
# Department of Chemistry

# College of Science

# University of Salahaddin

# Subject: Analytical Chemistry

# Course Book – (1 Grade)

# Lecturer's name: PhD. Hazha Omar Othman

# Academic Year: 2023-2024

# Course Book

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| **1. Course name** | **Analytical Chemistry** |
| **2. Lecturer in charge** | **Theory: Dr. Hazha Omar Othman**<br>**Practical: Dr.Hazha O., Msc. Suzan S.** |
| **3. Department/ College** | **Environment and health- Science** |
| **4. Contact** | **e-mail: hazha.Othman@su.edu.krd** |
| **5. Time (in hours) per week** | **Theory: 2**<br>**Practical: 2** |
| **6. Office hours** | **Sunday: 10:30 – 11:30, 12:30 – 13:30**<br>**Tuesday: 10:30 – 11:30, 13:30 – 14:30**<br>**Wednesday: 10:00 – 10:30** |
| **7. Course code** | |

**8. Teacher's academic profile**

**Academic achievements and Qualifications: (starting from the most recent degree)**

| From- To | Degree | College-University | Country |
|---|---|---|---|
| 2021 to date | PhD in NanoChemistry, Department of Chemistry | College of Science- University of Salahaddin | Iraq |
| 2015 – 2021 | M. Sc. in Analytical Chemistry, Department of Chemistry | College of Science- University of Salahaddin | Iraq |
| 2005 – 2009 | B.Sc. Chemistry, Department of Chemistry, | College of Science- University of Salahaddin | Iraq |

**Experiences: (starting from the most recent position), please mention Year, Position and Place**

***1- Assignments and Posts:***

| From- To | Post | Department -College | University |
|---|---|---|---|
| 2021 to date | Lecture | Chemistry Department-College of Science | Salahaddin University |
| 2015 – 2021 | Assistant Lecture | Chemistry Department-College of Science | Salahaddin University |
| 2009 – 2015 | Chemical Assistant | Chemistry Department-College of Science | Salahaddin University |
| 2015 – 2017 | Member of Examination Committee | Chemistry Department-College of Science | Salahaddin University |

## 2- Teaching Activities

| From- To | Subject | Stage-College | University |
|---|---|---|---|
| 2015- to date | Introduction to Analytical Chemistry – Volumetric Analysis Natural products | 1st-year students / Department of Environment Science and Health - College of Science | Salahaddin University |
| 2021-2022 | Food Chemistry | 4th-year students / Chemistry Department-College of Science | Salahaddin University |
| 2015-2018 | Analytical Chemistry- Gravimetric Analysis – Practical | College of Science, University of Salahaddin | Salahaddin University |

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| **9. Keywords** | Analytical chemistry, Volumetric analysis, Titration method (Neutralization titration, Precipitation titration, Oxidation-Reduction titration and Complexometric titration), Unit expression (Molarity, Normality, ppm…etc) |

**10. Course overview:**

Analytical chemistry is a branch of chemistry which is both broad in scope and requires a specialised and disciplined approach. Its applications extend to all parts of an industrialised society.'

“Introduction to Analytical Chemistry”, is designed to introduce students to the topic of chemical detection and measurement (qualitative and quantitative analysis). As well as being a varied and interesting discipline in its own right, analytical chemistry plays an essential role in many important fields such as biochemistry, clinical chemistry, environmental science, food and nutrition and pharmaceutical chemistry. Analytical chemistry touches every aspect of our daily lives. This subject was studied by the student in two courses.

During semester period, We try to provide a fundamental approach to chemical equilibrium, including calculations of chemical composition and of equilibrium concentrations acid/base systems. Buffer solutions, which are extremely important areas of science, are also discussed, and the properties of buffer solutions are described.

This semester is designed for college students majoring in chemistry and fields related to chemistry. They deal with the principles and methods of classical quantitative analysis, that is, how to determine how much of specific substance is contained in a sample. We will learn how to design an analytical method, based on what information is needed, how to obtain a laboratory sample that is representative of the whole, how to prepare its solution for analysis, and what measurement tool are available.

**11. Course objective:**

This course provides an introduction to the fundamental principles of chemical analysis. It will teach you how to correctly handle and interpret experimental measurements; you will also learn how to perform an analytical procedure like volumetric analysis.

**12. Student's obligation**

Each student at the end of the course must be preparing a report about any titration methods other than that mentioned or discussed during the course. This report includes Theory, principle and discussion on the selected technique how it helps to improve the understanding of the principles.

