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Protolytic solubility in water relates the absolute electrode potential to the zero of the absolute free energy scale $G_{H2O}=G_{CO2gas}=0$ $^{kJ}/_{mol}$ and depends on absolute temperature. In solubility and protolysis reactions with water molecules, instead of classical molar concentrations, thermodynamics requires the use of mole fractions of water, soluble reactants and products.

The solubility and protolysis process consumes water molecules for aqua dissolute product formation. Solubility of gases: oxygen $O_{2gas}+H_2O=O_{2aq}$; hydrogen $H_{2gas}+H_2O=H_{2aq}$; nitrogen $N_{2gas}+H_2O=N_{2aq}$; hydrogen sulfide $H_2S_{gas}+H_2O=H_2S_{aq}$; sulfur dioxide $SO_2^{gas}+H_2O=H_2SO_{3aq}$;

Electrodes of metals: hydrogen $\underline{H}(Pt)+H_2O=H_3O^++e^-$; iron $Fe_{(s)}+H_2O=Fe^{2+}+2e^-$.; zinc $Zn+H_2O=Zn^{2+}+2e^-$; cupper amalgam $Cu(Hg)+H_2O=Cu^{2+}+(Hg)+2e^-$; silver $Ag_{(s)}+H_2O=Ag^++e^-$; chromium $Cr+H_2O=Cr^{3+}+3e^-$;

For solid solubility: silver chloride $AgCl_{(s)}+2H_2O=Ag^++Cl^-$; calomel $Hg_2Cl_{2(s)}+3H_2O=Hg_2^{2+}+2Cl^-$; mercury(II) oxide $Hg+H_2O+2OH^-=HgO+2H_2O+2e^-$, mercury(I) sulfate $Hg_2SO_{4(s)}+2H_2O=Hg_2^{2+}+SO_4^{2-}$;

For protolysis: peroxide $H_2O_2+H_2O=H_3O^++HOO^-$ $pK_a=11{,}75$; water $2H_2O=H_3O^++OH^-$ $pK_w=14$.

The solubility of gaseous oxygen $O_{2gas}+H_2O=O_{2aq}$ in oxidation half-reaction compensates one water molecule $6H_2O=O_{2gas}+H_2O+4H_3O^++4e^-$ from six to five $5H_2O=O_{2aq}+4H_3O^++4e$. Its decreases the calculate free energy content of metal hydrogen from $G_{H(Pt)}=51.05$ $^{kJ}/_{mol}$ to $G_{H(Pt)}=48.56$ $^{kJ}/_{mol}$. The absolute standard potential scale reference increases from $E°_H=-0.29654$ V to $E°_H=-0.27073$ V less negative. The absolute potential scale shift down of thermodynamic $0{,}10166$ V to absolute -0.37239 V so coupled sum is $\Delta E°=+0.10166-0.37239$. Standard potential shift down to $E°_{O2}=1.0868$ V for oxygen and for glucose to $E°_{C6H12O6}=-0.13858$ V.

The operations sequence of the absolute standard potential determination: $E°_{O2}=1.0868$ Volts for two water oxygen oxidation in Nernst's half-reaction $5H_2O=O_{2aq}+4H_3O^++4e^-$.

From Nernst classical value $E°_{classicO2}=1.2288$ V subtract $E°_{H2O}=-0.0591/4*\log(1/55.3^5)=0.1287$ the counting logarithm of five water molecules. The concentration of water in one liter is 55.3 M if solution concentrations sum is less as 0.1 M. Then add the coupled sum $\Delta E°=+0.10166-0.37239$. The absolute standard potential is summing from three components: classic $E°_{classic}+$ water logarithm account $+\Delta E°$ the coupled sum:

$$E°_{O2}=E°_{classicO2}-0.0591/4*\log(1/55.3^5)+\Delta E°=1.2288+0.1287+0.10166-0.37239=1.0868 \text{ Volts.}$$

The Nernst half-reaction $5H_2O=O_{2aq}+4H_3O^++4e^-$ is expressed with absolute potential in mathematic equation:

$$E_{O2}=E°_{O2}+0.0591/4*\log \frac{[O_2]_{aqua}\cdot[H_3O^+]^4}{[H_2O]^5} =1.0868+0.0591/4*\log \frac{[O_2]_{aqua}\cdot[H_3O^+]^4}{55{,}3^5} \text{ Volts.}$$

The inverse standard potential for the reduction of oxygen $O_{2aq}+4H_3O^++4e^-=5H_2O$ has minus sign $-E°_{O2}$. The oxygen reducing reaction is exoergic $\Delta G_{eqO2}=E°_{O2}\cdot F\cdot n=-1.0868*96485*4/1000=-419.44$ $^{kJ}/_{mol}$; $\Delta G_{eqO2}=5G_{H2O}-(G_{O2aq}+4G_{H3O+})=5*0-(329.68+4*22.44)=-419.44$ $^{kJ}/_{mol}$; and coincides with the absolute potential scale. Oxygen energy $G_{O2gas}=303.1$ $^{kJ}/_{mol}$ grows $G_{O2aq}=G_{O2gas}+G_{O2sp}=303.1+26.58=329.68$ $^{kJ}/_{mol}$ at solubility.

Nernst's hydrogen oxidation $\underline{4(Pt)H}+4H_2O=4H_3O^++4e^-$ standard absolute potential is $E°_H=-0.27073$ Volts. In sum reduction reaction of oxygen with metallic hydrogen synthesize two water molecules:

$$O_{2aqua}+\underline{4(Pt)H}=2H_2O \text{ with absolute free energy exchange exoergic } -523.925 \text{ }^{kJ}/_{mol}:$$
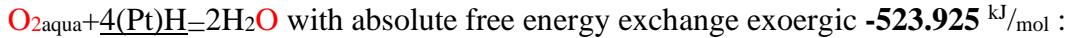
$$\Delta G_{eq}=(E°_H-E°_{O2})\cdot F\cdot 1\cdot 4=(-0.27073-1.0868)*96485*4=-1.3575*96485*4/1000=2*261.96=-523.925 \text{ }^{kJ}/_{mol}.$$

Exchange $\Delta G_{eq2H2O}=2G_{H2O}-4G_{(Pt)H}-G_{O2aqua}=2*0-(4*G_{(Pt)H}+329.68)=-523.925$ $^{kJ}/_{mol}$ gives metal hydrogen free energy content $G_{H(Pt)}=(2G_{H2O}-\Delta G_{eq2H2O}-G_{O2aqua})/4=(2*0+523.925-329.68)/4=194.245/4=48.56$ $^{kJ}/_{mol}$.

The determination of the hydrogen electrode reference point $E°_H=-0.27073$ V on the absolute potential and absolute free energy scales in the Nernst half reaction is based on the property of inverse symmetry: The potential and free energy change of the inverse reaction belong to the same number with opposite sign on both absolute scales.

Absolute and **inverse** free energy and potential scaling requires accounting for water and hydroxonium based on Alberty's data for hydrogen gas and the absolute free energy value of the solution. [8]

In the reaction, $\underline{H}(Pt)+H_2O=H_3O^++e^-$, the standard absolute potential is $E°_H=-0.27073$ V. The standard oxidation of hydrogen using absolute standard potential produced absolute free energy change is exoergic: $\Delta G_{eq}=E°_H\cdot F\cdot 1\cdot 1=-0.27073*96485*1=-26.12$ $^{kJ}/_{mol}$ and is identical to the change in the absolute free energy calculated by Hess's law on a scale related to the zero free energy content of water $G_{H2O}=0$ $^{kJ}/_{mol}$:

$$\Delta G_{Hess\_eq}=G_{H3O+}+G_{e^-}-(G_{H(Pt)}+G_{H2O})=22.44+0-(48.56+0)=-26.12 \text{ }^{kJ}/_{mol} .$$

The **absolute** standard potential $E°_H=-0.27073$ in Volts coincides with Alberty absolute free energy. [8,15]

I type electrode hydrogen metal **H**(**Pt**) interface / to its cations H_3O^+ solution application

Attractor pH=7.36 staying at equilibrium have true p**O**H=6.64 value as pK_w=14=pH+p**O**H=7.36 +6.64**.**
Water amount in titer is [**H₂O**]=963/18=53.5 M for [H_2SO_4]=[H_3O^+]=1 M solution with 1.061 $^g/_{mL}$ density
in Nernst equations for **hydrogen electrode** has classic standard potential $E_{o\_classic}$=0 V reference zero:
   H(**Pt**)=H^++e^-; $E_{classic}=E_{o\_classic}+0.0591\cdot\log K°_{classic}$**H(Pt)**=0+0.0591$\cdot\log[H^+]$=0+0.0591$\cdot\log$(1 M)=0 Volts. [11]
Thermodynamic account Hydroxonium ions demand the water: **H**(**Pt**)+**H₂O**<=>**H₃O⁺**+**e⁻** and $E°_H$=0.10166 V.
The ratio [H_3O^+]/([**H₂O**]-[H_3O^+])=1 M/52.5 M=X_{H3O+}/X_{H2O} is mol fraction instead molarity [**H⁺**]=1 M at classic
potential expression. The water account gave thermodynamic standard $E°_H$=0.10166 V on potential scale.
Nernst's expression with classic zero measurement demands thermodynamic standard potential $E°_H$=0.10166 V :
   E=$E°_H$+ ln(10)•R•T/F/1•log(X_{H3O+}/X_{H2O})=E_o+$E°_H$+0.0591*log(1/52.5)=0.10166-0.10166=0 V.
As ratio **1**=$K_{H(Pt)}$=X_{H3O+}/X_{H2O} is one than $E°_H$=0.10166 V is thermodynamic standard potential:

$$\mathbf{E}=E°_H+ \frac{\ln(10)\bullet R\bullet T}{F\bullet 1}\bullet\log\frac{X_{H_3O^+}}{X_{H_2O}}=0.10166+0.0591*\log(1)=0.10166\ V.$$ Metal oxidation free energy change
minimum is different endoergic $\Delta\mathbf{G_{eq}}$=$E°_H$•F•1•1=0.10166*96485*1=9.81 $^{kJ}/_{mol}$ instead Alberty is exoergic.
Alberty Hess value is in did exoergic: $\Delta\mathbf{G_{Hess\_eq}}$=$G_{H3O+}$+$G_{e-}$-($G_{H(Pt)}$ +G_{H2O})=22.44+0-(**48.56**+0)=**-26.12** $^{kJ}/_{mol}$.
   Free energy changes are determined on water and carbon dioxide gas as zero G_{H2O}=G_{CO2gas}=G_{e-}=0 $^{kJ}/_{mol}$
reference scale. Absolute scale hydrogen standard potential is $E°_H$=$\Delta\mathbf{G_{eq}}$/F/1=**-26.12**/96485/1=-0.27073 Volts.
Equilibrium free energy change minimum is exoergic $\Delta\mathbf{G_{eq}}$=$E°_H$•F•1=-0.27073*96485*1=**-26.12** $^{kJ}/_{mol}$ coincident
with Alberty data. Absolute potential scale decreases about ΔE=-0.27073-0.10166=-0,37239 Volts relative to
classic zero scale. Nernst's equilibrium constant is grater as one for metal oxidation to hydroxonium ion favored
K$_{H(Pt)\_Red}$=[H_3O^+]*[**e⁻**]/[**H₂O**]/[H(Pt)]=EXP(-$\Delta\mathbf{G_{Alberty}}$/R/T)=EXP(**26120**/8,3144/298,15)=37675,6.

I type electrode Metal interface **H**(Pt) / on its cation H_3O^+ solution application.

   High rate protolysis attractors [H_3O^+]=$10^{-7.36}$ M , pH=7.36 and water mass [**H₂O**]=996/18=55.3 M account in
liter shows metal hydrogen strong reducing potential **E**$_{pH=7.36}$=-0.27073+0.0591*log($10^{-7.36}$/55.3)=-0.8087 V and
free energy change at homeostasis exoergic $\Delta\mathbf{G_{eqpH\_7.36}}$=$E°_H$•F•1=-0.8087*96485*1/1000=-78,03 $^{kJ}/_{mol}$.
   Nernst's half reaction metal has reduction potential and energy change $E°_H$=-0.27073 V and $\Delta\mathbf{G_{eq}}$=**-26.12** $^{kJ}/_{mol}$.

Platinum sheet immersed in hydroxonium ions [H^+]=[H_3O^+]=[H_2SO_4]=1 M sulfuric acid
solutions **H**(**Pt**)<=>**H⁺**+**e⁻**: **E**=E°+0.0591•log[H^+]=**0.0**+0.0591•log(1 M)=**0** V is classic.
Ratio [H_3O^+]/[**H₂O**]=1/52.5=X_{H3O+}/X_{H2O} instead zero **0** classic give thermodynamic
standard potential: $E°_H$=0.10166 V and from Alberty data on absolute scale
the absolute standard potential is $E°_H$=-0.27073 Volts.

absolute $E°_H$=-0.27073 V   classic zero $E°_H$= 0 V   0.10166 V   E,V

$E_{(Pt)H/H^+}$=$E°_H$ + 0.0591*log($\frac{X_{H_3O^+}}{X_{H_2O}}$) $E_{H\_classic}$=$E°_H$+0.0591*log([H_3O])   thermodynamic $E°_H$

Absolute standard potential $E°_H$=-0.27073 V based on Alberty data G_{H2gas}=**85.64** $^{kJ}/_{mol}$ and
G_{H2aq}=**103.24** $^{kJ}/_{mol}$ for hydrogen, which was detected on water and carbon dioxide gas
G_{H2O}=G_{CO2gas}=G_{e-}=0 $^{kJ}/_{mol}$ as zero scale reference. Reducing agent metal hydrogen at
pH=7.36, [H_3O^+]=$10^{-7.36}$ M with potential **E**$_{pH=7.36}$=-0.27073+0.0591*log($10^{-7.36}$/55.3)=-0.8087 V is strong
reductant. Free energy content in one mol metal hydrogen is: $G_{H(Pt)}$=**48.56** $^{kJ}/_{mol}$.

Substance	$\Delta H°_H, ^{kJ}/_{mol}$	$\Delta S°_H, ^{J}/_{mol/K}$	$\Delta G°_H, ^{kJ}/_{mol}$
H₂O	-285.85	69.9565	-237.191
H₂O	**-286.65**	**-453.188**	**-151.549**
H₃O⁺	-285.81	-3.854	-213.2746
H₂gas	Alberty	pH=7,36	**85.64**
H(Pt)(aq)	$E°_H$=	-0,27073	**48,56**
H₂(aq)	**-5.02**	**-363.92**	**103.24**
O₂aqua	**-11.70**	**-94.2**	**16.4**

$\Delta G°_{H2O}$=G_{H2O}-(G_{H2aq}+G_{O2aq}/2)=**0**-(**103,24**+**88,04**/2)=**-147,26** $^{kJ}/_{mol}$;
G_{H2O}=ΔG_{H2O}Alberty-($\Delta G°_{H2O}$)=**-151.549**-(-237.191)=**85.6** $^{kJ}/_{mol}$ [8]
ΔG_H=ΔH_H-T*ΔS_H=**-286.65**-298.15*-**0.453188**=**-151.5** $^{kJ}/_{mol}$;
$\Delta G°$**H3O +**,$^{kJ}/_{mol}$ Mischenko 1972, Himia, Leningrad [26]
Biochem.Thermodyn. Massachusetts Technology Inst. [8]
$\Delta\mathbf{G_{Hess\_eq}}$=$G_{H3O+}$-($G_{H(Pt)}$ +G_{H2O})=22.44-(**48.56**+0)=**-26.12** $^{kJ}/_{mol}$.
2006, Massachusetts Technology Inst. Alberty pH=7,36 [8]
2006, Massachusetts Technology Inst. Alberty pH=7,36 [8]

The solubility of gaseous hydrogen $H_{2gas}+H_2O=H_{2aq}$ compensates for $H_{2gas}+2H_2O=H_{2aq}+H_2O=2H_3O^++2e^-$ one water molecule in Nernst oxidation of hydrogen to hydroxonium and is arbitrary because the change in absolute free energy is negative $\Delta G_{Hess\_H3O+}=2G_{H3O+}+2G_{e^-}-(G_{H2aq}+G_{H2O})=2*22.44+2*0-(103.24+0)=-58.36$ $^{kJ}/_{mol}$. A graphite electrode oxidizes a solution of H_{2aq} to hydroxonium at the absolute standard potential:

$$E^°_{H2aq}=-58.36*1000/96485/2=-0.3024 \text{ V.}$$

The sum of the Nernst and inverse half reactions $H_{2aq}+H_2O=2H_3O^++2e^-$; $2H_3O^++2e^-=2H(Pt)+2H_2O$ shows the solubility of hydrogen in the platinum crystal lattice $H_{2aq}=2H(Pt)+H_2O$;

The oxidation potential of hydrogen solution $H_{2aq}+H_2O=2H_3O^++2e^-$ $E^°_{Haq}=-0.302$ V plus the inverse potential $E^°_{H(Pt)}=+0.27073$ V in the electrochemical solubility of the metal $2H_3O^++2e^-=H(Pt)+2H_2O$ shows the solubility of hydrogen mole fraction $[H_{2aq}]/[H_2O]$ in platinum exoergic, arbitrary at value of equilibrium constant $K_{spH(Pt)}$ greater as one:

$\Delta G_{spH(Pt)}=\Delta E^°_{spH(Pt)}\bullet F\bullet 2=(E^°_{H2aq}-E^°_{H(Pt)})\bullet F\bullet 2=(-0.302+0.27073)*96485*2=-0.03128*96485*2=-6.03$ $^{kJ}/_{mol}$ and constant $K_{spH(Pt)}=[H(Pt)]^2*[H_2O]/[H_{2aq}]=EXP(-\Delta G_{spH(Pt)}/R/T)=EXP(6036,1/8,3144/298,15)=11,415$.

The solubility in platinum $H_{2aq}=2H(Pt)+H_2O$ shows the electrochemical solubility product of hydrogen in the metal exoergic $\Delta G_{sp\_H(Pt)}=2G_{H(Pt)}+G_{H2O}-(G_{H2aq})=2*48.56+0-(103.24)=-6.12$ $^{kJ}/_{mol}$ and constant grater as >1:

$$K_{sp\_H(Pt)}=[H(Pt)]^2*[H_2O]/[H_{2aq}]=EXP(-\Delta G_{spH(Pt)}/R/T)=EXP(6120/8.3144/298.15)=11.808 .$$

Solubility $H_{2gas}+H_2O=H_{2aq}$ constant $\Delta G_{H2spAlberty}=G_{H2aq}-G_{H2gas}-G_{H2O}=103,24-85,64-0=17,6$ $^{kJ}/_{mol}$ is weak:

$$K_{H2sp}=[H_{2aq}]/[H_2O]/X_{H2gas}=EXP(-\Delta G_{H2sp}/R/T)=EXP(-17600/8,3144/298,15)=0,0008253.$$

It calculates the solubility $[H_{2aq}]=K_{H2sp}*[H_2O]*X_{H2gas}=0,0008253*55,3*1=0,04564$ M, if the mole fraction of pure gas is one $X_{H2gas}=1$.

From the ratio $[H(Pt)]^2/[H_{2aq}]=K_{sp\_H(Pt)}/[H_2O]=11.808/55.3=0.213526$ obtains mol fraction of $H(Pt)$ metal square: $[H(Pt)]^2=K_{spH(Pt)}/[H_2O]*[H_{2aq}]=11.808/55.3*0.04564=0.009745$.

90.13 Pt

H 9.87
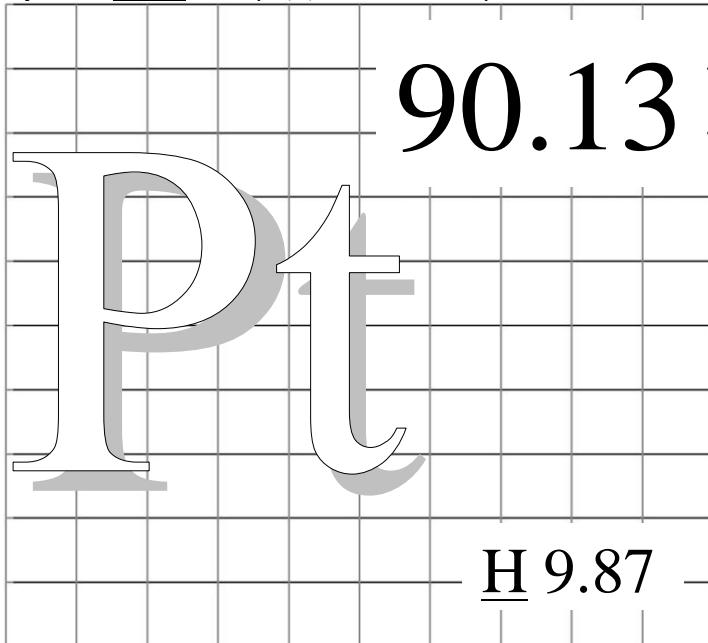
Saturated solubility in platinum lattice $[H(Pt)]=SQRT(0.009745)=0.0987$ in mol fraction units is hydrogen atom surface fraction 9.87% shared with platinum atoms fraction 90.13% on total 100% platinum lattice surface. $H_{2aqAlbery}=2H(Pt)+H_2O$ Solubility mol fractions concentrations are unit less as constant too $K_{sp\_H(Pt)}=11.808$.

$H(Pt)$ solubility in water $2H(Pt)+H_2O=H_{2aqAlberty}$ constant is less as one $K_{spH(Pt)\_H2aq}=1/11.808=0.08469$ and $\Delta G_{Alberty}=G_{H2aq}-2G_{H(Pt)}-G_{H2O}=6.12$ $^{kJ}/_{mol}$ positive, unfavored, non-spontaneous. It keeps metal lattice saturated with hydrogen 9.87%, because is positive 6.12 $^{kJ}/_{mol}$ and constant less as one 0.08469 so is unfavored for hydrogen dissolution

$$K_{spH(Pt)\_H2aq}=[H_{2aq}]/[H(Pt)]^2/[H_2O]=EXP(-\Delta G_{sp\_H(Pt)}/R/T)=EXP(-6120/8.3144/298.15)=0.08469.$$

Metal iron I-type electrode in $[Fe^{2+}]=0.1$ M solution, density 1.03 $^g/_{mL}$, 0.1 Molarity mass $FeSO_4=15.191$ g. $Fe_{(s)}+H_2O=Fe^{2+}+2e^-$. The absolute standard potential is composed of the classic $E^°_{classic}=-0.4402$ V standard potential [17], the logarithm of water accounting $-0.0591/2*log(1/(55.3)=0.0515$ and the coupled sum $\Delta E^°=+0.10166-0.37239$ in the expression:

$E^°_{Fe/Fe2+}=E^°_{classic}-0.0591/2*log(1/([H_2O]))+\Delta E^°=-0.4402+0.0515+0.10166-0.37239=$ **-0.65943** V.

$E_{Fe}=E^°_{Fe/Fe2+}+0.0591/2*log([Fe^{2+}]/[Fe]/([H_2O]))=$**-0.65943**$+0.0591/2*log(0.1/1/(55.3))=-0.74048$ V;

$\Delta G_{eq\_Fe}=E^°_{Fe}\bullet F\bullet 2=$**-0.65943**$*96485*2=$**-127.25** $^{kJ}/_{mol}$,

$\Delta G_{eq\_Fe}=G_{Fe2+}-(G_{Fe}+G_{H2O})=$**-82.14**$-($**45.1**$+0)=$**-127.25** $^{kJ}/_{mol}$;

$G_{Fe}=G_{Fe2+}-(\Delta G_{eq\_Fe}+G_{H2O})=$**-82.14**$-($**-127.25**$+0)=$**45.1** $^{kJ}/_{mol}$; Difference -0.74048 V in the 4th digit 4 -0.74059 V. $E_{Fe}=E^°_{Fe/Fe2+}+0.0591/2*log([Fe^{2+}]/[Fe]/([H_2O]-6[Fe^{2+}]))=$**-0.658382**$+0.0591/2*log(0.1/1/(56.38-0.6))=-0.7395$ V; $[H_2O]=55.3$ M$=(996^g/_L)/(18^g/_{mol})$; $m_{H2O}=m_L-m_{FeSO4}=1030-15.191=1014.8$ g; $[H_2O]=1014.8$ $^g/18$ $^g/_{mol}=56.38$ M.

Coordinate metal ion aqua complexes are hexagonal like the hexa aqua iron(II) ion $[Fe^{2+}(H_2O)_6]$ and like tetragonal as the tetra aqua copper(II) ion $[Cu^{2+}(H_2O)_4]$.

3

Substance	$\Delta H°_H$ kJ/mol	$\Delta S°_H$ J/mol/K	$\Delta G°_H$, kJ/mol	
Fe	$E°_{Fe}=$	**-0.6594** V	**45.11**	$G_{Fe}=G_{Fe2+}-(\Delta G_{eq\_Fe}+G_{H2O})=-82.14-(-127.25+0)=45.11$ kJ/mol;
Fe²⁺	**-87.45**	**-17.8**	**-82.14**	[8] Biochem.Thermodyn. Massachusetts Technology Inst. pH=7,36
Fe²⁺	-89.1	-137.7	-78.9	CRC 2010 [1]
Fe³⁺	**-44.79**	**-110**	**-11.99**	[8] Biochem.Thermodyn. Massachusetts Technology Inst. pH=7,36
Fe³⁺	-48.5	-315.9	-4.7	CRC 2010 [1]
Cu	$E°_{Cu}=$	0.**1243** V	**70.02**	$G_{Cu}=G_{Cu2+}-(\Delta G_{eq\_Cu}+G_{H2O})=94.0187-(24.0+0)=70.02$ kJ/mol ;
Cu²⁺	64.8	-98	**94.0187**	[1] $\Delta G_{Cu2+}=\Delta H_H-T*\Delta S_H=64.8-298.15*-0.098=$**94.0187** kJ/mol;
Zn	$E°_{Zn}=$	-0.**98098** V	**68.65**	$G_{Zn}=G_{Zn2+}-(\Delta G_{eq\_Zn}+G_{H2O})=$**-120.653**-(**-189.3**+0)=**68.65** kJ/mol;
Zn²⁺	-153.39	-109.8	**-120.653**	[1] $\Delta G_{Zn2+}=\Delta H_H-T*\Delta S_H=-153.39-298.15*-0.1098=$**-120.65** kJ/mol;

Metal cooper I-type electrode in $[Cu^{2+}]=1$ M solution, density 1.19 g/mL and Molar mass $M_{CuSO4}=159.602$ g/mol; $Cu(Hg)+H_2O=Cu^{2+}+(Hg)+2e^-$; The absolute standard potential is composed of the classic $E°_{classic}=0.3435$ V standard potential [18], the logarithm of water accounting $-0.0591/2*\log(1/(55.3))=0.0515$ and the coupled sum $\Delta E°=+0.10166-0.37239$ in the expression:

$E°_{Cu/Cu2+}=E°_{Classic}-0.0591/2*\log(1/([H_2O]))+\Delta E°_{Cu}=0.3435+0.0515+0.10166-0.371339=$**0.1243** V.

$E_{Cu}=E°_{Cu}+0.0591/2*\log([Cu^{2+}]/[Cu]/([H_2O]))=$**0.1243**$+0.0591/2*\log(1/1/(55.3))=0.0728$ V;

Distinguish on number 0.072**8** V in the second digit 0.073**3** V.

$m_{H2O}=(m_L-m_{cuSO4})/18=1190-159.602=1030.4/18=57.24-4=53.24$ mol;
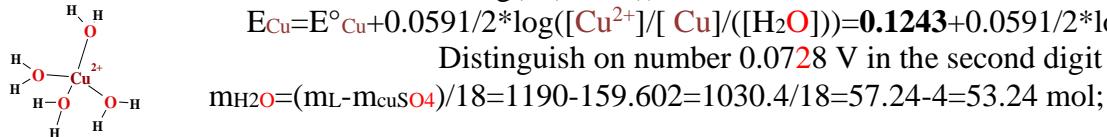
$E_{Cu}=E°_{Cu}+0.0591/2*\log([Cu^{2+}]/[Cu]/([H_2O]-4[Cu^{2+}]))=$**0.1243**$+0.0591/2*\log(1 M/1/(57.24-4))=0.073$**3** V;

$\Delta G_{eq\_Cu}=E°_{Cu}•F•2=$**0.1243**$*96485*2=$**24.0** kJ/mol, $\Delta G_{eq\_Cu}=G_{Cu2+}-(G_{Cu}+G_{H2O})=94.0187-(G_{Cu}+0)=$**24.0** kJ/mol ;

$G_{Cu}=G_{Cu2+}-(\Delta G_{eq\_Cu}+G_{H2O})=94.0187-($**24.0**$+0)=$**70.02** kJ/mol;

Metal cooper I-type electrode in $[Zn^{2+}]=C_{ZnSO4}=2$ M solution, density 1.31 g/mL, Molar mas $ZnSO_4=161.44$ g/mol,- and mas of two moles $m_{ZnSO4}=2*161.44=322.88$ g: $Zn+H_2O=Zn^{2+}+2e^-$, standard potential $E°_{Zn/Zn2+}=$**-0.98098** V. The absolute standard potential is composed of the classic $E°_{classic}=-0.7628$ V standard potential [18], the logarithm of water accounting $-0.0591/2*\log(1/(55.3))=0.0515$ and the absolute potential coupled sum $\Delta E°=+0.10166-0.37239$ in the expression:

$E°_{Zn/Zn2+}=E°_{classic}-0.0591/2*\log(1/([H_2O]))+\Delta E°_{Zn}=-0.7628+0.0515+0.10166-0.371339=$**-0.98098** V.

$E_{Zn}=E°_{Zn/Zn2+}+0.0591/2*\log([Zn^{2+}]/[Zn]/([H_2O]))=$**-0.980981**$+0.0591/2*\log(2/1/(55.3))=-1.02$**15** V

Distinguish on number -1.02**15** V in the fourth digit -1.02**358** V 2M;

Solubility 57.7 g/100g in hundred grams of voter; w%=57.7/157.7*100=36.6%;
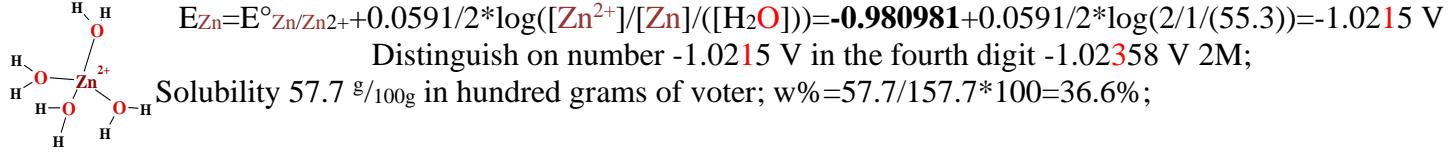
$m_{H2O}=m_L-m_{ZnSO4}=1310-161.44*2=987.12$ g; $m_{ZnSO4}=2*161.44=$ g; $[H_2O]=987.12$ g/18 g/mol$=54.84$ M.

$E_{Zn}=E°_{Zn/Zn2+}+0.0591/2*\log\dfrac{[Zn^{2+}]}{[Zn]\cdot([H_2O]-4\cdot[Zn^{2+}])}=$**-0.980981**$+0.0591/2*\log(2/1/(54.84-4*2))=-1.02$**358** V;

$\Delta G_{eq\_Zn}=E°_{Zn}•F•2=$**-0.980981**$*96485*2=$**-189.3** kJ/mol, $\Delta G_{eq\_Zn}=G_{Zn2+}-(G_{Fe}+G_{H2O})=$**-120.65**-($G_{Zn}+0)=$**-189.3** kJ/mol ;

$G_{Zn}=G_{Zn2+}-(\Delta G_{eq\_Zn}+G_{H2O})=$**-120.653**-(**-189.3**$+0)=$**68.65** kJ/mol;

Metal chromium I-type electrode in $[Cr^{3+}]=1$ M solution, M density 1.172 g/mL, molar $Cr_2(SO_4)_3=392.16$ g/mol mas, mas $m_{H2O}=m_L-m_{Cr2(SO4)2}=1172-392.16=779.84$ g/L, amount $[H_2O]=779.84$ g/18 g/mol$=43.3244$ M. $Cr+H_2O=Cr^{3+}+3e^-$, absolute standard potential $E°_{Cr/Cr3+}=$**-0.9793** V. The absolute standard potential is composed of the classic $E°_{classic}=-0.744$ V standard potential [18], the logarithm $-0.0591/3*\log(1/(55.3))=0.03433$ of water accounting and the absolute potential coupled sum $\Delta E°=+0.10166-0.37239$:

$E°_{Cr/Cr3+}=E°_{Classic}-0.0591/3*\log(1/[H_2O])+\Delta E°_{Cr}=-0.744+0.03433+0.10166-0.371339=$**-0.9793** V.

$E_{Cr}=E°_{Cr}+0.0591/3*\log([Cr^{3+}]/[Cr]/([H_2O]))=$**-0.9793**$+0.0591/3*\log(1/1/55.3)=-1.01$**36** V;

Distinguish on number -1.0**1**36 V 1M; in the third digit -1.0**0**208 V 2.32 M;
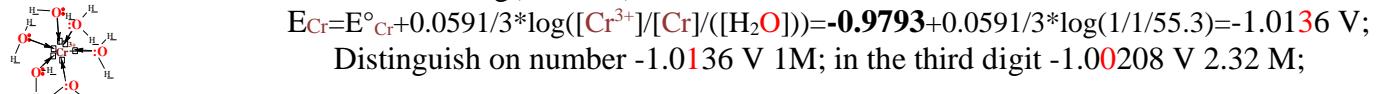
$E_{Cr}=E°_{Cr}+0.0591/3*\log\dfrac{[Cr^{3+}]}{[Cr]\cdot([H_2O]-6\cdot[Cr^{3+}])}=$**-0.9793**$+0.0591/3*\log(2,343/1/(39,59-6*1))=-1,0$**0**208 V;

Solubility 64 g/100g in hundred grams of water; w%=64/164*100=39.2%;

39.2/100g=X/??1172//g/L; 39.2/100*1172=459.4=X/g/L; $C_{Cr2(SO4)2}=459.4/392.16=2.343$ M $Cr_2(SO_4)_3$;

$m_{H2O}=m_L-m_{Cr2(SO4)2}=$??1172??$-459.4=712.6$ g; $m_{Cr2(SO4)2}=457.07$g; $[H_2O]=712.6$ g/18 g/mol$=39.59$ M.

Note: Oxidative stress cause **non-enzymatic** oxidation in multiple radical chain and reactions of parallel product formations to contaminate and destroy the organism! Destructive hazard for life!

Oxygen gas solubility $O_{2gas}+H_2O=O_{2aq}$ compensate one water molecule $6H_2O=O_{2gas}+H_2O+4H_3O^++4e^-$ on Nernst's half reaction $5H_2O=O_{2aq}+4H_3O^++4e^-$, forming absolute standard potential $E°_{5HOH}=$**1.0868 V**.

$E°_{5HOH}=E°_{classic}-0.0591/4*lg(1/[H_2O]^5)+\Delta E°=1.2288+0.1287+0.10166-0.37239=$**1.0868 V**.

Oxygen solution $O_{2aq}+4H_3O^++4e^-=5H_2O$ is strong oxidant with inverse standard potential $-E°_{5HOH}=$**-1.0868 V**. The oxygen attracts four free electrons with four protons from hydroxonium ions, forming two water molecules the reduced products. Solubility free energy content increases **26.58** $^{kJ}/_{mol}$ from **303.1** $^{kJ}/_{mol}$ to **330** $^{kJ}/_{mol}$:

Substance	$\Delta H°_H$, $^{kJ}/_{mol}$	$\Delta S°_H$, $^{J}/_{mol/K}$	$\Delta G°_H$, $^{kJ}/_{mol}$	
H₂O	-285.85	69.9565	-237.191	$G_{O2aq}=G_{O2gas}+G_{O2sp}=303.1+26.58=329.68=330$ $^{kJ}/_{mol}$.
H₂O	**-286.65**	**-453.188**	**-151.549**	$G_{O2gas}=2(G_{H2O}-(G_{H2gas}-\Delta G°_{H2O}))=2*(0-(85.64-237,19))=303.1$ $^{kJ}/_{mol}$
H₃O⁺	-285.81	-3.854	-213.2746	Mischenko 1972, Himia, Leningrad [26]
H₂gas	Alberty	pH=7,36	**85.64**	Biochem.Thermodyn. Massachusetts Technology Inst. [8]
H₂(aq)	23.4	-130	99.13	CRC 2010 [1}
H(Pt)(aq)	$E°_H-E°_{O2}=$	-1.3575	**48.56**	$G_{H(Pt)}=(2G_{H2O}-\Delta G_{eq2H2O}-G_{O2aqua})/4=$**48.56** $^{kJ}/_{mol}$;
H₂(aq)	**-5.02**	**-363.92**	**103.24**	pH=7,36 [8] Biochem.Thermodyn. Massachusetts Technology Inst.
O₂aqua	**-11.70**	**-94.2**	**16.4**	pH=7,36 [8] Massachusetts Technology Inst. Alberty [8]
O₂aqua	-11.715	110.876	16.4	CRC [1] $\quad$ $G_{O2gas}=303$ $^{kJ}/_{mol}$, $G_{O2aq}=329.68$ $^{kJ}/_{mol}$;

Oxygen solubility free energy change **is** exothermic and endoergic $O_{2gas}+H_2O=O_{2aq}$, which mol fraction for gas $[O_{2air}]=1$ and in water has $[O_{2aq}]/[H_2O]=1.22*10^{\wedge(-3)}$ M/55.3 M$=2.206*10^{-5}$ unit less concentration. $K_{speq}=[O_{2aq}]/[O_{2gas}]/[H_2O]=2.206*10^{-5}/1=2.206*10^{-5}$ constant is less as one. $\Delta G_{Hess}=\Delta G°_{O2aqua}-\Delta G°_{H2O}-\Delta G°_{O2gas}=16.4-(0-237.191)=253.6$ $^{kJ}/_{mol}$ Hess energy change for pure reagents is positive. So positive on absolute scale expressions $\Delta G_{AlbertyO2aq}=G_{O2aq}-(G_{H2O}+G_{O2gas})=330-(0+303.1)=26.58$ $^{kJ}/_{mol}$ and at equilibrium minimum $\Delta G_{speq}=-R•T•ln(K_{speq})=-8.3144*298.15*ln(2.206*10^{-5})=26.58$ $^{kJ}/_{mol}$. $[O_2]$ solubility Hess free energy change is positive $\Delta G_{Hess}=253.6$ $^{kJ}/_{mol}$, but minimized at equilibrium mixture $K_{speq}=[O_{2aq}]/[O_{2gas}]/[H_2O]=2.206*10^{-5}$. Equilibrium state is attractor for all non-equilibrium states. At minimum establishes equilibrium. 53rd page

$$G \quad 253,6\ ^{kJ}/_{mol} \quad G$$
$\Delta G>0$ $\quad$ Hess

$\Delta G_{min}=$ **26.58** $^{kJ}/_{mol}$

A+ B $\quad$ 50% $\quad$ C+D
Reactants
$O_{2gas}+H_2O_{Blood}$
product $O_{2aq-Blood}$.

