Nernsta pus reakcijas oksidēšanas potenciāls un membrānas potenciāls voltos
Oksidēšanās-reducēšanās balansēšana ar Nernsta pus reakcijām

Nernsts saņem Nobeļa Prēmiju ķīmijā 1920. gadā:

Metāls kontaktā ar šķīdumu, reducētāju un oksidētāju rada **elektroda** potenciālu voltos

Elektroķīmisko potenciālu abpus šūnu membrānai veido jonu koncentrācijas gradients $C_{labā\_puse}/C_{kreisā\_puse}$.

Elektroķīmiskas reakcijas šķērsojot membrānu virza E7 klases transporta enzīmi.

Metāla brīvo elektronu gāze atdod elektronus reducēšanās un paņem no oksidēšanās pus reakcijas

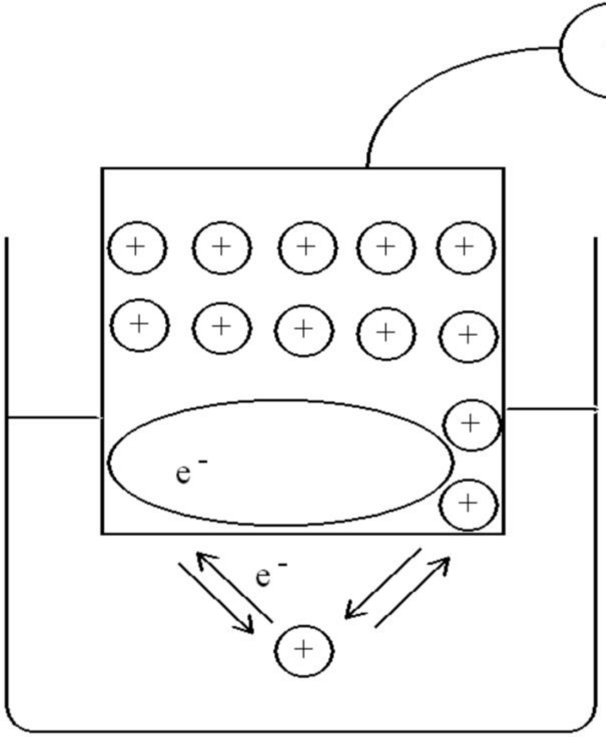
Metāla elektrods ir brīvo elektronu avots rezervuārs pus reakcijām.

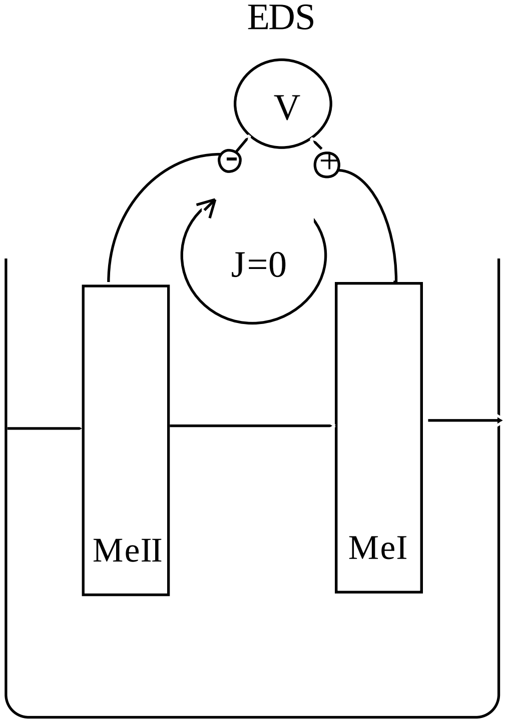
Klasificē šādus **elektrodu** veidus:

I veida: lādētu **jonu** un **elektronu** pārnese cauri fāžu **robežvirsmai**;
II veida : lādētu **jonu** un **elektronu** pārnese cauri fāžu **robežvirsmai**;
Red-Oks elektrodi: lādētu **jonu** un **elektronu** pārnese cauri fāžu **robežvirsmai**;
Membrānas elektrods: : lādētu **jonu** pārnese cauri šūnu **membrānām** bez **elektroniem**.

Elektroķīmiskajā reakcijā lādētu jonu virzīts gradients cauri **membrānas** kanāliem: veido **membrānas potenciālu E_M**.

Metāla sastāvā ir elektronu **e^-** gāze un + pozitīvi metāla atomu jonu kristāliskais režģis.





Voltmetrs ar mīnus "-" un plus "+" spailēm mēra potenciāla starpību jeb **EDS** (Elektro Dzinēj Spēks) elektriskā ķēdē starp diviem savienotiem elektrodiem **MeI** (**Indikatora**) un **MeII** (**Standarta**):

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

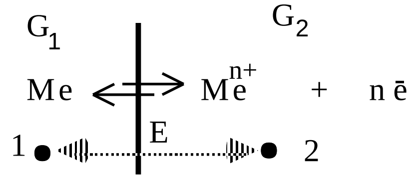
Indikatora elektrods ar E_I – ir mijiedarbība ar šķīdumu ,

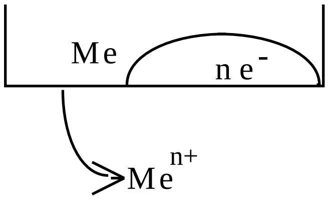
Standarta elektrods ar E_{II} = konstants – mijiedarbības ar apkārtējo vidi nav.

Pirmā (vienkāršotā) pieeja Nernsta vienādojuma izvedumam.

(Pirmā veida elektrods)

$\Delta G = G_2 - G_1$





$Red \rightleftarrows Ox^{\Delta n+} + ne^-$

Darbs W viena mola jonu Me^{n+} pārvietošanai no punkta 1 metālā uz punktu 2 šķīdumā ir vienāds ar Hesa likuma brīvās enerģijas izmaiņas negatīvo lielumu $-\Delta G^\circ$ viena mola lādiņam $q = nF$ pārvarot elektrisko potenciālu E ir, $W = qE = nFE$; $W_{darbs} = nFE = -\Delta G^\circ = RT\ln K_{līdzsv}$.

Red–Ox līdzsvara konstante ir $K_{līdzsv} = \dfrac{[Ox]\bullet[e^-]^n}{[Red]}$ tātad

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

$$E^\circ = \frac{RT}{F}\bullet\ln([\mathbf{e}^-]) \;;\; \ln([\mathbf{e}^-]) = \frac{E^\circ F}{RT} \;;\; [\mathbf{e}^-] = e^{\frac{E^\circ F}{RT}} = \text{const un } E^\circ = \text{const.}$$

Nernsta vienādojums naturālā (skaitļa **e=2,7**) logaritma ln un decimālā (skaitļa 10) logaritma lg formā $\ln(a) = \ln(10) \bullet \lg(a) = 2{,}3 \bullet \lg(a)$ un temperatūra ir T=298,15 K gradu:

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

Otrā termodinamiskā pieeja Nernsta vienādojuma izvedumam.

Kad ir iestājies līdzsvars tad izejvielu un produktu ķīmisko potenciālu summa ir vienāda $\mu_{Red}+EnF=\mu_{Ox}+n\mu_{e^-}$

bet katras ķīmiskās vielas ķīmiskais potenciāls ir: $\mu = \Delta G^\circ + RT\ln(N_A)$,

kur N_A ir A vielas koncentrācija molu daļās. ΔG° ir dotās vielas A veidošanās no elementiem brīvā enerģija. Tīru vielu veidošanās no elementiem brīvās enerģijas izmaiņa Hesa likumā ir ΔG°_{Ox} , $\Delta G^\circ_{e^-}$ un ΔG°_{Red} .

Ķīmiskā līdzsvara maisījumā $\Delta G^\circ_{Red} + RT\ln(N_{Red}) + \mathbf{EnF} = \Delta G^\circ_{Ox} + RT\ln(N_{Ox}) + n\Delta G^\circ_{e^-} + RT\ln(N_{e^-})$
No šejienes var izteikt elektroda potenciāla lielumu E:

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

Elektroni savā atsevišķajā fāzē (tā saucamajā elektronu gāzē) metālā tieši arī ir tīra viela $N_{e^-}=1$ tā pēc tīras vielas

$\ln(N_{e^-}{}^n)=0$ elektronu gāzei un $E=\dfrac{\Delta G^\circ_{Ox}+n\bullet\Delta G^\circ_{e^-}-\Delta G^\circ_{Red}}{nF}+\dfrac{RT}{nF}\bullet\ln\left(\dfrac{N_{Ox}}{N_{Red}}\right)$.

Standarta potenciāls $E^\circ=\dfrac{\Delta G^\circ_{Ox}+n\bullet\Delta G^\circ_{e^-}-\Delta G^\circ_{Red}}{nF}$ veido Prigožina atraktoru brīvās enerģijas izmaiņas minimumu līdzsvarā $\Delta G_{eq}=E^\circ nF=\Delta G_{eq}=\Delta G^\circ_{Ox}+n\Delta G^\circ_{e^-}-\Delta G^\circ_{Red}$.

Pārejot uz decimāliem logaritmiem un termodinamisko standartu T=298,15 K iegūst Nernsta vienādojumu reakcijai : izejvielas **Red**ucētā forma<=>**Ox**$^{\Delta n^+}$**+ne**$^-$ Oksidēto forma produkti; $E=E^\circ+\dfrac{0{,}0591}{n}\bullet\lg\left(\dfrac{[Ox]}{[Red]}\right)$.

Reakcijā zaudē **ne**$^-$ elektronus tātad šķīduma virzienā tiek pārvietoti Δ**n**$^+$ pozitīvi lādēti papildus joni. Elektroni **ne**$^-$ paliek metālā elektronu gāzē. Δ**n**$^+$ lādiņa pārvietošanās sistēmā produktos oksidētajā formā **Ox**$^{\Delta n^+}$ienes ķīmiskā potenciāla elektrisko elektrona **ne**$^-$ daļu $\mathbf{n\mu_{elektr}=n\Delta G^\circ_{e^-}=-nFE}$, kur μ_{elektr} **= -FE**.

I veida elektrods ūdeņraža metāla **H**(**Pt**) robežvirsma / ar tā katjona H_3O^+ šķīdumu pielietojums

Atraktoram pH=7,36 līdzsvara stāvoklī ir patiesa pOH=6,64 vērtība, jo pK_w=14= pH+pOH =7,36 +6,64**.** Ūdens daudzuma atlaide [$\mathbf{H_2O}$]=963/18=53,5 M litrā sērskābes [H_2SO_4]=[H_3O^+]=1 M šķīduma ar 1,061 $^g/_{mL}$ blīvumu **ūdeņraža elektrodam** Nernsta izteiksmē ir klasiska standarta potenciāla $E_{o\_classic}$=0 V atskaites vērtība:

H(**Pt**)=**H⁺+e⁻**; $\mathbf{E}_{classic}=E_{o\_classic}+0{,}0591\bullet\log\mathbf{K}^\circ_{classic\mathbf{H}(Pt)}=0+0{,}0591\bullet\log[H^+]=0+0{,}0591\bullet\log(1\ M)=0$ Volti. [11]

Termodinamiska hidroksonija jonu uzskaite pieprasa ūdeni: **H**(**Pt**)+$\mathbf{H_2O}$=$\mathbf{H_3O^+}$+**e⁻** un E°_H=0,10166 V. Attiecība [H_3O^+]/[$\mathbf{H_2O}$]=1 M/52,5 M=X_{H3O+}/X_{H2O} ir mol daļa aizstājot molus litrā [**H⁺**]=1 M klasiskajā potenciāla izteiksmē. Ūdens uzskaite dod termodinamisko standartu E°_H=0,10166 V potenciālu skalā.

Nernsta izteiksme ar klasisko mērījumu nulle pieprasa termodinamisko standarta potenciālu E°_H=0,10166 V :

$$\mathbf{E}=E^\circ_H+\ln(10)\bullet R\bullet T/F/1\bullet\log(X_{H3O+}/X_{H2O})=E_o+E^\circ_H+0{,}0591*\log(1/52{,}5)=0{,}10166-0{,}10166=0\text{ V.}$$

Ja attiecība ir viens $\mathbf{1=K}_{H(Pt)}=X_{H3O+}/X_{H2O}$, tad potenciāls E°_H=0,10166 V ir termodinamiskais standarts:

$$\mathbf{E}=E^\circ_H+\frac{\ln(10)\bullet R\bullet T}{F\bullet 1}\bullet\log\frac{X_{H_3O^+}}{X_{H_2O}}=0{,}10166+0{,}0591*\log(1)=0{,}10166\text{ V.}$$

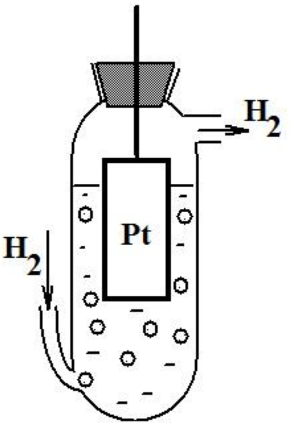
Metāla oksidēšanas brīvās enerģijas izmaiņa ir atšķirīga endoerģiska $\Delta\mathbf{G}_{eq}=E^\circ_H\bullet F\bullet 1\bullet 1=0{,}10166*96485*1=9{,}81$ $^{kJ}/_{mol}$ pretstatā eksoerģiskai. Albertija Hesa vērtība ir eksoerģiska: $\Delta\mathbf{G}_{Hess\_eq}=G_{H3O+}+G_{e-}-(G_{H(Pt)}+G_{H2O})=22{,}44+0-(\mathbf{48{,}56}+0)=\mathbf{-26{,}12}$ $^{kJ}/_{mol}$.

Brīvās enerģijas izmaiņa ir noteikta nulles atskaites skalā $G_{H2O}=G_{CO2gas}=G_{e-}=0$ $^{kJ}/_{mol}$. Iteratīvi izskaitļotais absolūtajā skalā ūdeņraža standarta potenciāls ir: $E^\circ_H=\Delta\mathbf{G}_{eqH(Pt)}/F/1=\mathbf{-26{,}12}/96485/1=-0.27073$ Volti. Līdzsvara brīvās enerģijas minimums ir eksoerģisks: $\Delta\mathbf{G}_{eqH(Pt)}=E^\circ_H\bullet F\bullet 1=-0.27073*96485*1=\mathbf{-26{,}12}$ $^{kJ}/_{mol}$ sakrītot ar Albertija datiem. Absolūtā potenciālu skala noslīd par ΔE=-0.27073-0,10166=-0,37239 Voltiem zemāk attiecībā pret klasisko nulles skalu. Nernsta līdzsvara konstante ir lielāka par vienu metāla oksidēšanai par hidroksonija jonu: $\mathbf{K}_{H(Pt)\_Red}=[H_3O^+]*[\mathbf{e^-}]/[\mathbf{H_2O}]/[H(Pt)]=\mathrm{EXP}(-\Delta\mathbf{G}_{Alberty}/R/T)=\mathrm{EXP}(\mathbf{26120}/8{,}3144/298{,}15)=37675{,}6$.

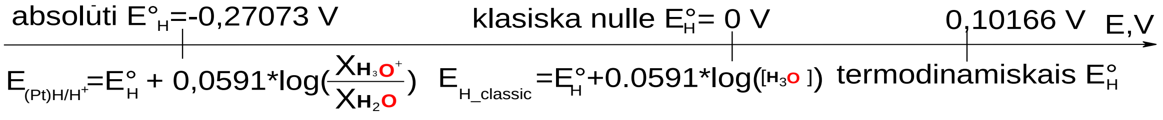
I veida elektrods metāls **H(Pt)** / iegremdēts tā katjonu H_3O^+ šķīdumā pielietojums.

Liela ātruma protolīzes atraktori [H_3O^+]=$10^{-7,36}$ M , pH=7,36 un ūdens masas [$\mathbf{H_2O}$]=997/18=55,3 M uzskaite litrā rāda metāla ūdeņraža stipru reducējošu potenciālu: $\mathbf{E}_{pH=7,36}=-0.27073+0{,}0591*\log(10^{-7,36}/55{,}3)=-0{,}8087$ V un brīvās enerģijas izmaiņas minimumu $\Delta\mathbf{G}_{eqpH\_7,36}=E^\circ_H\bullet F\bullet 1=-0{,}8087*96485*1/1000=-78{,}03$ $^{kJ}/_{mol}$.

Nernsta pus reakcijas metāla reducēšanas potenciāla E°_H=-0,27073 V enerģija ir $\Delta\mathbf{G}_{eq}=\mathbf{-26{,}12}$ $^{kJ}/_{mol}$.



Platīna plāksnīte iemērkta hidroksonija jonu [H^+]=[H_3O^+]=[H_2SO_4]=1 M sērskābes šķīdumā **H**(**Pt**)=**H⁺+e⁻**: $\mathbf{E=E^\circ}+0{,}0591\bullet\log[H^+]=\mathbf{0{,}0}+0{,}0591\bullet\log(1\ M)=\mathbf{0}$ V ir klasika. Attiecība [H_3O^+]/[$\mathbf{H_2O}$]=1/52,5=X_{H3O+}/X_{H2O} dod klasiskās nulles **0** vietā termodinamisko standarta potenciālu: E°_H=0,10166 V un no Alberty datiem absolūtajā skalā absolūto standarta potenciālu E°_H=-0,27073 Volti.



Absolūtais standarta potenciāls E°_H=-0,27073 V pamatojas uz Albertija ūdeņraža datiem $G_{H2gas}=\mathbf{85{,}64}$ $^{kJ}/_{mol}$ un $G_{H2aq}=\mathbf{103{,}24}$ $^{kJ}/_{mol}$, kuri ir noteikti ūdens un oglekļa dioksīda gāzes nulles skalā $G_{H2O}=G_{CO2gas}=G_{e-}=0$ $^{kJ}/_{mol}$. Pie pH=7,36 , [H_3O^+]=$10^{-7,36}$ M ir stiprs reducētājs metāls **H(Pt)** ar potenciālu $\mathbf{E}_{pH=7,36}=-0{,}27073+0{,}0591*\log(10^{-7,36}/55{,}3)=-0{,}8087$ V. Brīvās enerģijas saturs vienā molā metāla ūdeņraža ir: $G_{H(Pt)}=\mathbf{48{,}56}$ $^{kJ}/_{mol}$.

Viela	ΔH°_H, $^{kJ}/_{mol}$	ΔS°_H, $^{J}/_{mol/K}$	ΔG°_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]
$\mathbf{H_{2aq}}$	23,4	-130	99,13	CRC 2010 [1]
H(Pt)$_{(aq)}$	E°_H=	-0,27073	**48,56**	$\Delta\mathbf{G}_{Hess\_eq}=G_{H3O+}-(G_{H(Pt)}+G_{H2O})=22.44-(\mathbf{48.56}+0)=\mathbf{-26.12}$ $^{kJ}/_{mol}$.
$\mathbf{H_{2aq}}$	**-5,02**	**-363,92**	**103,24**	2006, Massachusetts Technology Inst. Alberty pH=7,36 [8]
$\mathbf{O_{2aqua}}$	**-11,70**	**-94,2**	**16,4**	

Gāzveida ūdeņraža šķīdība $\mathbf{H}_{2gas}+H_2O=\mathbf{H}_{2aq}$ kompensē ($\mathbf{H}_{2gas}+2H_2O=$)$\mathbf{H}_{2aq}+H_2O=2\mathbf{H}_3O^++2e^-$ vienu ūdens molekulu Nernsta ūdeņraža oksidēšanā par hidroksoniju un ir patvaļīga, jo **absolūtās** brīvās enerģijas izmaiņa ir negatīva. $\Delta\mathbf{G}_{Hess\_H3O+}=2G_{H3O+}+2G_{\underline{e}}-(G_{\mathbf{H}2aq}+G_{H2O})=2*22,44+2*0-(\mathbf{103,24}+0)=-58,36\ ^{kJ}/_{mol}$.

Ar grafītu oksidē $\mathbf{H}_{2aq}$ šķīdumu par hidroksoniju ar **absolūto** standarta potenciālu:

$E^\circ_{H2aq}=-58,36*1000/96485/2=-0,3024$ V.

Nernsta un inversās pus reakciju summa: $\mathbf{H}_{2aq}+H_2O=2\mathbf{H}_3O^++2e^-$; $2H_3O^++2e^-=2\underline{\mathbf{H}(Pt)}+2H_2O$

parāda ūdeņraža šķīdību platīna kristāla režģī $\mathbf{H}_{2aq}=2\underline{\mathbf{H}(Pt)}+H_2O$;

Ūdeņraža šķīduma oksidēšanas $\mathbf{H}_{2aq}+H_2O=2\mathbf{H}_3O^++2e^-$ potenciāls $E^\circ_{Haq}=-0,302$ V plus inversais potenciāls: $-E^\circ_{H(Pt)}=+0,27073$ V metāla elektroķīmiskā šķīdībā $2H_3O^++2e^-=2\underline{\mathbf{H}(Pt)}+2H_2O$ parāda ūdeņraža mola daļas $[\mathbf{H}_{2aq}]/[H_2O]$ šķīdību platīnā eksoerģisku, patvaļīgu:

$\Delta\mathbf{G}_{sp\mathbf{H}(Pt)}=\Delta E^\circ_{sp\mathbf{H}(Pt)}\bullet F\bullet 2=(E^\circ_{H2aq}-E^\circ_{H(Pt)})\bullet F\bullet 2=c(-0,302+0,27073)*96485*2=-0,03128*96485*2=\mathbf{-6,03}\ ^{kJ}/_{mol}$;

$\mathbf{K}_{sp\mathbf{H}(Pt)}=[\underline{\mathbf{H}(Pt)}]^2*[H_2O]/[\mathbf{H}_{2aq}]=EXP(-\Delta\mathbf{G}_{sp\mathbf{H}(Pt)}/R/T)=EXP(\mathbf{6036,1}/8,3144/298,15)=11,415$.

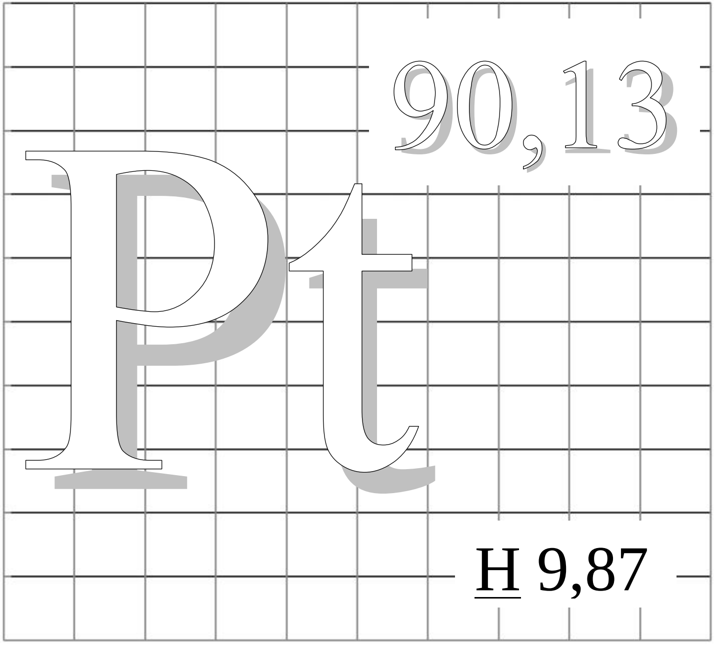
Šķīdība platīnā $\mathbf{H}_{2aq}=2\underline{\mathbf{H}(Pt)}+\mathbf{H_2O}$ parāda par ūdeņraža elektroķīmisko šķīdības produktu metālā nedaudz eksoerģiskāku, labvēlīgāku: $\Delta\mathbf{G}_{sp\_H(Pt)}=2G_{\mathbf{H}(Pt)}+G_{\mathbf{H2O}}-(G_{\mathbf{H}2aq})=2*\mathbf{48,56+0-(103,24)=-6,12}\ ^{kJ}/_{mol}$ un konstanti eksoerģiskāku, labvēlīgāku:

$\mathbf{K}_{sp\_\mathbf{H}(Pt)}=[\underline{\mathbf{H}(Pt)}]^2/[\mathbf{H}_{2aq}]*[\mathbf{H_2O}]=EXP(-\Delta\mathbf{G}_{sp\mathbf{H}(Pt)}/R/T)=EXP(\mathbf{6120}/8,3144/298,15)=11,808$.

Attiecība $K_{\mathbf{H}2sp}=[\mathbf{H}_{2aq}]/[\mathbf{H_2O}]/X_{\mathbf{H}2gas}=EXP(-\Delta\mathbf{G}_{\mathbf{H}2sp}/R/T)=EXP(\mathbf{-17600}/8,3144/298,15)=0,0008253$ dod šķīdību $[\mathbf{H}_{2aq}]=K_{\mathbf{H}2sp}*[\mathbf{H_2O}]*X_{\mathbf{H}2gas}=0,0008253*55,3*1=0,04564$ M, ja tīras gāzes mola daļa ir viens $X_{\mathbf{H}2gas}=1$.

Saskaņā ar Albertija matemātisko datu pielietojumu bioķīmijā, molu daļās bez mērvienībām konstante ir $K_{\mathbf{H}2sp}=[\mathbf{H}_{2aq}]/[\mathbf{H_2O}]/X_{\mathbf{H}2gas}=EXP(-\Delta\mathbf{G}_{\mathbf{H}2sp}/R/T)=EXP(\mathbf{-17600}/8,3144/298,15)=0,0008253$ endoerģiska, nelabvēlīga: $\Delta G_{\mathbf{H}2spAlberty}=G_{H2aq}-G_{\mathbf{H}2gas}-G_{H2O}=\mathbf{103,24-85,64-0=17,6}\ ^{kJ}/_{mol}$ gāzes šķīdībai $\mathbf{H}_{2gas}+\mathbf{H_2O}=\mathbf{H}_{2aq}$.

No attiecības $[\underline{\mathbf{H}(Pt)}]^2/[\mathbf{H}_{2aq}]=\mathbf{K}_{sp\_\mathbf{H}(Pt)}/[\mathbf{H_2O}]=11,808/55,3=0,21353$ iegūst H(Pt) laukuma mola daļas kvadrātu: $[\underline{\mathbf{H}(Pt)}]^2=K_{sp\mathbf{H}(Pt)}/[\mathbf{H_2O}]*[\mathbf{H}_{2aq}]=11,808/55,3*0,04564=0,009745$. Piesātināta šķīdība platīnā $[\underline{\mathbf{H}(Pt)}]=SQRT(0,009745)=0,0987$ molu daļās ir ūdeņraža atomu virsmas molu daļa 9,87% dalīta ar platīna atomu molu daļu 90,13% kopējā 100% kristāla režģa virsmā. Šķīdības $\mathbf{H}_{2aqAlbery}=2\underline{\mathbf{H}(Pt)}+\mathbf{H_2O}$ molu daļas koncentrācijas ir bez mērvienībām tā pat kā konstante bez mērvienībām $\mathbf{K}_{sp\_\mathbf{H}(Pt)}=11,808$.



Atomu rādiusi ir Pt 0,135 nm un H 0,053 nm. Rādiusa kvadrāta laukums ir Pt 0,0729 nm^2 , H 0,0112 nm^2. 0,0729+0,0112=0,0841 nm^2 kopējā 100% virsma tiek iedalīta platīna un ūdeņraža atomiem 0,0729/0,0841=86,7% un 0,0112/0,0841=9,53% atbilstoši. [25] $\underline{\mathbf{H}(Pt)}$ šķīdība ūdenī ir mazāka par vienu, endoerģiska: $2\underline{\mathbf{H}(Pt)}+\mathbf{H_2O}=\mathbf{H}_{2aqAlberty}$;

$\mathbf{K}_{sp\mathbf{H}(Pt)\_H2aq}=[\mathbf{H}_{2aq}]/[\underline{\mathbf{H}(Pt)}]^2/[\mathbf{H_2O}]=0,08469$;

un pozitīva $\Delta\mathbf{G}_{Alberty}=G_{\mathbf{H}2aq}-2G_{\mathbf{H}(Pt)}-G_{\mathbf{H2O}}=\mathbf{6,12}\ ^{kJ}/_{mol}$; nelabvēlīga, nepatvaļīga. Tas uztur metāla režģi piesātinātu ar ūdeņradi 9,87 %.

$\mathbf{K}_{sp\_\mathbf{H}(Pt)}=[\mathbf{H}_{2aq}]/[\underline{\mathbf{H}(Pt)}]^2/[\mathbf{H_2O}]=EXP(-\Delta\mathbf{G}_{sp\_\mathbf{H}(Pt)}/R/T)=EXP(\mathbf{-6120}/8,3144/298,15)=0,08469$ nelabvēlīga.

Ūdens oksidēšana par skābekli pus reakcijas $5H_2O=O_{2aq}+4H_3O^++4e^-$ Hesa brīvās enerģijas izmaiņa ir:

$\Delta G_{O2aqAlberty}=G_{O2aq}+4G_{\mathbf{H3O+}}-5G_{\mathbf{H2O}}=\mathbf{329,68\text{-}4*22,44\text{-}5*0=419,44}\ ^{kJ}/_{mol}$, jo aqua mol daļa $\mathbf{O}_{2gas\ AIR}+\mathbf{H_2O}=\mathbf{O}_{2aq}$ kompensē vienu ūdens molekulu no sešām $6H_2\mathbf{O}=\mathbf{O}_{2gas\ AIR}+\mathbf{H_2O}+4H_3O^++4e^-$ un Nernsta pus reakcijā paliek piecas: $5H_2\mathbf{O}=\mathbf{O}_{2aq}+4H_3O^++4e^-$ ar absolūto standarta potenciālu $E^\circ_{\mathbf{O}2aq}=1,0868$ V.

Tā ir identiska brīvās enerģijas izmaiņas minimumam elektroķīmiskos aprēķinos lietojot absolūto Nernsta standarta potenciālu: $\Delta\mathbf{G}_{\mathbf{eq}O2aq}=E^\circ_{O2aq}\bullet F\bullet n_{e-}=1,0868*96485*4=\mathbf{419,44}\ ^{kJ}/_{mol}$.

Metāla ūdeņraža H(Pt) pus reakcijas $\underline{\mathbf{H}}\mathbf{(Pt)+H_2O=H_3O^++e^-}$ Hesa brīvās enerģijas izmaiņa ir:

$\Delta\mathbf{G}_{H(Pt)\mathbf{eqAlberty}}=G_{H3O+}+G_{\underline{e}}-(G_{\mathbf{H2O}}+G_{\mathbf{H}(Pt)})=22,44+0-(\mathbf{48,56}+0)=\mathbf{-26,12}\ ^{kJ}/_{mol}$.

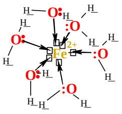
Tā sakrīt ar elektroķīmiskiem brīvās enerģijas izmaiņas minimuma aprēķiniem lietojot **absolūto** Nernsta standarta potenciālu $E^\circ_{H(Pt)}=-0,27073$ Volti :

$\Delta\mathbf{G}_{\mathbf{eqH(Pt)}}=E^\circ_{H(Pt)}\bullet F\bullet n_{e-}=-0,27073*96485*1=\mathbf{-26,12}\ ^{kJ}/_{mol}$ iekļaujoties Albertija datos. [8,15]

Metāls iegremdēts savu jonu šķīdumā Nernsta oksidēšanas pus reakcijā veido Elektroda potenciālu Voltos.
Metālu joni šķīdumā koordinējas. piesaistot ūdeni ar donoru akceptoru saitēm .

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

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

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

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

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

$E_{Fe}=E°_{Fe/Fe2+}+0,0591/2*\log([Fe^{2+}]/[Fe]/([H_2O]-6[Fe^{2+}]))=\mathbf{-0,65943}+0,0591/2*\log(0,1/1/(56,38-0,6))=-0,74059$ 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.

Viela	$\Delta H°_H$ $^{kJ}/_{mol}$	$\Delta S°_H$ $^J/_{mol/K}$	$\Delta G°_H$, $^{kJ}/_{mol}$
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**

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

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

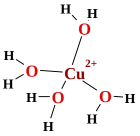
$\Delta G_{Cu2+}=\Delta H_H–T*\Delta S_H=64,8-298,15*-0,098=\mathbf{94,0187}$ $^{kJ}/_{mol}$;

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

$\Delta G_{Zn2+}=\Delta H_H–T*\Delta S_H=-153,39-298,15*-0,1098=\mathbf{-120,65}$ $^{kJ}/_{mol}$;

Reakcijā $Cu(Hg)+H_2O=Cu^{2+}+(Hg)+\mathbf{2e^-}$; $[Cu^{2+}]=1$ M blīvums 1,19 $^g/_{mL}$; 1 Mola masa $M_{CuSO4}=159,602$ $^g/_{mol}$;

$E°_{Cu/Cu2+}=E°_{Cu}+0,0591/2*\log(1/([H_2O]))=0,3435-0,0591/2*\log(1/55,3)+0,10166-0,37239=\mathbf{0,1243}$ 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;

$E_{Cu}=E°_{Cu}+0,0591/2*\log([Cu^{2+}]/[Cu]/([H_2O]-4[Cu^{2+}]))=\mathbf{0,1253}+0,0591/2*\log(1/1/(57,24-4))=0,0733$ V;

Atšķirības 0,0728 V ir skaitlī 2 0,0733 V

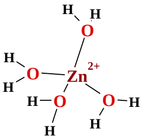
$m_{H2O}=(m_L-m_{cuSO4})/18=1190-159,602=1030,4/18=57,24-4=53,24$ mol;

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

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

$Zn+H_2O=Zn^{2+}+\mathbf{2e^-}$; $ZnSO_4=161,44$ $^g/_{mol}$ $[Zn^{2+}]=C_{ZnSO4}=2$ M blīvums 1,31 $^g/_{mL}$; $m_{ZnSO4}=2*161,44=322,88$ g;

$E°_{Zn/Zn2+}=E°_{Zn}+0,0591/2*\log(1/([H_2O]))=-0,7628-0,0591/2*\log(1/55,3)+0,10166-0,37239=\mathbf{-0,98098}$ 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

Atšķirības skaitlī -1,0215V ir ceturtajā zīmē -1,02358 V 2M;

Šķīdība 57,7 $^g/_{100g}$ simts gramos ūdens; 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.

