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Sēra savienojumu šķīšanas, protolīzes un reducēšanas-oksidēšanas Prigožina absolūtās enerģijas atraktori.

Viela	$\Delta H°_H$ kJ/mol	$\Delta S°_H$ J/mol/K	$\Delta G°_H$, kJ/mol
H_2S^{gas}	formation	ΔG°-33,4	**55,7436**
H_2S^{gas}	Solubility	promote	**69,073**
H_2S^{gas}	-20,6	205,81	-33,4
H_2S_{aq}	**-22,9596**	**-256,064**	**53,3896**
H_2S_{aq}	$E°_{S\downarrow/H2Saq}$=	**-0,025735** V	**53,3896**
H_2S_{aq}	S+2H(Pt)=	H_2S_{aq}	**53,3866**
HS^-	-16,3	67	12,5
HS^- G_{e-}	formation	12,5	**31,69**
HS^-	$E°_{S\downarrow/S2-}$=	**-0,8517**V	**90,5336**
HS^-	pK_{a1}=7,05	favored	**81,138**
HS^-	pK_{a2}=19	-	**92,63**
S_{rombic}	formation	-	**3,5436**
S_{rombic}	$E°_{S\downarrow/H2Saq}$=	**-0,025735** V	**3,5436**
S^{2-}	33,1	-14,6	85,8
S^{2-} G_{e-}	formation	85,8	2***34,1432**
S^{2-}	$E°_{S\downarrow/S2-}$=	**-0,79853**V	**157,63**

G_{H2}^{gas}=**85,6** kJ/mol; $G_{H2S_{aq}}$=**53,3896** kJ/mol; $G_{S_{rhombic}}$=**3,5436** kJ/mol;
favored G_{H2S}^{gas}=$\Delta G°_{H2S}^{gas}$+($G_{S_{rombic}}$+G_{H2})= **55,7436** kJ/mol;
G_{H2S}^{gas}=$G_{H2S_{aq}}$+(ΔG_{eq}+G_{H2O})=**84,343**+(**15,27**+**0**)=**69,073** kJ/mol;
[1] ΔG_{H2S}^{gas}=ΔH_H–T*ΔS_H=-20,6-298,15*0,20581=-81,96 kJ/mol;
2006, Massachusetts Technology Inst. pH=7,36 Alberty [8]
$G_{H2S_{aq}}$=$G_{S_{rombic}}$+2G_{H3O+}-($\Delta G_{eqH2S_{aq}}$ +2G_{H2O})=**53,3896** kJ/mol;
$G_{H2S_{aq}}$=$\Delta G_{HessH2S}$+(2$G_{H(Pt)}$+$G_{S_{rombic}}$)=**53,3866** kJ/mol;
[1] ΔG_{HS^-}=ΔH_H–T*ΔS_H=-16,3-298,15*0,067=-36,276 kJ/mol;
G_{e-}=G_{HS^-}-(G_{S_r}+**0,5**G_{H2}+$\Delta G°_{HS^-}$)=**31,69** kJ/mol;
pK_{a2}=19 G_{HS^-aq}=$G_{S_{rombic}}$+2G_{H2O}-(ΔG_{eqHS^-aq}+G_{OH})=**90,5336** kJ/mol;
favored G_{HS^-}=ΔG_{eq}-G_{H3O}+(G_{H2S}+G_{H2O})=**81,138** kJ/mol;
G_{HS^-}=G_{S2-}+G_{H3O}-(ΔG_{eq}+G_{H2O})=**92,65** kJ/mol;
$G_{S_{rombic}}$=G_{H2S}^{gas}-($\Delta G_{Hess\_H2S}^{gas}$+$G_{H2}$)=**3,5436** kJ/mol;
favored $G_{S_{rombic}}$=$\Delta G_{eqH2S_{aq}}$-2G_{H3O+}+($G_{H2S_{aq}}$+2G_{H2O})=**3,544** kJ/mol;
[1] ΔG_{HS^-}=ΔH_H–T*ΔS_H=33,1-298,15*-0,0146=-36,276 kJ/mol;
2G_{e-}=G_{S2-}-(G_{S_r}+$\Delta G°_{S2-}$)=**157,63**-(**3,5436**+85,8)= **2*34,1432** kJ/mol;
G_{S2-aq}=$G_{S_{rombic}}$+G_{H2O}-($\Delta G_{eqS2-aq}$)=**157,63** kJ/mol;

Veidošanās no elementiem $S_{rhombic}$+H_2^{gas}=H_2S^{gas} uzrāda enerģijas saturu G_{H2S}^{gas}=**55,7436** kJ/mol;
Enerģijas saturs ir G_{H2S}^{gas}=$\Delta G°_{H2S}^{gas}$+($G_{S_{rombic}}$+G_{H2})=-33,4+(**3,5436**+**85,6**)=**55,7436** kJ/mol. [1,8]
Enerģijas saturs ir $G_{S_{rombic}}$=G_{H2S}^{gas}-($\Delta G°_{H2S}^{gas}$+G_{H2})=**55,7436**-(-33,4+**85,6**)=**3,5436** kJ/mol. [1,8]
Formation $S_{rhombic}$+0,5H_2^{gas}+e^-=HS^-;

$\Delta G°_{HS^-}$=G_{HS^-}-(G_{S_r}+**0,5**G_{H2}+G_{e-})=**90,5336**-(**3,5436**+0,5***85,6**+G_{e-})=12,5 kJ/mol.
G_{e-}=G_{HS^-}-(G_{S_r}+**0,5**G_{H2}+$\Delta G°_{HS^-}$)=**90,5336**-(**3,5436**+0,5***85,6**+12,5)=**31,69** kJ/mol.
G_{HS^-}=$\Delta G°_{HS^-}$+(G_{S_r}+**0,5**G_{H2}+G_{e-})=12,5+(**3,5436**+0,5***85,6**+**31,69**)=**90,5336** kJ/mol.

