When we discussed the biosynthesis of cholesterol we began with a discussion of the importance of thioesters. Consider the three compounds shown below.

![Thioesters](image)

1. Which of the three compounds A, B or C is the most reactive with respect to nucleophiles? (3 pts.) C
2. Which of the three compounds A, B or C is the least reactive with respect to nucleophiles? (3 pts.) B
3. Which of the two compounds A or B is the most acidic? (3 pts) A

The following three compounds were subjected to an extraction separation scheme. At the end of the scheme there were five flasks, lettered A-E. Identify the final location of each of the three compounds.

![Separation Scheme](image)

4. Which flask would contain the decalin? (3 pts) E
5. Which flask would contain the cyclohexylcarboxylic acid? (3 pts) D
6. Which flask would contain the cyclohexylmethylamine? (3 pts) B

Electron counting is very important for transition metals. Identify the electron count for each of the following compounds.

A 12  B 14  C 16  D 18  E 20

7. Pd(PPh₃)₂Cl₂ (3 pts) C
8. Rh(PPh₃)₃ClH₂ (3 pts) D
Organometallic reactions can be classified by reaction type.

A. Oxidative addition
B. Reductive elimination
C. Ligand association
D. Ligand disassociation
E. Ligand insertion.

Classify the following reactions using these fundamental types.

9. (3 pts) E

\[
\begin{align*}
\text{H}_2\text{C}=\text{C} & \text{CH}_3 \\
\text{H} & \text{Rh(PPPh}_3\text{)}_2\text{Cl}
\end{align*}
\begin{align*}
\text{H} & \text{Rh(PPPh}_3\text{)}_2\text{Cl}
\end{align*}
\]

10. (3 pts) B

\[
\begin{align*}
\text{Rh(PPPh}_3\text{)}_2\text{Cl} & \\
\text{H} & \text{Rh(PPPh}_3\text{)}_2\text{Cl} + \text{H}
\end{align*}
\]

11. Predict the major product of the following reaction.

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

12. A molecular orbital energy diagram for the π orbital system of benzene would have six orbitals. Five of these MOs are shown below. Of these five benzene MOs, which one would have the highest energy (the least stable)?
13. Predict the major product of the following reaction.

\[
\text{CH}_3\text{CH}=\text{CH}OCH_3 + \text{CH}=\text{C}=\text{N} \xrightarrow{\text{heat}} \]

\[
\begin{array}{c}
\text{OCH}_3 \text{C} \equiv \text{N} \\
\text{CH}_3 \\
\text{A} \\
\text{OCH}_3 \text{C} \equiv \text{N} \\
\text{CH}_3 \\
\text{B} \\
\text{OCH}_3 \text{C} \equiv \text{N} \\
\text{CH}_3 \\
\text{C} \\
\text{OCH}_3 \text{C} \equiv \text{N} \\
\text{CH}_3 \\
\text{D} \\
\text{OCH}_3 \text{C} \equiv \text{N} \\
\text{CH}_3 \\
\text{E} \\
\end{array}
\]

14. Assume that the following ions are all planar. Which one would not be aromatic?

\[
\begin{array}{c}
\text{} \\
\text{A} \\
\text{B} \\
\text{C} \\
\text{D} \\
\text{E} \\
\end{array}
\]

15. Predict the major product of the following reaction sequence.

\[
\begin{array}{c}
\text{C} \\
\text{AlCl}_3 + \text{NBS} + \text{NaOH} \\
\text{A} \\
\text{B} \\
\text{C} \\
\text{D} \\
\text{E} \\
\end{array}
\]
16. Each of the following compounds is chiral. If a sample of a pure enantiomer is treated with base, four of the compounds are rapidly converted to a racemic mixture. One compound does not rapidly racemize. Identify the compound that does not rapidly racemize under these conditions.

![Diagram of single enantiomer reacting with NaOH to form a racemic mixture.](image)

A  B  C  D  E

17. Identify the missing reagent X in the following reaction scheme.

![Reaction scheme with P(C₆H₅)₃ and LiC₆H₅](image)

A  B  C  D  E

18. Under acid conditions the compound phthalaldehyde undergoes a rapid reaction with water to give compound Y. Use your knowledge of organic mechanisms and identify compound Y.

