IB CHEMISTRY YEAR 2 SUMMER ASSIGNMENT

1. Read Chapter 10—Organic Chemistry (p.461-524), take notes (make sure you pay attention to new vocabulary, reaction types, and conventions), complete all chapter exercises.*

2. Complete the Mixed Organic Nomenclature/Formulas worksheets.

3. Answer questions #29, 31, 32, 47, 48, 51, 55, 59-62 from p. 1093 in Zumdahl (copied book pages). After taking notes on topic 20.3, go back to numbers 31 & 32 and identify which compounds exhibit cis-trans or E/Z isomerism. Also 66a-b, 67, 68a-b

***Do not wait until the last weeks of summer to start this assignment. You are responsible for learning this material, and you will be tested on it early in the semester.***

*pages 464-477, 481, 516-519 are review from May 2019
Write the correct IUPAC name for each molecule below the structural formula shown.

1. \( \text{CH}_3\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{CH}_3 \)

6. \( \text{CH}_3\cdot\text{CH}={}^c\cdot\text{CH}_2\cdot\text{CH}_3 \)

2. \( \text{CH}_3\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{CH}_3 \)

7. \( \text{Cl} \cdot \text{CH}_3\cdot\text{C}={}^c\cdot\text{CH}_2\cdot\text{CH}_3 \)

3. \( \text{CH}_3\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{CH}_3 \)

8. \( \text{CH}_3\cdot\text{C}={}^c\cdot\text{CH}_2\cdot\text{CH}_3 \)

4. \( \text{CH}_3\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{CH}_3 \)

9. \( \text{CH}_3\cdot\text{CH}_3 \)

5. \( \text{CH}_3\cdot\text{C}={}^c\cdot\text{CH}_2\cdot\text{CH}_3 \)

10. \( \text{CH}_3 \)
Draw condensed structural formulas for the following hydrocarbons (Circled problems only)

1. 2, 3-dimethylpentane

2. 2, 4-dimethylhexane

3. cyclohexene

4. 2, 2-dimethylpropane

5. 2, 4-dimethylhex-1-ene

6. cis-2, 3-dichlorobut-2-ene

7. 1, 1, 2-trichloroethane

8. 1, 2-dimethylcyclohexane

9. 1, 4-dichlorobenzene

10. 1, 3-dimethylnaphthalene
Mixed Organic Nomenclature/Formula Practice

Write the correct IUPAC name for each molecule below the structural formula shown.

1. $\text{CH}_3-(\text{CH}_2)_4-\text{CH}_2\text{Br}$

2. $\text{O}$
   \[ \text{CH}_3-\text{CH}-\text{C}=\text{O} \cdot \text{H} \]
   \[ \text{NH}_3 \]

3. $\text{O}$
   \[ \text{H-CH-CH}_2-\text{CH}_3 \]
   \[ \text{CH}_3 \]

4. $\text{O}$
   \[ \text{CH}_3\text{C}=\text{C}=\text{CH}_2-\text{CH}_2-\text{CH}_3 \]
   \[ \text{CH}_3 \]

5. $\text{O}$
   \[ \text{O-H} \]
   \[ \text{O-H} \]

6. $\text{O}$
   \[ \text{C-O-CH}_3 \]

7. $\text{O}$
   \[ \text{CH}_3-\text{CH}_2-\text{C}=\text{C}=\text{CH}_2-\text{CH}_2\text{Br} \]
   \[ \text{H} \]
   \[ \text{H} \]

8. $\text{O}$
   \[ \text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}_3 \]

9. $\text{O}$
   \[ \text{CH}_3-\text{C}=\text{CH}-\text{CH}_2-\text{OH} \]
   \[ \text{CH}_3 \]

10. $\text{O}$
    \[ \text{Cl} \]

11. $\text{O}$
    \[ \text{CH}_3-\text{O-C-CH}_2-\text{CH}_3 \]

12. $\text{O}$
    \[ \text{CH}_3-\text{CH}_2-\text{C}-\text{NH}_2 \]
Draw condensed structural formulas for the following hydrocarbons (All)

1. pentane-1,3,5-triol

2. hexane-1,6-diamine

3. ethanol-1,2-diol

4. 3-methylpentanal

5. 1-chloropentan-2-one

6. methylpropanoate

7. 3-aminobutanoic acid

8. 2-hydroxybenzoic acid

9. propanamide

10. butan-1-ol

11. 2-methylpropan-2-ol

12. 2-methylpropan-1-ol

13. 3-methylpentan-2-ol

14. phenylpropanoate
28. Draw the structure for 4-ethyl-2,3-dimethylpentane. This name is incorrect. Give the correct systematic name.

