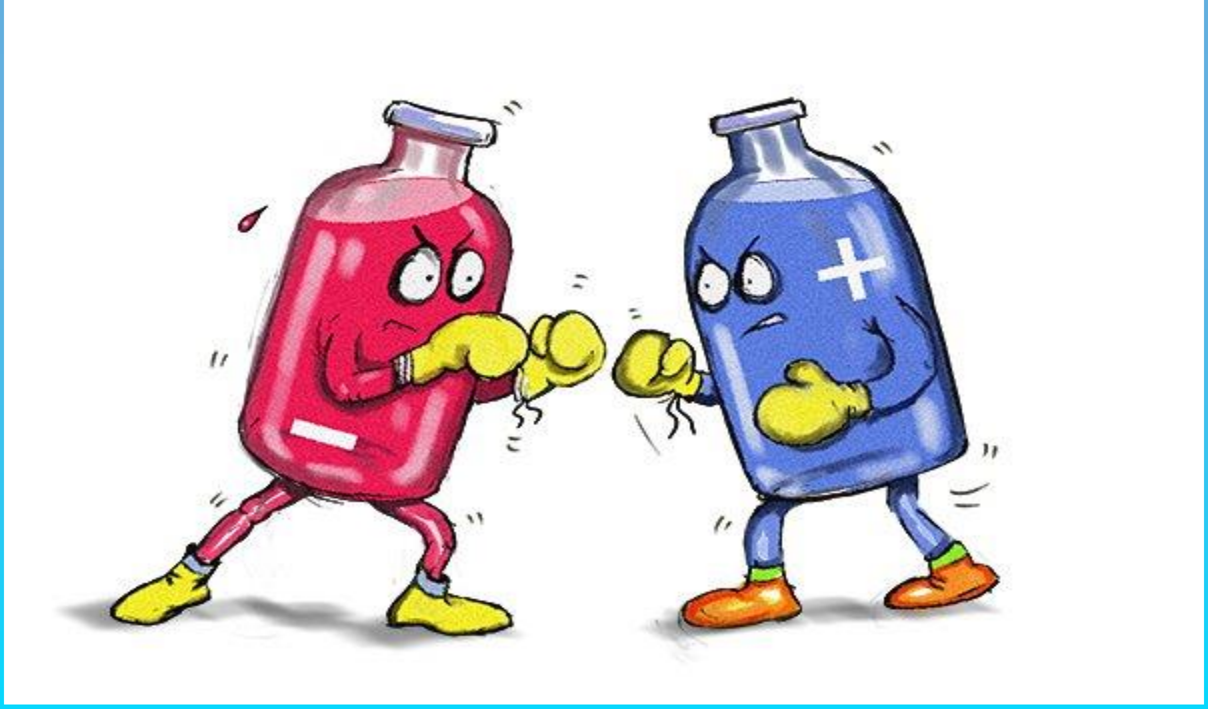
Organic Chem
Chapter 3:
Acids and Bases



Right side: NOTES!

Title and Highlight

Topic:
EQ:

NOTES:

- Write out the notes from my website.

Use different types of note-taking methods to help you recall info (different color pens/highlighters, bullets, etc)

Reflect Question: Reflect on the material by asking a question (its not suppose to be answered from notes)

- When I lecture we will add more info, so leave spaces in your notes

- DRAW **ALL** PICTURES, FIGURES, AND WRITE OUT ANY PRACTICE PROBLEMS/QUESTIONS.
- WE WILL ANSWER THEM TOGETHER. So…LEAVE SPACES SO WE CAN ANSWER QUES.

Summary (end of notes) :
1-2 Sentences of what you learned

left side: skillerbuilder problems

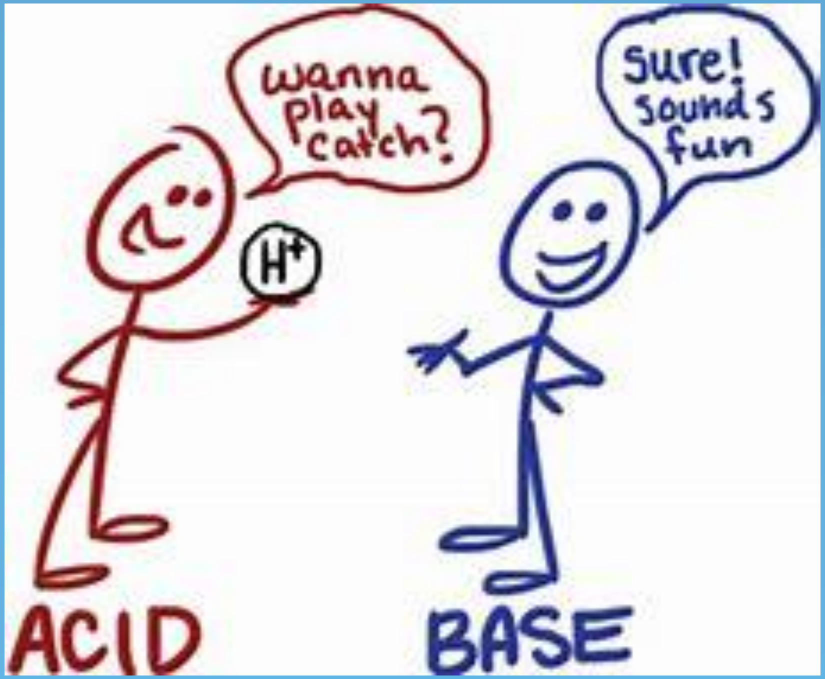
Title and Highlight

Skillbuilder #1.1

Date

Write out Question only

- We will practice the skill in class after lecture



Ch. 3.1

Topic: intro to Bronsted-Lowry Acids & Bases

EQ: What is consider a B-L Acid & Base?

