Thinking Like a Chemist About Acids and Bases Part V

UNIT6 DAY7

What are we going to learn today?

Review Buffers

Explore Acid – Base Titrations

Explore the concept of protonation and pKa

Explore Behavior of Polyprotic Acids

IMPORTANT INFORMATION

HW07 Due Tue 9AM ←

LM22 & 23 Due Tue 9AM

Exam 2 – Wed March, 5th - Rooms TBA

Quiz: Clicker Question 1

Given a solution containing 1 M HF and 1 M NaF, and knowing that the pKa of HF = 3.14. The pH of the solution should be:

A) 10.86
B) 8.14
C) 7.00
D) 5.86
E) 3.14

Quiz: Clicker Question 2

Calculate the ratio of the molarities of acetate ions and acetic acid needed to buffer a solution at pH=5.25. The pK_a of CH_3COOH is 4.75.

A) 1 to 1
B) 1 to 3.2
C) 3.2 to 1
D) 10 to 1
E) 1 to 10

$$\frac{[CH_3COO^-]}{[CH_3COOH]} > 1$$

MORE BASE

$$pH = pK_a + \log\frac{[CH_3COO^-]}{[CH_3COOH]}$$

Calculating pH of a Buffer

1. Look at what you are given, and think like a chemist.
2. Is the buffer acidic or basic?
3. Has additional acid or base been added to the buffer system?
4. If so, complete the neutralization reaction, and calculate the concentration of the buffer components
5. Choose the correct version of the Henderson-Hasselbalch equation.
6. Using the equation, calculate the pH.

All this is on website. Two worksheets for practice. Practice makes perfect.

Poll: Clicker Question 2

What is the purpose of a buffer?

One needs to keep an unusual microbial species alive in a laboratory setting. The microbe survives best in an alkaline environment with a pH > 9. The best choice of a buffering system would be equal molar amounts of:

50/50

A) $C_2H_5NH_2$, $C_2H_5NH_3^+$, $K_b = 5.6 \times 10^{-4}$ ← pOH = pK_b pOH ~ 4 pH = 10

B) $C_6H_5NH_2$, $C_6H_5NH_3^+$, $K_b = 3.8 \times 10^{-10}$ pOH = pK_b pOH = 10 pH = 4

C) $HClO_2$, ClO_2^-, $K_a = 1.2 \times 10^{-2}$ ← pH ~ 2 !

D) HOCl, OCl^-, $K_a = 3.5 \times 10^{-8}$ ← pH ~ 7.5

Choosing a Buffer

The best situation is:

Relatively high concentration of conjugate acid-base partners.

One to one molar concentration will buffer against both added acid and added base.

One to one molar concentration – buffer will have a pH = pKa.

PRACTICE! HOMEWORK & WORKSHEETS!

Acid Base Titration

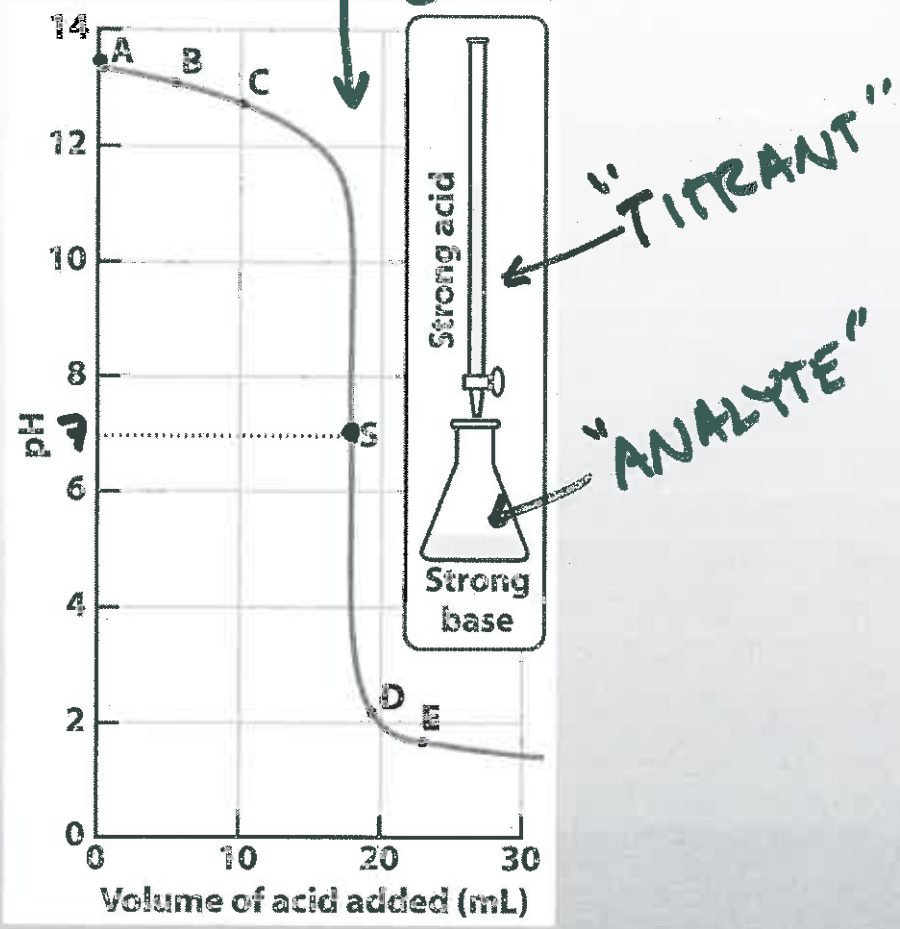
Why do a titration?

