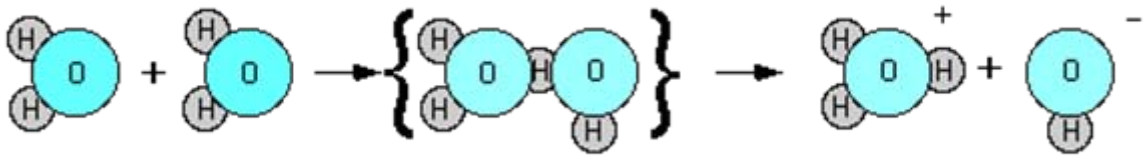
Acid-Base Titration and pH

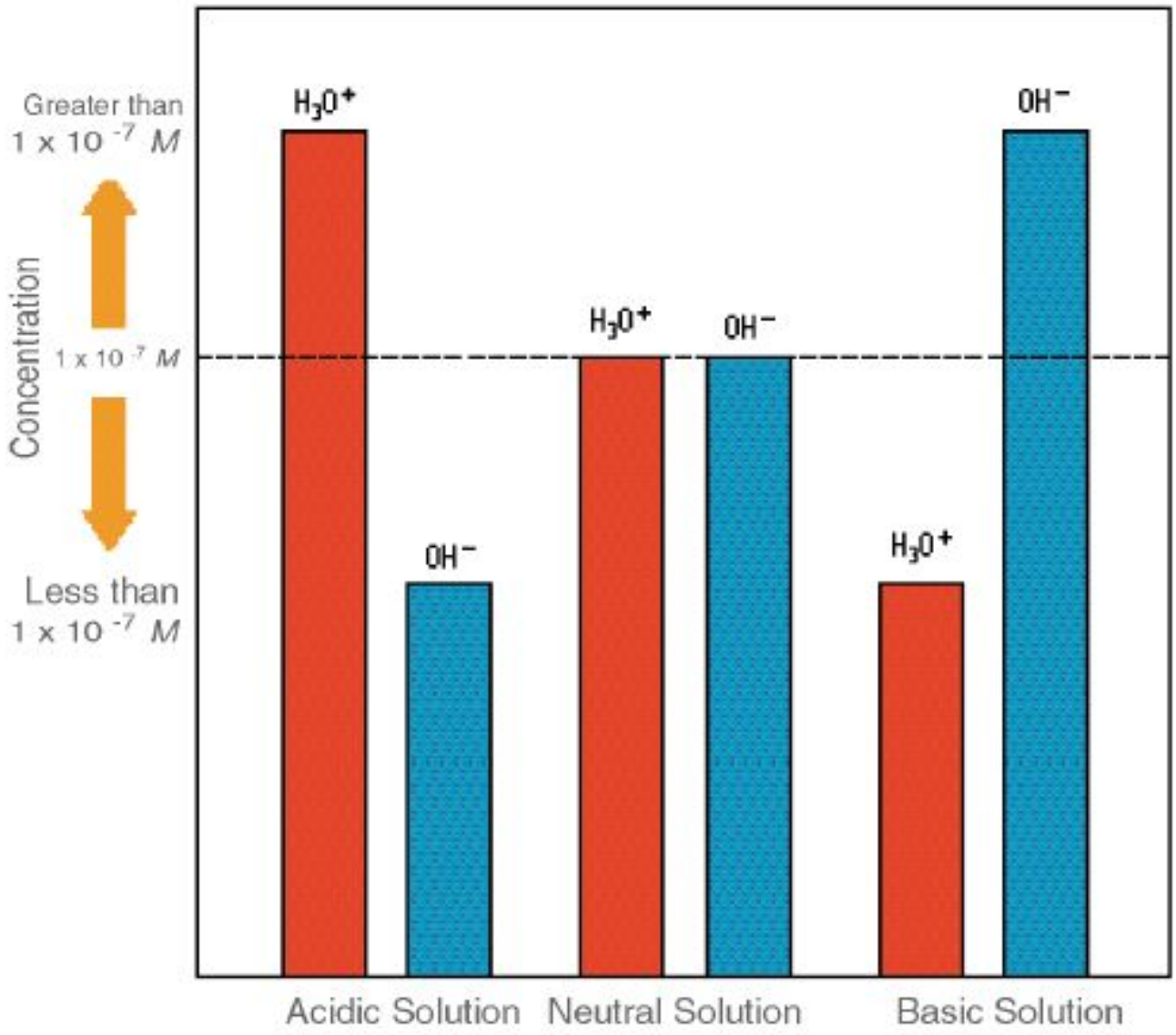
Self-Ionization of Water



$$H_2O + H_2O \rightarrow H_3O^+ + OH^-$$

Though pure water is considered a non-conductor, there is a slight, but measurable conductivity due to "self-ionization"

Ion Concentration in Solutions



K_w – Ionization Constant for Water

In pure water at 25 °C:

$[H_3O^+] = 1 \times 10^{-7}$ mol/L

$[OH^-] = 1 \times 10^{-7}$ mol/L

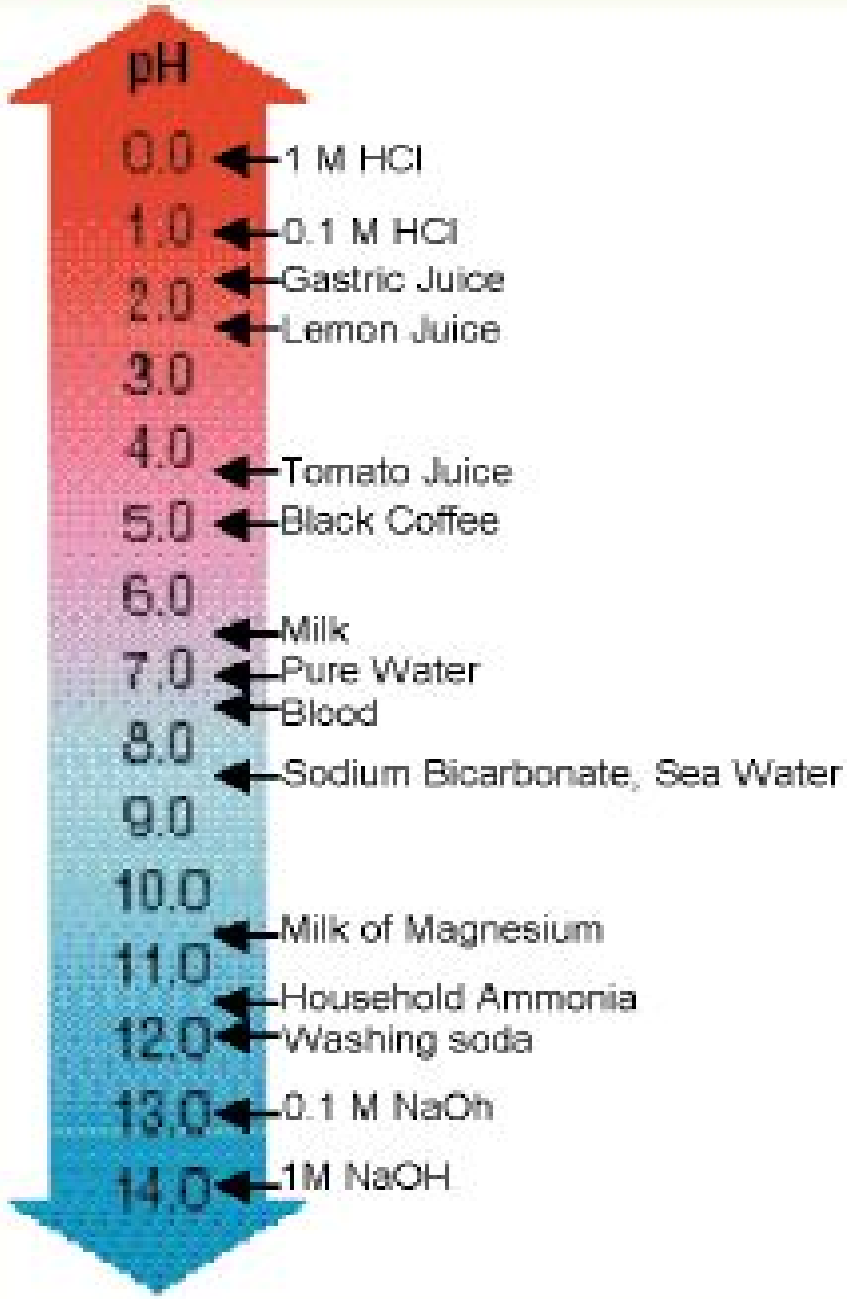
K_w is a constant at 25 °C:

$Kw = [H_3O^+][OH^-]$

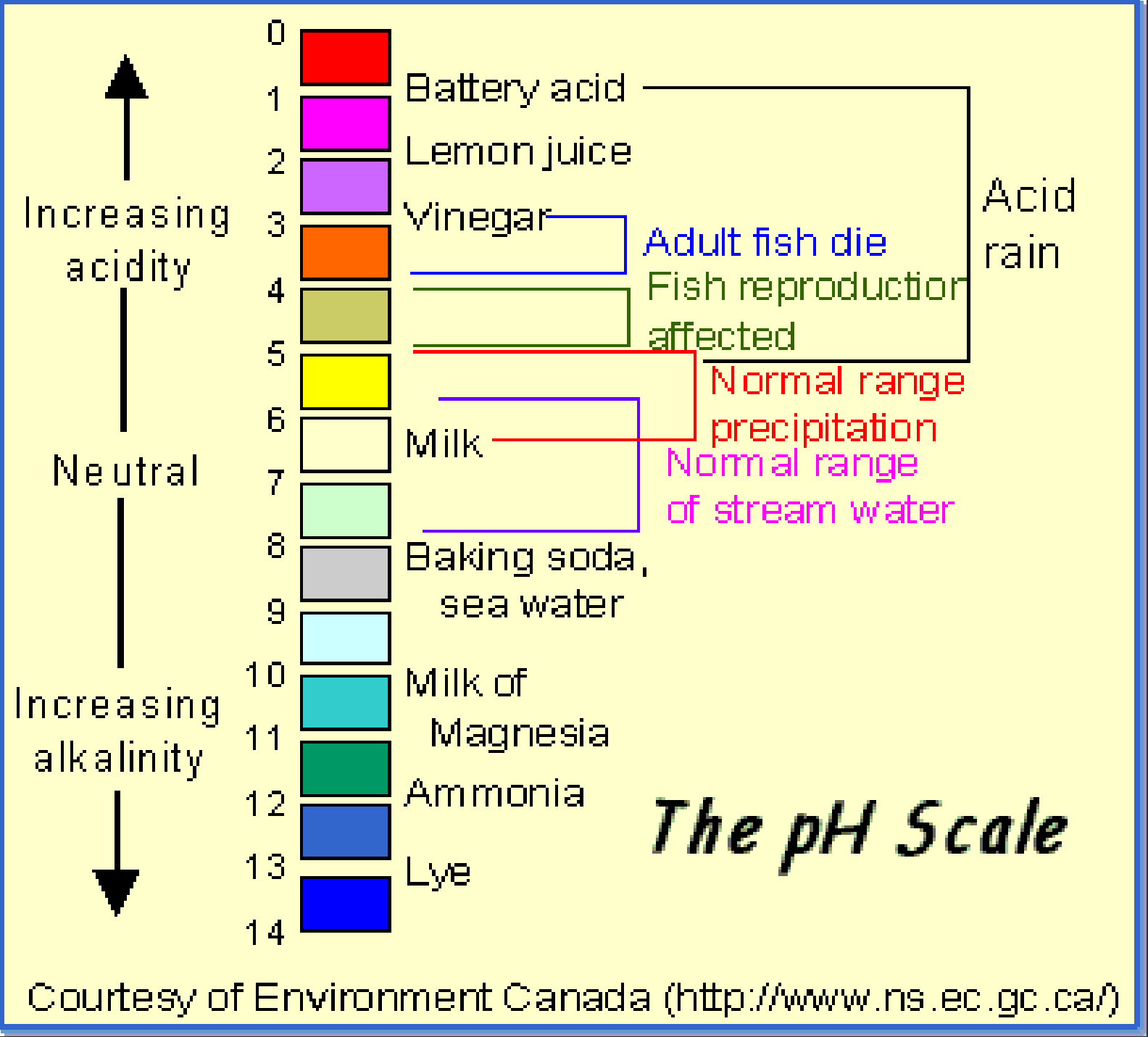
$Kw = (1 \times 10^{-7})(1 \times 10^{-7}) = 1 \times 10^{-14}$

Relationship among $[H^+]$, $[OH^-]$, and pH

	$[H^+]$ (mol/L)	$[OH^-]$ (mol/L)
Increasing acidity ↑	1×10^{0}	1×10^{-14}
	1×10^{-1}	1×10^{-13}
	1×10^{-2}	1×10^{-12}
	1×10^{-3}	1×10^{-11}
	1×10^{-4}	1×10^{-10}
	1×10^{-5}	1×10^{-9}
	1×10^{-6}	1×10^{-8}
Neutral	1×10^{-7}	1×10^{-7}
	1×10^{-8}	1×10^{-6}
	1×10^{-9}	1×10^{-5}
	1×10^{-10}	1×10^{-4}
	1×10^{-11}	1×10^{-3}
	1×10^{-12}	1×10^{-2}
	1×10^{-13}	1×10^{-1}
Increasing basicity ↓	1×10^{-14}	1×10^{0}



pH Scale



Courtesy of Environment Canada (http://www.ns.ec.gc.ca/)

