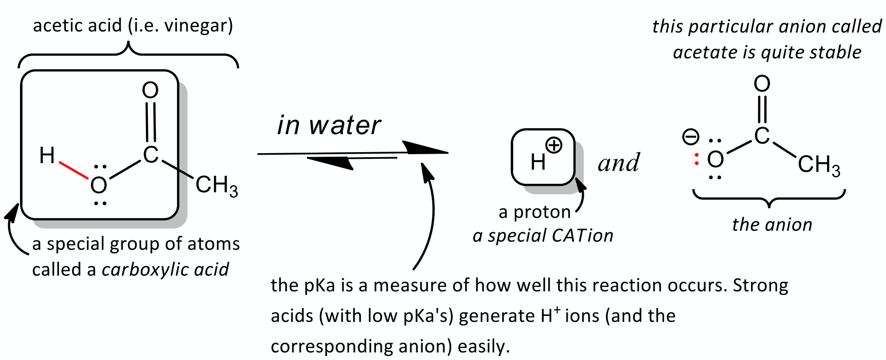
Model 1. What we perceive as the taste of "sour" is actually our tongues detecting the presence of H^+ cations. H^+ cations are special cations called *protons.* When they are released by molecules into water they make the solution *acidic,* and that *acidity* is what we taste as "sour". The term *acid* comes from the Latin *acidus,* meaning "sour or tart." And it is that same Latin word that is the origin for the word *acetus* – more commonly known as vinegar. What is it in vinegar that creates *acidity* and conveys the taste of sour?

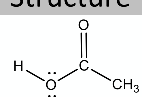
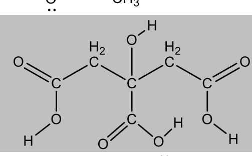
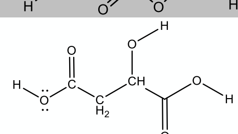
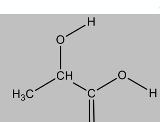


If acetic acid (the "sour taste" of vinegar) is added to water, then the *carboxylic acid* group will give up a *proton*, leaving behind an anion.

Figure 8.1. Acetic acid *dissociating* into ions

Why don't the proton and the anion just immediately recombine to make acetic acid again? Because the anion is quite stable. When the anion is stable, the *acid* is more *acidic.* To put this another way, the *more stable* the *anion* produced, the *more likely* the acid is to release a proton. Chemists measure *how readily an acid releases a proton* using a number called the pKa; the lower the pKa, the more *acidic* the acid and the more stable the anion produced.

Table 8.1. Acids found in typical foods.

Acid	Structure	pKa of acid	Food source
Acetic Acid		4.75	Vinegar
Citric Acid		3.15, 4.77, 5.19	Lemon juice
Malic Acid		3.40, 5.11	Apple juice
Lactic Acid		3.88	Yogurt

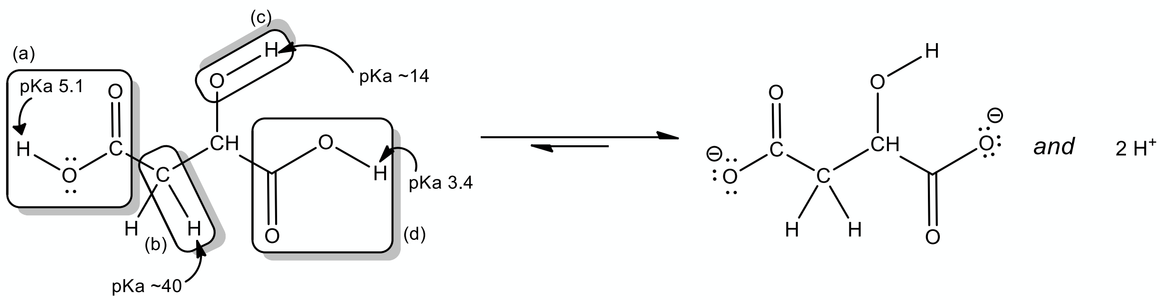


Figure 8.2. The dissociation of malic acid into ions. Hydrogens (a) and (d) are lost as *protons. De-protonation* (i.e. loss of a proton) does not occur for hydrogens (b) and (c).

<u>Questions</u>

1. What is the significance of the red bond on the left of Figure 8.1 and the two red electrons on the oxygen (on the right side of the figure)?

