CHEM 241 IN-CLASS PROJECT #4-Turn in one sheet per group.

NAMES ____________________________________________

1. a. **Draw and name** the all alkenes which have the molecular formula $C_5H_{10}$. (hint: there are 6 total)

   b. Which pair(s) of structures above would be considered ‘stereoisomers’ of each other.
2. Regarding the following 4 (#1-#4) reaction coordinate diagrams answer the following.

Which has the fastest rate? 
Which has the slowest rate?
Which is the most exothermic (exergonic)? 
Which is the most endothermic (Endergonic)?
Which has the smallest rate constant \( k \)
Which has the largest \( \Delta G^* \) Value?
Which has the largest equilibrium constant \( K \)
Which has the largest \( \Delta G \) Value?
Part II In this section we will analyze the addition reaction of a double bond. The 2 step mechanism is shown below:

\[ \text{step #1} \quad \text{step #2} \]

Stability of the carbocation intermediate

The first step of the reaction is the formation of two intermediates: X⁻ and a carbocation (note the lack of an octet for the carbocation). The hydrogen of HX will add to the carbon of the C=C that will generate the most stable carbocation. The Stability of the carbocation is determined by the number of carbons that surround the C⁺ atom. Adjacent carbons stabilized the carbocation by hyperconjugation (Bruice, sec 6.2) leading to the result that 3° is more stable than 2° which is more stable than 1°.

3.(a). Which of the structures drawn from question #1 would produce a 3° carbocation upon addition of H-Br?

(b) Draw the carbocation intermediate that would be formed for each of the compound(s) you choose in 3a above.

(c) Draw the products of the addition reactions for the compounds chosen in 3a

(d) Pertaining to the compounds you chose in 3a, note if the statements below are True or False

(T or F) For an addition reaction, the activation barrier (ΔG*) for these compounds is smaller than the rest.
(T or F) For an addition reaction, the Rate constant (k) for these compounds is smaller than the rest.
(T or F) These compounds would react more quickly than the rest.
In the reactions below we will analyze the same alkene reacting with 4 different acids. Each addition to the double bond will produce the same 3° carbocation but a different $X^\ominus$ intermediate.

4 a. Draw the $X^\ominus$ intermediate that would be formed for each of the reactions (A-D).

A:  

B:  

C:  

D:  

b. Note that the energy of 3° carbocation intermediate is the same for reactions A-D. We now will assess how the stability of the $X^\ominus$ intermediate can also determines the rate of the reaction. To determine the stability of $X^\ominus$ use the same parameters that you used to determine the stability of a ‘conjugate base’ in the previous acid/base assignment. The table below should also give you some clues

<table>
<thead>
<tr>
<th>Acidity and conjugate base</th>
<th>X$^-$</th>
<th>pK$\alpha$</th>
<th>HX $\rightarrow$ H$^+$ + X$^-$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Br$^-$</td>
<td>-2.2</td>
<td>HBr $\rightarrow$ H$^+$ + Br$^-$</td>
<td></td>
</tr>
<tr>
<td>F$^-$</td>
<td>3.2</td>
<td>HF $\rightarrow$ H$^+$ + F$^-$</td>
<td></td>
</tr>
<tr>
<td>HO$^-$</td>
<td>15.7</td>
<td>H$_2$O $\rightarrow$ H$^+$ + HO$^-$</td>
<td></td>
</tr>
<tr>
<td>CH$_3$O$^-$</td>
<td>16</td>
<td>CH$_3$O $\rightarrow$ H$^+$ + CH$_3$O$^-$</td>
<td></td>
</tr>
</tbody>
</table>

c. Using data in the table above, rank reactions A-D in order of reactivity (fastest to slowest) by matching the experimental order of reactivity given for reactions 1-4 below with reactions A-D.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Relative rate--(k value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0.0000001 (effectively no reaction)</td>
</tr>
<tr>
<td>4</td>
<td>0.0000001 (effectively no reaction)</td>
</tr>
</tbody>
</table>

1 is reaction _____ 2 is reaction _____ 3 is reaction _____ 4 is reaction _____

d. Construct a statement regarding on how $X^\ominus$ relates to the reactivity (rate of reaction) of an addition reaction.