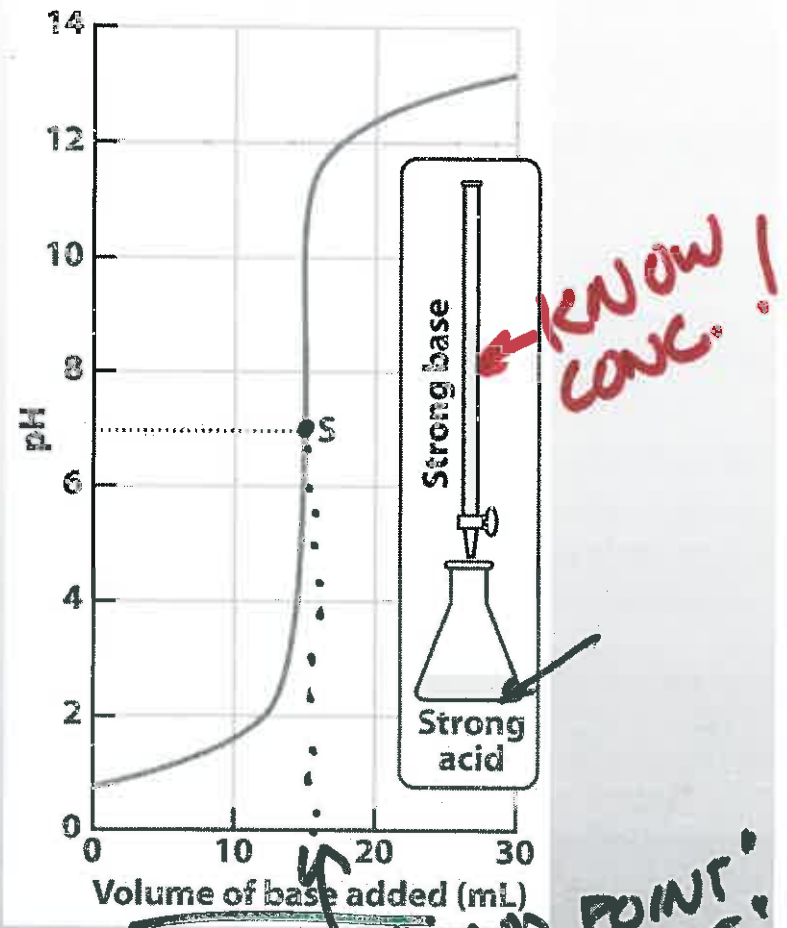
You have a solution with an unknown property

Unknown Concentration?
Unknown Ka (Kb)? ←
Both

Slowly neutralize the solution by adding
a strong base (acid)
monitor the pH with each addition

