Practice Exam #1
Chemistry 5.12
Organic Chemistry

• Midterm exam #1 will be held on Friday, February 21, from 12–1pm.

• Notes and calculators will not be allowed in the exam.

• You will be free to use molecular models during the exam.

• You will be given a periodic table.

• The exam will cover reading (Ch. 1, 2, 3.1–3.9) and lecture material through Tuesday, February 18.

• Dr. Tabacco will give a review session at 7pm on Tuesday, February 18

• Additional suggested problems from the book (some of these were already suggested during lecture): 1-23, 25, 27, 34, 36, 37, 39–43, 45–47, 2-27–31, 33, 3-34, 35, 38, 39, 41a, b, 42.

• For best results, take this test as if it were your exam. That way, you'll know which areas need extra work before you get to the real exam.

\textbf{ANSWER KEY}
1. Circle the correct answer.
   
   a) What is the approximate H–C–H bond angle in methane?
      
      \[ \boxed{109^\circ} \quad 120^\circ \quad 180^\circ \]
      
      b) What is the IUPAC name for isobutane?
      
      isopropylmethane   3-methylbutane   2-methylpropane
      
      c) How much is a gauche butane interaction worth?
      
      1.3 kcal/mol   \[ \boxed{0.9 \text{ kcal/mol}} \]   4.0 kcal/mol
      
      d) What is the barrier to rotation of ethane?
      
      1.0 kcal/mol   1.3 kcal/mol   \[ \boxed{3.0 \text{ kcal/mol}} \]
      
      e) What is the $pK_a$ of ethane?
      
      4.5   \[ \boxed{50} \]   15.7
      
2. a) Provide line drawings for the following compounds.
   
   b) How many degrees of unsaturation does each compound have?

   methylcyclopentane

   \[
   \begin{tikzpicture}
   \draw (0,0) circle (0.5cm);
   \draw (0,0) -- (1,0);
   \draw (0,0) -- (0,1);
   \draw (0,0) -- (-1,0);
   \draw (0,0) -- (0,-1);
   \node at (0,0) {d.\text{u.u.} = 1};
   \end{tikzpicture}
   \]

   phenol

   \[
   \begin{tikzpicture}
   \draw (0,0) circle (0.5cm);
   \draw (0,0) -- (1,0);
   \draw (0,0) -- (0,1);
   \draw (0,0) -- (-1,0);
   \draw (0,0) -- (0,-1);
   \node at (0,0) {d.\text{u.u.} = 4};
   \end{tikzpicture}
   \]

   5-\textit{tert}-butyl-4-\textit{ethyl}-2,3,4,7-\textit{tetramethyloctane}

   \[
   \begin{tikzpicture}
   \draw (0,0) circle (0.5cm);
   \draw (0,0) -- (1,0);
   \draw (0,0) -- (0,1);
   \draw (0,0) -- (-1,0);
   \draw (0,0) -- (0,-1);
   \node at (0,0) {Name \underline{Key}};
   \end{tikzpicture}
   \]
3. Below is a line drawing of beryllium chloride (BeCl₂).
   a) Draw in all of the lone pairs.
   b) Label the atoms with their appropriate hybridization.
   c) What is the bond angle in BeCl₂?

   \[ \text{Cl} - \text{Be} - \text{Cl} \]
   \[ 180^\circ \ (\text{linear}) \]

   d) Draw an orbital picture of BeCl₂. Label all orbitals (bonding and non-bonding).

   e) Would you expect BeCl₂ to be nucleophilic or electrophilic? Explain briefly.

   **Electrophilic.** Be has four valence electrons and two empty orbitals. It can accept electrons.

Name

Key
4. For each pair, circle the molecule with the **lowest pKₐ** and provide a brief explanation for your choice.

- **H – Cl** vs **H – Br**
  - **Electric**
  - **Inert**

- **H – Cl** vs **H – Br**
  - **Inductive effects**
  - **More EWGs → lower pKₐ**

- **Cl – Cl** vs **H – Cl**
  - **Resonance**
  - **More EN than N**

- **N – CH₃** vs **N – CH₃**
  - **Atom size**
  - **Larger atom → lower pKₐ**

5. Provide a line drawing for the alkane represented by the following Newman projections and predict the relative energies of the conformers.

- **E_{rel} = 1.8**
- **E_{rel} = 6.3**
- **E_{rel} = 0.9**
- **E_{rel} = 3.9**
6. Provide the products of the following reactions and use curved arrows to draw the reaction mechanisms. (Draw in all lone pairs and formal charges.)

(a) 

\[ \text{H}_3\text{C} - \text{O} - \text{CH}_3 \quad \rightarrow \quad \text{H}_3\text{C} - \text{C} = \text{CH}_3 \]

(b) 

\[ \text{H}_3\text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \quad + \quad \text{H}_3\text{C} - \text{N}_3 - \text{CH}_3 \quad \rightarrow \quad \text{H}_3\text{C} - \text{C} = \text{CH}_3 \quad + \quad \text{H}_3\text{C} - \text{N}_3 - \text{CH}_3\]

(c) In the above reactions, which of the four molecules is acting as a Bronsted base?

\[ \text{H}_3\text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \]

(d) In the above reactions, which of the four molecules is acting as a Lewis acid?

\[ \text{F} - \text{Al} - \text{F} \]

Name: [Student Name]

Key: [Student Key]
7. a) For each pair, circle the major (lowest energy) resonance structure and provide a brief explanation for your choice.

b) Draw curved arrows to convert the structures on the left to the structures on the right. **Draw in any lone pairs that you move with curved arrows.**

- [Diagram showing resonance structures and explanations.]

Name: [Signature]
8. a) Both of the nitrogen atoms in A are potentially Lewis basic. Draw the two possible products resulting from the reaction of A with BF$_3$. Use curved arrows to show the reaction mechanism. **Show all lone pairs and formal charges.**

\[
\begin{align*}
\text{H}_3\text{C}\text{NCH}_3 & + \text{BF}_3 & \rightarrow & \text{A} \\
\text{H}_3\text{C}\text{NCH}_3 & + \text{BF}_3 & \rightarrow & \text{B}
\end{align*}
\]

b) Which product from part a would you expect to be more stable? Draw resonance structures to illustrate your answer. **Product A would be more stable because the positive charge can be delocalized. The + in B is localized.**

Name: [Signature]