LAIKIPIA UNIVERSITY

UNIVERSITY EXAMINATIONS

SECOND SEMESTER 2023/2024 ACADEMIC YEAR

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

CHEM 422: ORGANIC SPECTROSCOPY

STREAM: R ***TIME: 2 HRS***

DAY: MONDAY [2.30P.M – 4.30 P.M] ***DATE: 08/04/2024***

THIS QUESTION PAPER CONSISTS OF EIGHT (8) PAGES

PLEASE DO NOT OPEN UNTIL THE INVIGILATOR SAYS SO.

INSTRUCTIONS

Answer all questions.

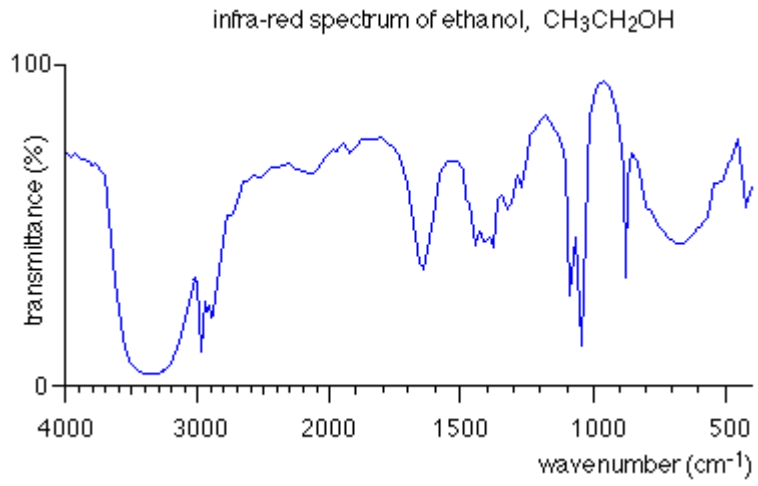
QUESTION ONE (30 MARKS)

a) As the wavelength of light increases, what happens to the frequency? **(1 Mark)**

b) Write the equation which relates the frequency of light to its energy, naming the constant involved. **(2 Marks)**

c) State two applications of spectroscopic techniques. **(2 Marks)**

d) The diagram below shows the infra-red spectrum of ethanol:



i. How, in principle, is a spectrum like this produced? **(2 Marks)**

ii. The vertical axis is labelled as "transmittance (%). What does that mean? **(2 Marks)**

iii. What is "wavenumber (cm-1)" a measure of? **(1 Mark)**

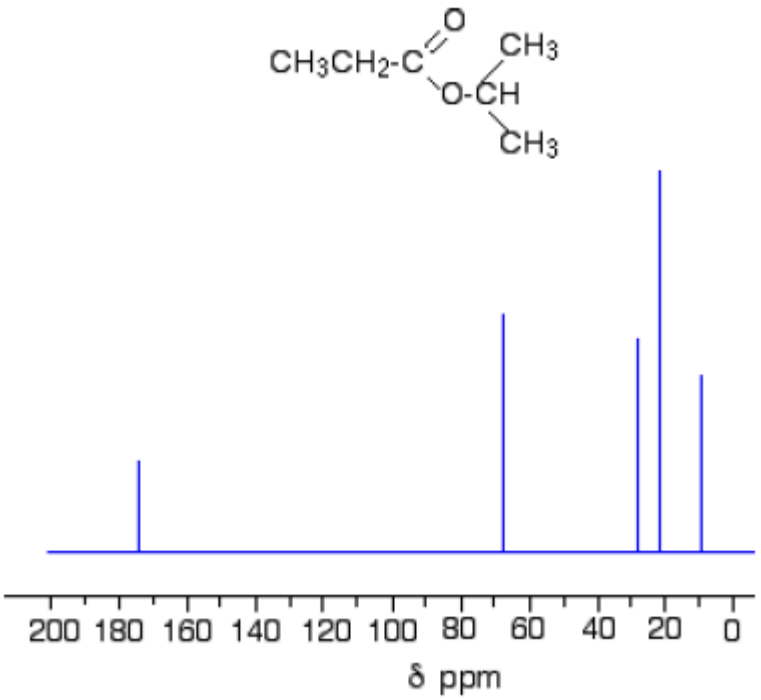
iv. What causes the troughs in the graph? **(1 Mark)**

e) Explain what you understand by the term chromophore . **(1 Mark)**

f) Define the term spectroscopy **(1 Mark)**

g) What is a chemical shift? **(1 Mark)**

h) The spectrum below is for the compound 1-methylethyl propanoate which has the structure:

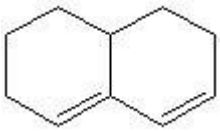


A. Explain carefully why the spectrum has five peaks. **(3 Marks)**

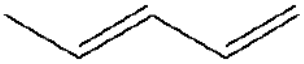
i) What are the functions performed by mass spectrometer in order to characterise organic compounds. **(3 Marks)**

j) i) How does conjugation of pi bonds affect λ_{max} ? **(1 Mark)**

ii) Calculate the λ_{max} for the compound below (See Appendix at the back **(2 Marks)**



k) Explain why the following two molecules have different λmax. (2mks)



λmax = 217 nm

λmax = 175 nm

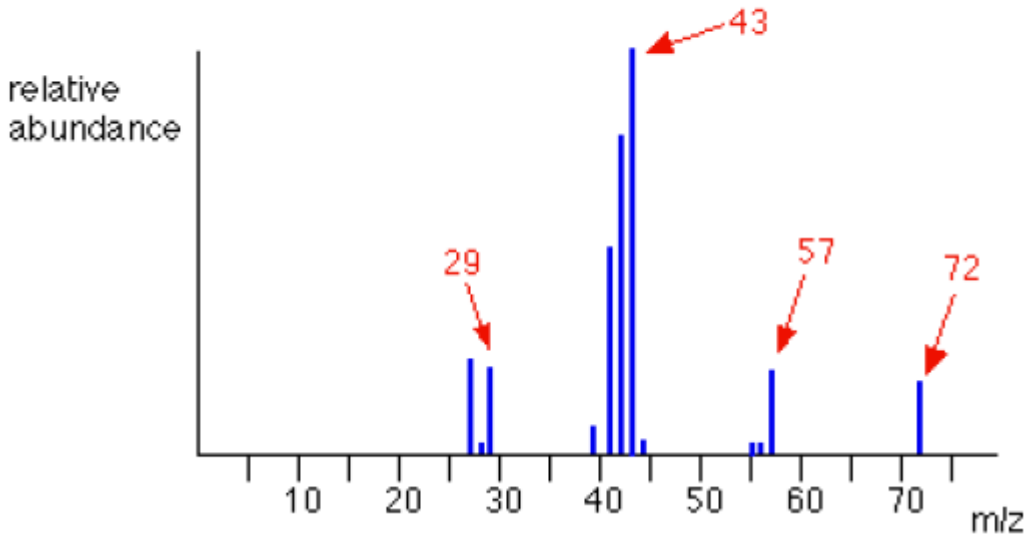
l) A photon of uv radiation has a wavelenth of 200 nm.

a) What is the frequency of this photon? **(2 Marks)**

b) Calculate the energy of this photon. **(2 Marks)**

m) The mass spectrum of pentane looks like this:

simplified mass spectrum of pentane - $CH_3CH_2CH_2CH_2CH_3$



i) What causes the peak at m/z = 72? **(1 Mark)**

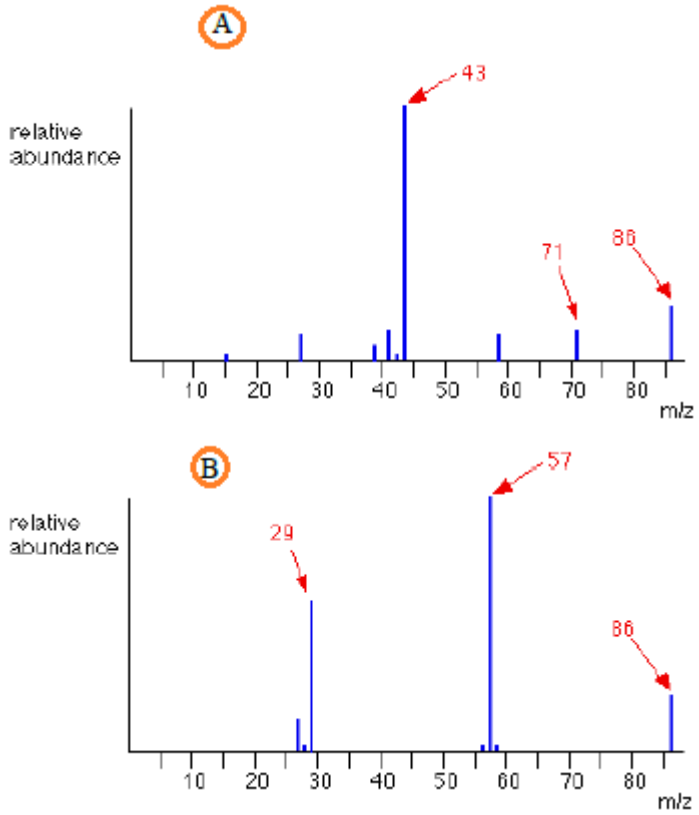
ii) What causes the peak at m/z = 57? **(1 Mark)**

iii) Write an equation to show how the species (molecule or ion) you quoted in part (b) is formed. **(1 Mark)**

QUESTION TWO (20 MARKS)

a) Differentiate between bathochromic and hypsochromic shifts. **(2 Marks)**

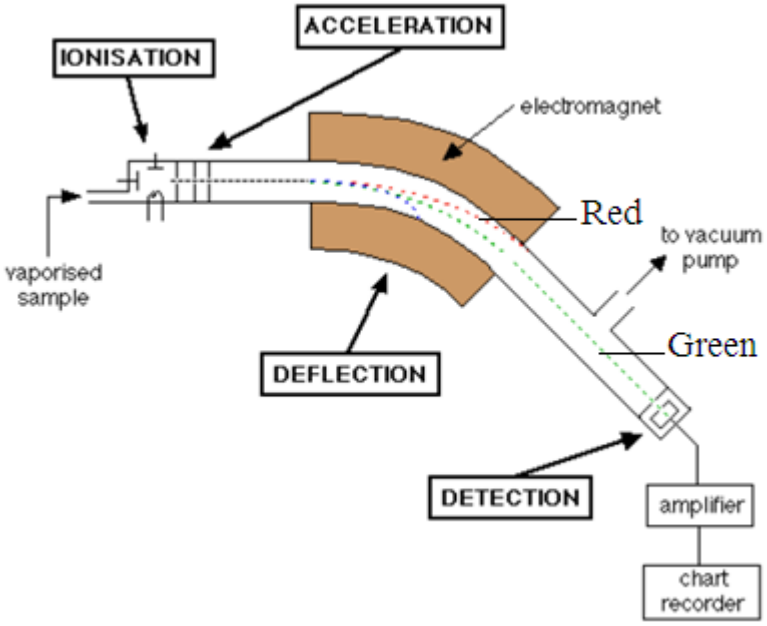
b) The mass spectra below are for pentan-2-one and pentan-3-one, but not necessarily in that order.Pentan-2-one is $CH_3COCH_2CH_2CH_3$. Pentan-3-one is $CH_3CH_2COCH_2CH_3$.



