NAME

What happens when you mix acids and bases?

Neutralization Reactions

Neutralization = double displacement
Acid + Base → salt + water
HCl + NaOH → NaCl + HOH

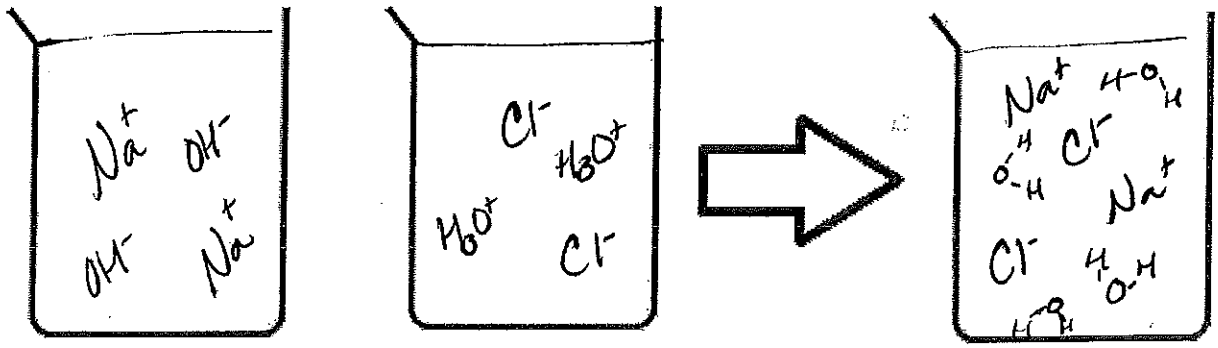
Neutralization reactions

Complete the following equations labeling both acid/ base and the strength.

Ex: $NaOH + HCl \rightarrow NaCl + H_2O$

strong Base strong acid Salt Water

2. $HCl + NH_4OH \rightarrow$ HOH + NH_4Cl
3. $2HCN + Ca(OH)_2 \rightarrow$ 2HOH + $Ca(CN)_2$
4. $Mg(OH)_2 + 2HC_2H_3O_2 \rightarrow$ 2HOH + $Mg(C_2H_3O_2)_2$
5. $2LiOH + H_2SO_4 \rightarrow$ 2HOH + Li_2SO_4
6. $H_3PO_4 + 3KOH \rightarrow$ 3HOH + K_3PO_4
7. $H_3PO_4 + 3LiOH \rightarrow$ 3HOH + Li_3PO_4
8. $2H_3PO_4 + 3Mg(OH)_2 \rightarrow$ 6HOH + $Mg_3(PO_4)_2$
9. In the beakers below 20mL of .5NaOH is added to 10mL of 1M HCl. Draw before and after the reaction completes.



Before

20mL
0.5 NaOH
0.01 mol

Before

10mL
1M HCl + $H_2O \rightarrow H_3O^+ + Cl^-$
0.01 mol

After

NAME

TITRATION EXERCISES

For a titration an unknown acid needs to be determined. A 45mL sample is to be examined. This sample is titrated against .2M KOH. In the titration, .043L of base was required to reach the equivalence.

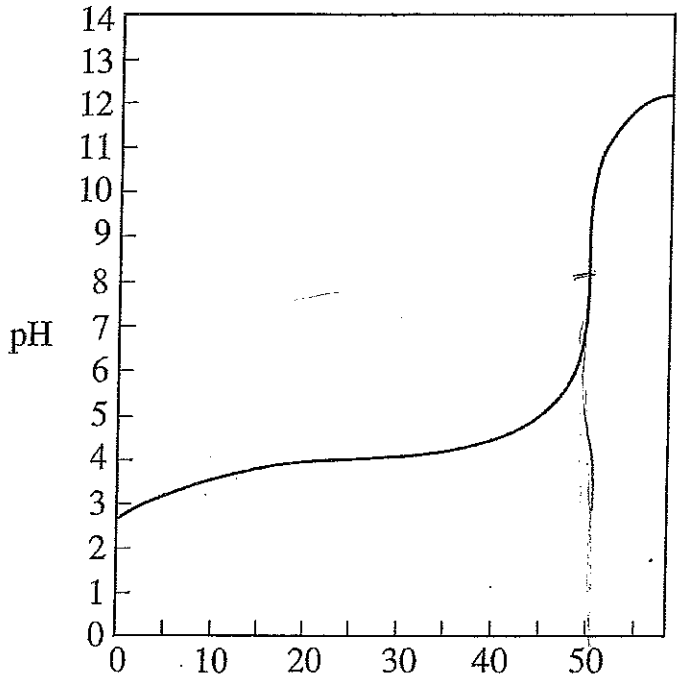
1. What two things are needed to determine the concentration of the unknown acid?
   amount of sample - 45mL
   Molarity & amount of base → to figure out moles
2. From number one what do you have and what do you need?
   yes
3. What is meant by the term "equivalence point"?
   the point in which there is equal number of moles in acid and base
4. How many moles of the base were used?
   $0.2M\ KOH = \frac{x}{0.043L}$ $x = 0.0086\ mol\ KOH$
5. During the titration how many moles of acid were neutralized?
   (same # of moles) $0.0086\ mol\ H_3O^+$
6. What is the concentration of the unknown acid? (Before titration)?
   $\frac{0.0086\ mol}{0.045L} = 0.19M$ acid

