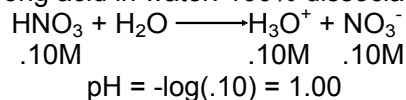


Unit 5: ACID/BASE 2

Aug 22-6:30 PM

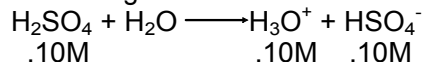
Chemistry 12 Acid/Base II -Helpful Equations

1) Strong acid in water: 100% dissociation

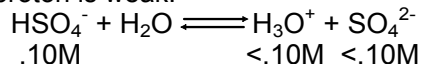


H₂SO₄ in water:

first proton is strong:

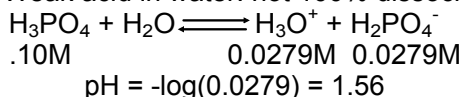


second proton is weak:

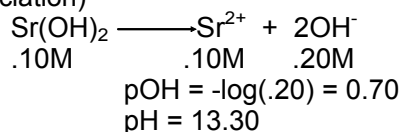


Aug 6-2:53 PM

2) Weak acid in water: not 100% dissociation

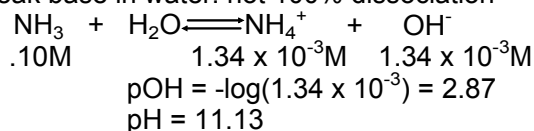


3) Strong base (hydroxide base) in water: 100% dissociation (water not in reaction; just a dissociation)



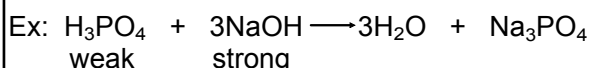
Aug 6-2:56 PM

4) Weak base in water: not 100% dissociation



Aug 6-2:59 PM

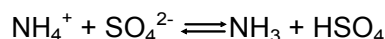
5) ANY reaction that involves a STRONG acid or base goes to 100% completion. So a weak acid with a strong base is 100% due to the strong base. A strong acid with a weak base is 100% due to the strong acid.



The OH⁻ ions take all three protons off of each H₃PO₄ molecule, such as in a titration. If H₃PO₄ was merely in water, only one proton would come off at less than 100% like #2 earlier.

Aug 6-3:01 PM

6) Weak acid and weak base:



-side with weaker acid is favoured

http://www.media.pearson.com.au/schools/cw/au_sch_derry_ibest_1/int/aqueous/tutor/f5/1501.html

Aug 6-3:04 PM

I) Weak Acid Equilibrium and K_a

How do strong acids behave in water?

Write an equation for, and give the $[H_3O^+]$ and pH for a 0.0010M solution of HCl.

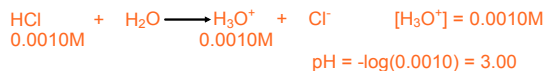
Aug 22-6:30 PM

I) Weak Acid Equilibrium and K_a

How do strong acids behave in water?

They react 100% with H_2O to create H_3O^+ - no equilibrium exists

Write an equation for, and give the $[H_3O^+]$ and pH for a 0.0010M solution of HCl.



Aug 22-6:30 PM

How do weak acids behave in water?

<http://www.absorblearning.com/media/attachment.action?quick=126&att=2737>

Write an equation for a 0.010M HF solution.

<http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons4.htm>

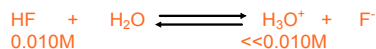
Aug 22-6:36 PM

How do weak acids behave in water?

They react with H_2O (much less than 100%) to create H_3O^+ , and an equilibrium results where reactants are favoured

<http://www.absorblearning.com/media/attachment.action?quick=126&att=2737>

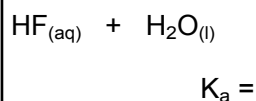
Write an equation for a 0.010M HF solution.



<http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons4.htm>

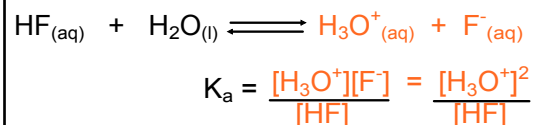
Aug 22-6:36 PM

It is not as simple to find the pH of a 0.010M solution of a weak acid as you must first have information on the extent of dissociation for the weak acid in question. K_a , the weak acid equilibrium constant, helps to determine this information and provides a means to solve **weak acid** problems. K_a is a K_{eq} for weak acids, so it is simply an equilibrium constant, and therefore all K_{eq} rules apply.



Aug 22-6:38 PM

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Aug 22-6:38 PM

Notice the K_a values _____ as you go down the table because the acids are getting progressively _____ (creating _____ H_3O^+ in solution).

In Chemistry 12, we work on quantitative problems that involve weak acids and weak bases.

Aug 22-6:40 PM

Notice the K_a values decrease as you go down the table because the acids are getting progressively weaker (creating less H_3O^+ in solution).

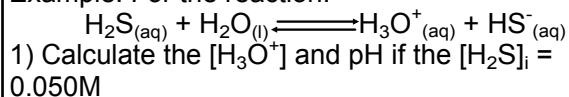
In Chemistry 12, we work on quantitative problems that involve weak acids and weak bases.

Aug 22-6:40 PM

Weak acid quantitative problems can be broken into three types.
Type 1 Problems: Finding pH of a weak acid solution

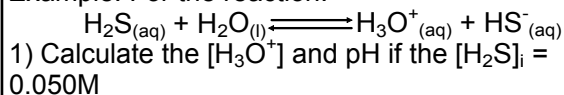
Aug 22-6:48 PM

Example: For the reaction:



Aug 22-6:45 PM

Example: For the reaction:



I	0.050M	0M	0M
C	-x	+x	+x
E	0.050 - x	x	x

Let $x = \Delta[H_3O^+]$ assume $0.050 - x \approx 0.050$

$$K_a = \frac{[H_3O^+]^2}{[H_2S]} \quad \text{thus, } 9.1 \times 10^{-8} = \frac{x^2}{0.050}$$

$$K_a \text{ from table} = 9.1 \times 10^{-8} \quad \text{so, } x = \sqrt{(9.1 \times 10^{-8})(0.050)}$$

Since the % dissociation of H_2S is $x = 6.745 \times 10^{-5}$ so small (less than 5%), we can assume that x is very small compared to 0.050M $[H_3O^+] = 6.7 \times 10^{-5}M$, pH = 4.17

Aug 22-6:45 PM

Example:

Calculate the pH of a 0.450M solution of $H_2PO_4^-$
 *Consider only the first proton dissociating from a polyprotic weak acid, as the dissociation of the second proton is negligible compared to the first

Aug 22-6:57 PM

Type 3 Problems: Finding the K_a of an Unknown Weak Acid

Example: A 0.20M solution of the weak acid, HA, has a pH of 1.32. Calculate the K_a of the weak acid and use this to identify it.

	$\text{HA} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{A}^-$		
I	0.20M	0	0
C	-0.04786	+0.04786	+0.04786
E	0.152	0.04786	0.04786

pH = 1.32
 $[\text{H}_3\text{O}^+] = 2\text{ndlog}(-1.32)$
 = 0.04786M

$$K_a = \frac{[\text{H}_3\text{O}^+]^2}{[\text{HA}]} = \frac{(0.04786)^2}{(0.152)} = 1.5 \times 10^{-2} \text{ the acid is H}_2\text{SO}_3$$

Aug 23-7:44 AM

Example: A 2.00M diprotic acid has a pH of 0.50. Calculate the K_a value.

Example: A 2.00M diprotic acid has a pH of 0.50. Calculate the K_a value.

	$\text{H}_2\text{A} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HA}^-$		
I	2.00M	0	0
C	-0.3162	+0.3162	+0.3162
E	1.6838	0.3162	0.3162

pH = 0.50
 $[\text{H}_3\text{O}^+] = 2\text{ndlog}(-0.50)$
 = 0.3162M

$$K_a = \frac{[\text{H}_3\text{O}^+]^2}{[\text{H}_2\text{A}]} = \frac{(0.3162)^2}{(1.6838)} = 5.9 \times 10^{-2}$$

Aug 23-7:51 AM

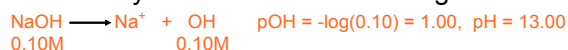
II) Weak Base Equilibrium and K_b

Write a reaction for and find the pH for 0.10M NaOH. Why is it considered a 'strong' base?

Write a reaction for 0.10M NH_3 solution. Why is it considered a 'weak' base? How would you find the pH of a weak base solution?

II) Weak Base Equilibrium and K_b

Write a reaction for and find the pH for 0.10M NaOH. Why is it considered a 'strong' base?



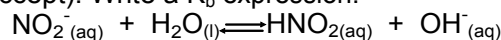
Write a reaction for 0.10M NH_3 solution. Why is it considered a 'weak' base? How would you find the pH of a weak base solution?



NH_3 is a weak base because it only reacts to a small extent in H_2O to create OH^- , thereby forming an equilibrium. Finding the pH of a weak base solution is a similar process to finding the pH for a weak acid solution.

Aug 23-7:54 AM

Weak base problems such as the one previous can be solved using the K_b constant, a K_{eq} for weak bases (similar to K_a for weak acids). The larger the K_b , the stronger the base (the more H^+ it will accept). Write a K_b expression:



$K_b =$ but since $K_b =$
 $[\text{OH}^-] = [\text{HNO}_2] \dots$

Aug 23-7:59 AM

Weak base problems such as the one previous can be solved using the K_b constant, a K_{eq} for weak bases (similar to K_a for weak acids). The larger the K_b , the stronger the base (the more H^+ it will accept). Write a K_b expression:

$$NO_2^-(aq) + H_2O(l) \rightleftharpoons HNO_2(aq) + OH^-(aq)$$

$K_b = \frac{[HNO_2][OH^-]}{[NO_2^-]}$ but since $[OH^-] = [HNO_2]$... $K_b = \frac{[OH^-]^2}{[NO_2^-]}$

Aug 23-7:59 AM

Relationship of K_w , K_a , and K_b for a Conjugate Acid-Base Pair

Write the K_a for HF: _____ Write the K_b for F^- : _____

multiply the K_a of HF by the K_b of F^- : _____

What results? _____

Conclusion? _____

Aug 23-8:03 AM

Relationship of K_w , K_a , and K_b for a Conjugate Acid-Base Pair

Write the K_a for HF: $\frac{[H_3O^+][F^-]}{[HF]}$ Write the K_b for F^- : $\frac{[OH^-][HF]}{[F^-]}$

multiply the K_a of HF by the K_b of F^- : $\frac{[H_3O^+][F^-]}{[HF]} \times \frac{[OH^-][HF]}{[F^-]} = [H_3O^+][OH^-]$

What results? The K_w ! $K_w = [H_3O^+][OH^-]$

Conclusion? $K_w = K_a \times K_b$

Aug 23-8:03 AM

The acid-base table only lists acid K_a values. Using what you learned above, how would you get the K_b for the corresponding conjugate base?

