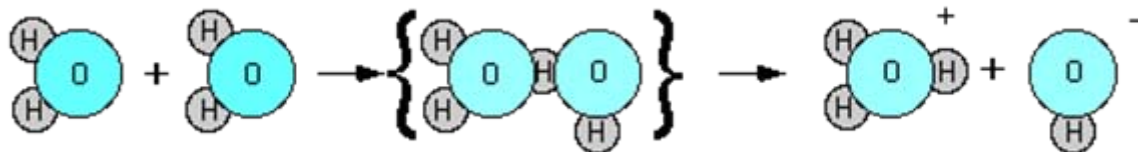


Acid-Base Titration and pH

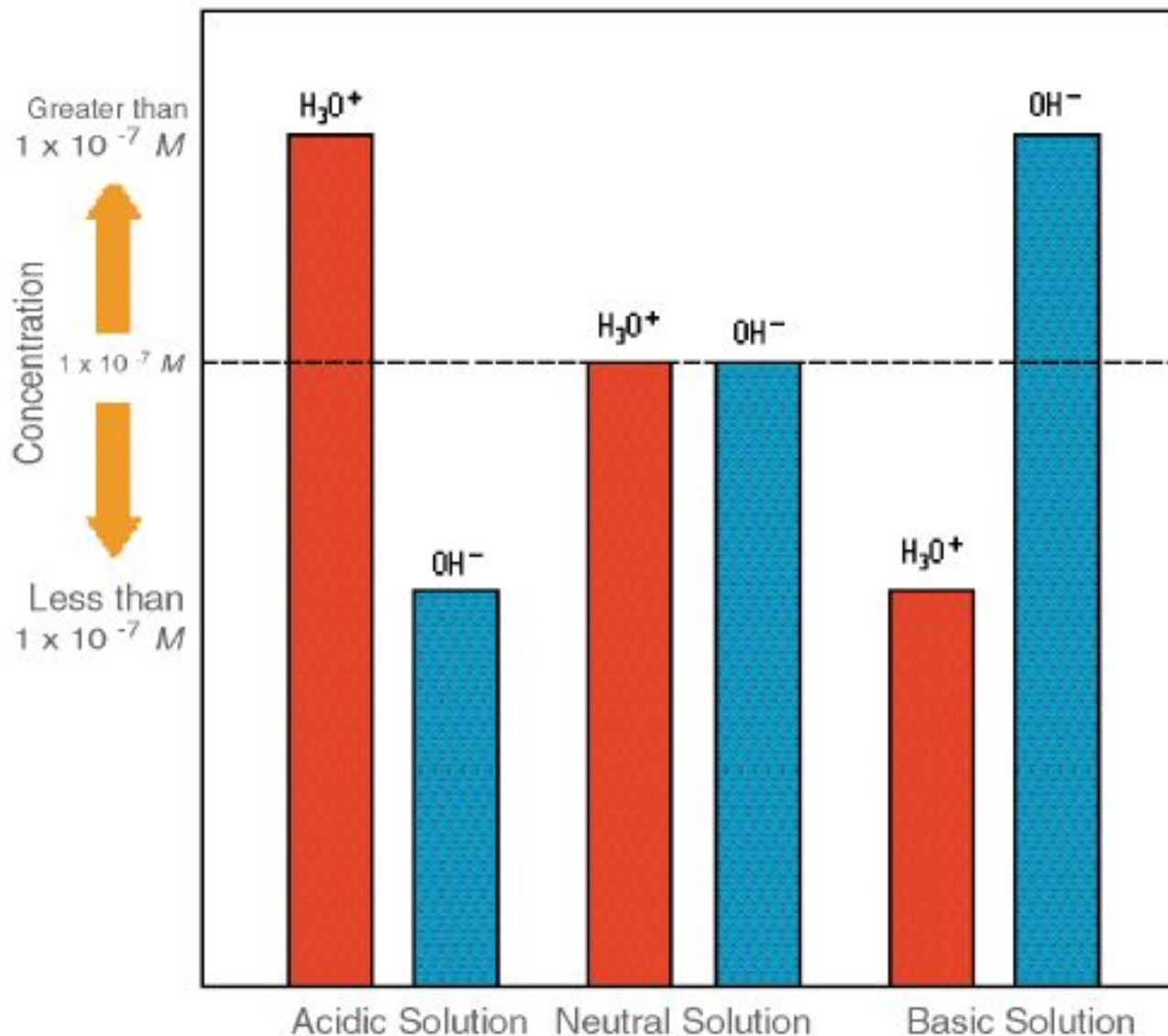


Self-Ionization of Water



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:

