Aris Kaksis 2021. Riga Stradin`s University http://aris.gusc.lv/BioThermodynamics/PhotoSynthesis15.pdf

Plant $\mathbf{CO_2}$ assimilation and $\mathbf{O_2}$ after photosynthesis **OSMOSIS** like human from air **OSMOSIS** to organism.

Gradual reaction first pathway sequences start with water 12$\mathbf{H_2O}$ flux from root to stomata cell membrane surface dissolute CO_{2aqua} and Carbonic Anhydrase CA $[CO_{2aqua}]+[HCO_3^-]=0.023$ M from 400 ppm CO_2 air.

I) $CO_{2gas}+\Delta G_{aqua}<=>Q+CO_{2aqua}$; in endoergic $\Delta G_{Hydratation}=10.77\ ^{kJ}/_{mol}$ and $\Delta H_{Hess}=-20.3\ ^{kJ}/_{mol}$ solubility product: $\mathbf{K_{sp}}=[CO_{2aqua}]/[CO_{2gas}]/[H_2O]=1/29.44=0.034045$ endoergic $\Delta G_{sp}=8.4\ ^{kJ}/_{mol}$ dissolute concentration:

$$[CO_{2aqua}]=\mathbf{K_{sp}}*[H_2O]*[CO_2\uparrow_{air}]=0.03397*55.3457*0.0004=1.878*0.0004=0.0007537\ M.$$

II) Carbonic Anhydrase $CO_{2aqua}+2H_2O+Q\xleftrightarrow{CA}H_3O^++HCO_3^-\xleftrightarrow{Membrane\_Channels}H_3O^++HCO_3^-$ improve carbon assimilation $[HCO_3^-]+[CO_{2aqua}]=[HCO_3^-]=0.0154\ M+0.0076\ M=0.023\ M$ times $30.6=0.023\ M\ /\ 0.0007537\ M$. Produced protons and bicarbonate concentration gradient driving exoergic to Photosynthesis with HCO_3^- , H^+:

$$2H_2O+CO_{2gas}<=>CO_{2aqua}+2H_2O+Q\xleftrightarrow{CA}H_3O^++HCO_3^-\xleftrightarrow{Membrane\_Channels}H_3O^+\ +HCO_3^-.$$

exothermic $\Delta H=-20.3\ ^{kJ}/_{mol}$; endothermic $\Delta H=9.76\ ^{kJ}/_{mol}$; athermic 0 $^{kJ}/_{mol}$; exothermic $\Delta H_{total}=-10.54\ ^{kJ}/_{mol}$; endoergic $\mathbf{\Delta G_{sp}}=+8,4\ ^{kJ}{}_{mol}$; endoergic $\mathbf{\Delta G_{eq}}=+60\ ^{kJ}{}_{mol}$; exoergic $\Delta G_{channel}=-10.62-7.48=-18.1\ ^{kJ}{}_{mol}$;

$\Delta G_H=RTln([H_3O^+]_{right}/[H_3O^+]_{left})=8.3144*298.15*ln(10\wedge(^{-7.36})/10\wedge(^{-5.5}))=-10.62\ ^{kJ}/_{mol}$..............

$\Delta G_{HCO3}=RTln([HCO_3^-]_{right}/[HCO_3^-]_{left})=8.3144*298.15*ln(0.0007537/0.0154)=-7.48\ ^{kJ}/_{mol}$........

HOMEOSTASIS Norma bicarbonate concentration sum 0.023 M sustain multipurposeAttractor pH=7.36:

$$pH=pK_a+log[HCO_3^-]/[CO_{2aqua}]=7.0512+log(0.0154/0.0076)=7.36;$$

Pathways I), II) reach ENZYME complex Photo Synthetic Reaction Center (PRC) in thylakoid cell.

