Aris Kaksis 2024. Riga Stradin's University aris.kaksis@rsu.lv

Nernst's Ox-Red potential and membrane potential in volts
Oxidation-reduction balancing with Nernst's half reactions .

Anniversary Nernst's Nobel Prize in Chemistry 1920:

Metal interface with solution, oxidant and reductant create **electrode** potential in volts.

Electrochemical potential both side membrane creates ionic concentrations gradients $C_{right\_side}/C_{left\_side}$.

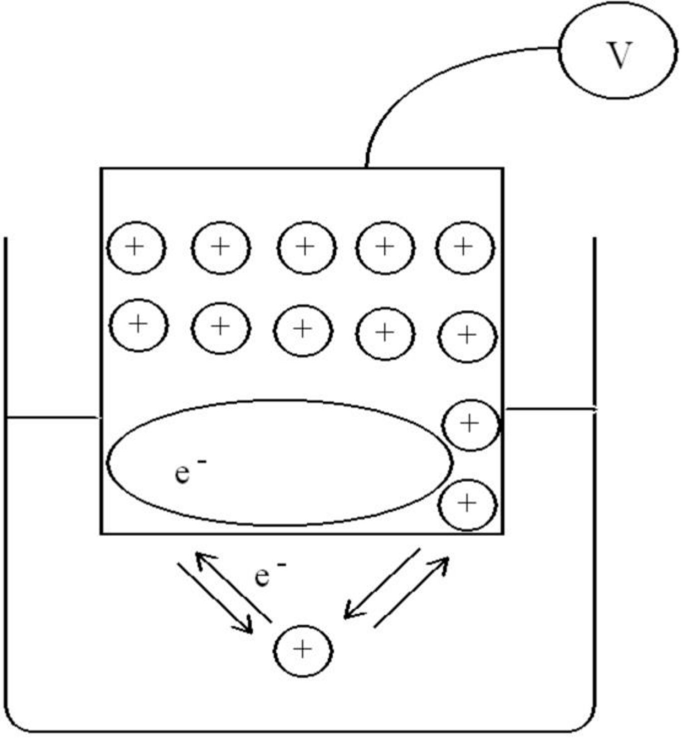
Electrochemical reactions across membranes drive E7 class transport enzymes .

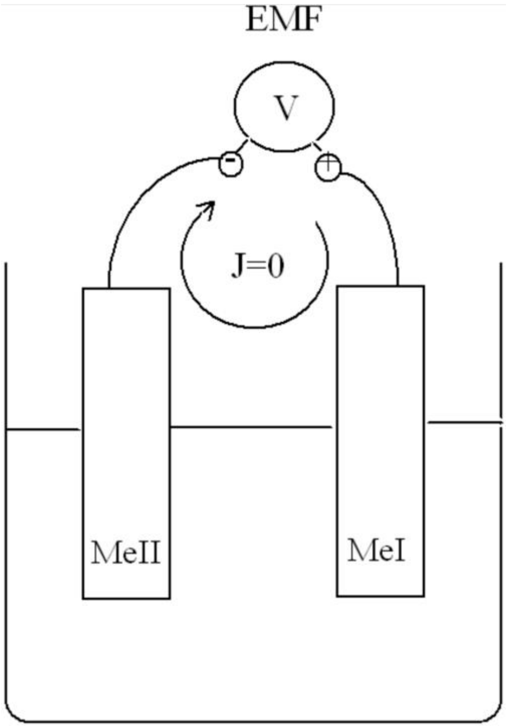
Metal free electron gas donate electrons to reduction and accept from oxidation half reactions .

Metallic Electrode is free electron source storage for half reactions.

Are classified such Type **electrodes**:
Type I: charged **ions** and free **electrons** transfer through **interface**;
Type II: charged **ions** and free **electrons** transfer through **interface**;
Red-Ox electrode: charged **ions** and free **electrons** transfer through **interface**;
Membrane electrode: charged **ions** transfer through **interface** absent free **electrons**;
Electrochemical reactions driven charged **ions** gradient through **membrane** channels form **Membrane potential E_M.**

Metal consist of electron e^- gas and crystalline metallic Me^+ ions lattice frame.





Voltmeter with minus "**-**" and plus "**+**" clamps measures difference of potentials or **EMF** (**E**lectric **M**otion **F**orce) between two **MeI** (**Indicator**) and **MeII** (**Standard**) on electric circuit linked electrodes :

$$EMF = E_I - E_{II} \quad ; \quad E_I = EMF + E_{II}$$

Indicator electrode **having** E_I – has reactivity with solution - electrode of investigations,

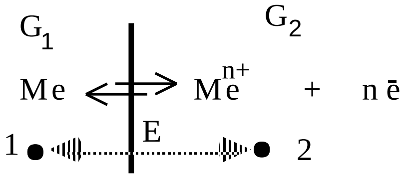
Standard electrode **having** E_{II} =constant– has no reactivity with environment into solution.

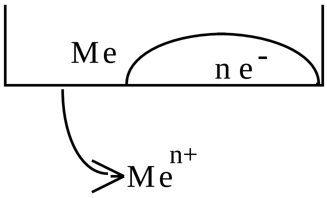
Reference

The obtaining of Nernst's equation for the Reduction - Oxidation equilibrium.

(First type electrode)

$\Delta G = G_2 - G_1$





$$\text{Red} \rightleftharpoons \text{Ox}^{\Delta n+} + n e^-$$

One **1** mol of the reduced form **Red** transfer from left side to right side in reaction to oxidized form **Ox** is the Hess law calculated free energy change work W of one mol Me^{n+} transfer from point 1 into metal to point 2 into solution applied with negative value $-\Delta G^\circ$ at electric potential value E.
One mole Me^{n+} charge is $q = nF$, and work calculated as $W = qE = nFE = W_{work} = nFE = -\Delta G^\circ = RT\ln K_{eq}$.

Red–Ox equilibrium constant $K_{eq} = \dfrac{[\text{Ox}]\bullet[e^-]^n}{[\text{Red}]}$ so

$$E = \frac{RT}{nF}\bullet\ln\left(\frac{[\text{Ox}]\bullet[e^-]^n}{[\text{Red}]}\right) = \frac{RT}{F}\bullet\ln([\mathbf{e}^-]) + \frac{RT}{nF}\bullet\ln\left(\frac{[\text{Ox}]}{[\text{Red}]}\right) \quad \text{ja} \quad \frac{[\text{Ox}]}{[\text{Red}]} = 1 \text{ then}$$

$$E^\circ = \frac{RT}{F}\bullet\ln([\mathbf{e}^-]) \ ; \ \ln([\mathbf{e}^-]) = \frac{E^\circ F}{RT} \ ; \ [\mathbf{e}^-] = e^{\frac{E^\circ F}{RT}}$$ = const on metal surface unite and therefore E° = const.

Nernst's equation in natural (number **e**=**2,7**) logarithm ln and decimal (number 10) logarithm lg form
$\ln(a) = \ln(10)\bullet\lg(a) = 2{,}3\ldots\bullet\lg(a)$ and temperature is T=298,15 K degree:

$$E = E^\circ + \frac{RT}{nF}\bullet\ln\left(\frac{[\text{Ox}]}{[\text{Red}]}\right); \frac{\ln(10)\bullet R\bullet T}{F} = \frac{2{,}3\bullet R\bullet T}{F} = 0{,}0591\ \text{V};\ E = E^\circ + \frac{0{,}0591}{n}\bullet\ln\left(\frac{[\text{Ox}]}{[\text{Red}]}\right)$$

Second thermodynamic approach to obtaining Nernst's expression.

When equilibrium is established reactant and product chemical potential sum is equal $\mu_{Red}+EnF=\mu_{Ox}+n\mu_{e^-}$ but each chemical compound chemical potential is: $\mu = \Delta G^\circ_A + RT\ln(N_A)$, were N_A is substance A concentration (mol fraction). ΔG° is given compound A standard free energy of formation from elements.
Free energy change Hess law of formation for pure compounds from elements ΔG°_{Ox}, $\Delta G^\circ_{e^-}$ and ΔG°_{Red}.
In chemical equilibrium mixture $\Delta G^\circ_{Red} + RT\ln(N_{Red}) + \mathbf{EnF} = \Delta G^\circ_{Ox} + RT\ln(N_{Ox}) + n\Delta G^\circ_{e^-} + RT\ln(N^n_{e^-})$
Expressing E from equilibrium conditions of the chemical potentials μ :

$$E = \frac{\Delta G^\circ_{Ox} + n\bullet\Delta G^\circ_{e^-} - \Delta G^\circ_{Red}}{nF} + \frac{RT}{nF}\bullet\ln\left(\frac{N_{Ox}\bullet N^n_{e^-}}{N_{Red}}\right)$$ pure compound mol fraction is $N_A = 1$.

Free electrons in separate phase (so called electron gas) of metal is just pure compound $N_{e^-} = 1$ therefore

$$E = \frac{\Delta G^\circ_{Ox} + n\bullet\Delta G^\circ_{e^-} - \Delta G^\circ_{Red}}{nF} + \frac{RT}{nF}\bullet\ln\left(\frac{N_{Ox}}{N_{Red}}\right).$$ As pure compound $\ln(N_{e^-}{}^n)=0$.

So standard potential $E^\circ = \dfrac{\Delta G^\circ_{Ox} + n\bullet\Delta G^\circ_{e^-} - \Delta G^\circ_{Red}}{nF}$ give Prigogine attractor the minimum of free energy change ΔG_{eq} at equilibrium state smaller $\left|E^\circ nF = \Delta G_{eq} = \Delta G^\circ_{Ox} + n\Delta G^\circ_{e^-} - \Delta G^\circ_{Red}\right| < \left|\Delta G_{\mathbf{Hess}}\right|$ as pure Hess law.
Conversion to decimal logarithm and thermodynamic standard T=298,15 K degree we have Nernst's equation for reaction of reactants: **<u>Red</u>**ucing form<=>**<u>Ox</u>**$^{\Delta n^+}$**+ne**$^-$ **<u>Ox</u>**idizing form $E = E^\circ + \dfrac{0{,}0591}{n}\bullet\lg\left(\dfrac{[\text{Ox}]}{[\text{Red}]}\right)$.

In reaction **ne**$^-$ electron lose (left at metal) exert towards solution transfer **Δn**$^+$ positively charged ions **<u>Ox</u>**$^{\Delta n^+}$.
Electrons **ne**$^-$ leaves at metal electron gas. Such **Δn**$^+$ positive charge entrance into solution as oxidized form **<u>Ox</u>**$^{\Delta n^+}$ in products brings the chemical potential electrical part of negative electrons the energy $\mathbf{n}\Delta G^\circ_{e^-} = \mathbf{-nFE}$.

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

Attractor pH=7.36 staying at equilibrium have true pOH=6.64 value as pK_w=14= pH+pOH =7.36 +6.64**.** Disaccount the water mass [$\mathbf{H_2O}$]=963/18=53.5 M over liter [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⁻**; $\mathbf{E}_{classic}=E_{o\_classic}+0.0591\bullet\log\mathbf{K}°_{classic\mathbf{H}(Pt)}=0+0.0591\bullet\log[H^+]=0+0.0591\bullet\log(1\ M)=0$ Volts. [11] Thermodynamic account Hydroxonium ions demand the water: $\mathbf{H(Pt)+H_2O{<=>}H_3O^++e^-}$ and $E°_H$=0.10166 V. The ratio $[H_3O^+]/([\mathbf{H_2O}]-[H_3O^+])=1\ M/52.5\ M=X_{\mathbf{H_3O^+}}/X_{\mathbf{H_2O}}$ 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 :

$$\mathbf{E}=E°_H+\ln(10)\bullet R\bullet T/F/1\bullet\log(X_{\mathbf{H_3O^+}}/X_{\mathbf{H_2O}})=E_o+E°_H+0.0591*\log(1/52.5)=0.10166-0.10166=0\text{ V.}$$

As ratio $\mathbf{1=K}_{\mathbf{H}(Pt)}=X_{\mathbf{H_3O^+}}/X_{\mathbf{H_2O}}$ is one than $E°_H$=0.10166 V is thermodynamic standard potential:

$$\mathbf{E}=E°_H+\frac{\ln(10)\bullet R\bullet T}{F\bullet 1}\bullet\log\frac{X_{H_3O^+}}{X_{H_2O}}=0.10166+0.0591*\log(1)=0.10166\text{ V.}$$

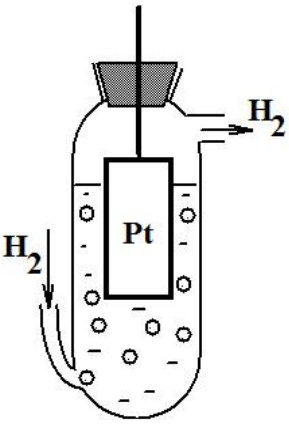
Metal oxidation free energy change minimum is different endoergic $\Delta\mathbf{G_{eq}}=E°_H\bullet F\bullet 1\bullet 1=0.10166*96485*1=9.81$ kJ/mol instead Alberty is exoergic. Alberty Hess value is in did exoergic: $\Delta\mathbf{G}_{Hess\_\mathbf{eq}}=G_{H3O+}+G_{e-}-(G_{\mathbf{H}(Pt)}+G_{\mathbf{H2O}})=22.44+0-(\mathbf{48.56}+0)=\mathbf{-26.12}$ kJ/mol .

Free energy changes are determined on water and carbon dioxide gas as zero $G_{\mathbf{H2O}}=G_{\mathbf{CO2}gas}=G_{e-}=0$ kJ/mol reference scale. Absolute scale hydrogen standard potential is: $E°_H=\Delta\mathbf{G_{eq}}/F/1=\mathbf{-26.12}/96485/1=-0.27073$ Volts. Equilibrium free energy change minimum is exoergic: $\Delta\mathbf{G_{eq}}=E°_H\bullet F\bullet 1=-0.27073*96485*1=\mathbf{-26.12}$ 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: $\mathbf{K}_{\mathbf{H}(Pt)\_Red}=[H_3O^+]*[\mathbf{e^-}]/[\mathbf{H_2O}]/[H(Pt)]=EXP(-\Delta\mathbf{G}_{Alberty}/R/T)=EXP(\mathbf{26120}/8,3144/298,15)=37675,6$.

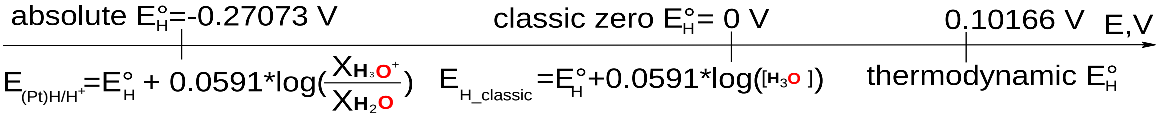
I type electrode Metal interface **H(Pt)** / on its cation H_3O^+ solution application.

High rate protolysis attractors $[H_3O^+]=10^{-7.36}$ M , pH=7.36 and water mass [$\mathbf{H_2O}$]=996/18=55.3 M account in liter shows metal hydrogen strong reducing potential: $\mathbf{E}_{pH=7.36}=-0.27073+0.0591*\log(10^{-7.36}/55.3)=-0.8087$ V and free energy change minimum $\Delta\mathbf{G}_{\mathbf{eq}pH\_7.36}=E°_H\bullet F\bullet 1=-0.8087*96485*1/1000=-78,03$ kJ/mol .

Nernst's half reaction metal reduction potential $E°_H$=-0.27073 V has energy change $\Delta\mathbf{G_{eq}}=\mathbf{-26.12}$ kJ/mol.



Platinum sheet immersed in hydroxonium ions $[H^+]=[H_3O^+]=[H_2SO_4]=1$ M sulfuric acid solutions $\mathbf{H(Pt){<=>}H^++e^-}$: $\mathbf{E=E}°+0.0591\bullet\log[H^+]=\mathbf{0.0}+0.0591\bullet\log(1\ M)=\mathbf{0}$ V is classic. Ratio $[H_3O^+]/[\mathbf{H_2O}]=1/52.5=X_{\mathbf{H3O+}}/X_{\mathbf{H2O}}$ 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 standard potential $E°_H$=-0.27073 V based on Alberty data $G_{\mathbf{H2}gas}=\mathbf{85.64}$ kJ/mol and $G_{\mathbf{H2}aq}=\mathbf{103.24}$ kJ/mol for hydrogen, which was detected on water and carbon dioxide gas $G_{\mathbf{H2O}}=G_{\mathbf{CO2}gas}=G_{e-}=0$ kJ/mol as zero scale reference. Reducing agent metal hydrogen at pH=7.36, $[H_3O^+]=10^{-7.36}$ M with potential $\mathbf{E}_{pH=7.36}=-0.27073+0.0591*\log(10^{-7.36}/55.3)=-0.8087$ V is strong reductant. Free energy content in one mol metal hydrogen is: $G_{\mathbf{H}(Pt)}=\mathbf{48.56}$ kJ/mol .

Substance	$\Delta H°_H$, kJ/mol	$\Delta S°_H$, J/mol/K	$\Delta G°_H$, kJ/mol	
$\mathbf{H_2O}$	-285.85	69.9565	-237.191	CRC 2010
$\mathbf{H_2O}$	**-286.65**	**-453.188**	**-151.549**	2006, Massachusetts Technology Inst. Alberty pH=7,36 [8]
$\mathbf{H_3O^+}$	-285.81	-3.854	-213.2746	Mischenko 1972, Himia, Leningrad [26]
$\mathbf{H_{2(aq)}}$	23.4	-130	99.13	CRC 2010 [1]
H(Pt)(aq)	$E°_H$=	-0,27073	**48,56**	$\Delta\mathbf{G}_{Hess\_\mathbf{eq}}=G_{H3O+}-(G_{\mathbf{H}(Pt)}+G_{\mathbf{H2O}})=22.44-(\mathbf{48.56}+0)=\mathbf{-26.12}$ kJ/mol.
$\mathbf{H_{2(aq)}}$	**-5.02**	**-363.92**	**103.24**	2006, Massachusetts Technology Inst. Alberty pH=7,36 [8]
$\mathbf{O_2}$aqua	**-11.70**	**-94.2**	**16.4**	

The solubility of gaseous hydrogen $\mathbf{H}_{2gas}+H_2O=\mathbf{H}_{2aq}$ compensates $(\mathbf{H}_{2gas}+2H_2O=)\mathbf{H}_{2aq}+H_2O=2\mathbf{H}_3O^++2e^-$ water molecule in Nernst's oxidation to hydroxonium and is spontaneous, because **absolute** free energy change is negative. $\Delta\mathbf{G}_{Hess\_H3O+}=2G_{H3O+}+2G_{\underline{e-}}-(G_{\mathbf{H2}aq}+G_{H2O})=2*22.44+2*0-(\mathbf{103.24}+0)=-58.36\ ^{kJ}/_{mol}$.

With graphite oxidizes $\mathbf{H}_{2aq}$ solution to hydroxonium with standard **absolute** potential is

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

Sum of Nernst and inverse half-reactions: $\mathbf{H}_{2aq}+H_2O=2\mathbf{H}_3O^++2e^-$; $2H_3O^++2e^-=2\underline{\mathbf{H}(Pt)}+2H_2O$

shows solubility of hydrogen in lattice of platinum $\mathbf{H}_{2aq}=2\underline{\mathbf{H}(Pt)}+H_2O$;

Oxidation of hydrogen solution $\mathbf{H}_{2aq}+H_2O=2\mathbf{H}_3O^++2e^-$ potential $E^\circ_{Haq}=-0.302$ V plus inverse potential $E^\circ_{H(Pt)}=+0.27072$ V of metal electrochemical solubility in platinum lattice $2H_3O^++2e^-=\underline{\mathbf{H}(Pt)}+2H_2O$ shows the solubility of hydrogen mole fraction $[\mathbf{H}_{2aq}]/[H_2O]$ from solution to platinum lattice exoergic, spontaneous:

$$\Delta\mathbf{G}_{sp\mathbf{H}(Pt)}=\Delta E^\circ_{sp\mathbf{H}(Pt)}\bullet F\bullet 2=(E^\circ_{H2aq}-E^\circ_{H(Pt)})\bullet F\bullet 2=(-0.302+0.27073)*96485*2=-0.03128*96485*2=\mathbf{-6.03}\ ^{kJ}/_{mol};$$

$$\mathbf{K}_{sp\mathbf{H}(Pt)}=[\underline{\mathbf{H}(Pt)}]^2/[\mathbf{H}_{2aq}]=EXP(-\Delta\mathbf{G}_{sp\mathbf{H}(Pt)}/R/T)=EXP(\mathbf{6036}/8.3144/298.15)=11.415\ .$$

Solubility product in platinum $\underline{\mathbf{H}(Pt)}$ from water $\mathbf{H}_{2aq}=2\underline{\mathbf{H}(Pt)}+\mathbf{H_2O}$ shows hydrogen solubility product in to metal slightly more exoergic favored: $\Delta\mathbf{G}_{sp\_\mathbf{H}(Pt)}=2G_{\mathbf{H}(Pt)}+G_{\mathbf{H2O}}-(G_{\mathbf{H2}aq})=2*\mathbf{48.56+0-(103.24)=-6.12}\ ^{kJ}/_{mol}$ and constant more favored:

$$\mathbf{K}_{sp\_\mathbf{H}(Pt)}=[\underline{\mathbf{H}(Pt)}]^2*[\mathbf{H_2O}]/[\mathbf{H}_{2aq}]=EXP(-\Delta\mathbf{G}_{sp\mathbf{H}(Pt)}/R/T)=EXP(\mathbf{6120}/8.3144/298.15)=11.808\ .$$

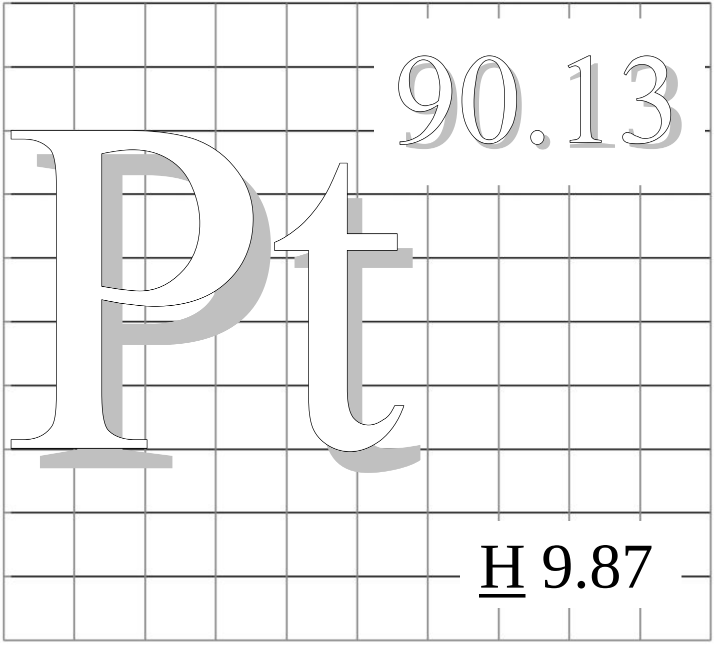
The ratio $K_{\mathbf{H}2sp}=[\mathbf{H}_{2aq}]/[\mathbf{H_2O}]/X_{\mathbf{H}2gas}=EXP(-\Delta\mathbf{G}_{\mathbf{H}2sp}/R/T)=EXP(\mathbf{-17600}/8.3144/298.15)=0.0008253$ gives solubility $[\mathbf{H}_{2aq}]=K_{\mathbf{H}2sp}*[\mathbf{H_2O}]*X_{\mathbf{H}2gas}=0.0008253*55.3*1=0.04564$ M, if pure gas mol fraction is one $X_{\mathbf{H}2gas}=1$.

As Alberty's Application of Mathematical Data in Biochemistry, the unit-free solubility product of mole fractions is $K_{\mathbf{H}2sp}=[\mathbf{H}_{2aq}]/[\mathbf{H_2O}]/X_{\mathbf{H}2gas}=EXP(-\Delta\mathbf{G}_{\mathbf{H}2sp}/R/T)=EXP(\mathbf{-17600}/8.3144/298.15)=0.0008253$ endoergic, unfavored: $\Delta G_{\mathbf{H}2spAlberty}=G_{H2aq}-G_{\mathbf{H}2gas}-G_{H2O}=\mathbf{103.24-85.64-0=17.6}\ ^{kJ}/_{mol}$ for gas solubility $\mathbf{H}_{2gas}+\mathbf{H_2O}=\mathbf{H}_{2aq}$.

From the ratio $[\underline{\mathbf{H}(Pt)}]^2/[\mathbf{H}_{2aq}]=\mathbf{K}_{sp\_\mathbf{H}(Pt)}/[\mathbf{H_2O}]=11.808/55.3=0.213526$ obtains mol fraction of **H**(Pt) square: $[\underline{\mathbf{H}(Pt)}]^2=K_{sp\mathbf{H}(Pt)}/[\mathbf{H_2O}]*[\mathbf{H}_{2aq}]=11.808/55.3*0.04564=0.009745$. Saturated solubility in platinum lattice $[\underline{\mathbf{H}(Pt)}]=SQRT(0.009745)=0.0987$ in mol fraction units is hydrogen atom surface fraction 9.87% shared with platinum atoms fraction 90.13% on total 100% platinum lattice surface. $\mathbf{H}_{2aqAlbery}=2\underline{\mathbf{H}(Pt)}+\mathbf{H_2O}$; Solubility mol fractions concentrations are unit less as constant too $\mathbf{K}_{sp\_\mathbf{H}(Pt)}=11.808$.

Atom radiuses are Pt 0.135 nm, H 0.053 nm. Area square of radiuses Pt 0.0729 nm^2, H 0.0112 nm^2 on surface 0.0729+0.0112=0.0841 nm^2 of lattice. Common are shared surface total area 100% progress for Platinum atom has 0.0729/0.0841=86.7% and 0.0112/0.0841=9.53% own H hydrogen atom. [25] $\underline{\mathbf{H}(Pt)}$ solubility in water $2\underline{\mathbf{H}(Pt)}+\mathbf{H_2O}=\mathbf{H}_{2aqAlberty}$ is less as one $\mathbf{K}_{sp\mathbf{H}(Pt)\_H2aq}=[\mathbf{H}_{2aq}]/[\underline{\mathbf{H}(Pt)}]^2/[\mathbf{H_2O}]=0.0846$ and $\Delta\mathbf{G}_{Alberty}=G_{\mathbf{H2}aq}-2G_{\mathbf{H}(Pt)}-G_{\mathbf{H2O}}=\mathbf{6.12}\ ^{kJ}/_{mol}$ positive, unfavored, non-spontaneous. It keeps metal lattice saturated with hydrogen 9,87%, because is positive

$$\mathbf{K}_{sp\mathbf{H}(Pt)\_H2aq}=[\mathbf{H}_{2aq}]/[\underline{\mathbf{H}(Pt)}]^2/[\mathbf{H_2O}]=EXP(-\Delta\mathbf{G}_{sp\_\mathbf{H}(Pt)}/R/T)=EXP(\mathbf{-6120}/8.3144/298.15)=0.08469\ \text{unfavored.}$$



Water oxidation to oxygen aqua O_{2aqua} half reaction $5H_2O=O_{2aq}+4H_3O^++4e^-$ Hess free energy change is:

$\Delta G_{O2aqAlberty}=G_{O2aq}+4G_{\mathbf{H3O}+}-5G_{\mathbf{H2O}}=\mathbf{329.68-4*22.44-5*0=419.44}\ ^{kJ}/_{mo}$, because aqua mol fraction: $\mathbf{O}_{2gas\ AIR}+\mathbf{H_2O}=\mathbf{O}_{2aq}$ compensate one water molecule of six $6H_2\mathbf{O}=\mathbf{O}_{2gas\ AIR}+\mathbf{H_2O}+4H_3O^++4e^-$ and Nernst's half reaction have five: $5H_2\mathbf{O}=\mathbf{O}_{2aq}+4H_3O^++4e^-$ with absolute standard potential $E^\circ_{\mathbf{O2}aq}=1.0868$ V.

It is identical to electrochemical calculation of free energy change minimum using absolute Nernst's standard potential: $\Delta\mathbf{G}_{\mathbf{eq}O2aq}=E^\circ_{O2aq}\bullet F\bullet n_{e-}=1.0868*96485*4=\mathbf{419.44}\ ^{kJ}/_{mol}$.

Hydrogen metal H(Pt) half reaction $\underline{\mathbf{H}}\mathbf{(Pt)+H_2O=H_3O^++e^-}$ Hess free energy change is:

$$\Delta\mathbf{G}_{H(Pt)\mathbf{eqAlberty}}=G_{H3O+}+G_{\underline{e-}}-(G_{\mathbf{H}(Pt)}+G_{\mathbf{H2O}})=22.44+0-(\mathbf{48.56}+0)\mathbf{=-26.12}\ ^{kJ}/_{mol}\ .$$

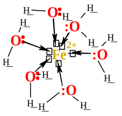
It is coincident with electrochemical calculation of free energy change minimum using **absolute** Nernst's standard potential $E^\circ_{H(Pt)}=-0.27073$ Volts:

$\Delta\mathbf{G}_{\mathbf{eqH(Pt)}}=E^\circ_{H(Pt)}\bullet F\bullet n_{e-}=-0.27073*96485*1=\mathbf{-26.12}\ ^{kJ}/_{mol}$ coinciding with Alberty data. [8,15]

Metal immersed in its ions solution by Nernst's oxidation half reaction first type Electrode potential in Volts.
Coordination of metal ions in solution bind water with donor-acceptor bonds.

$Fe_{(s)}+H_2O=Fe^{2+}+\mathbf{2e^-}$. $[Fe^{2+}]=0,1$ M; density 1,03 $^{g}/_{mL}$; 0,1 Mol mas $FeSO_4=15,191$ $^{g}/_{mol}$;

$E°_{Fe/Fe2+}=E°_{Fe}-0,0591/2*\log(1/([H_2O]))=-0,4402-0,0591/2*\log(1/55,3)+0,10166-0,37239=\mathbf{-0,6594}$ V.



$E_{Fe}=E°_{Fe/Fe2+}+0,0591/2*\log([Fe^{2+}]/[Fe]/([H_2O]))=\mathbf{-0,65943}+0,0591/2*\log(0,1/1/(55,3))=-0,74048$ V;

Distinguish -0,74048 V has 4 -0,74059 V. $\Delta \mathbf{G_{eq\_Fe}}=E°_{Fe}•F•2=\mathbf{-0.65943}*96485*2=\mathbf{-127,25}$ $^{kJ}/_{mol}$,

$\Delta \mathbf{G_{eq\_Fe}}=G_{Fe2+}-(G_{Fe}+\mathbf{G_{H2O}})=\mathbf{-82.14-(50.08}+0)=\mathbf{-127,25}$ $^{kJ}/_{mol}$;

$G_{Fe}=G_{Fe2+}\mathbf{-(\Delta G_{eq\_Fe}+G_{H2O})=-82.14-(-127,25}+0)=\mathbf{45,11}$ $^{kJ}/_{mol}$;

$E_{Fe}=E°_{Fe/Fe2+}+0,0591/2*\log([Fe^{2+}]/[Fe]/([H_2O]-6[Fe^{2+}]))=\mathbf{-0,658382}+0,0591/2*\log(0,1/1/(56,38-0,6))=-0,7395$ V;

$[H_2O]=55,3$ M$=(996^{g}/_{L})/(18^{g}/_{mol})$; $m_{H2O}=m_L-m_{FeSO4}=1030-15,191=1284,8$ g; $[H_2O]=1014,8$ $^{g}/18$ $^{g}/_{mol}=56,38$ M.

