
Opgave 1

Welke half-reactie kan men verwachten in de volgende gevallen?

- a Br⁻-ionen bij een positieve elektrode

Br⁻ kan gemakkelijk elektronen afstaan, is dan reductor: $2 \text{Br}^- \rightarrow \text{Br}_2 + 2 \text{e}^-$

- b H₃O⁺-ionen bij een negatieve elektrode

Een proton kan een elektron opnemen: $2 \text{H}_3\text{O}^+ + 2 \text{e}^- \rightarrow 2 \text{H}_2\text{O} + \text{H}_2(\text{g})$

- c Zn²⁺-ionen bij een negatieve elektrode

Metaalionen kunnen elektronen opnemen: $\text{Zn}^{2+} + 2 \text{e}^- \rightarrow \text{Zn}$

- d I₂-moleculen bij een negatieve elektrode

Jood wordt gemakkelijk jodide: $\text{I}_2 + 2 \text{e}^- \rightarrow 2 \text{I}^-$

Opgave 2

Wordt de elektrode positief of negatief, als steeds de volgende halfreactie aan de elektrode optreedt?

- a $\text{Mn}^{3+} + \text{e}^- \rightarrow \text{Mn}^{2+}$

Mn³⁺ neemt een elektron op van de elektrode, de elektrode wordt dus positief: +

- b $\text{O}_2(\text{g}) + 4 \text{H}_3\text{O}^+ + 4 \text{e}^- \rightarrow 6 \text{H}_2\text{O}$

O₂ neemt elektronen op uit de elektrode, de elektrode wordt dus positief: +

- c $\text{Mg}(\text{s}) \rightarrow \text{Mg}^{2+} + 2 \text{e}^-$

Magnesium geeft hier elektronen aan de elektrode, deze wordt dus negatief: -

- d $2 \text{S}_2\text{O}_3^{2-} \rightarrow \text{S}_4\text{O}_6^{2-} + 2 \text{e}^-$

Het thiosulfaation geeft hier elektronen aan de elektrode, deze wordt dus negatief: -

Opgave 3

De volgende reacties vinden plaats aan een elektrode. Is de betreffende elektrode een anode of kathode?

Anode: elektrode waar deeltjes geoxideerd worden.

Kathode: elektrode waar deeltjes gereduceerd worden.

- a $\text{PbSO}_4(\text{s}) + 2 \text{e}^- \rightarrow \text{Pb}(\text{s}) + \text{SO}_4^{2-}$

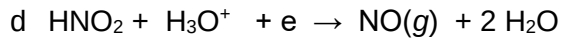
*Pb²⁺ in PbSO₄ wordt gereduceerd tot Pb. Reductie = **kathode***

- b $\text{Sn}(\text{s}) \rightarrow \text{Sn}^{2+} + 2 \text{e}^-$

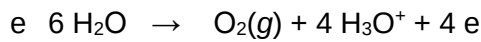
*Sn wordt geoxideerd tot Sn²⁺ Oxidatie = **anode***

- c $\text{Cr}^{3+} + \text{e}^- \rightarrow$

*Cr³⁺ wordt gereduceerd tot Cr²⁺ Reductie = **kathode***



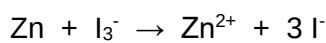
Stikstof in HNO_2 wordt gereduceerd (van +3 naar +2). Reductie = **kathode**



Zuurstof in H_2O wordt geoxideerd (van -2 naar 0). Oxidatie = **anode**

Opgave 4

Gegeven de volgende redoxreactie:



a Geef de halfreacties.

Zink wordt 2+ en geeft dus 2 e weg. Oxidatie aan de anode: $\text{Zn} \rightarrow \text{Zn}^{2+} + 2 e$

Jood ($\text{I}_3^- = \text{I}_2 + \text{I}^-$) gaat van 0 naar 1-. I_2 neemt dus 2 e op. Reductie aan de kathode: $\text{I}_3^- + 2 e \rightarrow 3 \text{I}^-$

b Bereken de standaardbronpotentiaal.

$$V_{\text{bron}} = V_k - V_a$$

$$V_k = 0,53 \text{ V} \quad \text{reductiepotentiaal voor: } \text{I}_3^- + 2 e \rightarrow 3 \text{I}^-$$

$$V_a = -0,76 \text{ V} \quad \text{aan de anode vindt de oxidatie plaats: } \text{Zn} \rightarrow \text{Zn}^{2+} + 2 e$$

*Omdat in de berekening van de bronspanning ($V_b = V_k - V_a$) al een min- teken staat voor de V_a , noteren we voor V_a de **reductiepotentiaal**: $V_a = +0,76 \text{ V}$*

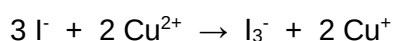
$$V_b = 0,53 - (-0,76) = \mathbf{+1,29 \text{ V}}$$

Maar je had dus ook kunnen stellen: $V_{\text{bron}} = V_k + V_a$

Met $V_k = 0,53 \text{ V}$ en $V_a = +0,76 \text{ V}$ zodat: $V_{\text{bron}} = 0,53 + 0,76 = 1,29 \text{ V}$

Opgave 5

Gegeven de volgende redoxreactie:



a Geef de halfreacties.

