Acids and Bases

Properties of acids and bases:

Acids are substances that dissolve to produce conducting solutions that taste sour, turn litmus red, have a low pH, react violently with metals, and neutralize bases.

Bases are substances that dissolve to produce conducting solutions that taste bitter, turn litmus blue, feel slippery, are corrosive, have a high pH and neutralize acids.

Empirical and theoretical definitions.

Empirical definitions are practical, observable, or experimental. Theoretical definitions are explanations or ideas.

Empirical definition of an acid would be any solution that conducts electricity, tastes sour, reacts with metals, turns litmus red, neutralizes bases and has a low pH (below 7).

Empirical definition of a base is any conductive solution that tastes bitter, is corrosive, turns litmus blue, neutralizes acids and has a high pH (above 7).

The first **theoretical definition** for an acid was proposed by **Arrhenius**: an acid is any substance that dissociates in water to increase the hydrogen ion concentration. A base is any substance that dissociates in water to increase the hydroxide ion concentration.

Scientists believe that since water is very polar and hydrogen ions being small are very mobile, they will attract and it is more likely that **hydronium ions** exist. H_3O^+.
Soon it was found that other substances showed properties of acid or base solutions but did not initially contain hydrogen ions or hydroxide ions. A modified Arrhenius definition was developed; an acid is any substance that **reacts** with water to produce hydronium ions. A base is any substance that reacts with water to produce hydroxide ions.

Acid naming rules:

Acid name	Ionic name
• Hydro____ic acid	hydrogen ____ide
• Per____ic acid	hydrogen per____ate
• ____ic acid	hydrogen ____ate
• ____ous acid	hydrogen ____ite
• Hypo____ous acid	hydrogen hypo____ite

Pure water has trace amounts of H_3O^+ and OH^- ions, coming from the slight dissociation of water. Placing an acid in water will increase the $[H_3O^+]$ and a base will increase $[OH^-]$.

Measuring the hydrogen ion concentration in a solution can be done with a conductivity tester. A pH meter was developed to accurately measure acidity in solutions. Other means was to use special indicators on paper that turns specific colors when in a solution with a given pH. The indicators are not as accurate as meters, but are quite useful.

pH or *power of hydrogen* simplifies comparing values that have as vast a range as hydrogen ion concentration in solutions. pH is the hydrogen ion concentration expressed in an exponent form. (logarithm scale) pH scale usually ranges from 1 to 14 but in fact can go as low as -1and as high as 15. The lower the pH, the more acidic a solution. The higher the pH the more basic it is. pH is calculated as follows

$pH = -\log[H^+]$ or $[H^+] = 10^{-pH}$

*Rounding: $[H_3O^+]$ significant digits convert to pH decimal places.

$[H_3O^+]$ of pure water is 1×10^{-7} which is a pH of 7. Acids have a pH below 7 while bases have a pH above 7

Although the pH of bases can be measured, a new similar value was determined for bases called pOH. $\underline{pOH = -\log[OH^-]}$

