1 Which compounds give rise to four $^1$H-NMR signals?

A. II and IV  
B. I and III  
C. II and V  
D. I and IV  

2 What is the correct order of the chemical shifts of the indicated hydrogens in the molecule at right?

A. downfield $H_a < H_d < H_c < H_b$ upfield  
B. downfield $H_c < H_b < H_d < H_a$ upfield  
C. downfield $H_b < H_c < H_d < H_a$ upfield  
D. downfield $H_d < H_c < H_a < H_b$ upfield  

3 Which, if any, is the theoretically expected $^1$H-NMR splitting pattern of the indicated hydrogen in the molecule at right?

A. dddq  
B. dtq  
C. sextet  
D. None of the preceding  

4 Which of these compounds are aromatic?

A. I and II  
B. II and V  
C. II and IV  
D. III and V  

5 Which compound is least likely to be useful in a crossed Claisen reaction with CH$_3$CO$_2$CH$_2$CH$_3$ in the presence of NaOCH$_2$CH$_3$?

A. CH$_3$CH$_2$CO$_2$CH$_2$CH$_3$  
B. PhCO$_2$CH$_2$CH$_3$  
C. HCO$_2$CH$_2$CH$_3$  
D. CH$_3$CH$_2$O$_2$CCO$_2$CH$_2$CH$_3$
6 Which substituents activate the benzene ring toward electrophilic aromatic substitution?

<p>| | | | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>Br</td>
<td>II.</td>
<td>CC(\text{OCl})</td>
</tr>
<tr>
<td>V.</td>
<td>Si Me_3</td>
<td>VI.</td>
<td>CH=CH</td>
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<td></td>
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<td></td>
<td>IV. B(\text{CH}_3)_2</td>
</tr>
</tbody>
</table>

A  I, II and VII  B  III, V and VI  C  II, IV and V  D  IV, VI and VIII

7 Which alkene reacts most rapidly with HCl?

![Alkenes](image)

A  B  C  D

8 What is the best method for carrying out this transformation?

![Transformation](image)

A  (1) Cl_2, AlCl_3; (2) KMnO_4; (3) Br_2, Fe
B  (1) KMnO_4; (2) Br_2, Fe; (3) Cl_2, AlCl_3
C  (1) KMnO_4; (2) Cl_2, AlCl_3; (3) Br_2, Fe
D  (1) Cl_2, AlCl_3; (2) Br_2, Fe; (3) KMnO_4
9 Which molecule undergoes electrophilic aromatic substitution most rapidly?

10 Compound X is optically active. Compound X reacts with H₂ over a Pd catalyst to afford optically inactive C₁₀H₂₂; Compound X reacts with H₂ over the Lindlar catalyst to afford optically active C₁₀H₁₈; and Compound X reacts with Na in NH₃(ℓ) to afford optically inactive C₁₀H₁₈. What is Compound X?

11 All but one of these reactions affords two enantiomers in equal amounts. Which reaction affords a single product?
12 What is the correct ranking of these carbocations by stability?

I.  
II.  
III.  
IV.  

A  III > II > IV > I  
B  I > IV > III > II  
C  I > II > IV > III  
D  II > IV > III > I

13 In view of the product distribution shown below, which of these statements is true concerning the mechanism of the reaction?

A  Two different cyclic chloronium cations are intermediates. 
B  A carbocation can be ruled out as an intermediate. 
C  A carbocation and a cyclic chloronium cation are intermediates. 
D  A cyclic chloronium cation can be ruled out as an intermediate.

14 Which of these molecules reacts with $\text{OH}^-$?

I.  
II.  
III.  
IV.  
V.  
VI.  

A  II, III, IV and VI  
B  I, III, V and VI  
C  I, II, IV and V  
D  II, IV and V
15 What is the correct ranking of these compounds by the reactivity of the carbonyl carbon toward addition of a nucleophile?

![Chemical structures](image)

A  IV > II > I > III  
B  III > II > IV > I  
C  III > II > I > IV  
D  I > IV > II > III

16 Which of the following is the most thermodynamically stable tautomer of the compound at right?

![Chemical structures](image)

A  
B  
C  
D

17 Which molecule, when treated with acid, cyclizes to afford the molecule at right?

![Chemical structures](image)

A  
B  
C  
D
18 Which compound can be most efficiently prepared by an aldol reaction?

A  3-hydroxy-2-methyl-1-phenyl-1-propanone  
B  3-hydroxy-3-phenylbutanal  
C  4-hydroxy-3,4-dimethyl-1-phenyl-2-pentanone  
D  4-hydroxy-4-phenyl-2-pentanone

19 In the reaction at right O* represents oxygen-18. Which compounds, if any, are intermediates in this reaction?

A  I, III and IV  
B  I and IV  
C  I, II and IV  
D  None of the compounds are intermediates.

20 What is the product of the reaction at right?

A  
B  
C  
D  

(1) EtOK  
(2) H⁺
Answers

1   B
2   C
3   A
4   C
5   A
6   B
7   C
8   A
9   C
10  D
11  A
12  C
13  C
14  B
15  D
16  B
17  A
18  A
19  D
20  B