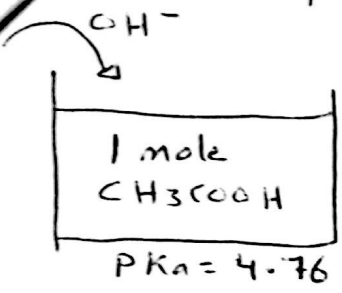


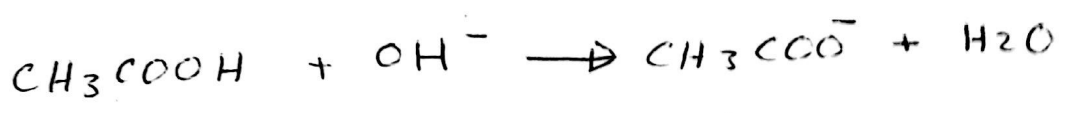
طريقة رسم مخطط احماسه تفاعله قويه على كحفر ضعيف  
 $\text{CH}_3\text{COOH}$   
 $\text{pKa} = 4.76$   
 $\text{NaOH}$   
 $\text{OH}^-$

دراسة تغيرات  
 PH  
 اثناء ذلك

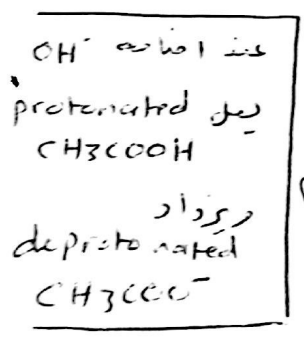


\* في البداية قبل احماسه  
 $\text{CH}_3\text{COOH}$   
 100%  
 protonated

\* عند احماسه  $\text{OH}^-$  تتفاعل مع  $\text{CH}_3\text{COOH}$  لتنتج  $\text{H}^+$



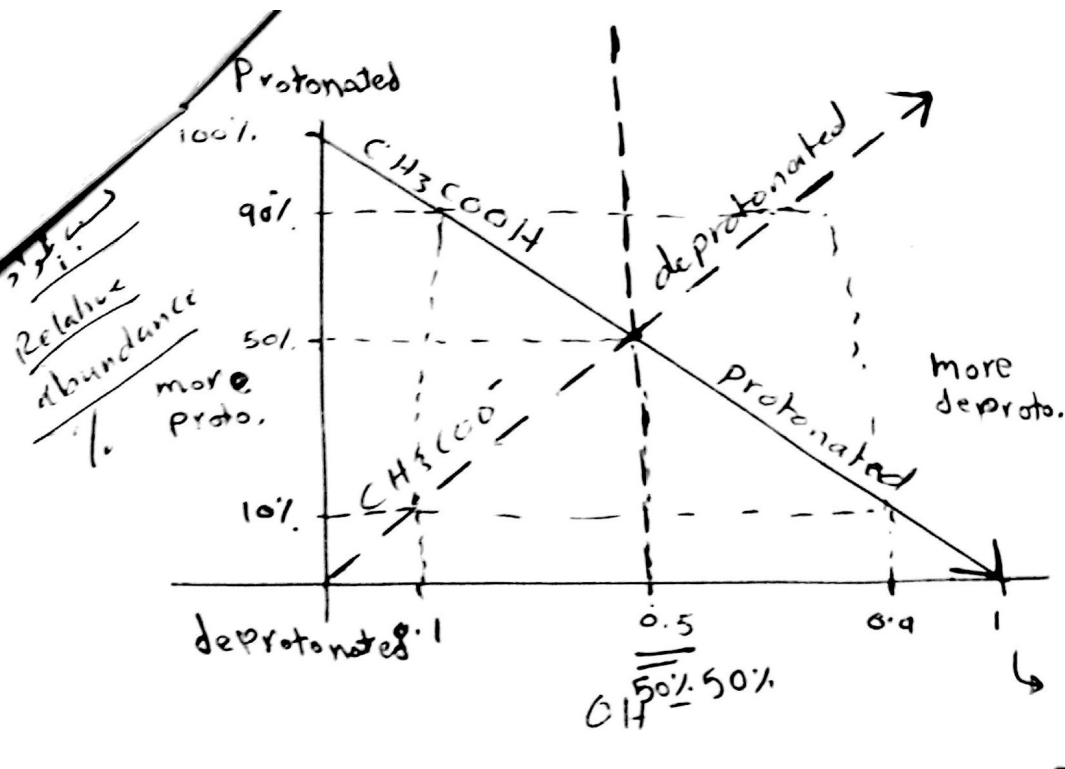
في البداية



0.9	تفاعل مع 0.1 $\text{CH}_3\text{COOH}$ يبقى	0.1	0.1	PH =
0.5	Protonated = deprotonated	0.5	0.5	
PH = pKa		0.9	0.9	
0.1		1	1	
Zero				

