Chapter 3: Polar Covalent Bonds; Acids and Bases

Concepts to Review from General Chemistry:

- ✓ Electronic Structure
- ✓ Molecular Orbitals and Atomic Orbitals
- ✓ Bonding and Antibonding
- ✓ Lewis, Condensed, or Kekule Structures
- ✓ Determining Formal Charge
- ✓ Resonance!!

Today –

- Brønstead-Lowry Acids and Bases
- Organic Acids and Bases
- Acid Dissociation Constants - pKa and pH
- Lewis Acids and Bases –
  - Nucleophiles and Electrophiles

Acids and Bases: pH and pKa

- _____ is a species that can donate a proton.
- _____ is a species that can accept a proton.

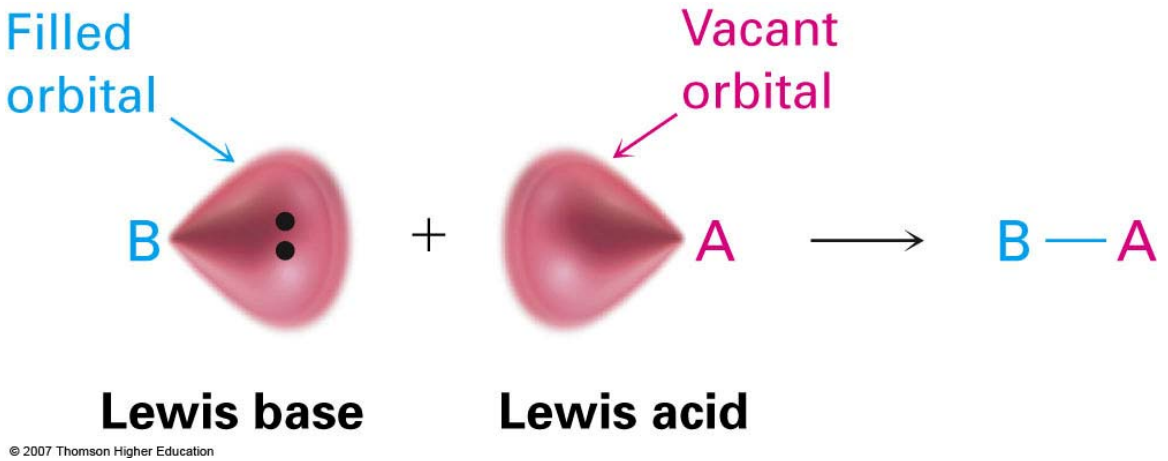
Remember ->

- Acid Base reactions are also called

Acids and Bases: The Lewis Definition

- Lewis acids are _____ and Lewis bases are _____
- Brønsted acids are not Lewis acids because

- The Lewis definition leads to a general description of many reaction patterns but

