



UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024**

- COURSE NAME : ANALYTICAL CHEMISTRY
- COURSE CODE : DAK 12603
- PROGRAMME CODE : DAK
- EXAMINATION DATE : JULY 2024
- DURATION : 2 HOURS AND 30 MINUTES
- INSTRUCTIONS :
1. ANSWER ALL QUESTIONS
 2. THIS FINAL EXAMINATION IS CONDUCTED VIA
 - Open book
 - Closed book
 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF SEVEN (7) PAGES

- Q1**
- (a) Define
- (i) Molar mass
 - (ii) Millimole
- (2 marks)
- (b) A 1.88 M solution of NaCl has an initial volume of 34.5 mL. Calculate the final concentration of the solution if it is diluted to 134 mL.
- (3 marks)
- (c) Differentiate between classical and instrumental approaches of analysis. Write the advantages and limitations of each approach.
- (4 marks)
- (d) Discuss the main steps in quantitative analysis.
- (5 marks)
- (e) Explain the importance of sample preparation in the context of chemical analysis.
- (2 marks)
- (f) Describe the impact of proper instrumentation and measurement parameters
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- Q2** UV-Visible spectroscopy is a cost-effective, simple, versatile, non-destructive, and analytical technique, which is suitable for a large spectrum of organic compounds and some inorganic species.
- (a) Explain the fundamental principles behind UV- Visible spectrophotometry.
- (4 marks)
- (b) Provides two (2) examples of practical applications where UV-Visible spectrophotometry is used to analyze the properties of compounds.
- (4 marks)
- (c) A solution of a compound has an absorbance of 0.75 at a wavelength of 450 nm in a 1 cm cuvette. If the molar absorptivity of the compound at this wavelength is $8000 \text{ L}\cdot\text{mol}^{-1}\cdot\text{cm}^{-1}$, calculate the concentration of the compound in the solution.
- (4 marks)

- (d) A 7.25×10^{-5} M solution of potassium permanganate has a transmittance of 44.1% when measured in a 2.10 cm cell at a wavelength of 525 nm. Calculate:
- the absorbance of this solution
 - the molar absorptivity of KMnO_4
- (5 marks)
- (e) The absorption coefficient of a glycogen-iodine complex is 0.20 at light of 450 nm. Calculate the concentration when the transmission is 40 % in a cuvette of 2 cm.
- (3 marks)

- Q3** (a) Tropicana orange juice is a rich vitamin C source as shown in **Figure Q3.1**, an important antioxidant supporting a healthy immune system and aiding iron absorption.

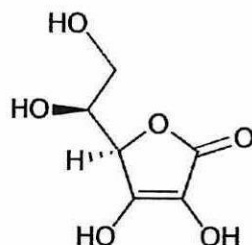


Figure Q3.1

- Based on the above statement, suggest the instrument used to identify the vitamin C in Tropicana orange juice.
(1 mark)
 - Justify your answer in **Q3(a)(i)**.
(1 mark)
 - According to **Figure Q3.1**, discuss two (2) main functional groups with wavenumber to identify the presence of vitamin C in Tropicana Orange Juice with the molecular structure of $\text{C}_6\text{H}_8\text{O}_6$.
(6 marks)
- (b) Explain one (1) type of vibrational modes.
(2 marks)

- (c) Match the infrared (IR) spectrum in **Figure Q3.2** to the following compounds. Label at least three (3) absorbance bands (or absence thereof) with a functional group in the IR that allows you to identify the compound conclusively.

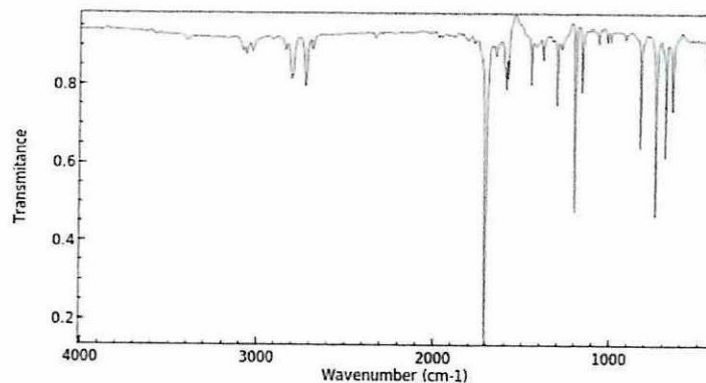
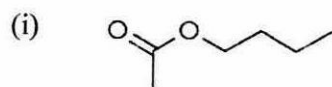


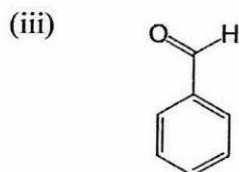
Figure Q3.2



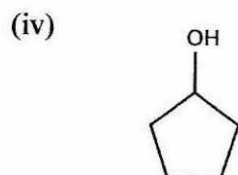
(2 marks)



(2 marks)



(2 marks)



(2 marks)

- (d) The IR spectrum can be displayed regarding absorbance or transmittance. State the equation that can be converted absorbance to transmittance or vice versa.