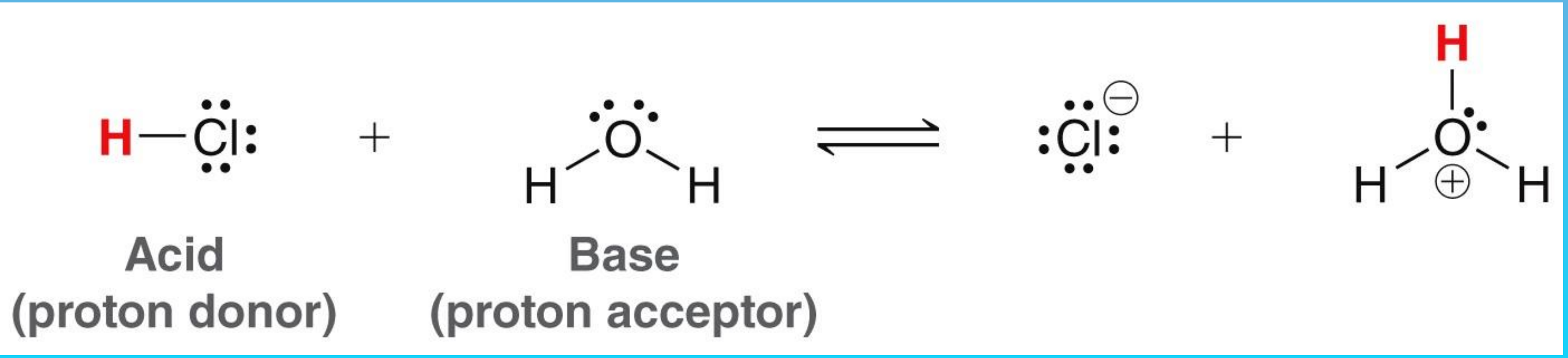
READ pg. 94 then take notes

Did you ever WONDER…
how dough rises to produce fluffy rolls and bread?

- Let’s read p. 93 together

- **Brønsted-Lowry definition**
  - **Acids donate** a proton (H+) - **Proton donor**
  - **Bases accept** a proton (H+) - **Proton acceptor**

- Remember from General Chemistry:
- Hydrogen atom – 1 proton and 1 electron
- H^+ ion – 1 proton only (lost e- to become an ion)

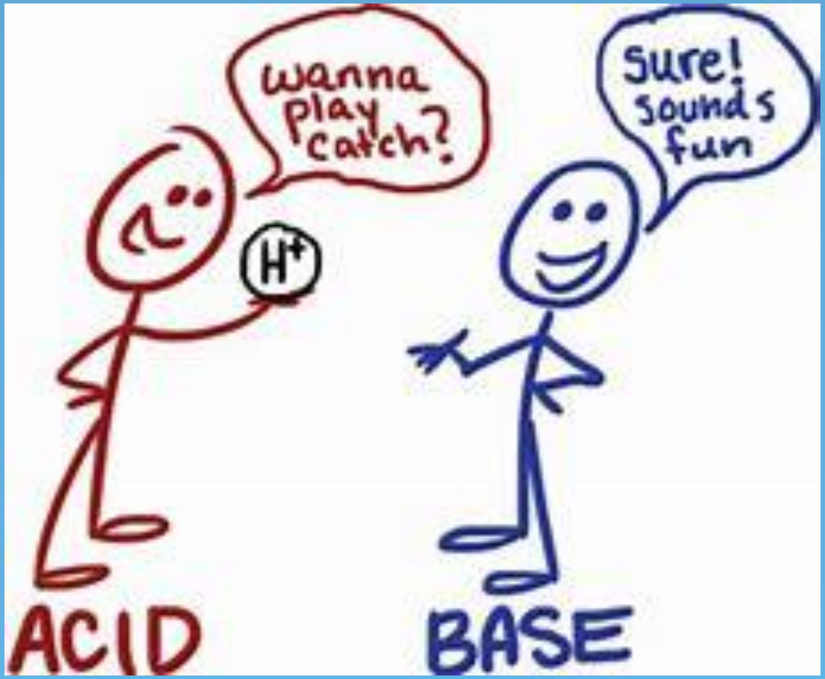


- Brønsted-Lowry definition
  - A **<u>conjugate acid</u>** results when a <u>base accepts a proton</u>
  - A **<u>conjugate base</u>** results when an <u>acid gives up a proton</u>

$$HCl + H_2O \rightleftharpoons Cl^- + H_3O^+$$

Acid	Base	Conjugate base	Conjugate acid

- Example:
- Label the acid, base, and the conjugates in the reaction below



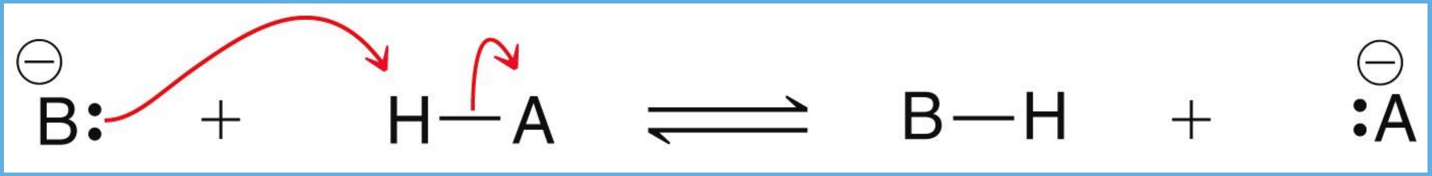
Ch. 3.2

Topic: Flow of Electron Density

EQ: What is curved-arrow notation?

