1. Which structure has the MOST signals for its proton NMR?

A.  
B.  
C.  
D.  

2. Which compound does not give a stable Grignard reagent when reacting with Mg metal?

A.  
B.  
C.  
D.  

3. Which of these reaction sequences gives m-nitropropylbenzene from benzene?

A.  
B.  
C.  
D.  

4. Which compound has the following π orbital energy level diagram?

![Diagram of π orbital energy levels]

A. ![Compound A]  
B. ![Compound B]  
C. ![Compound C]  
D. ![Compound D]

5. Which of the following compounds is insoluble in water and HCl (aq), and soluble in NaOH(aq) and NaHCO₃ (aq)?

A. ![Compound A]  
B. ![Compound B]  
C. ![Compound C]  
D. ![Compound D]

6. Which of the following structures is not involved in the aldol condensation of benzaldehyde and acetaldehyde with base catalyst?

A. ![Structure A]  
B. ![Structure B]  
C. ![Structure C]  
D. ![Structure D]
7. Which mechanistic step is involved in a Grignard reaction?

A. 

\[ \text{MgBr} + \text{alkyl halide} \rightarrow \text{alkyl Grignard} + \text{HBr} \]

B. 

\[ \text{MgBr} + \text{alkyl halide} \rightarrow \text{alkyl Grignard} + \text{HBr} \]

C. 

\[ \text{MgBr} + \text{alkyl halide} \rightarrow \text{alkyl Grignard} + \text{HBr} \]

D. 

\[ \text{MgBr} + \text{alkyl halide} \rightarrow \text{alkyl Grignard} + \text{HBr} \]

8. Which of the following compounds has two singlets, 1.30 ppm (6 H) and 4.00 ppm (4 H) in its proton NMR spectrum, and three peaks in its $^{13}$C NMR spectrum?

A. 

B. 

C. 

D.
9. Which structure is not a steroisomer of this sugar (ribulose) shown here?

9. Which structure is not a steroisomer of this sugar (ribulose) shown here?

![Sugar Structures]

A.  
B.  
C.  
D.  

10. What is the product of the following reaction sequence?

![Reaction Sequence]

10. What is the product of the following reaction sequence?

A.  
B.  
C.  
D.  

11. Which of the following is an intermediate involved in the reaction shown?

\[
\text{C}_6\text{H}_5\text{CH} \rightleftharpoons \text{CH}_2 + \text{HCl} \rightarrow 
\]

11. Which of the following is an intermediate involved in the reaction shown?

A. \( \text{C}_6\text{H}_5\text{CHCH}_2\text{Cl} \)  
B. \( \text{C}_6\text{H}_5\text{CHClCH}_2 \)  
C. \( \text{C}_6\text{H}_5\text{CHCH}_3 \)  
D. \( \text{C}_6\text{H}_5\text{CH}_2\text{CH}_2 \)
12. Which one is the major organic product expected from the following reaction?

![Reaction Diagram]

A. \( \text{N} N \text{Cl} \text{C}_3 \text{H}_3 \)
B. \( \text{C}_3 \text{H}_3 \text{N} N \text{Cl} \)
C. \( \text{D} \text{N} N \text{Cl} \text{H}_3 \)
D. \( \text{H} \text{Cl} \text{H} \text{Cl} \text{N} N \text{C}_3 \text{H}_3 \)

13. What is the structure of the major organic product expected from the following reaction?

\[ \text{N} \text{N} \text{C}_3 \text{H}_3 + \text{HCl} \rightarrow \]

A. \( \text{N} \text{N} \text{C}_3 \text{H}_3 \)
B. \( \text{C}_3 \text{H}_3 \text{N} \text{N} \text{Cl} \)
C. \( \text{D} \text{N} \text{N} \text{C}_3 \text{H}_3 \)
D. \( \text{H} \text{Cl} \text{N} \text{N} \text{C}_3 \text{H}_3 \)
14. Which of the following pathways is the best for the synthesis of

\[
\text{CCH}_3 \quad \xrightarrow{\text{O}} \quad \text{CH}_2\text{CH}_2\text{Br}
\]

A. \( \xrightarrow{\text{KMnO}_4, \text{H}_2\text{O}^+} \xrightarrow{\text{LiCu(CH}_3)_2} \)

B. \( \xrightarrow{\text{Mg, ether}} \xrightarrow{\text{HCH, H}_2\text{O}^+} \)

C. \( \xrightarrow{\text{KOH, heat}} \xrightarrow{\text{Br}_2, \text{CCl}_4} \xrightarrow{2\text{NaNH}_2, \text{heat}} \xrightarrow{\text{H}_2\text{SO}_4} \)

