Measuring pH

There are two ways to measure pH:

1. **pH meters**
   - consists of a digital probe connected to a data collection device (computer, etc.)
   - probe has two parts
     - a hydrogen sensitive bulb at the end
     - a reference electrode
   - the H_3O^+ ion concentration outside the probe is compared to the H_3O^+ ion concentration inside the probe
   - the probe sends a small electric current to the meter
     - amount of current is proportional to the pH of the solution outside the probe (e.g. for neutral water, the current is zero)
   - before being used, a probe must be calibrated by placing it in a solution with a known pH and adjusting the meter to read the correct value

2. **Indicators**
   - an indicator is a weak acid or base that undergoes a color change when it gains or loses hydrogen ions
   - common indicators:

Indicator	Low pH Color	pH Range	High pH Color
methyl violet	yellow	0.0–2.0	violet
thymol blue (first transition)	red	1.2–2.8	yellow
thymol blue (second transition)	yellow	8.0–9.6	blue
methyl orange	red	3.1–4.4	orange
methyl red	red	4.4–6.2	yellow
litmus	red	4.5–8.3	blue
bromothymol blue	yellow	6.0–7.6	blue
phenolphthalein	colorless	8.3–10.0	pink
alizarin yellow R	yellow	10.2–12.0	red

   - In solutions whose pH is below the pH range, the indicator will turn the low pH color.
   - In solutions whose pH is within the pH range, the indicator will be some combination of the two colors.
   - In solutions whose pH is above the pH range, the indicator will turn the high pH color.

How an Indicator Works

Litmus and other indicators can be explained by one simple equation. Using HIn to represent the acid form of the indicator and In^- to represent the base form, this equation is

$$HIn(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + In^-(aq)$$

Adding acid, which adds H_3O^+ ions to the solution, shifts the equilibrium to the left, increasing $[HIn]$. For litmus, HIn is colored red.

Adding base, which removes H_3O^+ ions, shifts the equilibrium to the right, increasing $[In^-]$. For litmus, In^- is colored blue.

Each indicator has a different equilibrium constant for this equation, which means that each has a different pH range over which it changes color. For example, litmus is red below pH 4.8, blue above pH 7.8, and has intermediate colors in the pH values in between.

Other indicators have different pH ranges and colors as indicated in the table on the previous page.