

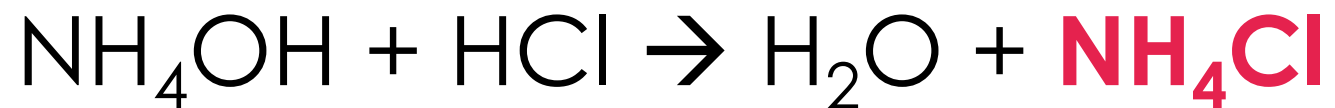
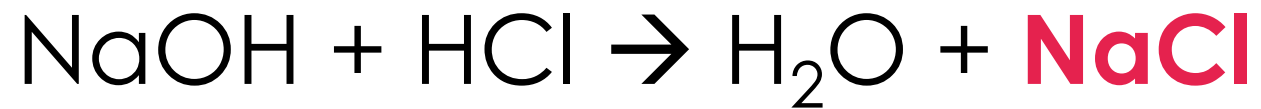
N49 - SALTS

TARGET:

I can identify if a salt is acidic, basic or neutral. I can use information about the composition of the salt to calculate the pH of an aqueous solution made with the salt

WHAT IS A SALT?

An ionic compound formed when an acid and a base react with each other



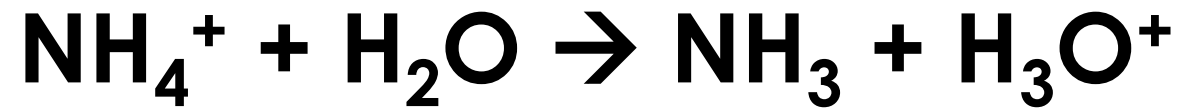
HOW DO SALTS BEHAVE WHEN YOU PUT THEM IN WATER?

They dissociate – the ions separate



HOW DO THE IONS BEHAVE ONCE THEY HAVE DISSOCIATED?

The ions can sometimes “hydrolyze”
Meaning they can react with the water.



The ion has to be “strong” enough for this to happen *(we will explain which ions are strong in a minute!)*

WHAT IS THE RESULT OF THIS (POTENTIAL) HYDROLYSIS?

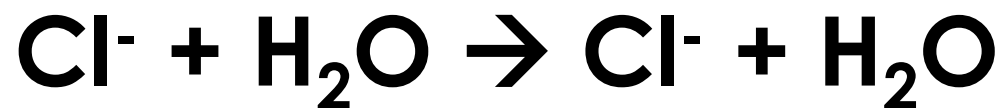
Once the ion hydrolyzes with the water it can make the salt solution acidic, basic, or neutral



solution is ACIDIC



solution is BASIC



Cl⁻ is not strong enough to hydrolyze so solution is NEUTRAL

HOW DO YOU KNOW IF IT IS “STRONG” ENOUGH TO HYDROLYZE?

Have to think about the properties of the acids/bases that the ion can form

	Turns into a...	Hydrolyzes?
Strong Acid	Weak conjugate base	No
Weak Acid	Strong conjugate base	Yes
Strong Base	Weak conjugate acid	No
Weak Base	Strong conjugate acid	Yes

WHY DOES STRONG TURN INTO WEAK AND VICE VERSA?

Think about where equilibrium lies for the original acid/base...



- Strong acid, most dissociates so eq. lies to the right.
- It “wants” to be broken into its ions.
- So if it wants to be broken into H^+ and Cl^- ...
 - Is the Cl^- going to be able to go around taking H^+ off water to form HCl ???

No!

STEPS TO PREDICT pH OF A SALT SOLUTION

1. Identify ions that the salt came from

STEPS TO PREDICT pH OF A SALT SOLUTION

2. Determine if the ions will hydrolyze

- Figure out if they came from a strong or weak acid/base
 - From strong → ion won't hydrolyze – neutral contribution
 - From weak → ion will hydrolyze – acidic or basic contribution

STEPS TO PREDICT pH OF A SALT SOLUTION

3. If it hydrolyzes identify if the hydrolysis of the ion would form acid or base.

	Turns into a...	Hydrolyzes?	Ion makes sol'n
Strong Acid	Weak conjugate base	No	Neutral
Weak Acid	Strong conjugate base	Yes	Basic
Strong Base	Weak conjugate acid	No	Neutral
Weak Base	Strong conjugate acid	Yes	Acidic

STEPS TO PREDICT pH OF A SALT SOLUTION

4. Figure out what the combo of each ion's contribution would be to the solution

	Makes the solution...
Acidic + Neutral	Acidic
Basic + Neutral	Basic
Neutral + Neutral	Neutral
Acidic + Basic	Compare K_a and K_b to determine which "wins"

STEPS TO PREDICT pH OF A SALT SOLUTION

5. To determine the “winner” when acidic + basic
- Compare the K_a and K_b values
 - The higher one means it is stronger, more dissociation so it will contribute more to the resulting solution

$K_{a(\text{ion})} > K_{b(\text{ion})}$	Acidic
$K_{a(\text{ion})} < K_{b(\text{ion})}$	Basic
$K_{a(\text{ion})} = K_{b(\text{ion})}$	Neutral

The problem...

