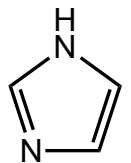
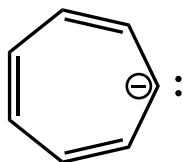


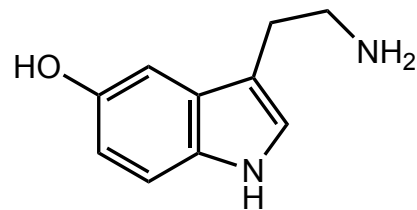
## Aromaticity and Benzene Worksheet

1. Identify any aromatic species shown in the set below. For all species, determine how many  $\pi$  e<sup>-</sup>s are present. For the aromatic species, determine the *n* value used in Huckel's Rule. If the system is not aromatic, explain why not.

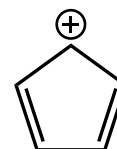
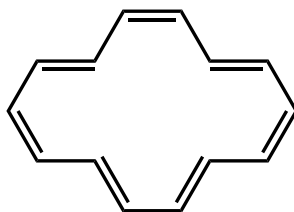
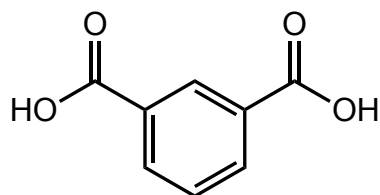
Note: Lone pairs on heteroatoms are implied.



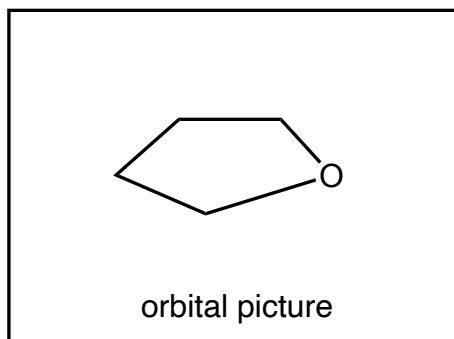
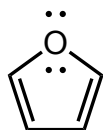
imidazole



serotonin



2A. Redraw furan (shown below) in a side on view clearly showing the p-orbital overlap that creates this aromatic system. Add electrons into the orbitals to help determine the number of  $\pi$  e<sup>-</sup>s present.



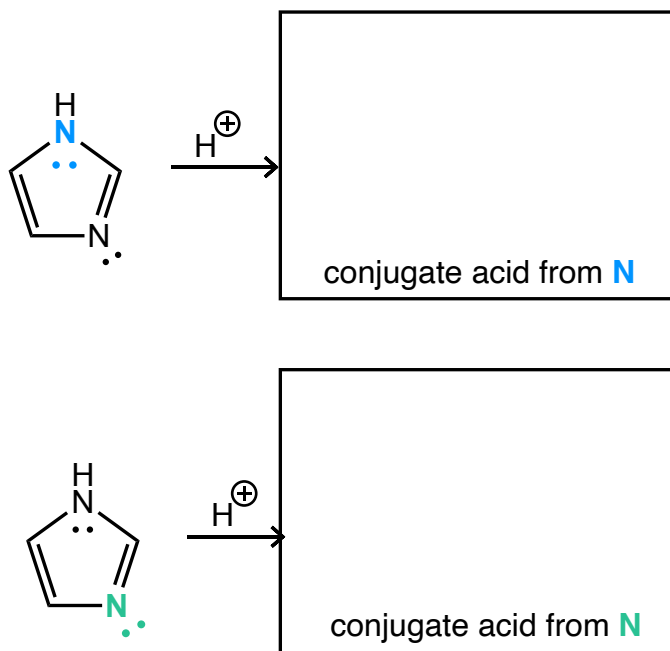
2B. What is the hybridization of the oxygen atom in furan?

2C. Based on your answer to 2B, what orbitals are the lone pairs on oxygen in?

3. Let's consider how aromaticity can influence acid-base chemistry by considering imidazole, an aromatic heterocycle. Aromaticity is an example of a stabilizing effect. Remember that systems that are more stable are often, less reactive.

