

Ūdeņraža elektroda atskaites punkta $E^\circ_H = -0.2965$ Voltu atklāšana
absolūto potenciālu skalā sinhronizē zinātnes ar **absolūtās** brīvās enerģijas skalu.

Mana šodienas runa ir vērsta uz pētījumiem par enerģijas un potenciālu **absolūto mērogu**, kas ir vienāds skaitlis ar pretēju zīmi apgrieztās reakcijas inversajā simetrijā.

Esmu patiesi priecīgs pievienoties jums 10. STARPTAUTISKAJĀ KONFERENCE par jaunām
Ķīmijas tendencēm vietnē ar atklājumu par tēmu:

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Ūdeņraža elektroda atskaites punkta $E^\circ_H = -0.2965$ V atklāšana **absolūtā** potenciāla un **absolūtās** brīvās enerģijas skalai pusreakcijā nosaka **inversās simetrijas** īpašību: Apgrieztais reakcijas potenciāls pieder vienam un tam pašam skaitlim ar pretēju zīmi.

Simetrija sakrīt ar **inverso absolūtu** brīvo enerģiju, kuras skaitlis ir vienāds, bet ar pretēju zīmi.

Absolūtās un **inversās** brīvās enerģijas un potenciāla mēroga noteikšanai nepieciešama ūdens un hidroksonija uzskaitē, kuras pamatā ir Alberty dati par ūdeņraža gāzi un šķīduma absolūtās brīvās enerģijas vērtību.

Nernsta klasiskā pusreakcija ar ūdens un hidroksonija atlaidi ir $\underline{\text{H(Pt)}} = \text{H}^+ + \text{e}^-$. [11]

Standarta klasiskais potenciāls nulle $E^\circ_H = 0.0$ V tiek ņemts $[\text{H}^+] = 1 \text{ M}$ sērskābes šķīdumā nomērīts potenciāls:

$$\mathbf{E = E^\circ_H + 0.0591 \cdot \log[H^+] = 0.0 + 0.0591 \cdot \log(1 \text{ M}) = 0 \text{ V}}$$

un ir nulls atskaitē klasiskā potenciālu skalā kopš 1920. gada Nobela prēmijas ķīmijā

Termodinamiskā pusreakcija ar ūdens un hidroksonija uzskaiti ir $\underline{\text{H(Pt)}} + \text{H}_2\text{O} = \text{H}_3\text{O}^+ + \text{e}^-$.

Termodinamiskā potenciāla izteiksme pusreakcijai uz ņemtā nulles potenciāla $E = 0$ V vērtības ir:

$$\mathbf{E = E^\circ_H + 0.0591 \cdot \log([\text{H}_3\text{O}^+]/[\text{H}_2\text{O}]) = 0.10166 + 0.0591 \cdot \log(1 \text{ M}/52.5 \text{ M}) = 0 \text{ V}}$$

kur $0.0591 \cdot \log(1/52.5) = -0.10166$ V ir termodinamiskā standarta potenciāla korekcija.

Ūdens uzskaitē koriģē termodinamisko standarta potenciālu: $E^\circ_H = \underline{0.10166}$ V termodinamiskā potenciāla skalā

$$\text{nulles vietā: } E = E^\circ_H + \frac{\ln(10) * R * T}{F * 1e^-} \cdot \log \frac{[\text{H}_3\text{O}^+]}{[\text{H}_2\text{O}]} = 0 \text{ V; } E^\circ_H = E - 0.0591 \cdot \log(1/52.5) = 0 - (-0.10166) = \underline{0.10166} \text{ V.}$$

Attiecība $[\text{H}_3\text{O}^+]/[\text{H}_2\text{O}] = 1/52.5$ dod koriģēto termodinamisko standarta potenciālu $E^\circ_H = \underline{0.10166}$ V nulles vietā.

Nernsta pusreakcijā ūdeņradim $\underline{\text{H(Pt)}} + \text{H}_2\text{O} = \text{H}_3\text{O}^+ + \text{e}^-$ standarta punkta absolūtais potenciāls ir

$$E^\circ_H = -0.29654 \text{ V.}$$

Nernsta pusreakcija **absolūtajā** standarta **potenciāla** producētā izmaiņas vērtība brīvās enerģijas skalā:

$$\Delta G_{eq} = E^\circ_H \cdot F \cdot 1 \cdot 1 = -0.29654 \cdot 96485 \cdot 1 = \underline{-28.61 \text{ kJ/mol}}$$

ir identisks Hesa likumā aprēķinātās brīvās enerģijas izmaiņai kā eksoergiskai absolūtajā skalā, kas attiecas uz ūdens nulles brīvās enerģijas saturu $G_{\text{H}_2\text{O}} = 0 \text{ kJ/mol}$:

$$\Delta G_{Hess_eq} = G_{\text{H}_3\text{O}^+} + G_{\text{e}^-} - (G_{\text{H(Pt)}} + G_{\text{H}_2\text{O}}) = 22.44 + 0 - (\underline{51.05} + 0) = \underline{-28.61 \text{ kJ/mol}}.$$

Absolūtais standarta **potenciāls** $E^\circ_H = -0.29654$ Volti sakrīt ar Alberty datu **absolūtās** brīvās enerģijas skalu

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[8,15]

Absolūtā OxRed potenciālu skala noslīd par $\Delta E = -0,29654 - 0,10166 = -0,3982$ Voltiem zemāk.
Ūdens uzskaitē zinātnēs pieprasī absolūto brīvās enerģijas skalu sinhronizējot Nernsta reakciju absolūto potenciālu skalu inversās simetrijas identiskās vērtībās bet ar pretēju zīmi.

Atraktoram pH=7,36 līdzsvara stāvoklī ir patiesa pOH=6,64 vērtība, jo pKw=14=pH+pOH=7,36+6,64.

Ūdens daudzuma atlaide [H₂O]=963/18=53,5 M litrā sērskābes [H₂SO₄]=[H₃O⁺]=1 M šķīduma ar 1,061 g/mL blīvumu **ūdeņraža elektrodam** Nernsta izteiksmē ir klasiska standarta potenciāla E_{o_classic}=0 V atskaites vērtība:

$$\underline{H(Pt)} = H^+ + e^-; E_{classic} = E_{o_classic} + 0,0591 \cdot \log K^{\circ}_{classic H(Pt)} = 0 + 0,0591 \cdot \log[H^+] = 0 + 0,0591 \cdot \log(1 \text{ M}) = 0 \text{ Volti. [11]}$$

Termodinamiska hidroksonija jonu uzskaitē pieprasī ūdeni: $\underline{H(Pt)} + H_2O \rightleftharpoons H_3O^+ + e^-$ un E[°]_H=0,10166 V.

Attiecība [H₃O⁺]/[H₂O]=1 M/52,5 M=X_{H₃O⁺}/X_{H₂O} ir mol daļa aizstājot molaritāti [H⁺]=1 M klasiskajā potenciāla izteiksmē. Ūdens uzskaitē dod termodinamisko standartu E[°]_H=0,10166 V potenciālu skalā.

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

$$E = E^{\circ}_{H^+} + \frac{\ln(10) \cdot R \cdot T}{F \cdot 1} \cdot \log \frac{X_{H_3O^+}}{X_{H_2O}} = E_{o_classic} + 0,0591 \cdot \log(1/52,5) = 0,10166 - 0,10166 = 0 \text{ V.}$$

Ja attiecība ir viens $1 = K_{H(Pt)} = X_{H_3O^+}/X_{H_2O}$, tad potenciāls E[°]_H=0,10166 V ir termodinamiskais standarts:

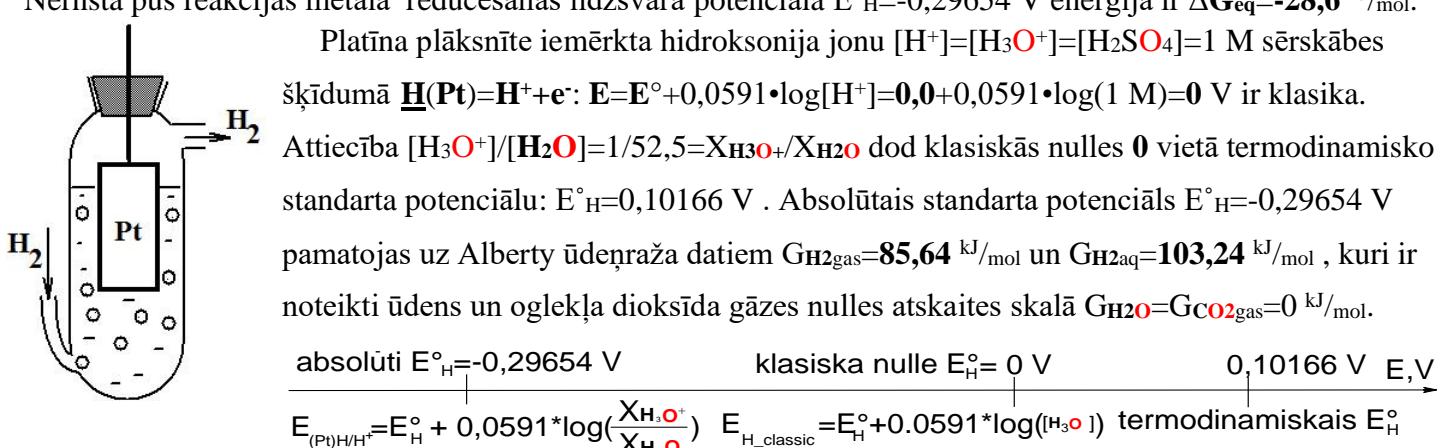
$$E = E^{\circ}_{H^+} + \frac{\ln(10) \cdot R \cdot T}{F \cdot 1} \cdot \log \frac{X_{H_3O^+}}{X_{H_2O}} = 0,10166 + 0,0591 \cdot \log(1) = 0,10166 \text{ V. Metāla oksidēšanas brīvās enerģijas izmaiņa ir atšķirīga endoerģiska } \Delta G_{eq} = E^{\circ}_{H^+} \cdot F \cdot 1 \cdot 1 = 0,10166 \cdot 96485 \cdot 1 = 9,81 \text{ kJ/mol pretstatā Alberty eksoerģiskai.}$$

[Alberty](#) Hesa vērtība ir eksoerģiska: $\Delta G_{Hess_eq} = G_{H_3O^+} + G_{e^-} - (G_{H(Pt)} + G_{H_2O}) = 22,44 + 0 - (51,05 + 0) = -28,61 \text{ kJ/mol.}$ Brīvās enerģijas izmaiņa ir noteikta nulles atskaites skalā $G_{H_2O} = G_{CO_2\text{gas}} = G_{e^-} = 0 \text{ kJ/mol}$. Iteratīvi izskaitļotais absolūtajā skalā **ūdeņraža** standarta potenciāls ir: E[°]_H= -0,29654 Volti. Līdzsvara brīvās enerģijas minimums ir eksoerģisks: $\Delta G_{eq} = E^{\circ}_{H^+} \cdot F \cdot 1 \cdot 1 = -0,29654 \cdot 96485 \cdot 1 = -28,61 \text{ kJ/mol}$ sakrītot ar Alberty datiem. Absolūtā potenciālu skala noslīd par $\Delta E = -0,29654 - 0,10166 = -0,3982$ Voltiem zemāk. Nernsta līdzsvara konstante ir lielāka par vienu: $K_{H(Pt)\text{Red}} = [H_3O^+]^* [e^-]^* / [H_2O] / [H(Pt)] = \text{EXP}(-\Delta G_{Alberty} / R/T) = \text{EXP}(28612 / 8,3144 / 298,15) = 102954$.

I veida elektrods metāls H(Pt) / iegremdēts tā katjonu H₃O⁺ šķīdumā pielietojums.

Liela ātruma protolīzes atraktori [H₃O⁺]=10^{-7,36} M , pH=7,36 un ūdens masas [H₂O]=997/18=55,3 M uzskaitē litrā rāda metāla ūdeņraža stipru reducējošu potenciālu: $E_{pH=7,36} = -0,29654 + 0,0591 \cdot \log(10^{-7,36} / 55,3) = -0,8345 \text{ V}$ un brīvās enerģijas izmaiņas minimumu $\Delta G_{eq,pH=7,36} = E^{\circ}_{H^+} \cdot F \cdot 1 = -0,8345 \cdot 96485 \cdot 1 / 1000 = -80,5 \text{ kJ/mol}$.

Nernsta pus reakcijas metāla reducēšanas līdzsvara potenciāla E[°]_H=-0,29654 V enerģija ir $\Delta G_{eq} = -28,6 \text{ kJ/mol}$.



Pie pH=7,36 , [H₃O⁺]=10^{-7,36} M ar potenciālu $E = -0,2965 + 0,0591 \cdot \log(10^{-7,36} / 55,3) = -0,8345 \text{ V}$ metāls H(Pt) ir stiprs reducētājs. Brīvās enerģijas saturs vienā molā ūdeņraža metāla ir: $G_{H(Pt)} = 51,05 \text{ kJ/mol}$.

Inversā pus reakcijā producējas ūdens $\text{O}_{2\text{aqua}} + 2\text{H}_{2\text{aqua}} \rightarrow 2\text{H}_2\text{O}$. Hesa brīvās energijas izmaiņa ir eksoergiskā:

$\Delta G_{\text{eq}2\text{H}_2\text{O}} = 6\text{G}_{\text{H}_2\text{O}} - (\text{G}_{\text{O}_{2\text{aqua}}} + 4\text{G}_{\text{H}_3\text{O}^+}) = 6*0 - (330 + 4*22.44) = -419.76 \text{ kJ/mol}$ **inversā absolūtā** standarta potenciālā - $E^\circ \text{O}_2 = -1.0868 \text{ V}$. Brīvās energijas izmaiņa ir negatīva $\Delta G_{\text{eq}} = E^\circ \text{O}_2 \cdot F \cdot 1 \cdot 4 = -1.0868 * 96485 * 4 = -419.44 \text{ kJ/mol}$ un sakrīt ar Alberty datiem eksoergisku Hesa vērtību pus reakcijai.

Cetras reducējošas pus reakcijas $4\text{H}(\text{Pt}) + 4\text{H}_2\text{O} \rightarrow 4\text{H}_3\text{O}^+ + 4\text{e}^-$, $E^\circ \text{H} = -0.2965 \text{ V}$ dod brīvās energijas izmaiņas minimum $\Delta G_{\text{eq}} = (E^\circ \text{H} - E^\circ \text{O}_2) \cdot F \cdot 4 = (-0.2965 - 1.0868) * 96485 * 4 = -1.38334 * 96485 * 4 / 1000 = -533.9 = 2 * -266.94 \text{ kJ/mol}$ ūdeni producējot $\text{O}_{2\text{aqua}} + 4\text{H}(\text{Pt}) \rightarrow 2\text{H}_2\text{O}$ no elementiem ar energijas saturu $\text{G}_{\text{H}(\text{Pt})} = 51 \text{ kJ/mol}$ un $\text{G}_{\text{O}_{2\text{aq}}} = 330 \text{ kJ/mol}$.

Ūdeņraža oksidēšanas reakcijā par ūdeni $\text{O}_{2\text{aqua}} + 2\text{H}_{2\text{aqua}} \rightarrow 2\text{H}_2\text{O}$ Hesa **absolūtās** brīvās energijas izmaiņa arī pat eksoergiskā: $\Delta G_{\text{HessH}_2\text{O}_{\text{aqua}}} = (2\text{G}_{\text{H}_2\text{O}} - (2\text{G}_{\text{H}_{2\text{aqua}}} + \text{G}_{\text{O}_{2\text{aqua}}})) / 2 = (0 - (2 * 103 + 330)) / 2 = -268 \text{ kJ/mol}$ sakrīt ar **absolūto** potenciāla energijas skalu $\Delta E_{\text{eqH}_2\text{O}} = (E^\circ \text{H} - E^\circ \text{O}_2) / 2 = (-0.2965 - 1.0868) / 2$ energijai $\Delta G_{\text{eqH}_2\text{O}} = -266.94 \text{ kJ/mol}$.

Hesa vienādojumā $\Delta G_{\text{eq}2\text{H}_2\text{O}} = 2\text{G}_{\text{H}_2\text{O}} - 4\text{G}_{\text{H}(\text{Pt})} - \text{G}_{\text{O}_{2\text{aqua}}} = 2 * 0 - (4 * \text{G}_{\text{H}(\text{Pt})} + 330) = -533.9 = 2 * -267 \text{ kJ/mol}$ iegūstams metāla **absolūtās** brīvās energijas satus $\text{G}_{\text{H}(\text{Pt})} = (2\text{G}_{\text{H}_2\text{O}} - \Delta G_{\text{eq}2\text{H}_2\text{O}} - \text{G}_{\text{O}_{2\text{aqua}}}) / 4 = (2 * 0 + 533.886 - 330) / 4 = 51.05 \text{ kJ/mol}$. **Absolūtās** brīvās energijas satus ir aprēķināts ūdens un gāzes $\text{CO}_{2\text{gas}}$ nulles skalā $\text{G}_{\text{H}_2\text{O}} = \text{G}_{\text{CO}_{2\text{gas}}} = 0 \text{ kJ/mol}$.

Ūdeņraža metāls ir iekļauts platīna režģī ar $\text{G}_{\text{H}(\text{Pt})} = 51 \text{ kJ/mol}$, elements slāpeklis satur $\text{G}_{\text{N}_{2\text{gas}}} = -15.26 \text{ kJ/mol}$, skābekļa gāze $\text{G}_{\text{O}_{2\text{gas}}} = 303 \text{ kJ/mol}$ plus $\text{G}_{\text{O}_{2\text{sp}}} = 26.58 \text{ kJ/mol}$ šķīdība ūdenī veido $\text{G}_{\text{O}_{2\text{aq}}} = 330 \text{ kJ/mol}$, for graphite in reaction with oxygen gas and hydrogen gas $\text{G}_{\text{graphite}} = \text{G}_{\text{CO}_{2\text{gr}}} = \text{G}_{\text{C}_{\text{gr}}\text{CH}_4\text{gas}} = 91.26 \text{ kJ/mol}$.

Šķīdības $\text{O}_{2\text{gas}} \text{ AIR} + \text{H}_2\text{O} \xrightarrow{\text{Aquaporins}} \text{O}_{2\text{aq}}$ to productu energija palielinās par $\text{G}_{\text{O}_{2\text{sp}}} = 26.58 \text{ kJ/mol}$:

$[\text{O}_{2\text{aq}}]/[\text{O}_{2\text{gas Gaiss}}]/[\text{H}_2\text{O}] = K_{\text{sk}} = 2.205 * 10^{-5}$. $\text{G}_{\text{O}_{2\text{sk}}} = -R \cdot T \cdot \ln(K_{\text{sk}}) = -8.3144 * 298.15 * \ln(2.205 * 10^{-5}) = 26.58 \text{ kJ/mol}$.

Dati no [CRC](#) gāzēm $\text{O}_{2\text{gas}} + 2\text{H}_{2\text{gas}} \rightarrow 2\text{H}_2\text{O}$ uz vienu mola saturu ūdenim ir $\Delta G_{\text{HessH}_2\text{O}} = -237.19 \text{ kJ/mol}$.

Skābekļa viens mols satur $\text{G}_{\text{O}_{2\text{gas}}} = 2 * \text{G}_{\text{H}_2\text{O}} - 2 * (\Delta G_{\text{HessH}_2\text{O}} + \text{G}_{\text{H}_{2\text{gas}}}) = 2 * 0 - 2 * (-237.19 + 85.64) = 303 \text{ kJ/mol}$ reakcijā no elementiem $\Delta G_{\text{HessH}_2\text{OBioChem}} = (2\text{G}_{\text{H}_2\text{O}} - (2\text{G}_{\text{H}_{2\text{gas}}} + \text{G}_{\text{O}_{2\text{gas}}})) / 2 = (0 - (2 * 85.64 + 303)) / 2 = -237.19 \text{ kJ/mol}$. [1,8]

[CRC](#) [1] $\Delta G_{\text{HessH}_2\text{O}} = -237.19 \text{ kJ/mol} = (2\text{G}_{\text{H}_2\text{O}} - (2\text{G}_{\text{H}_{2\text{gas}}} + \text{G}_{\text{O}_{2\text{gas}}})) / 2 = -237.19 \text{ kJ/mol} = \Delta G_{\text{HessH}_2\text{OBioChem}}$. [Alberty](#) [8]

Dati no [1] un [8] ir sakrītoši $-237.19 \text{ kJ/mol} = -237.19 \text{ kJ/mol}$. **Absolūtā** energija ūdens šķīdumos arī ir $\text{G}_{\text{H}_2\text{aqua}} = 103 \text{ kJ/mol}$ and $\text{G}_{\text{O}_{2\text{aqua}}} = \text{G}_{\text{O}_{2\text{gas}}} + \text{G}_{\text{O}_{2\text{sk}}} = 303 + 26.58 = 330 \text{ kJ/mol}$ eksoergiska $\text{O}_{2\text{aqua}} + 2\text{H}_{2\text{aqua}} \rightarrow 2\text{H}_2\text{O}$:

$\text{G}_{\text{HessH}_2\text{OBioChem}} = (2\text{G}_{\text{H}_2\text{O}} - (2\text{G}_{\text{H}_2\text{aqua}} + \text{G}_{\text{O}_{2\text{aqua}}})) / 2 = (2 * 0 - (2 * 103 + 330)) / 2 = -268 \text{ kJ/mol}$.

[Alberty](#) dati ūdeņraža gāzei $\text{G}_{\text{H}_{2\text{gas}}} = 85.64 \text{ kJ/mol}$ un ūdeņraža šķīdumam $\text{G}_{\text{H}_2\text{aqua}} = 103 \text{ kJ/mol}$ tiek lietoti šķīdības konstantes reakcijai ūdenī: $\text{H}_{2\text{gas}} + \text{H}_2\text{O} \rightarrow \text{H}_{2\text{aq}}$. Ūdeņraža šķīdības destilētā ūdenī **absolūta** energijas izmaiņa ir:

$$\Delta G_{\text{H}_2\text{skAlberty}} = \text{G}_{\text{H}_2\text{aq}} - \text{G}_{\text{H}_{2\text{gas}}} - \text{G}_{\text{H}_2\text{O}} = 103.24 - 85.64 - 0 = 17.6 \text{ kJ/mol}.$$

[Alberty](#) bioķīmijas matemātiskā pielietojuma dati veido šķīdības konstanti mol daļas $K_{\text{H}_2\text{sk}} = 0.0008253$:

$[\text{H}_{2\text{aq}}]/[\text{H}_{2\text{gas}}]/[\text{H}_2\text{O}] = K_{\text{H}_2\text{sk}} = \text{EXP}(-\Delta G_{\text{H}_2\text{skAlberty}}/R/T) = \text{EXP}(-17600/8.3144/298.15) = 0.0008253$ ar šķīdību

$[\text{H}_{2\text{aq}}] = K_{\text{H}_2\text{sk}} * [\text{H}_2\text{O}] = 0.0008253 * 55.3 = 0.04564 \text{ M}$, ja tīras gāzes mol daļa ir viens $[\text{H}_{2\text{gas}}] = 1$. [8]

$\text{H}_{2\text{gas}} + \text{H}_2\text{O} \rightarrow \text{H}_{2\text{aqCRC}}$; Šķīdība 100 gramos destilēta ūdens 0.000155 g/100g_{H2O}, blīvums 0.996 g/L veido koncentrāciju $[\text{H}_{2\text{aqCRC}}] = 0.000155 / 100.000155 * 996 = 0.0007719 \text{ M}$, [1] CRC

Šķīdības konstante $K_{\text{skCRC}} = [\text{H}_{2\text{aq}}]/[\text{H}_2\text{O}] = 0.0007719 / 55.3 = 0.000013958$ un **absolūtā** brīvās energijas izmaiņa ir $\Delta G_{\text{skH}_2\text{CRC}} = -R \cdot T \cdot \ln(K_{\text{skH}_2\text{CRC}}) = -8.3144 * 298.15 * \ln(0.000013958) = 27.7 \text{ kJ/mol}$.