$$[\text{H}_3\text{O}^+] = 1 \times 10^{-7} \text{ mol/L}$$

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

K_w is a constant at 25 °C:

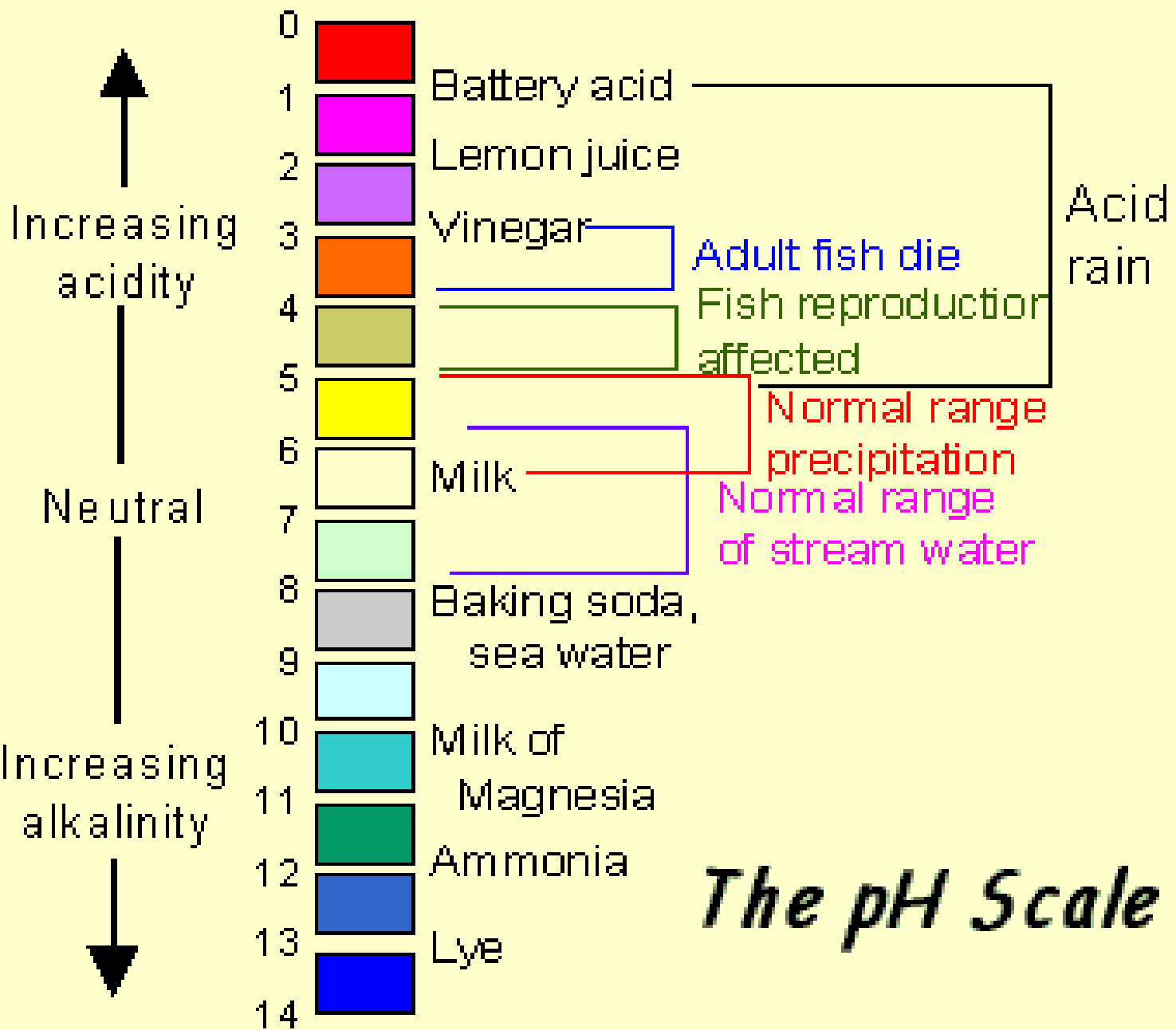
$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$$