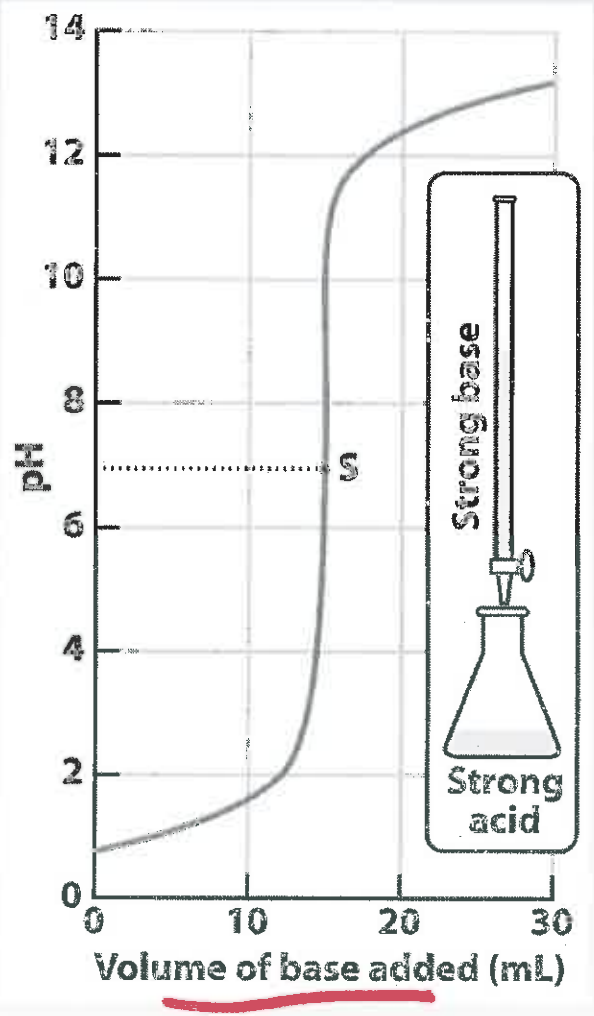
What do these plots tell you?