Example:
Determine K_b for the weak base SO_4^{2-} :

Aug 23-8:09 AM

The acid-base table only lists acid K_a values. Using what you learned above, how would you get the K_b for the corresponding conjugate base?

get the K_a for the conjugate acid, then divide K_w by K_a to get the K_b for the corresponding conjugate base

Example:
Determine K_b for the weak base SO_4^{2-} : conj acid is HSO_4^-
 K_a of $HSO_4^- = 1.2 \times 10^{-2}$
 K_b of $SO_4^{2-} = \frac{1.0 \times 10^{-14}}{1.2 \times 10^{-2}} = 8.3 \times 10^{-13}$

Aug 23-8:09 AM

Example: Determine K_b for HCO_3^- :

Practice Questions: Determine the K_b values for the following:
a) HPO_4^{2-} b) $H_2PO_4^-$

Aug 23-8:12 AM

Example: Determine K_b for HCO_3^- :

conj acid is H_2CO_3^*
 K_a of $\text{H}_2\text{CO}_3^* = 4.3 \times 10^{-7}$

$$K_b \text{ of } \text{CO}_3^{2-} = \frac{1.0 \times 10^{-14}}{4.3 \times 10^{-7}} = 2.3 \times 10^{-8}$$

Practice Questions: Determine the K_b values for the following:

a) HPO_4^{2-}

b) H_2PO_4^-

conj acid is H_2PO_4^-
 K_a of $\text{H}_2\text{PO}_4^- = 6.2 \times 10^{-8}$

conj acid is H_3PO_4
 K_a of $\text{H}_3\text{PO}_4 = 7.5 \times 10^{-3}$

$$K_b \text{ of } \text{HPO}_4^{2-} = \frac{1.0 \times 10^{-14}}{6.2 \times 10^{-8}}$$

$$K_b \text{ of } \text{H}_2\text{PO}_4^- = \frac{1.0 \times 10^{-14}}{7.5 \times 10^{-3}}$$

$$= 1.6 \times 10^{-7}$$

$$= 1.3 \times 10^{-12}$$

Aug 23-8:12 AM

Assignment 2

Hebden p.152 #77, 80, 82 & p.130 #35bce, 36

Aug 23-8:20 AM

Assignment 2

Hebden p.152 #77, 80, 82 & p.130 #35bce, 36

answers in the back of Hebden

Aug 23-8:20 AM

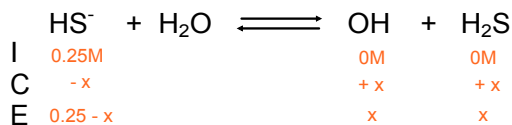
Weak base quantitative problems can be broken into three types.

Type 1 Problems: Finding the pH of a weak base solution

Aug 23-8:22 AM

Example: Calculate the $[\text{OH}^-]$ and pH for a 0.25M solution of the weak base HS

Example: Calculate the $[\text{OH}^-]$ and pH for a 0.25M solution of the weak base HS



Let $x = \Delta[\text{OH}^-]$

assume $0.25 - x \approx 0.25$

$$K_b = \frac{1.0 \times 10^{-14}}{9.1 \times 10^{-8}} = 1.1 \times 10^{-7}$$

$$\text{thus, } 1.1 \times 10^{-7} = \frac{x^2}{0.25}$$

$$K_b = \frac{[\text{OH}^-]^2}{[\text{HS}^-]}$$

$$\text{so, } x = \sqrt{(1.1 \times 10^{-7})(0.25)}$$

$$x = 1.66 \times 10^{-4}, [\text{OH}^-] = 1.7 \times 10^{-4}\text{M}$$

$$\text{pOH} = -\log(1.66 \times 10^{-4}) = 3.78$$

$$\text{pH} = 10.22$$

Aug 23-8:22 AM

Aug 23-8:22 AM

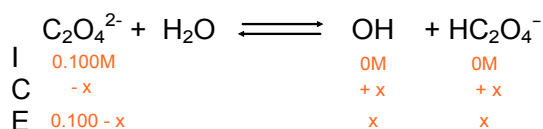
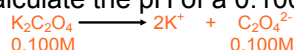
Sometimes, when salts dissolve in water, one of the ions can act as a weak base in solution, such as the salt in the next example.

Aug 23-8:30 AM

Example: Calculate the pH of a 0.100M solution of $K_2C_2O_4$.

Aug 23-8:31 AM

Example: Calculate the pH of a 0.100M solution of $K_2C_2O_4$.



Let $x = \Delta[OH^-]$ assume $0.100 - x \approx 0.100$

$$K_b = \frac{1.0 \times 10^{-14}}{6.4 \times 10^{-5}} = 1.56 \times 10^{-10} \quad \text{thus, } 1.56 \times 10^{-10} = \frac{x^2}{0.100}$$

$$K_b = \frac{[OH^-]^2}{[C_2O_4^{2-}]} \quad \text{so, } x = \sqrt{(1.56 \times 10^{-10})(0.100)}$$

$$x = 3.95 \times 10^{-6}$$

$$pOH = -\log(3.95 \times 10^{-6}) = 5.40$$

$$pH = 8.60$$

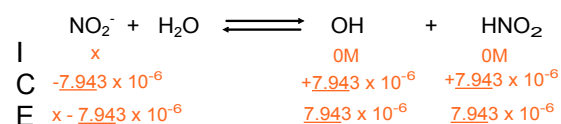
Aug 23-8:31 AM

Type 2 Problems: Calculating the Initial Concentration of a Weak Base

Aug 23-8:36 AM

Example: A solution of NO_2^- has a pH of 8.900. Calculate the $[NO_2^-]$ that would have been required to make this solution.

Example: A solution of NO_2^- has a pH of 8.900. Calculate the $[NO_2^-]$ that would have been required to make this solution.



$$pH = 8.900, pOH = 5.100 \quad 2.17 \times 10^{-11} = \frac{(7.943 \times 10^{-6})^2}{x - 7.943 \times 10^{-6}}$$

$$[OH^-] = 2 \text{ndlog}(-5.100) = 7.943 \times 10^{-6}M$$

$$2.17 \times 10^{-11}x - 1.727 \times 10^{-16} = 6.309 \times 10^{-11}$$

Let $x = [NO_2^-]$

$$K_b = \frac{1.0 \times 10^{-14}}{4.6 \times 10^{-4}} = 2.17 \times 10^{-11} \quad x = 2.9, \quad [NO_2^-] = 2.9M$$

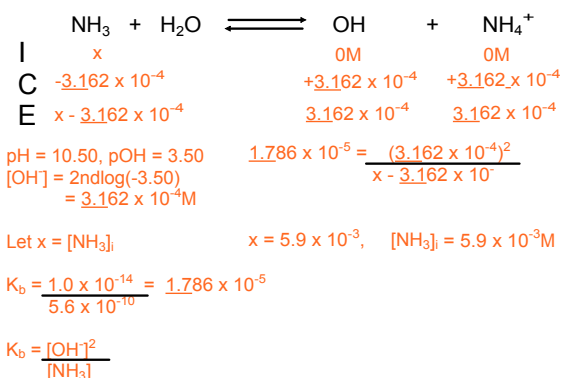
$$K_b = \frac{[OH^-]^2}{[NO_2^-]}$$

Aug 23-8:36 AM

Aug 23-8:36 AM

Example: A solution of ammonia, NH_3 , has a pH of 10.50. Calculate the $[\text{NH}_3]$ used to make the solution.

Example: A solution of ammonia, NH_3 , has a pH of 10.50. Calculate the $[\text{NH}_3]$ used to make the solution.

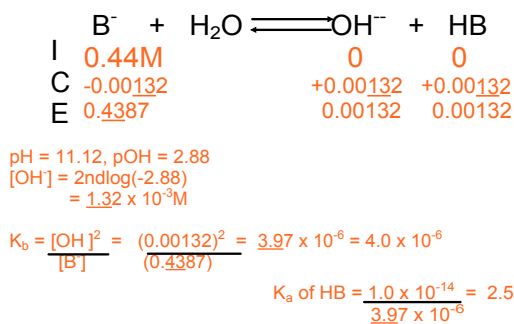


Aug 23-8:48 AM

Aug 23-8:48 AM

Type 3 Problems: Finding the K_b of an Unknown Weak Base

Example: A 0.44M solution of the weak base B^- has a pH of 11.12. Calculate the K_b for this base, and the K_a for the conjugate acid, HB at 25°C.



Aug 23-8:56 AM

Assignment 3

Hebden p.153 #84-89

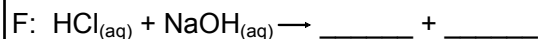
Aug 23-9:04 AM

Assignment 3

Hebden p.153 #84-89

answers in the back of Hebden

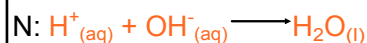
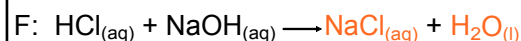
Aug 23-9:04 AM

III) Writing Formula (Molecular), Complete Ionic, and Net Ionic Equations for Acid/Base Reactions**1. Strong Acid / Strong Base (Neutralization)**

C:

N:

Aug 23-9:06 AM

III) Writing Formula (Molecular), Complete Ionic, and Net Ionic Equations for Acid/Base Reactions**1. Strong Acid / Strong Base (Neutralization)**

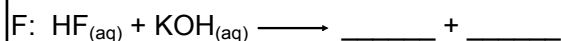
Aug 23-9:06 AM

Since 100% of strong acids and bases dissociate, they should be written as ions in the complete ionic and net ionic equations.

http://preparatorychemistry.com/Bishop_Solubility_frames.htm

If the resulting salt is low solubility and precipitates, it is included in the net ionic equation.

Aug 23-9:12 AM

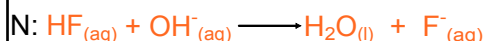
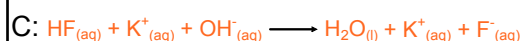
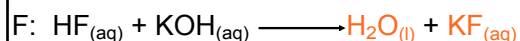
2) Weak Acid / Strong Base:

C:

N:

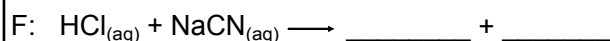
Since less than 5% of weak acids and bases dissociate, don't split them into ions for the complete ionic and net ionic equations, since the majority of weak acid molecules stay intact.