## 13. Forms of teaching

Data show and white board

## 14. Assessment scheme

The students are required to do two closed exams during the course period.

Exams (closed and optional): 10

Absence: 0

Quiz, classroom participation and assignments: 5

Practical: 35%

Final Exam: 50% theoretical

## 15. Student learning outcome:

Students should know the basic principles and have actual practice with the operational techniques of a wide variety of separation methods. In addition, they should be familiar with a great many other methods of separation that may be useful in the future.

## 16. Course Reading List and References:

The student can find additional information and examples in the following references

1. Modern Analytical Chemistry; by David Harvey.
2. Fundamentals of Analytical Chemistry; Eighth Edition, by Douglas A. Skoog, Donald M. West, F. James Holler and Stanley R. Crouch.
3. Principles and Practice of Analytical Chemistry, Fifth Edition, by F.W. Fifield and D. Kealey.
4. Vogels, Textbook of Quantitative Chemical Analysis, Fifth Edition, G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denney.
5. Quantitative Chemical analysis, Seventh Edition, -Daniel C. Harris.

| 17. The Topics: | Lecturer's name |
|---|---|
| **First Course**<br>Course Program (Analytical Methods) | Dr. Hazha Omar Othman<br>(2 hrs) |
| | **Week 1** |
| **General Introduction to analytical Chemistry**<br>1- Qualitative analysis<br>2- Quantitative analysis | |
| | **Week 2 – 5** |
| **Units for Expressing Concentration**<br>1. Molarity and Formality<br>2. Normality<br>3. Molality<br>4. Weight, Volume, and Weight-to-Volume Ratios<br>5. Converting Between Concentration Units<br>Preparing Solutions<br>1. Preparing Stock Solutions (solid and liquid)<br>2. Preparing Solutions by Dilution | |
| | **Week 5-7** |
| **Volumetric Methods of Analysis**<br>-Titration<br>- Volume as a Signal<br>-Titration Curves<br>- The Burette<br>-Equivalence Points and End Points<br>-Chemical indicator | |
| | **Week 8** |
| **- Acid–Base Titrations (Neutralization)**<br>-Overview of Acid-Base reactions and properties<br>- Buffer solution | |
| | **Week 9-10** |
| **Acid-Base titration Curve**<br>1- Strong Acid-Strong Base Titration Curve<br>2- Weak Acid- Strong Base Titration Curve<br>3- Examples | |
| | **Week 11** |
| **Closed Exam** | |
| | **Week 12 – 15** |

| 18. Practical Topics (If there is any) | |
|---|---|
| **First Course:**<br>***Week 1:***<br>*Preliminary Concept of Quantitative Analysis, Common Apparatus and Basic Techniques.*<br>***Week 2:***<br>*- Explanation of Volumetric analysis*<br>*-Laboratory Note and Techniques.*<br>*-Methods of Expressing Analytical Concentration.*<br>***Experimental No: 1***<br>*Preparation of solution from a solid and a liquid material.*<br>***Week 3:***<br>***Volumetric Analysis (Acid-Base Titration)***<br>***Experimental No: 2***<br>*Preparation and Standardization of 0.1 N Hydrochloric acid HCl).*<br>***Week 5:***<br>***Volumetric Analysis (Acid-Base Titration)***<br>***Experimental No: 3***<br>*Preparation and Standardization of 0.1 N Sodium Hydroxide (NaOH).*<br>***Week 6:***<br>***Volumetric Analysis (Acid-Base Titration)***<br>***Experimental No: 4***<br>*Preparation and Standardization of 0.1 N acetic acid ($CH_3COOH$).*<br>*Application: Determination of Actic Acid in Vinegar.*<br>***Week 7:***<br>***Volumetric Analysis (Precipitation Titration)***<br>***Experimental No: 6***<br>*Preparation and standardization of $AgNO_3$ Solution by Mohr Method*<br>*Application: Determination of $Cl^-$ in Soluble$Cl^-$ Solutions.*<br>***Week 8:***<br>***Volumetric Analysis (Precipitation Titration)***<br>***Experimental No: 7***<br>*Determination of $Cl^-$ in Soluble $Cl^-$ Solutions by Volhard.*<br>***Week 9:***<br>***Exam - Practic***<br>***Week 10:***<br>***Seminar*** | |

## 19. Examinations:

**Q1/** Calculate the pH and pOH for each of the following solution (answer only five):

a) 0.021M NaOH solution.

