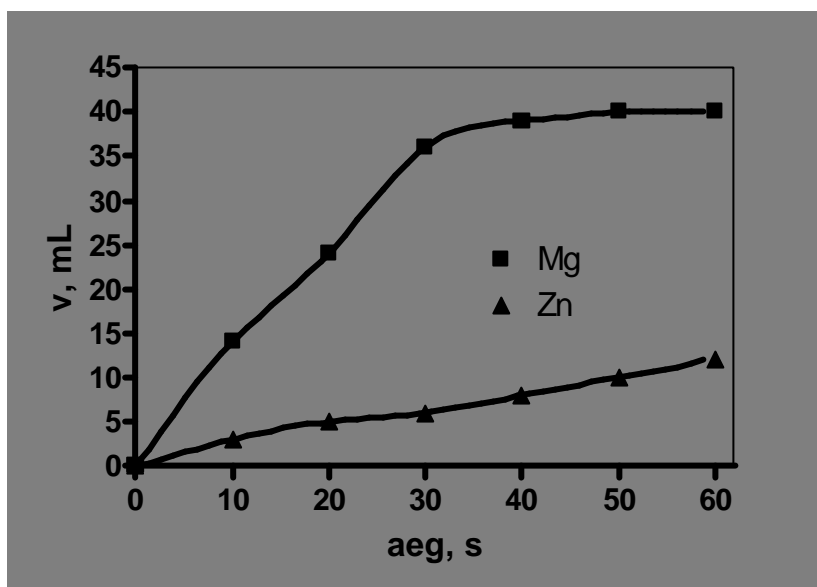


KEEMIAÜLESANNETE LAHENDAMISE LAHTINE VÕISTLUS

Noorem rühm (9. ja 10. klass)

Tallinn, Tartu, Kuressaare, Narva, Pärnu, Kohtla-Järve 5. november 2011

Ülesannete lahendused



1. a)



c) Mg, kuna Mg on aktiivsem metall kui Zn.

d) Mg, kuna vesiniku hulk pärast 50 sekundit enam ei suurene.

e) Saab arvutada vaid Mg andmete järgi.

$$m(\text{Mg}) = 0,04 \text{ L} \cdot \frac{1 \text{ mol}}{22,4 \text{ L}} \cdot \frac{24,3 \text{ g}}{1 \text{ mol}} = 0,04 \text{ g}$$

$$14,01 \cdot 2$$

2. a) X – NH_4NO_2 ($\frac{14,01 \cdot 2 + 1.008 \cdot 4 + 16,00 \cdot 2}{14,01 \cdot 2 + 1.008 \cdot 4 + 16,00 \cdot 2} = 0,437$) ammooniumnitrit

A – N – lämmastik

B – N_2 – lämmastik

C – H_2O – vesi (divesinikoksiid)

D – O_2 – hapnik

E – NO – (mono)lämmastikmonooksiid

F – NO_2 – (mono)lämmastikdioksiid

G – HNO_3 – lämmastikhape

H – HNO_2 – lämmastikushape

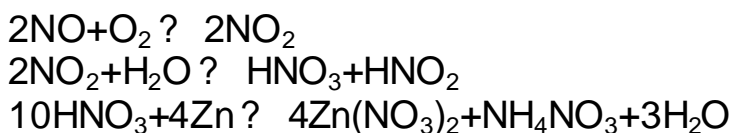
Y – $\text{Zn}(\text{NO}_3)_2$ – tsinknitraat

$$14,01 \cdot 2$$

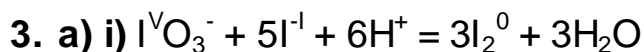
Z – NH_4NO_3 ($\frac{14,01 \cdot 2}{14,01 \cdot 2 + 1.008 \cdot 4 + 16,00 \cdot 3} = 0,350$)
ammooniumnitraat

b) $\text{NH}_4\text{NO}_2 ? \text{N}_2 + 2\text{H}_2\text{O}$

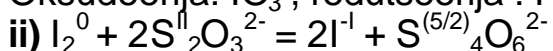
$\text{N}_2 + \text{O}_2 ? 2\text{NO}$



c) **G** (lämmastikhape) on tugevam, sest nitraatanioon on stabiilsem kui nitrit-
 anioon, kuna esimesel on rohkem resonsantsi piirstruktuure ning
 negatiivne laeng on laiali määratud üle rohkemate hapniku aatomite.