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

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

	$[H^+]$ (mol/L)	$[OH^-]$ (mol/L)	pH	
Increasing acidity ↑	1×10^0	1×10^{-14}	0.0 ← 1 M HCl	
	1×10^{-1}	1×10^{-13}	1.0 ← 0.1 M HCl	
	1×10^{-2}	1×10^{-12}	2.0 ← Gastric Juice ← Lemon Juice	
	1×10^{-3}	1×10^{-11}	3.0	
Neutral	1×10^{-4}	1×10^{-10}	4.0 ← Tomato Juice	
	1×10^{-5}	1×10^{-9}	5.0 ← Black Coffee	
	1×10^{-6}	1×10^{-8}	6.0 ← Milk	
	1×10^{-7}	1×10^{-7}	7.0 ← Pure Water ← Blood	
	1×10^{-8}	1×10^{-6}	8.0 ← Sodium Bicarbonate, Sea Water	
	1×10^{-9}	1×10^{-5}	9.0	
	1×10^{-10}	1×10^{-4}	10.0 ← Milk of Magnesium	
	1×10^{-11}	1×10^{-3}	11.0 ← Household Ammonia	
	1×10^{-12}	1×10^{-2}	12.0 ← Washing soda	
	1×10^{-13}	1×10^{-1}	13.0 ← 0.1 M NaOH	
	1×10^{-14}	1×10^0	14.0 ← 1M NaOH	
	Increasing basicity ↓			

