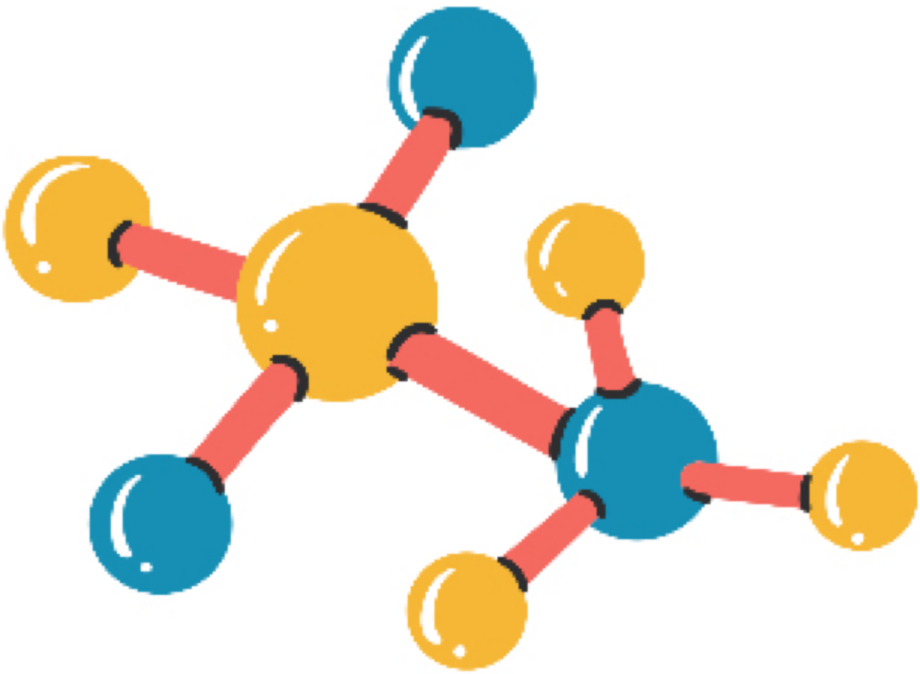
Sheet no.4

Biochemistry



Summer 2022

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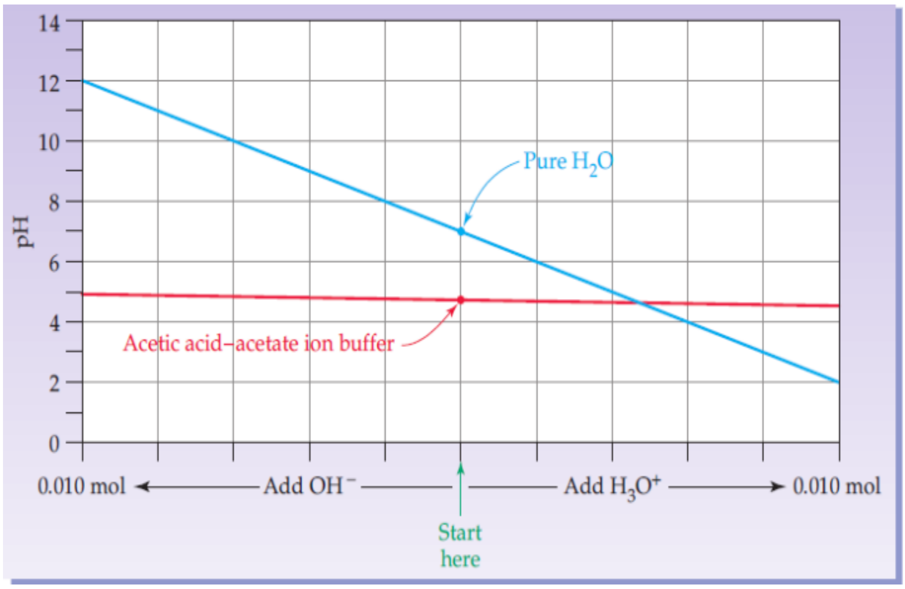
Note :

black for what is mentioned in the slides , Red for what doctor said ,other Color's for additional informations

comparison of the change in ph

(Water vs. acetic acid)

Our body contains a lot of fluids such as blood …. , then we need to maintain the ph levels to make sure that organs, enzymes and other components work at their normal levels , in the paragraph above we notice that water can't resist the changes of the ph , then we need to use another solution (material) to resist the changes of the ph , now can expect what buffers are ? (I just give an introduction)



What is a buffer?

