begin{array}{l}
 ppm^{-1} \\
 40 \text{ } \dot{C} \\
 \dot{C} \\
 47.2 = (110 ppm^{-1}) C_C + \dot{C} \\
 - \dot{C} \\
 \\
 ppm^{-1} \\
 2255 \text{ } \dot{C} \\
 \dot{C} \\
 429.55 = (110 ppm^{-1}) C_C + \dot{C} \\
 -382.35 = (-2215) C_D \\
 \\
 \frac{-382.35}{-2215} = \frac{(-2215) C_D}{-2215} \\
 C_D = 0.1726
 \end{array}$$

Substituting the value of $C_D = 0.1726$ to the original equation will get the value of C_C .

$$429.55 = \left(\frac{110 \text{ ppm}^{-1}}{2255 \text{ } \dot{C}} \right) C_C + \dot{C}$$

$$429.55 = (110 \text{ ppm}^{-1}) C_C + \dot{C}$$

$$429.55 = (110 \text{ ppm}^{-1}) C_C + 389.213$$

$$429.55 - 389.213 = (110 \text{ ppm}^{-1}) C_C$$

$$40.337 = (110 \text{ ppm}^{-1}) C_C$$

$$\frac{40.337}{110 \text{ ppm}^{-1}} = \left(\frac{110 \text{ ppm}^{-1}}{110 \text{ ppm}^{-1}} \right) C_C$$

$$C_C = 0.3667 \text{ ppm}$$

II. Examine and Create

1. Examine a procedure from any biological or environmental manual of standard analytical methods, and identify the steps taken to compensate for interferences, to calibrate equipment and instruments, to standardize the method, and to acquire a representative sample.

CHAPTER 4
EVALUATING ANALYTICAL DATA

ASSESSMENT:

- I. Calculate for the following sets of data. Show your solution.

1. Alexiev and associates describe an improved photometric method for the determination of Fe^{3+} based on its catalytic effect on the oxidation of sulphanic acid by KIO_4 . As part of their study the concentration of Fe^{3+} in human serum samples was determined by the proposed method and the standard method. Following are the results, with concentrations in micromoles/L.

Samples	Proposed Method	Standard Method
1	8.25	8.06
2	9.75	8.84
3	9.75	8.36
4	9.75	8.73
5	10.75	13.13
6	11.25	13.65
7	13.88	13.85
8	14.25	13.43

Determine whether there is a significant difference between the two methods at $\alpha=0.05$.

ANSWER:

Determine whether there is a significant difference between the two methods at $\alpha = 0.05$.

ANSWER:

Sample	Proposed Method	Standard Method	Difference d	$\frac{-\sum d}{n}$	$\frac{-\sum d^2}{n}$
1	8.25	8.06	0.19	-0.95625	0.914414
2	9.75	8.84	0.91	-0.23625	0.055814
3	9.75	8.36	1.39	0.24375	0.059414
4	9.75	8.73	1.02	-0.12625	0.015939
5	10.75	13.13	2.38	1.23375	1.522139
6	11.25	13.65	2.4	1.25375	1.571889
7	13.88	13.85	0.03	-1.11625	1.246014
8	14.25	13.43	0.85	-0.29625	0.087764
Σ			9.17		5.47338
Average $\frac{-\sum d}{n}$			1.14625		
Standard deviation, s			0.884258164		

We first determine the average value of differences between each pair of results:

$$d = \sum d/n = 9.17/8 = 1.146$$

Where **n** is the no. of paired measurements.

To determine the standard deviation:

$$s = \sqrt{\frac{\sum d^2 - (\sum d)^2/n}{n-1}}$$

$$s = 0.884$$

Statistic **t**:

$$t = \frac{d \sqrt{n}}{s}$$

$$t = 1.146 \times \frac{\sqrt{8}}{0.884} = 3.67$$

The no. of degrees of freedom of **t** is $n - 1 = 7$.

