

Name

Acid Base

BASICS & Notes

A long time ago, in a galaxy far, far away...





Acid Base BASICS

At one time acids and bases were just solutions, with no chemical understanding. In the late 1880's a man in Sweden named Svante Arrhenius developed his theory, the Arrhenius Theory of Acids and Bases. It covers nearly 99% of all acids and bases in chemistry. He won the Nobel Prize in Chemistry in 1903 for this.

That's him →



He stated that an acid was an aqueous solution with excess H^{+1} dissolved, and that a base had excess OH^{-1} dissolved into water. Further, he said that an acid plus a base neutralizes into water and salt.

Acids are molecular compounds that form ions in aqueous solutions. Molecules don't normally form ions, so acids are different than other molecular compounds. In our class, if the first letter in a formula is an "H", it's a head up for an acid. Acids are always aqueous. $HCl_{(G)}$ is not an acid, while $HCl_{(AQ)}$ is an acid. Without the water, there can be no loose ions. $HCl_{(G)}$ can be an acid, if dissolved into water.

Some acids are "strong" and others are "weak". That's different than concentrated and dilute. Think hard now: Strong acids almost completely dissociate. If you put 1 mole of HCl into water, you will end up with a mole of H^{+1} ions in solution, almost 100% dissociation. A weaker acid, like acetic acid has the same number of H^{+1} ions in the formula, but one mole of hydrogen acetate in water yields MUCH less loose H^{+1} ions (about 4% of a mole). All the hydrogen acetate dissolves (it's polar like water) but not all of it ionizes.

Concentrated acids have many moles of H^{+1} cations per liter; dilute acids have fractions of moles per liter. That's not the same as how many H's they have in their formula.

A list of acids you need to be familiar with is on Table K in your reference table. They are listed in strength from top to bottom.

$HCl_{(AQ)}$ hydrochloric acid	dissociates very well	<u>LOTS</u> of $H^{+}_{(AQ)}$	The stronger the acid, the more H^{+} ions in solution. More ions = better conduction of electricity. Strong acids are good electrolytes.
$HNO_{2(AQ)}$ nitrous acid	dissociates very well	<u>LOTS</u> of $H^{+}_{(AQ)}$	
$HNO_{3(AQ)}$ nitric acid	dissociates very well	<u>LOTS</u> of $H^{+}_{(AQ)}$	
$H_2SO_{3(AQ)}$ sulfurous acid	dissociates very well	A lot of $H^{+}_{(AQ)}$	Medium strength acids are medium electrolytes. These don't dissociate as well, they form less loose, mobile ions in solution.
$H_2SO_{4(AQ)}$ sulfuric acid	dissociates well	A lot of $H^{+}_{(AQ)}$	
$H_3PO_{4(AQ)}$ phosphoric acid	dissociates less well	<u>less</u> $H^{+}_{(AQ)}$	
$H_2CO_{3(AQ)}$ or $CO_{2(AQ)}$ carbonic acid	dissociates poorly	<u>few</u> $H^{+}_{(AQ)}$	Weak acids are poor electrolytes.
$HC_2H_3O_{2(AQ)}$ or $CH_3COOH_{(AQ)}$ acetic acid = ethanoic acid	dissociates quite poorly	<u>very few</u> $H^{+}_{(AQ)}$	Weak acids are poor electrolytes.

The “opposite” of acids are called bases. According to Arrhenius Theory, a base is that an aqueous solution that contains excess OH^{-1} (hydroxide ions) in solution is called a base.

Most bases dissociate very well but calcium hydroxide does so less well, and ammonia has no hydroxides in its formula. Ammonia is very weird.

NaOH sodium hydroxide	dissociates very well	LOTS of $\text{OH}^{-1}_{(\text{AQ})}$	The stronger the base, the more OH^{-1} ions in solution. More ions = better conductor. Strong bases are good electrolytes.
KOH potassium hydroxide	dissociates very well	LOTS of $\text{OH}^{-1}_{(\text{AQ})}$	
$\text{Ca}(\text{OH})_2$ calcium hydroxide	dissociates somewhat	Less $\text{OH}^{-1}_{(\text{AQ})}$	Weak bases are poor electrolytes. Ammonia is a weak base & a common household chemical, so you need to learn about it. An <u>Alternate Theory</u> explains it.
NH_3 ammonia	This does not follow the Arrhenius Theory, read more below.	There are no apparent $\text{OH}^{-1}_{(\text{AQ})}$	

Arrhenius Theory explains how acids and bases combine and that they “neutralize” each other.

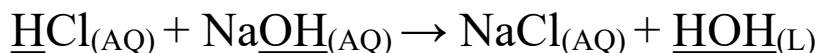
Acids + bases forms a SALT and WATER.

Salts are chemical compounds that are IONIC (metal cation + nonmetal anion).

The ACID BASE NEUTRALIZATION reaction summarized: acid + base yields a salt + water.

