Week 4
CHE 3331- Organic Chemistry

This week is <u>Week</u> <u>4</u> <u>of class</u>, and typically in this week of the semester, your professors are covering these topics below. If you do not see the topics your particular section of class is learning this week, please take a look at other weekly resources listed on our website for additional topics throughout of the semester.

We also invite you to **look at the group tutoring chart on our website to see if this course has a group tutoring session offered this semester**.

> If you have any questions about these study guides, group tutoring sessions, private 30 minute tutoring appointments, the Baylor Tutoring YouTube channel or any tutoring services we offer, please visit our website www.baylor.edu/tutoring or call our drop in center during open business hours. M-Th 9am-8pm on class days 254-710-4135.

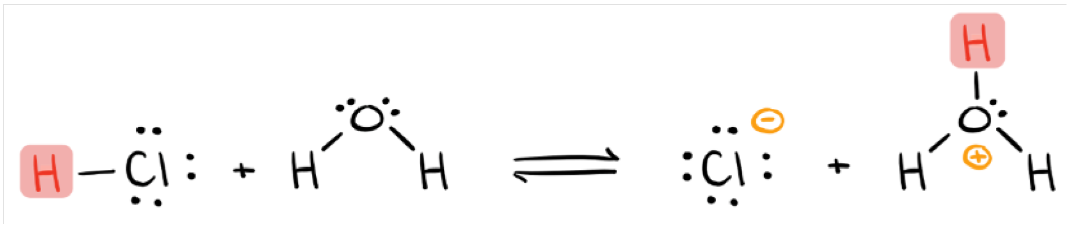
Keywords: Bronstead Acid, Bronsted Base, Conjugate Base, Conjugate Acid, Proton Transfer

TOPIC OF THE WEEK: ACIDS AND BASES

Understanding acids and bases are fundamental to Organic chemistry and many other courses that you may take at Baylor, such as Biochemistry, Human Physiology, etc. Make sure you try to really understand what this chapter is talking about because I promise you, you will see it again!

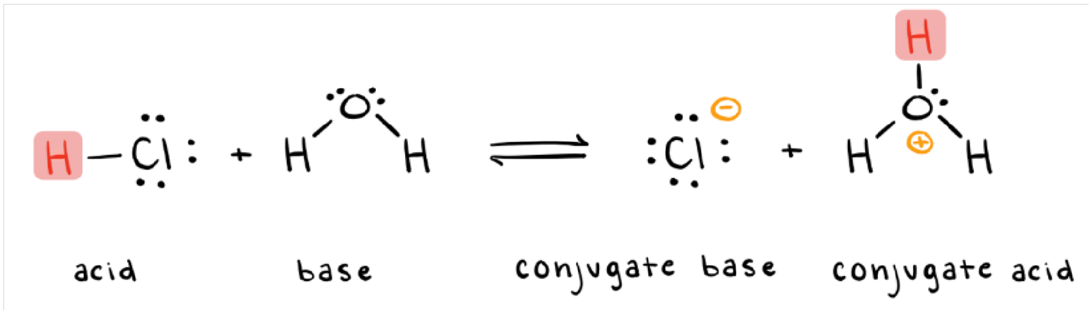
HIGHLIGHT #1: Defining Acids and Bases

- What are Bronstead-Lowry Acids and Bases? Defining whether something is an acid, or a base depends on the movement of protons within the solution!
  - A Bronstead acid is a *proton donor* while a Bronstead base is a *proton acceptor*. o You will typically see boyh an accid and a base in the reactants of a reaction and we will be able to figure out if it is an acid or a base baed on the movement of the proton (H+)



  - In the example above, we see that HCL is a Bronstead acid because it donates a proton, while the water (H20) is the Bronstead base because it accepts a proton!

- The products of a proton transfer are called the conjugate base and the conjugate acid. A conjugate base is what is left over after an acid has been deprotonated and a conjugate acid is what is created when a proton has been donated to the base, which is the proton acceptor.

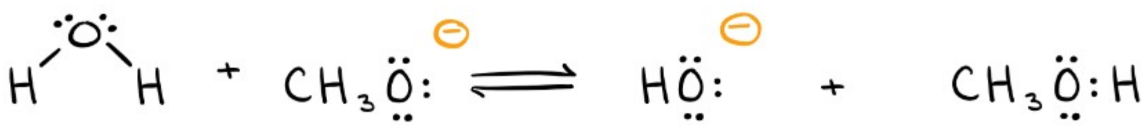


In this example, the conjugate base is the chloride ion, which is created after the acid becomes deprotonated. The conjugate acid is the hydronium ion (H30+) which is created when the base becomes protonated.

- A trick to quickly figuring out whether a substance is an acid, or a base is to determine the change in hydrogen ions between two species that share a common ion! For example, the HCl and Cl- would be similar species in a reaction because they share a common ion, Cl!
  - If you look at the species that share a common ion and you see that the number of hydrogens has decreased, the reactant is an acid and the similar species on the product side would be a ***conjugate base.***
  - If you look at the species that share a common ion and you see that the number of hydrogens has increased, the reactant is an base and the similar species on the product side would be a ***conjugate acid.***

Practice #1: Label the acid, base, conjugate acid, and conjugate base:

1.



