The BIG, BIG Picture About Acids and Bases

……. SO, to understand the whole thing you have to understand one simple idea and that is…-------

THINGS FALL APART

Now…. Things Fall Apart(1958) is a book by author Chinua Achebe you may encounter in an English class sometime in the future, or ….

It may neatly summarize <u>The Second Law of Thermodynamics</u> which states that:

"isolated systems spontaneously evolve toward thermodynamic equilibrium, the state of maximum <u>ENTROPY</u> !!!!"

ENTROPY defined in a non-scientific sense usually means:

"lack of order or predictability; gradual decline into Disorder",

Yet even in a more scientific context it still means loosely:

"*<u>the degree of disorder or randomness in the System</u>*"

IN OTHER WORDS:

Things Fall Apart !!!

EVERYTHING DOES.

YOUR ROOM FALLS INTO DISORDER EVERY TIME YOU CLEAN IT.

WE START AS A FERTILIZED EGG CELL, MULTIPLY, GROW AND DEVELOP INTO MATURITY, THEN WE AGE AND DIE.

THE GUITARIST JIMI HENDRIX CAPTURED IT NICELY WHEN HE SANG……

"…. And so Castles made of sand, fall in the sea, e-vent-u-ally"

EVERYTHING FALLS APART.

EVEN MOLECULES.

Especially Molecules !!!

SO…..

WATER MOLECULES FALL APART, ALL THE TIME, ON THEIR OWN, SPONTANEOUSLY

IT's KNOWN AS….

<u>THE AUTO-IONIZATION of WATER</u>

Or the

SELF-IONIZATION OF WATER

IT DOESN'T HAPPEN IN MASSIVE NUMBERS-

IF YOU HAD A GLASS OF WATER, MAYBE 5 or 6 WATER MOLECULES OUT OF 100 MILLION(or something like that) would actually be falling apart

THE COOL THING IS: We know EXACTLY HOW they break up. They always break up into TWO PIECES:

The Hydrogen part of the H_2O breaks apart and leaves it's single electron behind, becoming in the process….

H^+ (a Hydrogen Ion)

The other piece is the Oxygen and the other Hydrogen atom, along with the electron from The First One… becoming in the process…

OH^- (a Hydroxide ION aka Hydroxyl)

So if you are sitting there with a glass of water and there are trillions of water molecules in it(likely many more) and let's say 500 water molecules have auto-ionized, well……. You have nothing to worry about –

because you will have *exactly* 500 H^+'s and *exactly* 500 OH^-'s and that SITUATION, where you have exactly the same number of hydrogen ions as hydroxyls, THAT's what it means to be:

NEUTRAL !!

So we can say that the concentration of hydrogen ions is equal to the concentration of hydroxyls in this example.

…..Using the symbol [ ] as chemists do to represent "the CONCENTRATION of" we can write the EQUATION:

$$[H^+] = [OH^-]$$

And now we need to learn WHY when that equilibrium exists as above, we assign the value of "7" to it.

And to understand THAT, we need to talk about pH

MANY PEOPLE WILL TELL YOU WHAT pH actually stands for. Most are wrong. You will hear "Percent" Hydrogen and "Parts" Hydrogen, etc etc.

What it actually means is "Potenz" Hydrogen and "potenz" is a GERMAN word used first by a German chemist which translates loosely by most linguists as "power of".

S0…. It means Power of Hydrogen ????

NOT REALLY…..

It is an attempt to get some kind of quantitative measure of the relative amount of hydrogen ions compared to hydroxide ions in a solution.

WAIT A MINUTE…….!!!!

WE CAN MEASURE THIS STUFF???

YES !!

And we measure the number of hydrogen ions(or hydroxyls) as the <u>number of moles per Liter of solution</u>

……that is, mol/L **WAIT, WHAT?**

Isn't m/L a way of measuring concentration in Chemistry and isn't it called MOLARITY and isn't it symbolized by a capital M ??

Yes it is !

So, in a Liter of water do we know what the concentration of Hydrogen ions([H+]) actually is?

YES it is 0.0000001moles/Liter

Or we can say 0.0000001 M (right?)

Or we could use SCINOT and say <u>1.00 x 10^{-7} M</u>

<u>So in neutral water [H+] = 1.00 x 10^{-7} M</u>

Did he say 7 ??????

And most of the cells of living things on this planet have evolved with a biochemistry that pretty much works within a pretty tight range of that concentration of Hydrogen ions!!!!!!!!!!!!!!!!!!!

SO WHAT IS THE PROBLEM THEN:

The problem is this: you can throw stuff in water and it too can fall apart, it can break into separate ions, the polar ends of the water molecules you throw it into can break it up into IONS

OK then! And…….

Let's say the thing you throw in is made up of Hydrogen and something *other than an OH,* well now you have a problem, right?

IF you put HCl into water and it broke into H^+ and Cl^- then you would have essentially added

hydrogen ions to your solution without an off-setting hydroxyl and your concentration of H^+ would be much MORE than neutral water, maybe……. A LOT more!

LIKE MAYBE you would now have

$[H^+]$ = 0.01 moles per liter

Or

1.0×10^{-2} M

as compared to 0.0000001 M(1.00×10^{-7} M) as we had in neutral water

NOTICE: as the $[H^+]$ gets HIGHER, the exponent, a negative number, moves toward ZERO

On the other hand……

If we added something like NaOH to our glass of water, it would break apart into Na^+ and OH^- ; in other words, you would

be adding a LOT of OH^- without the corresponding H^+ 's to offset them

-in other words, your relative concentration of Hydroxyls would be going up and your concentration of Hydrogen would be getting SMALLER, real small……..

LIKE maybe….

0.000000000001 mol/L

Or… 1.00×10^{-12} M

So we can see a pattern here:

When: [H+] = [OH-] neutral = 10^{-7}

[H+] > [OH-] acid

[H+] < [OH-] base

…..so what is pH all about??

BECAUSE THE MOLARITIES ARE SUCH SMALL NUMBERS(like 0.000000000001), using SCIENTIFIC NOTATION is obviously a way to make life easier

BUT WHAT IF YOU WANTED TO MAKE IT REALLY SIMPLE, LIKE BEING ABLE TO EXPRESS THE CONCENTRATION OF HYDROGEN ATOMS AS A SIMPLE WHOLE NUMBER????????

Well… you could invent something called pH, right? YEP!!!

We will call it pH, and BY DEFINITION, it shall be: the negative logarithm of the hydrogen ion concentration

$pH = (-)\log[H^+]$

….where log refers to log10 which is that number which you raise 10 to in order to equal the given number:

FOR EXAMPLE:

log100= 2 because you would raise 10 to the 2^{nd} power to equal 100

log1000= 3 because you would raise 10 to the 3^{rd} power to equal 1000

OK but where is the negative sign coming from??

A TRICK TO MAKE THINGS EASY!!!

Because all of these Molarities are tiny, it's always going to have a negative exponent BUT by building the (-) into the

definition of your value, you can always measure the concentration of hydrogen ions and report it simply, and that is:

0----------7----------14

ACID Neutral BASE

CHECK YOUR UNDERSTANDING:

A pH of 7 means 1.00×10^{-7} M =[H+]

A pH of 13 means 1.00×10^{-13} M =[H+]

ANY TIME the Significand(??) is 1.00 all you have to do is take the (-) of the exponent to arrive at the value of the pH. IF THE SIGNIFICAND is other than 1.00, then you need a calculator as we will see later and in the homework!!!