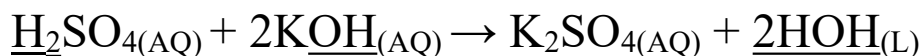
We will also be writing water, H_2O as HOH, to make balancing easier. It still has the same 2 H’s and one O, but “HOH” shows the acid “H” and the base “OH” combining into HOH, which is liquid water, $\text{HOH}_{(\text{L})}$

This reaction is vaguely similar to double replacement reactions, we start with 2 aqueous solutions and they “switch partners”, but these are an acid and base, and the products are always a salt and water, no precipitate. These are not the same reaction. Below, the acid and base neutralize each other, so calling this reaction type acid-base neutralization makes sense.



hydrochloric acid and sodium hydroxide base → a salt (sodium chloride here) and water

Another example could be:



Sulfuric acid and potassium hydroxide base → a salt (potassium sulfate here) and water

Acids have excess $[H^{+1}]$ while bases have excess $[OH^{-1}]$

When a solution has equal numbers of hydrogen and hydroxide ions, they combine PERFECTLY into salty water. The combined solution is no longer acid or base, it is said to be **NEUTRAL**. The acid is neutralized by the base. The base is neutralized by the acid. Each hydrogen ion is balanced out with a hydroxide ion, and each pair of those ions makes a water molecule. There are still many ions in solution (the anions of the acid and the cations of the base), so the resulting solution is still a good electrolyte.

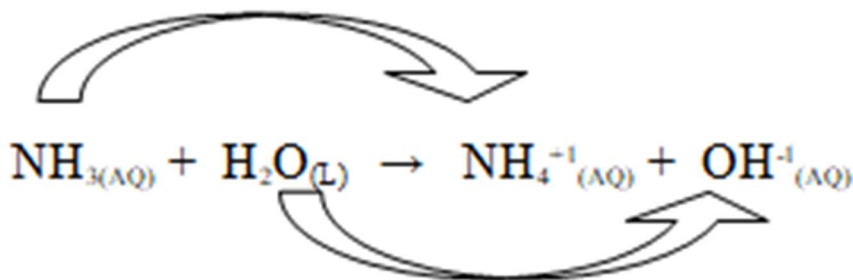
Ammonia is a base, an Exception NH_3 has no apparent OH^{-1} ions.

In chemistry there are many exceptions to many “rules”, including the Arrhenius Theory. Ammonia is a common substance used for cleaning houses (bathrooms mostly) and used in fertilizer production. When ammonia dissolves into water, it forms into a base even though there seem to be NO hydroxide ions present. In fact, there should be NO IONS at all, ammonia and water are both molecular.

How then can it act like a base? An alternate theory (Brønsted-Lowry Theory) describes acids and bases a *totally different way* than Arrhenius did. In our class it will only be about ammonia.

This alternate theory explains how ammonia is a base. The theory says: bases are compounds that can accept H^{+1} ions. In this theory, acids can “donate” these H^{+1} ions to the base.

Examine the equation, if ammonia “accepts” a H^{+1} ion it becomes ammonium. When water “donates” a H^{+1} ion all that’s left is the hydroxide part of it. This explains how hydroxide ions end up in solution and why ammonia dissolved into water acts like a base (the solution is basic).



The result is key: there are hydroxides in solution to provide the chemical properties that make this solution a base. Ammonia is the base (by definition) but in reality, it’s the OH^{-1} that provides the base properties.

The theory is sort of backwards, by claiming ammonia is the base, it avoids having to mention of the $OH^{-1}(AQ)$ ions make it a base. This theory explains ammonia at our level of chemistry, that is all. .

Another weird thing here is that water is an “acid” since it donated the H^{+1} ions. Water is pH 7, the standard of neutral, and will be a bit frustrating for you; I am sorry this is confusing.

There are other acid-base theories too. Some concern pairs of electrons doing tricks, but they are taught in college. Arrhenius theory explains all our acids & bases, except ammonia.

Sometimes the regents ask a backwards acid-base question, such as if a substance donates a H^{+1} ion, or a substance accepts this H^{+1} ion, is it an acid or base. If you memorize the diagram above, you’ll be set.

Measuring concentration of acid and base with the pH scale.

The pH scale (simply) means the proportion of H^{+1} ions in solution. The math is a little hard, but we only need to look at it, not deal too much with it in our class. It's an exponential scale, which might sound scary. The measure of the concentration of hydrogen ions is called the pH. The math for this is

$$pH = -\log [H^{+1}]$$

which reads that pH = to the negative logarithm of the concentration of hydrogen ions in solution.

The pH scale runs from 0 - 14. Low numbers are the strong acids; high numbers are the strong bases. Closer to the middle (7) they get weaker. At pH = 7, solutions are said to be NEUTRAL (not acid or base)

pH 0 means the $[H^{+1}] = 1 \times 10^0$ moles H^{+1} ions in solution. That's one mole, or 6.02×10^{23} H^{+1} /liter.

pH 1 means the $[H^{+1}] = 1 \times 10^{-1}$ moles H^{+1} ions in solution. That's one tenth of a mole or 6.02×10^{22} H^{+1} /liter. (1/10th of a mole is 10X weaker than pH 0)

pH 2 means that $[H^{+1}] = 1 \times 10^{-2}$ moles H^{+1} ions in solution.
That's 1/100th of a mole, 6.02×10^{22} H^{+1} /liter. (that's 1/100th the acidity of pH 0)

Each whole number change of pH is a 10X change in concentration of hydrogen ions.

