Keemia lahtine võistlus
Noorem rühm (9. ja 10. klass)
Tallinn, Tartu, Kuressaare, Narva, Pärnu, Kohtla-Järve 5. november 2005. a

1. a) i) m(võluaine) = 5450 cm^3·1,5 g/cm^3·0,0545 = 445,5 g ≈ **450 g**

ii) 0,5 = $\frac{445{,}5\ \text{g}}{445{,}5\ \text{g} + m(H_2O)}$

222,75 + 0,5 $m(H_2O)$ = 445,5 g

$m(H_2O)$ = $\frac{222{,}75}{0{,}5}$ = 445,5 g ≈ **450 g**

b) i) %(võluaine) = $\frac{400\ \text{cm}^3 \cdot 1{,}5\ \text{g/cm}^3 \cdot 0{,}47}{400\ \text{cm}^3 \cdot 1{,}5\ \text{g} + 348\ \text{g}} \cdot 100$ = 29,7 ≈ **30**

ii) Violetne → sinine → helesinine → roheline

c) Lahus muutub oranžist kollaseks, sest osa vett aurustub ja võluaine protsendiline sisaldus suureneb.

d) i) %(võluaine) = $\frac{540\ \text{cm}^3 \cdot 1{,}5\ \text{g/cm}^3 \cdot 0{,}05 + 435\ \text{g} \cdot 0{,}42}{540\ \text{cm}^3 \cdot 1{,}5\ \text{g/cm}^3 + 435} \cdot 100$ =17,9≈ **18**

ii) Punane, sinine ja kollane

iii) Reaalses maailmas punase ja sinise värvi segamine annab violetse värvi.

2. a) X – C, süsinik
Y – O, hapnik
Z – N, lämmastik
Q – H, vesinik

b) M(hemoglobiin) = 14,00674 g/mol · 780 mol/mol · $\frac{1}{0{,}164012}$ = **66631 g/mol**

c) i) M(A) = 16 g/mol · 2 = **32 g/mol**

%(**B**) =100–54,6550–20,9383–16,4012–7,2852–0,3850 = 0,3353

m(**B**) = 66631 g · 0,003353 = 223,414 g

VIII B rühma elemendi saame siis, kui võtta n = 4 mol

M(B) = 223,414 g · $\frac{1}{4\ \text{mol}}$ ≈ **55,85 g/mol**

ii) A – S, väävel
B – Fe, raud

d) n(C) = 1 mol · 6631 g/mol · 0,546550 · 1 mol/12,011 g ≈ 3032 mol
n(O) = 1 mol · 6631g/mol · 0,209383 · 1 mol/15,9994 g ≈ 872 mol
n(H) = 1 mol · 6631 g/mol · 0,072852 · 1 mol/1,00794 g ≈ 4816 mol
n(S) = 1 mol · 6631 g/mol · 0,003850 · 1 mol/32,066 g ≈ 8 mol

$C_{3032}H_{4816}O_{872}N_{780}S_8Fe_4$

e) $V(O_2,\text{seotud}) = 140\ g \cdot \frac{1\,mol}{66631\,g} \cdot 4\ mol/mol \cdot 25{,}4\ dm^3/mol \cdot 1000\ cm^3/dm^3 =$

$= 213{,}6\ cm^3 \approx 214\ cm^3$

$V(O_2$, maksimaalne) = 214 cm^3 + 2 cm^3 = **216 cm^3**

3. a) **A** – H_2O, vesinikoksiid, vesi
B – CO_2, süsinikdioksiid
D – CO, süsinikmonooksiid
G – C, süsinik

