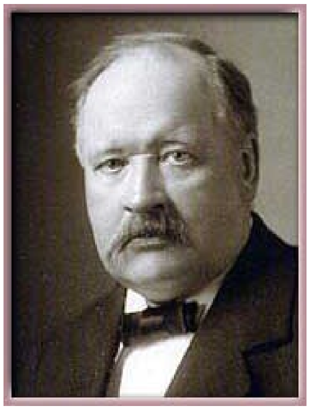
Name

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

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.

Acids are <u>molecular compounds</u> that form ions in solution. 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 an acid compound. 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.

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 nearly 1 mole of H^{+1} ions in solution, an 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 (think 4% of a mole). All of the hydrogen acetate dissolves (it's polar like water) but not all ionizes.

Concentrated acids have many moles per liter, while dilute acids have fractions of moles per liter. That's not the same as how well they can dissociate.

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	LOTS of $H^+_{(AQ)}$	The stronger the acid, the more H^+ ions The more ions, the better it conducts electricity. Strong acids are good electrolytes.
$HNO_{2(AQ)}$ nitrous acid	dissociates very well	LOTS of $H^+_{(AQ)}$	
$HNO_{3(AQ)}$ nitric acid	dissociates very well	LOTS of $H^+_{(AQ)}$	
$H_2SO_{3(AQ)}$ sulfurous acid	dissociates very well	A lot of $H^+_{(AQ)}$	Medium strong acids are medium electrolytes. These acids don't dissociate as well as those above, so there are 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	less $H^+_{(AQ)}$	
$H_2CO_{3(AQ)}$ or $CO_{2(AQ)}$ carbonic acid	dissociates poorly	few $H^+_{(AQ)}$	Weak acids are poor electrolytes.
$HC_2H_3O_{2(AQ)}$ = $CH_3COOH_{(AQ)}$ acetic acid = ethanoic acid	dissociates quite poorly	very few $H^+_{(AQ)}$	Weak acids are poor electrolytes.

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

Most bases will dissociate very well but calcium hydroxide does so less well, and ammonia has no hydroxides in it's formula. It's very weird. We'll need a different theory to explain how it's a base, later on.

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

Arrhenius Theory also explains how acids and bases combine and that they "neutralize" each other.

Acids and bases combine to ALWAYS form water + a salt.
Salts are chemical substances that are IONIC COMPOUNDS, which are: metal cation + nonmetal anion.

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

We will also be writing water, H_2O as HOH, to make balancing easier. Still 2 H's and one O, but this way better shows the acid "H" and the base "OH" forming HOH, which is always liquid, $HOH_{(L)}$

This is vaguely similar to double replacement reactions because we start with 2 aqueous solutions and they "switch partners", but since we start with acid and base, and end up with salt and water, and NOT with a precipitate, they are not the same reaction type. In this example below, the acid and base neutralizes each other into NOT acid or base, calling this reaction type acid-base neutralization makes sense.

The H^{+1} acid ion combines with the OH^{-1} base ion, forming HOH which is a different way to write H_2O

$$\underline{H}Cl_{(AQ)} + Na\underline{OH}_{(AQ)} \rightarrow \underline{HOH}_{(L)} + NaCl_{(AQ)}$$

The other ions, the cation from the base (Na^{+1}) plus the anion from the acid (Cl^{-1}), combine to form a salt, an ionic compound, which is NaCl or sodium chloride in this reaction.

Another example could be:

$$\underline{H_2}SO_{4(AQ)} + 2K\underline{OH}_{(AQ)} \rightarrow \underline{2HOH}_{(L)} + K_2SO_{4(AQ)}$$

Sulfuric <u>acid</u> and potassium hydroxide <u>base</u> → <u>water</u> and a <u>salt</u> (potassium sulfate)

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 molecule of neutral water. There are still many ions in solution (the anions of the acid and the cations of the base), so the resulting neutral solution is still a good electrolyte.

