1. Choose the major product of the following reaction.

\[ \text{Br} + \text{CH}_3\text{OH} \rightarrow \text{C}_6\text{H}_{10} \]

- A
- B
- C
- D
- E

2. Choose the order that has the following compounds correctly arranged with respect to increasing acidity of the indicated proton.

\[ \text{CO}_2\text{H} \quad \text{HCO}_2\text{H} \quad \text{CH}_2\text{OH} \]

- A. \( \text{iii} < \text{ii} < \text{i} \)
- B. \( \text{iii} < \text{i} < \text{ii} \)
- C. \( \text{i} < \text{ii} < \text{iii} \)
- D. \( \text{i} < \text{iii} < \text{ii} \)
- E. \( \text{ii} < \text{i} < \text{iii} \)

3. Choose the structure consistent with the following \(^1\)H NMR spectrum.
4. Choose the order that has the following hydrocarbons correctly arranged with respect to increasing acidity of the indicated proton.

\[
\begin{align*}
\text{i} & \quad \text{H} \\
\text{H} & \quad \text{ii} \\
\text{H} & \quad \text{iii}
\end{align*}
\]

A. \( \text{iii} < \text{ii} < \text{i} \)  
B. \( \text{iii} < \text{ii} < \text{i} \)  
C. \( \text{ii} < \text{iii} < \text{i} \)  
D. \( \text{ii} < \text{iii} < \text{i} \)  
E. \( \text{i} < \text{ii} < \text{iii} \)  

5. Choose among the following reactions those that will give a racemic mixture of two enantiomers as the products.

\[
\begin{align*}
\text{A. i} & \quad \text{1) CH}_3\text{Li} \\
& \quad \text{2) H}_2\text{O} \\
\text{B. ii} & \\
\text{C. iii} & \quad \text{1) CH}_3\text{Li} \\
& \quad \text{2) H}_2\text{O} \\
\text{D. i + ii} & \\
\text{E. ii + iii} & \quad \text{NaBH}_4 \\
& \quad \text{H}_2\text{O}
\end{align*}
\]

6. Choose the order that has the following carbonyl groups correctly arranged with respect to increasing reactivity with \( \text{NaBH}_4 \).

\[
\begin{align*}
\text{i} & \quad \text{CH}_3\text{C} - \text{H} \\
\text{ii} & \quad \text{CF}_3\text{C} - \text{H} \\
\text{iii} & \quad \text{CH}_3\text{C} - \text{CH}_3
\end{align*}
\]

A. \( \text{i} < \text{ii} < \text{iii} \)  
B. \( \text{i} < \text{iii} < \text{ii} \)  
C. \( \text{ii} < \text{iii} < \text{i} \)  
D. \( \text{ii} < \text{iii} < \text{i} \)  
E. \( \text{iii} < \text{ii} < \text{i} \)  

7. Choose the reaction that would not be successful for the preparation of the following alcohol.

\[
\begin{align*}
\text{A.} & \quad \text{1. CH}_3\text{MgBr} \\
& \quad \text{2. NH}_4\text{Cl, H}_2\text{O} \\
\text{B.} & \quad \text{1. CH}_3\text{CH}_2\text{MgBr} \\
& \quad \text{2. NH}_4\text{Cl, H}_2\text{O}
\end{align*}
\]

\[
\begin{align*}
\text{C.} & \quad \text{1. CH}_3\text{CH}_2\text{MgBr} \\
& \quad \text{2. NH}_4\text{Cl, H}_2\text{O} \\
\text{D.} & \quad \text{1. CH}_3\text{MgBr} \\
& \quad \text{2. NH}_4\text{Cl, H}_2\text{O}
\end{align*}
\]
8. Choose the order that has the following resonance structures correctly arranged with respect to increasing stability.

\[ \text{H}_2\text{C} \equiv \text{N} \equiv \text{O} : \quad \text{H} \quad \text{H}_2\text{C} \equiv \text{N} \equiv \text{O} : \quad \text{H} \quad \text{H}_2\text{C} \equiv \text{N} \equiv \text{O} : \]

i  ii  iii

A. i < ii < iii  B. i < iii < ii  C. ii < i < iii  D. ii < iii < i  E. iii < i < ii

9. Choose the major product of the following reaction.

\[
\text{Br} \quad \text{DMF} \quad \text{KCN} \quad \text{H}_2\text{C} = \text{N} \equiv \text{O} \]