Aan de kathode vindt de reductie plaats $\text{Cu}^{2+} + e \rightarrow \text{Cu}^+$

Aan de anode de oxidatie: $3 \text{I}^- \rightarrow \text{I}_3^- + 2 e$

b Bereken de standaardbronpotentiaal.

$$V_{\text{bron}} = V_k - V_a$$

$$V_k = 0,15 \text{ V} \quad \text{reductiepotentiaal voor: } \text{Cu}^{2+} + e \rightarrow \text{Cu}^+$$

$$V_a = 0,53 \text{ V} \quad \text{aan de anode vindt de oxidatie plaats: } 3 \text{I}^- \rightarrow \text{I}_3^- + 2 e$$

Omdat in de bronspanning al een min- teken staat noteren we voor V_a de **reductiepotentiaal** voor: $\text{I}_3^- + 2 e \rightarrow 3 \text{I}^-$

$$V_b = 0,15 - (0,53) = \mathbf{-0,38 \text{ V}}$$

Opgave 6

Gegeven de volgende redoxreactie:



a Geef de halfreacties.

$$\text{Kathode: reductie. } \text{Ce}^{4+} + e \rightarrow \text{Ce}^{3+} \quad V_k = 1,44 \text{ V}$$

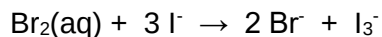
$$\text{Anode: oxidatie. } \text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + e \quad V_a = 0,68 \text{ V}$$

b Bereken de standaardbronpotentiaal.

$$V_b = 1,44 - 0,68 = \mathbf{+0,76 \text{ V}}$$

Opgave 7

Gegeven de volgende redoxreactie:



a Geef de halfreacties.

$$\text{Kathode: reductie. } \text{Br}_2 + 2 e \rightarrow 2 \text{Br}^- \quad V_k = 1,09 \text{ V}$$

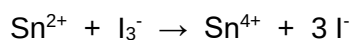
$$\text{Anode: oxidatie. } 3 \text{I}^- \rightarrow \text{I}_3^- + 2 e \quad V_a = 0,53 \text{ V}$$

b Bereken de standaardbronpotentiaal.

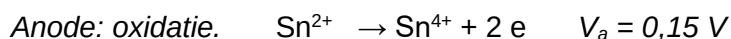
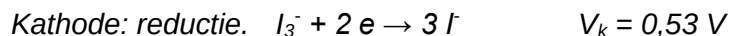
$$V_b = 1,09 - 0,53 = \mathbf{+0,56 \text{ V}}$$

Opgave 8

Gegeven de volgende redoxreactie:



a Geef de halfreacties.

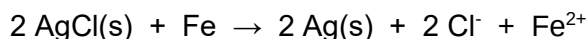


b Bereken de standaardbronpotentiaal.

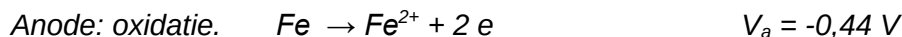
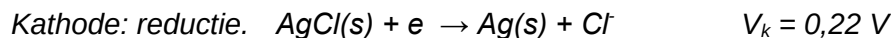
$$V_b = 0,53 - 0,15 = \mathbf{+0,38 \text{ V}}$$

Opgave 9

Gegeven de volgende redoxreactie:



a Geef de halfreacties.



b Bereken de standaardbronpotentiaal..

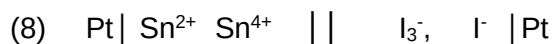
$$V_b = 0,22 - (-0,44) = \mathbf{+0,66 \text{ V}}$$

Opgave 10

Ga voor de opgaven 4 t/m 9 na of de voorgestelde reactie verloopt en geef in die gevallen de celnotatie, gebruik eventueel Pt als elektrode.



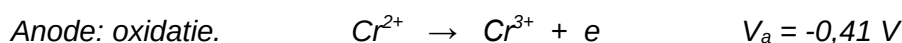
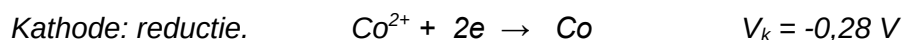
(5) reactie loopt niet. $V_b = -0,38 \text{ V}$ de reactie verloopt niet in de voorgestelde richting.



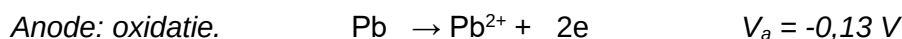
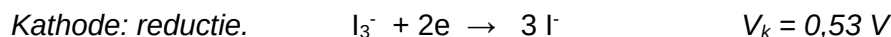


Opgave 11

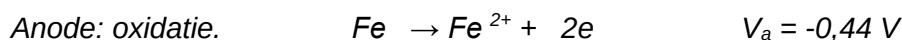
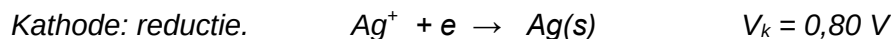
Geef de somreactie en bepaal de standaardbronpotentiaal van elk van de onderstaande galvanische cellen. Pt is alleen elektrodemateriaal en neemt niet deel aan de reacties.



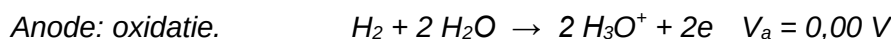
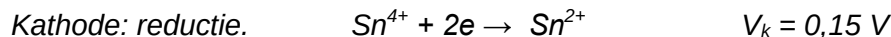
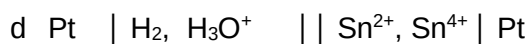
Somreactie:



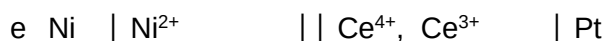
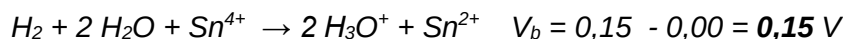
Somreactie:



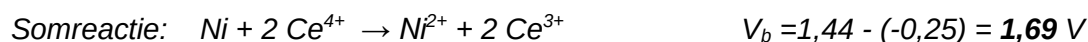
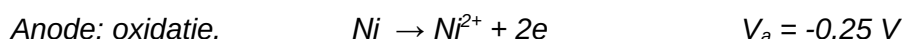
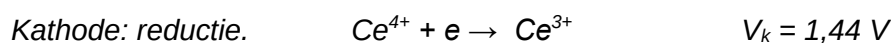
Somreactie:



Somreactie:

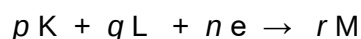


$c(\text{H}_2\text{SO}_4) = 1 \text{ mol/L}$



Opgave 12

Hoe luidt de wet van Nernst voor onderstaande reactie?