b) A solution prepared from the mixing of 50.0 mL of 0.02 M HCl with 25 mL of 0.01M KOH.

c) 0.01 M $H_2C_2O4$ solution. ( $Ka_1 = 5.9 \times 10^{-2}$; $Ka_2 = 6.4 \times 10^{-5}$)

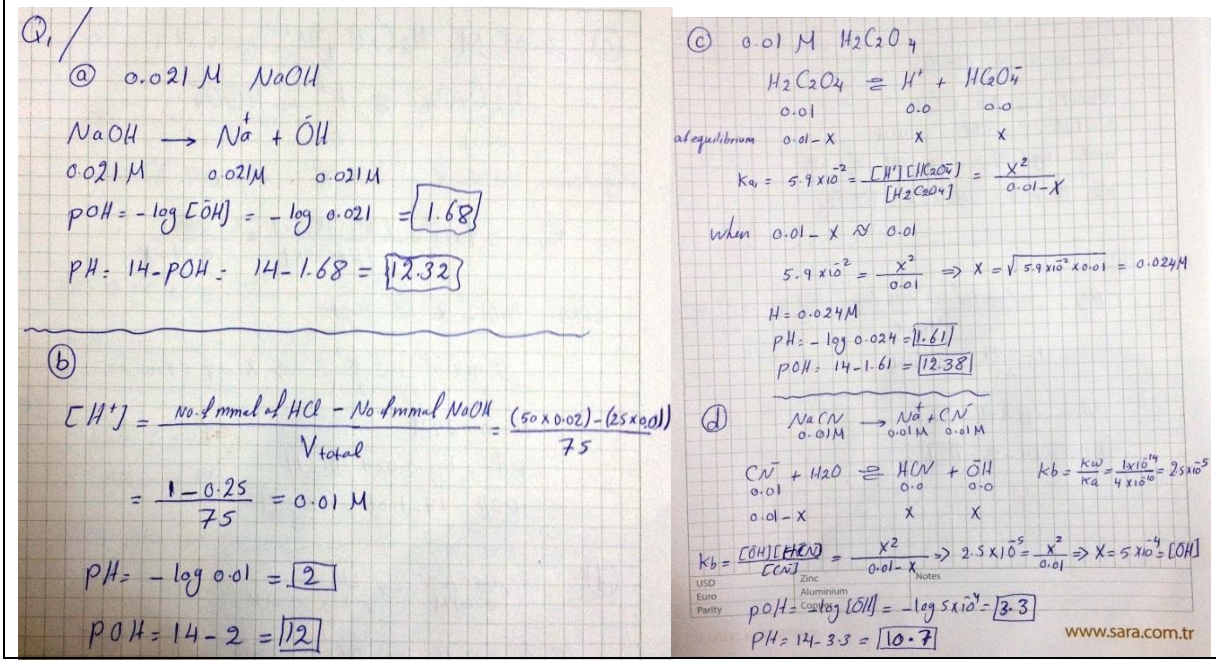
d) 0.01M sodium cyanide solution. (Ka HCN = $4.0 \times 10^{-10}$)

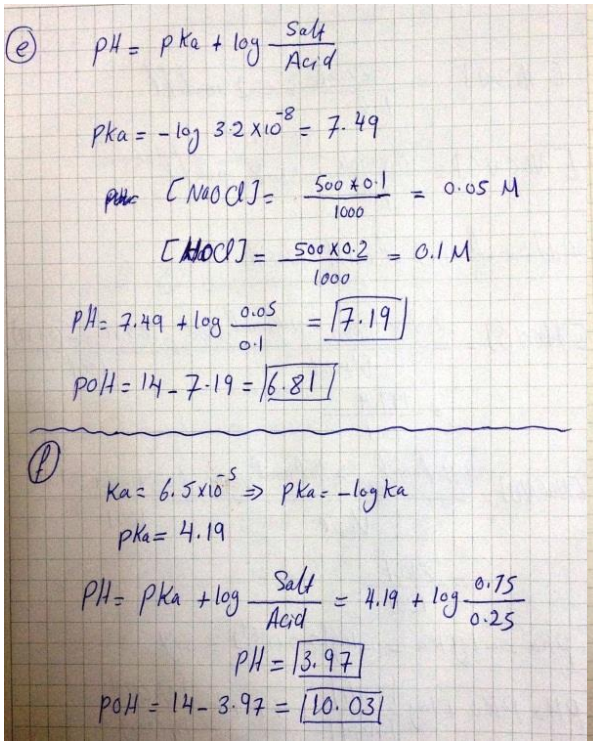
e) A buffer solution is prepared by mixing 500.0 mL of 0.10 M NaOCl and 500.0 mL of 0.20 M HOCl. [Ka(HOCl) = $3.2 \times 10^{-8}$].