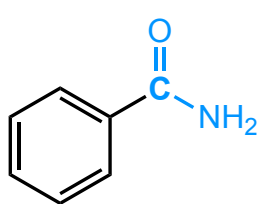
A. Given that imidazole has two nitrogen atoms, **draw structures for the two possible conjugate acids that can be formed.**

B. Based on your understanding of aromaticity and stability and **explain why one nitrogen atom in imidazole is actually more basic than the other.**

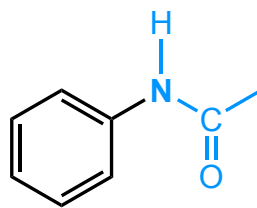


4. The connection to benzene is important to pay attention to when considering directing effects. Two amides are shown below, but notice **one is connected through a C—C bond whereas the other is connected through a C—N bond.**

A. Determine the directing effects of the group in compound **A** and compound **B**. Draw structures of the carbocation intermediates that support your prediction.



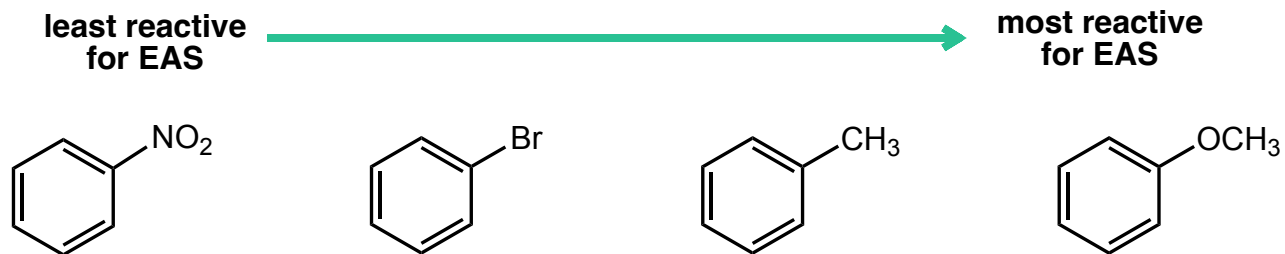
Compound **A**



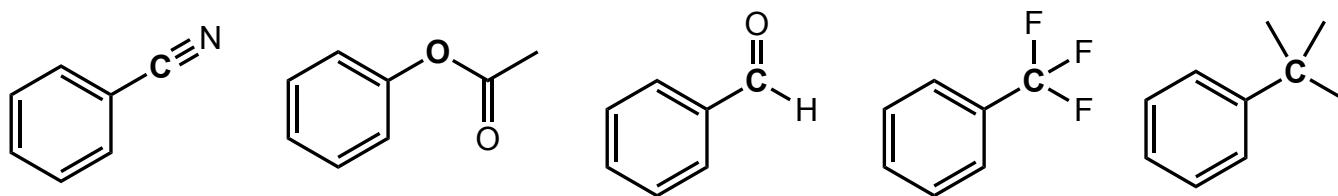
Compound **B**

C. Which compound (**A** or **B**) is more activated towards EAS chemistry, in which benzene serves as the nucleophile?

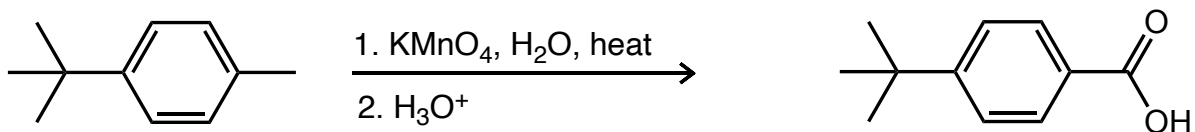
5. The substituted benzenes below are shown in order of increasing EAS reactivity. Explain the order.



6. Determine the directing ability of the groups shown below for EAS reactions.



7. Explain why only one R group was oxidized in the reaction below.



8. Draw the structure of the major organic product generated after each reaction in the series below. In reactions that generate *o*- and *p*- regioisomers, move forward with the *p*-product.

