



STRATHMORE UNIVERSITY
SCHOOL OF COMPUTING AND ENGINEERING SCIENCES
Bachelor of Electrical Engineering
Final Examination

BEE 2020 :Electrical Materials

DATE: November 30th 2022

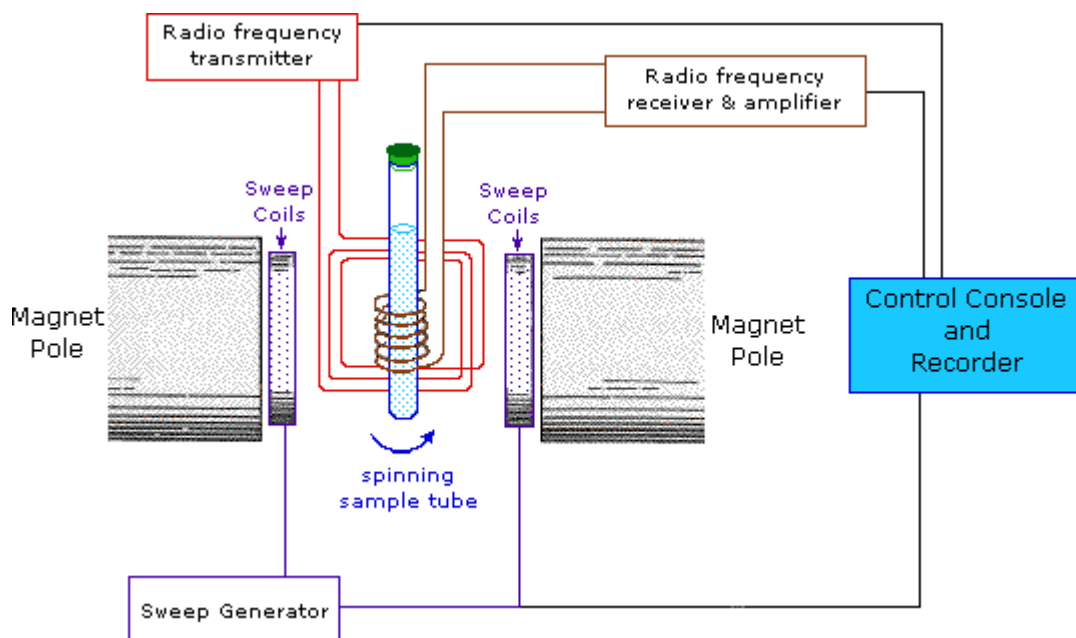
TIME: 3 hours

INSTRUCTION: ANSWER QUESTION ONE AND ANY TWO OTHER QUESTIONS.

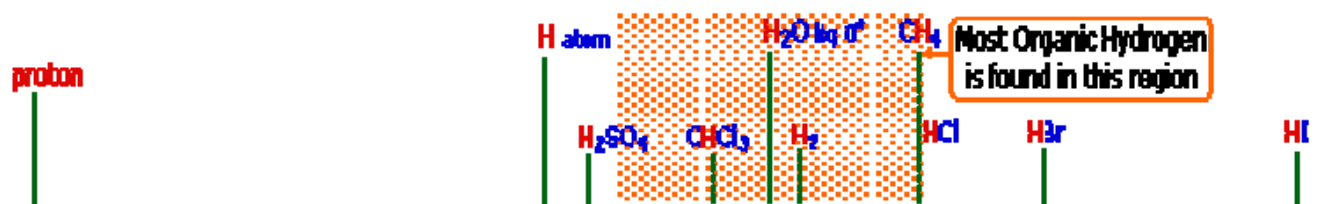
- 1) This is an Open-Book exam
- 2) Calculators, alphanumeric Programmable are allowed
- 3) No communication is permitted among students
- 4) All answer will be put in the booklet ask for additional pages if needed

QUESTION ONE [30 MARKS]

- a) What do you understand by magnetic and non-magnetic nuclei? Explain the empirical rules for determining nuclear spin. **(2 Marks)**
- ii) **Explain** NMR phenomenon in view of your knowledge of nuclear spin states. **(4 marks)**



The output of the signal is as shown.



