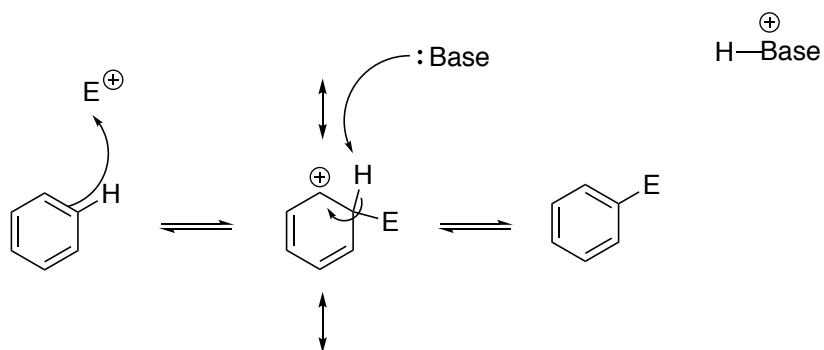

Electrophilic Aromatic Substitution Self-paced. To be completed while reading Chapter 15.

NAME:

List Study Partners:

Read sections 15.1 and 15.2. The General mechanism for electrophilic Aromatic Substitution (EAS) is:

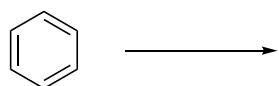


In order to nitrate the benzene ring...

1. What is the electrophile, E^+ in this case and what is the base?
2. Draw the three important resonance contributors for the arenium ion that forms.

3. Draw the hybrid arenium ion.

4. Write this as a reaction, add the reagents and draw the product.



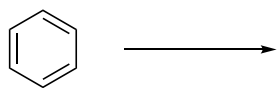
In order to brominate the benzene ring...

5. What is the electrophile, E^+ in this case and what is the base?

6. Draw the three important resonance contributors for the arenium ion that forms.

7. Draw the hybrid arenium ion.

8. Write this as a reaction, add the reagents and draw the product.



9. How do we chlorinate the benzene ring? What reagents are needed?

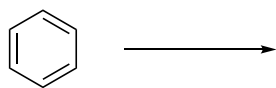
In order to sulfonate the benzene ring...

10. What is the electrophile, E^+ (be careful! - it's not ionic this time)?

11. Draw the three important resonance contributors for the arenium ion that forms.

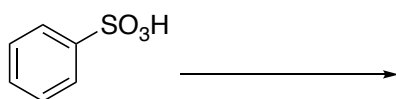
12. Draw the hybrid arenium ion.

13. Write this as a reaction, add the reagents and draw the product.



14. This is the only EAS reaction that is reversible. It is possible to remove the SO_3H group by heating the benzene sulfonic acid with aqueous acid (see section 15.5).

Demonstrate this as a reaction, add the reagents and draw the product.



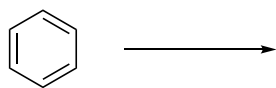
In order to alkylate the benzene ring...

15. What is the electrophile, E^+ (use a methyl group as a specific example)?

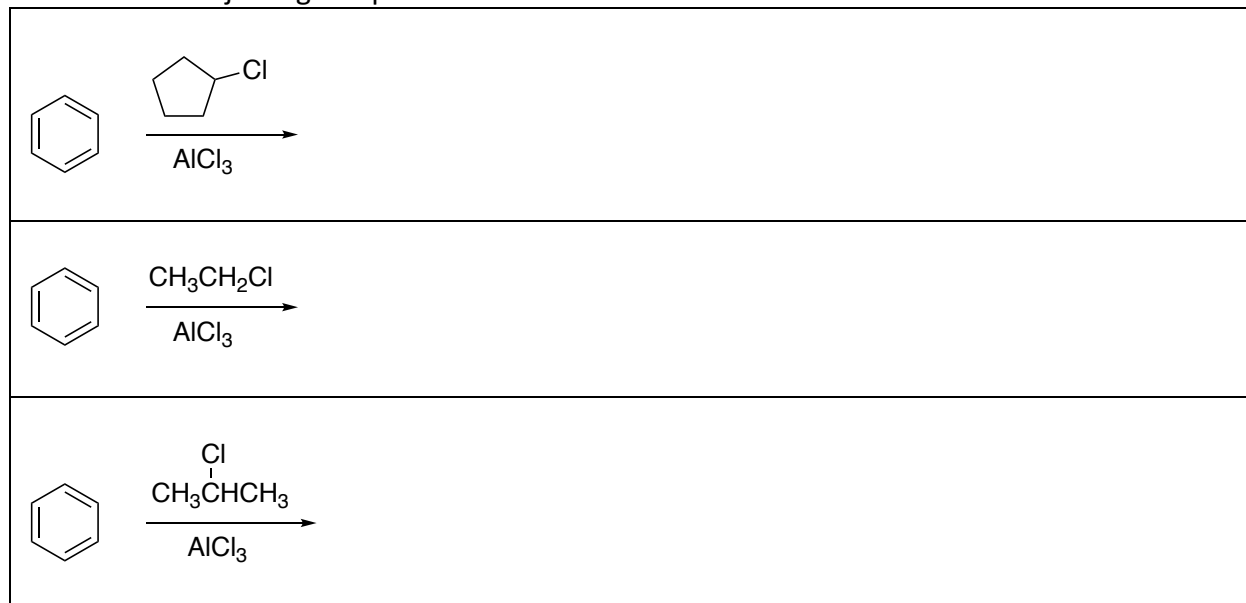
16. Draw the three important of the resonance contributors for the arenium ion that forms when adding a substituting a methyl group onto the ring.