Aug 23-9:13 AM

2) Weak Acid / Strong Base:

Since less than 5% of weak acids and bases dissociate, don't split them into ions for the complete ionic and net ionic equations, since the majority of weak acid molecules stay intact.

Aug 23-9:13 AM

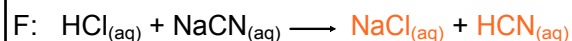
3) Strong Acid / Weak Base

C:

N:

Many weak bases originate as salts since weak bases often have a negative charge. The salt will dissociate 100% into ions, and the weak base component will then react 100% due to the strong acid present.

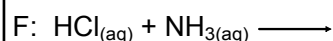
Aug 23-9:17 AM

3) Strong Acid / Weak Base

Many weak bases originate as salts since weak bases often have a negative charge. The salt will dissociate 100% into ions, and the weak base component will then react 100% due to the strong acid present.

Aug 23-9:17 AM

Here is an example when the weak base does not originate as a salt:



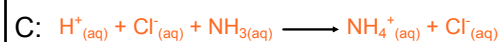
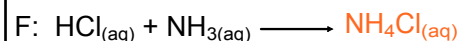
C:

N:

Sometimes when an acid and base react, only a salt is produced as the base does not contain OH, so no water can form.

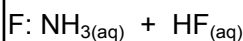
Aug 23-9:52 AM

Here is an example when the weak base does not originate as a salt:



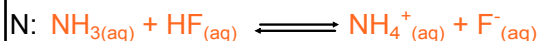
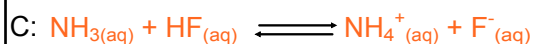
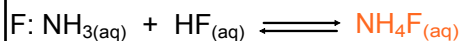
Sometimes when an acid and base react, only a salt is produced as the base does not contain OH, so no water can form.

Aug 23-9:52 AM

4) Weak Acid / Weak Base

C:

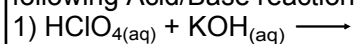
N:

4) Weak Acid / Weak Base

Aug 23-9:56 AM

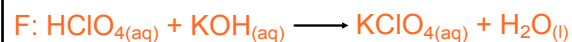
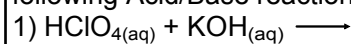
Aug 23-9:56 AM

Assignment 4: Write Formula (Molecular), Complete Ionic, and Net Ionic Equations for the following Acid/Base reactions:

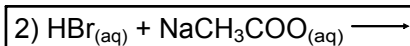


Aug 23-9:59 AM

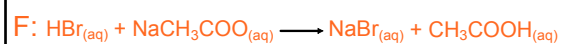
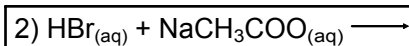
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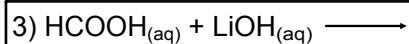
Aug 23-9:59 AM



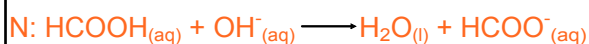
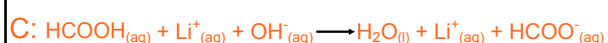
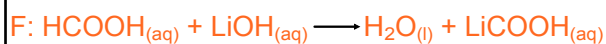
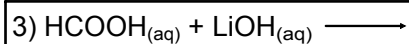
Aug 23-10:04 AM



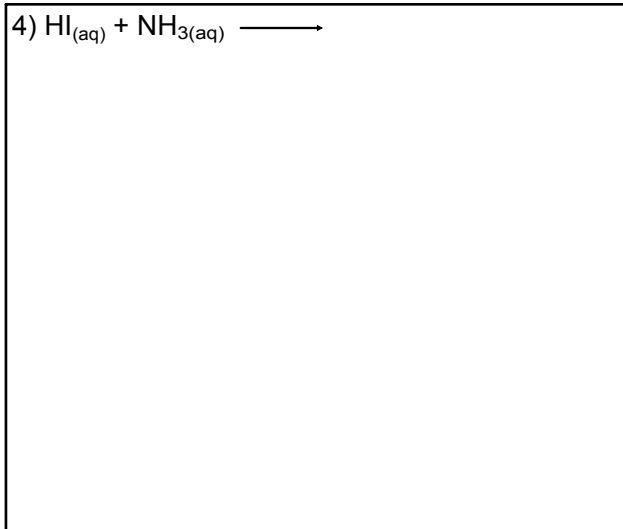
Aug 23-10:04 AM



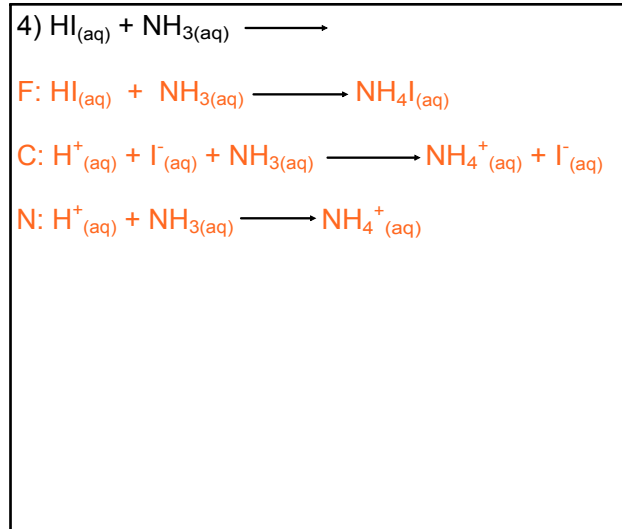
Aug 23-10:07 AM



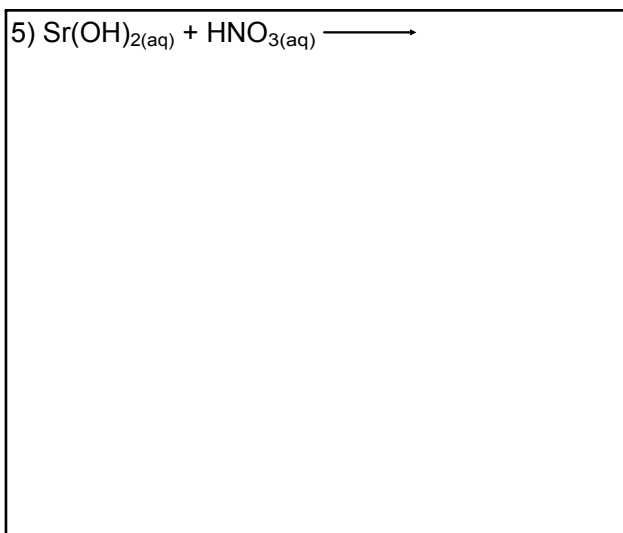
Aug 23-10:07 AM



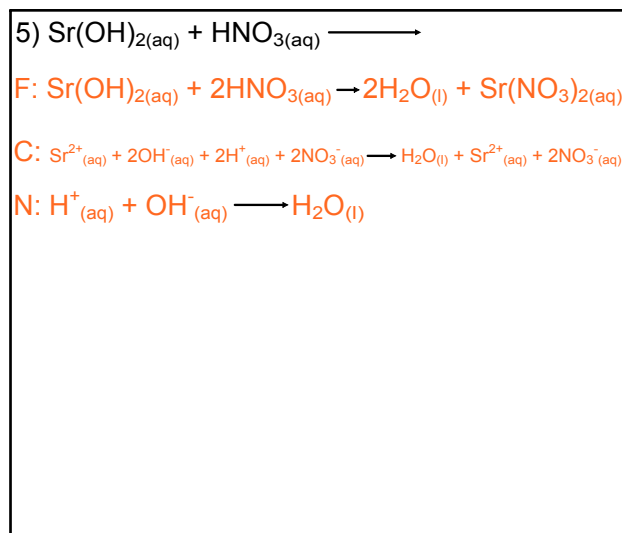
Aug 23-10:10 AM



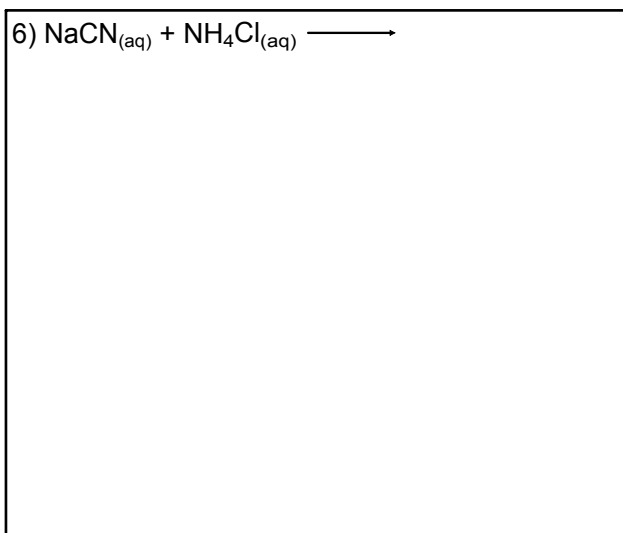
Aug 23-10:10 AM



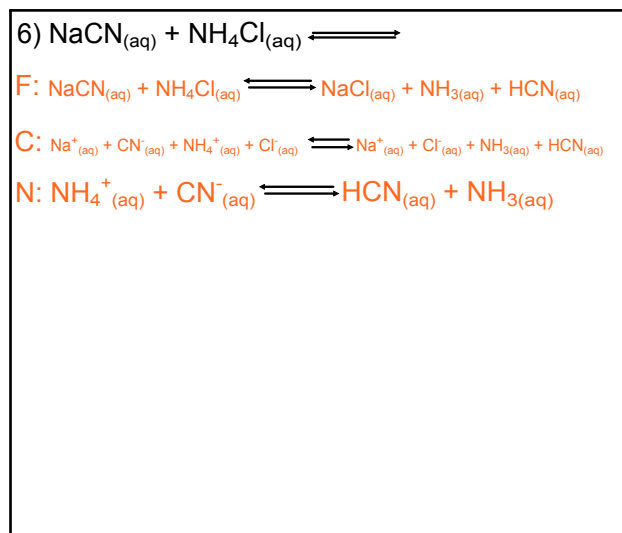
Aug 23-10:13 AM



Aug 23-10:13 AM



Aug 23-10:17 AM

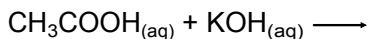
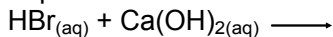


Aug 23-10:17 AM

IV) Hydrolysis

When any acid (strong or weak) reacts with a strong hydroxide base, the reaction is 100% (due to the strong base):

Examples



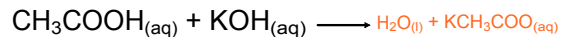
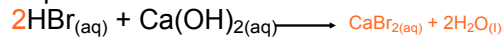
In general, the products are _____ and _____. These reactions are called _____ reactions.