Buffers are solutions that resist changes in pH by changing reaction equilibrium.

They are composed of mixtures of a weak acid and a roughly equal concentration of its conjugate base.

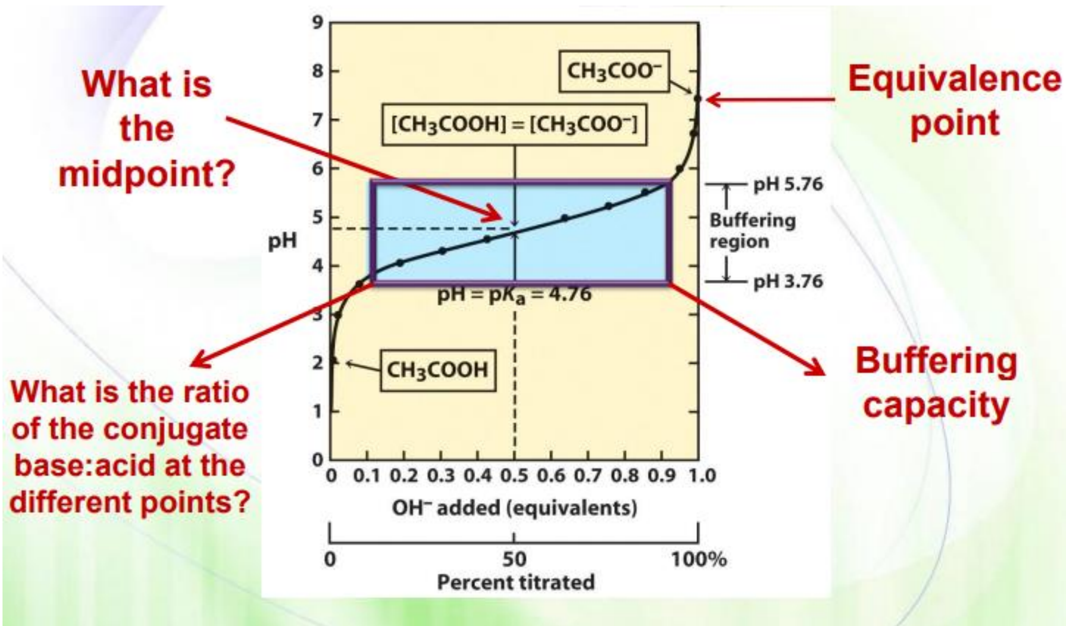
Conjugate base must be in a salt form , if we have the acetic acid CH3COOH then the conjugate base must be CH3COOH- , now the salt form of the conjugate base is CH3COONa , see the examples below

Acid	Conjugate base
CH_3COOH	CH_3COONa ($NaCH_3COO$)
H_3PO_4	NaH_2PO_4
H_2PO_4- (or NaH_2PO_4)	Na_2HPO_4
H_2CO_3	$NaHCO_3$

Which of the following pairs can't make a buffer mixture when mixed together

A.CH3COOH,CH3COONa B.NaOH,CH3COONa C.NH4+,NaNH3

Titration curve of the buffers



First thing look at the axises and what they represent , the x-axis represent the OH- added (equivalent) , y-axis represent the ph of the solution , then classify the acid to know how many equivalent you need for example diprotic acids need 2 equivalent of OH- and so on …..