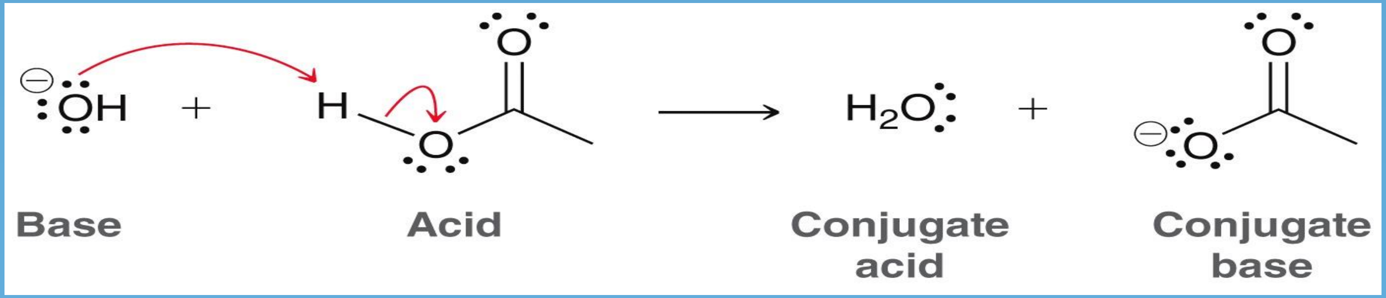
READ pg. 94-97 then take notes

- The making and breaking of bonds involves **electron movement**
- We use curved arrows to describe the flow of electron density (motion of electrons)



- There is a flow of electron density that causes a proton to be transferred from one reagent to another; the curved arrows illustrate this flow.
- These are the same as curved arrows used to draw resonance structures in Ch 2, BUT… here, the curved arrows **are actually describing the physical movement of electrons!!!**

- The arrows show the **Reaction Mechanism****, they show how the reaction occurs in terms of the motion of electron



- The base "attacks" the acid, using a pair of electrons
- The acid cannot lose its proton without the base taking it. All acid/base reactions occur in one step
- The mechanism of a proton transfer always involves at least two curved arrows.

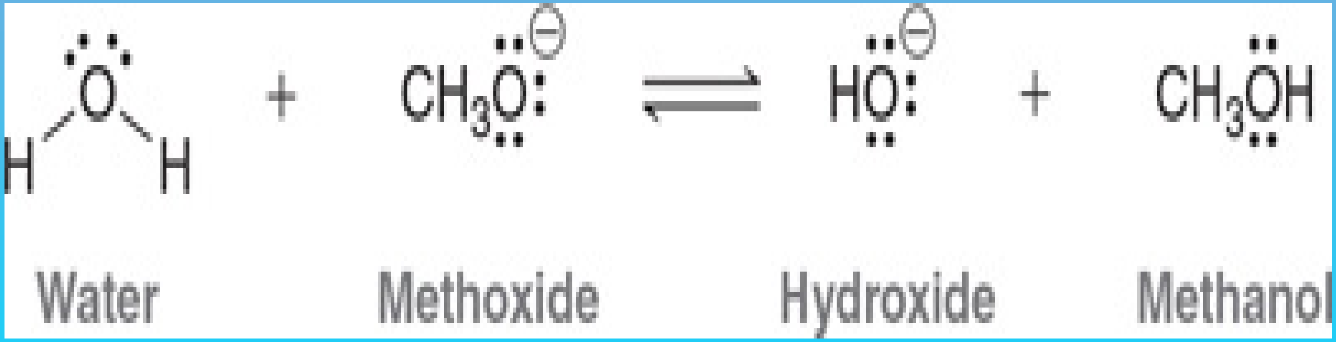
- ****One of the BIGGEST topics in Ochem (coming in Ch 6). It's the core of Ochem!!!**

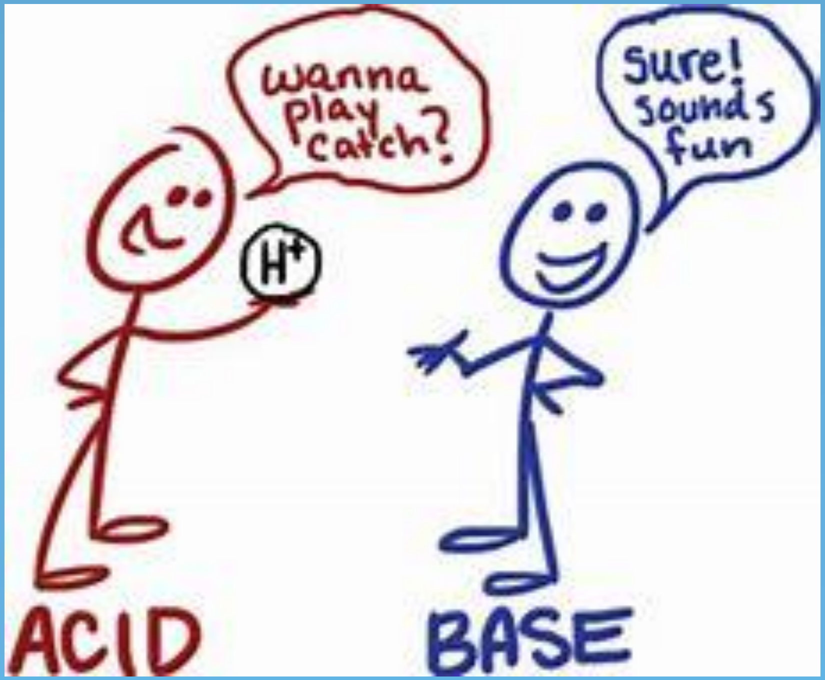
Practice with Skillbuilder 3.1 (p.95-96)

Write out Question only ("Learn the skill")

- We will practice the skill in class together after lecture

- Draw a mechanism for the following acid-base reaction. Label the acid, base, conjugate acid, and conjugate base:





Ch. 3.4

Topic: B-L Acidity (qual)

EQ: What are the factors that affect stability of conjugates?

READ pg. 104-115 then take notes

- To determine the relative strength of two acids, without knowing their pKa values, we look at the **conjugate base** of the each acid

$$HA + H_2O \rightleftharpoons A^- + H_3O^+$$

- If A^- is very stable (weak base), then HA is a strong acid
- If A^- is very unstable (strong base), then HA is a weak acid
- By using this method to compare the stability of conjugate bases of 2 acids we can determine the stronger acid

- Trend: The more effective a conjugate base can stabilize its negative charge (i.e. lone pair), the stronger the acid

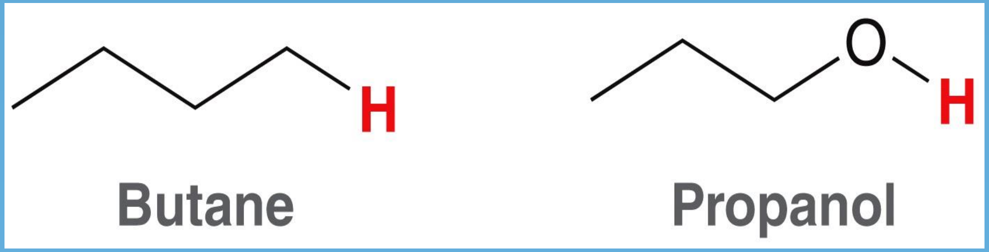
- **Four main factors affect the stability of a negative charge:**

