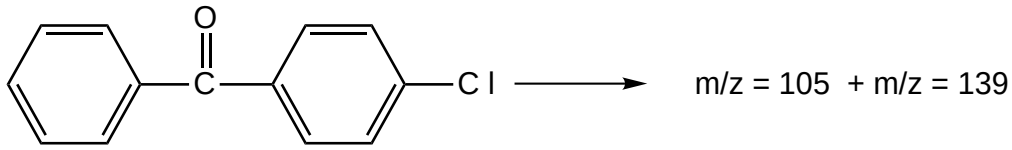
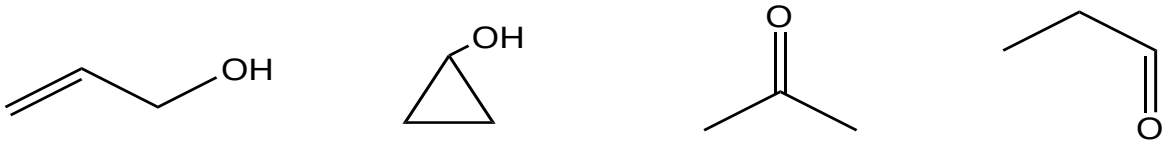
1. In the mass spectrum of p-chlorophenone there are two fragment ions observed with mass/charge ratios m/z = 105 and m/z = 139. Draw the chemical structure of the two ions that correspond to the observed fragments. Label each one with its appropriate mass/charge ratio. For atomic masses you should use C = 12 amu, H = 1 amu, Cl = 35 amu and O = 16 amu. Note that C_6H_5 = 77 amu.

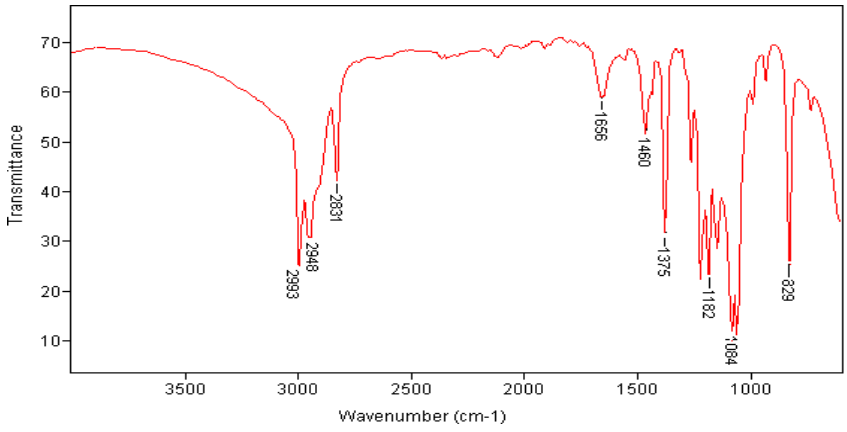


2. There are four *stable* isomers **A-D** with the structural formula C_3H_6O (shown below).

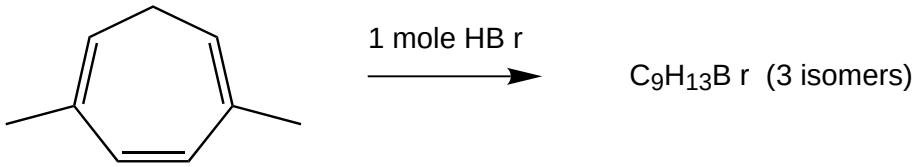


(a) From the following spectral data identify and label the structure of the four isomers **A-D**. Both **A** and **D** produce a broad resonance in their IR spectra at about 3200-3500 cm^{-1}. The NMR spectrum of **D** is very simple with only two resonances: one is a multiplet at about 3.0 ppm (1H) and the other is a doublet at about 0.3 ppm (4H). Both **B** and **C** produce a strong resonance in the IR spectrum just above 1700 cm^{-1}. The NMR spectrum of **C** is very simple with only a singlet at about 2.4 ppm.

3. A compound with the molecular formula $C_5H_{12}O_2$ has two NMR resonances, one at 3.18 ppm (s, 6H) and the other is at 1.33 ppm (s, 6H). The IR spectrum is given below. Deduce its chemical structure.