Formation $S_{rhombic}$+2e^-=S^{2-}; $\Delta G°_{S2-}$=G_{S2-}-(G_{S_r}+2G_{e-})=**157,63**-(**3,5436**+2G_{e-})=85,8 kJ/mol.
2G_{e-}=G_{S2-}-(G_{S_r}+$\Delta G°_{S2-}$)=**157,63**-(**3,5436**+85,8)=**2*34,1432** kJ/mol.
G_{S2-}=$\Delta G°_{S2-}$+(G_{S_r}+2G_{e-})=85,8+(**3,5436**+2***34,1432**)=**157,63** kJ/mol.

Šķīdības H_2S^{gas}+H_2O=H_2S_{aq} 3,98 g/L 20° C [30] M_{H2S}=34,08 g/mol produkts K_{sp}=[H_2S_{aq}]=3,98/34,08=0,11678 M līdzsvara konstante ir K_{eq}=K_{sp}/[H_2O]=0,116784/55,3=0,0021118 ar endoergonisku brīvās enerģijas izmaiņu pozitīvu ΔG_{eq}=-R•T•ln(K_{eq})=-8,3144*298,15*ln(0,0021118)=$G_{H2S_{aq}}$-(G_{H2S}^{gas}+G_{H2O})=**15,27** kJ/mol.

ΔG_{eq}=$G_{H2S_{aq}}$-(G_{H2S}^{gas}+G_{H2O})=**84,343**-(**69,073**+**0**)=**15,27** kJ/mol.

Brīvās enerģijas saturs molā sērūdeņraža ir G_{H2S}^{gas}=$G_{H2S_{aq}}$+(ΔG_{eq}+G_{H2O})=**84,343**-(**15,27**+**0**)=**69,073** kJ/mol.

S^{2-}=$S_{rombisks}$+H_2O+2e^-; Classic standarta potenciāls $E°_{Classic}$=-0,4763 V [1], plus ūdens uzskaite -0,0591/2*log([H_2O]^1)=-0,0515 un saistītā summa $\Delta E°$=+0,10166-0,37239 izteiksmē absolūtais potenciāls ir

$E°_{S\downarrow/S2-}$=$E°_{Classic}$-0,0591/2*log([H_2O]^1)+$\Delta E°$=-0,4763-0,0515+0,10166-0,37239=**-0,79853** V;

ΔG_{eqS2-}=$E°_{S2-}$*F*n=**-0,79853***96485*2=**-154,09** kJ/mol . $G_{S_{rombic}}$=**3.5436** kJ/mol;

$\Delta G_{eqS2-aq}$=$G_{S_{rombic}}$+G_{H2O}+2G_{e-}-(G_{S2-aq})=**3,5436**+0+2*0-(**157,6336**)=**-154,09** kJ/mol;
2G_{e-}=$\Delta G_{eqS2-aq}$-$G_{S_{rombic}}$-G_{H2O}+(G_{S2-aq})=**-154,09**-**3,5436**-0+(**157,6336**)=**0** kJ/mol;
G_{S2-aq}=$G_{S_{rombic}}$+G_{H2O}+2G_{e-}-($\Delta G_{eqS2-aq}$)=**3,5436**+**0**+2*0-(**-154,09**)=**157,63** kJ/mol;

HS^-+OH^-=$S_{rombisks}$+2H_2O+2e^-; Classic standarta potenciāls $E°_{Classic}$=-0,478 V [1] , plus ūdens uzskaite -0,0591/2*log([H_2O]^2)=-0,103 un saistītā summa $\Delta E°$=+0,10166-0,37239 izteiksmē absolūtais potenciāls ir

$E°_{S\downarrow/HS-}$=$E°_{Classic}$-0,0591/2*log([H_2O]^2)+$\Delta E°$=-0,478-0,103+0,10166-0,37239=**-0,8517** V;

ΔG_{eqHS-}=E_{HS-}*F*n=**-0,8517***96485*2=**-164,35** kJ/mol;

$\Delta G_{eqHS-aq}$=$G_{S_{rombic}}$+2G_{H2O}+2G_{e-}-(G_{HS-aq}+G_{OH})=**3,5436**+2*0+2*0-(**90,5336**+**77,36**)=**-164,35** kJ/mol;
G_{HS-aq}=$G_{S_{rombic}}$+2G_{H2O}+2G_{e-}-($\Delta G_{eqHS-aq}$+G_{OH})=**3,5436**+2*0+2*0-(**-164,35**+**77,36**)=**90,5336** kJ/mol;
2G_{e-}=$\Delta G_{eqHS-aq}$-$G_{S_{rombic}}$-2G_{H2O}+(G_{HS-aq}+G_{OH})=**-164,35**-**3,5436**-2*0+(**90,5336**+**77,36**)=**0** kJ/mol;

H_2S_{aq}+2H_2O=$S_{rombisks}$+2H_3O^++2e^-; Classic standarta potenciāls $E°_{Classic}$=0,142 V [1] , plus ūdens uzskaite -0,0591/2*log(1/[H_2O]^2)=0,103 un saistītā summa $\Delta E°$=+0,10166-0,37239 izteiksmē absolūtais potenciāls ir

$E°_{S\downarrow/H2S}$=$E°_{Classic}$-0,0591/2*log(1/[H_2O]^2)+$\Delta E°$=0,142+0,103+0,10166-0,37239=**-0,025735** V;

ΔG_{eqH2S}=$E°_{H2S}$*F*n=**-0,025735***96485*2=**-4,966** kJ/mol ;

