

Acids and Bases

Overview of Acids and Bases

Acid-base Acids and Bases

Acids: Donates its proton in these processes (H⁺)
 Base: Donates its lone pair to form a bond (H⁺)



Remember: It's only in water, it only HCl is a free

What does aqueous hydrochloric acid and sodium hydroxide solution?

Acid-base Acids and Bases

Acids are proton donors (the molecule is losing its proton)
 Bases are proton acceptors (the molecule is still losing the proton)



General Acids and Bases of Acid-Base Reactions

It shows the proton donor (the base) participating in the acid-base reaction and the proton acceptor (the acid) participating in the acid-base reaction.
 It shows the transfer of the proton and the resulting products in the other direction.

Remember: **acid reacts with base to form conjugate acid and base**

Acid-Base and General Definitions: Arrhenius, Brønsted-Lowry, and Lewis

What if there is no proton transfer?

Lewis Acids and Bases

Lewis acids: An electron pair acceptor.
 Lewis bases: An electron pair donor.



So, in the Lewis theory, acids and bases are described in terms of electron pairs.

What are the acid-base theories commonly in use today?

As a general practice, consider acids as **1** and bases as **2**.

Acid Strength

What does it mean "strong acid"?

Generally speaking, the more the acid dissociates into a proton, the stronger it is.



The dissociation of the acid is a reversible reaction that is described by the equilibrium constant.



Remember: $K_a = [\text{H}^+][\text{A}^-]$

Acid Strength and pKa

The Ka value of a weak acid (1) and a strong acid (2) are shown below.



The reaction is a stronger acid because it has a higher Ka.

To simplify the numbers, logKa is used, which is the pKa of the given acid.

$\text{pKa} = -\log K_a$

$\text{pKa}_1 = -\log K_{a1}$ (1) $\text{pKa}_2 = -\log K_{a2}$ (2)

So, the stronger the acid, the lower the pKa value. (It's the opposite for Kb)

Below are pKa values of some common functional groups.



What makes the Acid Strong?

The strength of the acid is defined by the stability of the conjugate base (the base after the acid dissociates).

The stronger the acid, the more stable its conjugate base.



What if a weak acid and a strong base react, does it form a strong acid?

There are no free electrons in a covalent bond, so forming the stability of the conjugate base.

1) The first and the best factor is the **charge** to which the conjugate base is converted. Strongly negative ions (Phenolates and Carboxylates).

2) When the same charge, electron-withdrawing groups (EWGs) or electronegativity in the base.



1) When comparing elements in a different row, the more electronegative the element, the more stable the conjugate base.

Larger atoms have higher polarizability and transfer the negative charge better in the conjugate base.



What are weak acids and strong bases in some circumstances from acids?

The sulfur atom is larger and stabilizes the negative charge better.

2) When comparing for same row, think which conjugate base is **more electronegative**.



1) The best factor for determining the acidity is called **inductive**.

Inductive or inductive effect is the transmission of charge through atoms.

Electronegative atoms pull the negative charge and help to stabilize the conjugate base.



The more electronegative, the more electron withdrawing, the stronger the acid.



The closer the electronegative atom to the hydrogen, the stronger the acid.

Resonance Acids

1) The best factor is the **charge** of the atom connected to the hydrogen.

The explains the great difference of pKa values of alcohols, aldehydes, and alkenes.



1) which is more electronegative than O, or the more electronegative, the stronger the acid.

Therefore, for **alkynes**, **alkenes** > **aldehydes** > **alcohols**.

The primary acids: **Alcohols**, **Carboxylic Acids**, **Aldehydes**, **Alkenes** (the increasing the acidity of a compound is shown as **down**).

Remember: the reaction for conjugate base.



The Position of Equilibrium for an Acid-Base Reaction

1) In the following reactions, choose the product.



Acid-base reactions are reversible, so another way of asking the question is:

1) In the equilibrium of the reaction, which is the right product or is the left reactant?

To answer this question, you need to remember that the equilibrium of acids and bases reaction is shifted towards the weaker acid and base.

So, you need to compare the pKa of the acid with acid and to compare with conjugate acid.

The equilibrium will be shifted to the higher pKa reaction with acid.



1) In the case the pKa of the conjugate acid is **greater** higher than the acid pKa, or the equilibrium is shifted to the right. Therefore, the right product will be shown higher.

Choosing a Base to Deprotonate a Given Compound

Suppose you need to deprotonate the following compound. → OH

Deprotonate means remove the proton acidic proton.

First, find its pKa value. → OH $\text{pKa} = 17$

What are the chemical equations of the conjugate reaction with a conjugate base (1) & (2).



The pKa of the conjugate acid must be higher than 17, so reaction with a strong base.

Find a conjugate base with pKa value with pKa > 17. Answer are react other pKa > 17.



Choosing an Acid to Protonate a Given Compound

Suppose you need to protonate a given compound about 17 (the pKa of the acid).

Which is a very reactive base and needs to be quenched before being shipped.

To do this, you use the chemical equation of acid + base with pKa.



The pKa of the conjugate acid of alcohol is 16. Therefore, the pKa of acid must be lower than 16, stronger acid than water and bases.

Therefore, a strong acid in a given state could be protonating for alcohol because its pKa is 14 and it is a strong enough of an acid than water.



Brønsted-Lowry's Equation

The equation shows whether the compound with a given pKa is an acid or base.

When deprotonated there is an aqueous solution depending on the pH of that solution.

$\text{pKa} + \text{pH} = \log \frac{[\text{A}^-]}{[\text{HA}]}$

Two general and applications of the Brønsted-Lowry's equation.

1) If the pH > pKa, 2) If the pH < pKa, 3) If the pH = pKa.



Remember: when acidic is in acidic form, when basic is in basic form.



The pKa of a given compound is about 4-11. Therefore, it is mostly in the acidic form (more molecules in protonated form) at a given pH. When the pH is 10, the log will be in the basic form. When the pH is 4.75, the log will be in the acidic form. When the pH is 14, the log will be in the basic form.

Holt Chemistry Acids And Bases Study Guide

Scott C. Dulebohn



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