Osmolar $C_{osm}=0$ M and ionic force $I=0$ M in water from air 20.95% oxygen solubility is $[O_{2aq}]=K_{speq}*[O_{2air}]*[H_2O]=2.206*10^{-5}*0.2095*55.3=0.00025546$ M.

Pure 1atm mol fraction $[O_{2gas}]=1$. Osmolar $C_{osm}=0.305$ M, ionic force $I=0.25$ M, air 20.95% oxygen dissolute $[O_{2aq}]=9.768·10^{-5}$ M. Therefore $K_{O2spAir}=[O_{2aq}]/[O_{2air}]=9.768·10^{-5}/0.2095=4.663*10^{-4}$ M is solubility on air.

Arterial $[O_{2aq}]=6·10^{-5}$ M and venous $[O_{2aq}]=0.426·10^{-5}$ M isooxia is maintained by osmosis oxygen molecules, which cross membranes through aquaporins channels against osmolar concentration gradient $C_{osm}=0.305$ M.

Inverse: $O_{2aqua}+4H_3O^++4e^-=6H_2O$; $-E°_{o2}=$**-1.0868** V; Nernst's: $4(Pt)H+4H_2O=4H_3O^++4e^-$; $E°_H=$**-0.27073** V;

$O_{2aqua}+4(Pt)H=2H_2O$ electrodes standard potential sum give standard free energy change:

$\Delta G_{eq}=(E°_H-E°_{o2})•F•1•4=(-0.27073-1.0868)*96485*4=-1.3575*96485*4/1000=2*261.96=-523.925$ $^{kJ}/_{mol}$;

Knowing equilibrium value $\Delta G_{eq2H2O}=2G_{H2O}-4G_{(Pt)H}-G_{O2aqua}=2*0-(4*G_{(Pt)H}+329.68)=-523.925$ $^{kJ}/_{mol}$, hydrogen metal free energy is $G_{H(Pt)}=(2G_{H2O}-\Delta G_{eq2H2O}-G_{O2aqua})/4=(2*0+523.925-329.68)/4=194.251/4=48.56$ $^{kJ}/_{mol}$.

Free energy $G_{H3O+OH}=G_{H3O+}+G_{OH-}=22.44+77.36=99.8$ $^{kJ}/_{mol}$ of water protolysis $H_2O+H_2O<=>H_3O^++OH^-$ Biochemistry oxygen O_{2aqua} decreases free energy content $G_{O2aqua}=$**329.68** $^{kJ}/_{mol}$ to $G_{O2Biochemistry}=88.22$ $^{kJ}/_{mol}$.

Arterial concentration $[O_{2aqua}]=6*10^{-5}$ M, pH=7.36 concentrations $[H_3O^+]=10^{-7.36}$ M potential is decreasing $E_{O2}=E°_{o2}+^{0.0591}/_4•lg([O_{2aqua}]•[H_3O^+]^4/_{[H2O]}^5)=$**1.0868**$+^{0.0591}/_4*log(6*10^{\wedge(-5)}*10^{\wedge(-7.36*4)}/_{55.3}^{\wedge5})=$**0.46174** V

by $\Delta E_{arterial}=-(E_{oO2}-E_{O2})=$**- 1.0868+0.46174**$=-0.62506$ Volts and free energy content by $\Delta G_{arterial}=\Delta E_{H2O}*F*n=0.62506*96485*4/1000=-241.24$ $^{kJ}/_{mol}$.

The free energy content of $O_{2gas\ AIR}+H_2O=O_{2Blood}$ with solubility contribution increases by:

$$K_{speq}=\frac{[O_{2\ aqua}]}{[O_{2\ gas}]·[H_2O]}=2.205*10^{-5}; G_{O2speq}=-R•T•ln(K_{speq})=-8.3144*298.15*ln(2.205*10^{-5})=26.58\ ^{kJ}/_{mol}.$$

Protolysis decreases free energy to $G_{O2Biochem\_arterial}=G_{O2aqu}+G_{O2sp}+\Delta G_{arterial}=$**303.1**$+$**26.58**$-241.456=$**88.22** $^{kJ}/_{mol}$ and oxygen becomes fire safe biochemical oxidant, forming arterial concentration $[O_{2aqua}]=6*10^{-5}$ M as safe Bioenergetic sustaining normal isooxia. [3];

1) Water 55.346 M decreases potential from **1.0868 V** about -**0.1288** V$=$**0.9580-1.0868**$=\Delta E_{H2O}$.

$\quad E_{oO2}=E°_{o2}+^{0.0591}/_4*log(^1/_{[H2O]}^5)=$**1.0868**$+0.01478*log(^1/_{55.346}^{\wedge5})=$**0.95805** V ;

2) Acid H_3O^+ increases 10 times the potential and free energy content increases about $\Delta E_{H3O+}=$**0.05912** V
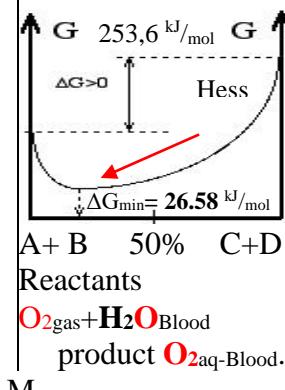
$\Delta E_{H3O}=0.01478 \cdot lg([H^+]^4)=$**0.05912** V and $\Delta G_{max}=\Delta E_{H3O}*F*n=0.05912*96485*4/1000=$ **22.817** $^{kJ}/_{mol}$;

3) Air 20.95% replaced with 100% oxygen [O_{2aqua}] concentration 5 times increase potential about

$\Delta E_{O2100\%}=0.01478 \cdot lg(100\% [O_{2aqua}])=0.01478*log(5)= +$**0.0103** V . Free energy content for

oxygen increases about $\Delta G_{max}=\Delta E_{H3O}*F*n=0.01033*96485*4/1000=$**3.987** $^{kJ}/_{mol}$. [6th page](#).

NASA Apollo Moon project closes 1972 because of oxidative stress and technical hazards risk.

Glucose and inverse oxygen absolute and standard potentials sum $\Delta E°=(E°_{C6H12O6}-E°_{O2})$:

$\Delta E°=(E°_{C6H12O6}-E°_{O2})=\Delta G_{Lehninger}/F/n=-2840000/96485/24=-1.2264$ V give the absolute free energy change

$\Delta G_{Lehninger}=\Delta E° \cdot F \cdot n=(E°_{C6H12O6}-E°_{O2}) \cdot F \cdot n=(-1.2264)* 96485*24=$**-2840** $^{kJ}/_{mol}$ for the oxidation reaction

$C_6H_{12}O_6+12H_2O+6O_{2aqua}=6H_3O^++6HCO_3^-$ by published data $\Delta G_{Lehninger}=$**-2840** $^{kJ}/_{mol}$. [1,6]
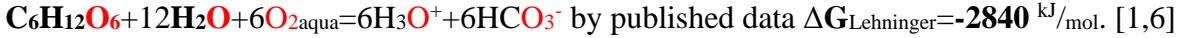
The sum of the absolute standard potentials $(E°_{C6H12O6}-E°_{O2})=(E_{C6H12O6}-$**1,086865**$)=-1,22644$ V of glucose and oxygen allows us to determine the absolute standard potential for glucose

$E°_{C6H12O6}=\Delta E+E°_{O2}=-1,22644+$**1,086865**$=$**-0,139575** V, which is calculated from the value of the

inverse Nernst's half reaction absolute standard potential of oxygen reduction $-E°_{O2}=$**-1.0868** V .

Glucose oxidation, the absolute standard potential is negative because the strong of 24-electron donor, what reduce the six oxygen molecules in Nernst's reaction $O_{2aqua}+4H_3O^++4e^-=5H_2O$ with an inverse absolute standard potential $-E°=$**-1.0868** V. Classic glucose standard potential $E°_{classic}=-0.04915$ V, 42 water account logarithm $-0,0591/24*log(1/55.3^{42})=0.18024$ and $\Delta E°=+0,10166-0,37239$ the coupled sum expressed potential is

$E°_{C6H12O6}=E°_{classic}-0,0591/24*log(1/55,3^{42})+\Delta E°=-0.04915+0.18024+0,10166-0,37239=$**-0,13964** V.

$C_6H_{12}O_6+42H_2O=24H_3O^++6H_3O^++6HCO_3^-+24$ e^- .

Arterial oxygen [$O_{2arteriālā}$]=$6*10^{(-5)}$ M; hydroxonium $[H_3O^+]^{30}=10^{(-7,36*30)}$ M and $[C_6H_{12}O_6]=0,005$ M

glucose concentrations in blood produce very negative arterial potential:

$E_{C6H12O6arterial}=E°_{C6H12O6}+^{0,0591}/_{24} \cdot lg([HCO_3^-]^6*[H_3O^+]^{30}/_{[H2O]}^{42}/[C_6H_{12}O_6]) =$

$=$**-0,13958**$+^{0,0591}/_{24}*lg(0,0154*10^{(-7,36*30)}/_{0,005}/55,346^{42}) =$**-0,86237** V

and inverse Nernst's half reaction absolute arterial potential of oxygen is

$E_{O2arterial}=E°_{O2}+^{0,0591}/_4 \cdot lg([H_2O]^5/_{[O2aqua]}/_{[H3O+]}^4)=$**-1,086865**$+^{0,0591}/_4*log(_{55,346}^5/_6/_{10}^{(-5)}/_{10}^{(-7,36*4)})=$**-0,46074** V.

Homeostasis potential sum is more negative $\Delta E_{arterial}=E_{C6H12O6arterial}+E_{O2arterial}=$**-0,86237-0,46074**=-1,3231 Volts.

Free energy change $\Delta G_{arterial}$ is more negative as standard value $\Delta G_{Lehninger}$:

$\Delta G_{arterial}=\Delta E \cdot F \cdot n=(E_{C6H12O6arterial}-E_{O2arterial}) \cdot F \cdot n=(-0,86237-0,46074)*96485*24=$**-3063,846** $^{kJ}/_{mol}$.

One mol glucose oxidize six mols of oxygen producing six mols bicarbonate $6H_3O^++6HCO_3^-$:

$C_6H_{12}O_6+42H_2O=24H_3O^++6H_3O^++6HCO_3^-+24$ e^- + sum + $6O_{2aqua}+24H_3O^++24e^-=30H_2O$;

$C_6H_{12}O_6+42H_2O+6O_{2aqua}+24H_3O^++24e^-=24H_3O^++6H_3O^++6HCO_3^-+24$ e^- +$30H_2O$;

$C_6H_{12}O_6+12H_2O+6O_{2aqua}$ $=$ $6H_3O^++6HCO_3^-$;
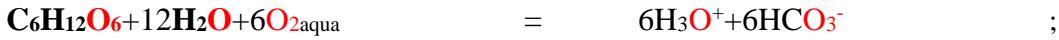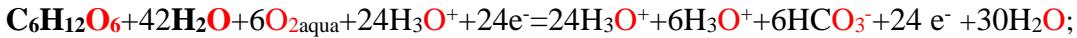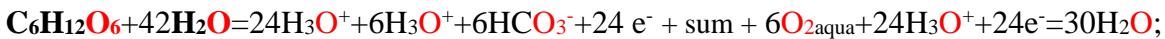
$G_{H3O+}+_{HCO3-}=G_{H3O+}+G_{HCO3-}=$**22,44+56,08=78,52** $^{kJ}/_{mol}$,

[Glc](#) 6th page Formation from elements $C+6H_{2gas}+3O_{2gas}=C_6H_{12}O_6$ free energy change calculates from Alberty data at pH=7.36 $\Delta G°_{Alberty}=G_{C6H12O6}-(6G_{Cgraph}+6*G_{H2gas}+3*G_{O2gas})=$**-402.05** $^{kJ}/_{mol}$;

Substance	$\Delta H°_H$ $^{kJ}/_{mol}$	$\Delta S°_H$ $^{J}/_{mol/K}$	$\Delta G°_H$ $^{kJ}/_{mol}$
$C_6H_{12}O_{6aq}$	-1263,78	269,45	-919,96
pH=7.36 **Glc**	**-1267,13**	**-2901,49**	**-402,05**

2006, Massachusetts Technology Inst. Alberty [8] pH=7,36.

CRC 2010

[8] $\Delta G°_{Alberty}+(6G_{Cgraph}+6*G_{H2gas}+3*G_{O2gas})=G_{C6H12O6}=$**1568** $^{kJ}/_{mol}$;

Calculation of free energy in glucose oxidation $C_6H_{12}O_6+6O_{2aqua}+12H_2O=6H_3O^++6HCO_3$ in three ways:

1) Alberty data at pH=7.36 pH=7,36 $\Delta G°_{Alberty}=G_{C6H12O6}-(6G_{Cgraph}+6*G_{H2gas}+3*G_{O2gas})=$**-402,05** $^{kJ}/_{mol}$ standard free energy content in the mol is:

$G_{C6H12O6}=\Delta G°_{Alberty}+(6G_{Cgraph}+6*G_{H2gas}+3*G_{O2gas})=$**-402,05**$+(6*91,26+6*85,6+3*303)=$**1568** $^{kJ}/_{mol}$,

2) Lehninger's $\Delta G_{C6H12O6}=6*G_{H3O+}+6*G_{HCO3-}-(G_{StandardC6H12O6}+6*G_{O2aqua}+12*G_{H2O}\_Biochem)=$_-2840_ $^{kJ}/_{mol}$

standard content in the mol of glucose $G_{StandardC6H12O6}=6*(22,44+56,08)-(-2840+6*330+12*0) =$**1331** $^{kJ}/_{mol}$ and

3) free energy content $\Delta G_{arterial\_C6H12O6}=6*G_{H3O+}+6*G_{HCO3-}-(G_{arterial\_C6H12O6}+6*G_{O2aqua}+12*G_{H2O})=$**-3064** $^{kJ}/_{mol}$

per mol of glucose at homeostasis $G_{arterial\_C6H12O6}=6*(22,44+56,08)-(-3064+6*88,22+12*85,64)=$**1978** $^{kJ}/_{mol}$.

[8,6]

Generated **$6HCO_3^-+6H_3O^+$** ions drive reactants $6O_{2aqua}$ and $6H_2O$ through membranes aquaporins channels by osmosis against the concentration gradients but transporting ions **$6HCO_3^-+6H_3O^+$** opposite down the gradients through bicarbonate and proton channels consuming produced free energy $\Delta G_{arterial}=$**-3064** $^{kJ}/_{mol}$.

Absolute potential and free energy values include accounting for hydroxonium H_3O^+ and water H_2O.

Oxygen in the inverse half-reaction with free energy G_{O2aqua}=**330** $^{kJ}/_{mol}$ is reduced to $O_{2aqua}+4H_3O^++4e^-=5H_2O$ with inverse potential $-E_{oO2}$=**-1.0868 V** by oxidizing four metal hydrogen atoms with free energy content per mole $G_{H(Pt)}$=**48.56** $^{kJ}/_{mol}$ in the Nernst half-reaction $4\underline{(Pt)H}+4H_2O=4H_3O^++4e^-$ and with standard absolute potential $E°_H$=**-0.27073** V. Standard free energy change in aqua reaction $O_{2aq}+4\underline{(Pt)H}=2H_2O$ from elements is

$$\Delta G_{Hes2H2O}=2G_{H2O}-4G_{H(Pt)}-G_{O2aqua}=2*0-(4*48.56+330))=-524.24=2*-262 \,^{kJ}/_{mol}.$$ Standard potentials sum

$$\Delta G_{eq}=(E°_H-E°_{O2})•F•4=(-0.27073-1.0868)*96485*4=-1.3575*96485*4=-523.925=2*-262 \,^{kJ}/_{mol}$$ let independently from Hess law calculate formation from elements in water oxygen O_{2aqua} and metal hydrogen (Pt)H free absolute energy change $\Delta G_{eq(Pt)H\_H2O}$=**-262** $^{kJ}/_{mol}$, which is coincident with absolute free energy $G_{H(Pt)}$=**48.56** $^{kJ}/_{mol}$ determination for free aqua elements O_{2aqua}, (Pt)H. Hydrogen standard free energy in water solution G_{H2aqua}=**103.24** $^{kJ}/_{mol}$ is at pH=7.36. [8] $O_{2aqua}+2H_{2aqua}=2H_2O$; The standard free energy change in Hess's law for the formation of aqua elements is

$$\Delta G_{HessCRCaqua}=2\Delta G°_{H2O}-2\Delta G°_{H2aqu}-\Delta G°_{O2aqua}=2*-237.191-(2*99.13/2+16.4)=-589.91=2*-295 \,^{kJ}/_{mol}. [1]$$

In Hess's law, changes are calculated from CRC data when pure reactants convert into pure products and the maximum possible change is greater than the standard $\Delta G_{HessCRCaqua}$=-295 $^{kJ}/_{mol}$ > $\Delta G_{eq(Pt)H\_2H2O}$=**-262** $^{kJ}/_{mol}$. Formation from aqua elements $\Delta G°_{H2O}$=**-151.55** $^{kJ}/_{mol}$ Alberty [8] and homeostasis $\Delta G°_{H2O}$=**-147,26** $^{kJ}/_{mol}$.

Substance	$\Delta H°_H$,$^{kJ}/_{mol}$	$\Delta S°_H$,$^{J}/_{mol/K}$	$\Delta G°_H$,$^{kJ}/_{mol}$
H_2O	-285.85	69.9565	-237.191
H_2O	**-286.65**	**-453.188**	**-151.549**
H_3O^+	-285.81	-3.854	-213.2746
$H_{2(aq)}$	23.4	-130	99.13
$H_{2(aq)}$	**-5.02**	**-363.92**	**103.24**
E°(Pt)H	**-0.27073**	**-1.0868**	**48.56**
O_{2aqua}	**-11.70**	**-94.2**	**16.4**
O_{2aqua}	-11.715	110.876	16.4

$\Delta G°_{H2O}=G_{H2O}-(G_{H2aq}+G_{O2aq}/2)=0-(103.24+88.22/2)=-147.35 \,^{kJ}/_{mol}$

$G_{H2O}=\Delta G_{H2O Alberty}-(\Delta G°_{H2O})=-151.549-(-237.191)=85.6 \,^{kJ}/_{mol}$ [8]

$\Delta G_H=\Delta H_H-T*\Delta S_H=-286.65-298.15*-0.453188=-151.5 \,^{kJ}/_{mol}$;

$\Delta G°_{H3O+}$,$^{kJ}/_{mol}$ [Mischenko](#) 1972, Himia, Leningrad [26]

CRC [1]

pH=7,36 [8] Massachusetts Technology Inst. Alberty

$G_{H(Pt)}=(2G_{H2O}-\Delta G_{eq2H2O}-G_{O2aqua})/4=48.56 \,^{kJ}/_{mol}$

pH=7,36 [8] Biochem. Thermodyn Massachusetts Technology Inst.

CRC [1] The equilibrium constant is favorably greater than one:

$$K_{eq2H2O}=K_{OxRed}=exp(-\Delta G_{OxRed}/R/T)=exp(261960.6/8.3144/298.15)=exp(105.675)=7.832*10^{45}.$$

Exothermic and exoergic O_{2aqua} reduction with metallic hydrogen $4\underline{(Pt)H}$ and H_2O_2 dismutation Hess free energy change negative $\Delta G_{HessAquaH2O}$=-295 $^{kJ}/_{mol}$, but reaching equilibrium state ΔG_{eq2H2O}=-262 $^{kJ}/_{mol}$ at minimum has constant greater over one K_{eq2H2O}=7.832*10^{45}. The equilibrium state is Prigogine attractor for all irreversible states. Free energy change minimum reaching establish equilibrium state. Oxidation and reduction of peroxide have absolute standard $E°_{H2O2Ox}$=**0.5268** V Ox $H_2O_2+2H_2O=O_{2aqua}+2H_3O^++2e^-$ and inverse standard $-E°_{H2O2Red}$=**-1.7113** V Red $H_2O_2+2H_3O^++2e^-=4H_2O$ potentials. Dismutation is exoergic, exothermic $2H_2O_{2aq}=>O_{2aqua}+2H_2O+Q+\Delta G$ standard sum $(E°_{H2O2Ox}-E°_{H2O2Red})=(0,5268-1,7113)=-1,1845$ V $\Delta G_{eqStandard\_H2O2}$=**-228,57** $^{kJ}/_{mol}$.

$\Delta G_{HessAqua\_H2O}$=-295 $^{kJ}/_{mol}$

$\Delta G<0$ Hess

ΔG_{eqH2O}=**-262** $^{kJ}/_{mol}$
$\Delta G_{eqStandard}$=**-228,6** $^{kJ}/_{mol}$

Reactants $4\underline{(Pt)H}+ O_{2aqua}$ and products $2H_2O$ 4A+B   50%   2D;
Reactants $2H_2O_{2aq}$ and products $O_{2aqua}+2H_2O$ 2A   50%   B+2C
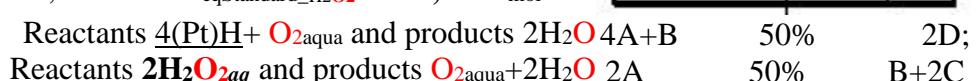
Classic peroxide oxidation standard potential $E°_{classicH2O2Ox}$=0.6945 V [19], plus 2 water account logarithm $-0.0591/2*lg(1/[H_2O]^2)$=0.103 and the coupled sum $\Delta E°$=+0.10166-0.37239 expressed absolute potential is $E°_{H2O2Ox}=E°_{classicH2O2Ox}-0.0591/2*lg(1/[H_2O]^2)+\Delta E°=0.6945+0.103+0.10166-0.37239=$**0.5268** V;

Classic peroxide reduction standard potential $E°_{classicH2O2Red}$=1.776 V [17], plus 4 water account logarithm $-0.0591/2*lg(1/[H_2O]^4)$=0.206 and the coupled sum $\Delta E°$=+0.10166-0.37239 expressed absolute potential is $E°_{H2O2Red}= E°_{classicH2O2Red}-0.0591/2*lg(1/[H_2O]^4)+\Delta E°=1.776+0.206+0.10166-0.37239=$**1.7113** V;

Peroxide oxidation and inverse reduction standard potentials sum calculates standard free energy change :

$$\Delta G_{eqStandart\_H2O2}=(E°_{H2O2Ox}-E°_{H2O2Red})*F*n=(0.5268-1.7113)*96485*2=-228.57 \,^{kJ}/_{mol}$$ and favored constant

$$G_{AlbertyH2O2}=(G_{O2Biochem\_arterial}+2*G_{H2OBioChemistry}-\Delta G_{eqBioChem})/2 =(330+2*0+228,57)/2=279,285 \,^{kJ}/_{mol}.$$

$$K_{eqStandart\_H2O2}= \frac{[O_2]_{aqua}·[H_2O]^2}{[H_2O_2]^2_{aqua}} =K_{H2O2}=exp(-\Delta G_{eq}/R/T)=exp(228573/8.3144/298.15)=1.11*10^{40}.$$

$E_{H2O2}=E°_{H2O2}+0.0591/2•lg(O_{2aqua}*[H_3O^+]^2/[H_2O_2]/[H_2O]^2)=0.5268+0.0591/2*lg(6*10^{(-5)}*10^{(-7.36*2)}/1/55.3^2)=-0.1359$ V

$E_{Ox}=E°_{H2O2Ox}+0.0591/2•log([H_2O]^4/[H_2O_2]/[H_3O^+]^2)=-1.7113+0.0591/2*log(55.3^4/1/10^{(-7.36*2)})=-1.0703$ V

Summary of Nernst's + inverse reaction for homeostasis absolute free energy electrochemical change has

$\Delta G_{eqBioChem}=(E_{Red}-E_{oOx})*F*n =(0.1359-1.0703)*96485*2=(-0.9344)*96485*2=$**-180.3** $^{kJ}/_{mol}$ molar energy content.
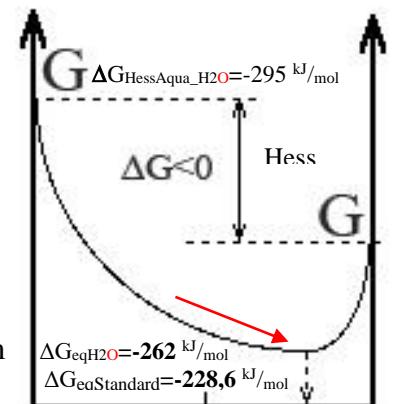
High rate protolysis peroxide anions collisions in peroxisomes produce 100% efficiency of essential $\omega=6$, $\omega=3$ fatty acids, oxygen, water and heat: $2H_2O_{2(aq)}=O_{2aqua}+2H_2O+Q$.

Collision $H^++HOO^-><^-OOH+H^+$ in water activation energy is high $E_a=79000\ ^J/_{mol}$ with slow rate of reaction. In collision $HOO^-=>Fe^{3+}$ with iron(III) ion peroxide has small activation energy $E_a=29\ ^J/_{mol}$. It increases reaction rate thirty million times faster. Peroxide formation from aqua elements $O_{2aqua}+H_{2aqua}=H_2O_2$ exoergic, negative

$\Delta G_{HessH2O2}=\Delta G^\circ_{H2O2}-\Delta G^\circ_{H2aqu}-\Delta G^\circ_{O2aqua}=-237.129-(99.13+16.4)=-352.66\ ^{kJ}/_{mol}$. [1] Dismutation reaction $\Delta G_{Hess2H2O2}=2\Delta G^\circ_{H2O2}-2\Delta G^\circ_{H2Oaqu}-\Delta G^\circ_{O2aqua}=2*-237.129-(2*237.191+16.4)=-303.094\ ^{kJ}/_{mol}$. [1] Alberty data in Hess expression $\Delta G_{Alberty2H2O2}=2G_{H2Oaqu}+G_{O2aqua}-(2G_{H2O2})=2*0+330-(2*279.285)=-228.57\ ^{kJ}/_{mol}$. [8]

Substance	$\Delta H^\circ_H, ^{kJ}/_{mol}$	$\Delta S^\circ_H, ^J/_{mol/K}$	$\Delta G^\circ_H, ^{kJ}/_{mol}$	
H_2O_{2aq}	-191.99	-481.688	-48.39	$G_{H2O2}=279.285\ ^{kJ}/_{mol}$; $G_{HOO-}=333.866\ ^{kJ}/_{mol}$;
H_2O_{2aq}	-191.17	143.9	-134.03	**Biochem. Thermodynamic 2006** Massachusetts Technology Inst.[8]
H_2O_{2aq}	Formation	-48.39	340.25	University Alberta 1997. [19]
H_2O_{2aq}	Formation	-134.03	254.61	$G_{H2O2aq}=\Delta G_{H2O2Alberty}+(G_{O2gas}+G_{H2gas})=340.25\ ^{kJ}/_{mol}$;
H_2O_{2aq}	$\Delta E^\circ_{H2O2RedOx}$	-1.1845	279.285	$G_{H2O2aq}=\Delta G_{H2O2Alberty}+(G_{O2gas}+G_{H2gas})=254.61\ ^{kJ}/_{mol}$;
HOO^-	$pK_a=11.75$	77.016	333.866	$G_{H2O2}=(G_{O2aqua}+2*G_{H2O}+\Delta G_{Alberty\_2H2O2})/2=558.57/2=279.285\ ^{kJ}/_{mol}$;
$H_2O_{2\ l}$	-237.129	69.91	-237.129	$G_{HOO-}=-G_{H3O+}+\Delta G_{aH2O2}+(G_{H2O2}+G_{H2O})=333.866\ ^{kJ}/_{mol}$; CRC [1]

Peroxide protolysis $H_2O_2+H_2O=H_3O^++HOO^-$ pKa=11.75 give the free energy change at equilibrium state $\Delta G_{aH2O2}=-R\cdot T\cdot ln(K_a/[H_2O])=-8.3144*298.15*ln(10^{\wedge(-11.75)}/55.3)=77.016\ ^{kJ}/_{mol}$ and by Hess law endoergic too $\Delta G_{aH2O2}=G_{H3O+}+G_{HOO-}-(G_{H2O2}+G_{H2O})=22.44+G_{HOO-}-(279.29+0)=77.016\ ^{kJ}/_{mol}$ Expressed anion free energy content is $G_{HOO-}=-G_{H3O+}+\Delta G_{aH2O2}+(G_{H2O2}+G_{H2O})=-22.44+77.016+(279.29+0)=333.866\ ^{kJ}/_{mol}$.

$HOO^-+H_2O=O_{2aqua}+H_3O^++2e^-$ peroxide anion half reaction standard potential is $E^\circ_{NernstHOO-}=0.09625$ Volts. Free energy change is $\Delta G_{NernstHOO-}=G_{O2aqua}+G_{H3O+}-(G_{HOO-}+G_{H2O})=330+22.44-(333.866+0)=18.574\ ^{kJ}/_{mol}$.

Absolute Nernst's reaction standard potential is $E^\circ_{NernstHOO-}=\Delta G_{NernstHOO-}/F/1=18574/96485/2=0.09625$ V.

$E^\circ_{HOOOx}=E^\circ-0.0591/2*lg(1/[H_2O]^1)+0.10166-0.37=0.31548-0.02955*lg(1/55.3^{\wedge1})+0.10166-0.37239=0.09625$ V;

$E^\circ_{HOO-}=E^\circ+0.372=0.09625+0.37239=0.46864$ V; $E^\circ_{HOO-}=0.46864-0.10166=0.36698$ V;

$E^\circ_{HOO-}=0.36698+0.0591/2*log(1/55.3^{\wedge1})=0.31548$ V;

Exothermic and exoergic H_2O_2 (aq) dismutation Hess $\Delta G_{HessH2O2}=-303.094\ ^{kJ}/_{mol}$ free energy change is negative, but minimized $\Delta G_{eqStandard}=-228.6\ ^{kJ}/_{mol}$ reaching standard equilibrium mixture favored constant $K_{eq}=1.11*10^{40}$. Le Chatelier principle is Prigogine attractor as free energy change minimum ΔG_{min} reaching. High rate protolysis attractors pH=7.36, oxygen 20.95% in air stay at equilibrium, while homeostasis irreversibly continues, as not equilibrium state are. Prigogine attractors are Nobel Prize in Chemistry 1977th. CATALASE erase peroxide molecules H_2O_2 reaching 100% efficiency for $\omega=6$, $\omega=3$ fatty acids C20:4 elongation synthesis in peroxisomes. CATALASE reactivity is indispensable irreversible homeostasis Brownian molecular engine for evolution and survival. Peroxide [Formation](#) from elements $O_{2gas}+H_{2gas}=H_2O_{2aq}$; are two sources $\Delta G^\circ_{UnivAlberta}=-134.03\ ^{kJ}/_{mol}$,[19] $\Delta G^\circ_{Alberty}=-48.39\ ^{kJ}/_{mol}$. [8] From Alberty data obtained $\Delta G_{HessH2O2}=G_{H2O2}-G_{H2gas}-G_{O2gas}=279.285-(85.64+303)=-109.155\ ^{kJ}/_{mol}$ values for $G_{H2O2}-G_{H2gas}-G_{O2gas}$ are located between $\Delta G^\circ_{UnivAlberta}=-134.03\ ^{kJ}/_{mol}$ [19] and $\Delta G^\circ_{Alberty}=-48.39\ ^{kJ}/_{mol}$ [8] much close as CRC data. [1] Analogous data on the absolute free energy scale $G_{AlbertyH2O2}=279,285\ ^{kJ}/_{mol}$ lie between the molar content $G_{H2O2aq}=254.61\ ^{kJ}/_{mol}$, [19] and $G_{H2O2aq}=340.25\ ^{kJ}/_{mol}$ [8]:

$G_{H2O2aq}=\Delta G_{H2O2CRC}+(G_{O2gas}+G_{H2gas})=-134.03+(303+85.64+0)=254.61\ ^{kJ}/_{mol}$; [19]

$G_{H2O2aq}=\Delta G_{H2O2Alberty}+(G_{O2gas}+G_{H2gas})=-48.39+(303+85.64+0)=340.25\ ^{kJ}/_{mol}$;[8] 41st,54th [page](#) [1,8,20]

$\Delta G_{HessH2O2}=-303.094\ ^{kJ}/_{mol}$

$\Delta G<0$ Hess

CATALASE

$\Delta G_{Standard}=-228.6\ ^{kJ}/_{mol}$

A+A   50%   B+2C
reactants $2H_2O_{2(aq)}$
products_$O_{2aqua}+2H_2O$
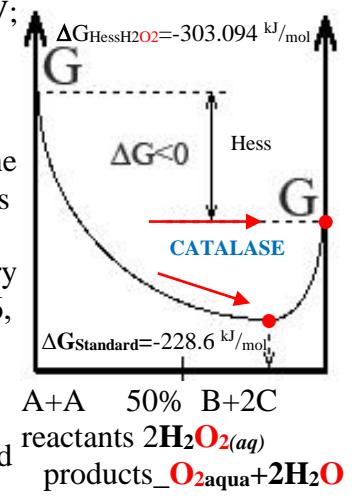
Sulfur / H_2S_{aq} red-ox systems. H_3O^+ and $[H_2O]$=55.3 M accounting on absolute free energy and potential scale.