Aug 23-10:20 AM

IV) Hydrolysis

When any acid (strong or weak) reacts with a strong hydroxide base, the reaction is 100% (due to the strong base):

Examples

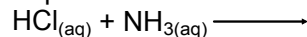


In general, the products are _____ water and _____ salt _____. These reactions are called _____ neutralization reactions.

Aug 23-10:20 AM

When a strong acid reacts with a base that does not contain hydroxide, it is still a neutralization reaction, however the only product is a salt. The reaction is 100% because a strong acid is reacting.

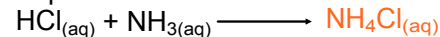
Example:



Aug 23-1:56 PM

When a strong acid reacts with a base that does not contain hydroxide, it is still a neutralization reaction, however the only product is a salt. The reaction is 100% because a strong acid is reacting.

Example:



Aug 23-1:56 PM

The salts that are produced can be soluble or insoluble (use your solubility table). The insoluble salts will form a solid and precipitate out of solution. The soluble salts will stay in solution as cations and anions and may act as weak acids or bases. For example, the salt produced above was $\text{NH}_4\text{Cl}_{(aq)}$. Is it soluble (use your table)?

Therefore, how will it actually exist in solution?

Is the cation or anion a weak acid or base?

Aug 23-1:53 PM

The salts that are produced can be soluble or insoluble (use your solubility table). The insoluble salts will form a solid and precipitate out of solution. The soluble salts will stay in solution as cations and anions and may act as weak acids or bases. For example, the salt produced above was $\text{NH}_4\text{Cl}_{(aq)}$. Is it soluble (use your table)? **Yes**

Therefore, how will it actually exist in solution?

as ions $\text{NH}_4^+_{(aq)}$ and $\text{Cl}^-_{(aq)}$

Is the cation or anion a weak acid or base?

NH_4^+ is a weak acid

Aug 23-1:53 PM

So what will that ion do in solution?

The reaction you just wrote above is a **hydrolysis** reaction, and it can cause salt solutions to be acidic or basic (acidic in the example above due to H_3O^+ formation).
So, whenever a salt is dissolved in solution OR whenever a salt is formed due to an acid reacting with a base, the resulting salt solution may be acidic or basic if a **hydrolysis** reaction occurs. If not, the solution will be neutral.

Aug 23-1:57 PM

So what will that ion do in solution?
react with water and form an equilibrium:
$$\text{NH}_4^+(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{NH}_3(\text{aq})$$

The reaction you just wrote above is a **hydrolysis** reaction, and it can cause salt solutions to be acidic or basic (acidic in the example above due to H_3O^+ formation).
So, whenever a salt is dissolved in solution OR whenever a salt is formed due to an acid reacting with a base, the resulting salt solution may be acidic or basic if a **hydrolysis** reaction occurs. If not, the solution will be neutral.

Aug 23-1:57 PM

The ions that make up the salts produced from the neutralization reactions may or may not undergo hydrolysis. Here are the guidelines:
1) Ions that will not undergo hydrolysis are...

2) Ions that will not undergo hydrolysis are...

Aug 23-2:00 PM

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1) Ions that will not undergo hydrolysis are...
conjugate bases of strong acids, because they are not bases at all.
These include: ClO_4^- , I^- , Br^- , Cl^- , NO_3^-

HSO_4^- is not a base, but is actually a weak acid so will hydrolyze acidically

2) Ions that will not undergo hydrolysis are...
conjugate acids of strong bases, because they are not acids at all.
These include: Li^+ , Na^+ , K^+ , Rb^+ , Cs^+ , Mg^{2+} , Ca^{2+} , Sr^{2+} , Ba^{2+}
(group 1 & 2 cations)

OH^- & NH_3 though not acids, are both bases

Aug 23-2:00 PM

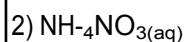
3) Ions that will undergo hydrolysis are...

Aug 23-2:08 PM

3) Ions that will undergo hydrolysis are...
weaks acids and bases, found on the middle (unshaded) portion of the acid/base table

Aug 23-2:08 PM

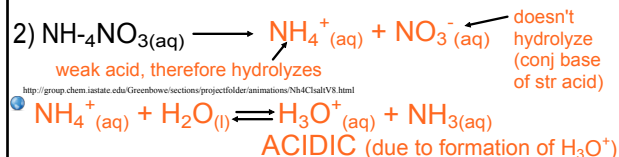
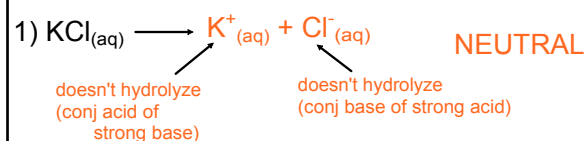
Write a dissociation equation for each salt, and then predict whether the resulting salt solutions will be acidic, basic, or neutral, and write any hydrolysis equations as support.



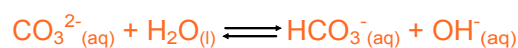
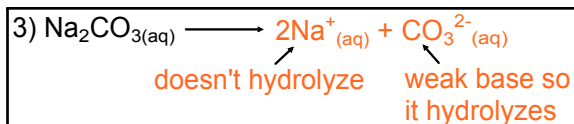
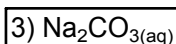
<http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/animations/Nh4ClSaltV8.html>

Aug 23-2:09 PM

Write a dissociation equation for each salt, and then predict whether the resulting salt solutions will be acidic, basic, or neutral, and write any hydrolysis equations as support.



Aug 23-2:09 PM

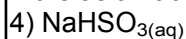


BASIC (due to OH^- formation)

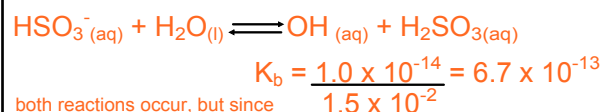
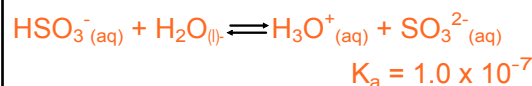
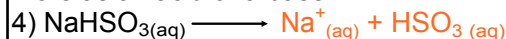
Aug 23-2:15 PM

Aug 23-2:15 PM

Sometimes, an ion is amphiprotic, so will it act more as an acid or a base?



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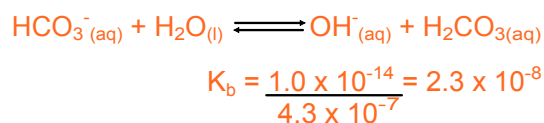
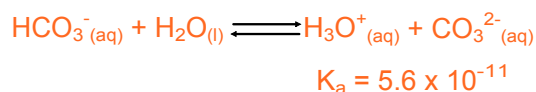
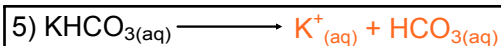


both reactions occur, but since $K_a > K_b$, the acidic hydrolysis (top reaction) occurs to a greater extent, therefore there is more H_3O^+ created compared to OH^- , therefore an **ACIDIC** solution

Aug 23-2:19 PM

Aug 23-2:19 PM

5) $\text{KHCO}_3(\text{aq})$



$K_b > K_a$, therefore BASIC

Aug 23-2:25 PM

Aug 23-2:25 PM

If an ion is amphiprotic, write an acidic hydrolysis with a K_a value, and a basic hydrolysis with a K_b value. Whichever K value is greater, that reaction will occur to a greater extent.

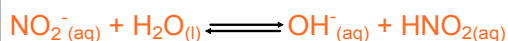
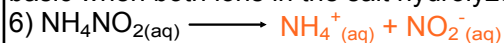
How do you predict if the solution is acidic or basic when both ions in the salt hydrolyze?

6) $\text{NH}_4\text{NO}_2(\text{aq})$

Aug 23-2:29 PM

Aug 23-2:31 PM

How do you predict if the solution is acidic or basic when both ions in the salt hydrolyze?



$$K_b = \frac{1.0 \times 10^{-14}}{4.6 \times 10^{-4}} = 2.2 \times 10^{-11}$$

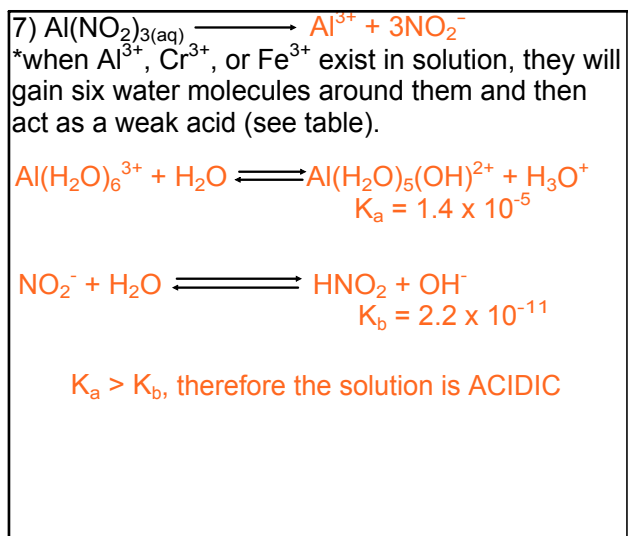
$K_a > K_b$, therefore the solution is ACIDIC.

Aug 23-2:31 PM

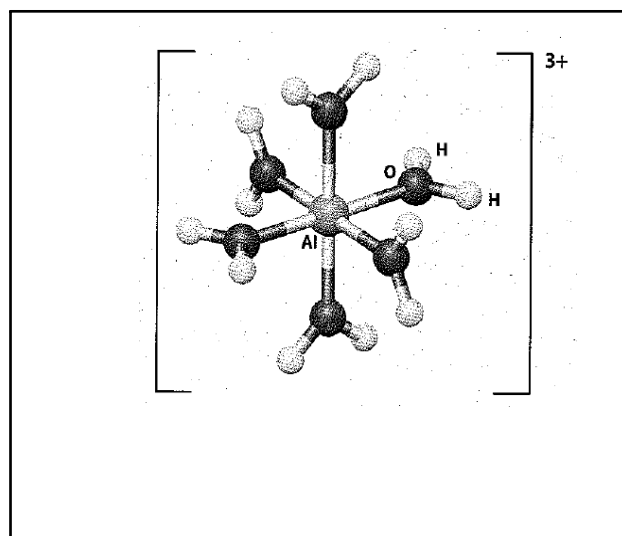
7) $\text{Al}(\text{NO}_2)_3(\text{aq})$

*when Al^{3+} , Cr^{3+} , or Fe^{3+} exist in solution, they will gain six water molecules around them and then act as a weak acid (see table).