\* عند احماسه كمية  $\text{OH}^-$  مكافئه (مساوية) للمحمض

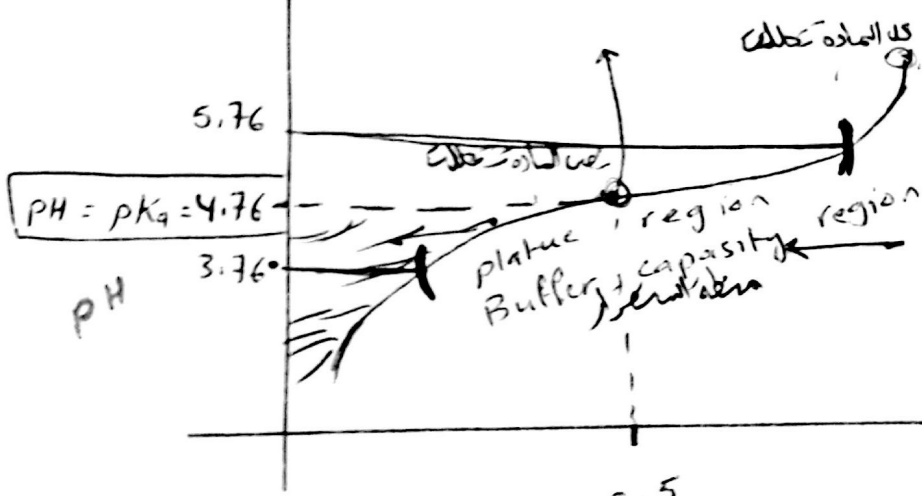
عندها كل الحمض يتحول ويصبح  
 deprotonated  
 $\text{CH}_3\text{COO}^-$



Inflection point نقطة انعطاف

- 1.  $CH_3COOH = CH_3COO^-$
- 2.  $pH = pK_a$

كل الكمية من كل المادة deprotonated "dissociated"



$pH = pK_a + 1$   
 $(3.76 - 5.76)$

$pH < pK_a$   
 $CH_3COOH$   
 more protonated

$pH > pK_a$   
 $CH_3COO^-$   
 more deprotonated

$pH > pK_a$  بس  $H^+$  اعلنت المادة تفقد

A mole of HA  $pK_a = 2$  is titrated  
 answer the following Qs?

a. when titrated with 0.3 mol NaOH

$$\text{moles of HA} = \underline{0.7} \text{ مولات}$$

$$\text{moles of } A^- = \underline{0.3} \text{ مولات}$$

b. what is the pH when titrating with

0.9 mol NaOH 0.9 mole NaOH react  
 with 0.9 mole HA

$$\text{HA مولات} = 0.1$$

$$\text{A}^- \text{ مولات} = 0.9$$

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

$$pH = 2 + \log \frac{0.9}{0.1}$$

c. what is the pH when titrating with

$$0.5 \text{ mol NaOH} \quad HA = 0.5$$

$$A^- = 0.5$$

$$pH = pK_a = 2$$

d. Buffer capacity region for this acid

$$\text{is } pH (1-3)$$

$$1 \leq pH \leq 3$$

المنطقة  
 الأكبر

e. at  $pH = 5$  most of this acid

will be

dissociated

HA

protonated

Base

undissociated

A<sup>-</sup>

deprotonated

Acid

HA is weak acid

$$pK_a = 3$$

what is  $\frac{A^-}{HA}$  deprotonated / protonated

PH=3  
= 50% 50%

$$(pK_a = 1)$$

a. PH = 2

$$PH = pK_a + \log \frac{A^-}{HA}$$

$$2 = 3 + \log \frac{A^-}{HA}$$

$$-1 = \log \frac{A^-}{HA}$$

$$\frac{A^-}{HA} = \frac{1}{10} \approx 90\% \text{ protonated}$$

b. PH = 1 (pKa = 2)