Calculating pH, pOH

$$pH = -\log_{10}(H_3O^+)$$

$$pOH = -\log_{10}(OH^-)$$

Relationship between pH and pOH

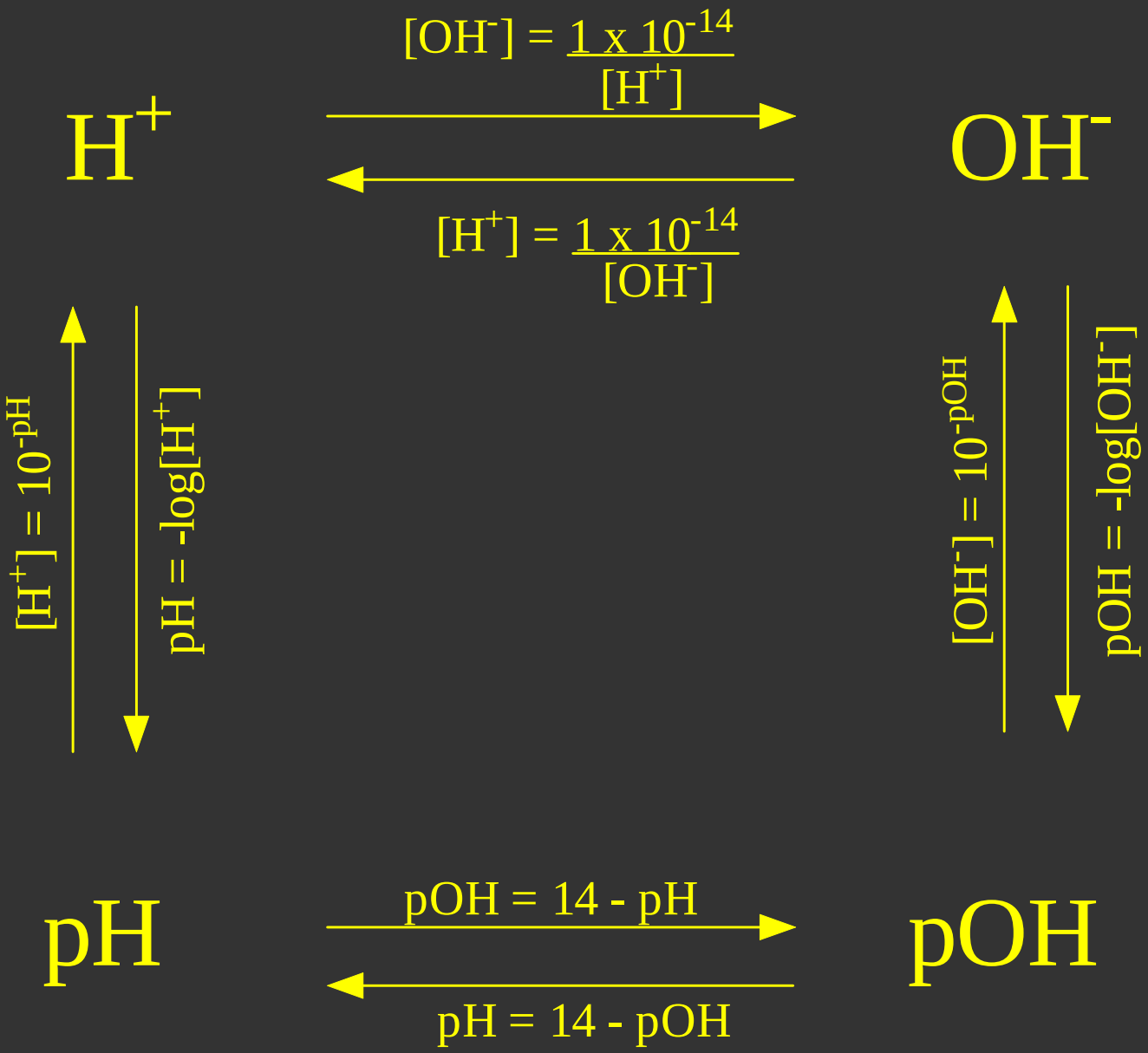
$$pH + pOH = 14$$

Finding $[H_3O^+]$, $[OH^-]$ from pH, pOH

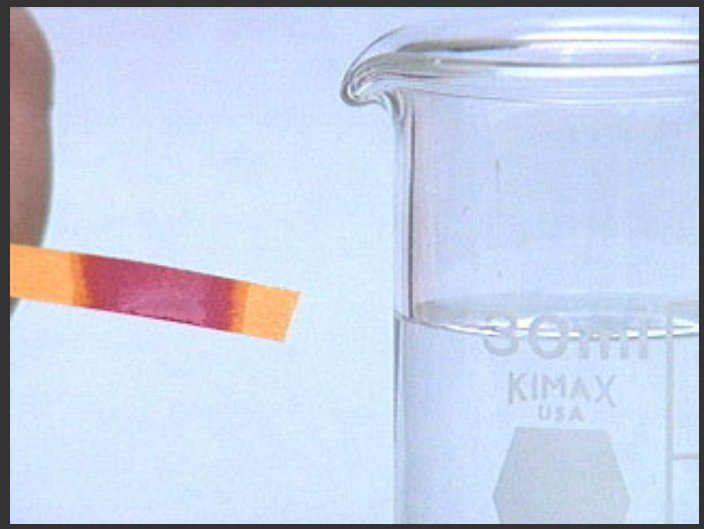
$$[H_3O^+] = 10^{-pH}$$