$\Delta G_{eqH2Saq}$=$G_{S_{rombic}}$+2G_{H3O+}+2G_{e-}-($G_{H2S_{aq}}$+2G_{H2O})=**3,5436**+2***22,44**+2*0-(**53,3896**+2*0)=**-4,966** kJ/mol;
$G_{S_{rombic}}$=$\Delta G_{eqH2Saq}$-2G_{H3O+}-2G_{e-}+($G_{H2S_{aq}}$+2G_{H2O})=**-4,966**-2***22,44**-2*0+(**53,3896**+2*0)=**3,5436** kJ/mol; favored

$G_{H2Saq}=G_{Srombic}+2G_{H3O+}+2G_{e-}-(\Delta G_{eqH2Saq}+2G_{H2O})=3,5436+2*22,44+2*0-(-4,966+2*0)=53,3896$ kJ/mol;
$2G_{e-}=\Delta G_{eqH2Saq}-G_{Srombic}-2G_{H3O+}+(G_{H2Saq}+2G_{H2O})=-4,966-3,5436-2*22,44+(53,3896+2*0)=2*0$ kJ/mol;

[1] $pK_{a1}=7,05$; $pK_{a2}=19$;

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

$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=-8,3144*298,15*\ln(0,000000001612)=G_{HS-}+G_{H3O}-(G_{H2S}+G_{H2O})=50,188$ kJ/mol;

$\Delta G_{eq}=G_{HS-}+G_{H3O}-(G_{H2S}+G_{H2O})=81,138+22,44-(53,3896+0)=50,188$ kJ/mol ;

$G_{HS-}=\Delta G_{eq}-G_{H3O}+(G_{H2S}+G_{H2O})=50,188-22,44+(53,3896+0)=81,138$ kJ/mol ;

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

$\Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})=-8,3144*298,15*\ln(10^{\wedge(-20,74)})=G_{S2-}+G_{H3O}-(G_{HS-}+G_{H2O})=118,40$ kJ/mol;

$\Delta G_{eq}=G_{S2-}+G_{H3O}-(G_{HS-}+G_{H2O})=186,4936+22,44-(90,5336+0)=118,40$ kJ/mol ;

$G_{S2-}=\Delta G_{eq}-G_{H3O}+(G_{HS-}+G_{H2O})=118,40-22,44+(90,5336+0)=186,4936$ kJ/mol ;

$G_{HS-}=G_{S2-}+G_{H3O}-(\Delta G_{eq}+G_{H2O})=186,4936+22,44-(118,40+0)=90,5336$ kJ/mol ;

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

$\underline{2H(Pt)}+2H_2O=2H_3O^++2e^-$; $E°_H=-0,27073$ V; sumārā reakcija $S_{rombic}+\underline{2H(Pt)}=H_2S_{aq}$;

$\Delta G_{eq}=(E°_H-E°_S)\bullet F\bullet n=(-0,27073+0,025735)*96485*2=-0,244995*96485*2=-47,277$ kJ/mol;

$\Delta G_{HessH2S}=G_{H2Saq}-(2G_{H(Pt)}+G_{Srombic})=53,3866-(2*48,56+3,5436)=-47,277$ kJ/mol .

$G_{H2Saq}=\Delta G_{HessH2S}+(2G_{H(Pt)}+G_{Srombic})=-47,277+(2*48,56+3,5436)=53,3866$ kJ/mol .

Albertija [8] un CRC [1] dati: $G_{H2}^{gas}=85,6$ kJ/mol , $G_{H2Saq}=53,3866$ kJ/mol [8] un $\Delta G°_{H2O}=-237,191$ kJ/mol, $\Delta G°_{H2S}^{gas}=-81,98$ kJ/mol [1] ļauj aprēķināt vielu absolūtās vērtības brīvās enerģijas saturam $G_{Srombisks}=3,5436$ kJ/mol, $G_{O2}^{gas}=303,1$ kJ/mol utt. attiecībā pret ūdens un oglekļa dioksīda gāzes nulli $G_{H2O}=G_{CO2}^{gas}=G_{e-}=0$ kJ/mol skalā.

[1] H_2SO_4 veidošanās no brīviem elementiem sērskābei un sulfātiem: $S_{rombisks}+2O_2^{gas}+H_2^{gas}=H_2SO_4$:

$\Delta G°_{H2SO4Form}=G_{H2SO4}-(G_{Srombisks}+2G_{O2}+G_{H2}^{gas})=-690,0$ kJ/mol; Saturs molā sērskābes ir

$G_{H2SO4}=\Delta G°_{H2SO4Form}+(G_{Srombisks}+2G_{O2}+G_{H2}^{gas})=-690,0+(3,5436+2*303,1+85,6)=5,3436$ kJ/mol.

[1] SO_3 veidošanās no elementiem $S_{rombisks}+1,5O_2^{gas}=SO_3$: $\Delta G°_{SO3Form}=G_{SO3}-(3,5436+1,5*303,1)=-373,8$ kJ/mol;

$G_{SO3}=\Delta G°_{SO3Form}+(G_{Srombisks}+1,5G_{O2})=-373,8+(3,5436+1,5*303,1)=84,3936$ kJ/mol;

100% sērskābes veidošanās, oleumam šķīstot ūdenī, ir eksoergoniska $SO_3+H_2O=H_2SO_4$:

$\Delta G°_{SO3+H2O}=G_{H2SO4}-(G_{SO3}+G_{H2O})=5,1436-(84,2436+0)=-79,1$ kJ/mol;

Protolīzes $pK_{a1}=-2,8$ līdzsvaru $H_2SO_4+H_2O=HSO_4^-+H_3O^+$ molu daļās aprēķina dalot skābes konstanti K_{a1} ar ūdens koncentrāciju $[H_2O]=55,3$ M $K_{eq1}=K_{a1}/[H_2O]=10^{\wedge(2,8)}/55,3=11,4097$. Prigožina atraktors un Hesa aprēķins ir vienādi eksoergonisks: $\Delta G_{eqH2SO4}=-R\bullet T\bullet\ln(K_{eq})=-8,3144*298,15*\ln(11,4097)=-6,0349$ kJ/mol;

$\Delta G_{eqH2SO4}=G_{HSO4-}+G_{H3O}-(G_{H2SO4}+G_{H2O})=27,5836+22,44-(56,0586+0)=-6,0349$ kJ/mol;

$G_{HSO4-}=\Delta G_{eqH2SO4}-G_{H3O}+(G_{H2SO4}+G_{H2O})=-6,0349-22,44+(56,0585+0)=27,5835$ kJ/mol;

H_2SO_4 molā ir $G_{H2SO4}=G_{HSO4-}+G_{H3O}-(\Delta G_{eqH2SO4}+G_{H2O})=27,5835+22,44-(-6,0349+0)=56,0585$ kJ/mol.

