بسم الله الرحمن الرحيم

BioChemistry | Lecture #3

pH and Buffers pt.1

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pH and buffers

Kw

- Kw is called the ion product for water

$$K_{eq}\,(55.5\ M) = [H^{\oplus}]\,[OH^{\ominus}]$$

$$K_w = [H^{\oplus}]\,[OH^{\ominus}] = 1.0 \times 10^{-14}\ M^2$$

TABLE 2.3 Relation of $[H^{\oplus}]$ and $[OH^{\ominus}]$ to pH

pH	$[H^{\oplus}]$ (M)	$[OH^{\ominus}]$ (M)
0	1	10^{-14}
1	10^{-1}	10^{-13}
2	10^{-2}	10^{-12}
3	10^{-3}	10^{-11}
4	10^{-4}	10^{-10}
5	10^{-5}	10^{-9}
6	10^{-6}	10^{-8}
7	10^{-7}	10^{-7}
8	10^{-8}	10^{-6}
9	10^{-9}	10^{-5}
10	10^{-10}	10^{-4}
11	10^{-11}	10^{-3}
12	10^{-12}	10^{-2}
13	10^{-13}	10^{-1}

Examples

- **Find the K_a of a 0.04 M weak acid HA whose $[H^+]$ is 1×10^{-4}?**
  - **$HA \rightleftharpoons H^+ + A^-$**
- **Ka = [A-] [H+] / [HA] = [H+]2 / [HA] = 10-4 x10-4 / 0.04 = 2.5 x 10-7**
- **What is the [H+] of a 0.05 M Ba(OH)2?**
  - **$Ba(OH)_2 \rightleftharpoons Ba + 2OH^-$**
- **[OH-] = 2x 0.05 = 0.10 M = 1 x 10-1**
- **[H+] = 1x 10-13**

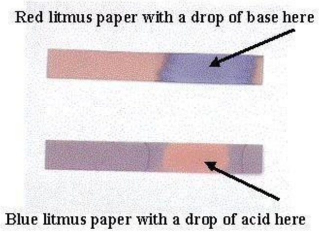
Always pay attention to the acid or base you are dealing with

The pH of Various Common Fluids	
Fluid	**pH**
Household lye	13.6
Bleach	12.6
Household ammonia	11.4
Milk of magnesia	10.3
Baking soda	8.4
Seawater	8.0
Pancreatic fluid	7.8–8.0
Blood plasma	7.4
Intracellular fluids	
Liver	6.9
Muscle	6.1
Saliva	6.6
Urine	5–8
Boric acid	5.0
Beer	4.5
Orange juice	4.3
Grapefruit juice	3.2
Vinegar	2.9
Soft drinks	2.8
Lemon juice	2.3
Gastric juice	1.2–3.0
Battery acid	0.35

What is ph?