You rarely have the K_a and K_b for the CONJUGATE IONS you are interested in. You usually only have them for the STARTING acid/base they came from. Ugh...

FINDING $K_{A(\text{ION})}$ AND $K_{B(\text{ION})}$

$$K_w = K_a \times K_b$$

If you want K_a of an ion \rightarrow need K_b of the base it came from

If you want K_b of an ion \rightarrow need K_a of the acid it came from

Practice Problem: What is the K_a of NH_4^+ ?

Use K_b of NH_3 (1.8×10^{-5})

plug in and solve for $K_{a(\text{ion})}$

$$(1 \times 10^{-14}) = K_{a(\text{ion})} \times (1.8 \times 10^{-5})$$

$$K_{a(\text{ion})} \text{NH}_4^+ = 5.56 \times 10^{-10}$$

PRACTICE PROBLEM #1

Is KBr an acidic, basic, or neutral salt?



$\text{K}^+ \rightarrow \text{KOH}$ Strong Base
→ so K^+ is Weak acid
→ No Hydrolysis
→ **Neutral effect**

$\text{Br}^- \rightarrow \text{HBr}$ Strong Acid
→ so Br^- is Weak base
→ No Hydrolysis
→ **Neutral effect**

	Turns into a...	Hydrolyzes?	Ion makes sol'n
Strong Acid	Weak conjugate base	No	Neutral
Weak Acid	Strong conjugate base	Yes	Basic
Strong Base	Weak conjugate acid	No	Neutral
Weak Base	Strong conjugate acid	Yes	Acidic

PRACTICE PROBLEM #1

Is KBr an acidic, basic, or neutral salt?



$K^+ \rightarrow KOH$ Strong Base \rightarrow so K^+ is Weak acid \rightarrow No Hydrolysis
 \rightarrow **Neutral effect**

$Br^- \rightarrow HBr$ Strong Acid \rightarrow so Br^- is Weak base \rightarrow No Hydrolysis
 \rightarrow **Neutral effect**

	Makes the solution...
Acidic + Neutral	Acidic
Basic + Neutral	Basic
Neutral + Neutral	Neutral
Acidic + Basic	Compare K_a and K_b to determine which "wins"

 So KBr is a **NEUTRAL SALT!**

PRACTICE PROBLEM #2

Is K_2CO_3 an acidic, basic, or neutral salt?



$K^+ \rightarrow KOH$ Strong Base \rightarrow so K^+ is Weak acid \rightarrow No Hydrolysis
 \rightarrow **Neutral effect**

$CO_3^{2-} \rightarrow H_2CO_3$ Weak Acid \rightarrow so CO_3^{2-} is Strong Base \rightarrow Hydrolysis
 \rightarrow **Basic effect**

	Turns into a...	Hydrolyzes?	Ion makes sol'n
Strong Acid	Weak conjugate base	No	Neutral
Weak Acid	Strong conjugate base	Yes	Basic
Strong Base	Weak conjugate acid	No	Neutral
Weak Base	Strong conjugate acid	Yes	Acidic

PRACTICE PROBLEM #2

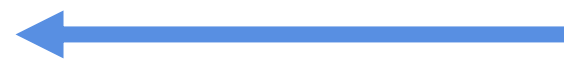
Is K_2CO_3 an acidic, basic, or neutral salt?



$K^+ \rightarrow KOH$ Strong Base \rightarrow so K^+ is Weak acid \rightarrow No Hydrolysis
 \rightarrow **Neutral effect**

$CO_3^{2-} \rightarrow H_2CO_3$ Weak Acid \rightarrow so CO_3^{2-} is Strong Base \rightarrow Hydrolysis
 \rightarrow **Basic effect**

	Makes the solution...
Acidic + Neutral	Acidic
Basic + Neutral	Basic
Neutral + Neutral	Neutral
Acidic + Basic	Compare K_a and K_b to determine which "wins"



So K_2CO_3
is a **BASIC**
SALT!

PRACTICE PROBLEM #3

Is NH_4Br an acidic, basic, or neutral salt?