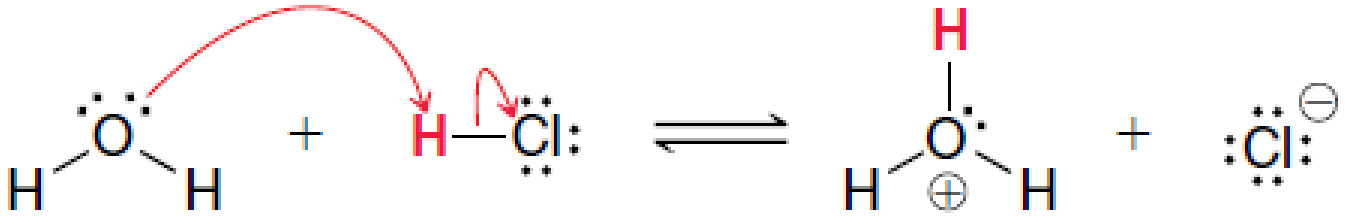


Lewis Acids and Bases

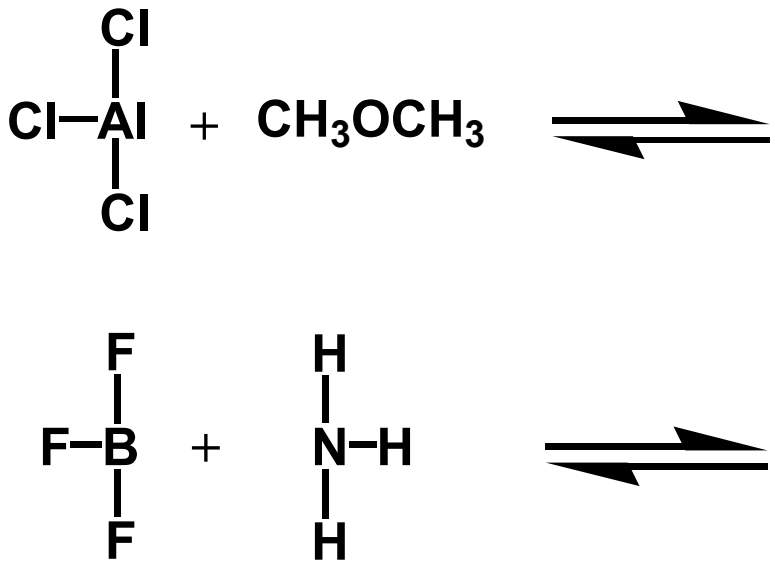
- Lewis acid/base definition:

- Acids under the Brønsted-Lowry definition are

- Bases under the Brønsted-Lowry definition are .



Lewis Acids and Bases:



- Since a Lewis acid is a species that accepts electrons, it is termed an
- A Lewis base is a species that donates electrons to a nucleus with an empty (or easily vacated) orbital, and is termed.

Acids and Bases: pH and pKa

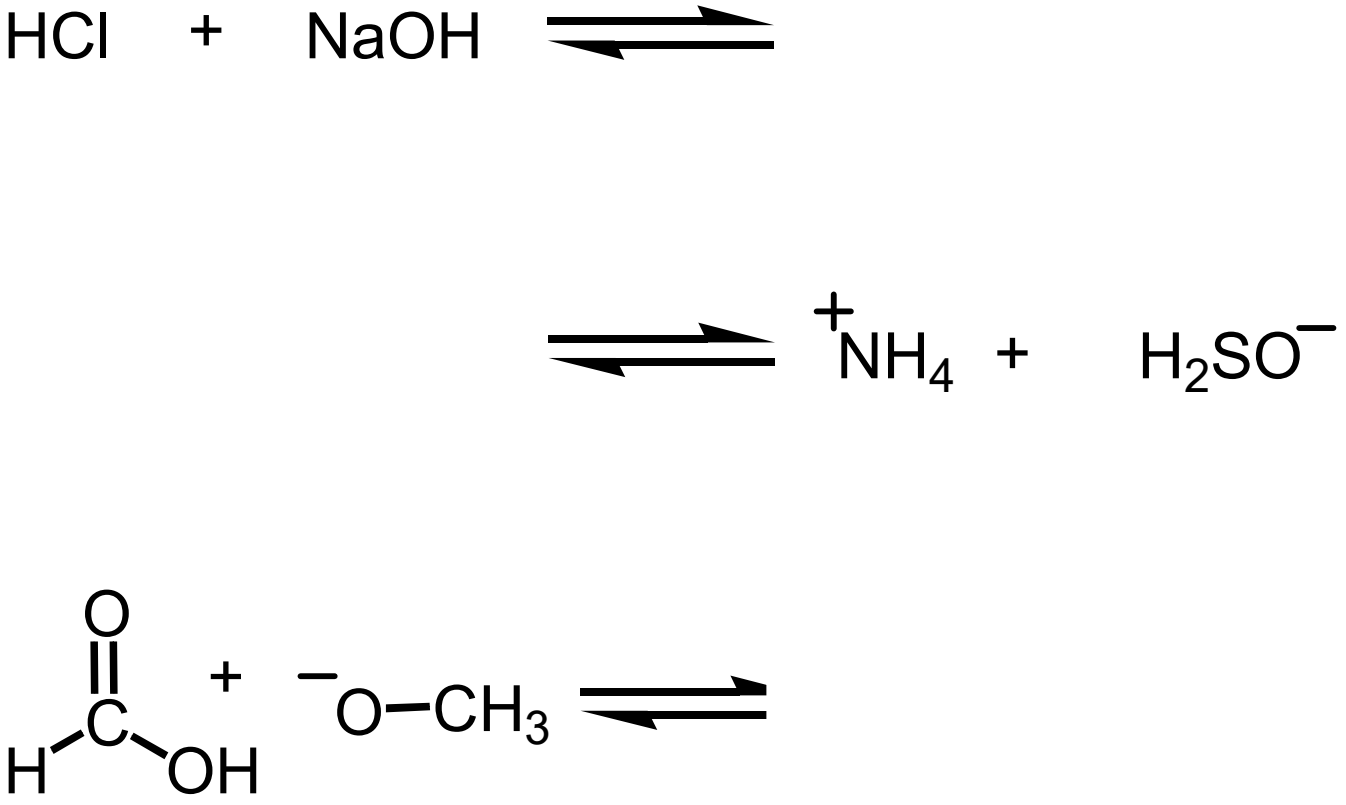
Remember from General Chemistry:

- The acidity of an aqueous solution is determined by the concentration of H_3O^+ ions.

- Water Autoprotolysis Constant, Kw = 1.00×10^{-14} at 24°C

$$Kw = [H_3O^+]\,[^-OH]$$

Acids and Bases: pH and pKa



Acids and Bases: pH and pKa

- In order to compare the reactivity of acids - what we need is a way to quantify their acid strengths.
- We can do this using the equilibrium constant for this reaction.

Acids and Bases: pH and pKa

- K_as typically range from 10^{14} to 10^{-50} in value.

$$pK_a = -\log K_a$$

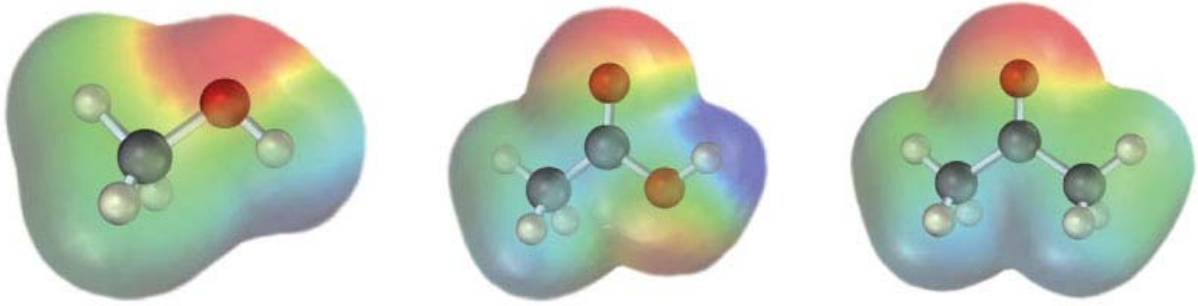
- Low or negative pK_a means strong acid →
- High pK_a value means weak acid ➔

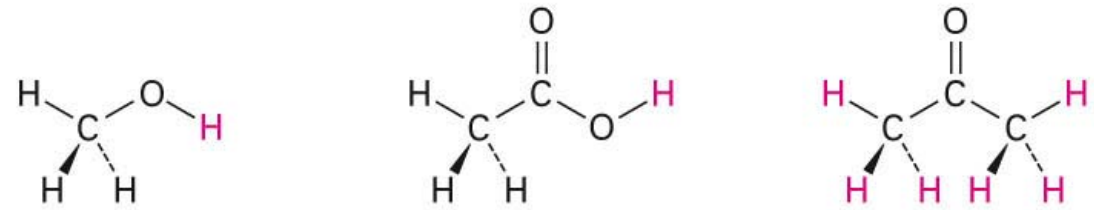
Typical values:

- Strong Acid
- Organic Acid
- Organic Compound

Organic Acids and Organic Bases

Organic Acids:





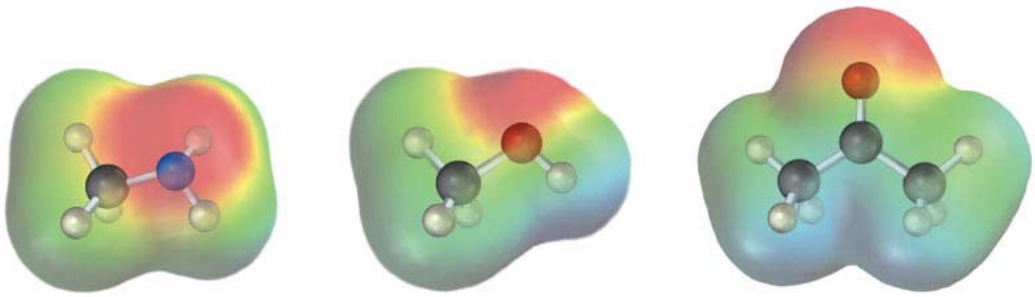
Some organic acids

Methanol
(pK_a = 15.54)