An unknown acid needs to be determined except the acid is solid. It has a mass of 2.32g. This acid is added to 50mL of water and dissolved. In a titration with NaOH (.2M), 43.5mL was needed to reach equivalence.

7. How many moles of the base were used?
   $0.2M\ NaOH = \frac{x}{0.0435L}$ $x = 0.0087\ mol\ NaOH$
8. During the titration how many moles of acid were neutralized?
   (same # of moles) $0.0087\ mol\ H_3O^+$
9. What is the concentration of the unknown acid? (Before titration)?
   $\frac{0.0087\ mol}{0.050L} = 0.174M$ acid
10. What is the pH of the unknown acid?
    $pH = -\log(0.174) = 0.76$

Bonus:

11. What is the molar mass of the unknown acid?
    grams per mol 4/4 $\frac{2.32g}{0.0087\ mol} = 265.5\ g/mol$



12. In a titration to determine the concentration of an unknown Acid 40 mL of HCl was titrated by .10M NaOH. 50mL NaOH

13. As you look at the graph, is the acid more or less concentrated then the base? Explain. the acid is more concentrated

14. How many mL of base are needed to reach equivalence? 50mL NaOH

15. What is the approximate pH of the equivalence? 8

16. Why isn't the equivalence point exactly neutral? equivalence depends on the strength of acid vs. base

17. What is the concentration of unknown?

$0.1M = \frac{X}{0.05}$ $X = 0.005 mol\ NaOH$ | $\frac{0.005 mol\ HCl}{0.040L} = 0.125\ M\ HCl$

18. If 20 ml of .1M HCl is mixed with .05M NaOH how many mL are needed to reach equivalence?

$0.1M = \frac{X}{0.02L}$ $X = 0.002\ mol\ HCl$ | $0.05M\ NaOH = \frac{0.002}{X}$ $X = 0.040L\ NaOH$

19. If 20mL of .1M HF is mixed with .01M NaOH how many mL of needed to reach equivalence?

$0.1M\ HF = \frac{X}{0.02L}$ $X = 0.002 mol$ | $0.01M\ NaOH = \frac{0.002}{X}$ $X = 0.2L\ NaOH$

a. Will the pH be acidic basic or neutral at equivalence?

basic

b. What will be the salt present at equivalence?

$HF + NaOH \rightarrow$ (NaF salt) $+ HOH$

Chemistry

pH of Strong Acids

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1. .5M HBr.
   a. Write the hydrolysis reaction and create and ISE table

$HBr + H_2O \rightarrow H_3O^+ + Br^{-1}$

I	0.5	+0.5	+0.5
S	-0.5		
E	Ø	0.5	0.5

   b. What is the concentration of H_3O^+ ions at the end?

0.5M H_3O^+

   c. What is the pH of the solution?

$pH = -\log[0.5] =$

2. .01M HCl
   a. Write the hydrolysis reaction and create and ISE table

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

I	0.1		
S	-0.1	+0.1	+0.1
E	Ø	0.1	0.1

   b. What is the concentration of H_3O^+ ions at the end?

0.1M H_3O^+

   c. What is the pH of the solution?

$pH = -\log[0.1M] =$

3. .001M HX (strong acid)
   a. Write the hydrolysis reaction and create and ISE table

$HX + H_2O \rightarrow H_3O^+ + X^-$

I	0.001		
S	-0.001	+0.001	+0.001
E		0.001	0.001

   b. What is the concentration of H_3O^+ ions at the end?

$[H_3O^+] = 0.001M$

   c. What is the pH of the solution?

