Midterm 2 Review Packet Key

[Sourced from Smith: Organic Chemistry 3rd and 6th Edition]

Key Concepts:
- Understand the reaction pathway taken by alcohols, epoxides, and ethers
- Become comfortable with transferring the substitution and elimination reaction concepts ($S_N^1$, $S_N^2$, $E_1$ and $E_2$) to alcohols, ethers and epoxides

Chapter 9
1. What three alkenes are formed when $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH(OH)}\text{CH}_3$ is treated with $\text{H}_2\text{SO}_4$? Label the major product (9.50 third edition)?

![Diagram of alkenes formed from reaction]

Alkene 1: Cis-disubstituted

Alkene 2: Trans-disubstituted major

Alkene 3: Monosubstituted
2. Sometimes carbocation rearrangements can change the size of a ring. Draw a stepwise, detailed mechanism for the following reaction. (9.57 third edition)

\[
\text{Cyclonexane} \xrightarrow{\text{H}_2\text{SO}_4} \text{Cyclohexene}
\]

a. 

b. 

3. Identify the reagents (a-h) needed to carry out each reaction. (9.78 third edition)
a.

b.
4. Explain why the treatment of anisole with HBr yields phenol with CH$_3$Br, but not bromobenzene (9.34 third edition).

![Chemical structure diagram]

a. $S_N$1 Route:

Ethers can be formed through either $S_N$1 or $S_N$2 reaction pathways. However, recall no sp$^2$ carbon can participate in both $S_N$1 and $S_N$2 reactions. The formation of phenyl carbocation is highly unstable - more unstable than primary carbocation - and thus will not form. Additionally, the conjugated pi system in the aromatic benzene ring makes it impossible for a nucleophillic backside attack.

ii. Ethers can be formed through either $S_N$1 or $S_N$2 reaction pathways. However, recall no sp$^2$ carbon can participate in both $S_N$1 and $S_N$2 reactions. The formation of phenyl carbocation is highly unstable - more unstable than primary carbocation - and thus will not form. Additionally, the conjugated pi system in the aromatic benzene ring makes it impossible for a nucleophillic backside attack.
5. Draw the products of each reaction, and indicate the stereochemistry where appropriate.

(9.75 third edition)

5a. 

\[
\begin{align*}
\text{HO} & \quad \xrightarrow{\text{HBr}} \quad \text{Br} \\
\text{H}_3\text{C} & \quad \text{H} \\
\end{align*}
\]

5b. 

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{C} \\
\text{H} & \quad \text{C} \\
\text{CH}_2\text{CH}_3 & \quad \text{H} \\
\end{align*}
\]

\[
\begin{align*}
\text{1. NaCN} & \quad \text{2. H}_2\text{O} \\
\text{H} & \quad \text{C} \quad \text{N} \\
\text{CH}_2\text{CH}_3 & \quad \text{OH} \\
\text{H}_3\text{C} & \quad \text{C} \\
\end{align*}
\]

5c. 

\[
\begin{align*}
\text{D} & \quad \text{H} \\
\text{HO} & \quad \xrightarrow{\text{TsCl}} \\
\text{H} & \quad \text{CH}_2\text{CH}_3 \\
\text{pyridine} & \quad \xrightarrow{\text{CH}_3\text{CO}_2^-} \\
\text{O}_2\text{CH}_2\text{C} & \quad \text{H} \\
\text{OCH}_2\text{CH}_3 & \quad \text{D} \\
\end{align*}
\]

5d. 

\[
\begin{align*}
\text{NaH} & \quad \text{CH}_3\text{CH}_2\text{I} \\
\text{CH}_2\text{CH}_3 & \quad \text{OH} \\
\end{align*}
\]

6. Epoxides are converted to allylic alcohols with nonnucleophilic bases such as lithium diethylamide [LiN(CH_3CH_2)_2]. Draw a stepwise mechanism for the conversion of 1,2-epoxycyclohexane to 2-cyclohexen-1-ol with this base. Explain why a strong bulky base must be used in this reaction. (9.81 third edition)

6a. 

\[
\begin{align*}
\text{H} & \quad \text{H} \\
\text{O} & \quad \xrightarrow{\text{LiN(CH}_3\text{CH}_2)_2} \\
\text{O} & \quad \xrightarrow{\text{H}_2\text{O}} \\
\end{align*}
\]
i. If a bulky base is not used, nucleophilic epoxide ring opening can happen more readily. A bulky base cannot act as a nucleophilic and thus it will only remove a proton.