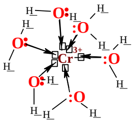
$$E_{Zn}=E°_{Zn/Zn2+}+0,0591/2*\log\frac{[Zn^{2+}]}{[Zn]\cdot([H_2O]-4\cdot[Zn^{2+}])}=\mathbf{-0,980981}+0,0591/2*\log(2/1/(54,84-4*2))=-1,02358\ V;$$

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

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

$Cr+H_2O=Cr^{3+}+\mathbf{3e^-}$; $Cr_2(SO_4)_2=159,602$ $^g/_{mol}$; $C_{Cr2(SO4)2}=0,5$ M$[Cr^{3+}]=2*C_{Cr2(SO4)2}=1$ M density 1,172 $^g/_{mL}$;

$E°_{Cr/Cr3+}=E°_{Cr}+0,0591/3*\log(1/[H_2O])=-0,744-0,0591/3*\log(1/55,3)+0,10166-0,37239=\mathbf{-0,9793}$ 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;

Atšķirības skaitlī -1,0136 V ir ceturtajā zīmē -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

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

Šķīdība 64 $^g/_{100g}$ simts gramos ūdens; w%=64/164*100=39%, $[H_2O]=714,93$ $^g/18$ $^g/_{mol}=39,718$ M;
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;

Tabula 1. Nernsta pus reakciju Standarta Electrodu Potenciāli klsikais, termodinamiskais, absolūtais V.

	Reducētā forma = Oksidētā forma + n e^-; [avoti klasiskie]	H_2O atlaide klasiskā nulle E_o	Termodinamiskā. skala 0,10166 V	Absolūtā skala -0,37239
H	$H(Pt)+H_2O=H_3O^+ +(Pt)+e^-$; CRC [1]	klasiskā nulle **0**	**0,10166**	-0,27073
	$H(Pt)+OH^-=H_2O+(Pt)+e^-$; CRC [1]	-0,8277	-0,8282	-1,1995
	$H(Pt)+OH^-=H_2O+(Pt)+e^-$; koriģēts CRC -0.8277+-0.10449	-0,9322	-0,93375	-1,30508
	$H_{2aq}+H_2O=2H_3O^+ +2e^-$; **grafīta** elektrods	-0,1343	0,07039	-0,302
O	$5H_2O=O_{2aq}+4H_3O^+ +4e^-$; Suchotina [17]	1,2288	1,4592	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	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	-0,3112
	$HNO_2+4H_2O=NO_3^- +3H_3O^+ +2e^-$; pH<3,15 [18]	0,94	1,2477	0,8763
	$NO_2^- +3H_2O=NO_3^- +2H_3O^+ +2e^-$; David A. Harris [21]	0.835	1.09115	0.71981
	$NO_{aq}+5H_2O=NO_3^- +4H_3O^+ +3e^-$; pH>3,15 [18]	0,96	1,2333	0,8609
	$NH_4^+ +13H_2O=NO_3^- +10H_3O^+ +8e^-$; Suchotina [17]	0,87	1,4180	1,0466
Br	$2Br^-=Br_2(aq)+2e^-$; CRC [1]	1,0873	1,18896	0,8176
Bi	$BiO^+ +6H_2O=BiO_3^- + 4H_3O^+ +2e^-$; Suchotina [17]	1,80	2,21065	1,83826
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	1,49326
	$Pb+H_2O = Pb^{2+} +2e^-$; 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
	$S^{2-}=S_{rombisks}+H_2O + 2\,e^-$; CRC [1]	-0,4763	-0,4261	-0,7985
	$HS^- + OH^- = S_{rombisks} + 2H_2O + 2e^-$; CRC [1]	-0,478	-0,4793	-0,8517
	$H_2S_{aq}+2H_2O=S_{rombisks}+2H_3O^+ +2e^-$; CRC [1]: [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	0,6327
	$Ag(s)+Cl^- =AgCl(s)+H_2O+e^-$; Kortly, Shucha [18]	0,2223	0,2210	-0,1514
	$Ag+2NH_{3aq}=Ag(NH_3)_2^+ +H_2O+e^-$; Suchotina [17]	0,373	0,57766	0,2053
	$2Ag+2OH^- =Ag_2O(s)+H_2O+2e^-$; Suchotina [17]	0,345	0,39516	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	$2Cr^{3+}+21H_2O=Cr_2O_7^{2-}+14H_3O^+ +6e^-$; Kortly, Shucha [18]	1,33	1,7921	1,41975
	$Cr^{3+}+11H_2O=HCrO_4^- +7H_3O^+ +3e^-$; Kortly, Shucha [18]	1,20	1,6793	1,30692
	$Cr(OH)_3+5OH^-=CrO_4^{2-}+4H_2O+3e^-$; pH>9 ; Suchotina [17]	-0,13	-0,1657	-0,53806
C	$H_2C_2O_4+2H_2O=2CO_2+2H_3O^+ +2e^-$; 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	-1,52601	-1,8984
	$Al+4OH^-= H_2AlO_3^- +H_2O+3e^-$; CRC [1]	-2,35	-2,28267	-2,63506

$H(Pt)+OH^-=H_2O+(Pt)+e^-$; $E°_{H\_OH}$=**-1,19952** V

Absolūtais potenciāls tiek koriģēts ar hidroksīda G_{OH^-}=**77,36** $^{kJ}/_{mol}$ brīvās enerģijas uzskaiti Hesa aprēķinā:

$\Delta G_{AlbertyH\_OH^-}=G_{H2O}-(G_{H(Pt)}+G_{OH^-})$=**0-(48,56025+77,36)=-125,92** $^{kJ}/_{mol}$ un aprēķina izteiksmē izlaboto absolūto potenciālu: $E°_H=\Delta G_{eq}/F/1$=**-125920**/96485/1=**-1,30508** V.

Ūdens daudzuma atlaide [H_2O]=963/18=53,5 M litrā sērskābes [H_2SO_4]=[H_3O^+]=1 M šķīdumam ar 1,061 $^{g}/_{mL}$ blīvumu **ūdeņraža elektrodam** ir klasiska $E_{o\_classic}$=-0,8277 V un absolūtā standarta potenciāls ir:

$E°_{H\_OH}=E°-0,0591/1*\lg([H_2O]^1)+0,10166-0,37239=-0,8277-0,0591/1*\lg(53,5^1)+0,10166-0,37239=$**-1,1995** V;

dati koriģē $\Delta G_{eqH\_OH^-}=E°_{H\_OH^-}•F•1$=**-1,30508***96485*1=**-125,92** $^{kJ}/_{mol}$ uz $E°_H$=-0,8277-0,10449=-0,9322 V.

$E°_{H\_OH}=E°-0,0591/1*\lg([H_2O]^1)+0,10166-0,37239=-0,9322-0,0591/1*\lg(53,5^1)+0,10166-0,37239=$**-1,30508** V;

Piezīme: Oksidatīvā stresā norisinās **ne enzimātiskas** oksidēšanās reakcijas daudzveidīgos ķēdes reakciju un paralēlos produktos, sagraujot organismu! Iznīcinoši bīstami dzīvībai!

Skābeklis šķīstot ūdenī $\mathbf{O_2}_{gas}+H_2O=\mathbf{O_2}_{aq}$ kompensē vienu ūdens molekulu $6H_2O=\mathbf{O_2}_{gas}+H_2O+4H_3O^++4e^-$ Nernsta pus reakcijā $5H_2O=O_{2aq}+4H_3O^++4e^-$, veidojot absolūto standarta potenciālu $E^\circ_{5HOH}=\mathbf{1,0868}$ V.

$E^\circ_{5HOH}=E^\circ-0,0591/4*\lg(1/[H_2O]^5)+0,10166-0,37238=1,2288-0,0591/4*\lg(1/53,5^{\wedge 5})+0,10166-0,37239=\mathbf{1,0868}$ V;

Viela	$\Delta H^\circ_H,{}^{kJ}/_{mol}$	$\Delta S^\circ_H,{}^{J}/_{mol/K}$	$\Delta G^\circ_H,{}^{kJ}/_{mol}$
$\mathbf{H_2O}$	-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
$\mathbf{H}(Pt)_{(aq)}$	$E^\circ_H-E^\circ_{\mathbf{O2}}=$	-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

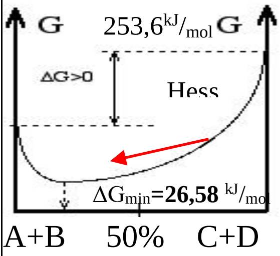
$\Delta G_{Hess}=2\Delta G^\circ_{\mathbf{H2O}}-4\Delta G^\circ_{(Pt)H}-\Delta G^\circ_{O2aqua}=-689=2*--344,521\ {}^{kJ}/_{mol}$;
$=2*-237,191-(4*99,13/2+\mathbf{16,4})=-689=2*344,5\ {}^{kJ}/_{mol}$. CRC 2010
2006, Massachusetts Technology Inst. Alberty [8]
Mischenko 1972, Himia, Leningrad [26]
CRC 2010 [1}
$G_{\mathbf{H(Pt)}}=(2G_{\mathbf{H2O}}-\Delta\mathbf{G}_{\mathbf{eq2}H2O}-G_{\mathbf{O2}aqua})/4=\mathbf{48,56}\ {}^{kJ}/_{mol}$;
Alberty 2006 Biochem.Thermodyn. Massachusetts Technology Inst.
Ūdens koncentrācijas $[H_2O]^5$ logaritms ekstraģē no $E^\circ_{classic}=1,2288$ V
Nernsta izteiksmes absolūto standarta potenciālu $E^\circ_{5HOH}=\mathbf{1,0868}$ V

Skābeklis $O_{2aq}+4H_3O^++4e^-=5H_2O$ ir stiprs oksidētājs ar inverso standarta potenciālu $-E^\circ_{5HOH}=\mathbf{-1,0868\ V}$:
Skābekļa oksidētā forma ar hidroksonija joniem piesaista četrus brīvos elektronus, veidojot četras ūdens molekulas reducētā formā kā produktus. Brīvās enerģijas saturs palielinās, izšķīdinot ūdenī:

$$G_{O2aq}=G_{O2gas}+G_{\mathbf{O2}šķ}=\mathbf{303,1+26,58=330}\ {}^{kJ}/_{mol}\ .$$

Skābekļa šķīdības brīvās enerģijas izmaiņa Hesa likumā **ir** eksotermiska, endoerģiska: $\mathbf{O_2}_{gaiss}+H_2O=\mathbf{O_2}_{aq}$; kurā skābekļa mol daļa gaisā $1=[\mathbf{O_2}_{gas}]>[\mathbf{O_2}_{gaiss}]=0,2095$ un ūdenī ir bez mērvienību koncentrācijas $[\mathbf{O_2}_{aq}]/[H_2O]=1,22*10^{\wedge(-3)}$ M/55,3 M$=2,206*10^{-5}$ un konstantes vērtība $\mathbf{K}_{\mathbf{šķ}}=[\mathbf{O_2}_{aq}]/[\mathbf{O_2}_{gaiss}]/[H_2O]=1,22*10^{\wedge(-3)}/1/55,3=2,206*10^{-5}$. Pozitīva enerģijas izmaiņa $\Delta G_{Hess}=\Delta G^\circ_{\mathbf{O2}aq}-\Delta G^\circ_{\mathbf{H2O}}-\Delta G^\circ_{\mathbf{O2}gas}=16,4-(0-237,191)=253,6\ {}^{kJ}/_{mol}$ ir arī abās izteiksmēs $\Delta G_{Alberty\mathbf{O2}aq}=G_{\mathbf{O2}aq}-(G_{\mathbf{H2O}}+G_{\mathbf{O2}gas})=\mathbf{330-(0+303,1)=26,58}\ {}^{kJ}/_{mol}$ absolūtajā enerģijas skalā $\Delta\mathbf{G}_{\mathbf{šķ}}\mathbf{=-R\bullet T\bullet ln(K_{šķ})}=-8,3144*298,15*\ln(2,205*10^{-5})=\mathbf{26,58}\ {}^{kJ}/_{mol}$. $[\mathbf{O_2}]$ šķīdības Hesa brīvās enerģijas izmaiņa ir pozitīva $\Delta\mathbf{G}_{\mathbf{Hess}}=253,6\ {}^{kJ}/_{mol}$, bet minimizējas līdzsvara maisījumā $\mathbf{K}_{\mathbf{šķ}}=[\mathbf{O_2}_{aq}]/[\mathbf{O_2}_{gas}]/[H_2O]=2.206*10^{-5}=10^{-4.656}$. Līdzsvara stāvoklis ir atraktors visiem nelīdzsvara stāvokļiem. Minimuma sasniegšanā iestājas līdzsvars. 53. lpp
Osmolārā $C_{osm}=0$ M, jonu spēka $\mathbf{I}=0$ M ūdenī no gaisa 20,95% skābekļa šķīdība ir:

$$[\mathbf{O_2}_{aq}]=\mathbf{K}_{šķ}*[\mathbf{O_2}_{gas}]*[H_2O]=2,205*10^{\wedge(-5)}*0,2095*55,3=0,00025546\ M.$$



izejvielas
$O_2\uparrow_{gas}+\mathbf{H_2O}_{Asinis}$
produkti $=\mathbf{O_2}_{aqua-Asinis}$.

Tīra 1atm mol daļa ir $[\mathbf{O_2}_{gas}]=1$. Osmolaritāte $C_{osm}=0,305$ M, jonu spēks $\mathbf{I}=0,25$ M, gaisa skābekli no 0 20,95% izšķīdina $\mathbf{[O_2}_{aq}\mathbf{]}=9,768\cdot10^{-5}$ M.

Arteriālo $[\mathbf{O_2}_{aq}]=6*10^{-5}$ M un venozo $[\mathbf{O_2}_{aq}]=0,426\cdot10^{-5}$ M izooksiju uztur skābekļa molekulu osmoze, kuras cauri akvaporīnu kanāliem šķērso membrānas pretēji osmolārās koncentrācijas $C_{osm}=0.305$ M gradientam.

Inversa: $O_{2aq}+4H_3O^++4e^-=5H_2O$; $-E^\circ_{\mathbf{O2}}=\mathbf{-1,0868}$ Volts; Nernsta: $\underline{4(Pt)H}+4H_2O=4H_3O^++4e^-$; $E^\circ_H=\mathbf{-0,27073}$ V

$O_{2aqua}+\underline{4(Pt)H}=2H_2O$ elektrodu standarta potenciālu summa dod standarta brīvās enerģijas izmaiņu:

$$\Delta\mathbf{G}_{\mathbf{eq2}H2O}=(E^\circ_H-E^\circ_{\mathbf{O2}})\bullet F\bullet1\bullet4=(\mathbf{-0,27073-1,0868})*96485*4=2*\mathbf{261,96=-523,925}\ {}^{kJ}/_{mol};$$

Zinot līdzsvara vērtību $\mathbf{\Delta}G_{eq\mathbf{2}H2O}=2G_{\mathbf{H2O}}-4G_{(Pt)H}-G_{O2aqua}=2*0-(4*G_{(Pt)H}+329,68)=\mathbf{-523,925}\ {}^{kJ}/_{mol}$, ūdeņraža metāla brīvā enerģija ir $G_{\mathbf{H(Pt)}}=(2G_{\mathbf{H2O}}-\Delta\mathbf{G}_{\mathbf{eq2}H2O}-G_{\mathbf{O2}aqua})/4=(2*0+\mathbf{523,925}-329,68)/4=\mathbf{194,245}/4=\mathbf{48,56}\ {}^{kJ}/_{mol}$.

Brīvā enerģija ir $G_{\mathbf{H3O+OH}}=G_{H3O+}+G_{OH-}=22,44+77,36=99,8\ {}^{kJ}/_{mol}$ protolīzes reakcijā $H_2O+H_2O<=>H_3O^++OH$.
Bioķīmija skābekļa $\mathbf{O_2}_{aqua}$ brīvo enerģijas saturu $G_{O2aqua}=\mathbf{329,68}\ {}^{kJ}/_{mol}$ samazina līdz $G_{O2Bio}=88,22\ {}^{kJ}/_{mol}$.

Arteriālo asiņu koncentrācijas $[O_{2aqua}]=6*10^{-5}$ M un koncentrācijas $[H_3O^+]=10^{-7,36}$ M potenciāls ir samazināts:

$$E_{\mathbf{O2}}=E^\circ+{}^{0,0591}/_4\bullet\lg([O_{2aqua}]\bullet[H_3O^+]^4/_{[H2O]}{}^5)=\mathbf{1,0868}+{}^{0,0591}/_4*\log(6*10^{\wedge(-5)}*10^{\wedge(-7,36*4)}/_{55,346^{\wedge5}})=\mathbf{0,46174}\ V$$

par $\Delta E_{arterial}=-(E_{o\mathbf{O2}}-E_{\mathbf{O2}})=\mathbf{=-1,0868+0,46174}=-0,62506$ Voltiem un

brīvās enerģijas saturs par $\Delta G_{arterial}=\Delta E_{H2O}*F*n=-0,62506*96485*4/1000=-241,24\ {}^{kJ}/_{mol}$.

Skābekļa brīvās enerģijas saturs $\mathbf{O_2}_{gas\ AIR}+\mathbf{H_2O}=\mathbf{O_2}_{Blood}$ ar šķīdības ieguldījumu palielinās par:

$$K_{šķ}=\frac{[O_{2\ aqua}]}{[O_{2\ gas}]\cdot[H_2O]}=2,205*10^{-5};\ G_{\mathbf{O2}šķ}\mathbf{=-R\bullet T\bullet ln(K_{šķ})}=-8,3144*298,15*\ln(2,205*10^{-5})=26,58\ {}^{kJ}/_{mol}.$$

Protolīze samazina brīvo enerģiju līdz $G_{O2arteriāla}=G_{O2aqua}+G_{\mathbf{O2}šķ}+\Delta G_{arteriāla}=\mathbf{303,1}+26,58-241,456=\mathbf{88,22}\ {}^{kJ}/_{mol}$ un skābeklis kļūst uguns drošs bioķīmisks oksidants, veidojot arteriālo koncentrāciju $[\mathbf{O_2}_{aqua}]=6*10^{-5}$ M kā bioenerģētiski drošu uzturētu izooksijas normu. [3];

1) Ūdens 55,346 M samazina potenciālu no **1,0868 V** par **-0,1288** V=**0,9580-1,0868**=$\Delta\mathbf{E}_{H2O}$.

$$E_{o\mathbf{O2}}=E^\circ_{\mathbf{O2}}+{}^{0,0591}/_4*\log({}^1/_{[H2O]}{}^5)=\mathbf{1,0868}+0,01478*\log({}^1/_{55,346}{}^{\wedge5})=\mathbf{0,95805}\ V\ ;$$

2) Paskābināšana H_3O^+ 10 reizes potenciālu un brīvās enerģijas saturu palielina par $\Delta E_{H3O+}=\mathbf{0{,}05912}$ V;

$\Delta E_{H3O}=0{,}01478\cdot\lg([H^+]^4)=\mathbf{0{,}05912}$ V un $\Delta\mathbf{G_{max}}=\Delta E_{H3O}*\mathbf{F*n}=0{,}05912*96485*4/1000=\mathbf{22{,}817}\ {}^{kJ}/_{mol}$;

3) Gaisa 20,95% aizvietojot ar 100% skābekļa $[O_{2aqua}]$ koncentrāciju 5 reizes lielāka palielina potenciālu par $\Delta E_{O2100\%}=0{,}01478\cdot\lg(100\%\ [O_{2aqua}])=0{,}01478*\log(5)=+\underline{\mathbf{0{,}0103}}$ V. Brīvās enerģijas saturs palielinās par $\Delta\mathbf{G_{max}}=\Delta E_{H3O}*\mathbf{F*n=0{,}01033}*96485*4/1000=\mathbf{3{,}987}\ {}^{kJ}/_{mol}$. 6. lapas puse:

Lielā oksidatīvā stresa un tehnoloģisko briesmu dēļ 1972. gadā slēdza NASA Apollo projektu.

Nernsta glikozes oksidēšanas pus reakcijā absolūtais standarta potenciāls ir negatīvs, jo spēcīgais 24 elektronu donors reducē sešas skābekļa molekulas Nernsta reakcijā $O_{2aqua}+4H_3O^++4e^-=5H_2O$ ar inverso absolūto standarta potenciālu -E°=**-1,0868** V. No klasiskā glikozes standarta potenciāla E°=-0,04915 V, ekstrahējot logaritma $\log(1/55{,}3^{\wedge42})$ 42 ūdens molekulas, glikozes absolūtais Nernsta standarta potenciāls ir

$$E°_{C6H12O6}=-0{,}04915-0{,}0591/24*\log(1/55{,}3^{\wedge42})+0{,}10166-0{,}37239=\mathbf{-0{,}13964}\ V.$$

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

Glikozes un skābekļa inversā absolūto standarta potenciālu summa **ΔE°**

$\mathbf{\Delta E°=(E°_{C6H12O6}-E°_{O2})}=\Delta\mathbf{G_{Lehninger}/F/n=-2840000}/96485/24=-1{,}2264$ V dod standarta brīvās enerģijas izmaiņu $\Delta\mathbf{G_{Lehninger}=\Delta E°\cdot F\cdot n=(E°_{C6H12O6}-E°_{O2})\cdot F\cdot n=(-0{,}13964-1{,}0868)*}\ 96485*24=\mathbf{-2840}\ {}^{kJ}/_{mol}$ reakcijā pēc publicētajiem datiem $\mathbf{C_6H_{12}O_6}+12\mathbf{H_2O}+6O_{2aqua}=6H_3O^++6HCO_3^-$. [1,6]

Glikozes un skābekļa absolūto standarta potenciālu summa $\mathbf{(E°_{C6H12O6}-E°_{O2})=(E°_{C6H12O6}-1{,}0868)}=-1{,}22644$ V ļauj noteikt absolūto standarta potenciālu glikozei $\mathbf{E°_{C6H12O6}=\Delta E+E°_{O2}}=-1{,}22644+\mathbf{1{,}0868=-0{,}13964}$ V, ko aprēķina no skābekļa inversā absolūtais standarta potenciāla vērtības $O_{2aqua}+4H_3O^++4e^-=5H_2O$; $-E°_{\mathbf{O2}}=\mathbf{-1{,}0868}$ V.

Arteriālā skābekļa $[O_{2arteriālā}]=6*10^{\wedge(-5)}$; hidroksonija $[H_3O^+]^{\wedge30}=10^{\wedge(-7,36*30)}$ M un $[\mathbf{C_6H_{12}O_6}]$=0,005 M glikozes koncentrācijas dod negatīvu arteriālo potenciālu:

$$E_{arterial}=E°_{\mathbf{C6H12O6}}+{}^{0,0591}/_{24}\cdot\lg([HCO_3^-]^6*[H_3O^+]^{30}/_{[H2O]}{}^{42}/[\mathbf{C_6H_{12}O_6}])=$$
$$\mathbf{=-0{,}13964}+{}^{0,0591}/_{24}*\lg(0{,}0154*10^{\wedge(-7,36*30)}/_{0,005/55,346^{\wedge42}})=\mathbf{-0{,}8624}\ V$$

un inversā skābekļa pus reakcijas arteriālais absolūtais potenciāls ir $E_{\mathbf{O2}arterial}=\mathbf{-0{,}46068}$ V

$$E_{\mathbf{O2}arterial}=E°_{\mathbf{O2}}+{}^{0,0591}/_{4}\cdot\lg([H_2O]^5/_{[O2aqua]/[H3O+]}{}^4)=\mathbf{-1{,}0868}+{}^{0,0591}/_{4}*\log(_{55,346^{\wedge5}/6/10^{\wedge(-5)}/10^{\wedge(-7,36*4)}})=\mathbf{-0{,}46068}\ V.$$

Homeostāzes summa ir vairāk negatīva $\Delta E_{arterial}=E_{\mathbf{C6H12O6}arterial}+E_{\mathbf{O2}arterial}=\mathbf{-0{,}8624-0{,}46068=-1{,}32308}$ Volti.

Brīvās enerģijas izmaiņa $\Delta\mathbf{G}_{arterial}$ ir vairāk negatīva kā standarta lielums $\Delta\mathbf{G}_{Lehninger}$:

$$\Delta\mathbf{G}_{arterial}\mathbf{=\Delta E\cdot F\cdot n=(E_{C6H12O6arterial}-E_{O2arterial})\cdot F\cdot n=(-0{,}86237-0{,}4607)*}96485*24=\mathbf{-3063{,}846}\ {}^{kJ}/_{mol}\ .$$

Vienu molu glikozes oksidē seši moli skābekļa producējot sešus molus bikarbonāta $6H_3O^++6HCO_3^-$:

$$\mathbf{C_6H_{12}O_6}+42\mathbf{H_2O}=24H_3O^++6H_3O^++6HCO_3^-+24\ e^-\ ;\ 6O_{2aqua}+24H_3O^++24e^-=30H_2O;$$
$$\mathbf{C_6H_{12}O_6}+42\mathbf{H_2O}+6O_{2aqua}+24H_3O^++24e^-=24H_3O^++6H_3O^++6HCO_3^-+24\ e^-+30H_2O;$$
$$\mathbf{C_6H_{12}O_6}+12\mathbf{H_2O}+6O_{2aqua}\qquad=\qquad6H_3O^++6HCO_3^-\qquad;$$
$$G_{\mathbf{H3O+}}+_{\mathbf{HCO3-}}=G_{\mathbf{H3O+}}+G_{\mathbf{HCO3-}}=\mathbf{22{,}44+56{,}08=78{,}52}\ {}^{kJ}/_{mol},$$

Glc (6. lpp.) veidošanās no elementiem $6\mathbf{C}+6\mathbf{H_{2gas}}+3\mathbf{O_{2}}{}_{gas}=\mathbf{C_6H_{12}O_6}$ brīvās enerģijas izmaiņu aprēķina no Albertija datiem pie pH=7,36 $\Delta\mathbf{G}°_{Alberty}=\mathbf{G_{C6H12O6}-(6G_{Cgraph}+6*}G_{\mathbf{H2}gas}\mathbf{+3*}G_{O2gas})=\mathbf{-402{,}05}\ {}^{kJ}/_{mol}$.

Viela	$\Delta H°_H,{}^{kJ}/_{mol}$	$\Delta S°_H,{}^{J}/_{mol/K}$	$\Delta G°_H,{}^{kJ}/_{mol}$
$\mathbf{C_6H_{12}O_{6aq}}$	-1263,78	269,45	-919,96
Glc	**-1267,13**	**-2901,492**	**-402,05**

2006, Massachusett's Technology Inst. Alberty [8] pH=7,36.

CRC 2010 [1]

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

Brīvo enerģiju glikozes oksidēšanā $\mathbf{C_6H_{12}O_6}+6\mathbf{O_2}{}_{aqua}+12\mathbf{H_2O}=6\mathbf{H_3O^+}+\mathbf{6HCO_3}$ aprēķina trīs veidos:

1) Albertija datos pie pH=7,36 $\Delta\mathbf{G}°_{Alberty}=\mathbf{G_{C6H12O6}-(6G_{Cgraph}+6*}G_{\mathbf{H2}gas}\mathbf{+3*}G_{O2gas})=\mathbf{-402{,}05}\ {}^{kJ}/_{mol}$, standarta brīvās enerģijas saturs molā ir

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

2) Lēningera $\Delta\mathbf{G_{C6H12O6}}=6*G_{\mathbf{H3O+}}+6*G_{\mathbf{HCO3-}}-(\mathbf{G}_{Standard\mathbf{C6H12O6}}+\mathbf{6*}G_{O2aqua}+\mathbf{12*}G_{\mathbf{H2O}})=\underline{-2840}\ {}^{kJ}/_{mol}$ standarta saturs glikozes molā $\mathbf{G}_{Standard\mathbf{C6H12O6}}=6*(\mathbf{22{,}44}+\mathbf{56{,}08})-(-\underline{2840}+6*\mathbf{330}+12*\mathbf{0})=\mathbf{1331}\ {}^{kJ}/_{mol}$ un

3) brīvās enerģijas saturs

$\Delta\mathbf{G}_{arterial\_\mathbf{C6H12O6}}=6*G_{\mathbf{H3O+}}+6*G_{\mathbf{HCO3-}}-(G_{arterial\_C6H12O6}+\mathbf{6*}G_{O2aqua}+\mathbf{12*}G_{\mathbf{H2O}})=\underline{\mathbf{-3064}}\ {}^{kJ}/_{mol}$ uz glikozes molu homeostāzē $G_{arterial\_C6H12O6}=6*(\mathbf{22{,}44}+\mathbf{56{,}08})-(\underline{\mathbf{-3064}}+6*\mathbf{88{,}22}+12*\mathbf{85{,}64})=\mathbf{1978}\ {}^{kJ}/_{mol}$. [8,6]

Ģenerētie $\mathbf{6HCO_3^-+6H_3O^+}$ joni virza izejvielas $6\mathbf{O_2}{}_{aqua}$ un $6\mathbf{H_2O}$ cauri membrānu akvaporīnu kanāliem osmozē pretēji koncentrācijas gradientiem, bet transportē jonus $\mathbf{6HCO_3^-+6H_3O^+}$ lejup pa gradientiem cauri membrānu bikarbonāta un protonu kanāliem lietojot producēto brīvo enerģiju $\Delta\mathbf{G}_{arteriālo}=\underline{\mathbf{-3064}}\ {}^{kJ}/_{mol}$.

Absolūtās potenciālu un brīvās enerģijas vērtībās iekļauj hidroksonija H_3O^+ un ūdens $\mathbf{H_2O}$ uzskaiti.

Skābekļa inversā pus reakcija ar brīvo enerģiju G_{O2aqua}=**330** $^{kJ}/_{mol}$ reducē $O_{2aqua}+4H_3O^++4e^-=5H_2O$ ar standarta potenciālu $-E_{oO2}$=**-1,0868** V oksidējot četrus metāla ūdeņraža atomus ar brīvo enerģiju $\mathbf{G_{H(Pt)}}$=**48,56** $^{kJ}/_{mol}$ Nernsta pus reakcijā: $\underline{4(Pt)H}+4H_2O=4H_3O^++4e^-$ un ar standarta potenciālu E°_H=**-0,27073** V. Standarta brīvās enerģijas izmaiņa reakcijā $O_{2aqua}+\underline{4(Pt)H}=2H_2O$ ir

$$\Delta G_{Hes2H2O}=2G_{\mathbf{H2O}}-4G_{\mathbf{H}(Pt)}-G_{O2aqua}=2*0-(4*\mathbf{48,56}+\mathbf{330})=\mathbf{-524,24}=2*\mathbf{-262}\ ^{kJ}/_{mol}..$$

Standarta potenciālu summa

$\Delta \mathbf{G_{eq2H2O}}=(E^\circ_H-E^\circ_{\mathbf{O2}})\bullet F\bullet 4=(\mathbf{-0,27073-1,0868})*96485*4=-1,3575*96485*4=\mathbf{-523,925}=2*\mathbf{-262}\ ^{kJ}/_{mol}$ ļauj neatkarīgi no Hesa likuma aprēķinātās veidošanās no brīviem elementiem skābekļa O_{2aqua} un metāla ūdeņraža (Pt)H brīvās absolūtās enerģijas izmaiņas $\Delta G_{eq(Pt)H\_2H2O}$=**-262** $^{kJ}/_{mol}$, kura ir sakrītoša ar absolūto brīvo enerģiju $G_{\mathbf{H}(Pt)}=(2G_{\mathbf{H2O}}-\Delta \mathbf{G_{eq2H2O}}-G_{\mathbf{O2}aqua})/4=(2*0+\mathbf{523,9-329,68})/4=\mathbf{48,56}\ ^{kJ}/_{mol}$ un absolūto potenciāla skalu.