$pH = -\log(0.001] =$

   d. What is the concentration of X^-

0.001M X^-

Name

pH of weak vs. Strong

Ka: HF = 6.6 E-4 (6.6E-4M) HCN = 6.2E-10 HNO_3 = Extremely large HNO_2 = 7.4 E-4

Write out the hydrolysis reaction and the equilibrium expression of the following acids.

1. .1M HF $HF + H_2O \rightleftharpoons H_3O^+ + F^-$ $K_a = 6.6\times10^{-4} = \frac{[F^-][H_3O^+]}{[HF]} = \frac{x^2}{0.1}$
2. .1M HCN $HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$ $K_a = \frac{[H_3O^+][CN^-]}{[HCN]} = 6.2E^{-10} = \frac{x^2}{0.1}$
3. .1M HNO_2 $HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$ $K_a = 7.4\times10^{-4} = \frac{[H_3O^+][NO_2^-]}{[HNO_2]} = \frac{x^2}{0.1}$
4. Indicate the 6 strong acids: HCl HBr HI HNO_3 H_2SO_4 $HClO_4$
5. What two factors will ultimately determine the $[H_3O^+]$
   - concentration
   - strength (nature) of acid

Determine the Hydrolysis equation, $[H_3O^+]$, and the pH of the following acids.

		Hydrolysis reaction	$[H_3O^+]$	pH
6.	.1M HCl	$HCl + H_2O \rightarrow H_3O^+ + Cl^-$	0.1 M	1
7.	.01M HBr	$HBr + H_2O \rightarrow H_3O^+ + Br^-$	0.01 M	2
8.	.015M HNO_3	$HNO_3 + H_2O \rightarrow H_3O^+ + NO_3^-$	0.015M	1.8
9.	.001M $HClO_4$	$HClO_4 + H_2O \rightarrow H_3O^+ + ClO_4^-$	0.001M	3
10.	1.5M HI	$HI + H_2O \rightarrow H_3O^+ + I^-$	1.5	-0.17

11. Why don't you need a K value to determine the pH of the previous acids?
    Strong acids have 100% ionization so all H^+ in acid becomes H_3O^+ - stoichiometrically the same

Determine the $[H_3O^+]$ and the pH of the acids listed in questions 1-6 acids. (Create an ISE table for each)

(12-15) ⑥ $HF + H_2O \rightarrow H_3O^+ + F^-$

	HF	H_2O	H_3O^+	F^-
I	0.1		0	0
C	-x		+x	+x
E	0.1-x		x	x

Name

pH of Acids/bases

Ka Table

HF = 6.6E-4; $HClO_2$ = 1.1E-2; HCN = 6.2E-10; $HC_2H_3O_2$ = 9.1E-5; HNO_2 = 7.2E-5

Strong Acids

1. Determine the pH of the following strong acids
   a. .5M HBr. pH = $-\log 0.5 = 0.3$
   b. .01M HCl pH = 2
   c. .005M HI pH = 2.3
2. In the previous question the actual type of acid was not needed to calculate the pH of the acid. Why? We just needed to know it was a strong acid that completely ionizes

3. For a weak acid two factors affect the number of hydronium ions that get produced. What are they?
   a. concentration
   b. Ka

4. Weak acids and bases undergo hydrolysis in order to produce hydronium and hydroxide ions.

5. Write the hydrolysis reaction for the following weak acids and bases.
   a. $HF + H_2O \rightleftharpoons H_3O^+ + F^-$
   b. $HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$
   c. $HClO_2 + H_2O \rightleftharpoons H_3O^+ + ClO_2^-$
   d. $HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$
   e. $HC_2H_3O_2 + H_2O \rightleftharpoons H_3O^+ + C_2H_3O_2^-$

6. Write the Equilibrium expression for each of the previous reactions.
   a. $K_a = \frac{[H_3O^+][F^-]}{[HF]} = 6.6E^{-4}$
   b.
   c. b) $K_a = \frac{[H_3O^+][CN^-]}{[HCN]} = 6.2E^{-10}$
   d.
   e. c) $K_a = \frac{[H_3O^+][ClO_2^-]}{[HClO_2]} = 1.1E^{-2}$

   d) $K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2]} = 7.2 \times 10^{-5}$

   e) $K_a = \frac{[H_3O^+][C_2H_3O_2^-]}{[HC_2H_3O_2]} = 9.1E^{-5}$

7. Determine the pH of a .1M solutions of $HC_2H_3O_2$. $K_a = 9.1 \times 10^{-5} = \frac{x^2}{0.1-x}$

$HC_2H_3O_2 + H_2O \rightleftharpoons H_3O^+ + C_2H_3O_2^-$

0.1		
$-x$	$+x$	$+x$
$0.1-x$	x	x

$x = [H_3O^+] = .00302M$ (pH = 2.52)