Protolīzes $pK_{a2}=1,99$ $HSO_4^-+H_2O=SO_4^{2-}+H_3O^+$

$K_{eq2}=K_{a2}/[H_2O]=10^{\wedge(-1,99)}/55,3=0,00018504$ enerģijas izmaiņa ir

$\Delta G_{eqHSO4}=-R\bullet T\bullet\ln(K_{eq2})=-8,3144*298,15*\ln(0,000185044)=21,3069$ kJ/mol. Izmaiņa Hesa izteiksmē

$\Delta G_{eqHSO4}=G_{SO42-}+G_{H3O}-(G_{HSO4-}+G_{H2O})=26,4509+22,44-(27,584+0)=21,3064$ kJ/mol

$G_{HSO4-}=G_{SO42-}+G_{H3O}-(\Delta G_{eqHSO4}+G_{H2O})=26,4509+22,44-(21,3069+0)=27,584$ kJ/mol ;

SO_4^{2-} anjona molā ir $G_{SO42-}=\Delta G_{eqHSO4}-G_{H3O}+(G_{HSO4-}+G_{H2O})=21,3069-22,44+(27,584+0)=26,4509$ kJ/mol;

[1] Formation $S_{rombic}+2O_2^{gas}+0,5H_2^{gas}+e^-=HSO_4^-$; $G_{e-}=119,5401$ kJ/mol; $G_{HSO4}=27,5837$ kJ/mol; $pK_{a2}=1,99$;

$\Delta G°_{HSO4}=G_{HSO4}-(G_{Srombic}+2G_{O2}+0,5G_{H2}^{gas}+G_{e-})=27,5837-(3,5436+2*303,1+0,5*85,6+119,5401)=-744,5$ kJ/mol;

$G_{HSO4}=\Delta G°_{HSO4}+(G_{Srombisks}+2G_{O2}+0,5G_{H2}^{gas}+G_{e-})=-744,5+(3,5436+2*303,1+0,5*85,6+119,54)=27,5837$ kJ/mol;

$G_{e-}=G_{HSO4}-(G_{Srombic}+2G_{O2}+0,5G_{H2}^{gas}+\Delta G°_{HSO4})=27,5837-(3,5436+2*303,1+0,5*85,6-744,5)=119,54$ kJ/mol;

[1] Formation $S_{rombic}+2O_2^{gas}+2+e^-=SO_4^{2-}$;

$\Delta G°_{SO42}=G_{SO42}-(G_{Srombic}+2G_{O2}+2G_{e-})=26,44977-(3,5436+2*303,1+2*80,603)=-744,5$ kJ/mol;

$2G_{e-}=G_{SO42}-(G_{Srombic}+2G_{O2}+\Delta G°_{SO42})=26,44977-(3,5436+2*303,1-744,5)=161,20617=2*80,603$ kJ/mol;

https://en.wikipedia.org/wiki/Sulfur_dioxide

Šķīdības konstantes molu daļās $K_{eq}=K_{sp}/[H_2O]$ aprēķina dalot piesātinātu šķīdības produktu ar ūdeni $[H_2O]$. Piesātināti izšķīst 94 g/L SO_2 M=64,066 g/mol $[SO_2]=[H_2SO_3]=94/64,066=1,46724$ M sērpaskābes ar blīvumu 1,05 g/mL $m_{solution}=1050$ g/L $M_{H2SO3}=82,075$ g/mol. Masu ūdenim dod $m_{H2O}=1050-120,4327=929,5673$ g skābes masa $m_{H2SO3}=[SO_2]*M_{H2SO3}=1,46724$ M*82,075 g/mol=120,4327 g/L. Ūdens koncentrācija konstantē ir $n_{H2O}=929,5673/18=51,64$ M. $SO_2^{gas}+H_2O=H_2SO_{3aq}$ $K_{eq}=[H_2SO_3]/[SO_2^{gas}]/[H_2O]=1,46724/1/51,64=0,028413$ konstante dod $\Delta G_{eqH2SO3}=-R\bullet T\bullet\ln(K_{eq})=-8,3144*298,15*\ln(0,028413)=G_{H2SO3}-(G_{SO2}+G_{H2O})=8,82727$ kJ/mol brīvās enerģijas izmaiņu $\Delta G_{eqH2SO3}=G_{H2SO3}-(G_{SO2}+G_{H2O})=16,2761-(7,44883+0)=8,82727$ kJ/mol.

$G_{SO2}^{gas}=G_{H2SO3}-(\Delta G_{eqH2SO3}+G_{H2O})=16,2761-(8,82727+0)=7,44883$ kJ/mol ; 2=<pH<7 [17]

Veidošanās no brīvajiem elementiem $S_{rombic}+O_2^{gas}=SO_2^{gas}$: $\Delta G°_{SO2Form}=G_{SO2}$-**(3,5436+303)**=-300,1 $^{kJ}/_{mol}$;

$G_{SO2}^{gas}=\Delta G°_{SO2Form}+(G_{Srombic}+G_{O2})$=-300,1+**(3,5436+303,1)=6,5436** $^{kJ}/_{mol}$;

Veidošanās no brīvajiem elementiem $S_{rombic}+1{,}5O_2^{gas}+H_2^{gas}=H_2SO_{3aq}$ un šķīdība $SO_2^{gas}+H_2O=H_2SO_{3aq}$.

