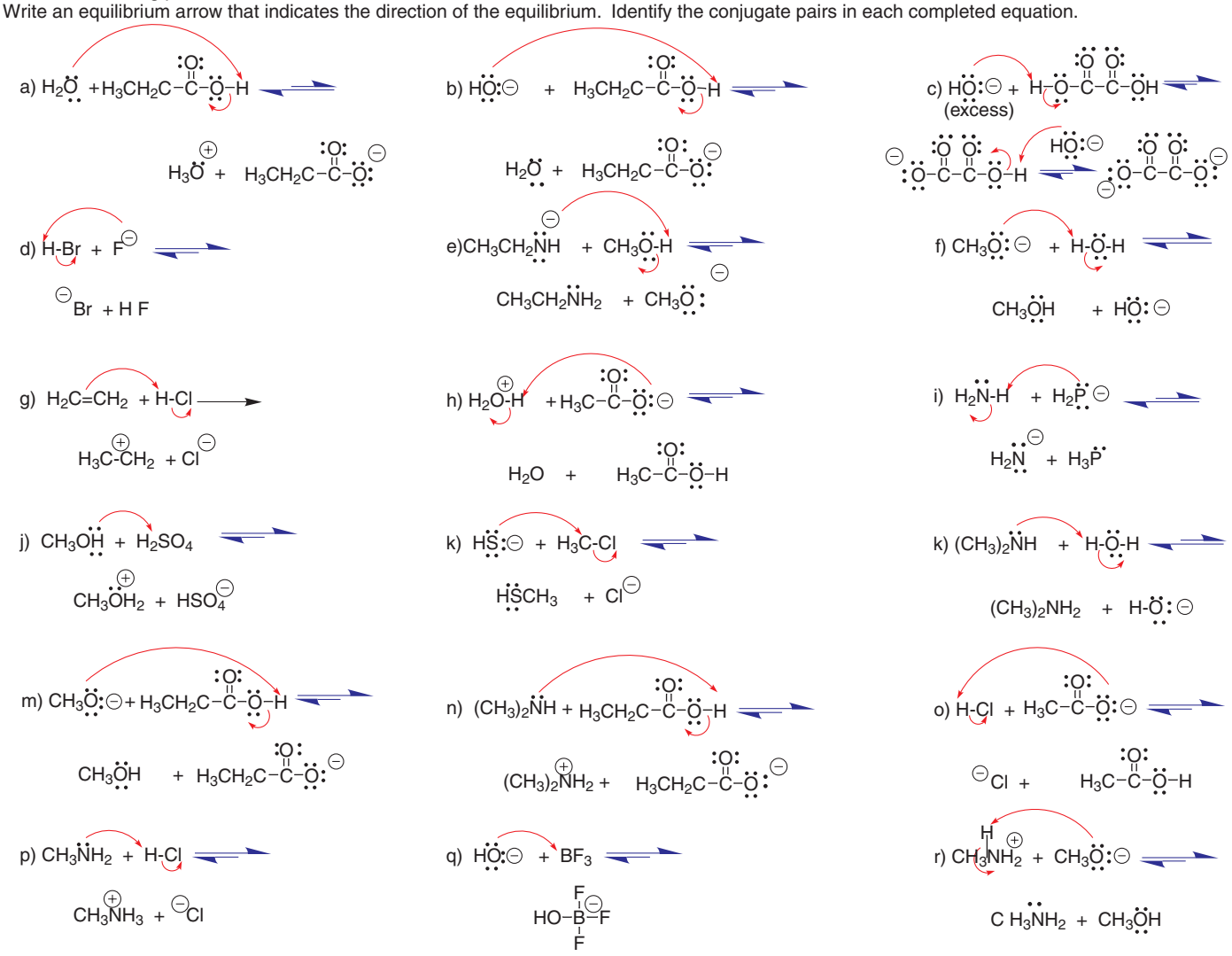
Problem Set
Acids and Bases

1. For the following pairs of reactants, write an acid-base reaction. Show electron dots and curved arrows that show the movement of electrons. Write an equilibrium arrow that indicates the direction of the equilibrium. Identify the conjugate pairs in each completed equation.



