

## Ch 2-3 Questions

1- How many equivalents of strong base are required to completely titrate fully protonated lysine -glutamic acid-arginine tripeptide?

- A- 5
- B- 7
- C- 2
- D- 3

Ans: A

2- For the reaction:  $\text{CO}_2 + \text{H}_2\text{O} \leftrightarrow \text{HCO}_3^- + \text{H}^+$ , at high  $\text{HCO}_3^-$ :

- A- the pH will decrease.
- B- the pKa will decrease.
- C- the pH will increase.
- D- the Pka will increase.
- E- the ratio  $\text{HCO}_3^- / \text{CO}_2$  will decrease.

Ans: C

3- Which of the following amino acids, if it is at the C-terminal end of a polypeptide, would contribute zero charges at a pH of 9?

- A- Cysteine
- B- Lysine
- C- Cystine
- D- Serine
- E- Valine

Ans: B

4- The peptide: glutamic acid-aspartic acid-glutamic acid-glycine-glutamine-arginine-proline". (pKa values to assume for amino acids – alpha amine = 9, alpha carboxyl = 2.0, R-group amine = 12, 10.5, 6.5, R-group carboxyl = 4.0,) then it:

- A- Carries positive charge at pH= 9
- B- Carries no net charge at pH= 3
- C- Carries positive charge at pH=7
- D- Carries a negative charge at pH=7
- E- Carries negative charge at all pH values

Ans: D

5- A protein of isoelectric point, 8.4:

- A- Contains more acidic than basic residues
- B- Has a net positive charge at pH 12
- C- Has no net charge at physiological PH
- D- Contains more basic than acidic residues

Ans: D

6- Calculate the PI of : Aspartic acid-arginine - valine. (pKa values to assume for amino acids – alpha amine = 9, alpha carboxyl = 2.0, R-group amine = 12, 10.5, 6.5, R-group carboxyl = 4.0, R-group sulfhydryl = 8)

- A- 3
- B- 6.5
- C- 10.5
- D- 2

Ans: B

7- How many moles of strong base are required to titrate 100 ml of 0.2 M fully protonated aspartic acid?

- A- 0.08
- B- 0.06
- C- 0.8
- D- 0.6

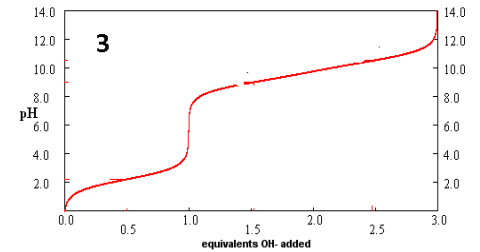
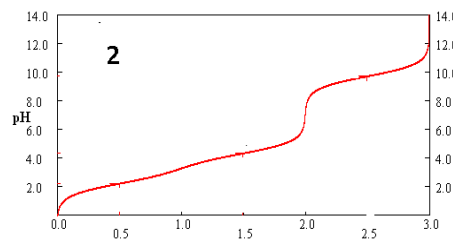
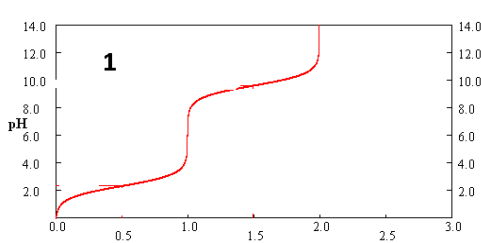
Ans: B

8- In the resonance structure of the peptide bond, the double bond is located between:

- A- alpha carbon and amino nitrogen
- B- carboxylic carbon and oxygen of carbonyl
- C- carboxylic carbon and nitrogen

Ans: B

9- Which one of the following figure(s) represent a titration curve for aspartic acid?



- A- 1
- B- 2
- C- 3
- D- 2 & 3

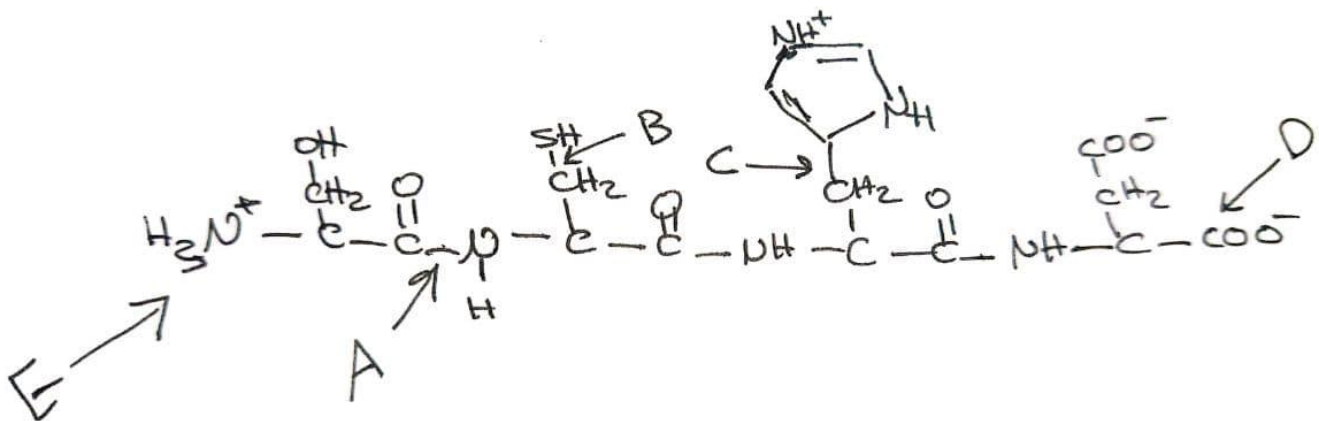
Ans: B

10- Which of the following match buffer solution:

- A- Consists of a mixture of a weak acid and its conjugate base
- B- Can resist change in pH when small to moderate amounts of weak acid or weak base is added
- C- Can resist change in pH when large amounts of strong acid or strong base are added
- D- Consists of a mixture of a strong acid & its conjugate base
- E- Can resist change in pH when small to moderate amounts of weak acid or strong base are added

Ans: A

Refer to this figure for questions 11-21



11- It is a tetrapeptide containing 4 peptide bonds:

- A- True
- B- False

Ans: B

12- E , A & D represent N terminus, peptide bond & C terminus respectively:

- A- True
- B- False

Ans: A

13- The third AA, at physiological pH, its R group is neutral:

- A- True

B- False

Ans: A

14- Calculate the pI, if you know that pKa values for: alpha COOH=2/ alpha NH<sub>3</sub><sup>+</sup>=9/basic R group= 6, 10.5 , 12.5 / Acidic R group= 3.65, 4.25 / phenol group=10/ sulfhydryl group=8.

A- 4.8

B- 7

C- 2.8

D- 8.5

Ans: A

15- It has a net -2 charge at pH:

A- 8

B- 8.4

C- 9

D- 12

Ans: B

16- It has a net positive charge at pH:

A- 1

B- 3

C- 8

D- A+B

Ans: D

17- It can be subjected to phosphorylation:

A- True

B- False

Ans: A

18- If we have 2 of this tetrapeptide, then we can have a disulfide bond:

A- True

B- False

Ans: A

19- you need a 50 ml \_\_\_\_ M of NaOH to neutralize 30 ml of 6M of that tetrapeptide:

A- 11.4

B- 6

C- 14.4

D- 18

Ans: D

20- You need \_\_\_\_ equivalent of OH<sup>-</sup> to reach pH=4.8:

A- 2

B- 1.5

C- 2.5

D- 4

Ans: A

21- At the midpoint of a titration curve

A- The concentration of a conjugate base is equal to the concentration of a weak acid

B- pH=pKa

C- the ability of the solution to buffer is best

D- all of the above

Ans: D

22- The order in which amino acids are linked in peptides is given:

A- In alphabetical order

- B- From C terminal to the N terminal end
- C- In order of increasing molecular weights of the amino acids residues
- D- From the N terminal to the C terminal end

**Ans: D**

**23- L-alanine & D-alanine are:**

- A- Non superimposable mirror image
- B- Enantiomers
- C- A+B
- D- Superimposable mirror image

**Ans: C**

**24- Considering a 0.1 M acid buffer (HA/A<sup>-</sup>). What is the concentration of the acid present in a solution of pH 4.25, if the pK<sub>a</sub> of the acid is 3.75**

- A- 0.024 M
- B- 0.076 M
- C- 0.033 M
- D- 0.067 M

**Ans: A**

**25- Which one of the following would be the strongest acid:**

- A- Succinic acid (diprotic) with pK=4.21 & 5.64
- B- Acetic acid with pK=4.76
- C- Formic acid with pK=3.75
- D- Ammonium ion with pK=9.25

**Ans: C**

**26- Based upon its side chain, how is the AA ser classified?**

- A- Polar
- B- +ve charged
- C- -ve charged
- D- Non-polar

**Ans: A**

**27- Which group consists only of AAs with polar R group?**

- A- Ser, Thr & Cys
- B- Ser, Thr & Leu
- C- Ser, Thr & Ile
- D- Ser, Thr & Val

**Ans: A**

**28- What is the charge on the tetrapeptide: Lys-lys-his-glu at pH=7? Back to pK table in L2**

- A- -1
- B- +1
- C- +2
- D- 0

**Ans: B**

**29- Which AA would have the greatest negative charge at pH=7?**

- A- His
- B- Glu
- C- Ser
- D- Tyr

**Ans: B**

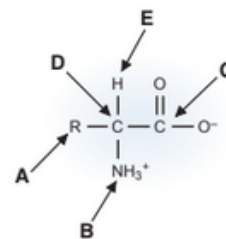
**30- The inflection point of the titration curve for a weak monoprotic acid is equal to pK<sub>a</sub>?**

- A- True

B- False

Ans: A

- 31- Consider the amino acid shown below. The configuration about which atom (labeled A through E) will determine whether the amino acid is in the D or L configuration?