A change of 2 whole numbers on the pH scale is 10 x 10 change, or 100X.

A change of 3 whole numbers (say from 2.0 to 5.0) is a 1000X change in concentration.

The pH is the negative of the negative exponent that is the pH.

pH 14 means that the $[H^{+1}] = 1 \times 10^{-14}$ moles H^{+1} ions in solution. Just 6.02×10^9 H^{+1} /liter.

At pH 7, the concentration of H^{+1} ions = the concentration of OH^{-1} ions. $[H^{+1}] = [OH^{-1}]$ neither acid nor base

At a pH of 5.0, there are more H^{+} ions than OH^{-} ions in solution.

At a pH of 12.8, there are more OH^{-} ions than H^{+} in solution.

Neutral pH is common. Many solutions have no ions, or if they are ionic, they contain neither H^{+} or OH^{-} ions

Aqueous solutions that are not acids or bases (ex: $NaCl_{(AQ)}$, $LiNO_{3(AQ)}$, or sugar water) are neutral, pH = 7.

Acid/Base/Neutral solutions		approx. pH	substance	approx. pH	example
		1	$HCl_{(AQ)}$	7	Pure water
		1	Lime juice	8	Baking soda
Acidic solutions	$[H^{+1}] > [OH^{-1}]$	2	Lemon juice	9	Hand soap
		2	Coca cola	10	$Mg(OH)_2$
Basic solutions	$[H^{+1}] < [OH^{-1}]$	3	Vinegar	11	Ammonia
		4	Acid rain	12	Bleach
Neutral solutions	$[H^{+1}] = [OH^{-1}]$ or no ions at all	5	Coffee	13	Lye

Acid Base Neutralization Reactions in the Titration Lab

We will neutralize acids and bases for a specific reason. If you have an acid (or base) of unknown strength, you can determine its strength by the process of titration.

If we start with an acid of a known molarity, and an acid-base indicator, you can figure out how strong a base is with the process called titration.

To do this, measure out a specific volume of acid from a burette. These are very accurate, long glass tubes with fancy valves that make tiny drops. These are the best measuring devices we'll use all year.

Carefully stop the valve, add 2 drops of phenolphthalein indicator to the beaker.

Write down the starting volume of the base burette. Carefully drip, drip, drip some base into the beaker, taking care not to spill any of the base by mistake. Each drop of base turns the beaker solution bright pink because a base shows up as pink with this indicator. A drop of base has a high pH, making the solution pink, but the acid neutralizes it so the solution stays acidic (but weaker). Each drop of base makes the pink linger a bit longer. At some point the solution turns bright pink, Stop, you have gone too far, but this is necessary. Once the solution is pink, you know it's a base.

Slowly add acid back into the beaker (back titrate the solution). Drop by drop. When the solution turns colorless, STOP. That is as close as you can get to neutral.

Re-read the volumes on both burettes, calculate the total volume of acid and base used you used.

The difference between initial + final burette levels is how many mL of acid and of base were used.

Titration math

First, know that we are not getting to exactly pH 7.0, but we're very close. Using phenolphthalein, we can never know exactly pH 7, it does not show pH 7 exactly. There is lots of math and graphs to explain how we can "fudge" the neutral a tiny bit, but we don't have to know that until college. This is close enough.

The titration math formula is on the reference tables, but we will MODIFY it a bit to get the math right every time. But using this formula, with the acid molarity, and the volumes of the acid and base used, you can calculate the molarity of the base. Because neutral means $H^{+1} = OH^{-1}$, and the indicator got us close enough to know how many mL of acid and base it took to make these ions equal.

The formula, which is on the back of your reference table is: $(M_A)(V_A) = (M_B)(V_B)$

we need to change it to this: $(\#H^{+1})(M_A)(V_A) = (M_B)(V_B)(\#OH^{-1})$

Now, the M_A stands for the molarity of the acid; the M_B stands for the molarity of the hydroxide ions. V_A = volume of acid you used, V_B = volume of the base you used. Any units are okay, probably they are mL.

$(\#H^{+1})$ = the number of H^{+1} ions in the acid formula. HCl is "1", H_2SO_4 is "2", and H_3PO_4 is "3"

$(\#OH^{-1})$ = the number of OH^{-1} ions in the base formula. NaOH is "1", $Ca(OH)_2$ and $Mg(OH)_2$ are "2"



The molarity of the acid does NOT always equal the molarity of the H^{+1} ions in solution. To avoid making mistakes, we will let M_A = the molarity of the acid, but we will multiply that by the # H^{+1} ions in the formula to keep the math straight. Same math on the base side. Not all base molarity will = OH^{-1} ion molarity.