2. For the following groups of compounds, arrange in order of increasing acidity for the underlined hydrogen. EXPLAIN your choices.

a) CH_3CH_2OH (alcohol) < CH_3COOH (carboxylic acid)

b) CH_4 < NH_3 < H_2O < HF

c) CH_3COOH < CH_3COOH

d) CH_3COOH < CCl_3COOH < CF_3COOH

e) $CH_3CH_2CH_3$ < $CH_3CH_2NH_2$ < CH_3CH_2OH

3. Arrange the following in order of increasing basicity. Explain.

a) H_2O < CH_3COO^- < $CH_3CH_2O^-$ < F^-

b) F^- < HO^- < NH_2^- < H_3C^-

c) I^- < Br^- < Cl^-

d) CH_3OCH_3 < $(CH_3)_3N$ < $(CH_3)_3C^-$ H_3N

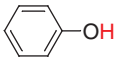
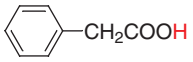
e) Cl^- < HS^- < H_2P^- < H_2N^-

f) H_2S < H_2O <

4. Sodium hydride, NaH, is an ionic compound.
a) Write the Lewis electron-dot structure for NaH. Na^+ H^-
b) If NaH is placed into water (a foolish thing to do), the hydride ion is converted to hydrogen gas (H_2). The resulting solution turns red litmus paper blue and has a pH >>7. Write a balanced equation showing the reaction of NaH with water.
Na^+ H^- + H_2O ⇌ H_2 + Na^+ OH^-
c) Is the hydride ion an acid or a base? What is the relationship of hydrogen and hydride? They are conjugate acid and base.
d) Sodium hydride reacts with alcohols in a similar way. Write the reaction of NaH with ethanol (CH_3CH_2OH).

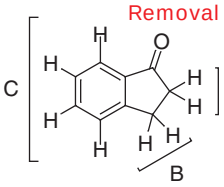
Na^+ H^- + CH_3CH_2OH ⇌ H_2 + Na^+ $^-OCH_2CH_3$

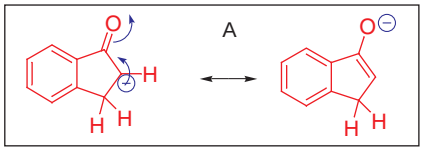
5. From the K_a values in the table, calculate the pK_a for each compound. Using these data, arrange the compounds in order of increasing acidity and explain the trend. (Hint: be sure to identify the hydrogen to which the K_a applies.)

		K_a	pK_a		K_a	pK_a	
2	CH_3COOH	1.75×10^{-5}	4.75	CH_3CH_2OH	1×10^{-16}	16	4
3		1.0×10^{-10}	10		5.2×10^{-5}	4.28	most acidic - 1
5	$CH_3CH_2NH_2$	1×10^{-36}	36	CH_3CH_3	10^{-50}	50	least acidic - 6

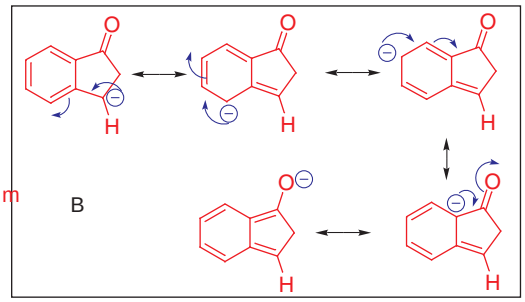
6. 1-Indanone (below) has three different types of hydrogen atoms (labeled A, B, and C in the structure). Removing the most a forms an anion that is stabilized by resonance. Draw a structure for the anion and its resonance form(s).

Removal of either an A or a B hydrogen results in a resonance stabilized anion:





Removal of an A hydrogen yields an enolate anion, particularly stable due to the resonance form in which the negative charge resides on oxygen.



Removal of a B hydrogen results in an anion with N resonance forms, including an enolate.

7. The conjugate acids of the following amines have the pK_a values shown. Explain the trend.

	pKa of conjugate acid
$CH_3CH_2CH_2CH_2NH_2$	10.60
$CH_3OCH_2CH_2CH_2NH_2$	9.92
$(CH_3O)_2CHCH_2CH_2NH_2$	8.54
N $CCH_2CH_2NH_2$	7.80

The presence of electronegative groups results in a weaker base (a stronger conjugate acid).