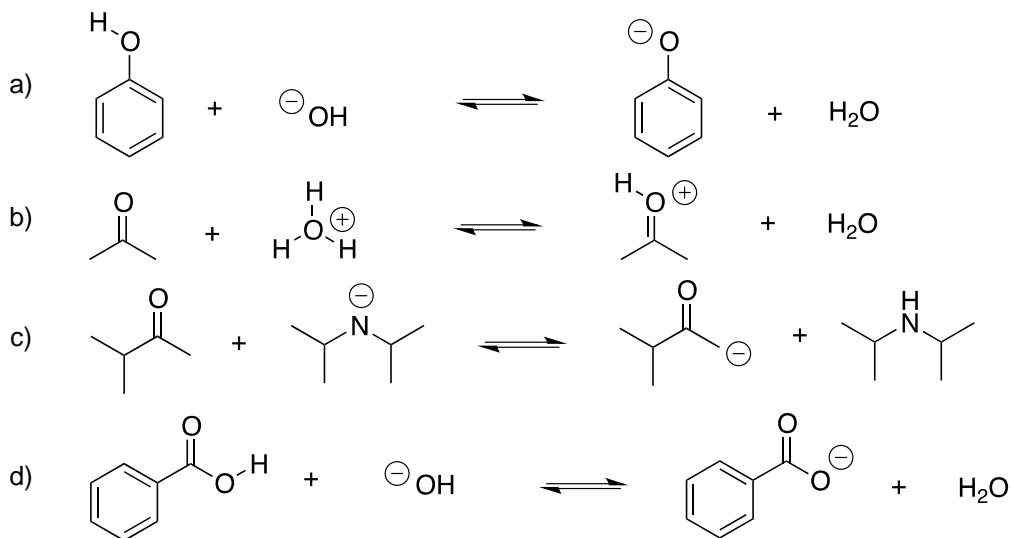
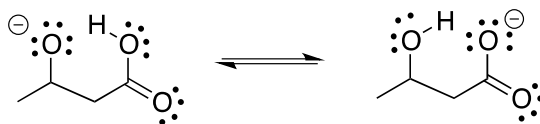


1. Below are a few examples of acid-base reactions in which structures of reactants and products are drawn without lone-pair electrons. 1) Fill-in lone pairs on atoms in both reactants and products, where necessary, 2) Using curved arrows, illustrate how the reaction is taking place, and 3) label the acid, base, conjugate acid, and conjugate base.

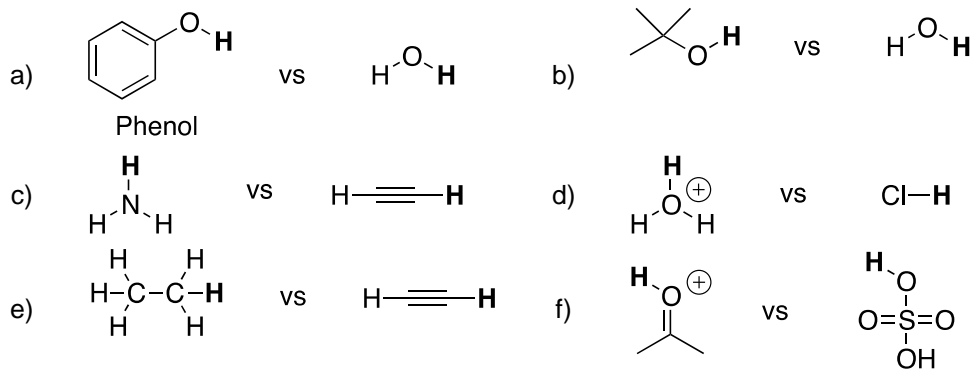


2. In an intramolecular (i.e. within the molecule) proton transfer reaction, the acidic site and the basic site are tethered to the same molecule, and a proton is passed from the acidic region of the molecule to the basic region of the molecule, as shown below:

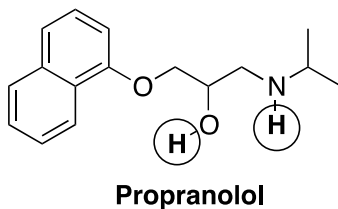


Draw the mechanism using curved-arrows for this process.

