Biochemistry Lecture 2 notes

Acid and Bases

Defention and Terms

There is alot of defentions for acids and bases but we don't care about all of them and this is the one we are going to deal with :

- **Acid :** A Substance that can produce H+ (H3O+) when diss -olved in water or reacts with other substances.

Acids differ in how many protons they can donate, some of them can donates one proton (Monoprotic Acids), some can donate more than one proton (Multiprotic acids), two protons (Diprotic acids), and others can donates three protones (Triprotic acids).

Examples

Monoprotic : HCl,HNO3,CH3COOH.

Diprotic : H2SO4

$$H_2SO_4 + 2H_2O \longrightarrow 2H_3O^+ + SO_4^{-2}$$

Since it is a strong acid we are going to assume that it gives all of its protons at once.

Triprotic : H3PO4

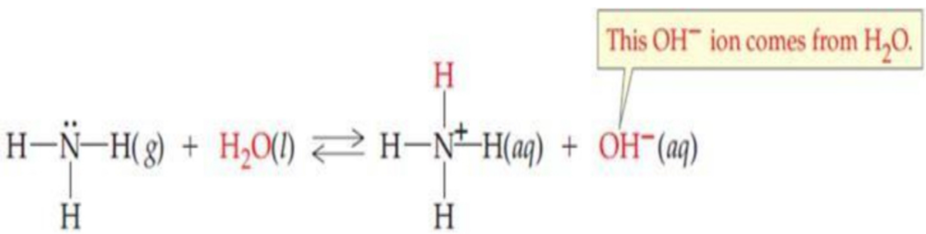
$$H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$$

Since H3PO4 is a weak acid it donates one proton on each reaction.

- **Base :** A Substance that can accept H+ when reacts with other substance or produces OH- when dissolved in water.

Examples

NH3



Amphoteric (Ampho means : dual or both)

Substances that can donate a proton on one reaction and accept a proton on other reaction depending on the other molecule it reacting with.

Example: water

- With ammonia (NH3), water acts as an acid because it donates a proton (hydrogen ion) to ammonia.

NH3 + H20 → NH4+ + OH-
Act as acid

- With hydrochloric acid, water acts as a base.

HCl + H20 → H3O+ + Cl-

Acid/Base Strength

Acids/bases differ in their ability to release/accept protons.

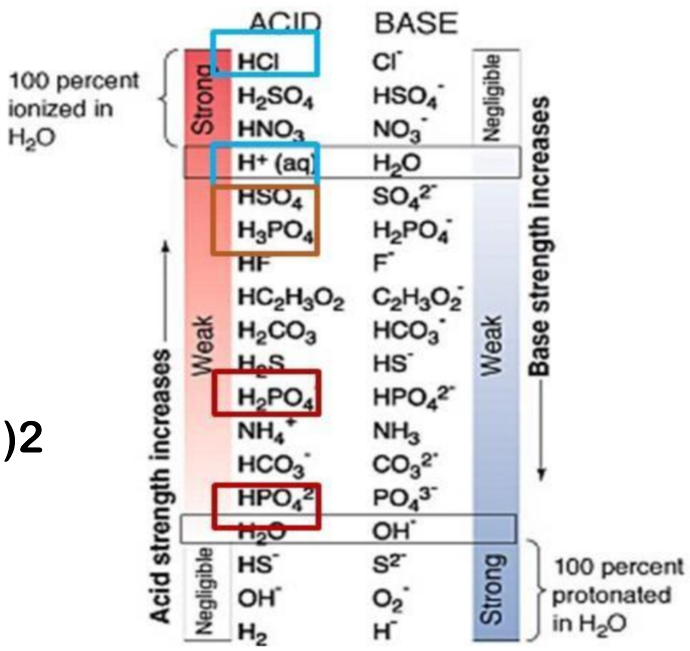
Memorise strong acids/bases.

Strong acids :

HCl,H2SO4,HNO3,

Strong bases :

NaOH,KOH,Ba(OH)2,Ca(OH)2,Mg(OH)2



- The stronger the acid the weaker its conjugated base.

Strong acids/bases ~> one way reaction (100% dissosiation).

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$ / $NaOH \rightarrow OH^- + Na^+$

Weak acids/bases ~> reversabile reaction (doesn't dissosiate completely).