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**
Fe^{2+}	**-87.45**	**-17.8**	**-82.14**
Fe^{2+}	-89.1	-137.7	-78.9
Fe^{3+}	**-44.79**	**-110**	**-11.99**
Fe^{3+}	-48.5	-315.9	-4.7
Cu	$E°_{Cu}=$	0,1243 V	**70,02**
Cu^{2+}	64.8	-98	**94.0187**
Zn	$E°_{Zn}=$	**-0,98098** V	**68,65**
Zn^{2+}	-153.39	-109.8	**-120.653**

$G_{Fe}=G_{Fe2+}\mathbf{-(\Delta G_{eq\_Fe}+G_{H2O})=-82.14-(-127,25}+0)=\mathbf{45.11}$ $^{kJ}/_{mol}$;

BioThermodynamic 2006

CRC 2010

$G_{Cu}=G_{Cu2+}\mathbf{-(\Delta G_{eq\_Cu}+G_{H2O})=94,0187-(24,0}+0)=\mathbf{70,02}$ $^{kJ}/_{mol}$;

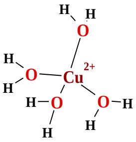
$\mathbf{\Delta} G_{Cu2+}=\mathbf{\Delta} H_H–T*\mathbf{\Delta} S_H=64.8-298.15*-0.098=\mathbf{94.0187}$ $^{kJ}/_{mol}$;

$G_{Zn}=G_{Zn2+}\mathbf{-(\Delta G_{eq\_Zn}+G_{H2O})=-120,653-(-189,3}+0)=\mathbf{68,65}$ $^{kJ}/_{mol}$;

$\mathbf{\Delta} G_{Zn2+}=\mathbf{\Delta} H_H–T*\mathbf{\Delta} S_H=-153.39-298.15*-0.1098=\mathbf{-120.65}$ $^{kJ}/_{mol}$;

$Cu(Hg)+H_2O=Cu^{2+}+(Hg)+\mathbf{2e^-}$; $[Cu^{2+}]=1$ M density 1.19 $^{g}/_{mL}$; 1 Molar mass $M_{CuSO4}=159.602$ $^{g}/_{mol}$;

$E°_{Cu/Cu2+}=E°_{Cu}+0,0591/2*\log(1/([H_2O]))=0,3435-0,0591/2*\log(1/55,3)+0,10166-0,371339=\mathbf{0,1243}$ V.



$E_{Cu}=E°_{Cu}+0,0591/2*\log([Cu^{2+}]/[\ Cu]/([H_2O]))=\mathbf{0,1243}+0,0591/2*\log(1/1/(55,3))=0,0728$ V;

Distinguish on number 0,0728 V in the second sign 0,0733 V

$m_{H2O}=(m_L-m_{cuSO4})/18=1190-159.602=1030.4/18=57.24-4=53.24$ mol;

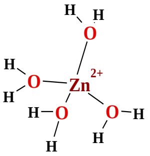
$E_{Cu}=E°_{Cu}+0,0591/2*\ \log([Cu^{2+}]/[\ Cu]/([H_2O]-4[Cu^{2+}]))=\mathbf{0,1243}+0,0591/2*\log(1\ M/1/(57,24-4))=0,0733$ V;

$\Delta \mathbf{G_{eq\_Cu}}=E°_{Cu}•F•2=\mathbf{0,1243}*96485*2=\mathbf{24,0}$ $^{kJ}/_{mol}$,$\Delta \mathbf{G_{eq\_\ Cu}}=G_{Cu2+}\mathbf{-(}G_{Fe}\mathbf{+G_{H2O})=94,0187-(}G_{Cu}+0\mathbf{)=24,0}$ $^{kJ}/_{mol}$;

$G_{Cu}=G_{Cu2+}\mathbf{-(\Delta G_{eq\_Cu}+G_{H2O})=94,0187-(24,0}+0\mathbf{)=70,02}$ $^{kJ}/_{mol}$;

$Zn+H_2O=Zn^{2+}+\mathbf{2e^-}$; $ZnSO_4=161.44$ $^{g}/_{mol}$ $[Zn^{2+}]=C_{ZnSO4}=2$ M density 1.31 $^{g}/_{mL}$; $m_{ZnSO4}=2*161.44=322.88$ g;

$E°_{Zn/Zn2+}=E°_{Zn}+0,0591/2*\log(1/([H_2O]))=-0,7628-0,0591/2*\log(1/55,3)+0,10166-0,371339=\mathbf{-0,98098}$ V.



$E_{Zn}=E°_{Zn/Zn2+}+0,0591/2*\log([Zn^{2+}]/[Zn]/([H_2O]))=\mathbf{-0,980981}+0,0591/2*\log(2/1/(55,3))=-1,0215$ V

Distinguish on number -1,0215 V in the forth sign -1,02358 V 2M;

Solubility 57.7 $^{g}/_{100g}$ in hundreds 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.

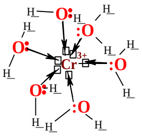
$$E_{Zn}=E°_{Zn/Zn2+}+0,0591/2*\log\frac{[Zn^{2+}]}{[Zn]\cdot([H_2O]-4\cdot[Zn^{2+}])}=\mathbf{-0,980981}+0,0591/2*\log(2/1/(54,84-4*2))=-1,02358\text{ V};$$

$\Delta \mathbf{G_{eq\_Zn}}=E°_{Zn}•F•2=\mathbf{-0,980981}*96485*2=\mathbf{-189,3}$ $^{kJ}/_{mol}$,$\Delta \mathbf{G_{eq\_Zn}}=G_{Zn2+}\mathbf{-(}G_{Fe}\mathbf{+G_{H2O})=-120,653-(}G_{Cu}+0\mathbf{)=-189,3}$ $^{kJ}/_{mol}$;

$G_{Zn}=G_{Zn2+}\mathbf{-(\Delta G_{eq\_Zn}+G_{H2O})=-120,653-(-189,3}+0\mathbf{)=68,65}$ $^{kJ}/_{mol}$;

$Cr+H_2O=Cr^{3+}+\mathbf{3e^-}$; $Cr_2(SO_4)_2=159.602$ $^{g}/_{mol}$; $C_{Cr2(SO4)2}=0.5$ M$[Cr^{3+}]=2*C_{Cr2(SO4)2}=1$ M density 1.172 $^{g}/_{mL}$;

$E°_{Cr/Cr3+}=E°_{Cr}+0,0591/3*\log(1/[H_2O])=-0,744-0,0591/3*\log(1/55,3)+0,10166-0,371339=-\ \mathbf{-0,9793}$ V.



$E_{Cr}=E°_{Cr}+0,0591/3*\log([Cr^{3+}]/[Cr]/([H_2O]))=\mathbf{-0,9793}+0,0591/3*\log(1/1/55,3)=-1,0136$ V;

Distinguish on number -1.0136 V in the fourth sign -1,01246 V 1M; 2.32 M;

$m_{H2O}=m_L-m_{Cr2(SO4)2}=1172-196.08=975.92$ g; $m_{Cr2(SO4)3}=392.16/2=196.08$;

$[Cr^{3+}]=2*C_{Cr2(SO4)2}=1$ M density 1.172 $^{g}/_{mL}$; $m_{Cr2(SO4)3}=196.08$g; $[H_2O]=975.92$ $^{g}/18$ $^{g}/_{mol}=54.21778$ M

$$E_{Cr}=E°_{Cr}+0.0591/3*\log\frac{[Cr^{3+}]}{[Cr\ ]\cdot([H_2O]-6\cdot[Cr^{3+}\ ])}=\mathbf{-0,9793}+0,0591/3*\log(1/1/(54,21778-6*1))=-1,01246\text{ V};$$

Solubility 64 $^{g}/_{100g}$ in hundred grams of water; w%=64/164*100=39%;
39/100g=X/??1172//$^{g}/_{L}$; 39/100*1172=457.07=X/$^{g}/_{L}$; $C_{Cr2(SO4)2}=457.07/392.16=1.1655$ M $Cr_2(SO_4)_3$;
$m_{H2O}=m_L-m_{Cr2(SO4)2}=??1172??-457.07=714.93$ g; $m_{Cr2(SO4)2}=457.07$g; $[H_2O]=714.93$ $^{g}/18$ $^{g}/_{mol}=39.718$ M

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

	Reduced form = Oxidized form + n e^-; [classic references]	H_2O disaccount classic zero E_o	Thermodynamic scale on H_2O account	Absolute scale -0,37239
H	**H**(Pt) $+H_2O=H_3O^+$ +(Pt)+ e^-; general reference CRC [1]	classic zero **0**	**0.10166**	-0.27073
	H(Pt) + $OH^-=H_2O$ +(Pt)+e^-; classic CRC [1]	-0.8277	-0.8282	-1.1995
	H(Pt)+$OH^-=H_2O$+(Pt)+e^-; corrected CRC -0.8277+-0.10449	-0.9322	-0.93375	-1.30508
	$H_{2aq}+H_2O=2H_3O^++2e^-$;graphite electrode	-0.1343	0.07039	-0.302
O	$5H_2O=O_{2aq}+4H_3O^++4e^-$; Suchotina [17]	1.2288	1.45924	1.0868
	$H_2O_2+2H_2O=O^-_{2aqua}+2H_3O^++e^-$; David A. 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	$C_6H_{12}O_6+42H_2O=24H_3O^++6H_3O^++6HCO_3^-+24e^-$;	-0.04915	0.2328	-0.13964
	$HOO^-+H_2O=O_{2aqua}+H_3O^++2e^-$;	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 [18]	0.94	1.2477	0.8753
	$NO_2^-+3H_2O=NO_3^-+2H_3O^++2e^-$ David A. Harris [21]	0.835	1.09115	0.7188
	$NO_{aq}+5H_2O=NO_3^-+4H_3O^++3e^-$; pH>3.15 [18]	0.96	1.2333	0.8609
	$NH_4^++13H_2O=NO_3^-+10H_3O^++8e^-$; 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	$MnO_2\downarrow+4OH^-=MnO_4^- + 2H_2O+3e^-$; Suchotina [17]	0.603	0.6360	0.2636
OH^-	$MnO_4^{2-}=MnO_4^-+e^-$; Suchotina [17]	0.558	0.65966	0.2873
Pb	$Pb^{2+} +6H_2O=PbO_2(s)+4H_3O^++2e^-$; 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	$SO_2^g+H_2O=H_2SO_{3aq}$;$H_2SO_3+3H_2O=HSO_4^-+3H_3O^++2e^-$;[17]	0.172	0.42815	0.10726
	$HSO_3^-+4H_2O=SO_4^{2-}+3H_3O^++2e^-$; 2=<pH<7 Suchotina [17]	0.172	0.47965	0.10726
	$SO_3^{2-}+2OH^-=SO_4^{2-}+H_2O+2e^-$; pH > 7 Suchotina [17]	-0.93	-0.87984	-1.2522
	$S^{2-}=S_{rombic}+H_2O + 2\,e^-$; CRC [1]	-0.4763	-0.4261	-0.7985
	$HS^- + OH^- = S_{rombic} + 2H_2O + 2e^-$; CRC [1]	-0.478	-0.4793	-0.8517
	$H_2S_{aq}+2H_2O=S_{rombic}+2H_3O^++2e^-$; CRC [1]: Suchotina [17]	0.142	0.3467	-0.025735
	$2S_2O_3^{2-}=S_4O_6^{2-}+2e^-$; 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	0.6317
	$Ag(s)+Cl^-=AgCl(s)+H_2O+e^-$; 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	0.39516	0.02277
Hg	$2Hg+H_2O=Hg_2^{2+}+2e^-$; Kortly, Shucha [18]	0.907	1.0602	0.6888
	$2Hg+2Cl^-=Hg_2Cl_{2(s)}+2H_2O+2e^-$; Suchotina ; [17]	0.2676	0.2663	-0.1059
	$2Hg+SO_4^{2-}=Hg_2SO_{4(s)}+H_2O+2e^-$; 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 [18]	1.20	1.6793	1.30692
	$Cr(OH)_3\downarrow+5OH^-=CrO_4^{2-}+4H_2O+3e^-$; 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]	-0.763	-0.6096	-0.98098
Al	$Al+ H_2O=Al^{3+}+3e^-$; CRC [1]	-1.662	-1.5260	-1.8984
	$Al+4OH^-= H_2AlO_3^-+H_2O+3e^-$; CRC [1]	-2.33	-2.2627	-2.63506

H(Pt) + $OH^-=H_2O$ +(Pt)+e^-; $E^\circ_{H\_OH}=\mathbf{-1.19952}$ V

The absolute potential is corrected by accounting for the absolute free energy of hydroxide $G_{OH-}=77{,}36\ ^{kJ}/_{mol}$ in the Hess calculation: $\Delta G_{AlbertyH\_OH-}=G_{H2O}-(G_{H(Pt)}+G_{OH-})=0-(48.56025+77.36)=\mathbf{-125.92}\ ^{kJ}/_{mol}$ and calculated in terms of the corrected absolute potential: $E^\circ_H=\Delta G_{eq}/F/1=\mathbf{-125.92}/96485/1=\mathbf{-1.30508}$ V.

Disaccount the water mass $[H_2O]=963/18=53.5$ M over liter $[H_2SO_4]=[H_3O^+]=1$ M solution with 1.061 $^g/_{mL}$ density the **hydrogen electrode** has classic $E_{o\_classic}=-0.8277$ V [17] and absolute standard potential:

$E^\circ_{H\_OH}=E^\circ-0.0591/1*\lg([H_2O]^1)+0.10166-0{,}37239=-0.8277-0.0591/1*\lg(53.5^1)+0.10166-0{,}37239=\mathbf{-1.1995}$ V.

data corrected $\Delta G_{eqH\_OH-}=E^\circ_{H\_OH-}\bullet F\bullet 1=\mathbf{-1.30508}*96485*1=\mathbf{-125.92}\ ^{kJ}/_{mol}$ to $E^\circ_H=-0.8277-0.10556=-0.9322$ V.

$E^\circ_{H\_OH}=E^\circ-0.0591/1*\lg([H_2O]^1)+0.10166-0{,}37239=-0.9322-0.0591/1*\lg(53.5^1)+0.10166-0{,}37239=\mathbf{-1.30508}$ V;

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 $\mathbf{O_{2}}_{gas}+H_2O=\mathbf{O_{2}}_{aq}$ compensate one water molecule $6H_2O=\mathbf{O_2}_{gas}+H_2O+4H_3O^++4e^-$ on Nernst's half reaction $5H_2O=O_{2aq}+4H_3O^++4e^-$, forming absolute standard potential $E°_{5HOH}=\mathbf{1.0868\ V}$.

$E°_{5HOH}=E°-0.0591/4*\lg(1/[H_2O]^5)+0.10166-0.37239=1.2288-0.0591/4*\lg(1/53.5^{\wedge 5})+0.10166-0.37239=\mathbf{1.0868\ V}$.

Substance	$\Delta H°_H$, kJ/mol	$\Delta S°_H$, J/mol/K	$\Delta G°_H$, kJ/mol
$\mathbf{H_2O}$	-285.85	69.9565	-237.191
$\mathbf{H_2O}$	**-286.65**	**-453.188**	**-151.549**
$\mathbf{H_3O^+}$	-285.81	-3.854	-213.2746
$\mathbf{H_{2(aq)}}$	23.4	-130	99.13
H(Pt)$_{(aq)}$	$E°_H-E°_{\mathbf{O2}}=$	-1.3575	**48.56**
$\mathbf{H_{2(aq)}}$	**-5.02**	**-363.92**	**103.24**
$\mathbf{O_2}_{aqua}$	**-11.70**	**-94.2**	**16.4**
$\mathbf{O_2}_{aqua}$	-11.715	110.876	16.4

$\Delta G_{Hess}=2\Delta G°_{\mathbf{H2O}}-4\Delta G°_{(Pt)H}-\Delta G°_{O2aqua}=-689=2*--344.521$ kJ/mol; $=2*-237.191-(4*99.13/2+\mathbf{16.4})=-689=2*344.5$ kJ/mol. CRC 2010

2006, Massachusetts Technology Inst. Alberty [8]

Mischenko 1972, Himia, Leningrad [26]

CRC 2010 [1}

$G_{\mathbf{H(Pt)}}=(2G_{\mathbf{H2O}}-\Delta \mathbf{G}_{\mathbf{eq2}H2O}-G_{\mathbf{O2}aqua})/4=\mathbf{48.56}$ kJ/mol;

2006, Massachusetts Technology Inst. Alberty [8]

Water concentration $[H_2O]^5$ logarithm extracted from $E°_{classic}=1.2288$ V absolute standard potential of Nernst's $E°_{5HOH}=\mathbf{1.0868}$ V.

Oxygen solution $O_{2aq}+4H_3O^++4e^-=5H_2O$ is strong oxidant with inverse standard potential $-E°_{5HOH}=\mathbf{-1.0868\ V}$. The oxidized form of oxygen attracts four free electrons with hydroxonium ions, forming four water molecules in the reduced form as products. The free energy content increases when dissolved in water:

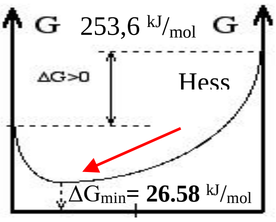
$$G_{O2aq}=G_{O2gas}+G_{\mathbf{O2}šķ}=\mathbf{303.1+26.58=330}\ \text{kJ/mol}\ .$$

Oxygen solubility free energy change Hess law solution **is** exothermic and endoergic $\mathbf{O_2}_{gas}+H_2O=\mathbf{O_2}_{aq}$, which mol fraction in air $1=[\mathbf{O_2}_{gas}]>[\mathbf{O_2}_{air}]=0.2095$ and in water has unit less value for concentration $[\mathbf{O_2}_{aq}]/[H_2O]=1.22*10^{\wedge(-3)}$ M/55.3 M$=2.206*10^{-5}$ and for constant too; $\mathbf{K_{speq}}=[\mathbf{O_2}_{aq}]/[\mathbf{O_2}_{gas}]/[H_2O]=1.22*10^{\wedge(-3)}/55.3=2.206*10^{-5}$. Energy change is positive $\Delta G_{Hess}=\Delta G°_{\mathbf{O2}aqua}-\Delta G°_{\mathbf{H2O}}-\Delta G°_{\mathbf{O2}gas}=16.4-(0-237.191)=253.6$ kJ/mol, so positive on scale of absolute expressions $\Delta G_{Alberty\mathbf{O2}aq}=G_{\mathbf{O2}aq}-(G_{\mathbf{H2O}}+G_{\mathbf{O2}gas})=\mathbf{330-(0+303.1)=26.58}$ kJ/mol and $\Delta \mathbf{G}_{sp}\mathbf{eq=-R\bullet T\bullet ln(K}_{speq})=-8.3144*298.15*\ln(2.205*10^{-5})=\mathbf{26.58}$ kJ/mol **.**

$[\mathbf{O_2}]$ solubility Hess free energy change is positive $\Delta\mathbf{G_{Hess}}=\Delta\mathbf{G_{solubility}}=253.6$ kJ/mol , but minimized at equilibrium mixture $\mathbf{K_{sp}=}[\mathbf{O_2}_{aq}]/[\mathbf{O_2}_{gas}]/[H_2O]\mathbf{=}2.206*10^{-5}\mathbf{=}10^{-4.656}$**.**

Equilibrium state is Prigogine attractor for all non-equilibrium states.

Free energy change minimum ΔG_{min} reaching establishes equilibrium. 53rd page.



Reactants

$O_{2gas}+\mathbf{H_2O}_{Blood}$

product $\mathbf{O_2}_{aq\text{-}Blood}$.

Osmolar $C_{osm}=0$ M and ionic force $\mathbf{I}=0$ M in water from air 20.95% oxygen solubility is $[\mathbf{O_2}_{aq}]=0.00025546$ M:

$$[\mathbf{O_2}_{aq}]=\mathbf{K}_{sp}*[\mathbf{O_2}_{air}]*[H_2O]=2.205*10^{-5}*0.2095*55.3=0.00025546\ \text{M}.$$

Pure 1atm mol fraction $[O_{2gas}]=1$. Osmolar $C_{osm}=0.305$ M, ionic force $\mathbf{I}=0.25$ M, air 20.95% oxygen dissolute $[O_{2aq}]=9.768\cdot10^{-5}$ M. Therefore $K_{O2spBlood}=[O_{2aq}]/[O_{2air}]=9.768\cdot10^{-5}/0.2095=4.663*10^{-4}$ M is physiologic solubility constant.

Arterial $[O_{2aq}]=6\cdot10^{-5}$ M and venous $[O_{2aq}]=0.426\cdot10^{-5}$ M isooxia is maintained by osmosis oxygen molecules, which cross membranes through aquaporins channels against osmolar concentration gradient $C_{osm}=0.305$ M.

Inverse: $O_{2aqua}+4H_3O^++4e^-=6H_2O$; $-E°_{\mathbf{O2}}=\mathbf{-1.0868}$ V; Nernst's: $\underline{4(Pt)H}+4H_2O=4H_3O^++4e^-$; $E°_H=\mathbf{-0.27073}$ V;

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

$$\Delta\mathbf{G_{eq}}=(E°_H-E°_{\mathbf{O2}})\bullet F\bullet1\bullet4=(\mathbf{-0.27073-1.0868})*96485*4=-1.3575*96485*4/1000=2*\mathbf{261.96=-523.925}\ \text{kJ/mol};$$

Knowing equilibrium value $\mathbf{\Delta}G_{eq2H2O}=2G_{\mathbf{H2O}}-4G_{(Pt)H}-G_{O2aqua}=2*0-(4*G_{(Pt)H}+329.68)=\mathbf{-523.925}$ kJ/mol , hydrogen metal free energy is $G_{\mathbf{H(Pt)}}=(2G_{\mathbf{H2O}}-\Delta\mathbf{G}_{\mathbf{eq2}H2O}-G_{\mathbf{O2}aqua})/4=(2*0+\mathbf{523.925}-329.68)/4=\mathbf{194.251}/4=\mathbf{48.56}$ kJ/mol .

$G_{\mathbf{H3O+OH}}=G_{H3O+}+G_{OH-}=22.44+77.36=99.8$ kJ/mol of water protolysis $H_2O+H_2O<=>H_3O^++OH$

Biochemistry oxygen $\mathbf{O_2}_{aqua}$ decreases free energy content $G_{O2aqua}=\mathbf{329.68}$ kJ/mol to $G_{O2Biochemistry}=88.22$ kJ/mol.

Arterial $[O_{2aqua}]=6*10^{-5}$ M and pH=7.36 concentrations $[H_3O^+]=10^{-7.36}$ M potential is decreasing

$$E_{\mathbf{O2}}=E°+{}^{0.0591}/_4\bullet\lg([O_{2aqua}]\bullet[H_3O^+]^4/_{[H2O]}{}^5)=\mathbf{1.0868}+{}^{0.0591}/_4*\log(6*10^{\wedge(-5)}*10^{\wedge(-7.36*4)}/_{55.346^{\wedge}}{}^5)=\mathbf{0.46174}\ \text{V}$$

by $\Delta E_{arterial}=-(E_{o\mathbf{O2}}-E_{\mathbf{O2}})=\mathbf{-\ 1.0868+0.46174}=-0.62506$ 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 $\mathbf{O_2}_{gas\ AIR}+\mathbf{H_2O}=\mathbf{O_2}_{Blood}$ with solubility contribution increases by:

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

Protolysis decreases free energy to $G_{O2Biochem\_arterial}=G_{O2aqu}+G_{\mathbf{O2}sp}+\Delta G_{arterial}=\mathbf{303.1}+26.58-241.456=88.22$ kJ/mol and oxygen becomes fire safe biochemical oxidant, forming arterial concentration $[\mathbf{O_2}_{aqua}]=6*10^{-5}$ M as safe Bioenergetic sustaining normal isooxia. [3];

1) Water 55.346 M decreases potential from **1.0868 V** about **-<u>0.1288</u>** V=**0.9580-1.0868**=$\Delta\mathbf{E}_{H2O}$.

$$E_{o\mathbf{O2}}=E°_{\mathbf{O2}}+{}^{0.0591}/_4*\log({}^1/_{[H2O]}{}^5)=\mathbf{1.0868}+0.01478*\log({}^1/_{55.346}{}^{\wedge5})=\mathbf{0.95805}\ \text{V}\ ;$$

2) Acid H_3O^+ increases 10 times the potential and free energy content increases about $\Delta E_{H3O+}=\mathbf{0.05912}$ V

$\Delta E_{H3O}=0.01478\bullet \lg([H^+]^4)=\mathbf{0.05912}$ V and $\Delta \mathbf{G}_{\mathbf{max}}=\Delta E_{H3O}*\mathbf{F}*\mathbf{n}=0.05912*96485*4/1000=\mathbf{22.817}$ $^{kJ}/_{mol}$;

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

$\Delta E_{O2100\%}=0.01478\bullet \lg(100\%\ [O_{2aqua}])=0.01478*\log(5)=+\underline{\mathbf{0.0103}}$ V . Free energy content for oxygen increases about $\Delta \mathbf{G}_{\mathbf{max}}=\Delta E_{H3O}*\mathbf{F}*\mathbf{n}=0.01033*96485*4/1000=\mathbf{3.987}$ $^{kJ}/_{mol}$. 6th page.

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

In the Nernst half-reaction of 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 $-E°=\mathbf{-1.0868}$ V. From the classic of glucose standard potential E°=-0.04915 V, by extracting by the logarithm $\log(1/55.3^{\wedge 42})$ 42 water molecules, the absolute Nernst standard potential of glucose is $E°_{C6H12O6}=-0{,}04915-0{,}0591/24*\log(1/55{,}3^{\wedge 42})+0{,}10166-0{,}37239=\mathbf{-0{,}13964}$ V.

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

Glucose and inverse oxygen absolute standard potentials sum $\Delta \mathbf{E°}$:

$\Delta \mathbf{E°}=(\mathbf{E°_{C6H12O6}}-\mathbf{E°_{O2}})=\Delta \mathbf{G}_{Lehninger}/\mathbf{F}/\mathbf{n}=\mathbf{-2840000}/96485/24=-1.2264$ V give the absolute free energy change $\Delta \mathbf{G}_{Lehninger}=\Delta \mathbf{E°}\bullet\mathbf{F}\bullet\mathbf{n}=(\mathbf{E°_{C6H12O6}}-\mathbf{E°_{O2}})\bullet\mathbf{F}\bullet\mathbf{n}=(\mathbf{-0.13958-1.086865})*\ 96485*24=\mathbf{-2840}$ $^{kJ}/_{mol}$ for the reaction by published data $\mathbf{C_6H_{12}O_6}+12\mathbf{H_2O}+6O_{2aqua}=6H_3O^++6HCO_3^-$. [1,6]

The sum of the absolute standard potentials $(\mathbf{E°_{C6H12O6}}-\mathbf{E°_{O2}})=(\mathbf{E_{C6H12O6}}\mathbf{-1{,}086865})=-1{,}22644$ V of glucose and oxygen allows us to determine the absolute standard potential for glucose

$\mathbf{E°_{C6H12O6}}=\Delta \mathbf{E}+\mathbf{E°_{O2}}=-1{,}22644+\mathbf{1{,}086865}=\mathbf{-0{,}139575}$ V, which is calculated from the value of the inverse Nernst's half reaction absolute standard potential of oxygen $O_{2aqua}+4H_3O^++4e^-=5H_2O$; $-E°_{O2}=\mathbf{-1.0868}$ V .

Arterial oxygen $[O_{2arteri\bar{a}l\bar{a}}]=6*10^{\wedge(-5)}$ M; hydroxonium $[H_3O^+]^{\wedge 30}=10^{\wedge(-7{,}36*30)}$ M and $[\mathbf{C_6H_{12}O_6}]=0{,}005$ M glucose concentration produce very negative arterial potential:

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

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

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

$$E_{O2arterial}=E°_{O2}+{}^{0{,}0591}/_{4}\bullet \lg([H_2O]^5/_{[O2aqua]/[H3O+]}{}^4)=\mathbf{-1{,}086865}+{}^{0{,}0591}/_{4}*\log(_{55{,}346^{\wedge 5}/6/10^{\wedge(-5)}/10^{\wedge(-7{,}36*4)}})=\mathbf{-0{,}46074}\ V.$$

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

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

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

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

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

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

$$\mathbf{C_6H_{12}O_6}+12\mathbf{H_2O}+6O_{2aqua}\quad=\quad 6H_3O^++6HCO_3^-\quad;$$

$$G_{H3O+}+_{HCO3-}=G_{H3O+}+G_{HCO3-}=\mathbf{22{,}44+56{,}08=78{,}52}\ {}^{kJ}/_{mol},$$

Glc 6th page Formation from elements $\mathbf{C}+6\mathbf{H_{2gas}}+3\mathbf{O_{2}}_{gas}=\mathbf{C_6H_{12}O_6}$ free energy change calculates from Alberty data at pH=7.36 $\Delta \mathbf{G}°_{Alberty}=\mathbf{G_{C6H12O6}}-(\mathbf{6G}_{Cgraph}+\mathbf{6*}G_{\mathbf{H2}gas}+\mathbf{3*}G_{O2gas})=\mathbf{-402.05}$ $^{kJ}/_{mol}$;

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

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

CRC 2010

$\Delta G°_{Alberty}+(\mathbf{6G}_{Cgraph}+\mathbf{6*}G_{\mathbf{H2}gas}+\mathbf{3*}G_{O2gas})=\mathbf{G_{C6H12O6}=1568}$ $^{kJ}/_{mol}$;

Calculation of free energy in glucose oxidation $\mathbf{C_6H_{12}O_6}+6\mathbf{O_2}_{aqua}+12\mathbf{H_2O}=\mathbf{6H_3O^+}+\mathbf{6HCO_3}$ in three ways:

1) Alberty data at pH=7.36 pH=7,36 $\Delta \mathbf{G}°_{Alberty}=\mathbf{G_{C6H12O6}}-(\mathbf{6G}_{Cgraph}+\mathbf{6*}G_{\mathbf{H2}gas}+\mathbf{3*}G_{O2gas})=\mathbf{-402{,}05}$ $^{kJ}/_{mol}$ standard free energy content in the mole is:

$$\mathbf{G_{C6H12O6}}=\Delta \mathbf{G}°_{Alberty}+(\mathbf{6G}_{Cgraph}+\mathbf{6*}G_{\mathbf{H2}gas}+\mathbf{3*}G_{O2gas})=\mathbf{-402{,}05+(6*91{,}26+6*85{,}6+3*303)=1568}\ {}^{kJ}/_{mol}\ ,$$

2) Lehninger's $\Delta \mathbf{G_{C6H12O6}}=6*G_{\mathbf{H3O+}}+6*G_{\mathbf{HCO3-}}-(\mathbf{G}_{Standard\mathbf{C6H12O6}}+\mathbf{6*}G_{O2aqua}+\mathbf{12*}G_{\mathbf{H2O}\_Biochem})=\underline{-2840}$ $^{kJ}/_{mol}$ standard content in the mole of glucose $\mathbf{G}_{Standard\mathbf{C6H12O6}}=6*(\mathbf{22{,}44}+\mathbf{56{,}08})-(-\underline{2840}+6*\mathbf{330}+12*\mathbf{0})=\mathbf{1331}$ $^{kJ}/_{mol}$ and

3) free energy content $\Delta \mathbf{G}_{arterial\_\mathbf{C6H12O6}}=6*G_{\mathbf{H3O+}}+6*G_{\mathbf{HCO3-}}-(G_{arterial\_C6H12O6}+\mathbf{6*}G_{O2aqua}+\mathbf{12*}G_{\mathbf{H2O}})=\mathbf{-3064}$ $^{kJ}/_{mol}$ per mole of glucose at homeostasis $G_{arterial\_C6H12O6}=6*(\mathbf{22{,}44}+\mathbf{56{,}08})-(\underline{\mathbf{-3064}}+6*\mathbf{88{,}22}+12*\mathbf{85{,}64})=\mathbf{1978}$ $^{kJ}/_{mol}$.

Generated $\mathbf{6HCO_3^-}+\mathbf{6H_3O^+}$ ions drive reactants $6\mathbf{O_2}_{aqua}$ and $6\mathbf{H_2O}$ through membranes aquaporins channels by osmosis against the concentration gradients but transporting ions $\mathbf{6HCO_3^-}+\mathbf{6H_3O^+}$ opposite down the gradients through bicarbonate and proton channels consuming produced free energy $\Delta \mathbf{G}_{arterial}=\underline{\mathbf{-3064}}$ $^{kJ}/_{mol}$.