Oksüdeerija: IO_3^- , redutseerija: I^-



Oksüdeerija: I_2 , redutseerija $\text{S}_2\text{O}_3^{2-}$

b) KI lisati lahusele üleliias:

$$n(\text{KI}) = c(\text{KI}) \cdot V(\text{KI}) = 1.0\text{M} \cdot 0.005\text{L} = 0.005\text{mol}$$

$$n(\text{KIO}_3) = c(\text{KIO}_3) \cdot V(\text{KIO}_3) = 0.0120\text{M} \cdot 0.0250\text{L} = 0.000300\text{mol}$$

$$5 \cdot n(\text{KIO}_3) < n(\text{KI})$$

KIO_3 lisamisel lahuses tekkinud I_2 hulk:

$$n(\text{I}_2) = 3 \cdot c(\text{KIO}_3) \cdot V(\text{KIO}_3) = 3 \cdot 0.0120\text{M} \cdot 0.0250\text{L} = 0.000900\text{mol}$$

Tiitritud I_2 hulk:

$$n(\text{I}_2 \text{ tiitritud}) = 0.5 \cdot c(\text{Na}_2\text{S}_2\text{O}_3) \cdot V(\text{Na}_2\text{S}_2\text{O}_3) = 0.5 \cdot 0.0500\text{M} \cdot 0.0280\text{L} = 0.000700\text{mol}$$
 Askor

biinhappega reageerinud I_2 hulk:

$$n(\text{I}_2 \text{ reageerinud}) = n(\text{I}_2) - n(\text{I}_2 \text{ tiitritud}) = 0.000900\text{mol} - 0.000700\text{mol} = 0.000200\text{mol}$$
 Ühe

s tabletis sisalduv askorbiinhappe hulk:

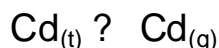
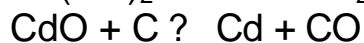
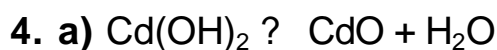
$$n(\text{askorbiinhape}) = \frac{1}{4} \cdot n(\text{I}_2 \text{ reageerinud}) \cdot \frac{2.5 \cdot 100\text{cm}^3}{20\text{cm}^3} = 0.000625\text{mol}$$

Ühes tabletis sisalduv askorbiinhappe mass:

$$m(\text{askorbiinhape}) = n(\text{askorbiinhape}) \cdot M(\text{askorbiinhape}) = 0.000625\text{mol} \cdot 176\text{g/mol} = 110\text{mg}$$

c) 150 g kaaluv õun sisaldab 6 mg · 150 g / 100 g = 9 mg C-vitamiini.

Keemik Kalle peab sööma 110 mg / 9 mg = 12,2 õuna, et saada sama
 kogus C-vitamiini, mis sisaldub ühes C-vitamiini tabletis.

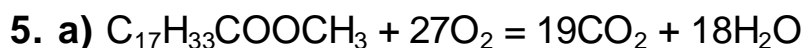


b) Maksumus = $(20\text{ kW} \cdot 1\text{h} + 500\text{ kW} \cdot 3\text{h} + 10\text{ kW} \cdot 0,5\text{h}) \cdot 0,10\text{ €/kWh} = 150\text{ €}$

c) Maksumus = $[0,23 \cdot 5\text{ €/kg} + (0,16 + 0,35 + 0,01) \cdot 0,2\text{ €/kg}] \cdot 1000\text{ kg} = 1250\text{ €}$

