MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SPECIAL NEEDS EDUCATION)

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

BACHELOR OF EDUCATION (SCIENCE)

SCH 303: STREOCHEMISTRY, CONFORMATIONAL STUDIES AND REACTION MECHANISMS

DATE: 1/9/2022 **TIME: 8.30-10.30 AM**

INSTRUCTIONS:

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

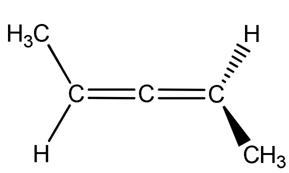
SECTION A

QUESTION ONE (30 MARKS)

a) Discuss three ways of testing chirality. (6 marks)

b) Write the enantiomeric forms of bromochlorofluoromethane and assign each enantiomer its correct (*R*) or (*S*) designation. (4 marks)

c) Classify the following molecules as chiral or an achiral. (4 marks)



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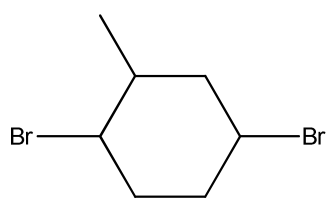

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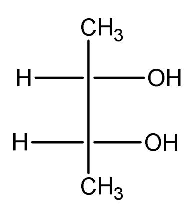

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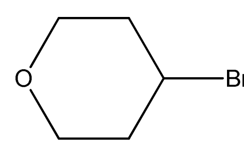
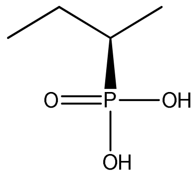


(iv)

d) Assign the (R,S) configuration at each chirality center in the following compounds.

(7 marks)



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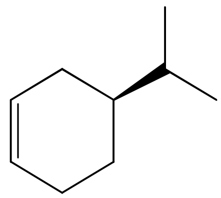

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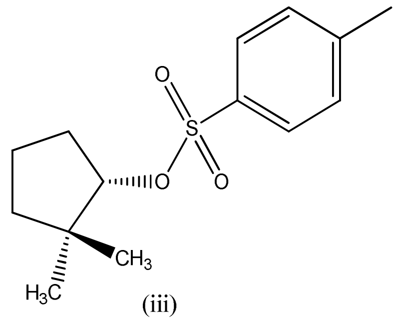

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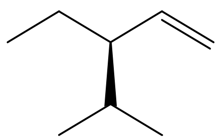

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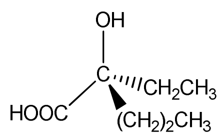

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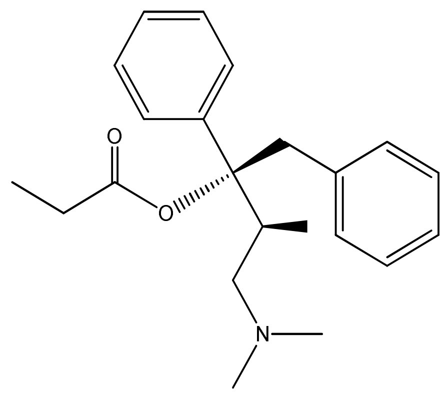
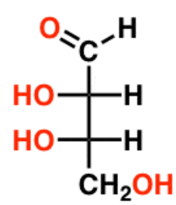


(vi)

e) For the following Fischer projection, determine the configuration at each chirality centre and convert the structure to a dashed wedge formula showing the correct stereochemistry. (5 marks)



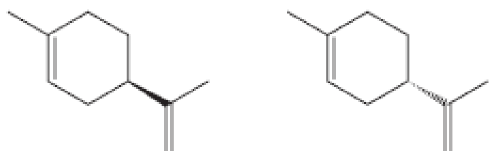
f) Draw a Newman projection of the most stable and least stable conformation of 2-methylpropane (2 marks)

g) Differentiate between stereoselective and stereospecific reactions. (2 marks)

SECTION B

QUESTION TWO (20 MARKS)

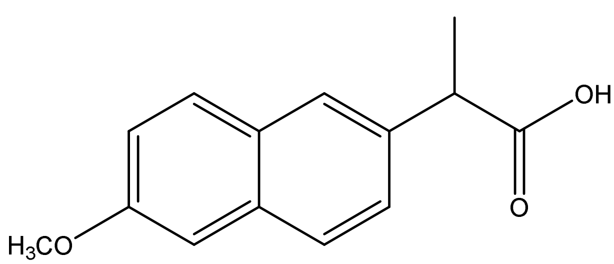
a) The two enantiomers of limonene shown below behave differently in that the first enantiomers is primarily responsible for the odor of oranges while the second is responsible for the odor of lemons. Discuss. (4 marks).



