**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**FACULTY OF APPLIED SCIENCE**

**DEPARTMENT OF APPLIED CHEMISTRY**

**ORGANIC CHEMISTRY I FOR SCH STUDENTS ONLY**

**SCH 1102**

**First Semester Examination Paper**

**December 2016**

This examination paper consists of 6 pages

**Time Allowed:** **3 hours**

**Total Marks:** **100**

**Special Requirements:** **Graph Paper (on request)**
**$R = 8.314\ JK^{-1}\ mol^{-1} = 1.98\ cal\ mol^{-1}K^{-1}$**

**Examiner's Name:** **DR B N YALALA**

**INSTRUCTIONS**

1. **Answer all questions from Section A and any three from Section B. Section A carries 40 marks and each question in Section B carries 20 marks.**

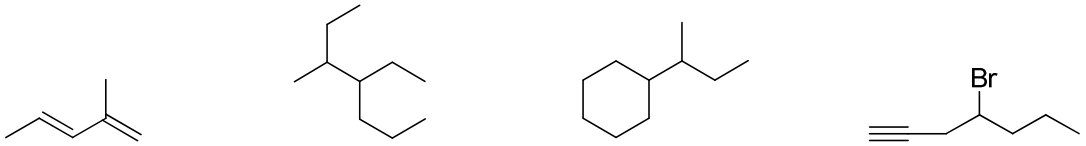
2. **Show mechanism, chemical steps or synthesis by means of curved arrows.**

**MARK ALLOCATION**

| QUESTION | MARKS |
|---|---|
| 1. | **40** |
| 2. | **20** |
| 3. | **20** |
| 4. | **20** |
| 5. | **20** |
| **TOTAL POSSIBLE MARKS** | **100** |

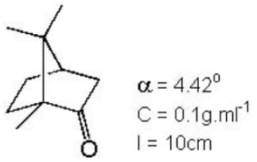
**SECTION A:**

1. (a) Give IUPAC names for the following compounds.




(4 Marks)

(b) What is the specific rotation $[\alpha]_D$ of the following molecule?



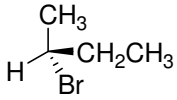

(2 Marks)

(c) Write the structural formulae for the following compounds.

(i) 3-propyl-4,7-dimethyl nonane
(ii) trans-1,2-dimethylcyclopentane

(2 Marks)

(d) Assign R and/or S designation to the chiral centre in the following compound. Show your reasoning for full credit.




(3 Marks)

(e) List the following compounds in order of increasing reactivity in an $S_N1$ reaction.

$CH_3Br$, $CH_3CH_2CH_2I$, $(CH_3)_3CI$, $CH_3CHBrCH_3$, $CH_3CHICH_3$

(4 Marks)

(f) 1-Hexene has a heat of hydrogenation of -125 kJ/mole (or -29.9 kcal/mole). 1,3,5,-Hexatriene has a heat of hydrogenation of -335 kJ/mole (or -80.1 kcal.mole). Does the triene display resonance stabilization? If so, how much?

(4 Marks)

(g) Draw any 3-D representation of butane with a C-C-C-C dihedral angle of 120°.

(3 Marks)

(h) Draw all the optically active compounds with formula $C_5H_{11}Cl$.

(4 Marks)

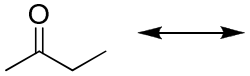
(i) Draw both chair conformations of trans-1-ethyl-3-methylcyclohexane. Clearly label the alkyl substituents as axial or equatorial. (You do not need to show all the hydrogens). Which conformer is lower energy?

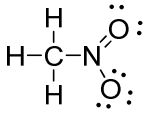
(6 Marks)

(j) With an appropriate example explain positional isomer.

(4 Marks)

(k) Provide complete resonance structures for the following compounds:

(i) 

(ii) 

(4 Marks)

**SECTION B:**

2. (a) (i) Draw Fisher projections for (2R, 3S)-2-bromo-3-chlorobutane and (2S, 3R)-2-bromo-3-chlorobutane, with the carbon chain on the vertical line. Label each structure as (2R, 3S) or (2S,3R).

(4 Marks)

(ii) Assume that you have a mixture of equal amounts of each of the compounds in part (a) (i). Can they be separated into two containers based on physical properties such as b.p., m.p., etc.? If yes, which technique would you use? If no, briefly explain why not.

(4 Marks)

(b) Discuss $sp^2$ hybridisation with an appropriate organic compound of your choice. Draw orbital as well as bonded structures and indicate the shape of the molecule.

(6 Marks)

(c) Draw a generic reaction energy diagram that fits the following profile: 1) the reaction is endothermic, 2) the reaction occurs in two steps mechanistically, and 3) the first step of the mechanism is rate determining. Be sure to label both axes.
(6 Marks)

3. (a) Given the bond dissociation energies below (in kcal/mol), calculate the overall ΔH° for the following reaction and write the chain propagation steps for the bromination reaction.