17. Draw the hybrid arenium ion.

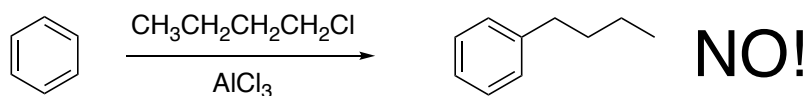
18. Write this as a reaction, add the reagents and draw the product.



19. Draw the major organic product for each of these reactions



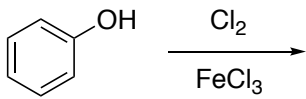
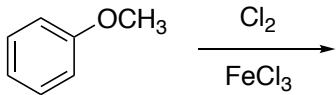
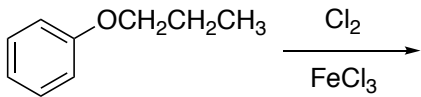
20. The following reaction does NOT happen. Why not? What is the major product instead?
Think carefully about the mechanism.

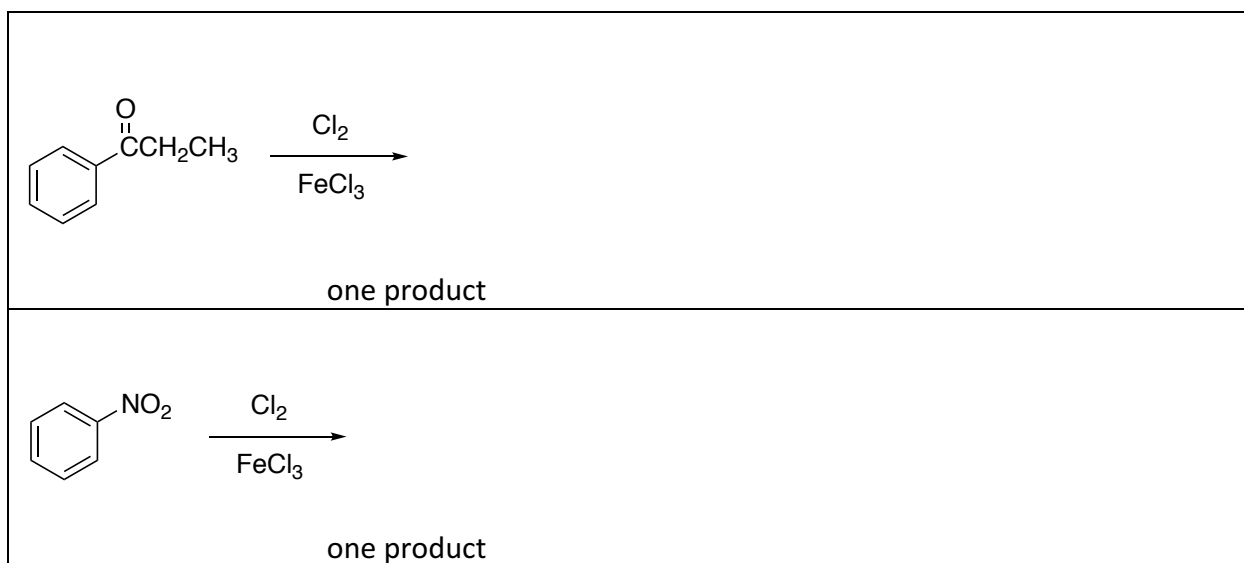


If one wished to make butyl benzene as in the previous example, the best plan is to perform an acylation reaction (see section 15.7 then to follow that with a reduction like the Clemmensen reduction (section 15.7A).