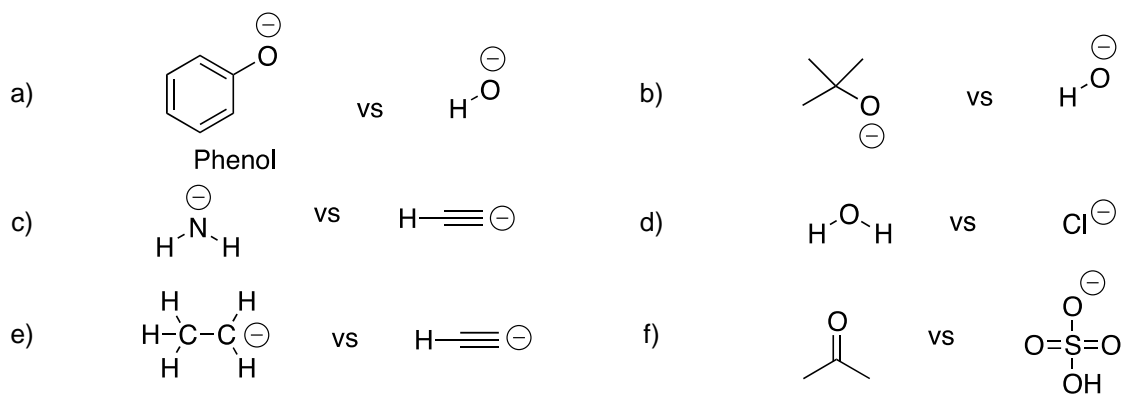
3. For each pair of compounds below, identify the more acidic compound.



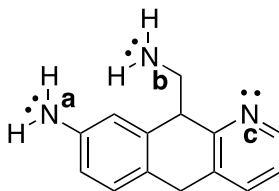
4. Propranolol is an antihypertensive agent (used to treat high blood pressure), which contains two acidic protons circled in the molecule below. By referring to the functional group priority list, which functional group can be related to each proton? Then, identify which of the two protons is more acidic.



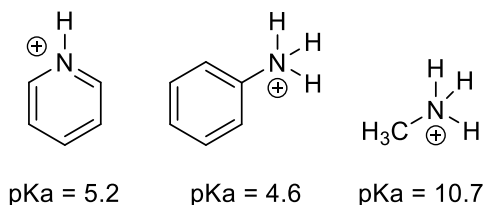
5. The followings are conjugate bases of compounds from question 3. For each pair of compounds below, identify the stronger base.



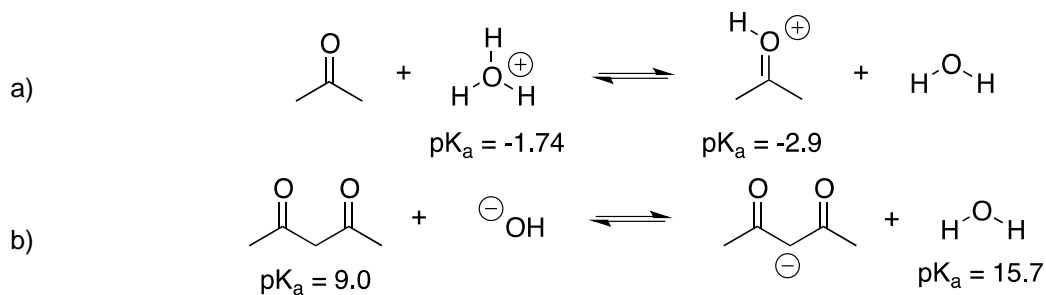
6. The following compound has three nitrogen atoms:



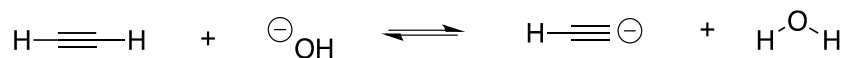
Each of the nitrogen atoms exhibits a lone pair that can function as a base (to abstract a proton from an acid). Rank these three atoms in terms of increasing base strength using the following information:



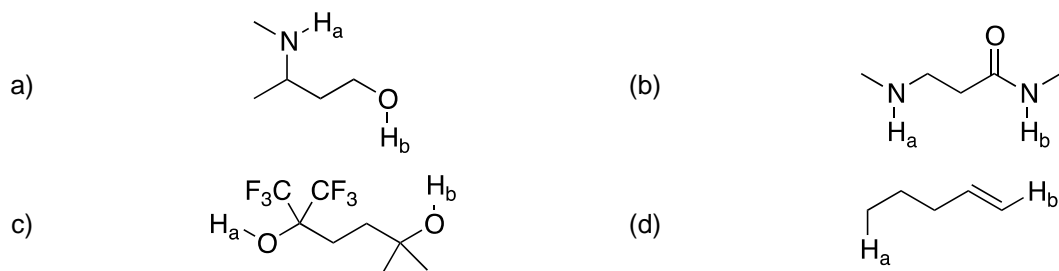
7. Using pK_a values provided, determine the position of equilibrium for each of the following two proton transfer reactions:



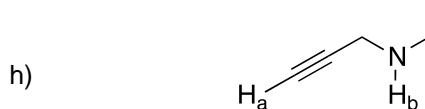
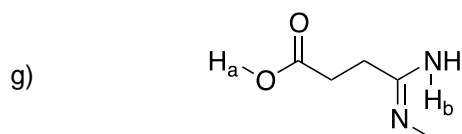
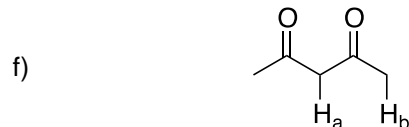
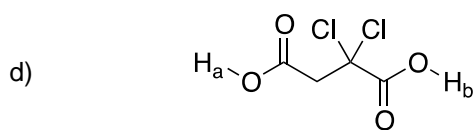
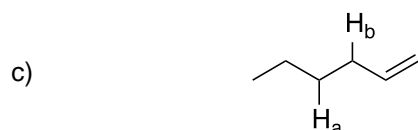
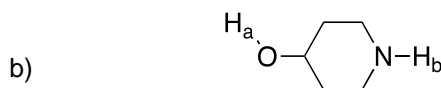
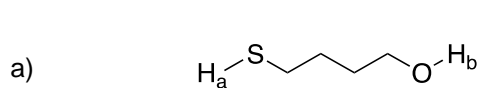
8. Identify the acid and the conjugate acid in the reaction below. What are pK_a for these? Would the following reaction equilibrium favour the reactants or the products? Explain your answer.



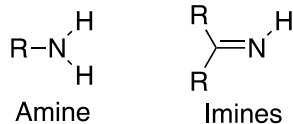
9. Compare the two protons (H_a and H_b) that are shown in each of the following compounds. Which one is more acidic? Explain your answer. (*i.e.* it may be very useful to draw out the structure of conjugate base obtained when each proton (H_a and H_b) has been donated)



10. In each of the compound below, identify which between the two protons (H_a vs H_b) is more acidic.



11. Amines contain C-N single bonds, while imines contain C-N double bonds:

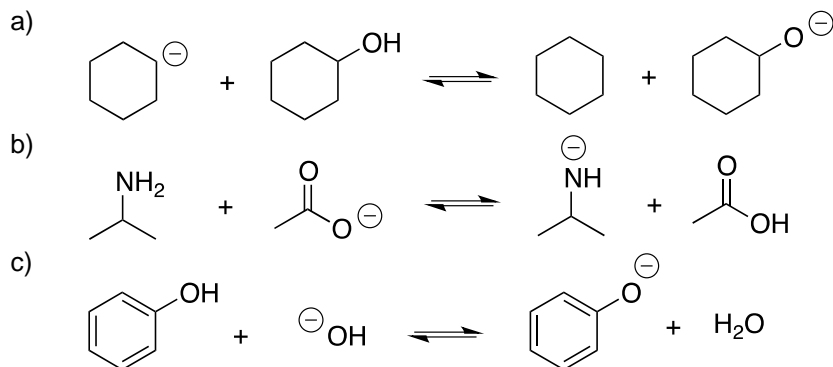


R = generic symbol for any alkyl groups

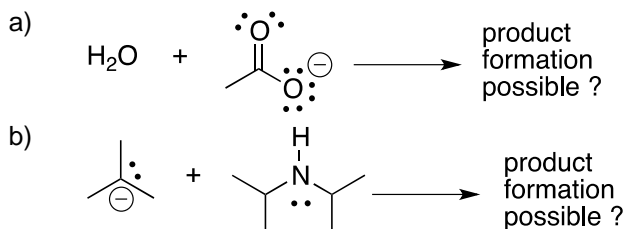
Most simple amines have a pK_a somewhere in the range between 35 and 45. Based on this information, predict which of the following statement is most likely to be true, and explain the reasoning behind your selection:

- (a) Most imines will have a pK_a below 35
- (b) Most imines will have a pK_a above 45
- (c) Most imines will have a pK_a in the range between 35 and 45