Tasuvus = $1250\text{ €} - 250\text{ €} = 1000\text{ €}$

d) Cd. Happelises vees kaadmium lahustub ja selle võib neutraliseerida,
 näiteks lubjakiviga: $\text{Cd}^{2+} + \text{CaCO}_3 = \text{Ca}^{2+} + \text{CdCO}_3$; või leeliselega: $\text{Cd}^{2+} + 2\text{OH}^- = \text{Cd}(\text{OH})_2$.



$$\text{b) } \frac{1}{1 \cdot \frac{100}{100-9} \cdot 0,75} \approx 1,2$$

Biodiislikütuse põletamisel eraldub sama energiakoguse saamiseks 1,2 korda vähem CO₂-e kui fossiilset päritolu diislikütuse põletamisel.

$$\text{c) i) } \frac{5001}{1 \text{ ha aasata}} \cdot \frac{1 \text{ ha}}{10000 \text{ m}^2} \cdot \frac{9,1 \text{ kWh}}{11} \approx 0,5 \frac{\text{kWh}}{\text{m}^2 \text{ aasta}}$$

ii) $\frac{900 \text{ kWh}}{1 \text{ m}^2 \text{ aasta}} \cdot \frac{10}{100} = 90 \frac{\text{kWh}}{\text{m}^2 \text{ aasta}}$ 90 ? 0,5 Oluliselt rohkem saab energiat päikesepatareide abil.

$$\text{d) i) } S = \frac{22000 \text{ TJ}}{1 \text{ aasta}} \cdot \frac{10^{12} \text{ J}}{1 \text{ TJ}} \cdot \frac{1 \text{ kWh}}{3,6 \cdot 10^6 \text{ J}} \cdot \frac{11}{9,1 \text{ kWh}} \cdot \frac{1 \text{ ha aasata}}{100 \text{ ha}} \cdot \frac{1 \text{ km}^2}{100 \text{ ha}} \approx 10000 \text{ km}^2$$

ii) Ei ole, kuna vajaliku hulga kütuse tootmiseks kuluv pindala moodustab mitukümmend protsenti Eesti riigi pindalast. Kui tahta asendada biodiislikütuse tootmiseks kulunud fossiilsed kütused omakorda kodumaise biodiislikütusega, oleks vajalik pindala veel oluliselt suurem.

6. Et 30% on 42% ja 18% keskmine, siis 42% lahust tuleb lahjendada sama massi 18% lahusega:

$$V(18\% \text{ lahus}) = \frac{135 \text{ cm}^3 \cdot 1,449 \frac{\text{g}}{\text{cm}^3}}{1,197 \frac{\text{g}}{\text{cm}^3}} = 163,4 \text{ cm}^3 \approx 163 \text{ cm}^3$$

Sama tulemuse saame võrrandi

$$0,300 = \frac{135 \text{ cm}^3 \cdot 1,449 \text{ g/cm}^3 \cdot 0,420 + V(18\% \text{ lahus}) \cdot 1,1979 \text{ g/cm}^3 \cdot 0,180}{135 \text{ cm}^3 \cdot 1,449 \text{ g/cm}^3 + V(18\% \text{ lahus}) \cdot 1,1979 \text{ g/cm}^3}$$

lahendamisel:

$$58,68 + 0,3591 \cdot V(18\% \text{ lahus})/\text{cm}^3 = 82,16 + 0,2155 \cdot V(18\% \text{ lahus})/\text{cm}^3$$

$$0,1436 \cdot V(18\% \text{ lahus})/\text{cm}^3 = 23,48$$

$$V(18\% \text{ lahus}) = 163,5 \text{ cm}^3 \sim 164 \text{ cm}^3$$

KEEMIAÜLESANNETE LAHENDAMISE LAHTINE VÕISTLUS

Vanem rühm (11. ja 12. klass)

