MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR EDUCATION (SCIENCE)

SCH 404: INSTRUMENTAL METHODS

DATE: 18/03/2022 **TIME: 2:00-4:00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Useful Data

Planck constant = 6.626×10^{-34} JS

$c = 3 \times 10^{8}$ ms^{-1}

QUESTION ONE (30 MARKS)

a) The typical range of a UV-VIS spectrophotometer is 195 nm to 900 nm. What is this range in Hertz? (6 marks)

b) What is the percent transmittance of radiation if the absorbance is

(i). 2.5 (4 marks)

(ii). 0.001? (4 marks)

c) What is the absorbance if the percent transmittance is

(i). 0.5% (4 marks)

(ii). 90% (4 marks)

d) The λ_{max} for the complex $[Fe(phen)_3]^{2+}$ is 510 nm. If the molar absorptivity is 1.89 X 10^4 $M^{-1}cm^{-1}$, what is the concentration of a $[Fe(phen)_3]^{2+}$ solution if it produced an absorbance of 0.03 in a 1 cm cell? (8 marks)

QUESTION TWO (20 MARKS)

a) Infrared spectroscopy is one of most powerful spectroscopic tools used in the structural determination of molecular compounds.

i. Explain in details the requirements for a molecule to be infrared active. (3 marks)

ii. The number of fundamental absorption bands (peaks) resulting from molecular vibrations can be predicted by either 3n-6 or 3n-5. Explain with the help of an example for each, how the two equations predict the fundamental bands of molecules. (4 marks)

iii. Give 5 reasons why the number of the fundamental absorption peaks predicted in part (ii) above is NOT the same as the number of peaks practically observed. (3 marks)

b) Hooke´s law can be used to predict the energy $\tilde{V}$ (wavenumber) where a vibrating molecule can absorb in the IR region.

i. State the equation representing Hooke law (equation), defining the various variables in the equation. (3 marks)

ii. Show from the equation how the strength of the vibrating molecular bond and the mass of the molecule affect the position of $\tilde{V}$ in the IR region. (3 marks)

c) Discuss briefly the major differences between the Dispersive Infrared Spectrophotomer (IR) and the Fourier Transform Infrared Spectrophotometer (FTIR). (4 marks)

QUESTION THREE (20 MARKS)

a)

i. Explain in details how the spinning nucleus in applied external magnetic field of strength of H_o interacts with a specific wavelength of frequency called resonance frequency in the radio region electromagnetic spectrum generates NMR peaks. 6 marks

ii. Explain how nuclei of atoms of various elements are assigned the spin value I which determines if a nucleus of an atom is NMR active. 2 marks

b) The frequency V_o, which is the resonance frequency at which the spinning nucleus absorbs in the radio region is given by the equation $V_o = \gamma/2\Pi (B_o)$ where γ is the gyromagnetic ratio of the spinning nucleus and is closely related with the magnetic moment of the spinning nucleus.

i. From the equation above, explain why different nuclei of atoms of different elements will have different values of V_o. (4 marks)

ii. Explain what chemical shift is and how chemical shift values are assigned to a compound. (4 marks)

iii. Explain clearly why ^{1}H NMR instrument is more sensitive than the ^{13}C NMR instrument. (2 marks)

iv. What advantages does ^{13}C NMR Instrument have over the ^{1}H NMR instruments?(2 marks)

QUESTION FOUR (20 MARKS)

a) In atomic spectroscopy, normally atoms of compounds interact with radiation in order to for the compound to absorb radiation and therefore, determine the compound at atomic state both qualitatively and quantitatively.

i. Briefly outline with the help of diagrams the principles of the three types of atomic spectroscopy: atomic absorption, atomic emission and atomic fluorescence spectroscopy. (9 marks)

ii. Explain stepwise process of conversion of the compound from solution to its atomic state by the flame method before determination by the methods described in (i). (5 marks)

b) Describe how the hollow cathode lamp generates the resonance radiation in the analysis of the relevant element in atomic spectroscopic method. (6 marks)

QUESTION FIVE (20 MARKS)

a) Mass spectrometry (MS) is a powerful analytical technique widely used by chemists, biologists, medical researchers, and environmental and forensic scientists, among others.