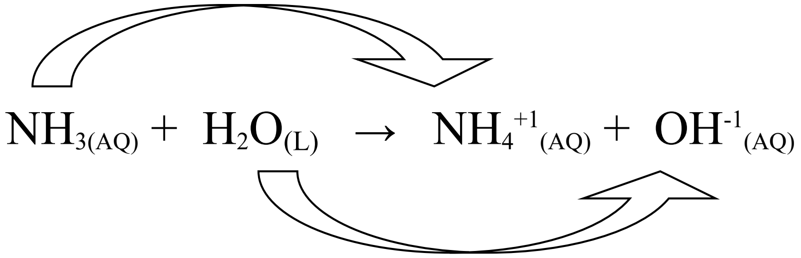
The Exceptional Situation of the base Ammonia: no apparent OH^{-1} ions.

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 also 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 relate to ammonia.

We only have to know this: 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, notice how ammonia "accepts" a H^{+1} ion and how water had to "donate" it to ammonia. Ammonia "becomes" NH_4^{+1} by gaining a H^{+1} ion. The "left-over" part of water, the OH^{-1} ion floats in the water as an anion.



$$NH_{3(AQ)} + H_2O_{(L)} \rightarrow NH_4{}^{+1}{}_{(AQ)} + OH^{-1}{}_{(AQ)}$$

Imagine this way: $NH_3 + H^{+1} = NH_4^{+1}$ $\quad$ $H_2O - H^{+1} = OH^{-1}$

The end result is the key: there are hydroxides in solution to provide the properties that make the end solution a base. By definition, ammonia is the base because it accepted the hydrogen ion. In reality, these hydroxide ions provide all the properties.

The theory is backwards, claiming that ammonia is really the base, and avoiding mention of the $OH^{-1}{}_{(AQ)}$ ions. This theory explains ammonia but is otherwise not a big deal in our level of chemistry.

A weird thing here, since water (which we all know and accept as neutral) has to be an "acid" since it donated the H^{+1} ions. Frustrating for you, I am sorry this is so confusing.

There are additional acid-base theories as well, some concerning pairs of electrons doing tricks, but they are taught in college chemistry. Arrhenius theory explains all of our acids & bases, except ammonia.

Sometimes the regents asks 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 just 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.

This scale runs from 0 - 14. Low numbers are the strongest acids, high numbers are the strongest bases. Towards the middle number 7 they get weaker. At pH = 7, the acid ions = the base ions, and they cancel out to NEUTRAL.

A pH of 0 means that the $[H^{+1}] = 1 \times 10^{0}$ moles H^{+1} ions in solution. That's = 6.02×10^{23} ions per liter.

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

A pH of 2 means that $[H^{+1}] = 1 \times 10^{-2}$ moles H^{+1} ions in solution.
That's = 6.02×10^{21} ions per liter. (that's one hundredth pH of 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 three number change in pH, say from 2.0 to 5.0 is a 1000X change in concentration.

It's the negative of the negative exponent that is the pH.

On the high end of the scale, a pH of 14 means that the $[H^{+1}] = 1 \times 10^{-14}$ moles H^{+1} ions in solution.
That's = 6.02×10^{9} moles of ions per liter (much, much less than 6.02×10^{23} ions per liter)

At exactly pH 7.0 the concentration of H^{+1} ions = the concentration of OH^{-1} ions, and they turn to water.

$$[H^{+1}] = [OH^{-1}] \text{ is NEUTRAL, neither acid or base}$$

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 not uncommon. Many solutions have no ions at all, or if they are ionic, they have no acid or base ions in solution.

All aqueous solution that are not acids or bases such as $NaCl_{(AQ)}$, or $LiNO_{3(AQ)}$, or dissolved sugar water, are also neutral, and have pH = 7.

Pure water has no ions of any kind, nor does any alcohol or gasoline, etc.

Acids have $[H^{+1}] > [OH^{-1}]$
Bases have $[H^{+1}] < [OH^{-1}]$
Neutrals have $[H^{+1}] = [OH^{-1}]$

approx. pH	substance	approx. pH	substance
1	$HCl_{(AQ)}$	7	Pure water
1	Lime juice	8	Baking soda
2	Lemon juice	9	Hand soap
2	Coca cola	10	Mg(OH)2
3	Vinegar	11	Ammonia
4	Acid rain	12	Bleach
5	Coffee	13	Lye

Acid Base Neutralization Reactions in Lab

We will neutralize acids and bases for a reason. We will be able to figure out how strong a base solution is, if we do the process correctly.