(+)-Limonene (–)-Limonene

b) Mixtures of the enantiomers of a compound have different properties than pure samples of each. For example, the natural isomer, (+)-tartaric acid, has a melting point of 168–170 °C, as does its unnatural enantiomer, (-)-tartaric acid. However, an equal mixture tartaric acid enantiomers, (+/-)-tartaric acid, has a melting point of 210–212 °C. Explain. (4 marks)

c) Chiral drugs are recommended for prescriptions as a single enantiomer. Naproxen (shown below) is an anti- inflammatory drug, which is mandated to be sold at greater than 97% enantiomeric excess (e.e.). The specific rotation of the R-enantiomer (in $CHCl_3$) is +65.5°. During a quality control exercise, a chemist sampled from a 50 kg batch of Naproxen produced at a pharmaceutical industry. She dissolved 2.6 g of product in 10 mL of chloroform and measured an optical rotation of +15.2° in a 10 cm (1 dm) polarimeter.



i. Draw the R-enantiomer of Naproxen (2 marks)

ii. Calculate the optical purity of the sample and determine whether it meets the set standard for it to be marketed (4 marks)

iii. Determine the mass of the 50 kg batch, which is actually the (+)(R)-enantiomer. (2 marks)

d) Dextrorotatory (d, +) and leverotarory (l, -) notation used in optical rotation are different from R, S configurations. Explain. (4 marks)

QUESTION THREE (20 MARKS)

a) Using an appropriate example, discuss the importance of stereochemistry in the pharmaceutical industry. (4 marks)

b) Discuss chiral chromatography in separation of enantiomers. (4 marks)

c) An aqueous solution of pure stereoisomer X of concentration 0.10 g mL^{-1} had an observed rotation of -30° in a 1.0-dm tube at 589.6 nm (the sodium D line) at 25 °C.

   i. Calculate its $[\alpha]_D$ at this temperature. (3 marks)

   ii. Under identical conditions but with a concentration of 0.050 g mL^{-1}, a solution of X had an observed rotation of +165°. Rationalize this observation and recalculate $[\alpha]_D$ for stereoisomer X. (3 marks)

d) If the optical rotation of a substance studied at only one concentration is zero, can it definitely be concluded to be achiral or Racemic? (2 marks)

e) (-)-2-butanol has a specific rotation of -13.5°, while the specific rotation of (+)-2-butanol is +13.5.

   i. Calculate the optical purity of a mixture containing (+) and (-)-2-butanol if the mixture has an observed rotation of -8.55°. (2 marks)

   ii. Determine the composition for both (+) and (-)-2-butanol. (4 marks)

QUESTION FOUR (20 MARKS)

a) Draw the two chair conformations of cis-1-isopropyl-4-methylcyclohexane. Evaluate if the two conformations are equivalent if not, determine which would be more stable and the preferred conformation at equilibrium. (4 marks)

b) Discuss how the heat of combustion can be used to determine the energy strain of a molecule. (3 marks)

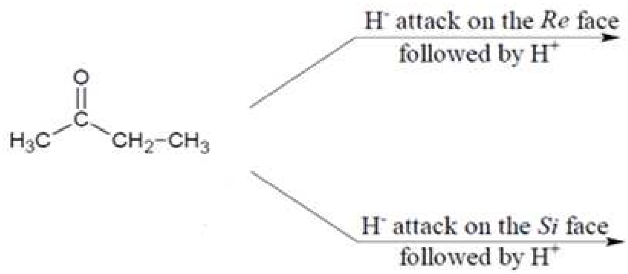
c) 1,3-diaxial interactions are a form of steric stained encountered in substituted chair conformation of cyclohexane. Illustrate how they occur. (2 marks)

d) Explain the source of torsional strain, steric strain, and angle strain (6 marks)

e) Discuss the four different conformations of cyclohexane, including information on their stability. (5 marks)

QUESTION FIVE (20 MARKS)

a) Provide the products formed when ketone shown below reacts with a Grignard reagent through attack on Si face and Re face. Be careful to show the correct stereochemistry of the products. (4 marks)



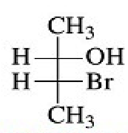
b) Differentiate between enantioselective and diastereoselective reactions. (2 marks)

c) Explain why the alkane formed by hydrogenation of (S)-4-methyl-1-hexene is optically active while the one formed by hydrogenation of (S)-3-methyl-1-pentene is not. (2 marks)

d) i. Determine the products that are formed from acid-catalyzed hydration of racemic (±)-4-methyl-1-hexene. (3 marks)

ii. Discuss the relative amounts of the products and determine if the product mixture is optically active. (3 marks)

e) The molecule shown below is a fisher projection of (2S, 3R)-3-bromo-2-butanol. Draw the other three stereoisomers indicating their configuration before the name. (6 marks)



(2*S*,3*R*)-3-bromo-2-butanol