INSTRUCTIONS —

This examination is in multiple choice format; the questions are in this Exam Booklet and the answers should be placed on the “Test Scoring Answer Sheet” which must be turned in and will be machine graded.

On the Test Scoring Answer Sheet, using a soft pencil, enter the following data (in the appropriate places): your name, instructor’s name, your OSC Student (or Social Security) number, course number (30022101) and the test number (01); darken the appropriate bubbles under the entries, making dark black marks which fill the bubbles. (If you use your OSC Student number, enter the whole number including the prefix letter but do not darken any bubbles under the letter.)

You may use a set of molecular models, but no other aids, during the exam.

Answer all questions. The questions are worth 3.33 points each.

You have 50 minutes. Good luck!
1. What is the shape of the carbon atoms in ethane?
   (a) linear, (b) trigonal, planar, (c) tetrahedral, (d) octahedral

2. What is the hybridization of the carbon atoms in ethane?
   (a) sp, (b) sp², (c) sp³, (d) d²sp³

3. The general molecular formula for *acyclic alkanes* is ________; the general molecular formula for *cyclic alkanes* containing one ring is ________; the general molecular formula for *acyclic alkenes* is ________; the general molecular formula for *cyclic alkenes* containing one ring is ________.
   (a) C\(_n\)H\(_{2n+2}\) / C\(_n\)H\(_{2n}\) / C\(_n\)H\(_{2n-2}\), (b) C\(_n\)H\(_{2n}\) / C\(_n\)H\(_{2n+2}\) / C\(_n\)H\(_{2n}\) / C\(_n\)H\(_{2n-2}\), (c) C\(_n\)H\(_{2n}\) / C\(_n\)H\(_{2n-2}\) / C\(_n\)H\(_{2n-2}\) / C\(_n\)H\(_{2n-4}\), (d) C\(_n\)H\(_{2n+2}\) / C\(_n\)H\(_{2n+2}\) / C\(_n\)H\(_{2n}\) / C\(_n\)H\(_{2n}\)

4. What is the relationship between I & II?
   (a) They are the same molecule, (b) They are constitutional (structural) isomers, (c) They are stereoisomers, (d) They are conformational isomers, (e) None of the above answers is correct.

5. What is the relationship between III & IV?
   (a) They are the same molecule, (b) They are constitutional (structural) isomers, (c) They are stereoisomers, (d) They are conformational isomers, (e) None of the above answers is correct.

6. Cyclohexane has a puckered rather than a flat structure. The puckered structure is favored over the flat one because the puckered one has less ____________ strain.
   (a) angle and torsional, (b) angle and steric, (c) torsional and steric, (d) eye, (e) brain

7. Considering rotation around the C(2)-C(3) bond of butane, which of the following conformations is least stable?
   (a) anti-periplanar, (b) anti-clinal, (c) syn-clinal, (d) syn-periplanar
8. Consider the following statement: "In relation to question #7, in a sample of butane at room temperature, all of the molecules will be in the most stable conformation."

(a) The above statement is true.
(b) The above statement is false. All of the indicated (anti-periplanar, anti-clinal, etc.) conformations of butane will be equally populated.
(c) The above statement is false. All of the indicated conformations of butane will be populated, but the more stable ones will have smaller populations.
(d) The above statement is false. All of the indicated conformations of butane will be populated, but the more stable ones will have larger populations.

The following figure relates to questions 9-13.

9. Which conformation of the compound shown above is most stable?
   (a) I,  (b) II,  (c) III,  (d) The conformations shown are of equal stability.

10. Which conformation of the compound shown above is least stable?
    (a) I,  (b) II,  (c) III,  (d) The conformations shown are of equal stability.

11. Which conformation of the compound shown above has 1,3-diaxial interactions?
    (a) I,  (b) II,  (c) III,  (d) None of the conformations has this sort of steric interaction.

12. What is the best name for the compound above?
    (a) cis-1,3-dimethylhexane, (b) trans-1,3-dimethylhexane,  
    (c) cis-1,3-dimethylcyclohexane, (d) trans-1,3-dimethylcyclohexane,  
    (e) None of the previous answers is correct.

13. Conversion of one of the conformations to another involves
    (a) breaking σ bonds.  (b) breaking π bonds.  (c) rotation around σ bonds.  (d) rotation around π bonds.
14. Select the statement below that accurately describes the nature of the carbons in the reactants in the two one-step reactions shown to the right.

(a) The carbon in (I) is electrophilic and one or both of the carbons in (II) are electrophilic.
(b) The carbon in (I) is electrophilic and one or both of the carbons in (II) are nucleophilic.
(c) The carbon in (I) is nucleophilic and one or both of the carbons in (II) are electrophilic.
(d) The carbon in (I) is nucleophilic and one or both of the carbons in (II) are nucleophilic.
(e) This question is bogus in that these reactions do not take place by a polar mechanism.

15-16. In the table below you will find values of $\Delta G^0$, the standard free energy changes for three different reactions (“A”, “B”, and “C”), and values of $\Delta G^\dagger$, the energies of activation for the same three reactions.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>$\Delta G^0$, kJ/mole</th>
<th>$\Delta G^\dagger$, kJ/mole</th>
</tr>
</thead>
<tbody>
<tr>
<td>“A”</td>
<td>-15</td>
<td>20</td>
</tr>
<tr>
<td>“B”</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>“C”</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>

15. Rank the three reactions in order of increasing $K_{eq}$ (reaction with smallest equilibrium constant first).

(a) A<B<C, (b) A<C<B, (c) B<A<C, (d) B<C<A, (e) C<A<B, (f) C<B<A, (g) There is not sufficient information to answer this question.