Substance	$\Delta H°_H$ kJ/mol	$\Delta S°_H$ J/mol/K	$\Delta G°_H$,kJ/mol
H_2S_{gas}	formation	-81.96	**7.1636**
H_2S_{gas}	Solubility	promote	**38.1196**
H_2S_{gas}	-20.6	205.81	-81.96
H_2S_{aq}	-38.6	126	-76.167
H_2S_{aq}	**-22.9596**	**-256.064**	53.3896
H_2S_{aq} S+2(Pt)H=		H_2S_{aq}	**84.343**
HS^-	-16.3	67	-36.276
HS^-	$E°_{S↓/HS2=}$	**-0.8517** V	**90.5336**
HS^-	pK_{a1}=7.05	favored	**81.138**
HS^-	pK_{a2}=19	-	**92.65**
S_{rombic}	formation	-81.96	**3.5436**
S_{rombic}	$E°_{S↓/H2Saq=}$	**-0.025735** V	**3.5436**
S^{2-}	$E°_{S↓/S2=}$	**-0.79853**V	**157.63**

G_{H2Sgas}=**85.6** kJ/mol; G_{H2Saq}=**53.3896** kJ/mol; $G_{Srhombic}$=**3.5436** kJ/mol;
favored G_{H2Sgas}=ΔG_{Hess_H2Sgas}+($G_{Srombic}$+G_{H2})=**7.1636** kJ/mol.
G_{H2Sgas}=G_{H2Saq}-(ΔG_{eq}+G_{H2o})=53.3896-(**15.27**+0)=**38.1196** kJ/mol
CRC ΔG_{H2Sgas}=ΔH_H–T*ΔS_H=-20.6-298.15*0.20581=-81.96 kJ/mol;
CRC ΔG_{H2Saq}=ΔH_H–T*ΔS_H=-38.6-298.15*0.126=-76.167 kJ/mol;
2006. Massachusetts Technology Inst. pH=7.36 Alberty [8]
G_{H2Saq}=$\Delta G_{HessH2S}$+($2G_{H(Pt)}$+$G_{Srombic}$)=**84.343** kJ/mol;
CRC [1] ΔG_{HS-}=ΔH_H–T*ΔS_H=-16.3-298.15*0.067=-36.276 kJ/mol;
G_{HS-aq}=$G_{Srombic}$+$2G_{H2O}$-($\Delta G_{eqHS-aq}$+G_{OH})=**90.5336** kJ/mol;
favored G_{HS-}=ΔG_{eq}-G_{H3O}+(G_{H2S}+G_{H2O})=**81.138** kJ/mol;
G_{HS-}=G_{S2-}+G_{H3O}-(ΔG_{eq}+G_{H2O})=**92.65** kJ/mol;
$G_{Srombic}$=G_{H2Sgas}-(ΔG_{Hess_H2Sgas}+G_{H2})=**3.5436** kJ/mol;
favored $G_{Srombic}$=$\Delta G_{eqH2Saq}$-$2G_{H3O+}$+(G_{H2Saq}+$2G_{H2O}$)=**3.5436** kJ/mol;
G_{S2-aq}=$G_{Srombic}$+G_{H2O}-($\Delta G_{eqS2-aq}$)=**157.63** kJ/mol;

Formation from elements $S_{rhombic}$+H_{2gas}=H_2S_{gas} G_{H2Sgas}=**85.6** kJ/mol; shows energy content G_{H2Sgas}=**7.1636** kJ/mol;
Energy content is G_{H2Sgas}=$\Delta G°_{H2Sgas}$+($G_{Srombic}$+G_{H2})=-81.98+(**3.5436**+85.6)=**7.1636** kJ/mol. [1,8]
Energy content is $G_{Srombic}$=G_{H2Sgas}-($\Delta G°_{H2Sgas}$+G_{H2})=**7.1636**-(-81.98+85.6)=**3.5436** kJ/mol. [1,8]
Solubility H_2S_{gas}+H2O=H_2S_{aq} 3.98 g/L 20° C [30] M_{H2S}=34.08 g/mol product K_{sp}=[H_2S_{aq}]=3.98/34.08=0.11678 M
at equilibrium constant is K_{eq}=K_{sp}/[H_2O]=0.116784/55.3=0.0021118 with free energy change endoergic positive
ΔG_{eq}=-R•T•ln(K_{eq})=-8.3144*298.15*ln(0.0021118)=G_{H2Saq}-(G_{H2Sgas}+G_{H2o})=**15.27** kJ/mol.
The free energy per mole of hydrogen sulfide is G_{H2Sgas}=G_{H2Saq}-(ΔG_{eq}+G_{H2O})=**53.3896**-(**15.27**+0)=**38.1196** kJ/mol.

S^{2-}=S_{rombic}+H2O+2e⁻; Standard potential $E°_{classic}$=-0.4763 V [1], plus water account logarithm
-0.0591/2*lg($[H_2O]^1$)=-0.0515 and the coupled sum $\Delta E°$=+0.10166-0.37239 expressed absolute potential is
$E°_{S↓/S2-}$=$E°_{classic}$-0.0591/2*lg($[H_2O]^1$)+$\Delta E°$=-0.4763-0.0515+0.10166-0.37239=**-0.79853**V;
ΔG_{eqS2-}=$E°_{S2-}$•Fn=**-0.79853***96485*2=**-154.09** kJ/mol . $G_{Srombic}$=**3.5436** kJ/mol;
$\Delta G_{eqS2-aq}$=$G_{Srombic}$+G_{H2O}-(G_{S2-aq})=**3.5436**+0-(**157.63**)=**-154.09** kJ/mol;
G_{S2-aq}=$G_{Srombic}$+G_{H2O}-($\Delta G_{eqS2-aq}$)=**3.5436**+0-(-154.09)=**157.63** kJ/mol;

HS^-+OH^-=S_{rombic}+$2H_2O$+2e⁻; Standard potential $E°_{classic}$=-0.478 V [1], plus water account logarithm
-0.0591/2*lg($[H_2O]^2$)=-0.103 and the coupled sum $\Delta E°$=+0.10166-0.37239 expressed absolute potential is
$E°_{S↓/HS-}$=$E°_{classic}$-0.0591/2*lg($[H_2O]^2$)+$\Delta E°$=-0.478-0.103+0.10166-0.37239=**-0.8517** V;
ΔG_{eqHS-}=E_{HS-}•Fn=**-0.8517***96485*2=**-164.35** kJ/mol .
$\Delta G_{eqHS-aq}$=$G_{Srombic}$+$2G_{H2O}$-(G_{HS-aq}+G_{OH})=**3.5436**+2*0-(**90.5336**+77.36)= **-164.35** kJ/mol;
G_{HS-aq}=$G_{Srombic}$+$2G_{H2O}$-($\Delta G_{eqHS-aq}$+G_{OH})=**3.5436**+2*0-(-164.35+77.36)=**90.5336** kJ/mol;

H_2S_{aq}+$2H_2O$=$S_{rombisks}$+$2H_3O^+$+2e⁻; Standard potential $E°_{classic}$=0.142 V [1], plus water account logarithm
-0.0591/2*lg($1/[H_2O]^2$)=0.103 and the coupled sum $\Delta E°$=+0.10166-0.37239 expressed absolute potential is
$E°_{S↓/H2S}$=$E°_{classic}$-0.0591/2*lg($1/[H_2O]^2$)+$\Delta E°$=0.142+0.103+0.10166-0.37239=**-0.025735** V;
ΔG_{eqH2S}=$E°_{H2S}$Fn=**-0.025735***96485*2=**-4.966** kJ/mol .
$\Delta G_{eqH2Saq}$=$G_{Srombic}$+$2G_{H3O+}$-(G_{H2Saq}+$2G_{H2O}$)=**3.5436**+2*22.44-(**53.3896**+2*0)=**-4.966** kJ/mol;
$G_{Srombic}$=$\Delta G_{eqH2Saq}$-$2G_{H3O+}$+(G_{H2Saq}+$2G_{H2O}$)=**-4.966**-2*22.44+(**53.3896**+2*0)=**3.5436** kJ/mol;
pKa=7.0 Wikipedia; [1] pK_{a1}=7.05; pK_{a2}=19
pK_{a1}=7.05 H_2S+H2O=HS^-+H_3O^+; K_{eq1}=K_{a1}/[H_2O]=10^(-7.05)/55.3= 0.000000001612;
ΔG_{eq}=-R•T•ln(K_{eq})=-8.3144*298.15*ln(0.000000001612)= G_{HS-}+G_{H3O}-(G_{H2S}+G_{H2O})=**50.188** kJ/mol;
ΔG_{eq}=G_{HS-}+G_{H3O}-(G_{H2S}+G_{H2O})=**81.138**+22.44-(**53.3896**+0)=**50.188** kJ/mol ;
G_{HS-}=ΔG_{eq}-G_{H3O}+(G_{H2S}+G_{H2O})=**50.188**-22.44+(**53.3896**+0)=**81.138** kJ/mol ;
pK_{a2}=19 HS^-+ H2O=S^{2-}+H_3O^+; K_{eq1}=K_{a1}/[H_2O]=10^(-19)/55.3=10^(-20.74);
ΔG_{eq}=-R•T•ln(K_{eq})=-8.3144*298.15*ln(10^(-20.74))=G_{S2-}+G_{H3O}-(G_{HS-}+G_{H2O})=**118.38** kJ/mol;
ΔG_{eq}=G_{S2-}+G_{H3O}-(G_{HS-}+G_{H2O})=**188.59**+22.44-(G_{HS-}+0)=**118.38** kJ/mol ;
G_{HS-}=G_{S2-}+G_{H3O}-(ΔG_{eq}+G_{H2O})=**188.59**+22.44-(**118.38**+0)=**92.65** kJ/mol ;
Sulfur reduction inverse potential: S_{rombic}+$2H_3O^+$+2e⁻=H_2S_{aq}+$2H_2O$; -$E°_S$=**-0.025735** V;
2(Pt)H+$2H_2O$=$2H_3O^+$+ 2e⁻; $E°_H$=**-0.27073** V; S_{rombic}+2(Pt)H=H_2S_{aq};
ΔG_{eq}=($E°_H$-$E°_S$)•F•1•2=(**-0.27073**+0.025735)*96485*2=**-0.244995***96485*2= **-47.277** kJ/mol;
G_{H2Saq}=$\Delta G_{HessH2S}$+($2G_{H(Pt)}$+$G_{Srombic}$)=**-47.277**+(2*48.56+34.5)=**84.343** kJ/mol . .

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Alberty [8] and CRC [1] data: G_{H2gas}=**85.6** $^{kJ}/_{mol}$, G_{H2Saq}=**53.3896** $^{kJ}/_{mol}$ [8] and $\Delta G°_{H2O}$=-237.191 $^{kJ}/_{mol}$, $\Delta G°_{H2Sgas}$=-81.98 $^{kJ}/_{mol}$ [1] allow calculating the absolute values of the free energy content of substances $G_{Srombic}$=**3.5436** $^{kJ}/_{mol}$; G_{O2gas}=**303** $^{kJ}/_{mol}$, etc. relative to water and carbon dioxide gas on a zero reference scale G_{H2O}=G_{CO2gas}=G_{e-}=0 $^{kJ}/_{mol}$. Formation from elements sulfuric acid and sulfates: S_{rombic}+$2O_{2gas}$+H_{2gas}=H_2SO_{4aq}; $\Delta G°_{H2SO4Form}$=G_{H2SO4}-($G_{Srombic}$+$2G_{O2}$+G_{H2gas})=-690.0 $^{kJ}/_{mol}$; [1] Content per mol

of H_2SO_4 is G_{H2SO4}=$\Delta G°_{H2SO4Form}$+($G_{Srombic}$+$2G_{O2}$+G_{H2gas})=-690.0+(**3.5436**+2***303**+**85.6**)=**5.1436** $^{kJ}/_{mol}$. S_{rombic}+$2O_{2gas}$+H_{2gas}/2=HSO_4^-; $\Delta G°_{HSO4Form}$=G_{HSO4}-($G_{Srombic}$+$2G_{O2}$+$0.5G_{H2gas}$)=**-755.9** $^{kJ}/_{mol}$. Content per mol of HSO_4^- is G_{HSO4}=$\Delta G°_{HSO4Form}$+($G_{Srombic}$+$2G_{O2}$+$0.5G_{H2gas}$)=-755.9+(**3.5436**+2***303**+**85.6/2**)=**-103.56** $^{kJ}/_{mol}$. S_{rombic}+$2O_{2gas}$=SO_4^{2-}; $\Delta G°_{SO4Form}$=G_{SO4}-($G_{Srombic}$+$2G_{O2}$)=**-747.75** $^{kJ}/_{mol}$. Content per mol of SO_4^{2-} is

G_{SO4}=$\Delta G°_{SO4Form}$+($G_{Srombic}$+$2G_{O2}$)=**-747.75**+(**3.5436**+2***303**)=**-138.2** $^{kJ}/_{mol}$.

The protolysis equilibrium H_2SO_4+H_2O=HSO_4^-+H_3O^+ in mol fractions is calculated by dividing the acid K_{eq1}=K_{a1}/[H_2O]=$10^{(2.8)}$/55.3=11.41 constant K_{a1} (pK_{a1}=-2.8) by water [H_2O]=55.3 M. The change in free energy is $\Delta G_{eqH2SO4}$=-R•T•ln(K_{eq})=-8.3144*298.15*ln(11.41)=G_{HSO4-}+G_{H3O}-(G_{H2SO4}+G_{H2O})=**-6.035** $^{kJ}/_{mol}$ and from the Hess's law expression $\Delta G_{eqH2SO4}$=G_{HSO4-}+G_{H3O}-(G_{H2SO4}+G_{H2O})=G_{HSO4-}+**22.44**-(**-84.04-151.549**)=**-6.035** $^{kJ}/_{mol}$ the free energy content per mol of HSO_4^- anion is obtained

G_{HSO4-}=$\Delta G_{eqH2SO4}$-G_{H3O}+(G_{H2SO4}+G_{H2O})=**-6.035-22.44**+(**5.1436+0**)=**-23.33** $^{kJ}/_{mol}$. Protolysis equilibrium HSO_4^-+H_2O=SO_4^{2-}+H_3O^+ pK_{a2}=1.99 K_{eq2}=K_{a2}/[H_2O]=$10^{(-1.99)}$/55.3=0.0001850 free energy is ΔG_{eqHSO4}=-R•T•ln(K_{eq2})=-8.3144*298.15*ln(0.0001850)=G_{SO42-}+G_{H3O}-(G_{HSO4-}+G_{H2O})=**21.307** $^{kJ}/_{mol}$. Hess expression ΔG_{eqHSO4}=G_{SO42-}+G_{H3O}-(G_{HSO4-}+G_{H2O})=G_{SO42-}+**22.44**-(**-23.33+0**)=**21.307** $^{kJ}/_{mol}$ free energy of SO_4^{2-} anion mol is G_{SO42-}=ΔG_{eqHSO4}-G_{H3O}+(G_{HSO4-}+G_{H2O})=**21.307-22.44**+(**-23.33+0**)=**-24.46** $^{kJ}/_{mol}$.

Formation from free elements S_{rombic}+$1.5O_{2gas}$+H_{2gas}=H_2SO_{3aq} and solubility SO_2^{gas}+H_2O=H_2SO_{3aq} . $\Delta G°_{H2SO3Form}$=G_{H2SO3}-($G_{Srombisks}$+$1.5\Delta G_{O2}$+ G_{H2gas})=-56.94-(**3.5436**+1.5***303**+**85.6**)=**-600.58** $^{kJ}/_{mol}$; G_{HSO3}=$\Delta G°_{HSO3Form}$+($G_{Srombisks}$+$1.5\Delta G_{O2}$+G_{H2gas}/2)=-486.5+(**3.5436**+1.5***303**+**85.6**/2)=**-74.84** $^{kJ}/_{mol}$; G_{SO3}=$\Delta G°_{SO3Form}$+$G_{Srombisks}$+$1.5\Delta G_{O2}$=**-490.38-85.64**+1.5***303**=**-121.52** $^{kJ}/_{mol}$; Equilibrium constants in mol fractions K_{eq}=K_a/[H_2O] calculate dividing the acid constant by water [H_2O]. H_2SO_3+H_2O=HSO_3^-+H_3O^+; pK_{a1}=1.85; K_{eq1}=K_{a1}/[H_2O]=$10^{(-1.85)}$/55.3=0.0002554; $\Delta G_{eqH2SO3}$=-R•T•ln(K_{eq1})=-8.3144*298.15*ln(0.0002554)=G_{HSO3-}+G_{H3O}-(G_{H2SO3}+G_{H2O})=**20.5075** $^{kJ}/_{mol}$; G_{HSO3-}=$\Delta G_{eqH2SO3}$-G_{H3O}+(G_{H2SO3}+G_{H2O})=**20.5075-22.44**+(**-56.93796+0**)=**-58.87** $^{kJ}/_{mol}$; HSO_3^-+H_2O=SO_3^{2-}+H_3O^+; pK_{a2}=7.21; K_{eq2}=K_{a2}/[H_2O]=$10^{(-7.21)}$/55.3= 0.000000001115; ΔG_{eqHSO3}=-R•T•ln(K_{eq2})=-8; 3144*298.15*ln(0.000000001115)=G_{SO32-}+G_{H3O}-(G_{HSO3-}+G_{H2O})=**51.1** $^{kJ}/_{mol}$; G_{HSO3-}=G_{SO32-}+G_{H3O}-(ΔG_{eqHSO3}+G_{H2O})=**-121.52**+**22.44**-(**51.1+0**)=**-150.2** $^{kJ}/_{mol}$; H_2SO_3+$4H_2O$=HSO_4^-+$3H_3O^+$+$2e^-$ Standard potential $E°_{classic}$=0.172 V [1], plus water account logarithm -0.0591/2*lg(1/[H_2O]^4)=0.206 and the coupled sum $\Delta E°$=+0.10166-0.37239 expressed absolute potential is $E°_{H2SO3}$=$E°_{classic}$-0.0591/2*lg(1/[H_2O]^4)+$\Delta E°$=0.172+0.206+0.10166-0.37239=**0.10726** V;

pH<2 E_{H2SO3}=$E°_{H2SO3}$+$\frac{0.0591}{2}$•log $\frac{[HSO_4^-]\cdot[H_3O^+]^4}{[H_2SO_3]\cdot[H_2O]^5}$ =**0.10726** V $+\frac{0.0591}{2}$•log $\frac{[HSO_4^-]\cdot[H_3O^+]^4}{[H_2SO_3]\cdot[H_2O]^5}$

$\Delta G_{eqH2SO3}$=$E°_{HSO3}$•F•2=**0.107260***96485*2=**20.69796** $^{kJ}/_{mol}$;

$\Delta G_{eqHS2O3}$=G_{HSO4-}+$3G_{H3O}$-(G_{H2SO3}+$4G_{H2O}$)= **-103.56**+3*22.44-(**-56.93796**+4*0)=**20.69796** $^{kJ}/_{mol}$;

G_{H2SO3}=G_{HSO4-}+$3G_{H3O}$-($\Delta G_{eqH2SO3}$+$4G_{H2O}$)=**-103.56**+3*22.44-(**20.69796**+4*0)=**-56.94** $^{kJ}/_{mol}$;

G_{HSO4-}=$\Delta G_{eqH2SO3}$-$3G_{H3O}$+(G_{H2SO3}+$4G_{H2O}$)=**20.69796**-3*22.44+(**-56.93796**+4*0)=**-103.56** $^{kJ}/_{mol}$;

Solubility constants in mol fractions K_{eq}=K_{sp}/[H_2O] calculate dividing saturate product with water [H_2O]. SO_2^{gas}+H_2O=H_2SO_{3aq}; K_{sp}=[H_2SO_3]/[SO_2^{gas}]/[H_2O]=1.46724/1/51.64=0.028413, as saturated state dissolute 94 $^g/_L$ SO_2 M=64.066 g/mol [SO_2]=94/64.066=1.46724 M sulfurous acid M_{H2SO3}=82.075 g/mol with density **1.05** g/mL $m_{solution}$=1050 $^g/_L$ and mas of acid m_{H2SO3}=[SO_2]*M_{H2SO3}=1.46724 M*82.075 $^g/_{mol}$=**120.4327** $^g/_L$. Water concentration is m_{H2O}=1050-120.4327=929.5673 g; n_{H2O}=929.5673/18=51.64 M. Free energy change is:

$\Delta G_{spH2SO3}$=-R•T•ln(K_{sp})=-8.3144*298.15*ln(0.028413)=G_{H2SO3}-(G_{SO2}+G_{H2O})=**8.82727** $^{kJ}/_{mol}$;

$\Delta G_{eqH2SO3}$=G_{H2SO3}-(G_{SO2}+G_{H2O})=**-56.93796**-(**-81.735**+0)=**8.82727** $^{kJ}/_{mol}$;

G_{SO2}=G_{H2SO3}-($\Delta G_{eqH2SO3}$+G_{H2O})=**-72.9075**-(**8.82727**+0)=**-81.73477** $^{kJ}/_{mol}$; pH<2 [1]

G_{SO2}=G_{H2SO3}-($\Delta G_{eqH2SO3}$+G_{H2O})=**-56.93796**-(**8.82727**+0)=**-65.76523** $^{kJ}/_{mol}$; 2=<pH<7 [17]

$\Delta G_{eqH2SO3}$=G_{H2SO3}-(G_{SO2}+G_{H2O})=**-56.93796**-(**-65.76523**+0)=**8.82727** $^{kJ}/_{mol}$;

Formation from free elements $S_{rombic}+O_{2gas}=SO_2$; $\Delta G°_{SO2Form}=G_{SO2}-(-85.64+303)=-370.82$ $^{kJ}/_{mol}$;

$G_{SO2}=\Delta G°_{SO2Form}+(G_{Srombisks}+G_{O2})=-370.82+(-85.64+303)=-153.46$ $^{kJ}/_{mol}$;

$HSO_3^-+4H_2O=SO_4^{2-}+3H_3O^++2e^-$ Standard potential $E°_{classic}=0.172$ V [17], plus water account logarithm $-0.0591/2*lg(1/[H_2O]^4)=0.206$ and the coupled sum $\Delta E°=+0.10166-0.37239$ expressed absolute potential is

$E°_{SO4-}=E°_{classic}-0.0591/2*lg(1/[H_2O]^4)+\Delta E°=0.172+0.206+0.10166-0.37239=0.10726$ V;

$2=<pH<7$ $E_{HSO3-}=E°_{HSO3-}+0.0591/2*log\dfrac{[SO_4^{2-}]\cdot[H_3O^+]^3}{[HSO_3^-]\cdot[H_2O]^4}$ $=0.10726$ V $+0.0591/2*log\dfrac{[SO_4^{2-}]\cdot[H_3O^+]^3}{[HSO_3^-]\cdot[H_2O]^4}$

$\Delta G_{eqSO4-}=E°_{HSO4-}\bullet F\bullet 2=0.10726*96485*2=20.69796$ $^{kJ}/_{mol}$;

$\Delta G_{eqSO4-}=G_{SO4-}+3G_{H3O}-(G_{HSO3}+4G_{H2O})=-24.46+3*22.44-(22.16+4*0)=20.7$ $^{kJ}/_{mol}$;

$G_{HSO3}=G_{SO4-}+3G_{H3O}-(\Delta G_{eqSO4-}+4G_{H2O})=-24.46+3*22.44-(20.69796+4*0)=22.16$ $^{kJ}/_{mol}$;

$G_{SO4-}=\Delta G_{eqSO4-}-3G_{H3O}+(G_{HSO3}+4G_{H2O})=20.69796-3*22.44+(22.16+4*0)=-24.46$ $^{kJ}/_{mol}$;

Substance	$\Delta H°_H$,$^{kJ}/_{mol}$	$\Delta S°_H$,$^J/_{mol/K}$	$\Delta G°_H$,$^{kJ}/_{mol}$	
H_2SO_4	-814.0	156.9	-690.0	CRC [1];
H_2SO_4	favored	formation	**5.1436**	$G_{H2SO4}=\Delta G°_{H2SO4}+G_{Srombisks}+2\Delta G_{O2}+G_{H2gas}+G_{H2O}=5.1436$ $^{kJ}/_{mol}$;
HSO_4^-	-887.3	131.8	-755.9	CRC [1]
HSO_4^-	-	$pK_{a1}=-2.8$	**-23.33**	$G_{HSO4-}=\Delta G_{eqH2SO4}-G_{H3O}+(G_{H2SO4}+G_{H2O})=-23.33$ $^{kJ}/_{mol}$;
HSO_4^-	pH<2	formation	**-103.56**	$G_{HSO4}=\Delta G°_{HSO4}+G_{Srombisks}+2\Delta G_{O2}+G_{H2gas}/2=-103.56$ $^{kJ}/_{mol}$;
SO_4^{2-}	**-907.62**	**-536.2**	**-747.75**	**BioTherm2006** pH=7.36 [8] $\Delta G\_{SO42-}=\Delta H–T*\Delta S=-747.75$ $^{kJ}/_{mol}$;
SO_4^{2-}	-	formation	**-138.2**	$G_{SO4}=\Delta G°_{SO4Form}+G_{Srombisks}+2\Delta G_{O2}=-747.75-85.64+2*303=-138.2$ $^{kJ}/_{mol}$;
SO_4^{2-}	$2=<pH<7$	$pK_{a2}=1.99$	**-24.46**	$G_{SO42-}=\Delta G_{eqHSO4}-G_{H3O}+(G_{HSO4-}+G_{H2O})=-24.46$ $^{kJ}/_{mol}$;
SO_4^{2-}	$E°_{HSO3}=$	**0.10726**	**-24.46**	$G_{SO4-}=\Delta G_{eqSO4-}-3G_{H3O}+(G_{HSO3}+4G_{H2O})=-24.46$ $^{kJ}/_{mol}$; $2=<pH<7$
SO_4^{2-}	$E°_{SO32}=$	**-1.2522**	**-213.4**	$G_{SO42-}=\Delta G_{eqSO32-OH}-G_{H2O}+(G_{SO32-}+2G_{OH})=-213.4$ $^{kJ}/_{mol}$;
SO_4^{2-}	-909.3	20.1	-744.5	CRC [1]
SO_2^{gas}	−296.81	248.223	-370.82	$\Delta G_H=\Delta H_H-T*\Delta S_H=-296.81-298.15*0.\,248223=-370.82$ $^{kJ}/_{mol}$;
SO_2^{gas}		formation	**-153.46**	$G_{SO2}=\Delta G°_{SO2Form}+(G_{Srombisks}+G_{O2})=-153.46$ $^{kJ}/_{mol}$;
SO_2^{gas}	$\Delta GK_{sp}=8.827$	pH<2	**-81.735**	$\Delta G_{SO2}=G_{H2SO3}-(\Delta G_{spH2SO3}+G_{H2O})=-72.9075-(8.82727+0)=-81.73477$ $^{kJ}/_{mol}$;
SO_2^{gas}	$\Delta GK_{sp}=8.827$	2<pH<7	**-65.765**	$G_{SO2}=G_{H2SO3}-(\Delta G_{spH2SO3}+G_{H2O})=-65.76523$ $^{kJ}/_{mol}$;
H_2SO_3	Alberty [8]	pH=7.36	**-600.58**	$\Delta G°_{H2SO3Form}=G_{H2SO3}-(G_{Srombisks}+1.5\Delta G_{O2}+G_{H2gas})=-600.58$ $^{kJ}/_{mol}$;
H_2SO_3		formation	**-72.9075**	$G_{H2SO3}=\Delta G°_{H2SO3Form}+(G_{Srombisks}+1.5\Delta G_{O2}+G_{H2gas})=-72.9075$ $^{kJ}/_{mol}$;
H_2SO_3	$E°_{H2SO3}=$	**0.10726**	**-56.93796**	$G_{H2SO3}=G_{HSO4-}+3G_{H3O}-(\Delta G_{eqHSO3-}+4G_{H2O})=-56.938$ $^{kJ}/_{mol}$; pH<2
HSO_3^-	$E°_{HSO3-}=$	**0.10726**	**22.16**	$G_{HSO3}=G_{SO4-}+3G_{H3O}-(\Delta G_{eqSO4-}+4G_{H2O})=22.16$ $^{kJ}/_{mol}$;
HSO_3^-		formation	**-74.84**	$G_{HSO3}=\Delta G°_{HSO3}+G_{Srombisks}+1.5\Delta G_{O2}+G_{H2gas}/2=-74.84$ $^{kJ}/_{mol}$;
HSO_3^-		$pK_{a1}=1.85$	**-58.87**	$G_{HSO3-}=\Delta G_{eqH2SO3}-G_{H3O}+(G_{H2SO3}+G_{H2O})=-58.87$ $^{kJ}/_{mol}$;
HSO_3^-	-635.5	-29	-486.5	CRC [1]
SO_3^{2-}	**-632.19**	**-475.628**	**-490.38**	**BioTherm2006** pH=7.36 [8]
SO_3^{2-}	-	formation	**-121.52**	$G_{SO3}=\Delta G_{Form}=\Delta G°_{SO3}+G_{Srombisks}+1.5\Delta G_{O2}=-121.52$ $^{kJ}/_{mol}$;
SO_3^{2-}		$pK_{a2}=7.21$	**-30.21**	$G_{SO32-}=\Delta G_{eqHSO3}+G_{H3O}-(G_{HSO3-}+G_{H2O})=-30,21$ $^{kJ}/_{mol}$;
SO_3^{2-}	$E°_{SO32-OH}=$	**-1.2522**	**62.457**	$G_{SO32-}=G_{SO42-}+G_{H2O}-(\Delta G_{eqSO32-OH}+2G_{OH})=62.457$ $^{kJ}/_{mol}$; pH>7

$G_{H2SO3}=\Delta G°_{H2SO3Form}+(G_{Srombic}+1.5\Delta G_{O2}+G_{H2gas})=-72.9075$ $^{kJ}/_{mol}$;

$SO_3^{2-}+2OH^-=SO_4^{2-}+H_2O+2e^-$; pH>7; $^-$ Standard potential $E°_{classic}=-0.93$ V [17], plus water account logarithm $-0.0591/2*lg([H_2O])=0.0515$ and the coupled sum $\Delta E°=+0.10166-0.37239$ expressed absolute potential is $E°_{SO32-OH}=E°_{classic}-0.0591/2*lg([H_2O])+\Delta E°=-0.93+0.0515+0.10166-0.37239=-1.2522$ V;

$E_{SO32-OH}=E°_{SO32-OH}+\dfrac{0.0591}{2}\bullet log\dfrac{[SO_4^{2-}]\cdot[H_2O]}{[SO_3^{2-}]\cdot[OH^-]^2}$ $=-1.2522$ V$+\dfrac{0.0591}{2}\bullet log\dfrac{[SO_4^{2-}]\cdot[H_2O]}{[SO_3^{2-}]\cdot[OH^-]^2}$

$\Delta G_{eqSO42-OH}=E°_{SO32-OH}\bullet F\bullet 2=-1.2522*96485*2=-241.637$ $^{kJ}/_{mol}$;

$\Delta G_{eqSO32-OH}=G_{SO42-}+G_{H2O}-(G_{SO32-}+2G_{OH})=24.46+0-(62.457+2*77.36)=-241.637$ $^{kJ}/_{mol}$;

$G_{SO32-}=G_{SO42-}+G_{H2O}-(\Delta G_{eqSO32-OH}+2G_{OH})=-24.46+0-(-241.637+2*77.36)=62.457$ $^{kJ}/_{mol}$;

$G_{SO42-}=\Delta G_{eqSO32-OH}-G_{H2O}+(G_{SO32-}+2G_{OH})=-241.637-0+(62.457+2*77.36)=-24.46$ $^{kJ}/_{mol}$;

Metal insoluble salt solution of salt anions II-type electrode.
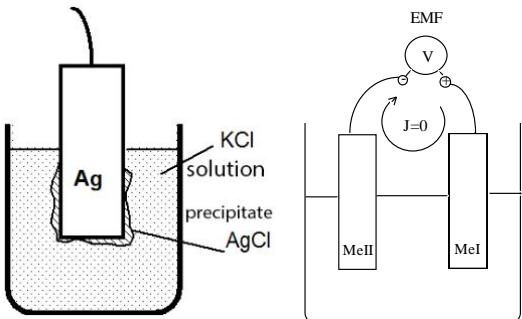
K$^+$Cl$^-$ solution, counter-ions Cl$^-$ of AgCl insoluble salt. Nernst's half reactions for electrode of silver metal Ag. Electric potential in volt measurement by couple of electrodes **E**lectric **M**otion **F**orce EMF in Volts. Between the indicator electrodes MeI and the reference electrode MeII connected in a closed electrical circuit, the potential of the MeI indicator electrode EI is calculated as the sum: EI=EMS+EII. The standard reference electrode EII serves as a constant potential and chloride concentration.

The silver I-type electrode: **Ag**(s)+H$_2$O=**Ag**$^+$+e$^-$ absolute potential is expression standard potential E°$_{Classic}$=0.7994 V [18], water logarithm -0.0591/1*lg(1/55.3^Λ^{1})=-0.103 and sum ΔE°=0.10166-0.37239: E$_{ag/Ag+}$=E°$_{classic}$-0.0591/1*lg(1/[H$_2$O]^1)+ΔE°=0.7994+0.103+0.10166-0.37239=**0.6317** V;

ΔG$_{eq\_Ag}$=E°$_{Ag}$•F•2=**0.6317***96485*1=**60.95** kJ/$_{mol}$. ΔG$_{eq\_As}$=G$_{Ag+}$-(G$_{Ag}$+G$_{H2O}$)=77.1-(G$_{Ag}$+0)=**60.95** kJ/$_{mol}$;

G$_{Ag}$=G$_{Ag+}$-(ΔG$_{eq\_Ag}$+G$_{H2O}$)=77.1-(**60.95**+0)=**16.15** kJ/$_{mol}$; [1]

G$_{Ag}$=G$_{Ag+}$-(ΔG$_{eq\_Ag}$+G$_{H2O}$)=**103.8**-(**60.95**+0)=**42.85** kJ/$_{mol}$;[8]

G$_{Ag+}$=ΔG$_{eq\_As}$+(G$_{Ag}$+G$_{H2O}$)=**60.95**+(**42.855**+0)=**103.8** kJ/$_{mol}$;[8]

Formation 2**Ag**$^+$+Cl$_2$=2**Ag**Cl(s); 2ΔG$_{eq\_AgCl}$=2G$_{AgCl}$-(2G$_{Ag}$+G$_{Cl2}$)=2G$_{AgCl}$-(2***42,85**+**394,2**)=-155,71 kJ/$_{mol}$; [1]

G$_{AgCl}$=(2ΔG$_{eq\_AgCl}$+(2G$_{Ag}$+G$_{Cl2}$))/2=(2*-155,71+(2***42,85**+**394,2**))/2=**84,24** kJ/$_{mol}$;

Solubility equilibrium in mol fractions **Ag**Cl(s)+2H$_2$O=**Ag**$^+$+Cl$^-$; **Ag**Cl(s)+2H$_2$O-Cl$^-$=**Ag**$^+$ absolute constant :

K$_{Absolute\textbf{AgCl}}$=K$_{sp\textbf{AgCl}}$/[H$_2$O]$^{\wedge2}$=[**Ag**$^+$]*[Cl$^-$]/[**Ag**Cl(s)]/[**H$_2$O**]$^{\wedge2}$=1.77*10$^{\wedge(-10)}$/55.3^2=5.79*10^{-14} ;

ΔG$_{Absolute\textbf{AgCl}}$=-**R**•**T**•**ln**(K$_{Absolute\textbf{AgCl}}$)=-8.3144*298.15*ln(5.788*10$^{\wedge(-14)}$)=**75.559** kJ/$_{mol}$;

ΔG$_{sp\textbf{AgCl}}$=G$_{Ag+}$+G$_{Cl-}$-(G$_{AgCl}$+2G$_{H2O}$)=**103,8**+**101,97**-(**130,211**+2*0)=**75,559** kJ/$_{mol}$;

G$_{AgCl}$=G$_{Ag+}$+G$_{Cl-}$-(ΔG$_{sp\textbf{AgCl}}$+2G$_{H2O}$)=**103,8**+**101,97**-(**75,559**+2*0)=**130,211** kJ/$_{mol}$;

compensate water molecule **Ag**(s)+H$_2$O=**Ag**$^+$+e$^-$; **Ag**(s)+H$_2$O+Cl$^-$=**Ag**Cl(s)+2H$_2$O+e$^-$ on summary reaction **Ag**(s)+Cl$^-$=**Ag**Cl(s)+H$_2$O+e$^-$ Expression of absolute potential has standard E°$_{Classic}$=0.2223 V [18], water and ΔE°: E$_{Ag/AgCl}$=E°$_{classic}$-0.0591/1*lg([H$_2$O]^1)+ΔE°=0.2223-0.103+0.10166-0.37239=**-0.1514** V;

ΔG$_{eq\_Ag}$=E°$_{Ag}$•F•1=**-0.1514***96485*1=**-14.61** kJ/$_{mol}$,

ΔG$_{eq\_Ag}$=G$_{AgCl}$+G$_{H2O}$-(G$_{Ag}$+G$_{Cl-}$)=**-155.71**+0-(**42.855**-**183.955**)=**-14.61** kJ/$_{mol}$;

G$_{Ag}$=G$_{AgCl}$+G$_{H2O}$-(ΔG$_{eq\_Ag}$+G$_{Cl-}$)=**-155.71**+0-(**-14.61**-**183.955**)=**42.855** kJ/$_{mol}$;

Solubility **NH$_3$**$_{gas}$ and **Ag** compensate each one water molecule in Nernst's half reaction products **NH$_3$**$_{gas}$+H$_2$O=NH$_{3aq}$;Ag+**H$_2$O**=Ag$^+$+**e**$^-$; Ag+H$_2$O+2NH$_{3aq}$=Ag(NH$_3$)$_2$$^+$+2**H$_2$O**+e$^-$; Absolute potential has standard E°$_{Classic}$=0.373 V [17], water -0.0591/1*lg([H$_2$O]^1)=-0.103 logarithm and sum ΔE°=0.10166-0.37239:

E°$_{Ag/Ag(NH3)2+}$=E°$_{classic}$-0.0591/1*lg([H$_2$O]^1)+ΔE°=0.373-0.103+0.10166-0.37239=**-0.000725** V;

ΔG$_{Ag/Ag(NH3)2+}$=E°$_{Ag/Ag(NH3)2+}$•F•1=**-0.000725***96485*1=**-0.06995** kJ/$_{mol}$;

G$_{Ag(NH3)2+}$=ΔG$_{Ag/Ag(NH3)2+}$-G$_{H2O}$+(G$_{Ag}$+2G$_{NH3aq}$)=**-0.06995**-0+(**42.855**-2***91.1**)=**-139.415** kJ/$_{mol}$;

2Ag+2OH$^-$=**Ag$_2$O**(s)+H$_2$O+2**e**$^-$; Expression of absolute potential has standard E°$_{Classic}$=0.345 V [17], water and ΔE°: E°$_{2Ag/\textbf{Ag2o}}$=E°$_{classic}$-0.0591/2*lg([H$_2$O]^1)+ΔE°=0.345-0.0515+0.10166-0.37239=**0.02277** V

ΔG$_{Ag/\textbf{Ag2o}}$=E°$_{Ag/\textbf{Ag2o}}$•F•2=**0.02277***96485*2=**4.394** kJ/$_{mol}$;

ΔG$_{Ag/\textbf{Ag2o}}$=G$_{\textbf{Ag2o}}$+G$_{H2O}$-(2G$_{Ag}$+2G$_{OH}$)=G$_{\textbf{Ag2o}}$+0-(2***42.855**-2*77.36)= **4.394** kJ/$_{mol}$;

G$_{\textbf{Ag2o}}$=ΔG$_{Ag/\textbf{Ag2o}}$-G$_{H2O}$+(2G$_{Ag}$+2G$_{OH}$)=**4.394**-0+(2***42.855**-2*77.36)=**-64.616** kJ/$_{mol}$;

$$E°_{Ag/Ag(NH3)2+}=\textbf{0.000725 V}+\frac{[Ag(NH_3)_2^+]}{[Ag]\cdot([NH_3]-2\cdot[Ag(NH_3)_2^+])^2}$$

$$E°_{2Ag/\textbf{Ag2o}}=\textbf{0.02277 V}+\frac{[Ag_2\textbf{o}]\cdot[\textbf{H}_2\textbf{o}]}{[Ag]^2\cdot[\textbf{oH}]^2}$$

Viela	ΔH°$_H$ kJ/mol	ΔS° J/mol/K	ΔG°$_H$, kJ/mol	
Ag	E°$_{Ag/Ag+}$=	**-0.6317** V	**16.15**	ion G$_{Ag+}$=**103.8** kJ/$_{mol}$ over G$_{Ag}$=**42.855** kJ/$_{mol}$ element **60.945**;[8]
Ag	E°$_{Ag/Ag+}$=	**-0.6317** V	**42.85**	CRC[1] G$_{Ag}$=G$_{Ag+}$-(ΔG$_{eq\_Ag}$+G$_{H2O}$)=77.1-(**60.95**+0)=**16.15** kJ/$_{mol}$;
Ag	E°$_{Ag/AgCl}$=	**-0.1514** V	**42.855**	G$_{Ag}$=G$_{Ag+}$-(ΔG$_{eq\_Ag}$+G$_{H2O}$)=**103.8**-(**60.95**+0)=**42.85** kJ/$_{mol}$; [8]
Ag+	105.6	72.7	77.1	G$_{Ag}$= G$_{AgCl}$+G$_{H2O}$-(ΔG$_{eq\_Ag}$+G$_{Cl-}$)=**-155.71**+0-(**-14.61**-**183.955**)=**42.855** kJ/$_{mol}$;
Ag+	E°$_{Ag}$=	**0.6317** V	**103.8**	CRC; [1] ion G$_{Ag+}$=77,1 kJ/$_{mol}$ over element zero ΔG°$_{Ag}$=0 kJ/$_{mol}$;
AgCl(s)	-127.01	96.25	-155.71	G$_{Ag+}$=ΔG$_{eq\_As}$+(G$_{Ag}$+G$_{H2O}$)=**60.95**+(**42.855**+0)=**103.8** kJ/$_{mol}$;
AgCl(s)	formation	-	**84.24**	ΔG$_{AgCl}$=ΔH$_H$–T*ΔS$_H$=-127.01-298.15*0.09625=-155.71 kJ/$_{mol}$;[1]
AgCl(s)	K$_{sp\textbf{AgCl}}$=	5,788*10^{-14}	130.2	G$_{AgCl}$=(2ΔG$_{eq\_AgCl}$+(2G$_{Ag}$+G$_{Cl2}$))/2=**84.24** kJ/$_{mol}$;
Cl-	K$_{sp\textbf{Hg2Cl2}}$=	10$^{\wedge(-23,1)}$	101.97	G$_{AgCl}$=G$_{Ag+}$+G$_{Cl-}$-(ΔG$_{sp\textbf{AgCl}}$+2G$_{H2O}$)=**130.2** kJ/$_{mol}$;
Ag(NH$_3$)$_2$$^+$	E°$_{Ag(NH3)2+}$	**-0.000725**	**-139.415**	G$_{Cl-}$=(-G$_{Hg22+}$+ΔG$_{eqHg2Cl2}$+(G$_{Hg2Cl2}$+3G$_{H2O}$))/2=**101.97** kJ/$_{mol}$;
AgCl	ΔG$_{sp\textbf{AgCl}}$=	K$_{sp\textbf{AgCl}}$=	**-155.714**	G$_{Ag(NH3)2+}$=ΔG$_{Ag/Ag(NH3)2+}$-G$_{H2O}$+(G$_{Ag}$+2G$_{NH3aq}$) =**-139.415** kJ/$_{mol}$;
Ag$_2$O(s)	-31.1	121.3	-11.2	G$_{AgCl}$=G$_{Ag+}$+G$_{Cl-}$-(ΔG$_{sp\textbf{AgCl}}$+2G$_{H2O}$)=**-155.714** kJ/$_{mol}$;
Ag$_2$O(s)	E°$_{Ag/\textbf{Ag2o}}$=	**0.02277**V	**-64.616**	CRC; [1]

G$_{\textbf{Ag2o}}$=ΔG$_{Ag/\textbf{Ag2o}}$-G$_{H2O}$+(2G$_{Ag}$+2G$_{OH}$)=**-64.616** kJ/$_{mol}$;

Nernst's potential studies $\underline{Hg}/Hg_2^{2+}/Hg^{2+}$, Hg_2Cl_2, $Hg_2SO_{4(s)}$, HgO accounting hydroxonium H_3O^+, water H_2O.