The critical value is for 7 degrees of freedom is $t_7 = 2.36 (\alpha = 0.05)$.

$$t > t_7 = \therefore H_0 \text{ is rejected}$$

- Since the calculated value of it is greater than the critical value, we have to reject the hypothesis: the methods are giving significantly different results for Fe³⁺ concentration/in serum.
2. Ten laboratories were asked to determine the concentration of an analyte A in three standard test samples. Following are the results, in parts per million.

Laboratory	Sample 1	Sample 2	Sample 3
1	22.6	13.6	16.0
2	23.0	14.2	15.9
3	21.5	13.9	16.3
4	21.9	13.9	16.9
5	21.3	13.5	16.7
6	22.1	13.5	17.4
7	23.1	13.9	17.5
8	21.7	13.5	16.8
9	22.2	12.9	17.2

Determine if there is a significant difference between sample 1, Sample 2, and Sample 3 at a significance level of $\alpha = 0.05$.

ANSWER:

- The significant difference between the mean of two or more groups is test using one way ANOVA. In this test f statistic is used to check whether there exists significant difference between the mean of groups.
- Given the values are;

Laboratory	Sample 1	Sample 2	Sample 3
1	22.6	13.6	16
2	23	14.2	15.9
3	21.5	13.9	16.3
4	21.9	13.9	16.9
5	21.3	13.5	16.7
6	22.1	13.5	17.4
7	23.1	13.9	17.5
8	21.7	13.5	16.8
9	22.2	12.9	17.2
Sum	199.4	122.9	150.7

- The Grand total is calculated by adding all the values, we get
 $G = 22.6 + 23.0 + 21.5 + \dots + 17.5 + 16.8 + 17.2$
G = 473
- The correction factor is nothing but the division of grand total and total sample size
 $C.F = G^2/N$
 Implies,
 $C.F = 473^2 / 27$
C.F = 8286.2593
- The raw sum of square is the sum of all the squared observations
 $RSS = 22.6^2 + 23.0^2 + 21.5^2 + \dots + 17.5^2 + 16.8^2 + 17.2^2$
RSS = 8626.54
- Total sum of square is the calculated using the values raw sum of square and correction factor as
 $SS_T = RSS - C.F$
 $SS_T = 8626.54 - 8286.2593$
 $SS_T = 340.281$
- Between sum of square is calculated as

$$SS_B = \left(\frac{T_1^2}{n_1} + \frac{T_2^2}{n_2} + \frac{T_3^2}{n_3} \right) - C.F$$

$$= \left(\frac{199.4^2}{9} + \frac{122.9^2}{9} + \frac{150.7^2}{9} \right) - 8286.2593$$
 $SS_B = 333.214$
- Within sum of square is calculated as,
 $SS_W = SS_T - SS_B$

$$SS_w = 340.281 - 333.214$$

$$SS_w = 7.067$$

- Since, the total sample size is 27, the total degree of freedom (N-1) is **26**
- Since we have three samples, the between degree of freedom (k-1) is **2**
- Then the within group degree of freedom (N-k) is **24**
- Between mean of sum of square is calculated as,

$$M \quad SS_B = SS_B / (k - 1)$$

$$M \quad SS_B = 333.214 / 2 \text{ is } 166.607$$

Within mean sum of square is calculated as,

$$M \quad SS_w = SS_w / (N - k)$$

$$M \quad SS_w = 7.067 / 24 \text{ is } 0.294$$

- The f-ratio is calculate by dividing the between mean sum of square and within mean sum of square,

$$F - ratio = 166.607 / 0.294$$

$$F - ratio = 565.8$$

- The ANOVA table will become

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F-ratio
Between	2	333.14	166.607	565.8
Within	24	7.067	0.294	
Total	27	340.281		

From the table, F table value $F_{(2,24)}$ at 0.05 level of significance is 3.40

- Let us consider the null and alternative hypothesis

$$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$$

$$H_1: \text{Not all means are equal}$$

- Thus, null hypothesis stated that there is no significant difference between sample 1, sample 2 and sample 3. And the null hypothesis claim that there is a significant difference between sample 1, sample 2 and sample 3.

Since, the f-ratio value 565.8 which is greater than the f-table value 3.40, we reject the null hypothesis.