21. Show how butyl benzene could be synthesized from benzene using the approach outlined above.

22. After reading section 15.8 and using Table 15.1 as a resource, for each of the following reaction conditions, draw the major organic product(s).

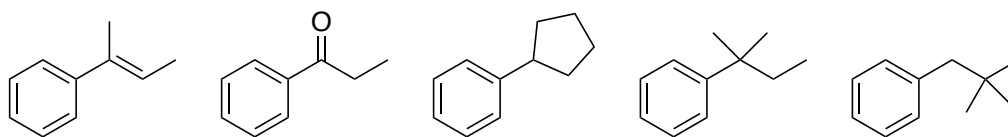
 <p>Reaction of phenol with Cl_2 and FeCl_3 catalyst.</p> <p>two products</p>
 <p>Reaction of anisole with Cl_2 and FeCl_3 catalyst.</p> <p>two products</p>
 <p>Reaction of propyl phenyl ether with Cl_2 and FeCl_3 catalyst.</p> <p>one product</p>



Read section 15.11D then answer the following questions.

23. What reagents are used to convert a benzene side chain into a carboxylic acid group?

24. Which of these molecules can not be easily converted to benzoic acid by side chain oxidation?



25. Beginning with benzene, outline the synthesis of m-nitrobenzoic acid.
 Monster Hint: alkylate first, then oxidize the side chain, then nitration last.

Synthesis of Complex Arenes

When considering the synthesis of a complex arene, there are a number of facts to consider:

- What groups can we attach?

Cl; Cl_2 / FeCl_3

Br; Br_2 / Fe powder

NO_2 ; HNO_3 / H_2SO_4

SO_3H ; SO_3 / H_2SO_4 (fuming sulfuric acid)

Alkyl; RCl / AlCl_3

Acyl; RCOCl / AlCl_3

- What groups have special facts?

SO_3H can also be removed later with H_3O^+

Alkyl might rearrange

Acyl can be reduced to alkyl with conc. HCl / Zn(Hg) / heat

Alkyl groups with benzylic H or π -bond can be oxidized to acid groups with KMnO_4

Alkyl and acyl can NOT be added in the presence of meta director

- Consider orientation of groups with respect to one another

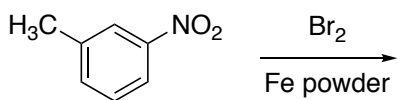
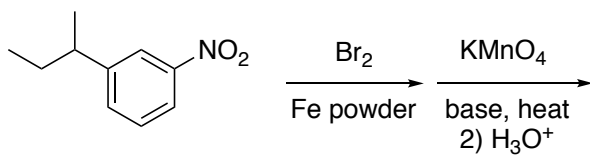
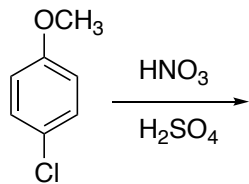
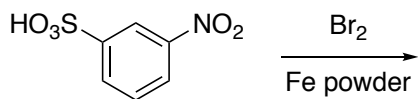
o/p- vs. m- directors

Learn this table:

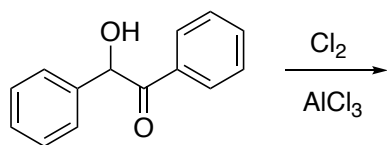
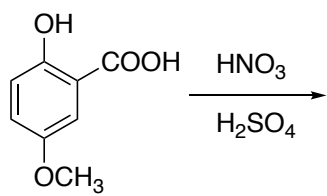
Ortho/para directors				Meta directors	
-OH -NH ₂	-OR -NH(C=O)R	-R	-X	-CN -SO ₃ H	-NO ₂ -NR ₃ (+)
Strongly activating	Moderately activating	Weakly activating	Weakly deactivating	Moderately deactivating	Strongly deactivating

- Important! When two or more groups are on the ring, the group that is more activating controls orientation
- When ring is activated to react between two meta- substituents, steric hindrance disfavors this reaction
- If a substituent is on the ring that is longer than three atoms, then ortho- substitution is disfavored.

26. For each of the following reaction conditions, draw the major organic product(s).



(two products)



Synthesis problems

Use the information from the synthesis of complex arenes page to guide you in these questions. Each problem begins with benzene and any other desired organic molecule with four or fewer carbons as well as any needed inorganic reagents and/or solvents. In each reaction, the desired product must be the major product.

27. Show how to prepare m-nitrobenzoic acid

28. Show how to prepare p-nitrobenzoic acid

29. Use sulfonation and desulfonation to show how to prepare o-nitrobenzoic acid on the back of the page.