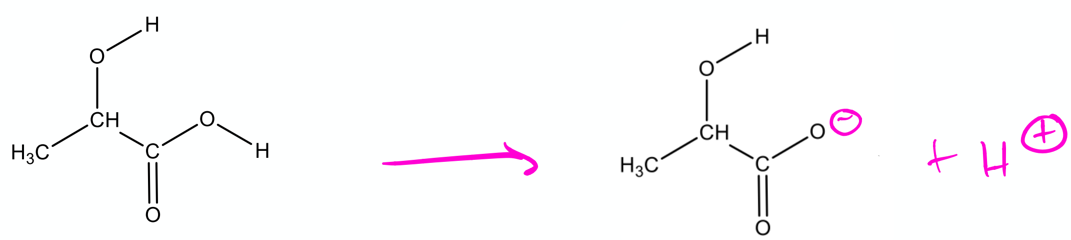
   Bond broken in acid-base.

   Bond to the acidic H.

2. As shown in Table 8.1., citric, malic and lactic Acids all have hydrogen atoms that are *not* part of carboxylic acids. Considering the information provided for malic acid in Figure 8.2, why does *de-protonation* (i.e. removal of a proton) not occur at positions (b) and (c)?

   pKa is to high (↓pKa = more acidic)

3. Using Figure 8.2 as a template, complete the reaction below by showing the ions produced from the *dissociation* of lactic acid.



Lactic Acid

4. In Table 8.1, why does citric acid have three pKa measurements listed, while malic acid has two and lactic and acetic acids each have one?

Citric acid has 3 carboxylic acid.

5. Vitamin C is a molecule with a pKa of 4.1. Is Vitamin C an acid or base? Explain.

Acid → low pKa

Model 2. Some molecules are the *opposite* of *acidic*; these molecules don't release protons, instead they take protons from other molecules. Taking a proton from water creates an anion with a special name – *hydroxide*. Molecules that produce *hydroxide* ions when mixed with water are *alkaline,* they are also called *bases* or *basic* molecules.

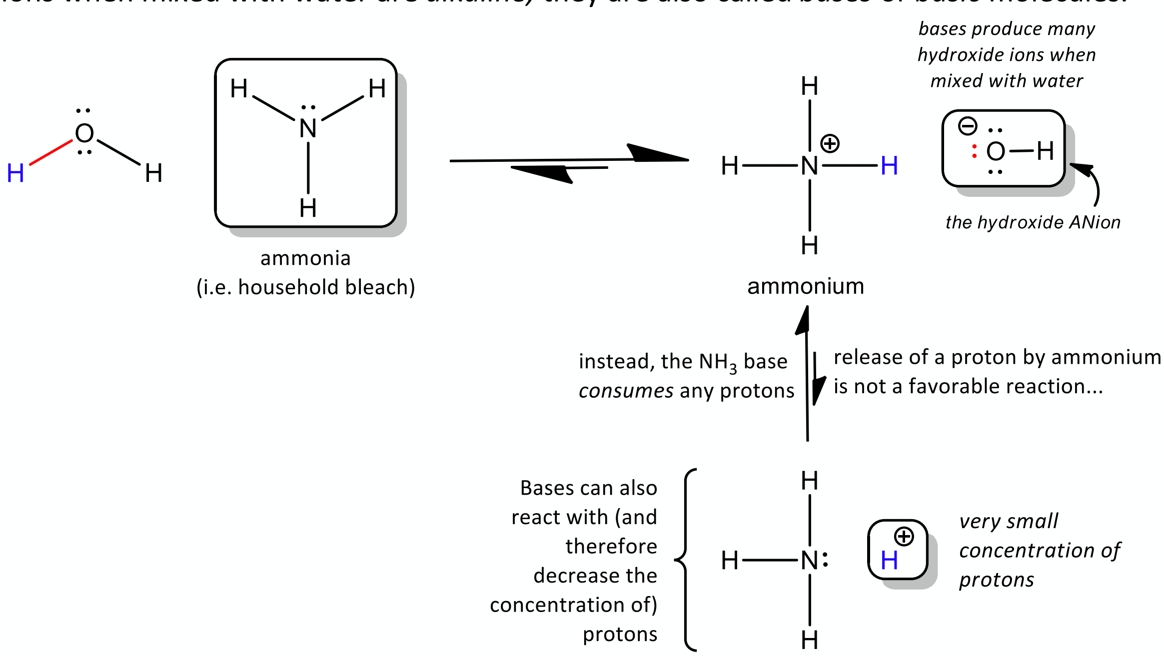


Figure 8.3. The base ammonia takes a proton from water to make the hydroxide anion.

