Buffers

What is a buffer (textbook definition)

What is a buffer (chemist's definition)

HA and A^- are the real players here!

Add OH^-

Add H_3O^+

Which of the following pairs of solutions make buffers?

a) 50.0 mL of 0.10 M HCl and 50.0 mL of 0.10 M NaOH

b) 50.0 mL of 0.10 M $HC_2H_3O_2$ and 50.0 mL of 0.10 M $NaC_2H_3O_2$

c) 50.0 mL of 0.10 M HF and 50.0 mL of 0.10 M NaF

d) 50.0 mL of 0.10 M $HC_2H_3O_2$ and 50.0 mL of 0.10 M NaOH

e) 50.0 mL of 0.10 M $HC_2H_3O_2$ and 25.0 mL of 0.10 M NaOH

f) 50.0 mL of 0.20 M $HC_2H_3O_2$ and 50.0 mL of 0.10 M NaOH

g) 25.0 mL of 0.10 M HNO_3 and 50.0 mL of 0.10 M NaF

What happens when we do some algebra and take some logarithms? Henderson–Hasselbach.

1) What is the pH of a solution which is 0.10M in NH_3 and 0.10M in NH_4NO_3? $K_b = 1.6x10^{-5}$ for ammonia.

Now let's look at a shorter method:

The pH of 0.10M ammonia is 11.1 why is this solution's pH lower?

2) What is the pH of some 0.100M KClO mixed with 0.050M HClO? $Ka=2.90x10^{-8}$ for HClO.

3) What is the pH of some 0.100M HF mixed with 0.20M NaF? $Ka=7.4\ x10^{-4}$ for HF

4) A buffer is prepared by mixing 0.10 M acetic acid and 0.10 M sodium acetate. What is the pH of the buffer if pKa is 4.76?

5) What is the pH after adding 0.001 moles of NaOH to 1.0 liters of this buffer?

6) What is the pH after adding 0.001 moles of HCl to 1.0 liters of this buffer?

7) A buffer is prepared by mixing 100.0 mL of 1.0M sodium acetate with 100.0 mL of 0.10 M acetic acid. The pKa for acetic acid is 4.76. What is the pH of this solution?

8) A buffer is prepared by mixing 100.0 mL of 0.10 M sodium acetate with 100.0 mL of 1.0 M acetic acid. The pKa for acetic acid is 4.76. What is the pH of this solution?

9) Why is number 7 more basic while number 8 is more acidic?

10) If I dilute the solution in question 8 to 400 mL what is the new pH?

11) What is the pH of a buffer prepared by mixing 8.2 g of $NaC_2H_3O_2$ with 17.0 mL of 6.0 M $HC_2H_3O_2$ and diluting to 100.0 mL?

Titration

Titrant

Analyte

Buret

Strong Acid/Strong Base

Strong Base/Strong Acid

Weak Acid/Strong Base

Weak Base/Strong Acid

Equivalence Point (stoichiometric point)

Mid Point (half way point)

Titration Particulate Diagrams

Consider the titration of 20.0 mL of a 0.10 M weak acid (HA) with 0.10 M NaOH. The Ka for HA is 1.0×10^{-6}.

1) What is the net ionic equation for this reaction?

2) Calculate the pH of the weak acid before the titration begins.

3) Calculate the expected pH at the mid-point.

4) Calculate the expected pH at the equivalence point.

5) Calculate the expected pH when 5.0 mL of excess NaOH has been added

6) Draw the expected titration curve for this titration.

Now to the particulate the drawings!

7) Starting with four HA molecules you will draw a particulate representation of the titration.

First prepare a legend so you know what the three major species will look like. Use a circle, square, triangle, or other shapes to indicate each species.

Now depict the four points in the titration listed in the questions on the previous page the boxes provided. Omit water molecules.

Initially

Midpoint

Equivalence point

Excess NaOH

Titration Lab Techniques

Hand Techniques

Stopcock

Wait Before Reading Meniscus

Contrast Card

Clean and Dirty Burets

Stirring

Rough Titration

Significant Figures

Approaching the Endpoint

Solubility

What does it mean to be soluble?

What is the difference between dissolving and dissociating?

What is a solubility product? What does it indicate?

Why does a salt dissociate? When a salt dissociates what does it turn into?

Draw a particulate diagram of what NaCl looks like dissolving in water.

Draw a particulate of a saturated solution of AgCl in water.

Draw a particulate diagram of the reaction of 0.10 M NaCl with 0.10 M $AgNO_3$.