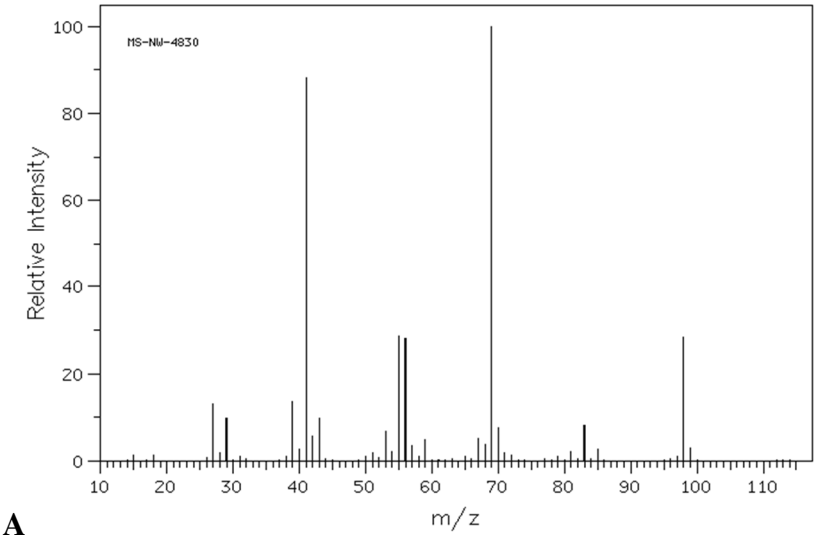
i. Describe how the two methods, Electron and Chemical ionization methods are used in the gas phase to generate ion fragments for generation of mass spectra of compounds.

(8 marks)

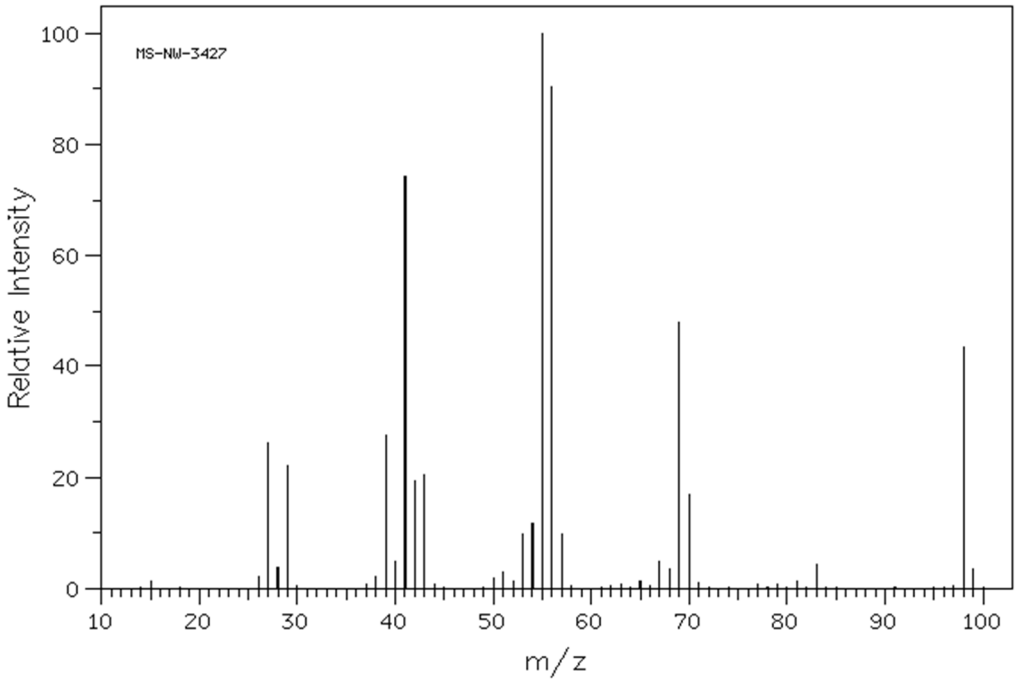
ii. Explain main differences between the two methods and explain why they are considered to be complementary to each other. (4 marks)

b) The following spectra A and B are for 2-methyl-2-hexene and 2-heptene, not necessarily in that order. Decide which spectrum belongs to the correct molecule. Explain your answers.

(8 marks)



Spectrum A


MS-NW-3427
Relative Intensity
100
80
60
40
20
0
10
20
30
40
50
60
70
80
90
100
m/z

Spectrum B