Tallinn, Tartu, Kuressaare, Narva, Pärnu, Kohtla-Järve 5. november 2011

Ülesannete lahendused

$$1. a) m_{\text{kaalutis}} = m_{\text{NaOH}} + m_{\text{H}_2\text{O}} = 0,510 \text{ M} \cdot 200 \text{ cm}^3 \cdot \frac{1 \text{ dm}^3}{1000 \text{ cm}^3} \cdot \frac{40,0 \text{ g}}{1 \text{ mol}} = 4,08 \text{ g}$$

$$m_{\text{lahus}} = m_{\text{NaOH}} + m_{\text{lahusti}} = 200 \text{ cm}^3 \cdot \frac{1,021 \text{ g}}{1 \text{ cm}^3} = 204,2 \text{ g}$$

$$m_{\text{NaOH}} = \frac{0,480 \text{ mol}}{1 \text{ kg}} \cdot \frac{1 \text{ kg}}{1000 \text{ g}} \cdot m_{\text{lahusti}} \cdot \frac{40,0 \text{ g}}{1 \text{ mol}} = 0,0192 \cdot m_{\text{lahusti}}$$

$$m_{\text{lahusti}} = 52,08 \cdot m_{\text{NaOH}}$$

$$m_{\text{NaOH}} + 52,08 \cdot m_{\text{NaOH}} = 53,08 \cdot m_{\text{NaOH}} = 204,2 \text{ g}$$

$$m_{\text{NaOH}} = \frac{204,2 \text{ g}}{53,08} = 3,847 \text{ g}$$

$$m_{\text{lisand, H}_2\text{O}} = 4,08 \text{ g} - 3,847 \text{ g} = 0,23 \text{ g}$$

$$\%(\text{H}_2\text{O}) = \frac{0,233 \text{ g}}{4,08 \text{ g}} \cdot 100 = 5,7\%$$

$$b) n(\text{H}_2\text{SO}_4) = \frac{1}{2} \cdot \frac{0,324 \text{ mol}}{1 \text{ dm}^3} \cdot 100 \text{ cm}^3 \cdot \frac{1 \text{ dm}^3}{1000 \text{ cm}^3} = 0,0162 \text{ mol}$$

$$n(\text{SO}_3) = x$$

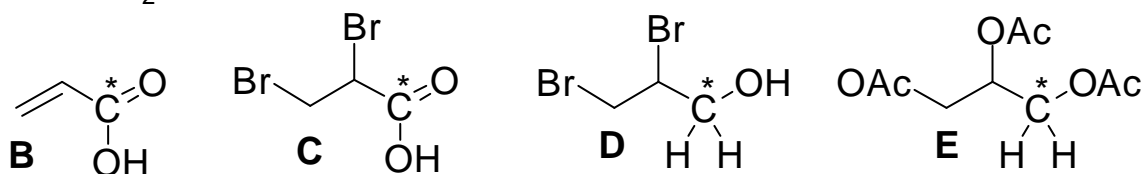
$$n(\text{H}_2\text{SO}_4) = 0,0162 \text{ mol} - x$$

$$\frac{80,07 \text{ g}}{1 \text{ mol}} \cdot x + \frac{98,08 \text{ g}}{1 \text{ mol}} \cdot (0,0162 \text{ mol} - x) = 1,50 \text{ g}$$

$$n(\text{SO}_3) = \frac{(98,08 \cdot 0,0162 - 1,50) \text{ g}}{(98,08 - 80,07) \text{ g/mol}} = 0,00494 \text{ mol}$$

$$\%(\text{SO}_3) = \frac{0,00494 \text{ mol} \cdot 80,07 \text{ g/mol}}{1,50 \text{ g}} \cdot 100 = 26\%$$

2. b) A – *CO₂



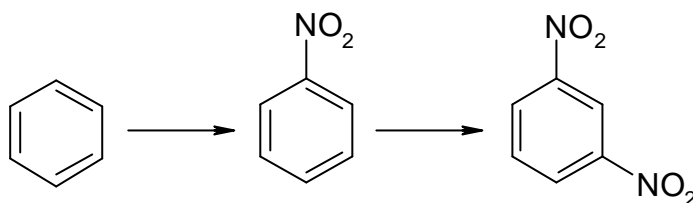
i) – H⁺ (HCl)

ii) – Br₂

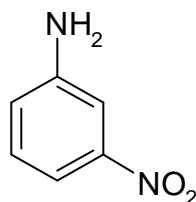
iii) – happeline või aluseline hüdrolyüs (HCl või NaOH)

