Answer 20 of the 25 questions below. Clearly circle the numbers of the 5 problems you do NOT want me to grade. Do NOT circle more than 5. Do NOT circle less than 5. I will only grade 20 problems. Each problem is worth 5 points.

SHORT ANSWER (5 pts each)

1. The following order of reactivity is observed when the alkenes shown below are subjected to acid-catalyzed hydration. Briefly explain this order of reactivity.

   *most reactive*  

   ![Chemical structures](image)

   *least reactive*

2. How many signals would each of the following compounds give in its $^{13}$C NMR spectrum?
3. Predict the product(s) and show the mechanism of the following reaction:

\[ \text{Br}_2 \quad \text{hv} \]

4. A chemist carries out the synthetic sequence shown below. Treatment of methylene-cyclohexane with borane-THF, followed by a basic solution of hydrogen peroxide gives compound A (C\textsubscript{7}H\textsubscript{14}O). Treatment of A with methanesulfonyl chloride (or “mesyl chloride”) and pyridine affords compound B (C\textsubscript{8}H\textsubscript{16}SO\textsubscript{3}). Finally, B reacts with sodium phenoxide (a nucleophile) in phenol to afford compound C (C\textsubscript{13}H\textsubscript{18}O). Identify compounds A, B and C.
5. Outline a reasonable synthesis of tetrahydrofuran from 3-buten-1-ol.

\[ \text{OH} \quad \rightarrow \quad \text{O} \]

6. Show the product(s) of the following reaction:

\[ \text{NaBH}_4 \quad \text{H}_2\text{O} \]

7. Show the product(s) of the following Diels-Alder reaction:

\[ \text{CO}_2\text{Et} \quad \rightarrow \]

8. Which diene and dienophile would you employ in a synthesis of the following?

\[ \quad \rightarrow \]
9. Outline a synthesis of the following aromatic target molecule using benzene as your starting material:

\[
\text{Br} \quad \text{NO}_2
\]

10. Predict the product(s) and show the mechanism of the following reaction:

\[
\text{MeO} \quad \text{H-Br} \quad \text{H-Br}
\]
MULTIPLE CHOICE (5 pts each)

11. Which of the following would you expect to be aromatic?

(a) ![Structure A](image1) (b) ![Structure B](image2) (c) ![Structure C](image3) (d) ![Structure D](image4)

12. Which product would you expect from the following acid-catalyzed hydrolysis?

![Reagent](image5) \[\text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4\] ?

(a) ![Product A](image6) (b) ![Product B](image7) (c) ![Product C](image8) (d) ![Product D](image9)

13. Which of the reagent(s) given below could be used to effect the following conversion?

![Reagent](image10) \[? \rightarrow \text{OH} \] \[\text{OH}\]

(a) KMnO\(_4\) (b) \[\text{HOOH}\] (c) H\(_2\)SO\(_4\) (d) none of these

14. A compound with the molecular formula C\(_{10}\)H\(_{13}\)Cl gave the following \(^1\text{H}\) NMR spectrum: \(\delta\)1.6 ppm (singlet, 6H), \(\delta\)3.1 ppm (singlet, 2H), \(\delta\)7.2 ppm (multiplet, 5H).
   The most likely structure for the compound is:

(a) ![Structure A](image11) (b) ![Structure B](image12) (c) ![Structure C](image13) (d) ![Structure D](image14)
15. What feature would you expect to see in the $^1$H NMR spectrum of B after subjecting A to the following reaction?

![Reaction Diagram]

(a) There would be only 4 aromatic protons at low field.
(b) The signal for the protons on the benzylic carbon would be a doublet.
(c) The signal for the methyl protons would be a doublet.
(d) The signal for the methyl protons would be a triplet.

16. Which free radical is most stable relative to the hydrocarbon from which it is formed?

(a) \[ \cdot \]
(b) \[ \cdot \]
(c) \[ \cdot \]
(d) \[ \cdot \]

17. Free radicals can be produced by:

(a) Use of high temperatures.  
(b) Irradiation with light.  
(c) Reaction of a molecule with another free radical.  
(d) All of the above.

18. Which is the correct IUPAC name for

![Molecule Diagram]

(a) ethyl butyl ether  
(b) ethyl pentyl ether  
(c) butyl ethyl ether  
(d) ethylene glycol

19. Which of the following resonance structure is not a significant contributor to the hybrid for the carbonyl group?

(a) \[ \cdot \]
(b) \[ \cdot \]
(c) \[ \cdot \]
(d) all are significant contributors
20. Which of the following compounds would be the most stable?

(a) \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]
(b) \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]
(c) \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]
(d) \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

21. A reaction under kinetic (or rate) control will yield predominantly:
(a) The most stable product.
(b) The product that can be formed in the fewest steps.
(c) The product whose formation requires the smallest free energy of activation.
(d) The product with the greatest potential energy.
(e) The product with the least potential energy.

22. Which of the following is NOT true of benzene?
(a) Benzene tends to undergo substitution rather than addition reactions, even though it has a high index of hydrogen deficiency (IHD).
(b) All of the hydrogen atoms of benzene are equivalent.
(c) The carbon-carbon bonds of benzene are alternately short and long around the ring.
(d) Benzene is more stable than the hypothetical compound “1,3,5-cyclohexatriene.”

23. Which of the following is NOT a Hückel number?
(a) 4  (b) 6  (c) 10  (d) 14  (e) 18

24. Benzene will only react under which of the following conditions?
(a) \( \text{H}_2, \text{Pt}, 25 \degree \text{C} \)  
(c) \( \text{Br}_2, \text{CCl}_4, \text{dark} \)
(b) \( \text{Cl}_2, \text{FeCl}_3, \text{heat} \)
(d) \( \text{KMnO}_4, \text{H}_2\text{O}, 25 \degree \text{C} \)

25. Which of the following would NOT be a contributor to the resonance hybrid of the benzyl cation?

(a) \[
\begin{array}{c}
\text{CH}_3 \\
\text{CH}_3 \\
\text{CH}_3 \\
\text{CH}_3 \\
\text{CH}_3 \\
\text{CH}_3 \\
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\text{CH}_3 \\
\text{CH}_3 \\
\text{CH}_3 \\
\end{array}
\]
(b) \[
\begin{array}{c}
\text{CH}_2 \\
\text{CH}_2 \\
\text{CH}_2 \\
\text{CH}_2 \\
\text{CH}_2 \\
\text{CH}_2 \\
\text{CH}_2 \\
\text{CH}_2 \\
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\text{CH}_2 \\
\end{array}
\]
(c) \[
\begin{array}{c}
\text{CH}_2 \\
\text{CH}_2 \\
\text{CH}_2 \\
\text{CH}_2 \\
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\text{CH}_2 \\
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\text{CH}_2 \\
\end{array}
\]
(d) \[
\begin{array}{c}
\text{CH}_2 \\
\text{CH}_2 \\
\text{CH}_2 \\
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\text{CH}_2 \\
\end{array}
\]
**Bonus (+8 pts): Using the spectra provided identify the unknown compound.