

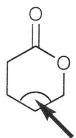
Calculators and Molecular Model Sets **may** be used on this exam

## Useful Data

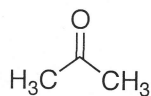
| Acid                                      | approximate pKa | Acid                                                | approximate pKa |
|-------------------------------------------|-----------------|-----------------------------------------------------|-----------------|
| $\text{C}_6\text{H}_5\text{NH}_3^+$       | 5               | $\text{C}_6\text{H}_5\text{OH}$                     | 10              |
| $\text{NH}_4^+$                           | 9               | $\text{C}_6\text{H}_5\text{CO}_2\text{H}$           | 4               |
| $((\text{CH}_3)_2\text{CH})_2\text{NH}$   | 33              | $\text{CH}_3\text{CO}_2\text{H}$                    | 5               |
| $\text{HCl}$                              | -7              | $(\text{CH}_3)_2\text{OH}^+$                        | -4              |
| $(\text{CH}_3)_2\text{C}=\text{O}$        | 19              | $\text{CH}_3\text{CH}_2\text{OH}$                   | 16              |
| $\text{C}_6\text{H}_5\text{SO}_3\text{H}$ | -1              | $\text{O}_2\text{N}-\text{C}_6\text{H}_4-\text{OH}$ | 7               |
| $\text{C}_6\text{H}_5\text{SH}$           | 7               |                                                     |                 |

**Multiple Choice Section (10 questions, 3 points each)**

1. The labelled bond angle would be expected to be:

A.  $109^\circ$ B.  $120^\circ$ C.  $165^\circ$ D.  $180^\circ$ E.  $90^\circ$ 

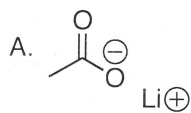
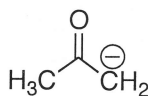
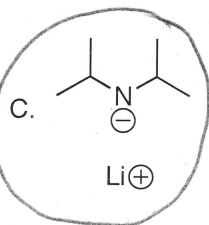
2. Which of the following bases would shift the following equilibrium completely to the right?



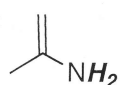
Base



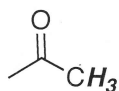
Base-H

B.  $\text{NH}_3$ D.  $\text{Cl}^-$ E.  $\text{CH}_3\text{O}^-$

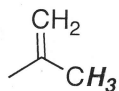
3. Predict relative order of acidity of the following molecules, most acidic first. (the acidic hydrogens on each molecule are indicated in **bold**)



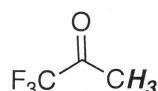
I



II



III



IV

A. I > II > III > IV

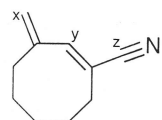
D. III > IV > I > II

B. II > I > IV > III

E. IV > II > I > III.

C. IV > III > I > II

4. The appropriate hybridization to describe bonding of the atoms x, y and z in the following molecule is:



A.  $sp^2, sp^2, sp$

B.  $sp^3, sp^2, sp$

C.  $sp, sp, sp$

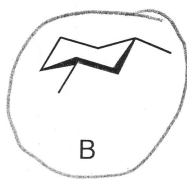
D.  $sp^3, sp^3, sp^2$

E.  $sp, sp^2, sp^3$

5. Which of the following structures is the lowest energy conformation of *cis*-1,3-dimethylcyclohexane.



A



B



C

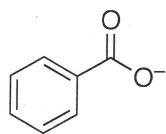


D

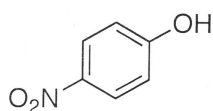


E

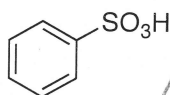
6. Which of the following acids would give the least protonation of the benzoate ion (shown below)



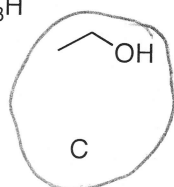
benzoate ion



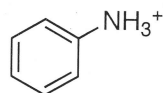
A



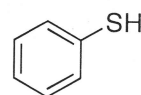
B



C

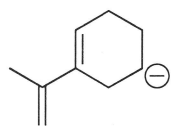
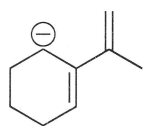