Ūdeņraža standarta brīvā enerģija ūdens šķīdumā $G_{\mathbf{H2}aqua}$=**103,24** $^{kJ}/_{mol}$ ir Albertija datos pH=7,36. [8]

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

$\Delta G_{HessCRCaqua}=2\Delta G^\circ_{\mathbf{H2O}}-2\Delta G^\circ_{H2aqua}-\Delta G^\circ_{O2aqua}=2*-237,191-(2*99,13/2+\mathbf{16,4})=-589,91=2*-295\ ^{kJ}/_{mol}$. CRC [1]

Viela	ΔH°_H, $^{kJ}/_{mol}$	ΔS°_H, $^{J}/_{mol/K}$	ΔG°_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
$\mathbf{H_{2aq}}$	23,4	-130	99,13
$\mathbf{H_{2aq}}$	**-5,02**	**-363,92**	**103,24**
E°(Pt)H	**-0.27073**	**-1.0868**	**48,56**
$\mathbf{O_{2aqua}}$	**-11,70**	**-94,2**	**16,4**
$\mathbf{O_{2aqua}}$	-11,715	110,876	16,4

CRC

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

Reakcijā $\underline{4(Pt)H}+O_{2aqua}=2\ H_2O$; absolūtā brīvā enerģijas izmaiņa ir $|\Delta G_{eq}=\mathbf{-262}\ ^{kJ}/_{mol}| < |\Delta G_{Hess}=-295\ ^{kJ}/_{mol}|$;

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$G_{\mathbf{H}(Pt)}=(2G_{\mathbf{H2O}}-\Delta \mathbf{G_{eq2H2O}}-G_{\mathbf{O2}aqua})/4=\mathbf{48,56}\ ^{kJ}/_{mol}$

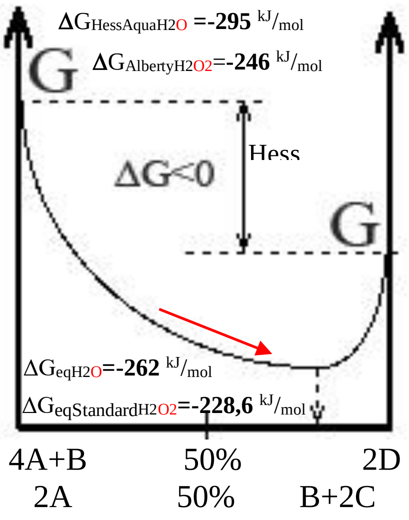
$\mathbf{K_{eqH2O}}=\mathbf{K_{OxRed}}=\mathbf{exp(-\Delta G_{OxRed}/R/T)}=exp(\mathbf{261960,6}/8,3144/298,15)=exp(105,675)=7,832*10^{45}$;

Eksotermiska un eksoerģiska O_{2aqua} reducēšana ar metālu ūdeņradi $\underline{4(Pt)H}$ un H_2O_2 dismutēšanas Hesa brīvās enerģijas izmaiņa negatīva $\Delta \mathbf{G_{HessAqua\_H2O}}$=-295 $^{kJ}/_{mol}$, $\Delta G_{AlbertyH2O2}$=-246 $^{kJ}/_{mol}$, bet minimizējas sasniedzot līdzsvaru $\Delta \mathbf{G_{eq2H2O}}$=**-262** $^{kJ}/_{mol}$ un $\Delta \mathbf{G_{eqStandart\_H2O2}}$=**-228,6** $^{kJ}/_{mol}$ konstantes $\mathbf{K_{eqH2O}}=7,832*10^{45}$ un $\mathbf{K_{eqStandard\_H2O2}}=1,11*10^{40}$ Līdzsvara stāvoklis minimums ir Prigožina atraktors visiem nelīdzsvara stāvokļiem.

Brīvās enerģijas izmaiņas minimuma sasniegšanā iestājas līdzsvara stāvoklis.

Red $H_2O_2+2H_2O=O_{2aqua}+2H_3O^++2e^-$; $\mathbf{E^\circ_{H2O2}}$=**0,5268** V Alberta University Edmontona Canada. [19] Peroksīda H_2O_2 vidē pH=7,36 absolūtais inversais standarta $H_2O_2+2H_3O^++2e=4H_2O$ potenciāls ir $\mathbf{-E^\circ_{Ox}}$=**-1,7113** V [17];

Summārā dismutācija $\mathbf{2H_2O_{2aq}=>O_{2aqua}+2H_2O+Q+\Delta G}$;



Reaktanti $\underline{4(Pt)H}+O_{2aqua}$ un produkti $2H_2O$

Reaktanti $\mathbf{2H_2O_{2aq}}$ un produkti $O_{2aqua}+2H_2O$

Summa $\Delta G_{eqStandard\_H2O2}=(E_{Red}-E_{oOx})*\mathbf{F*n}=(\mathbf{0,5268-1,7113})*96485*2=(-1,1845)*96485*2=\mathbf{-228,57}\ ^{kJ}/_{mol}$;

$$\mathbf{K_{eqStandart\_H2O2}}=\frac{[O_2]_{aqua}\cdot[H_2O]^2}{[H_2O_2]^2_{aqua}}=\mathbf{K_{H2O2}}=\mathbf{exp(-\Delta G_{eq}/R/T)}=exp(228573/8,3144/298,15)=1,11*10^{40}........$$

$E^\circ_{H2O2}=E^\circ-0,0591/2*lg(1/[H_2O]^2)+0,10166-0,372=0,6945-0,02955*lg(1/55,3\wedge^2)+0,10166-0,37239=\mathbf{0,5268}$ V;

$E^\circ_{H2O2Ox}=E^\circ-0,0591/2*lg(1/[H_2O]^4)+0,10166-0,372=1,776-0,02955*lg(1/55,3\wedge^4)+0,10166-0,37239=\mathbf{1,7113}$ V;

$E_{oH2O2}=E^\circ_{H2O2}+0,0591/2\bullet lg([O_{2aqua}]*[H_3O^+]^2/[H_2O_2]/[H_2O]^2)=0,5278+0,0591/2*lg(6*10^{\wedge(-5)}*10^{\wedge(-7,36*2)}/1/55,3^{\wedge 2})=-0,1349$ V

$E_{oOx}=E^\circ_{H2O2Ox}+0,0591/2\bullet log([H_2O]^4/[H_2O_2]/[H_3O^+]^2)=-1,7113+0,0591/2*lg(55,3^{\wedge 4}/1/10^{\wedge(-7,36*2)})=-1,0713$ V

Summā Nernsta + inversā reakcija homeostāzē ir

$$\Delta \mathbf{G_{eq}}_{BioChem}=(E_{Red}-E_{oOx})*\mathbf{F*n}=(-0,13493-1,0703)*96485*2=(\mathbf{-1,2062})*96485*2=\mathbf{-232,76}\ ^{kJ}/_{mol};$$

$G_{Homeostasis\mathbf{H2O2}}=(G_{\mathbf{O2}Biochem\_arteriaj}+2*G_{\mathbf{H2}OBioChemistry}-\Delta G_{Alberty})/2=(\mathbf{88,04+2*85,64+232,76})/2=\mathbf{246,04}\ ^{kJ}/_{mol};$

Sēra / H_2S_{aq} red-oks sistēmas. H_3O^+ un $[H_2O]=55{,}3$ M uzskaite absolūtās brīvās enerģijas un potenciālu skalai.

Viela	ΔH°_H kJ/mol	ΔS°_H J/mol/K	ΔG°_H , kJ/mol
H_2S	**-38,6**	**126**	**-76,167**
HS^-	**-16,3**	**67**	**-36,276**
HS^-	$E^\circ_{\underline{S}\downarrow/S2-}=$	**-0,8517**V	**6,16**
HS^-	$pK_{a1}=7{,}05$	$pK_{a1}=7{,}05$	**-3,072**
H_2S	$E^\circ_{\underline{S}\downarrow/S2-}=$	**-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;

$G_{HS\text{-}aq}=G_{S\,rombisks}+2G_{H_2O}-(\Delta G_{eqHS\text{-}aq}+G_{OH})=\mathbf{6{,}16}$ kJ/mol;

$G_{HS^-}=\Delta G_{eq}-G_{H_3O}+(G_{H_2S}+G_{H_2O})=\mathbf{50{,}188-22{,}44}+(\mathbf{-30{,}82}+0)=\mathbf{-3{,}072}$ kJ/mol;

$G_{H_2S\text{-}aq}=G_{S\,rombisks}+3G_{H_2O}-(\Delta G_{eqH_2S\text{-}aq}+2G_{OH})=\mathbf{-61{,}09}$ kJ/mol;

$G_{H_2S\,aq}=G_{S\,rombisks}+2G_{H_3O^+}-(\Delta G_{Hess\_H_2S\,aq}+2G_{H_2O})=\mathbf{88{,}82}$ kJ/mol ;

$G_{H_2S\,aq}=G_{S\,rhombic}+2G_{H_3O^+}-(\Delta G_{Hess\_H_2S\,aq}+2G_{H_2O})=\mathbf{-35{,}794}$ kJ/mol.

$G_{H_2S\,aq}=\Delta G_{HessH_2S}+(2G_{H(Pt)}+G_{S\,rombic})=\mathbf{-35{,}997}$ kJ/mol;

$G_{S2\text{-}aq}=G_{S\,rombisks}+G_{H_2O}-(\Delta G_{eqS2\text{-}aq})=\mathbf{68{,}45}$ kJ/mol;

$G_{S2-}=\Delta G_{eq}-G_{H_3O}+(G_{HS^-}+G_{H_2O})=\mathbf{118{,}38}\ \mathbf{-22{,}44}+(\mathbf{-3{,}072}+0)=\mathbf{92{,}868}$ kJ/mol;

$S^{2-}=S_{rombisks}+H_2O+2e^-$; $E^\circ_{\underline{S}\downarrow/S2-}=\mathbf{-0{,}79853}$ V Kortly, Shucha ;

$E^\circ_{\underline{S}\downarrow/S2-}=E^\circ-0{,}0591/2*\lg([H_2O]^1)+0{,}10166-0{,}37239=-0{,}4763-0{,}02955*\lg(55{,}3\text{^}^1)+0{,}10166-0{,}37239=\mathbf{-0{,}79853}$ V;

$\mathbf{\Delta G_{eqS2-}=E^\circ_{S2-}Fn=-0{,}79853}*96485*2=\mathbf{-154{,}09}$ kJ/mol . $G_{S\,rombisks}=\mathbf{-85{,}64}$ kJ/mol;

$\Delta G_{eqS2\text{-}aq}=G_{S\,rombisks}+G_{H_2O}-(G_{S2\text{-}aq})=\mathbf{-85{,}64}+0-(\mathbf{68{,}25})=\mathbf{-154{,}09}$ kJ/mol;

$G_{S2\text{-}aq}=G_{S\,rombisks}+G_{H_2O}-(\Delta G_{eqS2\text{-}aq})==\mathbf{-85{,}64}+0-(\mathbf{-154{,}09})=\mathbf{68{,}45}$ kJ/mol;

$HS^-+OH^-=S_{rombisks}+2H_2O+2e^-$; CRC 2010; $E^\circ_{\underline{S}\downarrow/HS-}=\mathbf{-0{,}8517}$ V;

$E^\circ_{\underline{S}\downarrow/HS-}=E^\circ-0{,}0591/2*\lg([H_2O]^2)+0{,}10166-0{,}37239=-0{,}478-0{,}02955*\lg(55{,}3\text{^}^2)+0{,}10166-0{,}37239=\mathbf{-0{,}8517}$ V;

$\mathbf{\Delta G_{eqHS-}=E_{HS-}Fn=-0{,}8517}*96485*2=\mathbf{-164{,}35}$ kJ/mol .

$\Delta G_{eqHS\text{-}aq}=G_{S\,rombisks}+2G_{H_2O}-(G_{HS\text{-}aq}+G_{OH})=\mathbf{-85{,}64}+2*0-(\mathbf{1{,}35+77{,}36})=\mathbf{-164{,}35}$ kJ/mol;

$G_{HS\text{-}aq}=G_{S\,rombisks}+2G_{H_2O}-(\Delta G_{eqHS\text{-}aq}+G_{OH})=\mathbf{-85{,}64}+2*0-(\mathbf{-164{,}35+77{,}36})=\mathbf{1{,}35}$ kJ/mol;

$H_2S_{aq}+2H_2O=S_{rombisks}+2H_3O^++2e^-$; $E^\circ_{\underline{S}\downarrow/H2S}=\mathbf{-0{,}025735}$ V Suchotina_1<pH< 7 ;

$E^\circ_{\underline{S}\downarrow/H2S}=E^\circ-{}^{0{,}0591}/_2*\lg(1/[H_2O]^2)+0{,}10166-0{,}37239=0{,}142-0{,}02955*\lg(1/55{,}3\text{^}^2)+0{,}10166-0{,}37239=\mathbf{-0{,}025735}$ V;

$\mathbf{\Delta G_{eqH_2S}=E^\circ_{H_2S}Fn=-0{,}025735}*96485*2=\mathbf{-4{,}966}$ kJ/mol .

$\Delta G_{eqH_2S\,aq}=G_{S\,rombisks}+2G_{H_3O^+}-(G_{H_2S\,aq}+2G_{H_2O})=\mathbf{-85{,}64}+2*\mathbf{22{,}44}-(\mathbf{-35{,}794}+2*0)=\mathbf{-4{,}966}$ kJ/mol;

$G_{H_2S\,aq}=G_{S\,rombisks}+2G_{H_3O^+}-(\Delta G_{Hess\_H_2S\,aq}+2G_{H_2O})=\mathbf{-85{,}64}+2*\mathbf{22{,}44}-(\mathbf{-4{,}966}+2*0)=\mathbf{-35{,}794}$ kJ/mol.

$pKa=7{,}0$ Wikipedia; CRC2010 $pK_{a1}=7{,}05$; $pK_{a2}=19$

$pK_{a1}=7{,}05$ $H_2S+H_2O=HS^-+H_3O^+$; $K_{eq1}=K_{a1}/[H_2O]=10\text{^}^{(-7{,}05)}/55{,}3=0{,}000000001612$;

$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=-8{,}3144*298{,}15*\ln(0{,}000000001612)=G_{HS^-}+G_{H_3O}-(G_{H_2S}+G_{H_2O})=\mathbf{50{,}188}$ kJ/mol;

$\Delta G_{eq}=G_{HS^-}+G_{H_3O}-(G_{H_2S}+G_{H_2O})=\mathbf{-3{,}072}+\mathbf{22{,}44}-(\mathbf{-30{,}82}+0)=\mathbf{50{,}188}$ kJ/mol ;

$G_{HS^-}=\Delta G_{eq}-G_{H_3O}+(G_{H_2S}+G_{H_2O})=\mathbf{50{,}188-22{,}44}+(\mathbf{-30{,}82}+0)=\mathbf{-3{,}072}$ kJ/mol ;

$pK_{a2}=19$ $HS^-+H_2O=S^{2-}+H_3O^+$; $K_{eq1}=K_{a1}/[H_2O]=10\text{^}^{(-19)}/55{,}3=10\text{^}^{(-20{,}74)}$;

$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=-8{,}3144*298{,}15*\ln(10\text{^}^{(-20{,}74)})=G_{S2-}+G_{H_3O}-(G_{HS^-}+G_{H_2O})=\mathbf{118{,}38}$ kJ/mol;

$\Delta G_{eq}=G_{S2-}+G_{H_3O}-(G_{HS^-}+G_{H_2O})=\mathbf{92{,}868}+\mathbf{22{,}44}-(\mathbf{-3{,}072}+0)=\mathbf{118{,}38}$ kJ/mol ;

$G_{S2-}=\Delta G_{eq}-G_{H_3O}+(G_{HS^-}+G_{H_2O})=\mathbf{118{,}38-22{,}44}+(\mathbf{-3{,}072}+0)=\mathbf{92{,}868}$ kJ/mol ;

Sēra reducēšana inversais potenciāls: $S_{rombic}+2H_3O^++2e^-=H_2S_{aq}+2H_2O$; $-E^\circ_S=\mathbf{-0{,}025735}$ 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;

$G_{H_2S\,aq}=\Delta G_{HessH_2S}+(2G_{H(Pt)}+G_{S\,rombic})=\mathbf{-47{,}277}+(2*\mathbf{48{,}46-85{,}64})=\mathbf{-35{,}997}$ kJ/mol . 2. lapas puse.

Nernsta pus reakcijai: $H_2S_{aq}+2H_2O=S_{rhombic}+2H_3O^++2e^-$ absolūtais standarta potenciāls $\mathbf{E^{\circ 1}_{H_2S}=-0{,}025735}$ V brīvās enerģijas izmaiņai: $\mathbf{\Delta G_{eqH_2S}=E^{\circ 1}_{H_2S}Fn=-0{,}025735}*96485*2=\mathbf{-4{,}966}$ kJ/mol .

Ūdeņraža sulfīda šķīduma pus reakcijā Hesa likuma brīvās enerģijas izmaiņas vērtība izteiksmē ir: $\Delta G_{Hess\_H_2S\,aq}=G_{S\,rhombic}+2G_{H_3O^+}-(G_{H_2S\,aq}+2G_{H_2O})=\mathbf{-85{,}64}+2*\mathbf{22{,}44}-(G_{H_2S\,aq}+2*0)=\mathbf{-4{,}966}$ kJ/mol, tad absolūtā vērtība ir: $G_{H_2S\,aq}=G_{S\,rhombic}+2G_{H_3O^+}-(\Delta G_{Hess\_H_2S\,aq}+2G_{H_2O})=\mathbf{-85{,}64}+2*\mathbf{22{,}44}-(\mathbf{-4{,}966}+2*0)=\mathbf{-35{,}794}$ kJ/mol.

Veidošanās no elementiem $S_{rombisks}+H_{2\,gāze}=H_2S_{gāze}$; $G_{S\,rombisks}=\mathbf{-85{,}64}$ kJ/mol; [1,6]

Veidošanās enerģijas izmaiņa ir $\Delta G_{Hess\_H_2S\,gāze}=G^\circ_{H_2S\,gāze}-({}_{Hess}G^\circ_{S\,rombisks}+{}_{Hess}G^\circ_{H_2})=-20{,}6-(\mathbf{0}+0)=-20{,}6$ kJ/mol.
Sēra enerģijas saturs molā ir $G_{S\,rombisks}=G^\circ_{H_2S\,gāze}-(\Delta G_{Hess\_H_2S\,gāze}+G_{H_2\,gāze})=-20{,}6-(-20{,}6+\underline{\mathbf{85{,}64}})=\mathbf{-85{,}64}$ kJ/mol;

Hidroksonija un ūdens uzskaite $[H_2O]=55{,}3$ M absolūtās brīvās enerģijas un potenciālu skalai.

Albertija dati ir doti par elementu absolūtajām vērtībām:
$G_{S\text{rombisks}}=\mathbf{-85{,}64}\ ^{kJ}/_{mol}$; $G_{O2\text{gas}}=\mathbf{303}\ ^{kJ}/_{mol}$; $G_{\mathbf{H2}\text{gas}}=\mathbf{85{,}6}\ ^{kJ}/_{mol}$; $\Delta G°_{\mathbf{SO4}\text{Form}}=\mathbf{-747{,}75}\ ^{kJ}/_{mol}$; attiecībā pret ūdeni un oglekļa dioksīda gāzi nulles $G_{\mathbf{H2O}}=G_{\mathbf{CO2}\text{gas}}=G_{\underline{e-}}=0\ ^{kJ}/_{mol}$ atskaites skalā. Veidošanās no brīviem elementiem:

$S_{\text{rombisks}}+2O_{2\text{gas}}+\mathbf{H}_{2\text{gas}}=\mathbf{H_2}SO_4$: $\Delta G°_{\mathbf{H2SO4}\text{Form}}=G_{\mathbf{H2SO4}}-(G_{S\text{rombisks}}+\mathbf{2}G_{\mathbf{O2}}+G_{\mathbf{H2}\text{gas}})=-690{,}0\ ^{kJ}/_{mol}$; [1]

$G_{\mathbf{H2SO4}}=\Delta G°_{\mathbf{H2SO4}\text{Form}}+(G_{S\text{rombisks}}+\mathbf{2}G_{\mathbf{O2}}+G_{\mathbf{H2}\text{gas}})=-690{,}0+(\mathbf{-85{,}64}+2*\mathbf{303}+\mathbf{85{,}6})=\mathbf{-84{,}04}\ ^{kJ}/_{mol}$;

$S_{\text{rombisks}}+2O_{2\text{gas}}+\mathbf{H}_{2\text{gas}}/2=\mathbf{H}SO_4^-$; $\Delta G°_{\mathbf{HSO4}\text{Form}}=G_{\mathbf{HSO4}}-(G_{S\text{rombisks}}+\mathbf{2}G_{\mathbf{O2}}+\mathbf{0{,}5}G_{\mathbf{H2}\text{gas}})=-755{,}9\ ^{kJ}/_{mol}$.

$G_{\mathbf{HSO4}}=\Delta G°_{\mathbf{HSO4}\text{Form}}+(G_{S\text{rombisks}}+\mathbf{2}G_{\mathbf{O2}}+\mathbf{0{,}5}G_{\mathbf{H2}\text{gas}})=-755{,}9+(\mathbf{-85{,}64}+2*\mathbf{303}+\mathbf{85{,}6/2})=\mathbf{-192{,}74}\ ^{kJ}/_{mol}$;

$S_{\text{rombisks}}+2O_{2\text{gas}}=SO_4^{2-}$; $\Delta G°_{\mathbf{SO4}\text{Form}}=G_{\mathbf{SO4}}-(G_{S\text{rombisks}}+\mathbf{2}G_{\mathbf{O2}})=\mathbf{-747{,}75}\ ^{kJ}/_{mol}$;

$G_{\mathbf{SO4}}=\Delta G°_{\mathbf{SO4}\text{Form}}+(G_{S\text{rombisks}}+\mathbf{2}G_{\mathbf{O2}})=\mathbf{-747{,}75-85{,}64}+2*\mathbf{303=-227{,}39}\ ^{kJ}/_{mol}$;

Līdzsvara konstantes molu daļās $K_{eq}=K_a/[H_2O]$ aprēķina dalot skābes konstanti ar ūdeni $[H_2O]=55{,}3$ M.

Protolīzes $H_2SO_4+H_2O=HSO_4^-+H_3O^+$ skābe $pK_{a1}=-2{,}8$ un līdzsvars ir $K_{eq1}=K_{a1}/[H_2O]=10\hat{}^{(2{,}8)}/55{,}3=11{,}41$;

$\Delta G_{eqH2SO4}=-R\bullet T\bullet\ln(K_{eq})=-8{,}3144*298{,}15*\ln(11{,}41)=G_{HSO4-}+G_{H3O}-(G_{H2SO4}+G_{H2O})=\mathbf{-6{,}035}\ ^{kJ}/_{mol}$;

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

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

Protolīze ar $HSO_4^-+\mathbf{H_2O}=SO_4^{2-}+H_3O^+$; $pK_{a2}=1{,}99$; $K_{eq2}=K_{a2}/[\mathbf{H_2O}]=10\hat{}^{(-1{,}99)}/55{,}3=0{,}0001850$;

$\Delta G_{eq\mathbf{HSO4}}=-R\bullet T\bullet\ln(K_{eq2})=-8{,}3144*298{,}15*\ln(0{,}0001850)=G_{\mathbf{SO42-}}+G_{\mathbf{H3O}}\mathbf{-(}G_{\mathbf{HSO4-}}+G_{\mathbf{H2O}})=\mathbf{21{,}307}\ ^{kJ}/_{mol}$;

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

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

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

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

Veidošanās no brīvajiem elementiem $S_{\text{rombisks}}+1{,}5O_{2\text{gas}}+\mathbf{H}_{2\text{gas}}=\mathbf{H_2}SO_{3aq}$; un šķīdība $SO_2^{gas}+H_2O=H_2SO_{3aq}$.

$\Delta G°_{\mathbf{H2SO3}\text{Form}}=G_{\mathbf{H2SO3}}-(G_{S\text{rombisks}}+\mathbf{1{,}5}\Delta G_{\mathbf{O2}}+\ G_{\mathbf{H2}\text{gas}})=G_{\mathbf{H2SO3}}\mathbf{-(-85{,}64}+1{,}5*\mathbf{303}+\mathbf{85{,}6})=\mathbf{-527{,}3675}\ ^{kJ}/_{mol}$;

$G_{\mathbf{H2SO3}}=\Delta G°_{\mathbf{H2SO3}\text{Form}}+(G_{S\text{rombisks}}+\mathbf{1{,}5}\Delta G_{\mathbf{O2}}+\ G_{\mathbf{H2}\text{gas}})=\mathbf{-527{,}3675}+(\mathbf{-85{,}64}+1{,}5*\mathbf{303}+\mathbf{85{,}6})=\mathbf{-72{,}9075}\ ^{kJ}/_{mol}$;

$G_{\mathbf{HSO3}}=\Delta G°_{\mathbf{HSO3}\text{Form}}+(G_{S\text{rombisks}}+\mathbf{1{,}5}\Delta G_{\mathbf{O2}}+G_{\mathbf{H2}\text{gas}}/2)=\mathbf{-486{,}5}+(\mathbf{-85{,}64}+1{,}5*\mathbf{303}+\mathbf{85{,}6}/2)=\mathbf{-74{,}84}\ ^{kJ}/_{mol}$;

$G_{\mathbf{SO3}}=\Delta G°_{\mathbf{SO3}\text{Form}}+G_{S\text{rombisks}}+\mathbf{1{,}5}\Delta G_{\mathbf{O2}}=\mathbf{-490{,}38-85{,}64}+1{,}5*\mathbf{303=-121{,}52}\ ^{kJ}/_{mol}$;

Līdzsvara konstantes molu daļās $K_{eq}=K_a/[H_2O]$ aprēķina dalot skābes konstanti ar ūdeni $[H_2O]=55{,}3$ M.

$H_2SO_3+\mathbf{H_2O}=HSO_3^-+H_3O^+$;$pK_{a1}=1{,}85$;$K_{eq1}=K_{a1}/[\mathbf{H_2O}]=10\hat{}^{(-1{,}85)}/55{,}3=0{,}0002554$

$\Delta G_{eq\mathbf{H2SO3}}=-R\bullet T\bullet\ln(K_{eq1})=-8{,}3144*298{,}15*\ln(0{,}0002554)=G_{\mathbf{HSO3-}}+G_{\mathbf{H3O}}\mathbf{-(}G_{\mathbf{H2SO3}}+G_{\mathbf{H2O}})=\mathbf{20{,}5075}\ ^{kJ}/_{mol}$;

$G_{\mathbf{H2SO3}}=G_{\mathbf{HSO3-}}+G_{\mathbf{H3O}}\mathbf{-}(\Delta G_{eq\mathbf{H2SO3}}+G_{\mathbf{H2O}})=\mathbf{-74{,}84}+\mathbf{22{,}44-(20{,}5075+0)=-72{,}9075}\ ^{kJ}/_{mol}$;

$HSO_3+\mathbf{H_2O}=SO_3^{2-}+H_3O^+$;$pK_{a2}=7{,}21$;$K_{eq2}=K_{a2}/[\mathbf{H_2O}]=10\hat{}^{(-7{,}21)}/55{,}3=\ 0{,}000000001115$

$\Delta G_{eq\mathbf{HSO3}}=-R\bullet T\bullet\ln(K_{eq2})=-8{,}3144*298{,}15*\ln(0{,}000000001115)=G_{\mathbf{SO32-}}+G_{\mathbf{H3O}}\mathbf{-(}G_{\mathbf{HSO3-}}+G_{\mathbf{H2O}})=\mathbf{51{,}1}\ ^{kJ}/_{mol}$;

$G_{\mathbf{HSO3-}}=G_{\mathbf{SO32-}}+G_{\mathbf{H3O}}\mathbf{-}(\Delta G_{eq\mathbf{HSO3}}+G_{\mathbf{H2O}})=\mathbf{-121{,}52}+\mathbf{22{,}44-(51{,}1+0)=-150{,}2}\ ^{kJ}/_{mol}$;

Sērpaskābes oksidēšanas $H_2SO_3+4H_2O=HSO_4^-+3H_3O^+\mathbf{+2e^-}$ elektroda standarta potenciāls $E°_{H2SO3}=\mathbf{0{,}1073}$ V.

$E°_{H2SO3}=E°+0{,}10166-0{,}0591/2*\lg(1/[H_2O]^4)-0{,}37239=0{,}172-0{,}0591/2*\lg(1/55{,}3\hat{}^4)+0{,}10166-0{,}37239=\mathbf{0{,}10726}$ V;

$$E_{H2SO3}=E°_{H2SO3}+\frac{0.0591}{2}\bullet\log\frac{[HSO_4^-]\cdot[H_3O^+]^4}{[H_2SO_3]\cdot[H_2O]^5}=\mathbf{0{,}10726}\ \text{V}+\frac{0.0591}{2}\bullet\log\frac{[HSO_4^-]\cdot[H_3O^+]^4}{[H_2SO_3]\cdot[H_2O]^5}$$

$\Delta\mathbf{G_{eq}}_{H2SO3}=E°_{HSO3}\bullet F\bullet 2=\mathbf{0{,}107260}*96485*2=\mathbf{20{,}69796}\ ^{kJ}/_{mol}$;

$\Delta\mathbf{G_{eq}}_{H2SO3}=G_{HSO4-}+3\mathbf{G_{H3O}-}(G_{H2SO3}+4\mathbf{G_{H2O}})=\mathbf{-192{,}74}+3*22{,}44-(\mathbf{-146{,}118+}4*0)=\ \mathbf{20{,}69796}\ ^{kJ}/_{mol}$;

$G_{H2SO3}=G_{HSO4-}+3\mathbf{G_{H3O}-}(\Delta\mathbf{G_{eq}}_{H2SO3}+4\mathbf{G_{H2O}})=\mathbf{-192{,}74}+3*22{,}44-(\mathbf{20{,}69796}+4*0)=\mathbf{-146{,}118}\ ^{kJ}/_{mol}$;

$G_{HSO4-}=\Delta\mathbf{G_{eq}}_{H2SO3}-3\mathbf{G_{H3O}}+(G_{H2SO3}+4\mathbf{G_{H2O}})=\mathbf{20{,}69796}-3*22{,}44+(\mathbf{-146{,}118}+4*0)=\mathbf{-192{,}74}\ ^{kJ}/_{mol}$;

Šķīdības konstantes molu daļās $K_{eq}=K_{sp}/[H_2O]$ aprēķina dalot piesātinātu šķīdības produktu ar ūdeni $[H_2O]$. $SO_2^{gas}+H_2O=H_2SO_{3aq}$; $K_{sp}=[H_2SO_3]/[SO_2^{gas}]/[H_2O]=1{,}46724/1/51{,}64=0{,}028413$, jo piesātinājuma stāvoklī izšķīst 94 $^g/_L$ SO_2 M=64,066 g/mol $[SO_2]=[H_2SO_3]=94/64{,}066=1{,}46724$ M sērpaskābes $M_{H2SO3}=82{,}075$ g/mol ar blīvumu **1,05** g/mL $m_{\text{solution}}=1050\ ^g/_L$ un $m_{H2SO3}=[SO_2]*M_{H2SO3}=1{,}46724$ M$*82{,}075\ ^g/_{mol}$=**120,4327** $^g/_L$ skābes masu $\mathbf{m}_{H2O}\mathbf{=}1050-120{,}4327=929{,}5673$ g. Ūdens koncentrācija ir $n_{H2O}=929{,}5673/18=51{,}64$ M. Brīvās enerģijas izmaiņa ir $\Delta G_{sp\mathbf{H2SO3}}=-R\bullet T\bullet\ln(K_{sp})=-8{,}3144*298{,}15*\ln(0{,}028413)=G_{\mathbf{H2SO3}}\mathbf{-(}G_{\mathbf{SO2}}+G_{\mathbf{H2O}})=\mathbf{8{,}82727}\ ^{kJ}/_{mol}$;

Veidošanās no brīvajiem elementiem $S_{rombisks}+O_{2gas}=SO_2$: $\Delta G°_{SO_2Form}=G_{SO_2}-(\mathbf{-85{,}64+303})=-370{,}82\ ^{kJ}/_{mol}$;

$G_{SO_2}=\Delta G°_{SO_2Form}+(G_{S rombisks}+G_{O_2})=-370{,}82+(\mathbf{-85{,}64+303})=\mathbf{-153{,}46}\ ^{kJ}/_{mol}$;

$\Delta G_{spH_2SO_3}=G_{H_2SO_3}-(G_{SO_2}+G_{H_2O})=\mathbf{-72{,}9075-(-81{,}73477}+0)=\mathbf{8{,}82727}\ ^{kJ}/_{mol}$;

$G_{SO_2}=G_{H_2SO_3}-(\Delta G_{spH_2SO_3}+G_{H_2O})=\mathbf{-72{,}9075-(8{,}82727}+0)=\mathbf{-81{,}73477}\ ^{kJ}/_{mol}$;

$HSO_3^-+4H_2O=SO_4^{2-}+3H_3O^++\mathbf{2e^-}$;   Suchotina $2=<pH<7$ $E°_{HSO_4^{2-}}=\mathbf{0{,}10726}$ V.

