NATIONAL UNIVERSITY OF LESOTHO

FACULTY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF CHEMISTRY & CHEMICAL TECHNOLOGY

BSc, BSc CHEM. TECH & BSc Ed FINAL EXAMINATION

C2730: ORGANIC CHEMISTRY I

June 2023 **Marks: 100** **Time: 3 Hours**

Instructions

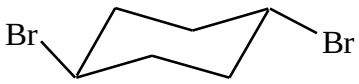
This question paper contains six (6) questions, each carrying a total of 25 marks. The number of marks for each section of a question are indicated in brackets to the right of each section.

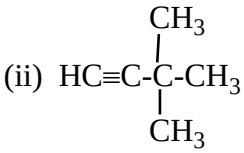
Answer Any Four (4) Questions

Begin each question on a fresh page, and write neatly

Question One

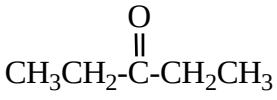
(a) Name the following compounds by the IUPAC system: [**8 Marks**]

(i) 

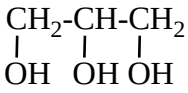
(ii) 

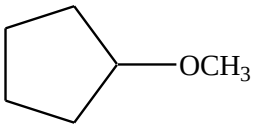
(iii) $CH_3CH_2CH_2CH_2CH_2CH_2CH{=}CH_2$

(iv) $CH_3(CH_2)_8CH_3$

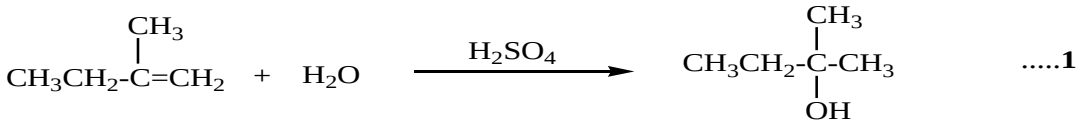
(v) 

(vi) CH_3CH_2CHO

(vii) 

(viii) 

(b) Equation 1 below shows one of the common reactions of alkenes. The reaction involves the conversion of an alkene to an alcohol by acid-catalysed hydration.



2- methyl-1-butene **2- methyl-2- butanol** **1**

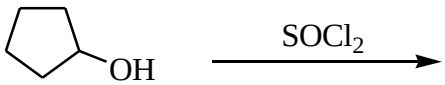
i) Provide a detailed mechanism for the above reaction. [**5 Marks**]

ii) Write down **the structure** as well as **the IUPAC name** for the anti-Markovnikov's product of the reaction. [**4 Marks**]

(c) Show a reaction sequence for the synthesis of *trans*-3-heptene from ethyne, alkyl halides and other appropriate reagents. **[8 marks]**

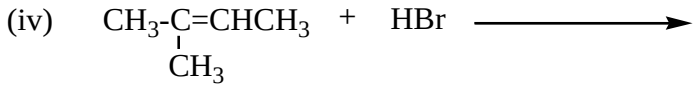
Question Two

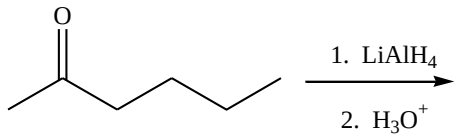
(a) Write down the **structure/s** for the main product/s of each of the following reactions. [**10 Marks**]

(i) 

(ii) $CH_3C{\equiv}CH$ $\xrightarrow[2.\ CH_3CH_2CH_2CH_2Br]{1.\ Na^+NH_2^-/\ NH_3}$

(iii) $CH_3CH_2CH_2CH_2CH_2OH$ $\xrightarrow[CH_2Cl_2]{PCC}$

(iv) 

(v) 

(b) Give the structure that corresponds to each of the following IUPAC names.

(i) 2-Methyl-1,3-butadiene

(ii) *trans*-4,5-Dimethyl-4-heptene

(iii) *cis*-1,2-Dibromocyclopentane

(iv) Ethanoic acid

(v) 1-Hepten-6-yne

(vi) *n*-Hexane

(vii) Propanone

(viii) Diethyl ether

(ix) Heptanal

(x) 2-Chloro-2,4-dimethylhexane **[10 Marks]**

(c) When 2-heptyne was treated with aqueous sulphuric acid containing mercuric sulphate, two products, each having a molecular formula $C_7H_{14}O$, were obtained in approximately equal amounts.

(i) Propose **the structures** of these two products. [**4 Marks**]
(ii) To which class of organic compounds do these products belong? **[1 mark]**

Question Three

(a) Describe, giving observations and relevant reaction equations, a test that can be used to distinguish *n*-pentane from 1-pentene. [**5 Marks**]

(b) An unknown compound, **A**, rapidly decolorizes bromine solution. When **A** was subjected to ozonolysis, the products were butanone ($CH_3CH_2COCH_3$) and propanal (CH_3CH_2CHO).

i) A decolorizes bromine solution. What can you conclude about **A**? [**1 mark**]
ii) From the above information, suggest the structure of **A**, and name it by the IUPAC system. [**2 +2 marks]**
iii) How many mole equivalents of hydrogen gas will react with **A**? [**1 mark**]
iv) Write down a complete reaction equation for the ozonolysis of **A**. [**2 marks**]

(c) Draw structures for all **eight** (8) isomeric alcohols of molecular formula $C_5H_{12}O$. [**8 marks**]

(d) Copy and complete the following by filling in the missing links with the words 'reduced' or oxidised'. [**4 Marks**]

(i) Primary alcohols can be _____to aldehydes.