$$pH = \log_{10}(1/[H^+]) = -\log_{10}[H^+]$$

- **Definition?**
- **Implications?**
- **Determination?**



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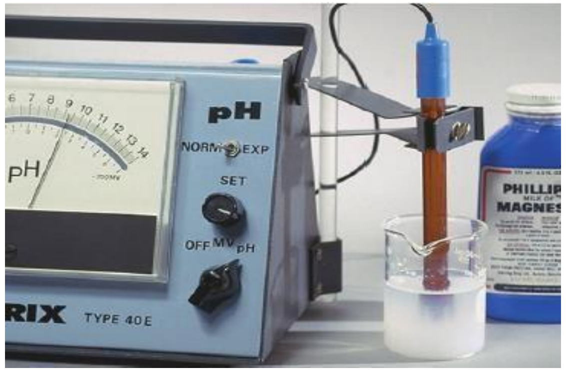
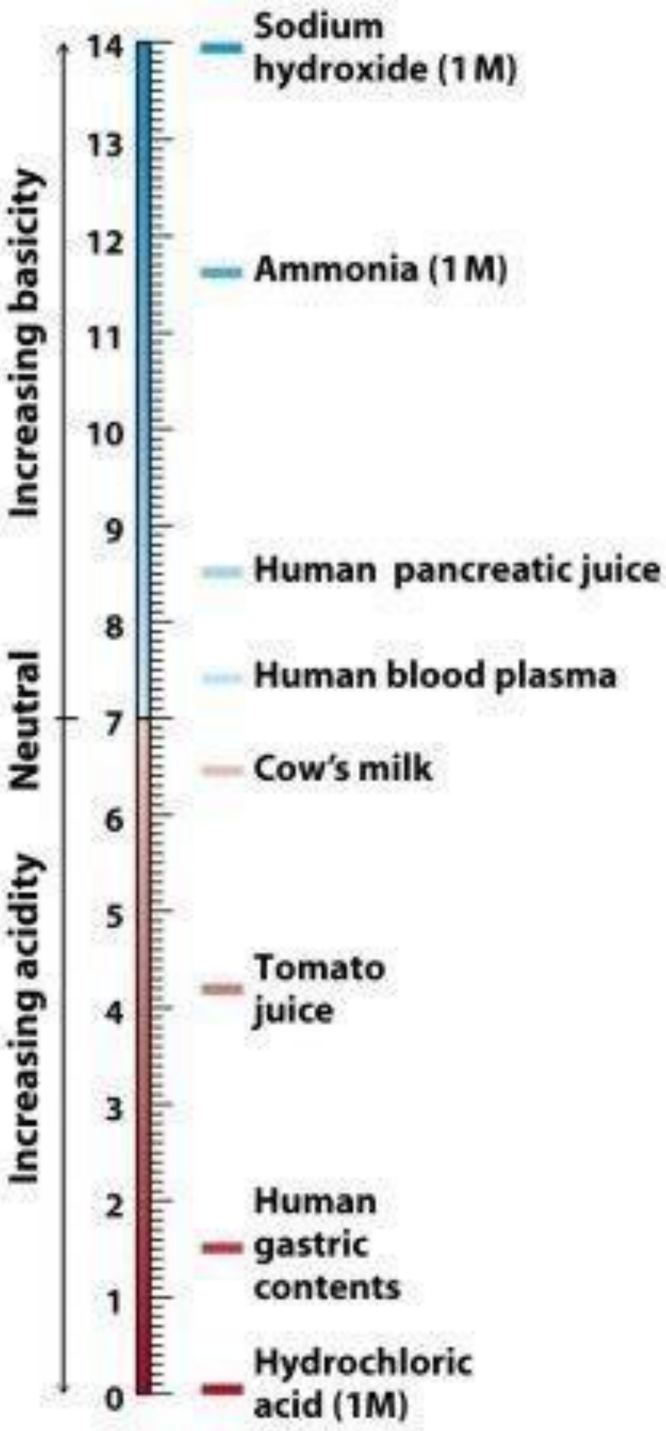
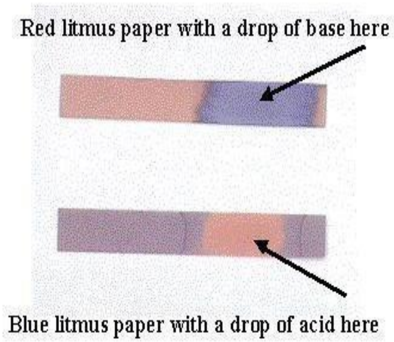




pH

Definition : It’s a logarithmic scale measuring the proton concentration in an aqueous solution.

In the past, special indicators were used to distinguish between acids and bases. However, nowadays, pH is used as a more precise concept by measuring the concentration of hydrogen ions in a solution using a specialized device equipped with two electrodes that detect proton concentration.