$E°_{HSO_3^-}=E°+0{,}10166-0{,}0591/2*\lg(1/[H_2O]^4)-0{,}37239=0{,}172-0{,}0591/2*\lg(1/55{,}3\hat{}4)+0{,}10166-0{,}37239=\mathbf{0{,}10726}$ V;

$E_{HSO_3^-}=E°_{HSO_3^-}+0{,}0591/2*\log([HSO_4^-]*[H_3O^+]^3/[H_2SO_{3aq}]/[H_2O]^4)=\mathbf{0{,}10726}\ V+0{,}0591/2*\log\frac{[SO_4^{2-}]\cdot[H_3O^+]^3}{[HSO_3^-]\cdot[H_2O]^4}$

$\Delta G_{eqSO_4^-}=E°_{HSO_4^-}\bullet F\bullet 2=\mathbf{0{,}10726}*96485*2=\mathbf{20{,}69796}\ ^{kJ}/_{mol}$,

$\Delta G_{eqSO_4^-}=G_{SO_4^-}+3G_{H_3O}-(G_{HSO_3}+4G_{H_2O})=\mathbf{-119{,}5295}+3*22{,}44-(\mathbf{-72{,}9075}+4*0)=\mathbf{20{,}69796}\ ^{kJ}/_{mol}$;

$G_{HSO_3}=G_{SO_4^-}+3G_{H_3O}-(\Delta G_{eqSO_4^-}+4G_{H_2O})=\mathbf{-119{,}5295}+3*22{,}44-(\mathbf{20{,}69796}+4*0)=\mathbf{-72{,}9075}\ ^{kJ}/_{mol}$;

$G_{SO_4^-}=\Delta G_{eqSO_4^-}-3G_{H_3O}+(G_{HSO_3}+4G_{H_2O})=\mathbf{20{,}69796}-3*22{,}44+(\mathbf{-72{,}9075}+4*0)=\mathbf{-119{,}5295}\ ^{kJ}/_{mol}$;

Viela	$\Delta H°_{H,}\ ^{kJ}/_{mol}$	$\Delta S°_{H,}\ ^{J}/_{mol/K}$	$\Delta G°_{H,}\ ^{kJ}/_{mol}$	
H_2SO_4	-814,0	156,9	-690,0	CRC;
H_2SO_4		formation	**-84,04**	$G_{H_2SO_4}=\Delta G°_{H_2SO_4}+G_{S rombisks}+2\Delta G_{O_2}+G_{H_2gas}+G_{H_2O}=\mathbf{-84{,}04}\ ^{kJ}/_{mol}$;
H_2SO_4		$pK_{a1}=-2{,}8$	**-415.04**	$G_{H_2SO_4}=G_{HSO_4-}+G_{H_3O}-(\Delta G_{eqH_2SO_4}+G_{H_2O})=\mathbf{-415{,}04}\ ^{kJ}/_{mol}$;
HSO_4^-	-887,3	131,8	-755,9	CRC
HSO_4^-	-	$pK_{a1}=-2{,}8$	**-264,06**	$G_{HSO_4-}=\Delta G_{eqH_2SO_4}-G_{H_3O}+(G_{H_2SO_4}+G_{H_2O})=\mathbf{-264{,}06}\ ^{kJ}/_{mol}$;
HSO_4^-	-	$pK_{a2}=1{,}99$	**-595,068**	$G_{HSO_4-}=G_{SO_42-}+G_{H_3O}-(\Delta G_{eqHSO_4}+G_{H_2O})=\mathbf{-595{,}068}\ ^{kJ}/_{mol}$;
HSO_4^-		formation	**-192,74**	$G_{HSO_4}=\Delta G°_{HSO_4}+G_{S rombisks}+2\Delta G_{O_2}+G_{H_2gas}/2=\mathbf{-192{,}74}\ ^{kJ}/_{mol}$;
HSO_4^-	$E°_{HSO_3^-}=$	**0,10726**	**-192,74**	$G_{HSO_4^-}=\Delta G_{eqHSO_3^-}-3G_{H_3O}+(G_{H_2SO_3}+4G_{H_2O})=\mathbf{-192{,}74}\ ^{kJ}/_{mol}$;
SO_4^{2-}	**-907,62**	**-536,2**	**-747,75**	**BioTherm2006**; $\Delta G\_{SO_42-}=\Delta H-T*\Delta S=\mathbf{-907{,}62}-298{,}15*-0{,}\mathbf{5362}=\mathbf{-747{,}75}\ ^{kJ}/_{mol}$;
SO_4^{2-}	-	formation	**-227,39**	$G_{SO_4}=\Delta G°_{SO_4Form}+G_{S rombisks}+2\Delta G_{O_2}=\mathbf{-747{,}75-85{,}64}+2*\mathbf{303}=\mathbf{-227{,}39}\ ^{kJ}/_{mol}$;
SO_4^{2-}	-	$pK_{a2}=1{,}99$	**-416,74**	$G_{SO_42-}=\Delta G_{eqHSO_4}-G_{H_3O}+(G_{HSO_4-}+G_{H_2O})=\mathbf{-416{,}74}\ ^{kJ}/_{mol}$;
SO_4^{2-}	$E°_{HSO_3^-}=$	**0,10726**	**-119,53**	$G_{SO_4^-}=\Delta G_{eqHSO_3^-}-3G_{H_3O}+(G_{HSO_3}+4G_{H_2O})=\mathbf{-119{,}5295}\ ^{kJ}/_{mol}$;
SO_4^{2-}	$E°_{SO_32^-}=$	**-1,2522**	**-213,4**	$G_{SO_42^-}=\Delta G_{eqSO_32-OH}-G_{H_2O}+(G_{SO_32-}+2G_{OH})=\mathbf{-213{,}4}\ ^{kJ}/_{mol}$;
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**	$G_{SO_2}=\Delta G°_{SO_2Form}+(G_{S rombisks}+G_{O_2})=\mathbf{-153{,}46}\ ^{kJ}/_{mol}$;
SO_2^{gas}	$\Delta GK_{sp}=8{,}827$	0,028413	**-81,735**	$\Delta G_{SO_2}=G_{H_2SO_3}-(\Delta G_{spH_2SO_3}+G_{H_2O})=\mathbf{-72{,}9075-(8{,}82727}+0)=\mathbf{-81{,}73477}\ ^{kJ}/_{mol}$;
H_2SO_3		formation	**-72,9075**	$G_{H_2SO_3}=\Delta G°_{H_2SO_3Form}+(G_{S rombisks}+1{,}5\Delta G_{O_2}+G_{H_2gas})=\mathbf{-72{,}9075}\ ^{kJ}/_{mol}$;
H_2SO_3		$pK_{a1}=1{,}85$	**-72,9075**	$G_{H_2SO_3aq}=\mathbf{-74{,}84+22{,}44-(20{,}5075+0)=-72{,}9075}\ ^{kJ}/_{mol}$;
H_2SO_3	$E°_{HSO_3^-}=$	**0,10726**	**-146,118**	$G_{H_2SO_3}=G_{HSO_4^-}+3G_{H_3O}-(\Delta G_{eqHSO_3^-}+4G_{H_2O})=\mathbf{-146{,}11796}\ ^{kJ}/_{mol}$;
HSO_3^-		formation	**-74,84**	$G_{HSO_3}=\Delta G°_{HSO_3}+G_{S rombisks}+1{,}5\Delta G_{O_2}+G_{H_2gas}/2=\mathbf{-74{,}84}\ ^{kJ}/_{mol}$;
HSO_3^-		$pK_{a2}=7{,}21$	**-150,2**	$G_{HSO_3-aq}=\mathbf{-121{,}52}+\mathbf{22{,}44-(51{,}1+0)=-150{,}2}\ ^{kJ}/_{mol}$;
HSO_3^-	$E°_{HSO_3^-}=$	**0,10726**	**-72,9075**	$G_{HSO_3}=G_{SO_4^-}+3G_{H_3O}-(\Delta G_{eqHSO_3^-}+4G_{H_2O})=\mathbf{-72{,}9075}\ ^{kJ}/_{mol}$;
HSO_3^-	-635,5	-29	-486,5	CRC
SO_3^{2-}	**-632,19**	**-474,05**	**-490,38**	**BioTherm2006** $\Delta G_{H\_SO_32-}=\Delta H_H-T*\Delta S_H=\mathbf{-632{,}1888}-298{,}15*-0{,}\mathbf{47405}=\mathbf{-490{,}85}\ ^{kJ}/_{mol}$;
SO_3^{2-}	-	formation	**-121,52**	$G_{SO_3}=\Delta G_{Form}=\Delta G°_{SO_3}+G_{S rombisks}+1{,}5\Delta G_{O_2}=\mathbf{-121{,}52}\ ^{kJ}/_{mol}$;
SO_3^{2-}	$E°_{SO_32-OH}=$	**-1,2522**	**-126,48**	$G_{SO_32-}=G_{SO_42^-}+G_{H_2O}-(\Delta G_{eqSO_32-OH}+2G_{OH})=\mathbf{-126{,}483}\ ^{kJ}/_{mol}$;

$G_{H_2SO_3}=\Delta G°_{H_2SO_3Form}+(G_{S rombisks}+1{,}5\Delta G_{O_2}+G_{H_2gas})=\mathbf{-72{,}9075}\ ^{kJ}/_{mol}$;

$SO_3^{2-}+2OH^-=SO_4^{2-}+H_2O+2e^-$; pH > 7 ; $E°_{SO_42^-}=\mathbf{-1{,}2522}$ V Suchotina

$E°_{SO_32-OH}=E°+0{,}10166+0{,}0591/2*\lg(1/[H_2O])=-0{,}93+0{,}10166+0{,}02955*\lg(1/55{,}3)-0{,}37239=\mathbf{-1{,}2522}$ V;

$$E_{SO_32-OH}=E°_{SO_32-OH}+\frac{0.0591}{2}\bullet\log\frac{[SO_4^{2-}]\cdot[H_2O]}{[SO_3^{2-}]\cdot[OH^-]^2}=\mathbf{-1{,}2522}\ V+\frac{0.0591}{2}\bullet\log\frac{[SO_4^{2-}]\cdot[H_2O]}{[SO_3^{2-}]\cdot[OH^-]^2}$$

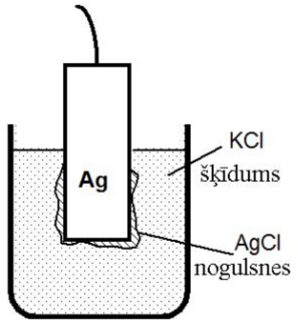
$\Delta G_{eqSO_42-OH}=E°_{SO_32-OH}\bullet F\bullet 2=\mathbf{-1{,}2522}*96485*2=\mathbf{-241{,}637}\ ^{kJ}/_{mol}$,;

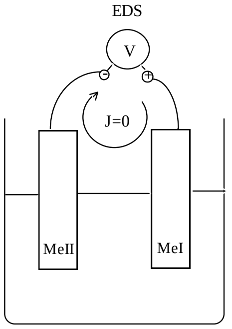
$\Delta G_{eqSO_32-OH}=G_{SO_42^-}+G_{H_2O}-(G_{SO_32-}+2G_{OH})=\mathbf{-213{,}4+0-(-126{,}483}+2*77{,}36)=\mathbf{-241{,}637}\ ^{kJ}/_{mol}$;

$G_{SO_32-}=G_{SO_42^-}+G_{H_2O}-(\Delta G_{eqSO_32-OH}+2G_{OH})=\mathbf{-213{,}4+0-(-241{,}637}+2*77{,}36)=\mathbf{-126{,}483}\ ^{kJ}/_{mol}$;

$G_{SO_42^-}=\Delta G_{eqSO_32-OH}-G_{H_2O}+(G_{SO_32-}+2G_{OH})=\mathbf{-241{,}637-0+(-126{,}483}+2*77{,}36)=\mathbf{-213{,}4}\ ^{kJ}/_{mol}$;

Metāls/tā nešķīstošā sāls/nešķīstošās sāls jonu šķīdums II-tipa elektrods





K^+Cl^- šķīduma ar AgCl pret joniem Cl^- nešķīstošajā sālī. Nernsta pus reakcijas sudraba metālam Ag. Elektriskā potenciāla mērījumi voltos ar elektrodu pāri ir **E**lektro **D**zinēja **S**pēks EDS volti. Starp diviem elektrodiem MeI indikatora elektrodu un un MeII salīdzināšanas elektrodu savienotiem noslēgtā elektriskā ķēdē aprēķina MeI indikatora elektroda potenciālu EI kā summu: EI=EDS+EII. Standarta salīdzināšanas elektrods ir EII ir ar konstantu hlorīda koncentrāciju.

$\mathbf{Ag}(s)+H_2O=\mathbf{Ag}^++e^-$; absolūtais standarta potenciāls $E^\circ_{Ag}=\mathbf{0,6317}$ 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;

$\Delta\mathbf{G}_{\mathbf{eq}\_Ag}=E^\circ_{Ag}\bullet F\bullet 2=\mathbf{0,6317}*96485*1=\mathbf{60,95}\ ^{kJ}/_{mol}$, $\Delta\mathbf{G}_{\mathbf{eq}\_As}=G_{Ag+}\mathbf{-}(G_{Ag}\mathbf{+G_{H2O}})=77,1\mathbf{-}(G_{Ag}\mathbf{+}0)=\mathbf{60,95}\ ^{kJ}/_{mol}$;

$G_{Ag}=G_{Ag+}\mathbf{-(\Delta G_{eq\_Ag}+G_{H2O})}=77,1\mathbf{-(60,95+}0)=\mathbf{16,15}\ ^{kJ}/_{mol}$;

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

$G_{Ag+}=\Delta\mathbf{G}_{\mathbf{eq}\_As}\mathbf{+}(G_{Ag}\mathbf{+G_{H2O}})=\mathbf{60,95+(42,855+}0)=\mathbf{103,8}\ ^{kJ}/_{mol}$;

Šķīdības līdzsvara mol daļās $\mathbf{Ag}Cl(s)+2H_2O=\mathbf{Ag}^++Cl^-$; $\mathbf{Ag}Cl(s)+2H_2O-Cl^-=\mathbf{Ag}^+$ absolūtā konstante :

$K_{Absolute\mathbf{Ag}Cl}=K_{sp\mathbf{Ag}Cl}/[H_2O]\wedge^2=[\mathbf{Ag}^+]*[Cl^-]/[\mathbf{Ag}Cl(s)]/[H_2O]\wedge^2=1,77*10\wedge^{(-10)}/55,3\wedge2=5,788*10^{-14}$;

$\Delta\mathbf{G}_{sp\mathbf{Ag}Cl}\mathbf{=-R\bullet T\bullet ln(K_{sp\mathbf{Ag}Cl})}=-8,3144*298,15*ln(5,788*10\wedge^{(-14)})=\mathbf{75,559}\ ^{kJ}/_{mol}$;

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

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

kompensē šķīdības ūdens molekulu summārajā $\mathbf{Ag}(s)+H_2O=\mathbf{Ag}^++e^-$; $\mathbf{Ag}(s)+H_2O+Cl^-=\mathbf{Ag}Cl(s)+2H_2O+e^-$; reakcijā $\mathbf{Ag}_s+Cl^-=\mathbf{Ag}Cl_s+H_2O+e^-$ ar absolūto standarta potenciālu $E^\circ_{Ag/AgCl}=\mathbf{-0,1514}$ V $[Cl^-]=0,1$ M$=[K^+Cl^-]$ kālija hlorīda šķīdumā. [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;

$\Delta\mathbf{G}_{\mathbf{eq}\_Ag}=E^\circ_{Ag}\bullet F\bullet 1=\mathbf{-0,1514}*96485*1=\mathbf{-14,61}\ ^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{\mathbf{eq}\_Ag}=G_{AgCl}\mathbf{+G_{H2O}-}(G_{Ag}\mathbf{+}G_{Cl-})=-155,71+0\mathbf{-}(G_{Ag}-183,955)=\mathbf{-14,61}\ ^{kJ}/_{mol}$;

$G_{Ag}=G_{AgCl}\mathbf{+G_{H2O}-(\Delta G_{eq\_Ag}+G_{Cl-})}=-155,71+0\mathbf{-(-14,61}-183,955)=\mathbf{42,855}\ ^{kJ}/_{mol}$;

Šķīdība $\mathbf{NH_{3gas}}$ un **Ag** kompensē katru ūdens molekulu Nernsta pus reakcijas produktos

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

$Ag+2NH_{3aq}=Ag(NH_3)_2^+\mathbf{+\ H_2O+e^-}$; absolūtais potenciāls $E^\circ_{Ag/Ag(NH3)2+}=\mathbf{0,000725\ V}$; [17] klasiskais $E^\circ=0,373$ 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;

$\Delta\mathbf{G}_{Ag/Ag(NH3)2+}=E^\circ_{Ag/Ag(NH3)2+}\bullet F\bullet 1=\mathbf{-0,000725}*96485*1=\mathbf{-0,06995}\ ^{kJ}/_{mol}$;

$G_{Ag(NH3)2+}=\Delta\mathbf{G}_{Ag/Ag(NH3)2+}\mathbf{-G_{H2O}}+(G_{Ag}\mathbf{+2}G_{NH3aq})=\mathbf{-0,06995}-0+(\mathbf{42,855-2*91,1})=\mathbf{-139,415}\ ^{kJ}/_{mol}$;

$2Ag+2OH^-=\mathbf{Ag_2O}(s)+H_2O\mathbf{+2e^-}$; absolūtais potenciāls $E^\circ_{2Ag/\mathbf{Ag2O}}=\mathbf{0,02277}$ V; [17] klasiskais $E^\circ=0,345$ 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

$\Delta\mathbf{G}_{Ag/\mathbf{Ag2O}}=E^\circ_{Ag/\mathbf{Ag2O}}\bullet F\bullet 2=\mathbf{0,02277}*96485*2=\mathbf{4,394}\ ^{kJ}/_{mol}$;

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

$\mathbf{G_{Ag2O}}=\Delta\mathbf{G}_{Ag/\mathbf{Ag2O}}\mathbf{-G_{H2O}}+(2G_{Ag}\mathbf{+2}G_{OH})=\mathbf{4,394}-0+(2*\mathbf{42,855-2*}77,36)=\mathbf{-64,616}\ ^{kJ}/_{mol}$;

$$E^\circ_{Ag/Ag(NH3)2+}=\mathbf{0,000725\ V+}\ \frac{[Ag(NH_3)_2^+]}{[Ag]\cdot([NH_3]-2\cdot[Ag(NH_3)_2^+])^2}\quad E^\circ_{2Ag/\mathbf{Ag2O}}=\mathbf{0,02277}\ V+\ \frac{[Ag_2\mathbf{O}]\cdot[\mathbf{H_2O}]}{[Ag]^2\cdot[\mathbf{OH}]^2}$$

Viela	$\Delta H^\circ_H\ ^{kJ}/_{mol}$	$\Delta S^\circ_H\ ^{J}/_{mol/K}$	$\Delta G^\circ_H\ ,\ ^{kJ}/_{mol}$	
Ag	-	CRC	**16,15**	$G_{Ag}=G_{Ag+}\mathbf{-(\Delta G_{eq\_Ag}+G_{H2O})}=77,1\mathbf{-(60,95+}0)=\mathbf{16,15}\ ^{kJ}/_{mol}$;
Ag	$E^\circ_{Ag/Ag+}=$	**-0,6317** V	**42,85**	$G_{Ag}=G_{Ag+}\mathbf{-(\Delta G_{eq\_Ag}+G_{H2O})=103,8-(60,95+}0)=\mathbf{42,85}\ ^{kJ}/_{mol}$;
Ag	$E^\circ_{Ag/AgCl}=$	**-0,1514** V	**42,855**	$G_{Ag}=\ G_{AgCl}\mathbf{+G_{H2O}}-(\Delta\mathbf{G}_{\mathbf{eq}\_Ag}\mathbf{+G_{Cl-}})=\mathbf{-155,71}+0-(\mathbf{-14,51-183,955})=\mathbf{42,855}\ ^{kJ}/_{mol}$;
Ag+	105,6	72,7	77,1	CRC;
Ag+	$E^\circ_{Ag}=$	**0,6317** V	**103,8**	$G_{Ag+}=\Delta\mathbf{G}_{\mathbf{eq}\_As}\mathbf{+}(G_{Ag}\mathbf{+G_{H2O}})=\mathbf{60,95+(42,855+}0)=\mathbf{103,8}\ ^{kJ}/_{mol}$;
AgCl(s)	-127,01	96,25	-155,71	$\Delta G_{AgCl}\mathbf{=\Delta H_H}\text{–}T^*\mathbf{\Delta S_H}=-127,01-298,15*0,09625=\mathbf{-155,71}\ ^{kJ}/_{mol}$;
Cl-	-167,08	56,6	-183,955	$\mathbf{\Delta}G_{Cl-}\mathbf{=\Delta H_H}\text{–}T^*\mathbf{\Delta S_H}=-167,08-298,15*0,0566=\mathbf{-183,955}\ ^{kJ}/_{mol}$;
$Ag(NH_3)_2^+$	$E^\circ_{Ag(NH3)2+}$	**-0,000725**	**-139,415**	$G_{Ag(NH3)2+}=\Delta\mathbf{G}_{Ag/Ag(NH3)2+}\mathbf{-G_{H2O}}+(G_{Ag}\mathbf{+2}G_{NH3aq})\ =\mathbf{-139,415}\ ^{kJ}/_{mol}$;
AgCl	-	-	**-155,71**	**BioThermodynamic 2006**
AgCl	$\Delta\mathbf{G}_{sp\mathbf{Ag}Cl}\mathbf{=}$	$\mathbf{K}_{sp\mathbf{Ag}Cl}\mathbf{=}$	**-155,714**	$G_{AgCl}\mathbf{=}G_{Ag+}\mathbf{+}G_{Cl-}\mathbf{-(\Delta G_{sp\mathbf{Ag}Cl}+2G_{H2O})=-155,714}\ ^{kJ}/_{mol}$;
Cl-	-	-	**-183,955**	**BioThermodynamic 2006**
$\mathbf{Ag_2O}(s)$	-31,1	121,3	-11,2	CRC;
$\mathbf{Ag_2O}(s)$	$E^\circ_{Ag/\mathbf{Ag2O}}=$	**0,02277**V	**-64,616**	$\mathbf{G_{Ag2O}}=\Delta\mathbf{G}_{Ag/\mathbf{Ag2O}}\mathbf{-G_{H2O}}+(2G_{Ag}\mathbf{+2}G_{OH})=\mathbf{-64,616}\ ^{kJ}/_{mol}$;

Nernsta potenciāla studijas $Hg/Hg_2^{2+}/Hg^{2+}$, Hg_2Cl_2, $Hg_2SO_{4(s)}$, HgO uzskaitot hidroksoniju H_3O^+ un ūdeni H_2O.

Viela	$\Delta H^\circ_{H}, {}^{kJ}/_{mol}$	$\Delta S^\circ_{H}, {}^{J}/_{mol/K}$	$\Delta G^\circ_{H}, {}^{kJ}/_{mol}$	$(E^\circ_{H2O2aqRed}-E^\circ_{HgO})\mathbf{*F*n=(0,5278+0,22423)=0,7520}V$
Hg	HgO ; $\mathbf{H_2O_2}$	75,9	**35,885**	$\mathbf{G_{Hg}}=G_{eqRedOx\_2H2O2}\mathbf{-G_{O2aqua}}+(G_{HgO}+\mathbf{G_{H2O2}})=\mathbf{35,885}{}^{kJ}/_{mol}$;
Hg	$E^\circ_{HgCl2}=$	**-0,1059 V**	**35,8**	$G_{Hg}=(G_{Hg2Cl2}+\mathbf{G_{H2O}}\mathbf{-(2G_{Cl-}}+\Delta\mathbf{G}_{\mathbf{eq}\_Hg2Cl2}))/2=\mathbf{35,8}\ {}^{kJ}/_{mol}$;
Hg_2^{2+}	-166,87	66,74	-146,97	$\mathbf{\Delta}G_{Hg22+}=\mathbf{\Delta H_H-T*\Delta S_H}=-166,87-298,15*0,06674=-146,97\ {}^{kJ}/_{mol}$;
Hg_2^{2+}	$E^\circ_{Hg/Hg22+}=$	**0,6888 V**	**204,52**	$G_{Hg22+}=\Delta\mathbf{G}_{\mathbf{eq}\_Hg}+(2G_{Hg}+\mathbf{G_{H2O}})=\mathbf{132,92}+(2*\mathbf{35,8+0})=\mathbf{204,52}\ {}^{kJ}/_{mol}$;
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**	$G_{Hg2SO4}=G_{\mathbf{Hg22+}}+\mathbf{G_{SO42-}}-(\Delta\mathbf{G}_{\mathbf{eq}}{}_{Hg2SO4}+\mathbf{2G_{H2O}})=\mathbf{-598,44}\ {}^{kJ}/_{mol}$;
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**	$\mathbf{G}_{Hg2Cl2(s)}=\mathbf{\Delta G^\circ}_{Hg2Cl2Form}+(\mathbf{G}_{Hg22+}+2*\mathbf{G}_{Cl-})=\mathbf{197,76}\ {}^{kJ}/_{mol}$;
$Hg_2Cl_{2(s)}$	$E^\circ_{HgCl2}=$	**-0,1059 V**	**255,1**	$G_{Hg2Cl2}=\Delta\mathbf{G}_{\mathbf{eq}\_Hg2Cl2}\mathbf{-2G_{H2O}}+(\mathbf{2G_{Cl-}}+2G_{Hg})=\mathbf{255,1}\ {}^{kJ}/_{mol}$;
$HgCl_{2(s)}$	-224,3	146	-178,6	CRC
Cl-	-167,08	56,6	**-183,955**	$\Delta G_{Cl-}=\mathbf{\Delta H_H-T*\Delta S_H}=-167,08-298,15*0,0566=\mathbf{-183,955}\ {}^{kJ}/_{mol}$;
Cl-	$K_{Absolute\mathbf{Hg2}Cl2}=$	$10^{\wedge(-23,1)}$	**101,97**	$\mathbf{G_{Cl-}}=(-G_{\mathbf{Hg22+}}+\Delta\mathbf{G}_{\mathbf{eq}}{}_{Hg2Cl2}+(G_{Hg2Cl2}+\mathbf{3G_{H2O}}))/2=\mathbf{101,97}\ {}^{kJ}/_{mol}$;
$HgO_{(s)}$	-99,79	70,25	-60,3675	$\mathbf{\Delta}G_{HgO}=\mathbf{\Delta H_H-T*\Delta S_H}=-99,79-298,15*0,07025=2*-60,3675\ {}^{kJ}/_{mol}$;
$HgO_{(s)}$	-90,8	70,3	-58,5	CRC $\mathbf{\Delta}G_{HgO}=-58,5\ {}^{kJ}/_{mol}$;
$HgO_{(s)}$	-	formation	**142,3**	$\mathbf{2G}_{HgO}=2\mathbf{\Delta G}_{HgO}+(2*G_{Hg}+G_{O2})=2*\mathbf{142,3}\ {}^{kJ}/_{mol}$
$HgO_{(s)}$	$E^\circ_{HgO}=$	**0,22423 V**	**147,25**	$G_{HgO}=\mathbf{\Delta}G_{eqHgO}-2G_{H2O}+(G_{Hg}+2G_{OH})=\mathbf{147,15}\ {}^{kJ}/_{mol}$;

$2\underline{Hg+}H_2O=Hg_2^{2+}+2e^-$; absolūtais standarta potenciāls $E^\circ_{Hg}=\mathbf{0,6888}$ V; Kortly, Shucha ; [18]

$E^\circ_{Hg}=E^\circ-0,0591/2*\lg(1/[H_2O]^1)+0,10166-0,37239=0,907-0,0591/2*\lg(1/55,3^{\wedge 1})+0,10166-0,37239=\mathbf{0,6888}$ V;

$\Delta\mathbf{G}_{\mathbf{eq}\_Hg}=E^\circ_{Hg}\bullet F\bullet 2=\mathbf{0,6888}*96485*2=\mathbf{132,92}\ {}^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}\_Hg}=G_{Hg22+}\mathbf{-(}2G_{Hg}+\mathbf{G_{H2O}})=G_{Hg22+}\mathbf{-(}2*\mathbf{35,8+0})=\mathbf{204,52-(}2*\mathbf{35,8+0})=\mathbf{132,92}\ {}^{kJ}/_{mol}$;

$G_{Hg22+}=\Delta\mathbf{G}_{\mathbf{eq}\_Hg}\mathbf{+(}2G_{Hg}+\mathbf{G_{H2O}})=\mathbf{132,92}+(2*\mathbf{35,8+0})=\mathbf{204,52}\ {}^{kJ}/_{mol}$;

Šķīdības līdzsvara $Hg_2Cl_{2(s)}+3H_2O=\mathbf{Hg}_2^{2+}+2Cl^-$; $2\underline{Hg+}H_2O=Hg_2^{2+}+2e^-$; absolūtā šķīdības konstante :

$K_{Absolute\mathbf{Hg2}Cl2}=K_{sp\mathbf{Hg2}Cl2}/[H_2O]^{\wedge 3}=[\mathbf{Hg}_2^{2+}]*[Cl^-]^2/[Hg_2Cl_{2(s)}]/[H_2O]^{\wedge 3}=1,43*10^{\wedge(-18)}/1/55,3^{\wedge}3=10^{-23,1}$;

$\Delta\mathbf{G}_{\mathbf{eqHg2}Cl2}\mathbf{=-R\bullet T\bullet ln(}K_{Absolute\mathbf{Hg2}Cl2}\mathbf{)=-8,314*298,15*ln(}10^{\wedge(-23,1)}\mathbf{)=131,85}\ {}^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{Hg2Cl2}=G_{\mathbf{Hg22+}}\mathbf{+2G_{Cl-}-(}G_{Hg2Cl2}+\mathbf{3G_{H2O}})=\mathbf{204,52+2G_{Cl-}-(276,61}+3*\mathbf{0)=204,52}+2*\mathbf{101,97-(276,61}+3*\mathbf{0)=131,85}\ {}^{kJ}/_{mol}$;

$\mathbf{G_{Cl-}}=(-G_{\mathbf{Hg22+}}+\Delta\mathbf{G}_{\mathbf{eq}}{}_{Hg2Cl2}+(G_{Hg2Cl2}+\mathbf{3G_{H2O}}))/2=(\mathbf{-204,52}+\mathbf{131,85}+(\mathbf{276,61}+3*\mathbf{0}))/2=\mathbf{101,97}\ {}^{kJ}/_{mol}$;

$Hg_2^{2+}+2Cl^-=Hg_2Cl_{2(s)}$; $\mathbf{G}_{Hg2Cl2(s)}=\mathbf{\Delta G^\circ}_{Hg2Cl2Form}+(\mathbf{G}_{Hg22+}+2*\mathbf{G}_{Cl-})=-210,7+(\mathbf{204,52}+2*\mathbf{101,97})=\mathbf{197,76}\ {}^{kJ}/_{mol}$;

Veidošanās $Hg_2^{2+}+2Cl^-$; $\mathbf{G}_{Hg2Cl2(s)}=\mathbf{G}_{Hg2Cl2(s)}-(\mathbf{G}_{Hg22+}+2*\mathbf{G}_{Cl-})=\mathbf{276,61-(204,52}+2*\mathbf{101,97)=-131,85}\ {}^{kJ}/_{mol}$;

$2\underline{Hg}+2Cl^-=Hg_2Cl_{2(s)}+2H_2O+2e^-$; absolūtais standarta potenciāls $E^\circ_{HgCl2}=\mathbf{-0,1059}$ V; Suchotina ; [18]

$E^\circ_{HgCl2}=E^\circ-0,0591/2*\lg([H_2O]^2)+0,10166-0,37239=0,2678-0,0591/2*\lg(55,3^{\wedge 2})+0,10166-0,37239=\mathbf{-0,1059}$ V;

$\Delta\mathbf{G}_{\mathbf{eq}\_Hg2Cl2}=E^\circ_{Hg2Cl2}\bullet F\bullet 2=\mathbf{-0,1059}*96485*2=\mathbf{-20,44}\ {}^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}\_Hg2Cl2}=G_{Hg2Cl2}\mathbf{+2G_{H2O}-(2G_{Cl-}}+2G_{Hg})=\mathbf{255,1+2*0-(}2*\mathbf{101,97}+2*\mathbf{35,8)=-20,44}\ {}^{kJ}/_{mol}$;

$G_{Hg2Cl2}=\Delta\mathbf{G}_{\mathbf{eq}\_Hg2Cl2}\mathbf{-2G_{H2O}+(2G_{Cl-}}+2G_{Hg})=\mathbf{-20,44}-2*\mathbf{0}+(2*\mathbf{101,97}+2*\mathbf{35,8)=255,1}\ {}^{kJ}/_{mol}$;

$G_{Hg}=(G_{Hg2Cl2}+\mathbf{G_{H2O}-(2G_{Cl-}}+\Delta\mathbf{G}_{\mathbf{eq}\_Hg2Cl2}))/2=(\mathbf{255,1+0-(}2*\mathbf{101,97-20,44}))/2=\mathbf{35,8}\ {}^{kJ}/_{mol}$;

Šķīdības līdzsvara $Hg_2SO_{4(s)}+2H_2O=\mathbf{Hg}_2^{2+}+SO_4^{2-}$; $2\underline{Hg+}2H_2O=Hg_2^{2+}+2e^-$; absolūtā šķīdības konstante :

$K_{Absolute\mathbf{Hg2}SO4}=K_{sp\mathbf{Hg2}SO4}/[H_2O]^{\wedge 2}=[\mathbf{Hg}_2^{2+}]*[SO_4^{2-}]/[Hg_2SO_{4(s)}]/[H_2O]^{\wedge 2}=6,5*10^{\wedge(-7)}/1/55,3^{\wedge}2=10^{--9,673}$;

$\Delta\mathbf{G}_{\mathbf{eqHg2}SO4}\mathbf{=-R\bullet T\bullet ln(}K_{Absolute\mathbf{Hg2}SO4}\mathbf{)=-8,314*298,15*ln(}10^{\wedge(-9,673)}\mathbf{)=55,21}\ {}^{kJ}/_{mol}$;

$\Delta\mathbf{G}_{\mathbf{eq}}{}_{Hg2SO4}=G_{\mathbf{Hg22+}}+\mathbf{G_{SO42-}}-(G_{Hg2SO4}+\mathbf{2G_{H2O}})=\mathbf{204,52-747,75-(-598,44}+2*\mathbf{0)=55,21}\ {}^{kJ}/_{mol}$;

$G_{Hg2SO4}=G_{\mathbf{Hg22+}}+\mathbf{G_{SO42-}}-(\Delta\mathbf{G}_{\mathbf{eq}}{}_{Hg2SO4}+\mathbf{2G_{H2O}})=\mathbf{204,52-747,75-(55,21}+2*\mathbf{0)=-598,44}\ {}^{kJ}/_{mol}$;

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

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

$2\underline{Hg}+SO_4^{2-}=Hg_2SO_{4(s)}+H_2O+2e^-$; absolūtais standarta potenciāls $E^\circ_{HgSO4}=\mathbf{0,291772}$ V; Kortly, Shucha ; [18]

$E^\circ_{HgSO4}=E^\circ-0,0591/2*\lg([H_2O]^1)+0,10166-0,37239=0,614-0,0591/2*\lg(55,3^{\wedge 1})+0,10166-0,37239=\mathbf{0,2918}$ V;

$\Delta\mathbf{G}_{\mathbf{eq}\_HgSO4}=E^\circ_{HgSO4}\bullet F\bullet 2=\mathbf{0,291772}*96485*2=\mathbf{56,30}\ {}^{kJ}/_{mol}$,

$\Delta\mathbf{G}_{\mathbf{eq}\_Hg2SO4}=G_{Hg2SO4}\mathbf{-(}2G_{Hg}+\mathbf{G}_{SO4})=\mathbf{-598,44-(}2*\mathbf{35,8-726,54)=56,50}{}^{kJ}/_{mol}$;

$\mathbf{G}_{SO4}=G_{Hg2SO4}\mathbf{-(}2G_{Hg}+\Delta\mathbf{G}_{\mathbf{eq}\_Hg2SO4})=\mathbf{-598,44-(}2*\mathbf{35,8+56,3)=-726,54}\ {}^{kJ}/_{mol}$;

Veidošanās $2Hg+\mathbf{O_2}{}_{aqua}=2HgO$; $\mathbf{2G}_{HgO}=2\mathbf{\Delta G}_{HgO}+(2*G_{Hg}+G_{O2})=2*-58,5+(2*\mathbf{35,8+330})=2*\mathbf{142,3}{}^{kJ}/_{mol}$;

$Hg+2OH^-=HgO+H_2O+2e^-$, Nernsta absolūtais standarta potenciāls $E^\circ_{HgO}=\mathbf{-0,2242}$ V;

$E^\circ_{HgO}=E^\circ-0,0591/2*\lg([H_2O]^1)+0,10166-0,37239=0,098-0,0591/2*\lg(55,3\hat{}^{1})+0,10166-0,37239=\mathbf{-0,22423}$ V;

$\Delta G_{eqHgO}=E^\circ_{HgO}*\mathbf{F*n}=\mathbf{-0,22423}*96485*2=\mathbf{-43,27}$ $^{kJ}/_{mol}$;

$\Delta G_{eqHgO}=G_{HgO}+G_{H2O}-(G_{Hg}+2G_{OH})=G_{HgO}+\mathbf{0}-(\mathbf{35,8}+2*77,36)=\mathbf{147,25}+\mathbf{0}-(\mathbf{35,8}+2*77,36)=\mathbf{-43,27}$ $^{kJ}/_{mol}$;

$G_{HgO}=\Delta G_{eqHgO}-G_{H2O}+(G_{Hg}+2G_{OH})=\mathbf{-43,27-0}+(\mathbf{35,8}+2*77,36)=\mathbf{147,25}$ $^{kJ}/_{mol}$;

Reducēšanas $HgO+2H_2O+2e^-=Hg+2OH^-$, inversais standarta potenciāls $-E^\circ_{HgO}=\mathbf{0,22423}$ V.