b) i) $Al_4C_3 + 12H_2O = 4Al(OH)_3 + 3CH_4$

ii) $CH_4 + 2O_2 \xrightarrow{{}^0t^0t} 2H_2O + CO_2$

iii) $CH_4 + H_2O \xrightarrow{{}^0t^0t} 3H_2 + CO$

iv) $CH_4 + 2H_2O \xrightarrow{{}^0t^0t} 4H_2 + CO_2$

v) $CH_4 = 2H_2 + C$

vi) $C + O_2 = CO_2$

vii) $C + CO_2 \xrightarrow{{}^0t^0t} 2CO$

viii) $Fe_3O_4 + 4CO \xrightarrow{{}^0t^0t} 3Fe + 4CO_2$

ix) $CuO + C \xrightarrow{{}^0t,p} CO + Cu$

x) $CO + 2H_2 \xrightarrow{kat} CH_3OH$

4. a) **A** – K, kaalium
B – O_2, hapnik
D – $KHCO_3$, kaaliumvesinikkarbonaat
E – KOH, kaaliumhüdroksiid (56,1 g/mol)
G – H_2O, vesi (vesinikoksiid)
X – KO_2, kaaliumsuperoksiid (kaaliumdioksiid)
Y – K_2O_2, kaaliumperoksiid
Z – K_2O, kaaliumoksiid
Q – H_2O_2, vesinikperoksiid

b) i) $4KO_2 + 2H_2O + 4CO_2 = 4KHCO_3 + 3O_2$

ii) $2KO_2 = K_2O_2 + O_2$

iii) $2KO_2 + 4H_2O = 3H_2O_2 + 2KOH$

iv) $K_2O_2 + 2H_2O = 2KOH + H_2O_2$

v) $K_2O + H_2O = 2KOH$

vi) $2H_2O_2 = 2H_2O + O_2$

5. a) M(**F**) – M(**E**) = 32 g/mol

$\frac{M(Y)}{0,29} - \frac{M(Y)}{0,392}$ = 32 g/mol

M(Y) = $\frac{32\ g/mol}{1/0,29 - 1/0,392} = \frac{32\ g/mol}{3,45 - 2,55}$ = **35,5 g/mol**

Y – Cl, kloor

b) i) M(E) = $\frac{35,5\ g/mol}{0,392}$ = **90,5 g/mol**

ii) M(F) = $\frac{35,5\ g/mol}{0,29}$ = 122,5 g/mol ≈ **123 g/mol**

c) X – Cl_2, kloor

A – H_2, vesinik

B – HCl, vesinikkloriid

C – HClO, hüpokloorishape

D – KCl, kaaliumkloriid

E – KClO, kaaliumhüpoklorit

F – $KClO_3$, kaaliumkloraat

d) i) $H_2 + Cl_2 = 2HCl$

ii) $Cl_2 + H_2O = HCl + HClO$

iii) $2KOH + Cl_2 = KCl + KClO + H_2O$

iv) $6KOH + 3Cl_2 = 5KCl + KClO_3 + 3H_2O$

6. a) i) Y – Na, naatrium (värvib leegi kollaseks)

ii) A – I_2, jood

b) i) $IO_x^- + nI^- + 2xH^+ = \frac{n+1}{2} \cdot I_2 + xH_2O$

ii) $I^{+n} + ne^- = I^0$ | 1

$I^- - e^- = I^0$ | n

c) i) $2S_2O_3^{2-} + I_2 = S_4O_6^{2-} + 2I^-$

II 2,5

ii) $2S_2O_3^{2-} - 2e^- = S_4O_6^{2-}$ | 1

$I_2 + 2e^- = 2I^-$ | 1

d) Et $NaIO_x$ annab neutraalse lahuse, siis HIO_x peab olema tugev hape, milleks saab olla kas HIO_3 või HIO_4.

$n(I_2) = \frac{1}{2} \cdot 0{,}03077\ dm^3 \cdot 0{,}65\ mol/dm^3 = 0{,}01000\ mol$

$m(NaIO_x) = 10{,}35\ cm^3 \cdot 1{,}034\ g/cm^3 \cdot 0{,}05 = 0{,}535\ g$

Kui võrrandis **b) i)** iooniks on $^{V}IO_3^-$, siis $nI^- = 5I^-$ ja $\frac{5+1}{2} \cdot I_2 = 3I_2$, mis annab vastavuse $IO_3^- \Leftrightarrow 3I_2$. Sellisel juhul $n(IO_3^-) = \frac{1}{3} \cdot 0{,}01\ mol = 0{,}00333\ mol$ ja $M(NaIO_3)$, määratud) = $\frac{0{,}535\ g}{0{,}0033\ mol} \approx 161\ g/mol$. See pole kooskõlas tabeli $M(NaIO_3) = 198\ g/mol$. Kui iooniks on $^{VII}IO_4^-$, siis $nI^- = 7I^-$ ja $\frac{7+1}{2} \cdot I_2 = 4I_2$, mis annab vastavuse $IO_4^- \Leftrightarrow 4I_2$. Sellisel juhul $n(IO_4^-) = \frac{1}{4} \cdot 0{,}01\ mol = 0{,}0025\ mol$ ja

$M(NaIO_4$, määratud) = $\frac{0{,}535\ g}{0{,}0025\ mol}$ = **214 g/mol**, mis on kooskõlas tabeli andmetega.