1. The **atom** that carries the charge
2. **Resonance**
3. **Induction**
4. The type of **orbital** where the charge resides

- These factors can be remembered with the acronym, **ARIO**

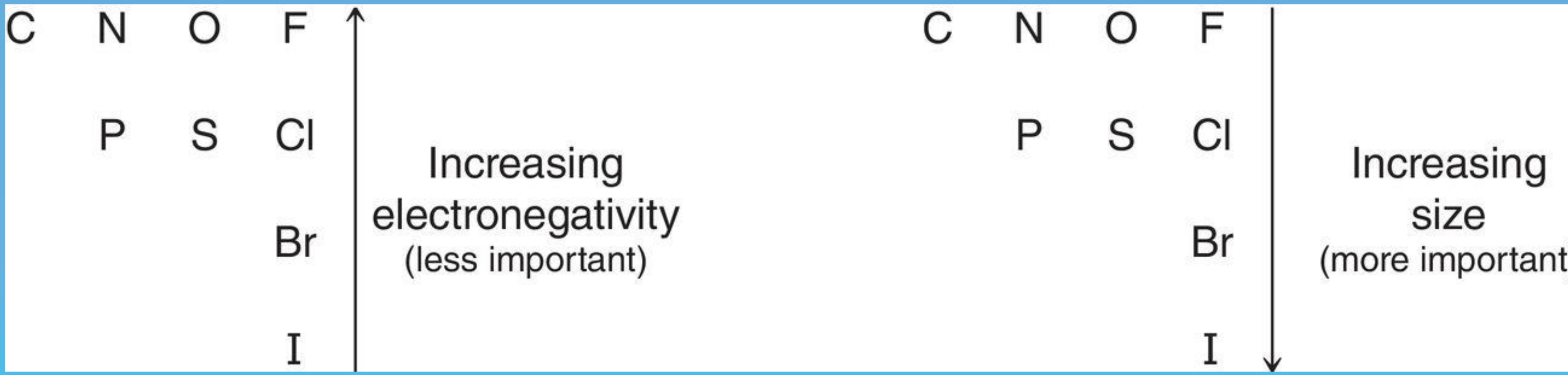
1. The **atom** that carries the charge

- In order to compare the acidity of the two compounds below



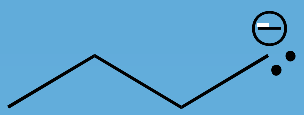
- We need to draw and then analyze the stability of the negative charge on the conjugate bases

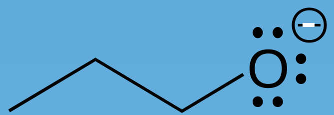
- If 2 atoms appear in the same period, then electronegativity is the factor to consider.
- If 2 atoms are in the same group, the **larger the atom**, the **more stable a negative charge** will be (size is the most important factor)



Since C and O are in the same period, they are similar in size. In this case, **the more electronegative atom (Oxygen) will better stabilize the negative charge**

Less stable

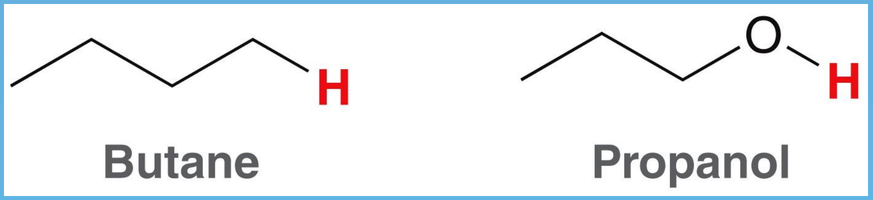




More stable

- The relative stability of the bases tells us the relative strength of the acids

Less acidic



More acidic

- But what if the negative charge is on the same atom for both acids?

Another example when comparing 2 atoms in the same group: H_2O and H_2S (Draw them from p. 106)

Draw Both First then deprotonate each & compare their conjugate bases:

the **more stable a negative charge** will be (**size** is the most important factor)

Less stable OH^- HS^- More stable

(Sulfur is larger than Oxygen)

Less acidic H_2O H_2S More acidic

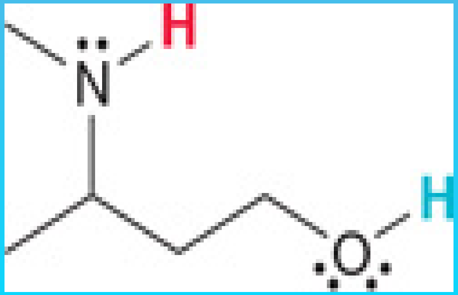
- **But what if the negative charge is on the same atom for both acids?(next rule - Resonance)**

Practice with Skillbuilder 3.5 (p.106)

Write out Question only (“Learn the skill”)

- We will practice the skill in class together after lecture

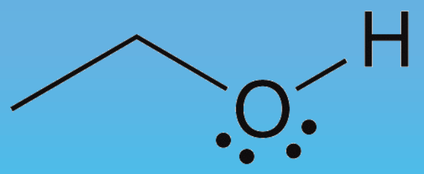
- Compare the two protons that are shown in the following compound. Which one is more acidic?



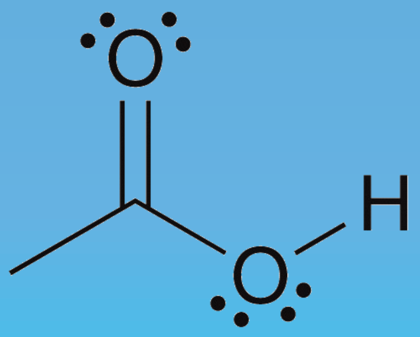
2. Resonance

- **Resonance** stabilizes a negative charge (i.e. lone pair) by spreading it out across multiple atoms

- Compare the acidity of the two compounds below by comparing the stabilities of their conjugate bases.