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

Inverse half reaction of oxygen with free energy $G_{O_2\text{aqua}}$=**330** kJ/mol reduction $O_{2\text{aqua}}+4H_3O^++4e^-=5H_2O$ with standard potential $-E_{oO_2}$=**-1.0868 V**: oxidize four metal hydrogen atoms with free energy $\mathbf{G}_{H(Pt)}$=**48.56** kJ/mol within Nernst's half reaction: $\underline{4(Pt)H}+4H_2O=4H_3O^++4e^-$ and with standard potential E°_H=**-0.27073** V. Standard free energy change in reaction $O_{2\text{aqua}}+\underline{4(Pt)H}=2H_2O$ is

$$\Delta G_{\text{Hes}2H_2O}=2G_{H_2O}-4G_{H(Pt)}-G_{O_2\text{aqua}}=2*0-(4*\mathbf{48.56}+\mathbf{330}))=\mathbf{-524.24}=2*\mathbf{-262}\ {}^{kJ}/_{mol}.$$

Standard potentials sum

$$\Delta \mathbf{G}_{\mathbf{eq}}=(E^\circ_H-E^\circ_{O_2})\bullet F\bullet 4=(\mathbf{-0.27073-1.0868})*96485*4=-1.3575*96485*4=\mathbf{-523.925}=2*\mathbf{-262}\ {}^{kJ}/_{mol}$$ let independently from Hess law calculate formation from free elements oxygen $O_{2\text{aqua}}$ and metal hydrogen (Pt)H free absolute energy change $\Delta G_{eq(Pt)H\_H_2O}$=**-262** kJ/mol, which is coincident with absolute free energy $G_{H(Pt)}$=**48.56** kJ/mol determination for free elements $O_{2\text{aqua}}$, (Pt)H and using absolute standard potential for oxidation – reduction.

Hydrogen standard free energy in water solution $G_{H_2\text{aqua}}$=**103.24** kJ/mol is from Alberty data pH=7,36. [8]

$$O_{2\text{gas}}+\underline{2H_{2\text{gas}}}=2H_2O;$$

$$\Delta G_{\text{HessCRCaqua}}=2\Delta G^\circ_{H_2O}-2\Delta G^\circ_{H_2\text{aqua}}-\Delta G^\circ_{O_2\text{aqua}}=2*-237{,}191-(2*99{,}13/2+\mathbf{16{,}4})=-589{,}91=2*-295\ {}^{kJ}/_{mol}.\ [1]$$

Substance	ΔH°_H, kJ/mol	ΔS°_H, J/mol/K	ΔG°_H, kJ/mol	
$\mathbf{H_2O}$	-285.85	69.9565	-237.191	CRC
$\mathbf{H_2O}$	**-286.65**	**-453.188**	**-151.549**	
$\mathbf{H_3O^+}$	-285.81	-3.854	-213.2746	
$\mathbf{H_{2(aq)}}$	23.4	-130	99.13	CRC
$\mathbf{H_{2(aq)}}$	**-5.02**	**-363.92**	**103.24**	2006, Massachusetts Technology Inst. Alberty [8]
E° (Pt)H	**-0.27073**	**-1.0868**	**48,56**	
$\mathbf{O_{2}}$aqua	**-11.70**	**-94.2**	**16.4**	
$\mathbf{O_{2}}$aqua	-11.715	110.876	16.4	

ΔG_{eq}=**-262** kJ/mol ; ΔG_{Hess}=-295 kJ/mol

The reaction $4\underline{(Pt)H}+O_{2\text{aqua}}=2\,H_2O$; absolute free energy change is $|\Delta G_{eq}=\mathbf{-262}\ {}^{kJ}/_{mol}| < |\Delta G_{Hess}=-295\ {}^{kJ}/_{mol}|$;

$$G_{H(Pt)}=(2G_{H_2O}-\Delta \mathbf{G}_{\mathbf{eq}2H_2O}-G_{O_2\text{aqua}})/4=\mathbf{48{,}56}\ {}^{kJ}/_{mol}$$

$$\mathbf{K}_{\mathbf{eq}2H_2O}=\mathbf{K}_{\text{OxRed}}=\mathbf{exp(-\Delta G_{\text{OxRed}}/R/T)}=\exp(\mathbf{261960.6}/8.3144/298.15)=\exp(105.675)=7.832*10^{45};$$

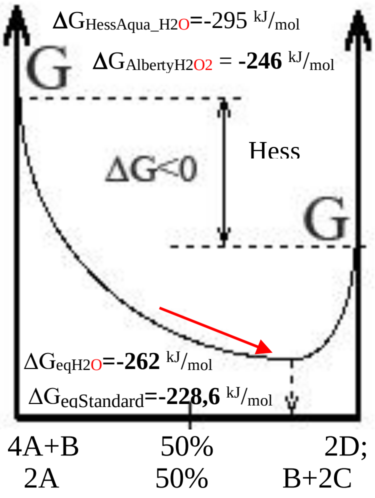
Exothermic and exoergic $O_{2\text{aqua}}$ reduction with metallic hydrogen $4\underline{(Pt)H}$ and H_2O_2 dismutation Hess free energy change negative $\Delta G_{\text{HessAquaH}_2O}$=-295 kJ/mol , $\Delta G_{\text{AlbertyH}_2O_2}$=-246 kJ/mol, but minimized reaching equilibrium $\Delta \mathbf{G}_{\mathbf{eq}2H_2O}$=**-262** kJ/mol and $\Delta \mathbf{G}_{\text{eqStandart\_H}_2O_2}$=**-228.6** kJ/mol mixtures constants $\mathbf{K}_{\mathbf{eq}2H_2O}=7.832*10^{45}$ and $\mathbf{K}_{\text{eqStandard\_H}_2O_2}=1.11*10^{40}$.

The equilibrium state minimum is Prigogine attractor for all irreversible states.

Free energy change minimum reaching establish equilibrium state.

Red $H_2O_2+2H_2O=O_{2\text{aqua}}+2H_3O^++2e^-$; $\mathbf{E^\circ}_{H_2O_2}$=**0.5268** V Alberta University Edmonton Canada. [19] Peroxide H_2O_2 in medium pH=7.36 absolute inverse standard $H_2O_2+2H_3O^++2e^-=4H_2O$ potential is $\mathbf{-E^\circ_{Ox}}$=**-1.7113** V Suhotina [17]

Summary dismutation $\mathbf{2H_2O_{2\mathit{aq}}=>O_{2}}_{\text{aqua}}\mathbf{+2H_2O+Q+\Delta G}$;



Reactants $\underline{4(Pt)H}+O_{2\text{aqua}}$ and products $2H_2O$

Reactants $\mathbf{2H_2O_{2\mathit{aq}}}$ and products $O_{2\text{aqua}}+2H_2O$

$$\text{Standard sum } \Delta G_{\text{eqStandart\_H}_2O_2}=(E_{\text{Red}}-E_{o\text{Ox}})*\mathbf{F*n}=(\mathbf{0.5268-1.7113})*96485*2=(-1.1845)*96485*2=\mathbf{-228.57}\ {}^{kJ}/_{mol};$$

$$\mathbf{K}_{\mathbf{eq}\text{Standart\_H}_2O_2}=\frac{[O_2]_{\text{aqua}}\cdot[H_2O]^2}{[H_2O_2]^2_{\text{aqua}}}=\mathbf{K}_{H_2O_2}=\mathbf{exp(-\Delta G_{eq}/R/T)}=\exp(228573/8.3144/298.15)=1.11*10^{40}........$$

$E^\circ_{H_2O_2}=E^\circ-0{,}0591/2*\lg(1/[H_2O]^2)+0{,}10166-0{,}372=0{,}6945-0{,}02955*\lg(1/55{,}3^{\wedge 2})+0{,}10166-0{,}37239=\mathbf{0{,}5268}$ V;

$E^\circ_{H_2O_2\text{Ox}}=E^\circ-0{,}0591/2*\lg(1/[H_2O]^4)+0{,}10166-0{,}372=1{,}776-0{,}02955*\lg(1/55{,}3^{\wedge 4})+0{,}10166-0{,}37239=\mathbf{1{,}7113}$ V;

$E_{H_2O_2}=E^\circ+0.0591/2\bullet\lg(O_{2\text{aqua}}]*[H_3O^+]^2/[H_2O_2]/[H_2O]^2)=0.5278+0.0591/2*\lg(6*10^{\wedge(-5)}*10^{\wedge(-7.36*2)}/1/55.3^{\wedge 2})=-0.1349$ V

$E_{o\text{Ox}}=E^\circ_{H_2O_2\text{Ox}}+0.0591/2\bullet\log([H_2O]^4/[H_2O_2]/[H_3O^+]^2)=-1.7123+0.0591/2*\lg(55.3^{\wedge 4}/1/10^{\wedge(-7.36*2)})=-1.0713$ V

Summary of Nernst's + inverse reaction for homeostasis is

$$\Delta \mathbf{G}_{\mathbf{eq}\text{BioChem}}=(E_{\text{Red}}-E_{o\text{Ox}})*\mathbf{F*n}=(-0.13493-1.0703)*96485*2=(\mathbf{-1.2062})*96485*2=\mathbf{-232.76}\ {}^{kJ}/_{mol};$$

$$G_{\text{Homeostasis}H_2O_2}=(G_{O_2\text{Biochem\_arteriaj}}+2*G_{H_2O\text{BioChemistry}}-\Delta G_{\text{Alberty}})/2=(\mathbf{88.04+2*85.64+232.76})/2=\mathbf{246.04}\ {}^{kJ}/_{mol};$$

Sulfur / H_2S_{aq} red-ox systems. H_3O^+ and $[H_2O]=55.3$ M accounting on absolute free energy and potential scale.

Substance	$\Delta H^\circ_H\ ^{kJ}/_{mol}$	$\Delta S^\circ_H\ ^{J}/_{mol/K}$	$\Delta G^\circ_H,\ ^{kJ}/_{mol}$
H_2S	**-38.6**	**126**	**-76.167**
HS^-	**-16.3**	**67**	**-36.276**
HS^-	$E^\circ_{\underline{S\downarrow}/HS2-}=$	**-0.8517** V	**1.35**
HS^-	$pK_{a1}=7.05$	$pK_{a1}=7.05$	**-3.072**
H_2S	$E^\circ_{\underline{S\downarrow}/H2S-}=$	**-0.9290** V	**-61.09**
H_2S	$E^\circ_{\underline{S\downarrow}/H2S}=$	**-0.6715** V	**88.82**
H_2S	$E^\circ_{\underline{S\downarrow}/H2S}=$	**-0.025735** V	**-35.794**
$S_{rombic}+$	$\underline{2(Pt)H}=$	H_2S_{aq}	**-35.997**
S^{2-}	$E^\circ_{\underline{S\downarrow}/S2-}=$	**-0.79853**V	**68.45**
S^{2-}	$pK_{a2}=19$	$pK_{a2}=19$	**92.868**

$\Delta G_{HS-}=\Delta H_H-T*\Delta S_H=-38.6-298.15*0.126=\mathbf{-76.167}\ ^{kJ}/_{mol}$;

$\Delta G_{HS-}=\Delta H_H-T*\Delta S_H=-16.3-298.15*0.067=\mathbf{-36.276}\ ^{kJ}/_{mol}$;

$G_{HS\text{-}aq}=G_{S\,rombic}+2G_{H2O}-(\Delta G_{eqHS\text{-}aq}+G_{OH})=\mathbf{1.35}\ ^{kJ}/_{mol}$;

$G_{HS-}=\Delta G_{eq}-G_{H3O}+(G_{H2S}+G_{H2O})=50.188-22.44+(-30.82+0)=\mathbf{-3.072}\ ^{kJ}/_{mol}$;

$G_{H2S\text{-}aq}=G_{S\,rombic}+3G_{H2O}-(\Delta G_{eqH2S\text{-}aq}+2G_{OH})=\mathbf{-61.09}\ ^{kJ}/_{mol}$;

$G_{H2S\,aq}=G_{S\,rombic}+2G_{H3O+}-(\Delta G_{Hess\_H2S\,aq}+2G_{H2O})=\mathbf{88.82}\ ^{kJ}/_{mol}$;

$G_{\ H2S\,aq}=G_{S\,rhombic}+2G_{H3O+}-(\Delta G_{Hess\_H2S\,aq}+2G_{H2O})=\mathbf{-35.794}\ ^{kJ}/_{mol}$.

$G_{H2S\,aquq}=\Delta G_{HessH2S}+(2G_{H(Pt)}+G_{S\,rombic})=\mathbf{-35.997}\ ^{kJ}/_{mol}$;

$G_{S2\text{-}aq}=G_{S\,rombic}+G_{H2O}-(\Delta G_{eqS2\text{-}aq})=\mathbf{68.45}\ ^{kJ}/_{mol}$;

$G_{S2-}=\Delta G_{eq}-G_{H3O}+(G_{\ HS-}+G_{H2O})=118.38-22.44+(-3.072+0)=\mathbf{92.868}\ ^{kJ}/_{mol}$;

$S^{2-}=S_{rombic}+H_2O+2e^-$; $E^\circ_{\underline{S\downarrow}/S2-}=\mathbf{-0.79853}$ V Kortly, Shucha ;

$E^\circ_{\underline{S\downarrow}/S2-}=E^\circ-0.0591/2*\lg([H_2O]^1)+0.10166-0.37239=-0.4763-0.02955*\lg(55.3\wedge^1)+0.10166-0.37239=\mathbf{-0.79853}$V;

$\mathbf{\Delta G_{eqS2-}=E^\circ_{S2-}Fn=-0.79853}*96485*2=\mathbf{-154.09}\ ^{kJ}/_{mol}$. $G_{S\,rombic}=\mathbf{-85.64}\ ^{kJ}/_{mol}$;

$\Delta G_{eqS2\text{-}aq}=G_{S\,rombic}+G_{H2O}-(G_{S2\text{-}aq})=\mathbf{-85.64}+0-(\mathbf{68.25})=\mathbf{-154.09}\ ^{kJ}/_{mol}$;

$G_{S2\text{-}aq}=G_{S\,rombic}+G_{H2O}-(\Delta G_{eqS2\text{-}aq})=\mathbf{-85.64}+0-(\mathbf{-154.09})=\mathbf{68.25}\ ^{kJ}/_{mol}$;

$\mathbf{HS^-}+\mathbf{OH^-}=S_{rombic}+2H_2O+2e^-$; CRC 2010 $E^\circ_{\underline{S\downarrow}/HS-}=\mathbf{-0.8517}$ V;

$E^\circ_{\underline{S\downarrow}/HS-}=E^\circ-0.0591/2*\lg([H_2O]^2)+0.10166-0.37239=-0.478-0.02955*\lg(55.3\wedge^2)+0.10166-0.37239=\mathbf{-0.8517}$ V;

$\mathbf{\Delta G_{eqHS-}=E_{\ HS-}Fn=-0.8517}*96485*2=\mathbf{-164.35}\ ^{kJ}/_{mol}$.

$\Delta G_{eqHS\text{-}aq}=G_{S\,rombic}+2G_{H2O}-(G_{HS\text{-}aq}+G_{OH})=\mathbf{-85.64}+2*0-(\mathbf{1.35+77.36})=\mathbf{-164.35}\ ^{kJ}/_{mol}$;

$G_{HS\text{-}aq}=G_{S\,rombic}+2G_{H2O}-(\Delta G_{eqHS\text{-}aq}+G_{OH})=\mathbf{-85.64}+2*0-(\mathbf{-164.35+77.36})=\mathbf{1.35}\ ^{kJ}/_{mol}$;

$\mathbf{H_2S}_{aq}+2H_2\mathbf{O}=S_{rombisks}+2\mathbf{H_3O^+}+2e^-$; $E^\circ_{\underline{S\downarrow}/H2S}=\mathbf{-0.025735}$ V Suchotina_1<pH< 7 ;

$E^\circ_{\underline{S\downarrow}/H2S}=E^\circ-^{0.0591}/_2*\lg(1/[H_2O]^2)+0.10166-0.37239=0.142-0.02955*\lg(1/55.3\wedge^2)+0.10166-0.37239=\mathbf{-0.025735}$ V;

$\mathbf{\Delta G_{eqH2S}=E^\circ_{H2S}Fn=-0.025735}*96485*2=\mathbf{-4.966}\ ^{kJ}/_{mol}$.

$\Delta G_{eqH2S\,aq}=G_{S\,rombisks}+2G_{H3O+}-(G_{\ H2S\,aq}+2G_{H2O})=\mathbf{-85.64}+2*\mathbf{22.44}-(\mathbf{-35.794}+2*0)=\mathbf{-4.966}\ ^{kJ}/_{mol}$;

$G_{H2S\,aq}=G_{S\,rombisks}+2G_{H3O+}-(\Delta G_{Hess\_H2S\,aq}+2G_{H2O})=\mathbf{-85.64}+2*\mathbf{22.44}-(\mathbf{-4.966}+2*0)=\mathbf{-35.794}\ ^{kJ}/_{mol}$.

pKa=7.0 Wikipedia; CRC2010 $pK_{a1}=7.05$; $pK_{a2}=19$

$pK_{a1}=7.05$ $\mathbf{H_2S}+H_2\mathbf{O}=\mathbf{HS^-}+H_3O^+$; $K_{eq1}=K_{a1}/[H_2O]=10\wedge^{(-7.05)}/55.3=0.000000001612$;

$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=-8.3144*298.15*\ln(0.000000001612)=G_{HS-}+G_{H3O}-(G_{H2S}+G_{H2O})=\mathbf{50.188}\ ^{kJ}/_{mol}$;

$\Delta G_{eq}=G_{HS-}+G_{H3O}-(G_{H2S}+G_{H2O})=\mathbf{-3.072+22.44-(-30.82}+0)=\mathbf{50.188}\ ^{kJ}/_{mol}$;

$G_{HS-}=\Delta G_{eq}-G_{H3O}+(G_{H2S}+G_{H2O})=\mathbf{50.188-22.44}+(\mathbf{-30.82}+0)=\mathbf{-3.072}\ ^{kJ}/_{mol}$;

$pK_{a2}=19$ $\mathbf{HS^-}+H_2\mathbf{O}=\mathbf{S^{2-}}+H_3O^+$; $K_{eq1}=K_{a1}/[H_2O]=10\wedge^{(-19)}/55.3=10\wedge^{(-20.74)}$;

$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=-8.3144*298.15*\ln(10\wedge^{(-20.74)})=G_{S2-}+G_{H3O}-(G_{\ HS-}+G_{H2O})=\mathbf{118.38}\ ^{kJ}/_{mol}$;

$\Delta G_{eq}=G_{S2-}+G_{H3O}-(G_{\ HS-}+G_{H2O})=\mathbf{92.868+22.44-(-3.072}+0)=\mathbf{118.38}\ ^{kJ}/_{mol}$;

$G_{S2-}=\Delta G_{eq}-G_{H3O}+(G_{\ HS-}+G_{H2O})=\mathbf{118.38-22.44}+(\mathbf{-3.072}+0)=\mathbf{92.868}\ ^{kJ}/_{mol}$;

Sulfur reduction inverse potential: $S_{rombic}+2\mathbf{H_3O^+}+2e^-=\mathbf{H_2S}_{aq}+2H_2\mathbf{O}$; $-E^\circ_S=\mathbf{-0.025735}$ V;

$\underline{2(Pt)H}+2H_2O=2H_3O^++2e^-$; $E^\circ_H=\mathbf{-0.27073}$ V; $S_{rombic}+\underline{2(Pt)H}=H_2S_{aq}$;

$\mathbf{\Delta G_{eq}}=(E^\circ_H-E^\circ_S)\bullet F\bullet 1\bullet 2=(\mathbf{-0.27073+0.025735})*96485*2=\mathbf{-0.244995}*96485*2=\mathbf{-47.277}\ ^{kJ}/_{mol}$;

$G_{H2S\,aq}=\Delta G_{HessH2S}+(2G_{H(Pt)}+G_{S\,rombic})=\mathbf{-47.277}+(2*\mathbf{48.46-85.64})=\mathbf{-35.997}\ ^{kJ}/_{mol}$. 2nd page.

Nernst's half: $\mathbf{H_2S}_{aq}+2H_2\mathbf{O}=S_{rhombic}+2\mathbf{H_3O^+}+2e^-$ has absolute standard potential $\mathbf{E^{\circ 1}_{H2S}=-0.025735}$ V

for free energy change: $\mathbf{\Delta G_{eqH2S}=E^{\circ 1}_{H2S}Fn=-0.025735}*96485*2=\mathbf{-4.966}\ ^{kJ}/_{mol}$

Expression value from Hess law for free energy change to hydrogen sulfide aqua solution in half reaction is $\Delta G_{Hess\_H2S\,aq}=G_{S\,rhombic}+2G_{H3O+}-(G_{\ H2S\,aq}+2G_{H2O})=\mathbf{-85.64}+2*\mathbf{22.44}-(G_{\ H2S\,aq}+2*0)=\mathbf{-4.966}\ ^{kJ}/_{mol}$, than absolute value is: $G_{\ H2S\,aq}=G_{S\,rhombic}+2G_{H3O+}-(\Delta G_{Hess\_H2S\,aq}+2G_{H2O})=\mathbf{-85.64}+2*\mathbf{22.44}-(\mathbf{-4.966}+2*0)=\mathbf{-35.794}\ ^{kJ}/_{mol}$.

Formation from elements $S_{rhombic}+\mathbf{H}_{2gas}=\mathbf{H_2S}_{gas}$ shows energy content in one mol $G_{S\,rhombic}=\mathbf{-85.64}\ ^{kJ}/_{mol}$; [1,6]
Formation energy change is $\Delta G_{Hess\_H2S\,gas}=G^\circ_{H2S\,gas}-({}_{Hess}G^\circ_{S\,rombic}+{}_{Hess}G^\circ_{H2})=-20.6-(\mathbf{0}+0)=-20.6\ ^{kJ}/_{mol}$. [1]
Sulfur energy content in mol is $G_{S\,rombic}=G^\circ_{H2S\,as}-(\Delta G_{Hess\_H2S\,gas}+G_{H2gas})=-20.6-\mathbf{(}-20.6+\underline{\mathbf{85.64}}\mathbf{)}=\mathbf{-85.64}\ ^{kJ}/_{mol}$;

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

Alberty data are given on absolute values for elements: $G_{S rombic}=\mathbf{-85.64}$ $^{kJ}/_{mol}$; $G_{O2gas}=\mathbf{303}$ $^{kJ}/_{mol}$; $G_{H2gas}=\mathbf{85.6}$ $^{kJ}/_{mol}$; $\Delta G°_{SO4Form}=\mathbf{-747.75}$ $^{kJ}/_{mol}$ relative to water and carbon dioxide gas as zero $G_{H2O}=G_{CO2gas}=G_{\underline{e-}}=0$ $^{kJ}/_{mol}$ reference scale. Formation from elements sulfuric acid and sulfates: $S_{rombic}+2O_{2gas}+H_{2gas}=H_2SO_{4aq}$; $\Delta G°_{H2SO4Form}=G_{H2SO4}-(G_{S rombic}+2G_{O2}+G_{H2gas})=-690.0$ $^{kJ}/_{mol}$; [1]

$G_{H2SO4}=\Delta G°_{H2SO4Form}+(G_{S rombic}+2G_{O2}+G_{H2gas})=-690.0+(\mathbf{-85.64}+2*\mathbf{303}+\mathbf{85.6})=\mathbf{-84.04}$ $^{kJ}/_{mol}$.

$S_{rombic}+2O_{2gas}+H_{2gas}/2=HSO_4^-$; $\Delta G°_{HSO4Form}=G_{HSO4}-(G_{S rombic}+2G_{O2}+0.5G_{H2gas})=-755.9$ $^{kJ}/_{mol}$.

$G_{HSO4}=\Delta G°_{HSO4Form}+(G_{S rombic}+2G_{O2}+0.5G_{H2gas})=-755.9+(\mathbf{-85.64}+2*\mathbf{303}+\mathbf{85.6/2})=\mathbf{-192.74}$ $^{kJ}/_{mol}$;

$S_{rombic}+2O_{2gas}=SO_4^{2-}$; $\Delta G°_{SO4Form}=G_{SO4}-(G_{S rombic}+2G_{O2})=\mathbf{-747.75}$ $^{kJ}/_{mol}$;

$G_{SO4}=\Delta G°_{SO4Form}+(G_{S rombic}+2G_{O2})=\mathbf{-747.75-85.64}+2*\mathbf{303}=\mathbf{-227.39}$ $^{kJ}/_{mol}$;

Equilibrium constants in mole fractions $K_{eq}=K_a/[H_2O]$ calculate dividing the acid constant by water $[H_2O]$. Protolysis $H_2SO_4+H_2O=HSO_4^-+H_3O^+$ acid $pK_{a1}=-2.8$ and equilibrium is $K_{eq1}=K_{a1}/[H_2O]=10\text{^}^{(2.8)}/55.3=11.41$;

$\Delta G_{eqH2SO4}=-R•T•\ln(K_{eq})=-8.3144*298.15*\ln(11.41)=G_{HSO4-}+G_{H3O}-(G_{H2SO4}+G_{H2O})=\mathbf{-6.035}$ $^{kJ}/_{mol}$;

$\Delta G_{eqH2SO4}=G_{HSO4-}+G_{H3O}-(G_{H2SO4}+G_{H2O})=G_{HSO4-}+\mathbf{22{,}44}-(\mathbf{-84{,}04-151{,}549})=\mathbf{-6{,}035}$ $^{kJ}/_{mol}$;

$G_{HSO4-}=G_{HSO4-}+G_{H3O}-(G_{H2SO4}+G_{H2O})=\mathbf{-6{,}035-22{,}44}+(\mathbf{-84{,}04-151{,}549})=\mathbf{-264{,}06}$ $^{kJ}/_{mol}$;

$HSO_4^-+H_2O=SO_4^{2-}+H_3O^+$; $pK_{a2}=1.99$; $K_{eq2}=K_{a2}/[H_2O]=10\text{^}^{(-1.99)}/55.3=0.0001850$;

$\Delta G_{eqHSO4}=-R•T•\ln(K_{eq2})=-8.3144*298.15*\ln(0.0001850)=G_{SO42-}+G_{H3O}-(G_{HSO4-}+G_{H2O})=\mathbf{21.307}$ $^{kJ}/_{mol}$;

$\Delta G_{eqHSO4}=G_{SO42-}+G_{H3O}-(G_{HSO4-}+G_{H2O})=\mathbf{-747{,}75+22{,}44}-(G_{HSO4-}\mathbf{-151{,}549})=\mathbf{21{,}307}$ $^{kJ}/_{mol}$;

$G_{HSO4-}=G_{SO42-}+G_{H3O}-(\Delta G_{eqHSO4}+G_{H2O})=\mathbf{-747{,}75+22{,}44-(21{,}307-151{,}549)=-595{,}068}$ $^{kJ}/_{mol}$;

$\Delta G_{eqHSO4}=G_{SO42-}+G_{H3O}-(G_{HSO4-}+G_{H2O})=G_{SO42-}+\mathbf{22{,}44-(-264{,}06-151{,}549)=21{,}307}$ $^{kJ}/_{mol}$;

$G_{SO42-}=\Delta G_{eqHSO4}-G_{H3O}+(G_{HSO4-}+G_{H2O})=\mathbf{21{,}307-22{,}44}+(\mathbf{-264{,}06-151{,}549})=\mathbf{-416{,}74}$ $^{kJ}/_{mol}$;

Formation from free elements $S_{rombic}+1.5O_{2gas}+H_{2gas}=H_2SO_{3aq}$ and solubility $SO_2^{gas}+H_2O=H_2SO_{3aq}$.

$\Delta G°_{H2SO3Form}=G_{H2SO3}-(G_{S rombic}+1.5\Delta G_{O2}+G_{H2gas})=G_{H2SO3}-(\mathbf{-85.64}+1.5*\mathbf{303}+\mathbf{85.6})=\mathbf{-527.3675}$ $^{kJ}/_{mol}$;

$G_{H2SO3}=\Delta G°_{H2SO3Form}+(G_{S rombic}+1.5\Delta G_{O2}+G_{H2gas})=\mathbf{-527.3675}+(\mathbf{-85.64}+1.5*\mathbf{303}+\mathbf{85.6})=\mathbf{-72.9075}$ $^{kJ}/_{mol}$;

$G_{HSO3}=\Delta G°_{HSO3Form}+(G_{S rombic}+1.5\Delta G_{O2}+G_{H2gas}/2)=-486.5+(\mathbf{-85.64}+1.5*\mathbf{303}+\mathbf{85.6}/2)=\mathbf{-74.84}$ $^{kJ}/_{mol}$;

$G_{SO3}=\Delta G°_{SO3Form}+G_{S rombic}+1.5\Delta G_{O2}=\mathbf{-490.38-85.64}+1.5*\mathbf{303}=\mathbf{-121.52}$ $^{kJ}/_{mol}$;

Equilibrium constants in mole fractions $K_{eq}=K_a/[H_2O]$ calculate dividing the acid constant by water $[H_2O]$.

$H_2SO_3+H_2O=HSO_3^-+H_3O^+$; $pK_{a1}=1.85$; $K_{eq1}=K_{a1}/[H_2O]=10\text{^}^{(-1.85)}/55.3=0.0002554$;

$\Delta G_{eqH2SO3}=-R•T•\ln(K_{eq1})=-8.3144*298.15*\ln(0.0002554)=G_{HSO3-}+G_{H3O}-(G_{H2SO3}+G_{H2O})=\mathbf{20.5075}$ $^{kJ}/_{mol}$;

$G_{H2SO3}=G_{HSO3-}+G_{H3O}-(\Delta G_{eqH2SO3}+G_{H2O})=\mathbf{-74.84+22.44-(20.5075+0)=-72.9075}$ $^{kJ}/_{mol}$;

$HSO_3+H_2O=SO_3^{2-}+H_3O^+$; $pK_{a2}=7.21$; $K_{eq2}=K_{a2}/[H_2O]=10\text{^}^{(-7.21)}/55.3=0.000000001115$;

$\Delta G_{eqHSO3}=-R•T•\ln(K_{eq2})=-8;3144*298.15*\ln(0.000000001115)=G_{SO32-}+G_{H3O}-(G_{HSO3-}+G_{H2O})=\mathbf{51.1}$ $^{kJ}/_{mol}$;

$G_{HSO3-}=G_{SO32-}+G_{H3O}-(\Delta G_{eqHSO3}+G_{H2O})=\mathbf{-121.52+22.44-(51.1+0)=-150.2}$ $^{kJ}/_{mol}$;

Oxidation standard potential of sulfurous acid electrode $H_2SO_3+4H_2O=HSO_4^-+3H_3O^++2e^-$ $E°_{H2SO3}=\mathbf{0.1073}$ V.

$E°_{H2SO3}=E°+0.10166-0.0591/2*\lg(1/[H_2O]^4)-0.37239=0.172-0.0591/2*\lg(1/55.3\text{^}4)+0.10166-0.37239=\mathbf{0.10726}$ V;

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

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

$\Delta G_{eqHS2O3}=G_{HSO3}+3G_{H3O}-(G_{H2SO3}+4G_{H2O})=\mathbf{-192.74}+3*22.44-(\mathbf{-146.118}+4*0)=\mathbf{20.69796}$ $^{kJ}/_{mol}$;

$G_{H2SO3}=G_{HSO4-}+3G_{H3O}-(\Delta G_{eqH2SO3}+4G_{H2O})=\mathbf{-192.74}+3*22.44-(\mathbf{20.69796}+4*0)=\mathbf{-146.118}$ $^{kJ}/_{mol}$;

$G_{HSO4-}=\Delta G_{eqH2SO4-}-3G_{H3O}+(G_{H2SO3}+4G_{H2O})=\mathbf{20.69796}-3*22.44+(\mathbf{-146.118}+4*0)=\mathbf{-192.74}$ $^{kJ}/_{mol}$;

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:

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

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

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

$\Delta \mathbf{G}_{spH2SO3}=G_{H2SO3}-(G_{SO2}+\mathbf{G}_{H2O})=\mathbf{-72.9075-(-81.73477}+0)=\mathbf{8.82727}$ ${}^{kJ}/_{mol}$;

$G_{SO2}=G_{H2SO3}-(\Delta\mathbf{G}_{spH2SO3}+\mathbf{G}_{H2O})=\mathbf{-72.9075-(8.82727}+0)=\mathbf{-81.73477}$ ${}^{kJ}/_{mol}$;

$HSO_3^-+4H_2O=SO_4^{2-}+3H_3O^++\mathbf{2e^-}$; Suchotina 2=<pH<7 $E^\circ_{HSO42-}=\mathbf{0.10726}$ V.