Bioķīmiskā ūdenī eksoergiska šķīdība $\text{G}_{\text{H}_2\text{skAlberty}} = \text{G}_{\text{H}_2\text{aq}} - \text{G}_{\text{H}_{2\text{gas}}} - \Delta G_{\text{H}_2\text{O_Biochemistry}} = 103.24 - 85.64 - 85.6 = -68 \text{ kJ/mol}$:

$[\text{H}_{2\text{aq}}]/[\text{H}_{2\text{gas}}]/[\text{H}_2\text{O}] = K_{\text{H}_2\text{sk_Biochemistry}} = \text{EXP}(-\Delta G_{\text{H}_2\text{skAlberty}}/R/T) = \text{EXP}(68000/8.3144/298.15) = 10^{11.9}$ ar

koncentrāciju $[\text{H}_{2\text{aq}}] = K_{\text{H}_2\text{sk_Biochemistry}} * [\text{H}_2\text{O}] = 10^{11.9} * 55.3 = 10^{13.6} \text{ M}$, ja tīras ūdeņraža $\text{H}_{2\text{gas}}$ gāzes mol daļa ir viens $[\text{H}_{2\text{gas}}] = 1$. [8]

Nernsta $\text{H}_{2\text{aq}} + 2\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{O}^+ + 2\text{e}^-$ ūdeņraža reducēšana par hidroksoniju ie patvaļīga, jo **absolūtā** brīvā enerģija ir pozitīva. $\Delta G_{\text{Hess-H}_3\text{O}^+} = G_{\text{H}_{2\text{aq}}} + 2G_{\text{H}_2\text{O}} - (2G_{\text{H}_3\text{O}^+} + 2G_e) = 2*22.44 + 2*0 - (\mathbf{103.24} + 2*0) = -58.36 \text{ kJ/mol}$.

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

$$E^\circ_{\text{H}_3\text{O}^+} = -58.36 * 1000 / 96485 / 2 = -0.302 \text{ V.}$$

H(Pt) pus reakcijas **inversais** standarta potenciāls $-E^\circ_{\text{H(Pt)}} = +0.2965 \text{ V}$ un Nernsta ūdeņraža šķīduma oksidēšanas pus reakcija sumā $E^\circ_{\text{H}_3\text{O}^+} = -0.302 \text{ V}$ $\text{H}_{2\text{aq}} + 2\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{O}^+ + 2\text{e}^-$; $2\text{H}_3\text{O}^+ + 2\text{e}^- \rightarrow \text{H(Pt)} + 2\text{H}_2\text{O}$; $-E^\circ_{\text{H(Pt)}} = +0.2965 \text{ V}$ uzrāda ūdeņraža mol daļas [$\text{H}_{2\text{aq}}\text{Alberty}$] šķīdību metālāā eksoergiski patvaļigu:

$\text{H}_{2\text{aq}}\text{Alberty} = 2\text{H(Pt)}$; $K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} = [\text{H(Pt)}]^2 / [\text{H}_{2\text{aq}}\text{Alberty}]$ mol daļu koncentrācijās bez mērvienībām:

$$\Delta G_{\text{elektro-}\dot{\text{sk}}\text{H(Pt)}} = \Delta E^\circ_{\text{H(Pt)}} \cdot F \cdot 2 = (E^\circ_{\text{H}_3\text{O}^+} - E^\circ_{\text{H(Pt)}}) \cdot F \cdot 2 = (-0.302 + 0.2965) * 96485 * 2 = -0.0055 * 96485 * 2 = -\mathbf{1.06 \text{ kJ/mol}}$$

$$K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} = [\text{H(Pt)}]^2 / [\text{H}_{2\text{aq}}\text{Alberty}] = \exp(-\Delta G_{\text{Alberty}} / R/T) = \exp(1060 / 8.3144 / 298.15) = 1,5336 . [8]$$

Šķīdības konstante reakcijā $\text{H}_{2\text{aq}}\text{Alberty} \rightarrow 2\text{H(Pt)} + \text{H}_2\text{O}$; $K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} = [\text{H(Pt)}]^2 * [\text{H}_2\text{O}] / [\text{H}_{2\text{aq}}\text{Alberty}]$ uzrāda ūdeņraža mol moldaļas bez mērvienībām $[\text{H}_{2\text{aq}}\text{Alberty}] / [\text{H}_2\text{O}]$ šķīdības konstanti metālā eksoerģisku:

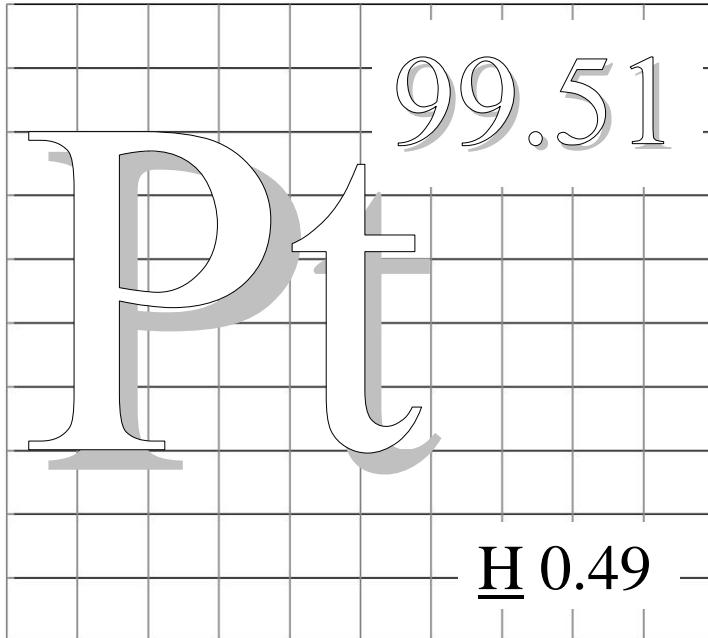
$$\Delta G_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} = 2G_{\text{H(Pt)}} + G_{\text{H}_2\text{O}} - (G_{\text{H}_{2\text{aq}}}) = 2 * \mathbf{51.05} + 0 - (\mathbf{103.24}) = -1.14 \text{ kJ/mol} .$$

$$K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} = [\text{H(Pt)}]^2 * [\text{H}_2\text{O}] / [\text{H}_{2\text{aq}}\text{Alberty}] = \exp(-\Delta G_{\text{Alberty}} / R/T) = \exp(1140 / 8.3144 / 298.15) = 1,584 . [8]$$

$[\text{H(Pt)}]^2 / [\text{H}_{2\text{aq}}\text{Alberty}] = K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} / [\text{H}_2\text{O}] = 1,58387 / 55.3 = 0.02864 \text{ M}$ ja $[\text{H}_{2\text{aq}}\text{Alberty}] = 0.0008253 \text{ mol daļa}$ ir piesātinājumā. Mol daļas šķīdības kvadrāta laukums ir:

$$[\text{H(Pt)}]^2 = K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} / [\text{H}_2\text{O}] * [\text{H}_{2\text{aq}}\text{Alberty}] = 1.584 / 55.3 * 0.0008253 = 0.00002364.$$

Mol daļas šķīdība $[\text{H(Pt)}] = \sqrt{0.00002364} = 0.004862$ ir ūdeņraža atomu virsmas daļa 0,486% daloties ar platīna atomu virsmas daļu 99,514% no kopējā 100% platīna kristāla virsmas.



Piesātināta ūdeņraža **H(Pt)** metāla mol daļa ir:

$K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} = \sqrt{0.00002364} = 0.004862 = \mathbf{0.49}$ mazāka par vienu, ja tīras gāzes mol daļa ir viens $[\text{H}_{\text{gas}}] = 1$.

Mol daļa šķīdības ir ūdeņraža virsmas daļa procentos 0,49%, ar kuru dalās platīna atomu daļa 99,51% uz kopējās platīna kristāla virsmas 100% laukuma. Viens kvadrāts 1□ ir viens percents 1% no virsmas un 100 kvadrāti ir 100%, jo $10 * 10 = 100 \square$. Šķīdības H_2O koncentrāciju mol daļas ir bez mērvienībām kā konstante arī: $K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} = 1,584$.

Atomu radiusi ir Pt 0.135 nm and H 0,053 nm.

Atomu kvadrātu laukumi uz virsmas ir Pt 0.0729 nm^2 un H 0.0112 nm^2 . Divi atomi $0.0729 + 0.0112 = 0.0841 \text{ nm}^2$ dalās virsmas kopējā laukumā 100%. Platīna atomam ir $0.0729 / 0.0841 = 86.7\%$ un $0.0112 / 0.0841 = 9.53\%$ pieder ūdeņraža atomam. [25]

H(Pt) šķīdība ūdenī ir mazāka par vienu $K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} = 0.631$:

$$2\text{H(Pt)} + \text{H}_2\text{O} \rightarrow \text{H}_{2\text{aq}}\text{Alberty}; K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} = [\text{H(Pt)}]^2 * [\text{H}_2\text{O}] / [\text{H}_{2\text{aq}}\text{Alberty}];$$

$$\Delta G_{\text{Alberty}} = G_{\text{H}_2\text{O}} - 2G_{\text{H(Pt)}} - G_{\text{H}_2\text{O}} = \mathbf{1.14 \text{ kJ/mol}};$$

$$K_{\text{Alberty-}\dot{\text{sk}}\text{H(Pt)}} = [\text{H}_{2\text{aq}}\text{Alberty}] / [\text{H(Pt)}]^2 * [\text{H}_2\text{O}] = \exp(-\Delta G_{\text{Alberty}} / R/T) = \exp(-1140 / 8.3144 / 298.15) = 0.631 \text{ unfavored. [8]}$$

Ūdens oksidēšana par skābekli ūdenī pus reakcijas $6\text{H}_2\text{O} \rightleftharpoons \text{O}_2\text{aqua} + 4\text{H}_3\text{O}^+ + 4\text{e}^-$ Hesa brīvās energijas izmaiņa

$$\text{ir: } \Delta G_{\text{O}_2\text{aq Alberty}} = G_{\text{O}_2\text{aq}} + 4G_{\text{H}_3\text{O}^+} - 6G_{\text{H}_2\text{O}} = 330 - 4 * 22,44 - \mathbf{419,76 \text{ kJ/mol}} .$$

Tā ir identiska brīvās energijas izmaiņas minimumam elektroķīmiskos aprēķinos lietojot **absolūto** Nernsta standarta potenciālu $E^\circ_{\text{O}_2\text{aq}} = 1,0868 \text{ Volti}$: $\Delta G_{\text{eq O}_2} = E^\circ_{\text{O}_2\text{aq}} \cdot F \cdot n_e = 1,0868 * 96485 * 4 = \mathbf{419,3 \text{ kJ/mol}}$.

Metāla ūdeņraža H(Pt) pus reakcijas $\text{H(Pt)} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{e}^-$ Hesa brīvās energijas izmaiņa ir:

$$\Delta G_{\text{H(Pt) eq Alberty}} = G_{\text{H}_3\text{O}^+} + G_e - (G_{\text{H}_2\text{O}} + G_{\text{H(Pt)}}) = 22,44 + 0 - (\mathbf{51,05} + 0) = -\mathbf{28,61 \text{ kJ/mol}}$$

Tā ir identiska elektroķīmiskiem brīvās energijas izmaiņas minimuma aprēķiniem lietojot **absolūto** Nernsta standarta potenciālu $E^\circ_{\text{H(Pt)}} = -0,29654 \text{ Volti}$:

$$\Delta G_{\text{eq H(Pt)}} = E^\circ_{\text{H(Pt)}} \cdot F \cdot n_e = -0,29654 * 96485 * 1 = -\mathbf{28,61 \text{ kJ/mol}}$$
 iekļaujoties Alberty datos. [8,15]

Veidošanās 41. no elementiem $\text{O}_2\text{gas} + \text{H}_2\text{gas} + \text{H}_2\text{O} = \text{H}_2\text{O}_2\text{aq}$ $\Delta G^\circ_{\text{UnivAlberta}} = -134.03 \text{ kJ/mol}$; $\Delta G^\circ_{\text{Alberty}} = -48.39 \text{ kJ/mol}$;

$$\Delta G_{\text{H}_2\text{O}_2\text{Alberty}} = \text{G}_{\text{H}_2\text{O}_2\text{aq}} - (\text{G}_{\text{O}_2\text{gas}} + \text{G}_{\text{H}_2\text{gas}} + \text{G}_{\text{H}_2\text{O}}) = \underline{\underline{284-(85.64+303+0)}} = \underline{\underline{-104.64 \text{ kJ/mol}}$$

$\text{H}_2\text{O}_2\text{aq}$ dismutācijas Nernsta pus reakcijās Red and Ox absolūto standarta brīvās energijas izmaiņu summa



$$\Delta G_{\text{eqStandartaAbsolutā}} = (E^\circ_{\text{H}_2\text{O}_2\text{aqRed}} - E^\circ_{\text{H}_2\text{O}_2\text{aqOx}}) * F * n = \underline{\underline{-238.5 \text{ kJ/mol}}}$$

$$\Delta G_{\text{Alberty}} = \text{G}_{\text{O}_2\text{aqua}} + 2 * \text{G}_{\text{H}_2\text{O}} - 2 * \text{G}_{\text{H}_2\text{O}_2} = \underline{\underline{90.63-329.13}} = \underline{\underline{-238.5 \text{ kJ/mol}}}$$

Red Nernsta: $\text{H}_2\text{O}_2\text{aqua} + 2\text{H}_2\text{O} = \text{O}_2\text{aqua} + 2\text{H}_3\text{O}^+ + 2e^-$; **absolūtais** potenciāls $E^\circ_{\text{H}_2\text{O}_2\text{aqRed}} = 0.4495 \text{ V}$ [20],

$$\Delta G_{\text{H}_2\text{O}_2\text{aqAlberty}} = \text{G}_{\text{O}_2\text{aq}} + 2\text{G}_{\text{H}_3\text{O}^+} - \text{G}_{\text{H}_2\text{O}_2} - 2\text{G}_{\text{H}_2\text{O}} = \underline{\underline{330+2*22.44-284.25-2*0}} = \underline{\underline{100.38 \text{ kJ/mol}}}$$

$$\Delta G_{\text{eqH}_2\text{O}_2} = E^\circ_{\text{H}_2\text{O}_2\text{aq}} * F * 2 = 0.4495 * 96485 * 2 = \underline{\underline{86.7 \text{ kJ/mol}}}$$

Ox inverse $\text{H}_2\text{O}_2 + 2 \text{H}_3\text{O}^+ + 2 e^- = 4 \text{H}_2\text{O}$; $-E^\circ_{\text{H}_2\text{O}_2\text{aqOx}} = -1.6855 \text{ V}$ Suhotina [18];

$$\Delta G_{\text{H}_2\text{O}_2\text{OxAlberty}} = 4 * \text{G}_{\text{H}_2\text{O}} - (\text{G}_{\text{H}_2\text{O}_2} + 2 * \text{G}_{\text{H}_3\text{O}^+}) = \underline{\underline{4*0-(284.25+2*22.44)}} = \underline{\underline{-319.38 \text{ kJ/mol}}}$$

$$\Delta G_{\text{eqOxH}_2\text{O}_2} = -E^\circ_{\text{H}_2\text{O}_2\text{aqOx}} * F * 2 = -1.6855 * 96485 * 2 = \underline{\underline{-325.25 \text{ kJ/mol}}}$$

$$\Delta G_{\text{eqStandarta}_2\text{H}_2\text{O}_2} = (E^\circ_{\text{H}_2\text{O}_2\text{aqRed}} - E^\circ_{\text{H}_2\text{O}_2\text{aqOx}}) * F * n = (0.4495 - 1.6855) * 96485 * 2 = (-1.236) * 96485 * 2 = \underline{\underline{-238.5 \text{ kJ/mol}}}$$

$$\Delta G_{\text{Alberty}_2\text{H}_2\text{O}_2} = \text{G}_{\text{O}_2\text{aqua}} + 2 * \text{G}_{\text{H}_2\text{O}} - 2 * \text{G}_{\text{H}_2\text{O}_2} = \underline{\underline{330+2*0-2*284.25}} = \underline{\underline{-238.5 \text{ kJ/mol}}}$$

$$\text{G}_{\text{H}_2\text{O}_2} = (\text{G}_{\text{O}_2\text{aqua}} + 2 * \text{G}_{\text{H}_2\text{O}} + \Delta G_{\text{Alberty}_2\text{H}_2\text{O}_2}) / 2 = \underline{\underline{(330+2*0+238.5)/2}} = \underline{\underline{568.5/2=284.25 \text{ kJ/mol}}}$$

Absolūtās energijas satus $\text{G}_{\text{H}_2\text{O}_2} = \underline{\underline{284.25 \text{ kJ/mol}}}$ ir notieks uz nulles $\text{G}_{\text{H}_2\text{O}} = \text{G}_{\text{CO}_2\text{gas}} = 0 \text{ kJ/mol}$ vielu fona. [8]

Veidošanās no elementiem $\text{H}_2\text{gas} + \text{O}_2\text{gas} \rightarrow \text{H}_2\text{O}_2$; $\Delta G^\circ_{\text{UnivAlberta}} = -134.03 \text{ kJ/mol}$, $\Delta G^\circ_{\text{Alberty}} = -48.39 \text{ kJ/mol}$:

$$\Delta G_{\text{Alberty}} = \text{G}_{\text{H}_2\text{O}_2} - (\text{G}_{\text{O}_2\text{gas}} + \text{G}_{\text{H}_2\text{gas}}) = \underline{\underline{284.25-(303+85.64)}} = \underline{\underline{-104.4 \text{ kJ/mol}}}$$

Homeostāzes atraktori $\text{pH}=7.36$, $[\text{H}_2\text{O}] = 55.3 \text{ M}$ pie peroksīda koncentrācijas viens. **Absolūtā** potenciālu skalā reducēšanas **absolūtā** un oksidēšanas **inversā** potenciālu summa ($E_{\text{Red}} - E_{\text{Ox}}$) = -1.26 V uzrāda **absolūtās** brīvās energijas saturu vienā molā $\text{G}_{\text{HomeostāzesH}_2\text{O}_2} = \underline{\underline{369.7 \text{ kJ/mol}}}$:

$$E_{\text{Red}} = E^\circ_{\text{RedH}_2\text{O}_2} + 0.0591/2 * \lg([\text{O}_2\text{aqua}] * [\text{H}_3\text{O}^+]^2 / [\text{H}_2\text{O}_2] / [\text{H}_2\text{O}]^2) = 0.4495 + 0.0591/2 * \log(6 * 10^{(-5)} * 10^{(-7.36 * 2)} / 1 / 55.3^2) = -0.213 \text{ V}$$

$$-E_{\text{Ox}} = E^\circ_{\text{H}_2\text{O}_2\text{Ox}} + 0.0591/2 * \log([\text{H}_2\text{O}_2] * [\text{H}_3\text{O}^+]^2 / [\text{H}_2\text{O}]^4) = -1.6855 + 0.0591/2 * \log(1 * 10^{(-7.36 * 2)} / 55.3^4) = -2.3265 \text{ V}$$

$$\text{Homeostāzes: } \Delta G_{\text{eqBioChem}} = (E_{\text{Red}} - E_{\text{Ox}}) * F * n = (-0.2132 - 2.3265) * 96485 * 2 = (-2.5397) * 96485 * 2 = \underline{\underline{-490.1 \text{ kJ/mol}}}$$

$$\Delta G_{\text{AlbertyBioChem}} = \text{G}_{\text{O}_2\text{BioChem_arteria}} + 2 * \text{G}_{\text{H}_2\text{OBioChemistry}} - 2 * \text{G}_{\text{H}_2\text{O}_2} = \underline{\underline{78.08+2*85.64-2*284.25}} = \underline{\underline{-490.1 \text{ kJ/mol}}}; [8]$$

$$2 * \text{G}_{\text{H}_2\text{O}_2} = \text{G}_{\text{O}_2\text{Biochem_arteria}} + 2 * \text{G}_{\text{H}_2\text{OBioChemistry}} - \Delta G_{\text{Alberty}} = \underline{\underline{78.08+2*85.64+490.1}} = \underline{\underline{2*369.7=739.5 \text{ kJ/mol}}}$$

Peroksīda liela ātruma protolīzes $\text{H}_2\text{O} + \text{H}_2\text{O}_2 \rightarrow \text{H}_3\text{O}^+ + \text{HO}^-$ līdzsvara konstante aprēķināta no $\text{pKa}=11.75$:

$$K_{\text{eqH}_2\text{O}_2} = K_{\text{a}} / [\text{H}_2\text{O}] = [\text{H}_3\text{O}^+] [\text{HO}^-] / [\text{H}_2\text{O}_2] / [\text{H}_2\text{O}] = 10^{(-11.57)} / 55.3 = 10^{(-13.31)}, \text{ pK}_{\text{eqH}_2\text{O}_2} = 13.31. [1]$$

Absolūtās energijas izmaiņas minimums 75.97 kJ/mol ļauj aprēķināt peroksīda anjona energiju molā G_{HO^-} :

$$\Delta G_{\text{eqH}_2\text{O}_2} = -R * T * \ln(K_{\text{eqH}_2\text{O}_2}) = -8.3144 * 298.15 * \ln(10^{(-13.31)}) / 1000 = \underline{\underline{75.97 \text{ kJ/mol}}}$$

$$\Delta G_{\text{eqH}_2\text{O}_2} = \text{G}_{\text{H}_3\text{O}^+} + \text{G}_{\text{HO}^-} - \text{G}_{\text{H}_2\text{O}_2} = \underline{\underline{75.97 \text{ kJ/mol}}}, \Delta G_{\text{eqH}_2\text{O}_2} = 22.44 + \text{G}_{\text{HO}^-} - 0 - 284.25 = \underline{\underline{75.97 \text{ kJ/mol}}}$$

$$\text{Anjona energija molā ir } \text{G}_{\text{HO}^-} = \Delta G_{\text{eqH}_2\text{O}_2} + \text{G}_{\text{H}_2\text{O}_2} - \text{G}_{\text{H}_3\text{O}^+} = \underline{\underline{-22.44+75.97+0+284.25}} = \underline{\underline{337.8 \text{ kJ/mol}}}$$

Elektroķīmiska anjonu HO^- oksidēšanas **absolūtais** standarta potenciāls ir $E^\circ_{\text{HO}^- \text{aqAlberty}} = 0.07587 \text{ Volts}$. Oksidēšanas brīvās energijas izmaiņa ir pozitīva endoerģiska ar zemu **absolūto** standarta potenciālu:

$$\Delta G_{\text{HO}^- \text{aqAlberty}} = \text{G}_{\text{O}_2\text{aq}} + \text{G}_{\text{H}_3\text{O}^+} - (\text{G}_{\text{HO}^- \text{aq}} + \text{G}_{\text{H}_2\text{O}_2}) = \underline{\underline{330+22.44-(337.8+0)}} = \underline{\underline{14.64 \text{ kJ/mol}}}$$

$$\text{HO}^- + \text{H}_2\text{O} \rightarrow \text{O}_2\text{aqua} + \text{H}_3\text{O}^+ + 2e^-; E^\circ_{\text{HO}^- \text{aq}} = \Delta G_{\text{HO}^- \text{aqAlberty}} / F / 2 = 14640 / 96485 / 2 = 0.07587 \text{ V}$$

$$\text{G}_{\text{H}_2\text{O}_2} = \underline{\underline{284.25 \text{ kJ/mol}}}; \text{G}_{\text{H}_3\text{O}^+} + \text{G}_{\text{HO}^-} = 22.44 + \underline{\underline{337.8}} = 360.24 \text{ kJ/mol}$$