Aug 23-2:36 PM



Aug 23-2:36 PM



Sep 11-5:08 PM

Summarize how you can predict whether a salt solution with two ions that hydrolyze will be acidic, basic, or neutral:

Aug 23-2:41 PM

Summarize how you can predict whether a salt solution with two ions that hydrolyze will be acidic, basic, or neutral:

write the hydrolysis equation for each and find the K_a and K_b

- if $K_a > K_b$, solution is acidic
- if $K_b > K_a$, solution is basic
- if $K_a = K_b$, solution is neutral

Aug 23-2:41 PM

Universal Indicator

pH	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Colour	RED	ORANGE	YELLOW	GREEN						BLUE	PURPLE-VIOLET			

Sep 11-5:10 PM

Assignment 5

1) Hydrolysis Mini-Lab: answer the questions from the lab for #1 of this assignment

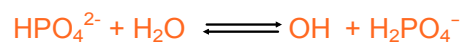
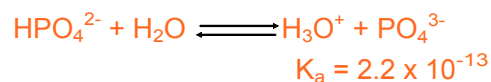
Aug 23-2:43 PM

2) Write dissociation equations, and any hydrolysis equation(s) occurring when the following salts are added to water and predict whether the resulting solution will be acidic, basic, or neutral.

a) Na_2HPO_4

2) Write dissociation equations, and any hydrolysis equation(s) occurring when the following salts are added to water and predict whether the resulting solution will be acidic, basic, or neutral.

a) $\text{Na}_2\text{HPO}_4 \longrightarrow 2\text{Na}^+ + \text{HPO}_4^{2-}$



$K_b > K_a$, so
the solution is
BASIC

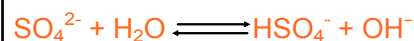
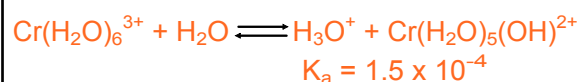
$$K_b = \frac{1.0 \times 10^{-14}}{6.2 \times 10^{-8}} = 1.6 \times 10^{-7}$$

Aug 23-2:45 PM

Aug 23-2:45 PM

b) $\text{Cr}_2(\text{SO}_4)_3$

b) $\text{Cr}_2(\text{SO}_4)_3 \longrightarrow 2\text{Cr}^{3+} + 3\text{SO}_4^{2-}$



$$K_b = \frac{1.0 \times 10^{-14}}{1.2 \times 10^{-2}} = 8.3 \times 10^{-13}$$

$K_a > K_b$, therefore the solution is ACIDIC

Aug 23-2:54 PM

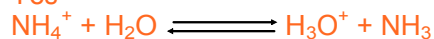
Aug 23-2:54 PM

3) NH_3 is titrated with HI . When the two react in the titration, what salt is formed? Does the salt undergo hydrolysis? If so, what is the hydrolysis equation and will the resulting pH be above or below 7?

3) NH_3 is titrated with HI . When the two react in the titration, what salt is formed? Does the salt undergo hydrolysis? If so, what is the hydrolysis equation and will the resulting pH be above or below 7?

NH_4I

Yes



Below 7 (acidic)

Aug 23-3:01 PM

Aug 23-3:01 PM

4) In a titration, which of the following combinations would result in an equivalence point with pH greater than 7.0? *HINT: find the resulting salt from each reaction and see if and how it undergoes hydrolysis

- A. HCl and NaOH
- B. HNO₃ and NH₃
- C. HBr and NaCH₃COO
- D. CH₃COOH and NaOH

Aug 23-3:03 PM

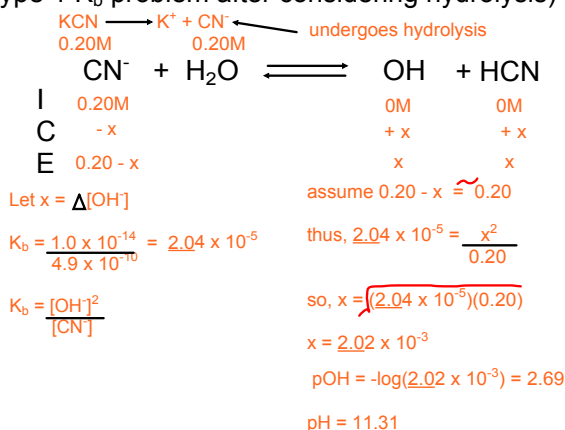
4) In a titration, which of the following combinations would result in an equivalence point with pH greater than 7.0? *HINT: find the resulting salt from each reaction and see if and how it undergoes hydrolysis

- A. HCl and NaOH
- B. HNO₃ and NH₃
- C. HBr and NaCH₃COO
- D. CH₃COOH and NaOH**

Aug 23-3:03 PM

5) Calculate the pH of a 0.20M KCN solution (type 1 K_b problem after considering hydrolysis)

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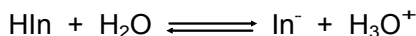


Aug 23-3:05 PM

Aug 23-3:05 PM

V) Indicators

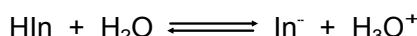
Indicators are used to signal the equivalence point (when _____) of an acid-base titration using a colour change. An indicator is a solution of a weak organic acid (an acid that contains _____), **HIn**, and its conjugate base, **In⁻**, at equilibrium. The acid form of the indicator, HIn, is a different colour than the conjugate base form, In⁻. The following is the general equilibrium for any acid-base indicator:



Aug 23-4:50 PM

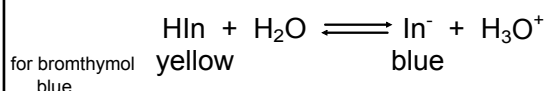
V) Indicators

Indicators are used to signal the equivalence point (when _____ moles of H₃O⁺ = moles of OH⁻) of an acid-base titration using a colour change. An indicator is a solution of a weak organic acid (an acid that contains _____ carbon), **HIn**, and its conjugate base, **In⁻**, at equilibrium. The acid form of the indicator, HIn, is a different colour than the conjugate base form, In⁻. The following is the general equilibrium for any acid-base indicator:



Aug 23-4:50 PM

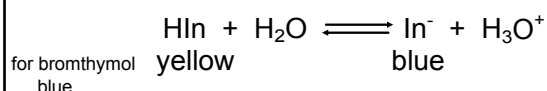
Let's look at how an indicator equilibrium works in solution using the indicator bromthymol blue:



If $[\text{HIn}] > [\text{In}^-]$, the system favours the _____ side and the solution will be a _____ colour.
 If $[\text{In}^-] > [\text{HIn}]$, the system favours the _____ side and the solution will be a _____ colour.

Aug 23-4:54 PM

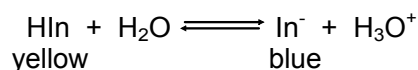
Let's look at how an indicator equilibrium works in solution using the indicator bromthymol blue:



If $[\text{HIn}] > [\text{In}^-]$, the system favours the _____ ^{left} side and the solution will be a _____ ^{yellow} colour.
 If $[\text{In}^-] > [\text{HIn}]$, the system favours the _____ ^{right} side and the solution will be a _____ ^{blue} colour.

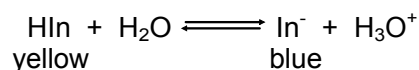
Aug 23-4:54 PM

What happens to the equilibrium if bromthymol blue is put into an acidic solution, and what is the resulting solution colour?



Aug 23-4:58 PM

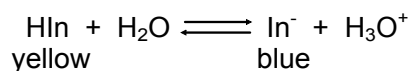
What happens to the equilibrium if bromthymol blue is put into an acidic solution, and what is the resulting solution colour?



in acid, $[\text{H}_3\text{O}^+]$ is high, therefore a shift left occurs, causing $[\text{HIn}]$ to be higher than $[\text{In}^-]$, therefore the solution is yellow

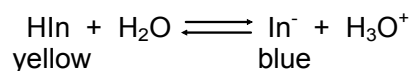
Aug 23-4:58 PM

What will happen if bromthymol blue is put into basic solution, and what is the resulting solution colour?



Aug 23-5:01 PM

What will happen if bromthymol blue is put into basic solution, and what is the resulting solution colour?



in basic solution, $[\text{OH}^-]$ is high, so $[\text{H}_3\text{O}^+]$ is low, causing a shift right, so $[\text{In}^-]$ is high and $[\text{HIn}]$ is low, therefore the solution is blue in colour

Aug 23-5:01 PM

During a titration, pH is constantly changing as base is being added to acid (or *visa versa*). If an indicator such as bromthymol blue is present, it will eventually undergo a colour change due to the continual change in $[H_3O^+]$ and resulting shift of the indicator equilibrium.

If there is acid in a flask with some bromthymol blue, what colour will it be?

If base is continually added from the buret, what shift results in the equilibrium?

How does this affect $[HIn]$ and $[In^-]$?

Aug 23-5:03 PM

During a titration, pH is constantly changing as base is being added to acid (or *visa versa*). If an indicator such as bromthymol blue is present, it will eventually undergo a colour change due to the continual change in $[H_3O^+]$ and resulting shift of the indicator equilibrium.

If there is acid in a flask with some bromthymol blue, what colour will it be? **yellow**

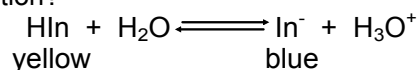
If base is continually added from the buret, what shift results in the equilibrium? **right**

How does this affect $[HIn]$ and $[In^-]$?

$[In^-]$ increases and $[HIn]$ decreases

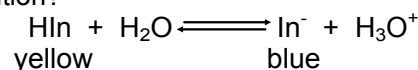
Aug 23-5:03 PM

What result will this have on the colour of the solution?



Aug 23-5:07 PM

What result will this have on the colour of the solution?



At first, $[HIn] > [In^-]$, thus the solution is yellow. As $[In^-]$ increases and $[HIn]$ decreases due to addition of base, eventually $[HIn] = [In^-]$, and the solution is green (the transition point - a mixture of yellow and blue). Then, as more base is added, $[In^-] > [HIn]$, so the solution turns blue.