D

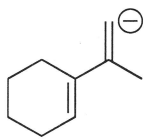


E

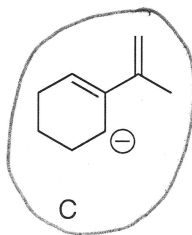
7. Which of the structures A-E is a valid resonance structure of the following:



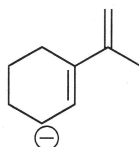
A



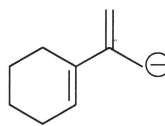
B



C

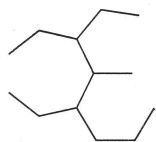


D



E

8. Which of the following is the correct name for the following structure



A. 4-ethyl-3,6-dimethyl-nonane

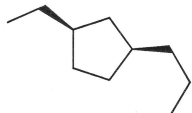
B. 1,1,3-triethyl-2-methylhexane

C. 3-ethyl-4-methyl-5-propyl-heptane

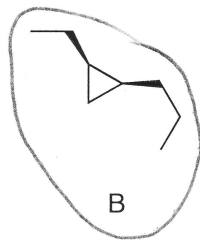
D. 2,5-diethyl-6-methyl-octane

E. 3,5-diethyl-4-methyl-octane

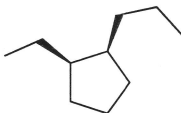
9. Which of the following structures represents *cis*-1-ethyl-2-propyl-cyclopropane



A



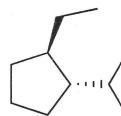
B



C



D



E

10. Which of the following completions are correct:

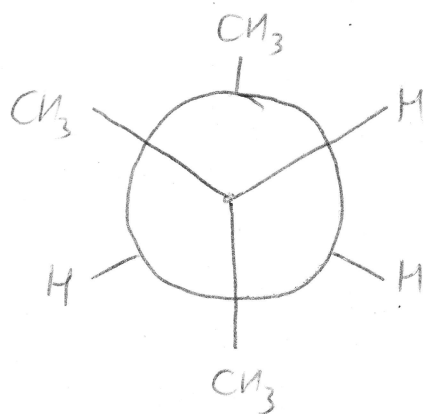
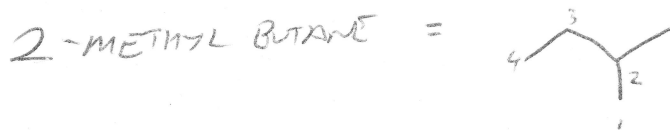
The rate determining step in a reaction is ...

- I. The slowest reaction step
- II. The first step in any reaction
- III. The most exothermic reaction step
- IV. The step that passes through the highest energy transition state
- V. The step with the lowest activation energy

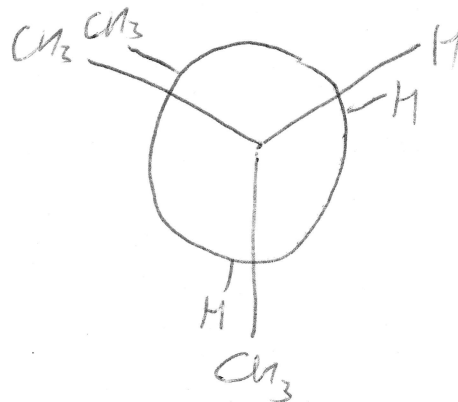
A. II and IV    **B. I and IV**    C. III and V    D. II, III and IV    E. All of the above

**Longer Answers:**

11. Draw Newman projections along the 2,3-bond of 2-methylbutane depicting the lowest energy (most stable) conformation and the highest energy (least stable) conformation (10 points)