pH Scale



The pH Scale

Calculating pH, pOH

$$\text{pH} = -\log_{10}(\text{H}_3\text{O}^+)$$

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

Relationship between pH and pOH

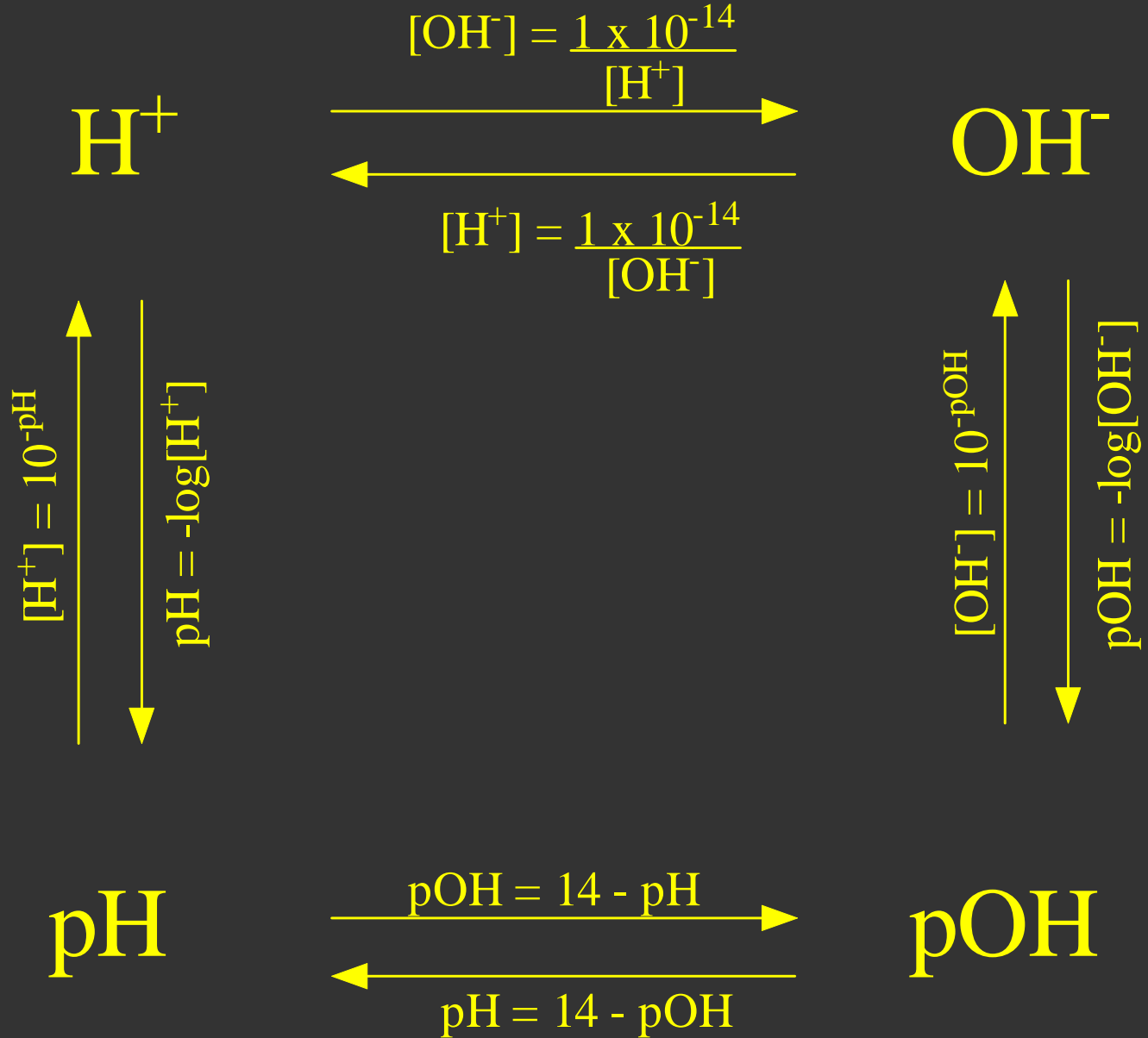
$$\text{pH} + \text{pOH} = 14$$

Finding $[\text{H}_3\text{O}^+]$, $[\text{OH}^-]$ from pH, pOH

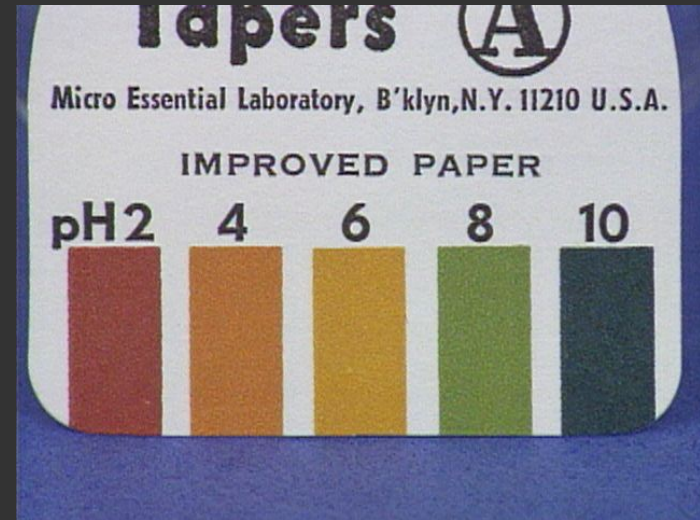
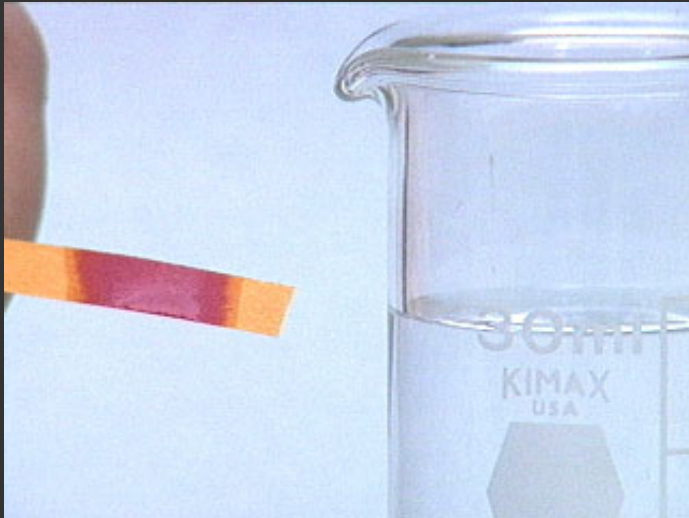
$$[\text{H}_3\text{O}^+] = 10^{-\text{pH}}$$