(ii) Ketones are normally _____to secondary alcohols

(iii) Alkenes can be _____ to carboxylic acids using acidic $KMnO_4$.

(iv) Alkenes are _____ to alkanes by hydrogenation.

Question Four

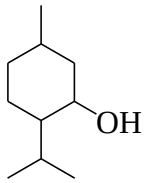
(a) 1-Pentyne and 2-pentyne are structural isomers of an alkyne of molecular formula C_5H_8. 1-Pentyne is a terminal alkyne while 2-pentyne is a non-terminal alkyne. Fully describe, giving expected observations and chemical reactions, a chemical test that can be used to distinguish one of these isomers from the other. [**5 marks**]

(b) Draw an orbital diagram of allene, $H_2C=C=CH_2$. What hybridisation must the central carbon atom have to form two double bonds? [**3+2 marks]**

(c) **(**i) State Markovnikoff's rule. **[2 Marks]**
(ii) Use the rule to predict the **main product** of a reaction between methylcyclopentene and HBr. **[2 Marks]**
(iii) Name the product by the IUPAC system. **[2 Marks]**

(d) Give the **structures** and **IUPAC names** for all **isomeric alkanes** of molecular formula C_5H_{12}. [**6 Marks**]

(e) Menthol is a cyclic alcohol. It has the following structure.



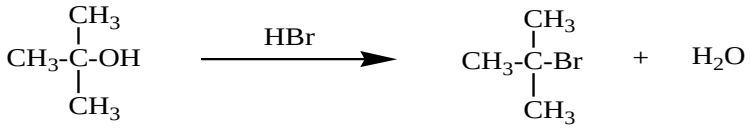
(i) Name the alcohol by IUPAC system **[2 Marks]**
(ii) Classify it as primary, secondary or tertiary alcohol. **[1 Marks]**

Question Five

(a) Give the functional group that distinguishes each of the following classes of organic compounds from one another. **[4 marks]**
(i) Aldehydes
(ii) Alkynes
(iii) Alkyl halides
(iv) Carboxylic acids

(b) The conversion of alcohols into alkyl halides by reaction with hydrogen halides is an example of a Nucleophilic Substitution Reaction. This kind of reaction can proceed by two different mechanisms depending on the structure of alcohol substrates used. Generally, primary alcohols are substituted via **S_N2** mechanism, while some secondary and tertiary react by **S_N1** mechanism.

Consider the following reaction.



(i) By which of the two mechanisms does the reaction proceed? **[1 Marks]**
(ii) Provide a detailed mechanism for the reaction. **[4 Marks]**

(c) Write down the structures for all **isomeric alkenes** of molecular formula C_5H_{10} (ignore *cis*-, *trans*- isomers). [**5 marks**]

(d) Write a **structural formula** and give the **systematic name** for each of the following:

(i) A ketone, C_4H_8O

(ii) An alcohol, $C_4H_{10}O$

(iii) A carboxylic acid, $C_3H_6O_2$

(iv) An ester, $C_4H_8O_2$. [**8 marks**]

(e) Describe the shape of sp^2 hybrid orbitals. [**3 marks]**

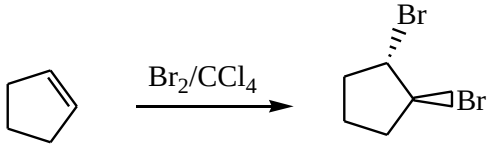
Question Six

(a) An unknown compound is either 2-methyl-2-propanol or 1-butanol. When a few drops of permanganate solution are added to it, the purple colour of permanganate fades and a brown precipitate of MnO_2 is formed.
(i) What is the identity of the unknown? **[2 Marks]**
(ii) Explain your answer. **[3 marks]**

(b) Explain, with illustrations, why alcohols generally have higher boiling points than alkanes of comparable molecular weight. [**4 Marks**]

(c) Give the **structure** as well as the **IUPAC name** for all tertiary alcohols with molecular formula $C_6H_{14}O$. [**6 marks**]

(d) When bromine reacts with cyclopentene, the observed product is 1,2-dibromocyclopentane. The stereochemistry of this product indicates that an *anti*-addition to the double bond has occurred. No *syn*-addition is observed. [**4 marks**]

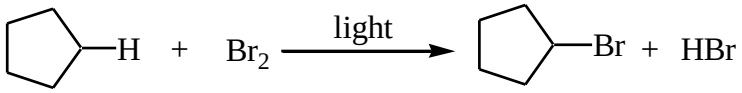


Suggest a mechanism that accounts for the formation of this product.

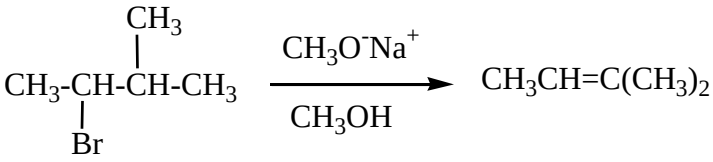
(e) Mention one importance of each of the following classes of organic molecules.
(i) Alcohols
(ii) Alkenes [**2 marks]**

(f) Classify each of the following reactions as an addition, elimination, substitution, oxidation or reduction reaction. [**4 marks**]

(i) $CH_3CH_2CH_2CH_2CH_2OH \xrightarrow[CH_2Cl_2]{PCC} CH_3CH_2CH_2CH_2CO_2H$

(ii) 

(iii) $CH_3CH_2CH_2\text{-}\overset{\overset{O}{\|}}{C}\text{-}CH_3 \xrightarrow[2.\ H_3O^+]{1.\ LiAlH_4} CH_3CH_2CH_2CH(OH)CH_3$

(iv) 

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