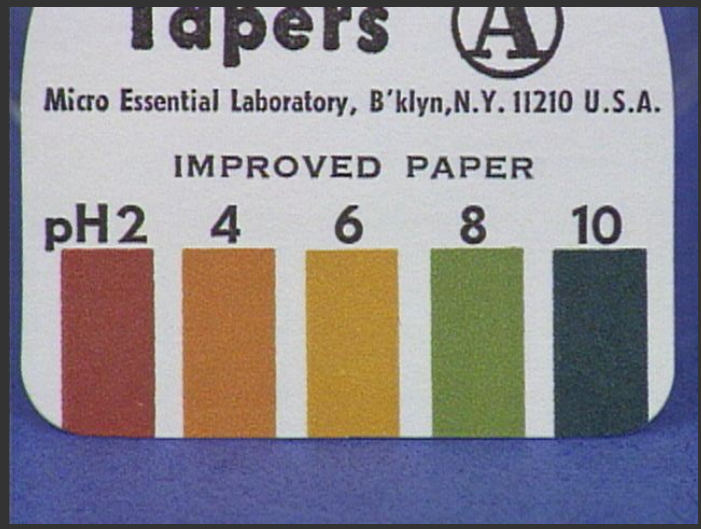
$$[OH^-] = 10^{-pOH}$$

pH Calculations

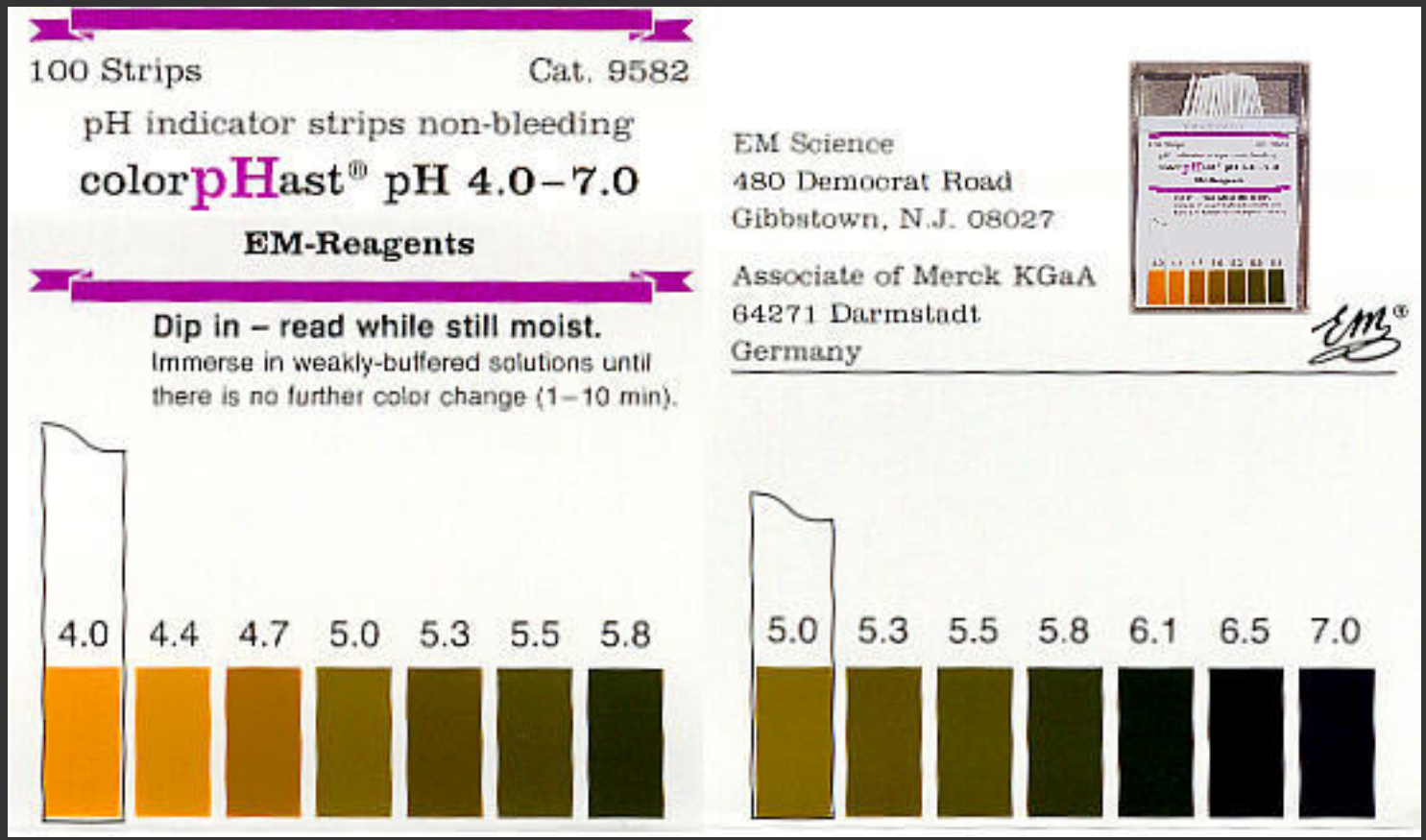


Measuring pH with wide-range paper

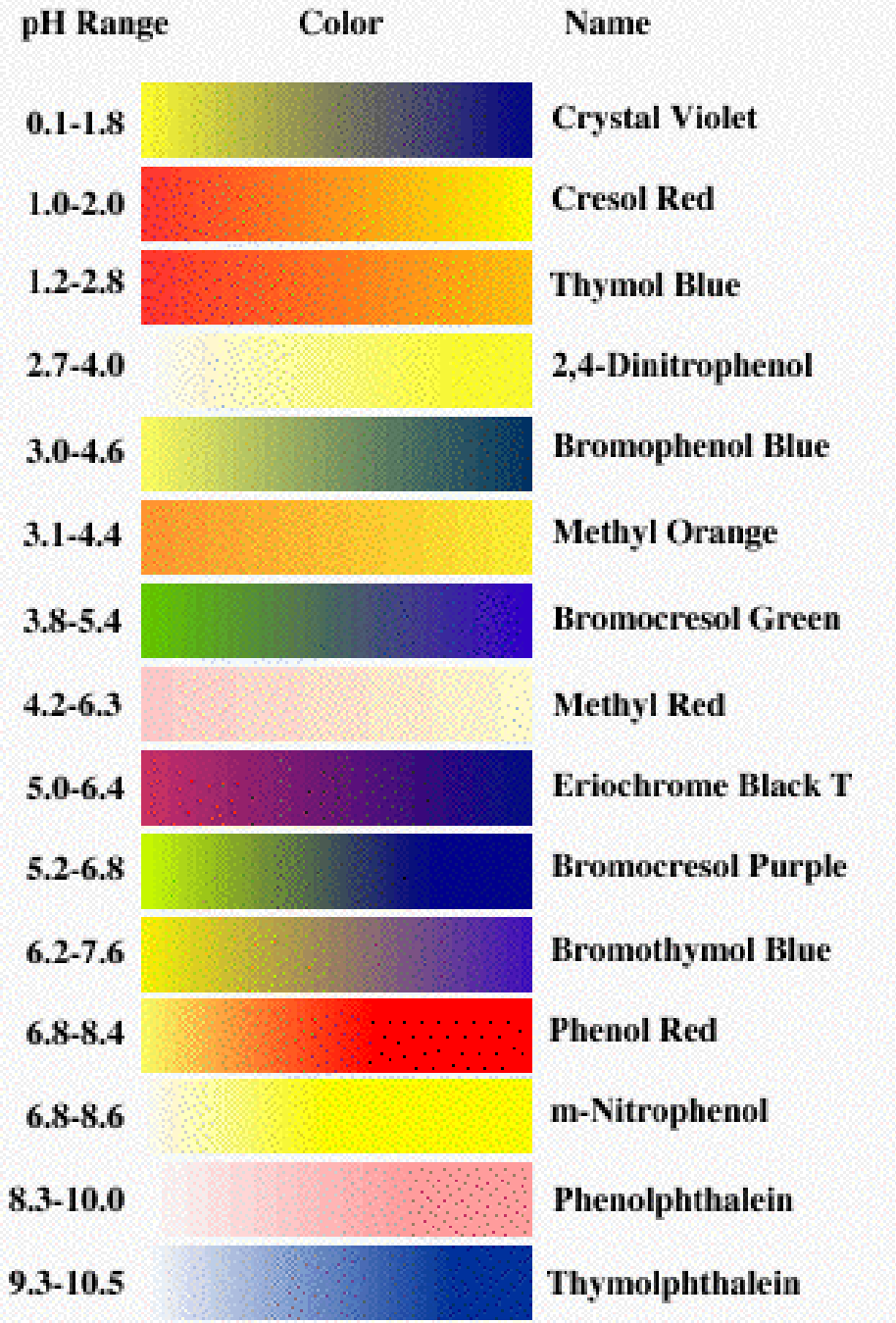




Narrow-Range pH Paper



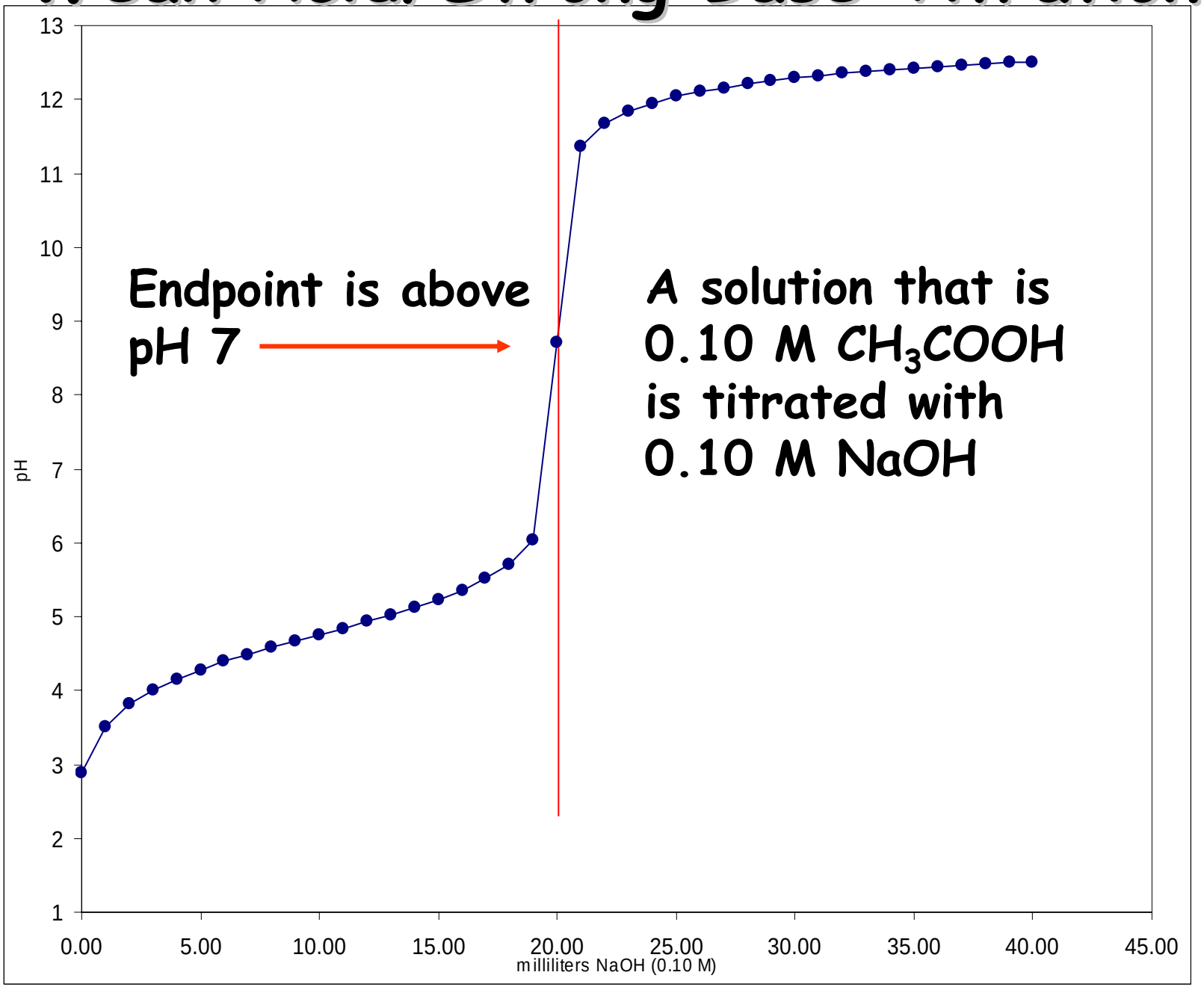
pH Indicators and their ranges