In the beginning of the reaction CH3COOH dissociate in a small amount (small amounts of H+) , then if we add OH- the ph will increase dramatically then it will increase slowly then it will increase dramatically again

Mid point (flection point) : the point where the acid get 50% dissociated , in this point the concentration of the acid equal the concentration of the conjugate base then pka=ph at this point (before reaching the mid point the concentration of the conjugate base is less than the concentration of the acid then the pka is higher than ph) , the equivalent of the OH- at that point equal ,5 equivalent of the acid

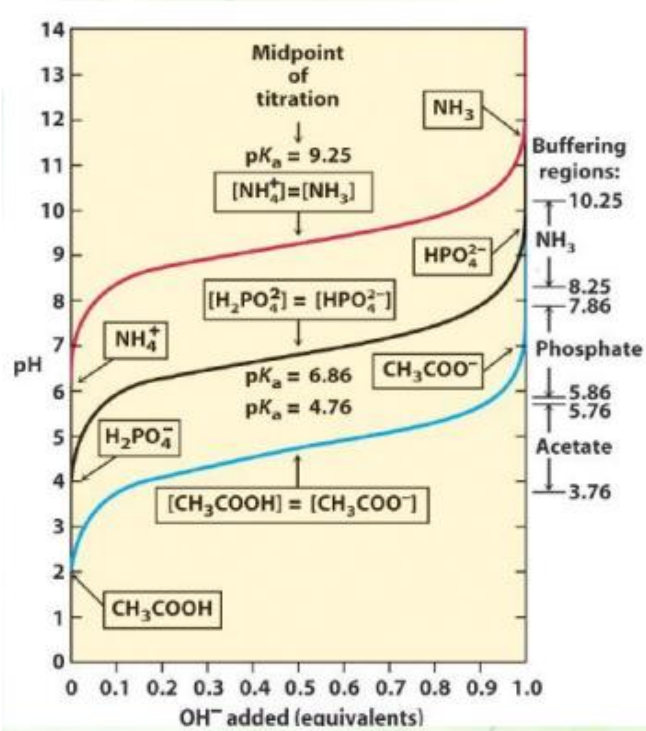
Buffering region [pka-1 , pka+1] (interval) , if we take a sample of the solution in this region then we can use it as a buffer , The buffering region is around the reflection point (1 unit above and 1 unit below).

Buffering depends on the pka of the acid , concentration of the acid , the percentage of the acid that had dissociated , for example if we want to get higher buffer capacity then we need to increase the concentration of the buffer solution then the concentration of the acid need to be increased , another example , if the ph that we want is 7,1 and the buffering range is [6,7] then we can add more acid to make the ph within the range

How do we make/choose a buffer?

- A buffer is made by combining weak acid/base and its salt.
- The ability of a buffer to function depends on:

1. Buffer concentration
2. Buffering capacity
3. pKa of the buffer (pka should be in The range of ph-1 or Ph+1)
4. The desired pH



From the curve we can know the strength Of the acids according to the values of the Pka at the mid point

If we have polyprotic acid then each H+ Will be donated at different pka , pka1 is The lowest pka

An exercise

- 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
  Ph = 4.8 + log(0.2/0.1) = 4.8+ log 2.0 = 4.8 +0.3 = 5.1