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

To do this, we measure out a specific volume of acid from a buret. 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.

Read the starting volume in the acid buret. Write that down too. Run about 5 mL into the beaker underneath. Carefully stop the valve, and then add 2 drops of phenolphthalein indicator to the beaker as well.

Write down the starting volume of the base buret. Now carefully drip, drip, drip some base into the beaker, taking care not to drop any base onto the table by mistake. Each drop of base turns the beaker solution bright pink because the base shows up as pink with this indicator. A small swirl mixes the acid and base, neutralizing some of it, while leaving it still an acid. Each drop of base lingers a bit longer. At some point the solution turns bright pink, and you stop.

Move the beaker back under the acid buret, and very carefully put one drop of acid into the beaker. If the solution turns colorless, STOP. That is as close as you can get to neutral. If it takes more than one drop to change color, make sure you stop after each drop, for accurate measuring.

When it takes ONE DROP to go from pink to colorless, that is as close to neutral that you can get. Re-read the volumes on both burets, and do some subtracting to determine the volume of acid used, and of base used.

The difference between initial + final readings is how many mL was used.

How to do titration math?

First, know that we are not getting to exactly pH 7.0, but we're close. Using phenolphthalein, we can never know exactly pH 7, it's not accurate that way. 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. We'll get close enough.

We will use the titration math formula, which is on the reference tables, but we will MODIFY it a bit to get the math right every time. But using the molarity of the acid, and the volume of the acid, and the volume of the base, we can calculate the molarity of the base because we know that neutral is when $H^{+1} = OH^{-1}$, and the indictor got us close enough to know how many mL of acid and base it took to make the 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.

The $\#H^{+1}$ is the number of H^{+1} ions in the acid formula. Ex: HCl has "1", H_2SO_4 has "2", and H_3PO_4 has "3"

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

The molarity of the acid does NOT always equal the molarity of the H^{+1} ions. 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	Means 1 mole H^{+1} ions	1.0 M NaOH	Means 1 mole OH^{-1} ions
1.0 M H_2SO_4	Means 2 moles H^{+1} ions	1.0 M $Ca(OH)_2$	Means 2 mole OH^{-1} ions
1.0 M H_3PO_4	Means 3 moles H^{+1} 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

$$2.753536... = (M_B)$$
$$2.75\text{ M} = (M_B)\text{ with 3 significant figures}$$

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

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Vocab Alert

If you think about it, a hydrogen atom is really just one proton and one electron. They have no neutrons. If an atom like this loses it’s electron and becomes a cation, the H atom becomes an H^{+1} cation. If you look at it a different way, the H^{+1} cation is really 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
and triprotic acids have THREE H^{+1} ions in solution, like H_3PO_4.

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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 on 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, which means phenolphthalein is our indicator of choice.

Think through Problems

One mole of hydrochloric acid and one mole of sodium hydroxide neutralize to one mole of sodium chloride and one mole of water.

$$HCl_{(AQ)} + NaOH_{(AQ)} \rightarrow NaCl_{(AQ)} + HOH_{(L)}$$

Below, it takes 2 moles of NaOH to neutralize one mole of sulfuric acid. Sulfuric acid is DIPROTIC, or a "double H^{+}" 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.

$$H_2SO_{4(AQ)} + 2NaOH_{(AQ)} \rightarrow Na_2SO_{4(AQ)} + 2HOH_{(L)}$$

Finally, it will take three moles of sodium hydroxide to neutralize one mole of phosphoric acid, because the acid is a "triple H^{+}" acid (triprotic) and the base is a "single OH^{-1}" base. The <u>ion ratio</u> has to be equal.

$$H_3PO_{4(AQ)} + 3NaOH_{(AQ)} \rightarrow Na_3PO_{4(AQ)} + 3HOH_{(L)}$$

By changing the titration formula the way we did, we accommodate the ratio of ions instead of the solution molarity. It's about the 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.