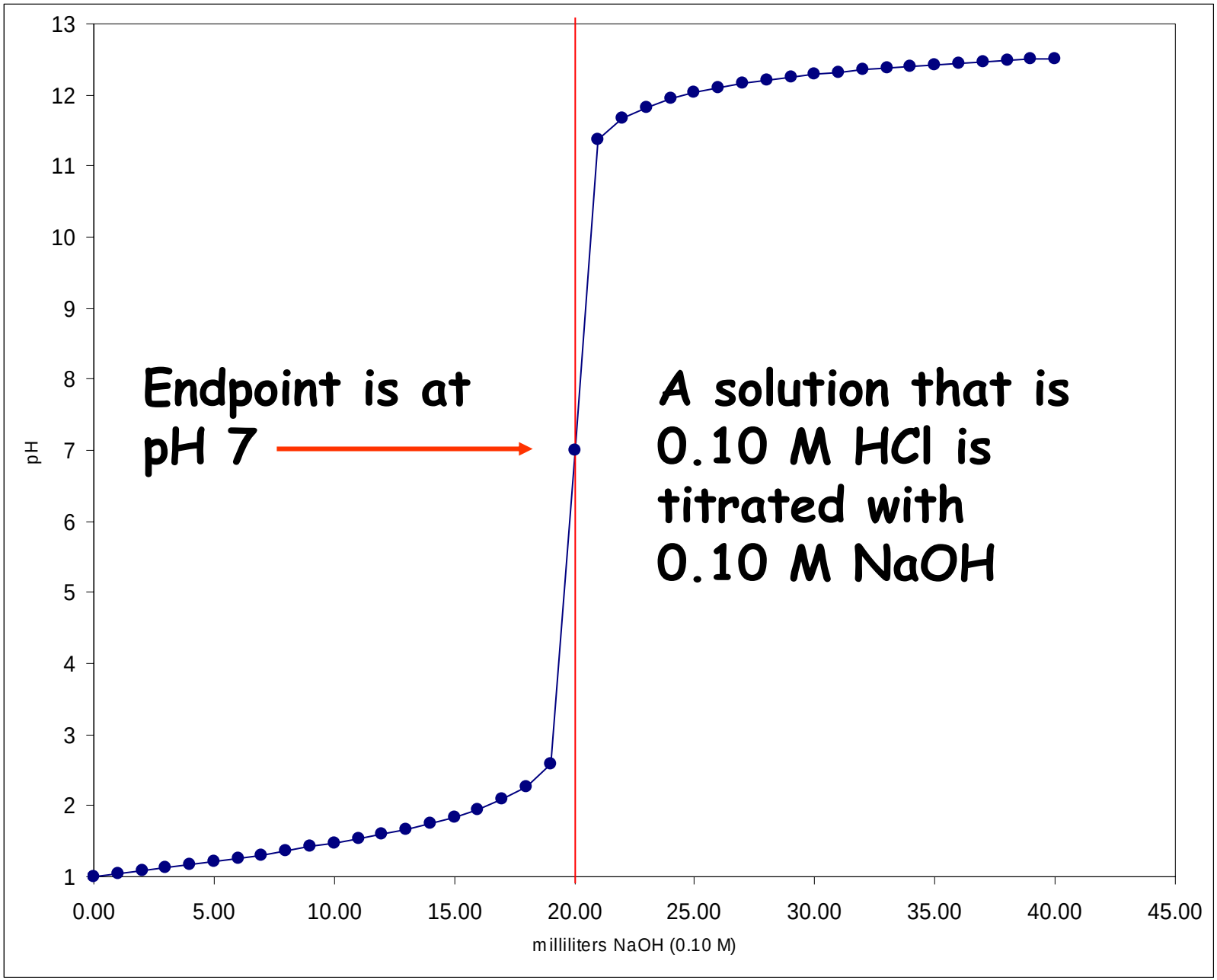
Some Acid-Base Indicators

Indicator	pH Range in which Color Change Occurs	Color Change as pH Increases
Crystal violet	0.0 - 1.6	yellow to blue
Thymol blue	1.2 - 2.8	red to yellow
Orange IV	1.4 - 2.8	red to yellow
Methyl orange	3.2 - 4.4	red to yellow
Bromcresol green	3.8 - 5.4	yellow to blue