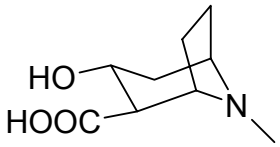
Keemia lahtine võistlus
Vanem rühm (11. ja 12. klass)
Tallinn, Tartu, Kuressaare, Narva, Pärnu, Kohtla-Järve 5. november 2005. a

1. a) Amino-, ester-, eeterrühmad

b) CH_3COOH

c) Estri hüdrolüüs

d) Estri hüdrolüüsi tulemusena tekivad C_6H_5COOH, CH_3OH ning



e) $C_6H_5COOCH_3$

f) Metüülbensoaat.

g) Kokaiini hüdrolüüsil tekkinud produktid reageerivad edasi omavahel, esterifikatsiooni tulemusena tekibki aine **B**.

2. a) (-)Ni | $Ni(NO_3)_2$ lahus | | $AgNO_3$ lahus | **Ag(+)**

b) $Ni + 2AgNO_3 = Ni(NO_3)_2 + 2Ag$

c) i) $\mathbf{E(Ag^+/Ag)} = 0{,}799\ V + 0{,}059\ V \cdot \log 0{,}300 = \mathbf{0{,}768\ V}$

$\mathbf{E(Ni^{2+}/Ni)} = -0{,}250\ V + \frac{0{,}059\ V}{2} \cdot \log 0{,}200 = \mathbf{-0{,}271\ V}$

ii) E = 0,768 – (-0,271) = **1,039 V**

$n(e^-) = 2{,}68 A \cdot h \cdot 3600\ s/h \cdot \frac{1\ mol}{96485\ A \cdot s} = 0{,}100\ mol$

d) $1\ Ni \Leftrightarrow 2e^-$ $n(Ni^{2+}) = 0{,}200 + 0{,}100/2 = 0{,}250\ M$

$1\ Ag^+ \Leftrightarrow 1\ e^-$ $n(Ag^+) = 0{,}300 - 0{,}100 = 0{,}200\ M$

e) i) $\mathbf{E(Ag^+/Ag)} = 0{,}799 + 0{,}059 \log 0{,}200 = \mathbf{0{,}758\ V}$

$\mathbf{E(Ni^{2+}/Ni)} = -0{,}250 + (0{,}059/2) \cdot \log 0{,}250 = \mathbf{-0{,}268\ V}$

ii) E = 0,758 – (-0,268) = **1,026 V**

3. a) i) $\lambda(^{14}C) = \frac{\ln 2}{T_{1/2}} = \frac{0{,}6931}{5730\ aastat} \cdot \frac{1\ aasta}{365\ päeva} \cdot \frac{1\ päev}{24\ tundi} \cdot \frac{1\ tund}{3600\ s} = \mathbf{3{,}83 \cdot 10^{-12}\ s}$

ii) $\lambda(^{40}K) = \frac{\ln 2}{T_{1/2}} = \frac{0{,}6931}{1{,}277 \cdot 10^9 \text{ aastat}} \cdot \frac{1 \text{ aasta}}{365 \text{ päeva}} \cdot \frac{1 \text{ päev}}{24 \text{ tundi}} \cdot \frac{1 \text{ tund}}{3600 \text{ s}}$ = **$1{,}72 \cdot 10^{-17}$ s**

b) i) $N(^{14}C) = \frac{12 \cdot 36 \text{ g} \cdot 6{,}02 \cdot 10^{23} \text{ mol}^{-1} \cdot 0{,}0000000000012}{(12{,}0 \cdot 12 + 1{,}0 \cdot 22 + 16{,}0 \cdot 11) \text{ g/mol}^{-1}}$ = $9{,}1 \cdot 10^{11}$ aatomit