Tabula 1. Nernsta pus- un inversās reakcijas	Standart potenciāli E° dati no [1-24]	Ūdens atlaide klasika E° _{H=0}	Termodinamiskā skala 0,10166 V	Absolūtā -0,3982 V
$\text{OH}^- = \text{HO} + \text{e}^-$	CRC	2,020	2,122	1,7235
$4\text{H}_2\text{O} = \text{H}_2\text{O}_{2\text{aqua}} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	Suchotina	1,776	2,0837	1,6855
$\text{H}_2\text{O}_2 + 2\text{H}_2\text{O} = \text{O}_{2\text{aqua}}^- + 2\text{H}_3\text{O}^+ + \text{e}^-$	David Harris	1,276	1,4811	1,0829
$6\text{H}_2\text{O} = \text{O}_{2\text{aqua}} + 4\text{H}_3\text{O}^+ + 4\text{e}^-$	Suchotina	1,229	1,4850	1,0868
$\text{HNO}_2 + 4\text{H}_2\text{O} = \text{NO}_3^- + 3\text{H}_3\text{O}^+ + 2\text{e}^-$	University Alberta	0,928	1,2352	0,8370
$\text{NO}_2^- + 3\text{H}_2\text{O} = \text{NO}_3^- + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	David Harris	0,835	1,0913	0,6931
$\text{Hydroquinone} + 2\text{H}_2\text{O} = \text{p-quinone} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$		0,699	0,9041	0,5059
$\text{H}_2\text{O}_{2\text{aqua}} + 2\text{H}_2\text{O} = \text{O}_{2\text{aqua}} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	University Alberta	0,695	0,8477	0,4495
$\text{H}_2\text{O}_{2\text{aqua}} + \text{H}_2\text{O} = \text{O}_{2\text{aqua}} + \text{H}_3\text{O}^+ + \text{H}^-(\text{H}^+ + 2\text{e}^-)$	University Alberta	0,695	0,8477	0,4495
$\text{Fe}^{2+} = \text{Fe}^{3+} + \text{e}^-$	University Alberta	0,769	0,8707	0,4725
$\text{Ubiquinol} + 2\text{H}_2\text{O} = \text{Ubiquinone} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$		0,459	0,6638	0,2656
$\text{Succinate}^{2-} + 2\text{H}_2\text{O} = \text{Fumarate}^{2-} + 2\text{H}_3\text{O}^+ + 2\text{e}^- \text{ pH}=7 \text{ E}_o=0,031 \text{ V}$		0,4447	0,6494	0,2512
$\text{ButyrylCoA} + 2\text{H}_2\text{O} = \text{CrotonylCoA} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$		0,399	0,6038	0,2056
$\text{Ascorbic Acid} + 2\text{H}_2\text{O} = \text{C}_6\text{H}_6\text{O}_6 + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	DC, Harris	0,390	0,5947	0,1965
$\text{glycolate} + 2\text{H}_2\text{O} = \text{Glyoxylate} + \text{H}^-(\text{H}^+ + 2\text{e}^-) + \text{H}_3\text{O}^+$	D.C.Harris	0,324	0,5287	0,1305
$\text{HOO}^- + \text{H}_2\text{O} = \text{O}_{2\text{aqua}} + \text{H}_3\text{O}^+ + 2\text{e}^-$	Aris Kaksis	-	-	0,07587
$\text{Fe}^{2+} = \text{Cytochrome F Fe}^{3+} + \text{e}^-$	David Harris	0,365	0,4667	0,0685
$[\text{Fe}^{\text{II}}(\text{CN})_6]^{4-} = [\text{Fe}^{\text{III}}(\text{CN})_6]^{3-} + \text{e}^-$	University Alberta	0,356	0,4574	0,0592
$\text{Malate}^{2-} + 2\text{H}_2\text{O} = \text{Oxalo-acetate}^{2-} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$		0,248	0,4528	0,0546
$\text{Fe}^{2+} = \text{Cytochrome a3 Fe}^{3+} + \text{e}^-$		0,350	0,4517	0,0535
$\text{Lactate}^- + \text{H}_2\text{O} = \text{Pyruvate}^- + \text{H}_3\text{O}^+ + \text{H}^-(\text{H}^+ + 2\text{e}^-)$		0,229	0,3823	-0,0159
$\text{FADH}_2 + 2\text{H}_2\text{O} = \text{FADfree} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$		0,195	0,3998	0,0016
$\text{CH}_3\text{COO}^- + 2\text{H}_2\text{O} = \text{glycolate} + \text{H}^-(\text{H}^+ + 2\text{e}^-) + \text{H}_3\text{O}^+$	D.C.Harris	0,161	0,3652	-0,0330
$\text{C}_6\text{H}_{12}\text{O}_6 + 42\text{H}_2\text{O} = 24\text{H}_3\text{O}^+ + 6\text{H}_3\text{O}^+ + 6\text{HC}_2\text{O}_3^- + 24\text{e}^-$	<u>6. lapa</u> Kaksis	0,0701	0,2590	-0,1392
$\text{H}_2\text{S}_{\text{aq}} + 2\text{H}_2\text{O} = \text{S}_{\text{rombisks}} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	CRC 2010	0,142	0,3467	-0,0515
$\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{O} = \text{CH}_3\text{CHO} + \text{H}_3\text{O}^+ + \text{H}^-(\text{H}^+ + 2\text{e}^-)$	KortlyShucha	0,190	0,3432	-0,0550
$\text{Fe}^{2+} = \text{Cytochrome a Fe}^{3+} + \text{e}^-$		0,2900	0,3917	-0,0065
$2\text{GlutathSH} + 2\text{H}_2\text{O} = \text{GlutaS-Sthione} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$		0,1841	0,3888	-0,0094
$\text{HSH} + 2\text{H}_2\text{O} = \text{Srhb} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	University Alberta	0,1739	0,3786	-0,0196
$\text{Fe}^{2+} = \text{Cytochrome c Fe}^{3+} + \text{e}^-$		0,2540	0,3557	-0,0425
$\text{LipSHSH} + 2\text{H}_2\text{O} = \text{LipoicAcidS-S} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$		0,1241	0,3288	-0,0694
$\text{Fe}^{2+} = \text{Cytochrome c1 Fe}^{3+} + \text{e}^-$		0,2200	0,3217	-0,0765
$\beta\text{-OH Butyrate}^- + 2\text{H}_2\text{O} = \text{AcetoAcetate}^- + 2\text{H}_3\text{O}^+ + 2\text{e}^-$		0,0681	0,2728	-0,1254
$\text{isocitrate}^{2-} + 2\text{H}_2\text{O} = \alpha\text{-Ketoglutarate}^{2-} + \text{CO}_2 + 2\text{H}_3\text{O}^+ + 2\text{e}^-$		0,0341	0,2388	-0,1594
$\text{Nernst's H}_2\text{aq} + 2\text{H}_2\text{O} = 2\text{H}_3\text{O}^+ + 2\text{e}^-$	Kaksis $\Delta G_{\text{Hess-H}_3\text{O}^+} = 58,12$ kJ/mol	-	-	0,3020
Inverse: $2\text{H}_3\text{O}^+ + 2\text{e}^- = \text{H}_2\text{aq} + 2\text{H}_2\text{O}$; $\Delta G_{\text{Hess-H}_2\text{aq}} = -58,12$ kJ/mol		-	-	-0,3020
$2\text{H}(\text{Pt}) + \text{H}_2\text{O} = \text{H}_2\text{aq}$	$\Delta G_{\text{Alberty-}\text{sk-H}(\text{Pt})} = \text{G}_{\text{H}_2\text{aq}} - 2\text{G}_{\text{H}(\text{Pt})} - \text{G}_{\text{H}_2\text{O}} = 1,14$ kJ/mol		$K_{\text{sk-H}(\text{Pt})} = [\text{H}(\text{Pt})]^2 * [\text{H}_2\text{O}] / [\text{H}_2\text{aq}] = 0,631$	
$\text{H}(\text{Pt}) + \text{H}_2\text{O} = \text{H}_3\text{O}^+ + (\text{Pt}) + \text{e}^-$; $[\text{H}_3\text{O}^+] = 1 \text{ M}$ pH=0 classic zero		0,0;	$[\text{H}_2\text{SO}_4] = 1 \text{ M}$	0,10166 -0,2965
$\text{Luciferin} + \text{OH}^- = ?\text{luciferin} + \text{CO}_2 + \text{H}_2\text{O} + 3\text{H}(\text{3H}^+ + 3\text{e}^-) + \text{e}^-$		0,0000	0,1017	-0,2965
$\text{Fe}^{2+} = \text{Cytochrome b Fe}^{3+} + \text{e}^-$		0,0770	0,1787	-0,2195
$\text{CH}_3\text{CHO} + 3\text{H}_2\text{O} = \text{CH}_3\text{COOH} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	Suchotina	-0,1180	0,1382	-0,2600
$\text{Glycaldeh3P}^{2-} + \text{H}_2\text{O} + \text{HPO}_4^{2-} = 13\text{PGlycerate}^{4-} + \text{H}_3\text{O}^+ + \text{H}^-$		-0,1314	0,0218	-0,3764
$\text{NADPH} = \text{NADP}^+ + \text{H}^-(\text{H}^+ + 2\text{e}^-)$		-0,1170	-0,0153	-0,4135
$\text{NADH} = \text{NAD}^+ + \text{H}^-(\text{H}^+ + 2\text{e}^-)$	David Harris	-0,1130	-0,0113	-0,4095
$\text{O}_{2\text{aqua}} = \text{O}_{2\text{aqua}} + \text{e}^-$	Suchotina	-0,2450	-0,1433	-0,5415
$\text{Ferredoxin Fe}^{2+} = \text{Ferredoxin Fe}^{3+} + \text{e}^-$		-0,4320	-0,3303	-0,7285
$\text{C}_6\text{H}_{12}\text{O}_6 + 4\text{H}_2\text{O} = 2\text{C}_3\text{H}_4\text{O}_3 + 4\text{H}_3\text{O}^+ + 4\text{e}^-$	Stryer	-0,5427	-0,3380	-0,7362
$\text{S}^{2-} = \text{S}_{\text{rombisks}} + 2 \text{ e}^-$	CRC 2010	-0,4763	-0,3746	-0,7728
$\text{HS}^- + \text{OH}^- = \text{S}_{\text{rombisks}} + \text{H}_2\text{O} + 2\text{e}^-$	CRC 2010	-0,4780	-0,3248	-0,7230
$\text{H}(\text{Pt}) + \text{OH}^- = \text{H}_2\text{O} + \text{e}^-$	Suchotina	-0,8280	-0,6233	-1,0215
$\text{Ubiquinol} + 2\text{H}_2\text{O} = \text{Ubiquinone} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	CRC 2012	-1,0500	-0,8453	-1,2435

Potenciālu skalas noteikšanas ūdens uzskaites un ūdenraža elektroda korekcija uz **Absolūto skalu** piemērs.
 Klasiska ūdens atlaide Nernsta skābekļa pus reakcijai: $6\text{H}_2\text{O}=\text{O}_2\text{aqua}+4\text{H}_3\text{O}^++4\text{e}^-$ $E^\circ_{\text{O}_2\text{klasika}}=1.229 \text{ V}$. [18]
 Ūdens uzskaites potenciāls: $E^\circ_{\text{H}_2\text{O}}=E^\circ_{\text{O}_2\text{klasika}}-0.0591/4\cdot\log(1/\text{[H}_2\text{O}])=1.229-0.014775*\log(1/55.3^6)=1.383 \text{ V}$.
 Hydrogen electrode correction +0.10166: $E^\circ_{\text{O}_2\text{Termodinamika}}=E^\circ_{\text{H}_2\text{O}}+0.10166=1.383+0.10166=1.485 \text{ Volts}$.
Absolūtā standarta potenciālu skala ir $E^\circ_{\text{O}_2\text{Absolūtā}}=E^\circ_{\text{O}_2\text{Termodinamika}}-0.3982=1.485-0.3982=1.0868 \text{ Volts}$.

Veidošanās no elementiem $\text{N}_2\text{gas}+3\text{H}_2\text{gas}>2\text{NH}_3\text{gas}$ absolūtā energija ir $G_{\text{N}_2\text{gas}}=107,28 \text{ kJ/mol}$; $G_{\text{NH}_3\text{gas}}=165,7 \text{ kJ/mol}$;
 Classic Hess elements have zero $2\Delta G_{\text{Hess-NH}_3\text{gas}}=2G^\circ_{\text{NH}_3\text{gas}}-(G^\circ_{\text{N}_2\text{gas}}+3*G^\circ_{\text{H}_2})=2*-16.4-(0+3*0)=-32.8 \text{ kJ/mol}$. [1]
 Alberty elementa ūdenraža $G_{\text{H}_2\text{gas}}=85.64 \text{ kJ/mol}$ **absolūtā** energija ar Hesa veidošanos -32.8 kJ/mol aprēķina slāpekļa **absolūto** energiju $G_{\text{N}_2\text{gas}}=2G_{\text{NH}_3\text{gas}}-(2\Delta G_{\text{Hess-NH}_3\text{gas}}+3*G_{\text{H}_2\text{gas}})=2*165,7-(2*-16.4+3*85.64)=107.28 \text{ kJ/mol}$; [8]
 $\Delta G_{\text{HessFormationN}_2\text{aqua}}=G_{\text{N}_2\text{aqua}}-(G_{\text{N}_2\text{gas}}+G_{\text{H}_2\text{O}})=18.7-(107.28+0)=-88.5 \text{ kJ/mol}$; [8]
 $G_{\text{N}_2\text{gas}}=G^\circ_{\text{N}_2\text{aqua}}-(\Delta G_{\text{Hess-}\text{N}_2\text{aqua}}+G_{\text{H}_2\text{O}})=18.7-(-88.5+0)=107.2 \text{ kJ/mol}$; [8] [Alberty](#)

Substance	$\Delta H^\circ_{\text{H}}$ kJ/mol	$\Delta S^\circ_{\text{H}}$ J/mol/K	$\Delta G^\circ_{\text{H}}$ kJ/mol
NH_3gas	-45,9	192,77	-16,4
NH_3gas			438,85
NH_3aq	-132,5608	-739,2922	91,1056
N_2gas	$G_{\text{N}_2\text{gas}}=$	-15,26	107,2
N_2aq	-10,54	98,1	18,7

Simts gramos ūdens izšķīst 0.00175 g/100g H_2O slāpekļa gāzes ar blīvumu 996 g/L.
 Šķīdība $[N_2\text{aqua}]=0.00175/100,00175*996=0.01743/28,02=10^{-3,206} \text{ M}$ un šķīdības konstante ir:
 $K_{\text{sk}}=10^{(-4,206)/[\text{H}_2\text{O}]}=10^{(-3,206)/55.3}=10^{-4.949}$; $\Delta G_{\text{sk}}=-R\cdot T\cdot\ln(K_{\text{sk}})=-8,3144*298,15*\ln(10^{(-4,949)})=28,25 \text{ kJ/mol}$.
 Mols brīvās energijas ir $G_{\text{N}_2\text{gas}}=G_{\text{N}_2\text{aqua}}-(\Delta G_{\text{Hess-}\text{N}_2\text{aqua}}+G_{\text{H}_2\text{O}})=18.7-(28.25+0)=-9,55 \text{ kJ/mol}$; CRC 2010 [1,8]

Šķīdības $\text{N}_2\text{gas}+\text{H}_2\text{O}+\Delta G=\text{N}_2\text{aq}+\text{Q}$; $G_{\text{N}_2\text{gas}}=-9,55 \text{ kJ/mol}$ brīvās energijas izmaiņa ir:
 $\Delta G_{\text{Hess-}\text{N}_2\text{aqua}}=G_{\text{N}_2\text{aqua}}-(G_{\text{N}_2\text{gas}}+G_{\text{H}_2\text{O}})=18.7-(-9.55+0)=28.25 \text{ kJ/mol}$. CRC 2010 [1,8] [Alberty](#)
 Šķīdības konstante ir $K_{\text{sk}}=[\text{N}_2\text{aqua}]/[\text{H}_2\text{O}]=10^{(-3,206)/55.3}=10^{-4.949}$, kuras brīvās energijas izmaiņas minimums ir $\Delta G_{\text{sk}}=-R\cdot T\cdot\ln(K_{\text{sk}})=-8.3144*298.15*\ln(10^{(-4.949)})=28.25 \text{ kJ/mol}$.
 Hesa brīvās energijas izmaiņa ir sakrītoša ar

$\Delta G_{\text{Hess-}\text{N}_2\text{aqua}}=G_{\text{N}_2\text{aqua}}-(G_{\text{N}_2\text{gas}}+G_{\text{H}_2\text{O}})=18.7-(G_{\text{N}_2\text{gas}}-0)=28.25 \text{ kJ/mol}$.
 Slāpekļa gāzes brīvās energijas satura izteiksme

$$G_{\text{N}_2\text{gas}}=G_{\text{N}_2\text{aqua}}-(\Delta G_{\text{Hess-}\text{N}_2\text{aqua}}+G_{\text{H}_2\text{O}})=18.7-(28.25+0)=-9.55 \text{ kJ/mol}$$
 ir negatīvs.

Solubility $\text{NH}_3\text{gas}+\text{H}_2\text{O}+\Delta G<>\text{NH}_3\text{aq}+\text{Q}$; $G_{\text{NH}_3\text{aq}}=91.1 \text{ kJ/mol}$;
 $\Delta H_{\text{Hydration}}=\Delta H^\circ_{\text{NH}_3\text{aq}}-\Delta H^\circ_{\text{NH}_3\text{gas}}-\Delta H^\circ_{\text{H}_2\text{O}}=-132,5608+45,94-286,65=373,3 \text{ kJ/mol}$;
 $\Delta S_{\text{Hydration}}=\Delta S^\circ_{\text{NH}_3\text{aqua}}-\Delta S^\circ_{\text{NH}_3\text{gas}}-\Delta S^\circ_{\text{H}_2\text{O}}=-739,2922-192,77-69,9565=-1002 \text{ J/mol/K}$;
 $\Delta G_{\text{Hess-NH}_3\text{gas}}=\Delta H_{\text{Hydrations}}-T\cdot\Delta S_{\text{Hydration}}=-373,3-298,15*-1,002=-74,5537 \text{ kJ/mol}$;
 $K_{\text{sk}}=\exp(-\Delta G_{\text{Hydration}}/R/T)=\exp(74553,7/8,3144/298,15)=10^{13,06}$
 $G_{\text{NH}_3\text{gas}}=\Delta G_{\text{NH}_3\text{aq}}-(\Delta G_{\text{Hess-}\text{N}_2\text{aqua}}+G_{\text{H}_2\text{O}})=91,1056-(-74,5537+0)=165,7 \text{ kJ/mol}$; [8] [Alberty](#)
 $G_{\text{NH}_3\text{gas}}=(2\Delta G_{\text{Hess-NH}_3\text{gas}}+(G_{\text{N}_2\text{gas}}+3*G_{\text{H}_2}))/-32.8+(107.2+3*85.64)/2=165.7 \text{ kJ/mol}$; Hess [1,8] [Alberty](#)
 $G_{\text{NH}_3\text{gas}}=\Delta G^\circ_{\text{NH}_3\text{aq}}-\Delta G_{\text{Hess-}\text{N}_2\text{aqua}}-G^\circ_{\text{H}_2\text{O}}=91,1056-(-74,5537)-(-0)=165,7 \text{ kJ/mol}$; [8] [Alberty](#)
 $G_{\text{NH}_3\text{gas}}=\Delta G^\circ_{\text{NH}_3\text{aq}}-\Delta G_{\text{Hess-NH}_3\text{gas}}-G_{\text{H}_2\text{O}}=91,1056-(-74,5537)-(-273,19)=438,85 \text{ kJ/mol}$; CRC 2010

Weak acid protolīze $\text{NH}_4^++\text{H}_2\text{O}=\text{NH}_3\text{aq}+\text{H}_3\text{O}^+$; $pK_{\text{eq}}=10.99$; shows energy $G_{\text{NH}_4^+}=232.9 \text{ kJ/mol}$,
 $\Delta G_{\text{eq}}=-R\cdot T\cdot\ln(K_{\text{eq}})=-8.3144*298.15*\ln(10^{(-10.99)})=G_{\text{NH}_3\text{Hydration}}+G_{\text{H}_3\text{O}^-}-G_{\text{NH}_4^+}-G_{\text{H}_2\text{O}}=62.76 \text{ kJ/mol}$, [16th page](#):
 $\Delta G_{\text{eq}}=G_{\text{NH}_3\text{aq}}+G_{\text{H}_3\text{O}^-}-G_{\text{NH}_4^+}-G_{\text{H}_2\text{O}}=91.1+22.44-G_{\text{NH}_4^+}-0=62.75 \text{ kJ/mol}$,
 $G_{\text{NH}_4^+}=G_{\text{NH}_3\text{aq}}+G_{\text{H}_3\text{O}^-}-\Delta G_{\text{eq}}-G_{\text{H}_2\text{O}}=91.1+22.44-62.75-0=232.9 \text{ kJ/mol}$,
 K_{eq3} ; protolīze $\text{NH}_4^++\text{H}_2\text{O}+\Delta G+Q>\text{NH}_3\text{aq}+\text{H}_3\text{O}^+$; $pK_{\text{eq}}=10.9944$; $\text{NH}_4^+=\text{H}^+ + \text{NH}_3\text{aqua}$; $pK_a=9.25$;
 $K_{\text{eq3}}=[\text{NH}_3\text{aq}]*[\text{H}_3\text{O}^+]/[\text{NH}_4^+]/[\text{H}_2\text{O}]=\exp(-\Delta G_{\text{Hydration}}/R/T)=\exp(-62755,6/8,3144/298,15)=10^{-10,994}$;
 $\Delta G_{\text{eq3}}=-R\cdot T\cdot\ln(K_{\text{eq}})=-8,3144*298,15*\ln(1,013*10^{-11})=62,75 \text{ kJ/mol}$;
 $K_{\text{eq3}}=[\text{NH}_3\text{aq}]*[\text{H}_3\text{O}^+]/[\text{NH}_4^+]/[\text{H}_2\text{O}]=[\text{H}_2\text{O}]*K_{\text{H}_2\text{O}}/K_{\text{NH}_4\text{OH}}=55,3*3,26*10^{(-18)}/1,78/10^{(-5)}=1,013*10^{(-11)}$;
 $\Delta G_{\text{Hydration}}=\Delta G_{\text{NH}_3\text{aq}}-\Delta G_{\text{NH}_3\text{gas}}-G_{\text{H}_2\text{O}}=91,1056-(-16,4-0)=107,5 \text{ kJ/mol}$;
 $G_{\text{NH}_3\text{aq}}=\Delta G_{\text{Hydration}}+G_{\text{NH}_3\text{gas}}+G_{\text{H}_2\text{O}}=107,5+165,7+0=273,2 \text{ kJ/mol}$;

Tabula 2. Neorganiskie Standarta Electrodū Potenciāli klissikais, termodinamiskais absolūtais Voltos.

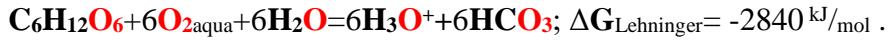
	Reduced form Oxidized	H ₂ O atlaide klasika nulle E _o	Termodinamiskā skala 0,10166 V	Absolūtā skala -0,3982 V
N	$\text{NO}_2^- + 2\text{OH}^- = \text{NO}_3^- + \text{H}_2\text{O} + 2\text{e}^-$	0,01	0,16316	-0,3380
	$\text{NO}_2 + 3\text{H}_2\text{O} = \text{NO}_3^- + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	0,94	1,09166	0,7980
	$\text{NO}^{(g)} + 2\text{H}_2\text{O} = \text{NO}_3^- + 4\text{H}^+ + 3\text{e}^-$	0,96	1,23526	0,8435
	$\text{NH}_3 + 9\text{OH}^- = \text{NO}_3^- + 6\text{H}_2\text{O} + 8\text{e}^-$	-0,12	0,0955	-0,4938
Br	$2\text{Br}^- = \text{Br}_2 + 2\text{e}^-$	1,0873	1,189	0,7908
Bi	$\text{Bi}^{3+} + 9\text{H}_2\text{O} = \text{BiO}_3^- + 6\text{H}_3\text{O}^+ + 2\text{e}^-$	1,80	2,36516	1,9669
Mn H⁺	$\text{Mn}^{2+} + 12\text{H}_2\text{O} = \text{MnO}_4^- + 8\text{H}_3\text{O}^+ + 5\text{e}^-$	1,51	+1,86	+1,86
H₂O	$\text{MnO}_2 \downarrow + 4\text{OH}^- = \text{MnO}_4^- + 2\text{H}_2\text{O} + 3\text{e}^-$	0,60	+0,63266	0,2345
OH⁻	$\text{MnO}_4^{2-} = \text{MnO}_4^- + \text{e}^-$	0,56	0,66166	0,2618
Pb S	$\text{Pb}^{2+} + 6\text{H}_2\text{O} = \text{PbO}_2(s) + 4\text{H}_3\text{O}^+ + 2\text{e}^-$	1,80	2,21066	1,4674
	$\text{SO}_3^{2-} + 3\text{H}_2\text{O} = \text{SO}_4^{2-} + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	0,20	+0,45616	0,0580
	$\text{SO}_3^{2-} + 2\text{OH}^- = \text{SO}_4^{2-} + \text{H}_2\text{O} + 2\text{e}^-$	-0,93	-0,87934	-1,2780
	$\text{S}^{2-} = \text{S}(s) + 2\text{e}^-$	-0,48	-0,37834	-0,7765
	$\text{H}_2\text{S} + 2\text{H}_2\text{O} = \text{S}(s) + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	0,142	0,3467	0,0515
	$2\text{S}_2\text{O}_3^{2-} = \text{S}_4\text{O}_6^{2-} + 2\text{e}^-$	0,08	0,18166	-0,2165
Fe	$\text{Fe}^{2+} = \text{Fe}^{3+} + \text{e}^-$	0,77	0,87166	0,4735
Ag	$\text{Ag} = \text{Ag}^+ + \text{e}^-$	0,799	0,90066	0,5025
I	$2\text{I}^- = \text{I}_2 + 2\text{e}^-$	0,54	0,64166	0,2435
Cu	$\text{Cu} = \text{Cu}^{2+} + 2\text{e}^-$	0,337	0,43866	0,0405
F	$2\text{F} = \text{F}_2 + 2\text{e}^-$	2,87	2,97166	2,5735
Cl	$2\text{Cl}^- = \text{Cl}_2 + 2\text{e}^-$	1,36	1,46166	1,0635
	$3\text{H}_2\text{O} + \text{Cl}^- = \text{OCl}^- + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	1,49	-	1,3480
Cr	$2\text{Cr}^{3+} + 21\text{H}_2\text{O} = \text{Cr}_2\text{O}_7^{2-} + 14\text{H}_3\text{O}^+ + 6\text{e}^-$	1,33	1,79216	1,7544
	$\text{Cr}(\text{OH})_3(s) + 5\text{OH}^- = \text{CrO}_4^{2-} + 4\text{H}_2\text{O} + 3\text{e}^-$	-0,13	-0,1657	-0,5639
C	$\text{H}_2\text{C}_2\text{O}_4 + 2\text{H}_2\text{O} = 2\text{CO}_2 + 2\text{H}_3\text{O}^+ + 2\text{e}^-$	-0,49	-0,28534	-0,6835
Cr	$\text{Cr} = \text{Cr}^{3+} + 3\text{e}^-$	-0,744	-0,64234	-1,0405
Zn	$\text{Zn} = \text{Zn}^{2+} + 2\text{e}^-$	-0,763	-0,66134	-1,0595
Al	$\text{Al} + 4\text{OH}^- = \text{AlO}_2^- + 2\text{H}_2\text{O} + 3\text{e}^-$	-2,35	-2,38534	-2,6609