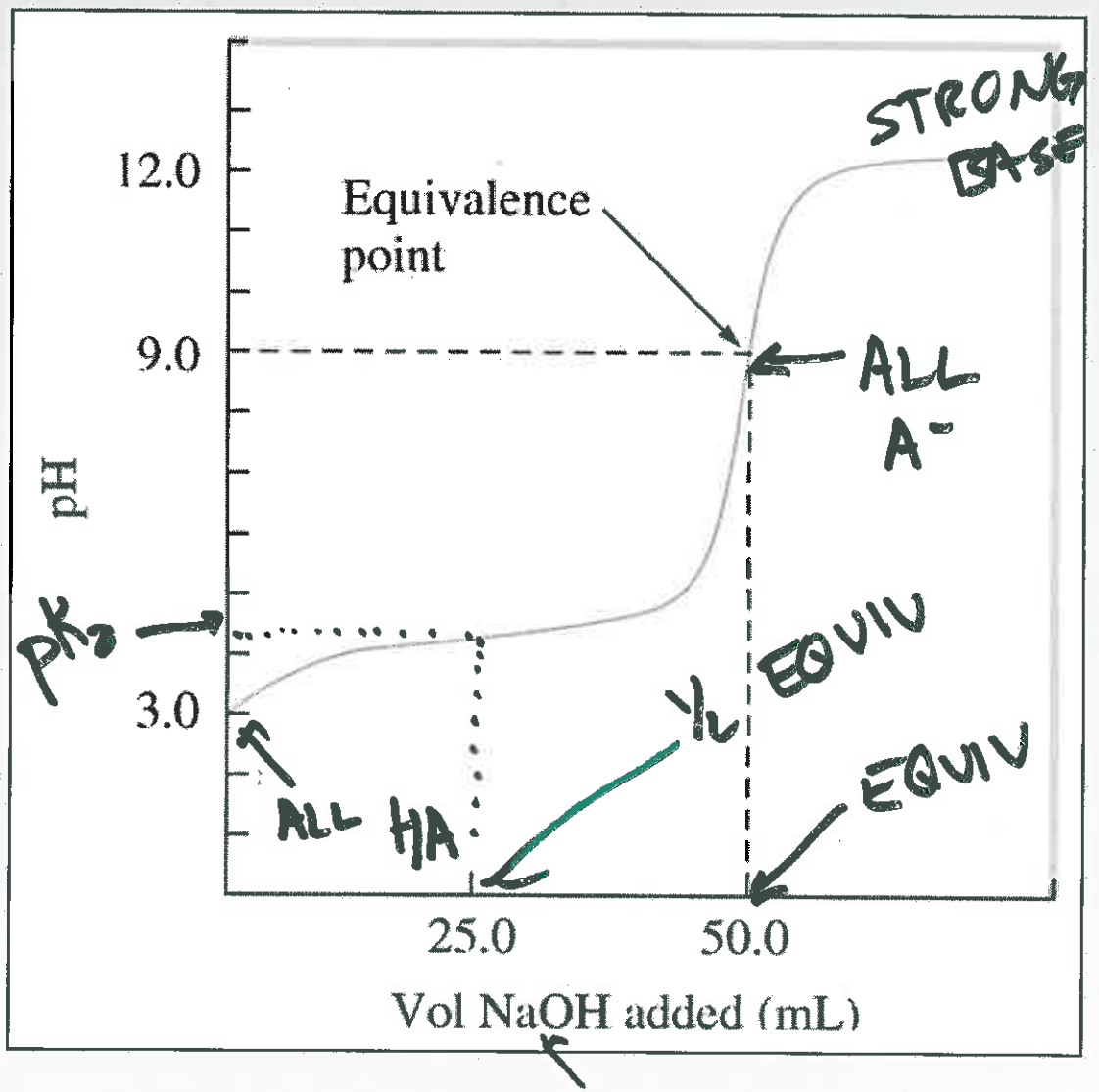




TITRATE STRONG BASE W/ STRONG ACID

How is the plot on the right different?





Work with neighbors on Titration Discovery Activity

Poll: Clicker Question 3

The initial concentration of the HBr is:

A) 7 M
B) .7 M
C) .007 M
D) .0007 M
E) 3.5 M

Poll: Clicker Question 4

The pK_a for acetic acid is:

A) 1.7×10^{-5}
B) 1.6×10^{-9}
C) 4.76
D) 8.32
E) 3.43

Poll: Clicker Question 5

The initial concentration of acetic acid is:

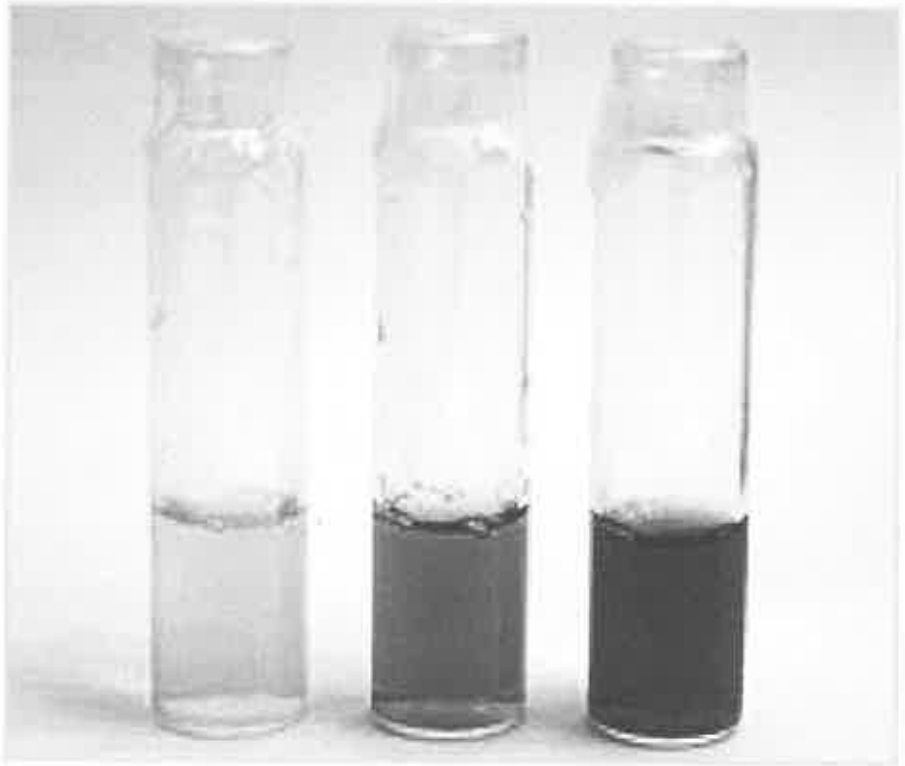
A) 8 M
B) .8 M
C) .08 M
D) .008 M
E) .00008 M

What is the point of pH indicator?