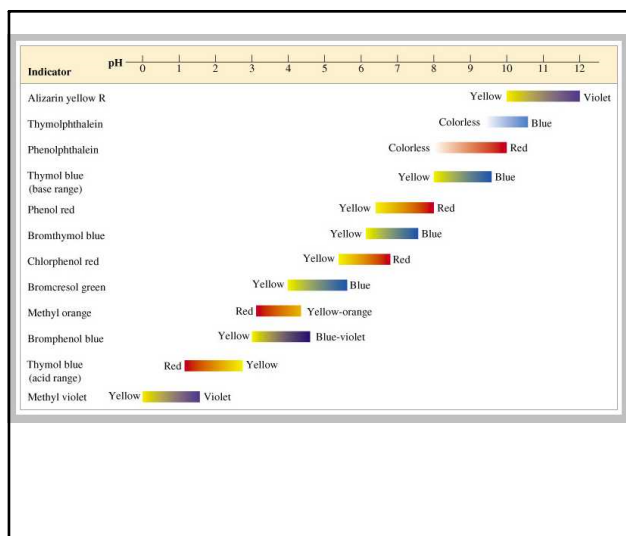
Aug 23-5:07 PM

The point at which the colour is an equal mixture of the $[HIn]$ colour and the $[In^-]$ colour is called the **transition point** for the indicator. Another name is the **endpoint**, as this is when a titration would come to an end as the endpoint signals that the equivalence point has been reached.

Aug 23-5:10 PM

The endpoint occurs at different pHs for different indicators, as each indicator has its own unique equilibrium. The acid-base indicator table in the data booklet shows different indicators and the pH range of their colour changes. Most indicators change colour over a range of about 2 pH units. For example, bromthymol blue is yellow at pH 6.0 and below and blue at pH 7.6 and above. From 6.0 to 6.8, it's yellow-green, at 6.8 it's perfect green, and from 6.8-7.6 it's blue-green.

Aug 23-5:13 PM



Aug 26-10:40 AM

It is very important to be able to distinguish between the two terms **equivalence point** and **endpoint**. The equivalence point is the point in the titration where moles of H_3O^+ = moles of OH^- . The endpoint is the point in the titration where the colour of the indicator changes. If the indicator is chosen correctly, it will change the colour of the solution at or very near the equivalence point.

Aug 23-5:14 PM

Practice Questions:

1) Which of the following indicators is red at pH 13?

- A. Orange IV
- B. Alizarin Yellow
- C. Indigo Carmine
- D. Thymol Blue

Aug 23-5:15 PM

Practice Questions:

1) Which of the following indicators is red at pH 13?

- A. Orange IV
- B. Alizarin Yellow
- C. Indigo Carmine
- D. Thymol Blue

use your indicator table in your data booklet

Aug 23-5:15 PM

2) What colour is a $1 \times 10^{-3}\text{M}$ NaOH solution containing the indicator Neutral Red?

2) What colour is a $1 \times 10^{-3}\text{M}$ NaOH solution containing the indicator Neutral Red?

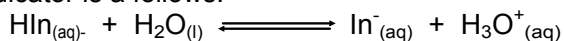
$[\text{OH}^-] = 1 \times 10^{-3}$, so $\text{pOH} = 3.0$, so $\text{pH} = 11.0$

Therefore, the colour is AMBER.

Aug 23-5:17 PM

Aug 23-5:17 PM

Recall that the general equilibrium equation for an indicator is as follows:



Write the K_a equation for the above:

$$K_a =$$

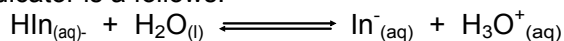
At the endpoint, what is true about $[\text{HIn}]$ and $[\text{In}^{-}]$?

Therefore, what will the K_a reduce to?

$$K_a =$$

Aug 23-5:18 PM

Recall that the general equilibrium equation for an indicator is as follows:



Write the K_a equation for the above:

$$K_a = \frac{[\text{In}^{-}][\text{H}_3\text{O}^{+}]}{[\text{HIn}]}$$

At the endpoint, what is true about $[\text{HIn}]$ and $[\text{In}^{-}]$?

at the endpt, $[\text{HIn}] = [\text{In}^{-}]$

Therefore, what will the K_a reduce to?

$$K_a = \frac{[\text{In}^{-}][\text{H}_3\text{O}^{+}]}{[\text{HIn}]} \text{ so } K_a = [\text{H}_3\text{O}^{+}] \text{ at the endpt.}$$

Aug 23-5:18 PM

So, **at the endpoint** (point of colour change), the $[\text{H}_3\text{O}^{+}]$ equals the value of the K_a for the indicator.

It is easy to find the K_a of each indicator (remember, indicators are weak organic acids) using the indicator data table and some simple calculations.

- i) Find the pH of the endpoint of the indicator using the table
- ii) Use the endpoint pH to find the $[\text{H}_3\text{O}^{+}]$ at this point ($2\text{ndlog}(-\text{pH})$)
- iii) At the endpoint, the $[\text{H}_3\text{O}^{+}]$ is equal to the K_a

Aug 24-1:35 PM

Example: Find the K_a of Orange IV

Aug 24-1:38 PM

Example: Find the K_a of Orange IV

Orange IV: 1.4 - 2.8
so endpt pH is 2.1

$$[\text{H}_3\text{O}^{+}] = 2\text{ndlog}(-2.1) \\ = 7.943 \times 10^{-3}\text{M}$$

$$K_a = 8 \times 10^{-3} \text{ for Orange IV}$$

Aug 24-1:38 PM

Assignment 6

1) Which of the following chemical indicators has a $K_a = 2.5 \times 10^{-5}$?

- A. methyl orange
- B. phenolphthalein
- C. thymolphthalein
- D. bromcresol green

2) Find the K_a of Alizarin Yellow.

Aug 24-1:40 PM

Assignment 6

1) Which of the following chemical indicators has a $K_a = 2.5 \times 10^{-5}$?

- A. methyl orange
- B. phenolphthalein
- C. thymolphthalein
- D. bromocresol green

2) Find the K_a of Alizarin Yellow.

Alizarin Yellow: 10.1 - 12.0
endpt pH = 11.05

$$[H_3O^+] = K_a = 2 \log(-11.05) = 9 \times 10^{-12}$$

Aug 24-1:40 PM

3) A weak acid is titrated with a strong base using the indicator phenolphthalein to detect the endpoint. What is the approximate pH at the transition point?

- A. 7.0
- B. 8.0
- C. 9.0
- D. 10.0

Aug 24-1:44 PM

3) A weak acid is titrated with a strong base using the indicator phenolphthalein to detect the endpoint. What is the approximate pH at the transition point?

- A. 7.0
- B. 8.0
- C. 9.0
- D. 10.0

Aug 24-1:44 PM

4) Read Hebden p.161 (bottom) & 162 on Universal Indicators. Do Hebden p.162 #108-112 and p.163 #116-119

5) The indicator thymol blue has two colour changes (see the acid-base indicator table). How is this possible?

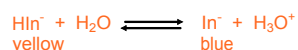
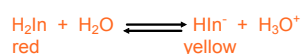
Aug 24-1:45 PM

4) Read Hebden p.161 (bottom) & 162 on Universal Indicators. Do Hebden p.162 #108-112 and p.163 #116-119

answers in the back of Hebden

5) The indicator thymol blue has two colour changes (see the acid-base indicator table). How is this possible?

It is a diprotic weak acid:



Aug 24-1:45 PM

VI) Buffers

What is a buffer?

What composes a buffer?

Aug 24-1:48 PM

VI) Buffers

What is a buffer?

A weak acid / weak conjugate base equilibrium solution that keeps pH steady even when acid or base is added.

What composes a buffer?

Large, equal concentrations of a weak acid and its conjugate base.

Aug 24-1:48 PM

How would you make an $\text{HSO}_3^- / \text{SO}_3^{2-}$ 2.0M buffer solution?

<http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons5.htm>

Would you have a buffer if you simply add 2.0M NaHSO_3 to water? Why or why not?

Aug 24-1:50 PM

How would you make an $\text{HSO}_3^- / \text{SO}_3^{2-}$ 2.0M buffer solution?

- 1) Add 2.0M NaHSO_3 to water to create an equilibrium.
 $\text{NaHSO}_3 \quad \text{Na}^+ + \text{HSO}_3^-$ then $\text{HSO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{SO}_3^{2-} + \text{H}_3\text{O}^+$
2.0M v. small v. small
- 2) Add Na_2SO_3 to increase $[\text{SO}_3^{2-}]$ to 2.0M
 $\text{HSO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{SO}_3^{2-} + \text{H}_3\text{O}^+$
2.0M 2.0M v. small

<http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons5.htm>

Would you have a buffer if you simply add 2.0M NaHSO_3 to water? Why or why not?

No, because the conjugate base SO_3^{2-} would have a very small molarity, not even close to 2.0M (like step 1 above).

Aug 24-1:50 PM

Let's suppose you've made a $\text{HSO}_3^- / \text{SO}_3^{2-}$ 2.0M buffer:
 $\text{HSO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{SO}_3^{2-} + \text{H}_3\text{O}^+$
2.0M 2.0M v. small

How does a buffer work?

What determines pH in any solution?

Therefore, if $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ can somehow be kept constant in the buffer solution, the pH will not drastically change.

Aug 24-1:55 PM

Let's suppose you've made a $\text{HSO}_3^- / \text{SO}_3^{2-}$ 2.0M buffer:
 $\text{HSO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{SO}_3^{2-} + \text{H}_3\text{O}^+$
2.0M 2.0M v. small

How does a buffer work?

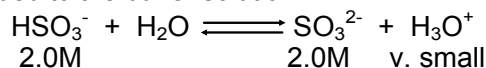
What determines pH in any solution?

$[\text{H}_3\text{O}^+]$ and/or $[\text{OH}^-]$

Therefore, if $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ can somehow be kept constant in the buffer solution, the pH will not drastically change.

Aug 24-1:55 PM

What would happen if a small amount of HCl was added to the buffer solution?



<http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons8.htm>

Aug 24-1:57 PM

Example: Find the buffering pH of an acetic acid / acetate buffer.

$$K_a = 1.8 \times 10^{-5}$$

thus, $[H_3O^+] = 1.8 \times 10^{-5}$

$$\text{buffering pH} = -\log(1.8 \times 10^{-5}) = 4.74 \quad \text{ACIDIC buffer}$$

Example: Find the buffering pH of an HCN / CN buffer.

$$K_a = 4.9 \times 10^{-10}$$

thus, $[H_3O^+] = 4.9 \times 10^{-10}$

$$\text{buffering pH} = -\log(4.9 \times 10^{-10}) = 9.31 \quad \text{BASIC buffer}$$

Aug 25-3:23 PM

Assignment 7

Read Hebden pages 177-181 (stop after first paragraph on p.181)

1) What composes a buffer and how would you make one?