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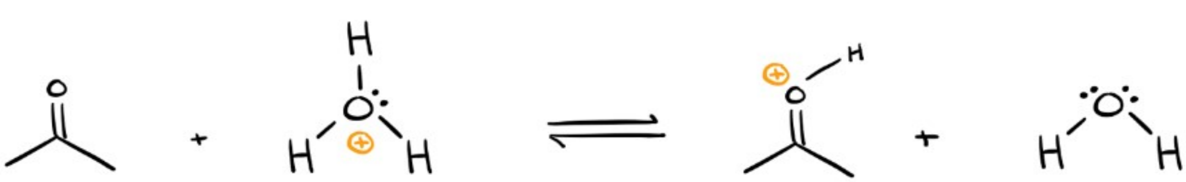


HIGHLIGHT #2: Comparing Activity

- Values used to measure the strength of an acid-base reactions ○ K_{eq} is the point at which the solution is at equilibrium
    - Equilibrium means that there is a perfectly exact amount of acid to neutralize the exact amount of base there is in the solution, or vice versa.
    - It can be measured by the expression: K_{eq}=Products divided by reactants. An example is shown below:

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

$$K_{eq} = \frac{\text{products}}{\text{reactants}} = \frac{[H_3O^+][A^-]}{[HA][H_2O]}$$

○ K_a is the value that measures the strength of an acid

- Strong acids have very large K_a values while weaker acids have low K_a values
- Because weak acids can have such low K_a values (even 10^{-50}) , sceintists use a new term pKa to express the strength of an acid instead of K_a. A pKa values can be mathematically expressed by:

$$pKa = -\log(Ka)$$

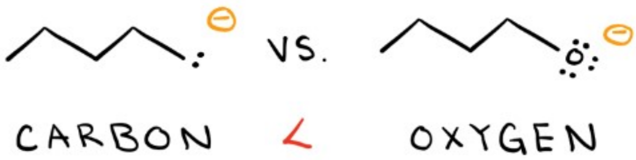
$$Ka = 10^{-pKa}$$

Be careful: A **strong acid** will have a **low pKa** value and a **high K_a** value, while a weak acid has a high pKa value, while a weak acid has a high pKa value and a low K_a value.

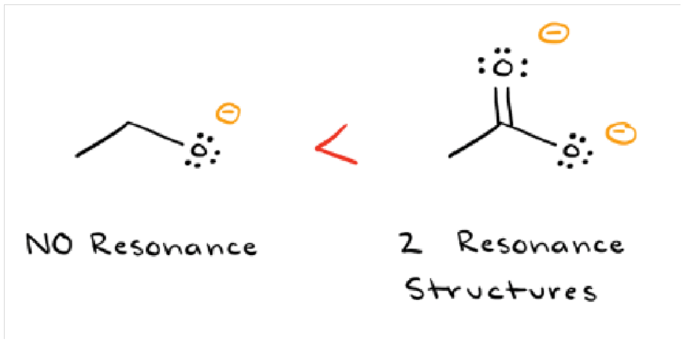
- You can compare the strength of acids by using the pKa values, however, when you do not have access to pKa values, you must look at the conjugate base of each acid to determine which is the stronger acid.
- The general rule of thumb is:

○ If you have a strong acid, you have a weak conjugate base ○ If you have a weak acid, you have a strong conjugate base ○ If you have a weak base, you have a strong conjugate acid ○ If you have a strong base, you have a weak conjugate acid

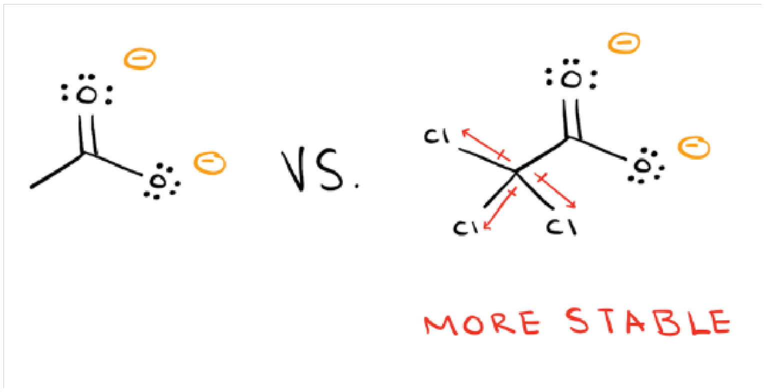
- If you want to measure the strength of acids but do **NOT** have access to their pKa values, you always want to look for the more stable conjugate (weak) base, because the *weaker the conjugate base* is, the *stronger the acid* will be! By determining the more stable conjugate base, we can identify the stronger acid.
- There are *4 factors affecting the stability of a base* and they are:
    - **Which atom bears the negative charge?**
        - The more electronegative atom will stabilize the negative charge better, so whichever atom is more electronegative will also be more stable with a negative charge!



