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BIOCHEMISTRY

Faculty of medicine – JU2018

◉ Sheet ○ Slides

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بسم اللهِ الرَّحمن الرَّحيم

As a quick revision for what we have took earlier:

- Amphoteric substance: a substance that acts as an acid and a base. e.g: water.

- The stronger the acid, the weaker the conjugate base. (This rule for base as well.)

- Remember that:

pKa = -log ka

-The larger the Ka, the smaller the pKa, and vice versa.

-The lower the pKa, the stronger the acid, and the opposite is true.

Also remember:

Molarity= Moles/volume

1 equivalent of a strong acid contains 1 mol of H^+ ions, and 1 g-Eq of an acid is the mass in grams that contains 1 mol of H^+ ions.
(Same for base, but instead of H^+ ions we have OH^- ions)

N= n x M (where n is an integer determined by the base and acid)

PH= -log10 $[H^+]$

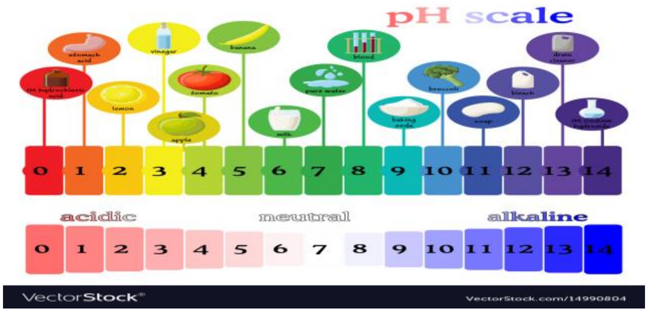
Now, take a breath and let's begin:

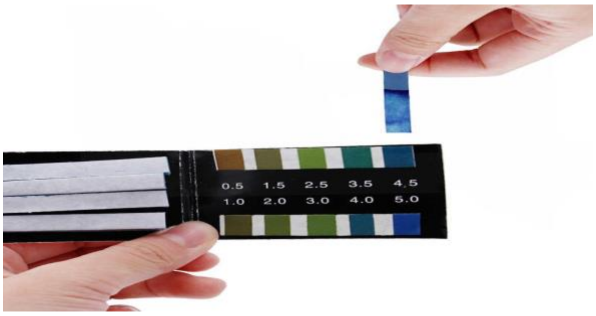
We talked about PH but we didn't discuss how we can measure it, so, we can measure the PH by two ways:

1)Acid-base indicator:

a- Litmus paper| ورقة عبّاد الشمس Which is the least accurate.

We use it to determine if it’s acidic or basic, but scientists have manufactured more accurate litmus paper, that can tell you what the PH almost exactly is. It gives you a scale with different colors. (It’s quite accurate).





And also there is a type of litmus paper, which uses the factor 0.5.

’’The colors of a pH strip correspond to pH ranges, not to a specific pH; usually, they read in increments of 0.5. Consequently, when you use pH paper, **you can't get an exact number**. If you need a definite number for the work you're doing, pH paper won't be very helpful. You can estimate the pH, but you'll have a high uncertainty value; pH meters, by contrast, will give you a more exact figure.’’

b- Universal indicator: ’’is a pH indicator made of a **solution** of several compounds that exhibits several smooth color changes over a wide range pH values to indicate the acidity or alkalinity of solutions.’’

Note: Dr.Mamoun didn’t mention so many details about the universal indicator.

2) Electronic PH meter (which is the most accurate).

Henderson-Hasselbalch equation:

$$pH = pK + \log\left(\frac{[A^-]}{[HA]}\right)$$

We use it when we want to know what is the relationship between the PH and the pKa.

Remember that, **PH** gives us an indication of how much protons are in a solution, and for that it gives us measurements. But **pKa** gives us the equilibrium of a strong acid (products/reactants), plus, showing us the strength of it → The lower the pKa, the stronger the acid is.

(Memorizing the equation definitely important, but the Derivatization of it absolutely not).

To explain the above, let's take acetic acid as an example. The acetic acid (CH_3COOH) a proton donator, but the acetate is the conjugate base of it with a negative charge (CH_3COO^-).

WAIT!

We explain every detail in the equation as a single one, but as a one equation, what it tells us?

➔ PH doesn't only depend on the concentration of the protons (as we took earlier), it also depends on the concentration of the conjugate base over the concentration of the acid.

So, when I can say that PH of an acid equal to the pKa of it?