Hence we conclude that there is a significant difference between sample 1, sample 2 and sample 3.

CHAPTER 5

CALIBRATIONS, STANDARDIZATIONS, AND BLANK CORRECTIONS

ASSESSMENT:

- In calibrating a 10-mL pipet, a measured volume of water was transferred to a tared flask and weighed, yielding a mass of 9.9814g. (a) Calculate, with and without correcting for buoyancy, the volume of water delivered by the pipet. Assume that the density of water is 0.99707 g/cm³ and that the density of the weights is 8.40 g/cm³. (b) What are the absolute and relative errors introduced by failing to account for the effect of buoyancy? Is this a significant source of determinate error for the calibration of a pipet? Explain.

ANSWER:

Given:

- Weight of air (W_a) = 9.9814 g
- Density of water (D_o) = 0.99707 g/cm³
- Density of calibration weight (D_w) = 8.40 g/cm³
- Density of air under normal condition = 0.0012

Find:

- Volume of water with/without accounting for buoyancy
- The absolute and relative errors in the mass

Solution:

- Without correcting for buoyancy

$$\frac{\text{weight in air}}{\text{density of water}} = \frac{W_a}{D_o}$$

$$\therefore \frac{9.9814 \text{ g}}{0.99707 \text{ g/cm}^3}$$

$$\therefore 10.011 \text{ cm}^3 \vee 10.011 \text{ mL}$$

- With correcting for buoyancy

$$W = W_a \times \left[1 + \left(\frac{1}{D_o} - \frac{1}{D_w} \right) \times 0.0012 \right]$$

$$\therefore 9.9814 \text{ g} \times \left[1 + \left(\frac{1}{0.99707 \text{ g/cm}^3} - \frac{1}{8.40 \text{ g/cm}^3} \right) \times 0.0012 \right]$$

$$\therefore 9.9814 \text{ g} \times [1 + (1.0029 - 0.1190) \times 0.0012]$$

$$\checkmark 9.9814 \text{ g} \times [1 + (0.8839) \times 0.0012]$$

$$\checkmark 9.9814 \text{ g} \times [1 + 0.0011]$$

$$\checkmark 9.9814 \text{ g} (1.0011)$$

$$\checkmark 9.9920 \text{ g}$$

b. The absolute and relative errors in the mass are:

$$\checkmark 10.011 \text{ mL} - 10.021 \text{ mL} = -0.010 \text{ mL}$$

$$\frac{-0.010 \text{ mL}}{10.021 \text{ mL}} \times 100 \% = 0.10 \%$$

- Thus, it shows that the standard deviation for the calibration of a 10-mL pipet is in the order of $\pm 0.006 \text{ mL}$. Failed to correct for the effect of buoyancy that gives a determine error of -0.010 mL which is larger than $\pm 0.006 \text{ mL}$, suggesting that it introduces a small, but significant determine error.

2. Repeat the questions in problem for the case when a mass of 0.2500 g is measures for a solid that has a density of 2.50 g/cm³.

→ (a) without correction: 0.2500 g, with correction 0.2501 g; (b) -0.0001 g , -0.040%

3. Is the failure to correct for buoyancy a constant or proportional source of determinate error?

→ The failure to correct for buoyancy is a proportional source of determinate error.

**ANALYTICAL
CHEMISTRY MODULE
2**

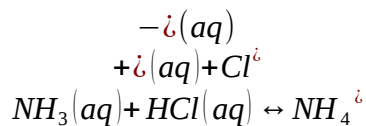
CHAPTER VI EQUILIBRIUM CHEMISTRY

ASSESSMENT:

1. Write equilibrium constant expressions for the following reactions. Determine the value for the equilibrium constant for each reaction using appropriate equilibrium constants which will be handed by your instructor or can be viewed on the following address:
 - a. $\text{NH}_3(\text{aq}) + \text{HCl}(\text{aq}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{Cl}^-(\text{aq})$
 - b. $\text{PbI}_2(\text{s}) + \text{S}^{2-}(\text{aq}) \rightleftharpoons \text{PbS}(\text{s}) + 2\text{I}^-(\text{aq})$
 - c. $\text{CdY}^{2-}(\text{aq}) + 4\text{CN}^-(\text{aq}) \rightleftharpoons \text{Cd}(\text{CN})_4^{2-}(\text{aq}) + \text{Y}^{4-}(\text{aq})$ [Y⁴⁻ is EDTA]
 - d. $\text{AgCl}(\text{s}) + 2\text{NH}_3(\text{aq}) \rightleftharpoons \text{Ag}(\text{NH}_3)_2^+(\text{aq}) + \text{Cl}^-(\text{aq})$
 - e. $\text{BaCO}_3(\text{s}) + 2\text{H}_3\text{O}^+(\text{aq}) \rightleftharpoons \text{Ba}^{2+}(\text{aq}) + \text{H}_2\text{CO}_3(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$

ANSWERS:

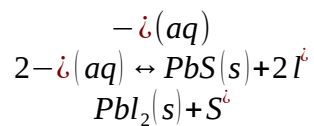
- a. Given equilibrium reaction is:



Now, the equilibrium constant expression is:

$$K_{eq} = \frac{[\text{NH}_4^+][\text{Cl}^-]}{[\text{NH}_3][\text{HCl}]}$$

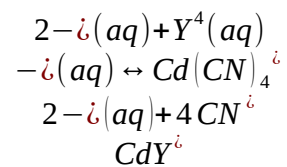
b. Given equilibrium reaction is:



Now, the equilibrium constant expression is:

$$K_{eq} = \frac{[\text{I}^{-}]^2}{[\text{S}^{2-}]}$$

c. Given equilibrium reaction is:



Now, the equilibrium constant expression is:

$$K_{eq} = \frac{[\text{I}^{-}]^2 [\text{S}^{2-}]}{[\text{I}^{-}]^2 [\text{S}^{2-}]}$$

d.

CHAPTER VII: OBTAINING AND PREPARING SAMPLES

ASSESSMENT:

1. Because of the risk of lead poisoning, the exposure of children to lead-based paint is a significant public health concern. The first step in the quantitative analysis of lead in dried paint chips is to dissolve the sample. Corl evaluated several dissolution techniques.²⁴ In this study, samples of paint were collected and pulverized with a Pyrex mortar and pestle. Replicate portions of the powdered paint were then taken for analysis. Results for an unknown paint sample and for a standard reference material, in which dissolution was accomplished by a 4–6-h digestion with HNO₃ on a hot plate, are shown in the following table.

Replicate	%w/w Pb %w/ in Unknown	Pb %w/ in Unknown
1	5.09	11.48
2	6.29	11.62
3	6.64	11.47
4	4.63	11.86

- a. (a) Determine the overall variance, the variance due to the method, and the variance due to sampling. (b) What percentage of the overall variance is due to sampling? How might the variance due to sampling be decreased?

ANSWER:

(a) The overall variance, which is the sum of the variance due to obtaining the sample and the variance due to the method

$$S^2_{\text{OVERALL}} = S^2_{\text{SAMPLING}} + S^2_{\text{METHOD}}$$

is the variance in the results for the four replicate analyses of the sample, or 0.9144. The variance due to the method is the variance in the results for the four replicate analyses of the standard, or 0.0330. The variance due to sampling, therefore, is

$$S^2_{\text{OVERALL}} = S^2_{\text{SAMPLING}} - S^2_{\text{METHOD}} = 0.9144 - 0.0330 = 0.8814$$

(b) The percentage of the overall variance due to sampling is

$$\frac{S^2_{\text{SAMPLING}}}{S^2_{\text{OVERALL}}} \times 100 = \frac{0.8814}{0.9144} \times 100 = 96.4\%$$

CHAPTER VIII: GRAVIMETRIC METHODS OF ANALYSIS

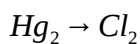
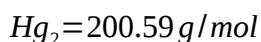
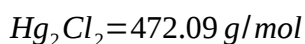
ASSESSMENT:

Solve for the following problems, show your solution:

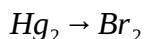
1. A mixture of mercurous chloride (FW 472.09) and mercurous bromide (FW 560.99) weighs 2.00 g. The mixture is quantitatively reduced to mercury metal (At wt 200.59) which weighs 1.50 g. Calculate the % mercurous chloride and mercurous bromide in the original mixture.

