1. Which of the following statements about benzene is FALSE?
   A) the molecule is planar and each carbon is at a corner of regular hexagon
   B) there are two resonance structures of equivalent energy
   C) the bond angles are all 120º and the bond lengths are all 1.39Å
   D) the typical mechanism by which reactions occur is by addition
   E) each carbon in the benzene ring is sp² hybridized

2. Which of the following is NOT an electrophile in an electrophilic aromatic substitution reaction?
   A) NO₂⁺
   B) (CH₃)₃C⁺
   C) SO₃
   D) Cl⁻
   E) all are

3. What is the correct name for the following molecule?

   A) o-bromobenzyl
   B) biphenyl bromide
   C) 2-bromodiphenylpropane
   D) bromobenzylbenzene
   E) o-benzylobromobenzene

4. Which of the following groups is a meta director?
   A) –Cl
   B) –COOH
   C) –OCH₃
   D) –OH
   E) –NH₂

5. What is the name of the major product from the following sequence of reactions?

   A) aniline
   B) anisole
   C) benzoic acid
   D) phenol
   E) toluene
6. Which is the best reaction sequence to synthesize m-bromobenzenesulfonic acid from benzene?

A) 1) Br₂, FeBr₃, 2) H₂SO₄, SO₃
B) 1) H₂SO₄, SO₃ 2) Br₂, FeBr₃
C) 1) ethene, HF, 2) Br₂, FeBr₃
D) 1) CH₃Cl, AlCl₃, 2) Br₂, AlBr₃
E) 1) Br₂, FeBr₃, 2) CH₃COCl, AlCl₃

7. In the mechanism for the nitration of benzene, what is the function of H₂SO₄?
   A) to act solely as a solvent
   B) to donate a proton to HNO₃
   C) to accept a proton from HNO₃
   D) to generate heat for reaction to occur
   E) to protonate the benzene ring

8. Among the following groups, which ones are o,p-directing?
   1. —OCH₃  2. —NO₂  3. —Br  4. —CN  5. —CH₂CH₃

   A) 1, 3, and 5
   B) 1 and 5
   C) 2 and 4
   D) 2, 3, and 4
   E) 1 and 3

9. The relative rates of nitration of the following are:

   A) 1 > 2 > 3 > 4
   B) 4 > 2 > 1 > 3
   C) 2 > 1 > 4 > 3
   D) 3 > 4 > 2 > 1
   E) 3 > 2 > 1 > 4
10. What is the best sequence of reactions to synthesize m-nitrophenol?

A) 

\[
\text{C}_6\text{H}_5\text{OH} \xrightarrow{\text{HNO}_3, \text{H}_2\text{SO}_4} \text{C}_6\text{H}_4\text{NO}_2\text{H}_2\text{SO}_4 \xrightarrow{\text{H}_2\text{O}, \Delta} \text{C}_6\text{H}_4\text{OH}
\]

B) 

\[
\text{C}_6\text{H}_5\text{OH} \xrightarrow{1) \text{HNO}_3, \text{H}_2\text{SO}_4, 2) \text{H}_2\text{O}, \Delta} \text{C}_6\text{H}_4\text{NO}_2\text{H}_2\text{SO}_4 \xrightarrow{3) \text{NaOH, 200°C}} \text{C}_6\text{H}_4\text{OH}
\]

C) 

\[
\text{C}_6\text{H}_4\text{OH} \xrightarrow{1) \text{H}_2\text{SO}_4, \Delta} \text{C}_6\text{H}_4\text{SO}_4 \xrightarrow{2) \text{NaOH, 200°C}} \text{C}_6\text{H}_4\text{OH}
\]

D) 

\[
\text{C}_6\text{H}_5\text{OH} \xrightarrow{1) \text{H}_2\text{SO}_4, \Delta} \text{C}_6\text{H}_4\text{OH} \xrightarrow{2) \text{NaOH, 200°C}} \text{C}_6\text{H}_4\text{OH}
\]

E) 

\[
\text{C}_6\text{H}_5\text{OH} \xrightarrow{1) \text{HNO}_3, \text{H}_2\text{SO}_4} \text{C}_6\text{H}_4\text{NO}_2\text{H}_2\text{SO}_4 \xrightarrow{2) \text{H}_2\text{O}, \Delta} \text{C}_6\text{H}_4\text{OH}
\]