Oksidēšanas $\mathbf{H_2O_{2aqua}+2H_2O=O_{2aqua}+2H_3O^++2e^-}$ Nernsta absolūtais standarta potenciāls $E^\circ_{\mathbf{Red}H2O2}=0,5278$ V;

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

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

Summā: $HgO+\mathbf{H_2O_{2aqua}}=Hg+\mathbf{O_{2aqua}}$; katalāze $G_{H2O2}=\mathbf{279,285}$ $^{kJ}/_{mol}$;

$\Delta G_{eqRedOx\_H2O2}=(E^\circ_{H2O2aqRed}-E^\circ_{HgO})*\mathbf{F*n}=(\mathbf{0,5278+0,22423})*96485*2=(\mathbf{0,7520})*96485*2=\mathbf{145,1}$ $^{kJ}/_{mol}$;

$\Delta G_{eqRedOx\_H2O2}=G_{Hg}+G_{O2aqua}-(G_{HgO}+G_{H2O2})=\mathbf{35,885+330}-(-58,5+\mathbf{279,285})=\mathbf{145,1}$ $^{kJ}/_{mol}$;

HgO ; $G_{Hg}=G_{eqRedOx\_H2O2}-G_{O2aqua}+(G_{HgO}+G_{H2O2})=\mathbf{145,1-330}+(-58,5+\mathbf{279,285})=\mathbf{35,885}$ $^{kJ}/_{mol}$;

$\Delta G_{eqRedOx\_H2O2}=G_{Hg}-G_{O2aqua}+(G_{HgO}+G_{H2O2})=$

Substance	ΔH°_H, $^{kJ}/_{mol}$	ΔS°_H, $^{J}/_{mol/K}$	ΔG°_H, $^{kJ}/_{mol}$	**Biochem. Thermodynamic 2006** Massachusetts Technology Inst.
Pb	$E^\circ_{Pb\downarrow Pb2+}=$	**-0,34523 V**	**-349,07**	$G_{Pb}=G_{Pb2+}-(\Delta G_{eqPb\downarrow Pb2+}+G_{H2O})=\mathbf{-415,895}-(\mathbf{-66,42+0})=\mathbf{-349,07}$ $^{kJ}/_{mol}$;
Pb	-	64,8	-	
Pb^{2+}	$E^\circ_{PbO2\downarrow Pb2+}=$	**1,49326 V**	**-415,69**	$G_{Pb2+}=G_{PbO2}+4G_{H3O+}-(\Delta G_{eqPbO2\downarrow Pb2+}+6G_{H2O})=\mathbf{-415,69}$ $^{kJ}/_{mol}$;
Pb^{2+}	0,92	18,5	-4,596	$\Delta G^\circ_{Pb2+}=\Delta H^\circ_H-T*\Delta S^\circ_H=0,92-298,15*0,0185=-4,596$ $^{kJ}/_{mol}$;
$PbO_2\downarrow$	-277,4	68,6	-217,3	CRC
$PbO_2\downarrow$	$E^\circ_{PbO2\downarrow Pb2+}=$	**1,49326 V**	**-217,3**	$G_{PbO2}=\Delta G_{eqPbO2\downarrow Pb2+}-4G_{H3O+}+(G_{Pb2+}+6G_{H2O})=\mathbf{-217,3}$ $^{kJ}/_{mol}$;
Al	-	28,3	-	
Al	$E^\circ_{Al/Al3+}=$	**-1,8984 V**	**108**	$G_{Al}=G_{Al3+}-(\Delta G_{eqAl/Al3+}+G_{H2O})=\mathbf{-441,5-(-549,5+0)=108}$ $^{kJ}/_{mol}$;
Al^{3+}	-538,4	-325	**-441,5**	$\Delta G^\circ_{Pb2+}=\Delta H^\circ_H-T*\Delta S^\circ_H=-538,4-298,15*-0,325=\mathbf{-441,5}$ $^{kJ}/_{mol}$;
$H_2AlO_3^-$	$E^\circ_{H2AlO3Al}=$	**-2,63506**	**-345,29**	$G_{H2AlO3}=\Delta G_{eqH2AlO3Al}-G_{H2O}+(G_{Al}+4G_{OH})=\mathbf{-345,29}$ $^{kJ}/_{mol}$;
$NaAlO_2\downarrow$	-1133,2	70,4	-	CRC

Veidošanās $Pb+O_{2gas}=PbO_2(s)$; $\mathbf{G}_{PbO2}=\mathbf{\Delta G}_{PbO2}+(G_{Pb}+G_{O2gas})=-217,3+(\mathbf{35,8+303,1})=2*\mathbf{142,3}$ $^{kJ}/_{mol}$;

$Pb^{2+}+6H_2O=PbO_2(s)+4H_3O^++\mathbf{2e^-}$; Nernsta pus reakcijas absolūtais standarta potenciāls $E^\circ_{PbO2}=\mathbf{1,49326\ V}$;

$E^\circ_{PbO2}=E^\circ-0,0591/2*\lg(1/[H_2O]^6)+0,10166-0,37239=1,455-0,0591/2*\lg(1/55,3\hat{}^{6})+0,10166-0,37239=\mathbf{1,49326\ V}$;

$\mathbf{\Delta G_{eq}}_{PbO2\downarrow Pb2+}=E^\circ_{PbO2\downarrow Pb2+}\bullet F\bullet 3=\mathbf{1,49326}*96485*3=\mathbf{288,15}$ $^{kJ}/_{mol}$;

$\mathbf{\Delta G_{eq}}_{PbO2\downarrow Pb2+}=G_{PbO2}+4G_{H3O+}-(G_{Pb2+}+6G_{H2O})=-217,3+4*\mathbf{22,44}-(\mathbf{-415,69+6*0})=\mathbf{288,15}$ $^{kJ}/_{mol}$;

$G_{PbO2}=\mathbf{\Delta G_{eq}}_{PbO2\downarrow Pb2+}-4G_{H3O+}+(G_{Pb2+}+6G_{H2O})=\mathbf{288,15}-4*\mathbf{22,44}+(\mathbf{-415,69+6*0})=\mathbf{-217,3}$ $^{kJ}/_{mol}$;

$G_{Pb2+}=G_{PbO2}+4G_{H3O+}-(\mathbf{\Delta G_{eq}}_{PbO2\downarrow Pb2+}+6G_{H2O})=\mathbf{-217,3}+4*\mathbf{22,44}-(\mathbf{288,15}+6*\mathbf{0})=\mathbf{-415,69}$ $^{kJ}/_{mol}$;

$$E_{PbO2\downarrow/Pb2+}=E^\circ_{PbO2\downarrow Pb2+}+\frac{0.0591}{2}\bullet\lg\frac{[PbO_2\downarrow]\cdot[H_3O^+]^4}{[Pb^{2+}]\cdot[H_2O]^6}=\mathbf{1,4674}\text{ V}+\frac{0.0591}{2}\bullet\lg\frac{[PbO_2\downarrow]\cdot[H_3O^+]^4}{[Pb^{2+}]\cdot[H_2O]^6};$$

$Pb+H_2O=Pb^{2+}+2e^-$; pH<7 Nernsta pus reakcijas absolūtais standarta potenciāls $E^\circ_{Pb/Pb2+}=\mathbf{-0,3452}$ V;

$E^\circ_{Pb/Pb2+}=E^\circ-0,0591/2*\lg(1/[H_2O])+0,10166-0,37239=-1,26-0,0591/2*\lg(1/55,3\hat{}^{1})+0,10166-0,37239=\mathbf{-0,3452}$ V;

$\mathbf{\Delta G_{eq}}_{Pb\downarrow Pb2+}=E^\circ_{Pb\downarrow Pb2+}*\mathbf{F*n}=\mathbf{-0,34523}*96485*2=\mathbf{-66,62}$ $^{kJ}/_{mol}$;

$\mathbf{\Delta G_{eq}}_{Pb\downarrow Pb2+}=G_{Pb2+}-(G_{Pb}+G_{H2O})=\mathbf{-415,69}-(G_{Pb}+\mathbf{0})=\mathbf{-71,59=-66,62}$ $^{kJ}/_{mol}$;

$G_{Pb}=G_{Pb2+}-(\mathbf{\Delta G_{eq}}_{Pb\downarrow Pb2+}+G_{H2O})=\mathbf{-415,69}-(\mathbf{-66,62+0})=\mathbf{-349,07}$ $^{kJ}/_{mol}$;

$Al+H_2O=Al^{3+}+3e^-$; CRC Nernsta pus reakcijas absolūtais standarta potenciāls $E^\circ_{Pb/Pb2+}=\mathbf{-1,8984}$ V;

$E^\circ_{Al/Al3+}=E^\circ-0,0591/3*\lg(1/[H_2O])+0,10166-0,37239=-1,662-0,0591/3*\lg(1/55,3\hat{}1)+0,10166-0,37239=\mathbf{-1,8984}$ V;

$\mathbf{\Delta G_{eq}}_{Al/Al3+}=E^\circ_{Al/Al3+}\bullet F\bullet 3=\mathbf{-1,8984}*96485*3=\mathbf{-549,5}$ $^{kJ}/_{mol}$;

$\mathbf{\Delta G_{eq}}_{Al/Al3+}=G_{Al3+}-(G_{Al}+G_{H2O})=\mathbf{-441,5-(108+0)=-549,5}$ $^{kJ}/_{mol}$;

$G_{Al}=G_{Al3+}-(\mathbf{\Delta G_{eq}}_{Al/Al3+}+G_{H2O})=\mathbf{-441,5-(-549,5+0)=108}$ $^{kJ}/_{mol}$;

$Al+4OH^-=H_2AlO_3^-+H_2O+3e^-$; CRC Nernsta absolūtais standarta potenciāls $E^\circ_{H2AlO3-Al}=\mathbf{-2,63506}$ V;

$E^\circ_{H2AlO3-Al}=E^\circ-0,0591/3*\lg([H_2O])+0,10166-0,37239=-2,33-0,0591/3*\lg(55,3\hat{}1)+0,10166-0,37239=\mathbf{-2,63506}$ V;

$\mathbf{\Delta G_{eq}}_{H2AlO3Al}=E^\circ_{H2AlO3Al}\bullet F\bullet 3=\mathbf{-2,63506}*96485*3=\mathbf{-762,73}$ $^{kJ}/_{mol}$;

$\mathbf{\Delta G_{eq}}_{H2AlO3Al}=G_{H2AlO3}+G_{H2O}-(G_{Al}+4G_{OH})=\mathbf{-345,29}+0-(\mathbf{108+4*77,36})=\mathbf{-762,73}$ $^{kJ}/_{mol}$;

$G_{H2AlO3}=\mathbf{\Delta G_{eq}}_{H2AlO3Al}-G_{H2O}+(G_{Al}+4G_{OH})=\mathbf{-762,73}-0+(\mathbf{108}+4*77,36)=\mathbf{-345,29}$ $^{kJ}/_{mol}$;

$$E_{AlO2-/Al\downarrow}=E^\circ_{AlO2-/Al\downarrow}+\frac{0.0591}{3}\bullet\lg\frac{[H_2AlO_3^-]\cdot[H_2O]}{[Al]\cdot[OH^-]^4}=\mathbf{-2,63506}\text{ V}+\frac{0.0591}{3}\bullet\lg\frac{[H_2AlO_3^-]\cdot[H_2O]}{[Al]\cdot[OH^-]^4};$$

Liela ātruma protolīzes Aktivēto peroksīda jonu sadursmē **HOO^-**><**^-OOH** ir liela **Ea**=79000 $^J/_{mol}$ aktivācijas enerģija, bet jonu **HOO^-=>Fe^{3+}** sadursmē aktivācijas enerģija ir maza **E_a**=29 $^J/_{mol}$. Elongācija peroksisomās producē ω=6, ω=3 neaizstājamās taukskābes, skābekli, ūdeni un siltumu: **$2H_2O_{2aq}=O_{2aqua}+2H_2O+Q+\Delta G_H$** ;

Red: $H_2O_2+2H_2O=O_2+2H_3O^++2e^-$; **$E°_{H2O2}$=0,5268** V Nernsta absolūtais potenciāls Alberta University;

Ox: $H_2O_2+2H_3O^++2e^-=4H_2O$; **-E° $_{OxH2O2}$=-1,7113** V inversais standarta potenciāls Suhotina ;

$\Delta G_{eqStandarta\_2H2O2}$=($E^\circ_{H2O2aqRed}$-$E^\circ_{H2O2aqOx}$)***F*n**=(**0,5268-1,7113**)*96485*2=(**-1,1845**)*96485*2=**-228,57** $^{kJ}/_{mol}$;

$\Delta G_{Alberty\_2H2O2}$=G_{O2aqua}+2*G_{H2O}-2*G_{H2O2}=**330+2*0-**2*G_{H2O2}=**-228,57** $^{kJ}/_{mol}$; **exoergic**

G_{H2O2}=(G_{O2aqua}+2*G_{H2O}+$\Delta G_{Alberty\_2H2O2}$)/2=(**330+2*0+228,57**)/2=**558,57**/2=**279,285** $^{kJ}/_{mol}$;

$$K_{eqStandart}=\frac{[O_2]_{aqua}\cdot[H_2O]^2}{[H_2O_2]^2_{aqua}}=K_{H2O2}=\exp(228573/8{,}3144/298{,}15)=1{,}11*10^{40}.$$

Pus reakciju RedOx Nernsta reducēšanas un oksidēšanas elektronu balanss 2 e^- pie pH=7,36, [O_{aq}]=6*10^{-5} M.

E_{Red}=$E°_{H2O2}$+0,0591/2•lg([O_{2aqua}]*[H_3O^+]^2/[H_2O_2]/[H_2O]^2)=**0,5268**+0,0591/2*lg(6*10$^{\wedge(-5)}$*10$^{\wedge(-7,36*2)}$/1/55,3$^{\wedge 2}$)=-0,13493 V;

E_{Ox}=-$E°_{H2O2Ox}$+0,0591/2•log([H_2O_2]*[H_3O^+]^2/[H_2O]^4)=**-1,7113**+0,0591/2*lg(1*10$^{\wedge(-7,36*2)}$/55,3$^{\wedge 4}$)=-1,0703 V;

H_2O_2 izmaiņa ir Δ**G**$_{Homeostasis}$/2=(E_{Red}-E_{oOx})***F*n**/2=(-0,13493-1,0703)*96485=(**-1,2062**)*96485=**-232,76** $^{kJ}/_{mol}$;

$G_{HomeostasisH2O2}$=($G_{O2Biochem\_arteriaj}$+2*$G_{H2OBioChemistry}$-$\Delta G_{Alberty}$)/2=(**88,04+2*85,64+232,76**)/2=**246,04** $^{kJ}/_{mol}$

Viela	$\Delta H°_H$, $^{kJ}/_{mol}$	$\Delta S°_H$, $^J/_{mol/K}$	$\Delta G°_H$, $^{kJ}/_{mol}$
H_3O^+	-285,81	-3,854	-213,275
O_{2aqua}	-11,715	110,876	16,4
O_{2aqua}	**-11,70**	**-94,2**	**16,40**
H_2O	-285,85	69,9565	-237,191
H_2O	**-286,65**	**-453,188**	**-151,549**
H_2O_{2aq}	**-191,99**	**-481,688**	**-48,39**
H_2O_{2aq}	-191,17	143,9	-134,03
H_2O_{2aq}	Formation	**-48,39**	**340,25**
H_2O_{2aq}	Formation	-134,03	**254,61**
H_2O_{2aq}	ΔE°_{H2O2aq}=	**1,1845 V**	**279,285**
HOO^-	pK_a=11,75	**77,016**	**333,866**
$H_2O_{2\,l}$	-237,129	69,91	-237,129

G_{H2O2}=**279,285** $^{kJ}/_{mol}$; G_{HOO-}=**333,866** $^{kJ}/_{mol}$;

Mischenko 1972, Himia, Leningrad [26]

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

ΔH_{Hess}=$\Delta H°_{O2}$+2$\Delta H°_{H2O}$-2$\Delta H°_{H2O2}$=-201,02=-201,06 $^{kJ}/_{mol}$

=**-11,7**-2***286,65**-(2***-191,99**)=**-201,02** $^{kJ}/_{mol}$ **eksotermiska**.

=-11,7-2*285,85-(2*-191,17)=-201,06 $^{kJ}/_{mol}$

Biochem.Thermodynamic 2006 Massachusetts Technology Inst.

University Alberta 1997.

G_{H2O2aq}=$\Delta G_{H2O2Alberty}$+(G_{O2gas}+G_{H2gas}+G_{H2O})=**340,25** $^{kJ}/_{mol}$;

G_{H2O2aq}=$\Delta G_{H2O2Alberty}$+(G_{O2gas}+G_{H2gas}+G_{H2O})=**254,61** $^{kJ}/_{mol}$;

G_{H2O2}=(G_{O2aqua}+2*G_{H2O}+$\Delta G_{Alberty\_2H2O2}$)/2=**279,285** $^{kJ}/_{mol}$;

G_{HOO-}=-G_{H3O+}+ΔG_{aH2O2}+(G_{H2O2}+G_{H2O})=**333,866** $^{kJ}/_{mol}$;

CRC

$H_2O_2+H_2O=H_3O^++HOO^-$; pK_a=11,75; G_{H2O2}=**279,29** $^{kJ}/_{mol}$; G_{HOO-}=**333,866** $^{kJ}/_{mol}$;

ΔG_{aH2O2}=**-R•T•ln(K_a/[H_2O])**=-8,3144*298,15*ln(10$^{\wedge(-11,75)}$/55,3)=**-8,3144*298,15*-31,07=77,016** $^{kJ}/_{mol}$;

ΔG_{aH2O2}=G_{H3O+}+G_{HOO-}-(G_{H2O2}+G_{H2O})=22,44+G_{HOO-}-(**279,29+0**)=**77,016** $^{kJ}/_{mol}$;

G_{HOO-}=-G_{H3O+}+ΔG_{aH2O2}+(G_{H2O2}+G_{H2O})=-22,44+**77,016**+(**279,29+0**)=**333,866** $^{kJ}/_{mol}$;

$HOO^-+H_2O=O_{2aqua}+H_3O^++2e^-$; Absolūtajā skalā peroksīda anjona standarta potenciāls ir: $E^\circ_{NernstHOO-}$=**0,09625** V.

$\Delta G_{NernstHOO-}$=G_{O2aqua}+G_{H3O+}-(G_{HOO-}+G_{H2O})=**330**+22,44-(**333,866+0**)=**18,574** $^{kJ}/_{mol}$;

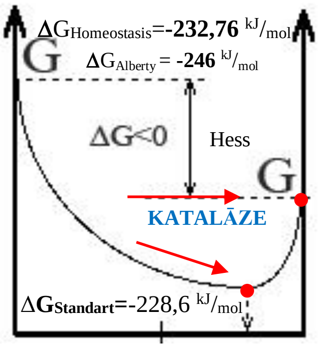
$E°_{HOOOx}$=E°-0,0591/2*lg(1/[H_2O]^1)+0,10166-0,37=**0,31548**-0,02955*lg(1/55,3$^{\wedge 1}$)+0,10166-0,37239=**0,09625** V;

$E°_{HOO-}$=E°+ 0,37239=**0,09625**+0,37239=**0,46864** V; $E°_{HOO-}$=**0,46864**-0,10166=**0,36698** V;

$E°_{HOO-}$=**0,36698**+0,0591/2*log(1/55,3$^{\wedge 1}$)=**0,31548** V;

Nernsta pus reakcijas absolūtais standarta potenciāls ir:

$E^\circ_{NernstHOO-}$=$\Delta G_{NernstHOO-}$/F/1=**18574**/96485/2=**0,09625** V.



A+A 50% B+2C

izejvielas 2**$H_2O_{2(aq)}$**

produkti_**$O_{2aqua}+2H_2O$**

Eksotermiska, eksoerģiska **H_2O_2** (aq) dismutēšanas Hesa izmaiņa $\Delta G_{Alberty\_2H2O2}$, **-246** $^{kJ}/_{mol}$ un homeostāzē Δ**G**$_{Homeostasis}$ **-232,76** $^{kJ}/_{mol}$ ir negatīva, bet standarta līdzsvaru maisījumā minimizējas Δ**G**$_{eqStandart}$**=-228,6** $^{kJ}/_{mol}$ sasniedzot konstanti: **K_{eq}**=1,11*****10^{40}.

Lešateljē princips ir Prigožina atraktors kā brīvās enerģijas izmaiņas minimums ΔG_{min} līdzsvarā. Liela ātruma protolīzes atraktori pH=7,36, skābeklis 20,95% gaisā atrodas līdzsvara stāvoklī, kamēr neatgriezeniskā homeostāze turpinās, jo ir nelīdzsvara stāvoklis. Prigožina atraktors ir Nobela prēmija ķīmijā 1977. gadā. KATALĀZE izdzēš peroksīda molekulas **H_2O_2** sasniedzot 100% ω=6, ω=3 taukskābju C20:4 iznākumam elongācijas sintēzē peroksisomās. KATALĀZES reaktivitāte ir nepieciešams neatgriezeniskas homeostāzes Brauna molekulārs dzinējs evolūcijai un izdzīvošanai.

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

Catalase; G_{H2O2aq}=$\Delta G_{H2O2Alberty}$+(G_{O2gas}+G_{H2gas}+G_{H2O})=-134,03**+(85,64+303+0)=254,61** $^{kJ}/_{mol}$;

Catalase; G_{H2O2aq}=$\Delta G_{H2O2Alberty}$+(G_{O2gas}+G_{H2gas}+G_{H2O})=**-48,39+(85,64+303+0)=340,25** $^{kJ}/_{mol}$;

41st,54th page [1,8,20] Δ**G**$^\circ_{UnivAlberta}$=-134,03 $^{kJ}/_{mol}$; Δ**G**$^\circ_{Alberty}$=**-48,39** $^{kJ}/_{mol}$;

Šķīdība $N_{2gas}+H_2O+\Delta G=N_{2aq}$ palielina slāpekļa enerģiju molā no $G_{N2gas}=-9,55\ ^{kJ}/_{mol}$ līdz $G_{N2aq}=18,7\ ^{kJ}/_{mol}$.

Publicētā Albertija slāpekļa šķīdumā **absolūtā** brīvā enerģija vienā molā ir $G_{N2aqua}=18,7\ ^{kJ}/_{mol}$, ja tīras gāzes mol daļa ir viens $[N_{2gas}]=1$. [8] Ūdenī Elements slāpeklis $N_{2gas}+H_2O=N_{2aqua}$ ir vāji šķīstošs ar 0,00175 $^{g}/_{100g\_H2O}$ izšķīdināto daudzumu $[N_{2aqua}]=0,00175/100,00175*996=0,01743/28,02=10^{-3,206}$ M un blīvumu 996 g/L. [1] Šķīdības konstante mol daļās ir mazāka par vienu $K_{sp}=[N_{2aqua}]/[H_2O]=10^{\wedge(-3,206)}/55,3=10^{-4,949}$, kuras brīvās enerģijas izmaiņa ir endoerģiska:

$$\Delta G_{sp}=-R\bullet T\bullet \ln(K_{sp})=-8,3144*298,15*\ln(10^{\wedge(-4,949)})=28,25\ ^{kJ}/_{mol}\ .$$

Hesa likuma brīvās enerģijas izmaiņa ir $\Delta G_{Hess\_sp\_N2aqua}=G_{N2aqua}-(G_{N2gas}+G_{H2O})=18,7-(G_{N2gas}-0)=28,25\ ^{kJ}/_{mol}$ sakrītoša absolūtajā enerģijas skalā. Mola $G_{N2gas}=G_{N2aqua}-(\Delta G_{Hess\_sp\_N2aqua}+G_{H2O})=18,7-(28,25+0)=-9,55\ ^{kJ}/_{mol}$ slāpekļa gāzes enerģijas saturs ir negatīvs relatīvi zem destilētā ūdens nulles $G_{H2O}=0\ ^{kJ}/_{mol}$. Izšķīdināta slāpekļa mola enerģijas saturs $G_{N2aqua}=18,7\ ^{kJ}/_{mol}$ ir pozitīvs.

Prigožina enerģijas izmaiņa šķīdināto produktu reakcijās ir sakrītoši ar Hesa likuma brīvās enerģijas izmaiņām Albertija datos: $\Delta G_{Hess\_sp\_N2aqua}=G_{N2aqua}-(G_{N2gas}+G_{H2O})=18,7-(G_{N2gas}-0)=28,25\ ^{kJ}/_{mol}$.
Slāpekļa gāzes brīvās enerģijas saturs izteiksmē ir negatīvs pret ūdens nulles atskaiti $G_{H2O}=0\ ^{kJ}/_{mol}$ skalā:

$$G_{N2gas}=G_{N2aqua}-(\Delta G_{Hess\_sp\_N2aqua}+G_{H2O})=18,7-(28,25+0)=-9,55\ ^{kJ}/_{mol}\ .$$

$$\Delta G_{spN2aqua}=G_{N2aqua}-(G_{N2gas}+G_{H2O})=18,7-(-9,55+0)=28,25\ ^{kJ}/_{mol};$$ [8] Albertijs

Viela	$\Delta H°_H\ ^{kJ}/_{mol}$	$\Delta S°_H\ ^{J}/_{mol/K}$	$\Delta G°_H\ ^{kJ}/_{mol}$
N_{2gas}	$G_{N2gas}=$	form NH_3	**107,2**
N_{2aq}	**–10,54**	**98,1**	**18,7**
N_{2gas}	$N_{2gas}+H_2O$	$=N_{2aq}$	**-9,55**

$G_{N2gas}=2G_{NH3gas}-(2\Delta G_{Hess\_NH3gas}+3*G_{H2gas})=107,28\ ^{kJ}/_{mol}$;

$G_{N2gas}=2*165,6593-(-32,8+3*\underline{85,64})=107,28\ ^{kJ}/_{mol}$; [1,8];

Šķīdums N_{2aq} pie pH=7,36 [8].

$G_{N2gas}=G_{N2aqua}-(\Delta G_{Hess\_šķ\_N2aqua}+G_{H2O})=18,7-(28,25+0)=-9,55\ ^{kJ}/_{mol}$;

Veidošanās no akva elementiem $N_{2aq}+3H_{2aq}>2NH_{3aq}$ ar absolūto enerģiju $G_{N2aq}=18,7\ ^{kJ}/_{mol}$; $G_{H2aq}=103,2\ ^{kJ}/_{mol}$ uzrāda eksoerģisku reakciju $2\Delta G_{Hess\_NH3aq}=2G_{NH3aq}-(G_{N2aq}+3*G_{H2aq})=2*91,1056-(18,7+3*103,24)=-146,2\ ^{kJ}/_{mol}$. [8] Veidošanās no elementiem $N_{2gas}+3H_{2gas}>2NH_{3gas}$ dod $G_{N2gas}=-9,55\ ^{kJ}/_{mol}$; $G_{H2gas}=85,64\ ^{kJ}/_{mol}$ ir eksoerģiska $2\Delta G_{Hess\_NH3gas}=2G_{NH3gas}-(G_{N2gas}+3*G_{H2gas})=2G_{NH3gas}-(-9,55+3*85,64)=2*-16,4=-32,8\ ^{kJ}/_{mol}$. [1] Enerģijas saturs molā NH_{3gas} ir $2G_{NH3gas}=2\Delta G_{Hess\_NH3gas}+(G_{N2gas}+3*G_{H2gas})=2*-16,4+(-9,55+3*85,64)=214,57=2*107,285\ ^{kJ}/_{mol}$.
Klasiski, Hess pieņemot nulles enerģiju brīviem elementiem ir dota eksoerģiska izmaiņa CRC datos:

$$2\Delta G_{Hess\_NH3gas}=2G°_{NH3gas}-(G°_{N2gas}+3*G°_{H2})=2*-16,4-(0+3*0)=-32,8\ ^{kJ}/_{mol}\ .$$ [1]

Šķīdība $NH_{3gas}+H_2O=NH_{3aq}$; $G_{NH3aq}=91,1\ ^{kJ}/_{mol}$; amonjakam pie pH=7,36 [8];
$\Delta H_{Hydration}=\Delta H°_{NH3aq}-\Delta H°_{NH3gas}-\Delta H°_{H2O}=-132,5608+45,94-286,65=373,3\ ^{kJ}/_{mol}$;
$S_{Hydration}=\Delta S°_{NH3aqua}-\Delta S°_{NH3gas}-\Delta S°_{H2O}=-739,2922-192,77-69,9565=-1002\ ^{J}/_{mol/K}$;
$\Delta G_{Hydrations}=\Delta H_{Hydrations}-T*\Delta S_{Hydration}=-373,3-298,15*-1,002=-74,5537\ ^{kJ}/_{mol}$;
$K_{sp}=\exp(-\Delta G_{Hydration}/R/T)=\exp(74553,7/8,3144/298,15)=10^{13,06}$;

Albertija šķīdumi amonjakam pie pH=7,36 $G_{NH3aq}=91,1056\ ^{kJ}/_{mol}$ un Hesa hidratācija ar izmaiņu enerģijai $\Delta G_{Hydrations}=-74,5537\ ^{kJ}/_{mol}$ aprēķina absolūto enerģijas saturu gāzei NH_{3gas} sakrītoši vienādi:

$$G_{NH3gas}=G_{NH3aq}-(\Delta G_{Hydration}+G_{H2O})=91,1056-(-74,5537+0)=165,7\ ^{kJ}/_{mol};$$

$G_{NH3gas}=(2\Delta G_{Hess\_NH3gas}+(G_{N2gas}+3*G_{H2}))/2=(-32,8+(107,2+3*\underline{85,64}))/2=165,7\ ^{kJ}/_{mol}$; [1,8] CRC, Albertijs
$G_{NH3gas}=(\Delta G_{Hess\_NH3gas}+(G_{N2gas}+3*G_{H2gas}))/2=(-32,8+(-9,55+3*\underline{85,64}))/2=107,285\ ^{kJ}/_{mol}$;

Enerģiju elementam ūdeņradim $G_{H2gas}=85,64\ ^{kJ}/_{mol}$, gāzei $G_{NH3gas}=165,7\ ^{kJ}/_{mol}$; ar Hesa izmaiņu -32,8 $^{kJ}/_{mol}$ aprēķina $G_{N2gas}=2G_{NH3gas}-(2\Delta G_{Hess\_NH3gas}+3*G_{H2gas})=2*165,7-(2*-16,4+3*\underline{85,64})=107,28\ ^{kJ}/_{mol}$ viena mola slāpekļa gāzes brīvās enerģijas saturu.

Šķīdība $NH_{3gas}+H_2O=NH_{3aq}$; $G_{NH3aq}=91,1\ ^{kJ}/_{mol}$; $G_{NH3gas}=107,285\ ^{kJ}/_{mol}$ absolūtajā enerģijas skalā ir eksoerģiska: $\Delta G_{Hydration}=G_{NH3aq}-(G_{NH3gas}+G_{H2O})=91,1056-(107,285+0)=-16,18\ ^{kJ}/_{mol}$. [1,8] CRC, Albertijs Šķīdības konstante ir $K_{sp}=\exp(-\Delta G_{Hydration}/R/T)=\exp(16179,4/8,3144/298,15)=683,17$ lielāka par vienu.