7. 1,2-Diols are converted to carbonyl compounds when treated with strong acids, in a reaction called the *pinacol rearrangement*. Draw a stepwise mechanism for this reaction. (9.83 third edition)

![Stepwise mechanism for pinacol rearrangement](image)

Chapter 10

8. Draw all stereoisomers formed in each reaction(10.51).

![Stereoisomers](image)
9. Draw a stepwise mechanism for the following reaction (10.55).

\[
\text{HCl} \quad \rightarrow \quad \begin{align*}
\text{Cl} & \quad + \\
\text{H} & \quad + \\
\end{align*}
\]
10. Draw a stepwise mechanism for the conversion of hex-5-en-1-ol to the cyclic ether (10.57).

11. Less stable alkenes can be isomerized to more stable alkenes by treatment with strong acid. For example, 2,3-dimethylbut-1-ene is converted to 2,3-dimethylbut-2-ene when treated with H2SO4. Draw a stepwise mechanism for this isomerization process (10.59).

12. Explain why the addition of HBr to alkenes A and C is regioselective, forming addition products B and D, respectively (10.61).
The carbocation made when A reacts with H-Br is resonance stabilized by the O atom, so B is preferentially formed.

The carbocation formed when C reacts with H-Br is formed preferentially and results in D. It is not destabilized by an adjacent electron-withdrawing COCH3 group. The carbocation does not form in this case because it is destabilized by the partial positive charge on the adjacent carbon.

13. Devise a synthesis of each product from the given starting material. More than one step is required (10.63).
b) 

{chemical_equation}

\[ \text{Br} \xrightarrow{\text{K}^+ \text{OC(\text{CH}_3)_3}} \text{\text{C}_2\text{H}_4} \xrightarrow{[\text{H}_2\text{Cl}_2, \text{HO}]} \text{\text{CH}_2\text{OH}} \xrightarrow{\text{NaH}} \text{\text{CH}_2}\text{O}^+ \xrightarrow{\text{CH}_3\text{I}} \text{\text{CH}_3\text{OCH}_3} \]

\[ \text{H}_2 \]


c) 

{chemical_equation}

\[ \text{\text{C}_3\text{H}_7\text{I}} \xrightarrow{\text{K}^+ \text{OC(\text{CH}_3)_3}} \text{\text{C}_2\text{H}_4} \xrightarrow{\text{HCl}} \text{\text{C}_3\text{H}_7\text{Cl}} \]


d) 

{chemical_equation}

\[ \text{\text{C}_7\text{H}_12\text{C}_2\text{H}_5} \xrightarrow{\text{Br}_2} \text{\text{C}_7\text{H}_12\text{Br}_2} \xrightarrow{\text{NaNH}_2, \text{excess}} \text{\text{C}_7\text{H}_12\text{C}_2\text{H}_5} \]


e) 

{chemical_equation}

\[ \text{\text{C}_3\text{H}_7\text{Br}} \xrightarrow{\text{K}^+ \text{OC(\text{CH}_3)_3}} \text{\text{C}_2\text{H}_4} \xrightarrow{\text{Br}_2} \text{\text{C}_3\text{H}_7\text{Br}_2} \xrightarrow{\text{NaNH}_2, \text{excess}} \text{\text{C}_3\text{H}_7\text{C}_2\text{H}_5}\]

\[ \text{Br} \]
f)