$$2HCl_{(AQ)} + Ca(OH)_{2(AQ)} \rightarrow CaCl_{2(AQ)} + 2HOH_{(L)}$$

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

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

$$(\#H^{+1})(M_A)(V_A) = (M_B)(V_B)(\#OH^{-1})$$
$$(1)(M_A)(3.56\text{ L}) = (2.15\text{ M})(2.46\text{ L})(2)$$
$$M_A = 2.97\text{ M} \quad \text{(3 SF)}$$

2. You neutralize 1.57 liters of 4.25 M $H_2SO_{4(AQ)}$ with 3.75 liters of $NaOH_{(AQ)}$. Calculate the base molarity.

$$(\#H^{+1})(M_A)(V_A) = (M_B)(V_B)(\#OH^{-1})$$
$$(2)(4.25\text{ M})(1.57\text{ L}) = (M_B)(3.75\text{ L})(1)$$
$$3.56\text{ M} = M_B$$

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

$$(\#H^{+1})(M_A)(V_A) = (M_B)(V_B)(\#OH^{-1})$$
$$(3)(1.75\text{ M})(2.49\text{ mL}) = (M_B)(3.99\text{ mL})(2)$$
$$3.28\text{ M} = M_B$$

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 shifts forwards or reverse, leaning molecular or ionic. Scientists have measured the specific color changes, by specific pH of solution and created table M for us to use.

For example, let's see phenolphthalein in water: the formula is like acetic acid, $HC_{20}H_{13}O_4$

$$HC_{20}H_{13}O_{4(AQ)} + H_2O_{(L)} \rightleftharpoons H^{+1}{}_{(AQ)} + C_{20}H_{13}O_4{}^{-1}{}_{(AQ)}$$

Molecules are CLEAR Anions are PINK

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

Molecular phenolphthalein is clear while the anions are pink. Adding more hydrogen ions will shift it to the reverse makes less pink, more colorless.

Adding base ions will shift it forward, because the hydroxides hook up with the H+1 ions and make water. Adding hydroxide is the same as taking H^{+1} ions out. This causes a forward shift, and the solution has more PINK ions than before, making 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 go on and on all day, as the acid and base combine into salt and water, but you can shift back and forth endlessly.

If you put thymol blue into an acid it would present yellow. 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, then 8.2, 8.3, etc., it starts to shift 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 9.6 it is just 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.

Water + hydrogen ions = hydronium ions $H_2O + H^{+1} \rightarrow H_3O^{+1}$

This ion shows up on the Regents exam from time to time, but it really indicates acid ions in solution. If you can imagine hydrogen ions loose in water as an acid, which is the Arrhenius theory, this seems to represent the hydrogen ions "becoming one with the water". Hydronium ions are the dumbest this I teach all year.

Just memorize the formula and remember that they mean acid ions.

There are FOUR WAYS to describe Acids
Acids are solutions that contain excess H^{+1} ions (Arrhenius theory), or are just protons (since H^{+1} is an H atom without it's electron which is just a proton), or a substance that can donate a H^{+1} ion (that alternate theory) or this dumb hydronium ion idea.

Practical Acid Base Neutralization

If you eat too much spicy foods 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, it has a pH of about 1.0, and any tiny scratches in there (from the pizza) will cause pain.

How do you spell relief? ROLAIDS, or possibly Alka-Seltzer Both over the counter medicines are ant-acids (anti is against). They are both weak bases. The TUMS or ROLAIDS are solid, but mix with the saliva and create a weak base solution. The Alka-Seltzer is already a weak base. Drink them down and the base combines with the acid in the stomach, forming salty water, which does not burn.

You feel better, and we both know, it's all about you. ☺

Here are the balanced reactions and some details…

ROLAIDS have 2 active ingredients… magnesium hydroxide $Mg(OH)_2$ which combines with HCl this way

$2HCl_{(AQ)} + Mg(OH)_{2(S)} \rightarrow MgCl_{2(AQ)} + 2HOH_{(L)}$

ROLAIDS also have calcium carbonate, which reacts with the hydrochloric acid this way…

$2HCl_{(AQ)} + CaCO_{3(S)} \rightarrow CaCl_{2(AQ)} + HOH_{(L)} + CO_{2(G)}$

Alka-Seltzer contains sodium hydrogen carbonate, which dissolves in water (and releases some CO2 gas) With the hydrochloric acid, this is what happens:

$NaHCO_{3(AQ)} + HCl_{(AQ)} \rightarrow NaCl_{(AQ)} + HOH_{(L)} + CO_{2(G)}$

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Acid Base Chemistry Notes

1	The Father of the Arrhenius Theory of Acids + Bases, a Nobel Prize Winner and a Swedish Chemist
2	ACIDS are aqueous solutions containing
3	BASES are aqueous solutions containing
4	All the acids we need to know are listed in Acetic acid is also called
5	Acids are strong because they For example: when HCl goes into water practically all of it ionizes into
6	Arrhenius ACIDS have more than

	Acid	Dissolves into water	And forms…	approx. ionization
7	$HCl_{(G)}$	$\overset{H_2O}{\rightleftarrows}$		100%
8	$HNO_{2(G)}$	$\overset{H_2O}{\rightleftarrows}$		100%
9	$H_2SO_{4(G)}$	$\overset{H_2O}{\rightleftarrows}$		45%
10	$H_3PO_{4(G)}$	$\overset{H_2O}{\rightleftarrows}$		10%
11	$HC_2H_3O_{2(S)}$	$\overset{H_2O}{\rightleftarrows}$		5%

12	You need to know all the bases in ALL aqueous ionic compound containing hydroxides are also bases, such as
14	______________________________ is special. It does not have a hydroxide in its formula, but we will learn a special theory to explain it in a few days. This is way cool.
15	Arrhenius Bases have more than
16	The more ions in solution, the the base.
17	Ammonia does not follow the Arrhenius theory for bases. It is a __________________________base.
18	Strong acids & strong bases have ____in solution.
19	Strong acids & strong bases are
20	All acids and all bases are
21	Their electrolytic strength (ability to ____) depends upon how well they dissociate in water.
22	Take out your tables K and L. Mark the acids and bases as strong or weak, and good or poor electrolytes.
23	Arrhenius Theory states that… A. B. C.
24	Salts are…
25	This name of this new chemical reaction is:

26	The formula for water is
27	That could also be written as

28. Balance hydrochloric acid and sodium hydroxide react…

Hydrochloric acid	and	Sodium hydroxide	forms	Sodium chloride	and	Water

→

Arrhenius theory states…

acid + base makes salt + water

29. Balance nitric acid and potassium hydroxide react…

Nitric acid	and	Potassium hydroxide	forms		and	

→

30. Balance hydrochloric acid and calcium hydroxide react…

Hydrochloric acid	and	Calcium hydroxide	forms		and	

→

31. Balance phosphoric acid and lithium hydroxide react…

Phosphoric acid	and	Lithium hydroxide	forms		and	

→

32. Balance nitric acid and magnesium hydroxide react…						
Nitric acid	and	Magnesium hydroxide	forms		and	

→

33	% %	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. Ammonia does not follow the Arrhenius theory. It is a weak base and it has no OH^{-1} in its formula.
34	An alternate theory	
35		
36		

37. Balance these acid base neutralization reactions (finish word equations too)
Carbonic acid + lithium hydroxide → lithium carbonate + water
Acetic acid + calcium hydroxide → calcium acetate + water
Phosphoric acid + sodium hydroxide → sodium phosphate + water

38	Acid Base indicators are compounds that change color, depending upon the pH (hydrogen ion concentration) of the solution. Acid Base Indicators are weak acids that work by ______________________________________. The molecules are one color, the ions another. The "stress" of adding more acid, or more base, causes a LeChatlier shift forward or reverse.
39	Phenolphthalein works like this… $HC_{20}H_{13}O_4 \qquad\qquad H^{+1}_{(AQ)} + C_{20}H_{13}O_4^{-1}{}_{(AQ)}$

40	Bromthymol blue works like this… $HC_{27}H_{27}Br_2O_5S \qquad H^{+1}{}_{(AQ)} + C_{27}H_{27}Br_2O_5S^{-1}{}_{(AQ)}$
41	Titration Formula (fixed)
42	Where… the $\#H^{+1}$ = the number of H^{+1} ions in the acid formula M_A is the molarity of this acid $\qquad$ V_A is the volume of this acid M_B is the molarity of this base $\qquad$ V_B is the volume of this base and the $\#OH^{-1}$ = the number of OH^{-1} ions in the base formula
43	If 7.91 mL of 1.25 M $H_2CO_{3(AQ)}$ is neutralized by 16.2 mL of NaOH, what is the molarity of this base?
44	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?

