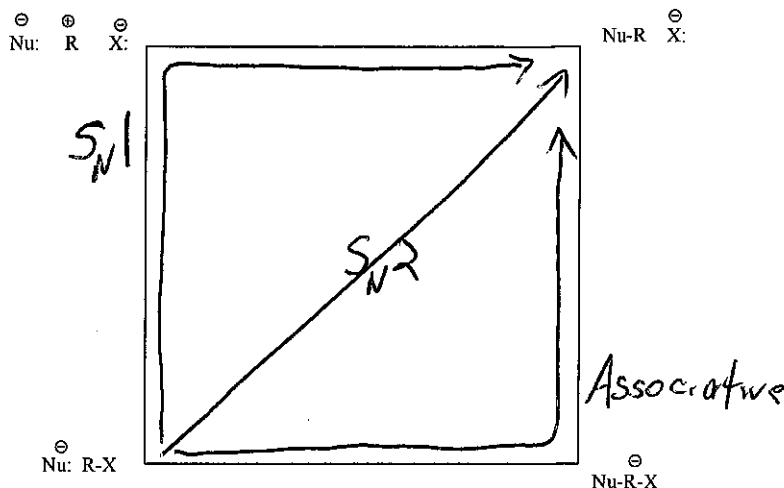


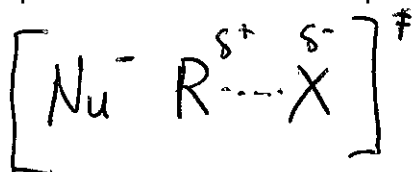
Name \_\_\_\_\_ Practice questions for exam

1. In the More-O'Farrell-Jencks Diagram below, draw the pathway for an  $S_N2$  reaction mechanism, an  $S_N1$  mechanism, and an associative mechanism.

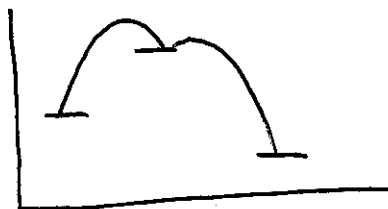


2. In a "coupled" substitution mechanism, bimolecular kinetics are observed because the presence of the nucleophile next to the substrate is required for ionization to occur, but no bond making occurs between the nucleophile and substrate in the transition state. It is a two step process, with the first step rate limiting.

- A. Draw a general transition state structure for this mechanism, using "Nu:-" for the nucleophile and "RX" for the electrophile.



- B. Draw an energy diagram that is consistent with this mechanism. (Assume that the reaction is exothermic.)

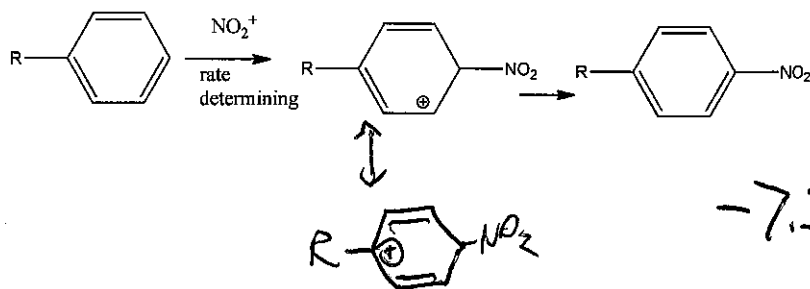


- C. Would you expect the stereochemistry to be retention, inversion, or a mixture of retention and inversion? Explain.

Inversion, because the  $\text{Nu:}^-$  stabilizes opposite of the leaving group, next to the carbocation that forms. The  $\text{Nu:}^-$  will attack quickly in the next step, giving primarily inversion, small amount of retention.

3. Match the following rho values with the appropriate reaction. Explain your reasoning. Rho values are +2.45, +0.75, -2.39, and -7.29

A. Nitration of substituted benzene



negative, large magnitude  
(resonance)

-7.29

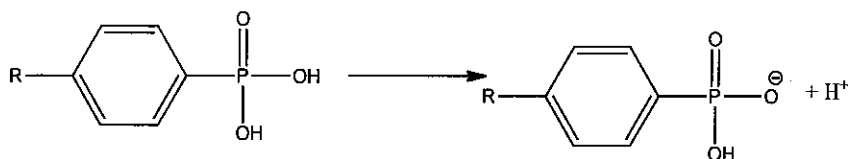
B. Ionization of substituted benzenethiols



positive, large magnitude  
(resonance)

+ 2.45

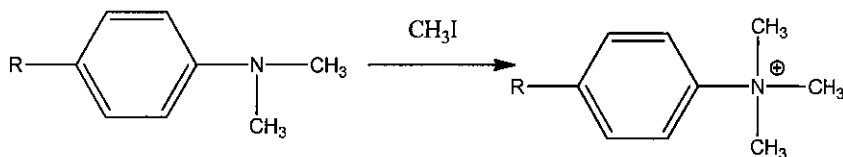
C. Ionization of substituted benzenephosphonic acids



positive, lower magnitude  
(no direct resonance)