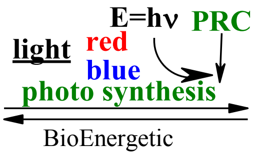
$$\text{endoergic }\mathbf{\Delta G_{H3O+HCO3}}=6*50.3=301.8\ ^{kJ}{}_{mol}\ .\ 6H_3O^++6HCO_3^-\overset{\mathbf{PRC}}{=}\!\!=>C_6H_{12}O_6+6O_{2aqua}+6H_2O$$

exothermic $\Delta H=6*-10.54=63.24\ ^{kJ}/_{mol}$ and endoergic $\mathbf{\Delta G_{H3O+HCO3}}=\mathbf{\Delta G_{sp}}+\mathbf{\Delta G_{eq}}+\Delta G_{channl}=8.4+60-18.1=50.3\ ^{kJ}{}_{mol}$;

Second pathway start with 1) (**PRC**) Photo Synthetic Reaction Center ENZYME cluster of green plants. **PRC** engine is **red** and **blue** light photons absorbed energy in glucose and one of 6 oxygen molecules to calculate on one $\mathbf{O_2}$ mole $\mathbf{\Delta H}=2805.27/6=467.5\ ^{kJ}/_{mol}$, $\Delta G=3049.55/6=508.3\ ^{kJ}/_{mol}$. Sun radiation is consumed also the heat energy drive evaporation **endothermic** of oxygen $\mathbf{6O_2}$ and water $\mathbf{6H_2O}$ out of green plant stomata open hole. So aquaporins and evaporation substrates oxygen $\mathbf{6O_2}$ and water $\mathbf{6H_2O}$ increase osmotic pressure outside cell

1) $C_{osm}=\mathbf{6+6=12}$
inside cell **PRC**
outside stomata
hole
$\mathbf{6HCO_3^-+6H_3O^+}$

$C_{osm}=1\ \mathbf{C_6H_{12}O_6}$



11 times as osmolar: concentration in cell decreases from 12 to one glucose $\mathbf{C_6H_{12}O_6}$ molecule and flow intensity through aquaporins increases pressure out of green plant cells. Pressure is proportional to osmolar concentration difference $\Delta C_{osm}=11*X$ M eleven

$\mathbf{C_6H_{12}O_6+6O_{2aqua}+6H_2O}$ times X higher pressure $\boldsymbol{\pi}=\Delta C_{osm}\bullet R\bullet T$ kPa.

$\Delta G_{osmos}=\mathbf{RTln}([\mathbf{O_{2aqua}}]_{right}/[\mathbf{O_{2aqua}}]_{left})=8.3144*298.15*\mathbf{ln}(1/12)=-6.16\ ^{kJ}/_{mol}.$; $6*-6.16=-36,96\ ^{kJ}/_{mol}$ for $\mathbf{6O_2}$

$\Delta G_{O2}=RTln([O_2]_{right}/[O_2]_{left})=8.3144*298.15*ln(2.556*10^{-4}\ M/0.005\ M)=-7.37\ ^{kJ}/_{mol}$; $6*-7.37=-44.2\ ^{kJ}/_{mol}$ for $\mathbf{6O_2}$

$$\boldsymbol{\pi}=11*X\bullet R\bullet T\text{ kPa};\ X=[\mathbf{C_6H_{12}O_6}]=0,005\ M;\ \boldsymbol{\pi}=11*0,005\bullet R\bullet T=0,055*8,3144*298,15=136,3\text{ kPa}$$

$\mathbf{6O_2}$ and $\mathbf{6H_2O}$ through aquaporins pushed out of cells against twelve times higher gradient as reactants 1/12:

2) aquaporins $\mathbf{H_2O+O_{2aqua}}\xleftrightarrow{\mathbf{Aquaporins}}\mathbf{O_{2aqua}}+\mathbf{H_2O}$ $\Delta G_{osmos}=-6,16\ ^{kJ}/_{mol}$ exoergic 1/12 gradient athermic $\Delta H=0$:

0.005 M $\mathbf{H_2O+O_{2aqua}}\xleftrightarrow{\mathbf{Aquaporins}}\mathbf{O_{2aqua}}+\mathbf{H_2O}$ $\Delta G_{O2}=-7.37\ ^{kJ}/_{mol}$ exoergic gradient real athermic $\Delta H=0$:

$\Delta G_{sum}=\Delta G_{osmos}+\Delta G_{O2}=-6.16-7.37=-13.53\ ^{kJ}/_{mol}$ osmosis and down along $\mathbf{O_2}$ gradient $2.556*10^{-4}$ M/0.005 M.