3. a) i) $C_6H_5NO_2 + 3(NH_4)_2S = C_6H_5NH_2 + 3S + 6NH_3 + 2H_2O$
 ii) $C_6H_5NO_2 + 2Zn + 4NH_4Cl = C_6H_5NHOH + 2Zn(NH_3)_2Cl_2 + H_2O$

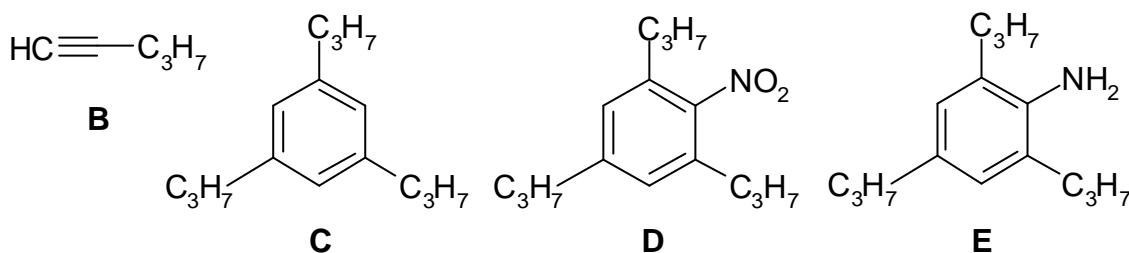
b) Benseeni nitreerimine:



c) Ammooniumvesiniksulfiidiga redutseerimisel tekib *m*-nitroaniliin mis sisaldab 20,3% lämmastikku.



d) Konts. väävelhape juuresolekul alküünid trimeriseeruvad, andes 1,3,5-trialküülbenseeni.



e) 1,3,5-tripropüülbenseen sisaldab kolm +R rühma ja seetõttu omab olulist nukleofiilset iseloomu elektrofiilse asenduse reaktsioonidel. Tavaliste nitreerimise tingimuste kasutamisel areeni tuuma sisse läheb kaks kuni kolm nitrorühma ja mononitroderivaati ei õnnestu saada.

4. a) $n(\text{EDTA}) = 52,6 \text{ cm}^3 \cdot 0,00312 \frac{\text{mmol}}{\text{cm}^3} = 0,164 \text{ mmol}$

$$c(\text{CaCO}_3) = \frac{0,164 \text{ mmol}}{50 \text{ cm}^3} \cdot \frac{1000 \text{ cm}^3}{1 \text{ dm}^3} \cdot 100 \frac{\text{mg}}{\text{mmol}} = 328 \frac{\text{mg}}{\text{dm}^3}$$

b) $n(\text{ioonid } 100 \text{ ml}) = 0,328 \text{ mmol}$

CaCO₃ sisaldus x mmol, siis MgCO₃ on $0,328 - x$ mmol ja nende massid on $100x$ ja $84 \cdot (0,328 - x)$ mg.

$$x = \frac{32,45 \text{ mg} - 84,3 \text{ mg/mmol} \cdot 0,328 \text{ mmol}}{(100,1 - 84,3) \text{ mg/mmol}} = 0,304 \text{ mmol}$$

$$c(\text{Ca}^{2+}) = 3,04 \frac{\text{mmol}}{\text{dm}^3}$$

$$c(\text{Mg}^{2+}) = 10 \cdot (0,328 - 0,306) \frac{\text{mmol}}{\text{dm}^3} = 0,24 \frac{\text{mmol}}{\text{dm}^3}$$

$$\text{c) } c(\text{Ca}^{2+}) = \frac{94,4 \text{ mg/dm}^3}{40,1 \text{ mg/mmol}} = 2,36 \frac{\text{mmol}}{\text{dm}^3}$$

Erinevus on tingitud sellest, et esimeses analüüsis saadud katioonide kontsentratsioon on suurendatud, kuna EDTA-ga saavad reageerida ka teised vees sisalduvad katioonid ja teises analüüsis kuiva aine massi suurendavad ka teised vees sisalduvad soolad.