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

pH Calculations



Measuring pH with wide-range paper



Narrow-Range pH Paper

100 Strips

Cat. 9582

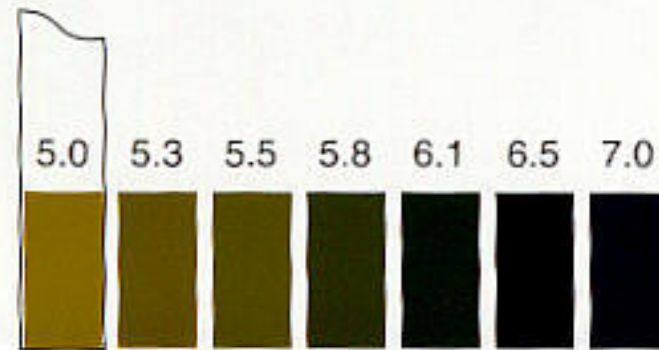
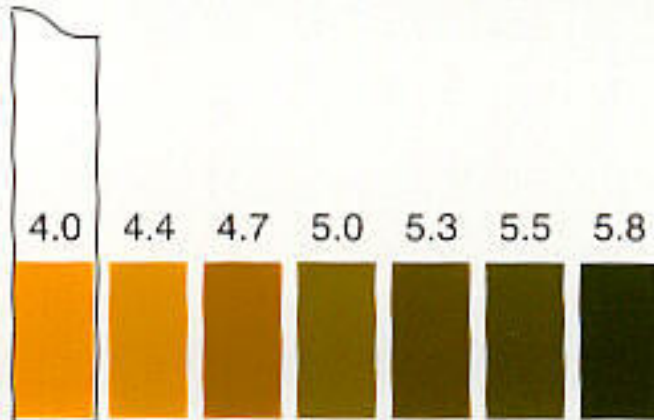
pH indicator strips non-bleeding
colorpHast[®] pH 4.0–7.0

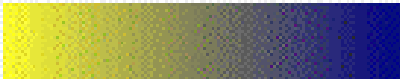
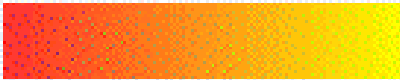


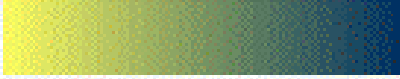

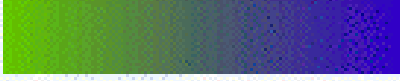

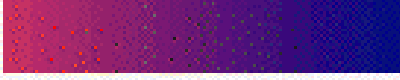
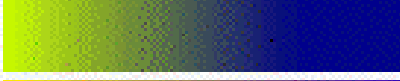
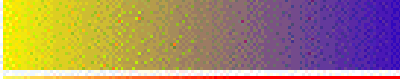
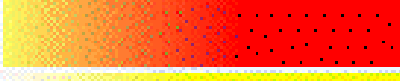


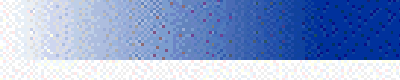
EM-Reagents

Dip in – read while still moist.
Immerse in weakly-buffered solutions until
there is no further color change (1–10 min).