Viela	$\Delta H°_{H,}$ $^{kJ}/_{mol}$	$\Delta S°_{H,}$ $^{J}/_{mol/K}$	$\Delta G°_{H,}$ $^{kJ}/_{mol}$
H_2O	-285,85	69,9565	-237,191
H_2O	**-286,65**	**-453,188**	**-151,549**
SO_3	-441,0	113,8	-373,8
SO_3	formation liq uid -373,8		**84,3936**
H_2SO_4	-814,0	156,9	-690,0
H_2SO_4	formation	liquid -690	**5,3436**
H_2SO_4	pK_{a1}=-2,8	protolysis	**56,0585**
HSO_4^-	-909,3	20,1	-744,5
HSO_4G_{e-}	formation	-744,5	**119,54**
HSO_4^-	pK_{a2}=1,99	protolysis	**27,584**
$SO_4^{2-}G_{e-}$	formation	-744,5	**80,603**
SO_4^{2-}	**-907,62**	**-536,2**	**-747,77**
$SO_4^{2-}G_{e-}$	formation[8]	**-747,75**	**82,228**
SO_4^{2-}	pK_{a2}=1,99	protolysis	**26,4509**
SO_4^{2-}	$E°_{HSO3-}$=	**0,10726**	**26,44996**
SO_4^{2-}	$E°_{SO32-}$=	**0,05576**	**26,44996**
SO_4^{2-}	$E°_{SO32-}$=	**-1,2522**	**54,9256**
SO_2^{gas}	−296,81	248,223	-300,1
SO_2^{gas}	formation	-300,1	**6,5436**
SO_2^{gas}	K_{sp}=0,02841	2<pH<7	**7,44883**
H_2SO_3	formation [8]	**-509,736**	**34,0575**
H_2SO_3	pK_{a1}=1,857		**34,0575**
HSO_3^-	-626,2	139,7	-527,7
HSO_3^-	G_{e-} formation	-527,7	**128,2536**
HSO_3^-	pK_{a2}=7,172		**32,125**
HSO_3^-	$E°_{HSO3-}$=	**0,10726**	**73,072**
SO_3^{2-}	$E°_{SO32-}$=	**0,05576**	**60,56996**
SO_3^{2-}	-635,5	-29	-486,5
SO_3^{2-}	G_{e-}formation	-486,5	**38,242**
SO_3^{2-}	pK_{a2}=7,172		**43,0036**
SO_3^{2-}	$E°_{SO32-OH}$=	**-1,25223**	**141,8484**

Bioķīmijas ūdenim ir standarta brīvā enerģija G_{H2O}=**85,6** $^{kJ}/_{mol}$. [8]

$G_{H2O}=\Delta G_{H2OAlberty}-(\Delta G°_{H2O})$=**-151,549**-(-237,191)=**85,6** $^{kJ}/_{mol}$.

$\Delta G_H=\Delta H_H$-T*ΔS_H=**-286,65**-298,15***-0,453188**=**-151,549** $^{kJ}/_{mol}$;

[1] $\Delta G_H=\Delta H_H$-T*ΔS_H=-441-298,15*0,1138=-474,92947 $^{kJ}/_{mol}$;

$G_{SO3}=\Delta G°_{SO3Form}+(G_{Srombic}$+**1,5**$G_{O2})$=**84,3936** $^{kJ}/_{mol}$;

[1] $\Delta G_H=\Delta H_H$-T*ΔS_H=-814,0-298,15*0,1569=-860,78 $^{kJ}/_{mol}$;

$G_{H2SO4}=\Delta G°_{H2SO4}+G_{Srombic}$+**2**$\Delta G_{O2}$+ G_{H2}^{gas}+G_{H2O}=**5,3436** $^{kJ}/_{mol}$;

$G_{H2SO4}=G_{HSO4-}+G_{H3O}-(\Delta G_{eqH2SO4}+G_{H2O})$=**56,0585** $^{kJ}/_{mol}$;

[1] $\Delta G=\Delta H$-T*ΔS=-909,3-298,15*0,0201=-915,293 kJ/mol;

$G_{e-}=G_{HSO4}-(G_{Srombic}+2G_{O2}+0{,}5G_{H2}^{gas}+\Delta G°_{HSO4})$=**119,54** $^{kJ}/_{mol}$;

$G_{HSO4-}=\Delta G_{eqH2SO4}-G_{H3O}+(G_{H2SO4}+G_{H2O})$=**27,584** $^{kJ}/_{mol}$;

[1] $2G_{e-}=G_{SO42}-(G_{Srombic}+2G_{O2}+\Delta G°_{SO42})$=**161,2062**=2***80,60** $^{kJ}/_{mol}$;

[8] $\Delta G_{SO42-}=\Delta H-T*\Delta S$=**-907,62**-298,15***-0,5362**=**-747,75** $^{kJ}/_{mol}$;

[8] $2G_{e-}=G_{SO42}-(G_{Srombic}+2G_{O2}+\Delta G°_{SO42})$=**164,456**=2***82,228** $^{kJ}/_{mol}$;

$G_{SO42-}=\Delta G_{eqHSO4}-G_{H3O}+(G_{HSO4-}+G_{H2O})$=**26,4509** $^{kJ}/_{mol}$; 2=<pH<7

$G_{SO42-}=\Delta G_{eqHSO42-}-3G_{H3O}+(G_{HSO3}$+4$G_{H2O})$=**26,44996** $^{kJ}/_{mol}$;