Table 8.2. Relative concentrations of protons and hydroxide ions in acidic, neutral and basic solutions			
	Concentration H^+ (protons)	**Concentration of ^-OH (hydroxide)**	
Acidic pH	High	Low	$H^+ > {}^-OH$
Neutral pH	Equal	Equal	$H^+ = {}^-OH$
Basic pH (Alkaline)	Low	High	$H^+ < {}^-OH$

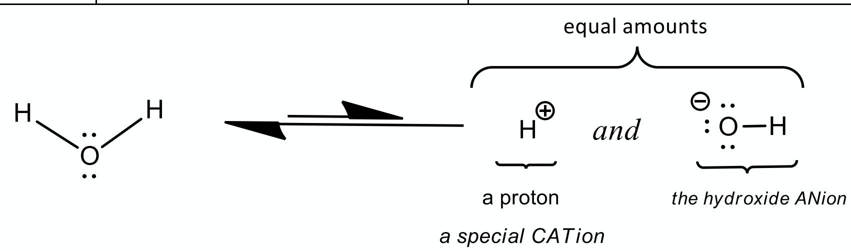


Figure 8.5. The *dissociation* of water. Water has a *neutral pH* - so the amounts of H^+ and ^-OH ions produced are equal.

The pH is a different number used to measure the *concentration* or the amount of H^+ ions in solution. The more protons (H^+) there are, the lower the pH. Alkaline or basic molecules produce *very few* H^+ ions, and they can also consume H^+ ions – both effects lower the H^+ concentration and raise the pH.

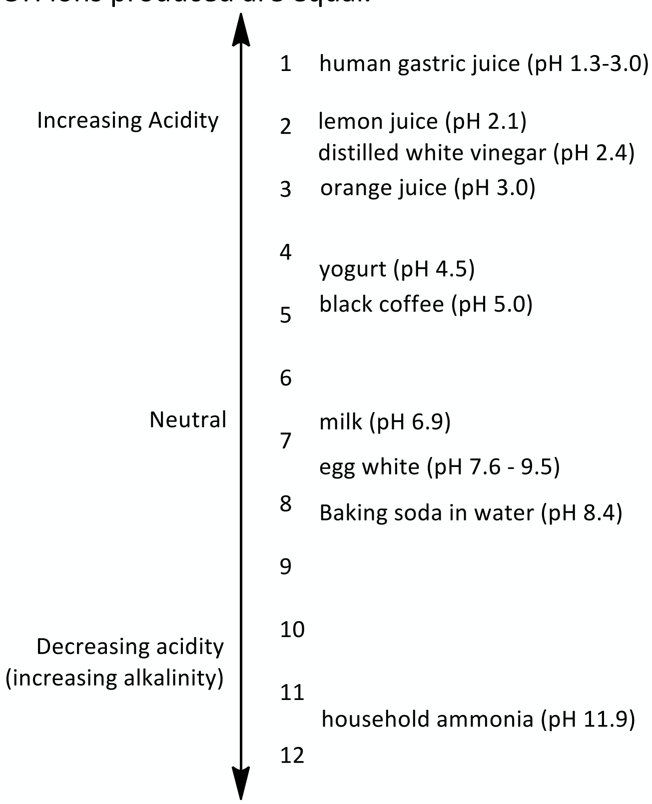


Figure 8.4. pH values of common foods.

Questions:

6. Based on the pH of milk, what would you predict about the relative concentration of H^+ and ^-OH ?

Slightly more H^+ than ^-OH

7. Water has a neutral pH. If you squirt some lemon juice into water, the pH changes.
   a) What do you expect will happen to the pH of the mixture of water and lemon juice? Will the number increase or decrease?

   pH decrease and the number ↓

   b) What do you expect about the relative concentrations of H^+ and ^-OH in the lemon juice and water mixture?

   More H^+ than ^-OH because pH ↓

8. If you measure carefully, it is possible to take some vinegar (acidic) and mix it with baking soda dissolved in water (basic/alkaline)- the mixture will get warm (evidence of a chemistry occurring), but the final mixture has a *neutral pH.* How can this be? Talk about the relative concentration of H^+ and ^-OH ions.

Adding an acid + base should keep the amount of H^+ and ^-OH the same

9. Natural unsweetened cocoa powder has a pH of about 5 (slightly acidic). Dutch processed cocoa is made by treating natural unsweetened cocoa powder with a *base* (an alkaline substance). The resulting Dutch processed cocoa is darker in color and milder in flavor. Should the pH of Dutch processed cocoa be *lower* or *higher* than natural unsweetened cocoa powder? Explain.

Higher. Adding a base, which generates ^-OH

10. When acid or base is added to protein molecules, there are side chains of amino acids that undergo a reaction with the protons (H+) in the acid or the hydroxide anions (^{-}OH) in the base. The reaction changes the overall charge of the amino acid. Using the structures show below – show the expected product of a reaction between the indicated side chain and a proton or the anion, hydroxide.