$$\frac{A^-}{HA} = \frac{1}{100} \approx 99\% \text{ protonated}$$

c. PH = zero (pKa = 3)

$$\frac{A^-}{HA} = \frac{1}{1000} \approx 99.9\% \text{ protonated}$$

d. PH = 4 (pKa = 1)

$$\frac{A^-}{HA} = 10 = \frac{10}{1} \approx 90\% \text{ deprotonated}$$

e. PH = 5 (pKa = 2)

$$\frac{A^-}{HA} = 100 = \frac{100}{1} \approx 99\% \text{ deprotonated}$$

f. PH = 6 (pKa = 3)

$$\frac{A^-}{HA} = 1000 = \frac{1000}{1} \approx 99.9\% \text{ deprotonated}$$

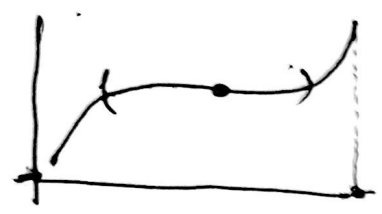
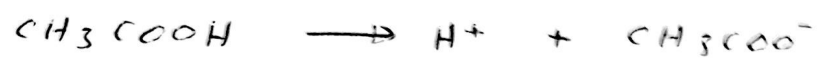
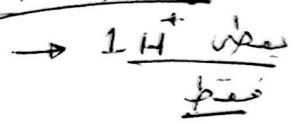
pH	$A^- / HA$ ratio
$pH = pK_a - 3$	1/1000 (99.9% HA) ١٥٣٤
$pH = pK_a - 2$	1/100 (99% HA) ١٥٣
$pH = pK_a - 1$	1/10 (90% HA) ١٥
$pH = pK_a$	1/1 (50% HA, 50% $A^-$ )
$pH = pK_a + 1$	10/1 (90% $A^-$ ) ١٥
$pH = pK_a + 2$	100/1 (99% $A^-$ ) ١٥٣
$pH = pK_a + 3$	1000/1 (99.9% $A^-$ ) ١٥٣٤

Q: HA is a weak acid,  $pK_a = 5$ , at what pH 90% of the acid <sup>تفكك ← فقد  $H^+$</sup>  dissociate?

$$pH = 6$$

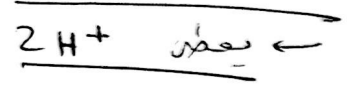
3 Types of acids in term of dissociation

Monoprotic acid

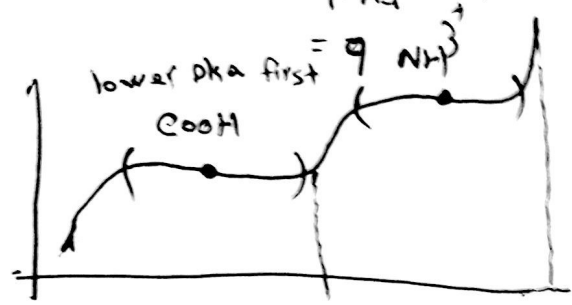
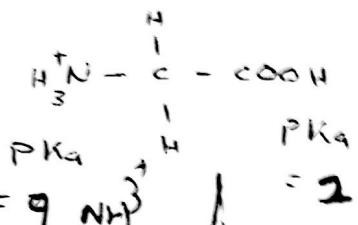


- 1 pKa
- 1 titration curve
- 1 inflection point
- 1 Buffer region
- 1  $OH^-$  equivalent needed
- 1 mol = 1 mol

2. Diprotic acid

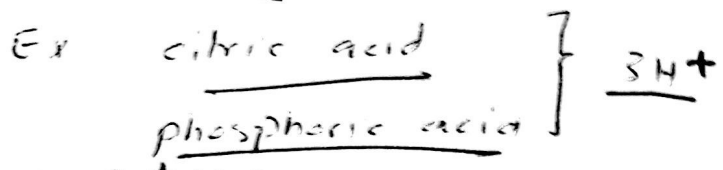
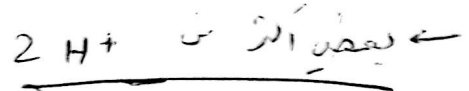