12. Considering the rules in predicting the equilibrium of acid-base reactions, and the factors determining the strength of acids (ex. Electronegativity, size, hybridization, inductive and resonance effect) we learned in class, predict the position of equilibrium, without using pKa, for each of the following reactions:

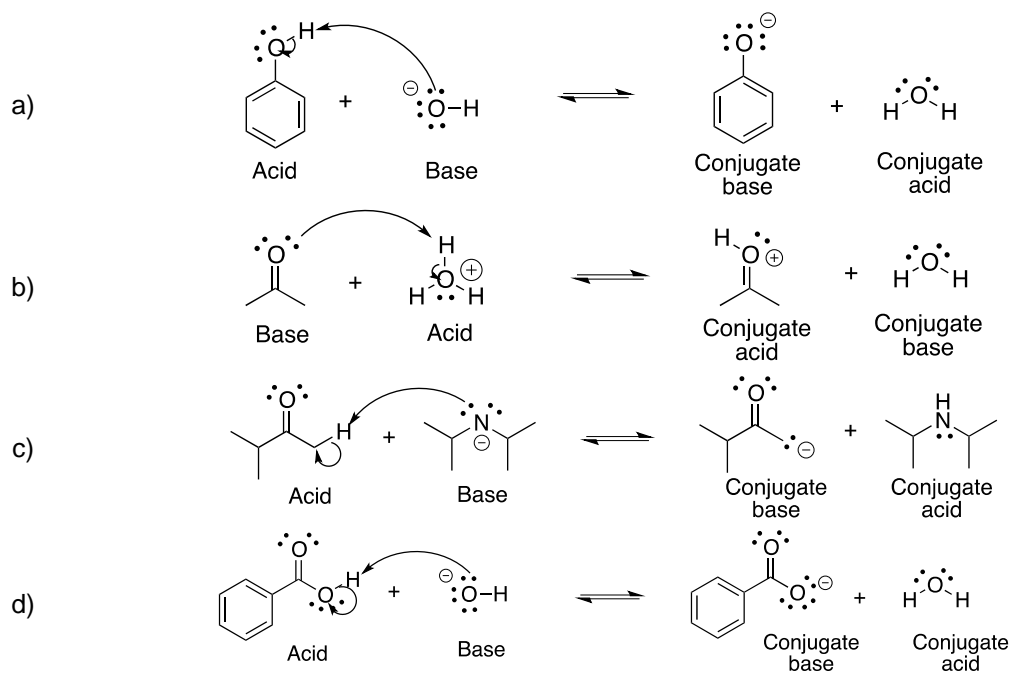


13. Referring to the list of the reactions in question 12, for each reaction, i) identify the Lewis acid and the Lewis base, ii) identify which is nucleophile and electrophile, and iii) Fill in the lone-pairs and show how the reaction is taking place using curved-arrows.
14. Can the mixing of the reactants provided in each of the following reactions successfully yield the products? Explain your answer. (Hint: In order for the reaction to proceed forward, the strength of base in the reactant side must be greater than the strength of the conjugate base of acid expected in the product side)

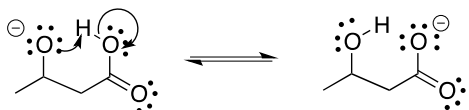


Solutions

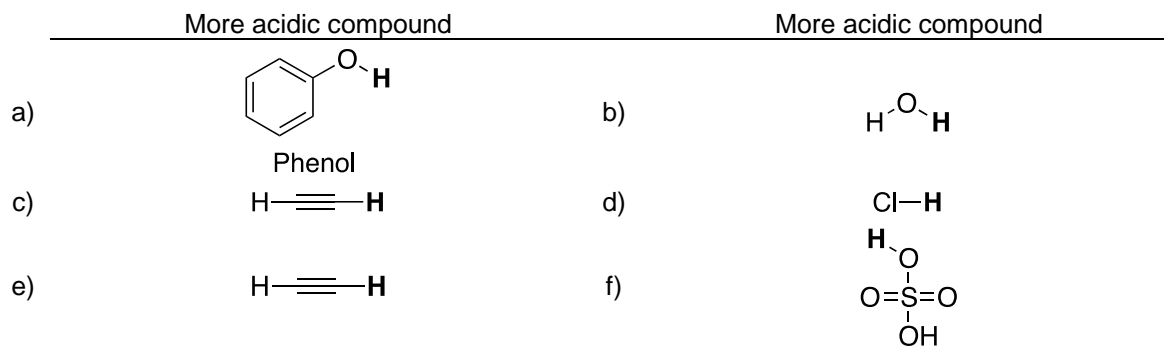
1.