$E^\circ_{SO4-}=E^\circ+0.10166-0.0591/2*\lg(1/[H_2O]^4)-0.37239=0.172-0.0591/2*\lg(1/55.3\text{^}4)+0.10166-0.37239=\mathbf{0.10726}$ V;

$E_{HSO4-}=E^\circ_{HSO4-}+0.0591/2*\log([HSO_4^-]*[H_3O^+]^3/[H_2SO_{3aq}]/[H_2O]^4)=\mathbf{0.10726}\text{ V}+0.0591/2*\log\dfrac{[SO_4^{2-}]\cdot[H_3O^+]^3}{[HSO_3^-]\cdot[H_2O]^4}$

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

$\Delta\mathbf{G}_{eqSO4-}=G_{SO4-}+3\mathbf{G}_{H3O}-(G_{HSO3}+4\mathbf{G}_{H2O})=\mathbf{-119.5295}+3*22.44-(\mathbf{-72.9075}+4*0)=\mathbf{20.69796}$ ${}^{kJ}/_{mol}$;

$G_{HSO3}=G_{SO4-}+3\mathbf{G}_{H3O}-(\Delta\mathbf{G}_{eqSO4-}+4\mathbf{G}_{H2O})=\mathbf{-119.5295}+3*22.44-(\mathbf{20.69796}+4*0)=\mathbf{-72.9075}$ ${}^{kJ}/_{mol}$;

$G_{SO4-}=\Delta\mathbf{G}_{eqSO4-}-3\mathbf{G}_{H3O}+(G_{HSO3}+4\mathbf{G}_{H2O})=\mathbf{20.69796}-3*22.44+(\mathbf{-72.9075}+4*0)=\mathbf{-119.5295}$ ${}^{kJ}/_{mol}$;

Substance	ΔH°_H, ${}^{kJ}/_{mol}$	ΔS°_H, ${}^{J}/_{mol/K}$	ΔG°_H, ${}^{kJ}/_{mol}$	
H_2SO_4	-814,0	156,9	-690,0	CRC;
H_2SO_4		formation	**-84,04**	$G_{H2SO4}=\Delta G^\circ_{H2SO4}+G_{Srombisks}+2\Delta G_{O2}+G_{H2gas}+\mathbf{G}_{H2O}=\mathbf{-84,04}$ ${}^{kJ}/_{mol}$;
H_2SO_4		$pK_{a1}=-2,8$	**-415.04**	$G_{H2SO4}=G_{HSO4-}+G_{H3O}-(\Delta G_{eqH2SO4}+G_{H2O})=\mathbf{-415,04}$ ${}^{kJ}/_{mol}$;
HSO_4^-	-887,3	131,8	-755,9	CRC
HSO_4^-	-	$pK_{a1}=-2,8$	**-264,06**	$G_{HSO4-}=\Delta G_{eqH2SO4}-G_{H3O}+(G_{H2SO4}+G_{H2O})=\mathbf{-264,06}$ ${}^{kJ}/_{mol}$;
HSO_4^-	-	$pK_{a2}=1,99$	**-595,068**	$G_{HSO4-}=G_{SO42-}+G_{H3O}-(\Delta G_{eqHSO4}+G_{H2O})=\mathbf{-595,068}$ ${}^{kJ}/_{mol}$;
HSO_4^-		formation	**-192,74**	$G_{HSO4}=\Delta G^\circ_{HSO4}+G_{Srombisks}+2\Delta G_{O2}+G_{H2gas}/2=\mathbf{-192,74}$ ${}^{kJ}/_{mol}$;
HSO_4^-	$E^\circ_{HSO3-}=$	**0,10726**	**-192,74**	$G_{HSO4-}=\Delta\mathbf{G}_{eqHSO3-}-3\mathbf{G}_{H3O}+(G_{H2SO3}+4\mathbf{G}_{H2O})=\mathbf{-192,74}$ ${}^{kJ}/_{mol}$;
SO_4^{2-}	**-907,62**	**-536,2**	**-747,75**	**BioTherm2006**; $\Delta G\_{SO42-}=\Delta H-T*\Delta S=\mathbf{-907,62}-298,15*-0,\mathbf{5362}=\mathbf{-747,75}$ ${}^{kJ}/_{mol}$;
SO_4^{2-}	-	formation	**-227,39**	$G_{SO4}=\Delta G^\circ_{SO4Form}+G_{Srombisks}+2\Delta G_{O2}=\mathbf{-747,75-85,64}+2*\mathbf{303}=\mathbf{-227,39}$ ${}^{kJ}/_{mol}$;
SO_4^{2-}	-	$pK_{a2}=1,99$	**-416,74**	$G_{SO42-}=\Delta G_{eqHSO4}-G_{H3O}+(G_{HSO4-}+G_{H2O})=\mathbf{-416,74}$ ${}^{kJ}/_{mol}$;
SO_4^{2-}	$E^\circ_{HSO3-}=$	**0,10726**	**-119,53**	$G_{SO4-}=\Delta\mathbf{G}_{eqHSO3-}-3\mathbf{G}_{H3O}+(G_{HSO3}+4\mathbf{G}_{H2O})=\mathbf{-119,5295}$ ${}^{kJ}/_{mol}$;
SO_4^{2-}	$E^\circ_{SO32-}=$	**-1,2522**	**-213,4**	$G_{SO42-}=\Delta\mathbf{G}_{eqSO32-OH}-\mathbf{G}_{H2O}+(G_{SO32-}+2\mathbf{G}_{OH})=\mathbf{-213,4}$ ${}^{kJ}/_{mol}$;
SO_4^{2-}	-909,3	20,1	-744,5	CRC
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**	$G_{SO2}=\Delta G^\circ_{SO2Form}+(G_{Srombisks}+G_{O2})=\mathbf{-153,46}$ ${}^{kJ}/_{mol}$;
SO_2^{gas}	$\Delta GK_{sp}=8,827$	0,028413	**-81,735**	$\Delta G_{SO2}=G_{H2SO3}-(\Delta\mathbf{G}_{spH2SO3}+\mathbf{G}_{H2O})=-72,9075-(8,82727+0)=\mathbf{-81,73477}$ ${}^{kJ}/_{mol}$;
H_2SO_3		formation	**-72,9075**	$G_{H2SO3}=\Delta G^\circ_{H2SO3Form}+(G_{Srombisks}+1,5\Delta G_{O2}+G_{H2gas})=\mathbf{-72,9075}$ ${}^{kJ}/_{mol}$;
H_2SO_3		$pK_{a1}=1,85$	**-72,9075**	$G_{H2SO3aq}=\mathbf{-74,84}+\mathbf{22,44}-(\mathbf{20,5075}+\mathbf{0})=\mathbf{-72,9075}$ ${}^{kJ}/_{mol}$;
H_2SO_3	$E^\circ_{HSO3-}=$	**0,10726**	**-146,118**	$G_{H2SO3}=G_{HSO4-}+3\mathbf{G}_{H3O}-(\Delta\mathbf{G}_{eqHSO3-}+4\mathbf{G}_{H2O})=\mathbf{-146,11796}$ ${}^{kJ}/_{mol}$;
HSO_3^-		formation	**-74,84**	$G_{HSO3}=\Delta G^\circ_{HSO3}+G_{Srombisks}+1,5\Delta G_{O2}+G_{H2gas}/2=\mathbf{-74,84}$ ${}^{kJ}/_{mol}$;
HSO_3^-		$pK_{a2}=7,21$	**-150,2**	$G_{HSO3-aq}=\mathbf{-121,52}+\mathbf{22,44}-(\mathbf{51,1}+\mathbf{0})=\mathbf{-150,2}$ ${}^{kJ}/_{mol}$;
HSO_3^-	$E^\circ_{HSO3-}=$	**0,10726**	**-72,9075**	$G_{HSO3}=G_{SO4-}+3\mathbf{G}_{H3O}-(\Delta\mathbf{G}_{eqHSO3-}+4\mathbf{G}_{H2O})=\mathbf{-72,9075}$ ${}^{kJ}/_{mol}$;
HSO_3^-	-635,5	-29	-486,5	CRC
SO_3^{2-}	**-632,19**	**-474,05**	**-490,38**	**BioTherm2006** $\Delta G_{H\_SO32-}=\Delta H_H-T*\Delta S_H=\mathbf{-632,1888}-298,15*-0,\mathbf{47405}=\mathbf{-490,85}$ ${}^{kJ}/_{mol}$;
SO_3^{2-}	-	formation	**-121,52**	$G_{SO3}=\Delta G_{Form}=\Delta G^\circ_{SO3}+G_{Srombisks}+1,5\Delta G_{O2}=\mathbf{-121,52}$ ${}^{kJ}/_{mol}$;
SO_3^{2-}	$E^\circ_{SO32-OH}=$	**-1,2522**	**-126,48**	$G_{SO32-}=G_{SO42-}+\mathbf{G}_{H2O}-(\Delta\mathbf{G}_{eqSO32-OH}+2\mathbf{G}_{OH})=\mathbf{-126,483}$ ${}^{kJ}/_{mol}$;

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

$SO_3^{2-}+2OH^-=SO_4^{2-}+H_2O+2e^-$; pH > 7 ; $E^\circ_{SO42-}=\mathbf{-1.2522}$ V Suchotina

$E^\circ_{SO32-OH}=E^\circ+0.10166+0.0591/2*\lg(1/[H_2O])=-0.93+0.10166+0.02955*\lg(1/55.3)-0.37239=\mathbf{-1.2522}$ V;

$$E_{SO32-OH}=E^\circ_{SO32-OH}+\frac{0.0591}{2}\bullet\log\frac{[SO_4^{2-}]\cdot[H_2O]}{[SO_3^{2-}]\cdot[OH^-]^2}=\mathbf{-1.2522}\text{ V}+\frac{0.0591}{2}\bullet\log\frac{[SO_4^{2-}]\cdot[H_2O]}{[SO_3^{2-}]\cdot[OH^-]^2}$$

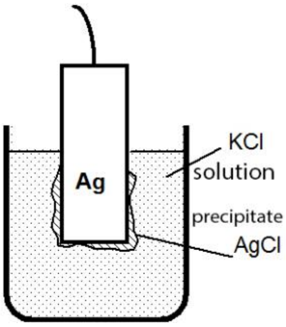
$\Delta\mathbf{G}_{eqSO42-OH}=E^\circ_{SO32-OH}\bullet F\bullet 2=\mathbf{-1.2522}*96485*2=\mathbf{-241.637}$ ${}^{kJ}/_{mol}$;

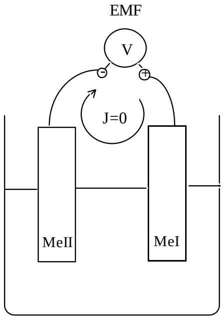
$\Delta\mathbf{G}_{eqSO32-OH}=G_{SO42-}+\mathbf{G}_{H2O}-(G_{SO32-}+2\mathbf{G}_{OH})=\mathbf{-213.4+0-(-126.483}+2*77.36)=\mathbf{-241.637}$ ${}^{kJ}/_{mol}$;

$G_{SO32-}=G_{SO42-}+\mathbf{G}_{H2O}-(\Delta\mathbf{G}_{eqSO32-OH}+2\mathbf{G}_{OH})=\mathbf{-213.4+0-(-241.637}+2*77.36)=\mathbf{-126.483}$ ${}^{kJ}/_{mol}$;

$G_{SO42-}=\Delta\mathbf{G}_{eqSO32-OH}-\mathbf{G}_{H2O}+(G_{SO32-}+2\mathbf{G}_{OH})=\mathbf{-241.637-0+(-126.483}+2*77.36)=\mathbf{-213.4}$ ${}^{kJ}/_{mol}$;

Metal/insoluble salt/ solution of salt ions II-type electrode





K^+Cl^- solution, counter-ions Cl^- of AgCl insoluble salt. Nernst's half reactions for silver metal Ag. Electric potential in volt measurement by couple of electrodes **E**lectric **M**otion **F**orce EMF in Volts. Between two electrodes MeI Indicator electrode and MeII Reference electrode on electric circuit linked can be expressed MeI Indicator EI as sum: EI=EMF+EII. Indicator electrode EI –has reactivity with solution that electrode of investigations, Standard reference electrode EII =constant, because chloride concentration is constant.

$\mathbf{Ag}(s)+H_2O=\mathbf{Ag}^{+}+e^{-}$; absolute standard potential $E^\circ_{Ag}=\mathbf{0.6317}$ V; Kortly, Shucha ; [18]

$E_{ag/Ag+}=E^\circ-0.0591/1*\lg(1/[H_2O]^1)+0.10166-0.37239=0.7994-0.0591/1*\lg(1/55.3^{\wedge 1})+0.10166-0.37239=\mathbf{0.6317}$ V;

$\Delta\mathbf{G}_{\mathbf{eq}\_Ag}=E^\circ_{Ag}\bullet F\bullet 2=\mathbf{0.6317}*96485*1=\mathbf{60.95}\ ^{kJ}/_{mol}$. $\Delta\mathbf{G}_{\mathbf{eq}\_As}=G_{Ag+}\mathbf{-}(G_{Ag}\mathbf{+G}_{\mathbf{H2O}})=77.1\mathbf{-}(G_{Ag}+0)=\mathbf{60.95}\ ^{kJ}/_{mol}$;

$G_{Ag}=G_{Ag+}\mathbf{-(}\Delta\mathbf{G}_{\mathbf{eq}\_Ag}\mathbf{+G}_{\mathbf{H2O}})=77.1\mathbf{-(60.95}+0)=\mathbf{16.15}\ ^{kJ}/_{mol}$;

$G_{Ag}=G_{Ag+}\mathbf{-(}\Delta\mathbf{G}_{\mathbf{eq}\_Ag}\mathbf{+G}_{\mathbf{H2O}})=\mathbf{103{,}8-(60{,}95}+0)=\mathbf{42{,}85}\ ^{kJ}/_{mol}$;

$G_{Ag+}=\Delta\mathbf{G}_{\mathbf{eq}\_As}+(G_{Ag}\mathbf{+G}_{\mathbf{H2O}})=\mathbf{60.95+(42.855}+0)=\mathbf{103.8}\ ^{kJ}/_{mol}$;

Solubility equilibrium in mol fractions $\mathbf{Ag}Cl(s)+2H_2O=\mathbf{Ag}^{+}+Cl^{-}$; $\mathbf{Ag}Cl(s)+2H_2O-Cl^{-}=\mathbf{Ag}^{+}$ absolute constant :

$K_{Absolute\mathbf{Ag}Cl}=K_{sp\mathbf{Ag}Cl}/[H_2O]^{\wedge 2}=[\mathbf{Ag}^+]*[Cl^-]/[\mathbf{Ag}Cl(s)]/[H_2O]^{\wedge 2}=1.77*10^{\wedge(-10)}/55.3^{\wedge}2=5.79*10^{-14}$;

$\Delta\mathbf{G}_{Absolute\mathbf{Ag}Cl}\mathbf{=-R\bullet T\bullet ln}(K_{Absolute\mathbf{Ag}Cl})=-8.3144*298.15*\ln(5.788*10^{\wedge(-14)})=\mathbf{75.559}\ ^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{sp\mathbf{Ag}Cl}\mathbf{=}G_{Ag+}\mathbf{+}G_{Cl-}\mathbf{-(}G_{AgCl}\mathbf{+2G}_{\mathbf{H2O}})=\mathbf{103{,}8}-183{,}955-(\mathbf{-155{,}714+2*0})=\mathbf{75{,}559}\ ^{kJ}/_{mol}$;

$G_{AgCl}\mathbf{=}G_{Ag+}\mathbf{+}G_{Cl-}\mathbf{-(}\Delta\mathbf{G}_{sp\mathbf{Ag}Cl}\mathbf{+2G}_{\mathbf{H2O}})=\mathbf{103{,}8}-183{,}955-(\mathbf{75{,}559+2*0})=\mathbf{-155{,}714}\ ^{kJ}/_{mol}$;

compensate solubility water molecule on summary $\mathbf{Ag}(s)+H_2O=\mathbf{Ag}^{+}+e^{-}$; $\mathbf{Ag}(s)+H_2O+Cl^{-}=\mathbf{Ag}Cl(s)+2H_2O+e^{-}$;

reaction $\mathbf{Ag}(s)+Cl^{-}=\mathbf{Ag}Cl(s)+H_2O+e^{-}$ with absolute standard potential $E^\circ_{Ag/AgCl}=\mathbf{-0.1514}$ V of $[Cl^-]=0.1$ M$=[K^+Cl^-]$ potassium chloride solution; [18]

$E_{Ag/AgCl}=E^\circ-0.0591/1*\lg([H_2O]^1)+0.10166-0.37239=0.2223-0.0591/1*\lg(55.3^{\wedge 1})+0.10166-0.37239=\mathbf{-0.1514}$ V;

$\Delta\mathbf{G}_{\mathbf{eq}\_Ag}=E^\circ_{Ag}\bullet F\bullet 1=\mathbf{-0.1514}*96485*1=\mathbf{-14.61}\ ^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}\_Ag}=G_{AgCl}\mathbf{+G}_{\mathbf{H2O}}\mathbf{-}(G_{Ag}+G_{Cl-})=\mathbf{-155.71}+0-(G_{Ag}\mathbf{-183.955})=\mathbf{-14.61}\ ^{kJ}/_{mol}$;

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

Solubility $\mathbf{NH_{3gas}}$ and **Ag** compensate each one water molecule in Nernst's half reaction products

$\mathbf{NH_{3gas}+H_2O=NH_{3aq}}$;$Ag+\mathbf{H_2O}=Ag^{+}\mathbf{+e^{-}}$; $Ag+H_2O+2NH_{3aq}=Ag(NH_3)_2^{+}\mathbf{+2H_2O+e^{-}}$;

$Ag+2NH_{3aq}=Ag(NH_3)_2^{+}\mathbf{+\ H_2O+e^{-}}$; absolute potential $E^\circ_{Ag/Ag(NH3)2+}=\mathbf{0.000725\ V}$; Suchotina classic $E^\circ=0.373$ V**;**

$E^\circ_{Ag/Ag(NH3)2+}=E^\circ-0.0591/1*\lg([H_2O]^1)+0.10166-0.3=0.373-0.0591/1*\lg(55.3^{\wedge 1})+0.10166-0.37239=\mathbf{-0.000725}$ V;

$\Delta\mathbf{G}_{Ag/Ag(NH3)2+}=E^\circ_{Ag/Ag(NH3)2+}\bullet F\bullet 1=\mathbf{-0.000725}*96485*1=\mathbf{-0.06995}\ ^{kJ}/_{mol}$;

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

$2Ag+2OH^{-}=\mathbf{Ag_2O}(s)+H_2O\mathbf{+2e^{-}}$; absolute potential $E^\circ_{2Ag/\mathbf{Ag2O}}=\mathbf{0.02277}$ V; Suchotina classic $E^\circ=0.345$ V**;**

$E^\circ_{2Ag/\mathbf{Ag2O}}=E^\circ-0.0591/2*\lg([H_2O]^1)+0.10166-0.37239=0.345-0.0591/2*\lg(55.3^{\wedge 1})+0.10166-0.37239=\mathbf{0.02277}$ V

$\Delta\mathbf{G}_{Ag/\mathbf{Ag2O}}=E^\circ_{Ag/\mathbf{Ag2O}}\bullet F\bullet 2=\mathbf{0.02277}*96485*2=\mathbf{4.394}\ ^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{Ag/\mathbf{Ag2O}}=G_{\mathbf{Ag2O}}\mathbf{+G}_{\mathbf{H2O}}\mathbf{-}(2G_{Ag}\mathbf{+2}G_{OH})=G_{\mathbf{Ag2O}}+0-(2*\mathbf{42.855-2*}77.36)=\ \mathbf{4.394}\ ^{kJ}/_{mol}$;

$\mathbf{G}_{\mathbf{Ag2O}}=\Delta\mathbf{G}_{Ag/\mathbf{Ag2O}}\mathbf{-G}_{\mathbf{H2O}}+(2G_{Ag}\mathbf{+2}G_{OH})=\mathbf{4.394}-0+(2*\mathbf{42.855-2*}77.36)=\mathbf{-64.616}\ ^{kJ}/_{mol}$;

$$E^\circ_{Ag/Ag(NH3)2+}=\mathbf{0{,}000725\ V}+\ \frac{[Ag(NH_3)_2^+]}{[Ag]\cdot([NH_3]-2\cdot[Ag(NH_3)_2^+])^2}\quad E^\circ_{2Ag/\mathbf{Ag2O}}=\mathbf{0{,}02277}\ \text{V}+\ \frac{[Ag_2O]\cdot[H_2O]}{[Ag]^2\cdot[OH]^2}$$

Viela	$\Delta H^\circ_H\ ^{kJ}/_{mol}$	$\Delta S^\circ_H\ ^{J}/_{mol/K}$	$\Delta G^\circ_H\ ,^{kJ}/_{mol}$	
Ag	-	-	**16.15**	$G_{Ag}=G_{Ag+}\mathbf{-(}\Delta\mathbf{G}_{\mathbf{eq}\_Ag}\mathbf{+G}_{\mathbf{H2O}})=77.1\mathbf{-(60.95}+0)=\mathbf{16.15}\ ^{kJ}/_{mol}$;
Ag	$E^\circ_{Ag/Ag+}=$	**-0,6317 V**	**42,85**	$G_{Ag}=G_{Ag+}\mathbf{-(}\Delta\mathbf{G}_{\mathbf{eq}\_Ag}\mathbf{+G}_{\mathbf{H2O}})=\mathbf{103{,}8-(60{,}95}+0)=\mathbf{42{,}85}\ ^{kJ}/_{mol}$;
Ag	$E^\circ_{Ag/AgCl}=$	**-0.1514 V**	**42.855**	$G_{Ag}=\ G_{AgCl}\mathbf{+G}_{\mathbf{H2O}}\mathbf{-(}\Delta\mathbf{G}_{\mathbf{eq}\_Ag}\mathbf{+G}_{\mathbf{Cl-}})=\mathbf{-155.71}+0-(\mathbf{-14.51-183.955})=\mathbf{42.855}\ ^{kJ}/_{mol}$;
Ag+	105.6	72.7	77.1	CRC;
Ag+	$E^\circ_{Ag}=$	**0.6317 V**	**103.8**	$G_{Ag+}=\Delta\mathbf{G}_{\mathbf{eq}\_As}+(G_{Ag}\mathbf{+G}_{\mathbf{H2O}})=\mathbf{60.95+(42.855}+0)=\mathbf{103.8}\ ^{kJ}/_{mol}$;
AgCl(s)	-127.01	96.25	**-155.71**	$\Delta G_{AgCl}=\mathbf{\Delta}H_H–T*\mathbf{\Delta}S_H=-127.01-298.15*0.09625=\mathbf{-155.71}\ ^{kJ}/_{mol}$;
Cl-	-167.08	56.6	**-183.955**	$\Delta G_{Cl-}=\mathbf{\Delta}H_H–T*\mathbf{\Delta}S_H=-167.08-298.15*0.0566=\mathbf{-183.955}\ ^{kJ}/_{mol}$;
$Ag(NH_3)_2^+$	$E^\circ_{Ag(NH3)2+}$	**-0.000725**	**-139.415**	$G_{Ag(NH3)2+}=\Delta\mathbf{G}_{Ag/Ag(NH3)2+}\mathbf{-G}_{\mathbf{H2O}}+(G_{Ag}\mathbf{+2}G_{NH3aq})\ =\mathbf{-139.415}\ ^{kJ}/_{mol}$;
AgCl	-	-	**-155.71**	**BioThermodynamic 2006**
AgCl	$\Delta\mathbf{G}_{sp\mathbf{Ag}Cl}\mathbf{=}$	$\mathbf{K}_{sp\mathbf{Ag}Cl}\mathbf{=}$	**-155,714**	$G_{AgCl}\mathbf{=}G_{Ag+}\mathbf{+}G_{Cl-}\mathbf{-(}\Delta\mathbf{G}_{sp\mathbf{Ag}Cl}\mathbf{+2G}_{\mathbf{H2O}})=\mathbf{-155{,}714}\ ^{kJ}/_{mol}$;
Cl-	-	-	**-183.955**	**BioThermodynamic 2006**
$\mathbf{Ag_2O}(s)$	-31.1	121.3	-11.2	CRC;
$\mathbf{Ag_2O}(s)$	$E^\circ_{Ag/\mathbf{Ag2O}}=$	**0.02277V**	**-64.616**	$\mathbf{G}_{\mathbf{Ag2O}}=\Delta\mathbf{G}_{Ag/\mathbf{Ag2O}}\mathbf{-G}_{\mathbf{H2O}}+(2G_{Ag}\mathbf{+2}G_{OH})=\mathbf{-64.616}\ ^{kJ}/_{mol}$;

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	$\Delta H^\circ_H,{}^{kJ}/_{mol}$	$\Delta S^\circ_H,{}^{J}/_{mol/K}$	$\Delta G^\circ_H,{}^{kJ}/_{mol}$	$(E^\circ_{H2O2aqRed}-E^\circ_{HgO})\mathbf{*F*n=(0.5278+0.22318)=0.7510}V$
$\underline{Hg}$	HgO ; $\mathbf{H_2O_2}$	75.9	**35.885**	$G_{\mathbf{Hg}}=G_{eqRedOx\_2H2O2}-\mathbf{G}_{\mathbf{O2aqua}}+(G_{HgO}+\mathbf{G}_{\mathbf{H2O2}})=\mathbf{35.885}\ ^{kJ}/_{mol}$;
$\underline{Hg}$	$E^\circ_{HgCl2}=$	**-0.1059** V	**35.8**	$G_{Hg}=(G_{Hg2Cl2}+\mathbf{G}_{\mathbf{H2O}}-(\mathbf{2G}_{\mathbf{Cl-}}+\Delta\mathbf{G}_{\mathbf{eq}\_Hg2Cl2}))/2=\mathbf{35.8}\ ^{kJ}/_{mol}$;
Hg_2^{2+}	-166.87	66.74	-146.97	$\Delta G_{Hg22+}=\Delta H_H-T*\Delta S_H=-166.87-298.15*0.06674=-146.97\ ^{kJ}/_{mol}$;
Hg_2^{2+}	$E^\circ_{Hg/Hg22+}=$	**0.6888** V	**204.52**	$G_{Hg22+}=\Delta\mathbf{G}_{\mathbf{eq}\_Hg}+(2G_{Hg}+\mathbf{G}_{\mathbf{H2O}})=\mathbf{132.92}+(2*\mathbf{35.702+0})=\mathbf{204.32}\ ^{kJ}/_{mol}$;
Hg^{2+}	-170.21	-36.19	-	CRC
$Hg_2SO_{4(s)}$	-743.1	200.7	-625.8	CRC
$Hg_2SO_{4(s)}$	$K_{Absolute\mathbf{Hg2}SO4}=$	$10^{\wedge(-9.673)}$	**-598.44**	$G_{Hg2SO4}=G_{\mathbf{Hg22+}}+\mathbf{G}_{\mathbf{SO42-}}-(\Delta\mathbf{G}_{\mathbf{eq}Hg2SO4}+\mathbf{2G}_{\mathbf{H2O}})=\mathbf{-598.44}\ ^{kJ}/_{mol}$;
SO_4^{2-}	**-907.62**	**-536.2**	**-747.75**	**Biochem. Thermodynamic 2006** Massachusetts Technology Inst.
SO_4^{2-}	$E^\circ_{Hg2SO4}=$	**0.2918** V	**-726.54**	$\mathbf{G}_{SO4}=G_{Hg2SO4}-(2G_{Hg}+\Delta\mathbf{G}_{\mathbf{eq}\_Hg2SO4})=\mathbf{-726.54}\ ^{kJ}/_{mol}$
SO_4^{2-}	-909.3	20.1	-744.5	CRC
$Hg_2Cl_{2(s)}$	-265.37	191.6	-210.7	CRC
$Hg_2Cl_{2(s)}$	$E^\circ_{HgCl2}=$	**-0.1059** V	**197.76**	$\mathbf{G}_{Hg2Cl2(s)}=\Delta\mathbf{G}^\circ_{Hg2Cl2Form}+(\mathbf{G}_{Hg22+}+2*\mathbf{G}_{Cl-})=\mathbf{197.76}\ ^{kJ}/_{mol}$;
$Hg_2Cl_{2(s)}$	$E^\circ_{HgCl2}=$	**-0.1059** V	**255.1**	$G_{Hg2Cl2}=\Delta\mathbf{G}_{\mathbf{eq}\_Hg2Cl2}-\mathbf{2G}_{\mathbf{H2O}}+(\mathbf{2G}_{\mathbf{Cl-}}+2G_{Hg})=\mathbf{255.1}\ ^{kJ}/_{mol}$;
$HgCl_{2(s)}$	-224.3	146	-178.6	CRC
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-	$K_{Absolute\mathbf{Hg2}Cl2}=$	$10^{\wedge(-23.1)}$	**-112.825**	$\mathbf{G}_{\mathbf{Cl-}}=(-G_{\mathbf{Hg22+}}+\Delta\mathbf{G}_{\mathbf{eq}Hg2Cl2}+(G_{Hg2Cl2}+\mathbf{3G}_{\mathbf{H2O}}))/2=\mathbf{-112.825}\ ^{kJ}/_{mol}$;
$HgO_{(s)}$	-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 $\Delta G_{HgO}=-58.5\ ^{kJ}/_{mol}$;
$HgO_{(s)}$	-	formation	**142.3**	$\mathbf{2G}_{HgO}=2\Delta\mathbf{G}_{HgO}+(2*G_{Hg}+G_{O2})=2*\mathbf{142.2}\ ^{kJ}/_{mol}$
$HgO_{(s)}$	$E^\circ_{HgO}=$	**0.22423 V**	**147.15**	$G_{HgO}=\Delta G_{eqHgO}-2G_{H2O}+(G_{Hg}+2G_{OH})=\mathbf{147.15}\ ^{kJ}/_{mol}$;

$2\underline{Hg+}H_2O=Hg_2^{2+}+2e^-$; absolute standard potential $E^\circ_{Hg}=\mathbf{0.6888}$ V; Kortly, Shucha ; [18]

$E^\circ_{Hg}=E^\circ-0.0591/2*\lg(1/[H_2O]^1)+0.10166-0.3713=0.907-0.0591/2*\lg(1/55.3^{\wedge1})+0.10166-0.37239=\mathbf{0.6888}$ V;

$\Delta\mathbf{G}_{\mathbf{eq}\_Hg}=E^\circ_{Hg}\bullet F\bullet 2=\mathbf{0.6888}*96485*2=\mathbf{132.92}\ ^{kJ}/_{mol}$,

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

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

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 :

$K_{Absolute\mathbf{Hg2}Cl2}=K_{sp\mathbf{Hg2}Cl2}/[H_2O]^{\wedge3}=[\mathbf{Hg}_2^{2+}]*[Cl^-]^2/[Hg_2Cl_{2(s)}]/[H_2O]^{\wedge3}=1.43*10^{\wedge(-18)}/1/55.3^{\wedge}3=10^{-23.1}$;

$\Delta\mathbf{G}_{\mathbf{eqHg2}Cl2}=\mathbf{-R\bullet T\bullet ln(}K_{Absolute\mathbf{Hg2}Cl2}\mathbf{)=-8.314*298.15*ln(}10^{\wedge(-23.1)}\mathbf{)=131.85}\ ^{kJ}/_{mol}$;