Ex: Glycine

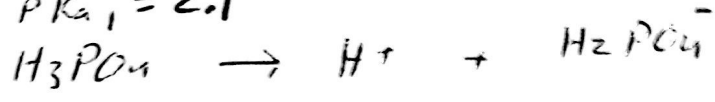


- 2 pKa
- 2 titration curves
- 2 inflection points
- 2 Buffer regions
- 2  $OH^-$  equivalent needed
- 1 mol = 2 mol

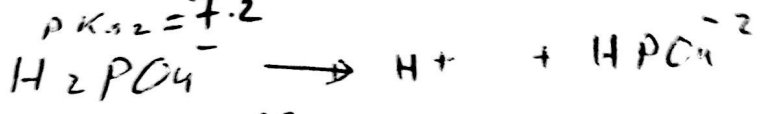
3. Polyprotic acids



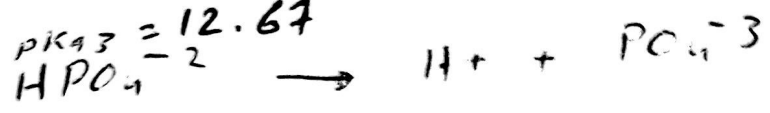
can lose up to  $3 H^+$   $H_3PO_4$   
 $PK_{a1} = 2.1$



$PK_{a2} = 7.2$



$PK_{a3} = 12.67$



- 3
- 3
- 3
- 3
- 3

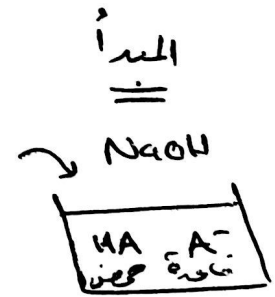
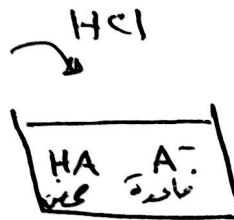
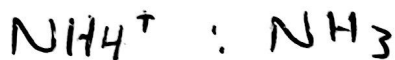
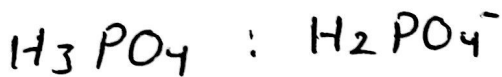
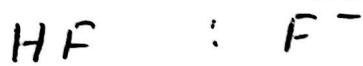
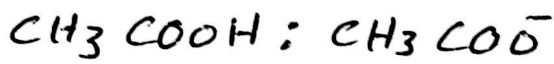
amino-acids and peptides are diprotic and polyprotic acids

المحاليل  
الكهربية

Solutions of weak acid and its conj base  
HA protonated A- deprotonated

تقاوم  
Resist changes in pH when Small amounts  
of strong acids (HCl) or strong Bases (NaOH)  
is added.

Ex:-



تفاعل مع  
HA  
وتتعاول

تفاعل مع  
HA  
وتتعاول

Henderson-Hasselbach  
equation

معادلة Buffer

$$pH = pKa + \log \frac{\text{deprot}}{\text{prot}}$$

# Buffers Work ?

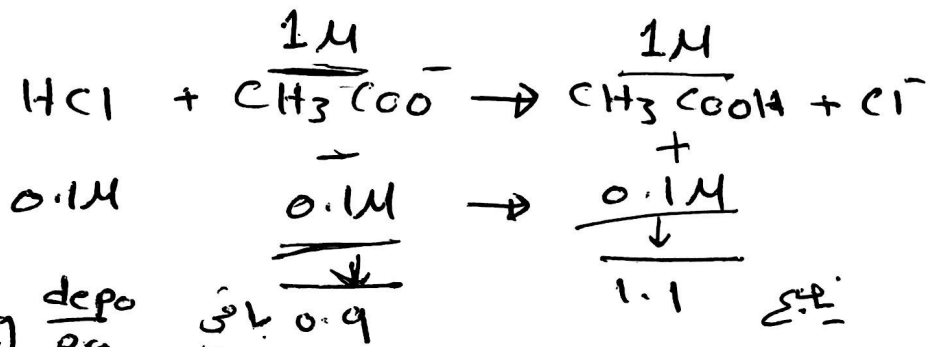
a buffer solution contain 1M of  $\text{CH}_3\text{COOH}$   
 $\text{pK}_a = 4.76$  and 1M of  $\text{CH}_3\text{COO}^-$  ?

① what is the pH of this solution ?

$$\text{pH} = \text{pK}_a = 4.76$$

② what is the pH when adding 0.1M HCl ?