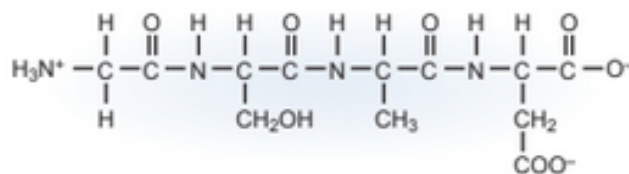
Ans: D

- 32- The protein albumin is a major buffer of the pH in the blood, which is normally kept between 7.2 and 7.4. Which of the following is an amino acid side chain of albumin that participates in this buffering range?

- A- His
- B- Arg
- C- Glu
- D- Lys
- E- Asp

Ans: A

- 33- Consider the following structure: This structure is best described as which of the following?



- A- An amino acid
- B- A tripeptide
- C- A tetrapeptide
- D- A lipid
- E- A carbohydrate

Ans: C

- 34- A drug contains one ionizable group, a weak base with a pKa of 9.0. The drug enters cells via free diffusion through the membrane in its uncharged form. This will occur most readily at which of the following pH values?

- A- 3.5
- B- 5.5
- C- 7.0
- D- 7.6
- E- 9.2

Ans: E

- 35- What is the pH of solution contains  $[\text{OH}^-] = 10^{-5}\text{M}$ :

- A- 5
- B- 9
- C- 14
- D- Cannot be calculated

Ans: B

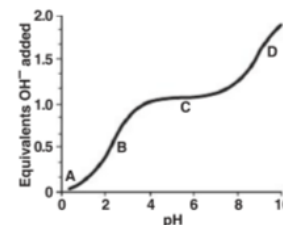
- 36- If you know that phosphoric acid ( $\text{H}_3\text{PO}_4$ ) pK values are: 2.15, 6.82, 12.38. the form that will be found at pH=4 is ....., while at pH 13 is ..... Respectively.

- A-  $\text{H}_2\text{PO}_4^- / \text{HPO}_4^{2-}$
- B-  $\text{HPO}_4^{2-} / \text{H}_2\text{PO}_4^-$
- C-  $\text{H}_3\text{PO}_4 / \text{HPO}_4^{2-}$
- D-  $\text{H}_2\text{PO}_4^- / \text{PO}_4^{3-}$
- E-  $\text{H}_3\text{PO}_4 / \text{PO}_4^{3-}$

Ans: D

37- Which one of the following statements concerning the titration curve for a nonpolar amino acid is correct? The letters A through D designate certain regions on the curve below.

- A- Point A represents the region where the amino acid is deprotonated.
- B- Point B represents a region of minimal buffering.
- C- Point C represents the region where the net charge on the amino acid is zero.
- D- Point D represents the pK of the amino acid's carboxyl group.
- E- The amino acid could be lysine.



Ans: C

38- Which one of the following statements concerning the peptide shown below is correct?

**Val-Gly-Glu-Ser-Asp-Arg-Cys**

- A- The peptide contains asparagine.
- B- The peptide contains a side chain with a secondary amino group.
- C- The peptide contains a side chain that can be phosphorylated.
- D- The peptide cannot form an internal disulfide bond.
- E- The peptide would move to the cathode (negative electrode) during electrophoresis at pH 5.

Ans: C

39- A 2-year-old child presents with metabolic acidosis after ingesting an unknown number of flavored aspirin tablets. At presentation, her blood pH was 7.0. Given that the pK<sub>a</sub> of aspirin (salicylic acid) is 3, calculate the ratio of its ionized to unionized forms at pH 7.0.

- A- 10000 to 1
- B- 1 to 10000
- C- 1000 to 1
- D- 1 to 1000

Ans: A

40- You have a globular protein in aqueous solution, the AA that will be at the surface of the protein is ..... & the AA that will be in the interior of the protein is ..... respectively:

- A- His/Lys
- B- His/Glu
- C- Val/Ser
- D- Ser/Val

Ans: D

41- What is the pI for free monoamino dicarboxylic AA with pK<sub>1</sub>=2.1, pK<sub>2</sub>=3.9 & pK<sub>3</sub>=9.8?

- A- 3
- B- 5.95
- C- 6.85
- D- Cannot be determined

Ans: A

42- In the previous question, what is the net charge of that AA at pH=11?

- A- +1
- B- +2
- C- 0
- D- -1
- E- -2

Ans: E

43- The pK of its side chain at physiological pH contributes to the buffering function of hemoglobin:

- A- Gly
- B- Leu
- C- Lys
- D- Pro
- E- His

Ans: E

44- This AA is most likely to be found in the interior of a globular protein

- A- Pro
- B- Lys
- C- His
- D- GLy
- E- Leu

Ans: E

45- This AA doesn't form D & L isomers

- A- His
- B- Lys
- C- Pro
- D- GLy
- E- Leu

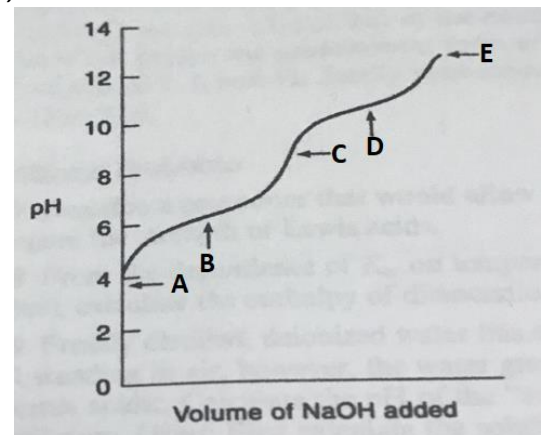
Ans: D

Consider having this titration curve for Carbonic Acid ( $\text{H}_2\text{CO}_3$ ), answer 24-29

46- At which point there is 1.5 eq of NaOH is added?