16. Assuming that the collision frequency factors are essentially the same for all three reactions, rank them in order of increasing rate of reaction (slowest reaction first).

(a) A<B<C, (b) A<C<B, (c) B<A<C, (d) B<C<A, (e) C<A<B, (f) C<B<A, (g) There is not sufficient information to answer this question.
For questions 17-20 consider the reaction coordinate (reaction energy) diagram to the right. This diagram represents a two-step reaction.

17. Reactants, if any, in this reaction are labeled:
   (a) A, (b) B, (c) C, (d) D, (e) There are no reactants in this reaction.

18. Intermediates, if any, in this reaction are labeled:
   (a) A, (b) B, (c) C, (d) D, (e) There are no intermediates in this reaction.

19. Transition states, if any, in this reaction are labeled:
   (a) A, (b) B, (c) C, (d) D, (e) There are no transition states in this reaction.

20. The rate limiting (rate determining) step in this reaction is likely to be the _____ step.
   (a) first, (b) second, (c) third, (d) fourth, (e) Bogus question, dude. In a multi-step reaction there is no such thing as a rate limiting step.

21. Select the IUPAC name for the compound shown to the right.
   (a) 3,4,4-trimethyl-1-hexene,
   (b) 4-ethyl-3,4-dimethyl-1-pentene,
   (c) 3,4,4-trimethyl-1-hexene,
   (d) 2-ethyl-2,3-dimethyl-4-pentene,
   (e) None of the above answers is correct.

22. Which of the following compounds can exist as pairs of cis-trans isomers?
   (I) CH₃CH=CH₂,  (II) CH₃CH=CHCH₃,  (III) CH₃CH₂CH=CHCH₃,
   (IV) (CH₃)₂C=CH(CH₃)CH₂CH₃,  (V) ClCH=CHCl,  (VI) BrCH=CCl₂
   (a) I&III, (b) II&IV, (c) III&V, (d) IV&VI, (e) None of the previous answers is correct.
23. Specify the configuration around the double bond in the compound shown to the right using the Cahn-Ingold-Prelog system. [Atomic numbers: H=1, C=6, N=7, O=8]

(a) A, (b) B, (c) E, (d) X, (e) Y, (f) Z

24. What is the relationship between the two molecules shown to the right?

(a) There is no relationship.
(b) They are constitutional isomers.
(c) They are conformational stereoisomers.
(d) They are geometric (cis-trans) stereoisomers.
(e) They are stereoisomers, but not of the geometric type.

25. Rank the following alkenes in order of decreasing stability (most stable first).

(I) 1-butene, (II) trans-2-butene, (III) cis-2-butene, (IV) 2-methyl-2-butene, (V) 2,3-dimethyl-2-butene

(a) I>II>III>IV>V, (b) V>IV>III>II>I, (c) V>IV>II>III>I, (d) I>III>II>IV>V, (e) None of the above answers is correct.

26. Rank the classes (methyl, 1°, 2°, 3°) of carbocation in order of decreasing stability (most stable first).

(a) methyl > 1° > 2° > 3°, (b) methyl > 1° > 3° > 2°, (c) methyl > 2° > 1° > 3°, (d) 3° > 2° > 1° > methyl

27. Select the major product of the following reaction.

(a) (b) (c) (d)

(a) (b) (c) (d)
28. Select the answer that best indicates the products that would be formed in significant amounts in the reaction. [Hint: Think about the mechanism.]

Consistent with Markovnikov’s rule, much more of the more stable secondary carbocation (A) would form compared to the less stable primary carbocation (B). Since little B forms, little of the alkyl chloride derived from it (I) forms. Some of the secondary carbocations that form would react with chloride ion to give the alkyl chloride II; others would rearrange to give the more stable tertiary carbocation (C), which would react with chloride ions to give alkyl chloride III.

(a) I&II,  (b) II&III,  (c) III&IV,  (d) I&III,  (e) I&IV,  (f) II&IV

29. Which of the following alkenes would be the best choice as the alkene starting material in the preparation of 1-iodo-1-methylcyclohexane. (“Best choice” means pick the alkene that will produce 1-ethyl-1-iodocyclohexane in highest yield with the fewest byproducts.)

(a)  (b)  (c)  (d) None of these alkenes would give a good yield of the desired product.
3° carbocation: much more stable, much more formed

1° carbocation: much less stable, much less formed

Not a bad choice, but as it turns out, not the best choice.

3° carbocation: much more stable, very much more formed

1° carbocation: much less stable, very much less formed

Best choice: 3° carbocation vs. 1°, compared to 3° carbocation vs. 2°, above.

Clearly, the worst choice.
Bottom line: the answer is (b).

30. In polar reactions bonds are broken ________ and formed ________, while in radical reactions bonds are broken ________ and formed ________.

(a) homolytically, homogenically, heterolytically, heterogenically.
(b) heterolytically, heterogenically, homolytically, homogenically.
(c) homogenically, homolytically, heterogenically, heterolytically.
(d) heterogenically, heterolytically, homogenically, homolytically.