Glc 6. lpp. veidošanās no elementiem $6\text{C} + 6\text{H}_2\text{gas} + 3\text{O}_2\text{gas} = \text{C}_6\text{H}_{12}\text{O}_6$ brīvās enerģijas izmaiņu aprēķina no Alberty datiem $\Delta G^\circ_{\text{Alberty}} = \text{G}_{\text{C}_6\text{H}_{12}\text{O}_6} - (6\text{G}_{\text{Cgraph}} + 6*\text{G}_{\text{H}_2\text{gas}} + 3*\text{G}_{\text{O}_2\text{gas}}) = -402,05 \text{ kJ/mol}$;

$$\Delta G^\circ_{\text{Alberty}} + (6\text{G}_{\text{Cgraph}} + 6*\text{G}_{\text{H}_2\text{gas}} + 3*\text{G}_{\text{O}_2\text{gas}}) = -402,05 + (6*91,26 + 6*85,6 + 3*303) = \text{G}_{\text{C}_6\text{H}_{12}\text{O}_6} = 1568 \text{ kJ/mol} ;$$

Glikoze (Glc) C₆H₁₂O₆ ar bioķīmisko ūdeni **6H₂O** un skābekls **6O₂aqua** reducējās radot energējaas izmaiņu $\Delta G_{\text{Lehninger}} = -2840 \text{ kJ/mol}$ un producējot **6HCO₃⁻** un **6H₃O⁺** jonus ģenerē koncentrācijas gradientus abpus membrānām darbinot osmozi un jonu transportu cauri akvaporīnu, bikarbonāta un protonu kanāliem membrānās:

Brīvā energēja glikozei (Glc) **G_{C6H12O6}** kvazi līdzsvaram aprēķināta lietojot Lehningera datus [6] oksidēšanā :



Energēja -2840 = G_{C6H12O6} - 6*G_{O2Homeostāzes_arterial} - 6*G_{H2O_Biochem} + (6*G_{H3O_+} + 6*G_{HCO3^-}) lauj izteikt glikozes **G_{C6H12O6} = 2840 - 6*G_{O2Homeostāzes_arterial} - 6*G_{H2O_Biochem} + (6*G_{H3O_+} + 6*G_{HCO3^-})** kvazi līdzvara standarta brīvās energējas saturu **G_{StandardC6H12O6} = 2840 - 6*330 - 6*85,64 + 6*(22,44 + 46,08) = 757,28 kJ/mol** un

brīvās energējas izmaiņu homeostāzē **G_{C6H12O6} = 2840 - 6*78,08 - 6*85,64 + 6*(22,44 + 46,08) = 2268,8 kJ/mol**. Glikozes brīvā energēja ir standarta Alberty **G_{C6H12O6} = 757 kJ/mol** un homeostāzes Lehningera **G_{C6H12O6} = 2268,8 kJ/mol**. [8,6]

Generētie **6HCO₃⁻ + 6H₃O⁺** joni virza **6O₂aqua + 6H₂O** cauri membrānu akvaporīnu kanāliem osmozē pretēji koncentrācijas gradientiem, bet transportē jonus **6HCO₃⁻ + 6H₃O⁺** lejup pa gradientiem cauri membrānu bikarbonāta un protonu kanāliem lietojot homeostāzes producēto $\Delta G_{\text{Lehninger}} = -2840 \text{ kJ/mol}$ brīvo energēju.

Potenciālu starpību $\Delta E = \Delta G_{eq}/F/n = (E^{\circ}_{C_6H_{12}O_6} - E^{\circ}_{O_2}) = -2840000/96485/24 = -1,2264$ V dod **absolūto** standarta potenciālu $E^{\circ}_{C_6H_{12}O_6} = \Delta E + E_{O_2} = -1,226 + 1,0868 = -0,1392$ V glikozes pusreakcijai no Lehningera **-2840 kJ/mol.** [6]

Nernsta pus reakcijai $C_6H_{12}O_6 + 42H_2O = 30H_3O^+ + 6HCO_3^- + 24e^-$ ir standarta potenciāls $E^{\circ}_{C_6H_{12}O_6} = -0,1392$ V : Alberty dati sakrīt ar **absolūto** potenciālu skalu. Skābekļa reducēšanas $O_2\text{aqua} + 4H_3O^+ + 4e^- = 6H_2O$ **inversais** standarta potenciāls $-E^{\circ}_{O_2} = -1,0868$ V ir **inverss**, jo produkti ir ūdens molekulas nevis skābeklis:

$$\Delta G_{O_2\text{aq}} = 6G_{H_2O} - (G_{O_2\text{aq}} + 4G_{H_3O^+}) = 6*0 - (330 - 4*22,44) = -419,76 \text{ kJ/mol.}$$

Absolūtās enerģijas izmaiņas minimums $\Delta G_{eq\text{Standard}O_2} = -E^{\circ}_{O_2} \cdot F \cdot 1 \cdot 4 = -1,0868 * 96485 * 4 = -419,44 \text{ kJ/mol}$ ar sešām skābekļa molekulā pus reakcijām oksidē glikozi (**Glc**) atbrīvojot energiju izmaiņā $\Delta G_{Homeostāzes} = -2840 \text{ kJ/C_mol.}$

Standarts $\Delta G_{Alberty\text{Absolute}C_6H_{12}O_6} = E^{\circ}_{C_6H_{12}O_6} \cdot F \cdot 1 \cdot 24 = -0,1392 * 96485 * 24 = -322 \text{ kJ/mol}$ ir eksoerģiska **absolūtās** brīvās enerģijas izmaiņa. Pus reakciju summa parāda sakritību Alberty datiem ar **absolūto** potenciālu skalu:

$$6\Delta G_{eq\text{Standard}O_2} = 6 * -419,44 = -2516,6 \text{ kJ/mol ; } 6\Delta G_{O_2\text{aq}} = 6 * -419,76 = -2518,6 \text{ kJ/mol ;}$$

$$6\Delta G_{eq\text{Standard}O_2} + \Delta G_{Alberty\text{Absolute}C_6H_{12}O_6} = -2516,6 - 322 = -2838,94 \text{ kJ/mol ;}$$

Inversie standarta potenciāli $-E^{\circ}_{O_2} = -1,0868$ V ar homeostāzes atraktoriem $[H_3O^+] = 10^{-7,36} \text{ M}$, $[HCO_3^-] = 0,0154 \text{ M}$, $[C_6H_{12}O_6] = 5 * 10^{-3} \text{ M}$, $[O_2\text{aqua}] = 6 * 10^{-5} \text{ M}$, $[H_2O] = 55,3 \text{ M}$ rada **absolūto** potenciālu summu skābeklim un glikozei eksoerģiskāku $\Delta G_{Lehninger} = -2840 \text{ kJ/mol} < \Delta G_{Homeostāze} = -3054,7 \text{ kJ/mol} :$

$$E_{O_2} = -E^{\circ}_{O_2} + 0,0591/4 \cdot \log([H_2O]^6/[O_2\text{aqua}]/[H_3O^+]^4) = -1,0868 + 0,0591/4 \cdot \log(55,346^6/6/10^{(-5)}/10^{(-7,36*4)}) = -0,4349 \text{ V}$$

un: $E_{C_6H_{12}O_6} = E^{\circ}_{C_6H_{12}O_6} + 0,0591/24 \cdot \log([HCO_3^-]^6 \cdot [H_3O^+]^{30}/[C_6H_{12}O_6]/[H_2O]^{42}) =$
 $= -0,1392 + 0,0591/24 \cdot \log(0,0154^{6*10^{-7,36*30}}/5/10^{-3}/55,346^{42}) = -0,8843 \text{ Volti .}$

Brīvā enerģijas izmaiņa ir eksoerģiska, negatīva vērtība standarta un homeostāzes apstākļos:

$$\Delta G_{Lehninger} = \Delta E \cdot F \cdot n = (E^{\circ}_{C_6H_{12}O_6} - E^{\circ}_{O_2}) \cdot F \cdot n = (-0,1392 - 1,0868) \cdot F \cdot n = -1,226 * 96485 * 24 = -2840 \text{ kJ/mol.}$$

$$\Delta G_{Homeostāzes} = \Delta E \cdot F \cdot n = (E^{\circ}_{C_6H_{12}O_6} - E^{\circ}_{O_2}) \cdot F \cdot n = (-0,88427 - 0,4349) \cdot F \cdot n = -1,31917 * 96485 * 24 = -3054,7 \text{ kJ/mol.}$$

Skābekļa reducēšanas $6(O_2\text{aqua} + 4H_3O^+ + 4e^- \leftrightarrow 6H_2O)$ **inversais** standarta potenciāls $E^{\circ}_{O_2} = 1,0868$ Volti un glikozes homeostāzes konstante ar atraktoriem $[H_3O^+] = 10^{-7,36} \text{ M}$, $[HCO_3^-] = 0,0154 \text{ M}$, $[C_6H_{12}O_6] = 5 * 10^{-3} \text{ M}$, ūdeni $[H_2O] = 55,3 \text{ M}$ un $\Delta G_{Lehninger} = -2840 \text{ kJ/mol}$ ir lielāka par vienu $K_{eq\text{Homeostāzes}} = 10^{498}$:

$$K_{eq\text{Homeostāzes}} = \frac{[HCO_3^-]^6 \cdot [H_3O^+]^6}{[C_6H_{12}O_6] \cdot [O_2]^6 \cdot [H_2O]^6} = \text{EXP}(-\Delta G_{eq\text{Homeostāzes}}/R/T) = \text{EXP}(2840000/8,3144/298,15) = 10^{498}:$$

Kvazi līdzsvara stāvoklis virzīts neatgriezeniskā sintēzē, kura kā dzinējs akumulē brīvo energiju produktos:

$$6H_3O^+ + 6HCO_3^- \text{Photosynthesis} \Rightarrow C_6H_{12}O_6 + 6O_2\text{aqua} + 6H_2O; \Delta G_{Lehninger} = 2840 \text{ kJ/mol.}$$

$$\text{Hesa likumā } 2840 \text{ kJ/mol} = G_{C_6H_{12}O_6} + 6 * G_{O_2\text{Homeostāzes_arterial}} + 6 * G_{H_2O\text{_Biochem}} - (6 * G_{H_3O^+} + 6 * G_{HCO_3^-})$$

brīvās enerģijas saturs vienā molā glikozes ir aprēķināts atsaucoties uz Alberty datiem. [8,15]

Veidošanās no elementiem $S_{\text{rombisks}} + H_2gāze \rightarrow H_2S_{\text{gāze}}$; $G_{\text{rombisks}} = -85,64 \text{ kJ/mol}$; [1,6]

Veidošanās enerģijas izmaiņa ir $\Delta G_{\text{Hess_}H_2S_{\text{gāze}}} = G^{\circ}_{H_2S_{\text{gāze}}} - (H_{\text{ Hess}} G^{\circ}_{\text{rombisks}} + H_{\text{ Hess}} G^{\circ}_{H_2}) = -20,6 - (0+0) = -20,6 \text{ kJ/mol}$.

Sēra enerģijas saturs molā ir $G_{\text{rombisks}} = G^{\circ}_{H_2S_{\text{gāze}}} - (\Delta G_{\text{Hess_}H_2S_{\text{gāze}}} + G^{\circ}_{H_2gāze}) = -20,6 - (-20,6 + 85,64) = -85,64 \text{ kJ/mol}$;

Brīvās enerģijas saturs sērūdeņraža šķīdumā $G_{H_2S_{\text{aqua}}} = -30,82 \text{ kJ/mol}$. [1,6]

Sēra reducēšanas Nernsta pus reakcijai $H_2S_{\text{aq}} + 2H_2O \rightarrow S_{\text{rombisks}} + 2H_3O^+ + 2e^-$ ir absolūtais standarta potenciāls $E^{\circ}_{H_2S} = -0,0515 \text{ V}$ brīvās enerģijas izmaiņai $\Delta G_{\text{eq}_{H_2S}} = E^{\circ}_{H_2S} F n = -0,0515 * 96485 * 2 = -9,938 \text{ kJ/mol}$. Tā uzrāda brīvās enerģijas saturu vienā molā $G_{H_2S_{\text{aqua}}} = -30,82 \text{ kJ/mol}$, kā izteiksmi no Hesa likuma brīvās enerģijas izmaiņai pus reakcijā $\Delta G_{\text{Hess_}H_2S_{\text{aq}}} = G_{\text{rombisks}} + 2G_{H_3O^+} - (G_{H_2S_{\text{aq}}} + 2G_{H_2O}) = -85,64 + 2 * 22,44 - (G_{H_2S_{\text{aq}}} + 2 * 0) = -9,938 \text{ kJ/mol}$ sērūdeņraža ūdens šķīdumā:

$$G_{H_2S_{\text{aq}}} = G_{\text{rombisks}} + 2G_{H_3O^+} - (\Delta G_{\text{Hess_}H_2S_{\text{aq}}} + 2G_{H_2O}) = -85,64 + 2 * 22,44 - (-9,938 + 2 * 0) = -30,82 \text{ kJ/mol}.$$

Sēra inversā pus reakcija $S_{\text{rombisks}} + 2H_3O^+ + 2e^- \rightarrow H_2S_{\text{aq}} + 2H_2O$; $-E^{\circ}_{H_2S} = 0,0515 \text{ Volti}$ ar diviem metāla ūdeņraža moliem pus reakcijā $2(Pt)H + 2H_2O \rightleftharpoons 2H_3O^+ + 4e^-$; $E^{\circ}_{H} = -0,2965 \text{ V}$ absolūtā standart potenciālu summa ir:

$$\Delta E^{\circ}_{\text{Red-Ox}} = (E^{\circ}_{H} - E^{\circ}_{H_2S}) = (-0,2965 + 0,0515) = -0,245 \text{ Volti}.$$

Metāls ūdeņradis $(Pt)H$ reducē rombisko sēru : $S_{\text{rombisks}} + 2(Pt)H \rightarrow H_2S_{\text{aq}}$; par ūdeņraža sulfīdu.

Brīvās enerģijas izmaiņas minimums metāla ūdeņraža $(Pt)H$ oksidēšanas ar sēru līdzsvara stāvoklī: ir negatīvs:

$$\Delta G_{\text{eq}} = (E^{\circ}_{H} - E^{\circ}_{H_2S}) \cdot F \cdot 1 \cdot 2 = (-0,2965 + 0,0515) * 96485 * 2 = -0,245 * 96485 * 2 / 1000 = -47,28 \text{ kJ/mol}.$$

Brīvās enerģijas izmaiņas izteiksmē no Hesa likuma:

$$\Delta G_{\text{Hess}_{H_2S}} = G_{H_2S_{\text{aqua}}} - (2G_{H(Pt)} + G_{\text{rombisks}}) = G_{H_2S_{\text{aqua}}} - (2 * 51,05 - 85,64) = -47,28 \text{ kJ/mol}$$

uzrāda sērūdeņraža šķīdumā identisku negatīvu enerģijas saturu kā $G_{H_2S_{\text{aqua}}} = -30,82 \text{ kJ/mol}$ reducēšanas pusreakcijā atsevišķi:

$$G_{H_2S_{\text{aqua}}} = \Delta G_{\text{Hess}_{H_2S}} + (2G_{H(Pt)} + G_{\text{rombisks}}) = -47,28 + (2 * 51,05 - 85,64) = -30,82 \text{ kJ/mol}.$$

Alberty dati sakrīt ar absolūto standarta potenciālu skalu abās pusreakcijās kā atsevišķā $E^{\circ}_{H_2S} = -0,0515 \text{ V}$ un tā arī sasaistītajās nokomplektētajās oksidēšanas - reducēšanas reakcijās ar standard potential summu līdzīgi kā

$$\Delta E^{\circ}_{\text{Red-Ox}} = (E^{\circ}_{H} - E^{\circ}_{H_2S}) = (-0,2965 + 0,0515) = -0,245 \text{ Volts}.$$

Ūdeņraža elektroda atskaites noteikšana $E^{\circ}_{H} = -0,2965 \text{ Volti}$ **absolūtā potenciāla skalā**
sinhronizē zinātnes ar **absolūtu** brīvās enerģijas skalas mērogū.

Ūdeņraža elektroda atskaites punkta $E^{\circ}_{H} = -0,2965 \text{ V}$ atklāšana **absolūtajam** potenciālam un **absolūtās** brīvās enerģijas skalai ar inversās simetrijas nozīmi pusreakcijā, kurai **inversais** potenciāls piemīt viens un tas pats skaitlis ar pretēju zīmi, jo simetrija sakrīt ar **inverso** absolūto brīvo enerģiju, tas pats skaitlis ar pretēju zīmi.

Absolūtās un **inversās** brīvās enerģijas un potenciāla mēroga noteikšanai ir nepieciešama ūdens un hidroksonija uzskaita, pamatojoties uz Alberty datiem par ūdeņraža gāzes un šķīduma termodinamisko **absolūtu** brīvo enerģiju.

Absolute Free Energy scale requires applied zero to water and carbon dioxide gas background reference for metabolites shown in Figure 1..

Absolūtās brīvās enerģijas skalai ir jāpiemēro metabolītu nulles vērtība ūdenim un oglekļa dioksīda gāzes fona atsauce, kas parādīti 1. attēlā.

Inversijas simetrija, ko abpusējas atbilstības rezultātā izmanto kā termodinamiskos rīkus: **absolūtās** brīvās enerģijas un **absolūtu potenciālu skalu**, lai atklātu Nernsta pus-, **inverso-** un pilno oksidēšanas-reducēšanas reakciju strukturālās detaļas.

Hesa elementu nulles standarta vērtības patiesībā ir pozitīvas bioķīmijas enerģijas.

$G_{H2\text{gas}}=85,6 \text{ kJ/mol}$ attiecinātas uz homeostāzes produktu ūdens un CO_2gas nulli $G_{H2O}=G_{CO_2\text{gas}}=0 \text{ kJ/mol}$.

Dažu reaktantu [1,8] brīvās enerģijas saturs attiecināti uz homeostāzes produktu nulles vērtību skalu ir:

Glikoze $G_{C6H12O_6}=2268,8 \text{ kJ/mol} >$ deprotoņēts peroksīda anjons $G_{HOO^-}=338 \text{ kJ/mol} > G_{O2\text{aqua}}=330 \text{ kJ/mol} >$

$> G_{O2\text{gas}}=303 \text{ kJ/mol} >$ peroksīds $G_{H2O_2}=284 \text{ kJ/mol} > G_{NH4^+}=232,9 \text{ kJ/mol} >$

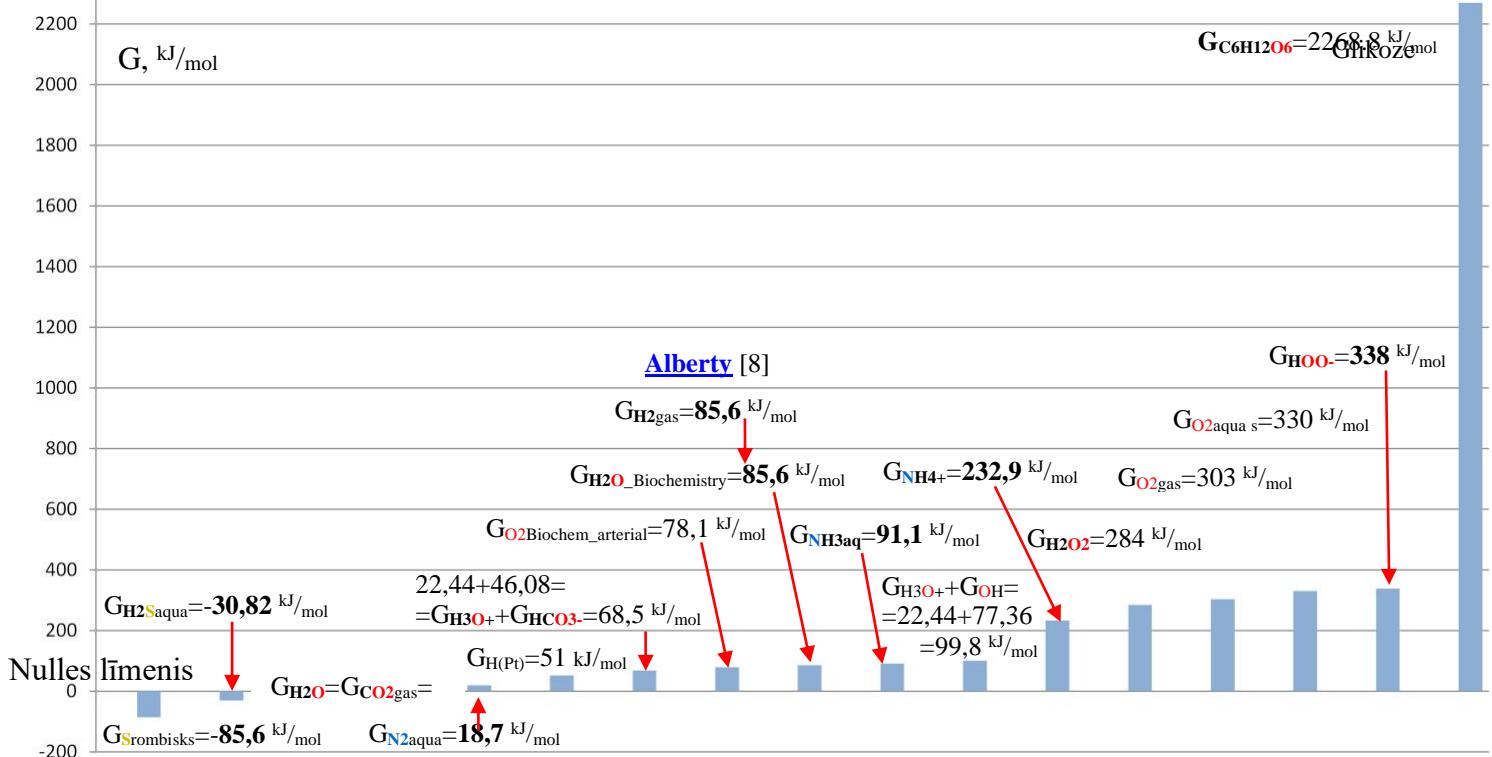
$>$ ūdens protolīzes $\text{pH}=\text{pOH}=7$ $G_{H3O^{++}\text{OH}^-}=G_{H3O^+}+G_{OH^-}=22,44+77,36=99,8 \text{ kJ/mol} >$

$> G_{NH3\text{aq}}=91,1 \text{ kJ/mol} > G_{H2\text{gas}}=85,6 \text{ kJ/mol} \equiv G_{H2O\text{ Biochemistry}}=85,6 \text{ kJ/mol} > G_{O2\text{Biochem_arterial}}=78,1 \text{ kJ/mol} >$

$> \text{CO}_2\text{aqua}$ šķīduma protolīze ar karbo anhidrāzi $G_{H3O^+}+G_{HCO_3^-}=G_{H3O^+}+G_{HCO_3}=22,44+46,08=68,5 \text{ kJ/mol} >$

$> G_{H(\text{Pt})}=51 \text{ kJ/mol} >$ homeostāzes produktu nulles vērtības $G_{H2O}=G_{CO_2\text{gas}}=0 \text{ kJ/mol} >$

$> G_{H2\text{aqua}}=-30,82 \text{ kJ/mol} > G_{S\text{rombisks}}=-85,64 \text{ kJ/mol} > G_{N2\text{gas}}=-257 \text{ kJ/mol};$



Grafiks 1. Augoša absolūtās brīvā enerģija metabolītiem attiecināta uz $G_{H2O}=G_{CO_2\text{gas}}=0 \text{ kJ/mol}$ nulles vērtību.

Atklājums zinātnē par **Absolūto potenciālu skalu** ir sakrītošs ar **absolūtās** brīvās enerģijas nozīmīgi.