- A- A
- B- B
- C- C
- D- D
- E- E

Ans: D



47- What is the predominant form at C

- A-  $\text{H}_2\text{CO}_3$
- B-  $\text{HCO}_3^-$
- C-  $\text{CO}_3^{2-}$

Ans: B

48- What is the net charge at D?

- A- -1.5
- B- -2.5
- C- 0
- D- -0.5

Ans: A

49- If we have 200 mmole of it, how many NaOH is needed to fully titrate it?

- A- 50
- B- 150
- C- 200
- D- 400

Ans: D

**50- If you know that the pK values for carbonic acid are 6.4 & 10.2, calculate the pH of a solution containing 0.1 M of  $\text{H}_2\text{CO}_3$  after adding 0.2M to the solution.**

- A- 10.2
- B- 12.1
- C- 6.4
- D- Can't be calculated

**Ans: B**

**51- If you have 150 mmole of NaOH, how many  $\text{H}_2\text{CO}_3$  is needed to reach point D?**

- A- 150 mmole
- B- 100 mmole
- C- 75 mmole
- D- 225 mmole

**Ans: B**

**52- Regarding this peptide “ Gly-Ala-Glu-Lys-His-Arg” what is its net charge at pH=5?**

- A- +4
- B- +2
- C- +3
- D- 0

**Ans: B**

**53- In the previous question, if you have a solution containing 100 mmole of this peptide, what is the pH of the solution if we added 250 mmole of NaOH?**

- A- 2
- B- 4.25
- C- 9
- D- 6

**Ans: C**

**54- In the previous question, if you have a solution containing 50 mmole of this peptide, what is the pH of the solution if we added 300 mmole of NaOH?**

- A- More than 13.48
- B- More than 12.48
- C- 12.48
- D- Can't be determined.

**Ans: A**

**55- Calculate the pI for that peptide**

- A- 5
- B- 7.5
- C- 9.75
- D- 11.5

**Ans: C**

**56- For the same peptide, what is the net charge at pH=6**

- A- +2
- B- +1
- C- 0
- D- +1.5

**Ans: D**

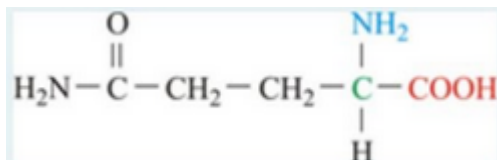


57- Given that  $K_a$  for pyruvic acid =  $3.1 \times 10^{-3}$ . What is the pH of a buffer made by mixing 0.1 M pyruvic acid with 0.12 M sodium pyruvate?

- A- 4.02
- B- 2.45
- C- 1.6
- D- 2.59
- E- 0.0821

Ans: D

58- What is the name of the amino acid shown below?



- A- Gln
- B- Asn
- C- Lys
- D- Glu
- E- Gly

Ans: A

59- what is the net charge of the GQKMDN peptide at pH 14?

- A- 0
- B- -1
- C- +2
- D- -2
- E- +1

Ans: D

60- If methionine has a positive charge (+1) in a buffer at pH = 1, then met-met-met tripeptide in the same buffer would have a net charge of:

- A- +3
- B- +1
- C- +2
- D- -1
- E- -2

Ans: B

61- Which of the following represents the reaction that occurs at pH=9.6 when fully protonated glycine is titrated by a strong base?

- A-  $\text{COO}^-$  protonation
- B-  $\text{NH}_3^+$  ionization
- C-  $\text{COOH}$  ionization
- D-  $\text{NH}_2$  protonation
- E-  $\text{NH}_3^+$  deprotonation

Ans: E

62- Which of the following statements is CORRECT?

- A- Ala is a basic AA
- B- Pro is aromatic AA
- C- GSH is a selenoprotein
- D- Only D AAs are found in human proteins
- E- Gly is the only optically inactive AA

Ans: E

63- Which of the following AAs has a buffering capacity at physiological pH?

- A- Gly
- B- Arg
- C- Histamine
- D- Lys
- E- None of the choices

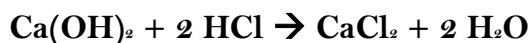
Ans: E

64- Which of the following mutations would you expect to cause the most drastic alteration in the functional performance of a polypeptide chain?

- A- Replacement of asp with glu
- B- Replacement of lys with arg
- C- Replacement of glu with lys
- D- Replacement of val with ala
- E- Replacement of ser with threonine

Ans: C

65- In titration of HCl against  $\text{Ca(OH)}_2$ , 10 ml of 0.5 M is required to neutralize 50 ml of HCl. What is the molarity of HCl?