D. \( \xrightarrow{\text{H}_2\text{CrO}_4} \xrightarrow{\text{CH}_3\text{MgBr, ether}} \)

15. Which of the following is an intermediate in this reaction?

A. \( \text{Cl} \quad \xrightarrow{\text{NaOH, reflux}} \)

B. \( \text{OH} \)

C. \( \text{Cl} \)

D. \( \text{OH} \)

16. What are the products of this reaction?

\[
\text{CCH}_3 \quad + \quad \text{CF}_3\text{SO-CH}_2\text{CH}_3
\]

A. \( \text{OCH}_2\text{CH}_3 \quad + \quad \text{CF}_3\text{SO-ONa} \)

B. \( \text{^{18}OCH}_2\text{CH}_3 \quad + \quad \text{CF}_3\text{SO-ONa} \)

C. \( \text{OCH}_2\text{CH}_3 \quad + \quad \text{CF}_3\text{SONa} \)

D. \( \text{ONa} \quad + \quad \text{CF}_3\text{^{18}OCH}_2\text{CH}_3} \)
17. From the following information given for tyrosine, which of the following forms will be predominant in solution at a pH 12?

![Tyrosine structure with pKa values]

18. What is the product of the following reaction?

\[
\text{Br} + \text{tBuOK} \rightarrow \text{tBuOH}
\]

A. 

B. 

C. 

D.
19. Which of the Following is a Zwitterion?

A. 1 and 3  B. 4 only  C. 5 only  D. 2 only

20. Rank the following bases in order of decreasing strength (strongest base first)


21. What is the main organic product from the reaction of CH\(_2\)CH=O + Ph\(_3\)P=C(CH\(_3\))\(_2\)?

A. (CH\(_3\))\(_2\)CHOH  B. CH\(_3\)CH=CH(CH\(_3\))\(_2\)  C. CH\(_3\)CH=CHCH\(_3\)  D. CH\(_3\)CH=CHPh

22. A compound with the molecular formula C\(_{10}\)H\(_{14}\) reacts with excess hydrogen and a catalyst to yield a compound with the formula C\(_{10}\)H\(_{18}\). The compound could have:

A. 2 rings and 2 double bonds  B. 1 ring and 3 double bonds  C. 3 rings and 1 double bond  D. 0 rings and 4 double bonds
23. What is the major product of the following reaction

\[
\begin{align*}
\text{Cyclohexene} & \xrightarrow{1) \text{BH}_3-\text{THF}} \text{Product} 1 \\
& \xrightarrow{2) \text{H}_2\text{O}_2, \text{OH}^-} \text{Product 2}
\end{align*}
\]

A. B 
B. C 
C. D 
D. E

24. What would be a simple chemical test to distinguish between benzene and cyclohexene?
A. NaOH in water 
B. Br$_2$ in CCl$_4$ 
C. AgNO$_3$ in C$_2$H$_5$OH 
D. NaHSO$_3$ in water

25. Rank the reactivity order of the following dienes with maleic anhydride, starting with the slowest

\[
\begin{align*}
\text{I} & \xrightarrow{\text{maleic anhydride}} \text{Product} 1 \\
\text{II} & \xrightarrow{\text{maleic anhydride}} \text{Product} 2 \\
\text{III} & \xrightarrow{\text{maleic anhydride}} \text{Product} 3 \\
\text{IV} & \xrightarrow{\text{maleic anhydride}} \text{Product} 4
\end{align*}
\]

A. IV<II<III 
B. III<IV<II<I 
C. III<II<I<IV 
D. IV<III<II<I

26. What is the IUPAC name for

\[
\text{Br} \quad \text{O} \\
\text{C} \quad \text{C}
\]

A. 4-bromo-1-phenyl-2-pentanone 
B. 2-bromo-5-phenyl-4-pentanone 
C. 4-bromo-1-benzyl-2-pentanone 
D. 2-bromo-5-benzyl-2-pentanone
27. What is the product of the following reaction?

![Chemical reaction diagram]

A. 
B. 
C. 
D. 

28. The relative reactivity of acyl compounds towards nucleophilic substitution is
A. Amide > ester > acid anhydride > acyl chloride
B. Acyl chloride > ester > acid anhydride > amide
C. Acyl chloride > acid anhydride > ester > amide
D. Acid Anhydride > acyl chloride > ester > amide

29. What is the name of the following compound?
A. Dimethylthioketone
B. Dimethylsulfoxide
C. Dimethylsulfone
D. Dimethylsulfide

30. The reaction that takes place here is called:

![Chemical reaction diagram]

A. Electrophilic Aromatic Substitution
B. Electrophilic Aromatic Addition
C. Nucleophilic Aromatic Substitution
D. Nucleophilic Phenolation
31. Arrange these dienes by stability, most stable first.

\[ \text{Dienes: } \begin{align*}
\text{I} & \quad \text{II} & \quad \text{III} & \quad \text{IV} \\
\text{A. } & \quad \text{I} & > & \quad \text{II} & > & \quad \text{III} & > & \quad \text{IV} \\
\text{B. } & \quad \text{II} & > & \quad \text{I} & > & \quad \text{III} & > & \quad \text{IV} \\
\text{C. } & \quad \text{IV} & > & \quad \text{III} & > & \quad \text{I} & > & \quad \text{II} \\
\text{D. } & \quad \text{IV} & > & \quad \text{I} & > & \quad \text{III} & > & \quad \text{II}
\end{align*} \]

32. What is the major organic product of this reaction?

\[ \text{Reaction: } \text{O} - \text{O} \xrightarrow{1) \text{MeO-}} \xrightarrow{2) \text{EtBr}} \xrightarrow{3) \text{NaOH, heat}} \text{C} \]
35. How would you convert an unsaturated fatty acid into a saturated fatty acid?