Vājas skābes $G_{NH4+}=50,81\ ^{kJ}/_{mol}$ protolīze $NH_4^++H_2O=NH_{3aq}+H_3O^+$; $pK_{eq}=10,99$; uzrāda enerģijas izmaiņu

$$\Delta G_{eq}=-R\bullet T\bullet \ln(K_{eq})=-8,3144*298,15*\ln(10^{\wedge(-10,99)})=G_{NH3Hydration}+G_{H3O}-G_{NH4+}-G_{H2O}=62,73\ ^{kJ}/_{mol}$$, 16th page:

$$\Delta G_{eq}=G_{NH3aq}+G_{H3O}-(G_{NH4+}+G_{H2O})=91,1+22,44-G_{NH4+}-0=62,73\ ^{kJ}/_{mol}.$$

Amonija brīvās enerģijas saturs ir $G_{NH4+}=G_{NH3aq}+G_{H3O}-(\Delta G_{eq}+G_{H2O})=91,1+22,44-62,73-0=50,81\ ^{kJ}/_{mol}$,
Protolīzes klasiskā skābes konstante ir $NH_4^+=H^++NH_{3aqua}$ $pK_a=9,25$;

Veidošanās no elementiem HNO_2 $\Delta G°_{HNO2}=-46\ ^{kJ}/_{mol}$ un HNO_3 $\Delta G°_{HNO3}=-250,53\ ^{kJ}/_{mol}$ Wikipedia:

$$G_{HNO2}=\Delta G°_{HNO2}+0,5N_{2gas}+O_{2gas}+0,5H_{2gas}=-46+(0,5*-9,55+303+0,5*85,6)=295,025\ ^{kJ}/_{mol}\ ;$$

$G_{N2gas}=G_{N2aqua}-(\Delta G_{Hess\_šķ\_N2aqua}+G_{H2O})=18,7-(28,25+0)=-9,55\ ^{kJ}/_{mol}$; $G_{H2gas}=85,6\ ^{kJ}/_{mol}$; $G_{O2gas}=303\ ^{kJ}/_{mol}$; [8]
$G_{NO2Form}=\Delta G°_{NO2aq}+0,5G_{N2gas}+G_{O2gas}+G_{H2O}=-33,01+0,5*-9,55+1*303+0=265,2\ ^{kJ}/_{mol}$;

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

Skābes un protolīzes līdzsvars $K_{eq}=K_a/[H_2O]$ aprēķina dalot skābes konstanti ar ūdeni $[H_2O]=55,3$ M.

1. $HNO_2+H_2O=NO_2^-+H_3O^+$;pK_a=3,15; $K_{eq}=K_a/[\mathbf{H_2O}]=10\wedge^{(-3,15)}/55,3=0,00001280$;

$\Delta G_{eqHNO2}=-R\bullet T\bullet \ln(K_{eq})=-8,3144*298,15*\ln(0,0000128)=G_{NO2-}+G_{\mathbf{H3O}}-(G_{HNO2}+G_{\mathbf{H2O}})=\mathbf{27,927}$ $^{kJ}/_{mol}$;

$\Delta G_{eqHNO2}=G_{NO2-}+G_{\mathbf{H3O}}-(G_{HNO2}+G_{\mathbf{H2O}})=\mathbf{265,2+22,44-(259,713+0)=27,927}$ $^{kJ}/_{mol}$;

$G_{NO2-}=\Delta G_{eqHNO2}-G_{\mathbf{H3O}}+(G_{HNO2}+G_{\mathbf{H2O}})=\mathbf{27,927+22,44-(259,713+0)=265,2}$ $^{kJ}/_{mol}$;

$G_{HNO2}=G_{NO2-}+G_{\mathbf{H3O}}-(\Delta G_{eqHNO2}+G_{\mathbf{H2O}})=\mathbf{265,2+22,44-(27,927+0)=259,713}$ $^{kJ}/_{mol}$;

2. $HNO_3+H_2O=NO_3^-+H_3O^+$;pK_a=-1,4; $K_{eq}=K_a/[\mathbf{H_2O}]=10\wedge^{(1,4)}/55,3=0,4542$;

$\Delta G_{eqHNO3}=-R\bullet T\bullet \ln(K_{eq})=-8,3144*298,15*\ln(0,4542)=G_{NO3-}+G_{\mathbf{H3O}}-(G_{HNO3}+G_{\mathbf{H2O}})=\mathbf{1,956}$ $^{kJ}/_{mol}$;

$\Delta G_{eqHNO3}=G_{NO3-}+G_{\mathbf{H3O}}-(G_{HNO3}+G_{\mathbf{H2O}})=\mathbf{340,2+22,44-(360,684+0)=1,956}$ $^{kJ}/_{mol}$;

$G_{HNO3}=G_{NO3-}+G_{\mathbf{H3O}}-(\Delta G_{eqHNO3}+G_{\mathbf{H2O}})=\mathbf{340,2+22,44-(1,956+0)=360,7}$ $^{kJ}/_{mol}$;

$G_{NO3-}=\Delta G_{eqHNO3}-G_{\mathbf{H3O}}+(G_{HNO3}+G_{\mathbf{H2O}})=\mathbf{1,956-22,44+(360,684+0)=340,2}$ $^{kJ}/_{mol}$;

Viela	$\Delta H°_H$ $^{kJ}/_{mol}$	$\Delta S°_H$ $^{J}/_{mol/K}$	$\Delta G°_H$, $^{kJ}/_{mol}$	
HNO_2	$E°_{NO3-H3O+}$	**=0,8763 V**	**238,42**	$G_{HNO2}=G_{NO3-}+3G_{\mathbf{H3O}}-(\Delta \mathbf{G_{eq}}{}_{NO3}+4G_{\mathbf{H2O}})=\mathbf{238,42}$ $^{kJ}/_{mol}$;
HNO_2	-	pK_a=3,15	**259,713**	$G_{HNO2}=G_{NO2-}-G_{\mathbf{H3O}}+(\Delta G_{eqHNO2}+G_{\mathbf{H2O}})=\mathbf{259,713}$ $^{kJ}/_{mol}$;
HNO_2	-79,5	254,1	-46,0	
HNO_2	-	formation	**295,025**	$G_{HNO2gas}=\Delta G°_{\mathbf{H}NO2gas}+0,5N_{2gas}+O_{2gas}+0,5\mathbf{H}_{2gas}=\mathbf{295,025}$ $^{kJ}/_{mol}$
NO_2^-	-	formation	**265,2**	$G_{NO2form}=\mathbf{\Delta} G°_{NO2aq}+0,5G_{N2gas}+G_{\mathbf{O2}gas}+G_{\mathbf{H2O}}=\mathbf{265,2}$ $^{kJ}/_{mol}$;
NO_2^-		pK_a=3,15	**265,2**	$G_{NO2-}=\Delta G_{eqHNO2}-G_{\mathbf{H3O}}+(G_{HNO2}+G_{\mathbf{H2O}})=\mathbf{265,2}$ $^{kJ}/_{mol}$;
NO_2^-	**-104,19**	**-238,7**	**-33,01**	**BioTherm2006**
NO_2^-			**482,3**	$G_{NO3-}=\Delta \mathbf{G_{eq}}{}_{NH4+H2O}-10G_{\mathbf{H3O}}+(G_{\mathbf{NH4+}}-13G_{\mathbf{H2O}})=\mathbf{580,31}$ $^{kJ}/_{mol}$
HNO_3	-207	146	-250,53	Wikiped $G°_{NO3-}=\Delta H_H-T*\Delta S_H=-207-298,15*0,146=-250,5886$ $^{kJ}/_{mol}$;
HNO_3	-	formation	**199,195**	
HNO_3	-	pK_a=-1,4	**360,7**	$G_{HNO3}=G_{NO3-}+G_{\mathbf{H3O}}-(\Delta G_{eqHNO3}+G_{\mathbf{H2O}})=\mathbf{360,7}$ $^{kJ}/_{mol}$;
NO_3^-	$E°_{NH4+H2O}$=	**0,7677** V	**601,06**	$G_{NO3-}=\Delta \mathbf{G_{eq}}{}_{NH4+H2O}-10G_{\mathbf{H3O}}+(G_{\mathbf{NH4+}}-13G_{\mathbf{H2O}})=\mathbf{601,06}$ $^{kJ}/_{mol}$;
NO_3^-	-206,85	146,7	-250,5886	$\Delta G°_{NO3-}=\Delta H_H-T*\Delta S_H=-206,85-298,15*0,1467=-250,5886$ $^{kJ}/_{mol}$;
NO_3^-	-	formation	**340,2**	$G_{NO3Form}=\mathbf{\Delta} G°_{\mathbf{H}NO3aq}+(0,5G_{N2gas}+\mathbf{1,5}G_{\mathbf{O2}gas}+G_{\mathbf{H2O}})=\mathbf{340,2}$ $^{kJ}/_{mol}$;
NO_3^-	-	pK_a=-1,4	**340,2**	$G_{NO3-}=\Delta G_{eqHNO3}-G_{\mathbf{H3O}}+(G_{HNO3}+G_{\mathbf{H2O}})=\mathbf{340,2}$ $^{kJ}/_{mol}$;
NO_3^-	$E°_{NO3-OH}$	**-0,3112** V	**359,87**	$G_{NO3-}=\Delta \mathbf{G_{eq}}{}_{NO3-OH}-G_{\mathbf{H2O}}+(G_{NO2-}+2G_{\mathbf{OH}})=\mathbf{359,87}$ $^{kJ}/_{mol}$,
NO_3^-	**-204,59**	**-318,8**	**-109,55**	**BioTherm2006**
NO_{gas}	91,3	210,8	87,6	CRC
NO_{gas}	Solubility	product -	**61,024**	$G_{NOgas}=G_{H2O}+G_{NOaq}-(\Delta G_{sp})=\mathbf{0+86,55-(25,526)=61,024}$ $^{kJ}/_{mol}$;
NO_{aq}	-	-	**86,55**	**BioTherm2006**
NO_{aq}	$E°_{NO(g)H3O+}$	**=0,8609**	**180,77**	$G_{NOaq}=G_{NO3-}+4G_{\mathbf{H3O}}-(\Delta \mathbf{G_{eq}}{}_{NO(g)H3O+}+5G_{\mathbf{H2O}})=\mathbf{180,77}$ $^{kJ}/_{mol}$,
$\mathbf{NH_{3gas}}$	$\Delta G_{Hydration}$	**-74,5537**	**165,7**	$G_{\mathbf{NH3}gas}=\Delta G_{\mathbf{NH3aq}}-(\Delta G_{Hydrations}+G_{\mathbf{H2O}})=\mathbf{91,1056-(-74,5537}+0)=\mathbf{165,7}$ $^{kJ}/_{mol}$;
$\mathbf{NH_{3gas}}$	[1,8] CRC	**Alberty**	**107,285**	$2G_{\mathbf{NH3}gas}=2\mathbf{\Delta}G_{Form\mathbf{NH3}gas}+(G_{\mathbf{N2}gas}+3\mathbf{*}G_{\mathbf{H2gas}})=2*\mathbf{107,285}$ $^{kJ}/_{mol}$;
$\mathbf{NH_{3gas}}$	-45,9	192,77	-16,4	CRC [1] $G_{\mathbf{NH3}gas}=(2*-16,4+(\mathbf{-9,55}+3*\mathbf{85,64}))/2=2*\mathbf{107,285}$ $^{kJ}/_{mol}$;
$\mathbf{NH_{3aq}}$	**-132,5608**	**-739,2922**	**91,1056**	Amonjaks pie pH=7,36 [8] **Albertijs**; $\mathbf{NH_{3}}{}_{aq}$ veidošanās
$\mathbf{NH_{3aq}}$	pK_{beq}=6,49475		**91,1**	$G_{\mathbf{NH3}aq}=G_{\mathbf{NH4+}}+G_{\mathbf{OH}}-(\Delta G_{beq}+G_{\mathbf{H2O}})=\mathbf{91,1}$ $^{kJ}/_{mol}$; Wikipedia [28]
NH_4^+	pK_{aeq}=10,99		**50,81**	$G_{\mathbf{NH4+}}=G_{\mathbf{NH3aq}}+G_{\mathbf{H3O}}-(\Delta G_{eq}+G_{\mathbf{H2O}})=\mathbf{91,1}+22,44-62,73-\mathbf{0}=\mathbf{50,81}$ $^{kJ}/_{mol}$;

Protolīzes $NH_{3aq}+H_2O=NH_4^++OH^-$ konstante $K_{beq}=K_b/[H_2O]=10\wedge(-)/55,3=3,20*10\wedge^{(-7)}=10\wedge^{(-6,4947)}$ pK_{beq}=6,4947 klasiski izteiksmē bez ūdens uzskaites ir $K_b=[NH_4^+]*[OH^-]/[NH_{3aq}]=10\wedge^{(-4,752)}=1,77*10\wedge^{(-5)}$; p$K_b$=4,752.

Enerģija akumulējas endoerģiski produktos $G_{NH4+}+G_{OH-}=\mathbf{50,81}+77,36=\mathbf{128,17}$ $^{kJ}/_{mol}$:

$\Delta G_{beq}=-R\bullet T\bullet \ln(K_{beq})=-8,3144*298,15*\ln(10\wedge^{(-6,4947)})=G_{\mathbf{NH4+}}+G_{\mathbf{OH}}-(G_{\mathbf{NH3}aq}+G_{\mathbf{H2O}})=37,07$ $^{kJ}/_{mol}$.

$\Delta G_{Hess\_beq}=G_{NH4+}+G_{OH}-(G_{NH3aq}+G_{H2O})=\mathbf{50,81}+77,36-(\mathbf{91,1056+0})=\mathbf{37,064}$ $^{kJ}/_{mol}$;

$G_{\mathbf{NH3}aq}=G_{\mathbf{NH4+}}+G_{\mathbf{OH}}-(\Delta G_{beq}+G_{\mathbf{H2O}})=\mathbf{50,81}+77,36-(37,07+\mathbf{0})=\mathbf{91,1}$ $^{kJ}/_{mol}$;

Izteikta gāzes šķīdībai $NH_{3gas}+H_2O=NH_{3aq}$ enerģijas vērtības ir $G_{\mathbf{NH3}aq}=\mathbf{91,1}$ $^{kJ}/_{mol}$, $G_{\mathbf{NH3}gas}=\mathbf{107,285}$ $^{kJ}/_{mol}$.

Vāja skābe $G_{\mathbf{NH4+}}=\mathbf{50,81}$ $^{kJ}/_{mol}$ protolīze $\mathbf{NH_4^++H_2O=NH_{3aq}+H_3O^+}$ pK_{eq}=10,99 rāda endoerģisku enerģijas izmaiņu $\Delta G_{aeq}=-R\bullet T\bullet \ln(K_{aeq})=-8,3144*298,15*\ln(10\wedge^{(-10,99)})=G_{\mathbf{NH3}Hydration}+G_{\mathbf{H3O}}-G_{\mathbf{NH4+}}-G_{\mathbf{H2O}}=62,73$ $^{kJ}/_{mol}$.

Amonija brīvās enerģijas saturs molā ir $G_{\mathbf{NH4+}}=G_{\mathbf{NH3aq}}+G_{\mathbf{H3O}}-(\Delta G_{aeq}+G_{\mathbf{H2O}})=\mathbf{91,1}+22,44-(62,73+0)=\mathbf{50,81}$ $^{kJ}/_{mol}$.

Nernsta potenciāla NO_3^-/NO_2^- red-oks sistēmas īpašības skābā H_3O^+ ūdens un baziskā OH^- vidē

$HNO_2+4H_2O=NO_3^-+3H_3O^+\mathbf{+2e^-}$; $E^\circ_{NO3-H3O+}=\mathbf{0{,}8753}$ V Kortly, Shucha pH<3,15;

$$E^\circ_{NO3}=E^\circ+0{,}10166-0{,}0591/2*\lg(1/[H_2O]^4)-0{,}37239=0{,}94+0{,}10166-0{,}02955*\lg(1/55{,}3^{\wedge 4})-0{,}37239=\mathbf{0{,}8753}\ V;$$

$$E_{NO3}=E^\circ_{NO3}+\frac{0.0591}{2}\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^3}{[HNO_2]\cdot[H_2O]^4}=\mathbf{0{,}8753}\ V+\frac{0.0591}{2}\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^3}{[HNO_2]\cdot[H_2O]^4}$$

$$\Delta\mathbf{G_{eq}}{}_{NO3}=E^\circ_{NO3}\bullet F\bullet 2=\mathbf{0{,}8753}*96485*2=\mathbf{168{,}9}\ {}^{kJ}/_{mol},$$

$$\Delta\mathbf{G_{eq}}{}_{NO3}=G_{NO3-}+3\mathbf{G_{H3O}}-(G_{HNO2}+4\mathbf{G_{H2O}})=\mathbf{340{,}2}+3*22{,}44-(\mathbf{238{,}62}+4*0)=\mathbf{168{,}9}\ {}^{kJ}/_{mol},$$

$$G_{HNO2}=G_{NO3-}+3\mathbf{G_{H3O}}-(\Delta\mathbf{G_{eq}}{}_{NO3}+4\mathbf{G_{H2O}})=\mathbf{340{,}2}+3*22{,}44-(\mathbf{168{,}9}+4*0)=\mathbf{238{,}62}\ {}^{kJ}/_{mol};$$

$NO_2^-+2OH^-=NO_3^-+H_2O\mathbf{+2e^-}$; $E^\circ_{NO3-H2O}=\mathbf{-0{,}3122}$ V; pH>3,15 Suchotina

$$E^\circ_{NO3-OH}=E^\circ+0{,}10166-0{,}0591/2*\lg([H_2O])-0{,}37239=0{,}01+0{,}10166-0{,}02955*\lg(55{,}3^{\wedge 1})-0{,}37239=\mathbf{-0{,}3122}\ V;$$

$$E_{NO3-OH}=E^\circ_{NO3-OH}+\frac{0.0591}{2}\bullet\log\frac{[NO_3^-]\cdot[H_2O]}{[NO_2^-]\cdot[OH^-]^2}=\mathbf{-0{,}3122}\ V+\frac{0.0591}{2}\bullet\log\frac{[NO_3^-]\cdot[H_2O]}{[NO_2^-]\cdot[OH^-]^2}$$

$$\Delta\mathbf{G_{eq}}{}_{NO3-OH}=E^\circ_{NO3-OH}\bullet F\bullet 2=\mathbf{-0{,}3122}*96485*2=\mathbf{-60{,}245}\ {}^{kJ}/_{mol},$$

$$\Delta\mathbf{G_{eq}}{}_{NO3-OH}=G_{NO3-}+\mathbf{G_{H2O}}-(G_{NO2-}+2\mathbf{G_{OH}})=\mathbf{359{,}675}+0-(\mathbf{265{,}3}+2*77{,}36)=\mathbf{-60{,}245}\ {}^{kJ}/_{mol},$$

$$G_{NO3-}=\Delta\mathbf{G_{eq}}{}_{NO3-OH}-\mathbf{G_{H2O}}+(G_{NO2-}+2\mathbf{G_{OH}})=\mathbf{-60{,}2455}-0+(\mathbf{265{,}3}+2*77{,}36)=\mathbf{359{,}775}\ {}^{kJ}/_{mol},$$

$$G_{NO2-}=G_{NO3-}+\mathbf{G_{H2O}}-(\Delta\mathbf{G_{eq}}{}_{NO3-OH}+2\mathbf{G_{OH}})=\mathbf{359{,}675}+0-(\mathbf{-60{,}245}+2*77{,}36)=\mathbf{265{,}3}\ {}^{kJ}/_{mol};$$

$\mathbf{NO_2^-+3H_2O=NO_3^-+2H_3O^++2e^-}$; David Harris; absolūtais standarta potenciāls $E^\circ_{NO3}=\mathbf{0{,}7188}$ V

$$E^\circ_{NO3}=E^\circ+0{,}10166-0{,}0591/2*\lg([H_2O]^3)-0{,}37239=0{,}835+0{,}10166-0{,}02955*\lg(1/55{,}3^{\wedge 3})-0{,}37239=\mathbf{0{,}7188}\ V$$

M_{NO}=30,006 $^g/_{mol}$; Šķīdība $NO^{(g)}$ 0,0056 $^g/_{99,6g}$ (20 C) ; w%=0,0056/(0,0056+99,6)*100=0,00562%; ūdenī $[NO_{aq}]$=(0,00562/100*996)/30,006=0,001865 M, ja tīras gāzes mol daļa ir viens $[NO^{(g)}]=1$;

Līdzsvara $NO_{gas}+H_2O=NO_{aq}$ konstante $\mathbf{K_{eq}}=[NO_{aq}]/[NO^{(g)}]/[H_2O]=0{,}001865/1/55{,}3=10^{\wedge(-4{,}472)}$.

$$\mathbf{\Delta G_{eq}=-R\bullet T\bullet \ln(K_{eq})}=-8{,}3144*298{,}15*\ln(10^{\wedge(-4{,}472)})=-8{,}3144\bullet 298{,}15\bullet -10{,}297=\mathbf{25{,}526}\ {}^{kJ}/_{mol}$$

$$\Delta G_{eq}=G_{NOaq}-(G_{H2O}+G_{NOgas})=\mathbf{86{,}55-(0+}G_{NOgas})=\mathbf{25{,}526}\ {}^{kJ}/_{mol};$$

$G_{NOgas}=G_{NOaq}-(G_{H2O}+\Delta G_{eq})=\mathbf{86{,}55-(0+25{,}526)=61{,}024}\ {}^{kJ}/_{mol}$, ja līdzsvara minimums ir $\Delta G_{eq}=\mathbf{25{,}526}\ {}^{kJ}/_{mol}$;

Gāzes NO_{gas} šķīdība kompensē vienu ūdens molekulu Nernsta izteiksmē no sešām $6H_2O$ uz piecām $5H_2O$:

$NO_{aq}+5H_2O=NO_3^-+4H_3O^+\mathbf{+3e^-}$; $E^\circ_{NO(g)H3O+}=\mathbf{0{,}8609}$ V; Kortly, Shucha ;

$$E^\circ_{NO(g)H3O+}=E^\circ+0{,}10166-0{,}0591/3*\lg(1/[H_2O]^5)-0{,}37239=0{,}96+0{,}10166-0{,}0197*\lg(1/55{,}3^{\wedge 5})-0{,}37239=\mathbf{0{,}8609}\ V;$$

$$E_{NO(g)H3O+}=E^\circ_{NO(g)H3O+}+0{,}0591/3\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^4}{[NO_{aq}]\cdot[H_2O]^6}=\mathbf{0{,}8609}\ V+0{,}0197\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^4}{[NO_{aq}]\cdot[H_2O]^6}$$

$$\Delta\mathbf{G_{eq}}{}_{NO(g)H3O+}=E^\circ_{NO(g)H3O+}\bullet F\bullet 3=\mathbf{0{,}8609}*96485*3=\mathbf{249{,}19}\ {}^{kJ}/_{mol},$$

$$\Delta\mathbf{G_{eq}}{}_{NO(g)H3O+}=G_{NO3-}+4\mathbf{G_{H3O}}-(G_{NOaq}+5\mathbf{G_{H2O}})=\mathbf{340{,}2}+4*22{,}44-(\mathbf{180{,}77}+5*0)=\mathbf{249{,}19}\ {}^{kJ}/_{mol},$$

$$G_{NOaq}=G_{NO3-}+4\mathbf{G_{H3O}}-(\Delta\mathbf{G_{eq}}{}_{NO(g)H3O+}+5\mathbf{G_{H2O}})=\mathbf{340{,}2}+4*22{,}44-(\mathbf{249{,}19}+5*0)=\mathbf{180{,}77}\ {}^{kJ}/_{mol},$$

$NH_{3gas}+H_2O=NH_{3aq}$ brīvā enerģija G_{NH3aq}=91,1 $^{kJ}/_{mol}$; $NH_{3aq}+H_2O=NH_4^++OH^-$;

$NH_4^++13H_2O+OH^-=NO_3^-+10H_3O^++OH^-\mathbf{+8e^-}$; $H_3O^++OH^-=2H_2O$**;**

$NH_4^++11H_2O+OH^-=NO_3^-+9H_3O^+\mathbf{+8e^-}$; $H_3O^++OH^-=2H_2O$;

$NH_4^++13H_2O=NO_3^-+10H_3O^+\mathbf{+8e^-}$; $E^\circ_{NH4+H2O}=\mathbf{0{,}7667}$ V Suchotina

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$$E^\circ_{NH4+H2O}=E^\circ+0{,}10166-0{,}0591/8*\lg(1/[H_2O]^{13})-0{,}37239=0{,}87+0{,}10166-0{,}00739*\lg(1/55{,}3^{\wedge 13})-0{,}37239=\mathbf{0{,}7667}\ V;$$

$$E_{NH4+H2O}=E^\circ_{NH4+H2O}+0{,}0591/8\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^{10}}{[NH_4^+]\cdot[H_2O]^{13}}=\mathbf{0{,}76669}\ V+0{,}00739\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^{10}}{[NH_4^+]\cdot[H_2O]^{13}}$$

$$\Delta\mathbf{G_{eq}}{}_{NH4+H2O}=E^\circ_{NH4+H2O}\bullet F\bullet 8=\mathbf{0{,}76669}*96485*8=\mathbf{591{,}8}\ {}^{kJ}/_{mol},$$

$$\Delta\mathbf{G_{eq}}{}_{NH4+H2O}=G_{NO3-}+10G_{H3O}-(G_{NH4+}-13\mathbf{G_{H2O}})=\mathbf{601{,}06}+10*22{,}44-(\mathbf{232{,}9}-13*\mathbf{0})=\mathbf{591{,}8}\ {}^{kJ}/_{mol},$$

$$G_{NO3-}=\Delta\mathbf{G_{eq}}{}_{NH4+H2O}-10G_{H3O}+(G_{NH4+}-13\mathbf{G_{H2O}})=\mathbf{591{,}8}-10*22{,}44+(\mathbf{232{,}9}-13*\mathbf{0})=\mathbf{601{,}06}\ {}^{kJ}/_{mol};$$

Nernsta potenciāla studijas $\underline{5(Pt)H}+MnO_4^-$ uzskaitot hidroksoniju H_3O^+ un ūdeni H_2O.

Inversais Nernsta standarta potenciāls: $MnO_4^-+8H_3O^++5e^-=Mn^{2+}+12H_2O$; $-E°_{Mn2+/MnO4-}=-1{,}4865$ V.

Divpadsmit ūdens molekulu uzskaite $[H_2O]=55{,}3$ M=(996_g/L)/(18_g/mol) palielina potenciālu līdz:

$E°_{Mn2+/MnO4-}=E°-0{,}0591/5•\log(1/[H_2O]^{12})=1{,}51-0{,}0591/5*\log(1/55{,}3^{\wedge 12})+0{,}10166-0{,}37239=1{,}4865$ V;

Ūdens koncentrācija $[H_2O]^{12}$ ir iekļauta klasiskā standarta potenciāla vērtībā E°=1,51 V kā logaritms:

Reducētāja Nernsta absol;ūtais standarta potenciāls: $\underline{5(Pt)H}+5H_2O=5H_3O^++5e^-$; $E°_H=-0{,}27073$ V

$E_{MnO4}=-1.4865\ V+0{,}0591/5•\log([H_2O]^{12}*[Mn^{2+}]/[MnO_4^-]/[H_3O^+]^8)$;

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

Elektronu balansēšana $+ne^-=5e^-=-ne^-$ summārajā Red-Ox reakcijā: $MnO_4^-+3H_3O^++\underline{5(Pt)H}=Mn^{2+}+7H_2O$;

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

Viela	$\Delta H°_H$, kJ/mol	$\Delta S°_H$, J/mol/K	$\Delta G°_H$, kJ/mol
H_2O	-285,85	69,9565	-237,191
H_2O	**-286,65**	**-453,188**	**-151,549**
H_3O^+	-285,81	-3,854	-213,2746
$H_{2(aq)}$	23,4	-130	99,13
$H_{2(aq)}$	**-5,02**	**-363,92**	**103.24**
$H(Pt)_{(aq)}$	-	-	**48,56**
MnO_4^-	-541,4	-191,2	-447,2
Mn^{2+}	–220,8	-73,6	-228,1
O_{2aqua}	**-11,7**	**-94,2**	**16,4**

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$\Delta G_{eq}=\mathbf{-847{,}7}$ kJ/mol ; $\Delta G_{Hess}=-1044{,}2$ kJ/mol

kā absolūti lielumi $|\Delta G_{eq}=-847{,}7\ kJ/mol|<|\Delta G_{Hess}=-1043{,}7\ kJ/mol|$;

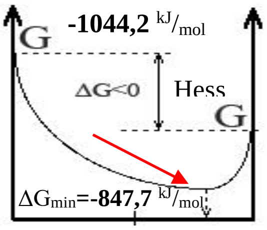
$\mathbf{\Delta G_{eq}}{}_{H/MnO4}=(E°_H-E°_{MnO4-})•F•1•5=(-0{,}27073-1{,}4865)*96485*5=\mathbf{-1{,}757}*96485*5=\mathbf{-847{,}7}$ kJ/mol .

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

Eksotermiska un eksoerģiskas MnO_4^- reducēšanas ar metālisku $\underline{5(Pt)H}$ Hesa brīvās enerģijas izmaiņa negatīva $\mathbf{\Delta G_{Hess}=\Delta G_{OxRed}}=-1043{,}7$ kJ/mol , bet minimizējas sasniedzot

līdzsvara maisījumu $\mathbf{\Delta G_{min}=\Delta G_{eq}}=-847{,}7$ kJ/mol;$10^{148{,}5}=K_{eq}=\dfrac{[H_2O]^7\cdot[Mn^{2+}]}{[(Pt)H]^5\cdot[MnO_4^-]\cdot[H_3O^+]^3}$;

Brīvās enerģijas izmaiņas minimums ΔG_{min} ir Prigožina atraktors. Brīvās enerģijas izmaiņas minimuma sasniegšanā iestājas līdzsvars. Līdzsvara stāvoklis ir atraktors visiem bezgalīga skaita ne līdzsvara stāvokļiem



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

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

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

$\underline{MnO_2}+4OH^-=MnO_4^-+2H_2O\mathbf{+3e^-}$; Reducētāja Nernsta absolūtais standarta potenciāls: $E°_{MnO2/MnO4-}=\mathbf{0{,}26465}$ V

$E°_{MnO2/MnO4-}=E°-0{,}0591/3•\log([H_2O]^2)+0{,}10166-0{,}37239=0{,}603-0{,}0591/3*\log(55{,}3^{\wedge 2}))+0{,}10166-0{,}37239=\mathbf{0{,}26465}$ V;

$MnO_4^{2-}=MnO_4^-\mathbf{+e^-}$; Reducētāja Nernsta absolūtais standarta potenciāls: $E°_{MnO2/MnO4-}=\mathbf{0{,}2883}$ V;

$E°_{MnO4/MnO4-}=E°-0{,}0591/3•\log([H_2O]^0)+0{,}10166-0{,}37239=0{,}558-0{,}0591/3*\log(55{,}3^{\wedge 0}))+0{,}10166-0{,}37239=\mathbf{0{,}2883}$ V;

2) Karbo anhidrāze CA ģenerē brīvo enerģiju no nulles $G_{CO2+2\mathbf{H2O}}=0$ kJ/mol līdz $G_{H3O+HCO3-}=78{,}52$ kJ/mol.

Šķīdība ūdenī rada brīvo enerģiju no nulles līmeņa $CO_{2gas}+H_2O=CO_{2aqua}$ līdz $G_{CO2aqua}=18{,}38$ kJ/mol ar konstanti:

$K_{eqCO2aqua}=[CO_{2aqua}]/[CO_{2gas}]/[H_2O]=EXP(-G_{CO2aqua}/R/T)=EXP(-18382{,}746/8{,}3144/298{,}15)=0{,}000601808$

palielinot brīvo enerģiju līdz $G_{CO2aqua}=-R•T•\ln(K_{šķCO2aqua})=-8{,}3144*298{,}15*\ln(0{,}000601808)=18{,}38$ kJ/mol.

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

ātruma konstante ir $k_{1CO2aqua}=1{,}5\times10^8\ M^{-1}s^{-1}$ un protolītiskā skābes CO_{2aqua} līdzsvara konstantes vērtība ir

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

CA liela ātruma protolīzes konstante akumulē brīvo enerģiju produktos $H_3O^++HCO_3^-$ aktivējot tos:

$\Delta G_{eqCACO2aqua}=-R•T•\ln(K_{eqCACO2aqua})=-8{,}3144*298{,}15*\ln(2{,}90636*10^{\wedge(-11)})/1000=60{,}14$ kJ/mol .

Kopējā brīvā enerģija palielinās aktivējot sasniedzot līdzsvara stāvokli liela ātruma protolīzē un šķīdībā:

$G_{H3O+HCO3}=G_{H3O+}+G_{HCO3-}=22{,}44+56{,}08=G_{CO2aqua}+\Delta G_{eqCACO2aqua}=18{,}38+60{,}14=78{,}52$ kJ/mol . [1,8,14]

Liela ātruma protolīzes atraktors ir pH=7,36. Novirze no atraktora izjauc neatgriezeniskās homeostāzes procesus, radot nekārtību un haosu.

Karbo anhidrāzes CA sintēze nepieciešams aktīvas biosfēras atraktors.

