Name: \_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_

Organic Chemistry Practice Exam 4 Answer Key

Questions 1-10: Predict the major organic product for the following reactions

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
9. 
10. 

Questions 11-15: Provide a reasonable mechanism to explain the following chemical transformations

11. 



12. 



13. 

14. 

15. 



16. Which of the following statements explains why alpha protons are acidic?

a. because they are near an electron-withdrawing group

b. because they form stabilized conjugate bases

c. because the conjugate base has resonance form

d. all of the above

17. Explain why the beta position of an alpha-beta unsaturated carbonyl compound is electrophilic. Please provide a verbal and pictorial description of this phenomena.

The beta position is electrophilic in an alpha-beta unsaturated carbonyl compound because the pi bond can be delocalized using the carbonyl oxygen’s pi bond so give a negative charge on the oxygen and a positive charge on the beta carbon. Electrophiles are positively charged chemicals and therefore the beta position becomes more electrophilic because of the pi network that is established due to the pi-sigma-pi resonance pattern.



18. Why can Friedel-Krafts reactions NOT be performed on aminobenzene derivatives but CAN be performed on hydroxybenzene derivatives?

The amino group is a better nucleophile and therefore it will create a complex with the AlCl3 catalyst necessary for the Friedel-Krafts reaction. Recall that nitrogen is less electronegative than oxygen and therefore it is more willing to give up its electrons and attack an incoming electrophile. This complex that is created by the amino group and the AlCl3 catalyst causes the amino group to become a strongly deactivating group because the nitrogen is now positively charged and therefore is electron-withdrawing. As we know, all strongly deactivated benzene rings cannot go through Friedel-Krafts reactions and therefore aminobenzene derivatives cannot undergo Friedel-Krafts alkylation or acylation.

19. Explain, in your own words why **electron-donating groups** will direct incoming ELECTROPHILES to the ortho/para positions. In the same vein, explain why **electron-withdrawing groups** will direct incoming NUCLEOPHILES to the ortho/para positions in benzene rings.

Electron-donating groups (EDG) will direct electrophiles to the ortho and para positions because those are the positions where the negative charge is delocalized. Recall that negative charges = nucleophile and therefore the electrophile will be attracted to and attacked by the negative charges that are present in the ortho/para positions. In the same vein, electron-withdrawing groups (EWG) will cause a positive charge to be delocalized around the ortho and para positions of the benzene ring and therefore those carbons will attract the negatively charged nucleophiles.

20. How many total products (including stereoisomers) can be made by the monochlorination of 2-methylbutane? Explain your answer by drawing all of the products. Hint: start with the regioisomers and then consider stereochemistry. There are five total products including stereoisomers that can be produce by the monochlorination of 2-methylbutane



21. Rationalize the “carbonyl reactivity tier list” in your own words.

The carbonyl reactivity tier list is built primarily on leaving group strength. The better leaving groups aka weaker bases will produce more reactive carbonyl compounds such as acyl chlorides or anhydrides. For those carbonyl compounds that do not have a leaving group (aldehyde and ketone) the difference between the two has to do with sterics, aldehydes have one less alkyl group that could hinder the approach of an incoming nucleophile and therefore aldehydes are more reactive than ketones. These compounds are more reactive than esters, carboxylic acids, and amides because the leaving group in those functional groups are incredibly bad since they are all strong bases.

22. Adderall is a drug that is used to treat ADHD and works by altering the chemistry of the brain such that the body is stimulated (details are not important). The structure of Adderall is shown below:



Provide a reasonable synthesis of this compound starting from benzene. Note: more than one answer is reasonable here. 

23. (BONUS) Mescaline is a hallucinogen with comparable psychedelic effects to LSD and magic mushrooms. This molecule is traditionally used by the Native American Church as part of religious ceremonies. The structure of mescaline is shown below:



Provide a reasonable synthesis of this compound starting from any disubstituted or trisubstituted benzene.