45 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 are being careful with the math.

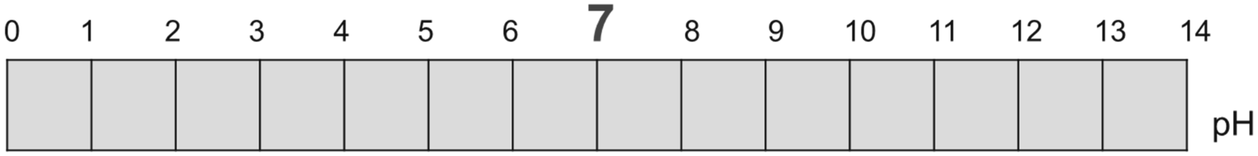
46 We will use the , it measures how acidic or basic a solution is.

47 It's an <u>odd</u> scale, it runs…

48 A pH of 7 is perfectly "balanced" as neither acid or base. We call that ________________________

A pH Lower than 7 is an _______________, and a pH that is higher than 7 is a _______________.

49 Label this diagram



50

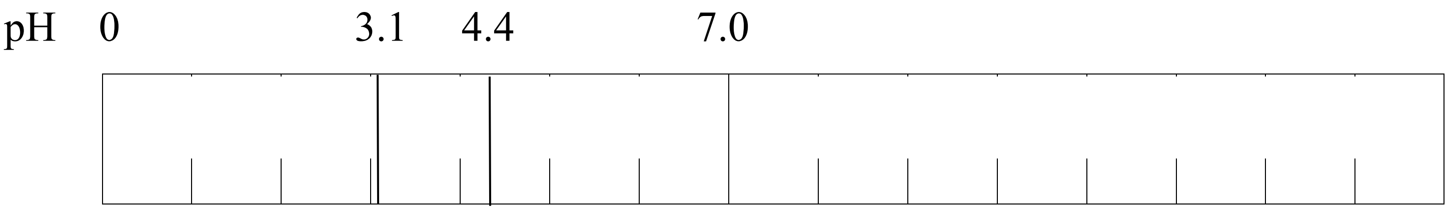
51 A pH of 7 means…

52	First, the pH scale is a logarithm scale. That means small changes in value or strength are really changes in
53	The pH scale is an exponent scale (liker the Richter scale) Each whole number change in pH... 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	What ever the…

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



61. Color this pH scale in for METHYL ORANGE. Below pH 3.1 is shows red. Above pH 4.4 it shows YELLOW. In between 3.1 and 4.4 it changes from red to yellow (gets a bit orangey in there)

62. Acid Base indicators “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 $H_2SO_{4(AQ)}$ 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 $Sr(OH)_2$. 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? $HC_{20}H_{13}O_4$ $H^{+1}{}_{(AQ)} + C_{20}H_{13}O_4{}^{-1}{}_{(AQ)}$
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 *hydronium ion*. The H^{+1} ion becomes
71	Hydronium ion: a model for acids, whereby the hydrogen ions become one with water and….

72	4 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 ACCEPTS a H^{+1} ion)*
	the weirdo hydronium ion
	or just as protons (what really is a hydrogen ion, if a hydrogen ion is a proton plus an electron, and the electron ionizes away to an anion, all that’s left is 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 $Mg(OH)_2$?

78	How many mL of 0.760 M NaOH is required to neutralize 145 mL of 4.33 M HCl acid?
79	Show the dissociation and dynamic equilibrium of Bromthymol blue with added acid and added base $HC_{27}H_{27}Br_2O_5S \qquad H^{+1}_{(AQ)} + C_{27}H_{27}Br_2O_5S^{-1}_{(AQ)}$
80A	You neutralize 134 mL of 2.45 M $H_3PO_{4(AQ)}$ with 202 mL of $KOH_{(AQ)}$. What is the molarity of the base?
80B	A bottle of 2,012 mL of 4.00 M $NaOH_{(AQ)}$ 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.