29. Name each of the following:
   a. \( \text{CH}_3 \text{CH} = \text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \)
   b. \( \text{CH}_2 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \)
   c. \( \text{CH}_3 - \text{C} = \text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \)
   d. \( \text{CH}_3 - \text{CH} = \text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \)

30. Name each of the following cyclic alkanes, and indicate the formula of the compound.
   a. \( \text{CH}_3 \text{CH} = \text{C} - \text{H} \)
   b. \( \text{CH}_3 \text{CH} = \text{CH} - \text{CH}_3 \)
   c. \( \text{CH}_3 \text{CH}_2 \text{CH}_2 \text{CH}_2 \text{CH}_3 \)

31. Name each of the following alkenes.
   a. \( \text{CH}_3 - \text{C} = \text{C} - \text{CH}_2 - \text{CH}_3 \)
   b. \( \text{CH}_3 - \text{C} = \text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \)
   c. \( \text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_3 \)
   d. \( \text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_3 \)
   e. \( \text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_3 \)

32. Name each of the following alkenes or alkynes.
   a. \( \text{CH}_3 \text{CH} = \text{C} - \text{CH}_3 \)
   b. \( \text{CH}_3 - \text{C} = \text{C} - \text{CH}_2 - \text{CH}_3 \)
   c. \( \text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_3 \)
   d. \( \text{CH}_3 \text{CH} = \text{C} - \text{CH}_3 \)
   e. \( \text{CH}_3 \text{CH} = \text{CH} - \text{Br} \)

33. Give the structure for each of the following:
   a. 3-hexene
   b. 2,4-heptadiene
   c. 3-methyl-4-octene

34. Give the structure for each of the following:
   a. 4-methyl-1-pentene
   b. 2,3,3-trimethyl-1-hexene
   c. 3-ethyl-4-decene

35. Give the structure of each of the following aromatic hydrocarbons.
   a. o-ethyltoluene
   b. p-di-tert-butylbenzene
   c. 1-phenyl-2-butene

36. Cumene is the starting material for the industrial production of acetone and phenol. The structure of cumene is

\[
\text{CH}_3 \text{CH} = \text{C} - \text{CH}_3
\]

Give the systematic name for cumene.

37. Name each of the following.
   a. \( \text{Cl} - \text{CH}_2 - \text{CH}_2 - \text{CH} = \text{CH}_3 \)
   b. \( \text{CH}_3 \text{CH}_2 \text{CH}_2 \text{CCl}_3 \)
   c. \( \text{Cl}_3 \text{CH} - \text{CH} = \text{CH} - \text{CH}_3 \)
   d. \( \text{CH}_2 \text{PCH}_2 \text{F} \)

38. Name each of the following compounds.
   a. \( \text{CH}_3 \text{CHCH} = \text{CH}_2 \)
   b. \( \text{CH}_3 \text{CH} = \text{C} - \text{CH}_2 - \text{CH}_3 \)
   c. \( \text{Cl} - \text{CH}_2 \text{CH}_2 \text{CH}_3 \)
   d. \( \text{CH}_3 \text{CH} = \text{C} - \text{CH}_2 - \text{CH}_3 \)
   e. \( \text{Br} - \text{CH}_2 \text{CH}_2 \text{CH}_3 \)
Isomerism

40. Which of the compounds in Exercises 31 and 33 exhibit cis-trans isomerism?

41. Draw all the structural isomers of C6H6. Ignore any cyclic isomers.

42. Which of the structural isomers in Exercise 41 exhibit cis-trans isomerism?

43. Draw all the structural and geometrical (cis-trans) isomers of C6H5Cl.

44. Draw all the structural and geometrical (cis-trans) isomers of bromochloropropene.

45. Draw all structural and geometrical (cis-trans) isomers of C6H5F. Ignore any cyclic isomers.

46. Cis-trans isomerism is also possible in molecules with rings. Draw the cis and trans isomers of 1,2-dimethylcyclohexane. In Exercise 45, you drew all of the noncyclic structural and geometric isomers of C6H5F. Now draw the cyclic structural and geometric isomers of C6H5F.