http://youtu.be/Q21c3L3Ui8Q

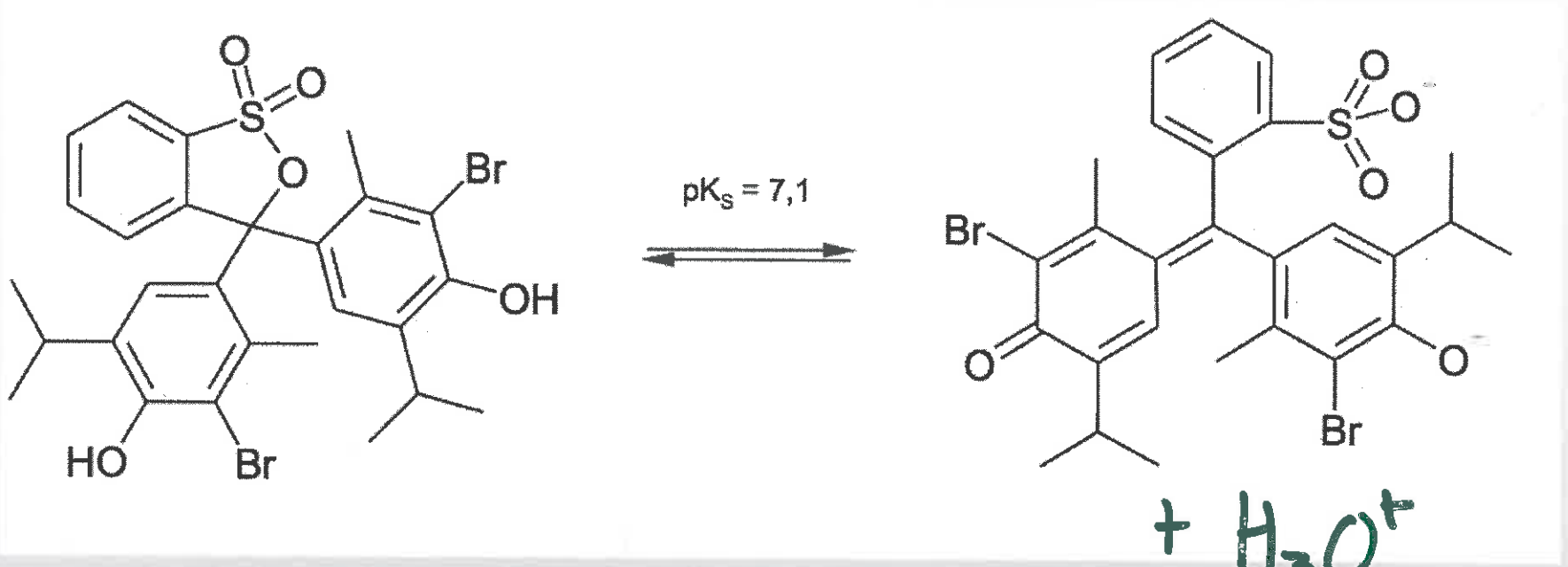
http://youtu.be/IcU1YUGElLk

Chemical Equilibrium
pH indicator



BTB indicator in acidic, neutral, and alkaline solutions (left to right).