A  B  C  D  E

10. Choose the major product of the following reaction.

\[
\text{I} \quad \text{H} \quad \text{I} \quad \text{H}_3\text{C} \quad \text{CH}_3
\]

A  B  C  D  E

11. Choose the major product of the following reaction.

\[
\text{Cl} \quad \text{H}_3\text{C} \quad \text{H} \quad \text{CH}_2\text{CH}_3 \quad \text{NaOEt} \quad \text{DMSO}
\]

A  B  C  D  E
12. Two major products with the formula C\(_7\)H\(_{14}\)O are formed in the following reaction. Choose the structures of these major products.

\[
\text{Cl} \quad 1 \quad \xrightarrow[40^\circ \text{C}]{\text{EtOH}} \quad \text{OH} \quad \text{OH}
\]

\(i\) and \(iii\)  
\(ii\) and \(iv\)  
\(iii\) and \(iv\)

13. Choose the major product of the following reaction.

\[
\text{OH} \quad \xrightarrow[\text{H}]{} \quad \text{H}
\]

\(A\)  
\(B\)  
\(C\)  
\(D\)  
\(E\)

14. The \(^1\text{H}\) NMR of (E)-1,3-dibromopropene shows the following coupling constants: \(J_{ab} = 14 \text{ Hz}\), \(J_{ac} = 1.75 \text{ Hz}\) and \(J_{bc} = 5.8 \text{ Hz}\). Choose the spin-spin coupling pattern predicted for \(H_b\).

\[\text{trans-1-bromo-3-methoxypropene}\]

\(\text{A triplet of doublets}\)  
\(\text{B quartet}\)  
\(\text{C triplet}\)  
\(\text{D doublet of triplets}\)  
\(\text{E doublet}\)

15. Calculate the \(\Delta H^\circ\) for the following reaction from the bond dissociation energies (kJ/mol) shown below.

\[
378 \quad 421 \quad 243 \quad \xrightarrow[\text{hv}]{} \quad 352
\]

\(\text{A} \ \Delta H^\circ = +269 \text{ kJ/mol} \quad \text{B} \ \Delta H^\circ = -83 \text{ kJ/mol} \quad \text{C} \ \Delta H^\circ = -352 \text{ kJ/mol}\)

\(\text{D} \ \Delta H^\circ = -41 \text{ kJ/mol} \quad \text{E} \ \Delta H^\circ = +41 \text{ kJ/mol}\)
16. Select the most likely first step in the mechanism of the following reaction.

17. Predict the major products of the following reaction.

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

19. Select the correct structure for \((R,E)\)-pent-3-en-2-ol
20. Using the following reaction profile choose the energy (indicated by the double arrow) that determines the rate of the reaction.

Short Answer

21. Provide reagents for performing the following transformations. (These transformations require more than one step and it is not necessary to show intermediate structures, just the reagents.). 15 pts

(a) 

(b) 

(c) 

22. Predict the major product(s) of the following reactions. 15 pts

(a) 

(b) 

(c) 

23. Using the curved arrow formalism show the bond making and bond breaking that occurs in the following transformation. 20 pts

(a)
24. Complete the following roadmap by drawing stereochemically correct structures for A-E. 10pts

1) NaBH₄/EtOH
2) HBr

1) Li
2) H₂C=O
3) H₃O⁺

1) PCC
2) CH₃MgBr
3) H₂O⁺

1) SOCl₂
2) KOH, heat
3) H₂, Pd/C

1) OsO₄
2) NaHSO₃, H₂O

1) H₂CrO₄
2) H⁺, heat (-H₂O)

25. Give the structure of a compound consistent with the formula C₅H₁₀O₂ and following IR and ¹H NMR spectra (all the nmr absorptions are singlets). 10pts

[Graph showing IR and NMR spectra]
26. Linalool is a fragrant natural product isolated from common plants. Give the best synthesis of linalool from compounds containing four carbon atoms or less. 10 pts

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

\[
\text{ HO } \quad \text{ CO } \\
\text{ H } \quad \text{ H}
\]

26. Linalool is a fragrant natural product isolated from common plants. Give the best synthesis of linalool from compounds containing four carbon atoms or less. 10 pts

\[
\begin{align*}
\text{OH} & \quad \text{CO} \\
\text{Li} & \quad \text{Li} \\
\text{Br} & \quad \text{H-Br}
\end{align*}
\]

\[
\begin{align*}
\text{Li} & \quad \text{O} \\
\text{Li} & \quad \text{H}_2\text{O}^\oplus
\end{align*}
\]