Substance	$\Delta H°_H$, kJ/mol	$\Delta S°_H$, J/mol/K	$\Delta G°_H$, kJ/mol	
$\underline{Hg}$	HgO ; $\mathbf{H_2O_2}$	75.9	**35.885**	$(E°_{H2O2aqRed}-E°_{HgO})*F*n=(0.5278+0.22318)=0.7510$V
$\underline{Hg}$	$E°_{HgCl2}=$	**-0.1059** V	**35.8**	$G_{Hg}=G_{eqRedOx\_2H2O2}-G_{O2aqua}+(G_{HgO}+G_{H2O2})=35.885$ kJ/mol ;
Hg_2^{2+}	-166.87	66.74	-146.97	$G_{Hg}=(G_{Hg2Cl2}+G_{H2O}-(2G_{Cl-}+\Delta G_{eq\_Hg2Cl2}))/2=35.8$ kJ/mol;
Hg_2^{2+}	$E°_{Hg/Hg22+}=$	**0.6888** V	**204.52**	$\Delta G_{Hg22+}=\Delta H_H-T*\Delta S_H=-166.87-298.15*0.06674=-146.97$ kJ/mol;
Hg^{2+}	-170.21	-36.19	-	$G_{Hg22+}=\Delta G_{eq\_Hg}+(2G_{Hg}+G_{H2O})=132.92+(2*35.702+0)=204.32$ kJ/mol;
$Hg_2SO_{4(s)}$	-743.1	200.7	-625.8	CRC [1]
$Hg_2SO_{4(s)}$	$K_{AbsoluteHg2SO4}=$	$10^{\wedge(-9.673)}$	**-598.44**	$G_{Hg2SO4}=G_{Hg22+}+G_{SO42-}-(\Delta G_{eqHg2SO4}+2G_{H2O})=-598.44$ kJ/mol;
SO_4^{2-}	**-907.62**	**-536.2**	**-747.75**	**Biochem. Thermodynamic 2006** Massachusetts Technology Inst. [8]
SO_4^{2-}	$E°_{Hg2SO4}=$	**0.2918** V	**-726.54**	$G_{SO4}=G_{Hg2SO4}-(2G_{Hg}+\Delta G_{eq\_Hg2SO4})=-726.54$ kJ/mol
SO_4^{2-}	-909.3	20.1	-744.5	CRC [1]
Cl_2	formation	$Hg_2Cl_{2(s)}$	**394,2**	$\mathbf{G_{Cl2}}=\mathbf{G_{Hg2Cl2(s)}}-(2\mathbf{G_{Hg}}+\Delta G°_{Hg2Cl2Form})=394,2$ kJ/mol;
$Hg_2Cl_{2(s)}$	-265.37	191.6	-210.7	CRC [1] $\Delta G°_{Hg2Cl2Form}=\mathbf{G_{Hg2Cl2(s)}}-(2\mathbf{G_{Hg}}+\mathbf{G_{Cl2}})=-210,7$ kJ/mol;
$Hg_2Cl_{2(s)}$	$E°_{HgCl2}=$	**-0.1059** V	**255.1**	$G_{Hg2Cl2}=\Delta G_{eq\_Hg2Cl2}-2G_{H2O}+(2G_{Cl-}+2G_{Hg})=255.1$ kJ/mol;
$HgCl_{2(s)}$	-224.3	146	-178.6	CRC [1]
$Cl-$	-167.08	56.6	**-183.955**	$\Delta G_{Cl-}=\Delta H_H-T*\Delta S_H=-167.08-298.15*0.0566=\mathbf{-183.955}$ kJ/mol;
$Cl-$	$K_{AbsoluteHg2Cl2}=$	$10^{\wedge(-23.1)}$	**-112.825**	$G_{Cl-}=(-G_{Hg22+}+\Delta G_{eqHg2Cl2}+(G_{Hg2Cl2}+3G_{H2O}))/2=\mathbf{-112.825}$ kJ/mol;
$HgO_{(s)}$	-99.79	70.25	-60.3675	$\Delta G_{HgO}=\Delta H_H-T*\Delta S_H=-99.79-298.15*0.07025=2*-60.3675$ kJ/mol;
$HgO_{(s)}$	-90.8	70.3	-58.5	CRC [1] $\Delta G_{HgO}=-58.5$ kJ/mol;
$HgO_{(s)}$	-	formation	**142.3**	$2G_{HgO}=2\Delta G_{HgO}+(2*G_{Hg}+G_{O2})=2*142.2$ kJ/mol
$HgO_{(s)}$	$E°_{HgO}=$	**0.22423 V**	**147.15**	$G_{HgO}=\Delta G_{eqHgO}-2G_{H2O}+(G_{Hg}+2G_{OH})=147.15$ kJ/mol;

$2\underline{Hg}+H_2O=Hg_2^{2+}+2e^-$; Expression of absolute potential has standard $E°_{Classic}=0.907$ V [18],

water and $\Delta E°$: $E°_{2Hg}=E°_{classic}-0.0591/2*lg(1/[H_2O]^1)+\Delta E°_{2Hg}=0.907+0.0515+0.10166-0.37239=\mathbf{0.6888}$ V;

$$\Delta G_{eq\_Hg}=E°_{2Hg}•F•2=\mathbf{0.6888}*96485*2=\mathbf{132.92} \text{ kJ/mol},$$

$$\Delta G_{eq\_Hg}=G_{Hg22+}-(2G_{Hg}+G_{H2O})=G_{Hg22+}-(2*35.8+0)=204.52-(2*35.8+0)=\mathbf{132.92} \text{ kJ/mol} ;$$

$$G_{Hg22+}=\Delta G_{eq\_Hg}+(2G_{Hg}+G_{H2O})=\mathbf{132.92}+(2*35.8+0)=\mathbf{204.52} \text{ kJ/mol} ;$$

Solubility equilibrium $Hg_2Cl_{2(s)}+3H_2O=\mathbf{Hg_2^{2+}}+2Cl^-$; $2\underline{Hg}+H_2O=Hg_2^{2+}+2e^-$; absolute solubility constant :

$$K_{AbsoluteHg2Cl2}=K_{spHg2Cl2}/[H_2O]^{\wedge}3=[\mathbf{Hg_2^{2+}}]*[Cl^-]^2/[Hg_2Cl_{2(s)}]/[H_2O]^{\wedge}3=1.43*10^{\wedge(-18)}/1/55.3^{\wedge}3=10^{-23.1};$$

$$\Delta G_{eqHg2Cl2}=\mathbf{-R•T•ln(K_{AbsoluteHg2Cl2})}=\mathbf{-8.314*298.15*ln}(10^{\wedge(-23.1)})=\mathbf{131.85} \text{ kJ/mol};$$

$$\Delta G_{Hg2Cl2}=G_{Hg22+}+2G_{Cl-}-(G_{Hg2Cl2}+3G_{H2O})=204.52+2G_{Cl-}-(276.61+3*0)=204.52+2*101.97-(276.61+3*0)=\mathbf{131.85} \text{ kJ/mol};$$

$$G_{Cl-}=(-G_{Hg22+}+\Delta G_{eqHg2Cl2}+(G_{Hg2Cl2}+3G_{H2O}))/2=(-\mathbf{204.52}+\mathbf{131.85}+(\mathbf{276.61}+3*0))/2=\mathbf{101.97} \text{ kJ/mol};$$

Formation $2Hg+Cl_2=Hg_2Cl_{2(s)}$; $\Delta G°_{Hg2Cl2Form}=\mathbf{G_{Hg2Cl2(s)}}-(2\mathbf{G_{Hg}}+\mathbf{G_{Cl2}})=\mathbf{255,1}-(2*\mathbf{35,8}+\mathbf{G_{Cl2}})=-210,7$ kJ/mol;

$$\mathbf{G_{Cl2}}=\mathbf{G_{Hg2Cl2(s)}}-(2\mathbf{G_{Hg}}+\Delta G°_{Hg2Cl2Form})=\mathbf{255,1}-(2*\mathbf{35,8}-210,7)=\mathbf{394,2} \text{ kJ/mol};$$

$2\underline{Hg}+2Cl^-=Hg_2Cl_{2(s)}+2H_2O+2e^-$; Expression of absolute potential has standard $E°_{Classic}=0.2678$ V [18],

water and $\Delta E°$: $E°_{HgCl2}=E°_{Classic}-0.0591/2*lg([H_2O]^2)+\Delta E°=0.2678-0.103+0.10166-0.37239=\mathbf{-0.1059}$ V;

$$\Delta G_{eq\_Hg2Cl2}=E°_{Hg2Cl2}•F•2=\mathbf{-0.1059}*96485*2=\mathbf{-20.44} \text{ kJ/mol},$$

$$\Delta G_{eq\_Hg2Cl2}=G_{Hg2Cl2}+2G_{H2O}-(2G_{Cl-}+2G_{Hg})=255.1+2*0-(2*101.97+2*35.8)=\mathbf{-20.44} \text{ kJ/mol} ;$$

$$G_{Hg2Cl2}=\Delta G_{eq\_Hg2Cl2}-2G_{H2O}+(2G_{Cl-}+2G_{Hg})=\mathbf{-20.44}-2*0+(2*\mathbf{101.97}+2*\mathbf{35.8})=\mathbf{255.1} \text{ kJ/mol} ;$$

$$G_{Hg}=(G_{Hg2Cl2}+G_{H2O}-(2G_{Cl-}+\Delta G_{eq\_Hg2Cl2}))/2=(\mathbf{255.1}+0-(2*\mathbf{101.97}-20.44))/2=\mathbf{35.8} \text{ kJ/mol} ;$$

Solubility equilibrium $Hg_2SO_{4(s)}+2H_2O=\mathbf{Hg_2^{2+}}+SO_4^{2-}$; $2\underline{Hg}+2H_2O=Hg_2^{2+}+2e^-$; absolute solubility constant:

$$K_{AbsoluteHg2SO4}=K_{spHg2SO4}/[H_2O]^{\wedge}2=[\mathbf{Hg_2^{2+}}]*[SO_4^{2-}]/[Hg_2SO_{4(s)}]/[H_2O]^{\wedge}2=6.5*10^{\wedge(-7)}/1/55.3^{\wedge}2=10^{-9.673};$$

$$\Delta G_{eqHg2SO4}=\mathbf{-R•T•ln(K_{AbsoluteHg2SO4})}=\mathbf{-8.314*298.15*ln}(10^{\wedge(-9.673)})=\mathbf{55.21} \text{ kJ/mol};$$

$$\Delta G_{eqHg2SO4}=G_{Hg22+}+G_{SO42-}-(G_{Hg2SO4}+2G_{H2O})=\mathbf{209.09-747.75}-(G_{Hg2SO4}+2*0)=\mathbf{55.21} \text{ kJ/mol};$$

$$G_{Hg2SO4}=G_{Hg22+}+G_{SO42-}-(\Delta G_{eqHg2SO4}+2G_{H2O})=\mathbf{209.09-747.75}-(55.21+2*0)=\mathbf{-593.87} \text{ kJ/mol};$$

$$Hg_2SO_{4(s)}+2H_2O=\mathbf{Hg_2^{2+}}+SO_4^{2-}; 2\underline{Hg}+H_2O=\mathbf{Hg_2^{2+}}+2e^-;$$

$Hg_2SO_{4(s)}+2H_2O-SO_4^{2-}=\mathbf{Hg_2^{2+}}$; $2\underline{Hg}+H_2O=\mathbf{Hg_2^{2+}}+2e^-$; $2\underline{Hg}+H_2O=Hg_2SO_{4(s)}+2H_2O-SO_4^{2-}+2e^-$;

$2\underline{Hg}+SO_4^{2-}=Hg_2SO_{4(s)}+H_2O+2e^-$; Expression of absolute potential has standard $E°_{Classic}=0.614$ V [18],

water and $\Delta E°$: $E°_{HgSO4}=E°_{Classic}-0.0591/2*lg([H_2O]^1)+\Delta E°=0.614-0.0515+0.10166-0.37239=\mathbf{0.2918}$ V;

$$\Delta G_{eq\_HgSO4}=E°_{HgSO4}•F•2=\mathbf{0.291772}*96485*2=\mathbf{56.30} \text{ kJ/mol},$$

$$\Delta G_{eq\_Hg2SO4}=G_{Hg2SO4}-(2G_{Hg}+G_{SO4})=\mathbf{-593.87}-(2*\mathbf{35.7}+G_{SO4})=\mathbf{56.30} \text{kJ/mol} ;$$

$$G_{SO4}=G_{Hg2SO4}-(2G_{Hg}+\Delta G_{eq\_Hg2SO4})=\mathbf{-593.87}-(2*\mathbf{35.7}+56.3)=\mathbf{-721.57} \text{ kJ/mol} ;$$

Formation $2H_g+O_{2\ aqua}=2HgO$; $2G_{HgO}=2\Delta G_{HgO}+(2*G_{Hg}+G_{O2})=2*-58.5+(2*35.8+330)=2*142.3$ $^{kJ}/_{mol}$;

$Hg+2OH^-=HgO+H_2O+2e^-$, Expression of absolute potential has standard $E°_{Classic}=0.098$ V [17],

water and $\Delta E°$: $E°_{HgO}=E°-0.0591/2*lg([H_2O]^1)+\Delta E°=0.098-0.0515+0.10166-0.37239=$**-0.22423** V;

$\Delta G_{eqHgO}=E°_{HgO}*F*n=$**-0.22423**$*96485*2=$**-43.27** $^{kJ}/_{mol}$;

$\Delta G_{eqHgO}=G_{HgO}+G_{H2O}-(G_{Hg}+2G_{OH})=G_{HgO}+0-(35.8+2*77.36)=$**147.25**$+0-(35.8+2*77.36)=$**-43.27** $^{kJ}/_{mol}$;

$G_{HgO}=\Delta G_{eqHgO}-G_{H2O}+(G_{Hg}+2G_{OH})=$**-43.27**$-0+(35.8+2*77.36)=$**147.25** $^{kJ}/_{mol}$;

Reduction $HgO+2H_2O+2e^-=Hg+2OH^-$, inverse standard potential $-E°_{HgO}=$**0.22423** V.

Oxidation $H_2O_{2aqua}+2H_2O=O_{2aqua}+2H_3O^++2e^-$ Nernst's absolute standard potential $E°_{RedH2O2}=0.5278$ V;

$HgO+2H_2O+2e^-+H_2O_{2aqua}+2H_2O=Hg+2OH^-+O_{2aqua}+2H_3O^++2e^-$;

$HgO+H_2O_{2aqua}+4H_2O=Hg+O_{2aqua}+(2OH^-+2H_3O^+)$; $HgO+H_2O_{2aqua}+4H_2O=Hg+O_{2aqua}+(4H_2O)$;

Summary: $HgO+H_2O_{2aqua}=Hg+O_{2aqua}$ catalase; $G_{H2O2}=$**279.285** $^{kJ}/_{mol}$;

$\Delta G_{eqRedOx\_H2O2}=(E°_{H2O2aqRed}-E°_{HgO})*F*n=(0.5278+0.22423)*96485*2=(0.7520)*96485*2=$**145.1** $^{kJ}/_{mol}$;

$\Delta G_{eqRedOx\_H2O2}=G_{Hg}+G_{O2aqua}-(G_{HgO}+G_{H2O2})=35.885+330-(-58.5+279.285)=$**145.1** $^{kJ}/_{mol}$;

HgO ; $G_{Hg}=G_{eqRedOx\_H2O2}-G_{O2aqua}+(G_{HgO}+G_{H2O2})=$**145.1**$-330+(-58.5+279.285)=$ **35.885** $^{kJ}/_{mol}$;

Substance	$\Delta H°_H$,$^{kJ}/_{mol}$	$\Delta S°_H$,$^{J}/_{mol/K}$	$\Delta G°_H$,$^{kJ}/_{mol}$	**Biochem. Thermodynamic 2006** Massachusetts Technology inst.
Pb	$E°_{Pb↓Pb2+}=$	-0,34523 V	62,024	$G_{Pb}=G_{Pb2+}-(\Delta G_{eqPb↓Pb2+}+G_{H2O})=$**-4,596**$-(-66,62+0)=$**62,024** $^{kJ}/_{mol}$;
Pb	-	64,8	-	CRC [1]
Pb^{2+}	$E°_{PbO2↓Pb2+}=$	**1,49326 V**	**-4,596**	$G_{Pb2+}=G_{PbO2}+4G_{H3O+}-(\Delta G_{eqPbO2↓Pb2+}+6G_{H2O})=$**-4,596** $^{kJ}/_{mol}$;
Pb^{2+}	0,92	18,5	-4,596	[1] $\Delta G°_{Pb2+}=\Delta H°_H-T*\Delta S°_H=0.92-298.15*0.0185=-4.596$ $^{kJ}/_{mol}$;
PbO$_2$↓	-277,4	68,6	-217,3	CRC [1]
PbO$_2$↓	$E°_{PbO2↓Pb2+}=$	**1,49326 V**	**193,794**	$G_{PbO2}=\Delta G_{eqPbO2↓Pb2+}-4G_{H3O+}+(G_{Pb2+}+6G_{H2O})=$**193,794** $^{kJ}/_{mol}$;
PbO$_2$↓	formation	**-**	**147,824**	$G_{PbO2}=\Delta G_{PbO2}+(G_{Pb}+G_{O2gas})=$**147,824** $^{kJ}/_{mol}$;
Al	-	28.3	-	CRC [1]
Al	$E°_{Al/Al3+}=$	**-1.8984** V	**108**	$G_{Al}=G_{Al3+}-(\Delta G_{eqAl/Al3+}+G_{H2O})=$**-441.5**$-(-549.5+0)=$**108** $^{kJ}/_{mol}$;
Al^{3+}	-538.4	-325	**-441.5**	$\Delta G°_{Pb2+}=\Delta H°_H-T*\Delta S°_H=-538.4-298.15*-0.325=$**-441.5** $^{kJ}/_{mol}$;
H$_2$AlO$_3^-$	$E°_{H2AlO3Al}=$	**-2.63506**	**-345.29**	$G_{H2AlO3}=\Delta G_{eqH2AlO3Al}-G_{H2O}+(G_{Al}+4G_{OH})=$**-345.29** $^{kJ}/_{mol}$;
NaAlO$_2$↓	-1133.2	70.4	-	CRC [1]

Formation $Pb+O_{2gas}=PbO_2(s)$; $G_{PbO2}=\Delta G_{PbO2}+(G_{Pb}+G_{O2gas})=-217,3+(62,024+303,1)=$ **147,824** $^{kJ}/_{mol}$;

$Pb^{2+}+6H_2O=PbO_2(s)+4H_3O^++2e^-$; Expression of absolute potential has standard $E°_{Classic}=1.455$ V [18],

water and $\Delta E°$: $E°_{PbO2}=E°_{Classic}-0.0591/2*lg(1/[H_2O]^6)+\Delta E°=1.455+0.309+0.10166-0.37239=$**1.49326 V**;

$\Delta G_{eqPbO2↓Pb2+}=E°_{PbO2↓Pb2+}•F•3=$**1.49326**$*96485*3=$**288.15** $^{kJ}/_{mol}$;

$\Delta G_{eqPbO2↓Pb2+}=G_{PbO2}+4G_{H3O+}-(G_{Pb2+}+6G_{H2O})=$**193,794**$+4*22,44-(-4,596+6*0)=$**288,15** $^{kJ}/_{mol}$;

$G_{PbO2}=\Delta G_{eqPbO2↓Pb2+}-4G_{H3O+}+(G_{Pb2+}+6G_{H2O})=$**288,15**$-4*22,44+(-4,596+6*0)=$**193,794** $^{kJ}/_{mol}$;

$G_{Pb2+}=G_{PbO2}+4G_{H3O+}-(\Delta G_{eqPbO2↓Pb2+}+6G_{H2O})=$**193,794**$+4*22,44-(288,15+6*0)=$**-4,596** $^{kJ}/_{mol}$;

$$E_{PbO2↓/Pb2+}=E°_{PbO2↓Pb2+}+\frac{0.0591}{2}•lg\frac{[PbO_2↓]·[H_3O^+]^4}{[Pb^{2+}]·[H_2O]^6}=1.49326\ V+\frac{0.0591}{2}•lg\frac{[PbO_2↓]·[H_3O^+]^4}{[Pb^{2+}]·[H_2O]^6}\ ;$$

$Pb+H_2O=Pb^{2+}+2e^-$; pH<7 Expression of absolute potential has standard $E°_{Classic}=-0.126$ V [18], water

logarithm and $\Delta E°$: $E°_{Pb/Pb2+}=E°_{Classic}-0.0591/2*lg(1/[H_2O])+\Delta E°=-1.26+0.0515+0.10166-0.37239=$**-0.3452** V;

$\Delta G_{eqPb↓Pb2+}=E°_{Pb↓Pb2+}*F*n=$**-0.34523**$*96485*2=$**-66.62** $^{kJ}/_{mol}$;

$\Delta G_{eqPb↓Pb2+}=G_{Pb2+}-(G_{Pb}+G_{H2O})=$**-4,596**$-(62,024+0)=$**-71,59**$=$**-66,62** $^{kJ}/_{mol}$;

$G_{Pb}=G_{Pb2+}-(\Delta G_{eqPb↓Pb2+}+G_{H2O})=$**-4,596**$-(-66,62+0)=$**62,024** $^{kJ}/_{mol}$;

$Al+H_2O=Al^{3+}+3e^-$; Expression of absolute potential has standard $E°_{Classic}=-1.662$ V [1], water

logarithm and $\Delta E°$: $E°_{Al/Al3+}=E°_{Classic}-0.0591/2*lg(1/[H_2O])+\Delta E°=-1.662+0.0343+0.10166-0.37239=$**-1.8984** V;

$\Delta G_{eqAl/Al3+}=E°_{Al/Al3+}•F•3=$**-1.8984**$*96485*3=$**-549.5** $^{kJ}/_{mol}$;

$\Delta G_{eqAl/Al3+}=G_{Al3+}-(G_{Al}+G_{H2O})=$**-441.5**$-(108+0)=$**-549.5** $^{kJ}/_{mol}$;

$G_{Al}=G_{Al3+}-(\Delta G_{eqAl/Al3+}+G_{H2O})=$**-441.5**$-(-549.5+0)=$**108** $^{kJ}/_{mol}$;

$Al+4OH^-=H_2AlO_3^-+H_2O+3e^-$; Expression of absolute potential has standard $E°_{Classic}=-1.662$ V [1], water

logarithm and $\Delta E°$: $E°_{H2AlO3-Al}=E°_{Classic}-0.0591/2*lg([H_2O])+\Delta E°=-2.33-0.0343+0.10166-0.37239=$**-2.63506** V;

$\Delta G_{eqH2AlO3Al}=E°_{H2AlO3Al}•F•3=$**-2.63506**$*96485*3=$**-762.73** $^{kJ}/_{mol}$;

$\Delta G_{eqH2AlO3Al}=G_{H2AlO3}+G_{H2O}-(G_{Al}+4G_{OH})=$**-345.29**$+0-(108+4*77.36)=$**-762.73** $^{kJ}/_{mol}$;

$G_{H2AlO3}=\Delta G_{eqH2AlO3Al}-G_{H2O}+(G_{Al}+4G_{OH})=$**-762.73**$-0+(108+4*77.36)=$**-345.29** $^{kJ}/_{mol}$;

$$E_{AlO2-/Al↓}=E°_{AlO2-/Al↓}+\frac{0.0591}{3}•lg\frac{[H_2AlO_3^-]·[H_2O]}{[Al]·[OH^-]^4}=-2.63506\ V+\frac{0.0591}{3}•lg\frac{[H_2AlO_3^-]·[H_2O]}{[Al]·[OH^-]^4}\ ;$$

Solubility $N_{2gas}+H_2O+\Delta G=N_{2aq}$ increases molar nitrogen energy from $G_{N2gas}=$**-9.55** $^{kJ}/_{mol}$ to $G_{N2aq}=$**18.7** $^{kJ}/_{mol}$.

Published content of Alberty dissolute nitrogen **absolute** free energy in one mol is $G_{N2aqua}=$**18.7** $^{kJ}/_{mol}$, if pure gas mol fraction is one $[N_{2gas}]=1$. [8] Hundred grams of water dissolute nitrogen gas 0.00175 $^{g}/_{100g\_H2O}$, which has density 996 g/L.[1] Solubility $[N_{2aqua}]=0.00175/100.00175*996=0.01743/28.02=0.01743=10^{-3.206}$ M and the solubility constant in mol fractions is less than one $K_{sp}=10^{\wedge(-3.206)}/[H_2O]=10^{\wedge(-3.206)}/55.3=10^{-4.949}$. Free energy change minimum in Prigogine expression for endoergic reaction is

$$\Delta G_{sp}=-R\bullet T\bullet \ln(K_{sp})=-8.3144*298.15*\ln(10^{\wedge(-4.949)})=\mathbf{28.25}\ ^{kJ}/_{mol}.$$

Hess law energy change coincides $\Delta G_{spHessN2aqua}=G_{N2aqua}-(G_{N2gas}+G_{H2O})=18.7-(-9.55+0)=\mathbf{28.25}\ ^{kJ}/_{mol}$ within absolute free energy scale. One mol $G_{N2gas}=G_{N2aqua}-(\Delta G_{spHessN2aqua}+G_{H2O})=18.7-(28.25+0)=$**-9.55** $^{kJ}/_{mol}$ contains the free energy below the zero reference for water on absolute free energy scale. One mol nitrogen absolute free energy content is positive $G_{N2aqua}=$**18.7** $^{kJ}/_{mol}$. [8]

Substance	$\Delta H°_H\ ^{kJ}/_{mol}$	$\Delta S°_H\ ^{J}/_{mol/K}$	$\Delta G°_H\ ^{kJ}/_{mol}$
N_{2gas}	$G_{N2gas}=$	form NH_3	**107.285**
N_{2aq}	**–10.54**	**98.1**	**18.7**
N_{2gas}	$N_{2gas}+H_2O=N_{2aq}$ pH=7,36		**-9.55**
NH_{3gas}	$\Delta G_{Hydration}$	**-74.5537**	**165.7**
NH_{3gas}	[1,8]	formation	**107.285**
NH_{3gas}	**–45.9**	**192.77**	**-16.4**
NH_{3aq}	**-132.5608**	**-739.2922**	**91.1056**
NH_{3aq}	$pK_{beq}=$	6.49475	**91.1**
NH_4^+	$pK_{aeq}=$	10.99	**50.81**

$G_{N2gas}=2G_{NH3gas}-(2\Delta G_{Hess\_NH3gas}+3*G_{H2gas})=\mathbf{107.285}\ ^{kJ}/_{mol}$;

$G_{N2gas}=2*\mathbf{165.6593}-(-32.8+3*\underline{\mathbf{85.64}})=\mathbf{107.285}\ ^{kJ}/_{mol}$; [1,8];

Solution N_{2aq} at pH=7.36 [8] .

$G_{N2gas}=G_{N2aqua}-(\Delta G_{Hess\_šk\_N2aqua}+G_{H2O})=\mathbf{18.7}-(\mathbf{28.25}+0)=$**-9.55** $^{kJ}/_{mol}$;

$G_{NH3gas}=\Delta G_{NH3aq}-(\Delta G_{Hydrations}+G_{H2O})=\mathbf{91.1056}-(-74.5537+0)=\mathbf{165.7}\ ^{kJ}/_{mol}$;

$2G_{NH3gas}=2\Delta G_{Hess\_NH3gas}+(G_{N2gas}+3*G_{H2gas})=2*\mathbf{107.285}\ ^{kJ}/_{mol}$;

$2G_{NH3gas}=2*-16.4+(\mathbf{-9.55}+3*\mathbf{85.64})=\mathbf{-214.57}=2*\mathbf{107.285}\ ^{kJ}/_{mol}$;

Ammonia pH=7.36 [8] **Alberty**; NH_{3aqua} formation

$G_{NH3aq}=G_{NH4+}+G_{OH}-(\Delta G_{beq}+G_{H2O})=\mathbf{91.1}\ ^{kJ}/_{mol}$; [Wikipedia](#) [28]

$G_{NH4+}=G_{NH3aq}+G_{H3O}-(\Delta G_{aeq}+G_{H2O})=\mathbf{91.1}+22.44-62.73-0=\mathbf{50.81}\ ^{kJ}/_{mol}$;

Formation from aqua elements $N_{2aq}+3H_{2aq}>2NH_{3aq}$ with absolute energy $G_{N2aq}=$**18.7** $^{kJ}/_{mol}$; $G_{H2aq}=$**103.24** $^{kJ}/_{mol}$ is exoergic reaction $2\Delta G_{Hess\_NH3aq}=2G_{NH3aq}-(G_{N2aq}+3*G_{H2aq})=2*\mathbf{91.1056}-(\mathbf{18.7}+3*\mathbf{103.24})=2*\mathbf{-73.1}\ ^{kJ}/_{mol}$. [8]

Formation $N_{2gas}+3H_{2gas}>2NH_{3gas}$ from elements energies $G_{N2gas}=$**-9.55** $^{kJ}/_{mol}$; $G_{H2gas}=$**85.64** $^{kJ}/_{mol}$ shows negative exoergic $2\Delta G_{Hess\_NH3gas}=2G_{NH3gas}-(G_{N2gas}+3*G_{H2gas})=2G_{NH3gas}-(\mathbf{-9.55}+3*\mathbf{85.64})=2*-16.4=-32.8\ ^{kJ}/_{mol}$ [1].

Two mols NH_{3gas} has energy content positive $G_{NH3gas}=$**107.285** $^{kJ}/_{mol}$

$$2G_{NH3gas}=2\Delta G_{Hess\_NH3gas}+(G_{N2gas}+3*G_{H2gas})=2*-16.4+(\mathbf{-9.55}+3*\mathbf{85.64})=\mathbf{-214.57}=2*\mathbf{107.285}\ ^{kJ}/_{mol}.$$

The gas solubility members $NH_{3gas}+H_2O=NH_{3aq}$ have energy values $G_{NH3aq}=$**91.1** $^{kJ}/_{mol}$, $G_{NH3gas}=$**107.3** $^{kJ}/_{mol}$.

The expression for the classical ammonia protolytic base $NH_{3aq}+H_2O=NH_4^++OH^-$ constant without accounting for water is $K_b=[NH_4^+]*[OH^-]/[NH_{3aq}]=10^{\wedge(-4.752)}$ with the exponent value $pK_b=4.752$. [1] The classical base constant is derived from the protolysis equilibrium constant with accounting for water in the reactants as $K_{beq}=K_b/[H_2O]=10^{\wedge(-4,752)}/55.3=3.20*10^{\wedge(-7)}=10^{\wedge(-6.4947)}$. The calculated value of the exponent of the equilibrium constant of ammonia protolysis is $pK_{beq}=6.4947$ endoergic, since the change in absolute free energy in the Prigogine expression and the Hess expression is positive and identical:

$$\Delta G_{beq}=-R\bullet T\bullet \ln(K_{beq})=-8.3144*298.15*\ln(10^{\wedge(-6.4947)})=G_{NH4+}+G_{OH}-(G_{NH3aq}+G_{H2O})=37.064\ ^{kJ}/_{mol}\ ;$$

$$\Delta G_{Hess\_beq}=G_{NH4+}+G_{OH}-(G_{NH3aq}+G_{H2O})=\mathbf{50.81}+77.36-(\mathbf{91.1056}+0)=37.064\ ^{kJ}/_{mol}\ .$$

The free energy content of a solution of one mole of ammonia in water is $G_{NH3aq}=$**91.1** $^{kJ}/_{mol}$

$$G_{NH3aq}=G_{NH4+}+G_{OH}-(\Delta G_{Hess\_beq}+G_{H2O})=\mathbf{50.81}+77.36-(37.07+\mathbf{0})=\mathbf{91.1}\ ^{kJ}/_{mol}\ .$$

Endoergic ammonia protolysis accumulates energy in the products $G_{NH4+}+G_{OH-}=$**50.81**+77.36=**128.17** $^{kJ}/_{mol}$.