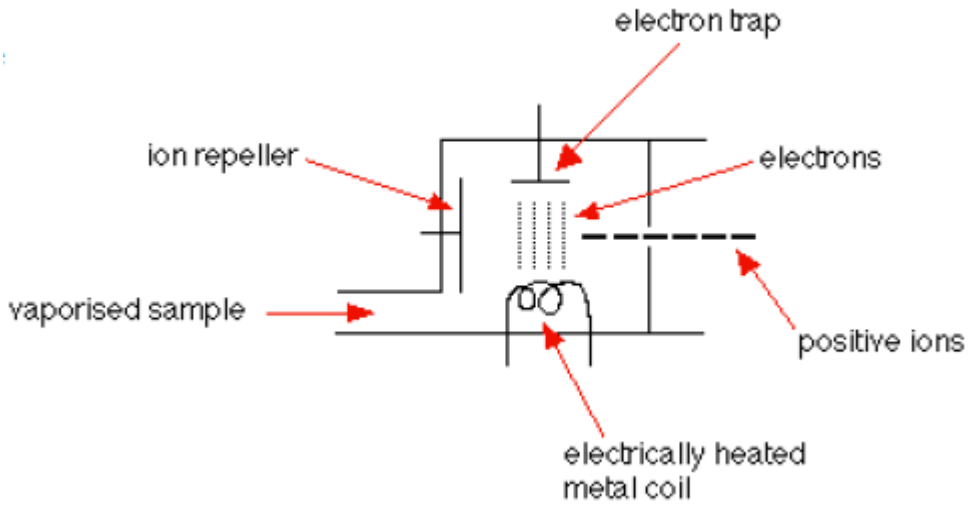
Decide which is which, explaining your thinking as fully as possible. **(6 Marks)**

c. Absorbance of a sample solution was measured at a particular wavelength using a spectrometer and found to be 1.92. The value for molar absorptivity was found to be 19400 for that wavelength used. Calculate the concentration. **(2 Marks)**

d) The diagram, shows the main parts of a mass spectrometer.



i. Explain what is happening in the ionisation part of the spectrometer which looks like this in close-up: (**2 Marks**)



ii. How are the ions produced in the ionisation chamber accelerated? **(2 Marks)**

iii.

a. Which two properties of the ions determine how much they are deflected by the magnetic field? What effect does each of these properties have on the amount of deflection? **(2 Marks)**

b. Of the three different ion streams in the diagram above, why is the red one least deflected? **(2 Marks)**

c. What would you have to do to focus the red stream on the detector? (**1 Mark)**

iv. Why is it important that there is a vacuum in the instrument? **(1 Mark)**

QUESTION THREE (20 MARKS) (1Mark extra)

a) Explain why solid forms of the sample are not suitable for UV vis spectroscopy?

(2 Marks)

b) State four applications of UV-visible spectroscopy? **(2 Marks)**

c) Why is quartz cuvette used in UV-visible spectroscopy? **(2 Marks)**

d) What are the main parts of infrared (IR) spectrometer? **(3 Marks)**

e) i) What is NMR Spectroscopy? (**1 Mark)**

ii) State two methods of solving problem of signal overlap in nmr spectroscopy

(2 Marks)

f) State and explain the number of peaks that you would expect to find in the C-13 NMR

g) spectrum for:

i) pentan-3-one, $CH_3CH_2COCH_2CH_3$. **(2 Marks)**

ii) pentan-2-one, $CH_3CH_2CH_2COCH_3$? **(2 Marks)**

h) **Light** which has wavelengths of around 380 - 435 nm is seen as a sequence of **violet** colours. Various **red** colours have wavelengths around 625 - 740 nm. Which has the highest energy? Explain **(2 Marks)**

i) Differentiate between auxochrome and chromophore and state the effect of attaching the auxochrome to chromophore. (**2 Marks)**

APPENDIX 1.

CONJUGATED DIENE CORRELATIONS:

i) Base value for homoannular diene = 253 nm
ii) Base value for heteroannular diene = 214 nm
iii) Alkyl substituent or Ring residue attached to the parent diene = 5 nm

iv) Double bond extending conjugation = 30 nm

v) Exocyclic double bonds = 5 nm

vi) Polar groups: a) -OAc = 0 nm

b) -OAlkyl = 6 nm

c) -Cl, -Br = 5 nm

Plank Constant (h) =$6.63X10^{-34}$ J.S
C=$3X10^{8}$