Methyl red	4.8 - 6.2	red to yellow
Chlorophenol red	5.2 - 6.8	yellow to red
Bromthymol blue	6.0 - 7.6	yellow to blue
Phenol red	6.6 - 8.0	yellow to red
Neutral red	6.8 - 8.0	red to amber
Thymol blue	8.0 - 9.6	yellow to blue
Phenolphthalein	8.2 - 10.0	colorless to pink
Thymolphthalein	9.4 - 10.6	colorless to blue
Alizarin yellow	10.1 - 12.0	yellow to blue
Indigo carmine	11.4 - 13.0	blue to yellow

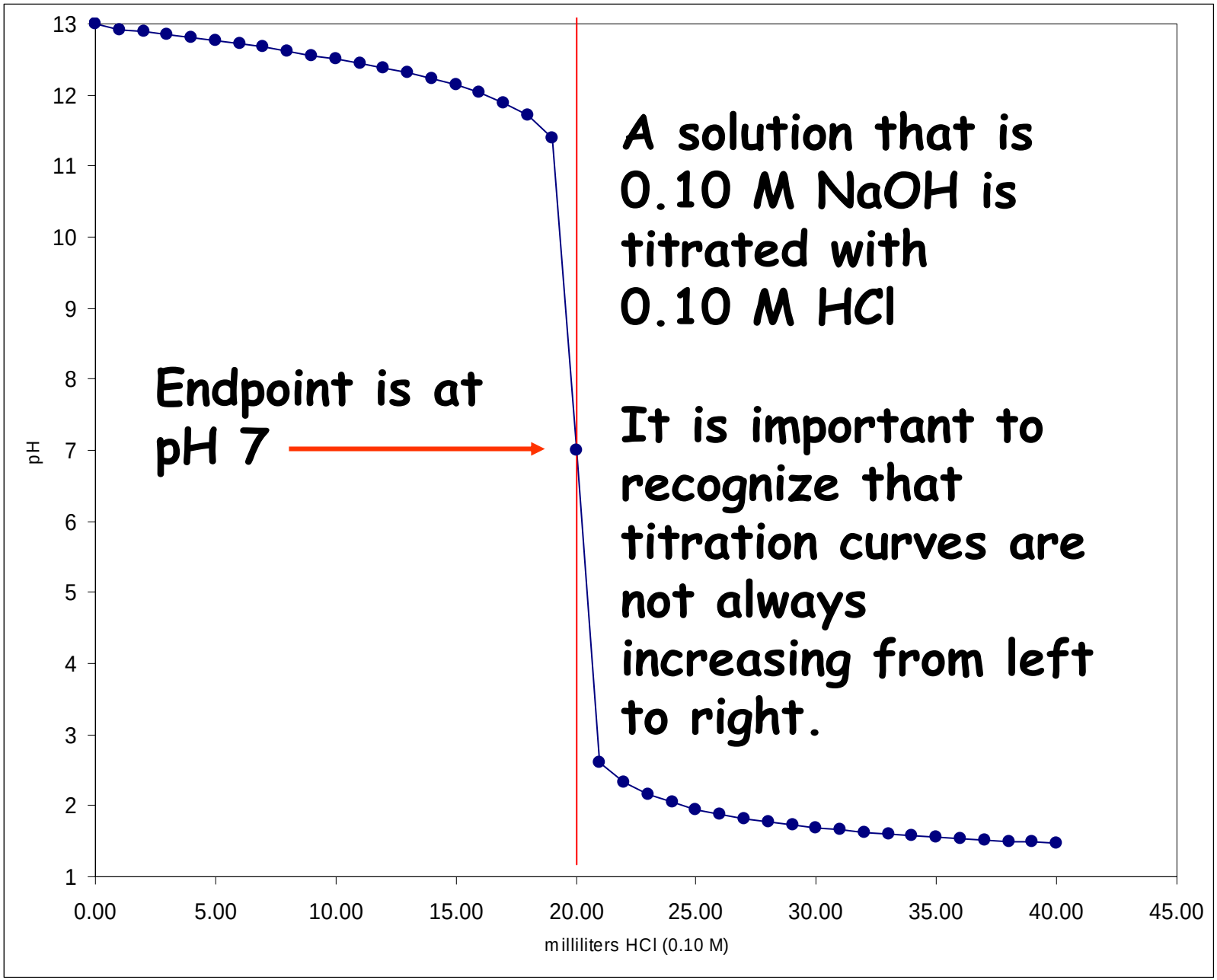
Weak Acid/Strong Base Titration



Strong Acid/Strong Base Titration



Strong Acid/Strong Base Titration



Strong Acid/Weak Base Titration