Ūdens un hidroksonija atlaide reakcijās ieskaitot protolīzi un elektroķīmiju Nernsta pus reakcijās ierobežo zinātniskās studijas termodinamikā, fizikālā ķīmijā un bioķīmijā. [8,14,15]

Inversijas simetrijas termodinamiskā īpašība ir tieša reakcija starp reaģentiem un produktiem, kas apgriežas pretējā virzienā, sākotnēji nozīmējot produktus kā reaģentus un atstājot reaģentus kā galaproductus. Ūdeni par skābekli oksidēšanas reducēšanas $6H_2O=O_2\text{aqua}+4H_3O^++4e^-$ Nernsta pus reakcijā ir **absolūtais standarta potenciāls**: $E^\circ_{O2\text{Absolute}}=1.0868 \text{ V}$. Par $O_2\text{aqua}+4H_3O^++4e^- \rightarrow 6H_2O$ iesaistīšanos **inversajā** reakcijā **absolūtam potenciālam** ir vienāds skaitlis ar pretēju zīmi $E^\circ_{O2\text{Absolute}}= -1.0868 \text{ V}$ negatīvs.

Atklātā **absolūtā potenciāla skala** Nernsta vai **inversajām** reakcijām sakrīt ar **absolūtās** brīvās enerģijas īpašību **inversajā simetrija**. [8, 14, 15] Nernsta vai **inverso** reakciju **inversās simetrijas** īpašība ar identiskām vērtībām, bet ar **pretēju zīmi**, kas izpaužas **absolūtā potenciāla skalā** ar **absolūtu** brīvo enerģiju, ir sakritīga termodinamiskā īpašība protolīzes reakcijai, Nernsta pusreakcijai vai **inversajai** reakcijai.

Koriģētā metāla ūdeņraža termodinamiskā standarta potenciāla atskaitē 0,10166 Volti dažu gadu laikā dod impulsu zinātnēm iegūt **absolūtās** termodinamiskās vērtības elementu un molekulu brīvajai enerģijai. Pateicoties Alberty dotaļiem datiem par ūdeņraža **absolūtu** brīvo enerģiju gāzei $G_{H2\text{gas}}=85,6 \text{ kJ/mol}$ un $G_{H2\text{aqua}}=103 \text{ kJ/mol}$ šķīdumā ir noteikti **absolūtie** standarta potenciāli metāla ūdeņraža vispārīgā atskaitē $E^\circ_H=-0.2965 \text{ Voltos}$.

Tabulā 1. tiek publicētas 50 bioķīmijā lietotas Nernsta oksidēšanas pus vai reducēšanas **inversās** reakcijas.

Trijos stabiņos mēs varam novērot attīslību ūdeņraža vispārīgai atskaites skalai no klasiskās nulles $E^\circ_H=0 \text{ V}$ ar ūdens atlaidi. Ūdens un hidroksonija katjona koriģē vispārīgo ūdeņraža termodinamisko standarta skalas atskaites potenciālu uz $E^\circ_H=0.10166 \text{ Voltiem}$. Trešajā stabiņā Alberty dati beidzot noved pie **absolūtās** standarta **potenciāla** vērtības $E^\circ_H=-0.29654 \text{ Volti}$ ūdeņraža elektrodam.

H₂O₂ veidošanās 41. lapa H₂gas+O₂gas=>H₂O₂; ΔG°_{UnivAlberta}=-134,03 kJ/mol ; ΔG°_{Alberty}=-48,39 kJ/mol ;
 $\Delta G_{\text{Alberty}} = G_{\text{H}_2\text{O}_2} - (G_{\text{O}_2\text{gas}} + G_{\text{H}_2\text{gas}}) = 284,25 - (85,64 + 303) = -104,64 \text{ kJ/mol}$ (-134,03 kJ/mol); (-48,39 kJ/mol)

Viela	ΔH° _H kJ/mol	ΔS° _H J/mol/K	ΔG° _H kJ/mol
H₂O₂aqua	-191,99	-481,688	-48,39
H₂O_{aqua}	-191,17	143,9	-134,03
Succinat²⁻	-908,69	-1295,576	-522,414
Fumarate²⁻	-776,56	-862,288	-519,4688

Alberty nulles G_{H₂O}=0 kJ/mol; atskaitē bāzēti G_{H₂O₂}=284,25 kJ/mol University Alberta

G_{SuccinatFor}=-522,4+(4*91,26+2*85,6+2*303)=619,8 kJ/mol; G_{Succinat}=650,8 kJ/mol;
 $G_{\text{FumaricFor}} = -519,5 + (4 * 91,26 + 85,6 + 2 * 303) = 537,1 \text{ kJ/mol}$; G_{Fumarat}=554,75 kJ/mol;

Succinat²⁻ veidošanās 4C+2H₂gas+2O₂gas=>(CH₂)₂(CO₂⁻)(CO₂⁻) ; ΔG_{Succinat}=-522,4 kJ/mol Alberty;

ΔG_{SuccinatFor}=G_{SuccinatFor}-(4G_{Cgraph}+2*G_{H₂gas}+2*G_{O₂gas})=-522,4 kJ/mol;

G_{SuccinatFor}=-522,4+(4*91,26+2*85,6+2*303)=619,8 kJ/mol;

Fumarate²⁻ veidošanās 4C+H₂gas+2O₂gas=>(CH)₂(CO₂⁻)(CO₂⁻) ; ΔG_{Fumarat}=-519,5 kJ/mol Alberty;

ΔG_{Fumarat}=G_{FumaratFor}-(4G_{Cgraph}+G_{H₂gas}+2*G_{O₂gas})= -519,5 kJ/mol;

G_{FumaratFor}=-519,5+(4*91,26+85,6+2*303)=537,1 kJ/mol; ; veidošanās 73. lapa

Inversais O₂aqua+2H₃O⁺+2e⁻=H₂O₂aqua+2H₂O; standarta potenciāls E°_{OxO₂_H₂O₂}=-0,4495 V University Alberta ;

ΔG_{AlbertyOxO₂_H₂O₂}=G_{H₂O₂}+2*G_{H₂O₂}-(G_{O₂aqua}+2*G_{H₃O₊})=284,25+2*0-(330+2*22,44)=-99,8 kJ/mol ;

ΔG_{eqAlbertyAbsoluteOxO₂_H₂O₂}=E°_{eqOxO₂_H₂O₂}*F•1•2=-0,4495*96485*2=-86,7 kJ/mol;

Succinat²⁻+O₂aqua=>fumarate²⁻+H₂O₂aqua+Q+ΔG; ΔG_{min}=ΔG_{eqSuccinat_H₂O₂}=-38,3 kJ/mol;

ΔG_{Hess}=ΔG°_{H₂O₂}+ΔG°_{fumarat}-ΔG°_{O₂}-ΔG°_{Succinat}=-48,39-519,4688-(16,4-522,414) = -61,845 kJ/mol;

ΔG_{min}=ΔG_{eq}=(E°_{RedSuccinate}-E°_{OxO₂})*F*n=(0,2512-0,4495)*96485*2=(-0,1983)* 96485*2=-38,3 kJ/mol;

Alberty Hesa ΔG_{Succinat_H₂O₂}=G_{Fumarat}+G_{H₂O₂}-(G_{Succinat}+G_{O₂aqua})=537,1+284,24-(619,8+330)=-128,5 kJ/mol ;

K_{eq}=exp(-ΔG_{eq}/R/T)=exp(38270/8,3144/298,15)=5065991 veidošanās 58. Lapa.

Absolūto termodinamisko parametru jēdzieni temperatūra, brīvā enerģija un potenciāls ir **absolūti** savstarpēji instrumenti, lai atklātu paralēlu un secīgu komplekso reakciju strukturālās detaļas, izmantojot inversijas simetrijas īpašības.

1. Absolūtā temperatūra T Kelvina grādos ir standarta vērtībā 298.15 K (25 ° C),

Lord Kelvin



2. Uz Alberty bāzētais absolūtais brīvās enerģijas saturs

G_{H₂gas}=85,6 kJ/mol ūdeņraža gāzei, tās šķīdumam ūdenī G_{H₂aqua}=103 kJ/mol un

metālam ūdeņradim G_{H(Pt)}=51 kJ/mol

atsaucoties uz nulles atskaites vērtību G_{H₂O}=G_{CO₂gas}=0 kJ/mol kā fonu

ūdenī un oglēkļa dioksīda gāzē CO₂gas.

Alberty Robert



3. Atklājums Absolūtā potenciālu skala.

Absolūtā potenciāla skala, pamatojas uz vispārīgu atsauci

metāla ūdeņraža absolūto standarta Potenciālu E°_H=-0,2965 Volts. [8, 14, 15]

feasible

CH₃CH₂OH etanola veidošanās no elementiem:



$$\Delta G^\circ_{\text{Alberty}} = \text{G}_{\text{CH}_3\text{CH}_2\text{OH}} - (2\text{G}_{\text{Cgraph}} + 3\text{G}_{\text{H}_2\text{gas}} + 1/2\text{G}_{\text{O}_2\text{gas}}) = 75,2864 \text{ kJ/mol};$$

$$\Delta G^\circ_{\text{CRC}} = \text{G}_{\text{CH}_3\text{CH}_2\text{OH}} - (2\text{G}_{\text{Cgraph}} + 3\text{G}_{\text{H}_2\text{gas}} + 1/2\text{G}_{\text{O}_2\text{gas}}) = -181 \text{ kJ/mol};$$

$$\Delta G^\circ_{\text{Alberty}} + (2\text{G}_{\text{Cgraph}} + 3\text{G}_{\text{H}_2\text{gas}} + 1/2\text{G}_{\text{O}_2\text{gas}}) = 75,2864 + (2*91,26 + 3*85,6 + 1/2*303) = \text{G}_{\text{CH}_3\text{CH}_2\text{OH}} = 666,106 \text{ kJ/mol};$$

$$\Delta G^\circ_{\text{CRC}} + (2\text{G}_{\text{Cgraph}} + 3\text{G}_{\text{H}_2\text{gas}} + 1/2\text{G}_{\text{O}_2\text{gas}}) = -181 + (2*91,26 + 3*85,6 + 1/2*303) = \text{G}_{\text{CH}_3\text{CH}_2\text{OH}} = 409,82 \text{ kJ/mol};$$

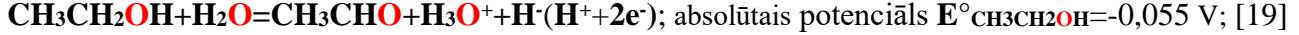
CH₃CHO acetaldehīda veidošanās no elementiem: $2\text{C} + 2\text{H}_2\text{gas} + 1/2\text{O}_2\text{gas} \Rightarrow \text{CH}_3\text{CHO}$;

$$\Delta G^\circ_{\text{Alberty}} = \text{G}_{\text{CH}_3\text{CHO}} - (2\text{G}_{\text{Cgraph}} + 2\text{G}_{\text{H}_2\text{gas}} + 1/2\text{G}_{\text{O}_2\text{gas}}) = 32,282 \text{ kJ/mol};$$

$$\Delta G^\circ_{\text{CRC}} = \text{G}_{\text{CH}_3\text{CHO}} - (2\text{G}_{\text{Cgraph}} + 2\text{G}_{\text{H}_2\text{gas}} + 1/2\text{G}_{\text{O}_2\text{gas}}) = 24,06 \text{ kJ/mol};$$

$$\Delta G^\circ_{\text{Alberty}} + (2\text{G}_{\text{Cgraph}} + 2\text{G}_{\text{H}_2\text{gas}} + 1/2\text{G}_{\text{O}_2\text{gas}}) = 32,282 + (2*91,26 + 2*85,6 + 1/2*303) = \text{G}_{\text{CH}_3\text{CHO}} = 537,5 \text{ kJ/mol};$$

$$\Delta G^\circ_{\text{CRC}} + (2\text{G}_{\text{Cgraph}} + 2\text{G}_{\text{H}_2\text{gas}} + 1/2\text{G}_{\text{O}_2\text{gas}}) = 24,06 + (2*91,26 + 2*85,6 + 1/2*303) = \text{G}_{\text{CH}_3\text{CHO}} = 529,28 \text{ kJ/mol};$$



$$\Delta G_{\text{eq}}_{\text{CH}_3\text{CH}_2\text{OH}} = E^\circ_{\text{eqNernsCH}_3\text{CH}_2\text{OH}} \cdot F \cdot 2 = -0,055 * 96485 * 2 = -10,6 \text{ kJ/mol};$$

$$\Delta G_{\text{HessCH}_3\text{CH}_2\text{OH}} = \text{G}_{\text{CH}_3\text{CHO}} + \text{G}_{\text{H}_3\text{O}^+} + \text{G}_{\text{H}^-} - (\text{G}_{\text{CH}_3\text{CH}_2\text{OH}} + \text{G}_{\text{H}_2\text{O}}) = 537,5 + 22,44 + \text{G}_{\text{H}^-} - (409,82 + 0) = -10,6 \text{ kJ/mol}.$$

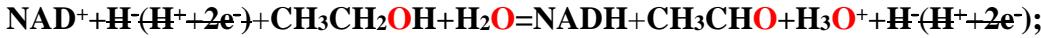
$$\Delta G_{\text{HessCH}_3\text{CH}_2\text{OH}} = \text{G}_{\text{CH}_3\text{CHO}} + \text{G}_{\text{H}_3\text{O}^+} + \text{G}_{\text{H}^-} - (\text{G}_{\text{CH}_3\text{CH}_2\text{OH}} + \text{G}_{\text{H}_2\text{O_Biochem}}) = 537,5 + 22,44 + \text{G}_{\text{H}^-} - (409,82 + 85,64) = -10,6 \text{ kJ/mol}.$$

$$\Delta G_{\text{HessCH}_3\text{CH}_2\text{OH}} - \text{G}_{\text{CH}_3\text{CHO}} - \text{G}_{\text{H}_3\text{O}^+} + (\text{G}_{\text{CH}_3\text{CH}_2\text{OH}} + \text{G}_{\text{H}_2\text{O}}) = \text{G}_{\text{H}^-} = -10,6 - 537,5 - 22,44 + (409,82 + 0) = -160,7 \text{ kJ/mol}.$$

$$\Delta G_{\text{HessCH}_3\text{CH}_2\text{OH}} - \text{G}_{\text{CH}_3\text{CHO}} - \text{G}_{\text{H}_3\text{O}^+} + (\text{G}_{\text{CH}_3\text{CH}_2\text{OH}} + \text{G}_{\text{H}_2\text{O_Biochem}}) = \text{G}_{\text{H}^-} = -10,6 - 537,5 - 22,44 + (409,82 + 85,64) = -75,08 \text{ kJ/mol}.$$

Vielas	$\Delta H^\circ_{\text{H}}$ kJ/mol	$\Delta S^\circ_{\text{H}}$ J/mol/K	$\Delta G^\circ_{\text{H}}$ kJ/mol
H ₃ C-CH=O	-212,23	-281,84	24,06
H ₃ C-CH=O	-213,88	-825,64	32,2824
NADH	-41,41	-4465,708	1175,5732
NADH	-1036,66	-140,50	1120,09
H ₃ O ⁺	-285,81	-3,854	-213,275
NAD ⁺	-10,30	-3766,008	1112,534
NAD ⁺	-1007,48	-183	1059,11
H ₃ CCH ₂ OH	-290,77	-1227,764	75,2864
H ₃ CCH ₂ OH _{adq}	-288,3	-357,7394	-181,64
H ₂ O	-285,85	69,9565	-237,191
H ₂ O	-286,65	-453,188	-151,549

NADH = NAD⁺ + H^{-(H⁺ + 2e⁻)}; $E^\circ_{\text{NADH}} = -0,4095 \text{ V}$; absolute David Harris; [22]



$$\Delta G_{\text{min}} = \Delta G_{\text{eq}} = (E^\circ_{\text{eqNernsCH}_3\text{CH}_2\text{OH}} - E^\circ_{\text{NAD}^+}) * F * n = (-0,055 + 0,4095) * 96485 * 2 = (0,4562) * 96485 * 2 = 68,408 \text{ kJ/mol};$$

$$\Delta G_{\text{HessAlbertyCH}_3\text{CH}_2\text{OH}} = \text{G}_{\text{NADH}} + \text{G}_{\text{H}_3\text{O}^+} + \text{G}_{\text{CH}_3\text{CHO}} - (\text{G}_{\text{NAD}^+} + \text{G}_{\text{CH}_3\text{CH}_2\text{OH}} + \text{G}_{\text{H}_2\text{O}}) = 68,02 \text{ kJ/mol}.$$

$$= 1112,534 + 22,44 + 32,282 - (1175,5 + 75,2864 - 151,549) = 68,02 \text{ kJ/mol}.$$



$$\Delta G_{\text{eqH}_3\text{CHC(OH)COO}} = E^\circ_{\text{eqH}_3\text{CHC(OH)COO}} \cdot F \cdot 2 = -0,0159 \cdot 96485 \cdot 2 = -3,068 \text{ kJ/mol};$$

$$\Delta G_{\text{HessCH}_3\text{CH}_2\text{OH}} = \text{G}_{\text{H}_3\text{CC=OCOO}} + \text{G}_{\text{H}_3\text{O}^+} + \text{G}_{\text{H}^-} - (\text{G}_{\text{H}_3\text{CHC(OH)COO}} + \text{G}_{\text{H}_2\text{O}}) = 534,2 + 22,44 + \text{G}_{\text{H}^-} - (668,8 + 0) = -3,068 \text{ kJ/mol}.$$

$$\Delta G_{\text{HessCH}_3\text{CH}_2\text{OH}} = \text{G}_{\text{H}_3\text{CC=OCOO}} + \text{G}_{\text{H}_3\text{O}^+} + \text{G}_{\text{H}^-} - (\text{G}_{\text{H}_3\text{CHC(OH)COO}} + \text{G}_{\text{H}_2\text{O_Biochem}}) = 534,2 + 22,44 + \text{G}_{\text{H}^-} - (668,8 + 85,64) = -3,068 \text{ kJ/mol}.$$

$$\Delta G_{\text{HessCH}_3\text{CH}_2\text{OH}} = \text{G}_{\text{H}_3\text{CC=OCOO}} - \text{G}_{\text{H}_3\text{O}^+} + (\text{G}_{\text{H}_3\text{CHC(OH)COO}} + \text{G}_{\text{H}_2\text{O_Biochem}}) = \text{G}_{\text{H}^-} - 3,068 - 534,2 - 22,44 + (668,8 + 0) = 109,092 \text{ kJ/mol}.$$

$$\Delta G_{\text{HessCH}_3\text{CH}_2\text{OH}} = \text{G}_{\text{H}_3\text{CC=OCOO}} - \text{G}_{\text{H}_3\text{O}^+} + (\text{G}_{\text{H}_3\text{CHC(OH)COO}} + \text{G}_{\text{H}_2\text{O_Biochem}}) = \text{G}_{\text{H}^-} - 3,068 - 534,2 - 22,44 + (668,8 + 85,64) = 194,7 \text{ kJ/mol}.$$

I=0,25 M, BioTherm06, pH=7,36, $\Delta G_h = G^\circ_{\text{H}_3\text{CC=OCOO}} + G^\circ_{\text{H}_3\text{O}^+} + \text{G}_{\text{H}^-} - \text{G}_{\text{H}_3\text{CHC(OH)COO}} - \text{G}_{\text{H}_2\text{O}} = \text{kJ/mol}$;

Vielas $\Delta H^\circ_h \text{ kJ/mol } \Delta S^\circ_h \text{ J/mol/K } \Delta G^\circ_h \text{ kJ/mol}$;

PyruvEnolP³⁻	-1400	-1100	-1189,73	$\text{G}_{\text{H}_2\text{O}} = 0 \text{ kJ/mol}; \text{G}_{\text{H}^-} = -3,068 - 534,2 - 22,44 + (668,8 + 0) = 109,092 \text{ kJ/mol}$
$\text{H}_3\text{CC=OCOO}^-$	-597,4	-850	-350,78	$\text{G}_{\text{H}_2\text{O_Biochem}} = 85,64 \text{ kJ/mol}; \text{G}_{\text{H}^-} = -3,068 - 534,2 - 22,44 + (668,8 + 85,64) = 194,7 \text{ kJ/mol}$
$\text{H}_3\text{CC=OCOO}^-$	-603,7	-433,54	-474,44	
$\text{H}_3\text{CC=OCOO}^-$	-597,04	-846,66	-344,62	$\text{G}_{\text{H}_3\text{CHC(OH)COO}} = 534,2 \text{ kJ/mol}; pK_a = 2,5;$
H_3O^+	-285,81	-3,854	-213,275	
H_2O	-285,85	69,9565	-237,191	
H_2O	-286,65	-453,188	-151,549	
$\text{H}_3\text{CHC(OH)COO}^-$	-688,29	-1290,9	-303,4	$\text{G}_{\text{H}_3\text{CHC(OH)COO}} = 668,8 \text{ kJ/mol}; pK_a = 3,86;$

$pK_a = 3,86; \Delta H_c^\circ = 1361,9 \text{ kJ/mol}; \text{G}_{\text{H}_3\text{CHC(OH)COO}} = 2271 \text{ kJ/mol}; \text{H}_3\text{CHC(OH)COO} + 3\text{O}_2\text{gas} = 3\text{CO}_2\text{gas} + 3\text{H}_2\text{O};$

$\Delta H_c^\circ = 3\text{G}_{\text{CO}_2\text{gas}} + 3\text{G}_{\text{H}_2\text{O}} - (\text{G}_{\text{H}_3\text{CHC(OH)COO}} + 3\text{G}_{\text{O}_2\text{gas}}) = 3 * 0 + 3 * 0 - (\text{G}_{\text{H}_3\text{CHC(OH)COO}} + 3 * 303) = 1361,9 \text{ kJ/mol};$

$\text{G}_{\text{H}_3\text{CHC(OH)COO}} = 3\text{G}_{\text{CO}_2\text{gas}} + 3\text{G}_{\text{H}_2\text{O}} - (3\text{G}_{\text{O}_2\text{gas}}) = 3 * 0 + 3 * 0 - (+3 * 303) - 1361,9 = \text{G}_{\text{H}_3\text{CHC(OH)COO}} = 2271 \text{ kJ/mol};$

Lactic acid Formation 71st page $3\text{C} + 3\text{H}_2\text{gas} + 1,5\text{O}_2\text{gas} \rightleftharpoons \text{H}_3\text{CHC(OH)COO}^- + \text{H}_3\text{O}^+$; $\text{G}_{\text{H}_3\text{CHC(OH)COO}} = -303,4 \text{ kJ/mol}$ [8];

$\Delta G_{\text{H}_3\text{CHC(OH)COO}} = \text{G}_{\text{H}_3\text{CHC(OH)COO}} - (3\text{G}_{\text{Cgraph}} + 3 * \text{G}_{\text{H}_2\text{gas}} + 1,5 * \text{G}_{\text{O}_2\text{gas}}) = -303,4 \text{ kJ/mol};$

$\text{G}_{\text{H}_3\text{CHC(OH)COO}} = -303,4 + (3 * 91,26 + 3 * 85,6 + 1,5 * 303) = 681,7 \text{ kJ/mol};$

Lactic acid $\text{H}_3\text{CHC(OH)COO}^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{CHC(OH)COO}^- + \text{H}_3\text{O}^+$; $pK_a = 3,86$;

$K_{\text{eq}} = [\text{H}_3\text{CHC(OH)COO}^-] * [\text{H}_3\text{O}^+] / [\text{H}_3\text{CHC(OH)COO}] / [\text{H}_2\text{O}] = K_a / [\text{H}_2\text{O}] = 10^{(-3,86)} / 55,3 = 2,5 * 10^{(-6)} = 10^{(-5,603)}$;

$\Delta G_{\text{eqH}_3\text{CHC(OH)COO}} = -R * T * \ln(K_{\text{eq}}) = -8,3144 * 298,15 * \ln(10^{(-5,603)}) / 1000 = 31,98 \text{ kJ/mol}.$

$\Delta G_{\text{H}_3\text{CHC(OH)COO}} = \text{G}_{\text{H}_3\text{CHC(OH)COO}} + 2\text{G}_{\text{H}_3\text{O}^+} - (\text{G}_{\text{LacticAc}} + 2\text{G}_{\text{H}_2\text{O}}) = \text{G}_{\text{Succinat}} + 2 * 22,44 - (681,7 + 2 * 0) = 31,98 \text{ kJ/mol};$

$\text{G}_{\text{H}_3\text{CHC(OH)COO}} = \Delta \text{G}_{\text{H}_3\text{CHC(OH)COO}} - 2\text{G}_{\text{H}_3\text{O}^+} + (\text{G}_{\text{LacticAc}} + 2\text{G}_{\text{H}_2\text{O}}) = 31,98 - 2 * 22,44 + (681,7 + 2 * 0) = 668,8 \text{ kJ/mol};$

Pyruvic acid Formation 71st page $3\text{C} + 2\text{H}_2\text{gas} + 1,5\text{O}_2\text{gas} \rightleftharpoons \text{H}_3\text{CC=OCOO}^- + \text{H}_3\text{O}^+$; $\Delta G_{\text{Succinat}} = -344,62 \text{ kJ/mol}$ Alberty;