$\text{NH}_4^+ \rightarrow \text{NH}_3$ Weak Base \rightarrow so NH_4^+ is Strong acid \rightarrow Hydrolysis
 \rightarrow **Acidic effect**

$\text{Br}^- \rightarrow \text{HBr}$ Strong Acid \rightarrow so Br^- is Weak Base \rightarrow No Hydrolysis
 \rightarrow **Neutral effect**

	Turns into a...	Hydrolyzes?	Ion makes sol'n
Strong Acid	Weak conjugate base	No	Neutral
Weak Acid	Strong conjugate base	Yes	Basic
Strong Base	Weak conjugate acid	No	Neutral
Weak Base	Strong conjugate acid	Yes	Acidic

PRACTICE PROBLEM #3

Is NH_4Br an acidic, basic, or neutral salt?



$\text{NH}_4^+ \rightarrow \text{NH}_3$ Weak Base \rightarrow so NH_4^+ is Strong acid \rightarrow Hydrolysis
 \rightarrow **Acidic effect**

$\text{Br}^- \rightarrow \text{HBr}$ Strong Acid \rightarrow so Br^- is Weak Base \rightarrow No Hydrolysis
 \rightarrow **Neutral effect**

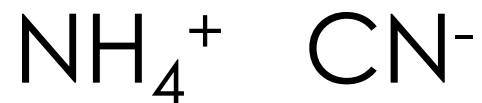
	Makes the solution...
Acidic + Neutral	Acidic
Basic + Neutral	Basic
Neutral + Neutral	Neutral
Acidic + Basic	Compare K_a and K_b to determine which "wins"



**So NH_4Br
is an
ACIDIC
SALT!**

PRACTICE PROBLEM #4

Is NH_4CN an acidic, basic, or neutral salt?



$\text{NH}_4^+ \rightarrow \text{NH}_3$ Weak Base \rightarrow so NH_4^+ is Strong acid \rightarrow Hydrolysis
 \rightarrow **Acidic effect**

$\text{CN}^- \rightarrow \text{HCN}$ Weak Acid \rightarrow so CN^- is Strong Base \rightarrow Hydrolysis
 \rightarrow **Basic effect**

	Turns into a...	Hydrolyzes?	Ion makes sol'n
Strong Acid	Weak conjugate base	No	Neutral
Weak Acid	Strong conjugate base	Yes	Basic
Strong Base	Weak conjugate acid	No	Neutral
Weak Base	Strong conjugate acid	Yes	Acidic

PRACTICE PROBLEM #4

Is NH_4CN an acidic, basic, or neutral salt?

$\text{NH}_4^+ \rightarrow \text{NH}_3$ Weak Base \rightarrow so NH_4^+ is Strong acid \rightarrow Hydrolysis \rightarrow **Acidic effect**

$\text{CN}^- \rightarrow \text{HCN}$ Weak Acid \rightarrow so CN^- is Strong Base \rightarrow Hydrolysis \rightarrow **Basic effect**

$$K_b \text{ NH}_3 = 1.8 \times 10^{-5} \longrightarrow K_a \text{ NH}_4^+ = (1.0 \times 10^{-14}) / (1.8 \times 10^{-5})$$

$$K_a \text{ HCN} = 4.9 \times 10^{-10} \longrightarrow K_b \text{ CN}^- = (1.0 \times 10^{-14}) / (4.9 \times 10^{-10})$$

$$K_a_{(\text{NH}_4^+)} = 5.56 \times 10^{-10}$$

$$K_b_{(\text{CN}^-)} = 2.04 \times 10^{-5}$$

$$K_a_{(\text{NH}_4^+)} < K_b_{(\text{CN}^-)}$$

NH_4CN is a **Basic Salt!**



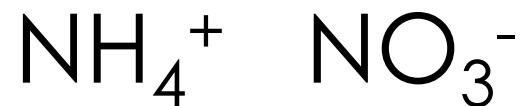
CALCULATING THE ACTUAL pH OF SALTS

WHAT IF YOU WANT THE ACTUAL pH VALUE?

1. Do all the steps needed to determine which ion is the “strong” one – which one is being hydrolyzed?
2. Write the hydrolysis reaction for that ion (or ions)
3. ICE Table time! Yes! More ICE tables! They just wont go away! 😊 Use your hydrolysis rxn for ICE Table
4. Find $[\text{H}_3\text{O}^+]$ or $[\text{OH}^-]$ from ICE Tables
5. Continue on with normal pH type calculations

PRACTICE PROBLEM #5

What is the pH of a 0.25M NH_4NO_3 salt solution?