The protolysis of the weak acid $G_{NH4+}=$**50.81** $^{kJ}/_{mol}$ $NH_4^++H_2O=NH_{3aq}+H_3O^+$ $pK_{eq}=10.99$ shows an endoergic energy change $\Delta G_{aeq}=-R\bullet T\bullet \ln(K_{aeq})=-8.3144*298.15*\ln(10^{\wedge(-10.99)})=G_{NH3Hydration}+G_{H3O}-G_{NH4+}-G_{H2O}=62.73\ ^{kJ}/_{mol}$. The free energy content of ammonium per mole is

$$G_{NH4+}=G_{NH3aq}+G_{H3O}-(\Delta G_{aeq}+G_{H2O})=\mathbf{91.1}+22.44-(62.73+0)=\mathbf{50.81}\ ^{kJ}/_{mol}\ .$$

Solubility $NH_{3gas}+H_2O=NH_{3aq}$; $G_{NH3aq}=$**91.1** $^{kJ}/_{mol}$; Ammonia at pH=7.36 [8]

$\Delta H_{Hydration}=\Delta H°_{NH3aq}-\Delta H°_{NH3gas}-\Delta H°_{H2O}=$**-132.5608**+45.94-**286.65**=373.3 $^{kJ}/_{mol}$;

$S_{Hydration}=\Delta S°_{NH3aqua}-\Delta S°_{NH3gas}-\Delta S°_{H2O}=$**-739.2922**-192.77-69.9565=**-1002** $^{J}/_{mol/K}$;

$\Delta G_{Hydrations}=\Delta H_{Hydrations}-T*\Delta S_{Hydration}=$**-373.3-298.15*-1.002=-74.5537** $^{kJ}/_{mol}$;

$K_{sp}=exp(-\Delta G_{Hydration}/R/T)=exp(74553.7/8.3144/298.15)=10^{13.06}$;

Alberty solutions for ammonia at pH=7.36 $G_{NH3aq}=$**91.1056** $^{kJ}/_{mol}$ and Hess hydration with change in energy $\Delta G_{Hydrations}=$**-74.5537** $^{kJ}/_{mol}$ calculate the absolute energy content of the gas NH_{3gas} coincidently as follows:

$G_{NH3gas}=G_{NH3aq}-(\Delta G_{Hydration}+G_{H2O})=\mathbf{91.1056}-(\mathbf{-74.5537}+0)=\mathbf{165.7}\ ^{kJ}/_{mol}$; and

$G_{NH3gas}=(2\Delta G_{Hess\_NH3gas}+(G_{N2gas}+3*G_{H2gas}))/2=(-32.8+(\mathbf{107.2}+3*\underline{\mathbf{85.64}}))/2=\mathbf{165.7}\ ^{kJ}/_{mol}$; [1,8] CRC, Alberty

Ammonium free energy content is $G_{NH4+}=G_{NH3aq}+G_{H3O}-(\Delta G_{eq}+G_{H2O})=\mathbf{91.1}+22.44-62.73-\mathbf{0}=\mathbf{50.81}\ ^{kJ}/_{mol}$.

Protolysis classic acid constant is $NH_4^+=H^++NH_{3aqua}$ $pK_a=9.25$;

Formation from elements HNO₂ $\Delta G°_{HNO2}$=-46 $^{kJ}/_{mol}$ and HNO₃ $\Delta G°_{HNO3}$=-250.53 $^{kJ}/_{mol}$:

Formation $G_{HNO3Form}=\Delta G°_{HNO3}+(0,5G_{N2gas}+\mathbf{1,5G_{O2gas}}+0,5G_{H2gas})$=-250,53+(0,5*-9,55+1,5*$\mathbf{303}$)=$\mathbf{199,195}$ $^{kJ}/_{mol}$

$G_{HNO2}=\Delta G°_{HNO2}+0.5N_{2gas}+O_{2gas}+0.5H_{2gas}$=-46+(0.5*$\mathbf{-9.55}$+303+0.5*$\mathbf{85.6}$)=$\mathbf{295.025}$ $^{kJ}/_{mol}$;

$G_{N2gas}=G_{N2aqua}-(\Delta G_{Hess\_šk\_N2aqua}+G_{H2O})$=18.7-(28.25+0)=$\mathbf{-9.55}$ $^{kJ}/_{mol}$; $G_{H2gas}=\mathbf{85.6}$ $^{kJ}/_{mol}$ [8]; $G_{O2gas}=\mathbf{303}$ $^{kJ}/_{mol}$;

$G_{NO2-Form}=\Delta G°_{NO2-}+0,5G_{N2gas}+G_{O2gas}=\mathbf{-33,01}+0,5*-9,55+1*\mathbf{303}=\mathbf{265,2}$ $^{kJ}/_{mol}$;

$G_{NO2-Form}=\Delta G°_{NO2-}+0,5G_{N2aq}+G_{O2aq}=\mathbf{-33,01}+0,5*18,7+1*\mathbf{330}+0=\mathbf{306,34}$ $^{kJ}/_{mol}$;

Acid and protolysis equilibrium constant $K_{eq}=K_a/[H_2O]$ calculate dividing the acid constant by water [H₂O].

1. $HNO_2+H_2O=NO_2^-+H_3O^+$;pKa=3.15; $K_{eq}=K_a/[\mathbf{H_2O}]=10^{\wedge(-3.15)}/55.3$= 0.00001280;

$\Delta G_{eqHNO2}=-R•T•ln(K_{eq})$=-8.3144*298.15*ln(0.0000128)=$G_{NO2-}+G_{H3O}-(G_{HNO2}+G_{H2O})$=$\mathbf{27.927}$ $^{kJ}/_{mol}$;

$\Delta G_{eqHNO2}=G_{NO2-}+G_{H3O}-(G_{HNO2}+G_{H2O})$=$\mathbf{82,618}$+$\mathbf{22,44}$-($\mathbf{77,131}$+0)=$\mathbf{27,927}$ $^{kJ}/_{mol}$;

$G_{NO2-}=\Delta G_{eqHNO2}-G_{H3O}+(G_{HNO2}+G_{H2O})$=$\mathbf{27,927}$-$\mathbf{22,44}$+($\mathbf{77,131}$+0)=$\mathbf{82,618}$ $^{kJ}/_{mol}$;

$G_{HNO2}=G_{NO2-}+G_{H3O}-(\Delta G_{eqHNO2}+G_{H2O})$=$\mathbf{82,618}$+$\mathbf{22,44}$-($\mathbf{27,927}$+0)=$\mathbf{77,131}$ $^{kJ}/_{mol}$;

2. $HNO_3+H_2O=NO_3^-+H_3O^+$;pKa=-1.4; $K_{eq}=K_a/[\mathbf{H_2O}]=10^{\wedge(1.4)}/55.3$=0.4542;

$\Delta G_{eqHNO3}=-R•T•ln(K_{eq})$=-8.3144*298.15*ln(0.4542)=$G_{NO3-}+G_{H3O}-(G_{HNO3}+G_{H2O})$=$\mathbf{1.956}$ $^{kJ}/_{mol}$;

$\Delta G_{eqHNO3}=G_{NO3-}+G_{H3O}-(G_{HNO3}+G_{H2O})$=$\mathbf{340.2}$+$\mathbf{22.44}$-($\mathbf{360.684}$+0)=$\mathbf{1.956}$ $^{kJ}/_{mol}$;

$G_{HNO3}=G_{NO3-}+G_{H3O}-(\Delta G_{eqHNO3}+G_{H2O})$=$\mathbf{340.2}$+$\mathbf{22.44}$-($\mathbf{1.956}$+0)=$\mathbf{360.7}$ $^{kJ}/_{mol}$;

$G_{NO3-}=\Delta G_{eqHNO3}-G_{H3O}+(G_{HNO3}+G_{H2O})$=$\mathbf{1.956}$-$\mathbf{22.44}$+($\mathbf{199.195}$+0)=$\mathbf{340.2}$ $^{kJ}/_{mol}$;

Substance	$\Delta H°_H$ $^{kJ}/_{mol}$	$\Delta S°_H$ $^{J}/_{mol/K}$	$\Delta G°_H$, $^{kJ}/_{mol}$	
HNO₂	$E°_{NO3-H3O+}$ =$\mathbf{0.8753}$ V		$\mathbf{77,131}$	$G_{HNO2}=G_{NO3-}+3G_{H3O}-(\Delta G_{eqNO3}+4G_{H2O})=\mathbf{77,131}$ $^{kJ}/_{mol}$;
HNO₂	-	pKa=3,15	$\mathbf{238,42}$	$G_{HNO2}=G_{NO2-}-G_{H3O}+(\Delta G_{eqHNO2}+G_{H2O})=\mathbf{238,42}$ $^{kJ}/_{mol}$;
HNO₂	-79.5	254,1	-46,0	CRC [1]
HNO₂	-	formation	$\mathbf{295,025}$	$G_{HNO2gas}=\Delta G°_{HNO2gas}+0,5N_{2gas}+O_{2gas}+0,5H_{2gas}=\mathbf{295,025}$ $^{kJ}/_{mol}$
pH=7,36 NO₂⁻	$\mathbf{-104.19}$	$\mathbf{-238,7}$	$\mathbf{-33,01}$	**Biochem.Thermodynamic 2006** Massachusetts Technology Inst.
NO₂⁻	$0,5G_{N2gas}+$	G_{O2gas}	$\mathbf{265,2}$	$G_{NO2-form}=\Delta G°_{NO2aq}+0,5G_{N2gas}+G_{O2gas}=\mathbf{265,2}$ $^{kJ}/_{mol}$;
NO₂⁻	$0,5G_{N2aq}+$	G_{O2aq}	$\mathbf{306,34}$	$G_{NO2-Form}=\Delta G°_{NO2-}+0,5G_{N2aq}+G_{O2aq}=\mathbf{306,34}$ $^{kJ}/_{mol}$;
NO₂⁻	$E°_{NO3-OH}$	$\mathbf{-0.3122}$ V	$\mathbf{84,236}$	$G_{NO2-}=G_{NO3-}+G_{H2O}-(\Delta G_{eqNO3-OH}+2G_{OH})=\mathbf{84,236}$ $^{kJ}/_{mol}$;
NO₂⁻	$E°_{NO2=}$	$\mathbf{0,7188}$ V	$\mathbf{84,446}$	$G_{NO2-}=G_{NO3-}+3G_{H3O}-(\Delta G_{eqNO2-}+3G_{H2O})=\mathbf{84,446}$ $^{kJ}/_{mol}$,
NO₂⁻		pKa=3,15	$\mathbf{82,618}$	$G_{NO2-}=\Delta G_{eqHNO2}-G_{H3O}+(G_{HNO2}+G_{H2O})=\mathbf{82,618}$ $^{kJ}/_{mol}$;
HNO₃	-207	146	-250,53	[1] $G°_{NO3-}=\Delta H_H-T*\Delta S_H$=-207-298,15*0,146=$\mathbf{-250,5886}$ $^{kJ}/_{mol}$; [1]
HNO₃	-	formation	$\mathbf{199,195}$	$G_{HNO3Form}=\Delta G°_{HNO3}+(0.5G_{N2gas}+\mathbf{1.5G_{O2gas}}+0.5G_{H2gas})=\mathbf{199.195}$ $^{kJ}/_{mol}$;
HNO₃	-	pKa=-1.4	$\mathbf{199,195}$	$G_{HNO3}=G_{NO3-}+G_{H3O}-(\Delta G_{eqHNO3}+G_{H2O})=\mathbf{199,195}$ $^{kJ}/_{mol}$;
pH=7,36 NO₃⁻	$\mathbf{-204.59}$	$\mathbf{-318.8}$	$\mathbf{-109.55}$	**Biochem.Thermodynamic 2006** Massachusetts Technology Inst.
NO₃⁻	$E°_{NO3-H3O+}$ =$\mathbf{0.8753}$ V		$\mathbf{178,711}$	$G_{NO3-}=\Delta G_{eqNO3}-3G_{H3O}+(G_{HNO2}+4G_{H2O})=\mathbf{178,711}$ $^{kJ}/_{mol}$,
NO₃⁻	$E°_{NO2=}$	$\mathbf{0,7188}$ V	$\mathbf{155,83}$	$G_{NO3-}=\Delta G_{eqNO2-}-3G_{H3O}+(G_{NO2-}+3G_{H2O})=\mathbf{155,833}$ $^{kJ}/_{mol}$,
NO₃⁻	$E°_{NH4+H2O}=$ $\mathbf{0.7677}$ V		$\mathbf{601.06}$	$G_{NO3-}=\Delta G_{eqNH4+H2O}-10G_{H3O}+(G_{NH4-}-13G_{H2O})=\mathbf{601.06}$ $^{kJ}/_{mol}$;
NO₃⁻	-206.85	146.7	-250.5886	$\Delta G°_{NO3-}=\Delta H_H-T*\Delta S_H$=-206.85-298.15*0.1467=$\mathbf{-250.5886}$ $^{kJ}/_{mol}$; [1]
NO₃⁻	-	pKa=-1.4	$\mathbf{340.2}$	$G_{NO3-}=\Delta G_{eqHNO3}-G_{H3O}+(G_{HNO3}+G_{H2O})=\mathbf{340.2}$ $^{kJ}/_{mol}$;
NO₃⁻	$E°_{NO3-OH}$	$\mathbf{-0,3122}$ V	$\mathbf{178,711}$	$G_{NO3-}=\Delta G_{eqNO3-OH}-G_{H2O}+(G_{NO2-}+2G_{OH})=\mathbf{178,711}$ $^{kJ}/_{mol}$,
NO gas	91.3	210.8	87.6	CRC [1]
NO gas	Solubility	product -	$\mathbf{61.024}$	$G_{NOgas}=G_{NOaq}-(G_{H2O}+\Delta G_{sp})=\mathbf{86.55}-(\mathbf{0}+25.526)=\mathbf{61.024}$ $^{kJ}/_{mol}$;
NO aq	-	pH=7,36	$\mathbf{86.55}$	**Biochem.Thermodynamic 2006** Massachusetts Technology Inst.
NO aq	$E°_{NO(g)H3O+}$ =$\mathbf{0.8266}$		$\mathbf{49,695}$	$G_{NOaq}=G_{HNO3}+4G_{H3O}-(\Delta G_{eqNO(g)H3O+}+5G_{H2O})=\mathbf{49,695}$ $^{kJ}/_{mol}$,

Nernst's potential NO₃⁻ / NO₂⁻ red-ox system behaving in acidic H₃O⁺ water and basic OH⁻ medium

$HNO_2+4H_2O=NO_3^-+3H_3O^++\mathbf{2e^-}$; pH<3.15; Expression of potential has standard $E°_{Classic}$=0.94 V [18], water logarithm and $\Delta E°$: $E°_{NO3-H3O+}=E°_{Classic}-0.0591/2*lg(1/[H_2O]^4)+\Delta E°$=0.94+0.206+0.10166-0.37239 =$\mathbf{0.8753}$ V;

$$E_{NO3-H3O+}=E°_{NO3-H3O+}+\frac{0.0591}{2}•log\frac{[\mathbf{NO_3^-}]·[\mathbf{H_3O^+}]^3}{[\mathbf{HNO_2}]·[\mathbf{H_2O}]^4}=\mathbf{0.8753}\text{ V}+\frac{0.0591}{2}•log\frac{[\mathbf{NO_3^-}]·[\mathbf{H_3O^+}]^3}{[\mathbf{HNO_2}]·[\mathbf{H_2O}]^4}$$

$\Delta G_{eqNO3}=E°_{NO3}•F•2=\mathbf{0.8753}*96485*2=\mathbf{168.9}$ $^{kJ}/_{mol}$;

$\Delta G_{eqNO3}=G_{NO3-}+3G_{H3O}-(G_{HNO2}+4G_{H2O})=\mathbf{178,711}+3*22,44-(\mathbf{77,131}+4*0)=\mathbf{168,9}$ $^{kJ}/_{mol}$,

$G_{HNO2}=G_{NO3-}+3G_{H3O}-(\Delta G_{eqNO3}+4G_{H2O})=\mathbf{178,711}+3*22,44-(\mathbf{168,9}+4*0)=\mathbf{77,131}$ $^{kJ}/_{mol}$;

$G_{NO3-}=\Delta G_{eqNO3}-3G_{H3O}+(G_{HNO2}+4G_{H2O})=\mathbf{168,9}-3*22,44+(\mathbf{77,131}+4*0)=\mathbf{178,711}$ $^{kJ}/_{mol}$,

$NO_2^- + 2OH^- = NO_3^- + H_2O + \mathbf{2e^-}$; pH>7; Expression of potential has standard $E°_{Classic}$=0.01 V [17], H_2O water logarithm and $\Delta E°$: $E°_{NO3-OH}$=$E°_{Classic}$-0.0591/2*lg([H_2O])+$\Delta E°$=0.01-0.0515+0.10166-0.37239 =**-0.3122** V;

$$E_{NO3-OH}=E°_{NO3-OH}+\frac{0.0591}{2}\bullet\log\frac{[NO_3^-]\cdot[H_2O]}{[NO_2^-]\cdot[OH^-]^2}=\textbf{-0.3122} \text{ V}+\frac{0.0591}{2}\bullet\log\frac{[NO_3^-]\cdot[H_2O]}{[NO_2^-]\cdot[OH^-]^2}$$

$\Delta G_{eqNO3-OH}$=$E°_{NO3-OH}\bullet F\bullet 2$=**-0.3122***96485*2=**-60.245** $^{kJ}/_{mol}$;
$\Delta G_{eqNO3-OH}$=G_{NO3-}+$\mathbf{G_{H2O}}$-(G_{NO2-}+2G_{OH})=**178,711**+0-(**84,446**+2*77,36)=**-60,245** $^{kJ}/_{mol}$,
G_{NO3-}=$\Delta G_{eqNO3-OH}$ -$\mathbf{G_{H2O}}$+(G_{NO2-}+2G_{OH})=**-60,2455**-0+(**84,446**+2*77,36)=**178,711** $^{kJ}/_{mol}$,
G_{NO2-}= G_{NO3-}+$\mathbf{G_{H2O}}$-($\Delta G_{eqNO3-OH}$+2G_{OH})=**178,711**+0-(**-60,245**+2*77,36)=**84,446** $^{kJ}/_{mol}$;

$NO_2^- + 3H_2O = NO_3^- + 2H_3O^+ + \mathbf{2e^-}$; pH>3.51 Expression of absolute potential has standard $E°_{Classic}$=0.835 V [21], water logarithm and $\Delta E°$: $E°_{NO2-}$=$E°$-0.0591/2*lg(1/[H_2O]^3)+$\Delta E°$=0.835+0,1545+0.10166-0.371339=**0.7188** V
ΔG_{eqNO2-}=$E°_{NO2-}\bullet F\bullet 2$=**0,7188***96485*2=**138,707** $^{kJ}/_{mol}$,
ΔG_{eqNO2-}=G_{NO3-}+3$\mathbf{G_{H3O}}$-(G_{NO2-}+3G_{H2O})=**155,833**+3*22,44-(**84,446**+3*0)=**138,707** $^{kJ}/_{mol}$,
G_{NO3-}=ΔG_{eqNO2-}-3$\mathbf{G_{H3O}}$+(G_{NO2-}+3G_{H2O})=**138,707**-3*22,44+(**84,446**+3*0)=**155,833** $^{kJ}/_{mol}$,
G_{NO2-}=G_{NO3-}+3$\mathbf{G_{H3O}}$-(ΔG_{eqNO2-}+3G_{H2O})=**155,833**+3*22,44-(**138,707**+3*0)=**84,446** $^{kJ}/_{mol}$,

Molarity M_{NO}=30.006 $^g/_{mol}$; solubility $NO^{(g)}$ 0.00562 $^g/_{99.6g}$ 20 C ; w%=0.0056/(0.00562+99.6)*100=0.00562%; product [NO_{aq}]=(0.00562/100*996)/30.006=0.001865 M, if pure gas mol fraction is one [$NO^{(g)}$]=1; Equilibrium NO_{gas}+H_2O=NO_{aq} constant is $\mathbf{K_{eq}}$=[NO_{aq}]/[$NO^{(g)}$]/[H_2O]=0.001865/1/55.3=10^(-4.472).

Equilibrium standard is $\Delta \mathbf{G_{eq}}$=**-R$\bullet$T$\bullet$ln(K$_{eq}$)**=-8.3144*298.15*ln(10^(-4.472))=-8.3144$\bullet$298.15$\bullet$-10.297=**25.526** $^{kJ}/_{mol}$;

Equilibrium Hess expression for standard is ΔG_{eq}=G_{NOaq}-(G_{H2O}+G_{NOgas})=**86.55**-(**0**+G_{NOgas})=**25.526** $^{kJ}/_{mol}$;

G_{NOgas}=G_{NOaq}-(G_{H2O}+ΔG_{eq})=**86.55**-(**0**+25.526)=**61.024** $^{kJ}/_{mol}$, if equilibrium minimum is ΔG_{eq}=**25.526** $^{kJ}/_{mol}$;

Solubility of gas NO_{gas} compensate water molecule from 6H_2O to 5H_2O and from 5H_2O to 4H_2O:

NO_{aq}+5H_2O=NO_3^-+4H_3O^++$\mathbf{3e^-}$; pH>1,4; Expression of potential has standard $E°_{Classic}$=0.96 V [18], water logarithm , $\Delta E°$: $E°_{NO(g)H3O+}$=$E°_{Classic}$-0.0591/3*lg(1/[H_2O]^5)+$\Delta E°$=0.96+0.1717+0.10166-0.37239=**0.8609** V;

$$E_{NO(g)H3O+}=E°_{NO(g)H3O+}+0.0591/3\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^4}{[NO_{aq}]\cdot[H_2O]^5}=\textbf{0.8609} \text{ V}+0.0197\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^4}{[NO_{aq}]\cdot[H_2O]^5}$$

$\Delta G_{eqNO(g)H3O+}$=$E°_{NO(g)H3O+}\bullet F\bullet 3$=**0,86093***96485*3=**249,20** $^{kJ}/_{mol}$,
$\Delta G_{eqNO(g)H3O+}$=G_{NO3-}+4$\mathbf{G_{H3O}}$-(G_{NOaq}+5G_{H2O})=**178,711**+4*22,44-(**19,271**+5*0)=**249,20** $^{kJ}/_{mol}$,
G_{NOaq}=G_{NO3-}+4$\mathbf{G_{H3O}}$-($\Delta G_{eqNO(g)H3O+}$+5G_{H2O})=**178,711**+4*22,44-(**249,20**+5*0)=**19,271** $^{kJ}/_{mol}$,

NO_{aq}+4H_2O=HNO_3^-+3H_3O^++$\mathbf{3e^-}$; pH<1,4 15 Expression of potential has standard $E°_{Classic}$=0,96 V [18], water logarithm and $\Delta E°$: $E°_{NO(g)H3O+}$=$E°_{Classic}$-0,0591/3*lg(1/[H_2O]^4)+$\Delta E°$=0,96+0,1373+0,10166-0,37239=**0,8266** V;

$$E_{NO(g)H3O+}=E°_{NO(g)H3O+}+0,0591/3\bullet\log\frac{[HNO_3^-]\cdot[H_3O^+]^3}{[NO_{aq}]\cdot[H_2O]^4}=\textbf{0,8266} \text{ V}+0,0197\bullet\log\frac{[HNO_3^-]\cdot[H_3O^+]^3}{[NO_{aq}]\cdot[H_2O]^4}$$

$\Delta G_{eqNO(g)H3O+}$=$E°_{NO(g)H3O+}\bullet F\bullet 3$=**0,8266***96485*3=**239,26** $^{kJ}/_{mol}$,
$\Delta G_{eqNO(g)H3O+}$=G_{HNO3}+4$\mathbf{G_{H3O}}$-(G_{NOaq}+5G_{H2O})=**199,195**+4*22,44-(**49,695**+5*0)=**239,26** $^{kJ}/_{mol}$,
G_{NOaq}=G_{HNO3}+4$\mathbf{G_{H3O}}$-($\Delta G_{eqNO(g)H3O+}$+5G_{H2O})=**199,195**+4*22,44-(**239,26**+5*0)=**49,695** $^{kJ}/_{mol}$,

NH_{3gas}+H_2O=NH_{3aq} brīvā enerģija G_{NH3aq}=91,1 $^{kJ}/_{mol}$; NH_{3aq}+H_2O=NH_4^++OH^- ;
NH_4^++13H_2O+OH^-=NO_3^-+10H_3O^++OH^-+$\mathbf{8e^-}$; H_3O^++OH^-=2H_2O**;**
NH_4^++11H_2O+OH^-=NO_3^-+9H_3O^++$\mathbf{8e^-}$; H_3O^++OH^-=2H_2O;

NH_4^++13H_2O=NO_3^-+10H_3O^++$\mathbf{8e^-}$; pH>3.15 Expression of potential has standard $E°_{Classic}$=0.87 V [17], water logarithm and $\Delta E°$: $E°_{NH4+H2O}$=$E°_{Classic}$-0.0591/8*lg(1/[H_2O]^{13})+$\Delta E°$=0.87+0.16737+0.10166 -0.371339 =**0.7667** V;

$$E_{NH4+H2O}=E°_{NH4+H2O}+0.0591/8\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^{10}}{[NH_4^+]\cdot[H_2O]^{13}}=\textbf{0.7666879} \text{ V }+0.00739\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^{10}}{[NH_4^+]\cdot[H_2O]^{13}}$$

$\Delta G_{eqNH4+H2O}$=$E°_{NH4+H2O}\bullet F\bullet 8$=**0.7666879***96485*8=**592.56** $^{kJ}/_{mol}$,
$\Delta G_{eqNH4+H2O}$=G_{NO3-}+10G_{H3O}-(G_{NH4+}-13G_{H2O})=**601.06**+10*22.44-(**232.9**-13*0)=**592.56** $^{kJ}/_{mol}$,
G_{NO3-}=$\Delta G_{eqNH4+H2O}$-10G_{H3O}+(G_{NH4+}-13G_{H2O})=**592.56**-10*22.44+(**232.9**-13*0)=**601.06** $^{kJ}/_{mol}$;

Nernst's potential studies $\underline{5(Pt)H}$ + MnO_4^- on hydroxonium H_3O^+ and water H_2O account

Inverse Nernst's standard potential: $MnO_4^- + 8H_3O^+ + 5e^- = Mn^{2+} + 12H_2O$; $-E°_{Mn2+/MnO4-} = -1.4865$ V.

Twelve water molecules account $[H_2O] = 55.3$ M $= (996\ ^g/_L)/(18\ ^g/_{mol})$ increase potential to:

$E°_{Mn2+/MnO4-} = E° - 0.0591/5 \cdot \log(1/[H_2O]^{12}) = 1.51 - 0.0591/5 \cdot \log(1/55.3^{12}) + 0.10166 - 0.37239 = 1.4865$ V.

Concentration $[H_2O]^{12}$ exponent 12 included in classic standard potential $E_o = 1.51$ V as logarithm.

Reductant oxidation Nernst's: $\underline{5(Pt)H} + 5H_2O = 5H_3O^+ + 5e^-$; absolute standard potential $E°_H = -0.27073$ V.

$E_{MnO4} = -1.4865$ V $+ 0.0591/5 \cdot \log([H_2O]^{12} \cdot [Mn^{2+}]/[MnO_4^-]/[H_3O^+]^8) =$;

$E_H = E°_H + 0.0591 \cdot \log([H_3O^+]/[H_2O]) = -0.27073$ V $+ 0.0591 \cdot \log([H_3O^+]/[H_2O])$;

Electrons balancing $+ne^- = 5e^- = -ne^-$ summary Red-Ox reaction: $MnO_4^- + 3H_3O^+ + \underline{5(Pt)H} = Mn^{2+} + 7H_2O$;

$\Delta G_{HessPt)H} = \Delta G°_{Mn2} + 7\Delta G°_{H2O} - (\Delta G°_{MnO4} + 3\Delta G°_{H3O} + 5G_{(Pt)H}) = -228.1 + 7 \cdot -237.191 - (3 \cdot -213.2746 - 447.2 + 5 \cdot \mathbf{48.56}) = -1044.21\ ^{kJ}/_{mol}$;

$\Delta G_{HessCRC} = \Delta G°_{Mn2} + 7\Delta G°_{H2O} - (\Delta G°_{MnO4} + 3\Delta G°_{H3O} + 5/2\Delta G°_{H2}) = -228.1 + 7 \cdot -237.191 - (3 \cdot -213.2746 - 447.2 + 5 \cdot 99.13/2) = -1049\ ^{kJ}/_{mol}$;

$\Delta G_{Alberty} = \Delta G°_{Mn2} + 7\Delta G°_{H2O} - (\Delta G°_{MnO4} + 3\Delta G°_{H3O} + 5/2G_{H2}) = -228.1 + 7 \cdot -237.191 - (3 \cdot -213.2746 - 447.2 + 5 \cdot \mathbf{103.24}/2) = -1059.5\ ^{kJ}/_{mol}$;

Substan	$\Delta H°_H, ^{kJ}/_{mol}$	$\Delta S°_H, ^J/_{mol/K}$	$\Delta G°_H, ^{kJ}/_{mol}$	
H_2O	-285.85	69.9565	-237.191	CRC Handbook of Chemistry.and Physics, 2010. D.Lide [1]
H_2O	**-286.65**	**-453.188**	**-151.549**	Biochem.Thermodyn., Massachusetts Technology Inst.[8] pH=7,36
H_3O^+	-285.81	-3.854	-213.2746	$\Delta G°\ _{H3O+}, ^{kJ}/_{mol}$ Mischenko 1972, Himia, Leningrad [26]
$H_{2(aq)}$	23.4	-130	99.13	CRC [1]
$H_{2(aq)}$	**-5.02**	**-363.92**	**103.24**	Biochem.Thermodyn., Massachusetts Technology Inst.[8] pH=7,36
$H(Pt)_{(aq)}$	-	-	**48.56**	$\Delta G_{eq} = \mathbf{-847.7}\ ^{kJ}/_{mol}$; $\Delta G_{Hess\mathbf{OxRed}} = -1044.2\ ^{kJ}/_{mol}$
MnO_4^-	-541.4	-191.2	-447.2	CRC [1]
Mn^{2+}	–220.8	-73.6	-228.1	$\|\Delta G_{eq} = -847.7\ ^{kJ}/_{mol}\| < \|\Delta G_{Hess} = -1044.2\ ^{kJ}/_{mol}\|$;
O_{2aqua}	**-11.7**	**-94.2**	**16.4**	Biochem.Thermodyn., Massachusetts Technology Inst.[8] pH=7,36

$\Delta G_{eqH/MnO4} = (E°_H - E°_{MnO4-}) \cdot F \cdot 1 \cdot 5 = (-0.27073 - 1.4865) \cdot 96485 \cdot 5 = \mathbf{-1.757} \cdot 96485 \cdot 5 = \mathbf{-847.7}\ ^{kJ}/_{mol}$.

$K_{eq} = \mathbf{exp(-\Delta G_{eq\ H/MnO4}/R/T)} = \exp(847732/8.3144/298.15) = \exp(341.96) = 10^{148.5}$;

Exothermic and exoergic MnO_4^- reduction by $\underline{5(Pt)H}$ Hess free energy change negative $\Delta G_{Hess} = \Delta G_{OxRed} = \mathbf{-1043.7}\ ^{kJ}/_{mol}$, but minimizes $\Delta G_{min} = \Delta G_{eqOxRed} = \mathbf{-847.7}\ ^{kJ}/_{mol}$ reaching

equilibrium mixture $10^{148.5} = \mathbf{K_{eq}} = \dfrac{[H_2O]^7 \cdot [Mn^{2+}]}{[(Pt)H]^5 [MnO_4^-] \cdot [H_3O^+]^3}$;

-1044.2 $^{kJ}/_{mol}$; $\Delta G < 0$ | Hess ; $\Delta G_{min} = \mathbf{-847.7}\ ^{kJ}/_{mol}$

5A+B+3C 50% D+8E

reactants $\underline{5(Pt)H} + MnO_4^- + 3H_3O^+$

products $Mn^{2+} + 7H_2O$

Prigogine attractor is free energy change minimum ΔG_{min} reaching. Free energy change minimum reaching establishes equilibrium. Equilibrium state is attractor for all infinite non-equilibrium states.
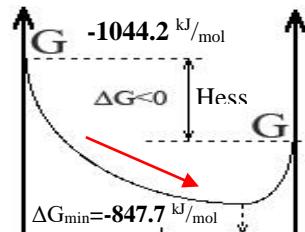
$\underline{MnO_2} + 4OH^- = MnO_4^- + 2H_2O + \mathbf{3e^-}$; Reductant Nernst's absolute standard potential: $E°_{MnO2/MnO4-} = \mathbf{0.26465}$ V,

$E°_{MnO2/MnO4-} = E° - 0.0591/3 \cdot \log([H_2O]^2) + 0.10166 - 0.37239 = 0.603 - 0.0591/3 \cdot \log(55.3^2) + 0.10166 - 0.37239 = \mathbf{0.26465}$ V ;

$MnO_4^{2-} = MnO_4^- + \mathbf{e^-}$; Reductant Nernst's absolute standard potential: $E°_{MnO2/MnO4-} = \mathbf{0.2883}$ V ;

$E°_{MnO4/MnO4-} = E° - 0.0591/3 \cdot \log([H_2O]^0) + 0.10166 - 0.37239 = 0.558 - 0.0591/3 \cdot \log(55.3^0) + 0.10166 - 0.37239 = \mathbf{0.2883}$ V ;

2) Carbonic anhydrase CA generate free energy from zero $G_{CO2+2H2O} = 0\ ^{kJ}/_{mol}$ to $G_{H3O+HCO3-} = 78.52\ ^{kJ}/_{mol}$.

Solubility in water creates free energy from zero level $CO_{2gas} + H_2O = CO_{2aqua}$ to $G_{CO2aqua} = 18.38\ ^{kJ}/_{mol}$ constant:

$K_{eqCO2aqua} = [CO_{2aqua}]/[CO_{2gas}]/[H_2O] = EXP(-G_{CO2aqua}/R/T) = EXP(-18382.746/8.3144/298.15) = 0.000601808$

increasing free energy by $\Delta G_{CO2aqua} = -R \cdot T \cdot \ln(K_{eqCO2aqua}) = -8.3144 \cdot 298.15 \cdot \ln(0.000601808 = 18.38\ ^{kJ}/_{mol}$.

Reaction $CO_{2aqua} + 2H_2O + \Delta G + Q = v1 \underline{CA} > H_3O^+ + HCO_3^-$ velocity constant is

$k_{1CO2aqua} = 1.5 \times 10^8$ M^{-1}s^{-1} and protolytic acid CO_{2aqua} equilibrium value of constant is

$\dfrac{[HCO_3^-]_{aqua} \cdot [H_3O^+]}{[CO_2]_{aqua} \cdot [H_2O]^2} = K_{eqCAHCO3aqua} = K_{a\_CO2aqua}/[H_2O]^2 = 10^{-7.0512}/55.3^2 = 2.906 \cdot 10^{-11}$.[9]

CA high rate protolysis constant accumulate free energy in products $H_3O^+ + HCO_3^-$ activating its:

$\Delta G_{eqCACO2aqua} = -R \cdot T \cdot \ln(K_{eqCACO2aqua}) = -8.3144 \cdot 298.15 \cdot \ln(2.906 \cdot 10^{\wedge(-11)})/1000 = 60.14\ ^{kJ}/_{mol}$.

Total free energy increases by activation reaching equilibrium state with high rate protolysis and solubility:

$G_{H3O+HCO3} = G_{H3O+} + G_{HCO3-} = 22.44 + 56.08 = G_{CO2aqua} + \Delta G_{eqCACO2aqua} = 18.38 + 60.14 = 78.52\ ^{kJ}/_{mol}$. [1,8,14]

High rate protolysis attractor is pH=7,36. Deviation from the attractor disrupts the order of irreversible homeostasis processes, creating disorder and chaos.

Carbonic anhydrase CA synthesis indispensable active Biosphere attractor.

The reactivity of carbonic anhydrase and the equilibrium-attractor value of the generated physiological buffer solution protolysis pH=7.36 is a self-organizing biosphere attractor. The accumulated free energy of the reaction CO_2+2H_2O in the products (CO_{2aqua}) $H_3O^++HCO_3^-$ accumulate free energy $G_{H3O++HCO3-}$=18.38+60.14=78.38 $^{kJ}/_{mol}$ is necessary for the functional activity of the bicarbonate buffer system for the perfect order of reactions in the complex processes of irreversible homeostasis.

CO_2 no reaction with water H_2O at absence of CA. CO_2 is weak solble and slow react with OH^- ions. [Wikipedia](#) [27] mol mas M_{CO2}=44.009 g/mol. Solubility $CO_{2gas}+H_2O=CO_{2aqua}$ 1.45 g/L at 0.99 atm and at 1 atm m_{CO2}=100*1.45/99=1.4646 g/L has concentration $[CO_{2aqua}]=m_{CO2}/M_{CO2}$=1.4646/44.009=0.03328 M.