HCl هو  
 قوي يتفاعل مع القاعدة  
 $\text{CH}_3\text{COO}^-$



$$\text{pH} = \text{pK}_a + \log \frac{\text{depro}}{\text{prot}}$$

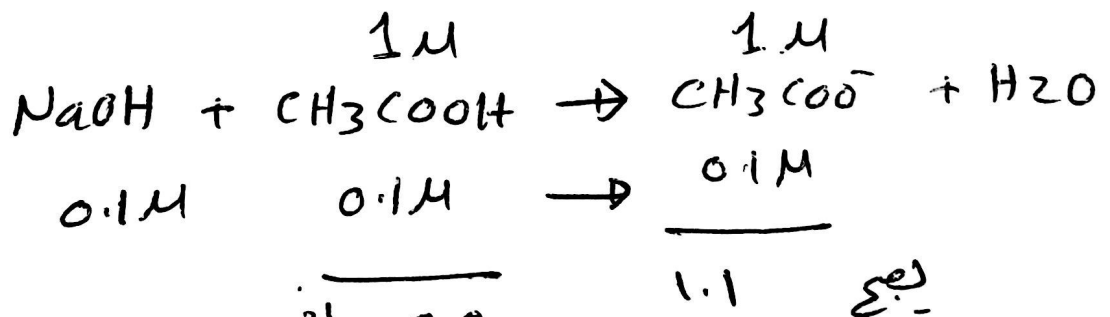
$$\text{pH} = 4.76 + \log \frac{0.9}{1.1}$$

$$\text{pH} = 4.67$$

عند إضافة حمض هيدروكلوريك HCl  
 تزداد الحمض prot  
 تقل القاعدة depro

③ what is the pH when adding 0.1M NaOH ?

NaOH قاعدة قوية تفاعل  
 مع الحمض prot



$$\text{pH} = \text{pK}_a + \log \frac{\text{depro}}{\text{prot}}$$

$$\text{pH} = 4.76 + \log \frac{1.1}{0.9}$$

$$\text{pH} = 4.84$$

عند إضافة قاعدة صوية NaOH  
 تزداد القاعدة depro  
 تقل الحمض prot

(2)



①  $\frac{A^-}{HA}$  ratio

[ Maximum buffer Capacity  
when  $\frac{A^-}{HA} = \frac{1}{1}$  ,  $pH = pK_a$  ]

Remember: Buffer capacity region

$pH = (pK_a - 1 - pK_a + 1)$

② amount of Both  $A^-$  and  $HA$

$HA : A^-$

5	5	1:1	low Buffer Capacity
<u>100</u>	<u>100</u>	1:1	<u>High Buffer Capacity</u>

Q: which of the following Buffers has the maximum buffering capacity at  $pH = 5$ ?

- a. Buffer A  $pK_a = 2.1$
- b. Buffer B  $pK_a = 4.705$
- c. Buffer C  $pK_a = 5.4$
- d. Buffer D  $pK_a = 7.1$

(9)

the following table, then answer  
following Questions:

Buffer	$pK_{a1}$	$pK_{a2}$	$pK_{a3}$
acetic acid	4.75		
Ammonia ( $NH_4^+$ )	9.25		
Carbonic acid $H_2CO_3$	6.37	10.2	
Citric acid	3.09	4.75	5.41
Formic acid	3.75		
phosphoric acid $H_3PO_4$	2.14	7.2	12.4
Pyruvic acid	2.5		
Tris	8.3		

Q: lysozyme has an optimum pH close to 5,

A suitable Buffer would be:-

- A. Acetate
- B. Carbonate
- C. phosphate
- D. Pyruvate

Q: which of the following make the best buffer at pH=10

- A. Acetic acid and Sodium acetate
- B. Tris
- C.  $H_2CO_3$  and  $NaHCO_3$
- D.  $NaH_2PO_4$  and  $Na_2HPO_4$
- E.  $NaHCO_3$  and  $Na_2CO_3$

Q: the ammonium buffer would work well at this pH

- a. 5.6
- b. 7.0
- c. 9.0
- d. 11.0

Physiological Buffers (In Vivo) ←

phosphate Buffer  $H_2PO_4^- / HPO_4^{2-}$   $pK_a = 7.2$   
the main buffer inside the cell  
(Intracellular)