$G_{SO42-}=\Delta G_{eqSO32-}-2G_{H3O}+(G_{SO32-}$+3$G_{H2O})$=**26,44996** $^{kJ}/_{mol}$;

$G_{SO42-}=\Delta G_{eqSO32-OH}-G_{H2O}+(G_{SO32-}+2G_{OH})$=**54,9256** $^{kJ}/_{mol}$;

[1] $\Delta G_H=\Delta H_H$-T*ΔS_H=-296,81-298,15*0,248223=-370,82 $^{kJ}/_{mol}$;

$G_{SO2}=\Delta G°_{SO2Form}+(G_{Srombic}+G_{O2})$=**6,5436** $^{kJ}/_{mol}$;

$G_{SO2}^{gas}=G_{H2SO3}-(\Delta G_{eqH2SO3}+G_{H2O})$=**7,44883** $^{kJ}/_{mol}$;

$G_{H2SO3}=\Delta G°_{H2SO3}+(G_{Srombic}+1{,}5DG_{O2}+G_{H2gas})$=**34,0575** $^{kJ}/_{mol}$;

$G_{H2SO3}=G_{HSO3-}+G_{H3O}-(\Delta G_{eqH2SO3}+G_{H2O})$=**34,0575** $^{kJ}/_{mol}$; pH=1,85

[1] $\Delta G_H=\Delta H_H$-T*ΔS_H=-626,2-298,15*0,1397=-667,85 $^{kJ}/_{mol}$;

$G_{e-}=G_{HSO3-}-(G_{Srom}+1{,}5\Delta G_{O2}+G_{H2}^{gas}/2+\Delta G°_{HSO3})$=**128,2536** $^{kJ}/_{mol}$;

$G_{HSO3-}=G_{SO32-}+G_{H3O}-(\Delta G_{eqHSO3}+G_{H2O})$=**32,125** $^{kJ}/_{mol}$;

$G_{HSO3}=G_{SO42-}$+3$G_{H3O}-(\Delta G_{eqHSO4-}$+4$G_{H2O})$=**73,072** $^{kJ}/_{mol}$;

$G_{SO32-}=G_{SO42-}$+2$G_{H3O}-(\Delta G_{eqSO32-}$+3$G_{H2O})$=**60,56996** $^{kJ}/_{mol}$;

[1] $\Delta G_H=\Delta H_H$-T*ΔS_H=-635,5-298,15*-0,029=-626,85 $^{kJ}/_{mol}$;

$2G_{e-}=G_{SO32-}-(G_{Srom}+1{,}5\Delta G_{O2}+G_{H2}^{gas}/2+\Delta G°_{SO32})$=**76,484**=2***38,24** $^{kJ}/_{mol}$;

$G_{SO32-}=\Delta G_{eqHSO3}+G_{H3O}-(G_{HSO3-}+G_{H2O})$=**43,0036** $^{kJ}/_{mol}$; pH=7,172;

$G_{SO32-}=G_{SO42-}+G_{H2O}-(\Delta G_{eqSO32-OH}$ +2$G_{OH})$=**141.8484** $^{kJ}/_{mol}$; pH>7

https://en.wikipedia.org/wiki/Sulfurous_acid

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

$H_2SO_3+H_2O=HSO_3^-+H_3O^+$; pK_{a1}=1,857;$K_{eq1}=K_{a1}/[H_2O]$=10^(-1,857)/55,3=10^(-3,5997251) ir

$\Delta G_{eqH2SO3}$=-R•T•ln(K_{eq1})=-8,3144*298,15*ln(10^(-3,5997251))=**20,5075** $^{kJ}/_{mol}$.

$\Delta G_{eqH2SO3}=G_{HSO3-}+G_{H3O}-(G_{H2SO3}+G_{H2O})$=**32,125**+**22,44**-(**34,0575**+**0**)=**20,5075** $^{kJ}/_{mol}$.

$G_{H2SO3}=G_{HSO3-}+G_{H3O}-(\Delta G_{eqH2SO3}+G_{H2O})$= **32,125**+**22,44**-(**20,5075**+**0**)=**34,0575** $^{kJ}/_{mol}$; pH=1,857

Veidošana [8] $\Delta G°_{H2SO3}=G_{H2SO3}-(G_{Srombic}+1{,}5DG_{O2}+G_{H2gas})$=**34,0575**-(**3,5436**+1,5***303,1**+**85,6**)= **-509,736** $^{kJ}/_{mol}$;

$G_{H2SO3}=\Delta G°_{H2SO3}+(G_{Srombic}+1{,}5DG_{O2}+G_{H2gas})$=**-509,736**+(**3,5436**+1,5***303,1**+**85,6**)=**34,0576** $^{kJ}/_{mol}$;

[1] protolīze $HSO_3^-+H_2O=SO_3^{2-}+H_3O^+$; pK_{a2}=7,172; $K_{eq2}=K_{a2}/[H_2O]$=10^(-7,172)/55,3=10^(-8,9147);

ΔG_{eqHSO3}=-R•T•ln(K_{eq2})=-8; 3144*298,15*ln(10^(-8,9147))=**50,8848** $^{kJ}/_{mol}$;

$\Delta G_{eqHSO3}=G_{SO32-}+G_{H3O}-(G_{HSO3-}+G_{H2O})$=**60,56996**+**22,44**-(**32,125**+**0**)=**50,8848** $^{kJ}/_{mol}$;

$G_{SO32-}=\Delta G_{eqHSO3}+G_{H3O}-(G_{HSO3-}+G_{H2O})$=**50,8848**-**22,44**+(**32,125**+**0**)=**60,56996** $^{kJ}/_{mol}$;

$G_{HSO3-}=G_{SO32-}+G_{H3O}-(\Delta G_{eqHSO3}+G_{H2O})$=**60,56996**+**22,44**-(**50,8848**+**0**)=**32,125** $^{kJ}/_{mol}$;