Solubility product is $K_{spCO2aqua}=[CO_{2aqua}]/[CO_{2gas}]$=0.03328 M but equilibrium constant in mol fractions is $K_{eqCO2aqua}=[CO_{2aqua}]/[CO_{2gas}]/[H_2O]=K_{spCO2aqua}/[H_2O]$=0.03328 M/55.3 M=0.000601808.

Free energy $\Delta G_{eqCO2aqua}$=-R•T•ln($K_{eqCO2aqua}$)=-8.3144*298.15*ln(0.000601808)/1000=**18.38** $^{kJ}/_{mol}$ has minimum value at solubility equilibrium $G_{CO2aqua}=\Delta G_{eqCO2aqua}+(G_{CO2gas}+G_{H2O})$=**18.38**+(0+0)=**18.38** $^{kJ}/_{mol}$.

From air 0.04 % mol fraction $[CO_{2gas}]$=0.0004 creates dissolute concentration:
$[CO_{2aqua}]=K_{eqCO2aqua}*[H_2O]*[CO_{2gas}]$=0.000601808*55.3457*0.0004=0.000753 M.

Carbon dioxide CO_{2aqua} reacts with OH^- ions times $10^{16.54}$ slower as bicarbonate HCO_3^- neutralization reaction: $H_3O^++HCO_3^-=CO_{2aqua}+2H_2O$, because neutralization velocity constant is k_2=5.16885*10^{18} $M^{-2}s^{-1}$, but OH^- ions $CO_{2aqua}+OH^-=HCO_3^-$ have velocity constant k_{1OH} 1.5*10^2 $M^{-2}s^{-1}$. Reaction has favored equilibrium constant:
$\Delta G_{HessHCO3-}=G_{HCO3-}-(G_{CO2aqua}+G_{OH-})$=56.08-(18.38+77.36)=-39.66 $^{kJ}/_{mol}$

$k_{1OH-}/k_{2HCO3-}=[HCO_3^-]/[CO_{2aqua}]/[OH^-]=K_{eq\_HCO3-}$=EXP(-$\Delta G_{eq\_HCO3-}$/R/T) =EXP(39660/8.3144/298.15)=8875.3 and produce exothermic heat Q: $\Delta H_{Hess}=\Delta H°_{HCO3}-\Delta H°_{CO2}-\Delta H°_{OH}$=-48.68 $^{kJ}/_{mol}$. Inverse $HCO_3^-=CO_{2aqua}+OH^-$ reaction has $k_{2HCO3-}=k_{1OH-}/K_{eq\_HCO3-}$=1.5*$10^2$/8875.3=0.0169 unfavored constant. Decomposition HCO_3^- =>$CO_{2aqua}+OH^-$ velocity constant k_{2HCO3-} is then billion 10^{10} times slower as CA velocity constant $k_{1CO2aqua}$=1.5×10^8 $M^{-1}s^{-1}$. [9]

CA protolytic reactivity creates functional active bicarbonate buffer self-organizing attractor pH=7.36 with generate concentrations gradients for transport of H_3O^+, HCO_3^-, CO_{2aqua} and of O_{2aqua}, H_2O by osmose through aquaporin channels. [9]

CA high rate protolysis require CO_{2aqua} react with two water molecules:
$CO_{2aqua}+2H_2O+\Delta G+Q=v1\underline{^{CA}}>H_3O^++HCO_3^-$, which velocity constant is: $k_{1CO2aqua}$=1.5×10^8 $M^{-1}s^{-1}$. [9]

Neutralization $H_3O^++HCO_3^-=CO_{2aqua}+2H_2O$ velocity constant is CA independent times $10^{10.54}$ greater about CA velocity constant: $k_2/k_{1CO2aqua}$=5.16885*10^18/1.5/10^8=34407299853=10^10.54.

CA protolysis equilibrium constant evaluate ratio of velocity constants in expression:
$K_{eqCAHCO3aqua}=k_{1CO2aqua}/k_2=K_{a\_CO2aqua}/[H_2O]^2$=10^(-7.0512)/55.3^2=2.906*10^{-11}=$10^{-10.54}$.

Bicarbonate buffer acid protolysis constant $pK_{a\_CO2aqua}$=7.0512 is friendly to attractor value pH=7.36:

$K_{a\_CO2aqua}=K_{eqCAHCO3aqua}*[H_2O]^2=\dfrac{[HCO_3^-]_{aqua}\cdot[H_3O^+]}{[CO_2]_{aqua}}$ =$10^{-7.0512}=10^{-pKa\_CO2aqua}$. Original $pK_{a\_CO2aqua}$=7.0512 value

obtained and calculated for [BUFFER](#) solutions. Hess free energy change is exoergic negative:
$\Delta G_{Hess}=2\Delta G°_{H2O}+\Delta G°_{CO2}-(\Delta G°_{H3O}+\Delta G°_{HCO3})$=2*-237.191-385.98-(-213.2746-**544.9688**)=**-102** $^{kJ}/_{mol}$. [1]
Neutralization: $H_3O^++HCO_3^-=CO_{2aqua}+2H_2O$ constant is inverse to protolysis and favored:
$K_{eqNeutralization}=1/K_{eqCAHCO3aqua}=[HCO_3^-]*[H_3O^+]/[CO_{2aqua}]/[H_2O]^2$=1/2.90636/10^(-11)= 34407299853.
$\Delta G_{Absolute\_Neutralization}=2G_{H2O}+G_{CO2qua}-G_{H3O}-G_{HCO3}$=2*0+**18.38**-22.44-56.08=**-60.14** $^{kJ}/_{mol}$ and
enthalpy Hess change in reaction is exothermic: $\Delta H_{Hess}=2\Delta H°_{H2O}+\Delta H°_{CO2}-\Delta H°_{H3O}-\Delta H°_{HCO3}$=**-7.2** $^{kJ}/_{mol}$.
Neutralization is favored reaction. Free energy change on minimum expression is negative:
$\Delta G_{eqNeutralization}$=-R•T•ln($K_{eqNeutralization}$)=-8.3144•298.15•ln(34407299853)=**-60.14** $^{kJ}/_{mol}$, but CO_{2aqua} protolysis minimum as inverse reaction of neutralization is positive:
$\Delta G_{eqCAHCO3aqua}$=-R•T•ln($K_{eqCA\_HCO3aqua}$)=-8.3144•298.15•ln(1/34407299853)=**60.14** $^{kJ}/_{mol}$.

-102 $^{kJ}/_{mol}$
$\Delta G<0$ Hess
ΔG_{min}= **-60** $^{kJ}/_{mol}$
A+B 50 % C+2D.

Attractor Fig. 2. Exothermic and exoergic neutralization Hess free energy change $\Delta G_{HessNeutralization}$ is negative **-102** $^{kJ}/_{mol}$, bet $\Delta G_{eqNeutralization}$=**-60.14** $^{kJ}/_{mol}$ minimized reaching equilibrium mixture K_{eq}=34407299853 at presence of CA carbonic anhydrase. Carbon dioxide reaction with hydroxide anions is slow, because of small factors: k_{1OH}=1.5*10^2 $M^{-2}s^{-1}$ velocity constant and concentrations $[CO_{2aqua}]$=0.0007512 M, $[OH^-]$=$10^{-6.64}$ M. Carbonic anhydrase synthesis resolves perfect order of bioenergetic homeostasis as self-organization attractor. [3.4] Reactants $H_3O^++HCO_3^-$, products $CO_{2aqua}+2H_2O$.

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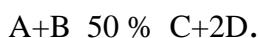
$2CO_2$ / $H_2C_2O_4$ / CH_{4gas} solubility and protolysis require hydroxonium H_3O^+ and water H_2O account.

The standard free energy change for the formation of carbon dioxide from free elements $C_{gr}+O_{2gas}=CO_{2gas}$ is negative $\Delta G°_{Hess\_CO2gas}=G_{CO2gas}-(G_{gr}+G_{O2gas})=-394,36$ $^{kJ}/_{mol}$. [1] If the background level for the absolute energy scale of biochemistry is zero $G_{CO2gas}=0$ $^{kJ}/_{mol}$, then by Hess's law the absolute free energy content of one mole of graphite is $G_{gr}=G_{CO2gas}-(\Delta G°_{Hess\_CO2gas}+G_{O2gas})=0-(-394,36+303,1=91,26$ $^{kJ}/_{mol}$.

The standard free energy change for methane formation from free elements $C_{gr}+2H_{2gas}>CH_{4gas}$ [1,8] is
$$\Delta G°_{Hess\_CH4gas}=G_{CH4gas}-(G_{Cgr}+2*G_{H2})=G_{CH4gas}-(91.26+2*\underline{85.64})=-50.5 \ ^{kJ}/_{mol} \ and$$
the free energy content per mol of methane remaining unused from free elements in Hess's law is
$$G_{CH4gas}=\Delta G°_{Hess\_CH4gas}+(G_{Cgr}+2*G_{H2})=-50.5+(91.26+2*\underline{85.64})=212.04 \ ^{kJ}/_{mol}.$$
This allows us to calculate the absolute free energy per mol of the element graphite on absolute free energy scale:
$$G_{CgrCH4gas}=G_{CH4gas}-\Delta G°_{Hess\_CH4gas}-2*G_{H2gas}=212.04-(-50.5+2*\underline{85.64})=91.26 \ ^{kJ}/_{mol} \ ,$$
which coincides with the zero of gas and water $G_{CO2gas}=G_{H2O}=0$ $^{kJ}/_{mol}$ on the biochemistry absolute energy scale.

The solubility of methane $CH_{4gas}+H_2O=CH_{4aq}$
is 22.7 $^{mg}/_L$ and the molar mass of methane is $M_{CH4}=16.043$ $^g/_{mol}$. The water account $[H_2O]=996/18=55.3$ M calculates the solubility constant $K_{eq}=K_{sp}/[H_2O]=0.001414947$ M/55.3 M$=10^{\wedge(-4.592)}$.
For the equilibrium solubility of methane $[CH_4]=0,0227/16,043=0,001414947$ M, the absolute free energy change is $\Delta G_{eq}=-R•T•ln(K_{eq})=-8.3144*298.15*ln(10^{\wedge(-4.592)})=-8.3144*298.15*-10.573=26.21$ $^{kJ}/_{mol}$.
Alberty data calculates the solubility energy change
$$\Delta G_{eqCH4gas}=G_{CH4aq}-(G_{CH4gas}+G_{H2O})=238.25-(212.04+0)=26.21 \ ^{kJ}/_{mol}$$
allows us to calculate the absolute free energy content of methane in water (aqua):
$$G_{CH4aq}=\Delta G_{eqCH4}+(G_{H2O}+G_{CH4}^{gas})=26.21+(0+212.04)=238.25 \ ^{kJ}/_{mol}.$$

Substance	$\Delta H°_H$ $^{kJ}/_{mol}$	$\Delta S°_H$ $^{J}/_{mol/K}$	$\Delta G°_H,^{kJ}/_{mol}$	
H_2O	-285.85	69.9565	-237.191	$\Delta G_{H2C2O4}=\Delta H_H–T*\Delta S_H=-829.9-298.15*-0.1098=-747.75$ $^{kJ}/_{mol}$;
H_3O^+	-285.81	-3.854	-213.2746	CRC [1] Mischenko 1972, Himia, Leningrad [26]
$H_2C_2O_{4cr}$	-829.9	-109.8	-797.16	CRC [1]
$H_2C_2O_{4cr}$	formation	-797.16	**76.96**	$G_{H2C2O4cr}=\Delta G°_{H2C2O4crForm}+(2G_{Cgr}+2G_{O2gas}+G_{H2gas})=76.96$ $^{kJ}/_{mol}$;
$H_2C_2O_{4aq}$	$\Delta G_{eq\_sp}=$	**9.0161**	**85.976**	$G_{H2C2O4aq}=\Delta G_{eq\_sp}+(G_{H2O}+G_{H2C2O4}^{cr})=85.976$ $^{kJ}/_{mol}$;
$H_2C_2O_{4aq}$	$E°_{H2C2O4}=$	**-0.6577 V**	**171.78**	$G_{H2C2O4}=2G_{CO2}+2G_{H3O}-(\Delta G_{eqH2C2O4}+2G_{H2O})=171.78$ $^{kJ}/_{mol}$;
$HC_2O_4^-$	**17.08**	$pK_{a2}=1.25$	**80.618**	$G_{HC2O4}=\Delta G_{eq1H2C2O4}-G_{H3O}+(G_{H2C2O4}+\Delta G_{H2O})=80.618$ $^{kJ}/_{mol}$;
$HC_2O_4^-$	$E°_{HC2O4}=$	**-0.7092 V**	**159.028**	$G_{HC2O4}=2G_{CO2}+G_{H3O}-(\Delta G_{eqHC2O4}+G_{H2O})=159.028$ $^{kJ}/_{mol}$;
$C_2O_4^{2-}$	-	-pH=7,36	**-677.14**	**Alberty 2006** Biochem.Thermodyn Massachusetts Techn. Inst.
$C_2O_4^{2-}$	**33.578**	$pK_{a2}=4.14$	**91.756**	$G_{C2O4}=\Delta G_{eq2HC2O4}-G_{H3O}+(G_{HC2O4}+G_{H2O})=91.756$ $^{kJ}/_{mol}$;
$C_2O_4^{2-}$	$E°_{C2O4}=$	**-0.7607 V**	**146.79**	$G_{C2O4}=2G_{CO2}-(\Delta G_{eqC2O4})=2*0-(-146.79)=146.79$ $^{kJ}/_{mol}$;
CH_{4gas}	-74.6	186.3	-50.5	$=\Delta G°_{Hess\_CO2gas}=G_{CO2gas}-(G_{gr}+G_{O2gas})$ Wikipedia CRC [1]
CH_{4gas}	formation	-50.5	**212.04**	$G_{CH4gas}=\Delta G°_{Hess\_CH4gas}+(G_{Cgr}+2*G_{H2})=212.04$ $^{kJ}/_{mol}$;
CH_{4gas}	pH=7,36	Alberty [8]	**120.56**	**Alberty 2006** Biochem.Thermodyn Massachusetts Techn. Inst.
CH_{4aq}	Solubility	**26.21**	**238.25**	$G_{CH4aq}=G_{CH4gas}+G_{CH4sp}=212.04+26.21=238.25$ $^{kJ}/_{mol}$;
CH_{4aq}	[8]	-pH=7,36	**136.95**	**Alberty 2006** Biochem.Thermodyn Massachusetts Techn. Inst.
C_{gr}	background	Biochemistry	**91.26**	$G_{gr}=G_{CO2gas}-(\Delta G°_{Hess\_CO2gas}+G_{O2gas})=91,26$ $^{kJ}/_{mol}$; pH=7.36
CO_{2gas}	-393.509	213.74	-394.359	CRC [1]
CO_{2aq}	-413.798	117.5704	-385.98	CRC [1]
CO_{2aq}	$E°_{H2C2O4}=$	**-0.6577 V**	**-42.90**	$2G_{CO2}=\Delta G_{eqH2C2O4}-2G_{H3O}+(G_{H2C2O4}+2G_{H2O})=2*-42.902$ $^{kJ}/_{mol}$;
CO_{2aq}	$E°_{HC2O4}=$	**-0.7092 V**	**-97.514**	$2G_{CO2}=\Delta G_{eqHC2O4}-G_{H3O}+(G_{HC2O4}+G_{H2sO})=2*-97.514$ $^{kJ}/_{mol}$;
CO_{2aq}	$E°_{C2O4}=$	**-0.7607 V**	**-27.517**	$2G_{CO2}=\Delta G_{eqC2O4}+(G_{C2O4})=-27.517$ $^{kJ}/_{mol}$;
CO_{2aq}	$K_{eqCO2aqua}$	Solubility	**18.38**	$G_{CO2aqua}=\Delta G_{eqCO2aqua}+(G_{CO2gas}+G_{H2O})=18.38+(0+0)=18.38$ $^{kJ}/_{mol}$.

Formation from free elements $2C_{gr}+2O_{2gas}+H_{2gas}=H_2C_2O_{4cr}$ and solubility $H_2C_2O_4^{cr}+H_2O=H_2C_2O_{4aq}$:

$G_{H2C2O4cr}=\Delta G°_{H2C2O4crForm}+(2G_{Cgr}+2G_{O2gas}+G_{H2gas})=-797.16+(2*91.26+2*303+85.6)=76.96$ kJ/mol.

Solubility of oxalic acid 118 g/L $H_2C_2O_4^{cr}+H_2O=H_2C_2O_{4aq}$ constant is calculated from [1,29] data with density 1.072 g/mL :

$$K_{eq\_sp}=[H_2C_2O_{4aq}]/[H_2C_2O_4^{cr}]/[H_2O]=1.3106/1/49.77=0.026329.$$

Molar mass $M_{H2C2O4}=90.034$ g/mol; $[H_2O]=982/18=49.777$ M; concentration $[H_2C_2O_4]=118/90.034=1.3106$ M and mas fraction in percent w%$=118/(118+982)*100=10.7272\%$, if pure solid mol fraction is one $[H_2C_2O_4^{cr}]=1$.

Oxalic acid solubility free energy change for unfavored equilibrium $K_{eq\_sp}=0.026329$ is positive:

$$\Delta G_{eq\_sp}=-R•T•ln(K_{eq\_sp})=-8.3144*298.15*ln(0.026329)=-8.3144•298.15•-3.637=9.0161 \text{ kJ/mol}.$$

In Hess law expression $\Delta G_{eq\_sp}=G_{H2C2O4aq}-(G_{H2O}+G_{H2C2O4}^{cr})=G_{H2C2O4aq}-(0+76.96)=9.0161$ kJ/mol was calculated the one mol free energy content $G_{H2C2O4aq}=\Delta G_{eq\_sp}+(G_{H2O}+G_{H2C2O4}^{cr})=9.0161+(0+76.96)=85.976$ kJ/mol. [29]

1. Week acid protolysis $H_2C_2O_4+H_2O=HC_2O_4^-+H_3O^+$; $pK_{a1}=1.25$; $K_{eq1}=K_{a1}/[H_2O]=10^{\wedge(-1.25)}/55.3= 0.0010169$;

$\Delta G_{eq1H2C2O4}=-R•T•ln(K_{eq1})=-8.3144*298.15*ln(0.0010169)=\Delta G_{HC2O4}+\Delta G_{H3O}-(\Delta G_{HC2O4}+\Delta G_{H2O})=17.08$ kJ/mol;

$\Delta G_{eq1H2C2O4}=G_{HC2O4}+G_{H3O}-(G_{H2C2O4}+\Delta G_{H2O})=G_{HC2O4}+22.44-(85.976+0)=17.082$ kJ/mol;

$G_{HC2O4}=\Delta G_{eq1H2C2O4}-G_{H3O}+(G_{H2C2O4}+\Delta G_{H2O})=17.082-22.44+(85.976+0)=80.618$ kJ/mol;

2. Week acid protolysis $HC_2O_4^-+H_2O=C_2O_4^{2-}+H_3O^+$; $pK_{a2}=4.14$; $K_{eq2}=K_{a2}/[H_2O]=10^{\wedge(-4.14)}/55.3=0.000001310$;

$\Delta G_{eq2HC2O4}=-R•T•ln(K_{eq2})=-8.3144*298.15*ln(0.000001310)=\Delta G_{C2O4}+\Delta G_{H3O}-(\Delta G_{HC2O4}+\Delta G_{H2O})=33.578$ kJ/mol;

$\Delta G_{eq2HC2O4}=G_{C2O4}+G_{H3O}-(G_{HC2O4}+G_{H2O})=G_{C2O4}+22.44-(80.618+0)=33.578$ kJ/mol;

$G_{C2O4}=\Delta G_{eq2HC2O4}-G_{H3O}+(G_{HC2O4}+G_{H2O})=33.578-22.44+(80.618+0)=91.756$ kJ/mol;

pH$<=1.25$ $H_2C_2O_4+2H_2O=2CO_2+2H_3O^++2e^-$; Expression composition contains the potential classic standard $E°_{Classic}=-0.49$ V [17], water logarithm $-0.0591/2•log(1/[H_2O]^1)=0.103$ and $\Delta E°=0.10166-0.37239$:

$E°_{H2C2O4}=E°_{Classic}-0.0591/2*lg(1/[H_2O]^2)+\Delta E°=-0.49+0.103+0.10166-0.37239=-0.6577$ V;

Absolute Nernst's Standard potential $E°_{H2C2O4}=-0.6577$ V; Suchotina [17]

$$E_{H2C2O4}=E°_{H2C2O4}+\frac{0.0591}{2}•lg\frac{[CO_2]^2·[H_3O^+]^2}{[H_2C_2O_2]·[H_2O]^2}=-0.6577 \text{ V}+\frac{0.0591}{2}•lg\frac{[CO_2]^2·[H_3O^+]^2}{[H_2C_2O_2]·[H_2O]^2}$$

$\Delta G_{eqH2C2O4}=E°_{H2C2O4}•F•2=-0.6577*96485*2=-126.9$ kJ/mol;

$\Delta G_{eqH2C2O4}=2G_{CO2}+2G_{H3O}-(G_{H2C2O4}+2G_{H2O})=2*0+2*22.44-(G_{H2C2O4}+2*0)=-126.9$ kJ/mol ;

$G_{H2C2O4}=2G_{CO2}+2G_{H3O}-(\Delta G_{eqH2C2O4}+2G_{H2O})=2*0+2*22.44-(-126.9+2*0)=171.78$ kJ/mol ;

$1.25<$pH$<=4.14$; $HC_2O_4^-+H_2O = 2CO_2+H_3O^++2e^-$; Expression composition contains the potential classic standard $E°_{Classic}=-0.49$ V [17], water logarithm $-0.0591/2•log(1/[H_2O]^1)=0.0515$ and $\Delta E°=0.10166-0.37239$:

$E°_{HC2O4}=E°_{Classic}-0.0591/2*lg(1/[H_2O]^1)+\Delta E°=-0.49+0.0515+0.10166-0.37239= -0.709$ V;

$\Delta G_{eqHC2O4}=E°_{HC2O4}•F•2=-0.7092*96485*2=-136.85$ kJ/mol;

$\Delta G_{eqHC2O4}=2G_{CO2}+G_{H3O}-(G_{HC2O4}+G_{H2O})=2*0+22.44-(G_{HC2O4}+0)=-136.85$ kJ/mol;

$G_{HC2O4}=2G_{CO2}+G_{H3O}-(\Delta G_{eqHC2O4}+G_{H2O})=2*0+22.44-(-136.85+0)=159.028$ kJ/mol;

$4.14 <$pH; $C_2O_4^{2-} = 2CO_2+2e^-$; Expression composition contains the potential classic standard $E°_{Classic}=-0.49$ V [17], water logarithm zero 0 and $\Delta E°=0.10166-0.37239$:

$E°_{C2O4}=E°_{Classic}-0.0591/2*lg([1/H_2O]^0)+\Delta E°=-0.49+0+0.10166-0.37239=-0.7607$ V;

$\Delta G_{eqC2O4}=E°_{C2O4}•F•2=-0.7607*96485*2=-146.79$ kJ/mol;

$\Delta G_{eqC2O4}=2G_{CO2}-(G_{C2O4})=2*0-(G_{C2O4})=-146.79$ kJ/mol;

$G_{C2O4}=2G_{CO2}-(\Delta G_{eqC2O4})=2*0-(-146.79)=146.79$ kJ/mol;

Nernst's potential studies reducing with vitamin B_3 ethanal $H_3CCH=O$ and oxidizing H_3CCH_2OH ethanol

Aerobic $[NAD^+]/[NADH]=10^6$; $H_3C\text{-}CH_2\text{-}OH+NAD^++H_2O+\Delta G+Q=>H_3C\text{-}CH=O+NADH+H_3O^+$

$\Delta G_{Hess}=\Delta G°_{H3O}+\Delta G°_{CH3CHO}+\Delta G°_{NADH}-(\Delta G°_{CH3CH2OH}+\Delta G°_{H2O}+\Delta G°_{NAD+})=159.1$ $^{kJ}/_{mol}$;

$\Delta G_{Hess}=32.2824+1175.5732-151.549-(75.2864+1059.11-237.191)=159.1$ $^{kJ}/_{mol}$ endoergic. [1]

Ox $NAD^+ + H^-(H^++2e^-)=NADH$; Expression of inverse absolute potential has standard $-E°_{Classic}=0.113$ V [22], water zero 0 and $\Delta E°=0.10166-0.37239$: $-E°_{NADH}=-E°_{Classic}+0+\Delta E°=0.113+0+0.10166-0.37239)=\mathbf{0.38373}$ V

Red $CH_3CH_2OH+H_2O=CH_3CHO+H_3O^++H^-(2e^-)$; Expression of absolute potential has standard $E°_{Classic}=0.19$ V [19], water logarithm $-0.0591/2\cdot\log(1/[H_2O]^1)=0.0515$ and $\Delta E°=0.10166-0.37239$:

$E°_{C2H5OH}=E°_{Classic}-0.0591/2\cdot\log(1/[H_2O]^1)+\Delta E°=0.19+0.0515+0.10166-0.37239=\mathbf{-0.02923}$ V;

Sum: $E°_{C2H5OH}-E°_{NAD+}=\mathbf{-0.02923}+\mathbf{0.38373}=0.3545$ V, $n=2$; $\Delta G_{eq}=\Delta E°\cdot F\cdot n=0.3545*96485*2=\mathbf{68.4}$ $^{kJ}/_{mol}$;

By convention balanced $n=2=m$ number of electrons $2e^-$ donors $E°_{NADH}=\mathbf{-0.38373}$ V plus acceptors of electrons $E°_{C2H5OH}=\mathbf{-0.02923}$ V, as $-E°_{NAD+}=\mathbf{0.38373}$ V accepting electrons from ethanol $E°_{C2H5OH}=\mathbf{-0.02923}$ V:

$$\Delta G_{eq}=-R\cdot T\cdot\ln(K_{eq})=\mathbf{68.4}\ ^{kJ}/_{mol};\ K_{eq}=\frac{[NADH]\cdot[CH_3CHO]\cdot[H_3O^+]}{[NAD^+]\cdot[CH_3CH_2OH]\cdot[H_2O]}=e^{-\frac{\Delta Geq}{R\cdot T}}=e^{-\frac{68408}{8.314\cdot298.15}}=1.036\cdot10^{-12}=10^{-11.985}$$

Anaerobic $[NADH]/[NAD^+]=10$; $H_3C\text{-}CH_2\text{-}OH+NAD^++H_2O+\Delta G+Q => H_3C\text{-}CH=O+NADH+H_3O^+$;

$\Delta G_{Hess}=\Delta G°_{CH3CH2OH}+\Delta G°_{H2O}+\Delta G°_{NAD+}-\Delta G°_{H3O}-\Delta G°_{CH3CHO}-\Delta G°_{NADH}=-159.1$ $^{kJ}/_{mol}$;

$\Delta G_{Hess}=75.2864+1059.11-237.191-(32.2824+1175.5732-151.549)=-159.1$ $^{kJ}/_{mol}$ endoergic; [1]

Red $NADH=NAD^++H^-(2e^-)$; Expression of absolute potential has standard $E°_{Classic}=-0.113$ V [22], water zero 0 and $\Delta E°=0.10166-0.37239$: $E°_{NADH}=E°_{Classic}+0+\Delta E°=-0.113+0+0.10166-0.37239=\mathbf{-0.38373}$ V;

Ox $CH_3CHO+2H_3O^++H^-(2e^-)=CH_3CH_2OH+2H_2O$; inverse standard potential $-E°_{CH3CHO}=\mathbf{0.02923}$ V; [19];

Sum:

$\Delta E°=E°_{NADH}-E°_{CH3CHO}=\mathbf{-0.38373}+\mathbf{0.02923}=-0.3545$ V, $\Delta G_{eq}=\Delta E°\cdot F\cdot n=-0.3545$ V$\cdot2$ mol$\cdot96485$ $^C/_{mol}=\mathbf{-68.4}$ $^{kJ}/_{mol}$;

By convention balanced $n=2=m$ number of electrons $2e^-\Delta E°$ donors $E°_{NADH}=\mathbf{-0.38373}$ V plus electrons acceptor $-E°_{CH3CHO}=\mathbf{0.02923}$ V, as $-E°_{CH3CHO}=\mathbf{0.02923}$ V accepting electrons from vitamin $E°_{NADH}=\mathbf{-0.38373}$ V .

$$\Delta G_{eq}=-R\cdot T\cdot\ln(K_{eq})=\mathbf{-68.408}\ ^{kJ}/_{mol};\ K_{eq}=\frac{[NAD^+]\cdot[CH_3CH_2OH]\cdot[H_2O]}{[NADH]\cdot[CH_3CHO]\cdot[H_3O^+]}=e^{-\frac{\Delta Geq}{R\cdot T}}=e^{-\frac{-68408}{8.314\cdot298.15}}=9.65\cdot10^{11}=10^{11.985}.$$

In aerobic organisms NADH oxidase with O_{2aqua} perform ratio $[NAD^+]/[NADH]=10^6$; $\Delta G_{Homeostasis}=\mathbf{68.408}+R\cdot T\cdot\ln(1*10^{\wedge(-7.36)}/10^{\wedge}6/1/55.3)=\mathbf{68.408}-86.2=-17.8$ $^{kJ}/_{mol}$.

Aerobic due to ratio is $[NAD^+]/[NADH]=10^3$; $\Delta G_{Homeostasis}=\mathbf{68.408}-69.08=-0.674$ $^{kJ}/_{mol}$.

Equilibrium is shifted far to reactants as aerobic constant $K_{eq}=10^{-11.985}$ and inverse anaerobic constant $K_{eq}=10^{11.985}$. Aerobic endothermic and endoergic vitamin B_3 ethanol oxidation Hess law free energy change positive $\Delta G_{Hess}=159$ $^{kJ}/_{mol}$ and inverse ethanal anaerobic reduction negative $\Delta G_{Hess}=-159$ $^{kJ}/_{mol}$, but minimizes reaching equilibrium aerobic $\Delta G_{min}=\Delta G_{eq}=68.4$ $^{kJ}/_{mol}$ and anaerobic $\Delta G_{min}=\Delta G_{eq}=\mathbf{-68.4}$ $^{kJ}/_{mol}$ reaching equilibrium mixture constants within inverse symmetry $10^{-11.985}=K_{eq}$ aerobic and anaerobic $10^{11.985}=K_{eq}$.

Prigogine attractor is free energy change absolute minimum ΔG_{min} reaching equilibrium $\Delta G_{min}=\mathbf{68.4}$ $^{kJ}/_{mol}=|\Delta G_{eq}|<|\Delta G_{Hess}|= 159$ $^{kJ}/_{mol}$.

Anaerobic $H_3C\text{-}CH=O+NADH+H_3O^+ =>H_3C\text{-}CH_2\text{-}OH+NAD^++H_2O+\Delta G+Q$;

Anaerobic $\Delta G_{eq}=\Delta E°\cdot F\cdot n=-0.3545$ V$\cdot2$ mol$\cdot96485$ $^C/_{mol}=\mathbf{-68.408}$ $^{kJ}/_{mol}$ favored.

Insufficient low O_{2aqua} concentration hypoxia to anaerobic alcohol oxidation unflavored but ethanal reduction to ethanol favored $[H_3CCH_2OH]/[H_3CCH=O]=1/10$ reduction with NADH reductase enzyme as negative free energy change $\Delta G_{Homeostasis}=-27.86$ $^{kJ}/_{mol}$

Anaerobic homeostasis ratio $[NADH]/[NAD^+]=10$ over $[NAD^+]$ favors reduction:
$\Delta G_{Anaerobic}=-68.41+8.3144*298.15*\ln(1*1*55.3/10/10/10^{\wedge(-7.36)})=-27.86$ $^{kJ}/_{mol}$;

Aerobic organisms $K_{Aerobic}=\dfrac{[NADH]\cdot[CH_3CHO]\cdot[H_3O^+]}{[NAD^+]\cdot[CH_3CH_2OH]\cdot[H_2O]}$ oxidation homeostasis ratio is $[NADH]/[NAD^+]=1/770$;

$\Delta G_{Homeostasis}=68.408+8.3144*298.15*\ln(1/770*1/1*10^{\wedge(-7.36)}/55.3)=-0.026$ $^{kJ}/_{mol}$.

A+B+C 50% D+E+F
reactants_ $NAD^++H_3CCH_2OH+H_2O$
products_ $NADH+H_3CCHO+H_3O^+$
aerobic

D+E+F 50% A+B+C
$NADH+H_3CCHO+H_3O^+$
$NAD^++H_3CCH_2OH+H_2O$

Table 1. Nernst's half reactions Standard Electrodes Potentials classic, Thermodynamic, Absolute Volts.

	Reduced form = Oxidized form + n e⁻;	H_2O disaccount classic zero E_o	Thermodynamic scale on H_2O account	Absolute scale -0.37239
H	$\underline{H(Pt)}$ +H_2O=H_3O^+ +(Pt)+ e⁻; scale reference potential [1]	classic zero **0**	**0.10166**	-0.27072
	$\underline{H(Pt)}$ + OH⁻=H_2O +(Pt)+e⁻; classic CRC [1]	-0.8277	-0.8282	-1.200576
	$\underline{H(Pt)}$ + OH⁻=H_2O +(Pt)+e⁻; correction -0.10449 of classic [1]	-0.93219	-0.9326	-1.30507
	H_{2aq}+2H_2O=2H_3O^++2e⁻+H_2O;graphite electrode	0.4687	0.6733	0.302
O	5H_2O=O_{2aq}+4H_3O^++4e⁻;	1.2288	1.4592	1.0868
	H_2O_2+2H_2O=O^-_{2aqua}+2H_3O^++e⁻; David Harris [21]	1.2764	1.4811	1.1087
	4H_2O=H_2O_2+2 H_3O^+ +2e⁻; Suchotina [17]	1.776	2.0837	1.7113
	H_2O_{2aqua}+2H_2O=O_{2aqua}+2H_3O^++2e⁻;University Alberta [19]	0.6945	0.8992	0.5268
CHO	$C_6H_{12}O_6$+42H_2O =24H_3O^++6H_3O^++6HCO_3^-+24e⁻; Kaksis	-0.04809	0.2338	-0.13858
	HOO^-+H_2O=O_{2aqua}+H_3O^++2e⁻; Kaksis	0.3155	0.4686	0.09625
N	NO_2^- + 2OH⁻=NO_3^-+ H_2O+2e⁻; pH>3.15 Suchotina [17]	0.01	0.0602	-0.3122
	HNO_2+4H_2O=NO_3^-+3H_3O^++2e⁻; pH<3.15 Kortly, Shucha [18]	0.94	1.2477	0.8753
	NO_{aq}+4H_2O=HNO_3+3H_3O^++3e⁻; pH<1,4 Kortly, Shucha [18]	0.96	1.19899	0.8266
	NH_4^++13H_2O=NO_3^-+10H_3O^++8e⁻; Suchotina [17]	0.87	1.1391	0.7667
Br	2Br⁻=Br_2(aq)+2e⁻; CRC [1]	1.0873	1.18896	0.8176
Bi	BiO^++6H_2O=BiO_3^-+4H_3O^++2e⁻; 1<pH<7 Suchotina [17]	1.80	2.21065	1.8383
Mn H⁺	Mn^{2+}+12H_2O=MnO_4^-+8H_3O^++5e⁻; Kortly, Shucha [18]	1.51	1.85885	1.4865
H_2O	$\underline{MnO_2}$↓+4OH⁻=MnO_4^- + 2H_2O+3e⁻; Suchotina [17]	0.603	0.6360	0.2636
OH⁻	MnO_4^{2-}=MnO_4^-+e⁻; Suchotina [17]	0.558	0.65966	0.2873
Pb	Pb^{2+} +6H_2O=$\underline{PbO_2}$(s)+4H_3O^++2e⁻; Kortly, Shucha [18]	1.455	1.86565	1.4933
	Pb+H_2O = Pb^{2+} +2e⁻; pH<7 Kortly, Shucha [18]	-0.126	0.02716	-0.3452
S	H_2SO_{3aq}+4H_2O=HSO_4^-+3H_3O^++2e⁻;pH<2 Suchotina [17]	0.172	0.47965	0.10726
	HSO_3^-+4H_2O=SO_4^{2-}+3H_3O^++2e⁻; Suchotina [17] 2=<pH<7	0.172	0.47965	0.10726
	SO_3^{2-}+2OH⁻=SO_4^{2-}+H_2O+2e⁻; Suchotina [17] pH > 7	-0.93	-0.87984	-1.2522
	S^{2-}=S_{rombic}+H_2O + 2 e⁻; CRC2010 [1]	-0.4763	-0.4261	-0.7985
	HS⁻ + OH⁻ = S_{rombic} + 2H_2O + 2e⁻; CRC 2010 [1]	-0.478	-0.4793	-0.8517
	H_2S_{aq}+2H_2O=S_{rombic}+2H_3O^++2e⁻; CRC 2010 [1] Suchotina [17]	0.142	0.3467	-0.025735
	2$S_2O_3^{2-}$=$S_4O_6^{2-}$+2e⁻; Suchotina [17]	0.08	0.1817	-0.1907
Fe	Fe^{2+}=Fe^{3+}+e⁻; Suchotina [17]	0.769	0.8707	0.4983
	Fe(s)+ H_2O =Fe^{2+}+2e⁻; Suchotina [17]	-0.4402	-0.2870	-0.6594
Ag	Ag+ H_2O=Ag^++e⁻; Kortly, Shucha [18]	0.7994	1.00406	0.6327
	Ag(s)+Cl⁻=AgCl(s)+H_2O+e⁻; Kortly, Shucha [18]	0.2223	0.2210	-0.1514
	Ag+2NH_{3aq}=Ag(NH_3)$_2^+$+H_2O+e⁻; Suchotina [17]	0.373	0.57766	0.2053
	2Ag+2OH⁻ =Ag_2O(s)+H_2O+2e⁻; Suchotina [17]	0.345	0.49816	0.1258
Hg	$2\underline{Hg}$+H_2O=Hg_2^{2+}+2e⁻; Kortly, Shucha [18]	0.907	1.0602	0.6888
	$2\underline{Hg}$+2Cl⁻=$Hg_2Cl_{2(s)}$+2H_2O+2e⁻; Suchotina ; [17]	0.2676	0.2663	-0.1059
	$2\underline{Hg}$+SO_4^{2-}=$Hg_2SO_{4(s)}$+H_2O+2e⁻; Kortly, Shucha ; [18]	0.614	0.6642	0.2918
	Hg+2OH⁻=HgO+H_2O+2e⁻, Suchotina ; [17]	0.098	0.1482	-0.2242
I	3I⁻=I_3^-+2e⁻; Kortly, Shucha [18]	0.6276	0.72926	0.35687
Cu	Cu(Hg)+H_2O=Cu^{2+}+(Hg)+2e⁻; Kortly, Shucha [18]	0.3435	0.4967	0.1243
F	2F⁻=F_2(g)+2e⁻; Kortly, Shucha [18]	2.87	2.97166	2.5993
Cl	2Cl⁻=Cl_2(g)+2e⁻; Kortly, Shucha [18]	1.358	1.45966	1.0873
Cl	Cl_2(g)+4H_2O=2HOCl+2H_3O^++2e⁻; Kortly, Shucha [18]	1.63	1.93765	1.5653
Cr	2Cr^{3+}+21H_2O=$Cr_2O_7^{2-}$+14H_3O^++6e⁻;1<pH<7 [18]	1.33	1.7921	1.41975
	Cr^{3+}+11H_2O=$HCrO_4^-$+7H_3O^++3e⁻; pH>7 Kortly, Shucha [18]	1.20	1.6793	1.30692
	$\underline{Cr(OH)_3}$↓+5OH⁻=CrO_4^{2-}+4H_2O+3e⁻; pH>9 ; Suchotina [17]	-0.13	-0.1657	-0.53806
C	$H_2C_2O_4$+2H_2O=2CO_2+2H_3O^++2e⁻; pH<1,25 Suchotina [17]	-0.49	-0.2853	-0.6577
Cr	Cr+H_2O=Cr^{3+}+3e⁻; Suchotina [17]	-0.744	-0.60801	-0.97935
Zn	Zn+H_2O=Zn^{2+}+2e⁻; Kortly, Shucha [18]	-0.7628	-0.6096	-0.98098
Al	$\underline{Al}$+ H_2O=Al^{3+}+3e⁻; CRC [1]	-1.662	-1.5260	-1.8984
	$\underline{Al}$+4OH⁻= $H_2AlO_3^-$+H_2O+3e⁻; CRC[1]	-2.33	-2.2627	-2.63506

$\underline{H(Pt)}$ + OH⁻=H_2O +(Pt)+**e⁻**; CRC [1]

$E°_{H-OH}$=$E°$-0.0591/1*lg([H_2O]^1)+0.10166-0.37239=-0.8277-0.0591/1*lg(53.5^1)+0.10166-0.37239=-1.200576 V

$\Delta G_{Hess\_H(Pt)\_OH^-}$= G_{H2O}-($G_{(Pt)H}$+G_{OH-})=0-(**48.56**+77.36)=**-125.92** $^{kJ}/_{mol}$;

$\Delta G_{eqH\_OH^-}$=$E°_{H\_OH^-}$•F•1=**-1.2005757***96485*1=**-125.92** $^{kJ}/_{mol}$;

Corrected $E°_{H\_OH^-}$=$\Delta G_{eqH\_OH^-}$/F/1=**-125920**/96485/1=**-1.30507** V;

Correction $\Delta E°_{H\_OH^-}$=-(**1.30507**-1.2005757)=-0.10449 V on absolute potential scale synchronized on Alberty data at pH=7,36 of absolute free energy scale related to the zero free energy content of water G_{H2O}=0 $^{kJ}/_{mol}$.