Ethanol

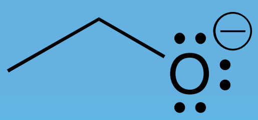


Acetic acid

In both cases, the negative charge is on the same element (Oxygen) – So we cant use Factor #1.

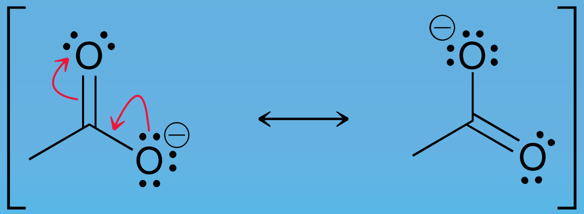
The first conjugate base has no resonance, while the second conjugate base does

In this case, the charge is **delocalized** over both oxygen atoms because of this the negative charge is **more stable** than a charge localized on one oxygen atom



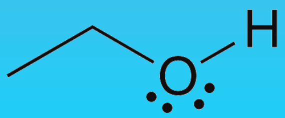
Charge is localized (less stable)

versus

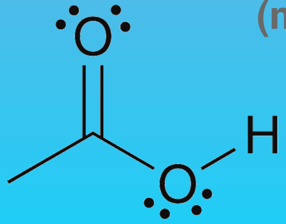


Charge is delocalized (more stable)

Less acidic



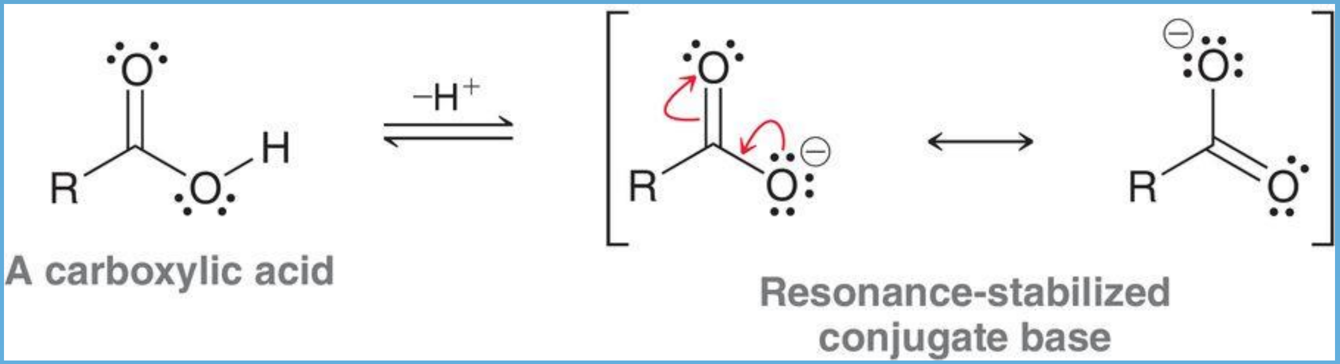
Ethanol



Acetic acid

More acidic

- Compounds containing a C=O bond directly next to an OH are generally mildly acidic, because their conjugate bases are resonance stabilized



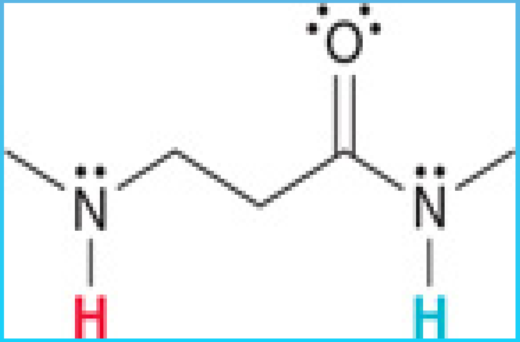
- These compounds are called ***Carboxylic acids***. The **R group** above simply refers to the rest of the molecule that has not been drawn.
- Carboxylic acids are actually not very acidic at all compared with inorganic acids such as H_2SO_4 or HCl.
- What if both resonance and the atom caring the charge don't help determine which acid is stronger

Practice with Skillbuilder 3.6 (p.108)

Write out Question only ("Learn the skill")

- We will practice the skill in class together after lecture

- Compare the two protons shown in the following compound. Which one is more acidic?

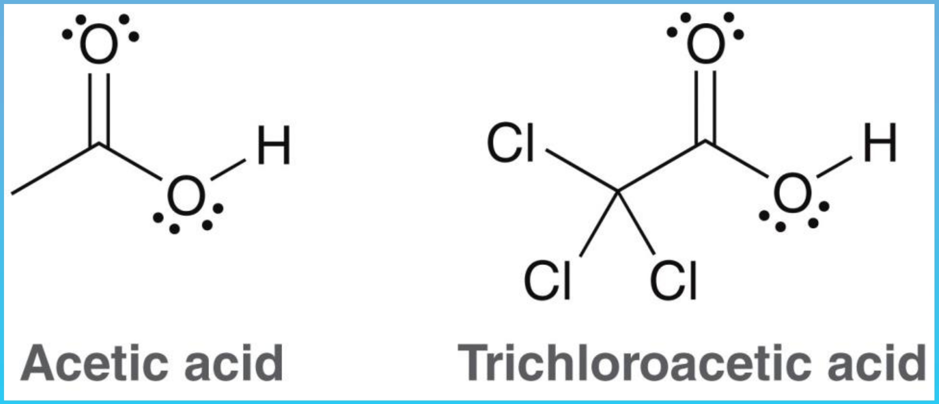


3. Induction

- **Induction (dipole moment)** can also stabilize a formal negative charge by spreading it out. How is induction different from resonance?