8. Determine the pH of a .1m solution of HF

$HF + H_2O \rightleftharpoons H_3O^+ + F^-$ $\quad K_a = 6.6 \times 10^{-4} = \frac{x^2}{0.1}$ $\quad x = 0.00812\,M$

0.1		
$-x$	$+x$	$+x$
$0.1-x$	x	x

$pH = -\log 0.00812 = 2.09$

9. Why don't the substances have the same pH?

The Ionization constants (K_a) are different and HF ionizes more than $HC_2H_3O_2$ so there is more $[H_3O^+]$ and a lower pH

10. Which substance would be considered the strongest acid? $HC_2H_3O_2$ or HF?

HF $K_a = 6.6 \times 10^{-4}$ ← bigger K_a so ionizes more & is the stronger acid

$HC_2H_3O_2$ $K = 9.1 \times 10^{-5}$

11. Determine the pH of a 3M HNO_2 solution:

$HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$ $\quad K_a = 7.2E^{-4} = \frac{x^2}{3}$ $\quad x = 0.046\,M$

3		
$-x$	$+x$	$+x$
$3-x$	x	x

$pH = -\log 0.046 = 1.34$

12. Determine the pH of a 3M HCN solution:

$HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$ $\quad K_a = \frac{x^2}{3} = 6.2 \times 10^{-10}$ $\quad x = 4.3E^{-5}\,M$

3		
$-x$	$+x$	$+x$
$3-x$	x	x

$pH = -\log 4.3E^{-5} = 4.37$

13. Determine the pH of a 3M $HClO_2$ solution:

$HClO_2 + H_2O \rightleftharpoons H_3O^+ + ClO_2^-$ $\quad K_a = 1.1 \times 10^{-2} = \frac{x^2}{3}$ $\quad x = 0.182\,M$

3		
$-x$	$+x$	$+x$
$3-x$	x	x

$pH = -\log 0.182 = 0.74$

14. Give an scenario where a weaker acid could produce a pH that is lower (more acidic)

a weaker acid could be more acidic with a higher concentration

$K_b \cdot K_a = 1.0E-14$

Stoichiometry
Weak Acids and Stoichiometry
Kb for NH_3 = 1.75E-5

A beaker contains 25 ml of .5M NH_3.

a) Write the Hydrolysis reaction for this base? $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

0.5 −x 0.5−x | +x x | +x x

b) What is the pH of this base?

$K_b = 1.75\times10^{-5} = \frac{x^2}{0.5}$ $x = [OH^-] = 0.00296M$ pOH = 2.5 pH = 11.5

c) .25M HCl is added to the base. Write the neutralization reaction.

$HCl + NH_3 \rightarrow NH_4^+ + Cl^-$

d) How many moles of HCl will be needed to convert half of the NH_3 to NH_4^+.

$0.5M = \frac{x}{0.025}$ $x = 0.0125$ moles NH_3 $\frac{0.0125}{2} = 0.00625$ (half)

e) How many mL of HCl are needed at this point?

$0.25M = \frac{0.00625}{x}$ $0.025L = 25mL$ HCl

f) What will be the pH at this point?

$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$

0.00625 0.00625

pH = −log 0.00625 = 2.2

g) How many moles & ~~mL of HCl~~ will be needed to reach the equivalency point?

0.0125 mol HCl $0.25M = \frac{0.0125\ mol}{xL}$ $x = 0.05L = 50mL$

h) Will this solution be acidic/basic or neutral at this point? How do you know?

equivalency pt. will be acidic

products NH_4^+ acidic + Cl^- neutral

i) What is the hydrolysis reaction for NH_4^+?

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

j) What is the value of K for NH_4^+?

$K_a \cdot K_b = 10^{-14}$ $K_a = \frac{10^{-14}}{K_b} = \frac{10^{-14}}{1.7\times10^{-5}} = 5.88\times10^{-10}$

K_a

K) Calculate the pH of the NH_4^+ solution.

$\frac{0.0125\ mol}{0.075} = 0.167\ M$ (25+50mL) $5.88\times10^{-10} = \frac{x^2}{0.0167}$ $x = [H_3O^+] = 3.13\times10^{-6}$

pH = −log 3.13×10^{-6} = 5.5