- Similarly, the pKa of an acid can be calculated

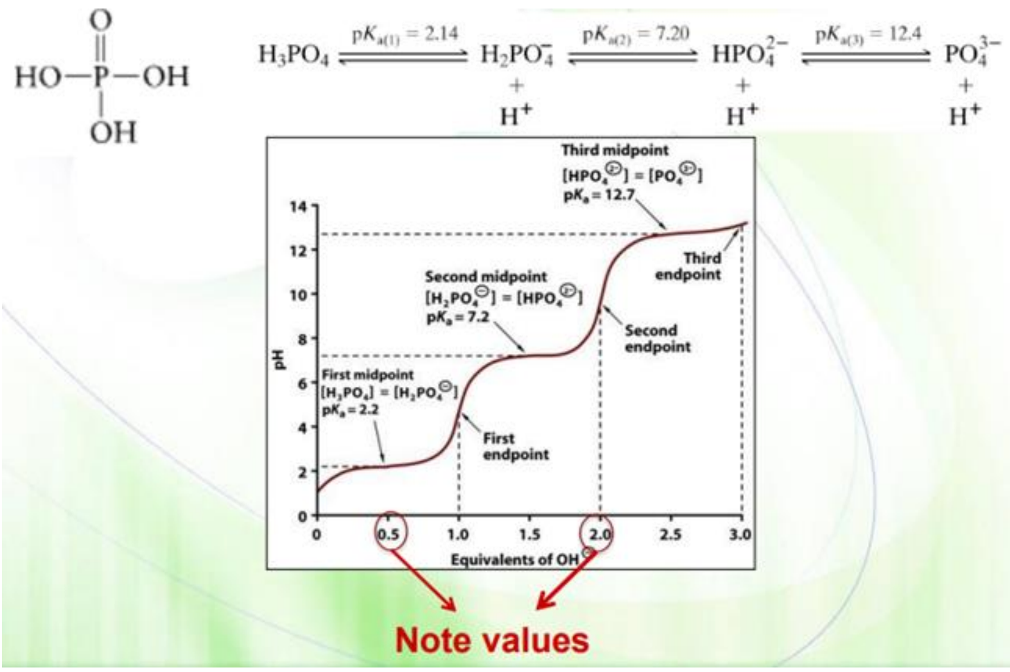
Exercises

- Predict then calculate the pH of a buffer containing
  - 0.1M HF and 0.12M NaF? (Ka = 3.5 x 10-4) (answer 3,53)
  - 0.1M HF and 0.1M NaF, when 0.02M HCl is added to the solution?
- What is the pH of a lactate buffer that contain 75% lactic acid and 25% lactate? (pKa = 3.86) (answer 3,382)
- What is the concentration of 5 ml of acetic acid knowing that 44.5 ml of 0.1 M of NaOH are needed to reach the end of the titration 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.

Solutions

- [F-]=[NaF]=,12M then ph=pka+log([F-]/[HF])=(4-log(3,5))=log(,12/,1)=3,53
- [F-] will increase ,02 and [HF] will decrease,02 then ph=pka+log([F-]/[HF])
  Ph=(4-log(3,5))+log((,1-,02)/(,1+,02))=3,279
- [acid]/[conjugate base] =75%/25% = 3 now ph = pka-log([acid]/[conjugate base])=3,86-log3=3,382
- Acetic acid is monoprotic acid then it has one equivalent, and NaOH has one equivalent, then N1=N2 , M1V1=M2V2 now
  M2V2=44,5ml*,1M=4,45mmoles , 4,45mmoles=M1V1
  4,45mmoles=M1*5ml then M1=,89

Titration curve of phosphate buffer



H3PO4 can donate 3H+ but each H+ will be donated in separated Steps , H3PO4 has 3 steps of titration

As we see we have 3 curves , each curve describe one step titration and has mid point and inflection points and others parts we mentioned in the previous curves , the first curve represent the titration of H3PO4 , the second represent the titration of H2PO4- , third curve represent the titration of HPO4-2

As we mention before , triprotic acid need 3 equivalent of OH- then phosphoric acid need 3 equivalent of OH-

At the mid point of the second curve the equivalent of OH- will be 1,5

At the first endpoint, no more H3PO4 is left over, as all molecules are converted toH2PO4 -

At the second end point, no more H2PO4 - is left as all molecules are converted HPO4-2

Same thing happens with the last endpoint with only PO4-3 molecules left

Exercises

- What is the pKa of a dihydrogen phosphate buffer when pH of 7.2 is obtained when 100 ml of 0.1 MNaH2PO4 is mixed with 100 ml of 0.1 M Na2HPO4 ?

  ph=pka+log([Na2HPO4]/[NaH2PO4])=7,2

- 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?