➔ When the acid is half dissociated, half of it is in the acidic form, and the other is in the conjugate base form. (½ over ½) gives us 1, and the log 1, equals to 0, **so the PH equals to the pKa.**

ما كان تعبٌ إلّا و زال, مقابل دعاءٍ من مُتعَب كنتَ سببًا في راحته.

لو ملّيت, و ما لقيت سبب لتكمّل تذكّر كمّ متعَب ينتظرك, وكم ّتحتاج مِن الدعاء, لتنهض.

00:10:00 ↓

Every weak acid, and weak base is governed by an equilibrium, and the equilibrium means that there is a certain amount of reactants and products and they reach Ka. So as well as we have the Ka, we don't care about how much proton, acid, and conjugate base do we have.

Le Châtelier's principle(مبدأ انزياح التوازن) : Chemical principle that says → if a system in equilibrium is disturbed by changes in determining factors (such as concentration), the system will tend to shift its equilibrium position so as to counteract the effect of the disturbance.

مثلًا, كان عنّا (1و2 متفاعِلات, 3و4 نواتج) زدنا كمّية الناتج 4, شو رح يصير؟ رح يصير عنا انزياح لليسار, رح تزيد كميّة 1,2 و3, و4 رح تبقى تقريبًا ثابتة. والمهم المهم لو قسمنا النواتج على المتفاعلات يعطينا Ka.

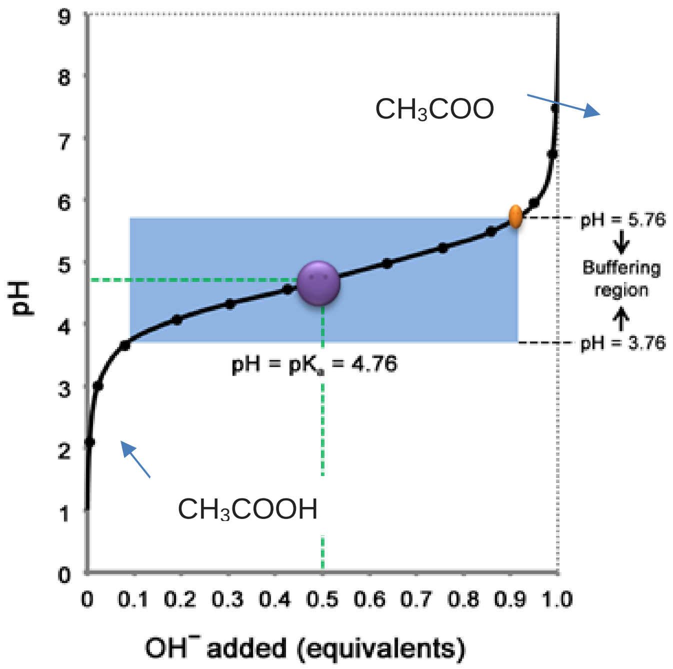
If we take water and acetic acid and make a comparison of changing in the PH when we add a base. we will notice that water's changing in PH goes up when we add strong base (e.g NaOH) and down when we add (OH^-), but if we take a look on the PH changing of acetic acid we will notice that the changing is low, and it's still almost constant. As a result, we call that **buffer**.

Buffer| مُنظّم : solution (basically weak acid or weak base) that resist changes in pH by changing reaction equilibrium. Contains at least two components (acidic form + conjugate base form, if we have more amount of one of them, we will have less amount from the other).

➔ يعني, تاكل الأخضر واليابس وتعطي برضو. تحط بروتونات بالتفاعل, تقوم هي تاخدهم, ما تحط بروتونات, تقوم معطية منها.

00:19:25 ↓

Titration curve of acetate buffer:



Note: This image isn't as that one in **slide 12**, but with the **same** concept and details.

It's made of two components:

1)Acetic acid

2)Conjugate base

And always we have a starting point, which is the mid one. (in purple), where we have **equivalent** of strong base of 0.5. Plus getting a point equal to (4.8), which we consider it as pKa, where we have concentration equality between the acid and the conjugate base, which means PH equals to pKa (depending on Henderson-Hasselbalch equation).