ANSWER:

Given:



$$\text{Gravimetric factor} \quad \downarrow \quad \frac{200.59 \text{ g}}{472.09} \times \frac{2}{1} = 0.8998 \text{ Hg } 1 \text{ g } Hg_2Cl_2$$



$$\text{Gravimetric factor} \quad \downarrow \quad \frac{200.59 \text{ g}}{560.99} \times \frac{2}{1} = 0.71513 \text{ Hg } 1 \text{ g } Hg_2Br_2$$

$$\text{Mass of mixture} \quad \downarrow \quad Hg_2Cl_2 + Hg_2Br_2 = 1.50 \text{ g}$$

$$\text{Mass of mixture} \quad \downarrow \quad 2.00 \text{ g}$$

$$\text{Mass of mixture} \quad \downarrow \quad Hg_2Cl_2 + Hg_2Br_2$$

$$\text{If, } Hg_2Cl_2 = y$$

$$Hg_2Br_2 = 2 - y$$

Then,

$$1.50 = (0.8498y) + [0.71513 \times (2 - y)]$$

$$1.50 = 0.8498y + 1.43026 - 0.71513y$$

$$y = 0.5179 \text{ g } Hg_2Cl_2$$

$$\text{and } 2 - y = 2 - 0.5179 = 1.4821 \text{ g } Hg_2Br_2$$

$$\% Hg_2Cl_2 = \frac{\text{mass of } Hg_2Cl_2}{\text{mass of mixture}} \times 100 = \frac{0.5179}{2.00} \times 100 = 25.90 \%$$

$$\% Hg_2Br_2 = 100 - 25.90 = 74.10 \%$$

$$\text{Thus, } \% Hg_2Cl_2 = 25.90 \%$$

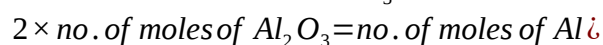
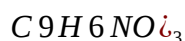
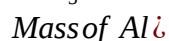
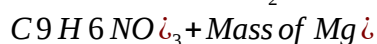
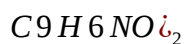
$$\% Hg_2Br_2 = 74.10 \%$$

2. A 0.6113 g sample of Dow metal, containing aluminum, magnesium, and other metals, was dissolved and treated to prevent interferences by the other metals. The aluminum and magnesium were precipitated with 8hydroxyquinoline. After filtering and drying, the mixture of $Al(C_9H_6NO)_3$ and $Mg(C_9H_6NO)_2$ was found to weight 7.8154 g. The mixture of dried precipitates was then ignited, converting the precipitate to a mixture of Al_2O_3 and MgO . The weight of this mixed solid was found to be 1.0022 g. Calculate the %w/w Al and %w/w Mg in the alloy.

ANSWER:

Given:

- Mass of sample = 0.6113 g
- Mass of mixture of $Al(C_9H_6NO)_3$ and $Mg(C_9H_6NO)_2$ = 7.815 g
- Mass of mixture of Al_2O_3 and MgO = 1.0022 g



$$\frac{\begin{array}{c} C_9H_6NO_3 \\ \downarrow \\ C_9H_6NO_3 \\ \text{Molar Mass of Al} \\ \text{Mass of Al} \\ 2 \times \text{mass of } Al_2O_3 \end{array}}{\text{Molar Mass of } Al_2O_3} = \frac{\begin{array}{c} C_9H_6NO_3 \\ \downarrow \\ \text{Mass of Al} \\ 2 \times \text{mass of } Al_2O_3 \end{array}}{101.96 \text{ g/mol}}$$