Veidošana $HSO_3^-=S_{romb}+1{,}5O_2+H_2^{gas}/2+e^-$;[1] $SO_4^{2-}=S_{romb}+1{,}5O_2+H_2^{gas}/2+2e^-$; [1,8]

Veidošana $\Delta G°_{HSO3}=G_{HSO3-}-(G_{Srom}+1{,}5\Delta G_{O2}+G_{H2}^{gas}/2+G_{e-})$=**101,54764**-(**3,544** +1,5***303,1**+**85,6**/2+G_{e-})=-527,7 $^{kJ}/_{mol}$;

$G_{e-}=G_{HSO3-}-(G_{Srom}+1{,}5\Delta G_{O2}+G_{H2}^{gas}/2+\Delta G°_{HSO3})$=**101,54764**-(**3,544** +1,5***303,1**+**85,6**/2-527,7)=**128,2536** $^{kJ}/_{mol}$;

Veidošana $\Delta G°_{SO32}=G_{SO32-}-(G_{Srom}+1{,}5\Delta G_{O2}+G_{H2}^{gas}/2+2G_{e-})$=**90,9781**-(**3,544** +1,5***303,1**+**85,6**/2+2G_{e-})=-486,5 $^{kJ}/_{mol}$;

$2G_{e-}=G_{SO32-}-(G_{Srom}+1{,}5\Delta G_{O2}+G_{H2}^{gas}/2+\Delta G°_{SO32})$=**90,9781**-(**3,544** +1,5***303,1**+**85,6**/2-486,5)=**76,484**=2***38,242** $^{kJ}/_{mol}$;

2<pH<7 $HSO_3^-+4H_2O=SO_4^{2-}+3H_3O^+$+**2e**$^-$; Classic standarta potenciāls $E°_{classic}$=0,172 V [1], plus ūdens uzskaite -0,0591/2*log(1/$[H_2O]^4$)=0,206 un saistītā summa $\Delta E°$=+0,10166-0,37239 absolūtais potenciāls ir

$E°_{HSO3^-}=E°-0,0591/2*\log(1/[H_2O]^4)+\Delta E°=0,172-0,0591/2*\log(1/55,3^{\wedge 4})+0,10166-0,37239=\mathbf{0,10726}$ V;

$2<pH<7\ E_{HSO3^-}=E°_{HSO3^-}+0,0591/2*\log\frac{[SO_4^{2-}]\cdot[H_3O^+]^3}{[HSO_3^-]\cdot[H_2O]^4}=\mathbf{0,10726}\ V+0,0591/2*\log\frac{[SO_4^{2-}]\cdot[H_3O^+]^3}{[HSO_3^-]\cdot[H_2O]^4}$

$\Delta G_{eqHSO3^-}=E°_{HSO4^-}\bullet F\bullet n=\mathbf{0,10726}*96485*2=\mathbf{20,69796}\ ^{kJ}/_{mol}$,

$\Delta G_{eqHSO3^-}=G_{SO42^-}+3\mathbf{G_{H3O}}+2G_{e^-}-(G_{HSO3}+4\mathbf{G_{H2O}})=\mathbf{26,44996}+3*22,44+2*\mathbf{0}-(\mathbf{73,072}+4*0)=\mathbf{20,69797}\ ^{kJ}/_{mol}$;

$G_{HSO3}=G_{SO42^-}+3\mathbf{G_{H3O}}+2G_{e^-}-(\Delta\mathbf{G_{eqHSO4^-}}+4\mathbf{G_{H2O}})=\mathbf{26,44996}+3*22,44+2*\mathbf{0}-(\mathbf{20,69796}+4*0)=\mathbf{73,072}\ ^{kJ}/_{mol}$;

$G_{SO42^-}=\Delta\mathbf{G_{eqHSO42^-}}-3\mathbf{G_{H3O}}-2G_{e^-}+(G_{HSO3}+4\mathbf{G_{H2O}})=\mathbf{20,69796}-3*22,44-2*\mathbf{0}+(\mathbf{73,072}+4*0)=\mathbf{26,44996}\ ^{kJ}/_{mol}$;

$2G_{e^-}=\Delta\mathbf{G_{eqHSO42^-}}-3\mathbf{G_{H3O}}-G_{SO42^-}+(G_{HSO3}+4\mathbf{G_{H2O}})=\mathbf{20,69796}-3*22,44-\mathbf{26,44996}+(\mathbf{73,072}+4*0)=2*\mathbf{0}\ ^{kJ}/_{mol}$;

$HSO_3^-+4H_2O=SO_4^{2-}+3H_3O^++\mathbf{2e^-}$; $SO_3^{2-}+H_3O^++3H_2O=SO_4^{2-}+3H_3O^++\mathbf{2e^-}$;

pH>7,21 $SO_3^{2-}+3H_2O=SO_4^{2-}+2H_3O^++\mathbf{2e^-}$; Classic standarta potenciāls $E°_{classic}=0,172$ V [1] , plus ūdens uzskaite $-0,0591/2*\log(1/[H_2O]^3)=0,15449$ un saistītā summa $\Delta E°=+0,10166-0,37239$ absolūtais potenciāls ir $E°_{H2SO3}=E°_{Classic}-0,0591/2*\log(1/[H_2O]^3)+\Delta E°=0,172-0,0591/2*\log(1/55,3^{\wedge 3})+0,10166-0,37239=\mathbf{0,055763}$ V;

pH>7,21 $E_{HSO3^-}=E°_{HSO3^-}+0,0591/2\bullet\log\frac{[SO_4^{2-}]\cdot[H_3O^+]^2}{[SO_3^{2-}]\cdot[H_2O]^3}=\mathbf{0,055763}\ V+0,0591/2\bullet\log\frac{[SO_4^{2-}]\cdot[H_3O^+]^2}{[SO_3^{2-}]\cdot[H_2O]^3}$