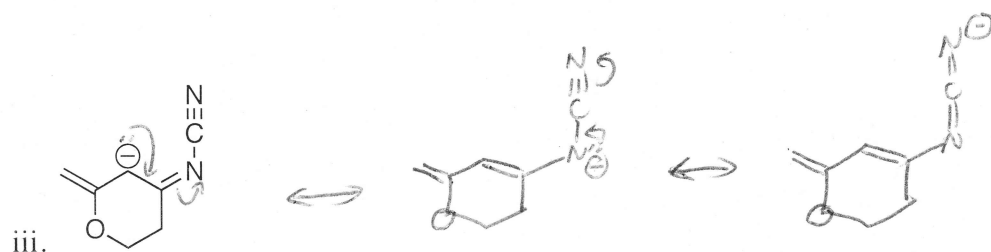
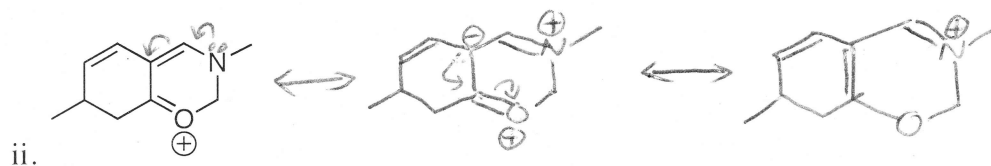
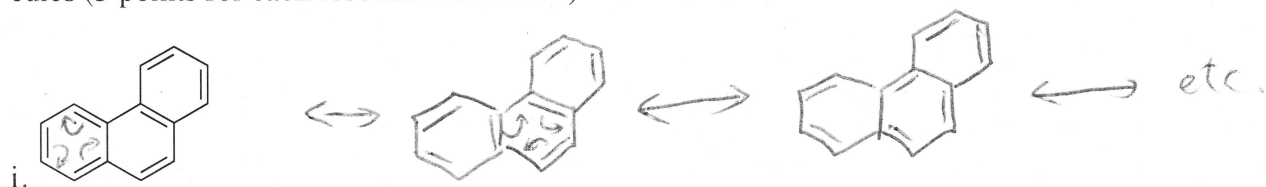


MOST  
STABLE



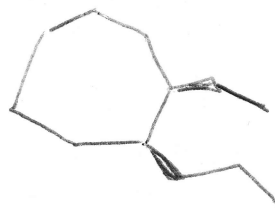
LEAST  
STABLE

12. Draw the two additional most important resonance structures for each of the following molecules (5 points for each resonance structure)

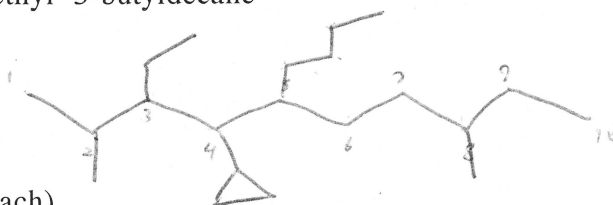


13. a) Draw the structure of the following (5 points each)

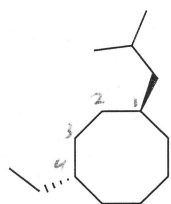
i. *cis*-2-Ethyl-1-propyl-cycloheptane



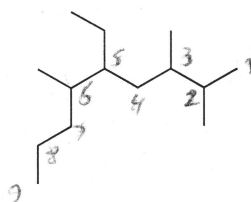
ii. 4-cyclopropyl-3-ethyl-2,8-dimethyl-5-butyldecane



b) Name the following (5 points each)

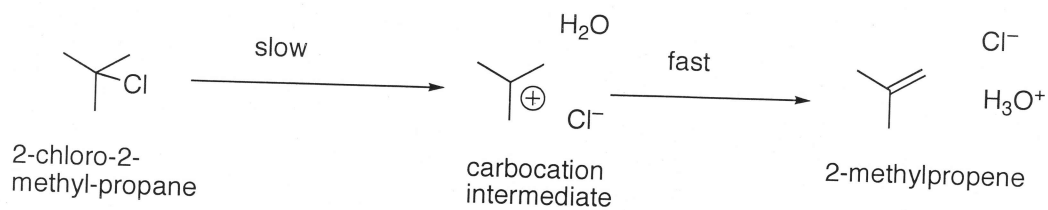


TRANS - 1-ISOBUTYL  
-4-ETHYL CYCLOOCTANE



~~5-ETHYL-2,3,6-TRIMETHYLNONANE~~  
5-ETHYL-2,3,6-TRIMETHYL NONANE

14. 2-chloro-2-methyl-propane reacts with water according to the following mechanism:



Which is the rate determining step? (1 point) *THE FIRST (SLOW) one.*

Draw an approximate reaction profile for this reaction (3 points) On your profile indicate

- The overall energy of reaction (2)
- The location of the carbocation intermediate (2)
- The location and relative energy of both transition states (2)