5. a) glütseriin: $\text{C}_3\text{H}_8\text{O}_3$; $M = 92,1 \text{ g/mol} = 0,0921 \text{ kg/mol}$
 $0,15x$

$$m = \frac{0,0921 \text{ kg/mol}}{(1 - 0,15) x \text{ kg}} = \frac{1,629x \text{ mol}}{0,85x \text{ kg}} = 1,916 \frac{\text{mol}}{\text{kg}}$$

$$\Delta T = K_f m = 1,86 \frac{\text{K} \cdot \text{kg}}{\text{mol}} \cdot 1,916 \frac{\text{mol}}{\text{kg}} = 3,6 \text{ K}$$

Jäätumistemperatuuri on **- 3,6 °C**.

$$\text{b) } c(15\%) = \frac{0,15x}{0,0921 \text{ kg/mol}} \cdot 1,05 \frac{\text{kg}}{\text{dm}^3} = 1,71 \frac{\text{mol}}{\text{dm}^3}$$

$$p = 1,711 \text{ M} \cdot 0,0821 \frac{\text{dm}^3 \cdot \text{atm}}{\text{K} \cdot \text{mol}} \cdot 298 \text{ K} = 42 \text{ atm}$$

$$c(\text{max}) = \frac{60 \text{ MPa}}{0,0821 \frac{\text{dm}^3 \cdot \text{atm}}{\text{K} \cdot \text{mol}} \cdot 298 \text{ K}} \cdot \frac{1 \text{ atm}}{1,01325 \text{ MPa}} = 2,4 \text{ M}$$

$$\text{6. a) } m(\text{HgS}) = \frac{7,652 \text{ g}}{200,59 \text{ g/mol}} \cdot 232,66 \text{ g/mol} = 8,875 \text{ g}$$

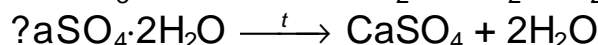
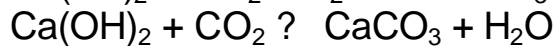
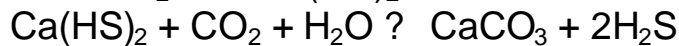
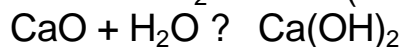
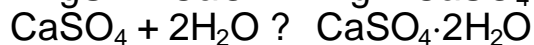
$$m(\text{FeS}) = m(\text{kinaver}) - m(\text{HgS}) = 1,125 \text{ g} = m(\text{A})$$

A – FeS, raud(II)sulfiid

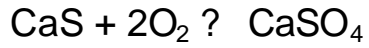
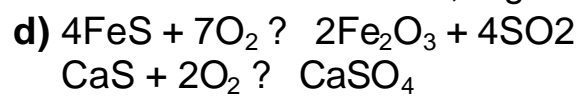
Olgu **B** on CaSO_4 , siis vastavalt reaktsioonivõrrandile $n(\text{B}) = \frac{1}{4} n(\text{Hg})$

$$M(\text{B}) = \frac{4m(\text{B})}{n(\text{HgS})} = 4 \cdot 1,2985 \text{ g} \cdot \frac{200,59 \text{ g/mol}}{7,652 \text{ g}} = 136,2 \text{ g}$$

B – CaSO_4 , kaltsium sulfaat



$$\mathbf{c)} \quad m(\text{CaO}) = 56,02 \text{ g} \cdot \frac{7,652 \text{ g}}{200,59 \text{ g/mol}} = \mathbf{2,137 \text{ g}}$$



$$\mathbf{e)} \quad \%(\text{FeS}) = \frac{1,1235 \text{ g}}{10,000 \text{ g}} \cdot 100 = \mathbf{11,23\%}$$

$$\%(\text{HgS}) = \left(1 - \frac{1,1235 \text{ g}}{10,000 \text{ g}} \right) \cdot 100 = \mathbf{88,77\%}$$