3) AIR $6O_{2gas}$ $6H_2O_{gas}$ evaporation for one $\mathbf{H_2O+O_{2aqua}+Q=>O_{2gas}}+\Delta G+\mathbf{H_2O}_{gas}$ endothermic , exoergic sum:

$$\Delta H_{H2O}=44\ ^{kJ}/_{mol};\ \Delta H_{O2}=11.75\ ^{kJ}/_{mol};\ \Delta G_{H2O}=8.591\ ^{kJ}/_{mol};\ \Delta G_{O2}=-77.55\ ^{kJ}/_{mol};$$

$\Delta G_{sum}=8.591-77.55=-68.96\ ^{kJ}/_{mol}$, $\Delta H_{sum}=44+11,75=55.75\ ^{kJ}/_{mol}$ and Photosynthesis sum endoergic:

$\Delta G_{sumPRC}=-68.96-13.53+508.3=425.8\ ^{kJ}/_{mol}$ and $\Delta H_{sumPRC}=55.75+0+467.5=523.25\ ^{kJ}/_{mol}$ endothermic on $\mathbf{O_2}$:

$$\Delta G_{sum\mathbf{C6H12O6}}=6*425.8=2554.8\ ^{kJ}/_{mol}\text{ and }\Delta H_{sum\mathbf{C6H12O6}}=6*523.25=3139.5\ ^{kJ}/_{mol}\ .$$

Plants need supply energy as heat to support **PRC** and evaporated products oxygen $\mathbf{O_2}{}_{gas}$ as well water $\mathbf{H_2O}_{gas}$ vapor through stomata open hole. According Le Chatelier principle heat as energy supply shift endothermic equilibrium evaporation of $\mathbf{O_2}{}_{gas}$ and $\mathbf{H_2O}_{gas}$ outside → through green plant stomata open hole. Opening the stomata holes depends on environment temperature and humidity. Evaporation velocity increases at higher temperature as heat supply if at enough water supply usually from roots.

Similar human O_2 OSMOSIS and oxidative assimilation with produced HCO_3^- and CO_{2aqua}

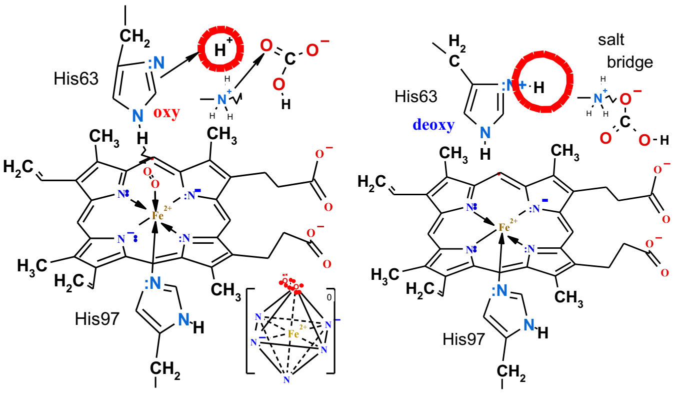
Reaction sequences start with root cells indispensible osmosis through membrane aquaporin channels.

I) **Oxygens** from AIR 20.95% O_2 disolution in water by osmosis through aquaporins entrance in organism: $\Delta H=-11.7\ ^{kJ}/_{mol}$ exothermic $O_{2gas}+H_2O \xleftrightarrow{\text{Aquaporin}} H_2O+O_{2aqua}+Q$ $\Delta G=16.36\ ^{kJ}/_{mol}$ endoergic. $C_{osm}=0.1$ M and soil C=0.005 M $\Delta G_{O2}=RT\ln([O_{2aqua}]/[O_{2gas}])=-8.3144*298.15*\ln(0.1/0.005)= -7.426\ ^{kJ}/_{mol}$ exoergic .

Plant **deoxy** Leghemoglobin LHb_T from water medium adsorb inspired AIR O_{2aqua} releases proton H^+: $LHb_R(His63O_2)+H^+\leftarrow[O_2]=1.85\cdot10^{-5}\ M\rightarrow(H^+His63)LHb_T+O_{2aqua}$ and HCO_3^-. In water solute oxygen $[O_{2aqua}]=9.768\bullet10^{-5}$ M concentration and average cytosolic value $[O_2]=1.85\cdot10^{-5}$ M. Concentration gradient across membrane $\Delta G_{O2}=RT\ln([O_2]_{right}/[O_2]_{left})=$

$=8.3144*298,.15*\ln(1.85/9.768)= -4.125\ ^{kJ}/_{mol}$.