24. Alanine is a critical amino acid that is used to make proteins in the body. The structure of alanine is shown below:



Provide a reasonable synthesis of this compound starting from propionic acid.



25. SALEN complexes are incredibly useful in asymmetric catalysis. The structure of the SALEN ligand is shown below:



Provide a reasonable synthesis for this ligand starting from any disubstituted benzene. Hint: this may require two equivalents of a benzene derivative and one equivalent of a diamine.



26. Kevlar is one of the strongest materials ever created and is 5x as strong as steel. It is a polymer with the following chemical structure:



1. Determine the monomer units that can be used to create this polymer



1. Determine how one would synthesize said monomers and explain why Kevlar has such high strength





The polymer is extremely strong because of the strong hydrogen bonding that is present within the bulk material. The NH is a good hydrogen bond donor and the C=O is a good hydrogen bond acceptor.

27. In the textile and food industry, there are many different types of dyes. These dyes can be made in a variety of ways, though the most common type of dye used in commercial products are azo dyes. These azo dyes are highly conjugated molecules connected together via an azo linkage. An example of an azo dye is acid red 74, which is shown below:



1. Determine the precursors of this molecule



1. Determine how you would synthesize the single-ring precursor molecule starting from benzene.



1. Explain how you could know that this molecule is a dye just looking at the structure alone.

You can tell that this is a dye because of the highly conjugated pi network among the benzene rings, the NO2 group and the azo linkage.

28. One of the most commonly used super absorbent polymers in diapers is polyacrylate. The structure of polyacrylate is shown below:



1. Determine what the monomer unit is for this polymer and what type of polymerization it would likely undergo (condensation or step-growth polymerization).

, this would undergo step-growth polymerization (free-radical)

1. Watch this super cool YouTube video <https://www.youtube.com/watch?v=SjfJeLlt7Gs&ab_channel=JimmyKimmelLive>

29. Two of the most widely used over the counter drugs are acetaminophen (Tylenol) and ibuprofen (Advil). The structures of these chemicals are shown below:





1. Perform a retrosynthetic analysis for both compounds





1. Propose a reasonable synthetic route to both compounds





30. Nylons are widely used worldwide for their high mechanical strength and chemical resistance. One of the most common nylons used is nylon 66. This polymer is shown below:



1. Determine the monomer units used to make nylon 66



1. Determine how to make the monomer units starting form any carbon-compound with less than 6 carbons.



Questions 31-40: Provide a reasonable synthesis for the following compounds starting from benzene using any necessary organic or inorganic reagents.

31. 

32. 

33. 

34. 

35. 



36. 

37. 



38. 

39. 



40. 



Questions 41-50: Predict the product(s) for the following chemical reactions

41. 

42. 

43. 



44. 

45. 



46. 



47. 



48. 



49. 



50. 



Questions 51-55: Determine the IUPAC name for the following compounds

51. 1-(cyclohex-1-en-1-yl)ethan-1-one

52.  methyl 3-ethoxypropanoate

53. 3-ethyl-5-methylhexanoic acid

54. (5S)-5-bromooct-7-enenitrile

55. methyl 3-oxocyclohexane-1-carboxylate

Questions 56-60: Rank the following compounds in order of increasing reactivity for the reaction specified

56. monobromination in UV light



57. Nucleophilic attack by OH-



58. Nucleophilic aromatic substitution



59. Electrophilic aromatic substitution



60. Nucleophilic acyl addition



Questions 61-65: Rank the following radicals in order of increasing stability

61. 

62. 

63. 

64. 

65. 

Questions 66-70: Determine how one would synthesize the following carboxylic acids starting from diethylmalonate

66. 



67. 



68. 



69. 



70. 



Questions 71-75: Determine how one would synthesize the following alkenes using the Wittig reaction. Be sure to determine the optimal reagents!

71. 



72. 



73. 



74. 



75. 