$\Delta G_{\text{Fumarat}} = \text{G}_{\text{Fumarat}} - (3\text{G}_{\text{Cgraph}} + 2\text{G}_{\text{H}_2\text{gas}} + 1,5 * \text{G}_{\text{O}_2\text{gas}}) = -344,62 \text{ kJ/mol};$

$\text{G}_{\text{Fumarat}} = -344,62 + (3 * 91,26 + 2 * 85,6 + 1,5 * 303) = 554,86 \text{ kJ/mol};$

Pyruvic acid $\text{H}_3\text{CC=OCOOH} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{CHC(OH)COO}^- + \text{H}_3\text{O}^+$; $pK_a = 2,5$;

$K_{\text{eq}} = [\text{H}_3\text{CHC(OH)COO}^-] * [\text{H}_3\text{O}^+] / [\text{H}_3\text{CC=OCOOH}] / [\text{H}_2\text{O}] = K_a / [\text{H}_2\text{O}] = 10^{(-2,5)} / 55,3 = 2,5 * 10^{(-6)} = 10^{(-4,243)}$;

$\Delta G_{\text{eqH}_3\text{CC=OCOOH}} = -R * T * \ln(K_{\text{eq}}) = -8,3144 * 298,15 * \ln(10^{(-4,243)}) / 1000 = 24,22 \text{ kJ/mol}.$

$\Delta G_{\text{H}_3\text{CHC(OH)COO}} = \text{G}_{\text{H}_3\text{CHC(OH)COO}} + 2\text{G}_{\text{H}_3\text{O}^+} - (\text{G}_{\text{LacticAc}} + 2\text{G}_{\text{H}_2\text{O}}) = \text{G}_{\text{Succinat}} + 2 * 22,44 - (554,86 + 2 * 0) = 24,22 \text{ kJ/mol};$

$\text{G}_{\text{H}_3\text{CHC(OH)COO}} = \Delta \text{G}_{\text{H}_3\text{CHC(OH)COO}} - 2\text{G}_{\text{H}_3\text{O}^+} + (\text{G}_{\text{LacticAc}} + 2\text{G}_{\text{H}_2\text{O}}) = 24,22 - 2 * 22,44 + (554,86 + 2 * 0) = 534,2 \text{ kJ/mol};$

$\text{NADH} = \text{NAD}^+ + \text{H}^-(\text{H}^+ + 2\text{e}^-)$; $E^\circ_{\text{NADH}} = -0,4095 \text{ V}$; absolute Lehninger; [6]-

Red lactate $\text{H}_2\text{O} \rightleftharpoons \text{pyruvate}^- + \text{H}_3\text{O}^+ + \text{H}^-(\text{H}^+ + 2\text{e}^-)$; absolute potential $E^\circ_{\text{H}_3\text{CHC(OH)COO}} = -0,0159 \text{ V}$;

Ox $\text{NAD}^+ + \text{H}^-(2\text{e}^-) = \text{NADH}$; $E^\circ_{\text{Ox}} = -0,4095 \text{ V}$; OksRed $\text{NAD}^+ + \text{lactate}^- + \text{H}_2\text{O} = \text{NADH} + \text{pyruvate}^- + \text{H}_3\text{O}^+$;

Balanced $n=2=m$ with 2e^- electrons $\Delta E^\circ \text{ NAD}^+$ accept electrons from lactate:

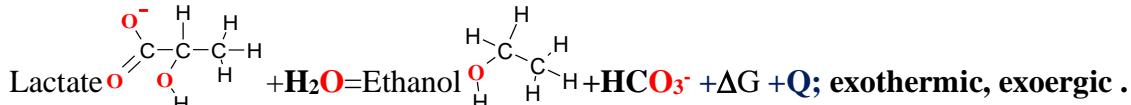
$$\Delta G_{\text{eqAerobic}} = \Delta E^\circ \cdot F \cdot n = (E^\circ_{\text{Red}} - E^\circ_{\text{Ox}}) \cdot F \cdot n = (-0,0159 - -0,4095) * 96485 * 2 = (0,3936) * 2 = 75,95 \text{ kJ/mol}$$

$$K_{\text{eqAerobic}} = \text{EXP}(-\Delta G_{\text{eqAerobic}} / R \cdot T) = \text{EXP}(-75950 / 8,3144 / 298,15) = 10^{-13,3};$$

$$K_{\text{eqAerobic}} = \frac{[\text{NADH}] \cdot [\text{pyruvate}^-] \cdot [\text{H}_3\text{O}^+]}{[\text{NAD}^+] \cdot [\text{lactate}^-] \cdot [\text{H}_2\text{O}]} = e^{-\frac{\Delta G_{\text{eqAerobic}}}{R \cdot T}} = e^{-\frac{75950}{8,314 \cdot 298,15}} = 10^{-13,3};$$

$\Delta G_{\text{Hess}} = \Delta H_{\text{Hess}} - T \cdot \Delta S_{\text{Hess}} = 45,764 - 298,15 * -0,5479605 = 209,14 \dots \text{kJ/mol endoergic}$; formation 62nd, 75th pages

Pyruvate $\text{H}_3\text{CC=OCOO}^-$ decarboxylation $\text{H}_3\text{CCHO} + \text{HCO}_3^- \rightarrow \text{H}_3\text{CC=OCOO}^- + \text{H}_2\text{O}$ $\Delta G = -14,71 \text{ kJ/mol}$



$$\Delta G_{\text{Hess}} = \Delta G^\circ_{\text{H}_3\text{CCH}_2\text{OH}} + \Delta G^\circ_{\text{HCO}_3^-} - \Delta G^\circ_{\text{H}_2\text{O}} - \Delta G^\circ_{\text{H}_3\text{CCH}_2\text{OHC}_2\text{O}} = 75,2864 - 544,9688 - (-151,549 - 303,4256) = -14,71 \text{ kJ/mol}$$

$$\Delta G_{\text{Alberty}} = \Delta G_{\text{H}_3\text{CCH}_2\text{OH}} + \Delta G_{\text{HCO}_3^-} - \Delta G_{\text{H}_2\text{O}} - \Delta G_{\text{H}_3\text{CCH}_2\text{OHC}_2\text{O}} = 666,1 + 46,08 - (0 + 668,8) = 43,38 \text{ kJ/mol}$$

$$\Delta G_{\text{Alberty_Biochem}} = \Delta G_{\text{H}_3\text{CCH}_2\text{OH}} + \Delta G_{\text{HCO}_3^-} \text{ Biochem} - \Delta G_{\text{H}_3\text{CCH}_2\text{OHC}_2\text{O}} = 666,1 + 46,08 - (85,64 + 668,8) = -42,26 \text{ kJ/mol}$$

$$\Delta H_{\text{Hess}} = \Delta H^\circ_{\text{H}_3\text{CCH}_2\text{OH}} + \Delta H^\circ_{\text{HCO}_3^-} - \Delta H^\circ_{\text{H}_2\text{O}} - \Delta H^\circ_{\text{H}_3\text{CCH}_2\text{OHC}_2\text{O}} = -290,77 - 692,4948 - (-286,65 - 688,29) = -8,325 \text{ kJ/mol}$$

$$\Delta S_{\text{izkliedes}} = -\Delta H_{\text{Hess}}/T = 8,325/298,15 = 27,9 \text{ J/K/mol};$$

$$\Delta S_{\text{Hess}} = \Delta S^\circ_{\text{H}_3\text{CCH}_2\text{OH}} + \Delta S^\circ_{\text{HCO}_3^-} - \Delta S^\circ_{\text{H}_2\text{O}} - \Delta S^\circ_{\text{H}_3\text{CCH}_2\text{OHC}_2\text{O}} = 21,51 \text{ J/mol/K};$$

$$= -1227,764 - 494,768 - (-453,188 - 1290,852) = 21,51 \text{ J/mol/K....}$$

$$\Delta S_{\text{kopējs}} = \Delta S_{\text{Hess}} + \Delta S_{\text{izkliedes}} = 21,51 + 27,9 = 49,41 \text{ J/mol/K};$$

$$\Delta G_{\text{Hess}} = \Delta H_{\text{Hess}} - T \cdot \Delta S_{\text{Hess}} = -8,325 - 298,15 \cdot 0,02151 = -14,738 \text{ kJ/mol exoergic.....}$$

$$T \cdot \Delta S_{\text{kopējs}} = 0,04941 \cdot 298,15 \text{ K} = 14,73 \text{ kJ/mol; bound } T \Delta S_n ; \underline{\text{izkliedes-lost energy patvalīga}}$$

Lactic acid Formation 71st page $3\text{C} + 3\text{H}_2\text{gas} + 1,5\text{O}_2\text{gas} \rightarrow \text{H}_3\text{CHC(OH)COOH}$; $G_{\text{H}_3\text{CHC(OH)COOH}} = -303,4 \text{ kJ/mol}$ [8];

$$\Delta G_{\text{H}_3\text{CHC(OH)COOH}} = G_{\text{H}_3\text{CHC(OH)COOH}} - (3G_{\text{Cgraph}} + 3*G_{\text{H}_2\text{gas}} + 1,5*G_{\text{O}_2\text{gas}}) = -303,4 \text{ kJ/mol};$$

$$G_{\text{H}_3\text{CHC(OH)COOH}} = -303,4 + (3*91,26 + 3*85,6 + 1,5*303) = 681,7 \text{ kJ/mol};$$

Lactic acid $\text{H}_3\text{CHC(OH)COOH} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{CHC(OH)COO}^- + \text{H}_3\text{O}^+$; $pK_a = 3,86$;

$$K_{\text{eq}} = [\text{H}_3\text{CHC(OH)COO}^-] * [\text{H}_3\text{O}^+] / [\text{H}_3\text{CHC(OH)COOH}] = K_a / [\text{H}_2\text{O}] = 10^{(-3,86)} / 55,3 = 2,5 * 10^{(-6)} = 10^{(-5,603)};$$

$$\Delta G_{\text{eqH}_3\text{CHC(OH)COOH}} = -R \cdot T \cdot \ln(K_{\text{eq}}) = -8,3144 * 298,15 * \ln(10^{(-5,603)}) / 1000 = 31,98 \text{ kJ/mol}.$$

$$\Delta G_{\text{H}_3\text{CHC(OH)COO}} = G_{\text{H}_3\text{CHC(OH)COO}} + 2G_{\text{H}_3\text{O}^+} - (G_{\text{LacticAc}} + 2G_{\text{H}_2\text{O}}) = G_{\text{Succinat}} + 2*22,44 - (681,7 + 2*0) = 31,98 \text{ kJ/mol};$$

$$G_{\text{H}_3\text{CHC(OH)COO}} = \Delta G_{\text{H}_3\text{CHC(OH)COO}} - 2G_{\text{H}_3\text{O}^+} + (G_{\text{LacticAc}} + 2G_{\text{H}_2\text{O}}) = 31,98 - 2*22,44 + (681,7 + 2*0) = 668,8 \text{ kJ/mol};$$

$\text{CH}_3\text{CH}_2\text{OH}$ ethanol formation from elements:

$$2\text{C} + 3\text{H}_2\text{gas} + 1/2\text{O}_2\text{gas} \rightarrow \text{CH}_3\text{CH}_2\text{OH} ; \Delta G^\circ_{\text{Alberty}} = 75,2864 \text{ kJ/mol} ; \Delta G^\circ_{\text{HessCRC}} = -181 \text{ kJ/mol} ;$$

$$\Delta G^\circ_{\text{Alberty}} = G_{\text{CH}_3\text{CH}_2\text{OH}} - (2G_{\text{Cgraph}} + 3*G_{\text{H}_2\text{gas}} + 1/2*G_{\text{O}_2\text{gas}}) = 75,2864 \text{ kJ/mol} ;$$

$$\Delta G^\circ_{\text{CRC}} = G_{\text{CH}_3\text{CH}_2\text{OH}} - (2G_{\text{Cgraph}} + 3*G_{\text{H}_2\text{gas}} + 1/2*G_{\text{O}_2\text{gas}}) = -181 \text{ kJ/mol} ;$$

$$\Delta G^\circ_{\text{Alberty}} + (2G_{\text{Cgraph}} + 3*G_{\text{H}_2\text{gas}} + 1/2*G_{\text{O}_2\text{gas}}) = 75,2864 + (2*91,26 + 3*85,6 + 1/2*303) = G_{\text{CH}_3\text{CH}_2\text{OH}} = 666,106 \text{ kJ/mol} ;$$

$$\Delta G^\circ_{\text{CRC}} + (2G_{\text{Cgraph}} + 3*G_{\text{H}_2\text{gas}} + 1/2*G_{\text{O}_2\text{gas}}) = -181 + (2*91,26 + 3*85,6 + 1/2*303) = G_{\text{CH}_3\text{CH}_2\text{OH}} = 409,82 \text{ kJ/mol} ;$$

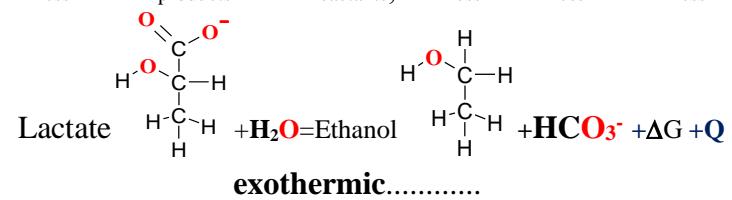
Substance	$\Delta H^\circ_{\text{H}}$ kJ/mol	$\Delta S^\circ_{\text{H}}$ J/mol/K	$\Delta G^\circ_{\text{H}}$ kJ/mol
$\text{H}_3\text{CCH(OH)COO}^-$	-688,29	-1290,852	-303,4256
$\text{H}_3\text{CCH(OH)COO}^-$	-686,2	-557,71	-313,70
$\text{H}_3\text{CCH}_2\text{OH}_{\text{aq}}$	-290,77	-1227,764	75,2864
$\text{H}_3\text{CCH}_2\text{OH}_{\text{l}}$	-277,6	160,7	62,96
H_2O	-285,85	69,9565	-237,191
H_2O	-286,65	-453,188	-151,549
HC_2O_3^-	-689,93	98,324	-586,94
HC_2O_3^-	-692,4948	-494,768	-544,9688

BioThermodynamics06; $G_{\text{H}_2\text{O}} \text{ Biochem} = 85,64 \text{ kJ/mol}$;

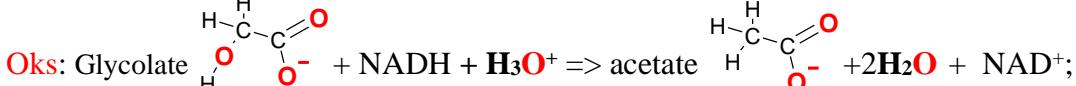
$$(G_{\text{H}_3\text{O}^+} + G_{\text{HCO}_3^-}) = 22,44 + 46,08 \text{ kJ/mol} ;$$

CRC 2010;

$$\Delta S_{\text{Hess}} = \sum \Delta S^\circ_{\text{products}} - \sum \Delta S^\circ_{\text{reactants}} ; \Delta G_{\text{Hess}} = \Delta H_{\text{Hess}} - T \cdot \Delta S_{\text{Hess}}$$

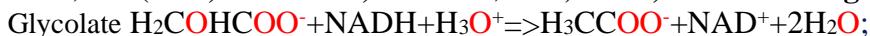


exothermic.....



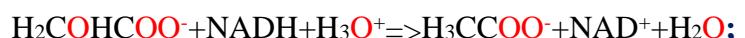
$$\Delta G_{\text{Hess}} = \Delta G^\circ_{\text{CH}_3\text{COO}} + \Delta G^\circ_{\text{NAD}^+} + 2\Delta G^\circ_{\text{H}_2\text{O}} - \Delta G^\circ_{\text{H}_2\text{COHCOO}} - \Delta G^\circ_{\text{NADH}} - \Delta G^\circ_{\text{H}_3\text{O}^+} = -161,8 \text{ kJ/mol};$$

$$= -240,963 + 1112,534 - 2 \cdot 237,191 - (-426,588 + 1175,5732 - 213,2746) = -161,8 \text{ kJ/mol exoergic.....}$$



$$\Delta G_{\text{eq}} = (E^\circ_{\text{Red}} - E^\circ_{\text{OxH}_2\text{COHCOO}}) * F * n = (-0,4095 - -0,033) * 96485 * 2 = (-0,38) * 96485 * 2 = -72,65 \text{ kJ/mol};$$

Substance	$\Delta H^\circ_{\text{Hess}}$ kJ/mol	$\Delta S^\circ_{\text{Hess}}$ J/mol/K	$\Delta G^\circ_{\text{Hess}}$ kJ/mol
Glyoxylate	-	-	-
OHCCOOH	-	-	-
OHCCOO^-	-	-	-426,588
$\text{H}_2\text{COHCOO}^-$	-	-	-403,2968
$\text{H}_2\text{COHCOOH}$	-651	318,6	-
$\text{NADH}_{(aq)}$	-1036,66	-140,5	-
$\text{NADH}_{(aq)}$	-1041,41	-4081,784	1175,5732
$\text{H}_3\text{O}^+_{(aq)}$	-285,81	-3,854	-213,2746
$\text{NAD}^+_{(aq)}$	-1007,48	-183	-
$\text{NAD}^+_{(aq)}$	-1010,3	-3766,008	1112,534
H_3CCOOH	-484,09	159,83	-531,743
H_3CCOO^-	-486,84	82,23	-247,83
H_3CCOO^-	-486	85,3	-240,963
H_2O	-285,85	69,9565	-237,191
H_2O	,65	-453,188	-151,549



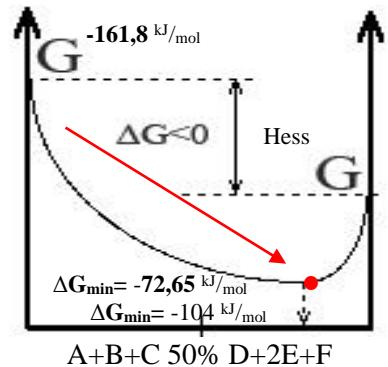
$$G_{\text{OHCCOOH}} = -426,588 + (2 \cdot 91,26 + 85,6 + 1,5 \cdot 303) = 296,032 \text{ kJ/mol}$$

$$G_{\text{OHCCOO}} = \Delta G_{\text{eq}} \text{OHCCOOH} - G_{\text{H}_3\text{O}^+} + (G_{\text{OHCCOOH}} + G_{\text{H}_2\text{O}}) = 305,6 \text{ kJ/mol}$$

$$G_{\text{OHCCOO}} = \Delta G_{\text{eq}} \text{OHCCOOH} - G_{\text{H}_3\text{O}^+} + (G_{\text{OHCCOOH}} + G_{\text{H}_2\text{O}}) = 414,3 \text{ kJ/mol}$$

$$G_{\text{H}_2\text{COHCOO}} = -403,2968 + (2 \cdot 91,26 + 2 \cdot 85,6 + 1,5 \cdot 303) = 404,9232 \text{ kJ/mol}$$

Exothermic, exoergic reduction Hess free energy change **-161,8** negative, but minimized reaching
 $\Delta G_{\text{min}} = \Delta G_{\text{eq}} = -72,65$ or **-104** kJ/mol equilibrium mixture.
 Le Chatelier principle is Prigogine attractor free energy change minimum ΔG_{min} reaching.



$$\Delta G_{\text{OHCCOOH}} = G_{\text{OHCCOOH}} - (2G_{\text{Cgraph}} + G_{\text{H}_2\text{gas}} + 1,5 \cdot G_{\text{O}_2\text{gas}}) = -426,588 \text{ kJ/mol};$$

$$G_{\text{OHCCOOH}} = -426,588 + (2 \cdot 91,26 + 85,6 + 1,5 \cdot 303) = 296,032 \text{ kJ/mol};$$

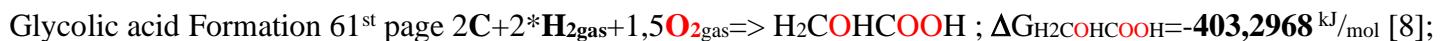


$$K_{\text{eq}} = [\text{OHCCOO}^-] * [\text{H}_3\text{O}^+] / [\text{OHCCOOH}] / [\text{H}_2\text{O}] = K_{\text{a}} / [\text{H}_2\text{O}] = 10^{(-3,32)} / 55,3 = 8,655 \cdot 10^{(-6)} = 10^{(-5,063)};$$

$$\Delta G_{\text{eq}} \text{OHCCOOH} = -R \cdot T \cdot \ln(K_{\text{eq}}) = -8,3144 \cdot 298,15 \cdot \ln(10^{(-5,063)}) / 1000 = 31,98 \text{ kJ/mol}.$$

$$\Delta G_{\text{eq}} \text{OHCCOOH} = G_{\text{OHCCOO}} + G_{\text{H}_3\text{O}^+} - (G_{\text{OHCCOOH}} + G_{\text{H}_2\text{O}}) = G_{\text{OHCCOO}} + 22,44 - (296,032 + 0) = 31,98 \text{ kJ/mol};$$

$$G_{\text{OHCCOO}} = \Delta G_{\text{eq}} \text{OHCCOOH} - G_{\text{H}_3\text{O}^+} + (G_{\text{OHCCOOH}} + G_{\text{H}_2\text{O}}) = 31,98 - 22,44 + (296,032 + 0) = 305,6 \text{ kJ/mol};$$



$$\Delta G_{\text{H}_2\text{COHCOO}} = G_{\text{H}_2\text{COHCOO}} - (2G_{\text{Cgraph}} + 2G_{\text{H}_2\text{gas}} + 1,5 \cdot G_{\text{O}_2\text{gas}}) = -403,2968 \text{ kJ/mol};$$

$$G_{\text{H}_2\text{COHCOO}} = -403,2968 + (2 \cdot 91,26 + 2 \cdot 85,6 + 1,5 \cdot 303) = 404,9232 \text{ kJ/mol};$$



$$K_{\text{eq}} = [\text{H}_2\text{COHCOO}^-] * [\text{H}_3\text{O}^+] / [\text{H}_2\text{COHCOO}^-] / [\text{H}_2\text{O}] = K_{\text{a}} / [\text{H}_2\text{O}] = 10^{(-3,83)} / 55,3 = 2,675 \cdot 10^{(-6)} = 10^{(-5,573)};$$

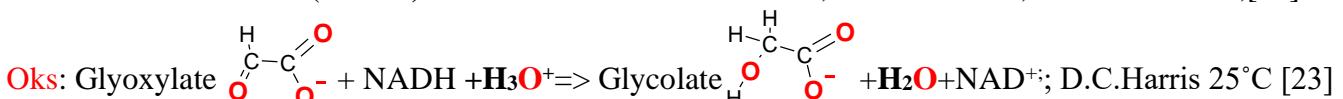
$$\Delta G_{\text{eq}} \text{OHCCOOH} = -R \cdot T \cdot \ln(K_{\text{eq}}) = -8,3144 \cdot 298,15 \cdot \ln(10^{(-5,573)}) / 1000 = 31,81 \text{ kJ/mol}.$$

$$\Delta G_{\text{eq}} \text{OHCCOOH} = G_{\text{OHCCOO}} + G_{\text{H}_3\text{O}^+} - (G_{\text{OHCCOOH}} + G_{\text{H}_2\text{O}}) = G_{\text{OHCCOO}} + 22,44 - (404,9232 + 0) = 31,81 \text{ kJ/mol};$$

$$G_{\text{OHCCOO}} = \Delta G_{\text{eq}} \text{OHCCOOH} - G_{\text{H}_3\text{O}^+} + (G_{\text{OHCCOOH}} + G_{\text{H}_2\text{O}}) = 31,81 - 22,44 + (404,9232 + 0) = 414,3 \text{ kJ/mol};$$

Nernst's half reaction glycolate + $\text{H}_2\text{O} = \text{Glyoxylate} + \text{H}^-(\text{H}^+ + 2\text{e}^-) + \text{H}_3\text{O}^+$; D.C.Harris 25°C [23]

Oks: $\text{OHCCOO}^- + \text{H}^-(\text{H}^+ + 2\text{e}^-) + \text{H}_3\text{O}^+ \Rightarrow \text{H}_2\text{COHCOO}^- + \text{H}_2\text{O}$; $E^\circ_{\text{H}_2\text{COHCOO}} = 0,1305$ V absolute; [23]



Nernst's half reaction Red: $\text{NADH} = \text{NAD}^+ + \text{H}^-(\text{H}^+ + 2\text{e}^-)$; $E^\circ_{\text{Red}} = -0,4095$ V David Harris absolute [22]

Glycolate $\text{OHCCOO}^- + \text{NADH} + \text{H}_3\text{O}^+ \Rightarrow \text{H}_2\text{COHCOO}^- + \text{NAD}^+ + \text{H}_2\text{O}$ Glycolate;

$$\Delta G_{\text{Hess}} = \Delta G^\circ_{\text{H}_2\text{COHCOO}} + \Delta G^\circ_{\text{NAD}^+} + \Delta G^\circ_{\text{H}_2\text{O}} - \Delta G^\circ_{\text{H}_2\text{COHCOO}} - \Delta G^\circ_{\text{NADH}} - \Delta G^\circ_{\text{H}_3\text{O}^+} = -63,66 \text{ kJ/mol};$$

$$= -403,2968 + 1112,534 - 237,191 - (-426,588 + 1175,5732 - 213,2746) = -63,66 \text{ kJ/mol exoergic.....};$$

$$\Delta G_{\text{min}} = \Delta G_{\text{eq}} = (E^\circ_{\text{eqNernst_NADH}} - E^\circ_{\text{H}_2\text{COHCOO}}) * F * n = (-0,4095 - 0,1305) * 96485 * 2 = (-0,54) * 96485 * 2 = -104,2 \text{ kJ/mol};$$

Nernst's potential $\text{O}_2\text{aqua}/\text{H}_2\text{O}$ red-ox system biochemical mechanism of acidosis and oxidative stress
(forced oxidizing agent power by potential E increase)

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

Water medium (blood plasma) oxygen is strong oxidant absolute potential $E^\circ \text{O}_2=1,0868$ V oxidized form free electrons reduced form by half reaction: $\text{O}_2\text{aqua}+4\text{H}_3\text{O}^++4\text{e}^-<=>\text{H}_2\text{O}$;

Free energy content is gas and water solubility product $G_{\text{O}_2\text{aqua}}=G_{\text{O}_2\text{gas}}+G_{\text{O}_2\text{sk}}=303.1+26.58=330$ kJ/mol ;

$\text{GH}_3\text{O}+\text{OH}=\text{GH}_3\text{O}++\text{GOH}=22.44+77.36=99.8$ kJ/mol of $\text{H}_2\text{O}+\text{H}_2\text{O}<=>\text{H}_3\text{O}^++\text{OH}$

Biochemistry oxygen O_2aqua decreases free energy content $G_{\text{O}_2\text{aqua}}=329.7$ kJ/mol to $G_{\text{O}_2\text{Biochemistry}}=78.08$ kJ/mol.

