Chemistry 233
Chapter 2 Problem Set

Acids and Bases – General Information

Bronsted-Lowry Acid – Proton (H^+) donor
Bronsted-Lowry Base – Proton (H^+) acceptor

Lewis Acid – Electron pair acceptor
Lewis Base – Electron pair donor

<u>Analyzing the acidity of organic acids:</u>

- As the pKa of a compound decreases, its acidity increases.
- As the stability of its conjugate base increases, the acidity of the acid increases.
  - Conjugate base stability factors:
    - For atoms in the same row, a negative charge on a more electronegative atom is more stable.
    - For atoms in the same column, a negative charge on a larger atom is more stable.
    - A conjugate base whose negative charge is delocalized through resonance is more stable than one that is not.
    - Inductive stabilization: nearby electron withdrawing groups help to stabilize a negative charge by inductively withdrawing electron density.
    - Orbital considerations: A negative charge on an sp-hybridized carbon is more stable than one on an sp^2-hybridized carbon, which is more stable than one on an sp^3-hybridized carbon
- To predict the equilibrium of an acid/base reaction, write out the full reaction and label the acid, base, conjugate acid, and conjugate base. Compare the stability of the base and conjugate base. The reaction will lie to the side of the more stable base/conjugate base.

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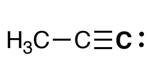
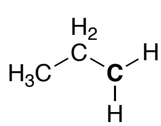
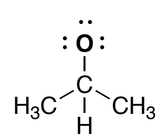
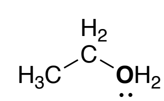
1) Classify each bond below as ionic, non-polar covalent, or polar covalent. For the polar covalent compounds, indicate the direction of the dipole.

$Na-Br$ $\quad$ $H-Cl$ $\quad$ $H_3C-CH_2CH_3$ $\quad$ H_3CO-H

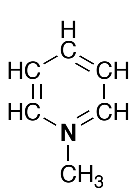
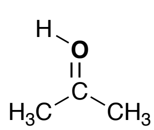
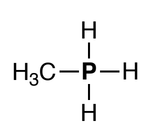
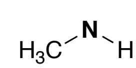
$Br-Br$ $\quad$ $H-OH$ $\quad$ H_3C-CF_3 $\quad$ $H-CH_3$

$F-Cl$ $\quad$ H_3C-OH $\quad$ $Br-Mg-Br$ $\quad$ $Li-CH_2CH_3$

2) Determine the formal charge on each of the **bold** atoms below. Lone pairs have been drawn in for you.

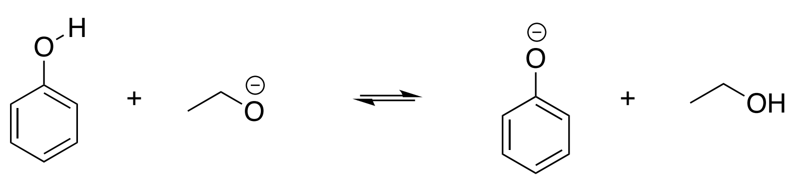
3) Determine the formal charge on each of the **bold** atoms below. You must draw in lone pairs as appropriate.

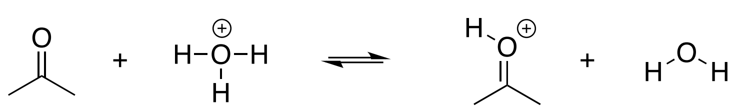





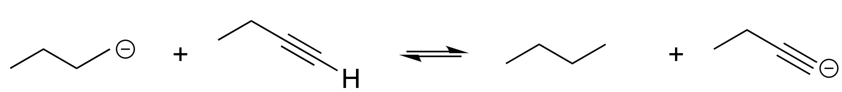
4) Draw Lewis structures for the following ions.
Heteroatoms with a "-" charge have one fewer bond and one more lone pair than usual.
Heteroatoms with a "+" charge have one more bond and one fewer lone pair than usual.

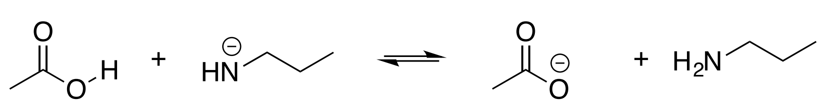
$C_3H_7O^-$	$C_4H_{12}N^+$	$C_3H_7^+$	$C_2H_3ClN^-$
a) ⊖ on oxygen	⊕ on nitrogen	⊕ on carbon	a) ⊖ on nitrogen
b) ⊖ on carbon			b) ⊖ on carbon

5) Use curved arrows to show the flow of electrons for each of the acid-base reactions shown below.