f) A buffer solution that contains 0.25M Benzoic acid (C6H5CO2H) and 0.15 M sodium benzoate ($C_6H_5COONa$). [Ka ($C_6H5CO2H$) = $6.5 \times 10^{-5}$].

g) A buffer solution prepared by dissolving 0.2 mole of cyanic acid (HCNO) and 0.8 mol of sodium cyanate (NaCNO) in enough water to make 1.0 liter of solution, Calculate the pH and pOH after addition of 1 mL of 0.1 M NaOH. [Ka(HCNO) = $2.0 \times 10^{-4}$]

**Answer/**





(e) $pH = pKa + \log \frac{Salt}{Acid}$

$pKa = -\log 3.2 \times 10^{-8} = 7.49$

$[NaOCl] = \frac{500 \times 0.1}{1000} = 0.05\ M$

$[HOCl] = \frac{500 \times 0.2}{1000} = 0.1\ M$

$pH = 7.49 + \log \frac{0.05}{0.1} = \boxed{7.19}$

$pOH = 14 - 7.19 = \boxed{6.81}$

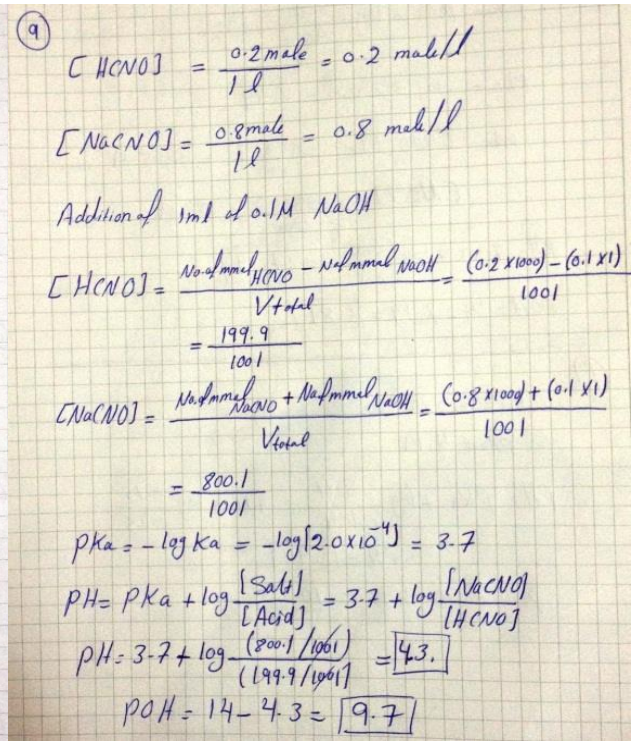
(f) $Ka = 6.5 \times 10^{-5} \Rightarrow pKa = -\log ka$

$pKa = 4.19$

$pH = pKa + \log \frac{Salt}{Acid} = 4.19 + \log \frac{0.75}{0.25}$

$pH = \boxed{3.97}$

$pOH = 14 - 3.97 = \boxed{10.03}$



(g) $[HCNO] = \frac{0.2\ mole}{1\ l} = 0.2\ mole/l$

$[NaCNO] = \frac{0.8\ mole}{1\ l} = 0.8\ mole/l$

Addition of 1ml of 0.1M NaOH

$[HCNO] = \frac{No.of\ mmol_{HCNO} - No.of\ mmol_{NaOH}}{V_{total}} = \frac{(0.2 \times 1000) - (0.1 \times 1)}{1001}$

$= \frac{199.9}{1001}$

$[NaCNO] = \frac{No.of\ mmol_{NaCNO} + No.of\ mmol_{NaOH}}{V_{total}} = \frac{(0.8 \times 1000) + (0.1 \times 1)}{1001}$

$= \frac{800.1}{1001}$

$pKa = -\log ka = -\log[2.0 \times 10^{-4}] = 3.7$

$pH = pKa + \log \frac{[Salt]}{[Acid]} = 3.7 + \log \frac{[NaCNO]}{[HCNO]}$

$pH = 3.7 + \log \frac{(800.1/1001)}{(199.9/1001)} = \boxed{4.3}$

$pOH = 14 - 4.3 = \boxed{9.7}$

## 20. Extra notes:

## 21. Peer review