Now, $\frac{\begin{array}{c} C_9H_6NO_2 \\ \downarrow \\ C_9H_6NO_2 \\ \text{Molar Mass of Mg} \\ \text{Mass of Mg} \\ \text{Mass of MgO} \end{array}}{\text{Molar Mass of MgO}} = \frac{\begin{array}{c} C_9H_6NO_2 \\ \downarrow \\ \text{Mass of Mg} \\ \text{Mass of MgO} \end{array}}{40.304 \text{ g/mol}}$

From of,

$$\begin{array}{l} C_9H_6NO_3 \times 101.96 \\ C_9H_6NO_2 \times 40.304 \\ \text{Mass of Mg} \\ \text{Mass of Al} \end{array}$$

$$\begin{array}{l} C_9H_6NO_2 = 1.0022 \\ C_9H_6NO_3 + 0.12893 \times \text{mass of Mg} \\ 0.11096 \times \text{mass of Al} \end{array}$$

On solving Eq. A and 3, we get

$$\begin{array}{l} C_9H_6NO_2 = 7.5125 \text{ g} \\ \text{Mass of Mg} \\ \text{and } C_9H_6NO_3 = 0.3029 \text{ g} \\ \text{Mass of Al} \end{array}$$

Now, $\frac{\begin{array}{c} C_9H_6NO_3 \\ \downarrow \\ \text{no. of moles of Al} \end{array}}{\text{no. of mole of Al}}$

$$\frac{m_{Al}}{26.982 \text{ g/mol}} = \frac{0.3029 \text{ g}}{459.45 \text{ g/mol}}$$

$$m_{Al} = \frac{0.3029}{459.45} \times 26.982 = 0.0178 \text{ g}$$

$$\% Al = \frac{\text{mass of Al}}{\text{Mass of sample}} \times 100 = \frac{0.0178}{0.6113} \times 100 = 2.91 \text{ w/w Al}$$

Also, $C_9H_6NO_2$
No. of moles of Mg = No. of moles of $C_9H_6NO_2$

$$\frac{m_{Mg}}{24.305 \text{ g/mol}} = \frac{7.5125 \text{ g}}{312.61 \text{ g/mol}}$$

$$m_{Mg} = 0.5841 \text{ g}$$

$$\% Mg = \frac{\text{Mass of Mg}}{\text{Mass of sample}} \times 100 = \frac{0.5841}{0.6113} \times 100 = 95.55\% \text{ w/w Mg}$$

CHAPTER IX: TITRIMETRIC METHODS OF ANALYSIS

ASSESSMENT:

Solve for the following problems, show your solution:

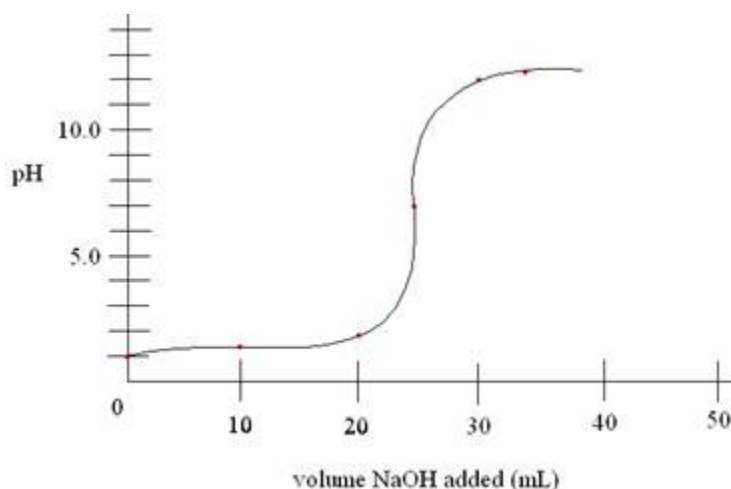
Calculate or sketches (or both) qualitatively correct titration curves for the following acid-base titrations

- 25.0 mL of 0.100 M NaOH with 0.0500 M HCl
- 50.0 mL of 0.0500 M HCOOH with 0.100 M NaOH
- 50.0 mL of 0.100 M NH₃ with 0.100 M HCl
- 50.0 mL of 0.0500 M ethylenediamine with 0.100 M HCl
- 50.0 mL of 0.0400 M citric acid with 0.120 M NaOH
- 50.0 mL of 0.0400 M H₃PO₄ with 0.120 M NaOH