EM Science
480 Democrat Road
Gibbstown, N.J. 08027

Associate of Merck KGaA
64271 Darmstadt
Germany



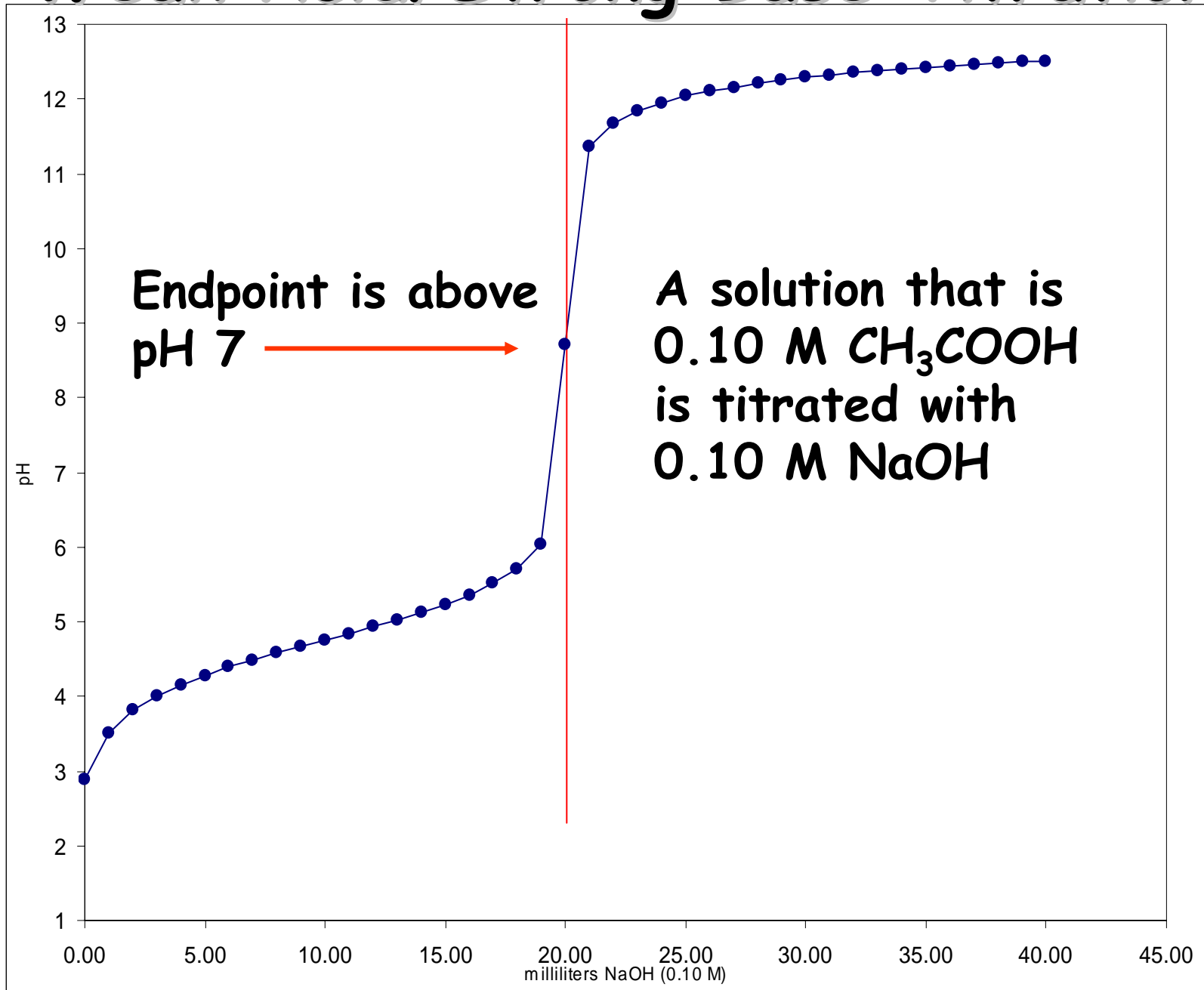
pH Range	Color	Name
0.1-1.8		Crystal Violet
1.0-2.0		Cresol Red
1.2-2.8		Thymol Blue
2.7-4.0		2,4-Dinitrophenol
3.0-4.6		Bromophenol Blue
3.1-4.4		Methyl Orange
3.8-5.4		Bromocresol Green
4.2-6.3		Methyl Red
5.0-6.4		Eriochrome Black T
5.2-6.8		Bromocresol Purple
6.2-7.6		Bromothymol Blue
6.8-8.4		Phenol Red
6.8-8.6		m-Nitrophenol
8.3-10.0		Phenolphthalein
9.3-10.5		Thymolphthalein