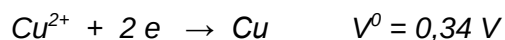
Concentraties boven de streep: de oxidatoren dus de deeltjes die gereduceerd worden.

$$V = V^0 + \frac{0,0591}{n} \log \frac{[K]^p \cdot [L]^q}{[M]^r}$$

Opgave 13

Bereken de elektrode-potentiaal (t.o.v. de standaardwaterstofelektrode) bij kamertemperatuur van de volgende halfcellen:

a Cu | CuCl₂ (0,0010 mol/L)



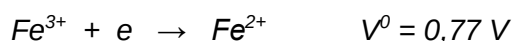
$$V = V^0 + \frac{0,0591}{2} \log \frac{[Cu^{2+}]}{1} \quad V = 0,34 + \frac{0,0591}{2} \log \frac{0,0010}{1} = \mathbf{0,25 V}$$

b Pb | Pb(NO₃)₂ (0,050 mol/L)



$$V = V^0 + \frac{0,0591}{2} \log \frac{[Pb^{2+}]}{1} \quad V = -0,13 + \frac{0,0591}{2} \log \frac{0,050}{1} = \mathbf{-0,17 V}$$

c Pt | FeCl₂ (0,050 mol/L), FeCl₃ (1,0 × 10⁻⁶ mol/L)



$$V = V^0 + \frac{0,0591}{1} \log \frac{[Fe^{3+}]}{[Fe^{2+}]} \quad V = 0,77 + \frac{0,0591}{1} \log \frac{1 \times 10^{-6}}{0,050} = \mathbf{0,49 V}$$

d Pt | [S₄O₆²⁻] = 0,0050 mol/L, [S₂O₃²⁻] = 1,0 × 10⁻⁵ mol/L)



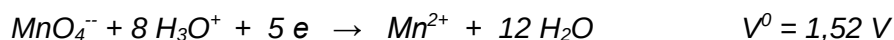
$$V = V^0 + \frac{0,0591}{2} \log \frac{[S_4O_6^{2-}]}{[S_2O_3^{2-}]^2} \quad V = 0,10 + \frac{0,0591}{2} \log \frac{0,0050}{(1 \times 10^{-5})^2} = \mathbf{0,33 \text{ V}}$$

e Pt | [I₃] = 0,010 mol/L, KI (0,50 mol/L)



$$V = V^0 + \frac{0,0591}{2} \log \frac{[I_3^-]}{[I^-]^3} \quad V = 0,53 + \frac{0,0591}{2} \log \frac{0,010}{0,50^3} = \mathbf{0,50 \text{ V}}$$

f Pt | [MnO₄⁻] = 5,0 × 10⁻⁵ mol/L; [Mn²⁺] = 0,010 mol/L, pH = 1,00



$$V = V^0 + \frac{0,0591}{5} \log \frac{[MnO_4^-] \times [H_3O^+]^8}{[Mn^{2+}]} \quad \text{pH} = 1,0 \text{ dus } [H_3O^+] = 0,10 \text{ mol/L}$$

$$V = 1,52 + \frac{0,0591}{5} \log \frac{5,0 \times 10^{-5} \times 0,10^8}{0,010} = \mathbf{1,40 \text{ V}}$$

g Pt | [Cr₂O₇²⁻] = 1,0 × 10⁻⁶ mol/L, [Cr³⁺] = 0,050 mol/L, pH = 2,00



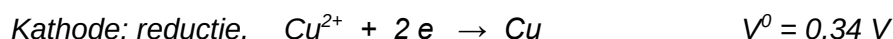
$$V = V^0 + \frac{0,0591}{6} \log \frac{[Cr_2O_7^{2-}] \times [H_3O^+]^{14}}{[Cr^{3+}]^2} \quad \text{pH} = 2,0 \text{ dus } [H_3O^+] = 0,010 \text{ mol/L}$$

$$V = 1,36 + \frac{0,0591}{6} \log \frac{1,0 \times 10^{-6} \times 0,01^{14}}{0,050^2} = \mathbf{1,05 \text{ V}}$$

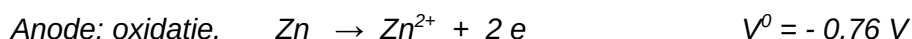
Opgave 14

Bereken de bronspanning van elk van de volgende galvanische cellen ($T = 298 \text{ K}$):

(de anodepotentiaal is steeds berekend als reductiepotentiaal en de bronspanning als verschil van reductiepotentialen: $V_b = V_k - V_a$)