- A- 0.2 M
- B- 2.5 M
- C- 0.05 M
- D- 0.4 M
- E- 0.1 M

Ans: A

66- One of the following AAs explains protein absorbance at 280nm:

- A- Phe
- B- Gly
- C- Gln
- D- Ile
- E- Pro

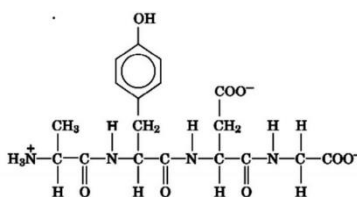
Ans: A

67- At their isoelectric point, proteins have:

- A- No positively charged R groups
- B- No negatively charged R groups
- C- An increase affinity for substrate
- D- No ionized R groups
- E- None of the above

Ans: E

68- This image below represents:



- A- A tripeptide with 2 peptide bonds
- B- A peptide has an AA derivative
- C- A tetrapeptide with 3 peptide bonds
- D- A tripeptide with 3 peptide bonds

E- A tetrapeptide with 4 peptide bonds

Ans: C

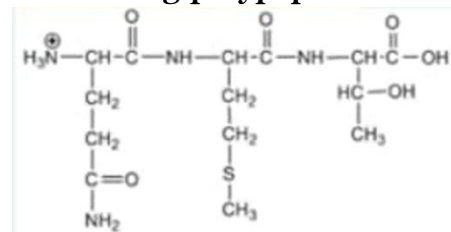
69- The 21<sup>st</sup> AA is:

- A- Selenolysine
- B- GSH
- C- Hydroxylysine
- D- Selenocysteine

Ans: D

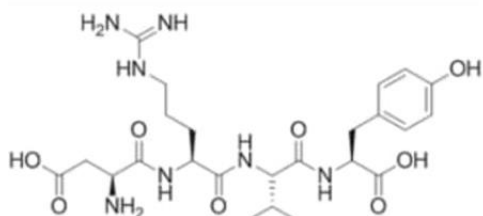
70- Back to pKa value table of AAs, what is the net charge of the following polypeptide at physiological pH?

- A- -2
- B- +2
- C- 0
- D- +1
- E- -1



Ans: C

71- The image below represents:



- A- Asp-Arg-Val-Tyr
- B- Tyr-Val-Arg-Asp
- C- Glu-Lys-Ala-Phe
- D- Asp-Arg-Tyr
- E- Gly-Lys-Ala-Phe

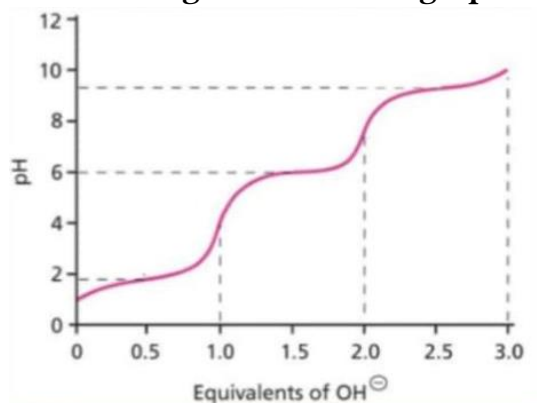
Ans: A

72- Calculate the ratio of [acetic acid]/[acetate] that gives a solution with pH=6, knowing that the pKa of acetic acid is 4.74

- A- 1.26
- B- 0.05
- C- 0.09
- D- 18.2
- E- 20.00

Ans: B

73- The graph below represents the titration curve of an AA with a base, which of the following AAs does the graph represent?



- A- Asn
- B- Arg
- C- Asp
- D- His
- E- Gly

**Ans: D**

**74- Determine the pI of the polypeptide: Gly-Asp-Val-Arg-Thr**

- A- 6.625
- B- 8.065
- C- 2.865
- D- 6.96
- E- 11.04

**Ans: A**

**75- Sulphur containing amino acids include:**

- A- C and T
- B- M and T
- C- C and S
- D- C and M
- E- K and S

**Ans: D**

**76- Which one of the following is a characteristic of the AA composition of a protein which has an pI of 9.5?**

- A- No acidic AAs
- B- No basic AAs
- C- More basic than acidic AAs
- D- More acidic than basic AAs
- E- No neutral AAs

**Ans: C**

### أسئلة متنوعة ومقالية على المحاضرات مع حلولها

- 1- Calculate the ratio of  $\text{HPO}_4^{2-}$  to  $\text{H}_2\text{PO}_4^-$  ( $\text{pK}_a=6.7$ ) at pH: 5.7 , 6.7 ,8.7.
- 2- Calculate the PH of a 1L solution containing 0.01M formic acid and 0.1M sodium formate before and after the addition of 1ml of 5M NaOH.
- 3- Using the Henderson-Hasselbalch equation, explain why when a solution is at a pH below the  $\text{pK}_a$  for an acid that more than 50% of the molecules is not dissociated. Use acetic acid and acetate solution to solve ( $\text{pK}_a$  of Acetic acid = 4.76).
- 4- Using the Henderson-Hasselbalch equation, determine the ratio of acetate ion (salt) to acetic acid (acid) present in a 1M solution at the following pHs = 1/5/9

5- Formic acid has a pKa of 3.75 and acetic acid has a pKa of 4.76. Why do we consider formic acid to be a "stronger" acid than acetic acid? Your answer should have a mathematical basis.