Karboanhidrāzes reaktivitāte un radītā fizioloģiskā bufera šķīduma protolīzes līdzsvara-atraktora vērtība pH=7,36 ir pašorganizējošais biosfēras atraktors. Reakcijas $\mathbf{CO_2}$+2$\mathbf{H_2O}$ uzkrātā brīvā enerģija produktos ($\mathbf{CO_{2aqua}}$) $\mathbf{H_3O^+ + HCO_3^-}$ akumulē brīvo enerģiju $G_{H3O++HCO3-}=18,38+60,14=78,52$ $^{kJ}/$, kas nepieciešama ķermeņa funkcionālai darbībai, tas ir bikarbonāta bufera sistēma ideālai reakciju secībai neatgriezeniskas homeostāzes kompleksajos procesos.

$\mathbf{CO_2}$ nereaģē ar ūdeni H_2O bez CA klātbūtnes. $\mathbf{CO_2}$ ir mazšķīstošs un lēni reaģē ar $\mathbf{OH^-}$.
Wikipedia [27] mol masa M_{CO2}=44,009 g/mol. Šķīdība $CO_{2gas}+H_2O=CO_{2aqua}$ 1,45 g/L pie 0,99 atm un pie 1 atm m_{CO2}=100*1,45/99=1,4646 g/L ar koncentrāciju $[CO_{2aqua}]=m_{CO2}/M_{CO2}$=1,4646/44,009=0,03328 M.

Šķīdība ir $K_{spCO2aqua}=[CO_{2aqua}]/[CO_{2gas}]$=0,03328 M bet līdzsvara konstante molu daļās ir bez mērvienības

$K_{eqCO2aqua}=[CO_{2aqua}]/[CO_{2gas}]/[H_2O]=K_{spCO2aqua}/[H_2O]$=0,03328 M/55,3 M=0,000601808.

Brīvā enerģija $\Delta G_{eqCO2aqua}=-R\bullet T\bullet \ln(K_{eqCO2aqua})$=-8,3144*298,15*ln(0,000601808)/1000=18,38 $^{kJ}/_{mol}$ ir minimumā ar šķīdības līdzsvara vērtību $G_{CO2aqua}=\Delta G_{eqCO2aqua}+(G_{CO2gas}+G_{H2O})$=18,38+(0+0)=18,38 $^{kJ}/_{mol}$.

No gaisa 0,04 % mol daļas $[CO_{2gas}]$=0,0004 izšķīdinātā koncentrācija ir:

$[CO_{2aqua}]=K_{eqCO2aqua}*[H_2O]*[CO_{2gas}]$=0,000601808*55,3457*0,0004=0,000753 M.

Oglekļa dioksīds CO_{2aqua} reaģē ar OH^- joniem reizes $10^{16,54}$ lēnāk par bikarbonāta HCO_3^- neitralizācijas reakciju: $H_3O^++HCO_3^-\Rightarrow CO_{2aqua}+2H_2O$, jo neitralizācijas ātruma konstante ir $k_2=5,16885*10^{18}$ $M^{-2}s^{-1}$, bet OH^- joniem $CO_{2aqua}+OH^-\Rightarrow HCO_3^-$ ir ātruma konstante $\mathbf{k_1}_{OH}$ no $1,5*10^2$ $M^{-2}s^{-1}$. Reakcija ir labvēlīga:

$\Delta G_{HessHCO3-}=G_{HCO3-}-(G_{CO2aqua}+G_{OH-})$=56,08-(18,38+77,36)=-39,66 $^{kJ}/_{mol}$ ar līdzsvara konstanti

$k_{1OH-}/k_{2HCO3-}=[HCO_3^-]/[CO_{2aqua}]/[OH^-]=K_{eq\_HCO3-}=EXP(-\Delta G_{eq\_HCO3-}/R/T)$ =EXP(39659/8,3144/298,15)=8875,3, eksotermiski izdalot siltumu Q $\Delta H_{Hess}=\Delta H°_{HCO3}-\Delta H°_{CO2}-\Delta H°_{OH}$=-48,68 $^{kJ}/_{mol}$. Inversā $HCO_3^-\Rightarrow CO_{2aqua}+OH^-$ reakcija ir nelabvēlīga $k_{2HCO3-}=k_{1OH-}/K_{eq\_HCO3-}=1,5*10^2/8875,3$=0,0169. Sadalīšanās $HCO_3^-\Rightarrow CO_{2aqua}+OH^-$ ātruma konstante k_{2HCO3-} ir desmit triljoni 10^{13} reizes lēnāka par CA ātruma konstanti $k_{1CO2aqua}=1.5\times10^8$ $M^{-1}s^{-1}$.

CA protolītiskā reaktivitāte rada funkcionāli aktīvu bikarbonāta bufera pašorganizēšanas atraktoru pH=7,36 ar ģenerētiem koncentrācijas gradientiem transportam H_3O^+, HCO_3^-, CO_{2aqua} un O_{2aqua}, H_2O osmozei cauri akvaporīnu kanāliem. [9]

CA liela ātruma protolīzē reaģē CO_{2aqua} ar divām ūdens molekulām:
$CO_{2aqua}+2H_2O+\Delta G+Q=v1\underline{^{CA}}H_3O^++HCO_3^-$, kurā ātruma konstante ir: $k_{1CO2aqua}=1,5\times10^8$ $M^{-1}s^{-1}$. [9] Neitralizācijas $H_3O^++HCO_3^-=\underline{^{CA}}CO_{2aqua}+2H_2O$ ātruma konstante ir reizes $10^{10,54}$ lielāka par karbo anhidrāzes ātruma konstanti: $k_2/k_{1CO2aqua}$=5,16885**10^18/1,5/10^8= 34459000000=10^10,537. CA protolīzes līdzsvara konstanti aprēķina ātruma konstanšu attiecības izteiksmē:

$K_{eqCAHCO3aqua}=k_{1CO2aqua}/k_2=K_{a\_CO2aqua}/[H_2O]^2=10^{\wedge(-7,0512)}/55,3^2=2,906*10^{-11}=10^{-10,54}$.

Bikarbonāta bufera skābes protolīzes konstante $pK_{a\_\mathbf{CO2}aqua}$=7,0512 ir draudzīga atraktora vērtībai pH=7,36:

$K_{a\_\mathbf{CO2}aqua}=K_{eqCAHCO3aqua}*[H_2O]^2=\dfrac{[HCO_3^-]_{aqua}\cdot[H_3O^+]}{[CO_2]_{aqua}}=10^{-7,0512}=10^{-pK_{a\_CO2aqua}}$. Oriģinālā $pK_{a\_\mathbf{CO2}aqua}$=7,0512 vērtība iegūta un aprēķināta BUFERA šķīdumam. Hesa brīvās enerģijas izmaiņa ir eksoerģiska negatīva:

$\Delta G_{Hess}=2\Delta G°_{\mathbf{H2O}}+\Delta G°_{\mathbf{CO2}}-(\Delta G°_{\mathbf{H3O}}+\Delta G°_{\mathbf{HCO3}})$=2*-237,191-385,98-(-213,2746-**544,9688**)=**-102** $^{kJ}/_{mol}$. [1]

Neitralizācijas: $\mathbf{H_3O^++HCO_3^-=CO_{2aqua}+2H_2O}$ konstante ir inversa protolīzei un labvēlīga:

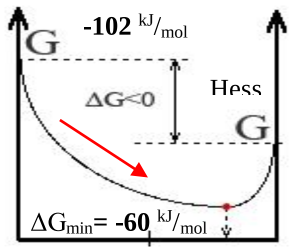
$K_{eqNeitralizācija}=1/\mathbf{K_{eq}}_{CAHCO3aqua}=\mathbf{[HCO_3^-]*[H_3O^+]/[CO_{2aqua}]/[H_2O]^2}=1/2,90636/10^{\wedge(-11)}$=34407299853.

$\Delta G_{Absolute}=2G_{\mathbf{H2O}}+G_{\mathbf{CO2}qua}-G_{\mathbf{H3O}}-G_{\mathbf{HCO3}}$=2*0+**18,38**-22,44-56,08=**-60,14** $^{kJ}/_{mol}$ un entalpijas Hesa izmaiņa ir eksotermiska: $\Delta H_{Hess}=2\Delta H°_{\mathbf{H2O}}+\Delta H°_{\mathbf{CO2}}-\Delta H°_{\mathbf{H3O}}-\Delta H°_{\mathbf{HCO3}}$=**-7,2** $^{kJ}/_{mol}$.

Neitralizācija ir labvēlīga reakcija. Brīvās enerģijas izmaiņas minimums izteiksmē ir negatīvs:

$\Delta\mathbf{G}_{eqNeitralizācija}=\mathbf{-R\bullet T\bullet ln}(\mathbf{K}_{eqNeitralizācija})=-8,3144\bullet298,15\bullet\mathbf{ln}(34407299853)=\mathbf{-60,14}$ $^{kJ}/_{mol}$, bet $\mathbf{CO_2}_{aqua}$ protolīzes minimums kā neitralizācijas inversā reakcija ir pozitīva:

$\Delta\mathbf{G}_{eqCAHCO3aqua}=\mathbf{-R\bullet T\bullet ln}(\mathbf{K}_{eqCA\_HCO3aqua})=-8,3144\bullet298,15\bullet\mathbf{ln}(1/34407299853)=\mathbf{60,14}$ $^{kJ}/_{mol}$.



Atraktora Zīm. 2. Eksotermiska un eksoerģiska neitralizācijā Hesa brīvās enerģijas izmaiņa $\Delta\mathbf{G}_{eqNeitralizācija}$ negatīva **-102** $^{kJ}/_{mol}$, bet $\Delta\mathbf{G}_{eqNeitralizācija}$=**-60,14** $^{kJ}/_{mol}$ minimizējas sasniedzot līdzsvara maisījumu: K_{eq}=34407299853 CA karbo anhidrāzes klātienē. Oglekļa dioksīds reakcija ar hidroksīda anjonu ir lēna, jo mazi reizinātāji: ātruma konstante $k_{1OH}=1,5*10^2$ $M^{-2}s^{-1}$, koncentrācijas $[CO_{2aqua}]$=0,000753 M, $[OH^-]=10^{-6,64}$ M. Karbo anhidrāzes sintēze atrisina bioenerģētikā perfektu kārtību homeostāzei kā pašorganizējošs atraktors. [3,4]

A+B 50 % C+2D.

Reaktanti $H_3O^++HCO_3^-$, produkti $\mathbf{CO_2}_{aqua}+2\mathbf{H_2O}$.

$2CO_2$ / $H_2C_2O_4$ / CH_{4gas} šķīdība un protolīze iekļauj hidroksonija $\mathbf{H_3O^+}$ un ūdens $\mathbf{H_2O}$ uzskaiti.

Oglekļa dioksīda veidošanās no brīviem elementiem $\mathbf{C}_{gr}+\mathbf{O}_{2gas}=\mathbf{CO}_{2gas}$ standarta brīvās enerģijas izmaiņa ir negatīva $\Delta G_{\mathbf{Hess\_CO2}gas}=-394{,}36\ ^{kJ}/_{mol}$. [1] Ja fona līmenis bioķīmijas absolūtās enerģijas skalai ir nulle, tad Hesa likumā grafītam absolūtās brīvās enerģijas saturs ir $G_{gr}=-\Delta G^\circ_{\mathbf{Hess\_CO2}gas}-G_{\mathbf{O2}gas}=394{,}36-\mathbf{303{,}1}=\mathbf{91{,}26}\ ^{kJ}/_{mol}$.

Standarta brīvās enerģijas izmaiņas metāna veidošanai no brīvajiem elementiem $\mathbf{C}_{gr}+2\mathbf{H}_{2gas}>\mathbf{CH}_{4gas}$ [1,8] ir

$$\Delta G_{Hess\_CH4gas}=G_{CH4gas}-(G_{Cgr}+2*G_{H2})=G_{CH4gas}-(\mathbf{91{,}26}+2*\underline{\mathbf{85{,}64}})=-50{,}5\ ^{kJ}/_{mol}$$ un

brīvās enerģijas saturs uz vienu molu metāna, kas paliek neizmantots no brīvajiem elementiem Hesa likumā ir

$$G_{CH4gas}=\Delta G_{\mathbf{Hess}\_CH4gas}+(G_{Cgr}+2*G_{H2})=-50{,}5+(\mathbf{91{,}26}+2*\underline{\mathbf{85{,}64}})=\mathbf{212{,}04}\ ^{kJ}/_{mol}.$$

Tas ļauj mums aprēķināt absolūto brīvo enerģiju uz grafīta elementa molu, izmantojot Albertija enerģijas datus:

$$G^\circ_{\mathbf{CgrCH4}gas}=G^\circ_{\mathbf{CH4}gas}-\mathbf{\Delta}G_{\mathbf{Hess\_CH4}gas}-2*G^\circ_{\mathbf{H2}gas}=\mathbf{212{,}04}-(-50{,}5+2*\underline{\mathbf{85{,}64}})=\mathbf{91{,}26}\ ^{kJ}/_{mol},$$

kas sakrīt ar oglekļa dioksīda gāzes nulles fonu $G^\circ_{\mathbf{CO2}gas}=\mathbf{0}\ ^{kJ}/_{mol}$ bioķīmijas absolūtās enerģijas skalā.

Metāna šķīdība $\mathbf{CH}_{4gas}+H_2O=\mathbf{CH}_{4aq}$ ir 22,7 mg/L un metāna mol masa ir $M_{CH4}=16{,}043\ ^{g}/_{mol}$. Ūdens uzskaite $[H_2O]=996/18=55{,}3$ M aprēķina konstanti $\mathbf{K_{eq}}=K_{sp}/[H_2O]=0{,}001414947\ M/55{,}3\ M=10^{\wedge(-4{,}592)}$. Albertija dati aprēķina šķīdības enerģijas izmaiņu $\Delta G_{eq\mathbf{CH4}gas}=G_{\mathbf{CH4}aq}-(G_{\mathbf{CH4}gas}+G_{\mathbf{H2O}})=\mathbf{238{,}25}-(\mathbf{212{,}04}+\mathbf{0})=\mathbf{26{,}21}\ ^{kJ}/_{mol}$.

$$G_{CH4aq}=\mathbf{\Delta}G_{eqCH4}+(G_{H2\mathbf{O}}+G_{CH4}{}^{gas})=\mathbf{26{,}21}+(\mathbf{0}+\mathbf{212{,}04})=\mathbf{238{,}25}\ ^{kJ}/_{mol};$$

Metāna šķīdības $[\mathbf{CH}_4]=0{,}0227/16{,}043=0{,}001414947$ M līdzsvaram absolūtā brīvās enerģijas izmaiņa ir

$$\Delta \mathbf{G_{eq}=-R\bullet T\bullet ln(K_{eq})}=-8{,}3144*298{,}15*\ln(0{,}001414947/55{,}3)=-8{,}3144\bullet 298{,}15\bullet -6{,}592=\mathbf{26{,}21}\ ^{kJ}/_{mol}.$$

Līdzsvara enerģijas izmaiņa $\Delta G_{eqCH4}=G_{CH4aq}-(G_{H2O}+G_{CH4}{}^{gas})=G_{CH4aq}-(\mathbf{0}+\mathbf{212{,}04})=\mathbf{26{,}21}\ ^{kJ}/_{mol}$ ļauj aprēķināt absolūto brīvās enerģijas saturu metānam ūdenī (aqua): $G_{CH4aq}=G_{CH4gas}+G_{CH4sp}=\mathbf{212{,}04}+\mathbf{26{,}21}=\mathbf{238{,}25}\ ^{kJ}/_{mol}$;

Viela	$\Delta H^\circ_H\ ^{kJ}/_{mol}$	$\Delta S^\circ_H\ ^{J}/_{mol/K}$	$\Delta G^\circ_H,\ ^{kJ}/_{mol}$	$\Delta G_{H2C2\mathbf{O4}}=\mathbf{\Delta}H_H-T*\mathbf{\Delta}S_H=-829{,}9-298{,}15*-0{,}1098=\mathbf{-747{,}75}\ ^{kJ}/_{mol}$;
$\mathbf{H_2O}$	-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**	$G_{H2C2O4cr}=\mathbf{\Delta}G^\circ_{H2C2O4crForm}+(2G_{Cgr}+2G_{\mathbf{O2}gas}+G_{\mathbf{H2}gas})=\mathbf{76{,}96}\ ^{kJ}/_{mol}$;
$H_2C_2O_{4sq}$	$\Delta G_{eq\_sp}=$	**9,0161**	**85,976**	$G_{H2C2O4aq}=\Delta G_{eq\_sp}+(G_{\mathbf{H2O}}+G_{H2C2O4}{}^{cr})=\mathbf{85{,}976}\ ^{kJ}/_{mol}$;
$H_2C_2O_{4sq}$	$E^\circ_{H2C2O4}=$	**-0,6577 V**	**171,78**	$G_{H2C2O4}=2G_{CO2}+2G_{\mathbf{H3O}}-(\mathbf{\Delta G_{eq}}_{H2C2O4}+2\mathbf{G_{H2O}})=\mathbf{171{,}78}\ ^{kJ}/_{mol}$;
$HC_2O_4^-$	**17,08**	$pK_{a2}=1{,}25$	**80,618**	$G_{\mathbf{HC2O4}}=\Delta G_{eq1\mathbf{H2C2O4}}-G_{\mathbf{H3O}}+(G_{\mathbf{H2C2O4}}+\mathbf{\Delta}G_{\mathbf{H2O}})=\mathbf{80{,}618}\ ^{kJ}/_{mol}$;
$HC_2O_4^-$	$E^\circ_{HC2O4}=$	**-0,7092** V	**159,028**	$G_{HC2O4}=2G_{CO2}+G_{\mathbf{H3O}}-(\mathbf{\Delta G_{eq}}_{HC2O4}+\mathbf{G_{H2O}})=\mathbf{159{,}028}\ ^{kJ}/_{mol}$;
$C_2O_4^{2-}$	-	-	**-677,14**	**Alberty 2006** Biochem.Thermodyn Massachusetts Techn. Inst.
$C_2O_4^{2-}$	**33,578**	$pK_{a2}=4{,}14$	**91,756**	$G_{\mathbf{C2O4}}=\Delta G_{eq2\mathbf{HC2O4}}-G_{\mathbf{H3O}}+(G_{\mathbf{HC2O4}}+G_{\mathbf{H2O}})=\mathbf{91{,}756}\ ^{kJ}/_{mol}$;
$C_2O_4^{2-}$	$E^\circ_{C2O4}=$	**-0,7607** V	**146,79**	$G_{C2O4}=2G_{CO2}-(\mathbf{\Delta G_{eq}}_{C2O4})=2*\mathbf{0}-(\mathbf{-146{,}79})=\mathbf{146{,}79}\ ^{kJ}/_{mol}$;
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**	$G^\circ_{\mathbf{CgrCH4}gas}=G^\circ_{\mathbf{CH4}gas}-G_{\mathbf{Hess\_CH4}gas}-2*G^\circ_{\mathbf{H2}gas}=\mathbf{91{,}26}\ ^{kJ}/_{mol}$;
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**	$G^\circ_{Cgr0\mathbf{CO2}}=-\mathbf{\Delta}G^\circ_{\mathbf{Hess\_CO2}gas}-G^\circ_{\mathbf{O2}gas0}=\mathbf{394{,}36}-\underline{303{,}1}=\mathbf{91{,}26}\ ^{kJ}/_{mol}$;
CO_{2gas}	-393,509	213,74	-394,359	CRC [1]
CO_{2aq}	-413,798	117,5704	-385,98	CRC [1]
CO_{2aq}	$E^\circ_{H2C2O4}=$	**-0,6577** V	**-42,90**	$2G_{CO2}=\ \mathbf{\Delta G_{eq}}_{H2C2O4}-2G_{\mathbf{H3O}}+(G_{H2C2O4}+2\mathbf{G_{H2O}})=2*\mathbf{-42{,}902}\ ^{kJ}/_{mol}$;
CO_{2aq}	$E^\circ_{HC2O4}=$	**-0,7092** V	**-97,514**	$2G_{CO2}=\ \mathbf{\Delta G_{eq}}_{HC2O4}-G_{\mathbf{H3O}}+(G_{HC2O4}+\mathbf{G_{H2O}})=2*\mathbf{-97{,}514}\ ^{kJ}/_{mol}$;
CO_{2aq}	$E^\circ_{C2O4}=$	**-0,7607** V	**-27,517**	$2G_{CO2}=\mathbf{\Delta G_{eq}}_{C2O4}+(G_{C2O4})=\mathbf{-27{,}517}\ ^{kJ}/_{mol}$;
CO_{2aq}	$K_{eqCO2aqua}$	šķīdība	**18,38**	$G_{CO2aqua}=\Delta G_{eqCO2aqua}+(G_{CO2gas}+G_{H2O})=\mathbf{18{,}38}+(0+0)=\mathbf{18{,}38}\ ^{kJ}/_{mol}$.

Veidošanās no brīviem elementiem $2C_{gr}+2O_{2gas}+H_{2gas}=H_2C_2O_{4cr}$ un šķīdība $H_2C_2O_4^{cr}+H_2O=H_2C_2O_{4aq}$: $G_{H2C2O4cr}=\Delta G°_{H2C2O4crForm}+(2G_{Cgr}+2G_{O2gas}+G_{H2gas})=-797{,}16+\mathbf{(2*91{,}26}+2*\mathbf{303}+\mathbf{85.6)=76{,}96}$ $^{kJ}/_{mol}$.

Skābeņskābes šķīdības 118 $^{g}/_{L}$ $H_2C_2O_4^{cr}+H_2O=H_2C_2O_{4aq}$ konstanti iegūst no CRC, Wikipēdijas datiem

$K_{eq\_sp}=[H_2C_2O_{4aq}]/[H_2C_2O_4^{cr}]/[H_2O]=1{,}3106/1/49{,}77=0{,}026329$. [1,29]

Mola masa $M_{H2C2O4}=90{,}034$ $^{g}/_{mol}$; $[H_2O]=982/18=49{,}777$ M; koncentrācija $[H_2C_2O_4]=118/90{,}034=1{,}3106$ M un masas daļa procentos $w\%=118/(118+982)*100=10{,}7272\%$, ja tīra kristāla mol daļa ir viens $[H_2C_2O_4^{cr}]=1$.

Skābeņskābes šķīdības brīvās enerģijas izmaiņa līdzsvarā ir nelabvēlīga $K_{eq\_sp}=0{,}026329$:

pozitīva $\Delta G_{eq\_sp}=-R•T•\ln(K_{eq\_sp})=-8{,}3144*298{,}15*\ln(0{,}026329)=-8{,}3144•298{,}15•-3{,}637=\mathbf{9{,}0161}$ $^{kJ}/_{mol}$.

Hesa izmaiņā $\Delta G_{eq\_sp}=G_{H2C2O4aq}-(G_{H2O}+G_{H2C2O4}^{cr})=G_{H2C2O4aq}-\mathbf{(0+76{,}96)=9{,}0161}$ $^{kJ}/_{mol}$ aprēķina saturu brīvai enerģijai $G_{H2C2O4aq}=\Delta G_{eq\_sp}+(G_{H2O}+G_{H2C2O4}^{cr})=\mathbf{9{,}0161}+\mathbf{(0+76{,}96)=85{,}976}$ $^{kJ}/_{mol}$ [29] Wikipedia.

1. Vājas skābes protolīze $H_2C_2O_4+H_2O=HC_2O_4^-+H_3O^+$; $pK_{a1}=1{,}25$; $K_{eq1}=K_{a1}/[\mathbf{H_2O}]=10^{\wedge(-1{,}25)}/55{,}3=0{,}0010169$;
$\Delta G_{eq1H2C2O4}=-R•T•\ln(K_{eq1})=-8{,}3144*298{,}15*\ln(0{,}0010169)=\Delta G_{HC2O4}+\Delta G_{H3O}-(\Delta G_{HC2O4}+\Delta G_{H2O})=\mathbf{17{,}08}$ $^{kJ}/_{mol}$;
$\Delta G_{eq1H2C2O4}=G_{HC2O4}+G_{H3O}-(G_{H2C2O4}+\Delta G_{H2O})=G_{HC2O4}+\mathbf{22{,}44}-\mathbf{(85{,}976+0)=17{,}082}$ $^{kJ}/_{mol}$;
$G_{HC2O4}=\Delta G_{eq1H2C2O4}-G_{H3O}+(G_{H2C2O4}+\Delta G_{H2O})=\mathbf{17{,}082-22{,}44+(85{,}976+0)=80{,}618}$ $^{kJ}/_{mol}$;

2. Vājas skābes protolīze $HC_2O_4^-+H_2O=C_2O_4^{2-}+H_3O^+$; $pK_{a2}=4{,}14$; $K_{eq2}=K_{a2}/[\mathbf{H_2O}]=10^{\wedge(-4{,}14)}/55{,}3=0{,}000001310$;
$\Delta G_{eq2HC2O4}=-R•T•\ln(K_{eq2})=-8{,}3144*298{,}15*\ln(0{,}000001310)=\Delta G_{C2O4}+\Delta G_{H3O}-(\Delta G_{HC2O4}+\Delta G_{H2O})=\mathbf{33{,}578}$ $^{kJ}/_{mol}$;
$\Delta G_{eq2HC2O4}=G_{C2O4}+G_{H3O}-(G_{HC2O4}+G_{H2O})=G_{C2O4}+\mathbf{22{,}44}-\mathbf{(80{,}618+0)=33{,}578}$ $^{kJ}/_{mol}$;
$G_{C2O4}=\Delta G_{eq2HC2O4}-G_{H3O}+(G_{HC2O4}+G_{H2O})=\mathbf{33{,}578-22{,}44+(80{,}618+0)=91{,}756}$ $^{kJ}/_{mol}$;

$pH<=1{,}25$ $H_2C_2O_4+2H_2O=2CO_2+2H_3O^++2e^-$; $E°_{H2C2O4}=\mathbf{-0{,}6577}$ V Suchotina [17]

$E°_{H2C2O4}=E°+0{,}10166-0{,}0591/2*\lg(1/[H_2O]^2)-0{,}37239=-0{,}49+0{,}10166-0{,}02955*\lg(1/55{,}3^2)-0{,}37239=\mathbf{-0{,}6577}$ V;

Absolute Nernst's Standard potential $E°_{H2C2O4}=\mathbf{-0{,}6577}$ V; Suchotina [17]

$$E_{H2C2O4}=E°_{H2C2O4}+\frac{0.0591}{2}•\lg\frac{[CO_2]^2\cdot[H_3O^+]^2}{[H_2C_2O_2]\cdot[H_2O]^2}=\mathbf{-0{,}6577}\text{ V}+\frac{0.0591}{2}•\lg\frac{[CO_2]^2\cdot[H_3O^+]^2}{[H_2C_2O_2]\cdot[H_2O]^2}$$

$\Delta \mathbf{G_{eq}}{}_{H2C2O4}=E^{\circ}_{H2C2O4}•F•2=\mathbf{-0{,}6577}*96485*2=\mathbf{-126{,}9}$ $^{kJ}/_{mol}$,

$\Delta \mathbf{G_{eq}}{}_{H2C2O4}=2G_{CO2}+2G_{H3O}-(G_{H2C2O4}+2G_{H2O})=2*0+2*\mathbf{22{,}44}-(G_{H2C2O4}+2*0)=\mathbf{-126{,}9}$ $^{kJ}/_{mol}$;

$G_{H2C2O4}=2G_{CO2}+2G_{H3O}-(\Delta \mathbf{G_{eq}}{}_{H2C2O4}+2G_{H2O})=2*0+2*\mathbf{22{,}44}-\mathbf{(-126{,}9}+2*0)=\mathbf{171{,}78}$ $^{kJ}/_{mol}$;

$1{,}25<pH<=4{,}14$; $HC_2O_4^-+H_2O=2CO_2+H_3O^++2e^-$;

Absolute Nernst's Standard potential $E°_{HC2O4}=\mathbf{-0{,}7092}$ V Suchotina [17]

$E°_{HC2O4}=E°+0{,}10166-0{,}0591/2*\lg(1/[H_2O]^1)-0{,}37239=-0{,}49+0{,}10166-0{,}0591/2*\lg(1/55{,}3^{\wedge 1})-0{,}37239=\mathbf{-0{,}709}$ V;

$\Delta \mathbf{G_{eq}}{}_{HC2O4}=E^{\circ}_{HC2O4}•F•2=\mathbf{-0{,}7092}*96485*2=\mathbf{-136{,}85}$ $^{kJ}/_{mol}$,

$\Delta \mathbf{G_{eq}}{}_{HC2O4}=2G_{CO2}+G_{H3O}-(G_{HC2O4}+G_{H2O})=2*0+\mathbf{22{,}44}-(G_{HC2O4}+0)=\mathbf{-136{,}85}$ $^{kJ}/_{mol}$,

$G_{HC2O4}=2G_{CO2}+G_{H3O}-(\Delta \mathbf{G_{eq}}{}_{HC2O4}+G_{H2O})=2*0+\mathbf{22{,}44}-\mathbf{(-136{,}85}+0)=\mathbf{159{,}028}$ $^{kJ}/_{mol}$,

$4{,}14<pH$; $C_2O_4^{2-}=2CO_2+2e^-$; Absolute Nernst's Standard potential $E°_{C2O4}=\mathbf{-0{,}7607}$ V; Suchotina [17]

$E°_{C2O4}=E°+0{,}10166-0{,}0591/2*\lg([1/H_2O]^0)-0{,}37239=-0{,}49+0{,}10166-0{,}0591/2*\lg(1/55{,}3^0)-0{,}37239=\mathbf{-0{,}7607}$ V;

$\Delta \mathbf{G_{eq}}{}_{C2O4}=E^{\circ}_{C2O4}•F•2=\mathbf{-0{,}7607}*96485*2=\mathbf{-146{,}79}$ $^{kJ}/_{mol}$,

$\Delta \mathbf{G_{eq}}{}_{C2O4}=2G_{CO2}-(G_{C2O4})=2*\mathbf{0}-(G_{C2O4})=\mathbf{-146{,}79}$ $^{kJ}/_{mol}$,

$G_{C2O4}=2G_{CO2}-(\Delta \mathbf{G_{eq}}{}_{C2O4})=2*\mathbf{0}-\mathbf{(-146{,}79)=146{,}79}$ $^{kJ}/_{mol}$, Nernsta potenciāla studijas reducējot ar vitamīnu B_3 etanālu $H_3CCH{=}O$ un oksidējot H_3CCH_2OH etanolu

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

$\Delta G_{Hess}=\Delta G°_{H3O}+\Delta G°_{CH3CHO}+\Delta G°_{NADH}-\Delta G°_{CH3CH2OH}-\Delta G°_{H2O}-\Delta G°_{NAD+}=159{,}1\ ^{kJ}/_{mol}$;
$\Delta G_{Hess}=32{,}2824+1175{,}5732-151{,}549-(75{,}2864+1059{,}11-237{,}191)=159{,}1\ ^{kJ}/_{mol}$ endoerģiska;
$NAD^++H^-(H^++2e^-)=NADH$; inversais standarta potenciāls $-E°_{NAD+}=\mathbf{0{,}38373}$ V; [22]
$CH_3CH_2OH+H_2O=CH_3CHO+H_3O^++H^-(H^++2e^-)$; absolūtais Nernsta potenciāls $E°_{C2H5OH}=\mathbf{0{,}02923}$ V;
$E°_{C2H5OH}=E°-0{,}0591/2\bullet\log(1/[H_2O]^1)=0{,}19-0{,}0591/2*\log(1/55{,}3^{\wedge1})+0{,}10166-0{,}37239=\mathbf{0{,}02923}$ V;
Summa: $E°_{C2H5OH}-E°_{NAD+}=\mathbf{0{,}02923}+\mathbf{0{,}38373}=0.3545$ V, n=2; $\Delta G_{eq}=\Delta E°\bullet F\bullet n=0.3545*96485*2=\mathbf{68{,}4}\ ^{kJ}/_{mol}$;
Novērtētajā balansā n=2=m ar elektronu skaitu $2e^-$ donors $E°_{C2H5OH}=\mathbf{0{,}02923}$ V plus electronu akceptors $-E°_{NAD+}=\mathbf{0{,}38373}$ V, jo $-E°_{NAD+}=\mathbf{0{,}38373}$ V akceptē elektronus no etanola $E°_{C2H5OH}=\mathbf{0{,}02923}$ V:

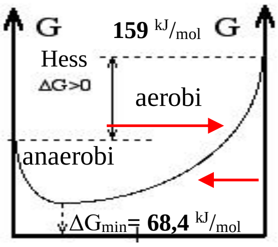
$$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=\mathbf{68{,}4}\ ^{kJ}/_{mol};\ K_{eq}=\frac{[NADH]\cdot[CH_3CHO]\cdot[H_3O^+]}{[NAD^+]\cdot[CH_3CH_2OH]\cdot[H_2O]}=e^{-\frac{\Delta Geq}{R\bullet T}}=\mathbf{e}^{-\frac{68408}{8.314\bullet298.15}}=1{,}036\bullet10^{-12}=10^{-11{,}985};$$

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

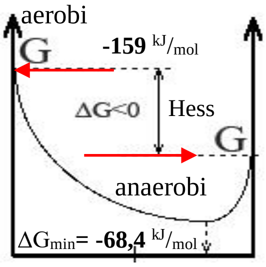
$\Delta G_{Hess}=\Delta G°_{CH3CH2OH}+\Delta G°_{H2O}+\Delta G°_{NAD+}-\Delta G°_{H3O}-\Delta G°_{CH3CHO}-\Delta G°_{NADH}=-159{,}1\ ^{kJ}/_{mol}$;
$\Delta G_{Hess}=75{,}2864+1059{,}11-237{,}191-(32{,}2824+1175{,}5732-151{,}549)=-159{,}1\ ^{kJ}/_{mol}$ endoerģiska;
Red $NADH=NAD^++H^-(H^++2e^-)$; absolūtais standarta potenciāls $E°_{NADH}=\mathbf{-0{,}38373}$ V; David Harris; [22]
$E°_{NADH}=E°-0{,}0591/2\bullet\log(1/[H_2O]^0)=-0{,}113-0{,}0591/2*\log(1/55{,}3^{\wedge0})+0{,}10166-0{,}37239=\mathbf{-0{,}38373}$ V;
Ox $CH_3CHO+2H_3O^++H^-(2e^-)=CH_3CH_2OH+2\ H_2O$; inversais potenciāls $-E°_{CH3CHO}=\mathbf{0{,}02923}$ V; [19];
Summa:
$\Delta E°=E°_{NADH}-E°_{CH3CHO}=\mathbf{-0{,}38373}+\mathbf{0{,}02923}=-0.3545$ V, $\Delta G_{eq}=\Delta E°\bullet F\bullet n=-0.3545\ V\bullet2\ mol\bullet96485\ ^{C}/_{mol}=\mathbf{-68{,}4}\ ^{kJ}/_{mol}$;
Novērtētajā balansā n=2=m ar elektronu skaitu $2e^-$ donors $E°_{NADH}=\mathbf{-0{,}38373}$ V plus electronu akceptors $-E°_{CH3CHO}=\mathbf{0{,}02923}$ V, jo $-E°_{CH3CHO}=\mathbf{0{,}02923}$ V akceptē elektronus no B3 vitamīna $E°_{NADH}=\mathbf{-0{,}38373}$ V .

$$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=\mathbf{-68{,}408}\ ^{kJ}/_{mol};\ K_{eq}=\frac{[NAD^+]\cdot[CH_3CH_2OH]\cdot[H_2O]}{[NADH]\cdot[CH_3CHO]\cdot[H_3O^+]}=e^{-\frac{\Delta Geq}{R\bullet T}}=\mathbf{e}^{-\frac{-68408}{8.314\bullet298.15}}=10^{11{,}985}.$$

<u>Aerobā</u> organismā O_{2aqua} NADH oksidāze reda attiecību $[NAD^+]/[NADH]=10^6$;
$\Delta G_{Homeostāze}=\mathbf{68{,}408}+R\bullet T\bullet\ln(10^6*1/1*10^{-7{,}36}/55{,}3)=68{,}408-86{,}2=-17{,}8\ ^{kJ}/_{mol}$.
$[NAD^+]/[NADH]=10^3$; $\Delta G_{Homeostāze}=\mathbf{68{,}408}-69{,}08=-0{,}676\ ^{kJ}/_{mol}$.
Līdzsvars novirzīts izejvielās kā <u>aerobā</u> konstante $K_{eq}=10^{-11{,}985}$ un ir inversa <u>anaerobi</u> produktos konstantē $K_{eq}=10^{11{,}985}$. <u>Aerobā</u> endotermiskā un endoerģiskā etanola oksidēšanā Hesa likuma brīvās enerģijas izmaiņa ir pozitīva $\Delta G_{Hess}=159\ ^{kJ}/_{mol}$ un asimetriski negatīva etanāla <u>anaerobai</u> reducēšanai $\Delta G_{Hess}=-159\ ^{kJ}/_{mol}$, bet minimizējas sasniedzot līdzsvaru $\Delta G_{min}=\Delta G_{eq}=68{,}4\ ^{kJ}/_{mol}$ <u>aerobi</u> izejvielas_
un asimetriski <u>anaerobi</u> $\Delta G_{min}=\Delta G_{eq}=\mathbf{-68{,}4}\ ^{kJ}/_{mol}$ sasniedzot līdzsvara produkti_
maisījumu ar asimetriskām konstantēm $10^{-11{,}985}=K_{eq}$ un $10^{11{,}985}=K_{eq}$.