$\Delta G_{eqHSO3^-}=E°_{HSO3^-}\bullet F\bullet n=\mathbf{0,055763}*96485*2=\mathbf{10,7600}\ ^{kJ}/_{mol}$;

$\Delta G_{eqSO32^-}=G_{SO42^-}+2\mathbf{G_{H3O}}+2G_{e^-}-(G_{SO32^-}+3\mathbf{G_{H2O}})=\mathbf{26,44996}+2*22,44+2*\mathbf{0}-(\mathbf{60,56996}+3*0)=\mathbf{10,7600}\ ^{kJ}/_{mol}$;

$G_{SO42^-}=\Delta\mathbf{G_{eqSO32^-}}-2\mathbf{G_{H3O}}-2G_{e^-}+(G_{SO32^-}+3\mathbf{G_{H2O}})=\mathbf{10,7600}-2*22,44-2*\mathbf{0}+(\mathbf{60,56996}+3*0)=\mathbf{26,44996}\ ^{kJ}/_{mol}$;

$G_{SO32^-}=G_{SO42^-}+2\mathbf{G_{H3O}}+2G_{e^-}-(\Delta\mathbf{G_{eqSO32^-}}+3\mathbf{G_{H2O}})=\mathbf{26,44996}+2*22,44+2*\mathbf{0}-(\mathbf{10,7600}+3*0)=\mathbf{60,56996}\ ^{kJ}/_{mol}$;

$2G_{e^-}=\Delta\mathbf{G_{eqSO32^-}}-2\mathbf{G_{H3O}}-G_{SO42^-}+(G_{SO32^-}+3\mathbf{G_{H2O}})=\mathbf{10,7600}-2*22,44-\mathbf{26,44996}+(\mathbf{60,56996}+3*0)=2*\mathbf{0}\ ^{kJ}/_{mol}$;

Formation $S_{romb}+2O_2{}^{gas}+2e^-=SO_4^{2-}$;

$\Delta G_{SO42^-}=G_{SO42^-}-(\mathbf{G}_{Sromb}+\mathbf{G}_{O2}{}^{gas}+2*G_{e^-})=\mathbf{26,44996}-(\mathbf{3,5436}+2*\mathbf{303,1}+2*\mathbf{94,841})=-744,5\ ^{kJ}/_{mol}$;

$2*G_{e^-}=G_{SO42^-}-(\mathbf{G}_{Sromb}+2*\mathbf{G}_{O2}{}^{gas}+\Delta G_{SO42^-})=\mathbf{26,44996}-(\mathbf{3,5436}+2*\mathbf{303,1}-744,5)=\mathbf{161,20636}=2*\mathbf{80,60318}\ ^{kJ}/_{mol}$;

$SO_3^{2-}+2OH^-=SO_4^{2-}+H_2O+2e^-$; pH>7; Classic standarta potenciāls $E°_{Classic}=-0,93$ V [17] , ūdens uzskaite $-0,0591/2*\log([H_2O])=0,0515$ un saistītā summa $\Delta E°=+0,10166-0,37239$ izteiksmē absolūtais potenciāls ir $E°_{SO32-OH}=E°_{classic}-0,0591/2*\lg([H_2O])+\Delta E°=-0,93-0,0591/2*\log(55,3)+0,10166-0,37239=\mathbf{-1,25223}$ V;

$E_{SO32-OH}=E°_{SO32-OH}+\frac{0.0591}{2}\bullet\log\frac{[SO_4^{2-}]\cdot[H_2O]}{[SO_3^{2-}]\cdot[OH^-]^2}=\mathbf{-1,252}\ V+\frac{0.0591}{2}\bullet\log\frac{[SO_4^{2-}]\cdot[H_2O]}{[SO_3^{2-}]\cdot[OH^-]^2}$

$\Delta G_{eqSO42-OH}=E°_{SO32-OH}\bullet F\bullet n=\mathbf{-1,25223}*96485*2=\mathbf{-241,6428}\ ^{kJ}/_{mol}$;

$\Delta G_{eqSO32-OH}=G_{SO42^-}+\mathbf{G_{H2O}}+2G_{e^-}-(G_{SO32^-}+2\mathbf{G_{OH}})=\mathbf{54,9256}+\mathbf{0}+2*\mathbf{0}-(\mathbf{141,8484}+2*77,36)=\mathbf{-241,6428}\ ^{kJ}/_{mol}$;

$G_{SO32^-}=G_{SO42^-}+\mathbf{G_{H2O}}+2G_{e^-}-(\Delta\mathbf{G_{eqSO32-OH}}+2\mathbf{G_{OH}})=\mathbf{54,9256}+\mathbf{0}+2*\mathbf{0}-(\mathbf{-241,6428}+2*77,36)=\mathbf{141,8484}\ ^{kJ}/_{mol}$;

$G_{SO42^-}=\Delta\mathbf{G_{eqSO32-OH}}-\mathbf{G_{H2O}}-2G_{e^-}+(G_{SO32^-}+2\mathbf{G_{OH}})=\mathbf{-241,6428}-\mathbf{0}-2*\mathbf{0}+(\mathbf{141,8484}+2*77,36)=\mathbf{54,9256}\ ^{kJ}/_{mol}$;

$2G_{e^-}=\Delta\mathbf{G_{eqSO32-OH}}-\mathbf{G_{H2O}}-G_{SO42^-}+(G_{SO32^-}+2\mathbf{G_{OH}})=\mathbf{-241,6428}-\mathbf{0}-\mathbf{54,9256}+(\mathbf{141,8484}+2*77,36)=2*\mathbf{0}\ ^{kJ}/_{mol}$;

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