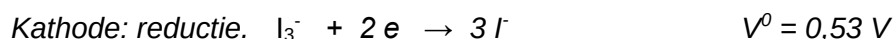
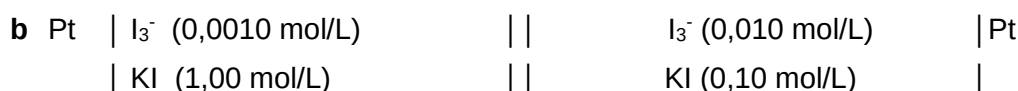


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Cu}^{2+}]}{1} \quad V = 0,34 + \frac{0,0591}{2} \log \frac{0,010}{1} = 0,281 \text{ V}$$

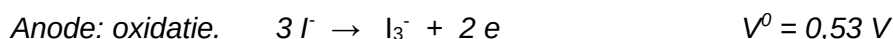


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Zn}^{2+}]}{1} \quad V = -0,76 + \frac{0,0591}{2} \log \frac{0,010}{1} = -0,819 \text{ V}$$

$$V_b = V_k - V_a \quad V_b = 0,281 - (-0,819) = \mathbf{1,10 \text{ V}}$$

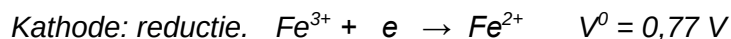
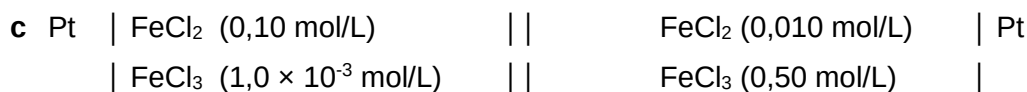


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{I}_3^-]}{[\text{I}^-]^3} \quad V = 0,53 + \frac{0,0591}{2} \log \frac{0,010}{0,1^3} = 0,560 \text{ V}$$

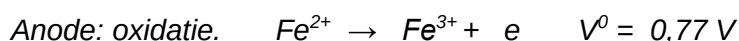


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{I}_3^-]}{[\text{I}^-]^3} \quad V = 0,53 + \frac{0,0591}{2} \log \frac{0,0010}{1^3} = 0,441 \text{ V}$$

$$V_b = V_k - V_a \quad V_b = 0,56 - 0,44 = \mathbf{0,12 \text{ V}}$$

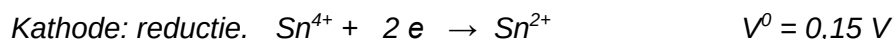
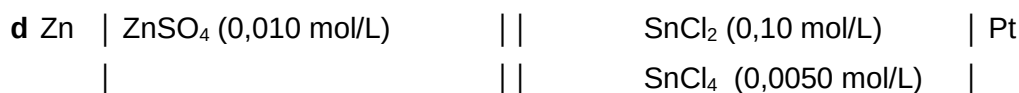


$$V = V^0 + \frac{0,0591}{1} \log \frac{[Fe^{3+}]}{[Fe^{2+}]} \quad V = 0,77 + \frac{0,0591}{1} \log \frac{0,50}{0,010} = 0,870 V$$

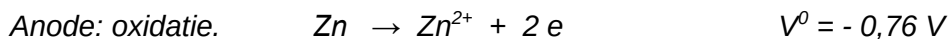


$$V = V^0 + \frac{0,0591}{1} \log \frac{[Fe^{3+}]}{[Fe^{2+}]} \quad V = 0,77 + \frac{0,0591}{1} \log \frac{0,0010}{0,10} = 0,652 V$$

$$V_b = V_k - V_a \quad V_b = 0,87 - 0,65 = \mathbf{0,22 V}$$



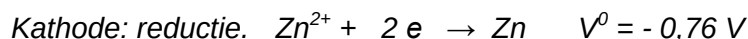
$$V = V^0 + \frac{0,0591}{2} \log \frac{[Sn^{4+}]}{[Sn^{2+}]} \quad V = 0,15 + \frac{0,0591}{2} \log \frac{0,0050}{0,10} = 0,112 V$$



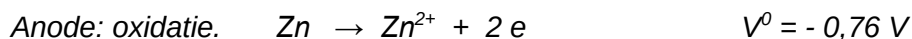
$$V = V^0 + \frac{0,0591}{2} \log \frac{[Zn^{2+}]}{1} \quad V = -0,76 + \frac{0,0591}{2} \log \frac{0,010}{1} = -0,819 V$$

$$V_b = V_k - V_a \quad V_b = 0,112 - (-0,819) = \mathbf{0,93 V}$$



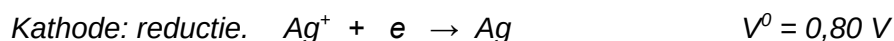
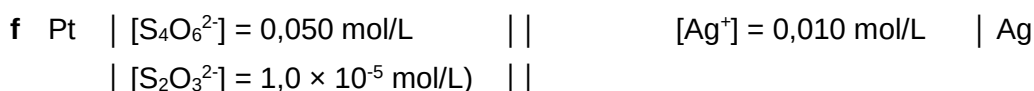


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Zn}^{2+}]}{1} \quad V = -0,76 + \frac{0,0591}{2} \log \frac{1,00}{1} = -0,76 \text{ V}$$