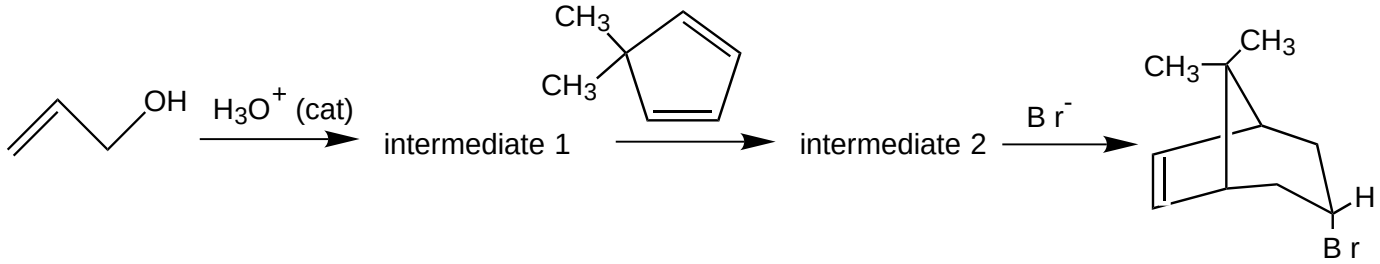


3. The reaction of 2,5-dimethyl-1,3,5-cycloheptatriene with 1 mole of HBr gives predominately three isomeric cycloheptadienyl bromides with the molecular formula $C_9H_{13}Br$.



Draw the chemical structures for each of the three isomers and indicate which one of the three is kinetically favored and which one is thermodynamically favored.

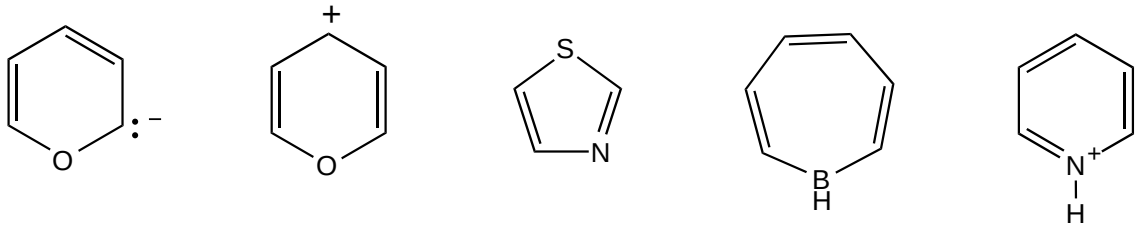
4. Consider the reaction of an allylic alcohol with dimethylcyclopentadiene illustrated below:



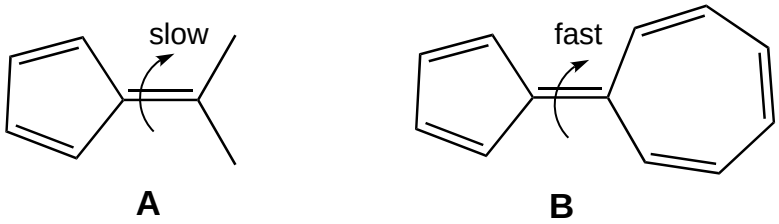
(a) Draw the chemical structure of intermediate 1. (b) Draw the chemical structure of intermediate 2.

(c) Using arrow formalism, illustrate how intermediate 2 is formed in the reaction of intermediate 1 with dimethylcyclopentadiene.

5. Circle each of the following molecules predicted to be aromatic.

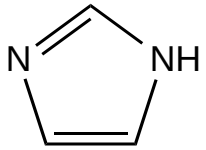


6. Consider the two molecules, **A** and **B**, given below. Rotation about the double bond indicated for **A** is slow, as would be expected. However, rotation about the comparable bond indicated for **B** is fast. Explain why the rotational barrier about the indicated bond for **B** is reduced. You should use a chemical structure as part of your explanation.



A **B**

7. The chemical structure of imidazole is given below. Imidazole is a weak base. Indicate with an arrow which of the two nitrogens is more basic. Use a drawing of the orbitals to explain your choice.



8. Draw the chemical structure(s) of the major product(s) expected for the following reactions. Indicate stereochemistry when relevant.