1. Choose the major product of the following reaction.

\[
\text{N}^\equiv\text{C} - \text{C} = \text{O} \xrightarrow{\text{H}_2/\text{Pd}} \text{?}
\]

\[
\text{H}_2\text{N} \quad \text{N}^\equiv\text{C} \quad \text{HO} \quad \text{N} \quad \text{N}
\]

A  B  C  D  E

2. Choose the order that has the following amines correctly arranged with respect to increasing basicity.

\[
\text{H}_2\text{N} \quad \text{H}_2\text{N} \quad \text{H}_2\text{N}
\]

i  ii  iii

A  B  C  D  E

\[
\text{i} < \text{ii} < \text{iii} \quad \text{i} < \text{iii} < \text{ii} \quad \text{ii} < \text{i} < \text{iii} \quad \text{ii} < \text{iii} < \text{i} \quad \text{iii} < \text{i} < \text{ii}
\]

increasing basicity  increasing basicity  increasing basicity  increasing basicity  increasing basicity

3. Choose the major product of the following reaction sequence.

\[
\text{O} \quad \Theta.. \quad :\text{O} = \text{H} \quad \Theta.. \quad \text{?}
\]

\[
\text{A}  \quad \text{B}  \quad \text{C}  \quad \text{D}  \quad \text{E}
\]
4. Choose the reactant that would give the following product.

\[
\text{\text{Ph}}\text{-C-} \text{OEt} + ? \xrightarrow{\text{OEt}} \text{\text{Ph}}\text{-C-} \text{OEt}
\]

\[
\begin{align*}
\text{H} & \text{C} \text{H} \\
\text{O} & \text{Et} \\
\text{O} & \text{Et}
\end{align*}
\]

A

B

C

D

E

5. Choose the major species present when piperdine is dissolved in distilled water and dissolved in water buffered at \( \text{pH} = 7.0 \).

\[
\text{\text{N}} \text{H} \quad + \quad \text{H} \quad \rightleftharpoons \quad \text{\text{N}} \text{H}^+ \\
\text{distilled water} \quad \text{pK}_a = 11
\]

\[
\begin{align*}
\text{\text{N}} & \text{H}^+ \\
\text{distilled water} \\
\text{\text{N}} & \text{H}^+ \\
\text{distilled water} \\
\text{\text{N}} & \text{H} \\
\text{pH} = 7.0 \\
\text{\text{N}} & \text{H} \\
\text{pH} = 7.0 \\
\text{\text{N}} & \text{H} \\
\text{pH} = 7.0 \\
\text{\text{N}} & \text{H} \\
\text{pH} = 7.0
\end{align*}
\]

6. An intermediate in the synthesis of Clopidogrel (Plavix) was formed by the following reaction. Choose the structure of this intermediate.

\[
\text{H} \text{C} \text{O} \\
\text{Cl} \quad : \text{NH}_3 \text{and} \quad : \text{C} = \text{N} : \\
\text{H}_2\text{O} \quad \xrightarrow{\text{E}} \quad ?
\]

\[
\begin{align*}
\text{\text{H}} & \text{O} \text{H} \\
\text{\text{Cl}} & \text{Ph} \\
\text{\text{H}} & \text{O} \text{C} \text{H} \\
\text{\text{Cl}} & \text{Ph} \\
\text{\text{H}} & \text{O} \text{C} \text{H} \\
\text{\text{Cl}} & \text{Ph}
\end{align*}
\]

A

B

C

D

E
7. Predict the product of the following deuterium exchange reaction.

\[ \text{H} = \text{D} \]

8. Choose the major products of the following reaction.

\[ \text{H}_2\text{O} \xrightarrow{\text{H}^+ \text{(cat.)}} \]

9. The following reaction sequence was used in the preparation of Diazepam, a commonly prescribed tranquilizer. Choose the major product of the following reaction sequence.

\[ \text{H} \xrightarrow{\text{Ac}_2\text{O}} \text{Ph}_2\text{Cl} \xrightarrow{\Theta \text{OH}} \]
10. The relative stability of axial –OH groups at the anomeric carbon in carbohydrates is called the anomeric effect. Choose the best explanation of this observation.