2) Do Hebden p.181-182 #131-140

Aug 25-3:26 PM

Assignment 7

Read Hebden pages 177-181 (stop after first paragraph on p.181)

1) What composes a buffer and how would you make one?

-large, equal concentrations of a weak acid and its conjugate base

-Add a large concentration of a weak acid to water. Then add an equal concentration of the conjugate base.

2) Do Hebden p.181-182 #131-140

answers in the back of Hebden

Aug 25-3:26 PM

3) Read Hebden p.182-183: *Buffers in Biological Systems*

What is the buffering pH in your blood?

What two buffering systems contribute to this?

Aug 25-3:29 PM

3) Read Hebden p.182-183: *Buffers in Biological Systems*

What is the buffering pH in your blood?

What two buffer systems contribute to this?

buffering pH = 7.35

two systems: see Hebden p. 182-183

Aug 25-3:29 PM

VII) Acid/Base Titration Curves

Titration is commonly carried out to find the concentration of an acidic or basic solution.

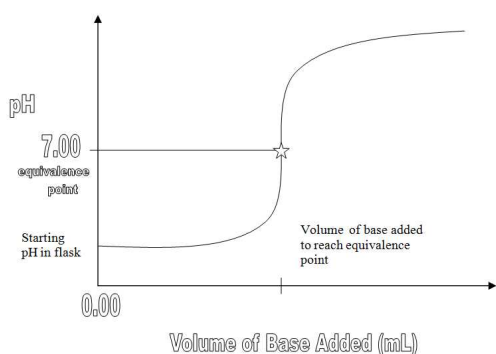
<http://www.chem-ilp.net/labTechniques/TitrationAnimation.htm>

A standard titration curve has an x axis that is the *Volume of Base (or Acid) Added* from the buret, and the y axis is the *pH* in the flask.

Aug 25-3:32 PM

Strong Acid/Strong Base Titration Curve

(strong acid in the flask, strong base in the buret)



Aug 25-3:34 PM

Notice the general shape of the titration curve. The pH rises very slowly at the start of the titration, drastically in the middle region, and then very slowly again at the end. Why is this so? At the start, in order to make the pH change 1 unit (from say 2 to 3), you have to add a large amount of OH⁻ from the buret. pH 2 is an [H₃O⁺] = _____ and pH 3 is an [H₃O⁺] = _____. Thus, you must add _____ - _____ = _____ OH⁻, quite a large amount. In the middle region, to change the pH from 6 to 7, you must add _____ - _____ = _____ OH⁻, one ten-thousandth of the OH⁻ needed to change the pH from 2 to 3!

Aug 25-3:36 PM

Notice the general shape of the titration curve. The pH rises very slowly at the start of the titration, drastically in the middle region, and then very slowly again at the end. Why is this so? At the start, in order to make the pH change 1 unit (from say 2 to 3), you have to add a large amount of OH⁻ from the buret. pH 2 is an [H₃O⁺] = 0.01M and pH 3 is an [H₃O⁺] = 0.001M. Thus, you must add 0.01M - 0.001M = 0.009M OH⁻, quite a large amount. In the middle region, to change the pH from 6 to 7, you must add 0.000001M - 0.0000001M = 0.0000009M OH⁻, one ten-thousandth of the OH⁻ needed to change the pH from 2 to 3!

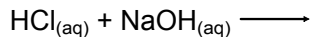
Aug 25-3:36 PM

This is why, from about pH 4 to pH 10, you add very little OH⁻ and the pH changes so quickly. After pH 10, the same effect takes place as early on. An analogy using \$: If you need to pay a \$10 000 loan down to \$1 000, it costs \$9 000. This may take a while to pay off! But suppose you had to pay a \$1 000 loan down to \$100, a \$100 loan down to \$10, a \$10 loan down to \$1, a \$1 loan down to \$0.10, and a \$0.10 loan down to \$0.01 (simulating the middle of the pH curve). This, in total, costs \$999.99, a fraction of the first loan!

http://www.mhhe.com/physsci/chemistry/animations/chan_7e_esp/crm3s5_5.swf

Aug 25-3:45 PM

Here is an example of a strong acid/strong base titration reaction:



What products result?

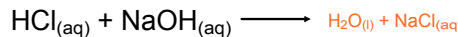
Water is, of course, neutral. Is the resulting salt neutral? Why or why not?

<http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/animations/HClandNaOHgV8.html>

Therefore, what is the pH at the **equivalence point** of a strong acid/strong base titration?

Aug 25-3:50 PM

Here is an example of a strong acid/strong base titration reaction:



What products result?

Water is, of course, neutral. Is the resulting salt neutral? Why or why not?

Yes, because neither Na⁺ or Cl⁻ hydrolyze.

<http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/animations/HClandNaOHgV8.html>

Therefore, what is the pH at the **equivalence point** of a strong acid/strong base titration?

7, as both products are neutral

Aug 25-3:50 PM

Strong acid/strong base titrations result in a salt that does not hydrolyze, therefore the **equivalence point** is always 7.

An ideal indicator for a titration is one in which the colour change encompasses the equivalence point. List the ideal indicators for a strong acid/strong base titration.

Aug 25-3:55 PM

Strong acid/strong base titrations result in a salt that does not hydrolyze, therefore the **equivalence point** is always 7.

An ideal indicator for a titration is one in which the colour change encompasses the equivalence point. List the ideal indicators for a strong acid/strong base titration.

bromthymol blue
phenol red
neutral red

Aug 25-3:55 PM

However, in our lab, we used phenolphthalein to indicate the equivalence point of a strong acid/strong base titration, even though the endpoint of phenolphthalein is 9.1. Why is this okay?

<http://www.chem-ilp.net/labTechniques/AcidBaseIndicatorSimulation.htm>

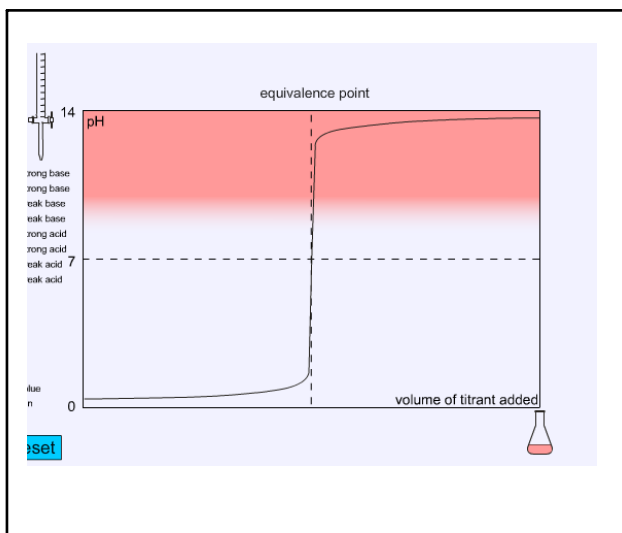
Aug 25-3:57 PM

However, in our lab, we used phenolphthalein to indicate the equivalence point of a strong acid/strong base titration, even though the endpoint of phenolphthalein is 9.1. Why is this okay?

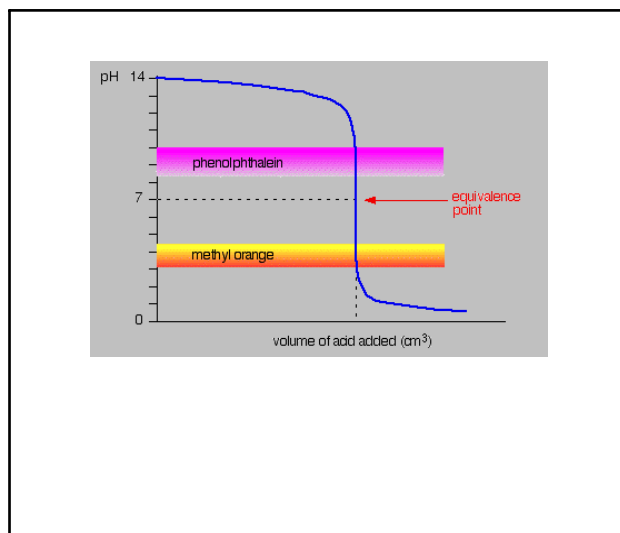
Remember the sharp vertical rise in the middle region. It only takes one or two drops to the pH to go from about 4 to 10. Thus, the pH will pass through 7 and 9 either in the same drop or within one drop of base, a small error only.

<http://www.chem-ilp.net/labTechniques/AcidBaseIndicatorSimulation.htm>

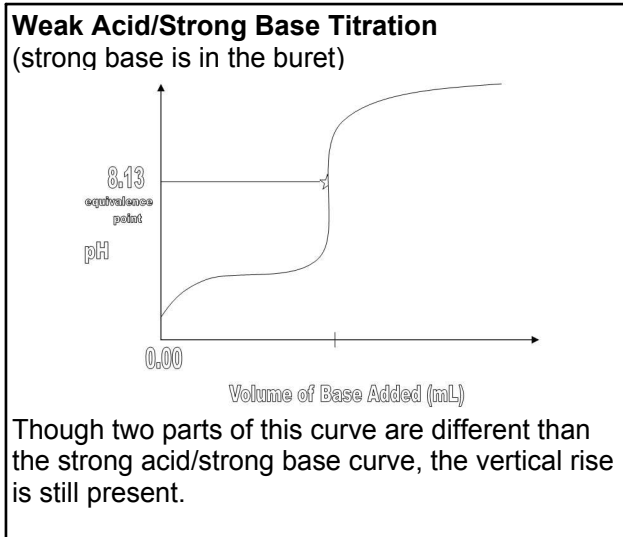
Aug 25-3:57 PM



May 15-9:00 AM



Aug 26-10:38 AM



Aug 25-4:06 PM

What is different compared to the strong acid/strong base titration?

- 1)
- 2)

Aug 25-4:07 PM

What is different compared to the strong acid/strong base titration?

- 1) Notice the small pH jump at the beginning of the curve. This is characteristic of any weak/strong titration.
- 2) The equivalence point for a weak acid/strong base titration is between pH 8 & 9.

Aug 25-4:07 PM

Why, for a weak acid/strong base titration, is the equivalence point between pH 8 & 9?

<http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons9.htm>

Aug 25-4:10 PM

Why, for a weak acid/strong base titration, is the equivalence point between pH 8 & 9?

The salt produced hydrolyzes basically, producing extra OH^- , thereby increasing the pH.