Chemical Equilibrium
pH indicator Bromothymol Blue, pKa = 7.1



Protonated form
yellow

Deprotonated form
blue

Poll: Clicker Question 5

Chemical Equilibrium
pH indicator Bromothymol Blue

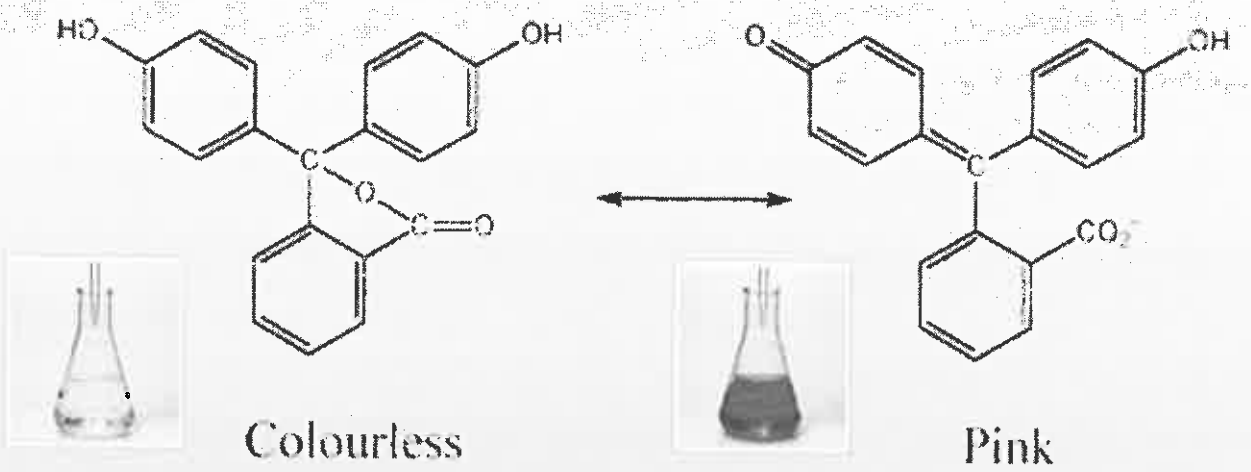
Bromophenol Blue has a pK_a of around 7. When it is protonated (HA form) it is yellow, when it is deprotonated (A^- form) it is blue.
What color would in be in a solution in which the pH was 9?