A. The -OH substituent is smaller than the –H substituent and therefore more stable in an axial position.
B. The –OH substituent forms more extensive hydrogen bonds with the other C-H bonds when it is axial.
C. There is an important stabilizing interaction of the axial lone pair of electrons on the ring oxygen with the anti bonding orbital C-OH bond.
D. There is an important stabilizing interaction of the bonding orbital of the C-OH bond with the anti bonding orbital or the ring C-O bond.

11. Choose the product of the following reaction sequence.

12. In the mechanism for the hydrolysis of an amide to the amine and carboxylate ion acid with hydroxide, identify the species that is an intermediate along the reaction pathway.
13. Nadolol is a beta blocker used in the treatment of high blood pressure, migraine headaches, and chest pain. Choose the structure of Nadolol based on the following synthetic scheme.

14. In the mechanism for the acid catalyzed hydrolysis of a carbamate to the carbamic acid, identify the species that is an intermediate along the reaction pathway.

15. Choose the order that has the following compounds correctly arranged with respect to increasing acidity.

A i < ii < iii  B i < iii < ii  C ii < iii < i  D ii < i < iii  E iii < i < ii
16. Choose the aldohexose that gives an optically inactive glucaric acid when treated with nitric acid.

\[
? \xrightarrow{\text{HNO}_3} \text{optically inactive glucaric acid}
\]


17. Choose the carbohydrate that does not react with NaBH₄/H₂O.

A  B  C  D  E

18. Assume a sample contains nicotine, the well-known tar, benzpyrene and benzoic acid. Identify where nicotine would be located in the following separation scheme.

Short Answer

19. Give the structure of the major product(s) of the following reaction. 5 pts
20. Give the major product(s) of the following reaction sequence. 5 pts

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \xrightarrow{\text{Et}_3\text{N}} \text{Ph}_3\text{P}==\text{CH}_2 \xrightarrow{\text{Olefin Metathesis}} ?
\]

21. Give the major product(s) of the following reaction sequence. 5 pts

\[
\text{H}_2\text{N}==\text{CH}_3 \xrightarrow{\text{excess}} \text{OCH}_3 \xrightarrow{1.\ \text{O}==\text{CH}_3} ? \xrightarrow{2.\ \text{H}_3\text{O}^+} (\text{C}_6\text{H}_{13}\text{NO}_3)
\]

22. Give the reactant(s) that would produce the following product of an aldol reaction. 5 pts

\[
? \xrightarrow{\text{heat}} \text{O} \quad \text{O}
\]

23. Give the reactant(s) that would give the following Diels-Alder product. 5 pts

\[
? \xrightarrow{\text{heat}} \text{H}_3\text{C} \quad \text{OCH}_3
\]

24. When the following Diels-Alder adduct is heated followed by treatment with dilute acid it gives a new product. Give the structure of this new product(s) 5 pts

\[
\text{OTMS} \quad \text{H}_3\text{C} \quad \text{OH} \xrightarrow{1.\ \text{heat}} ? \xrightarrow{2.\ \text{H}_3\text{O}^+}
\]
Pregabalin is an anticonvulsant drug used for neuropathic pain and as an adjunct therapy for partial seizures. Pregabalin binds to the α2δ subunit of the voltage-dependent calcium k channel in the central nervous system.

25. Give structures for compounds A and B consistent with the following reaction scheme. 10 pts

\[ \text{EtO} \text{C} \text{N} + \text{H} \text{C}=\text{O} \xrightarrow{\text{Base}} \text{A} \]

\[ \text{EtO} \text{C} \text{N} + \text{H} \text{C}=\text{O} \xrightarrow{\text{Base}} \text{EtO}_2\text{C} \text{C}=\text{N} \]

26. In the above diagram give structures for compounds C and D consistent with the reaction scheme. 10 pts

27. The following reaction, the Carroll Rearrangement, is often cited in discussions about the Claisen Rearrangement. Propose a mechanism for this reaction. 10 pts

28. Using curved arrow formalism show reasonable bond making and bond breaking in the following biosynthetic transformation. 10 pts

29. Using curved arrow formalism show reasonable bond making and bond breaking in the following biosynthetic transformation. 10 pts
30. Tamoxifen is an antagonist of the estrogen receptor. It has been the standard endocrine (anti-estrogen) therapy for hormone-positive cancer in post-menopausal women. Propose a synthesis of compound A from benzene, phenol and any other compounds containing four carbon atoms or less.