1.0 M HCl	has 1 mole $H^{+1}_{(AQ)}$ ions	1.0 M NaOH	has 1 mole $OH^{-1}_{(AQ)}$ ions
1.0 M H_2SO_4	has 2 moles H^{+1} ions	1.0 M $Ca(OH)_2$	has 2 mole $OH^{-1}_{(AQ)}$ ions
1.0 M H_3PO_4	has 3 moles $H^{+1}_{(AQ)}$ ions		

An example problem:

If it takes 35.6 mL of carbonic acid of 3.40 Molarity to completely neutralize 88.5 mL of KOH, what is the molarity of the base?

$$(\#H^{+1})(M_A)(V_A) = (M_B)(V_B)(\#OH^{-1})$$

$$(2)(M_A)(V_A) = (M_B)(V_B)(1)$$

$$(2)(3.40 \text{ M})(35.6 \text{ mL}) = (M_B)(88.5 \text{ mL})(1)$$

$$242.08 = (M_B)(88.5 \text{ mL})$$

Solve for molarity of base

$$2.75 \text{ M} = (M_B) \text{ with 3 SF}$$

In this problem, the acid was “diprotic” or has 2 H^{+1} ions per molecule. The molarity of 3.40 means it has a 6.80 molarity of H^{+1} ions. Without this “($\#H^{+1}$) adjustment”, most kids would have missed this.

Vocab Alert

If you think about it, a hydrogen atom is just one proton and one electron. H atoms have no neutrons. If an H atom loses its electron it becomes a H^{+1} cation. A different way, the H^{+1} cation is now just a proton.

Monoprotic acids have ONE H^{+1} ion in their formulas, like: HCl, HNO_3 , HNO_2 , HBr, or $HC_2H_3O_2$

Diprotic acids have TWO H^{+1} ions in their formulas, like: H_2SO_4 , or H_2CO_3

Triprotic acids have THREE H^{+1} ions in solution, like H_3PO_4 .

Phenolphthalein changes color at pH between 8 and 9.0 from colorless to pink. Since we add base to acid, drop by drop, making that acid less acidic and more neutral, when we get to neutral, we won't notice since the solution will be colorless before we get to pH 7 and stay colorless until pH 8 or so. This is clearly worth explaining since it makes NO SENSE at first glance.

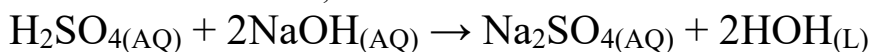
Because we're working with relatively small volumes, one drop will be enough base to move from colorless to clear, or in reverse, one drop of acid should make the pink basic solution return to colorless. We can get to within a drop of neutral in our lab, but not perfectly to a pH of 7.0 with this indicator. Complicated math that you don't want to learn shows us we are much closer than even a drop, just trust me about this.

Enjoy high school, it's not perfect but it's way better than anything else. Electronic pH meters exist, but they're difficult to maintain, expensive, and we'd only need them for a couple of days a year, so phenolphthalein is our indicator of choice.

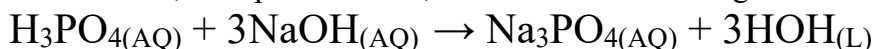
Think through Problems – they are already solved, just follow along. THINK...

One mole of hydrochloric acid and one mole of sodium hydroxide neutralize to one mole of sodium chloride and one mole of water. $\text{HCl}_{(\text{AQ})} + \text{NaOH}_{(\text{AQ})} \rightarrow \text{NaCl}_{(\text{AQ})} + \text{HOH}_{(\text{L})}$

It takes 2 moles of NaOH to neutralize one mole of sulfuric acid. Sulfuric acid is DIPROTIC, a “double H^{+1} ” acid rather than a single ion acid like HCl (monoprotic). To neutralize, it is NOT the molarity of the acid and base that needs to be 1:1, it’s the ratio of the H^{+1} to OH^{-1} that must be 1:1.

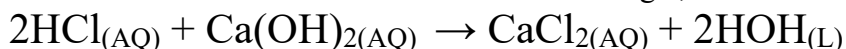


Finally, it will take three moles of sodium hydroxide to neutralize one mole of phosphoric acid, this acid is TRIPROTIC, a “triple H^{+1} ” acid, while the base is a “single OH^{-1} ” base. The ion ratio has to be 1:1.



By changing the titration formula the way we did, we accommodate the ratio of ions instead of the solution molarity. It’s about the number of acid and base ions, not the number of moles in a solution. This is very important, please ask if you don’t get this.

The same works in “reverse” when the acid is single, but the base is doubled.



It takes 2 moles of the “single H^{+} ” (monoprotic) acid to neutralize the “double OH^{-1} ” base.

1. You titrate 3.56 Liters of $\text{HCl}_{(\text{AQ})}$ with 2.46 Liters of 2.15 M $\text{Mg}(\text{OH})_{2(\text{AQ})}$. Calculate the acid molarity.

$$\begin{aligned}(\#\text{H}^{+1})(M_{\text{A}})(V_{\text{A}}) &= (M_{\text{B}})(V_{\text{B}})(\#\text{OH}^{-1}) \\(1)(M_{\text{A}})(3.56 \text{ L}) &= (2.15 \text{ M})(2.46 \text{ L})(2) \\M_{\text{A}} &= 2.97 \text{ M}\end{aligned}$$

2. You neutralize 1.57 liters of 4.25 M $\text{H}_2\text{SO}_{4(\text{AQ})}$ with 3.75 liters of $\text{NaOH}_{(\text{AQ})}$. Calculate the base molarity.

$$\begin{aligned}(\#\text{H}^{+1})(M_{\text{A}})(V_{\text{A}}) &= (M_{\text{B}})(V_{\text{B}})(\#\text{OH}^{-1}) \\(2)(4.25 \text{ M})(1.57 \text{ L}) &= (M_{\text{B}})(3.75 \text{ L})(1) \\3.56 \text{ M} &= M_{\text{B}}\end{aligned}$$

3. It takes 2.49 mL of 1.75 M H_3SO_4 to neutralize 3.99 mL of $\text{Ca}(\text{OH})_2$ solution. What is the base molarity?