$\Delta G_{sum}=16.36-7.426-4.125=4.809\ ^{kJ}/_{mol}$, $\Delta H_{sum}=-11.7\ ^{kJ}/_{mol}$.



II) pathway with carbonic anhydrase **AC** shifted to right by oxidative phosphorylation consume O_2 increase product HCO_3^- and H^+ Leghemoglobin capturing $(H^+His63)LHb_T$ stabilizes pH=7,36 concentration H_3O^+ .

II) $Q_{aqua}+CO_{2aqua}+2H_2O \xleftrightarrow{CA} H_3O^++HCO_3^-\xleftrightarrow{\text{Membrane}} H_3O^++HCO_3^-\leftrightarrow H_2O+H_2CO_3+Q_{gas}\leftrightarrow H_2O+CO_2\uparrow_{gas}+H_2O$ endothermic $\Delta H_H=+9.76\ ^{kJ}/_{mol}$; athermic $\Delta H_H=0\ ^{J}/_{mol}$ exothermic $\Delta H_H= -9.76\ ^{kJ}/_{mol}$; endothermic $\Delta H_H=+20.29\ ^{kJ}/_{mol}$;

gradient $\Delta G_{HCO3-}=-RT\ln(([HCO_3^-]_{right}/[HCO_3^-]_{left}))=-8.3144*298.15*\ln((0.0154/0.0338919))= -1.9554\ ^{kJ}/_{mol}$.

gradient $\Delta G_{H3O+}=-RT\ln(([H_3O^+]_{right}/[H_3O^+]_{left}))=-8.3144*298.15*\ln((10^{-5,5}/0.02754))= -22.49\ ^{kJ}/_{mol}$.

Sum $\Delta G_{Hess}=\Delta G_{HCO3}+\Delta G_{H3O}=-1.9554+-22.49=-24.44\ ^{kJ}/_{mol}$; endoergic $\Delta G_{Hess}=58.36\ ^{kJ}/_{mol}$;

exoergic $\Delta G_{Hess}=-22.44\ ^{kJ}/_{mol}$; exoergic $\Delta G_{Hess}=-58.205\ ^{kJ}/_{mol}$; $\Delta G_{Hess}=-8.538912\ ^{kJ}/_{mol}$ exoergic.

Total sum in sequence **endothermic** $\Delta H_{Hess}=+9.5876+0-9.76+20.291=+20.1\ ^{kJ}/_{mol}$ and free energy change **exoergic** $\Delta G_{Hess}=+58.36-22.44-58.205-8.538912=-30.82\ ^{kJ}/_{mol}$ spontaneous total sum in sequence.

Carbonic anhydrase make dominate buffer with protolysis constant $pK_a=7.0512$ on middle point:

$CO_{2aqua}+2H_2O \xleftrightarrow{CA} H_3O^++HCO_3^-$; $K_{eq}=[H_3O^+]\bullet[HCO_3^-]/[CO_{2aqua}]/ [H_2O]^2=2.901\bullet10^{-11}$ is constant, but Brenstad protolysis constant with $[H_2O]=55.3$ M square $K_a=K_{eq}\bullet[H_2O]^2=[H_3O^+]\bullet[HCO_3^-]/[CO_{2aqua}]=10^{-7.0512}$ forms its exponent $pK_a=-\log(K_a)=7.0512$. Weak acid CO_{2aqua} and HCO_3^- is ubiquities buffer system in living organism. The Attractor pH=7.36 reveals role of final product CO_{2aqua} for HOMEOSTASIS reach the multipurpose Attractor value pH=7.36±0.01 according Henderson Haselbalh equation with alkaline reserve 2.0263=0.0154 M / 0.0076 M: **7.36=pH=pK$_a$ +log([HCO$_3^-$]/[CO$_{2aqua}$])=7.0512+log(**0.0154 M / 0.0076 M) .