Acetic acid
(pK_a = 4.76)

Acetone
(pK_a = 19.3)

Organic Bases



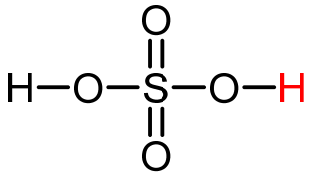
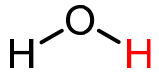
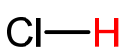
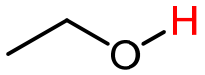
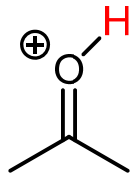
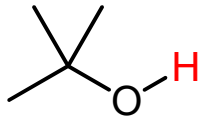
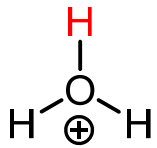
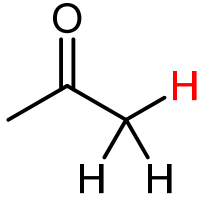
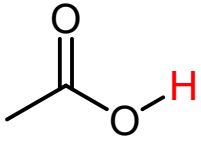
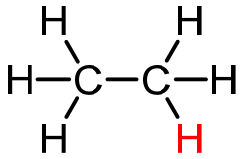
Some organic bases

Methylamine

Methanol

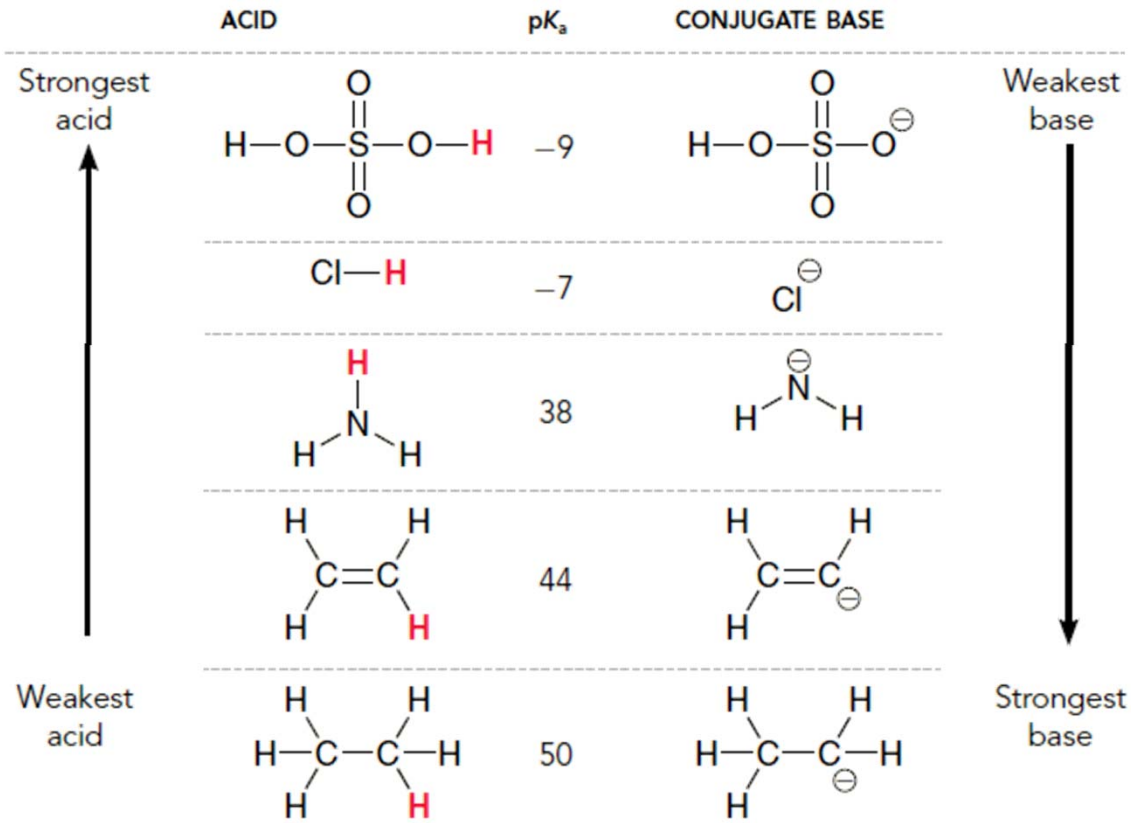
Acetone

Quantifying Acidity and Basicity – Acidity

ACID	pK_a	ACID	pK_a
	–9		15.7
	–7		16
	–2.9		18
	–1.74		19.2
	4.75		50

- There are more acids and pK_a values in Table 3.1.
- Each pK_a unit represents an order of magnitude or a power of 10.