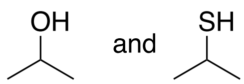


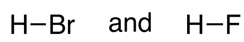


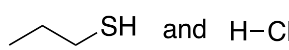


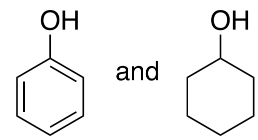


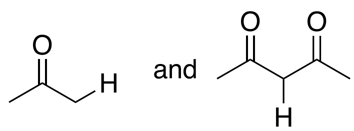
6) For each of the pairs of compounds below, identify the more acidic compound. List the factor that led you to your choice.

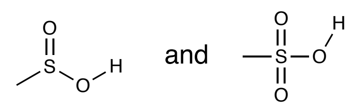


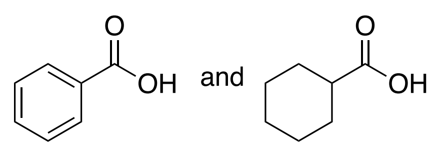


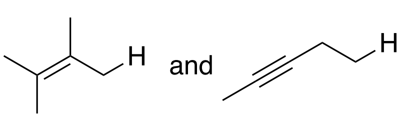


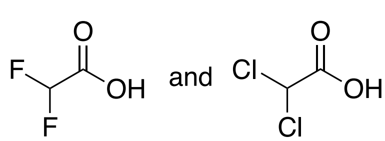


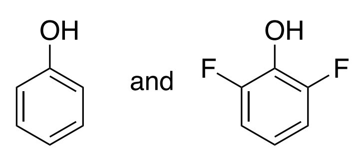












7) Rank each set of compounds in order of increasing acidity.

a. NH_3 H_2O HF

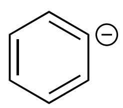
b. HBr HCl HF

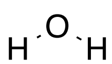
c. H_2O H_3O^+ HO^-

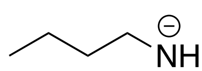
d. NH_3 H_2O H_2S

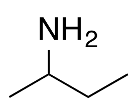
e. $CH_3CH_2CH_3$ $ClCH_2OH$ CH_3CH_2OH

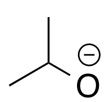
8) Draw the conjugate acid for each of the following bases.

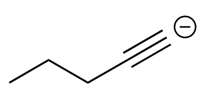


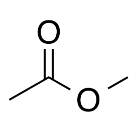








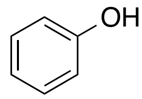




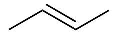
In this example there are two potential sites for protonation. Which would be preferred? Why?

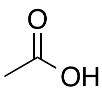
9) Draw the conjugate base for each compound shown below.

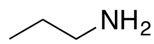
H_3O^+



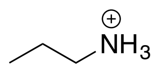
H_2O



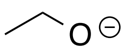
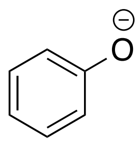




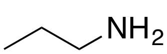
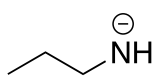
H_2SO_4

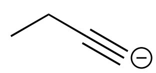
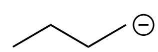


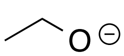
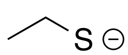
10) For each set below, determine which species is the stronger base.

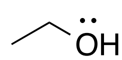
 or 

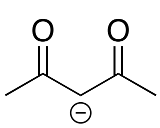
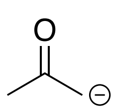
Cl^- or Br^-

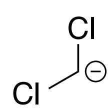
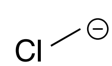
 or 

 or 

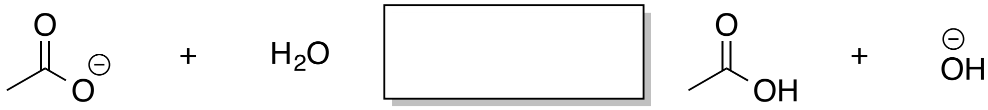
 or 

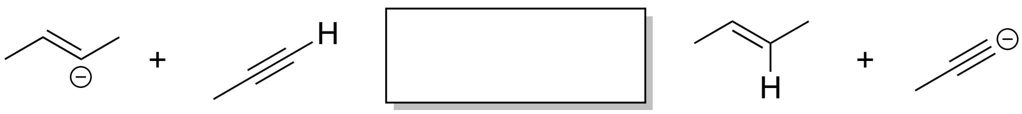
 or 

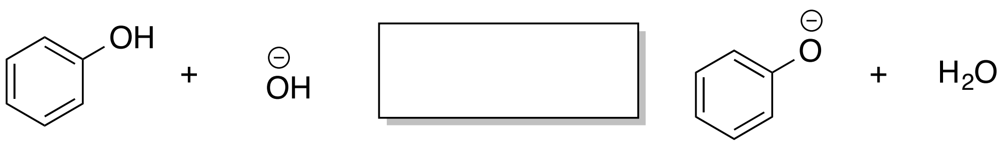
 or 

 or 

11) For each reaction shown below, use uneven equilibrium arrows to show whether the reaction favors reactants or products.







$HF \quad + \quad I^{-} \quad \square \quad HI \quad + \quad F^{-}$