Table 1. Standard potentials E° Nernst's and inverse half-reactions Data from [1-24]	Classic water disaccount 0	Thermodynamic. scale 0.10166 V	Absolute -0.37239
OH^- = HO+ e^- CRC	2.020	2.1217	1.750321
$4H_2O$=H_2O_{2aqua}+$2H_3O^+$+2 e^- Suchotina	1.776	2.0837	1.7113
H_2O_2+$2H_2O$=O^-_{2aqua}+$2H_3O^+$+e^- David Harris	1.276	1.4811	1.1087
$5H_2O$=O_{2aq}+4 H_3O^++4 e^-;	1.2288	1.4592	1.0868
HNO_2+$4H_2O$=NO_3^-+$3H_3O^+$+$2e^-$; pH<3.15 Kortly, Shucha	0.94	1.2477	0.8753
NO_2^-+$3H_2O$=NO_3^-+$2H_3O^+$+$2e^-$ David Harris [21]	0.835	1.09115	0.7188
Hydroquinone+$2H_2O$=p-quinone+$2H_3O^+$+$2e^-$	0.699	0.9041	0.5327
H_2O_{2aqua}+$2H_2O$=O_{2aqua}+$2H_3O^+$+$2e^-$ University Alberta	0.695	0.8992	0.5268
Fe^{2+}=Fe^{3+}+e^- University Alberta	0.769	0.8707	0.4983
Ubiquinol+$2H_2O$=Ubiquinone+$2H_3O^+$+$2e^-$	0.459	0.6638	0.2924
$Succinate^{2-}$+$2H_2O$=$Fumarate^{2-}$+$2H_3O^+$+$2e^-$	0.4447	0.6494	0.2780
BancylCoA+$2H_2O$=CrotonylCoA+$2H_3O^+$+$2e^-$	0.399	0.6038	0.2056
AscorbicAcid+$2H_2O$=$C_6H_6O_6$+$2H_3O^+$+$2e^-$ DC.Harris [22]	0.390	0.5947	0.1965
glycolate+$2H_2O$=Glyoxylate+H^-+H_3O^+ D.C.Harris	0.324	0.5287	0.1305
$C_6H_{12}O_6$+$42H_2O$=$24H_3O^+$+$6H_3O^+$+$6HCO_3^-$+$24e^-$;	-0.0491	0.2338	-0.1386
HOO^-+H_2O=O_{2aqua}+H_3O^++$2e^-$ Aris Kaksis	0.3155	0.4686	0.09625
Fe^{2+}=Cytochrome F Fe^{3+}+e^-David Harris	0.365	0.4667	0.0953
$[Fe^{II}(CN)_6]^{4-}$=$[Fe^{III}(CN)_6]^{3-}$+e^- University Alberta	0.356	0.4574	0.0860
$Malate^{2-}$+$2H_2O$=Oxalo-$acetate^{2-}$+$2H_3O^+$+$2e^-$	0.248	0.4528	0.0814
Fe^{2+}=Cytochrome a3 Fe^{3+}+e^-	0.350	0.4517	0.0803
$Lactate^-$ +H_2O=$Pyruvate^-$+H_3O^++H^-(H^++$2e^-$)$^-$	0.229	0.3823	0.0109
$FADH_2$+$2H_2O$=FADfree+$2H_3O^+$+$2e^-$;	0.195	0.3998	0.0284
CH_3COO^-+$2H_2O$=glycolate+H^-+H_3O^+; D.C.Harris	0.1605	0.3652	-0.00618
H_2S_{aq}+$2H_2O$=$S_{rhombic}$+$2H_3O^+$+$2e^-$; CRC 2010	0.142	0.3467	-0.025735
CH_3CH_2OH+H_2O=CH_3CHO+H_3O^++H^-(H^++2e-);	0.19	0,3432	-0,02923
Fe^{2+}=Cytochrome a Fe^{3+}+e^-	0.2900	0.3917	0.02032
$2GlutathSH$+$2H_2O$=GlutaS-Sthione+$2H_3O^+$+$2e^-$	0.1841	0.3888	0.01742
Fe^{2+}=Cytochrome c Fe^{3+}+e^-	0.2540	0.3557	-0.01568
LipSHSH+$2H_2O$=LipoicAcidS-S+$2H_3O^+$+$2e^-$	0.1241	0.3288	-0.04258
Fe^{2+}=Cytochrome c1 Fe^{3+}+e^-	0.2200	0.3217	-0.04968
β-OH $Butyrate^-$+$2H_2O$=$AcetoAcetate^-$+$2H_3O^+$+$2e^-$	0.0681	0.2728	-0.09858
$isocitrate^{2-}$+$2H_2O$=α-$Ketoglutarate^{2-}$+CO_2+$2H_3O^+$+2e-	0.0341	0.2388	-0.13258
Nernst's H_{2aq}+H_2O=$2H_3O^+$+$2e^-$; ΔG_{Hess_H3O+}=-58.36 $^{kJ}/_{mol}$	on graphite electrode oxidation		-0.302
Inverse: $2H_3O^+$+$2e^-$=H_{2aq}+H_2O; ΔG_{Hess_H2aq}=58.36 $^{kJ}/_{mol}$	on graphite electrode reduction		0.302
H_{2aq}=$2H(Pt)$+H_2O; $\Delta G_{sp\_H(Pt)}$=$2G_{H(Pt)}$+G_{H2O}-(G_{H2aq})=-6.12 $^{kJ}/_{mol}$	$K_{sp\_H(Pt)}$=$[H(Pt)]^2$*$[H_2O]$/$[H_{2aq}]$=11.8		
$H(Pt)$+H_2O=H_3O^++e^-; classic zero; at$[H_2SO_4]$=1 M, PH=0	0.0000	0.10166	-0.27072
Luciferin+OH^-=?luciferin+$CO_{2\ aqua}$+OH^-+$3H$($3H^+$+$3e^-$)+e^-	0	0.1017	-0.27073
Fe^{2+}=Cytochrome b Fe^{3+}+e^-	0.0770	0.1787	-0.1937
CH_3CHO+$3H_2O$=CH_3COOH+$2H_3O^+$+$2e^-$ Suchotina	-0.1180	0.1382	-0.2342
Glycaldeh3-P^{2-}+H_2O+HPO_4^{2-}=13$PGlycerate^{4-}$+H_3O^++H^-;	-0.1314	0.0218	-0.3506
NADPH=$NADP^+$+H^-(H^++$2e^-$);	-0.1170	-0,0153	-0,3877
NADH=NAD^++H^-(H^++2e-); David Harris	-0.1130	-0,0113	-0,3837
O^-_{2aqua}=O_{2aqua}+e- Suchotina	-0.2450	-0.1433	-0.5157
Ferredoxin Fe^{2+}=Ferredoxin Fe^{3+}+e^-	-0.4320	-0.3303	-0.7027
$C_6H_{12}O_6$+$4H_2O$=$2C_3H_4O_3$+$4H_3O^+$ + 4e^- Stryer	-0.5427	-0.3380	-0.7104
S^{2-}=$S_{rhombic}$+2 e^-; CRC 2010	-0.4763	-0.3746	-0.7470
HS^-+OH^-=$S_{rhombic}$+H_2O+$2e^-$; CRC 2010	-0.4780	-0.4278	-0.8002
$H(Pt)$+OH^-=H_2O+e^- [17] corrected (-0.8277+-0.10449)=	-0.9322	-0.9335	-1.3059
Ubiquinol6+$2H_2O$=Ubiquinone6+$2H_3O^+$+$2e^-$ CRC 2012	-1.0500	-0.8453	-1.2177

$\Delta G_{AlbertyH\_OH-}$=G_{H2O}-($G_{H(Pt)}$+G_{OH-})=0-(48.56+77.36)=-125.92 $^{kJ}/_{mol}$, E°$_H$=ΔG_{eq}/F/1=-125920/96485/1=-1.30508 V data corrected ΔG_{eqH_OH-}=E°$_{H\_OH-}$•F•1=-1.30508*96485*1=-125.92 $^{kJ}/_{mol}$ to E°$_H$=-0.8277-0.10556=-0.9322 V.

Table 2. Nernst's reactions Standard Electrodes Potentials classic, Thermodynamic and absolute Volts

	Reduced form = Oxidized form	H_2O disaccount classic zero E∘=0	Thermodynamic. scale E∘=0.10166 V	Absolut scale E° -0.37239 V
H	**H**(Pt) +H_2O=H_3O^+ +(Pt)+ **e⁻**; scale reference potential [1]	classic zero **0**	**0.10166**	-0.27072
N	NO_2^- + 2OH^-=NO_3^- + H_2O+**2e⁻**; pH>3.15 Suchotina [17]	0.01	0.0602	-0.3122
	HNO_2+4H_2O=NO_3^-+3H_3O^++**2e⁻**; pH<3.15 Kortly, Shucha	0.94	1.2477	0.8753
	NO_{aq}+4H_2O=HNO_3+3H_3O^++**3e⁻**; pH<1,4 Kortly, Shucha	0.96	1,19899	0,8266
	NH_4^++13H_2O=NO_3^-+10H_3O^++**8e⁻**; Suchotina [17]	0.87	1.1391	0.7667
Br	2Br^-=Br_2(aq)+**2e⁻**; CRC	1.0873	1.18896	0.8176
Bi	BiO^++6H_2O=BiO_3^-+4H_3O^++**2e⁻**; 1<pH<7 Suchotina [17]	1.80	2.21065	1.8393
Mn H⁺	Mn^{2+}+12H_2O=MnO_4^-+8H_3O^++**5e⁻**; Kortly, Shucha [18]	1.51	1.85885	1.4865
H_2O	$\underline{MnO_2}$↓+4OH^-=MnO_4^- + 2H_2O+**3e⁻**; Suchotina	0.603	0.6360	0.2636
OH⁻	MnO_4^{2-}=MnO_4^-+**e⁻**; Suchotina	0.558	0.65966	0.2873
Pb	Pb^{2+}+6H_2O=$\underline{PbO_2}$(s)+4H_3O^++**2e⁻**; Kortly, Shucha	1.455	1.86565	1.4933
S	H_2SO_{3aq}+3H_2O=HSO_4^-+3H_3O^++**2e⁻**;	0.172	0.47965	0.10726
	HSO_3^-+4H_2O=SO_4^{2-}+3H_3O^++**2e⁻**; Suchotina 2=<pH<7	0.172	0.47965	0.10726
	SO_3^{2-}+2OH^-=SO_4^{2-}+H_2O+**2e⁻**; Suchotina pH > 7	-0.93	-0.87984	-1.2522
	S^{2-}=S_{rombic}+H_2O + 2 e⁻; CRC2010	-0.4763	-0.4261	-0.7985
	H_2Saq+2H_2O=S_{rombic}+2H_3O^++2e⁻; CRC 2010: Suchotina	0.142	-0.4793	-0.8517
	2$S_2O_3^{2-}$=$S_4O_6^{2-}$+**2e⁻**; Suchotina	0.08	0.3467	-0.025735
Fe	Fe^{2+}=Fe^{3+}+**e⁻**; Suchotina [17]	0.769	0.8707	0.4983
	Fe(s)+ H_2O =Fe^{2+}+**2e⁻**; Suchotina	-0.4402	-0.2870	-0.6594
Ag	Ag+ H_2O=Ag^++**e⁻**; Kortly, Shucha [18]	0.7994	1.00406	0.6327
	Ag(s)+Cl^-=**AgCl**(s)+H_2O+e⁻; Kortly, Shucha	0.2223	0.2210	-0.1514
	Ag+2NH_{3aq}=Ag(NH_3)$_2^+$+**H_2O**+e⁻; Suchotina	0.373	0,57766	0,2053
	2Ag+2OH^- =**Ag_2O**(s)+H_2O+**2e⁻**; Suchotina	0.345	0,49816	0,1258
I	3I^-=I_3^-+**2e⁻**; Kortly, Shucha	0.6276	0.72926	0.35687
Cu	Cu(Hg)+H_2O=Cu^{2+}+(Hg)+**2e⁻**; Kortly, Shucha	0.3435	0.4967	0.1243
F	2F^-=F_2(g)+**2e⁻**; Kortly, Shucha	2.87	2.97166	2.5993
Cl	2Cl^-=Cl_2(g)+**2e⁻**; Kortly, Shucha	1.358	1.45966	1.0873
Cl	Cl_2(g)+4H_2O=2HOCl+2H_3O^++**2e⁻**; Kortly, Shucha	1.63	1.93765	1.5653
Cr	2Cr^{3+}+21H_2O=$Cr_2O_7^{2-}$+14H_3O^++**6e⁻**;1<pH<7 [18]	1.33	1.7921	1.41975
	Cr^{3+}+11H_2O=$HCrO_4^-$+7H_3O^++**3e⁻**; pH>7 Kortly, Shucha	1.20	1.6793	1.30692
	$\underline{Cr(OH)_3}$↓+5OH^-=CrO_4^{2-}+4H_2O+3e⁻; pH>9 ; Suchotina	-0.13	-0.1657	-0.53806
C	$H_2C_2O_4$+2H_2O=2CO_2+2H_3O^++**2e⁻**; pH<1.25 Suchotina [17]	-0.49	-0.2853	-0.6577
Cr	Cr+H_2O=Cr^{3+}+**3e⁻**; Suchotina	-0.744	-0.60801	-0.97935
Zn	Zn+H_2O=Zn^{2+}+**2e⁻**; Kortly, Shucha	-0.7628	-0.6096	-0.98098
H	**H**(Pt)+OH^-=H_2O+(Pt)+**e⁻**; corrected (-0.8277+-0.10449)=	-0.9322	-0.93375	-1.30508

Hess **zero** standard values of free elements on Biochemistry absolute free energy scale actually are positive. G_{H2gas}=**85.6** $^{kJ}/_{mol}$ [Alberty](#) referring to homeostasis products water and CO_{2gas} zero G_{H2O}=G_{CO2gas}=0 $^{kJ}/_{mol}$.
The free energy contents of the presented metabolites at homeostasis pH=7.36, which refers to zero values of water and CO_{2gas} gas on the energy scale, are:

Glucose $G_{C6H12O6}$=1978 $^{kJ}/_{mol}$ >deprotonate peroxide anion G_{HOO-}=333.9 $^{kJ}/_{mol}$ > G_{O2aqua}=330 $^{kJ}/_{mol}$>
> G_{O2gas}=303 $^{kJ}/_{mol}$> peroxide G_{H2O2}=279,3 $^{kJ}/_{mol}$>
> protolysis of water pH=pOH=7 $G_{H3O++OH-}$=G_{H3O+}+G_{OH}=22.44+77.36=99.8 $^{kJ}/_{mol}$>
> G_{NH3aq}=91.1 $^{kJ}/_{mol}$ > $G_{O2Biochem\_arterial}$=88.22 $^{kJ}/_{mol}$ > G_{H2gas}=85.6 $^{kJ}/_{mol}$ ≡ $G_{H2O\_Biochemistry}$=85.6 $^{kJ}/_{mol}$ >
> protolysis of CO_{2aqua} solution by Carbonic Anhydrase $G_{H3O+HCO3}$=G_{H3O+}+G_{HCO3-}=22.44+56.08=78.5 $^{kJ}/_{mol}$ >
> $G_{H2Saqua}$=53.4 $^{kJ}/_{mol}$ > G_{NH4+}=50.81 $^{kJ}/_{mol}$ > $G_{H(Pt)}$=48.56 $^{kJ}/_{mol}$ > G_{N2aqua}=18.7 $^{kJ}/_{mol}$ > $G_{CO2aqua}$=18.38 $^{kJ}/_{mol}$ >
> $G_{Srhombic}$=3.54 $^{kJ}/_{mol}$ > homeostasis products zero values G_{H2O}=G_{CO2gas}=0 $^{kJ}/_{mol}$ > G_{N2gas}=-9,55 $^{kJ}/_{mol}$;
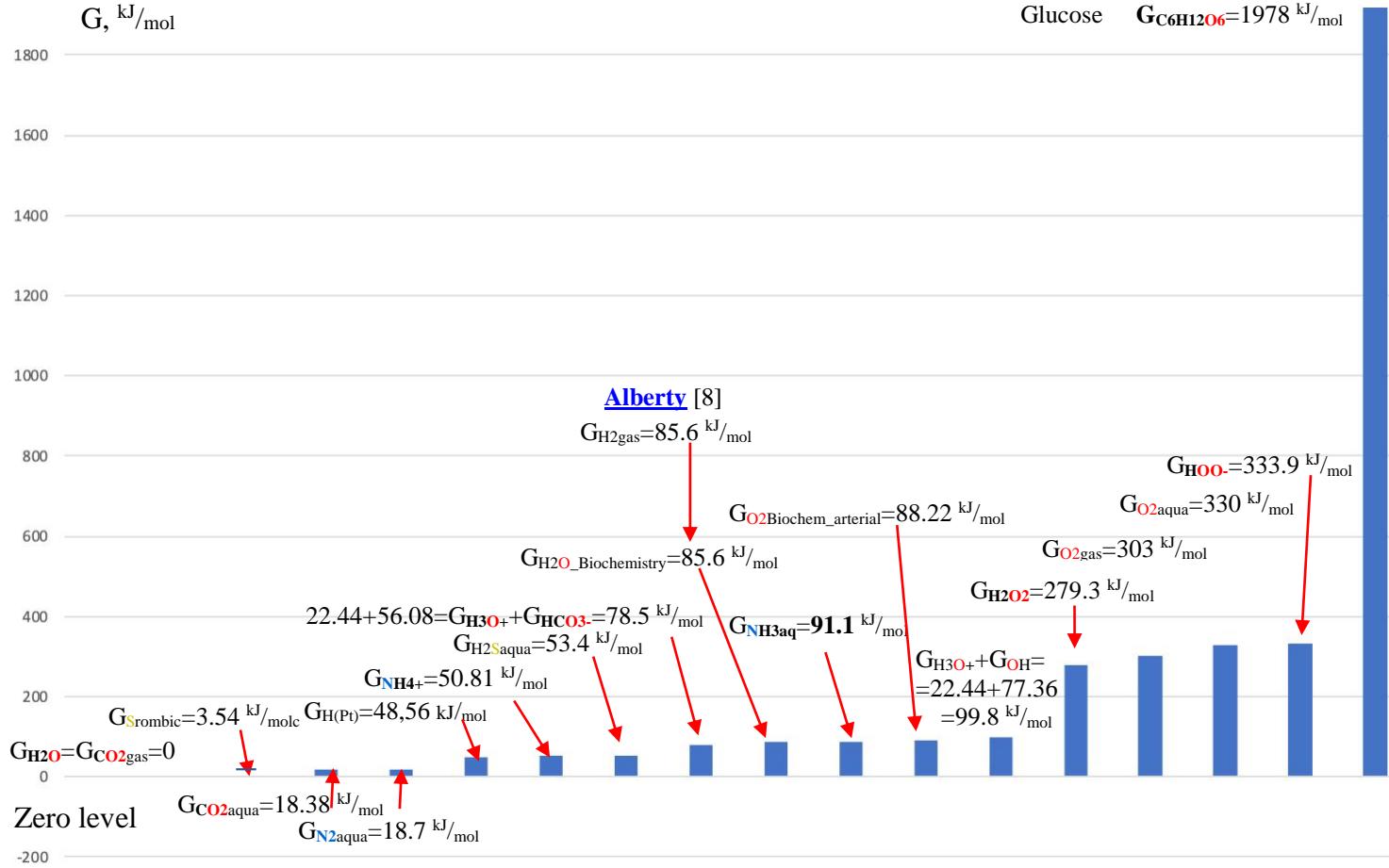
Figure 1. Ascending **Absolute** Free Energy of metabolites relative to G_{H2O}=G_{CO2gas}=0 $^{kJ}/_{mol}$ zero values. Discovery of **Absolute potential scale** is instrument coincident with **Absolute** Free Energy for sciences. The discovery in science of **Absolute Potentials scale** coincides with **Absolute** Free Energy meaning.

The water and hydroxonium disaccount in reactions including protolysis and electrochemistry Nernst's half reactions restrict the scientific studies of Thermodynamic, Physical Chemistry and Biochemistry. [8,14,15]

The thermodynamic property of **inversion** symmetry is a direct reaction between reactants and products that flips in the opposite direction, initially meaning products as reactants and leaving reactants as final products. Water to oxygen oxidation reduction $5H_2O$=O_{2aqua}+$4H_3O^+$+4e⁻Nernst's half reaction has **Absolute** standard **Potential**: $E°_{O2Absolute}$=1.0868 V. About O_{2aqua}+$4H_3O^+$+4e⁻=$5H_2O$ **inverse** reaction implication in **Absolute Potential** it has the same number with opposite sign -$E°_{O2Absolute}$= -1.0868 V negative.
Discovered the **Absolute Potential scale** for Nernst's or **inverse** reactions is coincident with **absolute** Free Energy property the **inverse** symmetry. [8, 14, 15] **Inverse symmetry** property of Nernst's or **inverse** reactions with **identical values** but with **opposite sign** manifests itself mutually in **Absolute Potential scale** with **Absolute** Free Energy is coincident thermodynamic property for protolytic, Nernst's half or **inverse** reaction. Corrected Thermodynamic standard potential reference of metal hydrogen 0.10166 Volts in few years give the impulse for sciences get **Absolute** thermodynamic values Free Energy of elements and molecules. Behalf of Alberty given data about Hydrogen **Absolute** Free Energy G_{H2gas}=**85.6** $^{kJ}/_{mol}$, G_{H2aqua}=**103** $^{kJ}/_{mol}$ is detected

Absolute standard **Potential** as general reference of hydrogen electrode $E°_H=-0.27073$ Volts. Table 1. presents 50 in Biochemistry used Nernst's oxidation half and reduction **inverse** reactions.

In three columns we can observe the development hydrogen general reference scale from classic zero $E°_H=0$ V with water disaccount. Accounting the water and hydroxonium cation corrected the general hydrogen thermodynamic standard potential scale reference to $E°_H=0.10166$ Volts. Third Alberty data finally lead to **Absolute** standard **Potential** value $E°_H=-0.27073w$ Volts of hydrogen electrode.

H_2O_2 formation 41st page $H_{2gas}+O_{2gas}=>H_2O_2$; $\Delta G°_{UnivAlberta}=-134.03$ $^{kJ}/_{mol}$; $\Delta G°_{Alberty}=-48.39$ $^{kJ}/_{mol}$;

$\Delta G_{Alberty}=G_{H2O2}-(G_{O2gas}+G_{H2gas})= 284-(85.64+303)=-104.64$ $^{kJ}/_{mol}(-134.03$ $^{kJ}/_{mol};)(=-48.39$ $^{kJ}/_{mol})$

Viela	$\Delta H°_H$ $^{kJ}/_{mol}$	$\Delta S°_H$ $^{J}/_{mol/K}$	$\Delta G°_H$ $^{kJ}/_{mol}$
H_2O_{2aqua}	**-191.99**	**-481.688**	**-48.39**
H_2O_{2aqua}	-191.17	143.9	-134.03
$Succinat^{2-}$	**-908.69**	**-1295.576**	**-522.414**
$Fumarate^{2-}$	**-776.56**	**-862.288**	**-519.4688**

$G_{H2O2}=279,29$ $^{kJ}/_{mo}$ Alberty zero $G_{H2O}=0$ $^{kJ}/_{mol}$; reference University Alberta

$G_{SuccinatFor}=-522.4+(4*91.26+2*85.6+2*303)=619.8$ $^{kJ}/_{mol}$;
$G_{Succinat}=650.8$ $^{kJ}/_{mol}$;
$G_{FumaricFor}=-519.5+(4*91.26+85.6+2*303)=537.1$ $^{kJ}/_{mol}$;
$G_{Fumarat}=554.75$ $^{kJ}/_{mol}$;

$Succinat^{2-}$ Formation $4C+2H_{2gas}+2O_{2gas}=>(CH_2)_2(CO_2^-)(CO_2^-)$; $\Delta G_{Succinat}=-522.4$ $^{kJ}/_{mol}$ Alberty;

$\Delta G_{SuccinatFor}=G_{SuccinatFor}-(4G_{Cgraph}+2*G_{H2gas}+2*G_{O2gas})= -522.4$ $^{kJ}/_{mol}$;
$G_{SuccinatFor}=-522.4+(4*91.26+2*85.6+2*303)=619.8$ $^{kJ}/_{mol}$;

$Fumarate^{2-}$ Formation $4C+H_{2gas}+2O_{2gas}=>(CH)_2(CO_2^-)(CO_2^-)$; $\Delta G_{Fumarat}=-519.5$ $^{kJ}/_{mol}$ Alberty;

$\Delta G_{Fumarat}=G_{FumaratFor}-(4G_{Cgraph}+G_{H2gas}+2*G_{O2gas})= -519.5$ $^{kJ}/_{mol}$;
$G_{FumaratFor}=-519.5+(4*91.26+85.6+2*303)=537.1$ $^{kJ}/_{mol}$; formation 73rd page

Inverse $O_{2aqua}+2H_3O^++2e^-=H_2O_{2aqua}+2H_2O$; standard potential $E°_{OxO2\_H2O2}=-0.5278$ V University Alberta ;
$\Delta G_{AlbertyHessOxO2\_H2O2}=G_{H2O2}+2*G_{H2O}-(G_{O2aqua}+2*G_{H3O+})=279,29+2*0-(330+2*22.44)=-95.59$ $^{kJ}/_{mol}$;
$\Delta G_{eqAlbertyAbsoluteOxO2\_H2O2}=E°_{eqOxO2\_H2O2}•F•1•2=-0.5278*96485*2=-101,85$ $^{kJ}/_{mol}$;

$Succinat^{2-}+O_{2aqua}=>fumarate^{2-}+H_2O_{2aqua}+Q+\Delta G$; $\Delta G_{min}=\Delta G_{eqSuccinat\_H2O2}=-38.3$ $^{kJ}/_{mol}$;
$\Delta G_{Hess}=\Delta G°_{H2O2}+\Delta G°_{fumarat}-\Delta G°_{O2}-\Delta G°_{Succinat}=-48.39-519.4688-(16.4-522.414) = -61.845$ $^{kJ}/_{mol}$;
$\Delta G_{min}=\Delta G_{eq}=(E°_{RedSuccinate}-E°_{OxO2})*F*n=(0.2512-0.4495)*96485*2=(-0.1983)* 96485*2=-38.3$ $^{kJ}/_{mol}$;
Alberty Hess $\Delta G_{Succinat\_H2O2}=G_{Fumarat}+G_{H2O2}-(G_{Succinat}+G_{O2aqua})=537.1+279,29.24-(619.8+330)=-128.5$ $^{kJ}/_{mol}$;
$K_{eq}=exp(-\Delta G_{eq}/R/T)=exp(38270/8.3144/298.15)=5065991$ spontaneous 58th page

The concepts of **Absolute** thermodynamic parameters temperature, free energy and potentia. are **absolutely** reciprocal tools for revealing the structural details of parallel and sequential complex reactions by exploiting inversion symmetry properties.

1. Absolute temperature T in Kelwin degree is standard value 298.15 K (25 ° C),

Lord Kelvin

2. On Alberty based **Absolute** free energy content

$G_{H2gas}=85.6$ $^{kJ}/_{mol}$ for hydrogen gas, it's solution in water $G_{H2aqua}=103$ $^{kJ}/_{mol}$ and

for metal hydrogen $G_{H(Pt)}=48,46$ $^{kJ}/_{mol}$

referring to zero reference $G_{H2O}=G_{CO2gas}=0$ $^{kJ}/_{mol}$ as background

in water and carbon dioxide gas CO_{2gas}.

Alberty Robert

3. Discovery **Absolute Potential** scale.
Absolute Potential scale based on a general reference
of metal hydrogen **Absolute** standard **Potential** $E°_H=-0.2965$ Volts. [8, 14, 15]
feasible

CH₃CH₂OH ethanol formation from elements:

$$2C+3H_{2gas}+1/2O_{2gas}=>CH_3CH_2OH \; ; \; \Delta G^\circ_{Alberty}=75.2864 \, ^{kJ}/_{mol} \; ; \; \Delta G^\circ_{HessCRC}=-181 \, ^{kJ}/_{mol} \; ;$$

$$\Delta G^\circ_{Alberty}=G_{CH3CH2OH}-(2G_{Cgraph}+3*G_{H2gas}+1/2*G_{O2gas})=75.2864 \, ^{kJ}/_{mol} \; ;$$

$$\Delta G^\circ_{CRC}=G_{CH3CH2OH}-(2G_{Cgraph}+3*G_{H2gas}+1/2*G_{O2gas})=-181 \, ^{kJ}/_{mol} \; ;$$

$$\Delta G^\circ_{Alberty}+(2G_{Cgraph}+3*G_{H2gas}+1/2*G_{O2gas})=75.2864 +(2*91.26+3*85.6+1/2*303)=G_{CH3CH2OH}=666.106 \, ^{kJ}/_{mol} \; ;$$

$$\Delta G^\circ_{CRC}+(2G_{Cgraph}+3*G_{H2gas}+1/2*G_{O2gas})=-181+(2*91.26+3*85.6+1/2*303)=G_{CH3CH2OH}=409.82 \, ^{kJ}/_{mol} \; ;$$
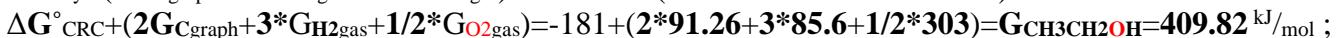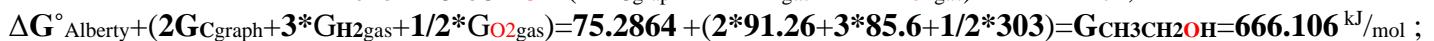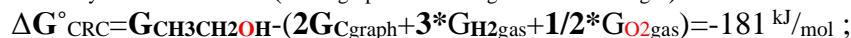
CH₃CHO acetaldehyde formation from elements: $2C+2H_{2gas}+1/2O_{2gas}=>CH_3CHO$;

$$\Delta G^\circ_{Alberty}=G_{CH3CHO}-(2G_{Cgraph}+2*G_{H2gas}+1/2*G_{O2gas})=32.282 \, ^{kJ}/_{mol} \; ;$$

$$\Delta G^\circ_{CRC}=G_{CH3CHO}-(2G_{Cgraph}+2*G_{H2gas}+1/2*G_{O2gas})= 24.06 \, ^{kJ}/_{mol} \; ;$$

$$\Delta G^\circ_{Alberty}+(2G_{Cgraph}+2*G_{H2gas}+1/2*G_{O2gas})=32.282+(2*91.26+2*85.6+1/2*303)=G_{CH3CHO}=537.5 \, ^{kJ}/_{mol} \; ;$$

$$\Delta G^\circ_{CRC}+(2G_{Cgraph}+2*G_{H2gas}+1/2*G_{O2gas})=24.06+(2*91.26+2*85.6+1/2*303)=G_{CH3CHO}=529.28 \, ^{kJ}/_{mol} \; ;$$
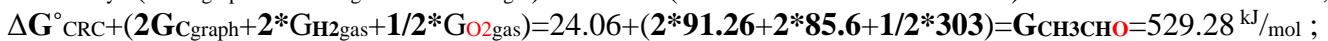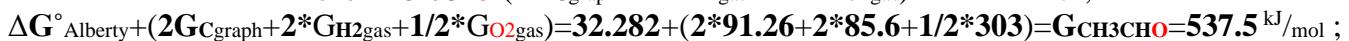
CH₃CH₂OH+H₂O=CH₃CHO+H₃O⁺+H⁻(H⁺+2e⁻); absolute potential **E°CH3CH2OH**=-0.055 V; Kortly, Shucha; [19]

$$\Delta G_{eqCH3CH2OH}=E^\circ_{eqNernsCH3CH2OH}\bullet F\bullet 2=-0.055*96485*2=-10.6 \, ^{kJ}/_{mol};$$

$$\Delta G_{HessCH3CH2OH}=G_{CH3CHO} +G_{H3O+}+G_{H-}-(G_{CH3CH2OH} +G_{H2O})=537.5+22.44+G_{H-}-(409.82+0)=-10.6 \, ^{kJ}/_{mol}.$$

$$\Delta G_{HessCH3CH2OH}=G_{CH3CHO} +G_{H3O+}+G_{H-}-(G_{CH3CH2OH} +G_{H2O\_Biochem})=537.5+22.44+G_{H-}-(409.82+85.64)=-10.6 \, ^{kJ}/_{mol}.$$

$$\Delta G_{HessCH3CH2OH}-G_{CH3CHO} -G_{H3O+}+(G_{CH3CH2OH} +G_{H2O})=G_{H-}=-10.6-537.5-22.44+(409.82+0)=-160.7 \, ^{kJ}/_{mol}.$$

$$\Delta G_{HessCH3CH2OH}-G_{CH3CHO} -G_{H3O+}+(G_{CH3CH2OH} +G_{H2O\_Biochem})=G_{H-}=-10.6-537.5-22.44+(409.82+85.64)=-75.08 \, ^{kJ}/_{mol}.$$

Substance	ΔH°H kJ/mol	ΔS°H J/mol/K	ΔG°H kJ/mol	
H₃C-CH=O	-212.23	-281.84	24.06	CRC Handbook of Chemistry and Physics 2010 90th David R. Lide
H₃C-CH=O	**-213.88**	**-825.64**	**32.2824**	**GCH3CHO=529.28 kJ/mol ;**
NADH	**-41.41**	**-4465.708**	**1175.5732**	**GCH3CHO=537.5 kJ/mol ;**
NADH	-1036.66	-140.50	1120.09	BioThermodynamic06;
H₃O⁺	-285.81	-3.854	-213.275	
NAD⁺	**-10.30**	**-3766.008**	**1112.534**	BioThermodynamic,2006,Massachusetts Tecnology Institute
NAD⁺	-1007.48	-183	1059.11	
H₃CCH₂OH	**-290.77**	**-1227.764**	**75.2864**	Alberty **GCH3CH2OH=666.106 kJ/mol ;**
H₃CCH₂OHaq	-288.3	-357.7394	-181.64	CRC **GCH3CH2OH=409.82 kJ/mol ;**
H₂O	-285.85	69.9565	-237.191	**GH2O=0 kJ/mol; GH-=-10.6-537.5-22.44+(409.82+0)=-160.7 kJ/mol.**
H₂O	**-286.65**	**-453.188**	**-151.549**	GH2O_Biochem=**85.64** kJ/mol. GH-=**-10.6-537.5-22.44+(409.82+85.64)=-75.08** kJ/mol

NADH = NAD⁺ + H⁻(H⁺+2e⁻); inverse potential -**E°NADH**=0.4095 V; absolute David Harris; [22]

NAD⁺+H⁻(H⁺+2e⁻)+CH₃CH₂OH+H₂O=NADH+CH₃CHO+H₃O⁺+H⁻(H⁺+2e⁻);

NAD⁺+CH₃CH₂OH+H₂O=NADH+CH₃CHO+H₃O⁺;
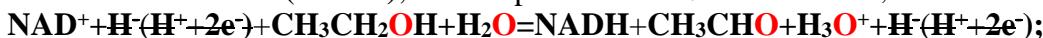
sum: **E°eqNernsCH3CH2OH-E°NAD+**=-0,055+0,4095=**0,4562**;

$$\Delta G_{min}=\Delta G_{eq}=(E^\circ_{eqNernsCH3CH2OH}-E^\circ_{NAD+})*F*n=(-0.055+0.4095)*96485*2=(0.4562)* 96485*2=68.408 \, ^{kJ}/_{mol};$$

$$\Delta G_{HessAlbertyCH3CH2OH}=G_{NADH}+G_{H3O+}+G_{CH3CHO}-(G_{NAD+}+G_{CH3CH2OH}+G_{H2O})=\underline{68.02 \, ^{kJ}/_{mol}.}$$

$$=\underline{1112.534+22.44+32.282-(1175.5+75.2864-151.549)=68.02 \, ^{kJ}/_{mol}.}$$

$H_3CHC(OH)COO^- + H_2O => H_3CC=OCOO^- + H_3O^+ + H^-(H^+ + 2e^-); E°_{H_3CHC(OH)COO} = -0.0159$ V;

$\Delta G_{eqH_3CHC(OH)COO} = E°_{eqH_3CHC(OH)COO} \bullet F \bullet 2 = -0.0159*96485*2 = -3.068$ $^{kJ}/_{mol}$;

$\Delta G_{HessCH_3CH_2OH} = G_{H_3CC=OCOO} + G_{H_3O+} + G_{H-} - (G_{H_3CHC(OH)COO} + G_{H_2O}) = 534.2 + 22.44 + G_{H-} - (668.8+0) = -3.068$ $^{kJ}/_{mol}$.