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

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

$Hg_2^{2+}+2Cl^-=Hg_2Cl_{2(s)}$; $\mathbf{G}_{Hg2Cl2(s)}=\Delta\mathbf{G}^\circ_{Hg2Cl2Form}+(\mathbf{G}_{Hg22+}+2*\mathbf{G}_{Cl-})=-210.7+(\mathbf{204.52}+2*\mathbf{101.97})=\mathbf{197.76}\ ^{kJ}/_{mol}$;

Formation $Hg_2^{2+}+2Cl^-$; $\mathbf{G}_{Hg2Cl2(s)}=\mathbf{G}_{Hg2Cl2(s)}-(\mathbf{G}_{Hg22+}+2*\mathbf{G}_{Cl-})=\mathbf{276.61}-(\mathbf{204.52}+2*\mathbf{101.97})=\mathbf{-131.85}\ ^{kJ}/_{mol}$;

$2\underline{Hg}+2Cl^-=Hg_2Cl_{2(s)}+2H_2O+2e^-$; absolute standard potential $E^\circ_{HgCl2}=\mathbf{-0.1059}$ V; Suchotina ; [18]

$E^\circ_{HgCl2}=E^\circ-0.0591/2*\lg([H_2O]^2)+0.10166-0.37239=0.2678-0.0591/2*\lg(55.3^{\wedge2})+0.10166-0.37239=\mathbf{-0.1059}$ V;

$\Delta\mathbf{G}_{\mathbf{eq}\_Hg2Cl2}=E^\circ_{Hg2Cl2}\bullet F\bullet 2=\mathbf{-0.1059}*96485*2=\mathbf{-20.44}\ ^{kJ}/_{mol}$,

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

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

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

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:

$K_{Absolute\mathbf{Hg2}SO4}=K_{sp\mathbf{Hg2}SO4}/[H_2O]^{\wedge2}=[\mathbf{Hg}_2^{2+}]*[SO_4^{2-}]/[Hg_2SO_{4(s)}]/[H_2O]^{\wedge2}=6.5*10^{\wedge(-7)}/1/55.3^{\wedge}2=10^{--9.673}$;

$\Delta\mathbf{G}_{\mathbf{eqHg2}SO4}=\mathbf{-R\bullet T\bullet ln(}K_{Absolute\mathbf{Hg2}SO4}\mathbf{)=-8.314*298.15*ln(}10^{\wedge(-9.673)}\mathbf{)=55.21}\ ^{kJ}/_{mol}$;

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

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

$Hg_2SO_{4(s)}+2H_2O=\mathbf{Hg}_2^{2+}+SO_4^{2-}$; $2\underline{Hg+}H_2O=\mathbf{Hg_2^{2+}}+2e^-$;

$Hg_2SO_{4(s)}+2H_2O-SO_4^{2-}=\mathbf{Hg}_2^{2+}$; $2\underline{Hg+}H_2O=\mathbf{Hg_2^{2+}}+2e^-$; $2\underline{Hg+}H_2O=Hg_2SO_{4(s)}+2H_2O-SO_4^{2-}+2e^-$;

$2\underline{Hg}+SO_4^{2-}=Hg_2SO_{4(s)}+H_2O+2e^-$; absolute standard potential $E^\circ_{HgSO4}=\mathbf{0.291772}$ V; Kortly, Shucha ; [18]

$E^\circ_{HgSO4}=E^\circ-0.0591/2*\lg([H_2O]^1)+0.10166-0.37239=0.614-0.0591/2*\lg(55.3^{\wedge1})+0.10166-0.37239=\mathbf{0.2918}$ V;

$\Delta\mathbf{G}_{\mathbf{eq}\_HgSO4}=E^\circ_{HgSO4}\bullet F\bullet 2=\mathbf{0.291772}*96485*2=\mathbf{56.30}\ ^{kJ}/_{mol}$,

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

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

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

Formation $2Hg+O_{2\,aqua}=2HgO$; $2\Delta\mathbf{G}_{HgO}=\mathbf{2G}_{HgO}-(2*\mathbf{35.7}+\mathbf{330})=2*-58.5=-117\ ^{kJ}/_{mol}$;

$\mathbf{2G}_{HgO}=2\Delta\mathbf{G}_{HgO}+(2*G_{Hg}+G_{O2})=2*-58.5+(2*\mathbf{35.7}+\mathbf{330})=2*\mathbf{142.2}\ ^{kJ}/_{mol}$;

$\Delta G_{eqHgO}=G_{HgO}+2G_{H2O}-(G_{Hg}+2G_{OH})=-58.5+2*\mathbf{0}-(\mathbf{35.7}+2*77.36)=\mathbf{-53.20}\ ^{kJ}/_{mol}$

$Hg+2OH^-=HgO+H_2O+2e^-$, Nernst's absolute standard potential $E°_{HgO}=\mathbf{-0.2242}\ V$;

$E°_{HgO}=E°-0.0591/2*\lg([H_2O]^1)+0.10166-0.37239=0.098-0.0591/2*\lg(55.3\text{^}^1)+0.10166-0.37239=\mathbf{-0.22423}\ V$;

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

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

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

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

Oxidation $\mathbf{H_2O_{2aqua}+2H_2O=O_{2aqua}+2H_3O^++2e^-}$ Nernst's absolute standard potential $E°_{\mathbf{Red}H2O2}=0.5278\ V$;

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

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

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

$\Delta G_{eqRedOx\_2H2O2}=(E°_{H2O2aqRed}-E°_{HgO})*\mathbf{F*n}=(\mathbf{0.5278+0.22318})*96485*2=(\mathbf{0.7510})*96485*2=\mathbf{144.9166}\ ^{kJ}/_{mol}$;

$\Delta G_{eqRedOx\_2H2O2}=G_{\mathbf{Hg}}+\mathbf{G}_{\mathbf{O2aqua}}-(G_{HgO}+\mathbf{G}_{\mathbf{H2O2}})=\mathbf{35{,}7+330}-(-58.5+\mathbf{279.285})=\mathbf{144.9166}\ ^{kJ}/_{mol}$;

HgO ; $G_{\mathbf{Hg}}=G_{eqRedOx\_2H2O2}-\mathbf{G}_{\mathbf{O2aqua}}+(G_{HgO}+\mathbf{G}_{\mathbf{H2O2}})=\mathbf{144.9166-330}+(-58.5+\mathbf{279.285})=\mathbf{35.70}\ ^{kJ}/_{mol}$;

Substance	$\Delta H°_H,^{kJ}/_{mol}$	$\Delta S°_H,^{J}/_{mol/K}$	$\Delta G°_H,^{kJ}/_{mol}$	**Biochem. Thermodynamic 2006** Massachusetts Technology inst.
Pb	$E°_{\underline{Pb}\downarrow Pb2+}=$	**-0.34523** V	**-349.07**	$G_{Pb}=G_{Pb2+}-(\Delta\mathbf{G}_{\mathbf{eq}\underline{Pb}\downarrow Pb2+}+G_{H2O})=\mathbf{-415.895}-(\mathbf{-66.42}+0)=\mathbf{-349.07}\ ^{kJ}/_{mol}$;
Pb	-	64.8	-	
Pb^{2+}	$E°_{\underline{PbO2}\downarrow Pb2+}=$	**1.49326 V**	**-415.69**	$G_{Pb2+}=G_{\underline{PbO2}}+4G_{\mathbf{H3O+}}-(\Delta\mathbf{G}_{\mathbf{eq}\underline{PbO2}\downarrow Pb2+}+6G_{\mathbf{H2O}})=\mathbf{-415.69}\ ^{kJ}/_{mol}$;
Pb^{2+}	0.92	18.5	-4.596	$\Delta G°_{Pb2+}=\Delta H°_H-T*\Delta S°_H=0.92-298.15*0.0185=-4.596\ ^{kJ}/_{mol}$;
$\underline{PbO_2}\downarrow$	-277.4	68.6	-217.3	CRC
$\underline{PbO_2}\downarrow$	$E°_{\underline{PbO2}\downarrow Pb2+}=$	**1.49326 V**	**-217.3**	$G_{\underline{PbO2}}=\Delta\mathbf{G}_{\mathbf{eq}\underline{PbO2}\downarrow Pb2+}-4G_{\mathbf{H3O+}}+(G_{Pb2+}+6G_{\mathbf{H2O}})=\mathbf{-217.3}\ ^{kJ}/_{mol}$;
$\underline{Al}$	-	28.3	-	
$\underline{Al}$	$E°_{Al/Al3+}=$	**-1.8984** V	**108**	$G_{Al}=G_{Al3+}-(\Delta\mathbf{G}_{\mathbf{eq}Al/\underline{Al3+}}+G_{\mathbf{H2O}})=\mathbf{-441.5-(-549.5+0)=108}\ ^{kJ}/_{mol}$;
$\underline{Al}^{3+}$	-538.4	-325	**-441.5**	$\Delta G°_{Pb2+}=\Delta H°_H-T*\Delta S°_H=-538.4-298.15*-0.325=\mathbf{-441.5}\ ^{kJ}/_{mol}$;
$H_2AlO_3^-$	$E°_{\underline{H2AlO3Al}}=$	**-2.63506**	**-345.29**	$G_{\underline{H2}AlO3}=\Delta\mathbf{G}_{\mathbf{eq}\underline{H2}AlO3\underline{Al}}-G_{\mathbf{H2O}}+(G_{Al}+4G_{\mathbf{OH}})=\mathbf{-345.29}\ ^{kJ}/_{mol}$;
$\underline{NaAlO_2}\downarrow$	-1133.2	70.4	-	CRC

$Pb^{2+}+6H_2O=\underline{PbO_2}(s)+4H_3O^++\mathbf{2e^-}$; Nernst's half reaction absolute standard potential $E°_{PbO2}=\mathbf{1.49326\ V}$;

$E°_{PbO2}=E°-0.0591/2*\lg(1/[H_2O]^6)+0.10166-0.37239=1.455-0.0591/2*\lg(1/55.3\text{^}^6)+0.10166-0.37239=\mathbf{1.49326\ V}$;

$\Delta\mathbf{G}_{\mathbf{eq}\underline{PbO2}\downarrow Pb2+}=E°_{\underline{PbO2}\downarrow Pb2+}\bullet F\bullet 3=\mathbf{1.49326}*96485*3=\mathbf{288.15}\ ^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{\mathbf{eq}\underline{PbO2}\downarrow Pb2+}=G_{\underline{PbO2}}+4G_{\mathbf{H3O+}}-(G_{Pb2+}+6G_{\mathbf{H2O}})=-217.3+4*\mathbf{22.44}-(\mathbf{-415.69}+6*\mathbf{0})=\mathbf{288.15}\ ^{kJ}/_{mol}$;

$G_{\underline{PbO2}}=\Delta\mathbf{G}_{\mathbf{eq}\underline{PbO2}\downarrow Pb2+}-4G_{\mathbf{H3O+}}+(G_{Pb2+}+6G_{\mathbf{H2O}})=\mathbf{288.15}-4*\mathbf{22.44}+(\mathbf{-415.69}+6*\mathbf{0})=\mathbf{-217.3}\ ^{kJ}/_{mol}$;

$G_{Pb2+}=G_{\underline{PbO2}}+4G_{\mathbf{H3O+}}-(\Delta\mathbf{G}_{\mathbf{eq}\underline{PbO2}\downarrow Pb2+}+6G_{\mathbf{H2O}})=\mathbf{-217.3}+4*\mathbf{22.44}-(\mathbf{288.15}+6*\mathbf{0})=\mathbf{-415.69}\ ^{kJ}/_{mol}$;

$$E_{\underline{PbO2}\downarrow/Pb2+}=E°_{\underline{PbO2}\downarrow Pb2+}+\frac{0.0591}{2}\bullet\lg\frac{[PbO_2\downarrow]\cdot[H_3O^+]^4}{[Pb^{2+}]\cdot[H_2O]^6}=\mathbf{1.4674}\ V+\frac{0.0591}{2}\bullet\lg\frac{[PbO_2\downarrow]\cdot[H_3O^+]^4}{[Pb^{2+}]\cdot[H_2O]^6}\ ;$$

$Pb+H_2O=Pb^{2+}+2e^-$; pH<7 Nernst's half reaction absolute standard potential $E°_{Pb/Pb2+}=\mathbf{-0.3452}\ V$;

$E°_{Pb/Pb2+}=E°-0.0591/2*\lg(1/[H_2O])+0.10166-0.37239=-1.26-0.0591/2*\lg(1/55.3\text{^}^1)+0.10166-0.37239=\mathbf{-0.3452}\ V$;

$\Delta\mathbf{G}_{\mathbf{eq}\underline{Pb}\downarrow Pb2+}=E°_{\underline{Pb}\downarrow Pb2+}*\mathbf{F*n}=\mathbf{-0.34523}*96485*2=\mathbf{-66.62}\ ^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{\mathbf{eq}\underline{Pb}\downarrow Pb2+}=G_{Pb2+}-(G_{Pb}+G_{\mathbf{H2O}})=\mathbf{-415.69}-(G_{Pb}+\mathbf{0})=\mathbf{-71.59}=\mathbf{-66.62}\ ^{kJ}/_{mol}$;

$G_{Pb}=G_{Pb2+}-(\Delta\mathbf{G}_{\mathbf{eq}\underline{Pb}\downarrow Pb2+}+G_{\mathbf{H2O}})=\mathbf{-415.69}-(\mathbf{-66.62}+\mathbf{0})=\mathbf{-349.07}\ ^{kJ}/_{mol}$;

$\underline{Al}+H_2O=Al^{3+}+3e^-$; CRC Nernst's half reaction absolute standard potential $E°_{Pb/Pb2+}=\mathbf{-1.8984}\ V$;

$E°_{Al/Al3+}=E°-0.0591/2*\lg(1/[H_2O])+0.10166-0.37239=-1.662-0.0591/3*\lg(1/55.3\text{^}1)+0.10166-0.37239=\mathbf{-1.8984}\ V$;

$\Delta\mathbf{G}_{\mathbf{eq}Al/\underline{Al3+}}=E°_{Al/\underline{Al3+}}\bullet F\bullet 3=\mathbf{-1.8984}*96485*3=\mathbf{-549.5}\ ^{kJ}/_{mol}$;

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

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

$\underline{Al}+4OH^-=H_2AlO_3^-+H_2O+3e^-$; CRC Nernst's half reaction absolute standard potential $E°_{H2AlO3-Al}=\mathbf{-2.63506}\ V$;

$E°_{H2AlO3-Al}=E°-0.0591/2*\lg([H_2O])+0.10166-0.37239=-2.33-0.0591/3*\lg(55.3\text{^}1)+0.10166-0.37239=\mathbf{-2.63506}\ V$;

$\Delta\mathbf{G}_{\mathbf{eq}\underline{H2}AlO3\underline{Al}}=E°_{\underline{H2}AlO3\underline{Al}}\bullet F\bullet 3=\mathbf{-2.63506}*96485*3=\mathbf{-762.73}\ ^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{\mathbf{eq}\underline{H2}AlO3\underline{Al}}=G_{\underline{H2}AlO3}+G_{\mathbf{H2O}}-(G_{Al}+\mathbf{4}G_{\mathbf{OH}})=\mathbf{-345.29}+0-(\mathbf{108+4*77.36})=\mathbf{-762.73}\ ^{kJ}/_{mol}$;

$G_{\underline{H2}AlO3}=\Delta\mathbf{G}_{\mathbf{eq}\underline{H2}AlO3\underline{Al}}-G_{\mathbf{H2O}}+(G_{Al}+\mathbf{4}G_{\mathbf{OH}})=\mathbf{-762.73}-0+(\mathbf{108}+4*77.36)=\mathbf{-345.29}\ ^{kJ}/_{mol}$;

$$E_{AlO2-/\underline{Al}\downarrow}=E°_{AlO2-/\underline{Al}\downarrow}+\frac{0.0591}{3}\bullet\lg\frac{[H_2AlO_3^-]\cdot[H_2O]}{[Al]\cdot[OH^-]^4}=\mathbf{-2.63506}\ V+\frac{0.0591}{3}\bullet\lg\frac{[H_2AlO_3^-]\cdot[H_2O]}{[Al]\cdot[OH^-]^4}\ ;$$

High rate protolysis peroxide anions $\mathbf{H^{+}+HOO^{-}}$><$\mathbf{^{-}OOH+H^{+}}$ collision activation energy is high **Ea**=79000 $^{J}/_{mol}$ opposite $\mathbf{HOO^{-}}$=>$\mathbf{Fe^{3+}}$ collision activation energy **Ea**=29 $^{J}/_{mol}$ is small. Elongation in peroxisomes produce essential ω=6, ω=3 fatty acids, oxygen, water and heat: $\mathbf{2H_2O_{2(aq)}}$<=>$\mathbf{O_{2aqua}+2H_2O+Q+}\Delta G_{H}$;

Red: $H_2O_2+2H_2O=O_2+2H_3O^{+}+2e^{-}$; $\mathbf{E°_{Red}}=E°_{RedH2O2}=\mathbf{0.5268}$ V Nernst’s absolute potential Alberta University;

Ox: $H_2O_2+2H_3O^{+}+2e^{-}=4H_2O$; -E° $_{OxH2O2}$=**-1.7113** V inverse standard potential Suhotina ;

$\Delta G_{eqStandarta\_2H2O2}=(E^{\circ}_{H2O2aqRed}-E^{\circ}_{H2O2aqOx})*F*n=(\mathbf{0.5268-1.7113})*96485*2=(\mathbf{-1.1845})*96485*2=\mathbf{-228.57}$ $^{kJ}/_{mol}$;

$\Delta G_{Alberty\_2H2O2}=G_{O2aqua}+2*G_{H2O}-2*G_{H2O2}=\mathbf{330+2*0}-2*G_{H2O2}=\mathbf{-228.57}$ $^{kJ}/_{mol}$; **exoergic**

$G_{H2O2}=(G_{O2aqua}+2*G_{H2O}+\Delta G_{Alberty\_2H2O2})/2=(\mathbf{330+2*0+228.57})/2=\mathbf{558.57}/2=\mathbf{279.285}$ $^{kJ}/_{mol}$;

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

Half reactions RedOx Nernst’s reduction and oxidation electrons balance 2 e^{-} at pH=7.36, $[\mathbf{O}_{aq}]=6*10^{-5}$ M.

$E_{Red}=E°_{H2O2}+0.0591/2\bullet lg([O_{2aqua}]*[H_3O^{+}]^2/[H_2O_2]/[H_2O]^2)=\mathbf{0.5268}+0.0591/2*lg(6*10^{\wedge(-5)}*10^{\wedge(-7.36*2)}/1/55.3^{\wedge 2})=-0.13493$ V;

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

Energy change is $\Delta\mathbf{G}_{Homeostasis}=(E_{Red}-E_{oOx})*\mathbf{F*n}=(-0.13493-1.0703)*96485*2=(\mathbf{-1.2062})*96485*2=\mathbf{-232.76}$ $^{kJ}/_{mol}$;

$G_{Homeostasis\mathbf{H2O2}}=(G_{\mathbf{O2}Biochem\_arteriaj}+2*G_{\mathbf{H2O}BioChemistry}-\Delta G_{Alberty})/2=(\mathbf{88.04+2*85.64+232.76})/2=\mathbf{246.04}$ $^{kJ}/_{mol}$

Substance	$\Delta H°_{H}$, $^{kJ}/_{mol}$	$\Delta S°_{H}$, $^{J}/_{mol/K}$	$\Delta G°_{H}$, $^{kJ}/_{mol}$
$\mathbf{H_3O^{+}}$	-285.81	-3.854	-213.275
$\mathbf{O_{2\mathit{aqua}}}$	-11.715	110.876	16.4
$\mathbf{O_{2\mathit{aqua}}}$	**-11.70**	**-94.2**	**16.40**
$\mathbf{H_2O}$	-285.85	69.9565	-237.191
$\mathbf{H_2O}$	**-286.65**	**-453.188**	**-151.549**
$\mathbf{H_2O_{2\ (aq)}}$	**-191.99**	**-481.688**	**-48.39**
$\mathbf{H_2O_{2(aq)}}$	-191.17	143.9	-134.03
$\mathbf{H_2O_{2aq}}$	Formation	**-48.39**	**340.25**
$\mathbf{H_2O_{2aq}}$	Formation	-134.03	**254.61**
$\mathbf{H_2O_{2(aq)}}$	$\Delta E^{\circ}_{H2O2RedOx}$	**-1.1845**	**279.285**
$\mathbf{HOO^{-}}$	pK_a=11.75	**77.016**	**333.866**
$\mathbf{H_2O_{2\ \mathit{l}}}$	-237.129	69.91	-237.129

$G_{H2O2}=\mathbf{279.285}$ $^{kJ}/_{mol}$; $G_{HOO-}=\mathbf{333.866}$ $^{kJ}/_{mol}$;

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

CRC 2010; $G_{O2aqua}=\mathbf{330}$ $^{kJ}/_{mol}$; $G_{H2O}=\mathbf{0}$ $^{kJ}/_{mol}$;

$\Delta H_{Hess}=\Delta H°_{O2}+2\Delta H°_{H2O}-2\Delta H°_{H2O2}=\mathbf{-201.02}.....=-201.06......$ $^{kJ}/_{mol}$

$=\mathbf{-11.7}-2*\mathbf{286.65}-(2*\mathbf{-191.99})=\mathbf{-201.02}......$ $^{kJ}/_{mol}$ **eksotermiska..**

$=-11.7-2*285.85-(2*-191.17)=-201.06......$ $^{kJ}/_{mol}$

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$G_{H2O2\mathit{aq}}=\Delta G_{H2O2Alberty}+(G_{O2gas}+G_{H2gas}+G_{H2O})=\mathbf{340.25}$ $^{kJ}/_{mol}$;

$G_{H2O2\mathit{aq}}=\Delta G_{H2O2Alberty}+(G_{O2gas}+G_{H2gas}+G_{H2O})=\mathbf{254.61}$ $^{kJ}/_{mol}$;

$G_{H2O2}=(G_{O2aqua}+2*G_{H2O}+\Delta G_{Alberty\_2H2O2})/2=\mathbf{558.57}/2=\mathbf{279.285}$ $^{kJ}/_{mol}$;

$G_{HOO-}=-G_{H3O+}+\Delta G_{aH2O2}+(G_{H2O2}+G_{H2O})=\mathbf{333.866}$ $^{kJ}/_{mol}$;

CRC

$\mathbf{H_2O_2+H_2O=H_3O^{+}+HOO^{-}}$; pKa=11.75; $G_{H2O2}=\mathbf{279.29}$ $^{kJ}/_{mol}$; $G_{HOO-}=\mathbf{333.866}$ $^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{aH2O2}=\mathbf{-R\bullet T\bullet ln(K_a/[H_2O])}=-8.3144*298.15*ln(10^{\wedge(-11.75)}/55.3)=\mathbf{-8.3144\bullet 298.15*-31.07=77.016}$ $^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{aH2O2}=G_{H3O+}+G_{HOO-}-(G_{H2O2}+G_{H2O})=22.44+G_{HOO-}-(\mathbf{279.29+0})=\mathbf{77.016}$ $^{kJ}/_{mol}$;

$G_{HOO-}=-G_{H3O+}+\Delta\mathbf{G}_{aH2O2}+(G_{H2O2}+G_{H2O})=-22.44+\mathbf{77.016}+(\mathbf{279.29+0})=\mathbf{333.866}$ $^{kJ}/_{mol}$;

$\mathbf{HOO^{-}+H_2O=O_{2aqua}+H_3O^{+}+2e^{-}}$; Absolute peroxide anion standard potential is $E^{\circ}_{NernstHOO-}=\mathbf{0.09625}$ Volts.

$\Delta\mathbf{G}_{NernstHOO-}=G_{O2aqua}+G_{H3O+}-(G_{HOO-}+G_{H2O})=\mathbf{330}+22.44-(\mathbf{333.866+0})=\mathbf{18.574}$ $^{kJ}/_{mol}$;

Absolute Nernst’s reaction standard potential is $E^{\circ}_{NernstHOO-}=\Delta\mathbf{G}_{NernstHOO-}/F/1=\mathbf{18574}/96485/2=\mathbf{0.09625}$ V.

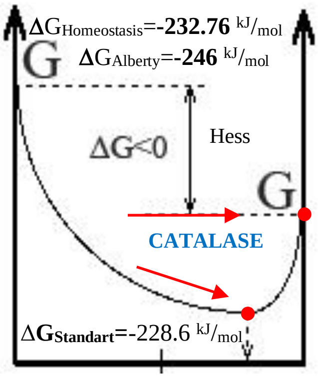
$E°_{HOOOx}=E°-0.0591/2*lg(1/[H_2O]^1)+0.10166-0.37=\mathbf{0.31548}-0.02955*lg(1/55.3^{\wedge 1})+0.10166-0.37239=\mathbf{0.09625}$ V;

$E°_{HOO-}=E°+0.372=\mathbf{0.09625}+0.37239=\mathbf{0.46864}$ V; $E°_{HOO-}=\mathbf{0.46864}-0.10166=\mathbf{0.36698}$ V;

$E°_{HOO-}=\mathbf{0.36698}+0.0591/2*log(1/55.3^{\wedge 1})=\mathbf{0.31548}$ V;

Exothermic and exoergic $\mathbf{H_2O_2}$ (aq) dismutation Hesa free energy change $\Delta\mathbf{G}_{Alberty\_2H2O2}$ **-246** $^{kJ}/_{mol}$ and in Homeostasis $\Delta\mathbf{G}_{Homeostasis}$ **-232.76** $^{kJ}/_{mol}$ is negative, but minimized $\Delta\mathbf{G}_{eqStandart}$**=-228.6** $^{kJ}/_{mol}$ reaching standard equilibrium mixture constant $\mathbf{K}_{eq}=1.11\mathbf{*}10^{40}$.

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 are non equilibrium state. Prigogine attractors are Nobel Prize in Chemistry 1977th. CATALASE erase peroxide molecules $\mathbf{H_2O_2}$ reaching 100% efficiency for ω=6, ω=3 fatty acids C20:4 elongation synthesis in peroxisomes. CATALASE reactivity is indispensable irreversible homeostasis Brownian molecular engine for evolution and survival.



A+A 50% B+2C
reactants $2\mathbf{H_2O_{2\mathit{(aq)}}}$
products_$\mathbf{O_{2aqua}+2H_2O}$

Formation from elements $\mathbf{O_{2gas}+H_{2gas}+H_2O=H_2O_{2\mathit{aq}}}$;

Catalase; $G_{H2O2\mathit{aq}}=\Delta G_{H2O2Alberty}+(G_{O2gas}+G_{H2gas}+G_{H2O}=)=-134.03\underline{\mathbf{+(85.64+303}}\mathbf{+0)=254.61}$ $^{kJ}/_{mol}$;

Catalase; $G_{H2O2\mathit{aq}}=\Delta G_{H2O2Alberty}+(G_{O2gas}+G_{H2gas}+G_{H2O})=\mathbf{-48.39}\underline{\mathbf{+(85.64+303}}\mathbf{+0)=340.25}$ $^{kJ}/_{mol}$;

41st,54th page [1,8,20] $\Delta\mathbf{G}^{\circ}_{UnivAlberta}=-134.03$ $^{kJ}/_{mol}$; $\Delta\mathbf{G}^{\circ}_{Alberty}=\mathbf{-48.39}$ $^{kJ}/_{mol}$;

0

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

Published content of Alberty dissolute nitrogen **absolute** free energy in one mol is $G_{N2aqua}=\mathbf{18.7}\ ^{kJ}/_{mol}$, if pure gas mol fraction is one $[N_{2gas}]=1$. [8] Hundred grams of water dissolute nitrogen gas 0.00175 $^{g}/_{100g\_H2O}$ density has 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 mole fractions is less than one $K_{sp}=10\wedge^{(-3.206)}/[H_2O]=10\wedge^{(-3.206)}/55.3=10^{-4.949}$, which free energy change minimum in 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 $\Delta G_{spHessN2aqua}=G_{N2aqua}-(G_{N2gas}+G_{H2O})=\mathbf{18.7}-(\mathbf{-9.55}+0)=\mathbf{28.25}\ ^{kJ}/_{mol}$ within absolute free energy scale. Mole $G_{N2gas}=G_{N2aqua}-(\Delta G_{spHessN2aqua}+G_{H2O})=\mathbf{18.7}-(\mathbf{28.25}+0)=\mathbf{-9.55}\ ^{kJ}/_{mol}$ contains the free energy below the zero reference scale for water. Dissolute nitrogen mol of energy content iss positive $G_{N2aqua}=\mathbf{18.7}\ ^{kJ}/_{mol}$. [1,8]

Prigogine energy change in solubility product reaction coincides with Hess law free energy change by data of Alberty: $\Delta G_{Hess\_sp\_N2aqua}=G_{N2aqua}-(G_{N2gas}+G_{H2O})=\mathbf{18.7}-(G_{N2gas}\ \mathbf{-0})=\mathbf{28.25}\ ^{kJ}/_{mol}$.
Expressed nitrogen gas free energy content on the zero reference scale for water $G_{H2O}=0\ ^{kJ}/_{mol}$ is negative

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

$$\Delta G_{spN2aqua}=G_{N2aqua}-(G_{N2gas}+G_{H2O})=\mathbf{18.7}-(\mathbf{-9.55}+0)=\mathbf{28.25}\ ^{kJ}/_{mol};\ [8]$$

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}	$N_{2gas}+H_2O$	$=N_{2aq}$	**-9.55**

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

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

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

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

Formation from aqua elements $N_{2aq}+3H_{2aq}>2NH_{3aqs}$ with absolute energy $G_{N2aq}=\mathbf{18.7}\ ^{kJ}/_{mol}$; $G_{H2aq}=\mathbf{103.24}\ ^{kJ}/_{mol}$ shows exoergic reaction $2\Delta G_{Hess\_NH3aq}=2G_{NH3aq}-(G_{N2aq}+3*G_{H2aq})=2*\mathbf{91.1056}-(\mathbf{18.7}+3*\mathbf{103.24})=\mathbf{-146.2}\ ^{kJ}/_{mol}$. [8]
Formation from elements $N_{2gas}+3H_{2gas}>2NH_{3gas}$ energies $G_{N2gas}=\mathbf{-9.55}\ ^{kJ}/_{mol}$; $G_{H2gas}=\mathbf{85.64}\ ^{kJ}/_{mol}$ shows negative data $2\Delta G_{Hess\_NH3gas}=2G_{NH3gas}-(G_{N2gas}+3*G_{H2gas})=2G_{NH3gas}-(\mathbf{-9.55}+3*\mathbf{85.64})=2*-16.4=-32.8\ ^{kJ}/_{mol}$. Ammonia gas has energy $2G_{NH3gas}=2\Delta G_{Hess\_NH3gas}+(G_{N2gas}+3*G_{H2gas})=2*-16.4+(\mathbf{-9.55}+3*\mathbf{85.64})=\mathbf{-214.57}=2*\mathbf{107.285}\ ^{kJ}/_{mol}$ content. Classically, Hess assumed zero energy for free elements zero values are CRC data exoergic change:

$$2\Delta G_{Hess\_NH3gas}=2G°_{NH3gas}-(G°_{N2gas}+3*G°_{H2})=2*-16.4-(\mathbf{0}+3*0)=-32.8\ ^{kJ}/_{mol}\ .\ [1]$$

Solubility $NH_{3gas}+H_2O=NH_{3aq}$; $G_{NH3aq}=\mathbf{91.1}\ ^{kJ}/_{mol}$; Ammonia at pH=7.36 [8]
$\Delta H_{Hydration}=\Delta H°_{NH3aq}-\Delta H°_{NH3gas}-\Delta H°_{H2O}=\mathbf{-132.5608}+45.94\mathbf{-286.65}=373.3\ ^{kJ}/_{mol}$;
$S_{Hydration}=\Delta S°_{NH3aqua}-\Delta S°_{NH3gas}-\Delta S°_{H2O}=\mathbf{-739.2922}-192.77-69.9565=\mathbf{-1002}\ ^{J}/_{mol/K}$;
$\Delta G_{Hydrations}=\Delta H_{Hydrations}-T*\Delta S_{Hydration}=-373.3\mathbf{-298.15*-1.002=-74.5537}\ ^{kJ}/_{mol}$;
$\mathbf{K_{sp}=exp(-\Delta G_{Hydration}/R/T)=exp(74553.7/8.3144/298.15)=10^{13.06}}$;

Albertius solutions for ammonia at pH=7.36 $G_{NH3aq}=\mathbf{91.1056}\ ^{kJ}/_{mol}$ and Hess hydration with change in energy $\Delta G_{Hydrations}=\mathbf{-74.5537}\ ^{kJ}/_{mol}$ 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
$G_{NH3gas}=(\Delta G_{Hess\_NH3gas}+(G_{N2gas}+3*G_{H2gas}))/2=(-32.8+(\mathbf{-9.55}+3*\underline{\mathbf{85.64}}))/2=\mathbf{107.285}\ ^{kJ}/_{mol}$;

The energy for the one mol element hydrogen $G_{H2gas}=\mathbf{85.64}\ ^{kJ}/_{mol}$, for the gas $G_{NH3gas}=\mathbf{165.7}\ ^{kJ}/_{mol}$, with energy of formation o $-32.8\ ^{kJ}/_{mol}$ $G_{N2gas}=2G_{NH3gas}-(2\Delta G_{Hess\_NH3gas}+3*G_{H2gas})=2*\mathbf{165.7}-(2*-16.4+3*\underline{\mathbf{85.64}})=\mathbf{107.28}\ ^{kJ}/_{mol}$ calculate the one mol nitrogen gas energy content.