$HA + H_2O \rightleftharpoons H_3O^+ + A^-$ / $B + H_2O \rightleftharpoons BH^+ + OH^-$

Any reaction in the universe seek to reach a balance state between reactents and products where rate of reactents making products is equal to rate of products making reactants, and reactants and prod-ucts concentration are constand (not necessary to be equal),This state is called equilibrum.

Equilibrum

Why equilibrum happens ? Why every reaction seeks to

Because we want the difference in energy between reactants and products reactions to be zero. Why do we need difference in ener-gy to be zero? Because it is more stable.

Equilibrum Constant Keq and Acid dissociation constant

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

Ka indicates the direction of the reaction.

- If Ka greater than one ~> products concentation is higher than reactents concentartion ~> reaction directed forward (toward producrs).

- If Ka is lesser than one ~> reactents concentration is higher than products concentration ~> reaction directed backward (toward reactants).

Ka vs PKa

Both gives us an indication about the strength of an acid.

Since Ka numbers are hard to deal with and hard to feal them, scientists have interduced PKa which is : PKa = -log(Ka).

PKa gives us numbers that we can feal since we are dealing with them every day : 2.7/ 11.2/ 3.1 while ka numbers are things like : 1.7 X 10^-10 / 4.25 X 10 ^-11

- The higher the Ka The lower the PKa and the greater the strength of an acid (stronger).

- The lower the Ka The higher the PKa and the lesser the strength of an acid (weaker).

Molarity

Moles = grams/molecular weight

Molarity = moles/volume(L)

Grams = molecular weight X moles = molecular weight X Volume X Molarity

Equivalents

When we deal with acid and bases its a little bit diffecult to deal with them with terms of molarity / grams all the time espically when you are talking about multiprotic acids and bases that have more than one OH group, so we are going to spdeal with them in terms of Equivalents.

Equivalents?

The number of different charge that I need to neutralize the chatge that I have.

Also it can be defined as the number of moles of H+ that the acid can produced or a base can accept.

For acids :

1 mole of HCl = 1 mole of H^+ = 1 equivalents

1 mole of H_2SO_4 = 2 moles of H^+ = 2 equivalents

1 equivalent of H_2SO_4 = $\frac{1}{2}$ mole of H_2SO_4

For bases :

1 mole of NaOH = 1 mole of OH^- = 1 equivalent.

1 mole of NH_3 = 1 mole of OH^- = 1 equivalent.

1 mole of $Ca(OH)_2$ = 2 moles of OH^- = 2 eq

1 eq of $Ca(OH)_2$ = $\frac{1}{2}$ mole of $Ca(OH)_2$

For ions :

1 mole of Na^+ = 1 equivalent = 23.1 g

1 mole of Cl^- = 1 equivalent = 35.5 g

Equivalents = n x Molarity x Volume

The little n is represinting the number of OH-/H+ it can produce or H+ it can accept.

One equivalents of an acid is neutrlized by one equivalents of a base.

Examples :

How many equivalents are in the following:

~> 5.0 g HNO3 MW= 63

1 mole of HNO_3 = 1 equivalents.

$\frac{5.0}{63}$ mole of HNO_3 = 0.0794 equivalents.

~> 12.5 g Ca(OH)2 MW = 74

1 mole of $Ca(OH)_2$ = 2 equivalents

$\frac{12.5}{74}$ mole of $Ca(OH)_2$ = 0.34 equivalents

~> 4.3 g H3PO4 MW = 98

$\frac{4.3}{98}$ mole of H_3PO_4 = $\frac{4.3}{98} * 3$ = 0.132 equivalents.

•The typical concentration of Mg+2 in blood is 3 mEq/L. How many milligrams of Mg+2 are in 250 mL of blood? MW = 24

لازم نحول من equivalents الى moles بعدين من moles الى grams.

1 mole = 2 equivalents

X mole = 3 equivelants

$X = \frac{3}{2}$ mole

$3 \text{ Eq/L} \Rightarrow \frac{3}{2} \text{ mmol/L}$

$\text{grams} = 24 \frac{g}{mol} \times 0.250 L \times \frac{3}{2} \frac{mmol}{L}$

grams = 9 mgram

• Calculate milligrams of Ca^{+2} in blood if total concentration of Ca^{+2} is 5 mEq/L.
Note: atomic weight of Ca^{+2} is 40.1 grams/mole

1 mole = 2 equivelants

X mole = 5 mequivelants / L

$X = \frac{5}{2}$ meq/L ⇒ grams = moles * MW

$\frac{5}{2}$ meq/L * 40.1

grams = 100.25 mgram/L

Or you can simply just say :

40.1 gram = 1 mole = 2 equivelants

y gram = x mole = 5 meq/L

$\frac{40.1 \times 5}{2} = y$ ⇒ **y = 100.25 mgram/L**

• Titration of a 12.0 mL solution of HCl requires 22.4 mL of 0.12 M NaOH. What is the molarity of the HCl solution?