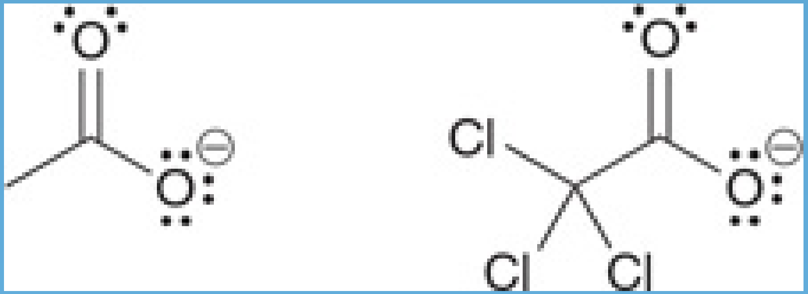
- Highly electronegative atoms that create a dipole moment inductively withdraw electron density from their surroundings, thus stabilizing a negative charge.

Less acidic



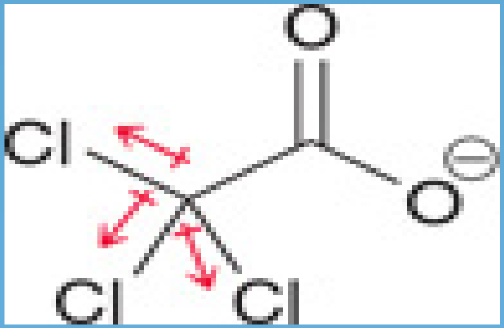
More acidic

- Draw the conjugate bases for each (see page 109)



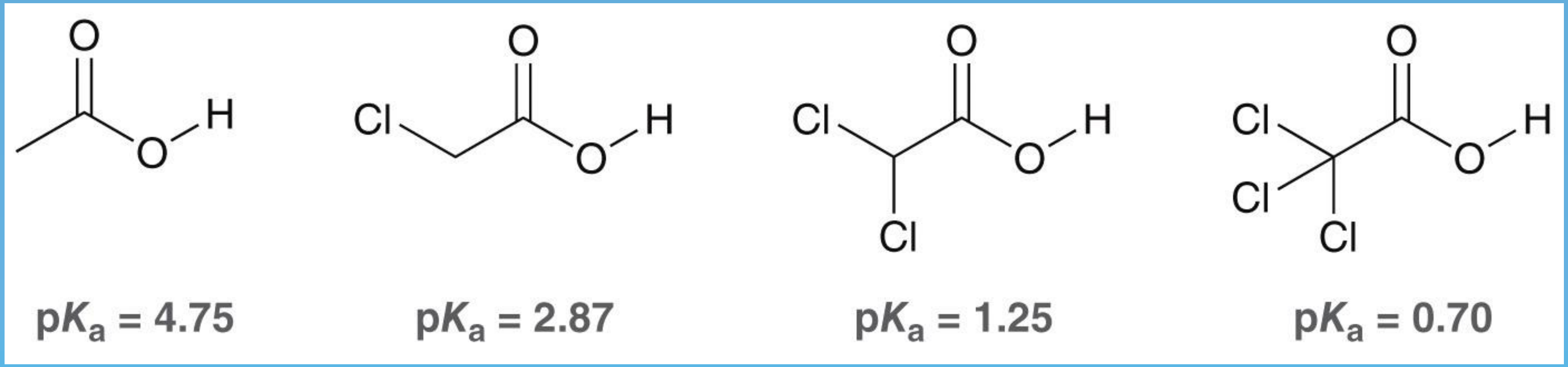
- Factor 1 does not answer the question because the negative charge is on oxygen in both cases.
- Factor 2 also does not answer the question because there are resonance structures that delocalize the charge over two oxygen atoms in both cases.
- The difference between these conjugate bases is clearly the chlorine atoms.

- Draw the dipole moments on the chlorines: (see page 109)



- The net effect of the chlorine atoms is to withdraw electron density away from the negatively charged region of the structure, thereby stabilizing the negative charge.
- **Therefore the conjugate base of trichloroacetic acid is more stable than the conjugate base of acetic acid:**

- More electronegative atoms that have a dipole moment = more stable conjugate base
- The closer the electronegative atoms with a dipole moment is to the negative charge = more stable the conjugate base

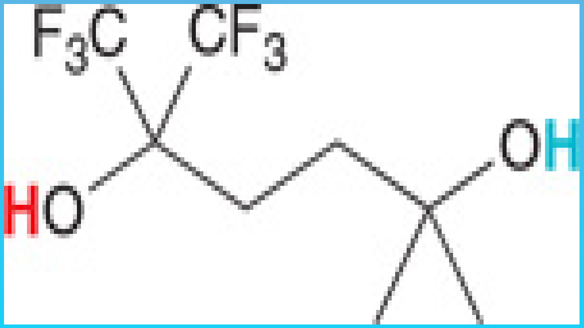


Practice with Skillbuilder 3.7 (p.110)

Write out Question only ("Learn the skill")

- We will practice the skill in class together after lecture

- Identify which of the protons shown below is more acidic:

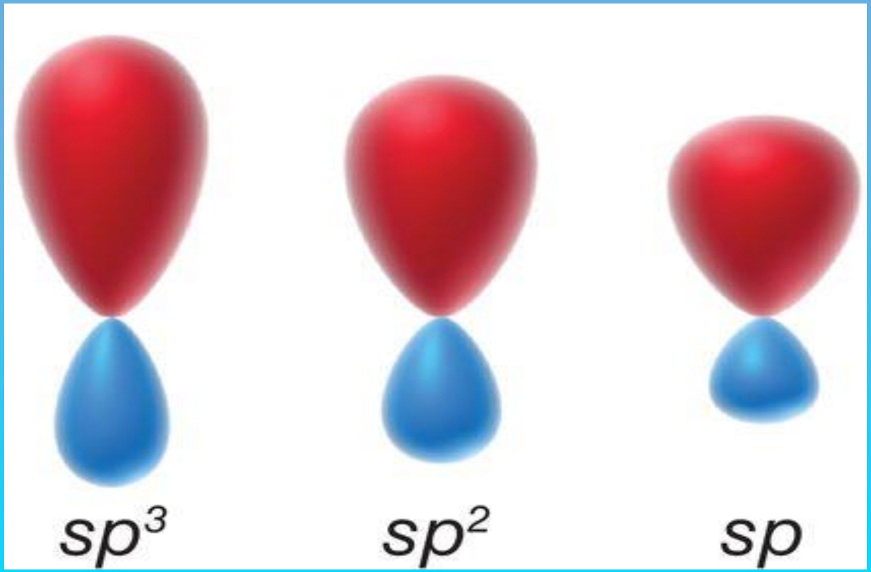


4. Orbitals

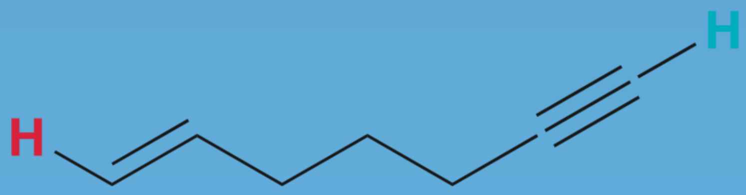
- The type of **orbital** also can affect the stability of a formal negative charge