47. Draw the following.
   a. cis-2-hexene
   b. trans-2-butene
   c. cis-2,3-dichloro-2-pentene

48. Name the following compounds.
   a. CH3\(\text{C} = \text{C}\)Br
   b. CH3\(\text{C} = \text{C}\)CH2CH3
   c. CH3CH2\(\text{C} = \text{C}\)CH2CH3
   d. CH3CH2CH2\(\text{C} = \text{C}\)CH2CH3

49. If one hydrogen in a hydrocarbon is replaced by a halogen atom, the number of isomers that exist for the substituted compound depends on the number of types of hydrogen in the original hydrocarbon. Thus there is only one form of chloroethane (all hydrogens in ethane are equivalent), but there are two isomers of propane that arise from the substitution of a methyl hydrogen or a methylene hydrogen. How many isomers can be obtained when one hydrogen in each of the compounds named below is replaced by a chlorine atom?
   a. n-pentane
   b. 2-methylbutane
   c. 2,4-dimethylpentane
   d. methylocyclohexane

50. There are three isomers of dichlorobenzene, one of which has now replaced naphthalene as the main constituent of mothballs.
   a. Identify the ortho, the meta, and the para isomers of dichlorobenzene.
   b. Predict the number of isomers for trichlorobenzene.
   c. It turns out that the presence of one chlorine atom on a benzene ring will cause the next substituent to add ortho or para to the first chlorine atom on the benzene ring. What does this tell you about the synthesis of m dichlorobenzene?
   d. Which of the isomers of trichlorobenzene will be the hardest to prepare?

Functional Groups

51. Identify each of the following compounds as a carboxylic acid, ester, ketone, aldehyde, or amine.
   a. Anthraquinone, an important starting material in the manufacture of dyes.
      ![Image of anthraquinone]
   b. ![Image of an ester]
   c. ![Image of a ketone]
   d. ![Image of an amine]

52. Identify the functional groups present in the following compounds.
   a. ![Image of testosterone]
53. Mimoseine is a natural product found in large quantities in the seeds and foliage of some legume plants and has been shown to cause inhibition of hair growth and hair loss in mice.

54. Minoxidil (C₁₅H₁₇N₄O₂) is a compound produced by Pharmacia Company that has been approved as a treatment of some types of male pattern baldness.

55. For each of the following alcohols, give the systematic name and specify whether the alcohol is primary, secondary, or tertiary.
   a. \( \text{CH}_3\text{CHCH}_2\text{CH}_2\text{OH} \)
   b. \( \text{CH}_3\text{CH}_2\text{CHCH}_3 \)
   c. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \)

56. Draw structural formulas for each of the following alcohols. Indicate whether the alcohol is primary, secondary, or tertiary.
   a. 1-butanol
   b. 2-butanol
   c. 2-methyl-1-butanol
   d. 2-methyl-2-butanol

57. Name all the alcohols that have the formula \( \text{C}_2\text{H}_₅\text{O} \). How many ethers have the formula \( \text{C}_₂\text{H}_₅\text{O} \)?