Rule :- One equivalents of an acid neutrlize one equivalents of a Base

equivelants H^+ = equivelants OH^- → $n_1 * V_1 * M_1 = n_2 \times V_2 \times M_2$

$1 * 0.012 * M_1 = 1 * 0.0224 * 0.12$

$M_1 = 0.224$ M

• What volume of 0.085 M HNO_3, is required to titrate 15.0 mL of 0.12 M $Ba(OH)_2$ solution?

Rule :- one equivalent of an acid neutrlizes one equivalent on a Base.

equivalent H^+ = equivalent OH^-

$$n_1 * V_1 * M_1 = n_2 * M_2 * V_2$$

$$1 \times V_1 \times 0.085 = 2 \times 0.12 \times 0.015$$

$$V_1 = 0.0424 \text{ L}$$

$$\boxed{V_1 = 42.4 \text{ mL}}$$

Electrolytes

- Electrically charged minerals when dissolved in water.

- Examples : Sodium, potassium, calicum, magnesium, phosphate, and bicarbonate.

- Important foe various bodily function such as :

~> **Nerve.** Sodium ions (Na^+)

~> **Muscles Contration.** Calicum ions (Ca^{+2})

~> **Fluid balance.** (All of them)

~> **acid-base balance.**

~> **Blood pressure.** (All of them)

→ Related to each other
Just think about it.(physiology final)
You remember?

Decreasing in sodium ions (Na^+)

Hyponatremia : Can be caused by heavliy and continuous diarrea (this also cause dehydration)

Hypo = low
Hyper = hig

Electrolytes are very important to our bodies.
They can be lost along with water during diarrhea, vomiting and sweating.
Excessive loss of electrolytes can lead to severe complications therefore should be restored for example by IV electrolyte replacement in hospitals.
Also athletes drink electrolyte rich drinks to restore what is lost by excessive
sweating during strenuous exercise.

Antacids

Exactly as modifieds

- Alkaline (basic) compounds (neutralize HCl) of the stomach.

- Reduce stomach acidity and providing relief (تُعالج) from heartburn (حُرقة في المعدة) and indigestion (dyspepsia) (عُسر الهضم)

- Reduce digestion of proteins by pepsin (pH 1-2 vs 3.5-5) (activity of pepsin declines as PH reaches 3.5 and above)

Antacids neutralize (HCl). This raises the pH of the stomach. At a higher pH (less acidic), pepsin becomes less active or inactive. This can slow or reduce protein digestion in the stomach.

إفهم لا تحفظ.. خليك حدق زي أخوك (:

• Examples:

Magnesium Hydroxide $Mg(OH)_2$

Aluminum Hydroxide $Al(OH)_3$

Calcium Carbonate $Ca(CO_3)_2$

Sodium Bicarbonate $NaHCO_3$

Memorise these (ولا عليك أمر)

Ionization of water

• H^+ exist in solution bonded to water as hydronium ion (H_3O^+)

• Whenever we write H^+ (for simplicity) understand it as H_3O^+

$$H_2O \rightleftharpoons H^+ + OH^-$$

$$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$$ Self ionization

Equilibrum constant and ion product of

$$H_2O \rightleftharpoons H^+ + OH^-$$

$$K_{eq} = \frac{[H^+][OH^-]}{[H_2O]} \Rightarrow 1.86\times10^{-16} = \frac{[H^+][OH^-]}{55.5}$$

$$[OH^-][H^+] = 1\times10^{-14}\,M^2$$

K_{eq}: Constant 1.86×10^{-16}

$[H_2O]$: Constant 55.5 mole/L

Imagine you are dissolving water into 1 Liter of water its always going to be the same concentration.

This is called the ion product of water.
It allows you to calculate [OH-] when you have [H+] known and vice versa.

- For pure water, there are equal concentrations of [H+] and [OH-], each with a value of 1 x 10-7 M.

- Since Kw is a fixed value, the concentrations of [H+] and [OH-] are inversely changing.

- If the concentration of H+ is high, then the concentration of OH- must be low, and vice versa. For example, if [H+] = 10-2 M, then [OH-] = 10-12 M