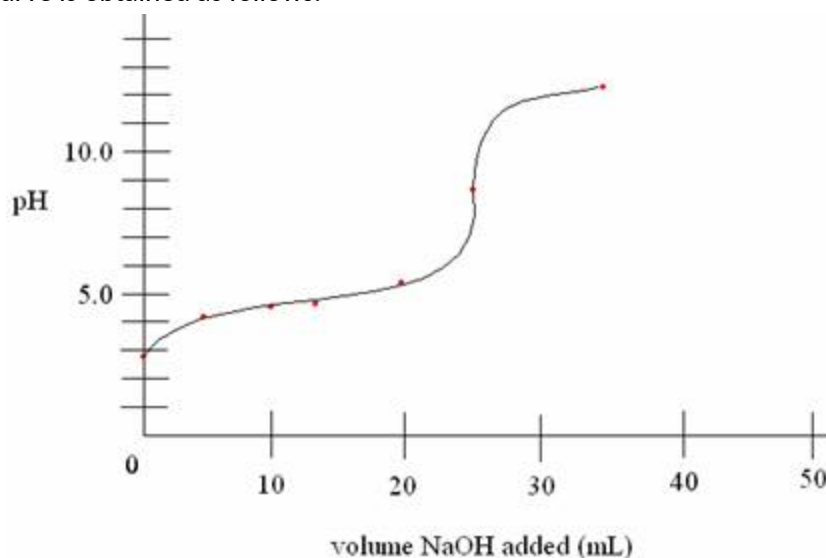
ANSWERS:

A titration curve is the plot of the pH of the analyte solution versus the volume of the titrant added as the titration progresses.

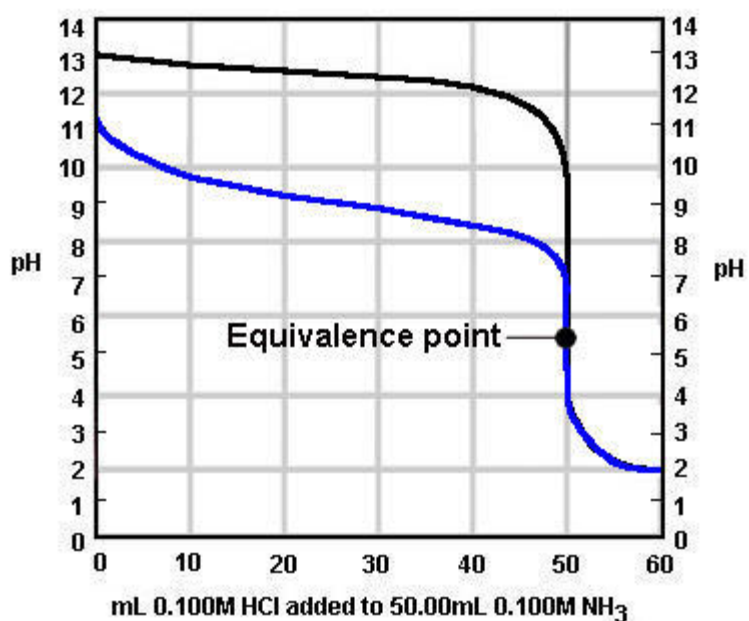
- (a) Suppose the analyte is HCl (strong acid) and the titrant is NaOH (strong base). Plot the pH of the analyte against the volume of NaOH added from the burette, the following titration curve is obtained as follows:



- (b) (b) Suppose the analyte is HCOOH (weak acid) and the titrant is NaOH (strong base). Plot the pH of the analyte against the volume of NaOH added from the burette, the following titration curve is obtained as follows:



- (c) Suppose the analyte is HCl (strong acid) and the titrant is NH_3 (weak base). Plot the pH of the analyte against the volume of NH_3 added from the burette, the following titration curve is obtained as follows:



(d)