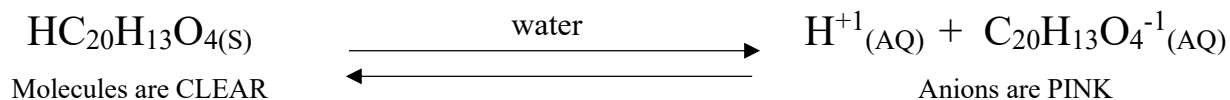
$$\begin{aligned}(\#\text{H}^{+1})(M_{\text{A}})(V_{\text{A}}) &= (M_{\text{B}})(V_{\text{B}})(\#\text{OH}^{-1}) \\(3)(1.75 \text{ M})(2.49 \text{ mL}) &= (M_{\text{B}})(3.99 \text{ mL})(2) \\3.28 \text{ M} &= M_{\text{B}}\end{aligned}$$

Use of an Indicator for Neutralization

There are dozens of acid and base color indicators. These compounds are mostly weak acids, which means that they don't dissociate well. The molecular compound has one color, and the dissociated ions present another color.

Depending upon how much acid or base is present in the solution, these indicators will undergo LeChatlier shift, either forward or reverse. Scientists have measured the specific color changes, by pH of solution, table M is the result.

For example, let's see phenolphthalein in water: the formula is like acetic acid, $\text{HC}_{20}\text{H}_{13}\text{O}_4$



Phenolphthalein in water forms a dynamic equilibrium with H^{+1} ions plus the "phenolphthalein anions"

Adding hydrogen ions will shift it reverse making solution less pink, more colorless.

Adding base ions will shift it forward, because the OH^{-1} combine to H^{+1} ions, making water. Adding OH^{-1} is the same as removing H^{+1} . Adding OH^{-1} causes a forward shift, the solution has more PINK ions than before, you "see" more pink color.

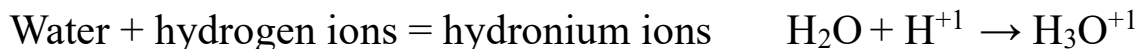
All acid base indicators will "shift" from molecular to ion, or back, depending upon how strong an acid or strong a base they are put into. For example, strong acids (pH of 2) with litmus will appear red. If you add sufficient base to change the pH up to say 9 and the litmus turns blue. Add more acid and you shift it back to red. Add even more base and you shift it back to blue. This can repeat back and forth, the dynamic equilibrium gets stressed, it shifts forward or reverse to accommodate the stress (and you see different colors).

If you put thymol blue into an acid it would present yellow at pH 7. By adding base, drop by drop you will change the pH slowly. At the pH hits 8.0, that is the highest pH that thymol blue is yellow. As the pH gets to 8.1, and higher, it shifts towards the blue color. Since it is MOSTLY yellow and only a little blue, you will see it turn a "green" color. Between 8.0 to 9.6 it's in between yellow and blue and will appear sort of greenish. At pH of 9.6 it is blue.

One last odd extra point:

The cation called the **hydronium ion** is from table E (Polyatomic ions) fits into acid - base.

A different way to write and to "understand" H^{+1} ions in water has these ions attached to the water.



This can show up on the Regents exam. It indicates acid ions in solution, but in a different way. Imagine hydrogen ions loose in water as an acid, which is the Arrhenius theory. Hydronium ions have the H^{+1} ions "become one with the water". Memorize the formula and remember that hydronium ions = acid ions.

FOUR WAYS to describe acids

They are aqueous solutions with excess H^{+1} ions (Arrhenius theory), or aqueous protons (H^{+1} = a proton), or a compound that can donate a H^{+1} ion (in our alternate theory), or as aqueous solutions with hydronium ions.

Practical Acid Base Neutralization

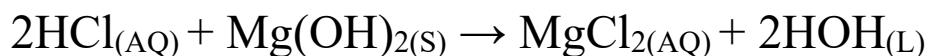
If you eat too much spicy food, you might end up with a belly ache. Often, it's called acid indigestion, due to excessive hydrochloric acid produced by the stomach. It literally burns your stomach. Stomach acid has pH of about 1.0, and any tiny scratches in there (from the pizza) will cause you pain.

How do you spell relief? TUMS, or Alka-Seltzer Both over the counter medicines are ant-acids (anti is against). They are both weak bases. The TUMS (or ROLAIDS) solids that you chew and they mix with the water in your saliva to create a weak base solution. The Alka-Seltzer is already a weak base. Eat them or drink them to bring the base to the acid, they combine into a salt and water. Neutral does not burn your insides.

You feel better.