- **The closer electrons are held to the nucleus, the more stable they are.** Because being close to the positively charged nucleus balances out the negative charge of the electrons

The shorter the atomic orbital, the closer electrons are to the nucleus.



- The three factors we have examined so far will not explain the difference in acidity between the two identified protons in the following compound:

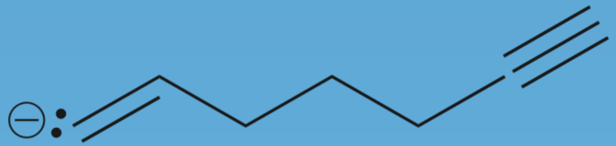


- Consider the relative stability of the H’s indicated below:

- To predict which H is more acidic, we first have to draw the two possible conjugate bases

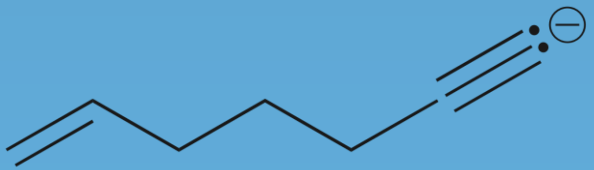
- Which carbanion is more stable?

The type of **orbital** also can affect the stability of a negative charge. The more s-character in the orbital, the more stable the negative charge.



Lone pair in a *sp*² orbital, not as close to the nucleus

LESS STABLE



Lone pair in a *sp* orbital, closer to the nucleus

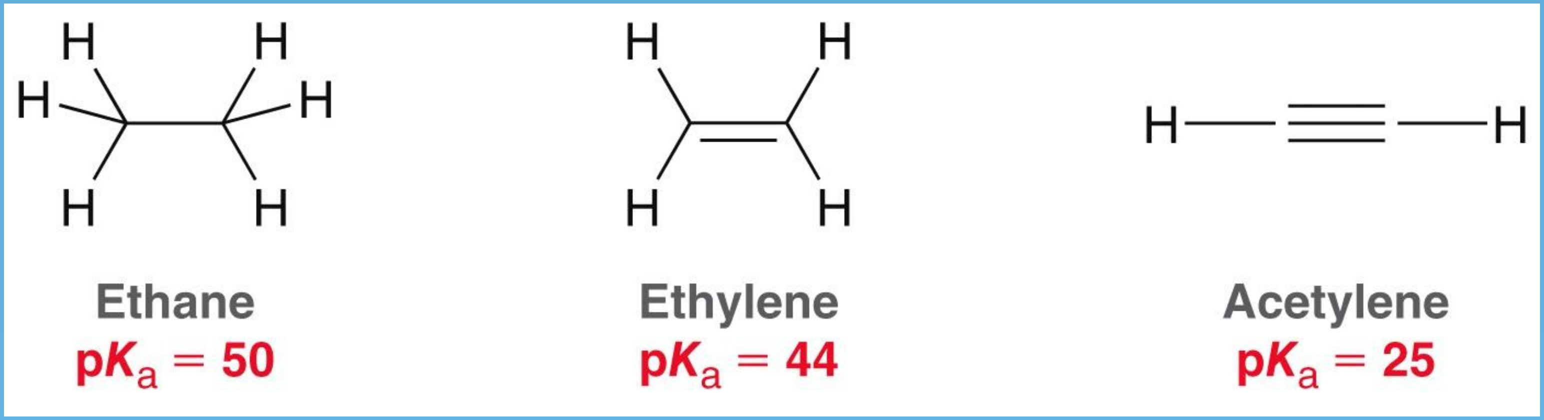
MORE STABLE

less acidic

MORE ACIDIC

A proton (H^+ ion) on a triple bond will be more acidic than a proton on a double bond, which in turn will be more acidic than a proton on a carbon atom with all single bonds

Compare the acidity of the compounds below by comparing the stabilities of their conjugate bases.



- When assessing the acidity of protons, we generally use **ARIO** as the order of importance of these stabilizing effects.

1. The type of **atom** that carries the charge
2. **Resonance**
3. **Induction**
4. The type of **orbital** where the charge resides

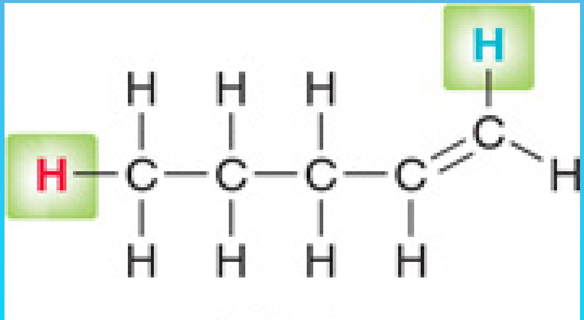
It is typically helpful to use this order of priority when comparing the stability of conjugate bases, but it isn't 100% reliable: there are exceptions (There always are in chemistry ☹)

Practice with Skillbuilder 3.8 (p.112)

Write out Question only ("Learn the skill")

- We will practice the skill in class together after lecture

- Determine which of the protons identified below is more acidic:



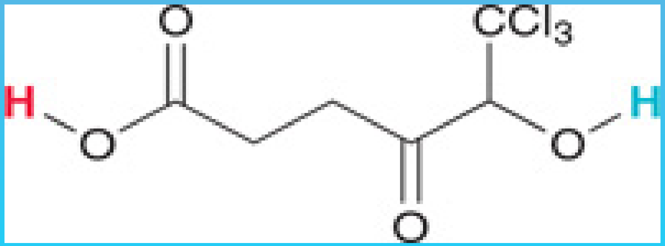
1-Pentene

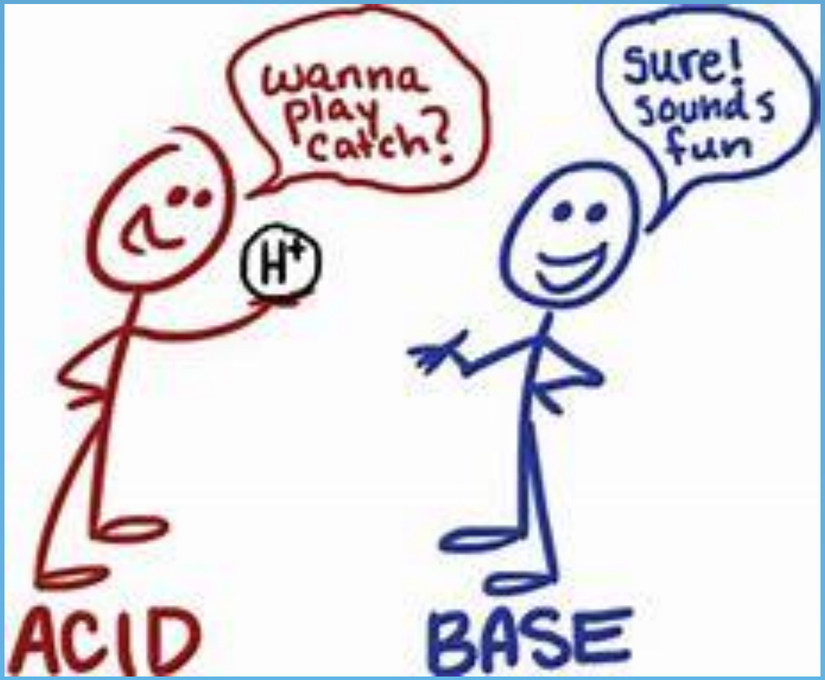
Practice with Skillbuilder 3.9 (p.114)

Write out Question only ("Learn the skill")

- We will practice the skill in class together after lecture

- Determine which of the two protons identified below is more acidic and explain why:





Ch. 3.9

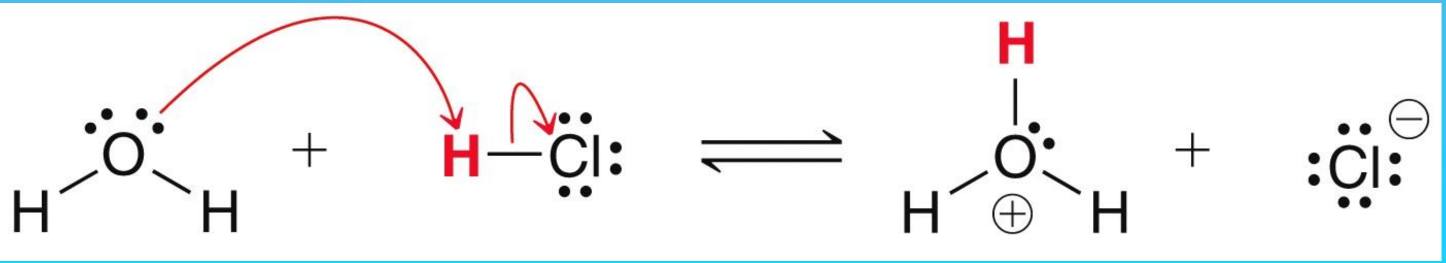
Topic: Lewis Acids and Bases

EQ: What is difference between B-L A/B and Lewis A/B?

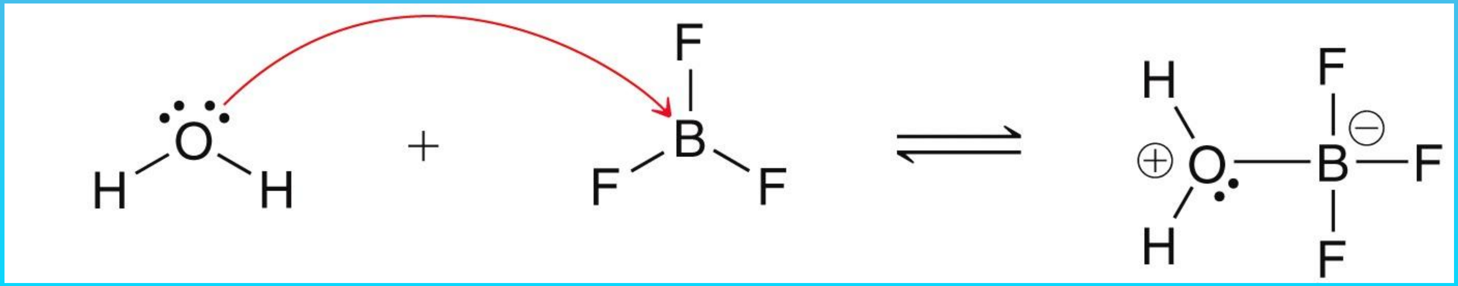
READ pg. 121-123 then take notes

- Lewis acid/base definition
  - A **Lewis acid accepts** a **pair** of **electrons**
  - A **Lewis base donates** a pair of **electrons**

- Acids under the Brønsted-Lowry definition are also acids under the Lewis definition
- Bases under the Brønsted-Lowry definition are also bases under the Lewis definition
- this reaction fits both definitions



- Lewis acid/base definition
  - A Lewis acid accepts and shares a pair of electrons
  - A Lewis base donates and shares a pair of electrons
- IMPORTANT: Some Lewis acid/base reactions can not be classified using the Brønsted-Lowry definition
- Explain how this reaction fits the Lewis definition but not the Brønsted-Lowry definition



Practice with Skillbuilder 3.12 (p.122)

Write out Question only ("Learn the skill")

- We will practice the skill in class together after lecture

- Identify the Lewis acid and the Lewis base in the reaction between BH_3 and THF.