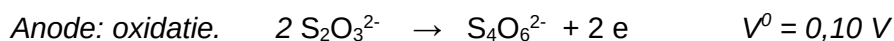


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Zn}^{2+}]}{1} \quad V = -0,76 + \frac{0,0591}{2} \log \frac{10^{-4}}{1} = -0,878 \text{ V}$$

$$V_b = V_k - V_a \quad V_b = 0,88 - (-0,76) = \mathbf{0,12 \text{ V}}$$

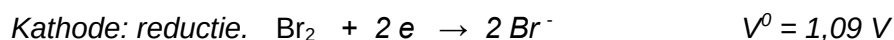
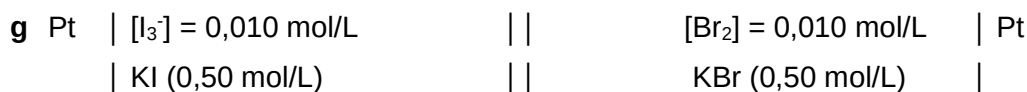


$$V = V^0 + \frac{0,0591}{1} \log \frac{[\text{Ag}^+]}{1} \quad V = 0,80 + \frac{0,0591}{1} \log \frac{0,010}{1} = 0,682 \text{ V}$$

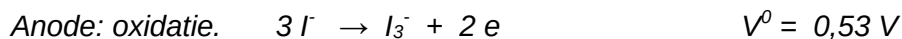


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{S}_4\text{O}_6^{2-}]}{[\text{S}_2\text{O}_3^{2-}]^2} \quad V = 0,10 + \frac{0,0591}{2} \log \frac{0,050}{(1 \times 10^{-5})^2} = 0,357 \text{ V}$$

$$V_b = V_k - V_a \quad V_b = 0,682 - 0,357 = \mathbf{0,33 \text{ V}}$$

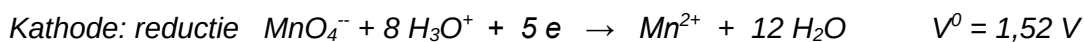
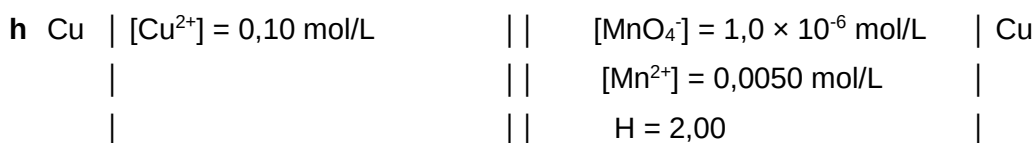


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Br}_2]}{[\text{Br}^-]^2} \quad V = 1,09 + \frac{0,0591}{2} \log \frac{0,010}{0,50^2} = 1,049 \text{ V}$$



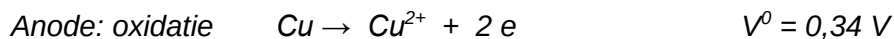
$$V = V^0 + \frac{0,0591}{2} \log \frac{[I_3^-]}{[I^-]^3} \quad V = 0,53 + \frac{0,0591}{2} \log \frac{0,010}{0,50^3} = 0,498 V$$

$$V_b = V_k - V_a \quad V_b = 1,049 - 0,498 = \mathbf{0,55 V}$$



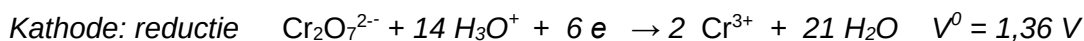
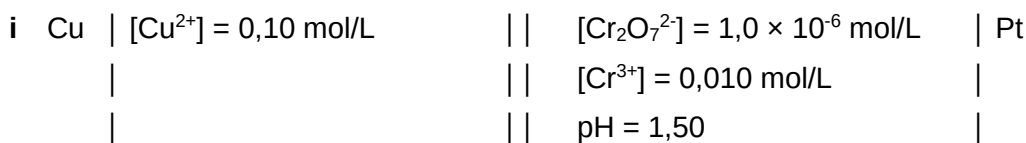
$$V = V^0 + \frac{0,0591}{5} \log \frac{[MnO_4^-] \times [H_3O^+]^8}{[Mn^{2+}]} \quad \text{pH} = 1,0 \text{ dus } [H_3O^+] = 0,10 \text{ mol/L}$$

$$V = 1,52 + \frac{0,0591}{5} \log \frac{10^{-6} \times 0,01^8}{0,005} = 1,287 V$$



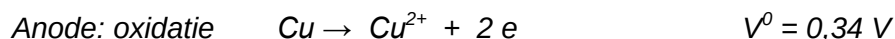
$$V = V^0 + \frac{0,0591}{2} \log \frac{[Cu^{2+}]}{1} \quad V = 0,34 + \frac{0,0591}{2} \log \frac{0,10}{1} = 0,3105 V$$

$$V_b = V_k - V_a \quad V_b = 1,287 - 0,3105 = \mathbf{0,98 V}$$



$$V = V^0 + \frac{0,0591}{6} \log \frac{[Cr_2O_7^{2-}] \times [H_3O^+]^{14}}{[Cr^{3+}]^2} \quad \text{pH} = 1,5 \blacktriangleright [H_3O^+] = 3,16 \times 10^{-2} \text{ mol/L}$$

$$V = 1,36 + \frac{0,0591}{6} \log \frac{10^{-6} \times (3,16 \times 10^{-2})^{14}}{0,010^2} = 1,133 V$$



$$V = V^0 + \frac{0,0591}{2} \log \frac{[Cu^{2+}]}{1} \quad V = 0,34 + \frac{0,0591}{2} \log \frac{0,10}{1} = 0,3105 V$$

$$V_b = V_k - V_a \quad V_b = 1,133 - 0,3105 = \mathbf{0,82 V}$$

Opgave 15

Hoeveel tijd is nodig om met $I = 0,500 A$ uit een koper(II)sulfaatoplossing, 500 mg koper neer te slaan?

$$q = I \times t$$

q : lading (C)