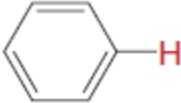
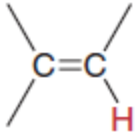
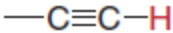
Why should the proton nuclei in different compounds behave differently in the NMR experiment? **(3 marks)**

c) Why is tetramethylsilane (TMS) taken as a reference for measuring the chemical shift? **(2 Marks)**

ii) Explain the shielding and de-shielding of nuclei giving suitable examples. **(3 marks)**

iii) Calculate the chemical shift for a proton in ppm that has resonance at 126 Hz downfield from TMS on spectrophotometer that operates at 60 MHz. **(4 Marks)**

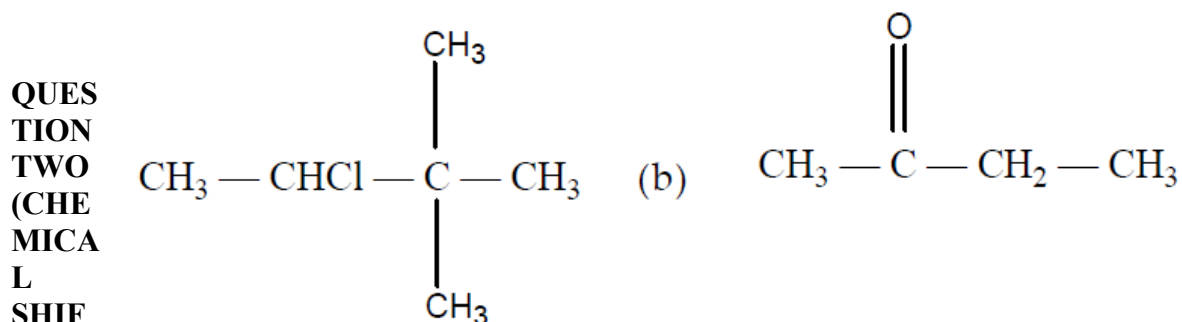
Using diagrams explain the differential in chemical shift in each of the chemical species below **(4 Marks)**

Proton type	Chemical shift (ppm)
	6.5–8
	4.5–6
	~2.5

e) The data in the table below shows the chemical shift of various chemical species. Conduct an analysis of the observed data. (4 Marks)

Typical ¹ H chemical shift ranges for OH and NH protons		δ / ppm
-OH	Alcohols	1-5
	Phenols	4-10
	Acids	9-13
	Enols	10-17
-NH	Amines	1-5
	Amides	5-6.5
	Amido groups in peptides	7-10

f) Suggest the splitting pattern of ¹H NMR signals of the following compounds (4 Marks)



T) [15 MARKS]

a) A compound with molecular formula C_8H_8O gives the following 1H NMR data: **(7 Marks)**

- (i) a multiplet, $\delta = 7.28$ ppm, counting for a group of **5** equivalent H
- (ii) a doublet, $\delta = 2.8$ ppm, counting for a group of **2** equivalent H
- (iii) a triplet, $\delta = 9.78$ ppm, counting for a single 1H

Suggest the structural formula of the compound.

b) Discuss the 1H NMR spectrum of ethanol : we consider two sample, giving two slightly different NMR spectra.

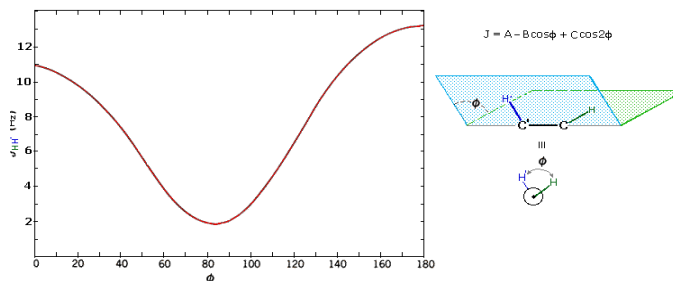
- (i) Aqueous ethyl alcohol $(CH_3.CH_2.OH)(H_2O)_n$ with labile hydroxyde protons
- (ii) Pure anhydrous ethyl alcohol $(CH_3.CH_2.OH)$ without exchange of protons