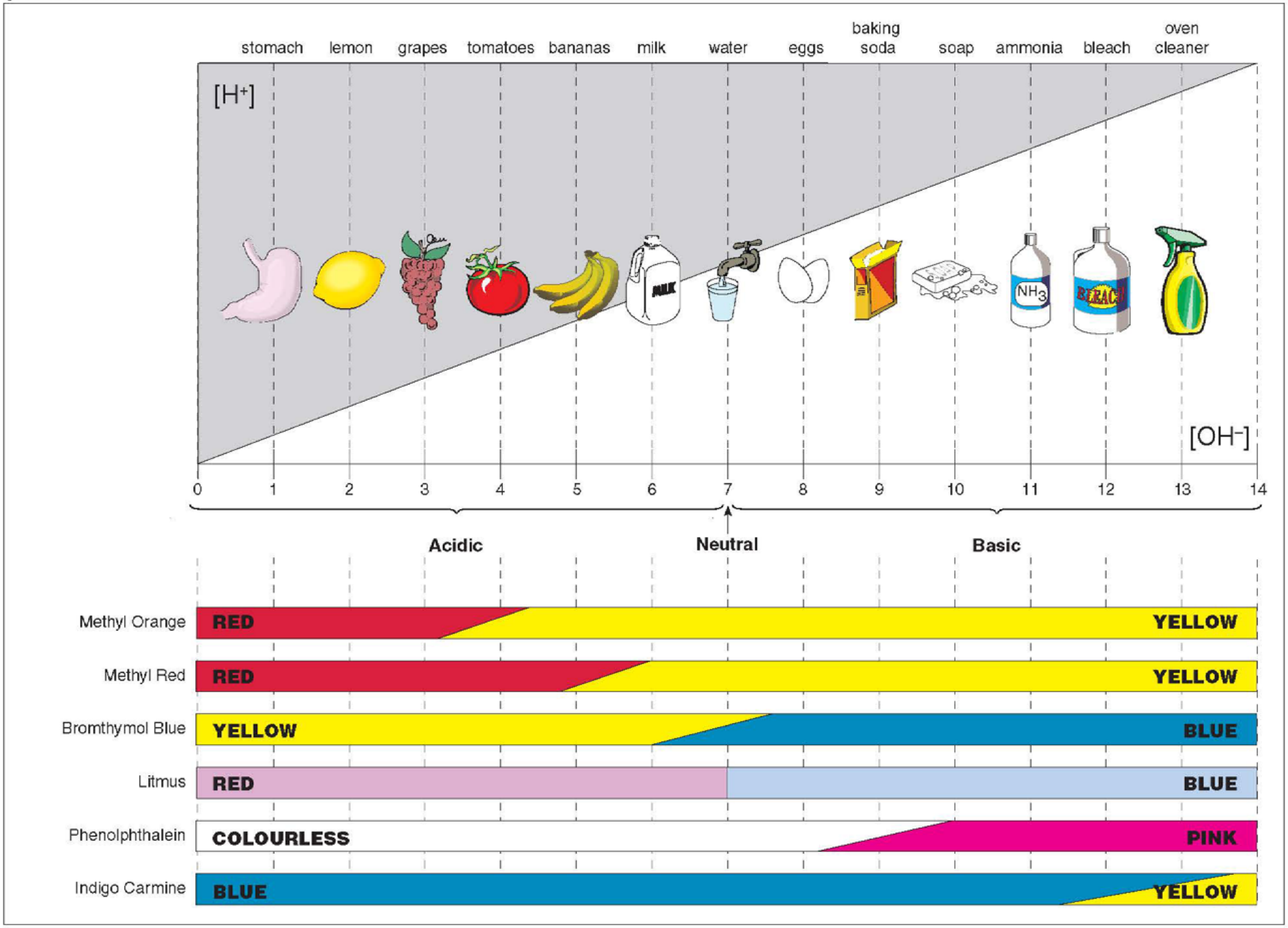
The pH and pOH of a solution are inversely related. The pH of a solution goes down the pOH of that solution will go up the same amount. $\underline{pH + pOH = 14}$

Indicators are usually weak acids that dissociate to produce ions that have a different color than the molecular acid. If the indicator is placed in an acidic solution there are already many hydrogen ions present so the indicator molecule is less inclined to dissociate. In a basic solution the hydrogen ions are neutralized or used so the indicator is more likely to dissociate producing the color of its ion.

$$HPr \rightarrow H^+ + Pr^-$$

Yellow red

pH SCALE


stomach
lemon
grapes
tomatoes
bananas
milk
water
eggs
baking soda
soap
ammonia
bleach
oven cleaner
[H+]
[OH−]
NH3
BLEACH
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Acidic
Neutral
Basic
Methyl Orange
RED
YELLOW
Methyl Red
RED
YELLOW
Bromthymol Blue
YELLOW
BLUE
Litmus
RED
BLUE
Phenolphthalein
COLOURLESS
PINK
Indigo Carmine
BLUE
YELLOW

Neutralization

An acid reacts with a base to produce a solution that doesn't have properties of an acid or a base. The simplest form of the net reaction is that the hydrogen ions join with the hydroxide ions to form water. $H^+_{(aq)} + OH^-_{(aq)} \rightarrow HOH_{(l)}$

Neutralization problems

Strong acids are those that dissociate most readily to easily produce hydrogen ions. Weak acids are not as soluble, (more molecular properties) and are less likely to produce hydrogen ions. The strength of the acid is an independent characteristic from its concentration. It is possible to have a dilute strong acid or a concentrated weak acid.

Many acids dissociate to produce a single hydrogen ion, but there are others that can dissociate to give up more than one hydrogen ion. If an acid has only one [H+] available it is called **monoprotic**. If an acid has more than one [H+] available it is considered **polyprotic**. Each hydrogen ion on a polyprotic acid has a different attraction to its anion. The probability of a second or third [H+] being released from an acid becomes less and less likely.

$H_2SO_4 \rightarrow H^+ + HSO_4^-$	100%
$HSO_4^- \rightarrow H^+ + SO_4^{-2}$	27%

Bases can also be monoprotic or polyprotic. Bases that have the ability to neutralize more than one hydrogen ion is called polyprotic. Eg. $Mg(OH)_2$