There are 14 multiple choice problems (5 points each) on this exam, however, you will only be graded out of 12 (i.e. two bonus questions). Record the answers to the multiple choice questions on THIS PAGE. There are also 4 short answer questions. Problems 19 and 20 are extra credit. Please make sure that your curved arrow mechanisms are drawn to precisely indicate the movement of electrons. You will be graded out of 100 points.

1 _____  8 _____ 
2 _____  9 _____ 
3 _____  10 _____ 
4 _____  11 _____ 
5 _____  12 _____ 
6 _____  13 _____ 
7 _____  14 _____
1. Which of the following terms best describes the relationship between the pair of compounds shown below?
   a) Enantiomers  
   b) Diastereomers  
   c) Constitutional isomers  
   d) The same compound

2. Which of the following terms best describes the relationship between the pair of compounds shown below?
   a) Enantiomers  
   b) Diastereomers  
   c) Constitutional isomers  
   d) The same compound

3. What products would you expect to obtain from the following SN2 reaction?

   a) I  
   b) II  
   c) an equimolar mixture of I and II  
   d) III  
   e) none of the above

4. Which alkyl halide would you expect to undergo an SN2 reaction most slowly?
   a) Cyclohexyl bromide  
   b) Methyl iodide  
   c) Isopropyl bromide  
   d) 3-chloro pentane  
   e) 3-iodo-3-methyl pentane

5. Which of the following statements correctly describe(s) E2 reactions of alkyl halides?

   I. Rate = k[base]  
   II. Rate = k[RX]  
   III. Rate = k[RX]  
   IV. The reaction mechanism usually involves an anti-periplanar orientation  
   V. Rearrangements are sometimes seen

   a) II and IV  
   b) III and IV  
   c) I, IV, and V  
   d) I only  
   e) II and V
6. How many distinct alkene products are possible when the alkyl iodide below undergoes E2 elimination?

a) 1  
b) 2  
c) 3  
d) 4  
e) 5

7. Which will be true for any nucleophilic substitution reaction?

a) $\Delta H^\circ$ is positive  
b) $\Delta H^\circ$ is negative  
c) $\Delta G^\ddagger$ is positive  
d) $\Delta G^\circ$ is positive

8. Which molecule would have the lowest heat of hydrogenation?

a) I  
b) II  
c) III  
d) IV  
e) V

9. Predict the major product (hint: the chair form of cyclohexane plays a key role).

a) I  
b) II  
c) III  
d) an equimolar mixture of I and II  
e) no E2 reaction will occur

10. Which of the following alkenes is the major product when 2-bromo-2-methylpentane is treated with a bulky base such as potassium tert-butoxide in tert-butanol?

a) 2-methyl-1-pentene  
b) 2-methyl-2-pentene  
c) $(E)$-4-methyl-2-pentene  
d) $(Z)$-4-methyl-2-pentene  
e) 4-methyl-1-pentene
11. What would be the major product of the following reaction?

\[
\begin{array}{c}
\text{HCl} \\
\text{Cl} \\
\end{array}
\]

a) I  
b) II  
c) III  
d) IV  
e) none of the above

12. Markovnikov addition of HCl to propene involves:

a) initial attack by a chloride ion  
b) formation of an isopropyl cation  
c) formation of a propyl cation followed by a hydride shift to give the isopropyl cation

d) all of these would be equally reactive

13. Which alkene would you expect to be the most reactive toward acid-catalyzed hydration?

a) I  
b) II  
c) III  
d) all of these would be equally reactive

d) all of these would be equally reactive

14. What is the index of hydrogen deficiency for a compound of molecular formula C₄H₉N?

a) 0  
b) 1  
c) 2  
d) 3  
e) 4

15. (10 pts) Label each chiral carbon atom in the compounds shown below as R or S. Use arrows to clearly indicate the carbon atoms being labeled (see example).
16. (10 pts) Provide a curved arrow mechanism for the following reaction and give the structures of all the possible products which result in the reaction below.

![Reaction Mechanism](image)

17. (10 pts) If the change in entropy of activation ($\Delta S^\ddagger$) for a given reaction were increased, what effect would this have on the reaction rate? Please include the following two equations and a free-energy diagram in your answer. *Use only the space provided below.*

$$\Delta G^\ddagger = \Delta H^\ddagger - T\Delta S^\ddagger$$

$$k = k_o e^{-\Delta G^\ddagger/RT}$$

![Free Energy Diagram](image)
18. (10 pts) Provide the curved arrow mechanism and the structure of the product(s) which result in the halohydrin reaction below. If more than one product results indicate their relationship.

19. (extra credit, 6 pts) Show the mechanism for the reduction of an alkyne to a trans-alkene.

20. (extra credit, 3 pts) Draw the exact structure and give the common name for DDT.