Solutions

Q1:-  $\frac{[HPO_4^{2-}]}{[H_2PO_4^-]} = ??$   $pK_a = 6.7$

at  $pH = 5.7/6.7/8.7$

at  $pH = 5.7$

$pH = pK_a + \log \frac{B}{A}$   $\rightarrow$  مثال

$5.7 = 6.7 + \log \frac{[HPO_4^{2-}]}{[H_2PO_4^-]}$

$-1 = \log \frac{[HPO_4^{2-}]}{[H_2PO_4^-]}$

$10^{-1} = \frac{[HPO_4^{2-}]}{[H_2PO_4^-]} \Rightarrow \frac{[HPO_4^{2-}]}{[H_2PO_4^-]} = \frac{1}{10}$   $\#$

نسبة الباقى  
 $\#$  الباقى

Q2:-

$pK_a = 3.75$

before

$pH = pK_a + \log \frac{B}{A}$

$pH = 3.75 + \log \frac{0.1}{0.01}$

$= 3.75 + \log 10 = 3.75 + 1$

$= 4.75$   $\#$

after:-

$[A]_{new} = 0.01 - [NaOH]$

$= 0.01 - 0.005$

$= 0.005 M$

$[B]_{new} = 0.1 + [NaOH]$

$= 0.1 + 0.005$

$= 0.105$

$pH = 3.75 + \log \frac{0.105}{0.005}$

$= 5.07$   $\#$

1M  
5M NaOH



Base 0.1 M formate

Q3:-

②

suppose we have a solution contain

Acetic acid & its conjugate base at  $pH = 3.76$

$pK_a = 4.76$

B = dissociated form

A = undissociated form

$pH = pK_a + \log \frac{B}{A}$

$\Rightarrow 3.76 = 4.76 + \log \frac{B}{A} \Rightarrow -1 = \log \frac{B}{A}$

$\frac{B}{A} = \frac{1}{10} \Rightarrow A = 10 B$

على ما ذكره من 10:1 من الباقى غير متأين  $\#$

Q4:-  $\frac{B}{A}$   $\rightarrow$  salt/acid

at  $pH = 1/5/9$

$pK_a = 4.76$

$pH = pK_a + \log \frac{B}{A}$

$1 = 4.76 + \log \frac{B}{A} \Rightarrow -3.76 = \log \frac{B}{A}$

$\frac{B}{A} = 10^{-3.76} = 10^{-4} \times 10^{-0.24}$

$\frac{B}{A} = 1.7 \times 10^{-4}$   $\#$

$\#$

$C_1 V_1 = C_2 V_2$

$5 \times 10^{-3} = C_2 \times 1$

$C_2 = 5 \times 10^{-3} M$

نظير الباقى

Q5:- suppose we have 0.1 M solution <sup>③</sup>  
from both acids  $\Rightarrow$  more  $H^+$  produced  
stronger the acid

Sol:-

- pKa of formic acid = 3.75

$$\Rightarrow K_a = 1.78 \times 10^{-4}$$

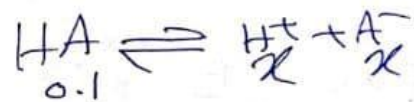
جوابه  
Sp

- pKa of Acetic acid = 4.76

$$\Rightarrow K_a = 1.76 \times 10^{-5}$$

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

acetic acid



formic acid

$$1.76 \times 10^{-5} = \frac{x^2}{0.1}$$

$$\sqrt{1.76 \times 10^{-6}} = \sqrt{x^2}$$

$$[H^+] = 1.33 \times 10^{-3} M$$

$$1.78 \times 10^{-4} = \frac{[H^+]^2}{0.1}$$
~~$$1.78 \times 10^{-4} = \frac{[H^+]^2}{0.1}$$~~

