1. Give the structure of the major product of each of the following reactions. In (b) and (d), think about how the reaction works and clearly show the relative stereochemistry of the product using wedges and dashed lines. In (b) do the two attaching atoms end up on the same side or on opposite sides of the ring? In (d) is the product cis or trans?

a. \((\text{CH}_3)_2\text{C}≡\text{CHCH}_3\) \(\xrightarrow{\text{H}_2\text{SO}_4, \text{H}_2\text{O}}\) c. \(\text{CH}_3\text{CH}_2\text{CH}≡\text{CH}_2\) \(\xrightarrow{\text{HCl}}\)

b. \(\text{CH}_3\) \(\xrightarrow{\text{Br}_2, \text{H}_2\text{O}}\) d. \(\text{CH}_3\)

2. In each case, assume that a mixture of products is expected, and show at least two possible products. Indicate which is the major product, and explain why. (CCl\(_4\) is a relatively nonreactive organic solvent.)

a. \(\text{Br}_2\) \(\xrightarrow{\text{H}_2\text{SO}_4, \text{H}_2\text{O}}\)

b. \(\text{CH}_3\text{CH}_2\text{OH}\) \(\xrightarrow{\text{HBr, CCl}_4}\)

c. \(\text{1. Hg(OAc)}_2, \text{H}_2\text{O, THF} \quad \text{2. NaBH}_4\)

d. \(\text{CH}_3\text{CO}_3\text{H}\)

3. Draw a reaction coordinate diagram for each of the following reactions. In each case, if more than one product is formed, be sure to draw more than one curve starting from the same reactant. Clearly indicate the relative vertical positions of reactants, transition states, intermediates, and products. Label each reactant, intermediate, and product with the structure for that species. Be sure to have a “balanced equation” — same atoms in reactant as product.

a. The reaction between 2-methyl-2-butene and HI. CACh calculations suggest that 2-iodo-2-methylbutane has a higher energy than 2-iodo-3-methylbutane.

b. The acid-catalyzed reaction between propene and methanol. Note that for this you will need both CH\(_3\)OH and CH\(_3\)OH\(^+\) as part of the reactants. Only one of these reacts in the first step.

4. Explain:

a. Why the complex mixture involving mercury is preferable to the addition of H\(_2\)SO\(_4\) with alkenes in organic synthesis. (What is the problem, and what is the solution?) Also address why from a Green Chemistry perspective we might want to try H\(_2\)SO\(_4\) anyway.

b. Why hydroboration results in the “anti-Markovnikov” addition of H\(_2\)O across 3-methyl-2-pentene. Include a carefully drawn depiction of the first transition state, comparing the two possibilities.

c. Why the addition of H\(_2\) to trans-2-pentene should release less energy than the addition of H\(_2\) to cis-2-pentene.