Q: Why we measure the added base in equivalents?
A:In this case, we are considering all three factors (volume, molarity and small n ''how many protons donated or accepted'')

-**Notice** that, when we add 0.5 equivalents of a base, we hit the pKa, which is the PH when the acid equals to its conjugate base.
Q: what will happen if we add more of strong base?
A: PH almost stays constant, it goes up by a little and increasing slowley, because of **resistance → from the buffer that resists any changes. → How it resists change? When we add a strong base, this strong base binds to the proton, the proton goes down, so the acid dissociates to the conjugate base plus proton, compensating (تعوّض) the loss of proton, maintaining the PH.**
WAIT!
Why does the PH goes up?
Because the PH depends on the concentration of proton, acid and conjugate base. (Remember Henderson-Hasselbalch equation), so if have a ratio;
1) 1:1 it means the log equals to zero.

2) 2:1 it means the log will be a fracture, so the PH=4.8+ the fracture.

→ Increasing the ratio→ Increasing the fracture→Increasing the PH.
(The opposite is also true).

-As we have a starting point, we have ending point also, Because the buffer has a capacity. When we add any additional strong base, the PH goes up (or down) fast, because of not having a buffer any more (the buffer has a range). **So we have a region called ''buffering region'', which is the same for all acids an bases and equal to:**

pKa for the strong acid or base + and - 1

So, to maintain any PH of a solution we want, it must be within the buffering capacity of the acid or base.

Q: If we want to maintain the PH of a solution to 5, can we use acetate buffer?
A: Yes we can, because the PH we want (5) it's within the buffering region which equals to (3.8, 5.8).

Q: What is the ratio on the mentioned orange point in the figure above?
A: 10:1

Q: what is the meaning of saying that pKa for acetate buffer equals to 4.8?

A: It means that acetic acid can acts as a buffer and resists any change in PH within the range of (3.8,5.8) → buffering capacity.

Must be noticed:

1) The ratio on the first end of the buffering capacity equals to 1:10
2) The ratio on the last end of the buffering capacity equals to 10:1
3) The ratio on the midpoint where the concentration of the acid, is as same as the concentration of the conjugate base equals to 1:1
4) The PH is affected not by proton only, but also by acid and conjugate base.

00:35:05 ↓

How do we make/choose a buffer?

we must ask ourselves, how much the PH of solution we want to maintain?

If we want it to be 5, the best buffer to use is acetate buffer, if we want it to be 7 the best buffer is phosphate buffer (the acid is: $H_2O_4P^-$, the base is HO_4P^{-2}).

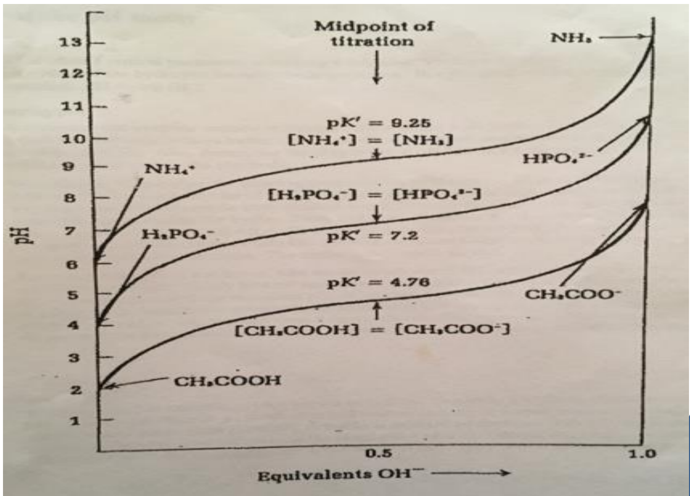
Remember that the ability of a buffer to function is:

1) Buffer concentration → it will **not affect** the buffering capacity, but it will **affect** the ability to resist the changing in the PH→ If you increase the concentration, the resistance will be increased because we have more base (or conjugate base) that will take or release protons, and the opposite is true).

2) Buffering capacity.

Q: Why the PH **suddenly** goes up (or down)?

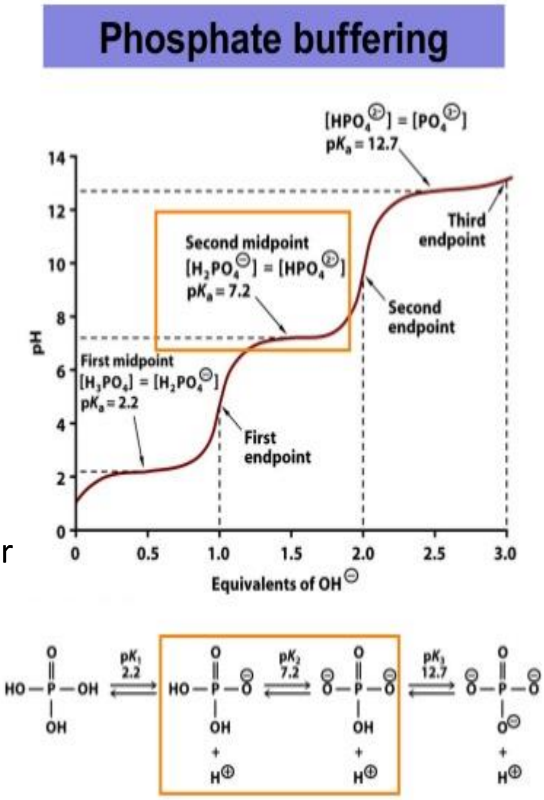
A: Because there isn't an enough amount of conjugate base and acid .