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



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

Prigožina atraktors ir brīvās enerģijas izmaiņas absolūts minimums ΔG_{min} sasniedzot līdzsvaru: $\Delta G_{min}=\mathbf{68{,}4}\ ^{kJ}/_{mol}=|\Delta G_{eq}|<|\Delta G_{Hess}|=159\ ^{kJ}/_{mol}$.

<u>Anaerobi</u> $H_3C\text{-}CH{=}O+NADH+H_3O^+ \Rightarrow H_3C\text{-}CH_2\text{-}OH+NAD^++H_2O+\Delta G+Q$;
reducēšana labvēlīgi $\Delta G_{eq}=\Delta E°\bullet F\bullet n=-0.3545\ V\bullet2\ mol\bullet96485\ ^{C}/_{mol}=\mathbf{-68{,}408}\ ^{kJ}/_{mol}$.

<u>Anaerobā</u> etanola oksidēšana nelabvēlīga zemās O_{2aqua} koncentrācijas hipoksijā, bet etanāla reducēšana par etanolu labvēlīga $[H_3CCH_2OH]/[H_3CCH{=}O]=1/10$ homeostāzē ar NADH reduktāzes enzīmu kā negatīva brīvās enerģijas izmaiņa $\Delta G_{Homeostāze}=-27{,}86\ ^{kJ}/_{mol}$

<u>Anaerobā</u> attiecība homeostāzē virs c labvēlīga reducēšanai:
$\Delta G_{Homeostāze}=-68{,}41+8{,}3144*298.15*\ln(K_{Homeostāze})=-68{,}41+40{,}54=-27{,}86\ ^{kJ}/_{mol}$

$$\Delta G_{Homeostāze}=-68{,}41+8{,}3144*298{,}15*\ln\left(\frac{1}{10}\frac{1}{10}\frac{55.333}{10^{-7.36}}\right)=-27{,}86\ ^{kJ}/_{mol};\ K_{Homeostāz}=\frac{[NAD^+]\cdot[CH_3CH_2OH]\cdot[H_2O]}{[NADH]\cdot[CH_3CHO]\cdot[H_3O^+]}$$

$[NADH]/[NAD^+]=1/770$; $\Delta G_{Homeostāze}=68{,}408+8{,}3144*298{,}15*\ln(700/1*1/1*55{,}3457/10^{-7{,}36})=0{,}028\ ^{kJ}/_{mol}$.

Stikla $\underline{SiO_2}\downarrow$ /////SiO_2//// $\downarrow\underline{SiO_2}$ membrānas elektrods un pH mērīšana

Stikla elektrods ir parasti lietotais elektrods šķīduma pH noteikšanai. Tas pieskaitāms membrānu elektrodiem, bet tā potenciāls veidojas uz silīcija dioksīda (SiO_2) kristāliskās virsmas silīcijskābes protolīzes reakcijā $\underline{SiO_2{-}SiO_3H}+H_2O=\downarrow\underline{SiO_2{-}SiO_3}^-+H_3O^+$. Stikla elektroda potenciāla rašanās izskaidrojama sekojoši.

Uz stikla virsmas atrodas silīcijskābes anjonu funkcionālās grupas $\downarrow\underline{SiO_2{-}SiO_3}^-$. Stikla virsmā iestājas protolītiskais līdzsvara stāvoklis starp kristālisku silīcijskābi $\underline{SiO_2{-}SiO_3H}$ un silikāta anjonu grupām $\underline{SiO_2{-}SiO_3}^-$. Silīcijskābe ir ūdenī nešķīstoša skābe un ļoti vājš protolīts: $\underline{SiO_2{-}SiO_3H}+H_2O=\downarrow\underline{SiO_2{-}SiO_3}^-+H_3O^+$.

Tā kā kristāliskai membrānai ir iekšējās virsmas līdzsvars un uz ārējās membrānas virsmas ir ārējais līdzsvars, kurš ir mainīgs no mērāmās vides H_3O^+ koncentrācijas testa eksperimentos.

$$H_3O^+_{iekš}+\underline{SiO_3^-{-}SiO_2}\downarrow=H_2O+\underline{HSiO_3{-}SiO_2}\downarrow/////SiO_2////\,\underline{SiO_2{-}SiO_3H}+H_2O=\downarrow\underline{SiO_2{-}SiO_3}^-+H_3O^+_{ārēj.}$$

Virknē saslēgtu līdzsvaru konstanšu reizinājums veido membrānas līdzsvara konstanti $K_{iekš}\bullet K_{ārēj.}=K_{membr}$:

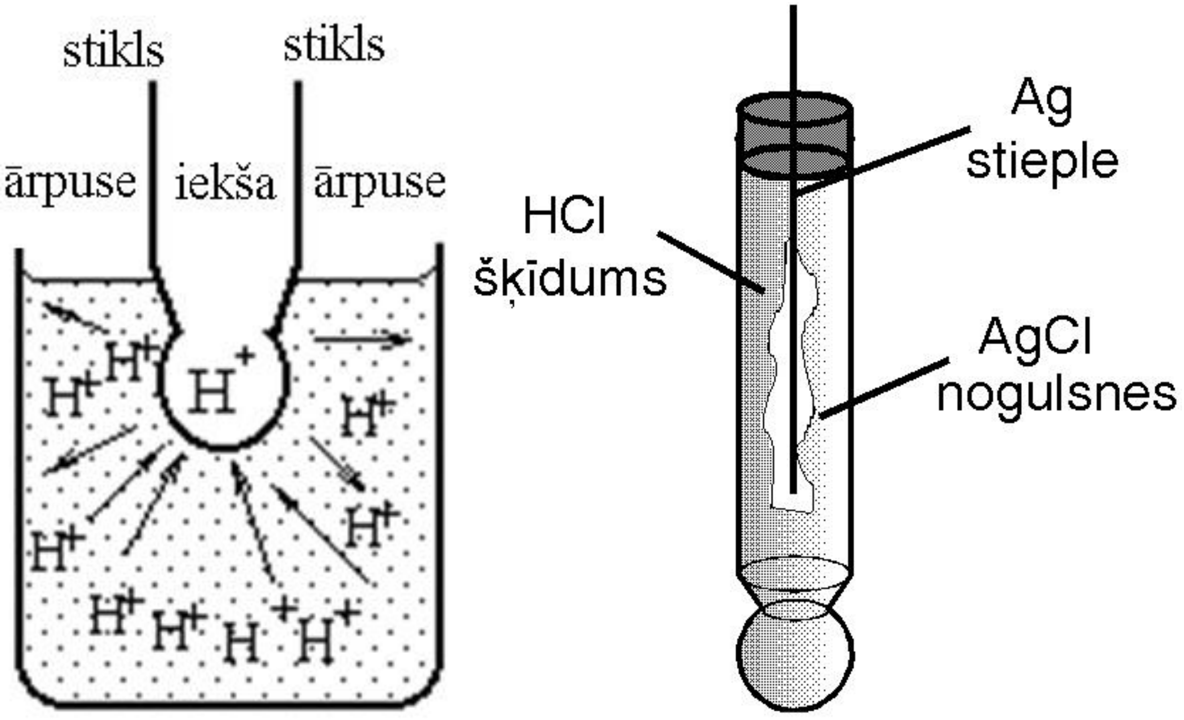
$$K_{iekš.}=\frac{[H_2O]}{[H_3O^+]_{iekš}}\ ;\qquad K_{ārēj.}=\frac{[H_3O^+]_{ārējs}}{[H_2O]}\ ;\qquad K_{iekš}\bullet K_{ārēj.}=K_{membr}=\frac{[H_3O^+]_{ārējs}}{[H_3O^+]_{iekš}}\ ;$$

$$E_{membr}=\frac{0{,}0591}{n}\log\frac{[H_3O^+]_{ārējs}}{[H_3O^+]_{iekš}}=0{,}0591(\log[H_3O^+_{ārēj}]-\log[H_3O^+_{iekš}])=E_{const}-0{,}0591\bullet pH\ ,$$

kur n=+1 ūdeņraža jona lādiņš H^+, bet logaritms no koncentrāciju attiecības ir logaritmu no koncentrācijām starpība. Jonu koncentrācija membrānas iekšpusē mainās un ir konstanta $E_{const.}=-0{,}0591\bullet\log[H_3O^+_{iekš}]$. Membrānas potenciāls ir atkarīgs tikai no šķīduma ūdeņraža joniem $H_3O^+_{ārēj}$ vai $pH=-\log[H_3O^+_{ārēj}]$.

$$E_{membr}=E_{const.}+0{,}0591\bullet\log[H_3O^+_{outer.}]\ .$$

Praktiski lietojama stikla elektroda uzbūves shēma parādīta attēlā. Stikla caurulītes galā ir izveidots plāns stikla pūslītis, kas kalpo par stikla membrānu. Stikla elektroda iekšpusē ieliets HC1 šķīdums ar zināmu koncentrāciju. Ārpusi iegremdē pētāmajā šķīdumā nomēra šķīduma pH.



Stikla membrāna $\underline{HSiO_3{-}SiO_2}\downarrow$ /////SiO_2//// $\downarrow\underline{SiO_2{-}SiO_3H}$ un elektroda komplekts ar sudraba stiepli.

Elektrisko kontaktu ar stikla membrānu iekšējā šķīdumā iegremdē sudraba stiepli, kas izveido otrā veida elektroda potenciālu $E_{AgCl\ iekš}$ virknē ar membrānas potenciālu $E_{membr.}+E_{AgCl\ iekš}$. Potenciāls ir atkarīgs tikai no ārējā – pētāmā šķīduma pH, jo sālsskābes koncentrācija ir konstanta.

EDS (Elektro Dzinēja Spēku) mēra noslēgtai elektriskai ķēdei. To panāk ārējā šķīdumā iemērcot salīdzināšanas elektrodu ar standarta potenciālu E_{AgCl}. Elektriskā ķēde noslēdzas pie pH-metra kontakta spailēm:

Kopējais EDS potenciāls sastāv no 3 virknē saslēgtiem elektrodiem no 3 daļām:

1) stikla elektroda iekšpusē izveidotā AgCl elektroda potenciāla $E_{AgCl\ iekš.}$;
2) stikla membrānas elektrods $E_{membr}= E_{const.}+0{,}0591\bullet \log[H_3O^{+}_{outer}]=E_{const.}-0{,}0591\bullet pH$.;
3) salīdzināšanas elektrods ar standarta potenciālu E_{AgCl}.

Saskaitot nemainīgo saskaitāmo daļas summā iegūst jaunu konstanti : $E'_{const}= (E_{AgCl}+E_{AgCl\ iekš}\ E_{const.})$

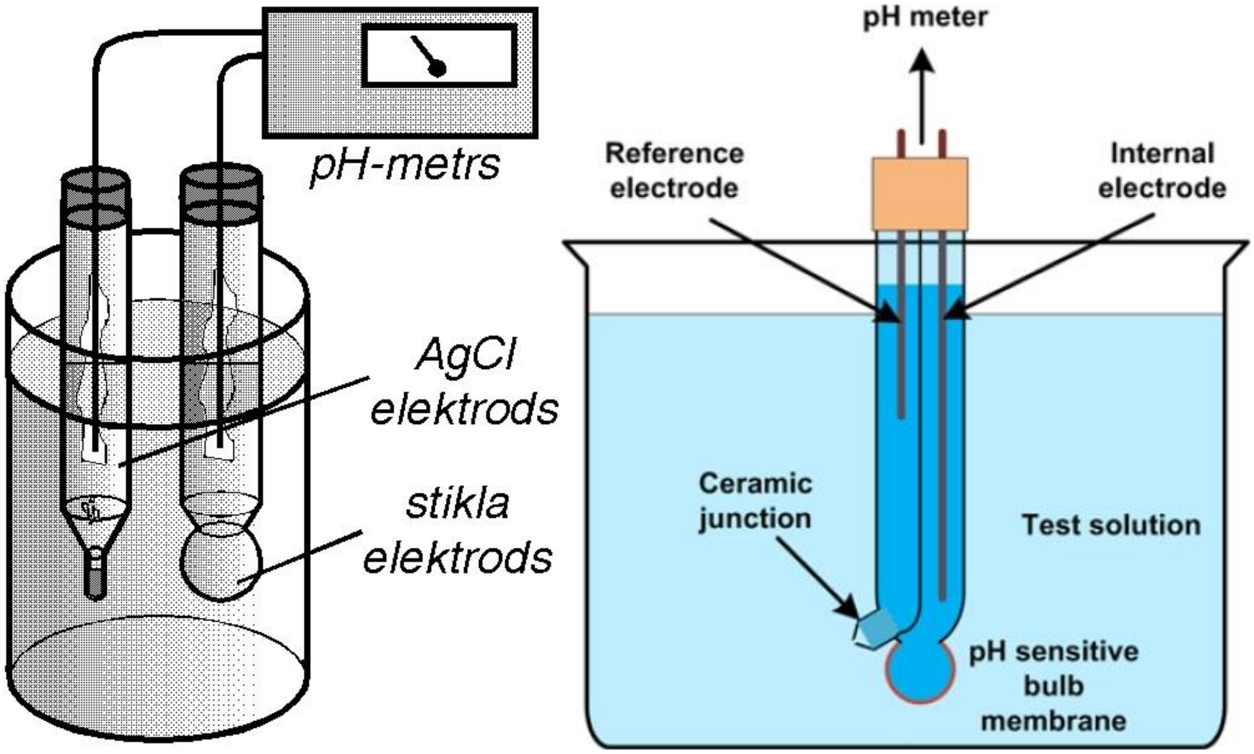
$$EDS=E_{AgCl}+E_{membr}+E_{AgCl\ iekš.}= (E_{AgCl}+E_{AgCl\ iekš}\ E_{const.})+0{,}0591\cdot lg\ [H_3O^{+}_{ārēj.}] = E'_{const}-0{,}0591\bullet pH\ ;$$

$$EDS = E'_{const}-0{,}0591\bullet pH\ .$$

Nomērītais Elektro Dzinēja Spēks (EDS) ir proporcionāls ārējā šķīduma pH vērtībai.

pH mērīšanai ar stikla elektrodu ir vairākas priekšrocības:

1) stikla elektrods ir lietojams visā nepieciešamajā pH intervālā (no pH = 0 līdz pH = 14);
2) mērījumi ir ļoti precīzi (līdz 0,01 pH vienībai);
3) mērījumi nav atkarīgi no oksidētāju, reducētāju un olbaltumvielu klātbūtnes šķīdumā;
4) nepārtraukti kontrolē pH izmaiņas pētāmajā sistēmā.



Šķīduma pH mērīšana ar kombinēto stikla un sudraba hlorīda elektrodu EDS pāri

Nernsta potenciāla $Cr_2O_7^{2-}$ / $2Cr^{3+}$ red-oks sistēmas īpašības skābā H_3O^+ , ūdens vidē

Nernsta absolūtais standarta potenciāls. $\log K_D=2,05$; $K_D=10$^^{2,05}; $2HCrO_4^-=Cr_2O_7^{2-}+H_2O$;

ΔG_D=-R•T•ln(K_D*[H_2O])=-8,3144*298,15*ln(10^^{2,05}*55,3)=G_{Cr2O7}+G_{H2O}-(2G_{HCrO4})= **-21,65** ^{kJ}/mol;

2G_{HCrO4}=G_{Cr2O7}+G_{H2O}-(ΔG_D)=G_{Cr2O7}+0-(**-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^(-1,8)/55,3= 0,0002866;

ΔG_{eq}=-R•T•ln(K_{eq})=-8,3144*298,15*ln(0,0002866)=G_{Cr2O7}+G_{H3O}-(G_{HCr2O7}+G_{H2O})=**20,22** ^{kJ}/mol;

G_{HCr2O7}=G_{Cr2O7}+G_{H3O}-(ΔG_{eq}+G_{H2O})=G_{Cr2O7}+22,44-(**20,22**+0)=??? ^{kJ}/mol;

Instability constant $\underline{[CrOH]^{2+}}+H_2O=Cr^{3+}+OH^-$; K_{inst}=10^$^{(-9,77)}$; $K_{eq}=K_{inst}/[H_2O]$=10^$^{(-9,88)}$/55,3=10^$^{(-11,51)}$;

ΔG_{eqinst}=-R•T•ln(K_{eqinst})=-8,3144*298,15*ln(10^$^{(-11,51)}$)=G_{Cr3+}+G_{OH}-($G_{[CrOH]2+}$+G_{H2O})= **65,7** ^{kJ}/mol;

$G_{[CrOH]2+}$=G_{Cr3+}+G_{OH}-(ΔG_{eqinst}+G_{H2O})=G_{Cr3+}+77,36-(**65,7**+0)=??? ^{kJ}/mol;

Instability $[\underline{Cr(OH)_2}]^++2H_2O=Cr^{3+}+2OH^-$; K_{inst}=10^$^{(-17,3)}$; $K_{eqinst}=K_{inst}/[H_2O]^2$=10^$^{(-17,3)}$/55,3^2=10^$^{(-20,785)}$;

ΔG_{eqinst}=-R•T•ln(K_{eqinst})=-8,3144*298,15*ln(10^$^{(-20,785)}$)=G_{Cr3+}+2G_{OH}-($G_{Cr(OH)2}$+2G_{H2O})=**118,64** ^{kJ}/mol;

$G_{Cr(OH)2}$=G_{Cr3+}+2G_{OH}-(ΔG_{eqinst}+2G_{H2O})=G_{Cr3+}+2*77,36-(**118,64**+2*0)=??? ^{kJ}/mol;

Instability constant $[\underline{Cr(OH)}_3]+3H_2O=Cr^{3+}+3OH^-$; K_{inst}=10^$^{(-24)}$; $K_{eq}=K_{inst}/[H_2O]$=10^$^{(-24)}$/55,3=10^$^{(-29,23)}$;

ΔG_{eqinst}=-R•T•ln(K_{eqinst})=-8,3144*298,15*ln(10^$^{(-29,23)}$)=G_{Cr3+}+3G_{OH}-($G_{[Cr(OH)3]}$+3G_{H2O})=**166,8** ^{kJ}/mol;

$G_{[Cr(OH)3]}$=G_{Cr3+}+3G_{OH}-(ΔG_{eqinst}+3G_{H2O})=G_{Cr3+}+3*77,36-(**166,8**+3*0)=??? ^{kJ}/mol;

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Viela	$\Delta H°_H$ ^{kJ}/mol	$\Delta S°_H$ ^{J}/mol/K	$\Delta G°_H$, ^{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_{HCrO4}=G_{Cr2O7}+0-(**-21,65**)=??? ^{kJ}/mol;

G_{HCr2O7}=G_{Cr2O7}+22,44-(**20,22**+0)=??? ^{kJ}/mol;

$G_{[CrOH]2+}$=G_{Cr3+}+77,36-(**65,7**+0)=??? ^{kJ}/mol;

$G_{Cr(OH)2}$=G_{Cr3+}+2*77,36-(**118,64**+2*0)=??? ^{kJ}/mol;

$G_{[Cr(OH)3]}$=G_{Cr3+}+3*77,36-(**166,8**+3*0)=??? ^{kJ}/mol;

2G_{2Cr3+}=$G_{Cr2O72-}$+14***22,44-(806,9**+21*0)=**???** ^{kJ}/mol;

G_{Cr3+}=G_{CrO4-}+14***22,44-(370,8**+21*0)=**???** ^{kJ}/mol;

$G_{Cr(\underline{OH})3}$=G_{CrO4-}+14***22,44-(163,2**+21*0)=**???** ^{kJ}/mol;

$G_{Cr(OH)3}$=G_{Cr3+}+3*77,36-(**211,99**+4*0)=??? ^{kJ}/mol;

Nernsta potenciāla BiO$_3^-$ / Bi^{3+} Nernsta absolūtais standarta potenciāls. 2Bi+6OH$^-$=Bi$_2$O$_3$+3H$_2$O+6e$^-$; pH>7; [7]

E°$_{Bi2O3–/Bi}$=E$_o$-0,0591/6*lg([H$_2$O]^3)+0,10166-0,37239=-0,46-0,0591/6*lg(55,3^^{3}) +0,10166-0,37239= **-0,78223** V ;

E°$_{Bi2O3–/Bi}$=E$_o$-0,0591/6*lg([H$_2$O]^6)+0,10166-0,37239=-0,46-0,0591/6*lg(55,3^^{6}) +0,10166-0,37239= **-0,8337** V ;

Viela	ΔH°$_H$ ^{kJ}/$_{mol}$	ΔS°$_H$ ^{J}/$_{mol/K}$	ΔG°$_H$, ^{kJ}/$_{mol}$
Bi^{3+}	-	82.8	-
Bi	E°$_{Bi2O3–/Bi}$	**-0.78223V**	**-249,6**
Bi	E°$_{Bi2O3–/Bi}$	**-0,67923V**	**-132,6**
Bi	E°$_{BiCl3–/Bi}$	**-0,21372V**	**298,725**
Bi	E°$_{BiCl4–/Bi}$	**-0,17939V**	**288,795**
Bi	E°$_{BiClO/Bi}$	**-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$_2$O$_3$	-573,9	151,5	-493.7
Bi(OH)$_3$	-711,3	-	-

2Bi+3OH$^-$+3H$_2$O=Bi$_2$O$_3$+3H$_3$O$^+$+6e$^-$; pH=7; Suchotina [17]

G$_{Bi}$=(G$_{Bi2O3}$+3G$_{H2O}$-(**ΔG**$_{eqBi2O3–/Bi}$+6**G**$_{OH}$))/2=**-249,6** ^{kJ}/$_{mol}$;

G$_{Bi}$=(G$_{Bi2O3}$+3G$_{H3O}$-(**ΔG**$_{eqBi2O3–/Bi}$+3**G**$_{OH}$+3G$_{H2O}$))/2=**-132,6** ^{kJ}/$_{mol}$;

G$_{Bi}$=G$_{BiCl3}$+3G$_{H2O}$-(**ΔG**$_{eqBiCl3–Bi}$**+3G**$_{Cl}$)=**298,725** ^{kJ}/$_{mol}$;

G$_{Bi}$=G$_{BiCl3}$+2G$_{H2O}$-(**ΔG**$_{eqBiCl3–Bi}$**+3G**$_{Cl}$)=**288,795** ^{kJ}/$_{mol}$;

G$_{Bi}$=G$_{BiClO}$+2G$_{H3O}$-(**ΔG**$_{eqBiClO–Bi}$+3H$_2$O**+G**$_{Cl}$)=**-91,03** ^{kJ}/$_{mol}$;

ΔH$_{Bi\_BiClO}$=**ΔG**+Δ**S*T**=**-91,03**+0,0567*298,15=**-74,125** ^{kJ}/$_{mol}$,

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

=**-0,78223**+0,0591/6*lg([Bi$_2$O$_3$]*[H$_2$O]^3/[Bi]^2/[OH$^-$]^6)

G$_{Bi}$=G$_{BiCl}$+3G$_{H2O}$-(**ΔG**$_{eqBiCl3–Bi}$**+3G**$_{Cl}$)= **306,2** ^{kJ}/$_{mol}$,

G$_{Bi}$=G$_{BiClO}$+2G$_{H3O}$-(**ΔG**$_{eqBiClO–Bi}$+3H$_2$O**+G**$_{Cl}$)=**291,44** ^{kJ}/$_{mol}$,

=**-0,67923**+0,0591/6*lg([Bi$_2$O$_3$]*[H$_3$O$^+$]^3/[Bi]^2/[OH$^-$]^3/[H$_2$O]^3=

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

ΔG$_{eqBi2O3–/Bi}$=E°$_{Bi2O3–/Bi}$•F•6=**-0,78223***96485*6= **-458,63** ^{kJ}/$_{mol}$,

ΔG$_{eqBi2O3–/Bi}$=G$_{Bi2O3}$+3G$_{H2O}$-(2G$_{Bi}$+6**G**$_{OH}$)=-493,7+3***0**-(2*G$_{Bi}$+6*77,36)= **-458,63** ^{kJ}/$_{mol}$,

G$_{Bi}$=(G$_{Bi2O3}$+3G$_{H2O}$-(**ΔG**$_{eqBi2O3–/Bi}$+6**G**$_{OH}$))/2=(-493,7+3***0**-(**-458,63**+6*77,36))/2=**-249,6** ^{kJ}/$_{mol}$,

ΔG$_{eqBi2O3–/Bi}$=E°$_{Bi2O3–/Bi}$•F•6=**-0,67923***96485*6= **-393,2** ^{kJ}/$_{mol}$,

ΔG$_{eqBi2O3–/Bi}$=G$_{Bi2O3}$+3G$_{H3O}$-(2G$_{Bi}$+3**G**$_{OH}$+3G$_{H2O}$)=-493,7+3***22.44**-(2*G$_{Bi}$+3*77,36+3***0**)= **-393,2** ^{kJ}/$_{mol}$,

G$_{Bi}$=(G$_{Bi2O3}$+3G$_{H3O}$-(**ΔG**$_{eqBi2O3–/Bi}$+3**G**$_{OH}$+3G$_{H2O}$))/2=(-493,7+3***22.44**-(**-393,2**+3*77,36+3***0**))/2=**-132,6** ^{kJ}/$_{mol}$,

Bi+3Cl$^-$=BiCl$_{3(s)}$+3H$_2$O+3e$^-$; pH=7 ; Suchotina [17]

E°$_{BiCl3–/Bi}$=E$_o$-0,0591/3*lg([H$_2$O]^3)+0,10166-0,37239=0,16-0,0591/3*lg(55,3^^{3})+0,10166-0,37239=**-0,21372** V ;

ΔG$_{eqBiCl3–Bi}$=E°$_{eqBiCl3–Bi}$•F•3=**-0,21372***96485*3=**-69,32** ^{kJ}/$_{mol}$,

ΔG$_{eqBiCl3–Bi}$=G$_{BiCl}$+3G$_{H2O}$-(G$_{Bi}$**+3G**$_{Cl}$)=-315+3***0**-(G$_{Bi}$+3***-183,955**)=**-69,32** ^{kJ}/$_{mol}$,

G$_{Bi}$=G$_{BiCl3}$+3G$_{H2O}$-(**ΔG**$_{eqBiCl3–Bi}$**+3G**$_{Cl}$)=-315+3***0**-(**-69,32**+3***-183,955**)=**298,725** ^{kJ}/$_{mol}$,

Bi+4Cl$^-$=BiCl$_4^-$+2H$_2$O+3e$^-$; pH=7 ; Suchotina [17]

E°$_{BiCl4–/Bi}$=E$_o$-0,0591/3*lg([H$_2$O]^2)+0,10166-0,37239=0,16-0,0591/3*lg(55,3^^{2})+0,10166-0,37239=**-0,17939** V ;

ΔG$_{eqBiCl3–Bi}$=E°$_{eqBiCl3–Bi}$•F•3=**-0,17939***96485*3=**-51,93** ^{kJ}/$_{mol}$,

ΔG$_{eqBiCl3–Bi}$=G$_{BiCl}$+2G$_{H2O}$-(G$_{Bi}$**+3G**$_{Cl}$)=-315+3***0**-(G$_{Bi}$+3***-183,955**)=**-51,93** ^{kJ}/$_{mol}$,

G$_{Bi}$=G$_{BiCl3}$+2G$_{H2O}$-(**ΔG**$_{eqBiCl3–Bi}$**+3G**$_{Cl}$)=-315+3*0-(**-51,93**+3***-183,955**)=**288,795** ^{kJ}/$_{mol}$,

Bi+3H$_2$O+Cl$^-$=BiClO$_{(s)}$+2H$_3$O$^+$+3e$^-$; Suchotina [17]

E°$_{BiClO/Bi}$=E$_o$-0,0591/3*lg(1/[H$_2$O]^3)+0,10166-0,37239=0,16-0,0591/3*lg(1/55,3^^{3})+0,10166-0,37239=**-0,007735** V;

ΔG$_{eqBiClO–Bi}$=E°$_{eqBiClO–Bi}$•F•3=**-0,007735***96485*3=**-2,2389** ^{kJ}/$_{mol}$,

ΔG$_{eqBiClO–Bi}$=G$_{BiClO}$+2G$_{H3O}$-(G$_{Bi}$+3H$_2$O**+G**$_{Cl}$)=-322,1+2***22,44**-(G$_{Bi}$**+3*0-183,955**)=**-2,2389** ^{kJ}/$_{mol}$,

G$_{Bi}$=G$_{BiClO}$+2G$_{H3O}$-(**ΔG**$_{eqBiClO–Bi}$+3H$_2$O**+G**$_{Cl}$)=-322,1+2***22,44-(-2,2389+3*0-183,955)**=**-91,03** ^{kJ}/$_{mol}$,

BiO$^+$+6H$_2$O=BiO$_3^-$+4H$_3$O$^+$+2e$^-$; 1<pH<7 ; Suchotina [17]

E°$_{BiO3–/BiO+}$=E$_o$-0,0591/2*lg(1/[H$_2$O]^6)+0,10166-0,37239=1,80-0,0591/2*lg(1/55,3^^{6})+0,10166-0,37239=**1,83826** V;

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

ΔG$_{eqBiO3–/BiO+}$=E°$_{eqBiO3–/BiO+}$•F•3=**1,83826***96485*2=**354,73** ^{kJ}/$_{mol}$,

ΔG$_{eqBiO3–/BiO+}$=G$_{BiO3–}$+4G$_{H3O}$-(G$_{BiO+}$+6H$_2$O)=G$_{BiO3–}$+4***22,44**-(G$_{BiO+}$**+6*0**)=**354,73** ^{kJ}/$_{mol}$,

G$_{BiO+}$=G$_{BiO3–}$+4G$_{H3O}$-(**ΔG**$_{eqBiO3–/BiO+}$+6H$_2$O)=G$_{BiO3–}$+4***22,44**-(**354,73+6*0**)=??? ^{kJ}/$_{mol}$,

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

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