I : stroomsterkte (A)

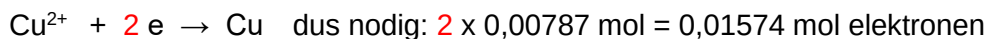
t : tijd (s)

$$n(e) = q / F$$

$n(e)$: hoeveelheid elektronen (mol)

F : Faradayconstante (96485 C/mol)

$$n = m / M \quad \blacktriangleright \quad 500 \text{ mg Cu is: } 0,500 \text{ g} / 63,55 \text{ g/mol} = 0,00787 \text{ mol Cu}$$



$$n(e) = q / F \quad \blacktriangleright \quad 0,01574 \text{ mol} = q / 96485 \text{ C/mol} \quad \blacktriangleright \quad q = 1518 \text{ C}$$

$$q = I \times t \quad \blacktriangleright \quad 1518 \text{ C} = 0,500 \text{ A} \times t \text{ (s)} \quad t = 3036 \text{ s} \quad \blacktriangleright \quad \mathbf{50,6 \text{ min}}$$

Of natuurlijk sneller: $n(e) = I \times t / F \quad 0,01574 = 0,5 \times t / 96485 \quad \blacktriangleright \quad t = 3036 \text{ s}$

Opgave 16

Hoeveel mg lood wordt elektrolytisch neergeslagen als men gedurende 10,0 minuten een stroom van 1,00 A door een lood(II)nitraatoplossing leidt?

$$n(e) = I \times t / F \quad \blacktriangleright \quad n(e) = 1,00 \text{ A} \times 600 \text{ s} / 96485 \text{ C/mol} = 0,006219 \text{ mol}$$

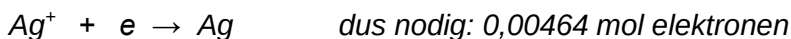


$$3,11 \text{ mmol Pb} = 3,11 \text{ mmol} \times 207,2 \text{ mg/mmol} = \mathbf{644 \text{ mg}}$$

Opgave 17

Hoe groot moet de stroomsterkte ten minste zijn om uit een zilvernitraatoplossing in 15,0 minuten 0,500 g zilver te winnen?

$$0,500 \text{ g Ag} = 0,500 \text{ g} / 107,9 \text{ g/mol} = 0,00464 \text{ mol Ag}$$



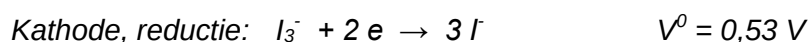
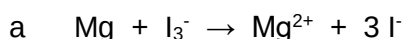
$$n(e) = I \times t / F \quad \blacktriangleright \quad 0,00464 = I \times 900 \text{ s} / 96485 \text{ C/mol} \quad \blacktriangleright \quad I = \mathbf{0,497 \text{ A}}$$

Opgave 18

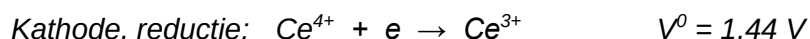
Tsja.. ontbrekende opgave.

Opgave 19

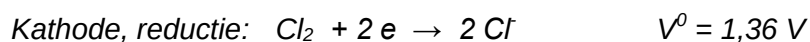
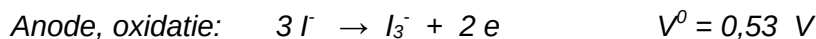
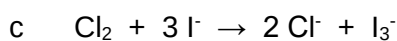
Hoe groot is de standaardbronpotentiaal voor een cel gebaseerd op elk van de volgende reacties?



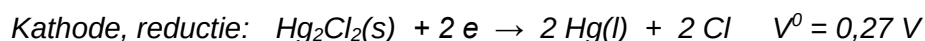
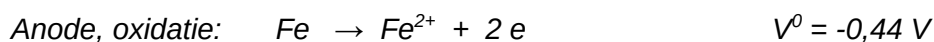
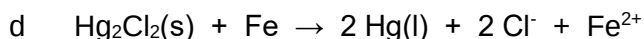
$$V_b = V_k - V_a \quad V_b = 0,53 - (-2,34) = \mathbf{2,87 \text{ V}}$$



$$V_b = V_k - V_a \quad V_b = 1,44 - 0,15 = \mathbf{1,29 \text{ V}}$$



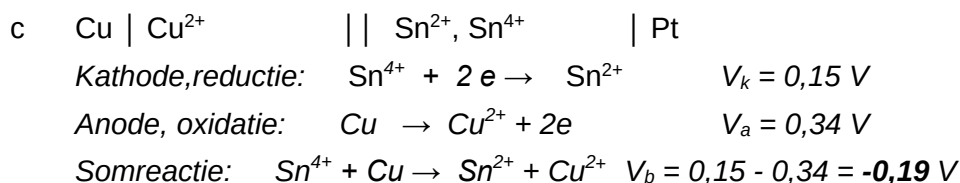
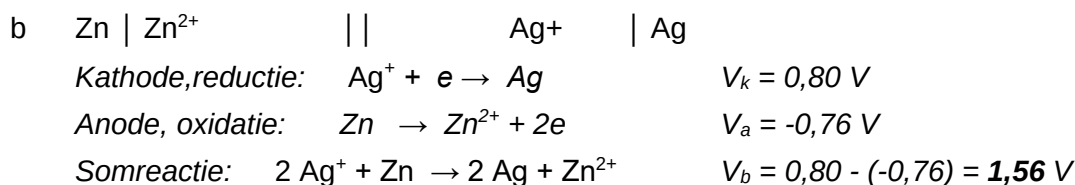
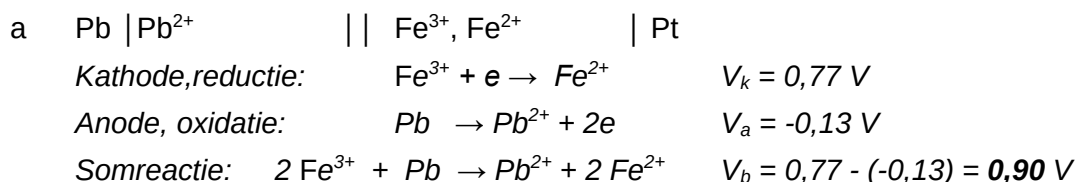
$$V_b = V_k - V_a \quad V_b = 1,36 - 0,53 = \mathbf{0,83 \text{ V}}$$