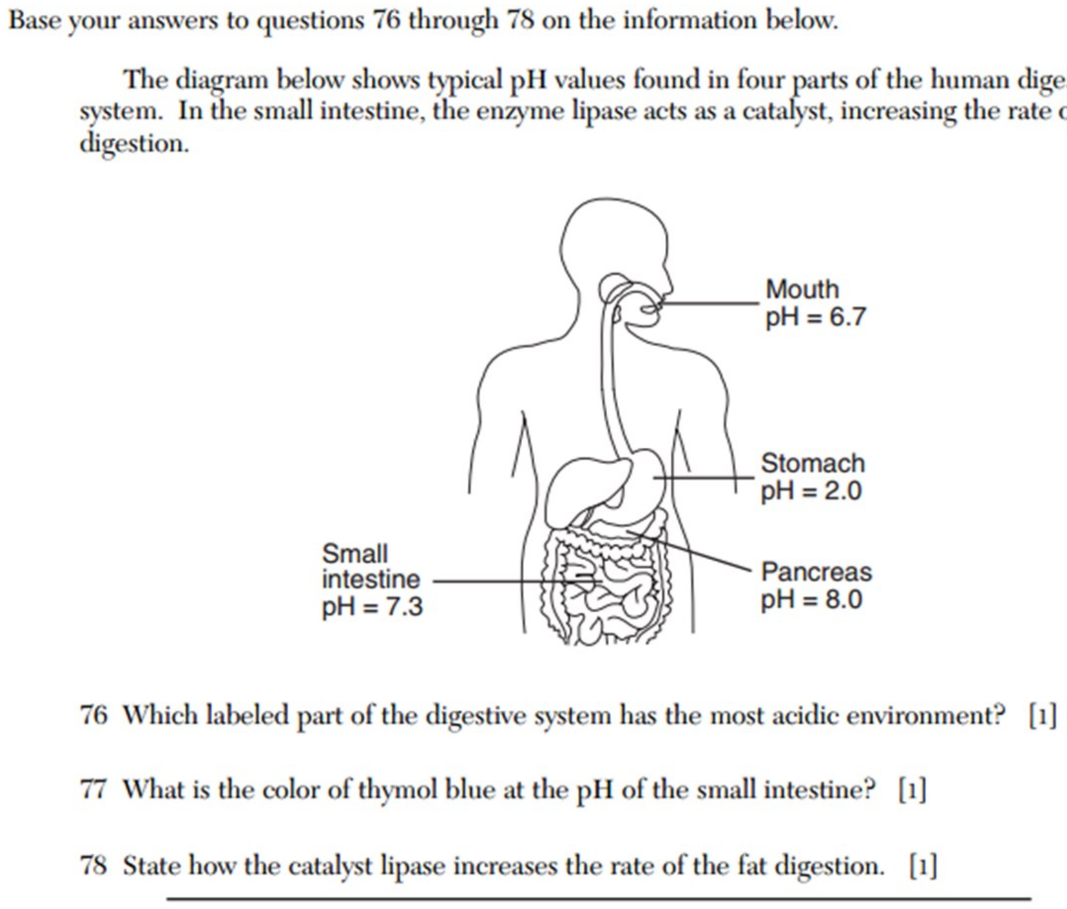
82	What is the pH of these 2 solutions? 1 x $10^{-6.5}$ moles H^{+1} ions/liter of solution. 1 x $10^{-11.3}$ moles H^{+1} ions/liter of solution.

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	$NH_{3(G)} + H_2O_{(L)}$ $NH_{4(AQ)}^{+1} + OH^{-1}_{(AQ)}$
89	Show the dissociation of Thymol Blue $HC_{27}H_{29}O_5S$ $H^{+1} + C_{27}H_{29}O_5S^{-1}$
90	Show the dissociation of Methyl Orange $HC_{14}H_{13}N_3NaO_3S$ $H^{+1} + C_{14}H_{13}N_3NaO_3S^{-1}$
91	The four ways to describe an acid are…
92	How many hydrogen ions are present per liter in a solution with a pH of 3.0? This is hard

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? [1]

77 What is the color of thymol blue at the pH of the small intestine? [1]

78 State how the catalyst lipase increases the rate of the fat digestion. [1]

Answers in this box

76

77

78

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