$\Delta G_{HessCH_3CH_2OH} = G_{H_3CC=OCOO} + G_{H_3O+} + G_{H-} - (G_{H_3CHC(OH)COO} + G_{H_2O\_Biochem}) = 534.2 + 22.44 + G_{H-} - (668.8+85.64) = -3.068$ $^{kJ}/_{mol}$.

$\Delta G_{HessCH_3CH_2OH} - G_{H_3CC=OCOO} - G_{H_3O+} + (G_{H_3CHC(OH)COO} + G_{H_2O}) = G_{H-} = -3.068 - 534.2 - 22.44 + (668.8+0) = 109.092$ $^{kJ}/_{mol}$.

$\Delta G_{HessCH_3CH_2OH} - G_{H_3CC=OCOO} - G_{H_3O+} + (G_{H_3CHC(OH)COO} + G_{H_2O\_Biochem}) = G_{H-} = -3.068 - 534.2 - 22.44 + (668.8+85.64) = 194.7$ $^{kJ}/_{mol}$.

I=0.25 M, **BioTherm06**, pH=7.36, $\Delta G_H = G°_{H_3CC=OCOO} - + G°_{H_3O+} + G_{H-} - G_{H_3CHC(OH)COO} - G_{H_2O} =$ $^{kJ}/_{mol}$;

Viela	$\Delta H°_H$ $^{kJ}/mol$	$\Delta S°_H$ $^{J}/mol/K$	$\Delta G°_H$, $^{kJ}/mol$;
PyruvEnolP³⁻	-1400	-1100	-1189.73
$H_3CC=OCOO^-$	-597.4	-850	-350.78
$H_3CC=OCOO^-$	-603.7	-433.54	-474.44
$H_3CC=OCOO^-$	**-597.04**	**-846.66**	**-344.62**
H_3O^+	-285.81	-3.854	-213.275
H_2O	-285.85	69.9565	-237.191
H_2O	**-286.65**	**-453.188**	**-151.549**
$H_3CHC(OH)COO^-$	**-688.29**	**-1290.9**	**-303.4**

$G_{H_2O}=0$ $^{kJ}/_{mol}$; $G_{H-} = -3.068 - 534.2 - 22.44 + (668.8+0) = 109.092$ $^{kJ}/_{mol}$

$G_{H_2O\_Biochem} = 85.64$ $^{kJ}/_{mol}$; $G_H = -3.068 - 534.2 - 22.44 + (668.8+85.64) = 194.7$ $^{kJ}/_{mol}$

$G_{H_3CHC(OH)COO} = 534.2$ $^{kJ}/_{mol}$; $pK_a = 2.5$;

$G_{H_3CHC(OH)COO} = 668.8$ $^{kJ}/_{mol}$; $pK_a = 3.86$;

$pK_a = 3.86$; $\Delta H_c° = 1361.9$ $^{kJ}/_{mol}$; $G_{H_3CHC(OH)COOH} = 2271$ $^{kJ}/_{mol}$; $H_3CHC(OH)COOH + 3O_{2gas} = 3CO_{2gas} + 3H_2O$;

$\Delta H_c° = 3G_{CO_{2gas}} + 3G_{H_2O} - (G_{H_3CHC(OH)COOH} + 3G_{O_{2gas}}) = 3*0 + 3*0 - (G_{H_3CHC(OH)COOH} + 3*303) = 1361.9$ $^{kJ}/_{mol}$;

$G_{H_3CHC(OH)COOH} + = 3G_{CO_{2gas}} + 3G_{H_2O} - (3G_{O_{2gas}}) = 3*0 + 3*0 - (+3*303) - 1361.9 = G_{H_3CHC(OH)COOH} = 2271$ $^{kJ}/_{mol}$;

Lactic acid Formation 71st page $3C + 3H_{2gas} + 1.5O_{2gas} => H_3CHC(OH)COOH$; $G_{H_3CHC(OH)COOH} = -303.4$ $^{kJ}/_{mol}$ [8];

$\Delta G_{H_3CHC(OH)COOH} = G_{H_3CHC(OH)COOH} - (3G_{Cgraph} + 3*G_{H_2gas} + 1.5*G_{O_2gas}) = -303.4$ $^{kJ}/_{mol}$;

$G_{H_3CHC(OH)COOH} = -303.4 + (3*91.26 + 3*85.6 + 1.5*303) = 681.7$ $^{kJ}/_{mol}$;

Lactic acid $H_3CHC(OH)COOH + H_2O <=> H_3CHC(OH)COO^- + H_3O^+$; $pK_a = 3.86$;

$K_{eq} = [H_3CHC(OH)COO^-]*[H_3O^+]/[H_3CHC(OH)COOH]/[H_2O] = K_a/[H_2O] = 10^{(-3.86)}/55.3 = 10^{(-5.603)}$;

$\Delta G_{eqH_3CHC(OH)COOH} = -R \bullet T \bullet ln(K_{aeq}) = -8.3144*298.15*ln(10^{(-5.603)})/1000 = 31.98$ $^{kJ}/_{mol}$.

$\Delta G_{H_3CHC(OH)COO} = G_{H_3CHC(OH)COO} + 2G_{H_3O+} - (G_{LacticAc} + 2G_{H_2O}) = G_{Succinat} + 2*22.44 - (681.7 + 2*0) = 31.98$ $^{kJ}/_{mol}$;

$G_{H_3CHC(OH)COO} = \Delta G_{H_3CHC(OH)COO} - 2G_{H_3O+} + (G_{LacticAc} + 2G_{H_2O}) = 31.98 - 2*22.44 + (681.7 + 2*0) = 668.8$ $^{kJ}/_{mol}$;

Pyruvic acid⁻ Formation 71st page $3C + 2H_{2gas} + 1.5O_{2gas} => H_3CC=OCOOH$; $\Delta G_{Succinat} = -344.62$ $^{kJ}/_{mol}$ Alberty;

$\Delta G_{Fumarat} = G_{Fumarat} - (3G_{Cgraph} + 2G_{H_2gas} + 1.5*G_{O_2gas}) = -344.62$ $^{kJ}/_{mol}$;

$G_{Fumarat} = -344.62 + (3*91.26 + 2*85.6 + 1.5*303) = 554.86$ $^{kJ}/_{mol}$; ;

Pyruvic acid $H_3CC=OCOOH + H_2O <=> H_3CHC(OH)COO^- + H_3O^+$; $pK_a = 2.5$;

$K_{eq} = [H_3CHC(OH)COO^-]*[H_3O^+]/[H_3CC=OCOOH]/[H_2O] = K_a/[H_2O] = 10^{(-2.5)}/55.3 = 2.5*10^{(-6)} = 10^{(-4.243)}$;

$\Delta G_{eqH_3CC=OCOOH} = -R \bullet T \bullet ln(K_{aeq}) = -8.3144*298.15*ln(10^{(-4.243)})/1000 = 24.22$ $^{kJ}/_{mol}$.

$\Delta G_{H_3CHC(OH)COO} = G_{H_3CHC(OH)COO} + 2G_{H_3O+} - (G_{LacticAc} + 2G_{H_2O}) = G_{Succinat} + 2*22.44 - (554.86 + 2*0) = 24.22$ $^{kJ}/_{mol}$;

$G_{H_3CHC(OH)COO} = \Delta G_{H_3CHC(OH)COO} - 2G_{H_3O+} + (G_{LacticAc} + 2G_{H_2O}) = 24.22 - 2*22.44 + (554.86 + 2*0) = 534.2$ $^{kJ}/_{mol}$;

NADH = NAD⁺ + H⁻(H⁺+2e⁻); E°_{NADH} = -0.4095 V; absolute Lehninger; [6]⁻

Red lactate⁻ $+ H_2O <=>$ pyruvate⁻ $+ H_3O^+ + H^-$($H^+ + 2e^-$) ; absolute potential $E°_{H_3CHC(OH)COO} = -0.0159$ V;

Ox $NAD^+ + H^-(2e^-) = NADH$; $E°^1 = -0.4095$ V; OksRed $NAD^+ + lactate^- + H_2O = NADH + pyruvate^- + H_3O^+$;

Balanced **n=2=m** with **2e⁻** electrons $\Delta E°$ **NAD⁺ accept** electrons from **lactate**:

$\Delta G_{eqAerobic} = \Delta E° \bullet F \bullet n = (E°_{Red} - E°_{Ox})*F*n = (-0.0159 - 0.4095)*96485*2 = (0.3936)*2 = 75.95$ $^{kJ}/mol$

$K_{eqAerobic} = EXP(-\Delta G_{eqAerobic}/R/T) = EXP(-75950/8.3144/298.15) = 10^{-13.3}$;

$$K_{eqAerobic} = \frac{[NADH] \cdot [pyruvate^-] \cdot [H_3O^+]}{[NAD^+] \cdot [lactate^-] \cdot [H_2O]} = e^{-\frac{\Delta G_{eqAerobic}}{R \bullet T}} = e^{-\frac{759500}{8.314 \bullet 298.15}} = 10^{-13.3};$$

$\Delta G_{Hess} = \Delta H_{Hess} - T*\Delta S_{Hess} = 45.764 - 298.15*-0.5479605 = 209.14$.......$^{kJ}/mol$ **endoergic**; [formation](#) 62nd , 75th pages

Pyruvate $H_3CC=OCOO^-$ decarboxylation $H_3CCHO+HCO_3^{-}$; $H_3CC=OCOO^-+H_2O\Delta G+Q=>H_3CCHO+HCO_3$

Lactate $+H_2O$=Ethanol $+HCO_3^-$ $+\Delta G$ $+Q;$ exothermic, exoergic .
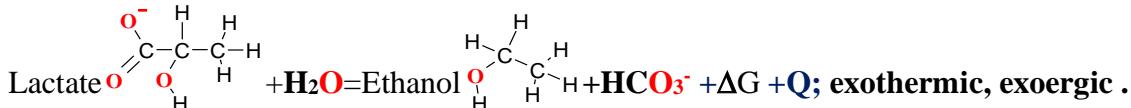
$\Delta G_{Hess}=\Delta G°_{H3CCH2OH}+\Delta G°_{HCO3}-\Delta G°_{H2O}-\Delta G°_{H3CCH2OHCOO-}=$ **75.2864-544.9688-(-151.549-303.4256)**=**-14.71** $^{kJ}/_{mol}$

$\Delta G_{Alberty}=\Delta G_{H3CCH2OH}+\Delta G_{HCO3}-\Delta G_{H2O}-\Delta G_{H3CCH2OHCOO-}=$**666.1+46.08-(0+668.8)**=**43.38** $^{kJ}/_{mol}$

$\Delta G_{Alberty\_Biochem}=\Delta G_{H3CCH2OH}+\Delta G_{HCO3}$ $G_{H2O\_Biochem}-\Delta G_{H3CCH2OHCOO-}=$**666.1+46.08-(85.64+668.8)**=**-42.26** $^{kJ}/_{mol}$

$\Delta H_{Hess}=\Delta H°_{H3CCH2OH}+\Delta H°_{HCO3}-\Delta H°_{H2O}-\Delta H°_{H3CCH2OHCOO-}=$**-290.77-692.4948-(-286.65-688.29)**= **-8.325** $^{kJ}/_{mol}$

$\Delta S_{dispersed}=-\Delta H_{Hess}/T=$**8.325**/298.15=**27.9** $^{J}/_{K/mol}$;

$\Delta S_{Hess}=\Delta S°_{H3CCH2OH}+\Delta S°_{HCO3}-\Delta S°_{H2O}-\Delta S°_{H3CCH2OHCOO-}=$ **21.51** $^{J}/_{mol/K}$;

=**-1227.764-494.768-(-453.188-1290.852)**=**21.51** $^{J}/_{mol/K}$....

$\Delta S_{total}=\Delta S_{Hess}+\Delta S_{dispersed}=$**21.51+27.9=49.41** $^{J}/_{mol/K}$;

$\Delta G_{Hess}=\Delta H_{Hess}-T*\Delta S_{Hess}=$**-8.325**-298.15*0.02151=**-14.738** $^{kJ}/_{mol}$ **exoergic**......

$T•\Delta S_{total}=$ **0.04941***298.15 K=**14.73** $^{kJ}/_{mol}$; bound $T\Delta Sn$;<u>dispersed-lost energy</u> **spontaneous**

Lactic acid Formation 71st page $3C+3H_{2gas}+1.5O_{2gas}=>H_3CHC(OH)COOH$; $G_{H3CHC(OH)COOH}=$**-303.4** $^{kJ}/_{mol}$ [8];

$\Delta G_{H3CHC(OH)COOH}=G_{H3CHC(OH)COOH}-($**3$G_{Cgraph}$+3*$G_{H2gas}$+1.5*$G_{O2gas}$**)= **-303.4** $^{kJ}/_{mol}$;

$G_{H3CHC(OH)COOH}=$**-303.4**+(**3*91.26+3*85.6+1.5*303**)=**681.7** $^{kJ}/_{mol}$;

Lactic acid $H_3CHC(OH)COOH+H_2O<=>H_3CHC(OH)COO^-+H_3O^+$; p$K_a$=3.86;

$K_{eq}=[H_3CHC(OH)COO^-]*[H_3O^+]/[H_3CHC(OH)COOH]/[H_2O]=K_a/[H_2O]=10^{\wedge(-3.86)}/55.3=10^{\wedge(-5.603)}$;

$\Delta G_{eqH3CHC(OH)COOH}=-R•T•ln(K_{aeq})=-8.3144*298.15*ln(10^{\wedge(-5.603)})/1000=$**31.98** $^{kJ}/_{mol}$.

$\Delta G_{H3CHC(OH)COO}=G_{H3CHC(OH)COO}+2G_{H3O+}-(G_{LacticAc}+2G_{H2O})=G_{Succinat}+2*22.44-(681.7+2*0)=$ **31.98** $^{kJ}/_{mol}$;

$G_{H3CHC(OH)COO}=\Delta G_{H3CHC(OH)COO}-2G_{H3O+}+(G_{LacticAc}+2G_{H2O})=$**31.98**-2*22.44+(**681.7+2*0**)=**668.8** $^{kJ}/_{mol}$;

CH_3CH_2OH ethanol formation from elements:

$2C+3H_{2gas}+1/2O_{2gas}=>CH_3CH_2OH$; $\Delta G°_{Alberty}=$**75.2864** $^{kJ}/_{mol}$; $\Delta G°_{HessCRC}=$-181 $^{kJ}/_{mol}$;

$\Delta G°_{Alberty}=G_{CH3CH2OH}-($**2$G_{Cgraph}$+3*$G_{H2gas}$+1/2*$G_{O2gas}$**)=**75.2864** $^{kJ}/_{mol}$;

$\Delta G°_{CRC}=G_{CH3CH2OH}-($**2$G_{Cgraph}$+3*$G_{H2gas}$+1/2*$G_{O2gas}$**)=-181 $^{kJ}/_{mol}$;

$\Delta G°_{Alberty}+($**2G_{Cgraph}+3*G_{H2gas}+1/2*G_{O2gas}**)= **75.2864** +(**2*91.26+3*85.6+1/2*303**)=$G_{CH3CH2OH}$=**666.106** $^{kJ}/_{mol}$;

$\Delta G°_{CRC}+($**2G_{Cgraph}+3*G_{H2gas}+1/2*G_{O2gas}**)=-181+(**2*91.26+3*85.6+1/2*303**)=$G_{CH3CH2OH}$=**409.82** $^{kJ}/_{mol}$;

Substance	$\Delta H°_H$ $^{kJ}/_{mol}$	$\Delta S°_H$ $^{J}/_{mol/K}$	$\Delta G°_H$ $^{kJ}/_{mol}$
$H_3CCH(OH)COO^-$	**-688.29**	**-1290.852**	**-303.4256**
$H_3CCH(OH)COO^-$	-686.2	-557.71	-313.70
$H_3CCH_2OH_{aq}$	**-290.77**	**-1227.764**	**75.2864**
$H_3CCH_2OH_l$	-277.6	160.7	62.96
H_2O	-285.85	69.9565	-237.191
H_2O	**-286.65**	**-453.188**	**-151.549**
HCO_3^-	-689.93	98.324	-586.94
HCO_3^-	**-692.4948**	**-494.768**	**-544.9688**

BioThermodynamics06; $G_{H2O\_Biochem}=$**85.64** $^{kJ}/_{mol}$;

$(G_{H3O+}+G_{HCO3-})=$**22.44+46.08** $^{kJ}/_{mol}$;

CRC 2010;

$\Delta S_{Hess}=\Sigma\Delta S°_{products}-\Sigma\Delta S°_{reactants}$;$\Delta G_{Hess}=\Delta H_{Hess}-T•\Delta S_{Hess}$

Lactate $+H_2O$=Ethanol $+HCO_3^-$ $+\Delta G$ $+Q$

exothermic..

Oks: $H_2COHCOO^- + H^-(H^+ + 2e^-) + H_3O^+ => H_3CCOO^- + 2H_2O$; $E°_{OxH2COHCOO} = -0.033$ V absolute; [23]

Oks: Glycolate $\overset{H}{\underset{H}{C}}\text{—}C\overset{O}{\underset{O^-}{}}$ + NADH + H_3O^+ => acetate $\overset{H}{\underset{H}{C}}\text{—}C\overset{O}{\underset{O^-}{}}$ + $2H_2O$ + NAD^+;

$\Delta G_{Hess} = \Delta G°_{CH3COO} + \Delta G°_{NAD+} + 2\Delta G°_{H2O} - \Delta G°_{H2COHCOO} - \Delta G°_{NADH} - \Delta G°_{H3O} = -161.8$ kJ/mol;
$= -240.963 + 1112.534 - 2*237.191 - (-403.2968 + 1175.5732 - 213.2746) = -161.8$ kJ/mol **exoergic**...........
Glycolate $H_2COHCOO^- + NADH + H_3O^+ => H_3CCOO^- + NAD^+ + 2H_2O$;
$\Delta G_{eq} = (E°_{Red} - E°_{OxH2COHCOO}) * F * n = (-0.4095 - -0.033)*96485*2 = (-0.38)*96485*2 = -72.65$ kJ/mol;
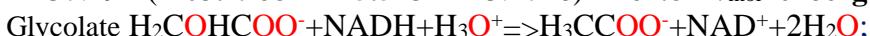
Substance Glyoxylate	$\Delta H°_{Hess}$ kJ/mol	$\Delta S°_{Hess}$ J/mol/K	$\Delta G°_{Hess}$ kJ/mol
OHCCOOH	-	-	-
OHCCOO⁻	-	-	**-426.588**
H₂COHCOO⁻	-	-	**-403.2968**
H₂COHCOOH	- 651	318.6	-
NADH_(aq)	-1036.66	-140.5	-
NADH_(aq)	**-1041.41**	**-4081.784**	**1175.5732**
H₃O⁺_(aq)	-285.81	-3.854	-213.2746
NAD⁺_(aq)	-1007.48	-183	-
NAD⁺_(aq)	**-1010.3**	**-3766.008**	**1112.534**
H₃CCOOH	-484.09	159.83	-531.743
H₃CCOO⁻	-486.84	82.23	-247.83
H₃CCOO⁻	**-486**	**85.3**	**-240.963**
H₂O	-285.85	69.9565	-237.191
H₂O	.65	-453.188	-151.549

$H_2COHCOO^- + NADH + H_3O^+ => H_3CCOO^- + NAD^+ + H_2O$;
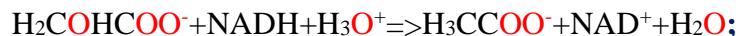
$G_{OHCCOOH} = -426.588 + (2*91.26 + 85.6 + 1.5*303) = 296.032$ kJ/mol
$G_{OHCCOO} = \Delta G_{eqOHCCOOH} - G_{H3O+} + (G_{OHCCOOH} + G_{H2O}) = 305.6$ kJ/mol
$G_{OHCCOO} = \Delta G_{eqOHCCOOH} - G_{H3O+} + (G_{OHCCOOH} + G_{H2O}) = 414.3$ kJ/mol
$G_{H2COHCOOH} = -403.2968 + (2*91.26 + 2*85.6 + 1.5*303) = 404.9232$ kJ/mol

Exothermic, exoergic reduction Hess free energy change -**161.8** negative, but minimized reaching $\Delta G_{min} = \Delta G_{eq} = -72.65$ or -**104** kJ/mol equilibrium mixture. Le Chatelier principle is Prigogine attractor free energy change minimum ΔG_{min} reaching.

A+B+C 50% D+2E+F
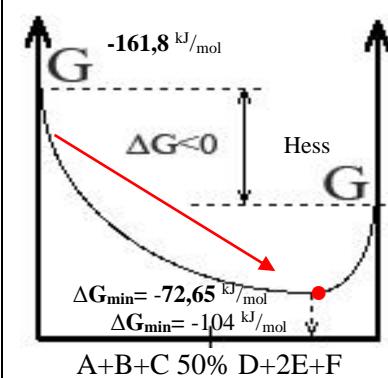
Glyoxylic acid Formation 61st page $2C + H_{2gas} + 1.5O_{2gas} => OHCCOOH$; $\Delta G_{OHCCOOH} = -426.588$ kJ/mol [8];
$\Delta G_{OHCCOOH} = G_{OHCCOOH} - (2G_{Cgraph} + G_{H2gas} + 1.5*G_{O2gas}) = -426.588$ kJ/mol;
$G_{OHCCOOH} = -426.588 + (2*91.26 + 85.6 + 1.5*303) = 296.032$ kJ/mol;

Glyoxylic acid $OHCCOOH + H_2O <=> OHCCOO^- + H_3O^+$; $pK_{a1} = 3.32$; Wikipedia
$K_{eq} = [OHCCOO^-]*[H_3O^+]/[OHCCOOH]/[H_2O] = K_a/[H_2O] = 10^{(-3.32)}/55.3 = 8.655*10^{(-6)} = 10^{(-5.063)}$;
$\Delta G_{eqOHCCOOH} = -R•T•\ln(K_{aeq}) = -8.3144*298.15*\ln(10^{(-5.063)})/1000 = 31.98$ kJ/mol .
$\Delta G_{eqOHCCOOH} = G_{OHCCOO} + G_{H3O+} - (G_{OHCCOOH} + G_{H2O}) = G_{OHCCOO} + 22.44 - (296.032 + 0) = 31.98$ kJ/mol;
$G_{OHCCOO} = \Delta G_{eqOHCCOOH} - G_{H3O+} + (G_{OHCCOOH} + G_{H2O}) = 31.98 - 22.44 + (296.032 + 0) = 305.6$ kJ/mol;
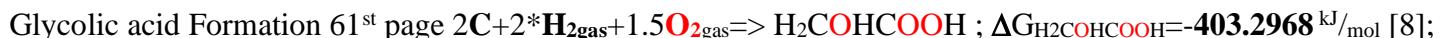
Glycolic acid Formation 61st page $2C + 2*H_{2gas} + 1.5O_{2gas} => H_2COHCOOH$; $\Delta G_{H2COHCOOH} = -403.2968$ kJ/mol [8];
$\Delta G_{H2COHCOOH} = G_{H2COHCOOH} - (2G_{Cgraph} + 2G_{H2gas} + 1.5*G_{O2gas}) = -403.2968$ kJ/mol;
$G_{H2COHCOOH} = -403.2968 + (2*91.26 + 2*85.6 + 1.5*303) = 404.9232$ kJ/mol;

Glycolic acid $H_2COHCOOH + H_2O <=> H_2COHCOO^- + H_3O^+$; $pK_{a1} = 3.83$; Wikipedia
$K_{eq} = [H_2COHCOO^-]*[H_3O^+]/[H_2COHCOOH]/[H_2O] = K_a/[H_2O] = 10^{(-3.83)}/55.3 = 2.675*10^{(-6)} = 10^{(-5.573)}$;
$\Delta G_{eqOHCCOOH} = -R•T•\ln(K_{aeq}) = -8.3144*298.15*\ln(10^{(-5.573)})/1000 = 31.81$ kJ/mol .
$\Delta G_{eqOHCCOOH} = G_{OHCCOO} + G_{H3O+} - (G_{OHCCOOH} + G_{H2O}) = G_{OHCCOO} + 22.44 - (404.9232 + 0) = 31.81$ kJ/mol;
$G_{OHCCOO} = \Delta G_{eqOHCCOOH} - G_{H3O+} + (G_{OHCCOOH} + G_{H2O}) = 31.81 - 22.44 + (404.9232 + 0) = 414.3$ kJ/mol;

Nernst's half reaction **glycolate +H₂O = Glyoxylate +H⁻(H⁺+2e⁻)+H₃O⁺** ; D.C.Harris 25°C [23]
Oks: $OHCCOO^- + H^-(H^+ + 2e^-) + H_3O^+ => H_2COHCOO^- + H_2O$; $E°_{H2COHCOO} = 0.1305$ V absolute; [23]

Oks: Glyoxylate $\overset{H}{\underset{O}{C}}\text{—}C\overset{O}{\underset{O^-}{}}$ + NADH + H_3O^+ => Glycolate $\overset{H}{\underset{H}{C}}\text{—}C\overset{O}{\underset{O^-}{}}$ + H_2O + NAD^+; D.C.Harris 25°C [23]
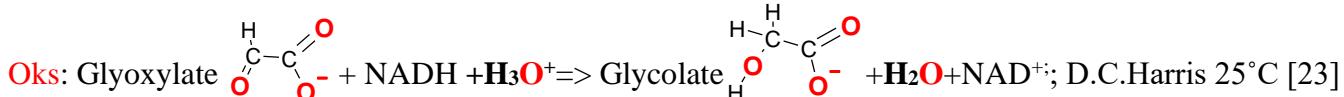
Nernst's half reaction Red: $NADH = NAD^+ + H^-(H^+ + 2e^-)$; $E°_{Red} = -0.4095$ V David Harris absolute [22]
Glyoxylate $OHCCOO^- + NADH + H_3O^+ = H_2COHCOO^- + NAD^+ + H_2O$ Glycolate;

$\Delta G_{Hess} = \Delta G°_{H2COHCOOH} + \Delta G°_{NAD+} + \Delta G°_{H2O} - \Delta G°_{H2COHCOO} - \Delta G°_{NADH} - \Delta G°_{H3O} = -63.66$ kJ/mol;
$= -403.2968 + 1112.534 - 237.191 - (-426.588 + 1175.5732 - 213.2746) = -63.66$ kJ/mol **exoergic**..............;
$\Delta G_{min} = \Delta G_{eq} = (E°_{eqNernst\_NADH} - E°_{H2COHCOO})*F*n = (-0.4095 - 0.1305)*96485*2 = (-0.54)*96485*2 = -104.2$ kJ/mol;

Protolytic solubility in water relates the absolute electrode potential to the zero of the absolute free energy scale $G_{H2O}=G_{CO2gas}=0$ $^{kJ}/_{mol}$ and depends on absolute temperature. The protolytic solubility reactions consume water molecules to form products with an absolute equilibrium constant in mol fractions without the usual units of molar concentration.

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Abstract

The solubility and protolysis process consumes water molecules for aqua dissolute product formation.

Solubility of gases: oxygen $O_{2gas}+H_2O=O_{2aq}$; hydrogen $H_{2gas}+H_2O=H_{2aq}$; nitrogen $N_{2gas}+H_2O=N_{2aq}$;

Electrodes of metals: hydrogen $\underline{H(Pt)}+H_2O=H_3O^++e^-$; iron $Fe_{(s)}+H_2O=Fe^{2+}+2e^-$.; zinc $Zn+H_2O=Zn^{2+}+2e^-$; cupper amalgam $Cu(Hg)+H_2O=Cu^{2+}+(Hg)+2e^-$; silver $Ag_{(s)}+H_2O=Ag^++e^-$; chromium $Cr+H_2O=Cr^{3+}+3e^-$;

For solid solubility: silver chloride $AgCl_{(s)}+2H_2O=Ag^++Cl^-$; calomel $Hg_2Cl_{2(s)}+3H_2O=Hg_2^{2+}+2Cl^-$;

mercury(II) oxide $Hg+H_2O+2OH^-=HgO+2H_2O+2e^-$, mercury(I) sulfate $Hg_2SO_{4(s)}+2H_2O=Hg_2^{2+}+SO_4^{2-}$;

For protolysis: peroxide $H_2O_2+H_2O=H_3O^++HOO^-$ pK_a=11,75; water $2H_2O=H_3O^++OH^-$ pK_w=14.

The solubility of gaseous oxygen $O_{2gas}+H_2O=O_{2aq}$ in oxidation half-reaction compensates one water molecule $6H_2O=O_{2gas}+H_2O+4H_3O^++4e^-$ from six to five $5H_2O=O_{2aq}+4H_3O^++4e$. Its decreases the calculate free energy content of metal hydrogen from $G_{H(Pt)}$=**51.05** $^{kJ}/_{mol}$ to $G_{H(Pt)}$=**48.56** $^{kJ}/_{mol}$. The absolute standard potential scale reference increases from $E°_H$=-0.29654 V to $E°_H$=-0.27073 V less negative. The absolute potential scale shift down of thermodynamic $E°_H$=0,10166 V increasing to $\Delta E_{absolute}$=-0.37239 V from $\Delta E_{absolute}$=-0.3982 V.

Standard potential shift down to $E°_{O2}$=**1.0868** V for oxygen and for glucose $E°_{C6H12O6}$=-0.13858 V.

The operations sequence of the absolute standard potential determination: $E°_{O2}$=**1.0868** Volts for two water oxygen oxidation in Nernst's half-reaction $5H_2O=O_{2aq}+4H_3O^++4e^-$.

From Nernst classical value [1] $E°_{classic O2}$=1.2288 V subtract $E°_{H2O}$=-0.0591/4*log(1/55.3^5) the counting value of five water molecules. The concentration of water is $[H_2O]$=996 $^g/_L$ /18 $g/_{mol}$=55.3 M in one liter. Then add the reference value of the Thermodynamic metal hydrogen electrode $E°_H$=+0.10166 Volts. The absolute scale reference value decreases from the 0.10166 V down by $\Delta E_{absolute}$=-0.37239 Volts. In sum, the absolute value $E°_{O2}$=1.2288-0.0591/4*log(1/55.3^5)+0.10166-0.37239=**1.0868** Volts of the standard potential for the Nernst half-reaction $5H_2O=O_{2aq}+4H_3O^++4e^-$ is obtained absolute potential expression in equation:

$$E_{O2}=E°_{O2}+0.0591/4*\log \frac{[O_2]_{aqua}\cdot[H_3O^+]^4}{[H_2O]^5} =\mathbf{1.0868}+0.0591/4*\log \frac{[O_2]_{aqua}\cdot[H_3O^+]^4}{55,3^5} \text{ Volts.}$$

The inverse standard potential for the reduction of oxygen $O_{2aq}+4H_3O^++4e^-=5H_2O$ has minus sign $-E°_{O2}$.

The oxygen reducing reaction is exoergic $\Delta G_{eqO2}=E°_{O2}\cdot F\cdot n$=-**1.0868***96485*4/1000=**-419.44** $^{kJ}/_{mol}$;

ΔG_{eqO2}=5G_{H2O}-(G_{O2aq}+4G_{H3O+})=5*0-(329.68+4*22.44)=**-419.44** $^{kJ}/_{mol}$; and coincides with the absolute potential scale. Oxygen energy G_{O2gas}=**303.1** $^{kJ}/_{mol}$ grows $G_{O2aq}=G_{O2gas}+G_{O2sp}$=**303.1**+26.58=**329.68** $^{kJ}/_{mol}$ at solubility.

Nernst's hydrogen oxidation $\underline{4(Pt)H}+4H_2O=4H_3O^++4e^-$ standard absolute potential is $E°_H$=-0.27073 Volts.

In sum reduction reaction of oxygen with metallic hydrogen synthesize two water molecules:

$O_{2aqua}+\underline{4(Pt)H}=2H_2O$ with absolute free energy exchange exoergic **-523.925** $^{kJ}/_{mol}$:

ΔG_{eq}=($E°_H-E°_{O2}$)*F*1*4=(-0.27073-**1.0868**)*96485*4=-1.3575*96485*4/1000=2***261.96**=**-523.925** $^{kJ}/_{mol}$.

Exchange ΔG_{eq2H2O}=2G_{H2O}-4$G_{(Pt)H}$-G_{O2aqua}=2*0-(4*$G_{(Pt)H}$+329.68)=**-523.925** $^{kJ}/_{mol}$ gives metal hydrogen free energy content $G_{H(Pt)}$=(2G_{H2O}-ΔG_{eq2H2O}-G_{O2aqua})/4=(2*0+**523.925**-329.68)/4=**194.245**/4=**48.56** $^{kJ}/_{mol}$.

In the reaction, $\underline{H}(Pt)+H_2O=H_3O^++e^-$, the standard potential $\Delta G_{eq}=E°_H\cdot F\cdot 1\cdot 1$=-0.27073*96485*1=**-26.12** $^{kJ}/_{mol}$ free energy is identical to the absolute free energy by Hess's law on a scale the zero G_{H2O}=0 $^{kJ}/_{mol}$ of water

$\Delta G_{Hess\_eq}=G_{H3O+}+G_{e-}-(G_{H(Pt)}+G_{H2O})$=22.44+0-(**48.56**+0)=**-26.12** $^{kJ}/_{mol}$.

The **absolute** standard potential $E°_H$=-0.27073 in Volts coincides with Alberty absolute free energy. [8]

Key Words: Physical Chemistry; Biochemistry; Thermodynamics; Attractors; *Electrode potential.*

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