CA carbon dioxide CO_{2aqua} convertion to bicarbonate buffer processes endothermic $\Delta H_{Hess}=+9.76\ ^{kJ}/_{mol}$, endoergic $\Delta G_{eq}=+60\ ^{kJ}/_{mol}$ create $[HCO_3^-]=0.0154$ M and $[CO_{2aqua}]=0.0076$ M concentrations. Consumed energy compensate exothermic and exoergic oxidation reactions produced energy and sun radiation absorbed heat and photon energy. Supplied energy is used to reach ENZYME clusters of Photo Synthetic Reaction Center (PRC) in thylakoid cell sustaining HOMEOSTASIS functional activity order with multipurpose Attractor value pH=7.36 as non equilibrium state:

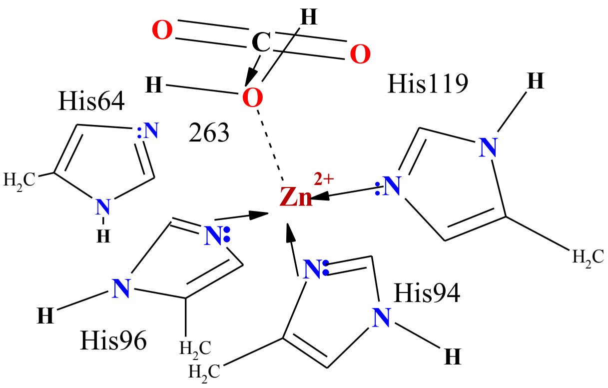
Henderson Haselbalh expression $pH=pK_a+\log[HCO_3^-]/[CO_{2aqua}]=7.0512+\log(0.0154/0.0076)=7.36$;

$\mathbf{O_2}$, $\mathbf{CO_2}$ metabolism, Carbonic Anhydrase, **Shutle** deoxy-oxy Leg**HEMOGLOBIN**

CA Brønsted protolysis and hemoglobin **shuttle** enzyme of $\mathbf{O_2}$, $\mathbf{HCO_3^-+H^+}$

Enzyme **Carbonic anhydrase** (**CA**) protolysis multi functional $\mathbf{HCO_3^-+H_3O^+}$ Attractor pH=7.36 .

Shuttle system, that stabilise **pH** at multi functional Attractor value **pH=7.36**±0.01 despite the organism produces the metabolic $[\mathbf{CO_{2aqua}}]=0.0275$ M. The **CA** made acidic products $[\mathbf{H_3O^+}]=0.0275$ M are compensated by **shuttle** hemoglobin captured $\mathbf{H^++HCO_3^-}$ after oxygen $[\mathbf{O_{2aqua}}]=0.0275$ M desorbtion due to oxidation product $\mathbf{CO_{2aqua}}$ in target cells of ***tissues***:



Hydrogen carbonate in human organism in amounts $[HCO_3^-]=0.0154$ M, $[CO_{2aqua}]=0.0076$ M, referring to 56.23 mL (50-60 mL) released volume CO_2 from 100 mL blood as *alkaline reserve* 2.036 / 1 in clinic evaluation.

Carbon dioxide forms by oxidation of carbohydrates, of fats and of proteins. Bicarbonate is created as product in hydration by CA enzyme $\mathbf{Zn^{2+}}$ ion coordination center active site pocket:

$CO_{2aqua} + 2H_2O \Rightarrow CA(\mathbf{Zn^{2+}}) \Rightarrow H_3O^+ + HCO_3^-$

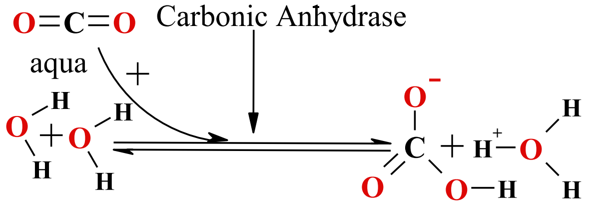
$H_2O(263)+CO_{2aqua}+H_2O \Leftarrow (\mathbf{Zn^{2+}} \leftarrow OH^-CA+H^++H_2O) \Rightarrow HCO_3^-+H_3O^+$.