(2 marks)

- Q4** (a) High-Performance Liquid Chromatography (HPLC) separates compounds dissolved in a liquid sample. It allows qualitative and quantitative analysis of what components and how much of each element is contained in the sample. Briefly retrieve the principle of HPLC with a simple sketch of a diagram. (5 marks)
- (b) There are two different ways by which we can run the HPLC method, namely isocratic and gradient elution. Differentiate the functionality of isocratic and gradient elution. (2 marks)
- (c) You are required to prepare a mobile phase with a polarity index of 9.5. Explain how you can prepare this mobile phase using carbon tetrachloride and water. Given the polarity index for carbon tetrachloride = 1.6 and water = 10.2. (5 marks)
- (d) Predict the elution order for separating butanone, butanol and butene when using the stationary phase of C18 (non-polar molecule). Describe the type of HPLC mode and explain your answer for the elution order. Given that the molecule polarity is in **Figure Q4.1**.

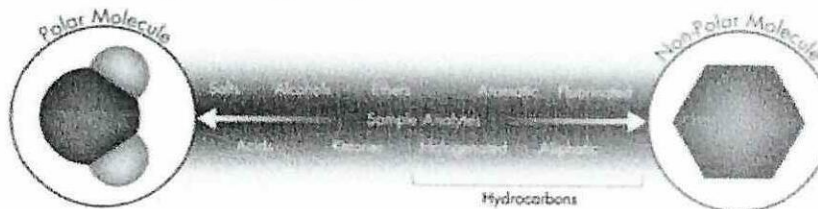


Figure Q4.1

- (4 marks)
- (e) Calculate the number of theoretical plates N when the retention time is 15.20 minutes and half of the base width is 0.55 minutes. (4 marks)
- Q5** (a) The instrument detector's needs often determine the carrier gas choice.
- (i) State the function of the detector. (2 marks)
- (ii) Distinguish the functionality between the mobile and stationary phases. (4 marks)

- (b) Because a capillary column's volume is significantly smaller than a packed column, it requires a different injector style to avoid overloading the column with the sample. Discuss one (1) type injector used in gas chromatography-mass spectroscopy (GC-MS).

(2 marks)

- (c) **Figure Q5.1** elucidates an example of a grapefruit oil analysis by utilizing multiple detectors; (a) Flame ionization (FID), (b) Flame thermionic detector (FTD) and (c) Flame photometric Detector (FPD) at the same time. Express your argument upon the criteria of a detector system suitable for analyzing grapefruit oil via GC-MS.

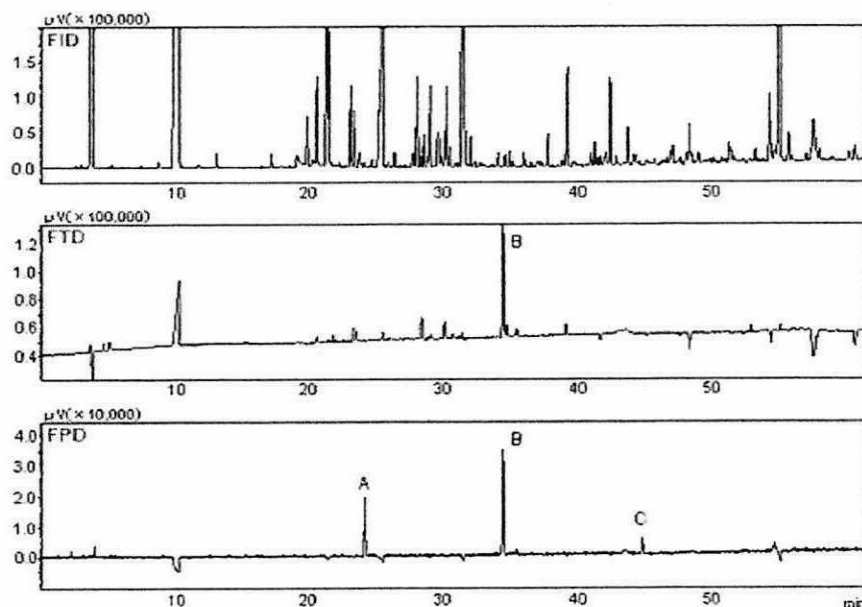


Figure Q5.1

(4 marks)

- (d) Fatima is responsible for identifying and quantifying the unknown sample. She is unsure whether to employ GC or GC-MS. You must recommend an appropriate tool and justify your answer to assist her.

(4 marks)

- (e) Mass spectroscopy (MS) is a technique for determining the mass of atoms and molecules. Depending on the method used to separate ions, there are numerous types of analyzers available. Explain one (1) type of mass analyzer used in GC-MS, including its benefits and limitations.

(4 marks)

- END OF QUESTIONS -

APPENDIX A

Table APPENDIX

Infrared Absorption

Bond	Location	Wavenumber/cm ⁻¹
C-H	Alkenes	2850-2950
	Alkenes, arenes	3000-3100
C-C	Alkanes	750-1100
C=C	Alkenes	1620-1680
aromatic C=C	Arenes	Several peaks in range 1450-1650 (variable)
C=O	Aldehydes	1720-1740
	Ketones	1705-1725
	Carboxylic acids	1700-1725
	Esters	1735-1750
	Amides	1630-1700
	Acyl chlorides and acid anhydrides	1750-1820
C-O	Alcohols, ethers, esters and carboxylic acids	1000-1300
C≡N	Nitriles	2220-2260
C-X	Fluoroalkanes	1000-1350
	Chloroalkanes	600-800
	Bromoalkanes	500-600
O-H	Alcohols, phenols	3200-3600 (broad)
	Carboxylic acids	2500-3300 (broad)
N-H	Primary amines	3300-3500
	Amides	ca. 3500