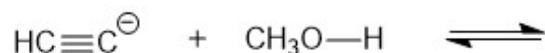
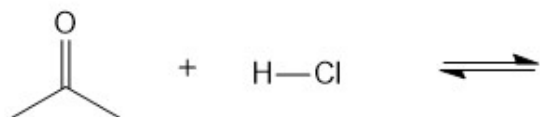


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 Chapter 3 Acid-Base Reactions (Proton Transfer) - Part 1

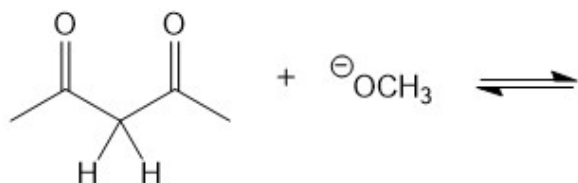
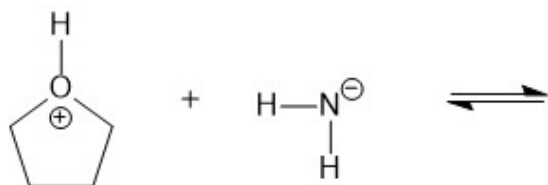


- 1 **Group work:** *protonate* each compound with the given acid (add missing lone pairs, draw curved arrows to show mechanism, draw the products and label them C.A. and C.B.).



2

- Group work:** *deprotonate* each compound with the given base (add missing lone pairs, draw curved arrows to show mechanism, draw the products and label them C.A. and C.B.).



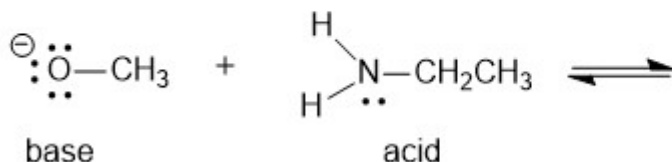
- 3 Draw the conjugate acid or conjugate base, as directed, for each.

conjugate base of
 NH_3

conjugate acid of
 H_2O

conjugate acid of
 $\text{H}:\ominus$

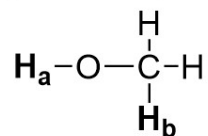
- 4 **Group work:** Predict the products, use curved arrows to show the mechanism for the proton transfer reaction, determine the favored direction of equilibrium, and explain your choice.



5 Which is the stronger acid? Explain briefly.

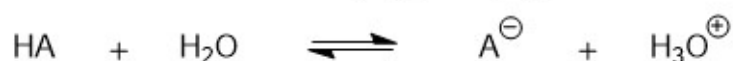


6 What is the most acidic proton in methanol, CH_3OH (H_a or H_b)? Explain briefly.



Acid Dissociation Constant, K_a , and $\text{p}K_a$ are measures of acid strength (3.3)

(from lecture notes page 3-7)



if HA is a STRONG acid

if HA is a WEAK acid

K_a is the acid
dissociation constant

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$$

since K_a is often VERY
large or VERY small, it's
easier to work with $\text{p}K_a$

$$\text{p}K_a = -\log(K_a)$$

K_{eq} is the
equilibrium constant

$$K_{\text{eq}} = \frac{[\text{products}]}{[\text{reactants}]}$$

if K_a is a LARGE number (>1), then the acid is stronger weaker

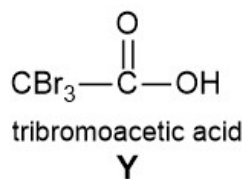
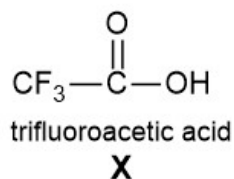
if an acid is stronger, then the $\text{p}K_a$ is higher lower

for example, sulfuric acid (H_2SO_4) has a K_a of $\sim 1.6 \times 10^5$ and a $\text{p}K_a$ of -5.2

acetic acid ($\text{CH}_3\text{CO}_2\text{H}$) has a K_a of 1.8×10^{-5} and a $\text{p}K_a$ of 4.75

7

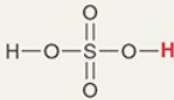
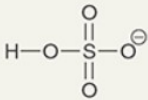






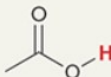
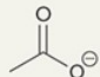
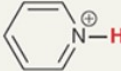

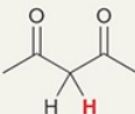
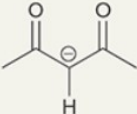
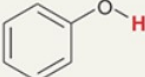
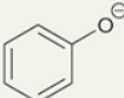


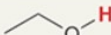

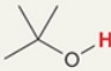

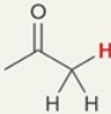
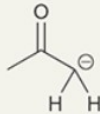
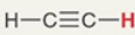
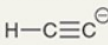



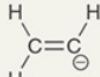
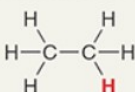
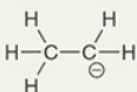
What predictions can you make about the relative K_a and $\text{p}K_a$ values of the two acids shown below? Justify your answers.