11. Which group is both ortho-para directing and ring deactivating?

A) \(-\text{Cl}\)
B) \(-\text{CH}_3\)
C) \(-\text{NO}_2\)
D) \(-\text{CHO}\)
E) \(-\text{OCH}_3\)

12. The only group among the following that is \emph{m}-directing is:

A) 

\[
\text{C} \quad \text{NH}_2
\]

B) 

\[
\text{F}
\]

C) 

\[
\text{N} \quad \text{C} \quad \text{CH}_3
\]

D) 

\[
\text{C(\text{CH}_3)_3}
\]

E) 

\[
\text{N(\text{CH}_3)_2}
\]

13. The name of the following molecule is:

A) toluene
B) ethylbenzene
C) cumene
D) styrene
E) anisole
14. What is the product of the following reaction?

\[ \text{CH}_3 \quad \text{+} \quad \text{CH}_3\text{C} \rightarrow \text{Cl} \quad \xrightarrow{\text{AlCl}_3} \]

A)  

B)  

C)  

D)  

E)  

15. Which position would be *para* to X?

A) 1  
B) 2  
C) 3  
D) 4  
E) 6
16. Starting with benzene as the only aromatic organic starting material, outline a plausible synthesis route for each of the listed compounds showing all reagents, conditions and intermediate substitution products clearly. The conversions are possible in at most 3 steps and at least 2 steps. (In case of a repeating step, use excess reagents and show as one step) 20 pts
17. Using chlorination of benzene as an example, write the reaction mechanism for showing all possible resonance structures of intermediates if any for the electrophilic aromatic substitution of benzene.  

Chapter 8 Questions

1. Which of the following is a secondary (2°) alcohol?

   A) I  
   B) II  
   C) III  
   D) IV  
   E) V

2. What is the IUPAC name for isobutyl alcohol?
   A) 1-butanol  
   B) 2-butanol  
   C) 2-methyl-2-butanol  
   D) 2-methyl-1-propanol

3. What is a correct name for (CH$_3$)$_3$CO$-$Na$^+$?
   A) sodium alkoxide  
   B) sodium trimethyloxide  
   C) sodium butoxide  
   D) sodium trimethylethoxide  
   E) sodium tert-butoxide
4. The correct name for the compound is

A) 2-hydroxybromobenzene.
B) 2-bromobenzyl alcohol.
C) 2-bromobenzol.
D) α-bromophenol.
E) 2-bromohexanol

5. If the pKₐ of isopropyl alcohol is 17, what is the Kₐ of isopropyl alcohol?
   A) 17 \times 10^{-17}
   B) 10^{-17}
   C) 10^{-3}
   D) 10^{17}
   E) 10^{3}
   F) 17 \times 10^{17}

6. Which of the following phenols is the strongest acid?
   A)
   B)
   C)
   D)
   E)

7. Phenols are stronger acids than alcohols because of the
   A) resonance stabilization of phenoxide ions.
   B) resonance stabilization of phenols.
   C) resonance stabilization of alkoxide ions.
   D) resonance stabilization of alcohols.
   E) hydrogen bonding in phenols.

8. Which reagents would you use to accomplish the following transformation?

\[
\text{CH}_3(\text{CH}_2)_6\text{CH}_2\text{OH} \quad \rightarrow \quad \text{CH}_3(\text{CH}_2)_6\text{CO}_2\text{H}
\]
A) \( \text{H}_2\text{SO}_4, \text{H}_2\text{O}, \text{acetone} \)
B) \( \text{CrO}_3, \text{H}_2\text{SO}_4, \text{acetone} \)
C) \( \text{PCC/CH}_2\text{Cl}_2 \)
D) \( \text{Zn, HCl, acetone} \)
E) \( \text{H}_2, \text{Pd, acetone} \)

9. What reagents would accomplish the following transformation?

A) 1. \( \text{PCl}_3 \) 2. \( \text{H}_3\text{O}^+ \)
B) \( \text{CrO}_3, \text{H}^+ \) in acetone
C) \( \text{PCC, CH}_2\text{Cl}_2 \)
D) 1. \( \text{Na} \) 2. \( \text{CH}_3\text{OH} \)
E) none of the above