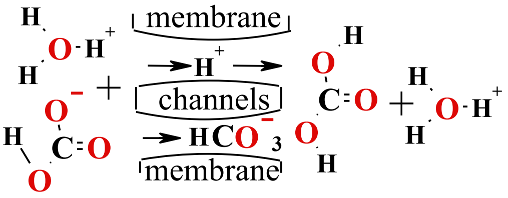
$\mathbf{H^+}$+**LHb**$_\mathbf{R}$(His63$\mathbf{O_2}$)+HCO_3^-⇔$\mathbf{O_{2aqua}}$+**LHb**(**H**$^+$His63)...salt bridge..HCO_3^- stabilizing concentration $[\mathbf{O_2}]=6\cdot10^{-5}$ M. Deoxy Leghemoglobin **LHb**(**H**$^+$His63) capture proton $\mathbf{H^+}$ at histidine residue and HCO_3^- forms deoxy **LHb**$_\mathbf{T}$(**H**$^+$His63)...salt bridge..HCO_3^- (Tense state). In thylakoid **shuttle** Leghemoglobin absorbs oxygen oxy **LHb**$_\mathbf{R}$(His63$\mathbf{O_2}$) (**Relax** state) and release proton $\mathbf{H^+}$, bicarbonate HCO_3^- . From air 0.04 % $\mathbf{CO_2}$:

$2H_2O+CO_{2gas} \Leftrightarrow CO_{2aqua}+\mathbf{Q}_{aqua}+\mathbf{CO_{2aqua}+2H_2O} \xleftrightarrow{CA} \mathbf{H_3O^++HCO_3^-} \xleftrightarrow{\mathbf{Membrane}} \mathbf{H_3O^++HCO_3}$ and metabolic $\mathbf{CO_{2aqua}}$ exchanged with $\mathbf{O_2}$ by ENZYME Carbonic Anhydrase (**CA**) convertes to $\mathbf{HCO_3^-}$, $\mathbf{H_3O^+}$ at stabilized pH=7.36±0.01 with ***alkaline reserve*** 2.036/1=$[\mathbf{HCO_3^-}]/[\mathbf{CO_2}]$ =0.0154 M / 0.0076 M.

1) <u>first</u> reaction with ENZYME Carbonic Anhydrase (**CA**) converts oxidation product $\mathbf{CO_{2aqua}}$, $\mathbf{2H_2O}$ to bicarbonate anion. Multipurpose Attractor pH=7,36 create primary Attractor Carbonic Anhydrase CA:

$\mathbf{Q+2H_2O+CO_{2aqua}} \xleftrightarrow{CA} \mathbf{H_3O^++HCO_3^-}$ endthermic $\Delta H_{Hess}=+9.7576$ kJ/mol; endoergic $\Delta G_{Hess}=+58.36$ kJ/mol





2) <u>Second process</u> athermic $\Delta H= 0$ kJ/mol $\mathbf{H_3O^++HCO_3^-} \xleftrightarrow{\mathbf{Membrane}} \mathbf{H_3O^++HCO_3^-}+\Delta G$; $\Delta G= -24.44$ kJ/mol exoergic gradients $\Delta G_{\mathbf{HCO3}}=\mathbf{RTln}([\mathbf{HCO_3^-}]_{right}/[\mathbf{HCO_3^-}]_{left})=\mathbf{RTln}((0.0154/0.0338919)= -1.9554$ kJ/mol; and $\Delta G_H=\mathbf{RTln}([\mathbf{H_3O^+}]_{right}/[\mathbf{H_3O^+}]_{left})=\mathbf{RTln}((10^{-5.5}/0.02754)= -22.49$ kJ/mol where R=8.3144 J/mol/K, T=298.15 K. Transport ENZYMES catalyzes bicarbonate $\mathbf{HCO_3^-}$, proton $\mathbf{H^+}$ move through membrane channels in thylakoid.

$[O_{2aqua}]=1.85\cdot10^{-5}$ M in ***mitochondria*** consumed for oxidation. Reactivity of O_{2aqua} cause desorption of O_{2aqua}:

1) $H^{+}+LHb_{R}(His63O_{2})+HCO_{3}^{-}\Leftarrow\Rightarrow(H^{+}His63)LHb_{T}$...salt bridge...$HCO_{3}^{-}+O_{2aqua}$.

Oxygen through aquaporins crosses membrane into mitochondria. Concentration decreases below $[O_{2aqua}]=1.85\cdot10^{-5}$ M. Each desorbed oxygen adsorbs one proton to distal histidine $H^{+}His63$ in LegHemoglobin $(H^{+}His63)LHb_{T}$ and bind with salt bridge the HCO_{3}^{-} . So sustain $[HCO_{3}^{-}]=0{,}0154$ M and $[CO_{2aqua}]=0{,}0076$ M with alkaline reserve 2.0263=0.0154 M / 0.0076 M according Henderson Haselbalh equation:

$7.36=pH=pK_{a}+\log([HCO_{3}^{-}]/[CO_{2aqua}])=7.0512+\log(0.0154\ M / 0.0076\ M)$ and drive HOMEOSTASIS to keep the multipurpose Attractor value pH=7.36 constant with concentration $[H_{3}O^{+}]=10^{-7.36}$ M.