Solubility $NH_{3gas}+H_2O=NH_{3aq}$; $G_{NH3aq}=\mathbf{91.1}\ ^{kJ}/_{mol}$; $G_{NH3gas}=\mathbf{107.285}\ ^{kJ}/_{mol}$ on absolute energy scale is exoergic too $\Delta G_{Hydration}=G_{NH3aq}-(G_{NH3gas}+G_{H2O})=\mathbf{91.1056}-(\mathbf{107.285}+0)=\mathbf{-16.18}\ ^{kJ}/_{mol}$. [1,8] CRC, Alberty Solubility product is favored $K_{sp}=exp(-\Delta G_{Hydration}/R/T)=exp(\mathbf{16179.4}/8.3144/298.15)=683.17$ greater as one.

Weak acid $G_{NH4+}=\mathbf{50.81}\ ^{kJ}/_{mol}$ protolysis progress $NH_4^++H_2O=NH_{3aq}+H_3O^+$; $pK_{eq}=10.99$; shows energy change $\Delta G_{eq}=-R\bullet T\bullet \ln(K_{eq})=-8.3144*298.15*\ln(10\wedge^{(-10.99)})=G_{NH3Hydration}+G_{H3O}-G_{NH4+}-G_{H2O}=62.73\ ^{kJ}/_{mol}$, 16th page: $\Delta G_{eq}=G_{NH3aq}+G_{H3O}-(G_{NH4+}+G_{H2O})=\mathbf{91.1}+22.44-G_{NH4+}\mathbf{-0}=62.73\ ^{kJ}/_{mol}$.
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 HNO_2 $\Delta G°_{HNO2}=-46\ ^{kJ}/_{mol}$ and HNO_3 $\Delta G°_{HNO3}=-250.53\ ^{kJ}/_{mol}$:

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

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

$$G_{NO2Form}=\Delta G°_{NO2aq}+0.5G_{N2gas}+G_{O2gas}+G_{H2O}=\mathbf{-33.01}+0.5*-9.55+1*\mathbf{303+0=265.2}\ ^{kJ}/_{mol};$$

$$G_{HNO3Form}=\Delta G°_{HNO3}+(0.5G_{N2gas}+\mathbf{1.5}G_{O2gas}+0.5G_{H2gas})=-250.53+(0.5*-9.55+1.5*\mathbf{303})=\mathbf{199.195}\ ^{kJ}/_{mol};$$

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

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

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

$\Delta G_{eqHNO2}=G_{NO2-}+G_{H3O}-(G_{HNO2}+G_{H2O})=\mathbf{265.2+22.44-(259.713\ +0)=27.927}\ {}^{kJ}/_{mol}$;

$G_{NO2-}=\Delta G_{eqHNO2}-G_{H3O}+(G_{HNO2}+G_{H2O})=\mathbf{27.927+22.44-(259.713\ +0)=265.2}\ {}^{kJ}/_{mol}$;

$G_{HNO2}=G_{NO2-}+G_{H3O}-(\Delta G_{eqHNO2}+G_{H2O})=\mathbf{265.2+22.44-(27.927+0)=259.713}\ {}^{kJ}/_{mol}$;

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

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

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

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

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

Substance	$\Delta H^\circ_H\ {}^{kJ}/_{mol}$	$\Delta S^\circ_H\ {}^{J}/_{mol/K}$	ΔG°_H , ${}^{kJ}/_{mol}$	
HNO_2	$E^\circ_{NO3-H3O+}$	**=0.8763 V**	**238.42**	$G_{HNO2}=G_{NO3-}+3G_{H3O}-(\Delta G_{eqNO3}+4G_{H2O})=\mathbf{238.42}\ {}^{kJ}/_{mol}$;
HNO_2	-	pKa=3.15	**259.713**	$G_{HNO2}=G_{NO2-}-G_{H3O}+(\Delta G_{eqHNO2}+G_{H2O})=\mathbf{259.713}\ {}^{kJ}/_{mol}$;
HNO_2	-79.5	254.1	-46.0	CRC
HNO_2	-	formation	**295.025**	$G_{HNO2gas}=\Delta G^\circ_{HNO2gas}+0.5N_{2gas}+O_{2gas}+0.5\mathbf{H}_{2gas}=\mathbf{295.025}\ {}^{kJ}/_{mol}$
NO_2^-	-	formation	**265.2**	$G_{NO2form}=\Delta G^\circ_{NO2aq}+0.5G_{N2gas}+G_{O2gas}+G_{H2O}=\mathbf{265.2}\ {}^{kJ}/_{mol}$;
NO_2^-		pKa=3.15	**265.2**	$G_{NO2-}=\Delta G_{eqHNO2}-G_{H3O}+(G_{HNO2}+G_{H2O})=\mathbf{265.2}\ {}^{kJ}/_{mol}$;
NO_2^-	**-104.19**	**-238.7**	**-33.01**	**BioTherm2006**
NO_2^-			**482.3**	$G_{NO3-}=\Delta G_{eqNH4+H2O}-10G_{H3O}+(G_{NH4+}-13G_{H2O})=\mathbf{580.31}\ {}^{kJ}/_{mol}$
HNO_3	-207	146	-250.53	Wikiped $G^\circ_{NO3-}=\Delta H_H-T*\Delta S_H=-207-298.15*0.146=-250.5886\ {}^{kJ}/_{mol}$;
HNO_3	-	formation	**199.195**	$G_{HNO3Form}=\Delta G^\circ_{HNO3}+(0.5G_{N2gas}+\mathbf{1.5}G_{O2gas}+0.5G_{H2gas})=\mathbf{199.195}\ {}^{kJ}/_{mol}$;
HNO_3	-	$pK_a=-1.4$	**360.7**	$G_{HNO3}=G_{NO3-}+G_{H3O}-(\Delta G_{eqHNO3}+G_{H2O})=\mathbf{360.7}\ {}^{kJ}/_{mol}$;
NO_3^-	$E^\circ_{NH4+H2O}$=	**0.7677** V	**601.06**	$G_{NO3-}=\Delta G_{eqNH4+H2O}-10G_{H3O}+(G_{NH4+}-13G_{H2O})=\mathbf{601.06}\ {}^{kJ}/_{mol}$;
NO_3^-	-206.85	146.7	-250.5886	$\Delta G^\circ_{NO3-}=\Delta H_H-T*\Delta S_H=-206.85-298.15*0.1467=-250.5886\ {}^{kJ}/_{mol}$;
NO_3^-	-	formation	**340.2**	$G_{NO3Form}=\Delta G^\circ_{HNO3aq}+(0.5G_{N2gas}+\mathbf{1.5}G_{O2gas}+G_{H2O})=\mathbf{340.2}\ {}^{kJ}/_{mol}$;
NO_3^-	-	$pK_a=-1.4$	**340.2**	$G_{NO3-}= \Delta G_{eqHNO3}-G_{H3O}+(G_{HNO3}+G_{H2O})=\mathbf{340.2}\ {}^{kJ}/_{mol}$;
NO_3^-	E°_{NO3-OH}	**-0.3112** V	**359.87**	$G_{NO3-}=\Delta G_{eqNO3-OH}-G_{H2O}+(G_{NO2-}+2G_{OH})=\mathbf{359.87}\ {}^{kJ}/_{mol}$;
NO_3^-	**-204.59**	**-318.8**	**-109.55**	**BioTherm2006**
NO_{gas}	91.3	210.8	87.6	CRC
NO_{gas}	Solubility	product -	**61.024**	$G_{NOgas}=G_{NOaq}-(G_{H2O}+\Delta G_{sp})=\mathbf{86.55-(0+25.526)=61.024}\ {}^{kJ}/_{mol}$;
NO_{aq}	**BioTherm 2006**		**86.55**	
NO_{aq}	$E^\circ_{NO(g)H3O+}$	**=0.8963**	**170.52**	$G_{NOaq}=G_{NO3-}+4G_{H3O}-(\Delta G_{eqNO(g)H3O+}+6G_{H2O})=\mathbf{170.52}\ {}^{kJ}/_{mol}$;
$\mathbf{NH_{3gas}}$	$\Delta G_{Hydration}$	**-74.5537**	**165.7**	$G_{NH3gas}=\Delta G_{NH3aq}-(\Delta G_{Hydrations}+G_{H2O})=\mathbf{91.1056-(-74.5537}+0)=\mathbf{165.7}\ {}^{kJ}/_{mol}$;
$\mathbf{NH_{3gas}}$	[1,8] CRC	**Alberty**	**107.285**	$2G_{NH3gas}=2\Delta G_{Hess\_NH3gas}+(G_{N2gas}+3*G_{H2gas})= 2*\mathbf{107.285}\ {}^{kJ}/_{mol}$;
$\mathbf{NH_{3gas}}$	–45.9	192.77	-16.4	$2G_{NH3gas}=2*-16.4+(\mathbf{-9.55}+3*\mathbf{85.64})=\mathbf{-214.57}=2*\mathbf{107.285}\ {}^{kJ}/_{mol}$;
$\mathbf{NH_{3aq}}$	**-132.5608**	**-739.2922**	**91.1056**	Ammonia pH=7.36 [8] **Alberty**; $\mathbf{NH_{3aqua}}$ formation
$\mathbf{NH_{3aq}}$	$pK_{beq}=6.49475$		**91.1**	$G_{NH3aq}=G_{NH4+}+G_{OH}-(\Delta G_{beq}+G_{H2O})=\mathbf{91.1}\ {}^{kJ}/_{mol}$; Wikipedia [28]
NH_4^+	$pK_{aeq}=$ 10.99		**50.81**	$G_{NH4+}=G_{NH3aq}+G_{H3O}-(\Delta G_{aeq}+G_{H2O})=\mathbf{91.1}+22.44-62.73-\mathbf{0}=\mathbf{50.81}\ {}^{kJ}/_{mol}$;

Protolysis $NH_{3aq}+H_2O=NH_4^++OH^-$ constant $K_{beq}= K_b/[H_2O]=10^{\wedge}(-)/55.3=3.20*10^{\wedge(-7)}=10^{\wedge(-6.4947)}$ $pK_{beq}=6.4947$ in classic expressed without water account is $K_b=[NH_4^+]*[OH^-]/[NH_{3aq}]=10^{\wedge(-4.752)}=1.77*10^{\wedge(-5)}$; $pK_b=4.752$.
Energy accumulates endoergic in products $G_{NH4+}+G_{OH-}=\mathbf{50.81}+77.36=\mathbf{128.17}\ {}^{kJ}/_{mol}$;

$\Delta G_{beq}=-R\bullet T\bullet \ln(K_{beq})=-8.3144*298.15*\ln(10^{\wedge(-6.4947)})=G_{NH4+}+G_{OH}-(G_{NH3aq}+G_{H2O})=37.07\ {}^{kJ}/_{mol}$.

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

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

The energy expressed for the gas solubility are $NH_{3gas}+H_2O=NH_{3aq}$ are $G_{NH3aq}=\mathbf{91.1}\ {}^{kJ}/_{mol}$, $G_{NH3gas}=\mathbf{107.3}\ {}^{kJ}/_{mol}$.
Weak acid $G_{NH4+}=\mathbf{50.81}\ {}^{kJ}/_{mol}$ protolysis $\mathbf{NH_4^++H_2O=NH_{3aq}+H_3O^+}$ $pK_{eq}=10.99$ shows endoergic energy change positive $\Delta G_{aeq}=-R\bullet T\bullet \ln(K_{aeq})=-8.3144*298.15*\ln(10^{\wedge(-10.99)})=G_{NH3Hydration}+G_{H3O}-G_{NH4+}-G_{H2O}=62.73\ {}^{kJ}/_{mol}$.
Ammonium free energy content in one mol is $G_{NH4+}=G_{NH3aq}+G_{H3O}-(\Delta G_{aeq}+G_{H2O})=\mathbf{91.1}+22.44-(62.73+0)=\mathbf{50.81}\ {}^{kJ}/_{mol}$.

Nernst's potential NO_3^-/ NO_2^- red-ox system behaving in acidic H_3O^+ water and basic OH^- medium

$HNO_2+4H_2O=NO_3^-+3H_3O^++\mathbf{2e^-}$; $E^\circ_{NO3-H3O+}=\mathbf{0.8753}$ V Kortly, Shucha pH<3.15;

$E^\circ_{NO3-H3O+}=E^\circ+0.10166-0.0591/2*\lg(1/[H_2O]^4)-0.37239=0.94+0.10166-0.02955*\lg(1/55.3^{\wedge 4})-0.37239=\mathbf{0.8753}$ V;

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

$\Delta\mathbf{G}_{\mathbf{eq}NO3}=E^\circ_{NO3}\bullet F\bullet 2=\mathbf{0.8753}*96485*2=\mathbf{168.9}\ ^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{\mathbf{eq}NO3}=G_{NO3-}+3\mathbf{G}_{\mathbf{H3O}}-(G_{HNO2}+4\mathbf{G}_{\mathbf{H2O}})=\mathbf{340.2}+3*22.44-(\mathbf{238.62}+4*0)=\mathbf{168.9}\ ^{kJ}/_{mol}$;

$G_{HNO2}=G_{NO3-}+3\mathbf{G}_{\mathbf{H3O}}-(\Delta\mathbf{G}_{\mathbf{eq}NO3}+4\mathbf{G}_{\mathbf{H2O}})=\mathbf{340.2}+3*22.44-(\mathbf{168.9}+4*0)=\mathbf{238.62}\ ^{kJ}/_{mol}$;

$NO_2^-+2OH^-=NO_3^-+H_2O+\mathbf{2e^-}$; $E^\circ_{NO3-H2O}=\mathbf{-0.3122}$ V; pH>3.15 Suchotina

$E^\circ_{NO3-OH}=E^\circ+0.10166-0.0591/2*\lg([H_2O])-0.37239=0.01+0.10166-0.02955*\lg(55.3^{\wedge 1})-0.37239=\mathbf{-0.3122}$ V;

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

$\Delta\mathbf{G}_{\mathbf{eq}NO3-OH}=E^\circ_{NO3-OH}\bullet F\bullet 2=\mathbf{-0.3122}*96485*2=\mathbf{-60.245}\ ^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{\mathbf{eq}NO3-OH}=G_{NO3-}+\mathbf{G}_{\mathbf{H2O}}-(G_{NO2-}+2\mathbf{G}_{\mathbf{OH}})=\mathbf{359.675}+0-(\mathbf{265.3}+2*77.36)=\mathbf{-60.245}\ ^{kJ}/_{mol}$,

$G_{NO3-}=\Delta\mathbf{G}_{\mathbf{eq}NO3-OH}-\mathbf{G}_{\mathbf{H2O}}+(G_{NO2-}+2\mathbf{G}_{\mathbf{OH}})=\mathbf{-60.2455}-0+(\mathbf{265.3}+2*77.36)=\mathbf{359.775}\ ^{kJ}/_{mol}$,

$G_{NO2-}=G_{NO3-}+\mathbf{G}_{\mathbf{H2O}}-(\Delta\mathbf{G}_{\mathbf{eq}NO3-OH}+2\mathbf{G}_{\mathbf{OH}})=\mathbf{359.675}+0-(\mathbf{-60.245}+2*77.36)=\mathbf{265.3}\ ^{kJ}/_{mol}$;

$\mathbf{NO_2^-+3H_2O=NO_3^-+2H_3O^++2e^-}$; David Harris; absolute standard potential $E^\circ_{NO3}=\mathbf{0.7188}$ V

$E^\circ_{NO3}=E^\circ+0.10166-0.0591/2*\lg([H_2O]^3)-0.371339=0.835+0.10166-0.02955*\lg(1/55.3^{\wedge 3})-0.371339=\mathbf{0.7188}$ V

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 $\mathbf{K_{eq}}=[NO_{aq}]/[NO^{(g)}]/[H_2O]=0.001865/1/55.3=10^{\wedge(-4.472)}$.

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

$\Delta G_{eq}=G_{NOaq}-(G_{H2O}+G_{NOgas})=\mathbf{86.55-(0+}G_{NOgas}\mathbf{)=25.526}\ ^{kJ}/_{mol}$;

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

Solubility of gas NO_{gas} compensate water molecule on Nernst's expression from six $6H_2O$ to five $5H_2O$:

$NO_{aq}+5H_2O=NO_3^-+4H_3O^++\mathbf{3e^-}$; $E^\circ_{NO(g)H3O+}=\mathbf{0.8609}$ V; Kortly, Shucha ;

$E^\circ_{NO(g)H3O+}=E^\circ+0.10166-0.0591/3*\lg(1/[H_2O]^5)-0.37239=0.96+0.10166-0.0197*\lg(1/55.3^{\wedge 5})-0.37239=\mathbf{0.8609}$ V;

$$E_{NO(g)H3O+}=E^\circ_{NO(g)H3O+}+0.0591/3\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^4}{[NO_{aq}]\cdot[H_2O]^6}=\mathbf{0.8609}\text{ V}+0.0197\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^4}{[NO_{aq}]\cdot[H_2O]^6}$$

$\Delta\mathbf{G}_{\mathbf{eq}NO(g)H3O+}=E^\circ_{NO(g)H3O+}\bullet F\bullet 3=\mathbf{0.8609}*96485*3=\mathbf{249.19}\ ^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}NO(g)H3O+}=G_{NO3-}+4\mathbf{G}_{\mathbf{H3O}}-(G_{NOaq}+5\mathbf{G}_{\mathbf{H2O}})=\mathbf{340.2}+4*22.44-(\mathbf{180.77}+5*0)=\mathbf{249.19}\ ^{kJ}/_{mol}$,

$G_{NOaq}=G_{NO3-}+4\mathbf{G}_{\mathbf{H3O}}-(\Delta\mathbf{G}_{\mathbf{eq}NO(g)H3O+}+5\mathbf{G}_{\mathbf{H2O}})=\mathbf{340.2}+4*22.44-(\mathbf{249.19}+5*0)=\mathbf{180.77}\ ^{kJ}/_{mol}$,

$NH_4^++13H_2O=NO_3^-+10H_3O^++\mathbf{8e^-}$; $E^\circ_{NH4+H2O}=\mathbf{0.7667}$ V Suchotina

$E^\circ_{NH4+H2O}=E^\circ+0.10166-0.0591/8*\lg(1/[H_2O]^{13})-0.371339=0.87+0.10166-0.00739*\lg(1/55.3^{\wedge 13})-0.371339=\mathbf{0.7667}$ V;

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

$\Delta\mathbf{G}_{\mathbf{eq}NH4+H2O}=E^\circ_{NH4+H2O}\bullet F\bullet 8=\mathbf{0.7666879}*96485*8=\mathbf{592.56}\ ^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}NH4+H2O}=G_{NO3-}+10G_{\mathbf{H3O}}-(G_{\mathbf{NH4+}}-13\mathbf{G}_{\mathbf{H2O}})=\mathbf{601.06}+10*22.44-(\mathbf{232.9}-13*\mathbf{0})=\mathbf{592.56}\ ^{kJ}/_{mol}$,

$G_{NO3-}=\Delta\mathbf{G}_{\mathbf{eq}NH4+H2O}-10G_{\mathbf{H3O}}+(G_{\mathbf{NH4+}}-13\mathbf{G}_{\mathbf{H2O}})=\mathbf{592.56}-10*22.44+(\mathbf{232.9}-13*\mathbf{0})=\mathbf{601.06}\ ^{kJ}/_{mol}$;

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

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

Twelve water molecules account $[H_2O] = 55.3$ M=(996_g/L)/(18_g/mol) increase potential to:

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

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

$E_H = E°_H + 0,0591 \cdot \log([H_3O^+]/[H_2O]) = -0,27073\ V + 0,0591 \cdot \log([H_3O^+]/[H_2O])$;

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

$\Delta G_{HessPt)H} = \Delta G°_{Mn2} + 7\Delta G°_{H2O} - (\Delta G°_{MnO4} + 3\Delta G°_{H3O} + 5G_{(Pt)H}) = -228,1 + 7*-237,191 - (3*-213,2746 - 447,2 + 5*\mathbf{48,56}) = -1044,21\ ^{kJ}/_{mol}$;

$\Delta G_{HessCRC} = \Delta G°_{Mn2} + 7\Delta G°_{H2O} - (\Delta G°_{MnO4} + 3\Delta G°_{H3O} + 5/2\Delta G°_{H2}) = -228,1 + 7*-237,191 - (3*-213,2746 - 447,2 + 5*99,13/2) = -1049\ ^{kJ}/_{mol}$;

$\Delta G_{Alberty} = \Delta G°_{Mn2} + 7\Delta G°_{H2O} - (\Delta G°_{MnO4} + 3\Delta G°_{H3O} + 5/2G_{H2}) = -228,1 + 7*-237,191 - (3*-213,2746 - 447,2 + 5*\mathbf{103,24}/2) = -1059,5\ ^{kJ}/_{mol}$;

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
H_2O	**-286.65**	**-453.188**	**-151.549**	Biochem. Thermodyn, Alberty, 2006, Massachusetts Techn. Inst.
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	
$H_{2(aq)}$	**-5.02**	**-363.92**	**103.24**	Alberty 2006 Biochem. Thermodyn. Massachusetts Technology Inst.
$H(Pt)_{(aq)}$	-	-	**48.56**	$\Delta G_{eq} = \mathbf{-847.7}\ ^{kJ}/_{mol}$; $\Delta G_{HessOxRed} = -1044.2\ ^{kJ}/_{mol}$
MnO_4^-	-541.4	-191.2	-447.2	
Mn^{2+}	–220.8	-73.6	-228.1	$\lvert \Delta G_{eq} = -847.7\ ^{kJ}/_{mol} \rvert < \lvert \Delta G_{Hess} = -1044.2\ ^{kJ}/_{mol} \rvert$;
O_{2aqua}	**-11.7**	**-94.2**	**16.4**	

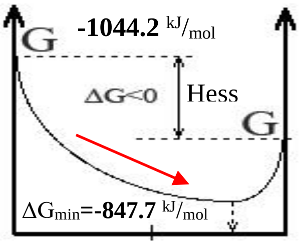
$\mathbf{\Delta G_{eq}}_{H/MnO4} = (E°_H - E°_{MnO4-}) \cdot F \cdot 1 \cdot 5 = (-0,27073 - 1,4865) * 96485 * 5 = \mathbf{-1,757} * 96485 * 5 = \mathbf{-847,7}\ ^{kJ}/_{mol}$.

$\mathbf{K}_{eq} \mathbf{= exp(-\Delta G_{eq}}_{H/MnO4}\mathbf{/R/T)} = \exp(847732/8,3144/298,15) = \exp(341,96) = 10^{148,5}$;

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

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

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.



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

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

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

$\underline{MnO_2} + 4OH^- = MnO_4^- + 2H_2O + \mathbf{3e^-}$; Reductant Nernst's absolute standard potential: $E°_{MnO2/MnO4-} = \mathbf{0.26465}$ V,

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

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

$E°_{MnO4/MnO4-} = E° - 0.0591/3 \cdot \log([H_2O]^0) + 0.10166 - 0.37239 = 0.558 - 0.0591/3 * \log(55.3^{\wedge 0})) + 0.10166 - 0.37239 = \mathbf{0.2883}$ 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 $\Delta G_{CO2aqua} = -R \cdot T \cdot \ln(K_{eqCO2aqua}) = -8,3144 * 298,15 * \ln(0,000601808 = 18,38\ ^{kJ}/_{mol}$.

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

$$\frac{[HCO_3^-]_{aqua} \cdot [H_3O^+]}{[CO_2]_{aqua} \cdot [H_2O]^2} = K_{eqCAHCO3aqua} = K_{a\_CO2aqua}/[H_2O]^2 = 10^{-7,0512}/55,3^2 = 2,906 * 10^{-11}.[9]$$

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

$\Delta G_{eqCACO2aqua} = -R \cdot T \cdot \ln(K_{eqCACO2aqua}) = -8,3144 * 298,15 * \ln(2,906 * 10^{\wedge}(^{-11}))/1000 = 60,14\ ^{kJ}/_{mol}$.

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

$G_{H3O+HCO3} = G_{H3O+} + G_{HCO3-} = 22,44 + 56,08 = \mathbf{G}_{CO2aqua} + \Delta\mathbf{G}_{eqCACO2aqua} = 18,38 + 60,14 = 78,52\ ^{kJ}/_{mol}$. [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 $G_{\mathbf{H3O++HCO3-}}=18.38+60.14=78.38$ $^{kJ}/_{mol}$ 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.

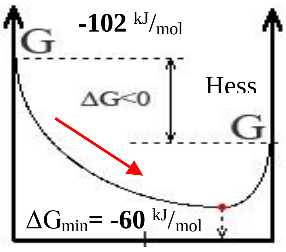
Solubility product is $K_{spCO2aqua}=[CO_{2aqua}]/[CO_{2gas}]=0.03328$ M but equilibrium constant in mol fractions is
$K_{eqCO2aqua}=[CO_{2aqua}]/[CO_{2gas}]/[H_2O]=K_{spCO2aqua}/[H_2O]=0.03328\text{ M}/55.3\text{ M}=0.000601808$.
Free energy $\Delta G_{eqCO2aqua}=-R\bullet T\bullet\ln(K_{eqCO2aqua})=-8.3144*298.15*\ln(0.000601808)/1000=\mathbf{18.38}$ $^{kJ}/_{mol}$ has minimum value at solubility equilibrium $G_{CO2aqua}=\Delta G_{eqCO2aqua}+(G_{CO2gas}+G_{H2O})=\mathbf{18.38}+(0+0)=\mathbf{18.38}$ $^{kJ}/_{mol}$.
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 $\mathbf{k_2}=5.16885\mathbf{*}10^{18}$ $M^{-2}s^{-1}$, but OH^- ions $CO_{2aqua}+OH^-=HCO_3^-$ have velocity constant $\mathbf{k}_{1OH}$ $1.5*10^2$ $M^{-2}s^{-1}$. 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 $k_{1CO2aqua}=1.5\times10^8$ $M^{-1}s^{-1}$. [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:
$CO_{2aqua}+2H_2O+\Delta G+Q=v1\xrightarrow{CA}H_3O^++HCO_3^-$, which velocity constant is: $\mathbf{k}_{1\mathbf{CO2}aqua}=1.5\times10^8$ $M^{-1}s^{-1}$. [9]
Neutralization $H_3O^++HCO_3^-=CO_{2aqua}+2H_2O$ velocity constant is CA independent times $10^{10.54}$ greater about CA velocity constant: $k_2/k_{1CO2aqua}=5.16885\mathbf{*}10^{18}/1.5/10^{8}=34407299853=10^{10.54}$.
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 $pK_{a\_\mathbf{CO2}aqua}=7.0512$ is friendly to attractor value pH=7.36:

$K_{a\_\mathbf{CO2}aqua}=K_{eqCAHCO3aqua}*[H_2O]^2=\dfrac{[HCO_3^-]_{aqua}\cdot[H_3O^+]}{[CO_2]_{aqua}}=10^{-7.0512}=10^{-pKa\_CO2aqua}$. Original $pK_{a\_\mathbf{CO2}aqua}=7.0512$ value obtained and calculated for BUFFER solutions. Hess free energy change is exoergic negative:

$\Delta G_{Hess}=2\Delta G°_{\mathbf{H2O}}+\Delta G°_{\mathbf{CO2}}-(\Delta G°_{\mathbf{H3O}}+\Delta G°_{\mathbf{HCO3}})=2*-237.191-385.98-(-213.2746-\mathbf{544.9688})=\mathbf{-102}$ $^{kJ}/_{mol}$. [1]
Neutralization: $\mathbf{H_3O^++HCO_3^-=CO_{2aqua}+2H_2O}$ constant is inverse to protolysis and favored:
$K_{eqNeutralization}=1/\mathbf{K_{eq}}_{CAHCO3aqua}=\mathbf{[HCO_3^-]*[H_3O^+]/[CO_{2aqua}]/[H_2O]^2}=1/2.90636/10^{(-11)}=34407299853$.
$\Delta G_{Absolute\_Neutralization}=2G_{\mathbf{H2O}}+G_{\mathbf{CO2}qua}-G_{\mathbf{H3O}}-G_{\mathbf{HCO3}}=2*0+\mathbf{18.38}-22.44-56.08=\mathbf{-60.14}$ $^{kJ}/_{mol}$ and
enthalpy Hess change in reaction is exothermic: $\Delta H_{Hess}=2\Delta H°_{\mathbf{H2O}}+\Delta H°_{\mathbf{CO2}}-\Delta H°_{\mathbf{H3O}}-\Delta H°_{\mathbf{HCO3}}=\mathbf{-7.2}$ $^{kJ}/_{mol}$.
Neutralization is favored reaction. Free energy change on minimum expression is negative:
$\mathbf{\Delta G_{eqNeutralization}=-R\bullet T\bullet ln(K_{eqNeutralization})}=-8.3144\bullet298.15\bullet\mathbf{ln}(34407299853)=\mathbf{-60.14}$ $^{kJ}/_{mol}$, but $\mathbf{CO_2}_{aqua}$ protolysis minimum as inverse reaction of neutralization is positive:
$\mathbf{\Delta G_{eqCAHCO3aqua}=-R\bullet T\bullet ln(K_{eqCA\_HCO3aqua})}=-8.3144\bullet298.15\bullet\mathbf{ln}(1/34407299853)=\mathbf{60.14}$ $^{kJ}/_{mol}$.



A+B 50 % C+2D.

Attractor Fig. 2. Exothermic and exoergic neutralization Hess free energy change $\Delta\mathbf{G}_{HessNeutralization}$ is negative $\mathbf{-102}$ $^{kJ}/_{mol}$, bet $\Delta\mathbf{G}_{eqNeutralization}\mathbf{=-60.14}$ $^{kJ}/_{mol}$ 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 $\mathbf{CO_2}_{aqua}+2\mathbf{H_2O}$.

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

Formation from free elements of carbon dioxide $\mathbf{C}_{gr}+\mathbf{O_2}_{gas}=\mathbf{CO_2}_{gas}$ standard free energy change is exoergic negative $\Delta G_{\mathbf{Hess\_CO2}gas}=-394.36$ kJ/mol. [1] If background level for biochemistry absolute energy scale is zero than in Hess law for graphite the absolute free energy content is $G_{gr}=\Delta G°_{\mathbf{Hess\_CO2}gas}-G_{\mathbf{O2}gas}=394.36-\mathbf{303.1}=\mathbf{91.26}$ kJ/mol.

