



**NATIONAL OPEN UNIVERSITY OF NIGERIA PLOT 91, CADASTRAL ZONE,  
NNAMDI AZIKIWE EXPRESSWAY, JABI – ABUJA  
FACULTY OF SCIENCES  
DEPARTMENT OF CHEMISTRY  
2022\_1 EXAMINATION QUESTIONS**

**COURSE CODE: CHM 309  
COURSE TITLE: ORGANIC SPECTROSCOPY  
COURSE UNIT: 2**

**INSTRUCTION: Answer question one (1) and any other two questions  
Time: 2 hours**

**QUESTION 1**

1. (a) Discuss briefly the principles of Infra-red spectroscopy. **(6 marks)**
- (b) State two (2) factors that can determine the intensity and energy level of absorption in Infra red (IR) spectroscopy. **(3 marks)**
- (c) Arrange the following bonds in increasing order of intensity of absorption in IR spectroscopy. Explain your answers.
- (i) C-H, O-H and N-H      (ii) C-C-OH, C-Cl, C-C-H, C-O **(6 marks)**
- (d) Proton NMR spectroscopy can be used to distinguish between the following isomers:



**A**



**B**



**C**

For each of these isomers, describe the appearance of the high-resolution proton NMR spectrum of each in terms of peak, intensity, splitting pattern and coupling. Assume that the OH protons are not coupled to any other protons.

**(10 marks)**

- (e) List five (5) factors governing the absorption of radiation in the UV/Visible region.

**(5 marks)**

**QUESTION 2**

2. (a) Draw a diagram showing the components of a continuous Wave Infra Red (IR) Instrument. **(12 marks)**

(b)            **Q**                            **R**                            **S**                            **T**



The proton NMR spectra of four compounds Q, R, S and T above can be used to distinguish between some of the structures the numbers of peaks and the ratios of the areas under them are considered. The following table shows some results of a <sup>1</sup>H NMR investigation into Q, R, S and T. Each of the four spectra is referred to by a number.

<b>Spectrum</b>	<b>Number of peaks</b>	<b>Ratio of areas under the peaks</b>
1	3	6 : 1 : 1
2	4	3 : 2 : 2 : 1
3	3	3 : 2 : 3
4	3	3 : 2 : 3

- (i) Which compound (**Q, R, S** or **T**) corresponds to spectrum 1? Give a reason for your choice.
- (ii) Which compound (**Q, R, S** or **T**) corresponds to spectrum 2? Give a reason for your choice.
- (ii) Explain why spectrum 3 and spectrum 4 have the same number of peaks and the same ratio of areas under them. **(8 marks)**

### **QUESTION 3**

3. (a) Compound **A** has the molecular formula C<sub>4</sub>H<sub>7</sub>ClO and does not produce misty fumes when added to water.
- i. The mass spectrum of **A** contains two molecular ion peaks at  $m/z = 106$  and  $m/z = 108$ . It also has a major peak at  $m/z = 43$ . Suggest why there are two molecular ion peaks.
- ii. A fragment ion produced from **A** has  $m/z = 43$  and contains atoms of **three** different elements. Identify this fragment ion and write an equation showing its formation from the molecular ion of **A**. **(7 marks)**
- (b) List five (5) main components of a typical NMR spectrometer. **(5 marks)**
- (c) Give one important application of Gas Chromatography-Mass Spectrometry (GC-MS) in pharmaceutical industry. **(2 marks)**

- (d) List the three main types of ionisation techniques used in Gas Chromatography-Mass Spectrometry (GC-MS). **(6 marks)**

#### QUESTION 4

4. (a) Why is jet separator very important in Gas Chromatography-Mass Spectrometry? **(2 marks)**
- (b) What do you understand by field sweep and frequency sweep? **(8 marks)**
- (c) Define resonance in NMR spectroscopy and explain how it occurs. **(7 marks)**
- (d) Give two (2) common solvents used in proton NMR spectroscopy. Explain why solvents are generally used. **(5 marks)**

#### QUESTION 5

5. (a) Explain why most of the carbon atoms in a molecule will be incapable of spin-spin coupling in Carbon-13 NMR spectroscopy. **(2 marks)**
- (b) Give three (3) applications of the Nuclear Magnetic resonance. **(6 marks)**
- (c) Define (i) coupling constant (J) (ii) spin-spin coupling **(4 marks)**
- (d) How many double bond equivalent (DBE) is present in compound with the formula  
(i)  $C_{10}H_7NO_2$ ? (ii)  $C_{11}H_{12}Cl_2N_2O_5$ ? **(8 marks)**