Describe what is the general description of the ethyl 1H NMR that is independent from hydration **(4 Marks)**

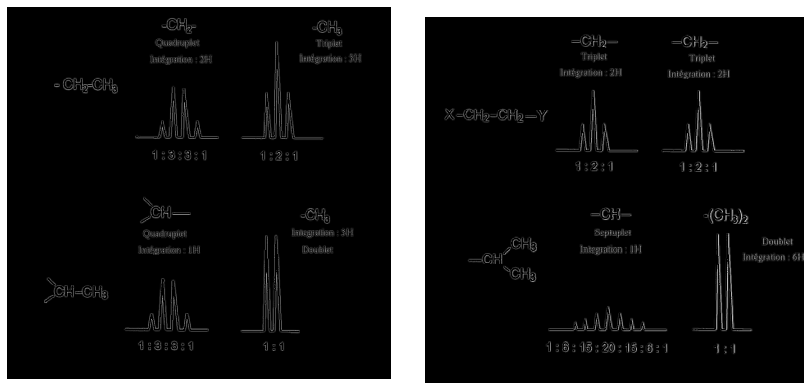
Analyze what specific changes in this spectra will be introduced when no proton exchange can be considered with any water molecule **(4 Marks)**.

QUESTION THREE (SCALAR COUPLING) [15 MARKS]

Givens: Influence of the Scalar coupling with the dihedral angle.



Different multiplets.



Molar masses:

$M(O) = 15.9994 \text{ g/mol}$, $M(C) = 12.0107 \text{ g/mol}$, $M(Br) = 79.904 \text{ g/mol}$, $M(Cl) = 35.453 \text{ g/mol}$, $M(H) = 1.00784 \text{ (g/mol)}$

a) What do you mean by spin-spin coupling ? Why does an NMR peak split into multiplets ? (2 Marks)

ii) What is a coupling constant ? Illustrate various factors which affect the value of the coupling constant. (3 Marks)

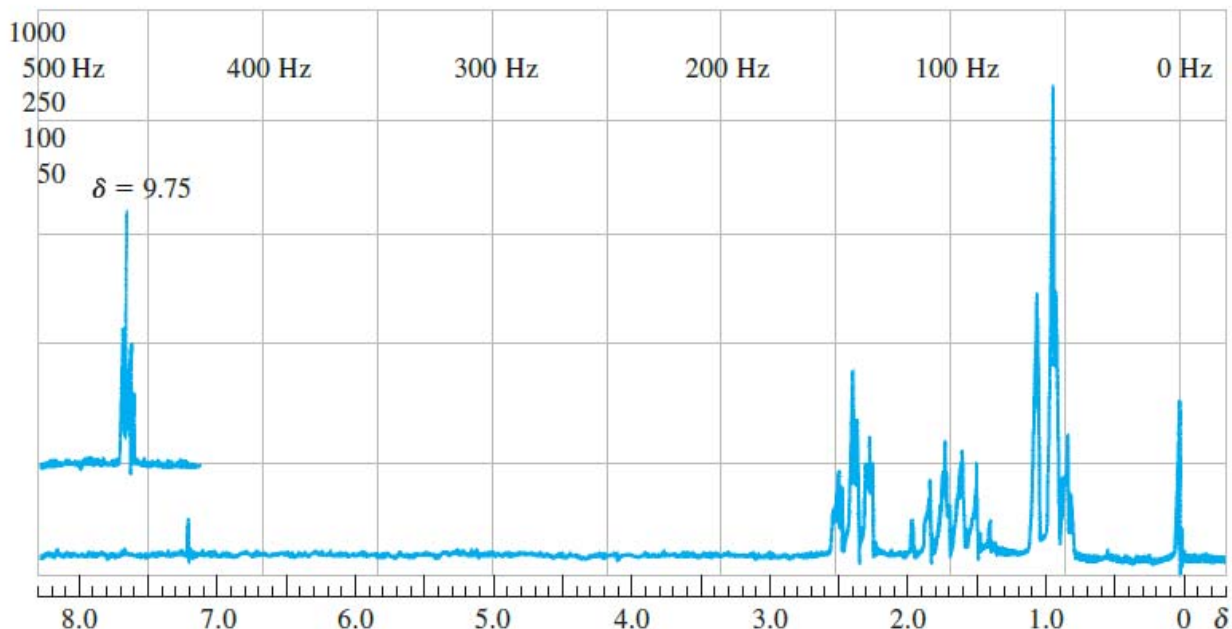
b) For each of the following compounds, calculate the number of multiplets for each band and their relative areas (3 Marks)