Concentration arterial $[\text{O}_2\text{aqua}]=6*10^{-5}$ M and pH=7.36 concentration $[\text{H}_3\text{O}^+]=10^{-7.36}$ M decrease potential:

$$E_{\text{O}_2}=E^\circ+0.0591/4\cdot\log([\text{O}_2\text{aqua}]\cdot[\text{H}_3\text{O}^+]^4/\text{[H}_2\text{O}]^6)=1.0868+0.0591/4\cdot\log(6*10^{-5})^4/10^{-7.36*4}/55.346^6)=0.4346$$
 V with

$$\text{difference } \Delta E_{\text{arterial}}=E^\circ-E_0=1.0865-0.4346=-0.652 \text{ V}; \Delta G_{\text{arterial}}=\Delta E_{\text{H}_2\text{O}}\cdot F\cdot n=-0.652\cdot 96485\cdot 4/1000=-251.6 \text{ kJ/mol.}$$

Solubility product value $\text{O}_2\text{gas AIR}+\text{H}_2\text{O}_{\text{Aquaporins}}>\text{O}_2\text{Blood}$ increases about $G_{\text{O}_2\text{sk}}=26.58$ kJ/mol:

$$\frac{[\text{O}_2\text{aqua}]}{[\text{O}_2\text{gas}]\cdot[\text{H}_2\text{O}]}=K_{\text{sk}}=2.205\cdot 10^{-5}. G_{\text{O}_2\text{sk}}=-R\cdot T\cdot \ln(K_{\text{sk}})=-8.3144\cdot 298.15\cdot \ln(2.205\cdot 10^{-5})=26.58 \text{ kJ/mol.}$$

Free energy protolysis decreases $G_{\text{O}_2\text{Biochem_arterial}}=G_{\text{O}_2\text{aqua}}+G_{\text{O}_2\text{sk}}+\Delta G_{\text{arterial}}=303.1+26.58-251.6=78.08$ kJ/mol and oxygen becomes fire safe biochemical oxidant, forming arterial concentration $[\text{O}_2\text{aqua}]=6*10^{-5}$ M as safe Bioenergetic sustaining normal isooxia. [3];

Oxygen solubility Prigogine attractor free energy change Hess law solution is exothermic and endoergic

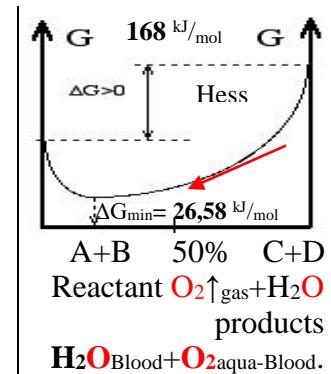
$\text{O}_2\text{air} + \text{H}_2\text{O} <=> \text{O}_2\text{aqua}$; $[\text{O}_2\text{air}]=0.2095$ oxygen mol fraction in air, in water $[\text{O}_2\text{aqua}]/[\text{H}_2\text{O}]$:

$$\Delta G_H=\Delta G^\circ \text{O}_2\text{aqua}-\Delta G^\circ \text{H}_2\text{O}-\Delta G^\circ \text{O}_2\text{gas}=16.4-(0-151.549)=168 \text{ kJ/mol endoergic};$$

$$\Delta G_{\text{sk}}=-R\cdot T\cdot \ln(K_{\text{sk}})=-8.3144\cdot 298.15\cdot \ln(2.205\cdot 10^{-5})=-8.3144\cdot 298.15\cdot 6.414=26.58 \text{ kJ/mol}$$

$[\text{O}_2]$ solubility Hess free energy change is positive $\Delta G_{\text{Hess}}=\Delta G_{\text{solubility}}=168$ kJ/mol , but minimized to $\Delta G_{\min}=\Delta G_{\text{sk}}=26.58$ kJ/mol reaching solubility product

$$\text{equilibrium mixture } K_{\text{sk}}=\frac{[\text{O}_2\text{aqua}]}{[\text{O}_2\text{air}]\cdot[\text{H}_2\text{O}]}=2.205\cdot 10^{-5}=10^{-4.66}.$$



Equilibrium reaching is Prigogine attractor free energy change minimum ΔG_{\min} .

Free energy change minimum ΔG_{\min} reaching establishes equilibrium. [53rd page.](#)

Zero osmolar $C_{\text{osm}}=0$ M and ionic force $I=0$ M in distilled water from air 20.95% solubility is:

$$[\text{O}_2\text{water}]=K_{\text{sk}}\cdot [\text{O}_2\text{air}]\cdot [\text{H}_2\text{O}]=2.205\cdot 10^{-5}\cdot 0.2095\cdot 55.3=2.5567\cdot 10^{-4} \text{ M.}$$

ELSEVIER, Rotating Electrode Method and Oxygen reduction Electrocatalysts, 2014, p.1-31,

1. WeiXinga, MinYinb, QingLvb, YangHub, ChangpengLiub, JiujunZhangc. Pure 1atm mol fraction $[\text{O}_2\text{gas}]=1$.

Osmolar $C_{\text{osm}}=0.305$ M, ionic force $I=0.25$ M, air oxygen 20.95% conditions dissolute $[\text{O}_2\text{aqua}]=9.768\cdot 10^{-5}$ M.

Therefore physiologic equilibrium constant is $K_{\text{O}_2\text{blood}}=[\text{O}_2\text{aqua}]/[\text{O}_2\text{air}]=9.768\cdot 10^{-5}/0.2095=4.663\cdot 10^{-4}=10^{-3.3314}$.

Arterial $[\text{O}_2\text{aqua}]=6\cdot 10^{-5}$ M versus venous $[\text{O}_2\text{aqua}]=0.426\cdot 10^{-5}$ M determines $pK_{\text{O}_2\text{Arterial}}=3.3314$. Oxygen molecules cross through aquaporins membranes against gradient of osmolar concentration.

Ox: $\text{O}_2\text{aqua}+4\text{H}_3\text{O}^++4\text{e}^-<=>6\text{H}_2\text{O}$; $E^\circ \text{O}_2=1.0865$ Volts; Red: $4\text{H}(\text{Pt})+4\text{H}_2\text{O}<=>4\text{H}_3\text{O}^++4\text{e}^-$; $E^\circ \text{H}=-0.2965$ V.

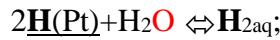
$$\text{O}_2\text{aqua}+4\text{H}(\text{Pt})=2\text{H}_2\text{O}; \Delta G_{\text{eq}}=(E^\circ \text{H}-E^\circ \text{O}_2)\cdot F\cdot 1\cdot 4=(-0.2965-1.0865)\cdot 96485\cdot 4=-1,383\cdot 96485\cdot 4/1000=-533,9 \text{ kJ/mol};$$

Equilibrium value $\Delta G_{\text{eq}2\text{H}_2\text{O}}=2G_{\text{H}_2\text{O}}-4G_{\text{H}(\text{Pt})}-G_{\text{O}_2\text{aqua}}=2\cdot 0-(4\cdot G_{\text{H}(\text{Pt})}+330)=-533,9=2\cdot 266,9$ kJ/mol expresses metal free energy $G_{\text{H}(\text{Pt})}=(2G_{\text{H}_2\text{O}}-\Delta G_{\text{eq}2\text{H}_2\text{O}}-G_{\text{O}_2\text{aqua}})/4=(2\cdot 0+533,9-330)/4=204,2/4=51,05$ kJ/mol .



$\Delta G_{\text{Hess}_{\text{H}_3\text{O}^+}} = \text{G}_{\text{H}_2\text{aq}} + 2\text{G}_{\text{H}_2\text{O}} - (\text{G}_{\text{H}_3\text{O}^+} + \text{G}_{\text{H}_2\text{O}}) = 103,24 + 2 \cdot 0 - (2 \cdot 22,44 - 2 \cdot 0) = 58,36 \text{ kJ/mol}$; and graphite electrode absolute potential $E^\circ_{\text{H}_3\text{O}^+} = 58360/96485/2 = 0,302 \text{ V}$ oxidizes hydrogen and liberate (Pt) lattice.

Red: $2\text{H(Pt)} + 2\text{H}_2\text{O} \rightleftharpoons 2\text{H}_3\text{O}^+ + 2\text{e}^-$; $E^\circ_{\text{H}^+} = -0,2965 \text{ V}$; **Ox+Red summary** $2\text{H(Pt)} + \text{H}_2\text{O} \rightleftharpoons \text{H}_{2\text{aq}}$;



$$\Delta E^\circ_{\text{eqH}_3\text{O}^+\text{H(Pt)}} = -0,2965 - 0,302 = -0,5985 \text{ V}; \Delta G_{\text{eqH}_3\text{O}^+\text{H(Pt)}} = \Delta E^\circ_{\text{eqH}_3\text{O}^+\text{H(Pt)}} \cdot F \cdot 2 = -0,5985 \cdot 96485 \cdot 2 = -115,5 \text{ kJ/mol};$$

$$\Delta G_{\text{eqH}_3\text{O}^+\text{H(Pt)}} = \text{G}_{\text{H}_2\text{aq}} + \text{G}_{\text{H}_2\text{O}} - 2\text{G}_{\text{H(Pt)}} = 103,24 + 0 - 2 \cdot 51,05 = 1,14 \text{ kJ/mol}.$$

$$\Delta G_{\text{eqH}_3\text{O}^+\text{H(Pt)}} = \text{G}_{\text{H}_2\text{aq}} + \text{G}_{\text{H}_2\text{O_Biochem}} - 2\text{G}_{\text{H(Pt)}} = 103,24 + 85,6 - 2 \cdot 51,05 = 86,74 \text{ kJ/mol}.$$

Platinum crystal lattice is indifferent referring to zero free energy for $\text{G}_{\text{H}_2\text{O}} = \text{G}_{\text{CO}_2\text{gas}} = \text{G}_{\text{e}} = 0 \text{ kJ/mol}$,

Reduction of sulfur Ox: $\text{S}_{\text{rombisks}} + 2\text{H}_3\text{O}^+ + 2\text{e}^- = \text{H}_2\text{S}_{\text{aq}} + 2\text{H}_2\text{O}$; $E^\circ_{\text{S}} = -0,0515 \text{ V}$;



$$\Delta G_{\text{eq}} = (E^\circ_{\text{H}} - E^\circ_{\text{S}}) \cdot F \cdot 1 \cdot 2 = (-0,2965 - (-0,0515)) \cdot 96485 \cdot 2 = -0,245 \cdot 96485 \cdot 2 / 1000 = -47,3 \text{ kJ/mol};$$

$$\text{G}_{\text{H}_2\text{S}_{\text{aq}}\text{uqq}} = \Delta G_{\text{HessH}_2\text{S}} + (2\text{G}_{\text{H(Pt)}} + \text{G}_{\text{S}_{\text{rombisks}}}) = -47,3 + (2 \cdot -219 - 85,64) = -571 \text{ kJ/mol}.$$

Abstrakts.

Uz Alberti bāzēts absolūtās brīvās enerģijas saturs $\text{G}_{\text{H}_2\text{gas}} = 85,6 \text{ kJ/mol}$ gāzei, $\text{G}_{\text{H}_2\text{aqua}} = 103 \text{ kJ/mol}$ ūdenim un $\text{G}_{\text{H(Pt)}} = 51 \text{ kJ/mol}$ metālam ūdeņradim pie nulles atskaites $\text{G}_{\text{H}_2\text{O}} = \text{G}_{\text{CO}_2\text{gas}} = 0 \text{ kJ/mol}$ fona enerģijas ūdenim un oglekļa dioksīda CO_2gas gāzei. [8,15] Metāla ūdeņraža nulles klasiskā standarta potenciāla atskaitē tiek izmantota tā hidroksonija katjona $[\text{H}_3\text{O}^+] = 1,01 \text{ M}$ koncentrācija sērskābes $[\text{H}_2\text{SO}_4] = 1 \text{ M}$ šķīdumā ar blīvumu $1,061 \text{ g/mL}$. Kopš 1920. gada Nernsta Nobela prēmijas ķīmijā saņemšanas visas elektroķīmijas sērijas reducētāju oksidēšanas pusreakciju standarta potenciāli ir noteikti attiecībā pret ūdeņraža metāla pusreakcijas klasisko standarta potenciālu E°_{H} nulle. [1,15] Skābekļa, oglekļa dioksīda un ūdens protolīzes funkcionālās aktivitātes kvantitatīvie pētījumi atklāj ģenerētus daudzveidīgus Dzīvības pašorganizējošus atraktorus: ūdens $[\text{H}_2\text{O}] = 55,3 \text{ mol/Litrā}$ koncentrāciju, $\text{pH} = 7,36$, enzīma karbo anhidrāzes (CA) reaktivitāte, gaisa skābekļa līmenis $20,95 \%$, osmolārā koncentrācija $0,305 \text{ M}$, jonu spēks $0,25 \text{ M}$, temperatūra $310,15 \text{ K}$ grādi utt. . [1,15]

Liela ātruma protolīze ūdenī padara skābekli ugunsdrošu, CA funkcionāli aktivizē oglekļa dioksīdu, reāgējot ar divām ūdens molekulām, veidojot $\text{H}_3\text{O}^+ + \text{HCO}_3^-$ koncentrācijas gradientus abpus membrānei osmozei pretēji koncentrācijas gradientiem bet protonu un bikarbonāta jonu transportēšanai lejup cauri protonu un bikarbonātu jonu kanāliem.

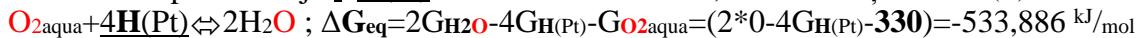
Iepriekšējās publikācijas atklāj neaizstājamu ūdens un hidroksonija uzskaiti līdzsvara reakciju termodinamiskajās izpausmēs, ieskaitot protolīzi un elektroķīmijas Nernsta pusreakcijas. [8,14,15] Pētījumi sasniedz metāla ūdeņraža termodinamiskā standarta potenciāla atsauces vērtību $0,10166 \text{ Volti}$. Alberty vārdā sniegtie dati par ūdeņraža brīvo enerģiju $\text{G}_{\text{H}_2\text{gas}} = 85,6 \text{ kJ/mol}$, $\text{G}_{\text{H}_2\text{aqua}} = 103 \text{ kJ/mol}$ ir atklājies **absolūtais** standarta **potenciāls** $E^\circ_{\text{H}} = -0,2965 \text{ Volts}$ kā elektroda termodinamiskā atskaites vērtība ar absolūtās brīvās enerģijas izmaiņas vērtību $\Delta G_{\text{eq}} = -28,6 \text{ kJ/mol}$.

Atslēgas vārdi: Fizikālā ķīmija; Elektroķīmija; Termodinamika; Atraktori; Biokīmija.

Nernsta absolūtā potenciāla $\text{O}_2\text{aqua} / \text{H}_2\text{O} | \text{H}(\text{Pt}) / \text{H}_3\text{O}^+$ un $\text{H}_2\text{O}_2 / \text{H}_2\text{O} | \text{H}_2\text{O}_2 / \text{O}_2$ studijas

Ox oksidanta reaktanta pus reakcija: $\text{O}_2\text{aqua} + 4\text{H}_3\text{O}^+ + 4e^- \rightleftharpoons 6 \text{H}_2\text{O}$; $G_{\text{O}_2\text{aqua}}=330 \text{ kJ/mol}$; $E^\circ_{\text{O}_2}=0,9851 \text{ V}$:

Red reduktanta reaktanta pus reakcija: $4\text{H}(\text{Pt}) + 4\text{H}_2\text{O} \rightleftharpoons 4 \text{H}_3\text{O}^+ + 4e^-$; metāls ūdeņradis $G_{\text{H}(\text{Pt})}=51.05 \text{ kJ/mol}$:



$$E_{\text{O}_2} = E^\circ_{\text{O}_2} + 0.0591/4 \cdot \lg([O_2\text{aqua}] * [H_3O^+]^4 / [H_2O]^6) = 1,0868 + 0.0591/4 \cdot \log([O_2\text{aqua}] * [H_3O^+]^4 / [H_2O]^6);$$

$$E_{\text{H}} = E^\circ_{\text{H}} + 0.0591 \cdot \lg([H_3O^+] / [H_2O]) = -0.2965 \text{ V} + 0.0591 \cdot \lg([H_3O^+] / [H_2O]); E^\circ_{\text{H}} = -0.2965 \text{ V}.$$



Ūdeņraža Alberts R.A. Biochemical Thermodynamic's 1-463. (2006). brīvā enerģija $G_{\text{H}_2\text{aqua}}=103 \text{ kJ/mol}$

Vielas	$\Delta H^\circ_{\text{H}}$, kJ/mol	$\Delta S^\circ_{\text{H}}$, J/mol/K	$\Delta G^\circ_{\text{H}}$, 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
$\text{H}_2(\text{aq})$	23.4	-130	99.13
O_2aqua	-11.70	-94.2	16.4
O_2aqua	-11.715	110.876	16.4

$$\Delta G_{\text{eqOxRed}} = (E^\circ_{\text{H}} - E^\circ_{\text{O}_2}) \cdot F \cdot 1 \cdot 4 = (-0.2965 - 1,0868) \cdot 96485 \cdot 4 = -1,383 \cdot 96485 \cdot 4 / 1000 = -533,9 = 2*-266,9 \text{ kJ/mol};$$

$$K_{\text{eq}2\text{H}_2\text{O}} = \exp(-\Delta G_{\text{OxRed}} / R/T) = \exp(533870,8 / 8.3144 / 298,15) = \exp(215,363) = 10^{93,53}$$

$$G_{\text{H}(\text{Pt})} = (2G_{\text{H}_2\text{O}} - \Delta G_{\text{eq}2\text{H}_2\text{O}} - G_{\text{O}_2\text{aqua}}) / 4 = (2*0 + 533,871 - 330) / 4 = 204,2 / 4 = 51,05 \text{ kJ/mol}$$

Eksotermiska un eksoergiska O_2aqua reducēšana ar metālisku ūdeņradi $4\text{H}(\text{Pt})$

un H_2O_2 dismuntācijas Hesa brīvās enerģijas izmaiņa negatīva

$$\Delta G_{\text{Hess}2\text{H}_2\text{O}} = -347,5 \text{ kJ/mol}, \Delta G_{\text{Hess}_{\text{H}_2\text{O}_2}} = -242,5 \text{ kJ/mol}, \text{ bet minimizējas}$$

sasniedzot līdzsvara $\Delta G_{\text{eq}2\text{H}_2\text{O}} = -247 \text{ kJ/mol}$ and $\Delta G_{\text{eqStandart}} = -238,5 \text{ kJ/mol}$

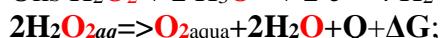
maisījuma konstantes $K_{\text{eq}2\text{H}_2\text{O}} = 10^{86,65}$ un $K_{\text{eqStandart}} = 10^{38,35}$.

Minimums ΔG_{\min} ir Prigožina atraktors. Brīvās enerģijas izmaiņas minima sasniegšanā iestājas līdzsvara stāvoklis.

Absolūtā potenciālu skalā Nernsta pus reakciju standarta potenciāli ir:

$$\text{Red } \text{H}_2\text{O}_2 + 2 \text{H}_2\text{O} - 2 e^- \rightarrow \text{O}_2\text{aqua} + 2 \text{H}_3\text{O}^+; E^\circ_{\text{H}_2\text{O}_2} = 0,4495 \text{ V} \text{ Alberta University};$$

$$\text{Oks } \text{H}_2\text{O}_2 + 2 \text{H}_3\text{O}^+ + 2 e^- = 4 \text{H}_2\text{O}; E^\circ_{\text{Ox}} = 1,6855 \text{ V} \text{ Suhotina};$$



Reaktanti $4\text{H}(\text{Pt}) + \text{O}_2\text{aqua}$ un produkti $2\text{H}_2\text{O}$

Reaktanti $2\text{H}_2\text{O}_{2\text{aq}}$ un produkti $\text{O}_2\text{aqua} + 2\text{H}_2\text{O}$

$$\Delta G_{\text{Hess}} = \text{G}_{\text{O}_2\text{aqua}} + 2G_{\text{H}_2\text{O}} - 2G_{\text{H}_2\text{O}_2} = 16,4 + 2*-151,549 - 2*-134 = -18,7 \text{ kJ/mol};$$

$$\Delta G_{\text{HessCRC}} = \text{G}_{\text{O}_2\text{aqua}} + 2G_{\text{H}_2\text{O}} - 2G_{\text{H}_2\text{O}_2} = 16,4 + 2*-237,19 - 2*-134 = -189,98 \text{ kJ/mol};$$

$$\Delta G_{\text{eqStandart}} = (E_{\text{Red}} - E_{\text{Ox}}) \cdot F \cdot n = (0,4495 - 1,6855) \cdot 96485 \cdot 2 = (-1,24) \cdot 96485 \cdot 2 = -238,5 \text{ kJ/mol};$$

$$\Delta G_{\text{AlbertyStandart}} = \text{G}_{\text{O}_2\text{Biochem}} + 2G_{\text{H}_2\text{O}_{\text{BioChemistry}}} - 2G_{\text{H}_2\text{O}_2} = 78,08 + 2*85,64 - 2*284,25 = -238,5 \text{ kJ/mol}; \text{ Alberty}$$

$$2G_{\text{H}_2\text{O}_2} = \text{G}_{\text{O}_2\text{aqua}} + 2G_{\text{H}_2\text{O}} + \Delta G_{\text{AlbertyStandart}} = 330 + 2*0 + 218,9 = 2*284,25 = 548,9 \text{ kJ/mol};$$

$$K_{\text{eqStandart}} = \frac{[\text{O}_2]_{\text{aqua}} \cdot [\text{H}_2\text{O}]^2}{[\text{H}_2\text{O}_2]_{\text{aqua}}^2} = K_{\text{H}_2\text{O}_2} = \exp(-\Delta G_{\text{eq}} / R/T) = \exp(238510 / 8.3144 / 298.15) = 10^{41,75} \dots$$

$$\text{Red: } E_{\text{O}_2\text{H}_2\text{O}_2} = E^\circ_{\text{H}_2\text{O}_2} + 0.0591 / 2 \cdot \lg(O_2\text{aqua}) * [H_3O^+]^2 / [H_2O_2]^2 = 0.4495 + 0.0591 / 2 \cdot \lg(6 \cdot 10^{-5} \cdot 10^{-7.36 \cdot 2} / 1 / 55.3^2) = -0.213 \text{ V}$$

$$\text{Ox: } E_{\text{Ox}} = E^\circ_{\text{H}_2\text{O}_2\text{Ox}} + 0.0591 / 2 \cdot \log([H_2O_2] * [H_3O^+]^2 / [H_2O]^4) = 1,6855 + 0.0591 / 2 \cdot \log(1 \cdot 10^{-7.36 \cdot 2} / 55.3^4) = 1,0445 \text{ V}$$

$$\text{Homeostāze: } \Delta G_{\text{eqBioChem}} = (E_{\text{Red}} - E_{\text{Ox}}) \cdot F \cdot n = (-0.2132 - 1,0445) \cdot 96485 \cdot 2 = (-1,258) \cdot 96485 \cdot 2 = -242,7 \text{ kJ/mol};$$

$$1. \Delta H_{\text{Hess}} = \Delta H^\circ_{\text{O}_2} + 2\Delta H^\circ_{\text{H}_2\text{O}} - 2\Delta H^\circ_{\text{H}_2\text{O}_2} = -11.7 - 2*286.65 - (2*-191.99) = -201.02 \text{ kJ/mol} = -11.7 - 2*285.85 - (2*-191.17) = -201.06 \text{ kJ/mol}$$

$$2. \Delta S_{\text{izklides}} = -\Delta H_{\text{H}} / T = -(-201.02) / 298.15 = 674.2 \text{ J/mol/K}; \Delta S_{\text{izklides}} = -\Delta H_{\text{H}} / T = -(-201.06) / 298.15 = 674.36 \text{ J/mol/K};$$

$$\Delta S_{\text{Hess}} = \Delta S^\circ_{\text{O}_2} + 2\Delta S^\circ_{\text{H}_2\text{O}} - 2\Delta S^\circ_{\text{H}_2\text{O}_2} = -94.2 + 2*-453.188 - (2*-481.688) = -37.2 \text{ J/mol/K};$$