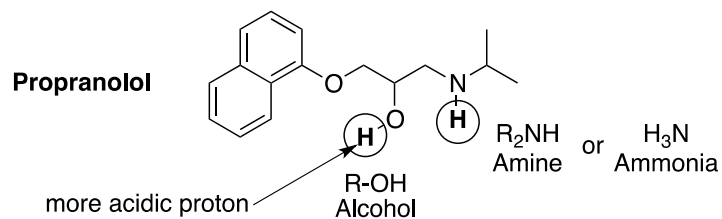
2.



3.

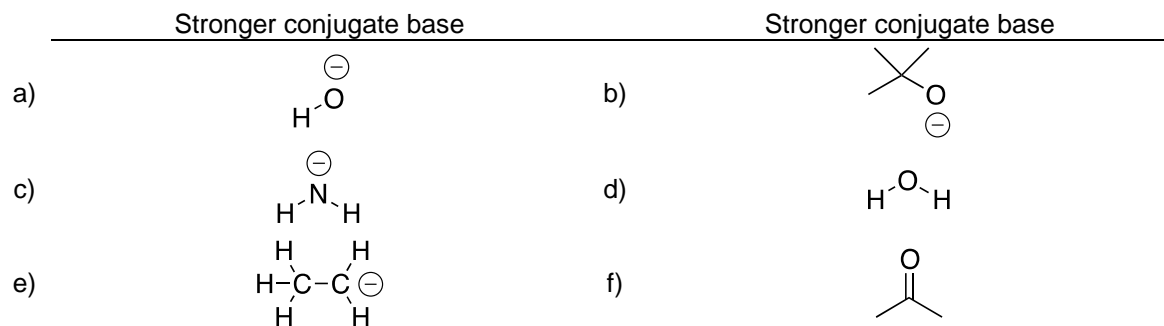


4.

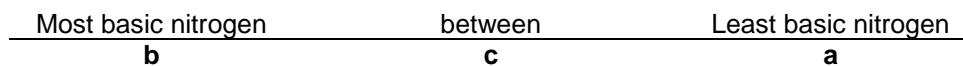


pK_a alcohol is much lower than pK_a amine (or ammonia)

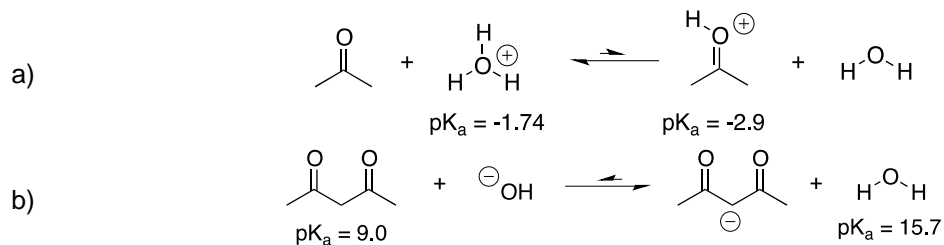
5.



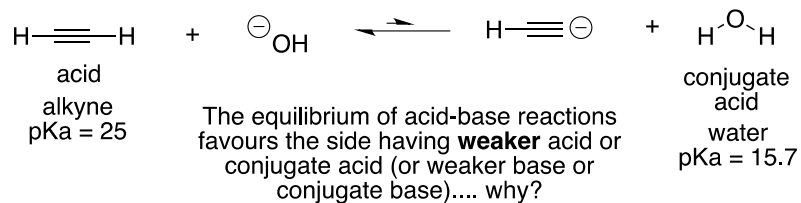
6.



7.



8.



9.