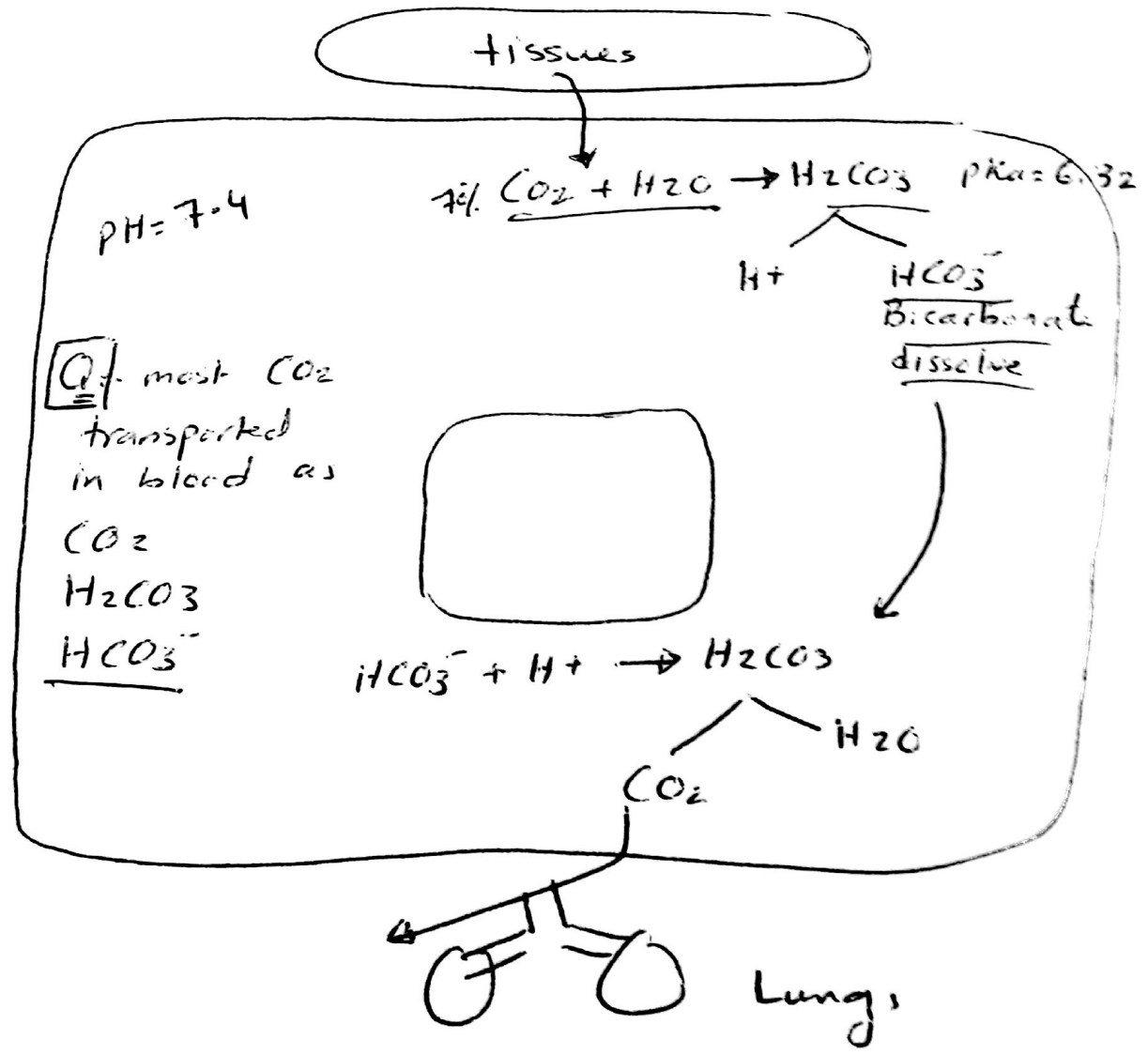
② Carbonic acid Buffer

$H_2CO_3 / HCO_3^-$   $pK_a = 6.32$

the main <sup>bicarbonate</sup> Buffer in Blood

PH blood = 7.4

Produced from CO<sub>2</sub>



# Buffers (in vitro)

خارج  
الخلية

phosphate buffer.

② TRIS

③ Zwitter ion buffers (have + and - charges)

include TES

HEPES

MOPS

PIPES

② + ③ are less likely to interfere with  
biochemical reactions.