pH Indicators and their ranges

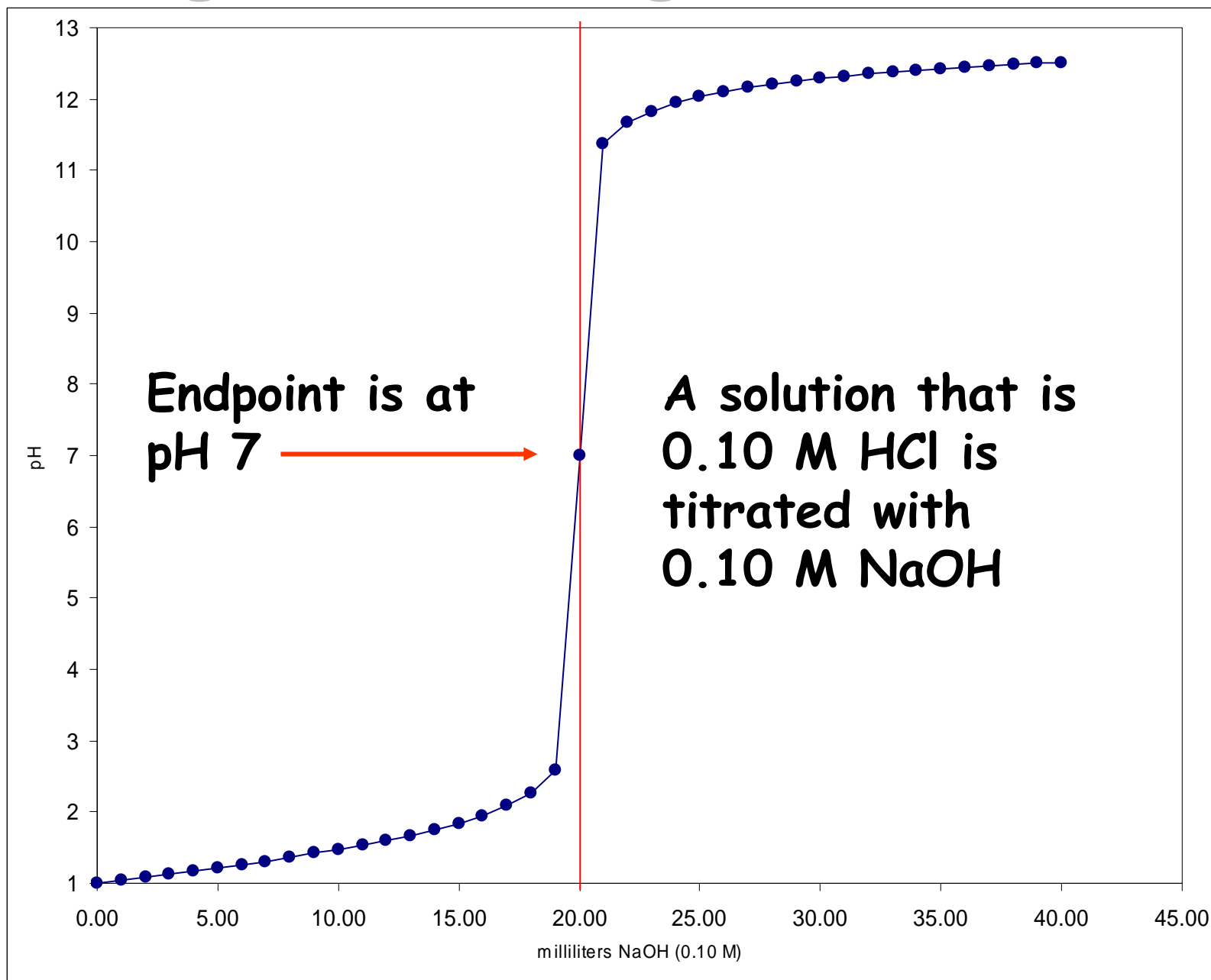
Some Acid-Base Indicators

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