Klein Table 3.1 pK_a Values of Various Acids

TABLE 3.1

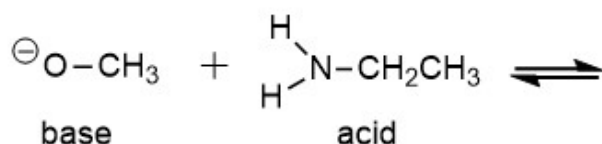
pK_a VALUES OF COMMON COMPOUNDS AND THEIR CONJUGATE BASES

	ACID	pK _a	CONJUGATE BASE	
Strongest acid		-9		Weakest base
		-7.3		
		-7		
		-1.74		
		4.75		
		5.3		
		9.0		
		9.9		
		15.7 (see margin note)		
		16.0		
		18.0		
		19.2		
		25		
		38		
		44		
Weakest acid		50		Strongest base

3 Draw the conjugate acid or conjugate base, as directed, for each.

	conjugate base of NH_3	conjugate acid of H_2O	conjugate acid of $\text{H}:\ominus$
A)	NH_2^\ominus	$\text{H}_3\text{O}^\oplus$	H_2O
B)	NH_4^\oplus	OH^\ominus	H_2O
C)	NH_2^\ominus	OH^\ominus	H_2
D)	NH_2^\ominus	$\text{H}_3\text{O}^\oplus$	H_2
E)	NH_4^\oplus	OH^\ominus	H_2

4 Predict the products and determine the direction of the equilibrium (forward or reverse favored?). Explain briefly.



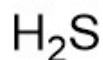
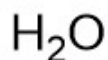
A) **Reverse** reaction is favored. (-) charge on electronegative oxygen is more stable, making CH_3O^- a **weaker base** than $\text{CH}_3\text{CH}_2\text{NH}^-$.

B) **Reverse** reaction is favored. (-) charge on electronegative oxygen is more stable, making CH_3O^- a **stronger base** than $\text{CH}_3\text{CH}_2\text{NH}^-$.

C) **Forward** reaction is favored. (-) charge on electronegative oxygen is more stable, making CH_3O^- a **weaker base** than $\text{CH}_3\text{CH}_2\text{NH}^-$.

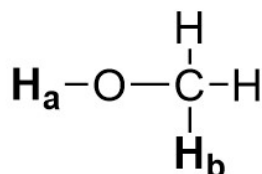
D) **Forward** reaction is favored. (-) charge on electronegative oxygen is more stable, making CH_3O^- a **stronger base** than $\text{CH}_3\text{CH}_2\text{NH}^-$.

5 Which is the stronger acid? Explain briefly.



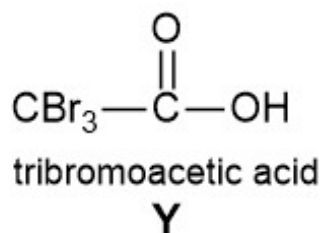
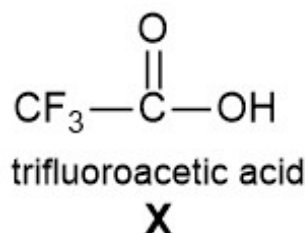
- A) H_2O is the stronger acid because HO^- is **more** stable than HS^- .
- B) H_2O is the stronger acid because HO^- is **less** stable than HS^- .
- C) H_2S is the stronger acid because HS^- is **more** stable than HO^- .
- D) H_2S is the stronger acid because HS^- is **less** stable than HO^- .
- E) It's impossible to predict acid strength without pK_a data.

6 What is the most acidic proton in methanol, CH_3OH (H_a or H_b)? Explain briefly (CB = Conjugate Base).



- A) **H_b is more acidic.** Because carbon is less electronegative, CB-b is more stable than CB-a.
- B) **H_b is more acidic.** Because carbon is less electronegative, H_a is more stable than H_b .
- C) **H_a is more acidic.** Because oxygen is more electronegative, CB-a is more stable than CB-b.
- D) **H_a is more acidic.** Because oxygen is more electronegative, H_a is more stable than H_b .
- E) **H_a is more acidic.** Because oxygen is more electronegative, H_b is more stable than H_a .

What predictions can you make about the relative K_a and pK_a values of the two acids shown below? Justify your answers.



- A) **X** has the larger K_a and the larger pK_a .
- B) **X** has the larger K_a and the smaller pK_a .
- C) **Y** has the larger K_a and the larger pK_a .
- D) **Y** has the larger K_a and the smaller pK_a .