Table of typical Ksp values:

Formula	**K_{sp}**	**Formula**	**K_{sp}**
$Al(OH)_3$	1.0×10^{-33}	PbF_2	3.7×10^{-8}
Sb_2S_3	1.7×10^{-93}	$Pb(IO_3)_2$	2.6×10^{-13}
$BaCO_3$	8.1×10^{-9}	PbI_2	1.4×10^{-8}
BaF_2	1.7×10^{-6}	$PbSO_4$	1.6×10^{-8}
$BaSO_4$	1.1×10^{-10}	PbS	8.8×10^{-29}
Bi_2S_3	1.0×10^{-97}	$MgNH_4PO_4$	2.5×10^{-13}
$CaCO_3$	8.7×10^{-9}	$MgCO_3$	1.0×10^{-5}
CaF_2	4.0×10^{-11}	MgF_2	6.4×10^{-9}
$Ca(OH)_2$	5.5×10^{-6}	$Mg(OH)_2$	1.1×10^{-11}
$CaSO_4$	2.4×10^{-5}	Hg_2Cl_2	1.3×10^{-18}
CuBr	4.2×10^{-8}	Hg_2I_2	1.2×10^{-28}
CuCl	1.0×10^{-6}	HgS “Black”	1.6×10^{-52}
CuI	5.1×10^{-12}	HgS “Red”	1.4×10^{-53}
Cu_2S	2.0×10^{-47}	$Ni(OH)_2$	6.5×10^{-18}
$Cu(IO_3)_2$	1.4×10^{-7}	AgBr	7.7×10^{-13}
CuC_2O_4	2.9×10^{-8}	Ag_2CO_3	6.2×10^{-12}
CuS	1.3×10^{-36}	AgCl	1.6×10^{-10}
$Fe(OH)_2$	1.6×10^{-14}	AgOH	1.5×10^{-8}
FeS	6.3×10^{-18}	AgI	1.5×10^{-16}
$Fe(OH)_3$	2.0×10^{-39}	Ag_2S	6.3×10^{-51}
$PbBr_2$	7.9×10^{-5}	$Zn(OH)_2$	2.0×10^{-17}
$PbCl_2$	1.6×10^{-5}	ZnS	1.6×10^{-24}

1) What is the molar solubility of AgCl in water?

2) What is the molar solubility of PbF_2 in water?

3) What is the solubility of $CaCO_3$ in water? Answer in grams per liter.

4) The solubility of copper (I) bromide is 2.0×10^{-4} M. What is the value of Ksp?

What happens when we dissolve a salt in a solution rather than in distilled water?
Common Ion Effect

1) What is the molar solubility of AgCl in 0.10M NaCl?

2) What is the molar solubility of PbF_2 in 0.100M NaF?

The Reaction Quotient

What is the physical meaning of Ksp?

Q > Ksp Q < Ksp Q = Ksp

1) A solution is prepared mixing 100.0 mL of 1.0×10^{-3} M $CuNO_3$ and 100.0 mL of 1.0×10^{-3} M KI. Will a precipitate form?

2) A solution is prepared mixing 500.0 mL of 3.0×10^{-6} M $Ca(NO_3)_2$ and 500.0 mL of 2.0×10^{-6} M NaF. Will a precipitate form?

3) The pH of a saturated solution of $Fe(OH)_2$ is 9.50. Calculate its solubility and Ksp.

4) What is the pH of a saturated solution of silver hydroxide?

5) What happens if I add one more drop of $PbCl_2$ to a saturated solution of $PbCl_2$?

6) If I have a 1.0 L flask and a 2.0 L of saturated PbI_2 which flask has more moles of Pb^{2+} ion?

7) If I have a 1.0 L flask and a 2.0 L of saturated PbI_2 which flask has the higher concentration of Pb^{2+} ion?

Strong Acid/Strong Base Titration

Consider the titration of 100.0 mL of 0.10 M HCl with 0.10 M NaOH.
Calculate the pH after the addition of the following volumes of NaOH.

a. 0 mL (before adding any)

b. 15.0 mL(during the early part of the titration)

c. 35.0 mL(during the early part of the titration)

d. 50.0 mL(half way point)

e. 99.0 mL(right before equivalence point)

f. 100.0 mL(equivalence point)

g. 101.0 mL(after the end point)

Strong Base/Weak Acid Titration

Consider the titration of 20.0 mL of 0.10 M acetic acid with 0.10 M NaOH.
Calculate the pH after the addition of the following volumes of NaOH.

a. 0 mL (before adding any)

b. 2.0 mL(during the early part of the titration)

c. 5.0 mL(what would we call this point?)

d. 10.0 mL(what would we call this point?)

e. 19.0 mL(what would we call this point?)

f. 20.0 mL(what would we call this point?)

g. 21.0 mL(what would we call this point?)

Strong Acid/Weak Base Titration

Consider the titration of 25.0 mL of 0.20 M ammonia with 0.10 M HCl.
Calculate the pH after the addition of the following volumes of HCl.

a. 0 mL (before adding any)

b. 2.0 mL(during the early part of the titration)

c. 12.5 mL(what would we call this point?)

d. 25.0 mL(what would we call this point?)

e. 49.9 mL(what would we call this point?)

f. 50.0 mL(what would we call this point?)

g. 51.0 mL(what would we call this point?)