+ .75

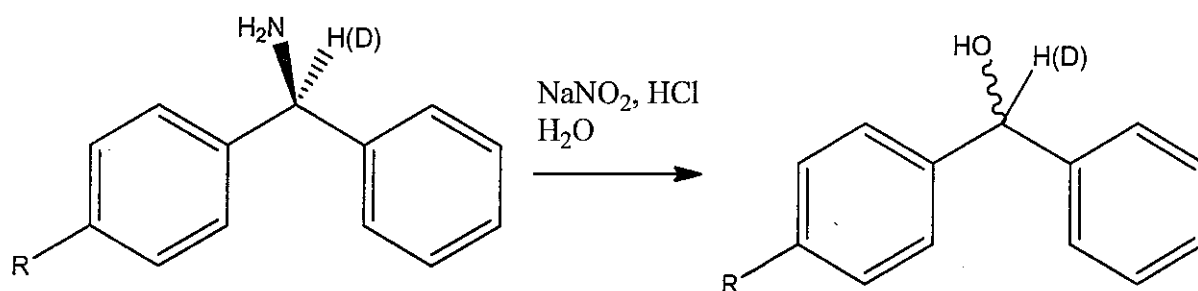
D. Substitution of aniline derivative



negative, lower magnitude  
(no direct resonance)

- 2.39

4. (16pts) You decide to explore the mechanism of a substitution reaction that is very similar to the one that you already performed in lab:



First, you ran a series of LFER experiments with various R groups, and you obtained a very large, negative rho value of -5.7. What does this suggest about the mechanism of your reaction?

A large, positive charge is being stabilized in the TS

Next, you ran the experiment with and without deuterium label, and you obtained a Kinetic isotope effect of 1.35. What does this suggest about the mechanism of your reaction?

Probably a secondary KIE. It is normal, suggesting rehybridization of  $\text{sp}^3 \rightarrow \text{sp}^2$ .

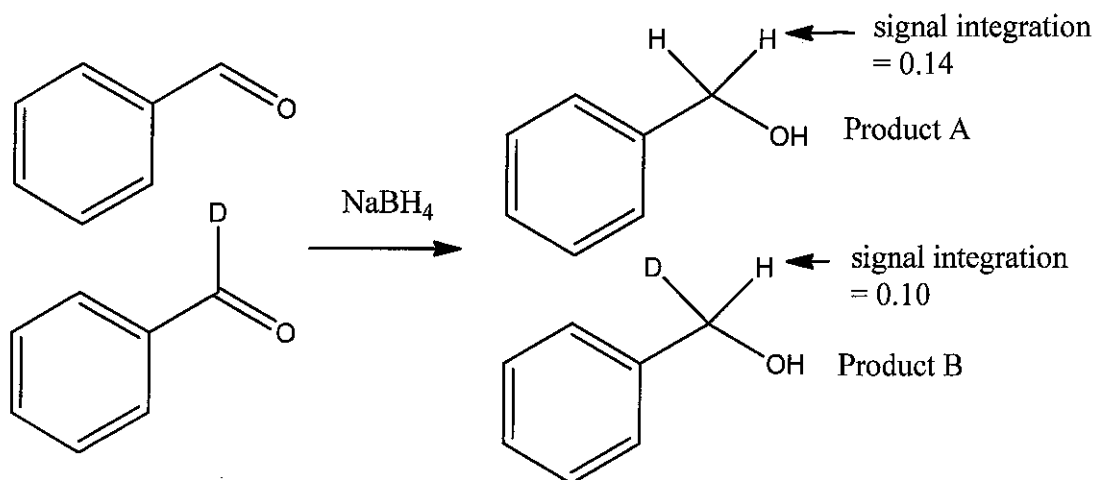
Based on these data, is the mechanism most likely  $\text{S}_{\text{N}}1$ ,  $\text{S}_{\text{N}}2$ , anchimeric assisted, or a borderline mechanism?

$\text{S}_{\text{N}}1$  is most consistent.

Based on your proposed mechanism, would you expect the optical rotation of your final product to be positive, negative, or approximately zero, or can't you tell from these data?

IF full  $\text{S}_{\text{N}}1$ , then optical rotation would approach zero, but there is likely some retention.

5. (10pts) To study borohydride reductions of aryl carbonyls, you ran a competition reaction for the reduction of benzaldehyde and deuterated benzaldehyde.



- Relative to the amount of benzaldehyde you start with in your competition, how many equivalents of hydride should you use in your competition experiment? How many equivalents of sodium borohydride?
- You looked at the NMR of the crude mixture and saw a singlet at 3.4ppm with integration of 0.14 that corresponded to the benzyl protons of product A. There was a triplet at 3.45 ppm with integration of 0.10 that corresponds to the benzyl proton of product B. (The triplet occurs because of how deuterium splits hydrogen, which you haven't seen before.) Based on these data, what is the relative amount of products A and B formed? (Think through this!)
- Calculate the Kinetic isotope effect for this experiment. ( $\text{KIE} = k_{\text{H}}/k_{\text{D}}$ ). Show how you determined this value.
- Is this kinetic isotope effect primary or secondary? Is it normal or inverse?
- Propose a mechanism for this borohydride reduction, and explain how these KIE data support this mechanism.

- A. Ideally, 0.2 equivalents (10% conversion) but up to 1 eq.
- B. Each  $\text{NaBH}_4$  has 4 equiv. of Hydride, so ideally, 0.05 equiv.
- B. Remember that pdt B has only one H/molecule, so take that into account.

$$\text{Relative [A]} = 0.14 \quad \text{Relative [B]} = 2(0.10) = 0.20$$

C. 
$$\text{KIE} = \frac{k_H}{k_D} = \frac{0.14}{0.20} = 0.7$$

D. This is a secondary, inverse effect.

E. Mechanism involves  $sp^2 \rightarrow sp^3$  rehybridization