58. Name all the aldehydes and ketones that have the formula \( \text{C}_₂\text{H}_₅\text{O} \).

59. Name the following compounds.
   a. \( \text{Cl} \text{CHCHCH}_2\text{CH}_2\text{Cl} \)
   b. \( \text{CH}_3\text{CH}_2\text{O} \text{CHCHCH}_3 \)
   c. \( \text{CH}_3\text{O} \text{CHCHCH}_3 \)

60. Name the following compounds.
   a. \( \text{Cl} \text{CHCHCH}_2\text{CH}_2\text{OH} \)
   b. \( \text{CH}_3\text{CH}_2\text{O} \text{CHCHCH}_3 \)
   c. \( \text{HCOOH} \)

Reactions of Organic Compounds

61. Complete the following reactions.
   a. \( \text{CH}_2\text{CH}═\text{CHCH}_3 + \text{H}_2\text{O} \)
b. CH$_2$=CHCHCH=CH + 2Cl$_2$ $\rightarrow$

Reagents such as HCl, HBr, and HOH (H$_2$O) can add across carbon-carbon double and triple bonds, with H forming a bond to one of the carbon atoms in the multiple bond and Cl, Br, or OH forming a bond to the other carbon atom in the multiple bond. In some cases, two products are possible. For the major organic product, the addition occurs so that the hydrogen atom in the reagent attaches to the carbon atom in the multiple bond that already has the greater number of hydrogen atoms bonded to it. With this rule in mind, draw the structure of the major product in each of the following reactions.

a. CH$_3$CH$_2$CH=CH$_2$ + H$_2$O $\rightarrow$

b. CH$_3$CH$_2$CH=CH$_2$ + HBr $\rightarrow$

c. CH$_3$CH=CH+2HBr $\rightarrow$

d. CH$_3$CH$_2$C=CH+H$_2$O $\rightarrow$

e. CH$_3$CH$_2$C=CH+HCl $\rightarrow$

63. When toluene (C$_6$H$_5$CH$_3$) reacts with chlorine gas in the presence of iron(III) catalyst, the product is a mixture of the ortho and para isomers of C$_6$H$_5$ClCH$_3$. However, when the reaction is light-catalyzed with no Fe$^{3+}$ catalyst present, the product is C$_6$H$_5$CHCl. Explain.

64. Why is it preferable to produce chloroethane by the reaction of HC1(g) with ethene than by the reaction of Cl$_2$(g) with ethene? (See Exercise 62.)

65. Using appropriate reactants, alcohols can be oxidized into aldehydes, ketones, and/or carboxylic acids. Primary alcohols can be oxidized into aldehydes, which can then be oxidized into carboxylic acids. Secondary alcohols can be oxidized into ketones, while tertiary alcohols do not undergo this type of oxidation. Give the structure of the product(s) resulting from the oxidation of each of the following alcohols.

a. 3-methyl-1-butanol
b. 3-methyl-2-butanol
c. 2-methyl-2-butanol
d. OH

66. Oxidation of an aldehyde yields a carboxylic acid:

\[ R-CH_2=CHOH \rightarrow R-COOH \]

draw the structures for the products of the following oxidation reactions.

a. propanal $^{[ox]}$

b. 2,3-dimethylpentanal $^{[ox]}$

c. 3-ethylbenzaldehyde $^{[ox]}$

67. How would you synthesize each of the following?

a. 1,2-dibromo propane from propene

b. acetone (2-propanone) from an alcohol

c. (2-methyl)-2-propanol from an alkene

d. propanoic acid from an alcohol

68. What tests could you perform to distinguish between the following pairs of compounds?

a. CH$_3$CH$_2$CH$_2$CH$_3$, CH$_2$:=CHCH$_2$CH$_3$

b. CH$_3$CH$_2$CH$_2$COOH, CH$_3$CH$_2$CCH$_3$

c. CH$_3$CH$_2$OH, CH$_3$CCH$_3$

d. CH$_3$CH$_2$NH$_2$, CH$_3$OCH$_3$

69. How would you synthesize the following esters?

a. n-octyl acetate

b. CH$_3$CH$_2$CH$_2$CH$_2$COOCH$_3$, CH$_3$CCH$_3$

70. Salicylic acid has the following structure:

\[
\text{CO}_2\text{H}
\]

Since salicylic acid has both an alcohol functional group and a carboxylic acid functional group, it can undergo two different esterification reactions depending on which functional group reacts. For example, when treated with ethanoic acid (acetic acid), salicylic acid behaves as an alcohol and the ester produced is acetylsalicylic acid (aspirin). On the other hand, when reacted with methanol, salicylic acid behaves as