ROLAIDS contain 2 active ingredients

magnesium hydroxide reacts this way with HCl

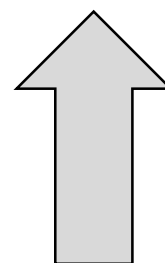


calcium carbonate, which reacts with the hydrochloric acid this way...



Alka-Seltzer is sodium hydrogen carbonate

sodium hydrogen carbonate reacts this way with HCl



That is the burp!

With the Roloids, there is some CaCO_3 , so there is less burp. With Alka-Seltzer, you really burp big!

Acid Base Chemistry Notes

1	The Father of the Arrhenius Theory of Acids + Bases, and a Nobel Prize Winner and a Swedish Chemist
2	ACIDS are aqueous solutions that contain
3	BASES are aqueous solutions that contain
4	When you react an acid with base you always get
5	Acid and Base makes...
6	Acids we need to know are listed in
7	Bases we need to know are listed in
8	Acids are strong because they
9	Acids are weird, they are molecular compounds, that share electrons in covalent bonds. But when you put them into water they ionize like this:

	Acid	Dissolves	And forms...
10	$\text{HNO}_2(\text{G})$	$\begin{array}{c} \xrightarrow{\text{H}_2\text{O}} \\ \xleftarrow{\hspace{1cm}} \end{array}$	
11	$\text{HNO}_3(\text{G})$	$\begin{array}{c} \xrightarrow{\text{H}_2\text{O}} \\ \xleftarrow{\hspace{1cm}} \end{array}$	
12	$\text{H}_2\text{SO}_4(\text{G})$	$\begin{array}{c} \xrightarrow{\text{H}_2\text{O}} \\ \xleftarrow{\hspace{1cm}} \end{array}$	

	Acid	Dissolves	And forms...
14	$\text{H}_3\text{PO}_{4(s)}$	$\xrightleftharpoons{\text{H}_2\text{O}}$	
15	$\text{H}_3\text{C}_2\text{H}_3\text{O}_{2(s)}$	$\xrightleftharpoons{\text{H}_2\text{O}}$	
16			
17	<p>BASES are listed in They are also listed in strength order. <u>NaOH is the strongest base</u> it has the most OH^{-1} anions in solution</p>		
18	<p>ALL aqueous ionic compound containing OH^{-1} anions are bases. examples:</p>		
19	<p>Ammonia is NH_3, it has no hydroxides, but it is a base. It requires...</p>		

20	<p>These are not the same things They have different formulas</p>
Ammonia is a molecule	
Ammonium is a polyatomic cation	
Urea forms from ammonia	

21	have loose mobile ions in solution
22	The more ions in solution, the better the solution conducts electricity, the
23	Strong acids & strong bases have
24	Strong acids & strong bases are
25	
26	Electrolytic strength (ability to conduct electricity) depends upon how well they dissociate in water.
27	Mark up your table K and table L now...
28	The name of this new chemical reaction is
29	
30	

31. Balance hydrochloric acid and sodium hydroxide react...						
Hydrochloric acid	and	Sodium hydroxide	Form	Sodium chloride	and	Water

→

Arrhenius theory states...						
acid	+	base	makes	a salt	+	water

32. Balance nitric acid and potassium hydroxide react...

Nitric
acid

and

Potassium
hydroxide

forms

and

→

33. Balance hydrochloric acid and calcium hydroxide react...

Hydrochloric
acid

and

Calcium
hydroxide

forms

and

→

34. Balance phosphoric acid and lithium hydroxide react...

Phosphoric
acid

and

Lithium
hydroxide

forms

and

→

34. Balance phosphoric acid and lithium hydroxide react...

Phosphoric
acid

and

Lithium
hydroxide

forms

and

→

Acid Base Class #2 OBJECTIVES:

A. Master the alternate theory explaining how ammonia is a base, Acid base chemical indicators

36	0/0	of acids and bases follow the ARRHENIUS theory. Acids have excess H^{+1} ions in solution, while Bases have excess OH^{-1} ions in solution. They combine into salt and water.
	0/0	Ammonia does not follow the Arrhenius theory. Ammonia is a weak base and it has no OH^{-1} in its formula.
37	An alternate theory	
38		
39		

40. Balance these acid-base neutralization reactions

carbonic acid + lithium hydroxide \rightarrow lithium carbonate + water

acetic acid + calcium hydroxide \rightarrow calcium acetate + water

phosphoric acid + sodium hydroxide \rightarrow sodium phosphate + water

41	<p>Acid Base indicators are compounds that change color, depending upon the pH (hydrogen ion concentration) of the solution.</p> <p>Acid Base Indicators are weak acids that work by _____.</p> <p>The molecules are one color, the ions another.</p> <p>The “stress” of adding more acid, or more base, causes a LeChatlier shift forward or reverse.</p>
42	<p>Phenolphthalein works like this...</p> $\text{HC}_{20}\text{H}_{13}\text{O}_4(\text{S}) \rightleftharpoons \text{H}^{+1}(\text{AQ}) + \text{C}_{20}\text{H}_{13}\text{O}_4^{-1}(\text{AQ})$