$\alpha(^{14}C) = N \cdot \alpha = 9{,}1 \cdot 10^{11} \cdot 3{,}83 \cdot 10^{-12} \text{ s}^{-1}$ = **3,5 dps**

ii) $N(^{40}K) = \frac{0{,}602 \text{ g} \cdot 6{,}02 \cdot 10^{23} \text{ mol}^{-1} \cdot 0{,}000117}{39{,}1 \text{ g} \cdot \text{mol}^{-1}}$ = $1{,}08 \cdot 10^{18}$ aatomit

$\alpha(^{40}K) = N \cdot \alpha = 1{,}08 \cdot 10^{18} \cdot 1{,}72 \cdot 10^{-17} \text{ s}^{-1}$ = **18,7 dps**

iii) $\alpha(^{14}C) + \alpha(^{40}K)$ = 22,2 dps ≈ **22,2 dps**

4. a) M(A) = $\frac{0{,}474}{n} \cdot 135{,}0 \text{ g/mol} = \frac{64{,}0}{n} \text{ g/mol}$, kui n = 2, siis M(**A**) = 32 g/mol

I II

B – S_2Cl_2 , **C** – SCl_2

b) A – S **G** – SO_2

B – S_2Cl_2 **H** – $SOCl_2$

C – SCl_2 **I** – HCl

D – NaCl **J** – SO_3

E – SF_4 **K** – HSO_3F

F – S_4N_4 **L** – H_2SO_4

c) i) $2S + Cl_2 = S_2Cl_2$

ii) $S_2Cl_2 + Cl_2 \rightleftharpoons 2SCl_2$

iii) $3SCl_2 + 4NaF = S_2Cl_2 + SF_4 + 4NaCl$

iv) $6SCl_2 + 16NH_3 = S_4N_4 + 12NH_4Cl + 2S$

v) $S + O_2 = SO_2$

vi) $SO_2 + COCl_2 = CO_2 + SOCl_2$

vii) $2SO_2 + S_2Cl_2 + 3Cl_2 = 4SOCl_2$

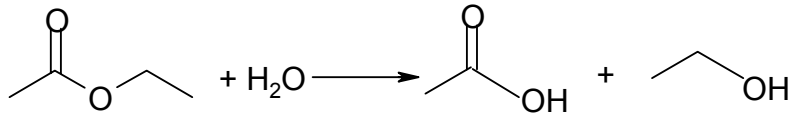
viii) $SOCl_2 + H_2O = SO_2 + 2HCl$

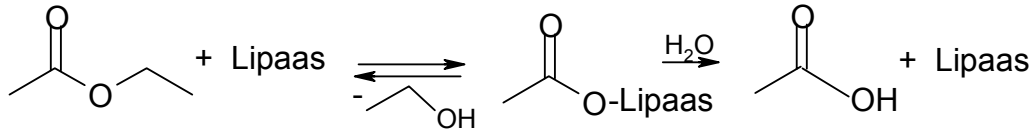
ix) $2SO_2 + O_2 \xrightarrow{\text{kat}} 2SO_3$

x) $SO_3 + HF(\text{gaas}) = HSO_3F$

xi) $HSO_3F + H_2O = H_2SO_4 + HF$

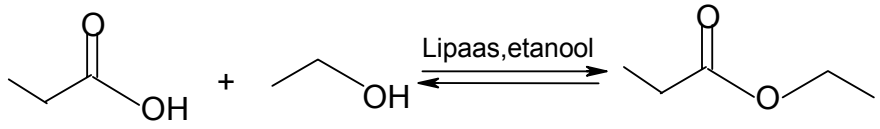
5. 1)



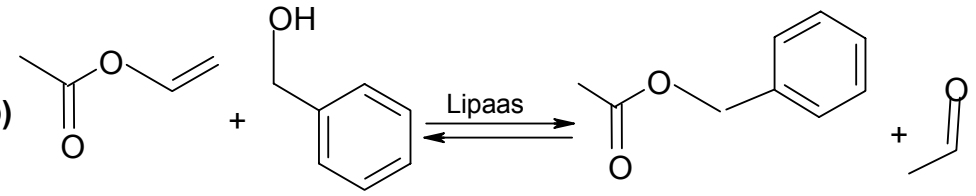


Näide on etüülatsetaadiga, aga sobib ka iga teine ester.