(i) $\text{Cl}(\text{CH}_2)_3\text{Cl}$

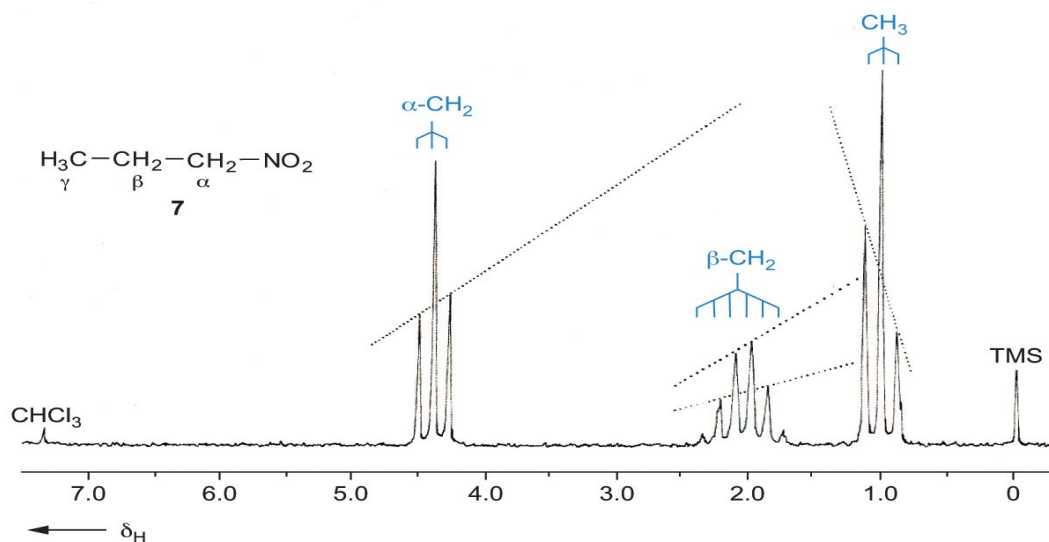
(ii) $\text{CH}_3\text{CHBrCH}_3$

(iii) $\text{CH}_3\text{CH}_2\text{OCH}_3$.

b) The proton spectrum shown in figure below is for an organic compound having a molecular mass of 72.10 g/mol and containing carbon, hydrogen, and oxygen only. Identify the compound (4 Marks)

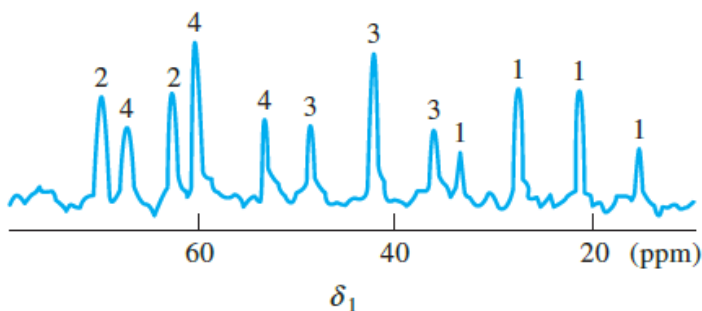


c) Explain the difference in height in chemical shifts as shown in the diagram below. (3 Marks)



QUESTION FOUR (CARBON SHIFT ^{13}C) [15 MARKS]