  - Which is stronger, HCl or H_2SO_4, and by exactly HOW MUCH?

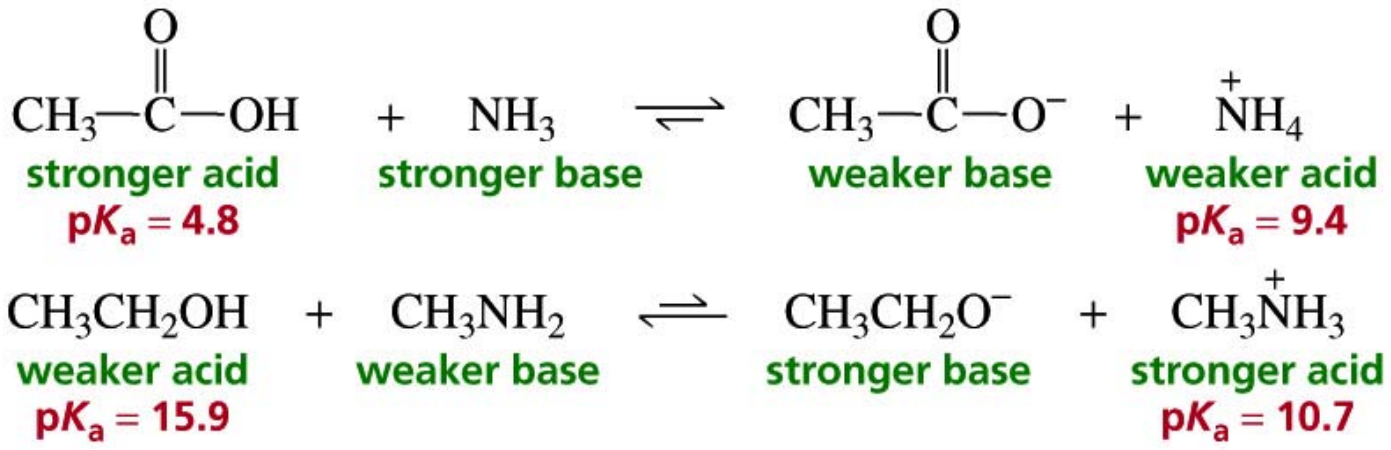
Quantifying Acidity and Basicity – Basicity



- You can also use pK_a values to compare the strengths of bases:
  - The stronger the acid the weaker its conjugate base. WHY?

Acids and Bases: pH and pKa

- Strong reacts to give weak.
- The stronger the acid, the weaker its conjugate base.
- Stable bases are weak bases.
- For an Acid-Base Reaction, the equilibrium lies toward the acid with the higher pKa, the predominant species at equilibrium.



Qualifying Acidity

- The more effectively a conjugate base can stabilize its negative charge, the stronger the acid.
- What factors affect the stability of a negative formal charge?