![Phthalaldehyde reacting with water under acidic conditions](image)

A  B  C  D  E
19. Predict the major product of the following reaction sequence.

\[
\text{HNO}_3 \quad \text{H}_2\text{SO}_4 \quad \text{Br}_2 \quad \text{Pd(PPh}_3)_4, \text{NaOEt} \quad \text{H}_2 / \text{Ni} \quad \text{NaNO}_2 / \text{HCl} \quad \text{CuCl}
\]

![Chemical structures](image)

- A
- B
- C
- D
- E

20. Which of the indicated H atoms is the most acidic?

![Chemical structure](image)

- A
- B
- C
- D
- E

21. Predict the major product of the following reaction.

\[
\text{[Chemical structure]} \quad \text{catalytic H}^+\n\]

![Chemical structures](image)

- A
- B
- C
- D
- E
22. Predict the major product of the following reaction.

\[
\text{CH}_3\text{CH}_2\text{CHO} + \text{C}_6\text{H}_5\text{CHO} \xrightarrow{\text{NaOH}} \]

![Image of reaction products]

23. Farnesyl pyrophosphate is an important intermediate in the biosynthesis of sesquiterpenes. The biosynthetic pathway leads to a cyclic cation that is a common precursor to many sesquiterpenes. Identify this common cyclic cation.

![Image of farnesyl pyrophosphate reaction]

Farnesyl pyrophosphate

![Image of cyclic cations]
24. Melibiose is a disaccharide used for chemical communication between various insects. Deduce the structure of melibiose from the following information.

i. Acid hydrolysis of melibiose yields and equal mixture of D-galactose and D-glucose.

ii. Melibiose is hydrolyzed by $\alpha$-galactodase enzymes, but not by $\beta$-galactodase enzymes.
   An $\alpha$-galactodase enzyme hydrolizes the $\alpha$-glycosidic bond of D-galactose specifically.

iii. Melibiose is a reducing sugar and reacts with sodium borohydride.

iv. Methylation of melibiose followed by hydrolysis of the glycosidic bonds yields the two derivatives shown below.

What is the structure of melibiose?

- A
- B
- C
- D
- E
25. This problem is based upon the ideas used in the classic Fisher glucose proof. (10 points)

Suppose you had two unknown D-aldohexoses, compounds A and B. The following reactions were run to identify compounds.

a. Fisher developed a method for interchanging the ends of an aldohexose. Applying this procedure converts A to B (and B to A).

b. The Ruff degradation of an aldohexose removes the C-2 carbon and yields an aldopentose.

The Ruff degradation of A followed by nitric acid oxidation gives an achiral five carbon aldaric acid. Ruff degradation of B followed by nitric acid oxidation gives a chiral five carbon aldaric acid.

Identify the two compounds A and B. On the answer form fill in the blanks using the numbers given under the structure names in the figure at the top of this page.

26. Identify the following sugar. (Use the numbers given in the preceding problem.) (6 points)
27. Using the curved arrow formulism give a reaction mechanism showing the bond making and bond breaking in the following reaction. (10 pts)

\[
\begin{align*}
\text{Ph} & \text{O} \\
& \text{Na}^+ \text{OEt} \quad \text{Na}^+ \text{OEt} \\
\text{HOEt} & \quad \text{Ph} \text{O} \\
\text{H} & \quad \text{H}
\end{align*}
\]

Predict the product of the following reaction sequences. (6 pts each)

28.

\[
\begin{align*}
\text{OSi(CH}_3\text{)}_3 & \quad \text{O} \\
\text{O} \quad \text{O} \quad \text{O} \\
\text{O} \\
\text{AC} & \quad \text{heat} \\
\text{O} \quad \text{O} \quad \text{O} \\
\text{HF} & \quad \text{HF} \\
\text{O} \quad \text{O} \quad \text{O}
\end{align*}
\]

29.

\[
\begin{align*}
\text{O} \quad \text{O} \quad \text{O} \\
\text{O} \quad \text{OH} \\
\text{C}_9\text{H}_{10}\text{O}_2 & \quad \text{C}_9\text{H}_{10}\text{O}_2
\end{align*}
\]

Robinson Annulation

30.

\[
\begin{align*}
\text{SOCl}_2 & \quad \text{O} \\
\text{O} \quad \text{O} \quad \text{O} \\
\text{Ru} & \quad \text{Ph}
\end{align*}
\]

Grubbs catalyst
31. The terpene Borneol can be isolated from the mugwort herb and has been used in Chinese medicine. The compound geranyl diphosphate is the precursor in the biosynthetic pathway to borneol. Using the curved arrow formulism give a reaction mechanism showing the bond making and bond breaking in the acid catalyzed transformation of geranyl diphosphate to the terpene borneol. (12 pts)

32. Complete the following reaction scheme. (12 pts)
33. Fenfluramine is a drug that was part of the Fen-Phen anti-obesity medication. Propose a good synthesis of fenfluramine starting with (trifluoromethyl)benzene and other compounds of four carbons or less. (12 pts)