2) CO_{2aqua}, which is a product of metabolism comes from ***mitochondria*** and irreversible reacts with two water molecules **endothermic** cooling the environment , because consume the heat **Q**:

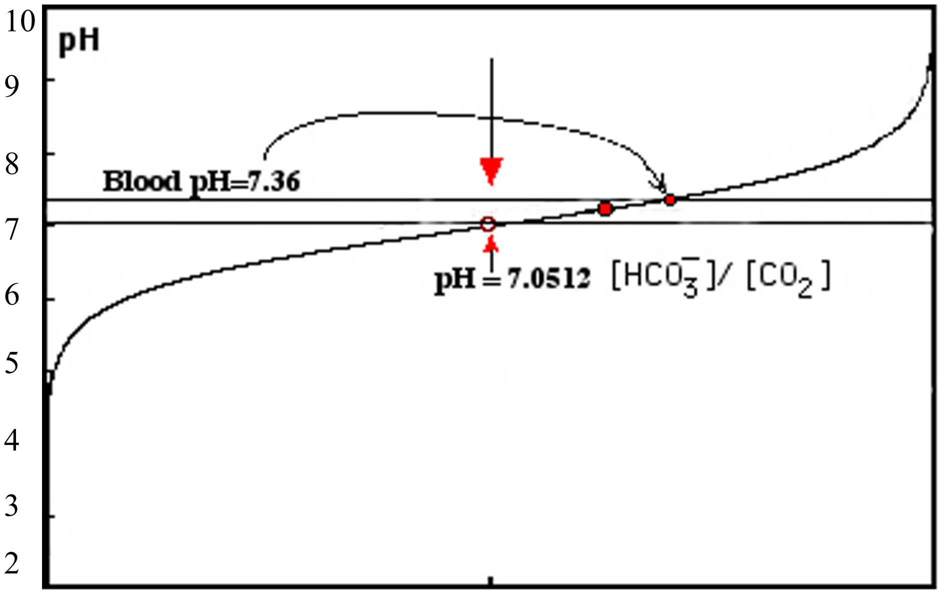
$$Q+CO_{2aqua}+2H_{2}O\underline{=CA}>H_{3}O^{+}+HCO_{3}^{-}.$$

ENZYME Carbonic Anhydrase (**CA**) reaction shifts to right by heat **Q** supply, high water $[H_{2}O]$ concentration 55.3 M, low hydroxonium ion concentration $[H_{3}O^{+}]=10^{-7.36}$ M . The acid protolytic constant value $pK_{a}=7.0512$ is friendly to multipurpose Attractor pH=7.36 to prevent of carbonic dioxide accumulation, as CA Carbonic Anhydrase CO_{2aqua} converts to products $H_{3}O^{+}+HCO_{3}^{-}$.

Green plants never evaporate CO_{2aqua} because Photosynthesis assimilate carbonic dioxide but in winter time at low temperatures stop the metabolism and did not produce the acid CO_{2aqua} For animals buffer systems struggle with acidic products of metabolism final waste CO_{2aqua}, more and more of the acid form CO_{2aqua} of the buffer systems are produced. For this reason, the acid CO_{2aqua} have to be transported out of organism. For sustain of animal multipurpose Attractor pH=7.36 endothermic evaporate $CO_{2}\uparrow_{gas}$, or through kidneys membrane channels eliminate $H_{3}O^{+}$ and HCO_{3}^{-} .

Multipurpose Attractor pH=7.36 **Henderson-Haselbalh** calculations

$\frac{[HCO_3^-]}{[CO_{2\,aqua}]} = 10^{(pH-pK)} = 10^{(7.36-7.0512)} = 10^{0.3088} = \frac{2.0263}{1}$ the ratio **$[HCO_3^-]/[CO_{2aqua}]$** being approximately **2/1**.