A. KMnO₄, OH-, heat  
B. OH-, H₂O heat; then H₃O⁺  
C. H₂, Ni, pressure  
D. H₃O⁺, H₂O, heat

36. Which of the following pathways is the best for the synthesis of the following compound from benzene?

![chemical structure]

A. Br₂/FeBr₃, then KOH  
B. Br₂/FeBr₃, then HNO₃/H₂SO₄, then NaNO₂/HCl, then H₂/Pt, then Cu₂O/Cu²⁺/H₂O  
C. Br₂/FeBr₃, then HNO₃/H₂SO₄, then HNO₃/H₂SO₄, then H₂/Pt, then NaNO₂/HCl, then Cu₂O/Cu²⁺/H₂O  
D. HNO₃/H₂SO₄, then HNO₃/H₂SO₄, then Br₂/FeBr₃, then H₂/Pt, then NaNO₂/HCl, then Cu₂O/Cu²⁺/H₂O

37. Which compound reacts with H₂NCH₃ and H₂/Pt to form CH₃CH₂CH₂CH(CH₃)NHCH₃?

A. CH₃CH₂CH₂CH(CH₃)OH  
B. CH₃CH₂CH₂COCH₃  
C. CH₃CH₂CH₂CH₂CH₂OH  
D. CH₃CH₂CH₂CH₂CHO

38. Which of these can be used to transform butanoic acid into 1-butanol?

A. NaBH₄  
B. LiAlH₄  
C. PCC  
D. H₂CrO₄

39. Which of these forms when 1,3-butadiene reacts with HBr (no peroxides)?

A. CH₂=CH-CH₂-CH₂Br  
B. CH₂=CH-CBr=CH₂  
C. CH₃-CBr=CH-CH₃  
D. CH₂=CH-CHBr-CH₃
40. Which is the major product of the following reaction?

\[ \text{A} + \text{B} \rightarrow \text{C} \]

A. 
B. 
C. 
D. 

41. In the following derivative of guanine, what is the splitting pattern of the proton located at the position marked?

A. singlet  
B. doublet  
C. triplet  
D. multiplet

42. Which of the following reagents would you use in order to synthesize 2-methyl-1-propanamine, using NaN₃ followed by reduction?

A. tert-butyl bromide  
B. isobutyl bromide  
C. isopropyl bromide  
D. propyl bromide

43. Which functional group is not present in all peptides?

A. Amine  
B. Aldehyde  
C. Carboxylic acid  
D. Amide

44. omit

45. omit
46. Which of these is an intermediate involved in the following reaction:

\[
\begin{align*}
\text{Br}_2 & \quad \text{Br} \\
\text{Light} & \quad \text{Br} \\
\end{align*}
\]

A. [Image of an intermediate]  
B. [Image of an intermediate]  
C. [Image of an intermediate]  
D. [Image of an intermediate]

47. Which of the following is the strongest acid?
A. Aniline  
B. Toluene  
C. Phenol  
D. Styrene

48. Which of these syntheses would yield butanoic acid from 1-propanol:
A. \[
\text{HBr} \quad \text{Mg} \quad \text{CO}_2 \quad \text{H}_3\text{O}^+ \\
\text{ether} \quad \text{ether} \quad \text{H}_2\text{CO} \quad \text{H}_3\text{O}^+ \\
\]
B. PCC  
C. \[
\text{KMnO}_4 \quad \text{OH}^- \quad \text{heat} \\
\]
D. \[
\text{SOCl}_2 \quad \text{Mg} \quad \text{H}_2\text{CO} \quad \text{H}_3\text{O}^+ \\
\text{ether} \quad \text{ether} \\
\]

49. What is the major product of the following reaction?

\[
\begin{align*}
\text{Br} & \quad \text{NaCN} \quad \text{LiAlH}_4 \\
\end{align*}
\]

A. [Image of a product]  
B. [Image of a product]  
C. [Image of a product]  
D. [Image of a product]

50. Which statement is correct for this sugar?
A. This is a hemiacetal and a reducing sugar.  
B. This is an acetal and a reducing sugar.  
C. This is a hemiacetal and a non-reducing sugar  
D. This is an acetal and a non-reducing sugar