$$[H^+]^2 = 1.78 \times 10^{-5}$$

$$\sqrt{[H^+]^2} = \sqrt{1.78 \times 10^{-5}}$$

$$[H^+] = 4.2 \times 10^{-3} M$$

Acetic Acid < formic acid  
Acid

فأقوى  
أما

u.p. 1.5

lys - His - Glu - Gln - Asp

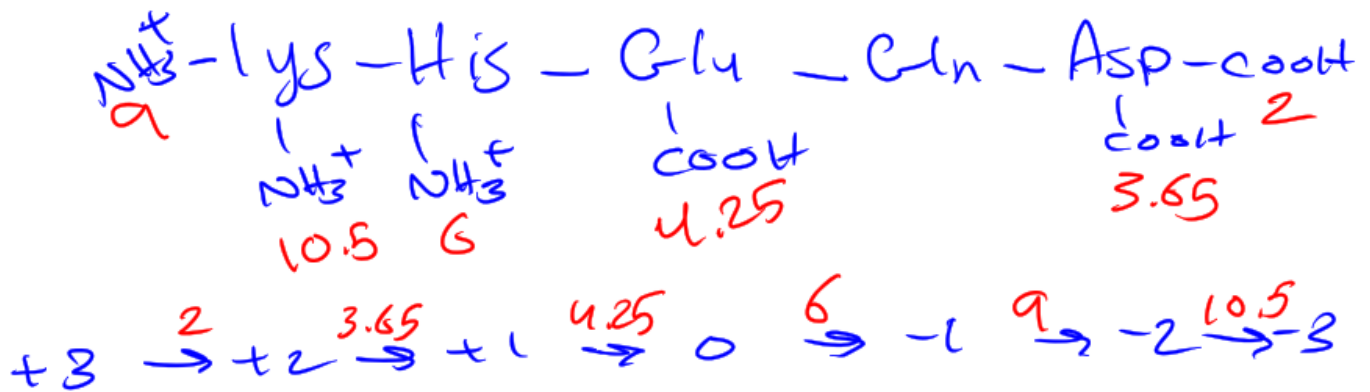
① calculate pI

② what is the net charge at  
pH = 7 / 11 / 5 / 1

Knowing that

|                           |            |
|---------------------------|------------|
| pKa of                    |            |
| $\alpha\text{COOH} = 2$   | lys = 10.5 |
| $\alpha\text{NH}_3^+ = 9$ | Asp = 3.65 |
| His = 6                   | Glu = 4.25 |

**Solution**



$$\text{pI} = \frac{6 + 4.25}{2} = 5.125$$

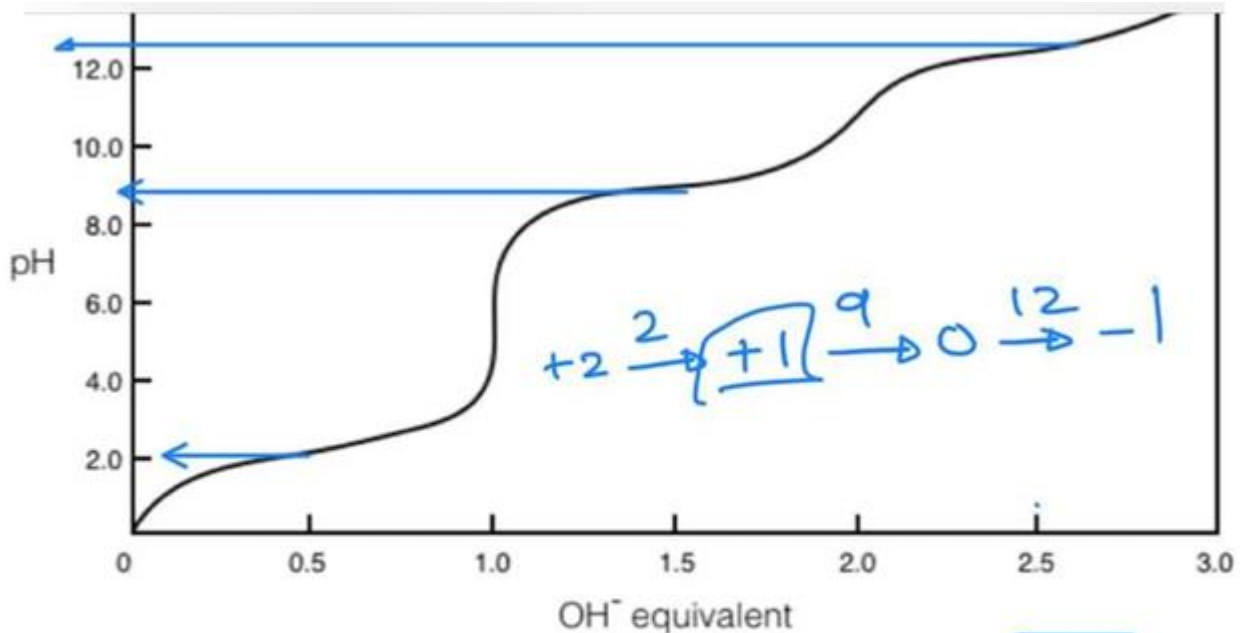
at pH = 1  $\rightarrow +3$

pH = 7  $\rightarrow -1$

pH = 5  $\rightarrow 0$

pH = 11  $\rightarrow -3$





- 1- What is the type of this amino acid? (non-polar, polar, acidic, **basic**)
- 2- How many buffer regions regarding this titration curve? **3**
- 3- Calculate the pI for this amino acid **10.5**
- 4- If we have 300 mmole of this amino acid, how much  $\text{OH}^-$  is needed for full deprotonation of it?  **$3 \times 300 = 900 \text{ mmole}$**
- 5- If we add a **0.225** mole of  $\text{OH}^-$  to solution containing 150 mmole of this amino acid, what is the pH of the solution after adding the base? **9**
- 6- If this amino acid presented as  $\text{H}_3\text{A}$ , then what is the dominant form at pH=5?  **$\text{H}_2\text{A}^+$**
- 7- In previous question, if we want to make a buffer from this amino acid at pH=9.5 determine the pair is responsible to make the buffer.  **$\text{H}_2\text{A}^+ / \text{HA}^0$**
- 8- If 100 ml buffer solution from this amino acid at pH=9 containing equal concentration of the acid and its conjugate base=0.3M, calculate the new pH when 2 ml of 0.3 M HCl is added to the solution
- 9- **#moles =  $0.002 \times 0.3 = 0.0006$  moles of HCl added**