$$V_b = V_k - V_a \quad V_b = 0,27 - (-0,44) = \mathbf{0,71 \text{ V}}$$

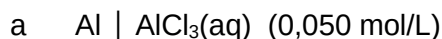
Opgave 20

Geef de somreactie en bepaal de standaardbronpotentiaal van elk van de volgende galvanische cellen:

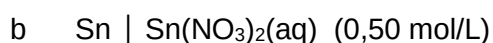


Opgave 21

Bereken de elektrode-potentiaal (t.o.v. de standaardwaterstofelektrode) bij kamertemperatuur van de volgende halfcellen:



$$V = V^0 + \frac{0,0591}{3} \log \frac{[\text{Al}^{3+}]}{1} \quad V = -1,66 + \frac{0,0591}{3} \log \frac{0,050}{1} = \mathbf{-1,69 \text{ V}}$$



$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Sn}^{2+}]}{1} \quad V = -0,14 + \frac{0,0591}{2} \log \frac{0,50}{1} = \mathbf{-0,15 \text{ V}}$$

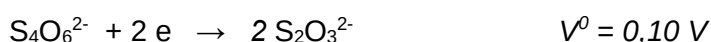
c Pt | HClO₃ (0,10 mol/L); Cl₂ (1,0 mol/L)



$$V = V^0 + \frac{0,0591}{10} \log \frac{[\text{ClO}_3^-]^2 \times [\text{H}_3\text{O}^+]^{12}}{[\text{Cl}_2]}$$

$$V = 1,47 + \frac{0,0591}{10} \log \frac{0,10^2 \times 0,10^{12}}{1,0} = \mathbf{1,39 \text{ V}}$$

d Pt | [S₄O₆²⁻] = 1,0 × 10⁻⁶ mol/L; [S₂O₃²⁻] = 0,020 mol/L

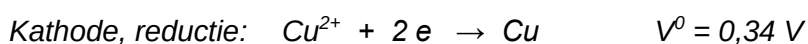


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{S}_4\text{O}_6^{2-}]}{[\text{S}_2\text{O}_3^{2-}]^2} \quad V = 0,10 + \frac{0,0591}{2} \log \frac{1,0 \times 10^{-6}}{0,020^2} = \mathbf{0,023 \text{ V}}$$

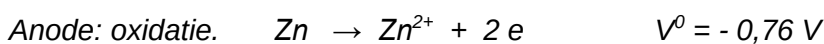
Opgave 22

Bereken de bronspanning van elk van de volgende galvanische cellen (*T* = 298 K):

a Zn | ZnSO₄(aq) 0,010 mol/L || CuSO₄(aq) (0,010 mol/L) | Cu



$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Cu}^{2+}]}{1} \quad V = 0,34 + \frac{0,0591}{2} \log \frac{0,010}{1} = 0,281 \text{ V}$$



$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Zn}^{2+}]}{1} \quad V = -0,76 + \frac{0,0591}{2} \log \frac{0,010}{1} = -0,819 \text{ V}$$

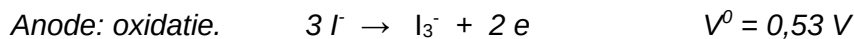
$$V_b = V_k - V_a \quad V_b = 0,281 - (-0,819) = \mathbf{1,10 \text{ V}}$$

(Beide halfcellen hebben 0,01 mol/L, uitwisseling 2 e. Je kan daarom ook meteen stellen: $V_b = V_k - V_a \quad V_b = 0,34 - (-0,76) = 1,10 \text{ V}$.)

b Pt | I₃⁻ (0,0500 mol/L) || I₃⁻ (0,010 mol/L) | Pt
 | KI (0,0020 mol/L) || KI (0,0010 mol/L) |

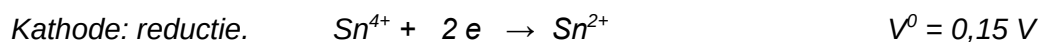
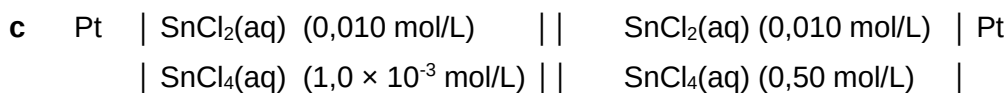


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{I}_3^-]}{[\text{I}^-]^3} \quad V = 0,53 + \frac{0,0591}{2} \log \frac{0,010}{0,001^3} = 0,737 \text{ V}$$