    - **Resonance**
        - We learned last week that the more resonance structures a molecule has, the more stable it will be. Negative charges are more stable when they can be delocalized over multiple atoms versus just one atom.
        - If you do not remember how to draw resonance structures or just want a quick refresher, be sure to look at last week's resource! Try to draw out the 2 other resonance structures for acetic acid in the example below!



    - **Induction**
        - Induction refers to the electronegativity of an atom. The more electronegative it is, the more it will "pull" the charge away from the region of the structure where it is highly condensed and spread out of the charge. Think about if it would be more stable to have all the charge condensed in one area or all the charge spread out between 3 areas. The latter would be more stable!
        - The more "spread out" the charge is, the more stable the structure will be. Therefore, the more induction that is occurring, the more stable the molecule will be.



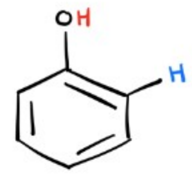
- **Orbitals**
  - Electrons residing in an *sp* orbital are closer to the nucleus, which stabilizes them compared to an orbital that is sp^2 hybridized. Therefore, a negative charge on the *sp* hybridized carbon will be more stable.

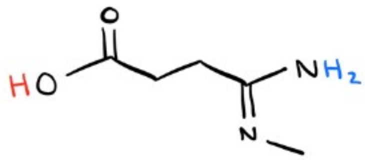
The factors that affect the stability of a negative charge are ranked in order of their priority as:

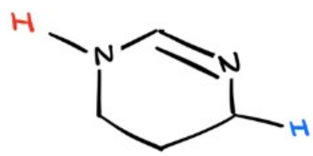
1. Atom
2. Resonance
3. Induction
4. Orbital

This system of comparing stability is called **ARIO.**

Practice #2: In each of the compounds below, determine which of the two protons is more acidic based on ARIO.

1. 

2. 

3. 

THINGS YOU MAY STRUGGLE WITH

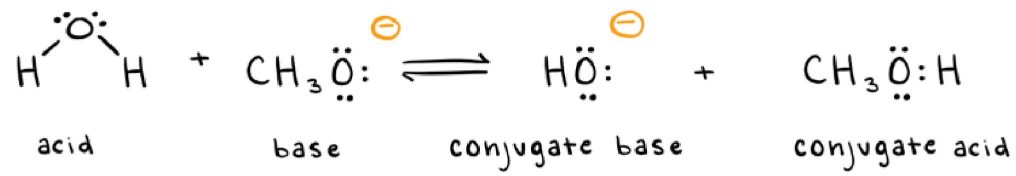
1. Understanding resonance is fundamental to ALL organic chemistry topics! IF you still are having a hard time understanding resonance, read over last week's resource, or come into the tutoring center for more help! O-chem is a skill, it doesn't come naturally but rather with lots of practice! Have a good foundation with resonance and it will greatly help you with this chapter as well as many others!
2. ARIO can get a bit complex when comparing two different molecules but take everything into bite sizes and work upwards from there. It is easy to look at a foreign molecule and feel overwhelmed, but simply, start every single problem with bite size pieces of what you know. First, look at one factor and when you have mastered that one, go onto the next one. You can't eat an elephant in one bite!

Thanks for checking out these weekly resources!
Don't forget to check out our website for group tutoring times, video tutorials and lots of other resources: www.baylor.edu/tutoring ! Answers to check your learning questions are below!

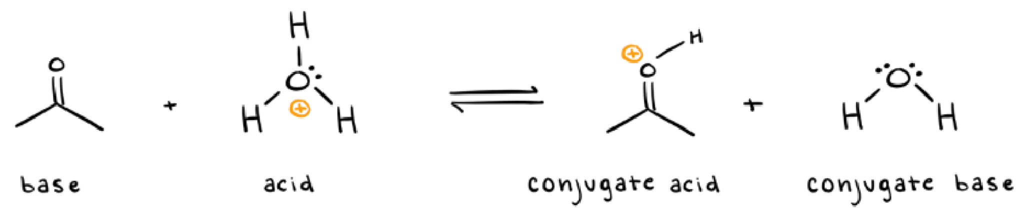
Answers to practice problems!

1.

a.

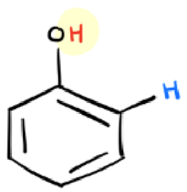


b.



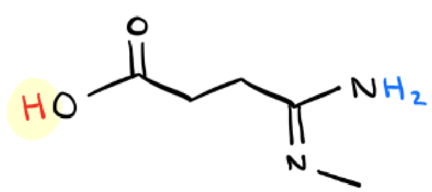
2.

a.



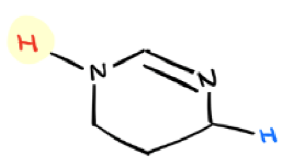
The red hydrogen is more acidic because the conjugate base is stabilized by resonance.

b.



The red hydrogen is more acidic due to
The higher electronegativity of the Oxygen!

c.



The red hydrogen is more acidic because of
the higher electronegativity of the Nitrogen!