CHEMISTRY 3331 Resource

Week 4: Week of 09/13/2021
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Hello everyone! We are back and super excited to be able to provide you guys with another resource this week which will clarify major topics and go over some examples of the material you are learning! This week we will be going over acids and bases in group tutoring! **Don't forget that we have group tutoring every Thursday from 6:30 – 7:30 in Sid Rich Room 74! Here is the link to sign up: https://www.baylor.edu/support_programs/index.php?id=40917**

Keywords: Brønstead acid, Brønstead base, conjugate base, conjugate acid, proton transfer

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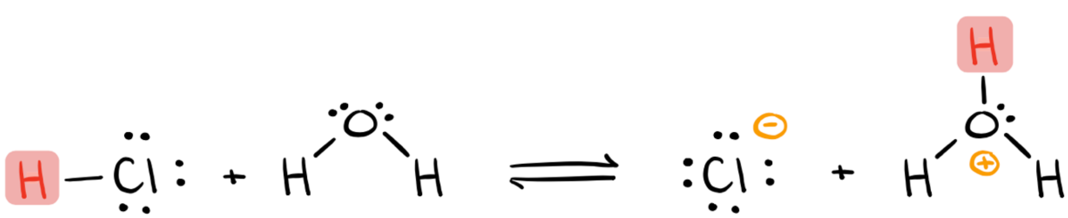
TOPIC OF THE WEEK: ACIDS AND BASES

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 you really understand what this chapter is talking about because I promise you, you **will** see it again!

HIGHLIGHT #1: Defining Acids and Bases

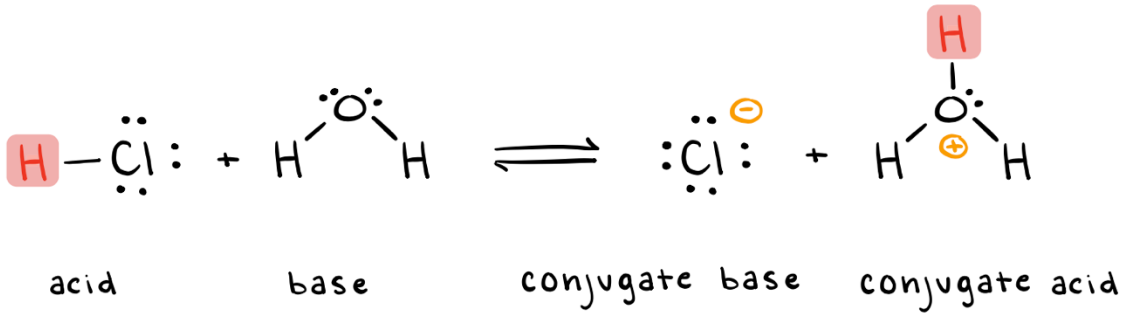
- What are Brønstead-Lowry Acids and Bases? Defining whether something is an acid, or a base depends on the movement of protons within the solution!
  - A Brønstead acid is a *proton donor* while a Brønstead base is a *proton acceptor!*
  - You will typically see both an acid and a base in the reactants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



    - In the example above, we can see that the HCl is a Brønstead acid because it donates a proton, while the water (H_2O) is the Brønstead base because it accepts a proton!

  - You will notice that following hydrogen molecules will be very important in this course, in both determining whether something is a Brønstead acid or a Brønstead base, and in the future when we get further into the semester.

- 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.

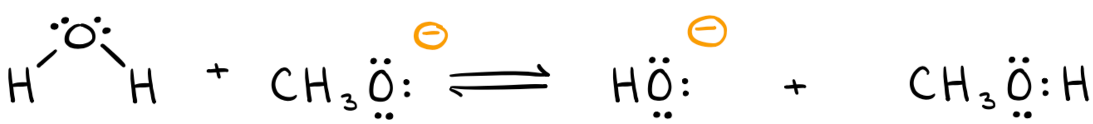


    - In this example that we used above, the conjugate base is the chloride ion, which is created after the acid becomes deprotonated. The conjugate acid is the hydronium ion (H_3O^+) which is created when the base becomes protonated.

- ***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 the 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, that 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, that reactant is a 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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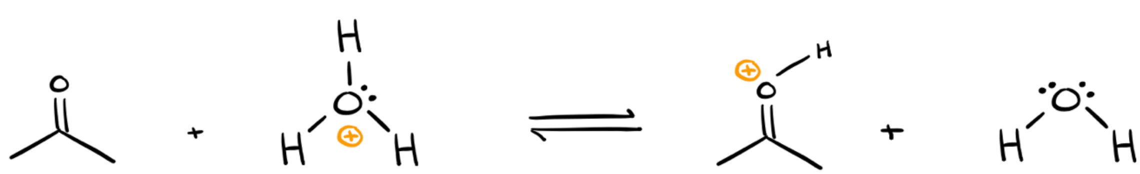


HIGHLIGHT #2: Comparing Acidity

- Values used to measure the strength of an acid-base reaction
  - **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}!), scientists use a new term, pK_a, to express the strength of an acid instead of K_a. A pKa value can be mathematically expressed by:

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

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

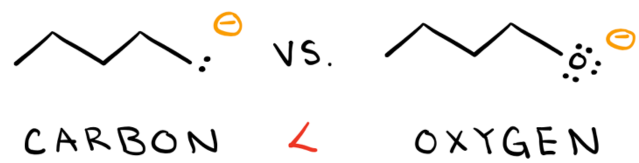
Be careful: A strong acid will have a low pK_a value and a high K_a value, while a weak acid has a high pK_a value and a low K_a value.