$\text{NH}_4^+ \rightarrow \text{NH}_3$ Weak Base \rightarrow so NH_4^+ is Strong acid \rightarrow Hydrolysis
 \rightarrow **Acidic effect**

$\text{NO}_3^- \rightarrow \text{HNO}_3$ Strong Acid \rightarrow so NO_3^- is Weak Base \rightarrow No Hydrolysis
 \rightarrow **Neutral effect**

	Makes the solution...
Acidic + Neutral	Acidic
Basic + Neutral	Basic
Neutral + Neutral	Neutral
Acidic + Basic	Compare K_a and K_b to determine which "wins"



**So NH_4NO_3
is an
ACIDIC
SALT!**

PRACTICE PROBLEM #5

What is the pH of a 0.25M NH_4NO_3 salt solution?

NH_4^+ is the ion contributing an acidic effect

Hydrolysis



We don't have K_a NH_4^+

BUT...we do have...

$$K_b (\text{NH}_3) = 1.8 \times 10^{-5}$$

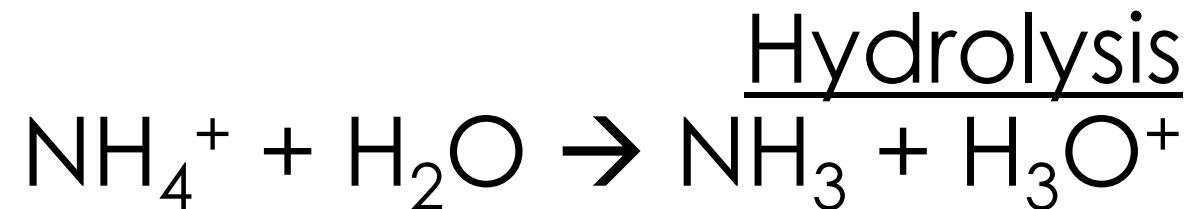
And remember...

$$\mathbf{K_w = K_a \times K_b}$$

We know the K_b for our conjugate (NH_3), so we just solve for the K_a of the ion we are interested in!

PRACTICE PROBLEM #5

What is the pH of a 0.25M NH_4NO_3 salt solution?

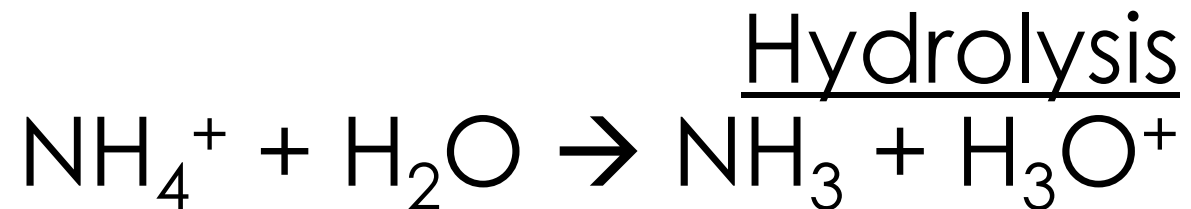


$$K_a (\text{NH}_4^+) = (1.0 \times 10^{-14}) / (1.8 \times 10^{-5}) = 5.56 \times 10^{-10}$$

Time for an ICE Table!

PRACTICE PROBLEM #5

What is the pH of a 0.25M NH_4NO_3 salt solution?



	NH_4^+	+ H_2O	\rightarrow	NH_3	+ H_3O^+
I	0.25	---		0	0
C	- x	---		+ x	+ x
E	$0.25 - x$	---		x	x
5%	0.25	---		x	x
Ans.		---			

PRACTICE PROBLEM #5

What is the pH of a 0.25M NH_4NO_3 salt solution?

	NH_4^+	+ H_2O	\rightarrow NH_3	+ H_3O^+
I	0.25	---	0	0
C	- x	---	+ x	+ x
E	$0.25 - x$	---	x	x
5%	0.25	---	x	x
Ans.	0.25	---	1.18×10^{-5}	1.18×10^{-5}

$$K_a = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]}$$

$$5.56 \times 10^{-10} = \frac{(x)(x)}{(0.25)}$$

$$x = 1.18 \times 10^{-5}$$

Time for pH calculation!

PRACTICE PROBLEM #5

What is the pH of a 0.25M NH_4NO_3 salt solution?

$$[\text{H}_3\text{O}^+] = 1.18 \times 10^{-5}$$

$$\text{pH} = -\log(1.18 \times 10^{-5})$$

$$\text{pH} = 4.93$$

Finally finished!