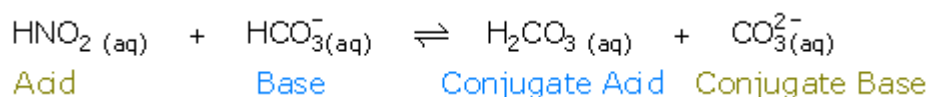


## Amphoteric Species

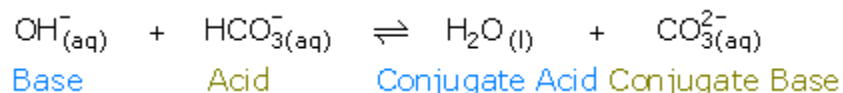
Any species that has the ability to behave as an acid in one situation and as a base in another is called an **amphoteric species**.

Here's another example. Baking soda, sodium hydrogen carbonate, can be used to clean-up either an acid spill or a base spill in a chemistry lab. Or, if you accidentally spilled nitrous acid on yourself, you would rinse the area thoroughly with water and then apply a paste of baking soda to neutralize any remaining acid on your skin.

The net ionic equation for this neutralization reaction is:



If you spilled sodium hydroxide, the hydrogen carbonate ion would neutralize the hydroxide ion in this reaction:



Note: In both reactions the aqueous sodium ions do not undergo chemical changes, so they are omitted from the net ionic equation. Species like sodium that do not undergo chemical changes in reactions are called **spectators**.

Hydrogen carbonate ion,  $\text{HCO}_3^-$ , is an amphoteric species. Like water, it reacts as a base in some circumstances and as an acid in others. At this point, at least three important questions should be entering your mind.

1. How do you recognize an amphoteric species?
2. How do you know when an amphoteric species will behave as an acid or a base?
3. Why are some species written as ions in these equations while others keep their full chemical formulas?

## Characteristics of Amphoteric Species

An amphoteric (sometimes called amphiprotic) species must possess at least one removable hydrogen atom and have "room" to accept one additional proton in an acid-base reaction.

For example,  $\text{HSO}_3^-$  is amphoteric because it can accept another hydrogen ion to become  $\text{H}_2\text{SO}_3$  or it can lose a hydrogen ion to become  $\text{SO}_3^{2-}$ .

Ions like phosphate ( $\text{PO}_4^{3-}$ ) cannot be amphoteric because they lack a hydrogen that can be removed. Such species can only accept protons in acid-base reactions. Species like  $\text{H}_3\text{PO}_4$  cannot be amphoteric because accepting a proton would result in an unfamiliar ion species ( $\text{H}_4\text{PO}_4^+$ ).

Classify each species as amphoteric or not amphoteric.

- a.  $\text{H}_2\text{BO}_3^-$ (aq)
- b.  $\text{S}^{2-}$ (aq)
- c.  $\text{CH}_3\text{COO}^-$ (aq)

### **Arrhenius versus Brønsted-Lowry**

Brønsted-Lowry theory explains the special cases of acidic and basic solutions that the Arrhenius theory could not explain.

Since Brønsted-Lowry acids lose protons in acid-base reactions, and since Arrhenius acids were defined as releasing hydrogen ions in water, you can consider Arrhenius acids as a subset of Brønsted-Lowry acids.

Arrhenius theory restricted the definition of acids to hydrogen containing compounds that dissociate in water to produce hydrogen ions. However, as you have seen, Brønsted-Lowry theory extends the idea by stating that acids lose protons in acid-base reactions.

Brønsted-Lowry theory defines bases as species that accept protons in acid-base reactions thereby eliminating the need for mention of hydroxide ions in the definition of a base. This explains why species such as sulfate, sulfide, carbonate, phosphate, hydrogen phosphate, hydrogen carbonate and many, many others can behave as bases in acid base reactions.

Both Arrhenius theory and Brønsted-Lowry theory deal with aqueous acids and bases. Neither of them accounts for the behaviour of acids like  $\text{BF}_3$ . Understanding the behaviour of these species requires knowledge of Lewis theory - something encountered at college/university level chemistry.