

In depth explanation of Bronsted-Lowry acids and bases

If you read the tutorial where I introduced acids and bases, you may not have understood exactly what I was talking about when I discussed the idea of Brønsted-Lowry acids and bases. Not to worry – some of you have teachers who don't understand this concept either, so you're not alone in being confused.

Fortunately, here's a tutorial that goes into much greater detail with the goal of making it a little easier to understand. Additional goal, to make stupid jokes:



Brønsted came from Denmark. Denmark is known for the pastry known as a “danish.” The next time somebody tells you chemistry and baking are different, stick that in their eye!

What's a Brønsted-Lowry acid or base?

If you'll think back to the Arrhenius definition of acids, you'll recall that they're any compound that give off H^+ ions when you put them in water (HBr , for example). Arrhenius bases are compounds that give off OH^- ions in water (NaOH , for example). If you want to know whether something is an Arrhenius acid or base, you just look at the formula of the compound because a compound is always either an acid or a base.

The big difference between Arrhenius acids and bases and Brønsted-Lowry acids and bases is that Arrhenius acids describe what a compound *is*, while Brønsted-Lowry describes what a compound *does*. To give you a better idea of what I mean, let's compare the definitions to human strength:

In one definition of strength, you're defined as being strong by how much you can bench press. If you can bench press 150 pounds, you're strong, and if you can't, you're weak. There's no wiggle room here, and you can definitively call anybody strong or weak depending on this criterion.



These weaklings make me sick

However, you could also define strength by whether or not you can beat somebody up. For example, if I were to fight a toddler they would probably consider me to be strong. On the other hand, if I were to fight the enraged toddler's father, he'd consider me weak after I was beaten into pulp. By this definition, strength doesn't measure how strong you are in any absolute way, but how strong you act under certain circumstances.

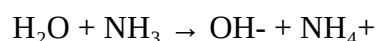
In the same way, Brønsted-Lowry acids and bases can only be defined in terms of how they react with one another. By themselves, no compound is either acidic or basic because there's nothing to compare them to. However, once you get them combining with each other, you can start to figure out which one is which. To illustrate this, let's use water as an example.



Damon was thirsty.

An example of a Brønsted-Lowry acid: water

The Arrhenius definition says that water is neutral. However, Brønsted-Lowry says that it needs to react with something before you can make this determination. Let's consider this example:



In this example, *water acts as a Brønsted-Lowry acid*. Why? This reaction shows water giving an H^+ ion to ammonia to form the ammonium ion. This is the sort of thing that acids do, according to the definition below:

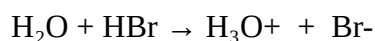
- **Brønsted-Lowry acid:** A compound behaves as a Brønsted-Lowry acid when it gives one or more H^+ ions to something else.

Likewise, in this case, ammonia is a Brønsted-Lowry base, because the Brønsted-Lowry definition tells us that:

- **Brønsted-Lowry bases:** A compound behaves as a Brønsted-Lowry base when it grabs one or more H^+ ions from another compound.

An example of a Brønsted-Lowry base: water

I know I just did an example in which I told you that water is an acid, but bear with me for a moment. Let's consider what happens when water combines with HBr:



You see what happened here? In this example, the water molecule grabbed an H^+ ion from HBr, which means that it acted as a base. HBr, on the other hand, acted as an acid because it gave the H^+ ion to water.

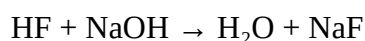
What does this all mean? It means that chemical compounds aren't acids and they aren't bases. Instead, they *behave* as acids or bases depending on the circumstances in which you put them. As a result, water can be either an acid or a base, depending on what else is in the beaker.



If you put this guy in a beaker, every chemical wants to act like a very strong acid.

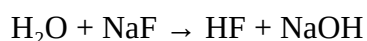
Conjugate acid-base pairs

When talking about Brønsted-Lowry acids and bases, we need to talk about something called Brønsted-Lowry acid-base pairs. Let's see what happens when HF reacts with NaOH:



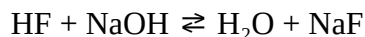
In this example, HF acts like an acid because it gives H^+ to NaOH. Likewise, NaOH acts as a base because it takes the H^+ from HF. Not too bad yet.

However, let's ask ourselves another question: What happens after the reaction takes place? Let's consider our products of water and NaF. Because all chemical reactions can behave as equilibria to some extent, there will be some reverse reaction that looks something like this:

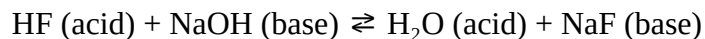


In this reaction, water acts as an acid because it gives an H^+ ion to NaF, while NaF acts as a base because it grabs an H^+ from water. Again, this isn't particularly surprising by itself.

Now, let's put everything together in one big equation:



or, to make it a little clearer what I'm going to talk about:



Looking at this, you can see that when HF loses H^+ (i.e. it acts like an acid), it becomes NaF (which will act like a base when it reacts with water). As a result, we'd refer to HF and NaF as being a *conjugate acid-base pair*, because they're related to one another by this gaining or losing electrons. Specifically, HF is an acid and NaF is its conjugate base.

Likewise, NaOH and water are another conjugate acid-base pair, where NaOH is the base and water is its conjugate acid.

Some good rules of thumb about Brønsted-Lowry conjugate acid-base pairs:

- The stronger an acid is, the weaker its conjugate base. HF is an acid with moderate strength, so its conjugate base, NaF will be a lousy base.
- The stronger a base is, the weaker its conjugate acid. NaOH is a terrific base, so its conjugate acid, water, will be a lousy acid in this case. Together with the point above, this tells us that the reaction will lie mostly toward the water/NaF side of the equation (and in fact, this is overwhelmingly the case in real life).
- The relative strengths of acids and bases can be determined by a term known as K_a . Though K_a won't tell us whether something is an acid by itself (the term acid doesn't make sense unless there's a base around), compounds with higher K_a values will act as acids when they react with compounds that have smaller K_a values. For example, acetic acid has a K_a of 0.000018, and water has a K_a of 0.0000001. Though the K_a of acetic acid isn't particularly large, the K_a of water is even less, so if you put them in a beaker together the acetic acid will give an H^+ ion to water.
- Anything with a K_a value greater than 1 is referred to as a "strong acid." Strong acids almost completely dissociate in water, so if you've got one of those guys around, look for some cool acid action to happen sometime soon.

OK... go study some more acid-base stuff.