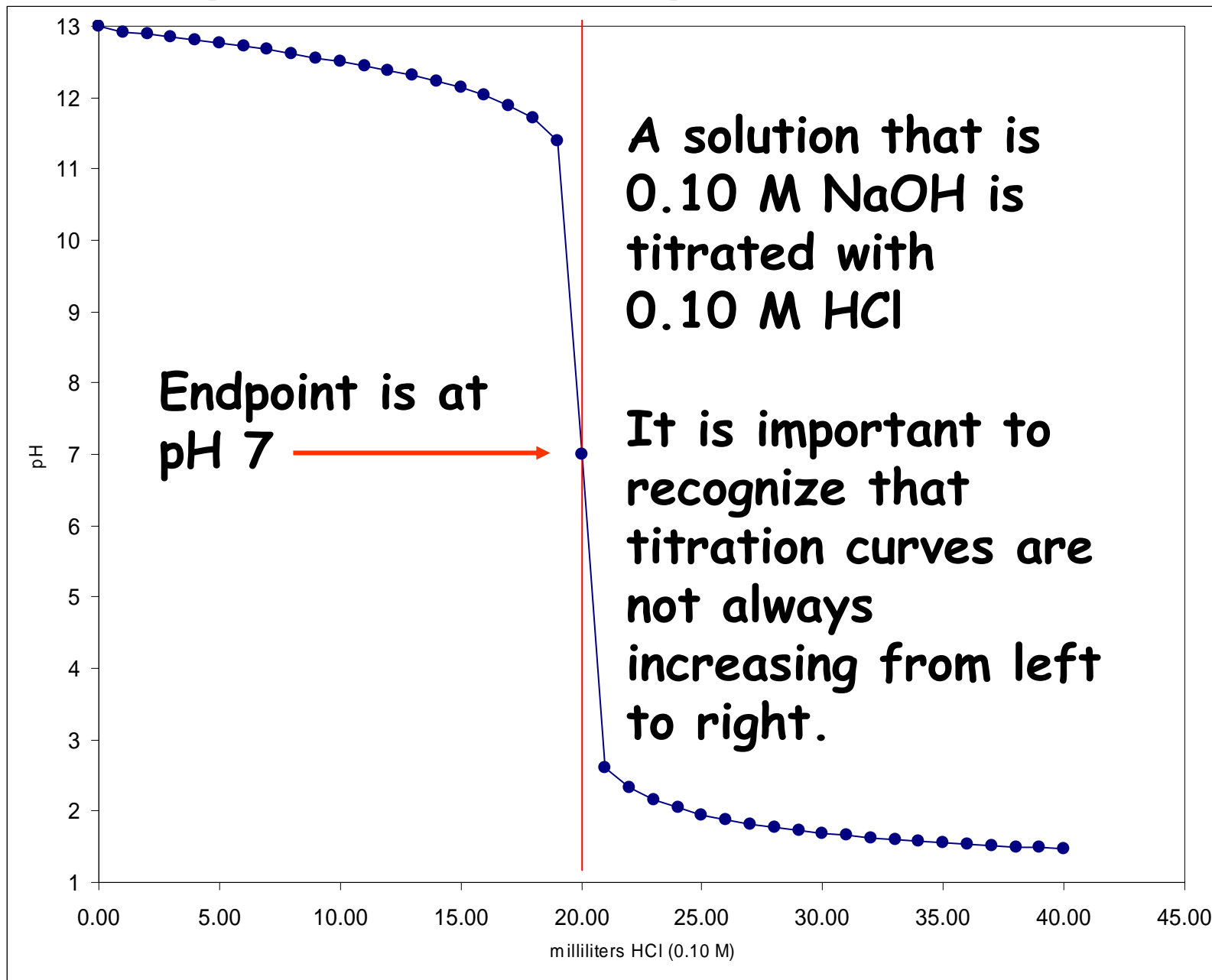
Weak Acid/Strong Base Titration



Strong Acid/Strong Base Titration



Strong Acid/Strong Base Titration



Strong Acid/Weak Base Titration