A. blue
B. yellow
C. green

Indicator dye

Phenolphthalein

$pK_a = 8.2 \quad K_a = 6.3 \times 10^{-9}$



Colourless

Pink

$$K_a = [H^+] \times \frac{[A^-]}{[HA]}$$

$$= [H^+] \times \frac{\text{Pink}}{\text{Clear}}$$

HA

$[H^+] > 6.3 \times 10^{-9}$

pH < 8.2

$$\frac{\text{Pink}}{\text{Clear}} < 1$$

A^-

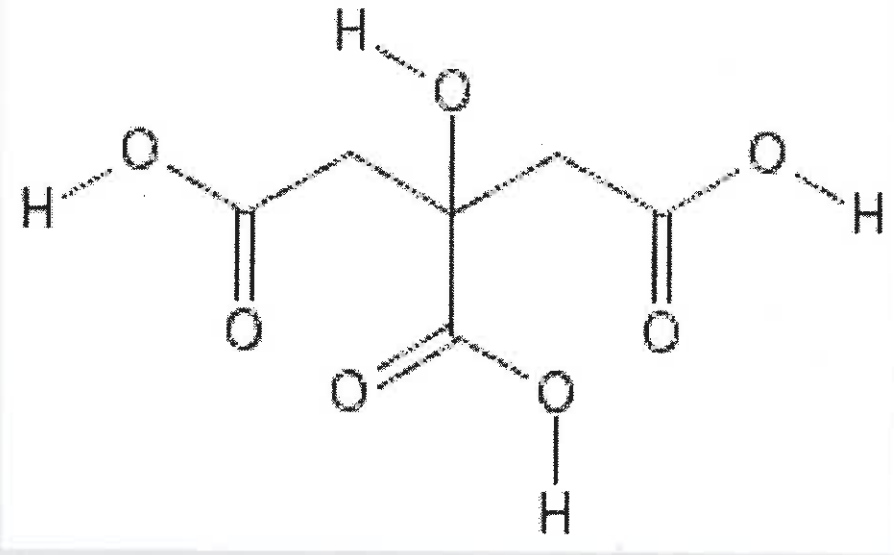
$[H^+] < 6.3 \times 10^{-9}$

pH>8.2

$$\frac{\text{Pink}}{\text{Clear}} > 1$$

Poll: Clicker Question 7

Polyprotic Acid



$Ka_1 = 7.4 \times 10^{-4}$

$Ka_2 = 1.7 \times 10^{-5}$

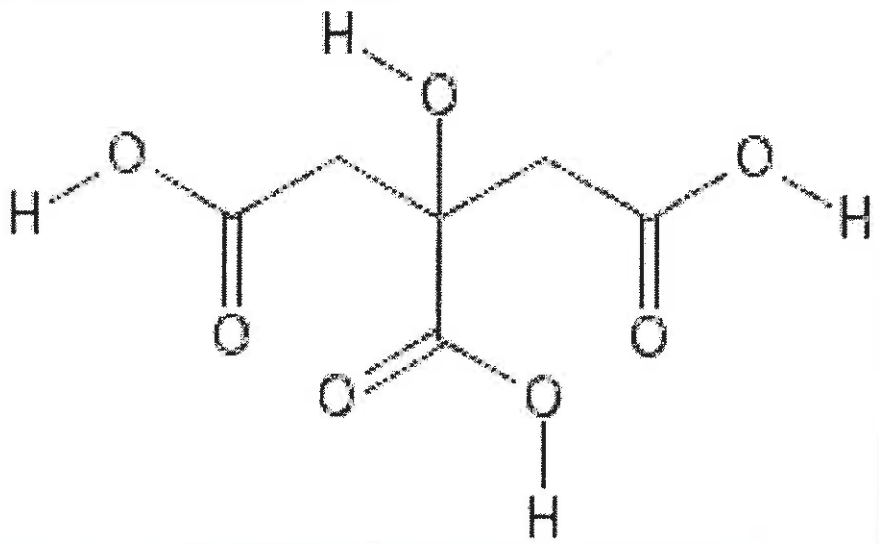
$Ka_3 = 4.0 \times 10^{-7}$

At pH = 2 will the acid be protonated or deprotonated?

a) Protonated
b) Deprotonated
c) Can't tell

Poll: Clicker Question 8

Polyprotic Acid



$Ka_1 = 7.4 \times 10^{-4}$

$Ka_2 = 1.7 \times 10^{-5}$

$Ka_3 = 4.0 \times 10^{-7}$

At pH = 12 will the acid be protonated or deprotonated?

a) Protonated

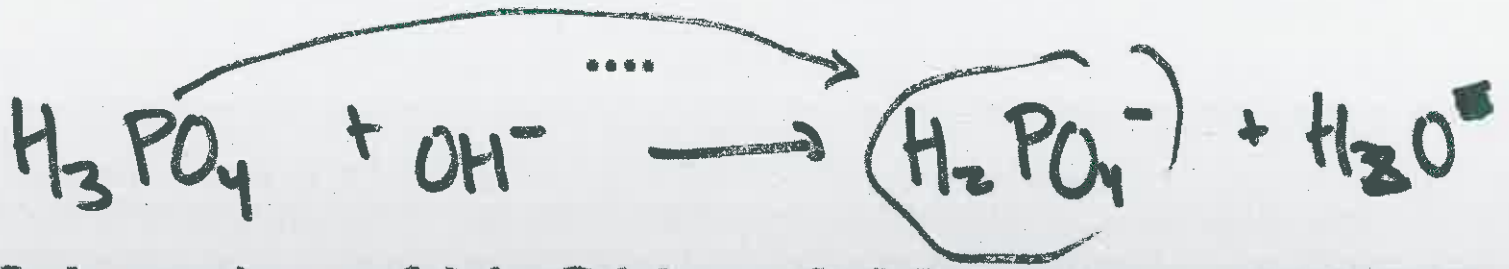
b) Deprotonated

c) Can't tell

When do I care about the other protons?

When I neutralize the acid. ⇐

As you neutralize the first protons,
the second will come off,



If I add 0.1 moles of NaOH to 0.05 moles of H_3PO_4
what will be the dominant species in solution?

If I add 0.1 moles of NaOH to 0.05 moles of H_3PO what will be the dominant species in solution?