43	<p style="text-align: center;">Bromthymol blue works like this...</p> $\text{HC}_{27}\text{H}_{27}\text{Br}_2\text{O}_5\text{S}(\text{s}) \quad \text{H}^{+1}(\text{AQ}) + \text{C}_{27}\text{H}_{27}\text{Br}_2\text{O}_5\text{S}^{-1}(\text{AQ})$
44	<p>Titration Formula (fixed)</p> <p style="text-align: center;">Where... the $\#H^{+1}$ = the number of H^{+1} ions in the acid <u>formula</u></p> <p style="text-align: center;">M_A is the molarity of this acid V_A is the volume of this acid M_B is the molarity of this base V_B is the volume of this base</p> <p style="text-align: center;">and $\#OH^{-1}$ = the number of OH^{-1} ions are in the base <u>formula</u></p>
45	<p>If 7.91 mL of 1.25 M $\text{H}_2\text{CO}_3(\text{AQ})$ is neutralized by 16.2 mL of NaOH, what is the molarity of this base?</p>
46	<p>If 25.8 mL of HCl of 2.75 Molarity will neutralize 43.8 mL of calcium hydroxide, what is the molarity of this base?</p>

47 It takes 12.4 mL of 1.90 M HCl to neutralize 104 mL of NaOH. What is the molarity of the base?

* An important note here...
You're not wasting your effort here by multiplying by (1) on both sides.
You are reminding yourself that **SOMETIMES** the ACID:BASE ratios are not 1:1
and you are **ALWAYS** going to be careful with the math.

We will use the _____ it measures how acidic or basic a solution is.
The pH scale is an odd scale, it runs...

48 A pH below 7 is an _____ A pH higher than 7 is a _____

49 Label this diagram

0 1 2 3 4 5 6 **7** 8 9 10 11 12 13 14 pH

50

51 A pH of 7 means...

52	First, the pH scale is a LOG SCALE (logarithm scale) That means small changes in value or strength are really changes in
53	The pH scale is an exponent scale (like the Richter scale) <u>Each whole number change in the pH</u> - A pH 3.5 acid is 10X stronger than a pH 4.5 acid.

	pH of Solution A	pH of Solution B	compare these two
54	7.9	9.9	
55	1.0	6.0	
56	13.1	7.1	
57	1.2	5.2	

58	pH =
58	Which means...
60	Whatever the...

Get some colored pencils now, to draw pretty colors on the next page.

pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Methyl orange acid base indicator color ranges

61. ↑ Color this pH scale in for METHYL ORANGE. LOOK AT TABLE M for the colors and the pH that you need to be aware of.
62. Acid Base “indicates” ranges of pH, not

63	782.2 mL of KOH neutralizes 1500. mL of H_2SO_4 that has a 1.56 M, what is the molarity of this base?
64	What volume of 3.75 M $\text{H}_2\text{SO}_{4(\text{AQ})}$ is necessary to exactly neutralize 34.7 liters of 1.88 M KOH?
65	12.45 mL of 2.00 M H_3PO_4 is neutralized with 25.33 mL $\text{Sr}(\text{OH})_2$. What is the molarity of the base?

66	Acid Base indicators are mostly...
67	When you put these indicators into solutions containing H^{+1} ions or OH^{-1} ions, they will undergo a LeChatleier's Shift, shifting _____.
68	With phenolphthalein which way does the equilibrium shift when adding acid or base? $HC_{20}H_{13}O_4(S) \rightleftharpoons H^{+1}_{(AQ)} + C_{20}H_{13}O_4^{-1}_{(AQ)}$
69	The H^{+1} ions from the acid “join” with the H_2O molecules forming <u>hydronium</u> ions:
70	The acid exists as part of a water molecule, called the <i>hydronium ion</i> . The H^{+1} ion becomes
71	Hydronium ion: a model for acids, whereby the hydrogen ions become one with water and....

72 The FOUR ways acids can be described	
	(Svante Arrhenius was right,)
	Any compound that donates a H^{+1} ion, according to the Bronsted-Lowry theory (NH_3 ammonia is a base because it <i>ACCEPTS</i> a H^{+1} ion)
	the weirdo hydronium ion
	or just as protons (A hydrogen atom, proton and electron) minus the electron = just a proton.

73. Balance these chemical equations from these word equations

Hydrochloric acid + calcium hydroxide yields...

Sulfuric acid + ammonium hydroxide yields...

Nitrous acid + lithium hydroxide yields...

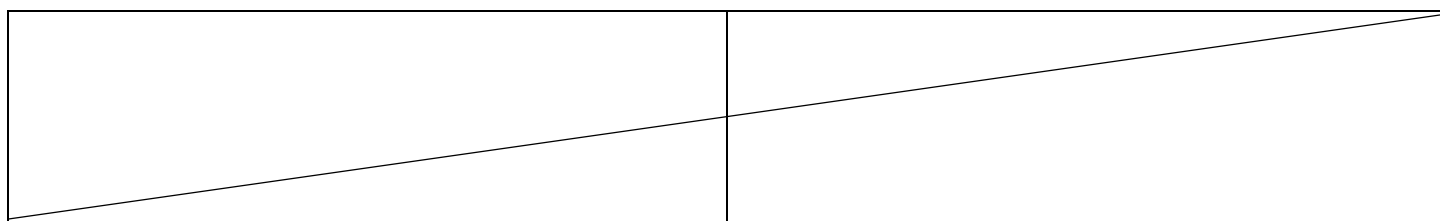
74 Show the dissociation for sulfurous acid into water. *Use phase symbols.*