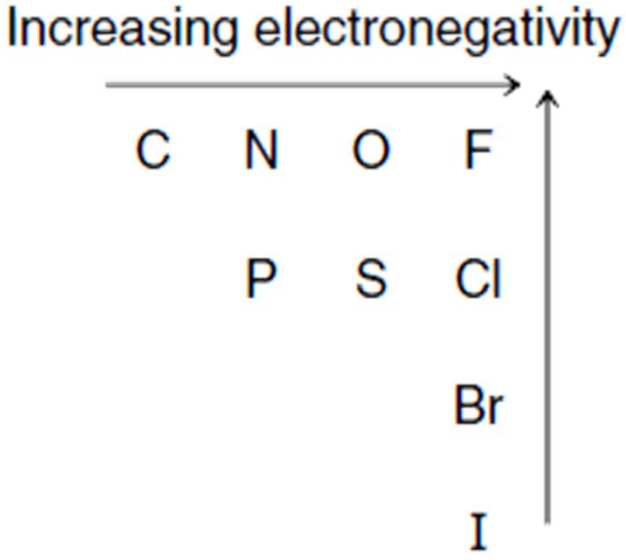
- These factors can be remembered with the acronym, **ARIO**.

Qualifying Acidity – The Type of Atom

- **A**RIO—The type of **atom** that carries the charge:
  - More electronegative atoms are better at stabilizing negative charge. WHY?
  - Compare the acidity of the two compounds below:

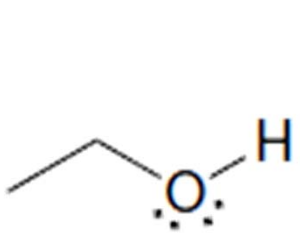
Butane

Propanol

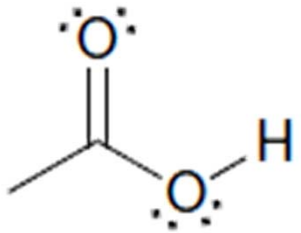


Qualifying Acidity – Resonance

- A**R**IO—**Resonance** can greatly stabilize a formal negative charge by spreading it out into partial charges.
- Compare the acidity of the two compounds below by comparing the stabilities of their conjugate bases. How does resonance play a role?



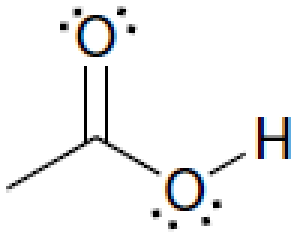
Ethanol



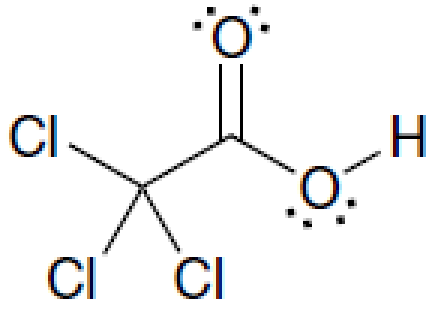
Acetic acid

Qualifying Acidity – Induction

- AR**I**O—**Induction** can also stabilize a formal negative charge by spreading it out. How is induction different from resonance?
- Compare the acidity of the two compounds below by comparing the stabilities of their conjugate bases. How does induction play a role?



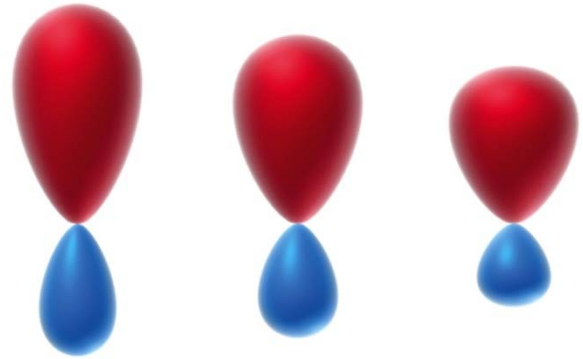
Acetic acid



Trichloroacetic acid

Qualifying Acidity – Orbital

- ARI**O** —The type of **orbital** also can affect the stability of a formal negative charge.
- Is a negative charge more stable or less stable if it is held closely to an atom's nucleus? WHY?
- Rank the ability of these orbitals (2s, 2p, sp^3, sp^2, and sp) to stabilize electrons, and explain.



For Next Time….

- Friday Start Chapter 4 (4.1 – 4.5)
  - BRING YOUR MODEL SET!
- Homework Problems Chapter 3
  #1,4,7,15,34,35,37,39,43,44, 47
- Homework Problems Chapter 4
  #1, 6, 10, 19, 25, 28, 36, 43, 48, 51,52, 63