- You can compare the strength of acids by using the pK_a values, however, whenever you do not have access to pK_a 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

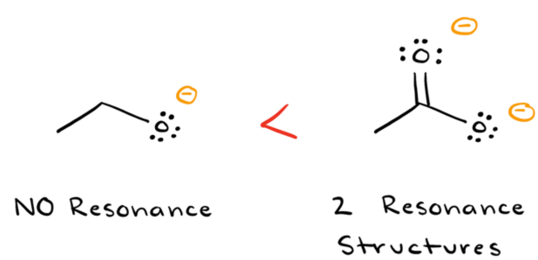
- If you want to measure the strength of acids but do **NOT** have access to their pK_a values, you always want to look for the more stable conjugate (weak) base, because the *weaker the conjugate base* is, the *stronger the acid* will be! By determining the more stable conjugate base, we can identify the stronger acid.

- There are 4 factors affecting the stability of a base and they are:
  - ***Which atom bears the negative charge?***

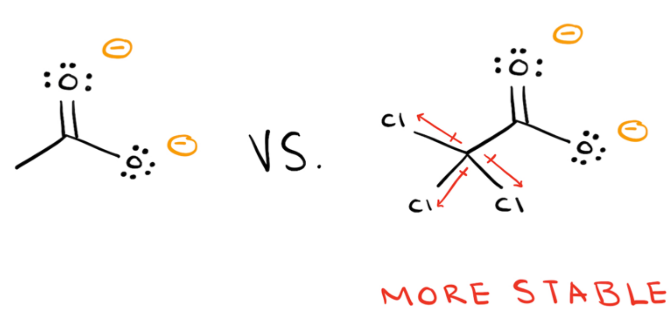
- The more electronegative atom will stabilize the negative charge better, so whichever atom is more electronegative will also be more stable with a negative charge!



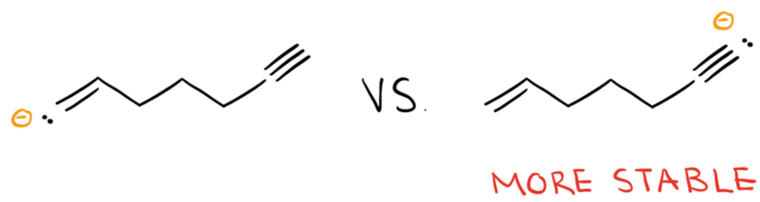
- ***Resonance***
  - We learned last week that the more resonance structures a molecule has, the more stable it will be. Negative chargers are more stable when they can be delocalized over multiple atoms versus just one atom.
  - If you do not remember how to draw resonance structures or just want a 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 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 to 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 an *sp* hybridized carbon will be more stable.

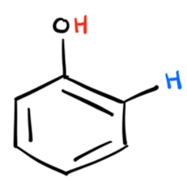


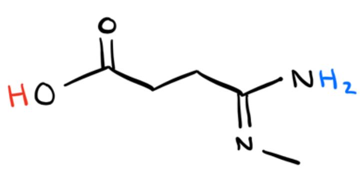
The factors that affect the stability of a negative charged are ranked in order of their priority as:

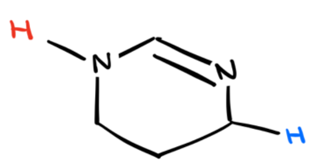
1. Atom
2. Resonance
3. Induction
4. Orbital

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! Organic chemistry is a skill, it does not 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!

SUMMARY VIDEOS

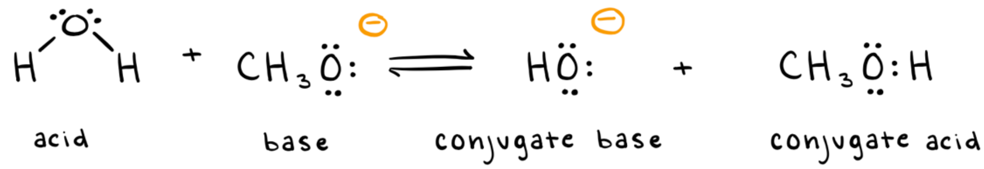
https://www.youtube.com/watch?v=I2GpoU4zpgA&ab_channel=RyanJeske

https://leah4sci.com/acidity-and-basicity-of-alcohols-organic-chemistry-video/

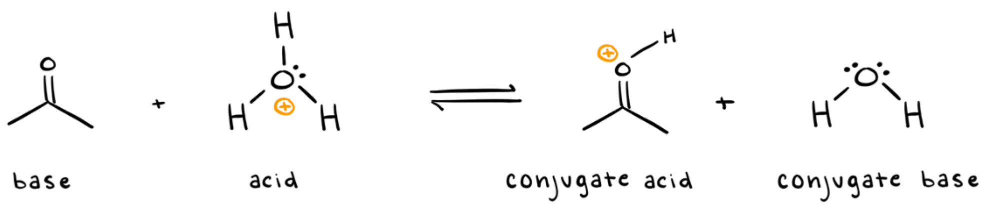
Answers to practice problems!

1.

a.

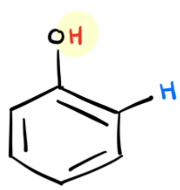


b.



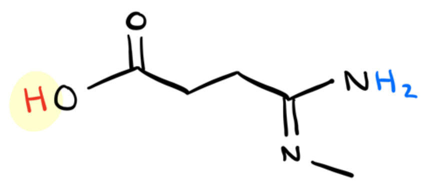
2.

a.



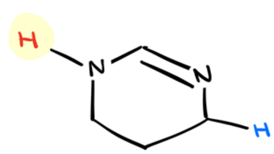
The red hydrogen is more acidic because the conjugate base is stabilized by resonance.

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!