  M=N/V=,02 now sqrt(Ka*[acid])=[H3O+] then ph=3,4-log(sqrt2))=3,249

- 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) .

CH3COOH + NaOH -> CH3COONa + H2O
0,02 moles. 0,008 moles 0,008 moles
0,008 mole cosmued the N final = 0,02-0,008 = 0,012moles
PH = pKa + log ([salt]/[acid]) = 4,8 + log ((0,008/v)/(0,012/v)) = 4,62

Buffers in human body (biological buffers)

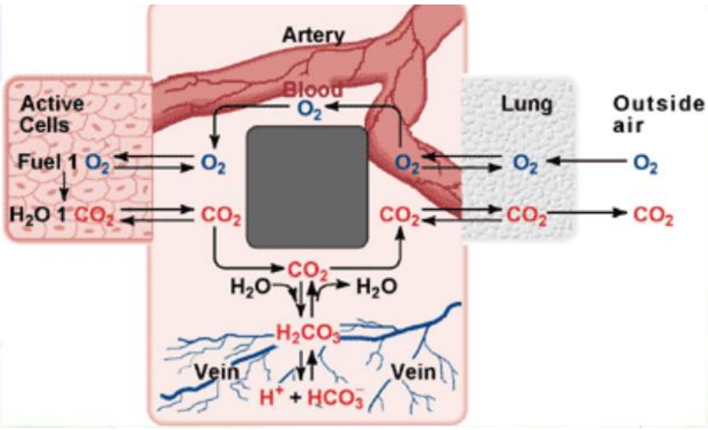
- Carbonic acid-bicarbonate system (blood)
- Dihydrogen phosphate-monohydrogen phosphate system (intracellular)
  - ATP, glucose-6-phosphate, bisphsphoglycerate (RBC)
- Proteins (extra- and intracellular) (why?)
  - Hemoglobin in blood
  - Other proteins in blood and cells
- Important: these biological buffers have a feature which is

these are open systems ,interfere with other systems in body.
so the basic of chemical buffers cant apply it
كما قالت الدكتورة.

- Any protein can act as a buffer regarding to the nature of the protein because protein has 3’ which is OH- and PO4-3 which can act as a buffers

- Main reason that the protein acts as a buffer because the amino acids Chains (at least one)

Bicarbonate buffer



$$CO_2(d) + H_2O \xrightleftharpoons{K_h} H_2CO_3$$
$$H_2CO_3 \xrightleftharpoons{K_a} H^+ + HCO_3^-$$

Any change in ph of blood may be fatal because it affects the CNS and may cause death. Regulation process :

CO2 reacts with water to produce H2CO3 which is rapidly breakup into HCO3- (carbonic acid) and proton .

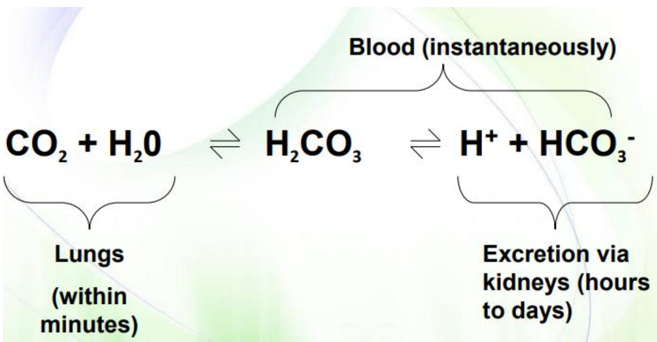
Bicarbonate buffer occur in the RBC (Red blood cells) not in the blood stream