في كلّ مرّة تظنّ بأنّك لن تجتازَ ما تمرُّ به الآن, تذكّر كلّ الصّعاب السابقة, وكيف أنّ يد الله مسحَت على قلبك, وجعلَت من حاضرك الصعب, ماضيًا كان مُرًّا, ومَرَّ.

00:48:45

Titration curve of <u>phosphate</u> buffer:



We consider the phosphate buffer as a "multi-protic buffer'' which is solutions that can maintain PH of solution at <u>different ranges.</u> (e.g: phosphoric acid, carbonic acid).

-Every time the acid loses a proton, it will be harder to lose another one the next time.

-Remember the **buffering capacity**.

00:57:35

In our bodies we have also buffers, and they are really important, and they are different from each other.

1) Carbonic acid-bicarbonate system→ The predominant buffer in <u>blood</u>.

2) Dihydrogen phosphate-monohydrogen phosphate system (<u>intracellular)</u> → The best buffer inside the cells, because the PH is almost 7.

{ATP, glucose-6-phosphate, bisphsphoglycerate (RBC)}

3) Proteins are composed of different amino acids, and they have the ability to binding to a proton, or release it, because of that we have millions of amino acids inside every single cell. Examples:

a) Hemoglobin in blood.

b) Other proteins in blood and cells.

Here are the questions in the slides:

1) What is the pH of?

a) 0.01 M HCl?

b) 0.01 N H2 SO4?

c) 0.01 N NaOH?

d) 1 x 10-11 HCl? (this is a tricky one).

e) 0.1 M of acetic acid (CH3COOH)? Remember Ka

2) A solution of 0.1 M acetic acid and 0.2 M acetate ion. The pKa of acetic acid is 4.8. Hence, the pH of the solution is given by (4.8+log(0.2/0.1)=4.8+log 2.0=4.8+0.3=5.1)

3) a) A solution was prepared by dissolving 0.02 moles of acetic acid (HOAc; pKa = 4.8) in water to give 1 liter of solution. What is the pH?

b) To this solution was then added 0.008 moles of concentrated sodium hydroxide (NaOH). What is the new pH? (In this problem, you may ignore changes in volume due to the addition of NaOH).

4) Predict then calculate the pH of a buffer containing :

a) 0.1M HF and 0.12M NaF? (Ka = 3.5 x 10-4)

b) 0.1M HF and 0.1M NaF, when 0.02M HCl is added to the solution?

5) What is the pH of a lactate buffer that contain 75% lactic acid and 25% lactate? (pKa = 3.86)

6) What is the concentration of 5 ml of acetic acid knowing that 44.5 ml of 0.1 N of NaOH are needed to reach the end of the titration of acetic acid? Also, calculate the normality of acetic acid. (The number of equivalents of OH- required for complete neutralization is equal to the number of equivalents of hydrogen ion present as H+ and HA)

7) What is the pKa of a dihydrogen phosphate buffer when pH of 7.2 is obtained when 100 ml of 0.1 M NaH2PO4 is mixed with 100 ml of 0.1 M Na2HPO4 ?

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تذكَّر دومًا: أنّ "لكلِّ مجتهدٍ نصيب" وبما أنّ للعملةِ وجهان دائمًا, فهذا الوجه الأول، أما الآخر فهو التَتمّة. لكلّ مجتهدٍ نصيب، ولا مكانَ أو زمانَ أو هيئة لهذا النصيب. اليوم أو غدًا، في الدنيا أو الآخرة، هنا أو هناك، مع هذا أو ذاك, واجتهادُك ما كان أبدًا ليصيرَ هباءً منثورًا مع ربٍّ عادلٍ كريم, فنصيبُك سيصيبُك لا محالة. اطمئِن!

النهاية