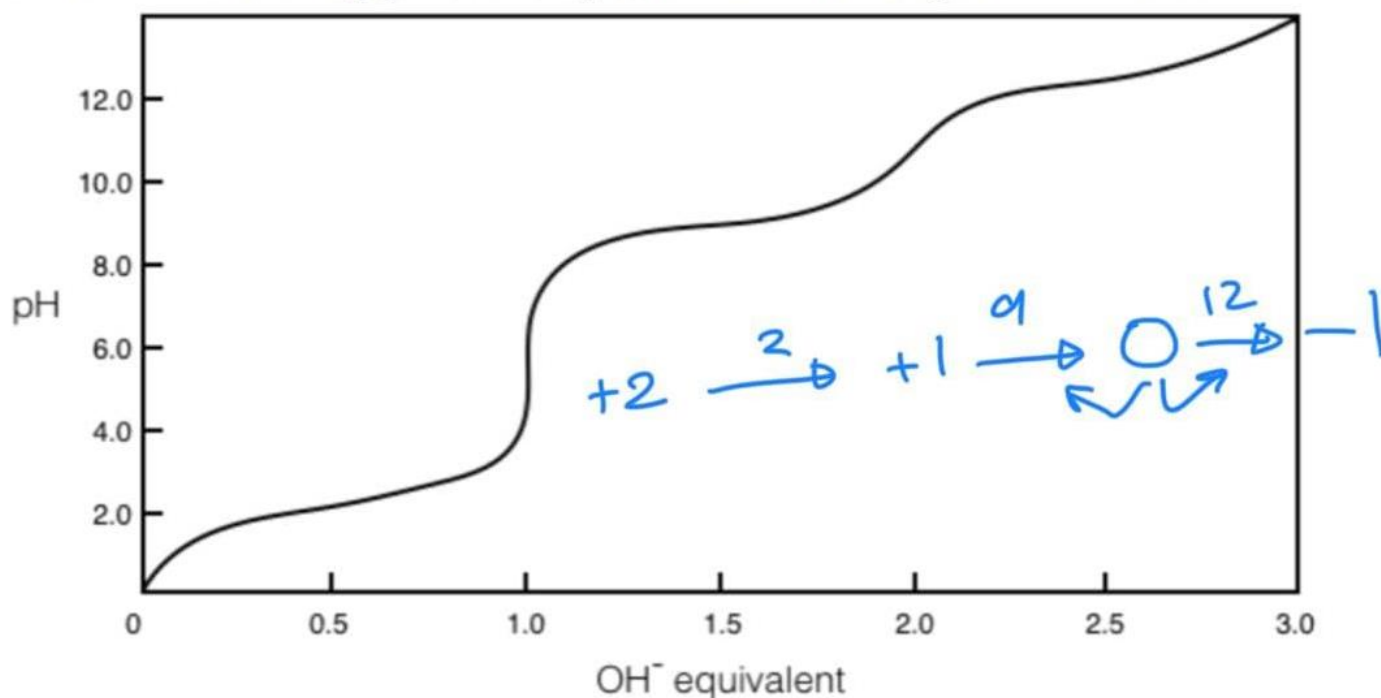
السؤال التاسع فارغ، شغل مخك البيوكيميائي واكتب سؤال بتحسه حيبي عن أول شابتري

concentration:  $\frac{0.0006}{0.1} = 0.006 \text{ M HCl}$

New pH =  $9 + \log \frac{0.3 - 0.006}{0.3 + 0.006} = 9 + \log \frac{0.294}{0.306} = \boxed{8.98}$



3. Answer the following questions using the titration curve of arginine shown below.



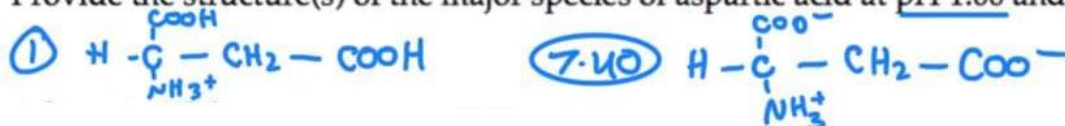
a. What are the values of  $\text{pK}_a$  for the  $\alpha$ -carboxyl,  $\alpha$ -amino and the side chain of arginine? (3 points)

$\downarrow$        $\downarrow$        $\downarrow$   
 2      9      12

b. What is the value of the isoelectric pH for arginine? (2 points)

$$\text{pI} = 10.5$$

c. Provide the structure(s) of the major species of aspartic acid at pH 1.00 and pH 7.40. (4 points)



One liter of 1M acetate buffer at  $\text{pH} = 4.5$  is mixed with 600 ml of 0.5M acetate buffer at  $\text{pH} = 4.8$  and then one liter of HCl (0.1M) is added. What is the pH of the final solution?