The standard free energy change for methane formation from free elements $\mathbf{C}_{gr}+2\mathbf{H}_{2gas}>\mathbf{CH}_{4gas}$ [1,8] is

$$\Delta G_{Hess\_CH4gas}=G_{CH4gas}-(G_{Cgr}+2*G_{H2})=G_{CH4gas}-(\mathbf{91.26}+2*\underline{\mathbf{85.64}})=-50.5 \text{ kJ/mol}$$ and

the free energy content per mole of methane remaining unused from free elements in Hess's law is

$$G_{CH4gas}=\Delta G_{\mathbf{Hess}\_CH4gas}+(G_{Cgr}+2*G_{H2})=-50.5+(\mathbf{91.26}+2*\underline{\mathbf{85.64}})=\mathbf{212.04} \text{ kJ/mol}.$$

This allows us to calculate the absolute free energy per mole of the element graphite using Alberty's energy data:

$$G°_{\mathbf{CgrCH4}gas}=G°_{\mathbf{CH4}gas}-\mathbf{\Delta}G_{\mathbf{Hess\_CH4}gas}-2*G°_{\mathbf{H2}gas}=\mathbf{212.04}-(-50.5+2*\underline{\mathbf{85.64}})=\mathbf{91.26} \text{ kJ/mol},$$

which coincides with the zero background of carbon dioxide gas $G°_{\mathbf{CO2}gas}=\mathbf{0}$ kJ/mol on the absolute energy scale.

Solubility of methane $\mathbf{CH}_{4gas}+H_2O=\mathbf{CH}_{4aq}$ is 22.7 mg/L and methane molar mas is $M_{CH4}=16.043$ g/mol. Water account $[H_2O]=996/18=55.3$ M give constant $\mathbf{K_{eq}}=K_{sp}/[H_2O]=0.001414947 \text{ M}/55.3 \text{ M}=10^{\wedge(-4.592)}$. Alberty given data calculate solubility energy change $\Delta G_{eq\mathbf{CH4}gas}=G_{\mathbf{CH4}aq}-(G_{\mathbf{CH4}gas}+G_{\mathbf{H2O}})=\mathbf{238.25}-(\mathbf{212.04}+\mathbf{0})=\mathbf{26.21}$ kJ/mol .

$$G_{CH4aq}=\mathbf{\Delta}G_{eqCH4}+(G_{H2\mathbf{O}}+G_{CH4}{}^{gas})=\mathbf{26.21}+(\mathbf{0}+\mathbf{212.04})=\mathbf{238.25} \text{ kJ/mol};$$

Methane solubility $[\mathbf{CH}_4]=0.0227/16.043=0.001414947$ M equilibrium absolute free energy change is

$$\Delta\mathbf{G_{eq}}=-\mathbf{R}\bullet\mathbf{T}\bullet\mathbf{ln}(\mathbf{K_{eq}})=-8.3144*298.15*\ln(0.001414947/55.3)=-8.3144\bullet298.15\bullet-6.592=\mathbf{26.21} \text{ kJ/mol}.$$

Equilibrium energy change $\Delta G_{eqCH4}=G_{CH4aq}-(G_{H2O}+G_{CH4}{}^{gas})=G_{CH4aq}-(\mathbf{0}+\mathbf{212.04})=\mathbf{26.21}$ kJ/mol let us calculate absolute free energy content for methane in water (aqua): $G_{CH4aq}=G_{CH4gas}+G_{CH4sp}=\mathbf{212.04}+\mathbf{26.21}=\mathbf{238.25}$ kJ/mol;

Substance	$\Delta H°_H$ kJ/mol	$\Delta S°_H$ J/mol/K	$\Delta G°_H$, kJ/mol	$\mathbf{\Delta}G_{H2C2\mathbf{O4}}=\mathbf{\Delta}H_H-T*\mathbf{\Delta}S_H=-829.9-298.15*-0.1098=\mathbf{-747.75}$ kJ/mol;
$\mathbf{H_2O}$	-285.85	69.9565	-237.191	CRC
$\mathbf{H_3O^+}$	-285.81	-3.854	-213.2746	CRC Mischenko 1972, Himia, Leningrad [26]
$H_2C_2O_{4cr}$	-829.9	-109.8	-797.16	CRC
$H_2C_2O_{4cr}$	formation		**76.96**	$G_{H2C2O4cr}=\mathbf{\Delta}G°_{H2C2O4crForm}+(2G_{Cgr}+2G_{\mathbf{O2}gas}+G_{\mathbf{H2}gas})=\mathbf{76.96}$ kJ/mol;
$H_2C_2O_{4aq}$	$\Delta G_{eq\_sp}=$	**9.0161**	**85.976**	$G_{H2C2O4aq}=\Delta G_{eq\_sp}+(G_{H2\mathbf{O}}+G_{H2C2O4}{}^{cr})=\mathbf{85.976}$ kJ/mol;
$H_2C_2O_{4aq}$	$E°_{H2C2O4}=$	**-0.6577 V**	**171.78**	$G_{H2C2O4}=2G_{CO2}+2G_{\mathbf{H3O}}-(\Delta\mathbf{G_{eq}}_{H2C2O4}+2\mathbf{G_{H2O}})=\mathbf{171.78}$ kJ/mol;
$HC_2O_4^-$	**17.08**	$pK_{a2}=1.25$	**80.618**	$G_{\mathbf{HC2O4}}=\Delta G_{eq1\mathbf{H2C2O4}}-G_{\mathbf{H3O}}+(G_{\mathbf{H2C2O4}}+\Delta G_{\mathbf{H2O}})=\mathbf{80.618}$ kJ/mol ;
$HC_2O_4^-$	$E°_{HC2O4}=$	**-0.7092** V	**159.028**	$G_{HC2O4}=2G_{CO2}+G_{\mathbf{H3O}}-(\Delta\mathbf{G_{eq}}_{HC2O4}+\mathbf{G_{H2O}})=\mathbf{159.028}$ kJ/mol;
$C_2O_4^{2-}$	-	-	**-677.14**	**Alberty 2006** Biochem.Thermodyn Massachusetts Techn. Inst.
$C_2O_4^{2-}$	**33.578**	$pK_{a2}=4.14$	**91.756**	$G_{\mathbf{C2O4}}=\Delta G_{eq2\mathbf{HC2O4}}-G_{\mathbf{H3O}}+(G_{\mathbf{HC2O4}}+G_{\mathbf{H2O}})=\mathbf{91.756}$ kJ/mol ;
$C_2O_4^{2-}$	$E°_{C2O4}=$	**-0.7607** V	**146.79**	$G_{C2O4}=2G_{CO2}-(\Delta\mathbf{G_{eq}}_{C2O4})=2*\mathbf{0}-(\mathbf{-146.79})=\mathbf{146.79}$ kJ/mol;
CH_{4gas}	-74.6	186.3	-50.5	Wikipedia CRC [1]
CH_{4gas}	formation	-50.5	**212.04**	$G_{CH4gas}=\Delta G_{\mathbf{Hess}\_CH4gas}+(G_{Cgr}+2*G_{H2})=\mathbf{212.04}$ kJ/mol;
CH_{4gas}	**Alberty**	**2006**	**120.56**	$G°_{\mathbf{CgrCH4}gas}=G°_{\mathbf{CH4}gas}-G_{\mathbf{Hess\_CH4}gas}-2*G°_{\mathbf{H2}gas}=\mathbf{91.26}$ kJ/mol;
CH_{4aq}	Solubility	**26.21**	**238.25**	$G_{CH4aq}=G_{CH4gas}+G_{CH4sp}=\mathbf{212.04}+\mathbf{26.21}=\mathbf{238.25}$ kJ/mol;
CH_{4aq}	**Alberty**	**2006**	**136.95**	**Alberty 2006** Biochem.Thermodyn Massachusetts Techn. Inst.
C_{gr}	background	Biochemistry	**91.26**	$G°_{Cgr0\mathbf{CO2}}=-\mathbf{\Delta}G°_{\mathbf{Hess\_CO2}gas}-G°_{\mathbf{O2}gas0}=\mathbf{394.36}-\underline{303.1}=\mathbf{91.26}$ kJ/mol;
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**	$2G_{CO2}=\Delta\mathbf{G_{eq}}_{H2C2O4}-2G_{\mathbf{H3O}}+(G_{H2C2O4}+2\mathbf{G_{H2O}})=2*\mathbf{-42.902}$ kJ/mol;
CO_{2aq}	$E°_{HC2O4}=$	**-0.7092** V	**-97.514**	$2G_{CO2}=\Delta\mathbf{G_{eq}}_{HC2O4}-G_{\mathbf{H3O}}+(G_{HC2O4}+\mathbf{G_{H2sO}})=2*\mathbf{-97.514}$ kJ/mol;
CO_{2aq}	$E°_{C2O4}=$	**-0.7607** V	**-27.517**	$2G_{CO2}=\Delta\mathbf{G_{eq}}_{C2O4}+(G_{C2O4})=\mathbf{-27.517}$ kJ/mol;
CO_{2aq}	$K_{eqCO2aqua}$	šķīdība	**18.38**	$G_{CO2aqua}=\Delta G_{eqCO2aqua}+(G_{CO2gas}+G_{H2O})=\mathbf{18.38}+(0+0)=\mathbf{18.38}$ kJ/mol .

Formation from free elements $2C_{gr}+2O_{2gas}+\mathbf{H}_{2gas}=H_2C_2O_{4cr}$ and solubility $H_2C_2O_4^{cr}+H_2O=H_2C_2O_{4aq}$:
$G_{H2C2O4cr}=\Delta G^\circ_{H2C2O4crForm}+(2G_{Cgr}+2G_{\mathbf{O2}gas}+G_{\mathbf{H2}gas})=-797.16+(\mathbf{2*91.26}+2*\mathbf{303}+\mathbf{85.6})=\mathbf{76.96}\ {}^{kJ}/_{mol}$.

Solubility of oxalic acid 118 ${}^{g}/_{L}$ $H_2C_2O_4^{cr}+H_2O=H_2C_2O_{4aq}$ constant is calculated from CRC, Wikipedia data

$K_{eq\_sp}=[H_2C_2O_{4aq}]/[H_2C_2O_4^{cr}]/[H_2O]=1.3106/1/49.77=0.026329$. [1,29]

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:

$\Delta G_{eq\_sp}=-R\bullet T\bullet\ln(K_{eq\_sp})=-8.3144*298.15*\ln(0.026329)=-8.3144\bullet298.15\bullet-3.637=\mathbf{9.0161}\ {}^{kJ}/_{mol}$.

Hess law for change $\Delta G_{eq\_sp}=G_{H2C2O4aq}-(G_{\mathbf{H2O}}+G_{H2C2O4}{}^{cr})=G_{H2C2O4aq}-(\mathbf{0}+\mathbf{76.96})=\mathbf{9.0161}\ {}^{kJ}/_{mol}$ let us calculate free energy content: $G_{H2C2O4aq}=\Delta G_{eq\_sp}+(G_{\mathbf{H2O}}+G_{H2C2O4}{}^{cr})=\mathbf{9.0161}+(\mathbf{0}+\mathbf{76.96})=\mathbf{85.976}\ {}^{kJ}/_{mol}$ [29] Wikipedia.

1. Week acid protolysis $H_2C_2O_4+H_2O=HC_2O_4^-+H_3O^+$; $pK_{a1}=1.25$; $K_{eq1}=K_{a1}/[\mathbf{H_2O}]=10^{\wedge(-1.25)}/55.3=0.0010169$;
$\Delta G_{eq1\mathbf{H2C2O4}}=-R\bullet T\bullet\ln(K_{eq1})=-8.3144*298.15*\ln(0.0010169)=\Delta G_{\mathbf{HC2O4}}+\Delta G_{\mathbf{H3O}}-(\Delta G_{\mathbf{HC2O4}}+\Delta G_{\mathbf{H2O}})=\mathbf{17.08}\ {}^{kJ}/_{mol}$;
$\Delta G_{eq1\mathbf{H2C2O4}}=G_{\mathbf{HC2O4}}+G_{\mathbf{H3O}}-(G_{\mathbf{H2C2O4}}+\Delta G_{\mathbf{H2O}})=G_{\mathbf{HC2O4}}+\mathbf{22.44}-(\mathbf{85.976}+\mathbf{0})=\mathbf{17.082}\ {}^{kJ}/_{mol}$;
$G_{\mathbf{HC2O4}}=\Delta G_{eq1\mathbf{H2C2O4}}-G_{\mathbf{H3O}}+(G_{\mathbf{H2C2O4}}+\Delta G_{\mathbf{H2O}})=\mathbf{17.082}-\mathbf{22.44}+(\mathbf{85.976}+\mathbf{0})=\mathbf{80.618}\ {}^{kJ}/_{mol}$;

2. Week acid protolysis $HC_2O_4^-+H_2O=C_2O_4^{2-}+H_3O^+$; $pK_{a2}=4.14$; $K_{eq2}=K_{a2}/[\mathbf{H_2O}]=10^{\wedge(-4.14)}/55.3=0.000001310$;
$\Delta G_{eq2\mathbf{HC2O4}}=-R\bullet T\bullet\ln(K_{eq2})=-8.3144*298.15*\ln(0.000001310)=\Delta G_{\mathbf{C2O4}}+\Delta G_{\mathbf{H3O}}-(\Delta G_{\mathbf{HC2O4}}+\Delta G_{\mathbf{H2O}})=\mathbf{33.578}\ {}^{kJ}/_{mol}$;
$\Delta G_{eq2\mathbf{HC2O4}}=G_{\mathbf{C2O4}}+G_{\mathbf{H3O}}-(G_{\mathbf{HC2O4}}+G_{\mathbf{H2O}})=G_{\mathbf{C2O4}}+\mathbf{22.44}-(\mathbf{80.618}+\mathbf{0})=\mathbf{33.578}\ {}^{kJ}/_{mol}$;
$G_{\mathbf{C2O4}}=\Delta G_{eq2\mathbf{HC2O4}}-G_{\mathbf{H3O}}+(G_{\mathbf{HC2O4}}+G_{\mathbf{H2O}})=\mathbf{33.578}-\mathbf{22.44}+(\mathbf{80.618}+\mathbf{0})=\mathbf{91.756}\ {}^{kJ}/_{mol}$;

pH<=1.25 $H_2C_2O_4+2H_2O=2CO_2+2H_3O^++2e^-$; $E^\circ_{H2C2O4}=\mathbf{-0.6577}$ V Suchotina [17]
$E^\circ_{H2C2O4}=E^\circ+0.10166-0.0591/2*\lg(1/[H_2O]^2)-0.37239=-0.49+0.10166-0.02955*\lg(1/55.3^2)-0.37239=\mathbf{-0.6577}$ V;
Absolute Nernst's Standard potential $E^\circ_{H2C2O4}=\mathbf{-0.6577}$ V; Suchotina [17]

$$E_{H2C2O4}=E^\circ_{H2C2O4}+\frac{0.0591}{2}\bullet\lg\frac{[CO_2]^2\cdot[H_3O^+]^2}{[H_2C_2O_2]\cdot[H_2O]^2}=\mathbf{-0.6577}\text{ V}+\frac{0.0591}{2}\bullet\lg\frac{[CO_2]^2\cdot[H_3O^+]^2}{[H_2C_2O_2]\cdot[H_2O]^2}$$

$\Delta\mathbf{G_{eq}}{}_{H2C2O4}=E^\circ_{H2C2O4}\bullet F\bullet2=\mathbf{-0.6577}*96485*2=\mathbf{-126.9}\ {}^{kJ}/_{mol}$;
$\Delta\mathbf{G_{eq}}{}_{H2C2O4}=2G_{CO2}+2G_{\mathbf{H3O}}-(G_{H2C2O4}+2\mathbf{G_{H2O}})=2*0+2*\mathbf{22.44}-(G_{H2C2O4}+2*0)=\mathbf{-126.9}\ {}^{kJ}/_{mol}$;
$G_{H2C2O4}=2G_{CO2}+2G_{\mathbf{H3O}}-(\Delta\mathbf{G_{eq}}{}_{H2C2O4}+2\mathbf{G_{H2O}})=2*0+2*\mathbf{22.44}-(\mathbf{-126.9}+2*0)=\mathbf{171.78}\ {}^{kJ}/_{mol}$;

1.25<pH<=4.14; $HC_2O_4^-+H_2O=2CO_2+H_3O^++2e^-$;
Absolute Nernst's Standard potential $E^\circ_{H2C2O4}=\mathbf{-0.7092}$ V Suchotina [17]
$E^\circ_{HC2O4}=E^\circ+0.10166-0.0591/2*\lg(1/[H_2O]^1)-0.37239=-0.49+0.10166-0.0591/2*\lg(1/55.3^{\wedge1})-0.37239=\mathbf{-0.709}$ V;
$\Delta\mathbf{G_{eq}}{}_{HC2O4}=E^\circ_{HC2O4}\bullet F\bullet2=\mathbf{-0.7092}*96485*2=\mathbf{-136.85}\ {}^{kJ}/_{mol}$;
$\Delta\mathbf{G_{eq}}{}_{HC2O4}=2G_{CO2}+G_{\mathbf{H3O}}-(G_{HC2O4}+\mathbf{G_{H2O}})=2*0+\mathbf{22.44}-(G_{HC2O4}+0)=\mathbf{-136.85}\ {}^{kJ}/_{mol}$;
$G_{HC2O4}=2G_{CO2}+G_{\mathbf{H3O}}-(\Delta\mathbf{G_{eq}}{}_{HC2O4}+\mathbf{G_{H2O}})=2*0+\mathbf{22.44}-(\mathbf{-136.85}+0)=\mathbf{159.028}\ {}^{kJ}/_{mol}$;

4.14 <pH; $C_2O_4^{2-}=2CO_2+2e^-$; Absolute Nernst's Standard potential $E^\circ_{C2O4}=\mathbf{-0.7607}$ V; Suchotina [17]
$E^\circ_{C2O4}=E^\circ+0.10166-0.0591/2*\lg([1/H_2O]^0)-0.37239=-0.49+0.10166-0.0591/2*\lg(1/55.3^0)-0.37239=\mathbf{-0.7607}$ V;
$\Delta\mathbf{G_{eq}}{}_{C2O4}=E^\circ_{C2O4}\bullet F\bullet2=\mathbf{-0.7607}*96485*2=\mathbf{-146.79}\ {}^{kJ}/_{mol}$;
$\Delta\mathbf{G_{eq}}{}_{C2O4}=2G_{CO2}-(G_{C2O4})=2*\mathbf{0}-(G_{C2O4})=\mathbf{-146.79}\ {}^{kJ}/_{mol}$;
$G_{C2O4}=2G_{CO2}-(\Delta\mathbf{G_{eq}}{}_{C2O4})=2*\mathbf{0}-(\mathbf{-146.79})=\mathbf{146.79}\ {}^{kJ}/_{mol}$;

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

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

$\Delta G_{Hess}=\Delta G^\circ_{H3O}+\Delta G^\circ_{CH3CHO}+\Delta G^\circ_{NADH}-\Delta G^\circ_{CH3CH2OH}-\Delta G^\circ_{H2O}-\Delta G^\circ_{NAD+}=159.1\ ^{kJ}/_{mol}$;
$\Delta G_{Hess}=32.2824+1175.5732-151.549-(75.2864+1059.11-237.191)=159.1\ ^{kJ}/_{mol}$ endoergic. Anaerobic:
Ox $NAD^+ + H^-(H^++2e^-)= NADH$; inverse $-E^\circ_{NADH}=\mathbf{0.38373}$ V; absolute potential David Harris; [22]
Red $CH_3CH_2OH+H_2O=CH_3CHO+H_3O^++H^-(2e^-)$; absolute Nernst's potential $E^\circ_{CH3CH2OH}=\mathbf{0.02923}$ V; [19]
$E^\circ_{C2H5OH}=E^\circ-0{,}0591/2\bullet\log(1/[H_2O]^1)=0{,}19-0{,}0591/2*\log(1/55{,}3^{\wedge 1})+0{,}10166-0{,}37239=\mathbf{0{,}02923}$ V;
Sum: $E^\circ_{C2H5OH}-E^\circ_{NAD+}=\mathbf{0{,}02923}+\mathbf{0{,}38373}=0.3545$ V, n=2; $\Delta G_{eq}=\Delta E^\circ\bullet F\bullet n=0.3545*96485*2=\mathbf{68{,}4}\ ^{kJ}/_{mol}$;
By convention balanced n=2=m number of electrons $2e^-$ donors $E^\circ_{NADH}=\mathbf{-0.38373}$ V plus acceptors of electrons $-E^\circ_{C2H5OH}=\mathbf{0.02923}$ V, as $-E^\circ_{NAD+}=\mathbf{0.38373}$ V accepting electrons from ethanol $E^\circ_{C2H5OH}=\mathbf{-0.02923}$ V:

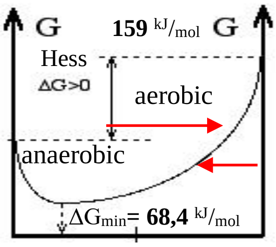
$$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=\mathbf{68{,}4}\ ^{kJ}/_{mol};\ K_{eq}=\frac{[NADH]\cdot[CH_3CHO]\cdot[H_3O^+]}{[NAD^+]\cdot[CH_3CH_2OH]\cdot[H_2O]}=e^{-\frac{\Delta Geq}{R\bullet T}}=e^{-\frac{68408}{8.314\bullet 298.15}}=1.036\bullet 10^{-12}=10^{-11.985}$$

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

$\Delta G_{Hess}=\Delta G^\circ_{CH3CH2OH}+\Delta G^\circ_{H2O}+\Delta G^\circ_{NAD+}-\Delta G^\circ_{H3O}-\Delta G^\circ_{CH3CHO}-\Delta G^\circ_{NADH} = -159.1\ ^{kJ}/_{mol}$;
$\Delta G_{Hess}=75.2864+1059.11-237.191-(32.2824+1175.5732-151.549)= -159.1\ ^{kJ}/_{mol}$ endoerģiska;
Red $NADH=NAD^++H^-(2e^-)$; $E^\circ_{NADH}=\mathbf{-0.38373}$ V; absolute Nernst's potential David Harris; [22]
Ox $CH_3CHO+2H_3O^++H^-(2e^-)=CH_3CH_2OH+2H_2O$; inverse potential $-E^\circ_{CH3CHO}=\mathbf{0.02923}$ V; [19];
Sum:
$\Delta E^\circ=E^\circ_{NADH}-E^\circ_{CH3CHO}=\mathbf{-0{,}38373}+\mathbf{0{,}02923}=-0.3545$ V, $\Delta G_{eq}=\Delta E^\circ\bullet F\bullet n=-0.3545\ V\bullet 2\ mol\bullet 96485\ ^{C}/_{mol}=\mathbf{-68{,}4}\ ^{kJ}/_{mol}$;
By convention balanced n=2=m number of electrons $2e^-\Delta E^\circ$ donors $E^\circ_{NADH}=\mathbf{-0.38373}$ V plus electrons acceptor $-E^\circ_{CH3CHO}=\mathbf{0.02923}$ V, as $-E^\circ_{CH3CHO}=\mathbf{0.02923}$ V accepting electrons from vitamin $E^\circ_{NADH}=\mathbf{-0.38373}$ V .

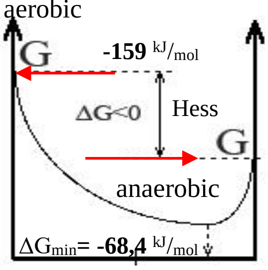
$$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=\mathbf{-68.408}\ ^{kJ}/_{mol};\ K_{eq}=\frac{[NAD^+]\cdot[CH_3CH_2OH]\cdot[H_2O]}{[NADH]\cdot[CH_3CHO]\cdot[H_3O^+]}=e^{-\frac{\Delta Geq}{R\bullet T}}=e^{-\frac{-68408}{8.314\bullet 298.15}}=9.65\bullet 10^{11}=10^{11.985}.$$

In aerobic organisms NADH oxidase with O_{2aqua} perform ratio $[NAD^+]/[NADH]=10^6$;
$\Delta G_{Homeostasis}=\mathbf{68.408}+R\bullet T\bullet\ln(10^6*1/1*10^{-7.36}/55.3)=\mathbf{68.408}-86.2=-17.8\ ^{kJ}/_{mol}$.
$[NAD^+]/[NADH]=10^3$; $\Delta G_{Homeostasis}=\mathbf{68.408}-69.08=-0.676\ ^{kJ}/_{mol}$.
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 $10^{-11.985}=K_{eq}$ aerobic and anaerobic $10^{11.985}=K_{eq}$.



reactants _
A+B+C50%D+E+F
$NAD^++H_3CCH_2OH+H_2O$
products_
$NADH+H_3CCHO+H_3O^+$

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 $H_3C\text{-}CH{=}O+NADH+H_3O^+ \Rightarrow H_3C\text{-}CH_2\text{-}OH+NAD^++H_2O+\Delta G+Q$;
Anaerobic $\Delta G_{eq}=\Delta E^\circ\bullet F\bullet n=-0.3545\ V\bullet 2\ mol\bullet 96485\ ^{C}/_{mol}=\mathbf{-68.408}\ ^{kJ}/_{mol}$ favored.
Insufficient low O_{2aqua} concentration hypoxia to anaerobic alcohol oxidation unflavored but ethanal reduction to ethanol favored $[H_3CCH_2OH]/[H_3CCH{=}O]=1/10$ homeostasis reduction with NADH reductase enzyme as negative free energy change $\Delta G_{Homeostasis}=-27.86\ ^{kJ}/_{mol}$



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

Anaerobic homeostasis ratio $[NADH]/[NAD^+]=10$ over $[NAD^+]$ favors reduction:

$\Delta G_{Homeostasis}=-68.41+8.3144*298.15*\ln(K_{Homeostasis})=-68.41+40.54 =-27.86\ ^{kJ}/_{mol}$

$$\Delta G_{Homeostasis}=-68.41+8.3144*298.15*\ln\left(\frac{1}{10}\frac{1}{10}\frac{55.333}{10^{-7.36}}\right)=-27.86\ ^{kJ}/_{mol};\ K_{Homeostasi}=\frac{[NAD^+]\cdot[CH_3CH_2OH]\cdot[H_2O]}{[NADH]\cdot[CH_3CHO]\cdot[H_3O^+]}$$

$[NADH]/[NAD^+]=1/770$; $\Delta G_{Homeostasis}=68.408+8.3144*298.15*\ln(700/1*1/1*55.3457/10^{-7.36})=0.028\ ^{kJ}/_{mol}$.

Glass $\underline{SiO_2}\downarrow$ /////SiO_2//// $\downarrow\underline{SiO_2}$ membrane electrode and pH detection

Glass electrodes are usually applicate to solution pH determination. As membrane electrode its potential forms on surface of silicon dioxide (SiO_2/) crystalline in protolysis of silicon acid reaction: $\underline{SiO_2{-}SiO_3H}+H_2O=\downarrow\underline{SiO_2{-}SiO_3}^-+H_3O^+$. So glass electrode potential have formed following.

On glass surface locate silicone anions functional groups $\downarrow\underline{SiO_2{-}SiO_3}^-$. On glass surface establishes protolytic equilibrium state between crystalline silconic acid $\underline{SiO_2{-}SiO_3H}$ and anionic groups of silicate $\underline{SiO_2{-}SiO_3}^-$. Siliconic acid is water insoluble acid and therefore weak protolyte:

$$\underline{SiO_2{-}SiO_3H}+H_2O=\downarrow\underline{SiO_2{-}SiO_3}^-+H_3O^+.$$

As crystalline membrane has inner surface equilibrium and outer surface of membrane has outer equilibrium, where last depends on tested medium H_3O^+ concentration.

$$H_3O^+_{inner}+\underline{SiO_3}^-\underline{{-}SiO_2}\downarrow=H_2O+\underline{HSiO_3{-}SiO_2}\downarrow/////SiO_2////\ \underline{SiO_2{-}SiO_3H}+H_2O=\downarrow\underline{SiO_2{-}SiO_3}^-+H_3O^+_{outer}.$$

Product in sequence conected equilibrium constants are membrane equilibrium constant $K_{inner}\bullet K_{outer}=K_{membr}$:

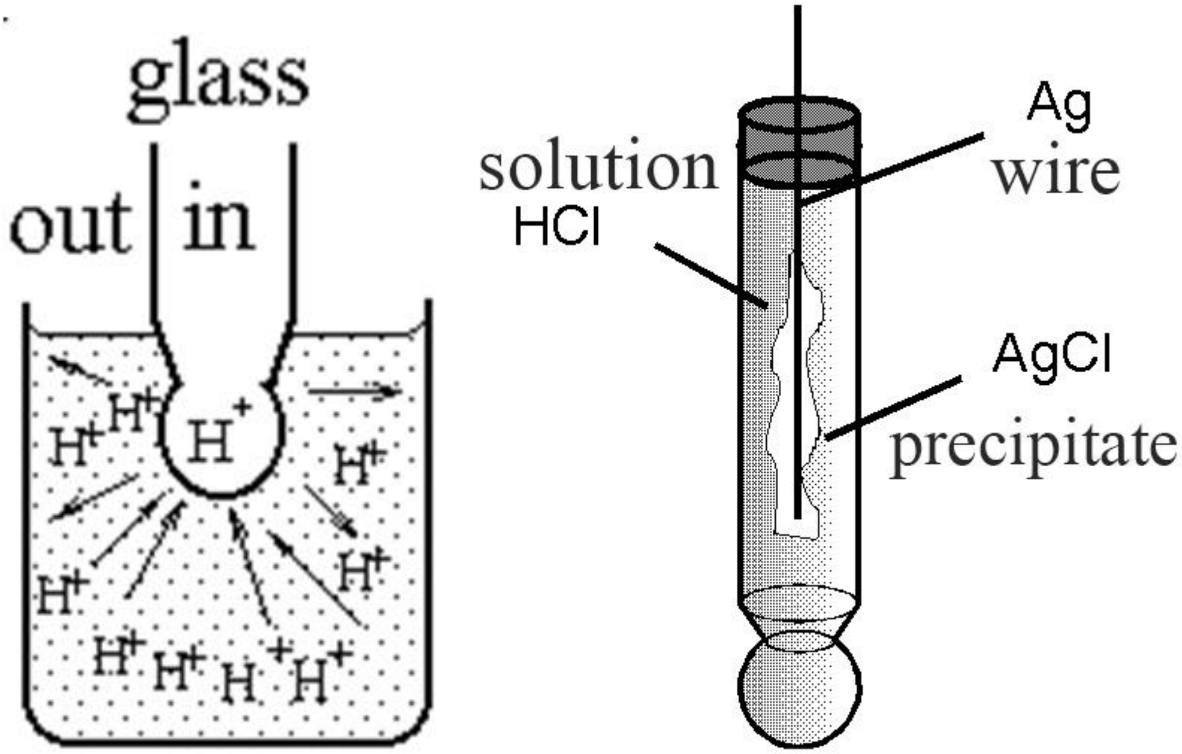
$$K_{inner}=\frac{[H_2O]}{[H_3O^+]_{inner}};\qquad K_{outer}=\frac{[H_3O^+]_{outer}}{[H_2O]};\qquad K_{inner}\bullet K_{outer}=K_{membr}=\frac{[H_3O^+]_{outer}}{[H_3O^+]_{inner}};$$

$$E_{membr}=\frac{0,0591}{n}\log\frac{[H_3O^+]_{outer}}{[H_3O^+]_{inner}}=0.0591(\log[H_3O^+_{outer.}]-\log[H_3O^+_{inner}])=E_{const}-0.0591\bullet pH,$$

where n=+1 hydrogen ion charge H^+, but logarithm of concentrations ratio is subtraction two logarithms from concentration ratio. Ions concentration inside membrane is constant $E_{const.}=-0.0591\bullet\log[H_3O^+_{inner}]$. Membrane potential depends only on solution $H_3O^+_{outer}$ and $pH=-\log[H_3O^+_{outer}]$.

$$E_{membr}=E_{const.}+0.0591\bullet\log[H_3O^+_{outer.}]\ .$$

Figure shows on end of glass tube thin bulb, that serves about glass membrane. Inside bulb HC1 solution with known concentration. Outside emerge in test solution and measure the pH of solution potenciometric.