Buffer region middle point is the over inflection point in graph ○: **pH=pK$_a$ =7.0512** as ratio $[HCO_3^-]/[CO_{2aqua}]=1$ is one as well buffer component concentrations are equal **$[HCO_3^-]=[CO_{2aqua}]$** . Bicarbonate protolytic **base** **$[HCO_3^-]$** concentration is equal to Brensted **acid** **CO_{2aqua}** concentration **$[CO_{2aqua}]$**.

Alkaline reserve at 7.36=**pH** is physiologic **<u>Norma</u>** and ratio is

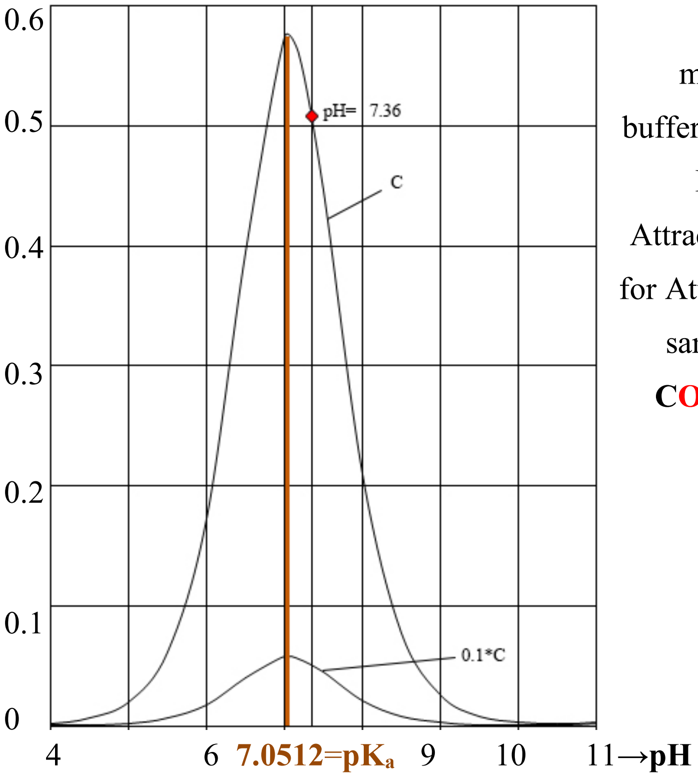
$$\frac{[HCO_3^-]}{[CO_{2\,aqua}]} = \frac{0.0154\ M}{0.0076\ M} = \frac{2.0263}{1}.$$

HCO_3^- 0% **50%** 100% protolytic **base**

CO_{2aqua} + $2H_2O$ 100% **50%** 0% **acid** buffer component

If **H^+** concentration grows <u>Carbonic Anhydrase</u> equilibrium is shifted to left and **CO_2** transported out as **H^+** with **HCO_3^-** by respiration through ***stomata*** spongy mesophyll cell surface and acid concentration [**H^+**] decreases. If concentration **H^+** decreases, <u>Carbonic anhydrase</u> equilibrium is shifted to the right and the extra amount of **HCO_3^-** through ***stomata*** cell surface passes transported out. Bicarbonate channels in ***stomata*** spongy mesophyll cell surface are open at values of pH=7.36 and higher from inside of cytosol circulation, but are open to outside at low values perhaps proposed 5<pH<7.36 for cytosol **HCO_3^-** bicarbonate evaporation out to air as **CO_2** form.

β, eq.mol/L buffer capacity .



The **pK$_a$=7.0512** of protolytic acid constant is friendly to multipurpose Attractor **pH=7.36**. Acidic in organism has to buffering with reserve of alkalinity. Therefore the ratio between **HCO_3^-** and **CO_2** concentrations is **2**/**1** and the **pH** value of Attractor is **7.36**. *The **alkaline reserve*** 2.036/1=[**HCO_3^-**]/[**CO_2**] for Attractor pH=7.36 is controlled by adding **H_2SO_4** to **100** mL sample (**H_2SO_4** reacts with **HCO_3^-** and the **CO_{2aqua}**, liberated **CO_2**). If **56.23** mL of gaseous **CO_2** are liberated, the ***alkaline reserve*** in **homeostasis** is **<u>norma</u>** and total amount concentration **0.023M**=[**HCO_3^-**]+[**CO_2**] is of [**HCO_3^-**]=**0.0154 M** with [**CO_2**]=**0.0076M**.