	Structure	More acidic proton?	Your explanation must be based on,
a)		H_b	electronegativity
b)		H_b	Resonance stabilization
c)		H_a	Inductive stabilization
d)		H_b	Hybridization

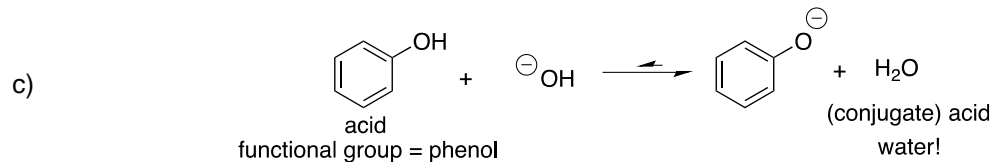
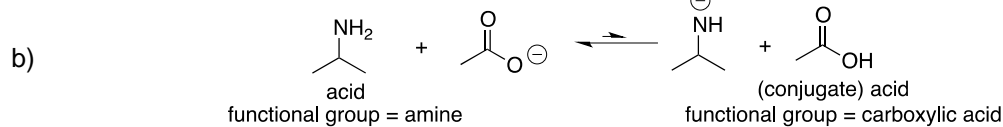
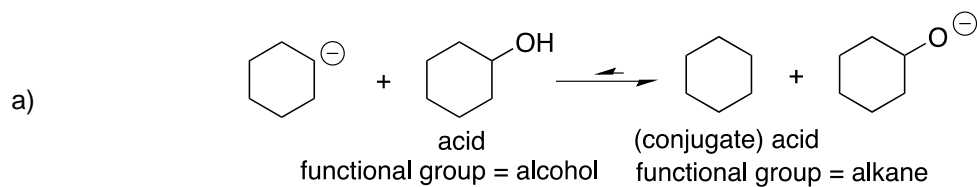
10. Convert each of the compounds given in condensed structures, first, into dash-line structures and, finally, into bond-line structures. Include lone-pair electrons and formal charges, where necessary.

	More acidic proton	Factor(s) to consider in determining the more acidic proton
a)	H_a	size
b)	H_a	Electronegativity
c)	H_b	Resonance stabilization
d)	H_b	Both Inductive and resonance stabilization
e)	H_a	Resonance stabilization and hybridization
f)	H_a	(A number of) Resonance stabilization
g)	H_a	Electronegativity and resonance stabilization
h)	H_a	Electronegativity and hybridization

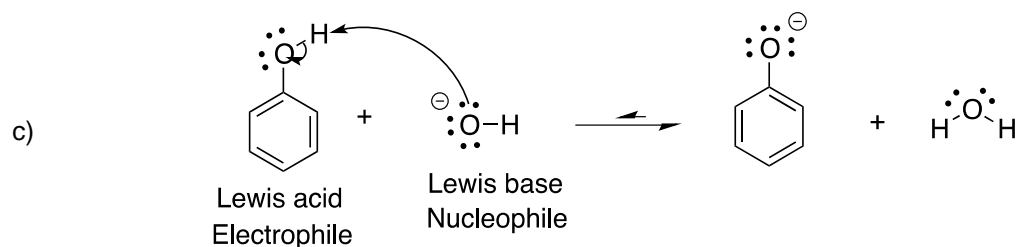
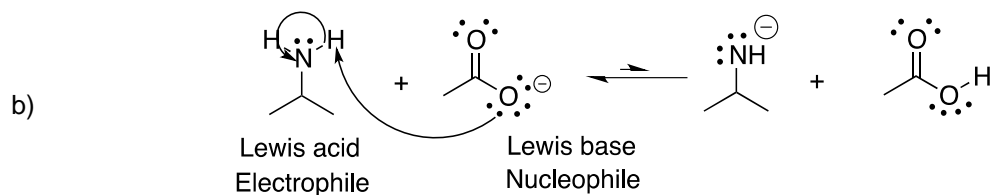
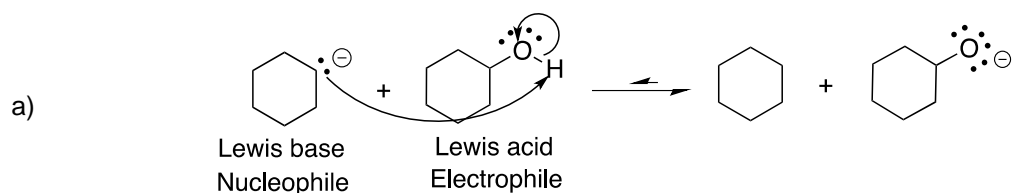
** Attempt to come with your own reason in a short answer (or paragraph) that clearly defines why H_a is more acidic than H_b (or vice versa) based on the factors determining the strength of acids.

11. The statement (a), "Most imines will have a pK_a below 35", is most likely to be true based on the hybridization factor.

12.



13.



14. a) The reaction cannot proceed forward when these reactants are mixed; therefore, no product formation is observed

b) The reaction will proceed forward, and the successful yield of products are allowed.

*Please try to rationalize these results in a + b. Are you fully convinced with the statements above?