Bicarbonate buffer and interaction with other systems

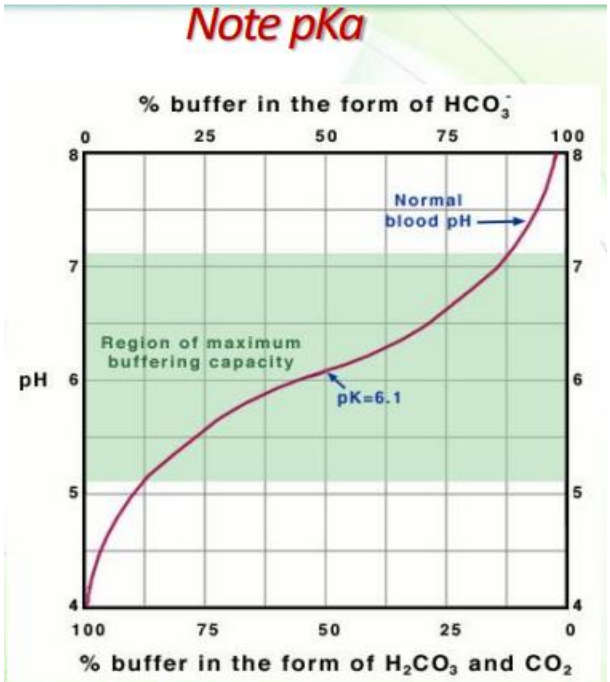
The Respiratory buffer system:

If the ph drops , here the lungs excrete CO2 (the acidity source) through exhalation (the breathing rate increases) , if the ph raises the lung kept CO2 by the slow rate of breathing.

The Renal buffer system :
If the ph drops , the kidney regulate it by reabsorption of HCO3- to increase the ph , vice versa.



Titration curve of bicarbonate buffer



When High concentrations of acids are added to blood, many molecules of H+ will be released into the blood, HCO3- will react with excess H+ forming H2CO3 which will be broken to H20 and CO2. Starting from here, the function of bicarbonate buffer system ends and the respiratory system (the collaborator) starts functioning by releasing CO2 ,hence keeping the CO2 levels low , preventing our body from converting CO2 back to acid. By this excess acid is removed. The renal system is also involved in regulating the pH, it does so by reabsorbing HCO - restoring reacted molecules

When high concentrations of bases are added to blood, many molecules of OH- will be released into the blood, H2CO3 will react with excess OH- producing salt (HCO3-) and water. However, concentration of H2CO3 decreases, thus respiratory system will accumulates CO2 in blood (respiration rate decreases) which will be converted back to acid, and the renal system will excrete more HCO3-.

As a conclusion we can say that

If the blood becomes more acidic (Concentration of H+ increases) the H+ reacts with HCO3- to form H2CO3 .

If the blood becomes more basic (Concentration of H+ decreases) the H2CO3 dissociate into H+ and HCO3-. This response is transient.

Why is the buffer effective?

- Even though the normal blood pH of 7.4 is outside the optimal buffering range of the bicarbonate buffer, which is 6.1, this buffer pair is important due to two properties:
  - bicarbonate is present in a relatively high concentration in the ECF (24mmol/L)
  - the components of the buffer system are effectively under physiological control: the CO2 by the lungs, and the bicarbonate by the kidneys
  - It is an open system (not a closed system like in laboratory)
  - An open system is a system that continuously interacts with its environment.

Acidosis and alkalosis

- Both pathological conditions can be either metabolic or respiratory.

- Acidosis (pH< 7.35)
  - Metabolic: production of ketone bodies (starvation) , uncontrolled diabetes (cells can't absorb the sugar from the blood , then the main source of the energy will be lipids and fats and as a result Keaton bodies will be activated and produced)
  - Respirator : pulmonary (asthma (problem in exhalation the CO2 kept inside and react to be H2CO3) , emphysema (less elasticity in alveoli then CO2 didn't exit)(causes from mutations or smoking))

- Alkalosis (pH > 7.45)
  - Metabolic: administration of salts (excess of salts that dissociate and gives a conjugate base)
  - Respiratory: hyperventilation (O2 didn't enter with enough amounts and CO2 decreased) (anxiety)