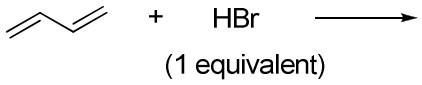
$$(CH_3)_3CH + Br_2 \rightarrow (CH_3)_3CBr + HBr$$

| | |
|---|---|
| $(CH_3)_3C$-H | 91 |
| $(CH_3)_3C$-Br | 65 |
| Br-Br | 46 |
| H-Br | 88 |
| $CH_3$-Br | 70 |

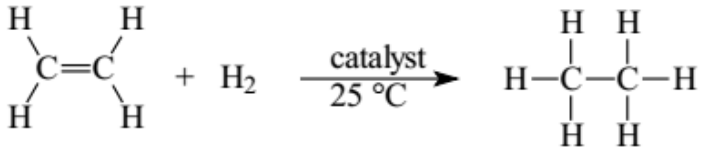
(10 Marks)

(b) Two organic products are formed in the following electrophilic addition reaction shown below:

(i) Draw the products. (3 points)
(ii) Identify the kinetic product. (1 point)
(iii) Identify the thermodynamic product. (1 point)
(iv) Draw the reaction energy profiles for the formation of both products on the same energy diagram. Clearly label transition states and intermediates. Show the structure of any starting material, intermediate, or product on the diagram. You do not need to show transition state structures.
(5 points)



4. (a) At the room temperature (25 °C), ethene can be hydrogenated (add one mole of $H_2$ to the double bond) to give ethane in the presence of a catalyst, as shown below:




ethene ethane

It is known from the experiment that $\Delta G^\circ$= -30kcal/mol. Answer the following questions:

(i) Calculate the equilibrium constant for this reaction.

(4 Marks)

(ii) Predict the sign of this $\Delta S^\circ$ for this reaction. Briefly explain your reasoning.

(2 Marks)

(iii) Predict the sign of $\Delta H^\circ$ for this reaction. Explain briefly how you arrive at this conclusion.

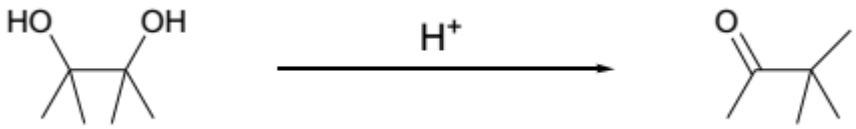
(2 Marks)

(b) Sketch a potential energy diagram for rotations about the carbon-carbon bond of $BrCH_2CH_2Br$.

Draw Newman projections to indicate locations of the various conformations.

(8 Marks)

(c) The mechanism of the following reaction involves mechanistic steps that you are already familiar with. Provide a detailed mechanism.

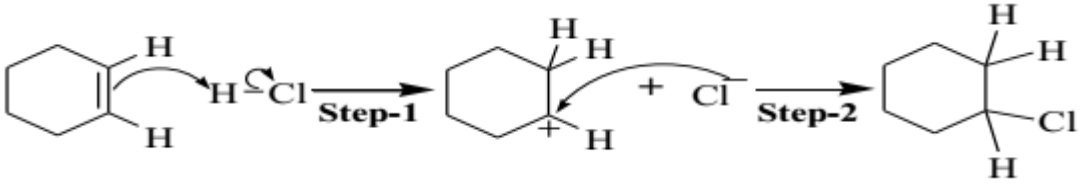



(4 Marks)

5. (a) 3-Methyl-2-butanol and 2-methyl-1-propanol are converted to their corresponding bromides when heated with hydrogen bromide. Write a suitable mechanism for each reaction, and state whether the reaction is $S_N1$ or $S_N2$.

(6 Marks)

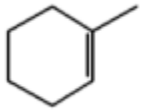
(b) Consider the following two-step reaction:

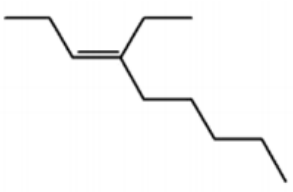



(i) How many bonds are broken and formed in Step-1?
(ii) Would you predict the ΔH° of Step-1 to be positive or negative?
(iii) How many bonds are broken and formed in Step-2?
(iv) Would you predict the ΔH° of Step-2 to be positive or negative?
(v) Which is the rate-determining step?
(vi) Draw the structures for the transition states in both steps of the mechanism.

(6 Marks)

(c) Draw structural formulas for the products of ozonolysis of the following alkenes:

(i) 

(ii) 

(4 Marks)

(d) (i) Give the major product of the reaction of 2-bromo-3-methylbutane with sodium hydroxide.

(ii) Show the mechanism of the reaction.

(4 marks)

**END OF QUESTION PAPER**