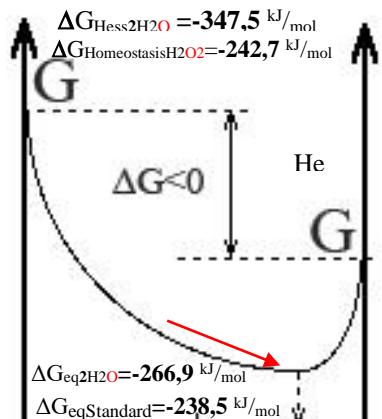
$$\Delta S_{\text{Hess}} = \Delta S^\circ_{\text{O}_2} + 2\Delta S^\circ_{\text{H}_2\text{O}} - 2\Delta S^\circ_{\text{H}_2\text{O}_2} = 110.876 + 2*69.9565 - (2*143.9) = -37 \text{ J/mol/K};$$

$$2. \Delta S_{\text{kopējs}} = \Delta S_{\text{H}} + \Delta S_{\text{izklides}} = -37.2 + 674.2 = 637 \text{ J/mol/K} \Delta S_{\text{kopējs}} = -37.011 + 674.36 = 637.35 \text{ J/mol/K};$$

$$4. \Delta G_{\text{Hess}} = \Delta H_{\text{H}} - T \cdot \Delta S_{\text{H}} = -201.02 - 298.15 * -0.0372 = -189.9 \text{ kJ/mol exoergic patvalīga.}$$

$$\Delta G_{\text{Hess}} = \Delta H_{\text{H}} - T \cdot \Delta S_{\text{H}} = -201.06 - 298.15 * -0.037 = -190 \text{ kJ/mol};$$

$$T \cdot \Delta S_{\text{kopējs}} = 0.637 * 298.15 = 189.9 \text{ kJ/mol}; T \cdot \Delta S_{\text{kopējs}} = 0.63735 * 298.15 = 190 \text{ kJ/mol};$$



Nernst's potential studies reducing with vitamin B₃ ethanal H₃CCH=O and oxidising H₃CCH₂OH ethanol



$$\Delta G_{\text{Hess}} = \Delta G^{\circ}_{\text{H}_3\text{O}^+} + \Delta G^{\circ}_{\text{CH}_3\text{CHO}} + \Delta G^{\circ}_{\text{NADH}} - \Delta G^{\circ}_{\text{CH}_3\text{CH}_2\text{OH}} - \Delta G^{\circ}_{\text{H}_2\text{O}} - \Delta G^{\circ}_{\text{NAD}^+} = 159.1 \text{ kJ/mol}$$

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

$$\Delta G_{\text{Hess Albery}} = \text{GNADH} + \text{GH}_3\text{O}^+ + \text{GCH}_3\text{CHO} - (\text{GNAD}^+ + \text{GCH}_3\text{CH}_2\text{OH} + \text{GH}_2\text{O}) = 68.02 \text{ kJ/mol;} \\ = 1112.534 + 22.44 + 32.282 - (1175.5 + 75.2864 - 151.549) = 68.02 \text{ kJ/mol.}$$

Ox NAD⁺+H·(2e⁻)<=>NADH ; absolute potential E°_{NADH}=-0,4095 V; David Harris; [22]

Red CH₃CH₂OH+2H₂O<=>CH₃CHO+2H₃O⁺+H·(2e⁻); absolute potential E°_{CH₃CH₂OH}=-0,055 V; [19]

By convention balanced n = 2 = m number of electrons 2e⁻ΔE° is expressed as E°²H₂O of the electron **donor** minus E°¹ of the electron **acceptor**. Because NAD⁺ is **accepting** electrons from **ethanol**:

$$\Delta G_{\min} = \Delta G_{\text{eq}} = (E^{\circ}_{\text{eq Nernst}} \text{CH}_3\text{CH}_2\text{OH} - E^{\circ}_{\text{NAD}^+}) * F * n = (-0,055 + 0,4095) * 96485 * 2 = (0,3545) * 96485 * 2 = 68,408 \text{ kJ/mol};$$

$$\Delta G_{\text{eq}} = -R \cdot T \cdot \ln(K_{\text{eq}}); K_{\text{eq}} = \frac{[\text{NADH}] \cdot [\text{CH}_3\text{CHO}] \cdot [\text{H}_3\text{O}^+]}{[\text{NAD}^+] \cdot [\text{CH}_3\text{CH}_2\text{OH}] \cdot [\text{H}_2\text{O}]} = e^{-\frac{\Delta G_{\text{eq}}}{R \cdot T}} = e^{-\frac{68408}{8.314 \cdot 298.15}} = 1.036 \cdot 10^{-12} = 10^{-11.985}$$

Anaerobic [NADH]/[NAD⁺]=10; H₃C-CH₂-OH+NAD⁺+H₂O+ΔG+Q=>H₃C-CH=O+NADH+H₃O⁺;

$$\Delta G_{\text{Hess}} = \Delta G^{\circ}_{\text{CH}_3\text{CH}_2\text{OH}} + \Delta G^{\circ}_{\text{H}_2\text{O}} + \Delta G^{\circ}_{\text{NAD}^+} - \Delta G^{\circ}_{\text{H}_3\text{O}^+} - \Delta G^{\circ}_{\text{CH}_3\text{CHO}} - \Delta G^{\circ}_{\text{NADH}} = -159.1 \text{ kJ/mol};$$

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

$$\Delta G_{\text{Hess Albery}} = \text{GNADH} + \text{GH}_3\text{O}^+ + \text{GCH}_3\text{CHO} - (\text{GNAD}^+ + \text{GCH}_3\text{CH}_2\text{OH} + \text{GH}_2\text{O}) = -68.02 \text{ kJ/mol;} \\ = 1175.5 + 75.2864 - 151.549 - (1112.534 + 22.44 + 32.282) = -68.02 \text{ kJ/mol.}$$

Red NADH <=> NAD⁺ + H·(2e⁻); absolute potential E°_{NADH}=-0,4095 V; David Harris; [22];

Ox CH₃CHO+2H₃O⁺+H·(2e⁻)<=>CH₃CH₂OH+2H₂O; absolute potential E°_{CH₃CHO}=-0,055 V; [19].

By convention balanced n=2=m number of electrons 2e⁻ΔE° is expressed as E°¹ of the electron **donor** minus E°²H₂O of the electron **acceptor**. Because CH₃CHO is **accepting** electrons from NADH in our example

$$\Delta G_{\min} = \Delta G_{\text{eq}} = (E^{\circ}_{\text{NAD}^+} - E^{\circ}_{\text{eq Nernst}} \text{CH}_3\text{CH}_2\text{OH}) * F * n = (-0,4095 + 0,055) * 96485 * 2 = (-0,3545) * 96485 * 2 = -68,408 \text{ kJ/mol};$$

$$\Delta G_{\text{eq}} = -R \cdot T \cdot \ln(K_{\text{eq}}) = -68,408 \text{ kJ/mol}; K_{\text{eq}} = \frac{[\text{NAD}^+] \cdot [\text{CH}_3\text{CH}_2\text{OH}] \cdot [\text{H}_2\text{O}]}{[\text{NADH}] \cdot [\text{CH}_3\text{CHO}] \cdot [\text{H}_3\text{O}^+]} = e^{-\frac{\Delta G_{\text{eq}}}{R \cdot T}} = e^{-\frac{-68408}{8.314 \cdot 298.15}} = 9.65 \cdot 10^{11} = 10^{11.985}.$$

In aerobic organisms NADH oxidase with O₂_{aqua} perform ratio [NAD⁺]/[NADH]=10⁶:

$$\Delta G_{\text{Homeostases}} = 68.408 + R \cdot T \cdot \ln(10^6 * 1 / 10^{-7.36} / 55.3) = 68.408 - 86.2 = -17.8 \text{ kJ/mol.}$$

$$[\text{NAD}^+] / [\text{NADH}] = 10^3; \Delta G_{\text{Homeostases}} = 68.408 - 69.08 = -0.676 \text{ kJ/mol.}$$

Equilibrium is shifted far to **reactants** as aerobic constant K_{eq}=10^{-11.985} and inverse anaerobic constant K_{eq}=10^{11.985}. Aerobic endothermic and endoergic vitamin B₃ ethanol oxidation Hess law free energy change positive ΔG_{Hess}=159.....kJ/mol and inverse

ethanal anaerobic reduction negative ΔG_{Hess}=-159.....kJ/mol, but minimises reaching equilibrium aerobic ΔG_{min}=ΔG_{eq}=68.4.....kJ/mol and anaerobic

$$\Delta G_{\min} = \Delta G_{\text{eq}} = -68.4 \text{ kJ/mol reaching equilibrium mixture}$$

$$\text{constants } 10^{-11.985} = K_{\text{eq}} \text{ aerobic and anaerobic } 10^{11.985} = K_{\text{eq}}.$$

Prigogine attractor is free energy change absolute minimum ΔG_{min} reaching

$$\text{equilibrium } \Delta G_{\min} = 68.4 \text{ kJ/mol} = |\Delta G_{\text{eq}}| < |\Delta G_{\text{Hess}}| = 159 \text{ kJ/mol.}$$

Anaerobic H₃C-CH=O+NADH+H₃O⁺>H₃C-CH₂-OH+NAD⁺+H₂O+ΔG+Q;

Anaerobic ΔG_{eq}=ΔE°·F·n=-0,3545 V·2 mol·96485 C/mol=-68.408.....kJ/mol favored.

Insufficient low O₂_{aqua} concentration hypoxia to anaerobic alcohol oxidation unflavored but ethanal reduction to ethanol favored [H₃CCH₂OH]/[H₃CCH=O]=1/10

Homeostases reduction with NADH reductase enzyme as negative free energy change

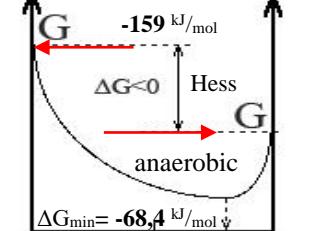
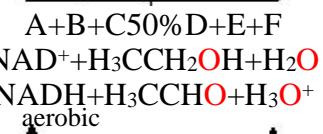
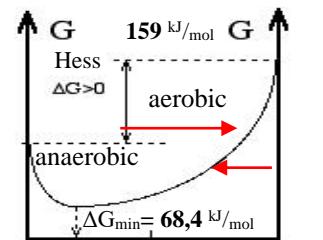
$$\Delta G_{\text{Homeostases}} = -27.86 \text{ kJ/mol}$$

Anaerobic Homeostases ratio [NADH]/[NAD⁺]=10 over [NAD⁺] favors reduction:

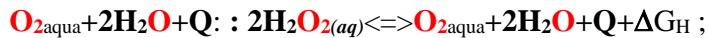
$$\Delta G_{\text{Homeostases}} = -68.41 + 8.3144 * 298.15 * \ln(K_{\text{Homeostases}}) = -68.41 + 40.54 = -27.86 \text{ kJ/mol}$$

$$\Delta G_{\text{Homeostases}} = -68.41 + 8.3144 * 298.15 * \ln\left(\frac{1}{10} \frac{1}{10} \frac{55.333}{10^{-7.36}}\right) = -27.86 \text{ kJ/mol; } K_{\text{Homeostases}} = \frac{[\text{NAD}^+] \cdot [\text{CH}_3\text{CH}_2\text{OH}] \cdot [\text{H}_2\text{O}]}{[\text{NADH}] \cdot [\text{CH}_3\text{CHO}] \cdot [\text{H}_3\text{O}^+]}$$

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



Liela ātruma protolīzes peroksīda anjonu $\text{H}^+ + \text{HO}_2 \rightleftharpoons \text{OOH} + \text{H}^+$ sadursmes aktivācijas energija ir $E_a = 79000 \text{ J/mol}$ pretēji $\text{HO}_2 \rightarrow \text{Fe}^{3+}$ sadursmais aktivācijas energija $E_a = 29 \text{ J/mol}$ ir neliela, producējot $\omega = 6$, $\omega = 3$ taukskābes,



$$\Delta G_{\text{Hess}} = \Delta G^\circ_{\text{O}_2} + 2\Delta G^\circ_{\text{H}_2\text{O}} - 2\Delta G^\circ_{\text{H}_2\text{O}_2} = 16.40 + 2*(-237.191) - (2*-134.03) = -189.9 \text{ kJ/mol eksoerģiska}$$

$$\Delta G_{\text{HessAlberty}} = \Delta G^\circ_{\text{O}_2} + 2\Delta G^\circ_{\text{H}_2\text{O}} - 2\Delta G^\circ_{\text{H}_2\text{O}_2} = 303.1 + 2*(0) - (2*364.79) = -426.5/2 \text{ kJ/mol} = -213.25 \text{ kJ/mol eksoerģiska}$$

Vielas	$\Delta H^\circ_{\text{H}_2}, \text{kJ/mol}$	$\Delta S^\circ_{\text{H}_2}, \text{J/mol/K}$	$\Delta G^\circ_{\text{H}_2}, \text{kJ/mol}$
H_3O^+	-285.81	-3.854	-213.275
$\text{O}_{2\text{aqua}}$	-11.715	110.876	16.4
$\text{O}_{2\text{aqua}}$	-11.70	-94.2	16.40
H_2O	-285.85	69.9565	-237.191
H_2O	-286.65	-453.188	-151.549
$\text{H}_2\text{O}_{2(aq)}$	-191.99	-481.688	-48.39
$\text{H}_2\text{O}_{2(aq)}$	-191.17	143.9	-134.03
H_2O_2	-237.129	69.91	-237.129

Miščenko 1968, Himia, Leningrad

CRC 2010;

$$\Delta H_{\text{Hess}} = \Delta H^\circ_{\text{O}_2} + 2\Delta H^\circ_{\text{H}_2\text{O}} - 2\Delta H^\circ_{\text{H}_2\text{O}_2} = -201.02 \text{ kJ/mol}$$

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

$$= -11.7 - 2*285.85 - (2*-191.17) = -201.06 \text{ kJ/mol}$$

BiochemThermodynamic 2006 Masachusets Technology institute University Alberta 1997.

$$2. \Delta S_{\text{izklides}} = -\Delta H_{\text{H}}/T = -(-201.02)/298.15 = 674.2 \text{ J/mol/K} ; \Delta S_{\text{izklides}} = -\Delta H_{\text{H}}/T = -(-201.06)/298.15 = 674.36 \text{ J/mol/K} ;$$

$$\Delta S_{\text{Hess}} = \Delta S^\circ_{\text{O}_2} + 2\Delta S^\circ_{\text{H}_2\text{O}} - 2\Delta S^\circ_{\text{H}_2\text{O}_2} = -94.2 + 2*(-453.188) = -37.2 \text{ J/mol/K} ;$$

$$\Delta S_{\text{Hess}} = \Delta S^\circ_{\text{O}_2} + 2\Delta S^\circ_{\text{H}_2\text{O}} - 2\Delta S^\circ_{\text{H}_2\text{O}_2} = 110.876 + 2*69.9565 - (2*143.9) = -37 \text{ J/mol/K} ;$$

$$2. \Delta S_{\text{kopējs}} = \Delta S_{\text{H}} + \Delta S_{\text{izklides}} = -37.2 + 674.2 = 637 \text{ J/mol/K} \Delta S_{\text{kopējs}} = -37.011 + 674.36 = 637.35 \text{ J/mol/K} ;$$

$$4. \Delta G_{\text{Hess}} = \Delta H_{\text{H}} - T * \Delta S_{\text{H}} = -201.02 - 298.15 * -0.0372 = -189.9 \text{ kJ/mol eksoerģiska patvalīga.....}$$

$$\Delta G_{\text{Hess}} = \Delta H_{\text{H}} - T * \Delta S_{\text{H}} = -201.06 - 298.15 * -0.037 = -190 \text{ kJ/mol} ;$$

$$T * \Delta S_{\text{kopējs}} = 0.637 * 298.15 = 189.9 \text{ kJ/mol} ; T * \Delta S_{\text{kopējs}} = 0.63735 * 298.15 = 190 \text{ kJ/mol} ;$$

$[\text{H}_2\text{O}_2] = 1; 10^{-10} \text{ M}$ biokīmijas koncentrācijas $[\text{O}_{2\text{aqua}}] = 6*10^{-5} \text{ M}$, $[\text{H}_3\text{O}^+] = 10^{-7.36} \text{ M}$, $[\text{H}_2\text{O}] = 55.3 \text{ M}$.

Red $\text{H}_2\text{O}_2 + 2\text{H}_2\text{O} = \text{O}_2 + 2\text{H}_3\text{O}^+ + 2\text{e}^-$; $E^\circ_{\text{H}_2\text{O}_2} = 0.4495 \text{ V}$ **absolūtais** standarta potenciāls; $E_{\text{Red}} = E^\circ_{\text{H}_2\text{O}_2} + 0.0591/2 \cdot$

$$\bullet \lg([\text{O}_{2\text{aqua}}]^* [\text{H}_3\text{O}^+]^2 / [\text{H}_2\text{O}_2]^* [\text{H}_2\text{O}]^2) = 0.4495 + 0.0591/2 * \log(6*10^{-5}) * 10^{(-7.36*2)} / 10^{(-10)} / 55.3^2 = 0.08227 \text{ V}$$

$$E_{\text{Red}} = E^\circ_{\text{H}_2\text{O}_2} + 0.0591/2 * \lg([\text{O}_{2\text{aqua}}]^* [\text{H}_3\text{O}^+]^2 / [\text{H}_2\text{O}_2]^* [\text{H}_2\text{O}]^2) = 0.4495 + 0.0591/2 * \lg(6*10^{-5}) * 10^{(-7.36*2)} / 10^{(-10)} / 55.3^2 = -0.2132 \text{ V}$$

Ox $\text{H}_2\text{O}_2 + 2\text{H}_3\text{O}^+ + 2\text{e}^- = 4\text{H}_2\text{O}$; $E^\circ_{\text{oxH}_2\text{O}_2} = -1.6855 \text{ V}$ **absolūtais inversais** standarta potenciāls;

$$-E_{\text{ox}} = E^\circ_{\text{H}_2\text{O}_2 \text{Ox}} + 0.0591/2 * \log([\text{H}_2\text{O}_2]^4 / [\text{H}_3\text{O}^+]^2) = -1.6855 + 0.0591/2 * \log(55.3^4 / 10^{(-7.36*2)}) = -0.749 \text{ V} ;$$

$$-E_{\text{ox}} = E^\circ_{\text{H}_2\text{O}_2 \text{Ox}} + 0.0591/2 * \log([\text{H}_2\text{O}_2]^* [\text{H}_3\text{O}^+]^2 / [\text{H}_2\text{O}]^4) = -1.6855 + 0.0591/2 * \lg(1 * 10^{(-7.36*2)} / 55.3^4) = -2.3265 \text{ V}$$

$$[\text{H}_2\text{O}_2] = 1 \text{ M}; [\text{H}_2\text{O}_2] = 10^{-10} \text{ M}; \text{koncentrācijas } 2\text{H}_2\text{O}_{2\text{aq}} \Rightarrow \text{O}_{2\text{aqua}} + 2\text{H}_2\text{O} ;$$

$$[\text{H}_2\text{O}_2] = 10^{-10} \text{ M}; \Delta G_{\text{eqBioChem}} = (E^\circ_{\text{Red}} - E^\circ_{\text{Ox}}) * F * n = (0.08227 - 0.749) * 96485 * 2 = (-1.236) * 96485 * 2 = -128.7 \text{ kJ/mol} ;$$

$$[\text{H}_2\text{O}_2] = 1 \text{ M}; \Delta G_{\text{eqBioChem}} = (E^\circ_{\text{Red}} - E^\circ_{\text{Ox}}) * F * n = (-0.2132 - 2.3265) * 96485 * 2 = (-2.5397) * 96485 * 2 = -490.1 \text{ kJ/mol} ;$$

$$\Delta G_{\text{Alberty}} = G_{\text{O}_2 \text{Biochem_arterijai}} + 2 * G_{\text{H}_2\text{O}_2 \text{BioChemistry}} - 2 * G_{\text{H}_2\text{O}_2} = 78.08 + 2 * 85.64 - 2 * 364.79 = -480.22 \text{ kJ/mol} ;$$

$2\text{H}_2\text{O}_{2(aq)} \Rightarrow \text{O}_{2\text{aqua}} + 2\text{H}_2\text{O} + \text{Q} + \Delta G$; Homeostāzes produktu aktivēšana, hidroksonija un peroksīda anjonu:

$$G_{\text{H}_2\text{O}_2} = 364.8 \text{ kJ/mol}; G_{\text{H}_3\text{O}^+} + G_{\text{HO}_2} = 22.44 + 418.32 = 440.76 \text{ kJ/mol}$$

absolūtās brīvās energijas attiecinātas uz ūdens un CO_2 gas nulles $G_{\text{H}_2\text{O}} = G_{\text{CO}_2\text{gas}} = 0 \text{ kJ/mol}$ vērtību:

$$\Delta G_{\text{eqStandard}} = (E^\circ_{\text{H}_2\text{O}_2} - E^\circ_{\text{H}_2\text{O}_2 \text{Ox}}) * F * n = (0.4495 - 1.6855) * 96485 * 2 = (-1.1845) * 96485 * 2 = -238.5 \text{ kJ/mol} ;$$

$$\Delta G_{\text{HessAlberty}} = G_{\text{O}_2} + 2G_{\text{H}_2\text{O}} - 2G_{\text{H}_2\text{O}_2} = 330 + 2*(0) - (2*284) = -238 \text{ kJ/mol} ; \text{Alberty}$$

$$K_{\text{eqStandart}} = K_{\text{H}_2\text{O}_2} = \exp(-\Delta G_{\text{eq}} / R / T) = \exp(238500 / 8.3144 / 298.15) = 10^{41.8} \text{.....}$$

Eksotermiska un eksoerģiska H_2O_2 dismutēšanas Hesa brīvās energijas izmaiņa $\Delta G_{\text{Alberty}}$ ir

negatīva -480 kJ/mol , bet minimizējas $\Delta G_{\text{eqStandart}} = -238.5 \text{ kJ/mol}$ sasniedzot līdzsvara

maisījuma konstanti $K_{\text{eq}} = 10^{41.8} \text{.....}$ Lešateljē princips ir Prigožina atraktors brīvās energijas

izmaiņas minimuma ΔG_{min} sasniegšana. Liela ātruma protolīzes atraktori pH=7.36, skābeklis

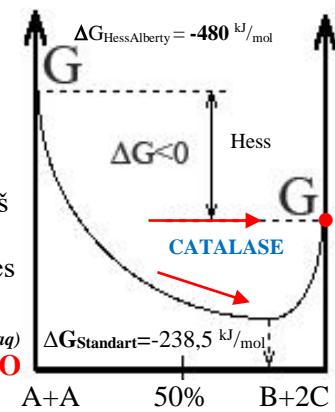
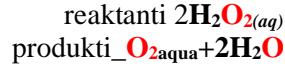
20.95% gaisā atrodas līdzsvara stāvoklī, kamēr Homeostāze neatgriezeniski turpinās, jo ir

nelīdzsvara stāvoklis. Prigožina atraktors Nobela Prēmija ķīmijā 1977. gadā. CATALĀZE dzēš

peroksīda molekulas H_2O_2 līdz 100% $\omega = 6$, $\omega = 3$ taukskābju C20:4 iznākumam elongācijas

sintēzē peroksisomās. CATALĀZES reaktivitāte ir nepieciešams neatgriezeniskās Homeostāzes

Brauna molekulārais dzinējs evolūcijai un izdzīvošanai.



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