Name ..........................................................................................

The total number of points in this midterm is 100. The total exam time is 120 min (2 h). Good luck!

1. (9 pts) Mark as true (T) or false (F) the following statements. Do not explain!
   - Reactions occurring according to E1 mechanism have only one elementary step;
   - More stable alkenes have larger heats of hydrogenation;
   - More stable carbocations are generated faster;
   - Carbocations are electrophiles;
   - Alcohols are Brønsted bases;
   - Primary alcohols are dehydrated faster than secondary alcohols;
   - The rate-determining step is the fastest elementary step;
   - Free radicals are electron deficient;
   - Carbocations are electron deficient;

2. Circle ALL that apply:
   A. (3 pts) Free-radical chlorination:
      a. Occurs via a polar mechanism;
      b. Is a chain reaction;
      c. Requires an initiation step;
      d. Occurs fastest at primary positions;
   B. (3 pts) S_N 1 reactions:
      a. Occur via carbocation intermediate;
      b. Have a bimolecular rate-determining step;
      c. Are stepwise;
      d. Are likely to yield rearranged products;
   C. (3 pts) E1 reactions:
      a. Are concerted;
      b. Require strong bases;
      c. Occur via carbocations;
      d. Require coplanar arrangement of C – H and C – X bonds;
   D. (3 pts) The Zaitsev rule:
      a. Determines regioselectivity in reactions of alkene formation;
      b. Determines stereoselectivity in reactions of alkene formation;
      c. Accounts for the alkene stability order;
      d. Explains the Hammond postulate;

3. (3 pts) Provide an acceptable name for each of the following molecules:

4. (5 pts) Provide structural formula for each of the following molecules:

   1-Ethylcyclopentene  (Z)-2,4-dibromo-2-pentene  (E)-3-bromo-2-penten-1-ol  Bicyclo[1,1,1]pentane  trans-3,6-dimethylcyclohexene
5. (4 pts) Assign E or Z configuration to each of the following alkenes. Do not explain!

6. (4 pts) Arrange the following alkenes in order of increasing stability.
   A. cis-2-pentene;
   B. Trans-2-pentene;
   C. 2-Methyl-2-butene;
   D. 1-pentene;
   E. 2-methyl-1-butene;

7. (4 pts) Arrange the following alcohols in order of increasing reactivity in reaction with hydrobromic acid.
   A. 3-methylcyclohexanol;
   B. 1-methylcyclohexanol;
   C. 2-cyclohexylethanol;
   D. 2-cyclohexyl-2,2-difluoroethanol (Hint: In this case, think how the inductive effect of fluorine will affect the stability of the carbocation);

8. (20 pts) Predict the organic product in each of the following reactions. If more than one product is formed, indicate the major component.
9. (4 pts) Each of the following carbocations can rearrange to a more stable ion. Propose structures for the likely rearranged species.

\[
\begin{align*}
\text{CH}_3 & \quad \text{Br}_2 & \quad \text{hv, } \Delta \\
\text{NaOCH}_3 & \quad \text{CH}_3\text{OH}
\end{align*}
\]

\[
\begin{align*}
\text{OH} & \quad \text{SOCl}_2 & \quad \text{pyridine} \\
\text{NaOC}_2\text{H}_5 & \quad \text{C}_2\text{H}_5\text{OH}
\end{align*}
\]

10. When \textit{trans}-2-methylcyclohexanol is subjected to acid-catalyzed dehydration, the major product is 1-methylcyclohexene. However, when \textit{trans}-1-bromo-2-methylcyclohexane is subjected to dehydrohalogenation with NaOCH\textsubscript{3}/CH\textsubscript{3}CH\textsubscript{2}OH, the only product is 3-methylcyclohexene.

A. (4 pts) Provide equations for the above outlined reactions:

B. (8 pts) Account for the different products in the two reactions (Show explicit structures; I will not accept a verbal only explanation!! More structures, fewer words!).
11. (5 pts) Draw the complete potential energy diagram for the dehydration reaction in problem 9. Indicate the likely structures for the minima and transition states. What is the molecularity of the reaction? What is the mechanism?

12. (4 pts) What other product(s) is(are) expected to form in the dehydration reaction in problem 9? Why are they obtained in smaller quantities?

13. (5 pts) One of the following dichloronorbornanes undergoes elimination, while the other does not. Determine which one reacts and explain the difference in their reactivity.

14. (4 pts) The photochemical reaction of chlorine with 2,3-dimethylbutane leads to a mixture of monochlorides. Write the equation of the reaction and indicate all possible different monochlorinated products.
15. (5 pts) The addition of HCl to 1-isopropylcyclohexene yields a rearranged product as shown below. Offer a detailed mechanism to account for the reaction outcome.

\[
\text{\begin{align*}
\text{C}_6\text{H}_{11}\text{CH}=\text{CH} & + \text{HCl} \rightarrow \text{C}_6\text{H}_{11}\text{CHCl} \\
\end{align*}}
\]

16. (4 pts) BONUS PROBLEM (In order to receive credit for this problem, it has to be solved entirely!!). tert-Butyl peroxide is a stable, easy to handle liquid that serves as a convenient source of free radicals via thermal or light initiation:

\[
\text{O-O} \quad \begin{cases} \text{130 °C} \\ \text{or } \nu \end{cases} \rightarrow 2 \text{O•}
\]

A mixture of 2-methylpropane and carbon tetrachloride (CCl\textsubscript{4}) is quite stable at 130 °C, but if a small amount of tert-butyl peroxide is added, a reaction occurs, yielding tert-butyl chloride and chloroform. Provide a detailed, plausible mechanism for the reaction.

\[
\text{\begin{align*}
\text{CH}_3\text{CHCH}_3 & + \text{CCl}_4 \xrightarrow{\text{t-butyl peroxide}} 130 \degree \text{C} \rightarrow \text{Cl} \quad \text{Cl} + \text{CHCl}_3 \\
\end{align*}}
\]