Example:

$$\text{HF}_{(aq)} + \text{NaOH}_{(aq)} \longrightarrow \text{H}_2\text{O}_{(l)} + \text{NaF}_{(aq)}$$

$$\text{NaF}_{(aq)} \longrightarrow \text{Na}^+_{(aq)} + \text{F}^-_{(aq)}$$

Na^+ doesn't hydrolyze but F^- does:

$$\text{F}^- + \text{H}_2\text{O} \rightleftharpoons \text{HF} + \text{OH}^-$$

The extra OH^- make the equiv pt. pH higher (b/w 8 & 9)

<http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons9.htm>

Aug 25-4:10 PM

Which indicators would be **ideal** for a weak acid/strong base titration?

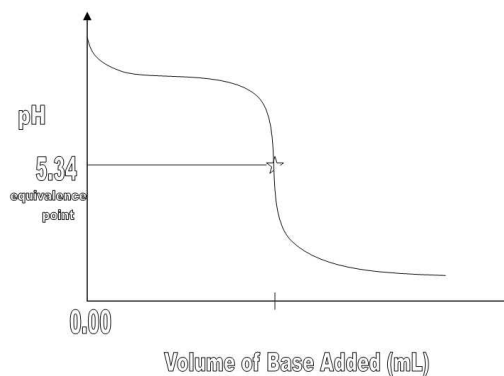
Aug 25-4:13 PM

Which indicators would be **ideal** for a weak acid/strong base titration?

thymol blue
phenolphthalein

Aug 25-4:13 PM

Weak Base/Strong Acid Titration
(strong acid in the buret)



Aug 25-4:14 PM

Why does this curve start at a high pH and end at a low pH?

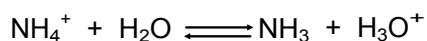
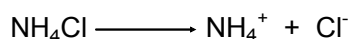
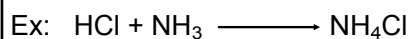
Why does this curve start at a high pH and end at a low pH?

The curve monitors the pH in the flask. If we are starting with weak base in the flask, the pH will be high. When we add acid to the flask from the buret, the pH will decrease.

Aug 25-4:15 PM

Aug 25-4:15 PM

Characteristics include an initial dip in pH and an equivalence point pH of 5-6. This is because the salt produced will hydrolyze acidically:



The extra H_3O^+ produced due to the hydrolysis of the salt lowers the equivalence point pH to 5-6.

List the ideal indicators for a weak base/strong acid titration:

<http://www.chem-ilp.net/labTechniques/AcidBaseIndicatorSimulation.htm>

Aug 25-4:17 PM

Aug 25-4:19 PM

List the ideal indicators for a weak base/strong acid titration:

methyl red
chlorophenol red

<http://www.chem-illp.net/labTechniques/AcidBaseIndicatorSimulation.htm>

Aug 25-4:19 PM

Assignment 8

1) Do Hebden p.176 #125

Aug 26-8:21 AM

Assignment 8

1) Do Hebden p.176 #125

answers in the back of Hebden

Aug 26-8:21 AM

2) A student titrated a 25.00mL sample of 0.20M HX acid with 0.20M NaOH. The following data was collected:

Volume of NaOH added (mL)	pH
0.00	2.72
10.00	4.57
24.90	7.14
24.99	8.14
25.00	8.88
25.01	9.60
26.00	11.59
35.00	12.52

a) What volume of NaOH must be added to reach the endpoint?

b) Is HX weak or strong? How do you know?

c) Select an indicator that would be ideal for this titration and give the colour at the equiv. pt.

Aug 26-8:23 AM

2) A student titrated a 25.00mL sample of 0.20M HX acid with 0.20M NaOH. The following data was collected:

Volume of NaOH added (mL)	pH
0.00	2.72
10.00	4.57
24.90	7.14
24.99	8.14
25.00	8.88
25.01	9.60
26.00	11.59
35.00	12.52

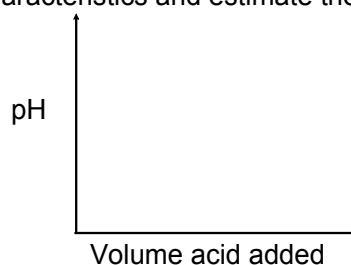
a) What volume of NaOH must be added to reach the endpoint? 25.00mL

b) Is HX weak or strong? How do you know?
weak, as the pH at the equiv pt is 8.88

c) Select an indicator that would be ideal for this titration and give the colour at the equiv. pt.
thymol blue; green colour

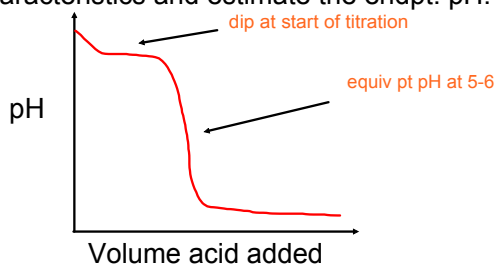
Aug 26-8:23 AM

3) Draw a typical curve for a weak base / strong acid titration (strong acid in the buret). Show all characteristics and estimate the endpt. pH:



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IX) Acidic & Basic Anhydrides

How are acids and bases produced in nature?
Both are produced from **oxides**.
What are oxides?

Acids are produced from **non-metal oxides** and bases are produced from **metal oxides**.

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IX) Acidic & Basic Anhydrides

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What are oxides?

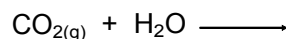
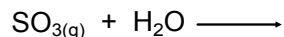
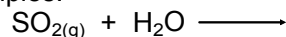
compounds made from oxygen and one other element

Acids are produced from **non-metal oxides** and bases are produced from **metal oxides**.

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When **non-metal oxides** react with water in a synthesis reaction, an acid is formed. Thus, **non-metal oxides** are called **acidic anhydrides** (_____). These reactions often occur in the atmosphere as most non-metal oxides are gases.

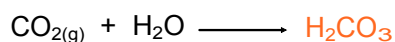
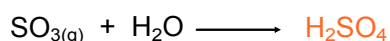
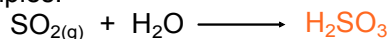
Examples:



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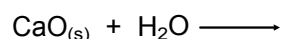
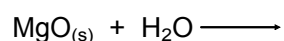
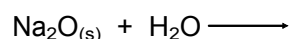
When **non-metal oxides** react with water in a synthesis reaction, an acid is formed. Thus, **non-metal oxides** are called **acidic anhydrides** (acids without water). These reactions often occur in the atmosphere as most non-metal oxides are gases.

Examples:



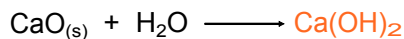
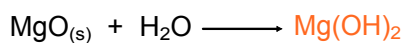
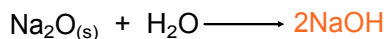
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When Group 1 and 2 **metal oxides** react with water in a synthesis reaction, a base is formed. **Metal oxides** are called **basic anhydrides**.



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When Group 1 and 2 **metal oxides** react with water in a synthesis reaction, a base is formed. **Metal oxides** are called **basic anhydrides**.



Aug 26-8:37 AM

X) Acid Rain

Fuels that contain sulphur are combusted in an industrial setting to form sulphur dioxide gas (_____). Some of that sulphur dioxide then reacts with oxygen in the air to produce sulphur trioxide gas (_____).

What do we call these compounds?

What will they do when they go up into the atmosphere?

Thus, what results?

Aug 26-8:42 AM

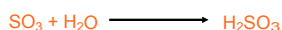
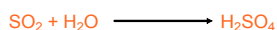
X) Acid Rain

Fuels that contain sulphur are combusted in an industrial setting to form sulphur dioxide gas (SO₂). Some of that sulphur dioxide then reacts with oxygen in the air to produce sulphur trioxide gas (SO₃).

What do we call these compounds?

acidic anhydrides

What will they do when they go up into the atmosphere? *react with water vapour to make acids*



Thus, what results? **Acid Rain**

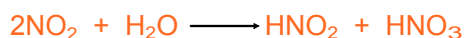
Aug 26-8:42 AM

When fuel combusts in a car engine, it is so hot that N₂ from the air reacts with O₂ to form nitrogen monoxide gas (_____). Though the catalytic converter reverses this reaction, some nitrogen monoxide escapes through the exhaust and reacts with O₂ in the air to make nitrogen dioxide (_____). What happens next?

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When fuel combusts in a car engine, it is so hot that N₂ from the air reacts with O₂ to form nitrogen monoxide gas (NO). Though the catalytic converter reverses this reaction, some nitrogen monoxide escapes through the exhaust and reacts with O₂ in the air to make nitrogen dioxide (NO₂). What happens next?

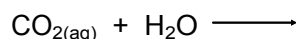
The gaseous acidic anhydride NO₂ reacts with H₂O in the atmosphere to make acid rain:



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Acid rain is defined as rainwater that has a pH less than **5.6**.

It is important to note that even 'normal' rainwater is acidic (between pH 5.6 & 7) due to atmospheric CO₂ (an acidic anhydride) dissolving in water to produce carbonic acid:



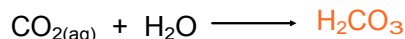
http://www.wvnorton.com/college/chemistry/gilbert2/tutorials/interface.asp?chapter=chapter_16&folder=acid_rain

<http://www.absorblearning.com/media/attachment.action?quick=vd&att=2248>

Aug 26-9:56 AM

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It is important to note that even 'normal' rainwater is acidic (between pH 5.6 & 7) due to atmospheric CO₂ (an acidic anhydride) dissolving in water to produce carbonic acid:



http://www.wnorton.com/college/chemistry/gilbert2/tutorials/interface.asp?chapter=chapter_16&folder=acid_rain

<http://www.absorblearning.com/media/attachment.action?quick=vd&att=2248>

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Assignment 9

1) There are many environmental problems associated with acid rain. Read Hebden pages 187 & 188.

2) Do Hebden p.185 #144, 145 & p.188 #147

Aug 26-9:59 AM

Assignment 9

1) There are many environmental problems associated with acid rain. Read Hebden pages 187 & 188.

2) Do Hebden p.185 #144, 145 & p.188 #147

answers in the back of Hebden

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XI) Acid/Base Testing

Suppose you had a 1.0M solution of strong acid and weak acid but did not know which was which. Describe any testing you could do to identify each solution.

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Aug 26-10:02 AM

XI) Acid/Base Testing

Suppose you had a 1.0M solution of strong acid and weak acid but did not know which was which. Describe any testing you could do to identify each solution.

- 1) Use an indicator that changes colour at low pH such as thymol blue
- 2) Use pH paper or universal indicator
- 3) Use a pH meter
- 4) Do a conductivity test - the stronger acid will light the bulb up brighter

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Aug 26-10:02 AM