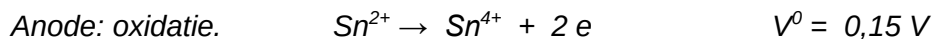


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{I}_3^-]}{[\text{I}^-]^3} \quad V = 0,53 + \frac{0,0591}{2} \log \frac{0,050}{0,002^3} = 0,731 \text{ V}$$

$$V_b = V_k - V_a \quad V_b = 0,737 - 0,731 = \mathbf{0,006 \text{ V}}$$

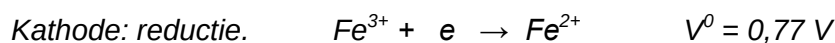
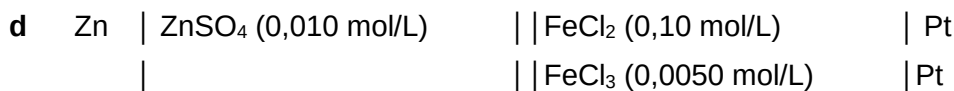


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Sn}^{4+}]}{[\text{Sn}^{2+}]} \quad V = 0,15 + \frac{0,0591}{2} \log \frac{0,50}{0,010} = 0,20 \text{ V}$$

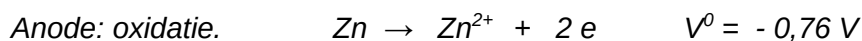


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Sn}^{4+}]}{[\text{Sn}^{2+}]} \quad V = 0,15 + \frac{0,0591}{2} \log \frac{1,0 \times 10^{-3}}{0,010} = 0,12 \text{ V}$$

$$V_b = V_k - V_a \quad V_b = 0,20 - 0,12 = \mathbf{0,08 \text{ V}}$$

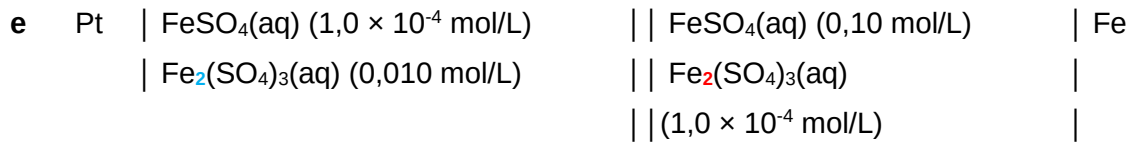


$$V = V^0 + \frac{0,0591}{1} \log \frac{[\text{Fe}^{3+}]}{[\text{Fe}^{2+}]} \quad V = 0,77 + \frac{0,0591}{1} \log \frac{0,0050}{0,10} = 0,693 \text{ V}$$

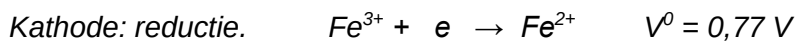


$$V = V^0 + \frac{0,0591}{2} \log \frac{[\text{Zn}^{2+}]}{[\text{Zn}]} \quad V = -0,76 + \frac{0,0591}{2} \log \frac{0,010}{1} = -0,819 \text{ V}$$

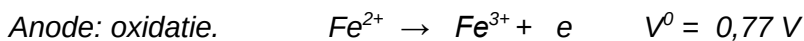
$$V_b = V_k - V_a \qquad V_b = 0,693 - (-0,819) = \mathbf{1,51 \text{ V}}$$



1 mol $Fe_2(SO_4)_3$ levert 2 mol Fe^{3+}



$$V = V^0 + \frac{0,0591}{1} \log \frac{[\text{Fe}^{3+}]}{[\text{Fe}^{2+}]} \quad V = 0,77 + \frac{0,0591}{1} \log \frac{2,0 \times 10^{-4}}{0,10} = 0,610 \text{ V}$$



$$V = V^0 + \frac{0,0591}{1} \log \frac{[\text{Fe}^{3+}]}{[\text{Fe}^{2+}]} \quad V = 0,77 + \frac{0,0591}{1} \log \frac{0,020}{1,0 \times 10^{-4}} = 0,906 \text{ V}$$

$$V_b = V_k - V_a \qquad V_b = 0,610 - 0,906 = - \mathbf{0,30 \text{ V}}$$

Opgave 23

Hoeveel tijd is nodig om met $I = 1,500 \text{ A}$ uit een cadmiumsulfaatoplossing, 500 mg cadmium neer te slaan?

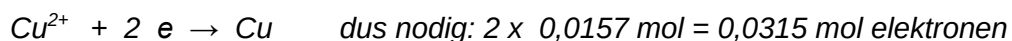
$$q = I \times t \qquad n(e) = q / F \qquad n(e) = I \times t / F$$

$n = m / M$ ► 500 mg Cd is: $0,500 \text{ g} / 112,4 \text{ g/mol} = 0,00445 \text{ mol Cd}$
 $\text{Cd}^{2+} + 2 \text{e} \rightarrow \text{Cd}$ dus nodig: $2 \times 0,00445 \text{ mol} = 0,00890 \text{ mol elektronen}$
 $n(\text{e}) = I \times t / F$ $0,00890 = 1,5 \times t / 96485$ ► $t = 572 \text{ s}$ ► **9,5 min**

Opgave 24

Hoe groot moet de stroomsterkte ten minste zijn om uit een kopersulfaatoplossing in 15,0 minuten 1,00 g koper te winnen?

$$1,00 \text{ g Cu} = 1,00 \text{ g} / 63,55 \text{ g/mol} = 0,0157 \text{ mol Cu}$$



$$n(e) = I \times t / F \quad \blacktriangleright \quad 0,0315 = I \times 900 \text{ s} / 96485 \text{ C/mol} \quad \blacktriangleright \quad I = \mathbf{3,38 \text{ A}}$$