A. H_3PO_4 and $H_2PO_4^-$

B. $H_2PO_4^-$

C. $H_2PO_4^-$ and HPO_4^{2-}

D. HPO_4^{2-}

E. HPO_4^{2-} and PO_4^{3--}

$H_3PO_4 + OH^- \rightarrow H_2PO_4 + H_2O$

I .05 .1

C -.05 -.05 +.05

.05 .05

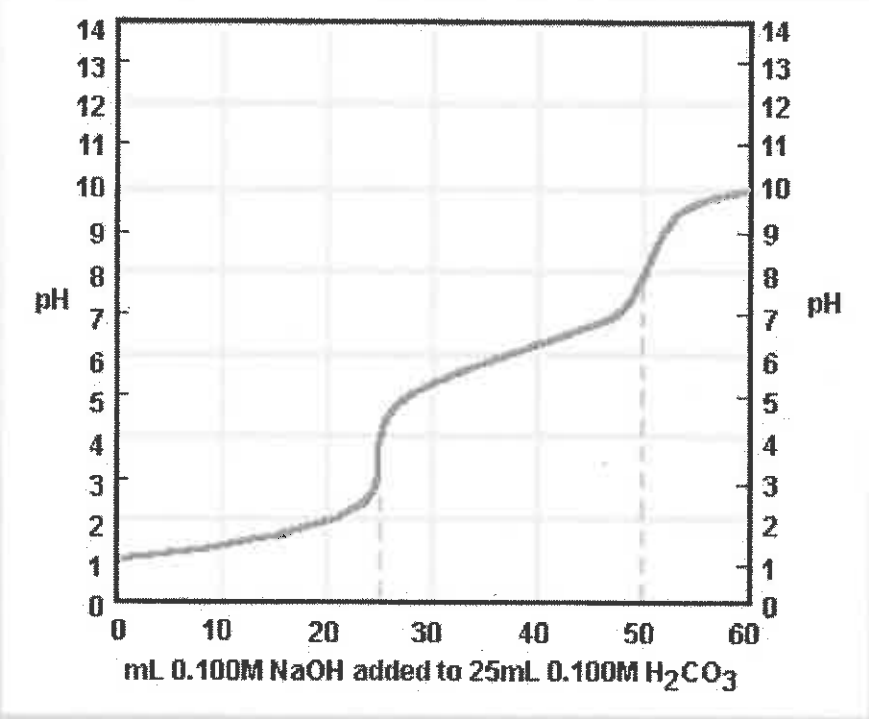
$H_2PO_4^- + OH^- \rightarrow HPO_4^{2-} + H_2O$

.05 .05

-.05 -.05 +.05

$\emptyset$ $\emptyset$ .05

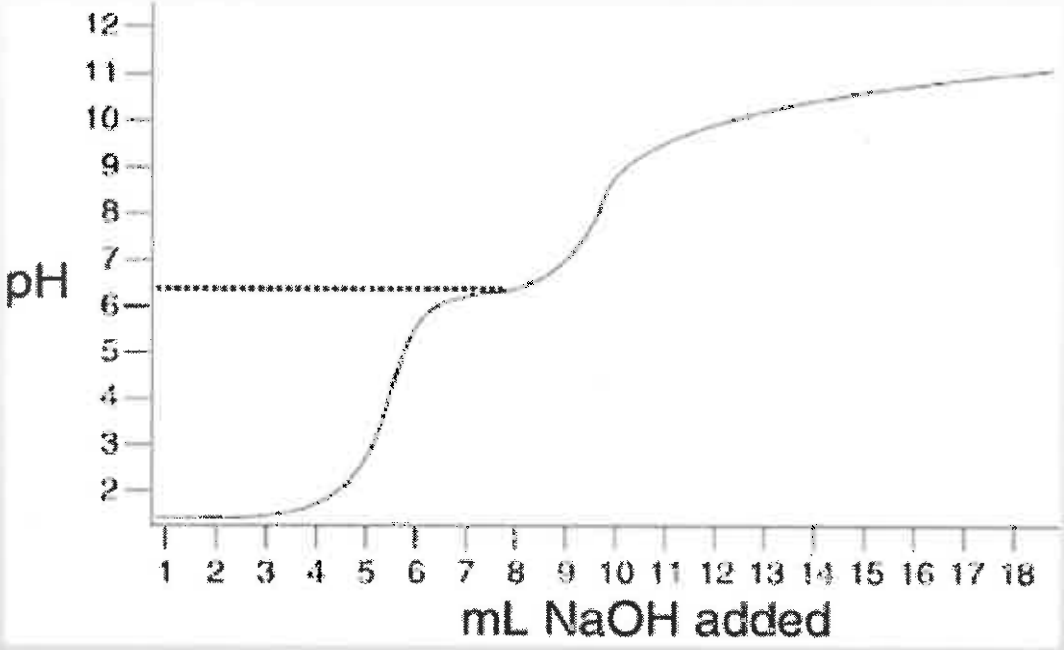
Titration of a polyprotic



Two equivalence points

Diprotic H_2A

Given the following curve estimate K_{a2} for this unknown acid



at 1/2 equiv
pH = pKa
pH = 6.3
pKa = 6.3
$K_a = 5 \times 10^{-7}$

A. 1 B. 6.3 C. 5×10^{-6} D. 5×10^{-7}

What did we learn today?

Acid Base titrations are performed to determine the concentration of an acid or base and/or the Ka of an acid or Kb of a base.

The pH can be calculated by determining the ending concentrations after a series of neutralization reactions are performed.

pKa indicates the extent of ionization of an acid
Lower the pKa value, the more acidic an environment necessary to keep the acid protonated