Glass membrane $\underline{HSiO_3{-}SiO_2}\downarrow$ /////SiO_2//// $\downarrow\underline{SiO_2{-}SiO_3H}$ and electrodes combination with silver wire.

For electric connection with glass membrane in inner solution immerses one silver wire, that forms second type electrode potential $E_{AgCl\ inner}$ in sequence with membrane potential $E_{membr.}+E_{AgCl\ inner}$ Potential depends only on outer pH of investigated solution, because hydrochloric acid concentration is constant.

EMF (Electric Motion Force) measure for closed electric circle. That achieved in outer solution coupled reference electrode with standard potential E_{AgCl}. Electric chain closed at pH-meter contact clumps:

Total EMF potential consist of three electrodes in sequence connected as well from 3 parts:

1) inside glass electrode immersed AgCl electrode potential $E_{AgCl\ inner}$;

2) glass membrane electrode $E_{membr}= E_{const.}+0.0591\bullet\log[H_3O^+_{outer}]=E_{const.}-0.0591\bullet pH$;

3) reference electrode with standard potential E_{AgCl}.

By additive sum of constant values parts is calculated new constant: $E'_{const}= (E_{AgCl}+E_{AgCl\ inner} + E_{const.})$.

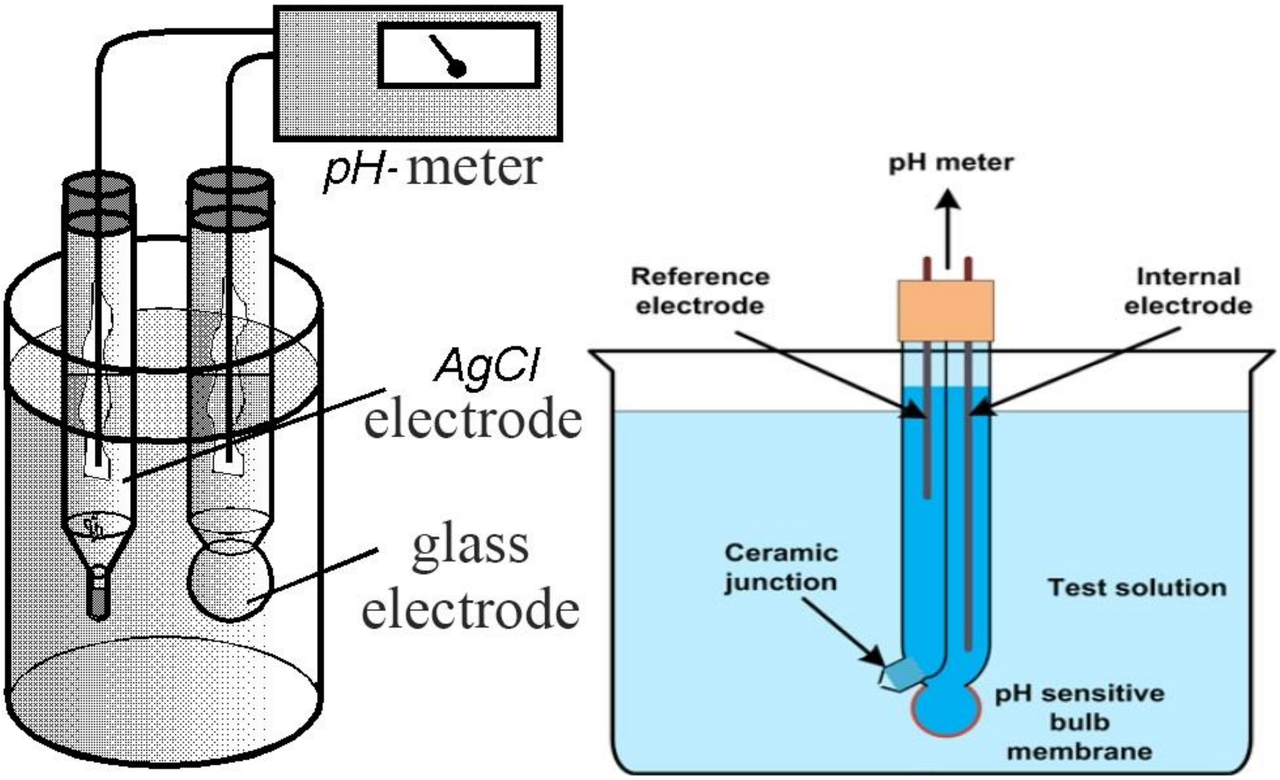
$$EDS=E_{AgCl}+E_{membr}+E_{AgCl\ inner}= (E_{AgCl}+E_{AgCl\ inner}\ E_{const.})+0.0591\cdot lg\ [H_3O^+_{inner}] = E'_{const}-0.0591\bullet pH$$

$$EDS = E'_{const}-0.0591\bullet pH\ .$$

Measured Electric Motion Force (EMF) is proportional to pH value in solution.

pH measurement by glass electrodes have some advantages:

1) glass electrode is useable on complete pH interval (from pH = 0 to pH = 14);
2) measurement precision reaches 0.001 pH units;
3) measurements not depend on oxidation, reduction and proteins in solution;
4) permanent direct control of pH by pH-meter.



pH measurement by EMF couple with combined glass and silver chloride electrodes

Nernst's potential $Cr_2O_7^{2-}$ / $2Cr^{3+}$ red-ox system behaving in acidic H_3O^+ , water medium

Nernst's absolute standard potential. $\log K_D=2.05$; $K_D=10^{\wedge 2.05}$; $2HCrO_4^-=Cr_2O_7^{2-}+H_2O$;

$\Delta G_D=-R\bullet T\bullet\ln(K_D*[H_2O])=-8.3144*298.15*\ln(10^{\wedge 2.05}*55.3)=G_{Cr2O7}+G_{\mathbf{H2O}}-(2G_{HCrO4})=\mathbf{-21.65}\ ^{kJ}/_{mol}$;

$2G_{HCrO4}=G_{Cr2O7}+G_{\mathbf{H2O}}-(\Delta G_D)=G_{Cr2O7}+0-(\mathbf{-21.65})=???\ ^{kJ}/_{mol}$;

$pK_a=1.8$; $HCr_2O_7^-+H_2O=Cr_2O_7^{2-}+H_3O^+$; $K_{eq}=K_a/[H_2O]=10{\wedge}(-1.8)/55.3=0.0002866$;

$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=-8.3144*298.15*\ln(0.0002866)=G_{Cr2O7}+G_{\mathbf{H3O}}-(G_{HCr2O7}+G_{\mathbf{H2O}})=\mathbf{20.22}\ ^{kJ}/_{mol}$;

$G_{HCr2O7}=G_{Cr2O7}+G_{\mathbf{H3O}}-(\Delta G_{eq}+G_{\mathbf{H2O}})=G_{Cr2O7}+22.44-(\mathbf{20.22}+0)=???\ ^{kJ}/_{mol}$;

Instability constant $[\underline{CrOH}]^{\underline{2+}}+H_2O=Cr^{3+}+OH^-$; $K_{inst}=10^{\wedge(-9.77)}$; $K_{eq}=K_{inst}/[H_2O]=10^{\wedge(-9.88)}/55.3=10^{\wedge(-11.51)}$;

$\Delta G_{eqinst}=-R\bullet T\bullet\ln(K_{eqinst})=-8.3144*298.15*\ln(10^{\wedge(-11.51)})=G_{Cr3+}+G_{\mathbf{OH}}-(G_{[CrOH]2+}+G_{\mathbf{H2O}})=\mathbf{65.7}\ ^{kJ}/_{mol}$;

$G_{[CrOH]2+}=G_{Cr3+}+G_{\mathbf{OH}}-(\Delta G_{eqinst}+G_{\mathbf{H2O}})=G_{Cr3+}+77.36-(\mathbf{65.7}+0)=???\ ^{kJ}/_{mol}$;

Instability $[\underline{Cr(OH)}_2]^++2H_2O=Cr^{3+}+2OH^-$; $K_{inst}=10^{\wedge(-17.3)}$; $K_{eqinst}=K_{inst}/[H_2O]^2=10^{\wedge(-17.3)}/55.3{\wedge}2=10^{\wedge(-20.785)}$;

$\Delta G_{eqinst}=-R\bullet T\bullet\ln(K_{eqinst})=-8.3144*298.15*\ln(10^{\wedge(-20.785)})=G_{Cr3+}+2G_{\mathbf{OH}}-(G_{Cr(OH)2}+2G_{\mathbf{H2O}})=\mathbf{118.64}\ ^{kJ}/_{mol}$;

$G_{Cr(OH)2}=G_{Cr3+}+2G_{\mathbf{OH}}-(\Delta G_{eqinst}+2G_{\mathbf{H2O}})=G_{Cr3+}+2*77.36-(\mathbf{118.64}+2*0)=???\ ^{kJ}/_{mol}$;

Instability constant $[\underline{Cr(OH)}_3]+3H_2O=Cr^{3+}+3OH^-$; $K_{inst}=10^{\wedge(-24)}$; $K_{eq}=K_{inst}/[H_2O]=10^{\wedge(-24)}/55.3=10^{\wedge(-29.23)}$;

$\Delta G_{eqinst}=-R\bullet T\bullet\ln(K_{eqinst})=-8.3144*298.15*\ln(10^{\wedge(-29.23)})=G_{Cr3+}+3G_{\mathbf{OH}}-(G_{[Cr(OH)3]}+3G_{\mathbf{H2O}})=\mathbf{166.8}\ ^{kJ}/_{mol}$;

$G_{[Cr(OH)3]}=G_{Cr3+}+3G_{\mathbf{OH}}-(\Delta G_{eqinst}+3G_{\mathbf{H2O}})=G_{Cr3+}+3*77.36-(\mathbf{166.8}+3*0)=???\ ^{kJ}/_{mol}$;

$2Cr^{3+}+21H_2O=Cr_2O_7^{2-}+14H_3O^++6e^-$; 1< pH<7 ; Standard potential $E^\circ_{Cr2O72}=\mathbf{1,41975}$ V Kortly, Shucha [18]

$E^\circ_{Cr2O72}=E^\circ+0,10166-0,0591/6*\lg(1/[H_2O]^{21})-0,372=1,33+0,10166-0,0591/6*\lg(1/55,3^{\wedge 21})-0,37239=\mathbf{1,41975}$ V;

$$E_{Cr2O72-/2Cr3+}=E^\circ_{Cr2O72-/2Cr3+}+\frac{0.0591}{6}\bullet\lg\frac{[Cr_2O_7^{2-}]\cdot[H_3O^+]^{14}}{[Cr^{3+}]^2\cdot[H_2O]^{21}}=\mathbf{1,41975}\text{ V}+\frac{0.0591}{6}\bullet\lg\frac{[Cr_2O_7^{2-}]\cdot[H_3O^+]^{14}}{[Cr^{3+}]^2\cdot[H_2O]^{21}}$$

$\Delta\mathbf{G}_{\mathbf{eq}Cr2O72-/2Cr3+}=E^\circ_{Cr2O72-/2Cr3+}\bullet F\bullet 6=\mathbf{1,41975}*96485*6=\mathbf{821,9}\ ^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}Cr2O72-/2Cr3+}=G_{Cr2O72-}+14G_{\mathbf{H3O}}-(2G_{2Cr3+}+21\mathbf{G}_{\mathbf{H2O}})=G_{Cr2O72-}+14*\mathbf{22,44}-(2G_{2Cr3+}+21*0)=\mathbf{821,9}\ ^{kJ}/_{mol}$,

$2G_{2Cr3+}=G_{Cr2O72-}+14*\mathbf{22,44}-(\mathbf{821,9}+21*0)=\mathbf{???}\ ^{kJ}/_{mol}$;

$Cr^{3+}+11H_2O=HCrO_4^-+7H_3O^+\mathbf{+3e^-}$;; pH>7 ; Standard potential $E^\circ_{Cr2O72}=\mathbf{1,30692}$ V Kortly, Shucha [18]

$E^\circ_{CrO4}=E^\circ+0,10166-0,0591/3*\lg(1/[H_2O]^{11})-0,37239=1,2+0,10166-0,0591/3*\lg(1/55,3^{\wedge 11})-0,37239=\mathbf{1,30692}$ V;

$\Delta\mathbf{G}_{\mathbf{eq}CrO4/Cr3+}=E^\circ_{CrO4/Cr3+}\bullet F\bullet 3=\mathbf{1,30692}*96485*3=\mathbf{378,3}\ ^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}H2C2O4}=G_{CrO4-}+14G_{\mathbf{H3O}}-(2G_{2Cr3+}+21\mathbf{G}_{\mathbf{H2O}})=G_{CrO4-}+14*\mathbf{22,44}-(2G_{2Cr3+}+21*0)=\mathbf{378,3}\ ^{kJ}/_{mol}$,

$2G_{2Cr3+}=G_{CrO4-}+14*\mathbf{22,44}-(\mathbf{378,3}+21*0)=\mathbf{???}\ ^{kJ}/_{mol}$;

$\underline{Cr(OH)}_3\downarrow+5OH^-=CrO_4^{2-}+4H_2O+3e^-$; pH>9 ; $E^\circ_{CrO42-\underline{OH}}=\mathbf{-0,53806}$ V Suchotina [17]

$E^\circ_{CrO42-\underline{OH}}=E^\circ-0,0591/3*\lg([H_2O]^4)+0,10166-0,37239=-0,13-0,0591/3*\lg(55,3^{\wedge 4})+0,10166-0,37239=\mathbf{-0,53806}$ V;

$\Delta\mathbf{G}_{\mathbf{eq}CrO42-\underline{OH}}=E^\circ_{CrO42-\underline{OH}}\bullet F\bullet 3=\mathbf{-0,53806}*96485*3=\mathbf{-155,74}\ ^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}CrO42-\underline{OH}}=G_{CrO4-}+4G_{\mathbf{H3O}}-(G_{Cr(\underline{OH})3}+5\mathbf{G}_{\mathbf{OH}})=G_{CrO4-}+4*\mathbf{22,44}-(2G_{2Cr3+}+5*77,36)=\mathbf{-155,74}\ ^{kJ}/_{mol}$,

$G_{Cr(\underline{OH})3}=G_{CrO4-}+14*\mathbf{22,44}-(\mathbf{-155,74}+21*0)=\mathbf{???}\ ^{kJ}/_{mol}$;

$$E_{CrO42-/\underline{Cr(OH)}3\downarrow}=E^\circ_{CrO42-/\underline{Cr(OH)}3\downarrow}+\frac{0.0591}{3}\bullet\lg\frac{[CrO_4^{2-}]\cdot[H_2O]^4}{[Cr(OH)_3]\cdot[OH^-]^5}=\mathbf{-0,563806}\text{ V}+\frac{0.0591}{3}\bullet\lg\frac{[CrO_4^{2-}]\cdot[H_2O]^4}{[Cr(OH)_3]\cdot[OH^-]^5}\text{ V;}$$

Solubility product $\underline{Cr(OH)}_3+4H_2O=Cr^{3+}+3OH^-$; $K_{sp}=6,7*10^{\wedge(-31)}$; $K_{eq}=K_{sp}/[H_2O]^4=6,7*10^{\wedge(-31)}/55,3^{\wedge 4}=10^{\wedge(-37,145)}$;

$\Delta G_{sp}=-R\bullet T\bullet\ln(K_{sp})=-8,3144*298,15*\ln(10^{\wedge(-37,145)})=G_{Cr3+}+3G_{\mathbf{OH}}-(G_{Cr(OH)3}+4G_{\mathbf{H2O}})=\mathbf{212,02}\ ^{kJ}/_{mol}$;

$G_{Cr(OH)3}=G_{Cr3+}+3G_{\mathbf{OH}}-(\Delta G_{sp}+4G_{\mathbf{H2O}})=G_{Cr3+}+3*77,36-(\mathbf{212,02}+4*0)=???\ ^{kJ}/_{mol}$;

Substance	ΔH°_H $^{kJ}/_{mol}$	ΔS°_H $^{J}/_{mol/K}$	ΔG°_H , $^{kJ}/_{mol}$
$CrCl_{2(cr)}$	-395.4	115.3	-356
$CrCl_{3(cr)}$	-556.5	123	-486.1
Cr	-	23.8	-
$CrO_{3(l)}$	-292.9	266.2	-
$Cr_2O_{3(cr)}$	-1139.7	81.2	1058.1

$2G_{2Cr3+}=G_{CrO4-}+14*\mathbf{22.44}-(\mathbf{370.8}+21*0)=\mathbf{???}\ ^{kJ}/_{mol}$;

$G_{Cr(\underline{OH})3}=G_{CrO4-}+14*\mathbf{22.44}-(\mathbf{163.2}+21*0)=\mathbf{???}\ ^{kJ}/_{mol}$;

$2G_{HCrO4}=G_{Cr2O7}+0-(\mathbf{-21.65})=???\ ^{kJ}/_{mol}$;

$G_{HCr2O7}=G_{Cr2O7}+22.44-(\mathbf{20.22}+0)=???\ ^{kJ}/_{mol}$;

$G_{[CrOH]2+}=G_{Cr3+}+77.36-(\mathbf{65.7}+0)=???\ ^{kJ}/_{mol}$;

$G_{Cr(OH)2}=G_{Cr3+}+2*77.36-(\mathbf{118.64}+2*0)=???\ ^{kJ}/_{mol}$;

$G_{[Cr(OH)3]}=G_{Cr3+}+3*77.36-(\mathbf{166.8}+3*0)=???\ ^{kJ}/_{mol}$;

$2G_{2Cr3+}=G_{Cr2O72-}+14*\mathbf{22.44}-(\mathbf{806.9}+21*0)=\mathbf{???}\ ^{kJ}/_{mol}$;

$G_{Cr(OH)3}=G_{Cr3+}+3*77.36-(\mathbf{211.99}+4*0)=???\ ^{kJ}/_{mol}$;

Nernst's potential BiO_3^- / Bi^{3+} $2Bi+6OH^-=Bi_2O_3+3H_2O+6e^-$; pH>7; [7]

$E^\circ_{Bi2O3-/Bi}=E_o-0{,}0591/6*\lg([H_2O]^3)+0{,}10166-0{,}37239=-0{,}46-0{,}0591/6*\lg(55{,}3{\wedge}^{3})+0{,}10166-0{,}37239=\mathbf{-0{,}78223}\ V$;

$E^\circ_{Bi2O3-/Bi}=E_o-0{,}0591/6*\lg(1/[H_2O]^3)+0{,}10166-0{,}3723=-0{,}46-0{,}0591/6*\lg(1/55{,}3{\wedge}^{3})+0{,}10166-0{,}37239=\mathbf{-0{,}67923}\ V$;

Substance	$\Delta H^\circ_H\ {}^{kJ}/_{mol}$	$\Delta S^\circ_H\ {}^{J}/_{mol/K}$	ΔG°_H , ${}^{kJ}/_{mol}$
Bi^{3+}	-	82.8	-
Bi	$E^\circ_{Bi2O3-/Bi}$	**-0.78223V**	**-249,6**
Bi	$E^\circ_{Bi2O3-/Bi}$	**-0,67923V**	**-132,6**
Bi	$E^\circ_{BiCl3-/Bi}$	**-0,21372V**	**298,725**
Bi	$E^\circ_{BiCl4-/Bi}$	**-0,17939V**	**288,795**
Bi	$E^\circ_{BiClO/Bi}$	**-0,007735V**	**-91,03**
Bi	**-74,125**	56.7	**-91,03**
Bi_2	219,7		-
$BiOH^{2+}$	-	-146.4	-
Cl^-	-167.08	56.6	**-183.955**
$Cl_{(g)}$	-121.301	165.19	
Cl_2	-	223.081	
$BiCl_{3(s)}$	-379.1	177	-315.0
$BiClO_{(s)}$	-366.9	120.5	-322.1
Bi_2O_3	-573.9	151.5	-493.7
$Bi(OH)_3$	-711.3	-	-

$2Bi+3OH^-+3H_2O=Bi_2O_3+3H_3O^++6e^-$; pH=7; Suchotina [17]

$G_{Bi}=(G_{Bi2O3}+3G_{\mathbf{H2O}}-(\Delta\mathbf{G}_{\mathbf{eq}Bi2O3-/Bi}+6\mathbf{G}_{\mathbf{OH}}))/2=\mathbf{-249{,}6}\ {}^{kJ}/_{mol}$;

$G_{Bi}=(G_{Bi2O3}+3G_{\mathbf{H3O}}-(\Delta\mathbf{G}_{\mathbf{eq}Bi2O3-/Bi}+3\mathbf{G}_{\mathbf{OH}}+3G_{\mathbf{H2O}}))/2=\mathbf{-132{,}6}\ {}^{kJ}/_{mol}$;

$G_{Bi}=G_{BiCl3}+3G_{\mathbf{H2O}}-(\Delta\mathbf{G}_{\mathbf{eq}BiCl3-Bi}+3\mathbf{G}_{\mathbf{Cl}})=\mathbf{298{,}725}\ {}^{kJ}/_{mol}$;

$G_{Bi}=G_{BiCl3}+2G_{\mathbf{H2O}}-(\Delta\mathbf{G}_{\mathbf{eq}BiCl3-Bi}+3\mathbf{G}_{\mathbf{Cl}})=\mathbf{288{,}795}\ {}^{kJ}/_{mol}$;

$G_{Bi}=G_{BiClO}+2G_{\mathbf{H3O}}-(\Delta\mathbf{G}_{\mathbf{eq}BiClO-Bi}+3H_2O+\mathbf{G}_{\mathbf{Cl}})=\mathbf{-91{,}03}\ {}^{kJ}/_{mol}$;

$\Delta\mathbf{H}_{Bi\_BiClO}=\mathbf{\Delta G+\Delta S*T=-91{,}03}+0{,}0567*298{,}15=\mathbf{-74{,}125}\ {}^{kJ}/_{mol}$,

$$E_{Bi2O3-/Bi}=E^\circ_{Bi2O3-/Bi}+\frac{0.0591}{6}\bullet\lg\frac{[Bi_2O_3]\cdot[H_2O]^3}{[Bi]^2\cdot[OH^-]^6}=$$

$$=\mathbf{-0{,}78223}+0{,}0591/6*\lg([Bi_2O_3]*[H_2O]^3/[Bi]^2/[\ OH^-]^6)$$

$G_{Bi}=G_{BiCl}+3G_{\mathbf{H2O}}-(\Delta\mathbf{G}_{\mathbf{eq}BiCl3-Bi}+3\mathbf{G}_{\mathbf{Cl}})=\mathbf{306{,}2}\ {}^{kJ}/_{mol}$,

$G_{Bi}=G_{BiClO}+2G_{\mathbf{H3O}}-(\Delta\mathbf{G}_{\mathbf{eq}BiClO-Bi}+3H_2O+\mathbf{G}_{\mathbf{Cl}})=\mathbf{291{,}44}\ {}^{kJ}/_{mol}$,

$$=\mathbf{-0{,}8337}+0{,}0591/6*\lg([Bi_2O_3]*[H_2O]^6/[Bi]^2/[\ OH^-]^6)$$

$$E_{Bi2O3-/Bi}=E^\circ_{Bi2O3-/Bi}+\frac{0.0591}{6}\bullet\lg\frac{[Bi_2O_3]\cdot[H_2O]^6}{[Bi]^2\cdot[OH^-]^6}=$$

$\Delta\mathbf{G}_{\mathbf{eq}Bi2O3-/Bi}=E^\circ_{Bi2O3-/Bi}\bullet F\bullet 6=\mathbf{-0{,}78223}*96485*6=\mathbf{-458{,}63}\ {}^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}Bi2O3-/Bi}=G_{Bi2O3}+3G_{\mathbf{H2O}}-(2G_{Bi}+6\mathbf{G}_{\mathbf{OH}})=-493{,}7+3*\mathbf{0}-(2*G_{Bi}+6*77{,}36)=\mathbf{-458{,}63}\ {}^{kJ}/_{mol}$,

$G_{Bi}=(G_{Bi2O3}+3G_{\mathbf{H2O}}-(\Delta\mathbf{G}_{\mathbf{eq}Bi2O3-/Bi}+6\mathbf{G}_{\mathbf{OH}}))/2=(-493{,}7+3*\mathbf{0}-(\mathbf{-458{,}63}+6*77{,}36))/2=\mathbf{-249{,}6}\ {}^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}Bi2O3-/Bi}=E^\circ_{Bi2O3-/Bi}\bullet F\bullet 6=\mathbf{-0{,}67923}*96485*6=\mathbf{-393{,}2}\ {}^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}Bi2O3-/Bi}=G_{Bi2O3}+3G_{\mathbf{H3O}}-(2G_{Bi}+3\mathbf{G}_{\mathbf{OH}}+3G_{\mathbf{H2O}})=-493{,}7+3*\mathbf{22.44}-(2*G_{Bi}+3*77{,}36+3*\mathbf{0})=\mathbf{-393{,}2}\ {}^{kJ}/_{mol}$,

$G_{Bi}=(G_{Bi2O3}+3G_{\mathbf{H3O}}-(\Delta\mathbf{G}_{\mathbf{eq}Bi2O3-/Bi}+3\mathbf{G}_{\mathbf{OH}}+3G_{\mathbf{H2O}}))/2=(-493{,}7+3*\mathbf{22.44}-(\mathbf{-393{,}2}+3*77{,}36+3*\mathbf{0}))/2=\mathbf{-132{,}6}\ {}^{kJ}/_{mol}$,

$Bi+3Cl^-=BiCl_{3(s)}+3H_2O+3e^-$; pH=7 ; Suchotina [17]

$E^\circ_{BiCl3-/Bi}=E_o-0{,}0591/3*\lg([H_2O]^3)+0{,}10166-0{,}37239=0{,}16-0{,}0591/3*\lg(55{,}3{\wedge}^{3})+0{,}10166-0{,}37239=\mathbf{-0{,}21372}\ V$;

$\Delta\mathbf{G}_{\mathbf{eq}BiCl3-Bi}=E^\circ_{\mathbf{eq}BiCl3-Bi}\bullet F\bullet 3=\mathbf{-0{,}21372}*96485*3=\mathbf{-69{,}32}\ {}^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}BiCl3-Bi}=G_{BiCl}+3G_{\mathbf{H2O}}-(G_{Bi}+3\mathbf{G}_{\mathbf{Cl}})=-315+3*\mathbf{0}-(G_{Bi}+3*\mathbf{-183{,}955})=\mathbf{-69{,}32}\ {}^{kJ}/_{mol}$,

$G_{Bi}=G_{BiCl3}+3G_{\mathbf{H2O}}-(\Delta\mathbf{G}_{\mathbf{eq}BiCl3-Bi}+3\mathbf{G}_{\mathbf{Cl}})=-315+3*\mathbf{0}-(\mathbf{-69{,}32}+3*\mathbf{-183{,}955})=\mathbf{298{,}725}\ {}^{kJ}/_{mol}$,

$Bi+4Cl^-=BiCl_4^-+2H_2O+3e^-$; pH=7 ; Suchotina [17]

$E^\circ_{BiCl4-/Bi}=E_o-0{,}0591/3*\lg([H_2O]^2)+0{,}10166-0{,}37239=0{,}16-0{,}0591/3*\lg(55{,}3{\wedge}^{2})+0{,}10166-0{,}37239=\mathbf{-0{,}17939}\ V$;

$\Delta\mathbf{G}_{\mathbf{eq}BiCl3-Bi}=E^\circ_{\mathbf{eq}BiCl3-Bi}\bullet F\bullet 3=\mathbf{-0{,}17939}*96485*3=\mathbf{-51{,}93}\ {}^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}BiCl3-Bi}=G_{BiCl}+2G_{\mathbf{H2O}}-(G_{Bi}+3\mathbf{G}_{\mathbf{Cl}})=-315+3*\mathbf{0}-(G_{Bi}+3*\mathbf{-183{,}955})=\mathbf{-51{,}93}\ {}^{kJ}/_{mol}$,

$G_{Bi}=G_{BiCl3}+2G_{\mathbf{H2O}}-(\Delta\mathbf{G}_{\mathbf{eq}BiCl3-Bi}+3\mathbf{G}_{\mathbf{Cl}})=-315+3*0-(\mathbf{-51{,}93}+3*\mathbf{-183{,}955})=\mathbf{288{,}795}\ {}^{kJ}/_{mol}$,

$Bi+3H_2O+Cl^-=BiClO_{(s)}+2H_3O^++3e^-$; Suchotina [17]

$E^\circ_{BiClO/Bi}=E_o-0{,}0591/3*\lg(1/[H_2O]^3)+0{,}10166-0{,}37239=0{,}16-0{,}0591/3*\lg(1/55{,}3{\wedge}^{3})+0{,}10166-0{,}37239=\mathbf{-0{,}007735}\ V$;

$\Delta\mathbf{G}_{\mathbf{eq}BiClO-Bi}=E^\circ_{\mathbf{eq}BiClO-Bi}\bullet F\bullet 3=\mathbf{-0{,}007735}*96485*3=\mathbf{-2{,}2389}\ {}^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}BiClO-Bi}=G_{BiClO}+2G_{\mathbf{H3O}}-(G_{Bi}+3H_2O+\mathbf{G}_{\mathbf{Cl}})=-322{,}1+2*\mathbf{22{,}44}-(G_{Bi}\mathbf{+3*0-183{,}955})=\mathbf{-2{,}2389}\ {}^{kJ}/_{mol}$,

$G_{Bi}=G_{BiClO}+2G_{\mathbf{H3O}}-(\Delta\mathbf{G}_{\mathbf{eq}BiClO-Bi}+3H_2O+\mathbf{G}_{\mathbf{Cl}})=-322{,}1+2*\mathbf{22{,}44}-(\mathbf{-2{,}2389+3*0-183{,}955})=\mathbf{-91{,}03}\ {}^{kJ}/_{mol}$,

$BiO^++6H_2O=BiO_3^-+4H_3O^++2e^-$; 1<pH<7 ; Suchotina [17]

$E^\circ_{BiO3-/BiO+}=E_o-0{,}0591/2*\lg(1/[H_2O]^6)+0{,}10166-0{,}37239=1{,}80-0{,}0591/2*\lg(1/55{,}3{\wedge}^{6})+0{,}10166-0{,}37239=\mathbf{1{,}83826}\ V$;

$$E_{BiO3-/BiO+}=E^\circ_{BiO3-/BiO+}+\frac{0.0591}{2}\bullet\lg\frac{[BiO_3^-]\cdot[H_3O^+]^4}{[BiO^+]\cdot[H_2O]^6}=\mathbf{1{,}83826}V+\frac{0.0591}{2}\bullet\lg\frac{[BiO_3^-]\cdot[H_3O^+]^4}{[BiO^+]\cdot[H_2O]^6}$$

$\Delta\mathbf{G}_{\mathbf{eq}BiO3-/BiO+}=E^\circ_{\mathbf{eq}BiO3-/BiO+}\bullet F\bullet 3=\mathbf{1{,}83826}*96485*2=\mathbf{354{,}73}\ {}^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}BiO3-/BiO+}=G_{BiO3-}+4G_{\mathbf{H3O}}-(G_{BiO+}+6H_2O)=G_{BiO3-}+4*\mathbf{22{,}44}-(G_{BiO+}\mathbf{+6*0})=\mathbf{354{,}73}\ {}^{kJ}/_{mol}$,

$G_{BiO+}=G_{BiO3-}+4G_{\mathbf{H3O}}-(\Delta\mathbf{G}_{\mathbf{eq}BiO3-/BiO+}+6H_2O)=G_{BiO3-}+4*\mathbf{22{,}44}-(\mathbf{354{,}73+6*0})=???\ {}^{kJ}/_{mol}$,

$G_{Bi}=\mathbf{-249{,}6}\ {}^{kJ}/_{mol}$, $G_{Bi}=\mathbf{-132{,}6}\ {}^{kJ}/_{mol}$, $G_{Bi}=\mathbf{298{,}7}\ {}^{kJ}/_{mol}$; $G_{Bi}=\mathbf{288{,}8}\ {}^{kJ}/_{mol}$,$G_{Bi}=\mathbf{-91{,}0}\ {}^{kJ}/_{mol}$,$G_{Bi}=\mathbf{-83{,}57}\ {}^{kJ}/_{mol}$,

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