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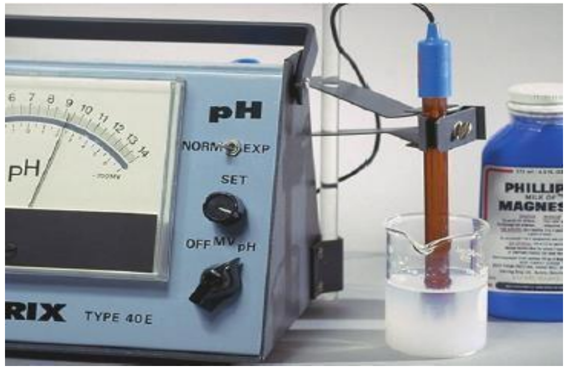

Why do we care about pH? Because the concentration of H^+ mainly affects proteins. Proteins have a three-dimensional structure maintained by various interactions, including ionic bonds. Since these ionic bonds depend on charge-charge interactions, any change in H^+ concentration can disrupt them, which alters the protein’s final shape and consequently affects its function.

Some enzymes are not affected by pH, as their final structure is not governed by the concentration of H^+.

Exercises

To calculate the pH, you first need to determine the concentration of H^+, which depends on the nature of the acid or base – whether it is strong or weak, monoprotic or polyprotic, or contains a single hydroxyl group or multiple ones.

- **What is the pH of**
- 0.01 M HCl?

$[HCl]=[H+]=0.01$

$pH=-\log(10^{-2})=2$

- 0.01 M H2SO4?

It's a strong acid so for simplicity we consider that it dissociates the 2 H+ all at once one after the other

$[H+]=0.02$

$pH=-\log(2x10^{-2})=1.699$

- 0.01 M NaOH?

And here we have 1 OH- which has the same concentration of the base, so we can calculate the concentration of the H+ in the solution

$pH=12$

- **What is the pH of**
- 1 x 10-11 M HCl? (<u>this is a tricky one</u>)

As this is considered a strong acid that dissociates completely giving us $[H+]=1x10^{-11}$
So when we want to calculate the pH using the law we learnt before the answer with be pH=11 and that doesn't make sense because this is an acid
So because we added a very slight amount HCl compared to the concentration of H+ in water (10^{-7}) so it doesn't really affect the pH causing a big change in it, that means that the main source of H+ is water so the answer will be just a little bit below 7 nearly 6.9

When adding a high concentration of acid for example 0.01 M of HCl-> $[H+]=1x10^{-2}$ we have 5 digits difference compared from the H+ coming from water ionisation so water effect can be disregarded

- **What is the pH of**
- 0.1 M of acetic acid (CH_3COOH)? Remember Ka

1.8 x 10 -5

This is a weak acid with a carboxylic group
For each H+ we have an A-
So we can calculate the concentration of H+ -> pH

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$Ka=[H+]^2\backslash[HA]$...

There are two things that control how much an acid gives H+ in a solution:

- The strength, ability of this acid to give protons which is defined by Ka, pKa
- The amount of H+ inside the solution itself that the acid is added to which is defined as the pH

If the solution have:

- High concentration of H+ -> protonated
- Low concentration of H+ -> deprotonated

Henderson-Hasselbalch Equation

- $HA \longleftrightarrow H^+ + A^-$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$[H^+] = \frac{Ka[HA]}{[A-]}$$

$$\log[H^+] = \mathrm{Log}K_a + \log\frac{[HA]}{[A-]}$$

If [A-] is higher than [HA] -> the logarithmic value will be + -> pH higher than pKa and vice versa

$$pH = pK_a - \log\frac{[HA]}{[A^-]}$$

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			

رسالة من الفريق العلمي:

إذا أهملت الصلاة، وهجرت القرآن، وغفلت عن ذكر الله، فانتظر الهم، والغم،والحُزن، والكدر، والقلق،لأن ذكر الله أمان، والغفلة عنه خذلان،هناك حقيقتان:"ألا بذكر الله تطمئن القلوب" ،"ومن أعرض عن ذكري فإن له معيشة ضنكا"

اللهم أعنّا على ذكرك، وشُكرك، وحُسن عبادتك.