- a) What information would you get from a proton-coupled ^{13}C NMR spectrum of a compound? **(2 Marks)**
- ii) What is meant by proton-decoupling with regard to ^{13}C NMR spectroscopy? Describe off-resonance proton decoupling. **(2 Marks)**
- b) How many signals would you get in the proton-decoupled ^{13}C NMR spectrum of 3-methylbutanone? **(3 Marks)**
- c) Spin-spin coupling between two adjacent carbon atoms in a molecule does not occur. Why? **(2 Marks)**
- d) Figure below is a ^{13}C 1D NMR spectrum (not ^1H decoupled) for an organic compound. Draw the structure of the compound. **(6 Marks)**

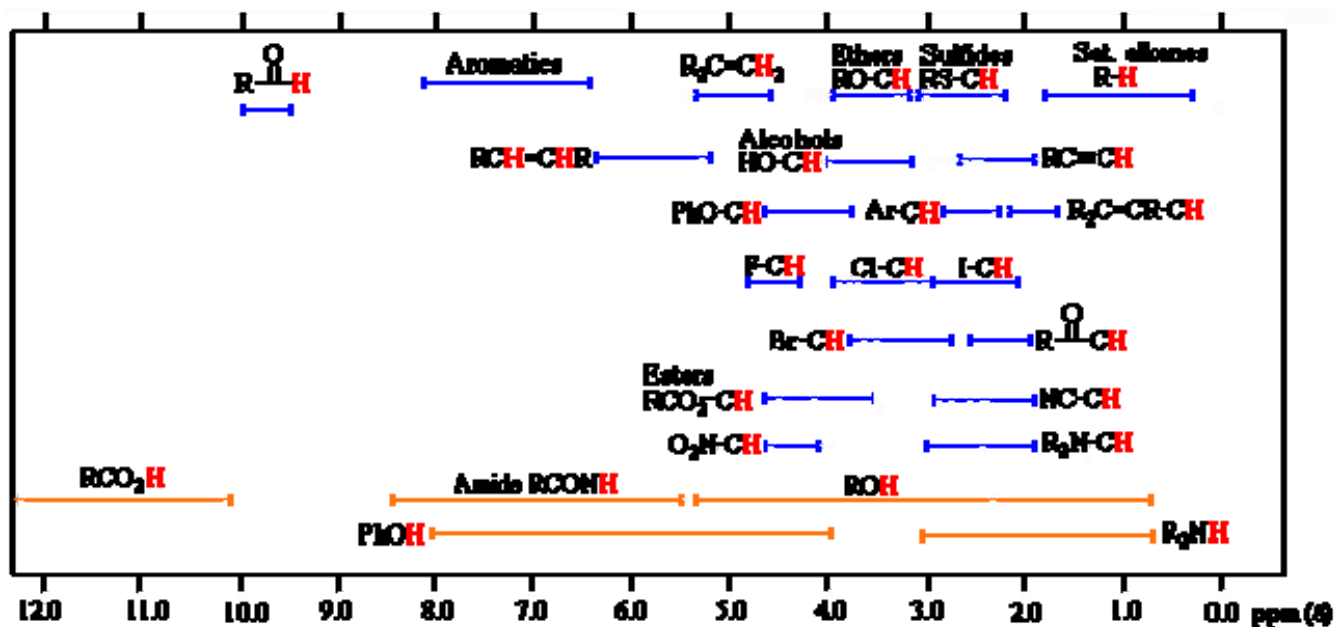


QUESTION FIVE (STRUCTURAL APPLICATIONS) [15 MARKS]

- a) How would you distinguish between cis-2-butene and trans-2-butene using NMR spectroscopy? (3 Marks)
- b) Explain why NMR signal for protons in benzene is observed much downfield in comparison to that for protons in acetylene? (3 Marks)
- c) How would you differentiate between intermolecular and intramolecular hydrogen bonding using ^1H NMR spectroscopy? (3 Marks)
- d) Cyclohexane displays only one ^1H NMR signal, although it has two types of hydrogen atoms, axial and equatorial. Explain (6 Marks)

CHEMICAL SHIFT TABLES

Proton Chemical Shift Ranges



Carbon Chemical Shift Ranges