75 Show the dissociation of potassium hydroxide in water as well. *Use phase symbols.*

76 How many milliliters of 1.25 M NaOH base can 12.0 mL of 2.50 M HCl acid neutralize?

77 How many mL of H_3PO_4 acid of 1.15 M is needed to neutralize 56.0 mL of 2.50 M $\text{Mg}(\text{OH})_2$?

78	How many mL of 0.760 M NaOH is required to neutralize 145 mL of 4.33 M HCl acid?
79	<p>Show the dissociation and dynamic equilibrium of Bromthymol blue with added acid, and added base</p> $\text{HC}_{27}\text{H}_{27}\text{Br}_2\text{O}_5\text{S}(\text{s}) \quad \text{H}^{+1}(\text{AQ}) + \text{C}_{27}\text{H}_{27}\text{Br}_2\text{O}_5\text{S}^{-1}(\text{AQ})$
80A	You neutralize 134 mL of 2.45 M $\text{H}_3\text{PO}_4(\text{AQ})$ with 202 mL of $\text{KOH}(\text{AQ})$. What is the molarity of the base?
80B	A bottle of 2,012 mL of 4.00 M $\text{NaOH}(\text{AQ})$ is spilled in lab. You use a weak sulfuric acid of just 0.450 M to clean up. How many mL are used?
80C	45.6 mL nitric acid is neutralized with 33.2 mL calcium hydroxide solution of 1.24 M, what is strength of the acid?



81.

82. What is the pH of these 2 solutions?

$1 \times 10^{-6.5}$ moles H^{+1} ions/liter of solution.

$1 \times 10^{-11.3}$ moles H^{+1} ions/liter of solution

Let's compare solutions on the left, to solutions on the right.

	Solution 1	Solution 2	Solution 1 is...
ex	pH 4.3	pH 6.3	100x MORE ACIDIC
83	pH 11.2	pH 13.2	
84	pH 1.2	pH 0.2	
85	pH 12.0	pH 8.0	
86	pH 1.3	pH 6.3	

87. Acid-Base Indicator Color changes. What color would each be?

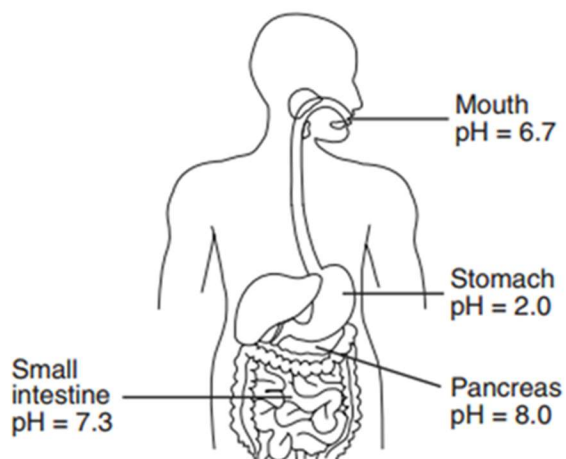
Methyl orange indicator goes into an ammonia solution.	
Bromthymol blue indicator goes into vinegar.	
Thymol blue indicator goes into deionized water.	
Litmus indicator goes into potassium hydroxide.	
Bromcresol green indicator goes into Mixed Berry seltzer.	

88	$\text{NH}_3(\text{G}) + \text{H}_2\text{O}(\text{L}) \rightleftharpoons \text{NH}_4(\text{AQ})^{+1} + \text{OH}^{-1}(\text{AQ})$
89	<p style="text-align: center;">Show the dissociation of Thymol Blue</p> $\text{HC}_{27}\text{H}_{29}\text{O}_5\text{S}(\text{S}) \rightleftharpoons \text{H}^{+1}(\text{AQ}) + \text{C}_{27}\text{H}_{29}\text{O}_5\text{S}^{-1}(\text{AQ})$
90	<p style="text-align: center;">Show the dissociation of Methyl Orange</p> $\text{HC}_{14}\text{H}_{13}\text{N}_3\text{NaO}_3\text{S}(\text{s}) \rightleftharpoons \text{H}^{+1}(\text{AQ}) + \text{C}_{14}\text{H}_{13}\text{N}_3\text{NaO}_3\text{S}^{-1}(\text{AQ})$
91	<p>The four ways to describe an acid are...</p>
92	<p>How many hydrogen ions are present per liter in a solution with a pH of 3.0? This is hard</p>

93 Show the dissociation of a strong acid HCl and a weak acid ethanoic acid in dynamic equilibrium.

Base your answers to questions 76 through 78 on the information below.

The diagram below shows typical pH values found in four parts of the human digestive system. In the small intestine, the enzyme lipase acts as a catalyst, increasing the rate of fat digestion.



76 Which labeled part of the digestive system has the most acidic environment? _____

77 What is the color of thymol blue at the pH of the small intestine? _____

78 State how the catalyst lipase increases the rate of fat digestion?