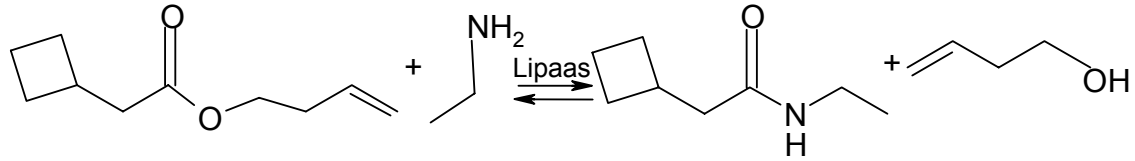
2) a)



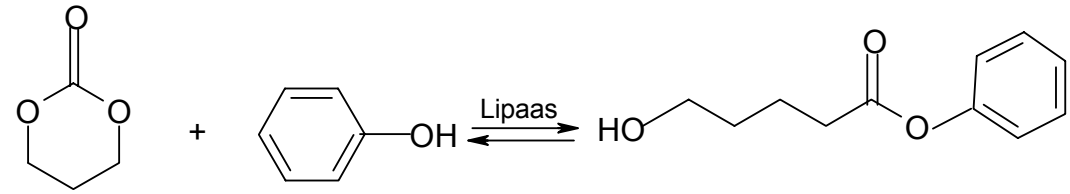
b)



c)



d)



6. a) A – Fe_2O_3, raud(III)oksiid

B – Fe_3O_4, triraudtetraoksiid

C – FeO, raud(II)oksiid

X – CO, süsinikmonooksiid

Y – CO_2, süsinikdioksiid

koks – C , süsinik

lubjakivi – $CaCO_3$, kaltsiumkarbonaat

räbu – $CaSiO_3$, kaltsiumsilikaat

b) i) $C + O_2 = CO_2$

$t^0 t^0$

ii) $CO_2 + C = 2CO$

$t^0 t^0$

iii) $CaCO_3 = CaO + CO_2$

iv) $CaO + SiO_2 = CaSiO_3$

c) $\Delta H_r(C \rightarrow CO_2) = -397268\ J/mol \cdot 500\ kg \cdot \frac{1000\ g}{1\ kg} \cdot \frac{1\ mol}{12\ g} = -1{,}65528 \cdot 10^{10}\ J \approx$

$\approx \mathbf{-1{,}66 \cdot 10^{10}\ J}$

d) $\Delta H_f(CO) = \frac{1}{2} \cdot (-1{,}655 \cdot 10^{10} - 6{,}93 \cdot 10^9)\ J \cdot \frac{12\ g}{1\ mol} \cdot \frac{1}{500\ kg} \cdot \frac{1\ kg}{1000\ g} =$

$= -1{,}15 \cdot 10^5\ J/mol = \mathbf{-115\ kJ/mol}$

e) i) $3Fe_2O_3(t) + CO(g) = 2Fe_3O_4(t) + CO_2(g)$ $\quad \Delta H_r = 19090\ J$

ii) $FeO(t) + CO(g) = Fe(t) + CO_2(g)$ $\quad \Delta H_r = -39597\ J$

iii) $Fe_2O_3(t) + 3CO(g) = 2Fe(t) + 3CO_2(g)$ $\quad \Delta H_r = -83535\ J$

f) $2Fe_3O_4 + CO_2 = 3Fe_2O_3 + CO$ $\quad -19090\ J$ $\quad \cdot 0{,}5$

$Fe_2O_3 + 3CO = 2Fe + 3CO_2$ $\quad -83535\ J$ $\quad \cdot 1{,}5$

$Fe + CO_2 = FeO + CO$ $\quad +39597\ J$ $\quad \cdot 3$

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i) $Fe_3O_4 + 0{,}5CO_2 + 1{,}5Fe_2O_3 + 4{,}5CO + 3Fe + 3CO_2 =$

$= 1{,}5\ Fe_2O_3 + 0{,}5\ CO + 3Fe + 4{,}5CO_2 + 3FeO + 3CO$

$[0{,}5 \cdot (-19090) - 1{,}5 \cdot 83535 + 3 \cdot 39597]J = \mathbf{-16057\ J}$

ii) $Fe_3O_4(t) + CO(g) = 3FeO(t) + CO_2$ $\quad (\Delta H_r = \mathbf{-16057\ J})$