



CHEM 415

UNIVERSITY EXAMINATIONS

FIRST SEMESTER 2025/2026 ACADEMIC YEAR

**FOURTH YEAR EXAMINATION FOR THE DEGREES OF
BACHELOR OF EDUCATION (SCIENCE) AND BACHELOR
OF SCIENCE (GENERAL)**

CHEM 415: ANALYTICAL CHEMISTRY II

STREAMS: *BEd (Sci), BSc (Gen)*

TIME: *2 HRS*

DAY: *MONDAY [14.30 -16.30 P.M]*

DATE: *26/01/2026*

THIS QUESTION PAPER CONSISTS OF FOUR (4) PAGES

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INSTRUCTIONS TO CANDIDATES

Answer All Questions. Question 1 carries 30 marks, while the other questions carry 20 marks each

QUESTION ONE (30 MARKS)

- a) Define the following terms
- i) Fluorescence quenching (1 Mark)
 - ii) Reverse phase chromatography (1 Mark)
 - iii) Determinate errors (1 Mark)
 - iv) Chemical shift in NMR (1 Mark)
 - v) Glass transition point (1 Mark)
- b) Distinguish between
- i. Thermal Gravimetric Analysis and Differential thermal analysis (1 Mark)
 - ii. Repeatability and reproducibility (2 Marks)
 - iii. Base and molecular peak (2 Marks)
- c) Briefly describe the principle of neutron activation analysis (NAA) (3 Marks)
- i. An X ray tube has an accelerating potential of 50 Kv. Determine the shortest wavelength in its X ray beam. (2 Marks)
 - ii. What are the factors affecting fluorescence and phosphorescence? (2 Marks)
- d) i) Indicate the order in which the following compounds would be eluted from an HPLC column containing reversed - phase packing: Ethyl acetate, isopropanol and carbon tetrachloride. (3 Marks)
- ii) Name **two** classical methods of analysis. (2 Marks)

- e) i) How many total vibrational bands does hexane have? **(1 Mark)**
- ii) Predict the frequency and wavenumber of maximum absorption for the O – H vibration.
Given that the force constant is $7.7 \times 10^5 \text{ dyne/cm}$, Mwt for O = 16 and H = 1. 1 atomic mass unit = $1.67 \times 10^{-24} \text{ g}$ **(2 Marks)**
- iii) Describe the variables that lead to band broadening in chromatography **(5 Marks)**

QUESTION TWO (20 MARKS)

A pesticide mixture of atrazine and hydroxyatrazine standards was separated using 30 cm column in a liquid chromatograph. The peak due to atrazine had a retention time of 5.01 min and a baseline width of 0.11 min while that of hydroxyatrazine had a retention time of 5.71 min and a baseline width of 0.2 min. **(4 Marks)**

Calculate

- The average number of theoretical plates of the column
 - The plate height in (mm)
 - Briefly, discuss the shortcomings of the column efficiency plate theory (name **two**) **(3 Marks)**
- b) Perform a least squares analysis of the following data:

Absorbance	2.1	5	9	13	17.3	21	24.7
Concentration (ppm)	0	2	4	6	8	10	12

- Determine the coefficient of correlation, r **(2 Marks)**
- Calculate the slope and intercept **(2 Marks)**

- iii) Determine the standard deviations of the slope and intercept (2 Marks)
- iv) Calculate the concentration for a solution with absorbance of 11.5 units and its standard deviation. (3 Marks)
- c) A sample contains an unknown mass of an organic compound (Mx). A tracer of the same compound labeled with a radioisotope is prepared with a known mass of 5.0 mg and a specific activity of 1500 counts/min/mg. After thoroughly mixing the tracer with the sample, a portion of the pure compound is isolated. The isolated portion which weighs 10.0 mg, has a specific activity of 600 counts/min/mg. Find the mass of the organic compound in the original sample. (4 Marks)

QUESTION THREE (20 MARKS)

- a) 100.00 mg of pure of calcium oxalate monohydrate ($\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$) of molar mass 146.11 g/mol is heated. Write chemical equations for the three steps in the decomposition. Assuming complete decomposition, calculate the theoretical mass remaining at each plateau of the thermogram. Given the molar masses of $\text{H}_2 = 18.02$ g/mol; $\text{CO} = 28.01$ g/mol; $\text{CO}_2 = 44.01$ g/mol and CaO , final residue = 56.08 g/mol. (10 Marks)
- b) i) What fundamental property of atomic nuclei does NMR rely on? (2 Marks)
- ii) What information about a molecule does the following information provide: Chemical shift in ppm, integration (area under peak), and Multiplicity (splitting pattern) (3 Marks)
- iii) Consider the ^1H NMR spectra for propane ($\text{CH}_3\text{CH}_2\text{CH}_3$) and propan-1-ol ($\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$). How many unique proton environments and splitting patterns are present in each spectrum? (5 Marks)