

Keemia lahtise võistluse ülesannete lahendused

Noorem rühm (9. ja 10. klass)

16. november 2002. a.

1. 1) $2\text{Na} + \text{O}_2 = \text{Na}_2\text{O}_2$
- 2) $2\text{Na} + \text{Na}_2\text{O}_2 = 2\text{Na}_2\text{O}$
- 3) $2\text{Na} + \text{I}_2 = 2\text{NaI}$
- 4) $2\text{NaI} + \text{Cl}_2 = 2\text{NaCl} + \text{I}_2$
- 5) $2\text{NaCl} = 2\text{Na} + \text{Cl}_2$ (sulatatud soola elektrolüüs)
- 6) $\text{Na}_2\text{CO}_3 + 2\text{HCl} = 2\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2\uparrow$; või $\text{Na}_2\text{CO}_3 + \text{CaCl}_2 = 2\text{NaCl} + \text{CaCO}_3\downarrow$;
- 7) $4\text{Na} + 2\text{CO}_2 + \text{O}_2 = 2\text{Na}_2\text{CO}_3$
- 8) $2\text{Na} + 2\text{H}_2\text{O} = 2\text{NaOH} + \text{H}_2$
- 9) $2\text{Na} + \text{S} = \text{Na}_2\text{S}$

2. a) Gaaside tihedused suhtuvad nagu nende molaarmassid.

Gaas **B** on lämmastik (28 g/mol).

$$M(\text{gaas D}) = 1 \cdot 28 \text{ g/mol} = \mathbf{28 \text{ g/mol}}$$

$$M(\text{gaas F}) = 3,54 \cdot 28 \text{ g/mol} = \mathbf{99 \text{ g/mol}}$$

$$M(\text{gaas E}) = 99 \text{ g/mol} - 28 \text{ g/mol} = \mathbf{71 \text{ g/mol}}$$

- b) **X** - C, süsinik

A – O₂, hapnik

B – N₂, lämmastik

C – CO₂, süsinikdioksiid

D – CO, süsinikmonooksiid

E – Cl₂, kloor

F – COCl₂, fosgeen

- c) i) $\text{C} + \text{O}_2 = \text{CO}_2$

ii) $\text{CO}_2 + \text{C} = 2\text{CO}$

iii) $\text{CO} + \text{Cl}_2 = \text{COCl}_2$

3. a) ask.hape \Leftrightarrow 2NaOH

$$n(\text{ask.hape}) = \frac{1}{2} \cdot 0,01600 \text{ dm}^3 \cdot 0,125 \text{ mol/dm}^3 = 0,00100 \text{ mol} = \mathbf{1,00 \times 10^{-3} \text{ mol}}$$

$$\text{b) } m(\text{värske petersell}) = 15,93 \text{ g} \cdot 0,800 \cdot \frac{1}{0,181} = 70,4 \text{ g}$$

$$m(\text{ask.hape}) = 70,4 \text{ g} \cdot 0,00250 = \mathbf{0,176 \text{ g}}$$

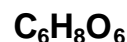
$$\text{c) } M(\text{ask.hape}) = \frac{0,176 \text{ g}}{0,00100 \text{ mol}} = \mathbf{176 \text{ g/mol}}$$

$$\text{d) } n(\text{H}) = 176 \text{ g} \cdot 0,0455 \cdot \frac{1 \text{ mol}}{1,008 \text{ g}} = 8 \text{ mol}$$

$$n(\text{C}) = 176 \text{ g} \cdot 0,4091 \cdot \frac{1 \text{ mol}}{12 \text{ g}} = 6 \text{ mol}$$

$$\%(\text{O}) = 100 - 40,91 - 4,55 = 54,54$$

$$n(\text{O}) = 176 \text{ g} \cdot 0,5454 \cdot \frac{1 \text{ mol}}{16 \text{ g}} = 6 \text{ mol}$$



4. a) $\text{NaNO}_3 + \text{KCl} = \text{KNO}_3 + \text{NaCl}$

$$\text{b) } n(\text{NaNO}_3) = 10,04 \text{ g} \cdot \frac{1 \text{ mol}}{85,0 \text{ g}} = 0,118 \text{ mol}$$

$$n(\text{KCl}) = 8,50 \text{ g} \cdot \frac{1 \text{ mol}}{74,6 \text{ g}} = 0,1139 \text{ mol} \approx 0,114 \text{ mol}$$

Seega saab tekkida

$$m(\text{KNO}_3) = \frac{1}{1} \cdot 0,1139 \text{ mol} \cdot 101,1 \text{ g/mol} = \mathbf{11,5 \text{ g}}$$

$$m(\text{NaCl}) = \frac{1}{1} \cdot 0,1139 \text{ mol} \cdot 58,5 \text{ g/mol} = \mathbf{6,66 \text{ g}}$$

c) 25,0 dm³ vees lahustub 4 korda vähem, kui on lahustuvus. Seega

$$m(\text{NaNO}_3, \text{ lahuses}) = 21,9 \text{ g};$$

$$m(\text{KCl}, \text{ lahuses}) = 8,50 \text{ g};$$

$$m(\text{KNO}_3, \text{ lahuses}) = 7,88 \text{ g};$$

$$m(\text{NaCl}, \text{ lahuses}) = 8,95 \text{ g}.$$

Ainsa ainenä on moodustunud KNO₃ mass suurem kui tema lahustuvus.

$$m(\text{KNO}_3, \text{ väljakristalliseeruv}) = 11,5 \text{ g} - 7,88 \text{ g} = \mathbf{3,6 \text{ g}}$$

$$\text{d) \% (saagis)} = \frac{3,6 \text{ g}}{11,5 \text{ g}} \cdot 100 = \mathbf{31}$$

5. a) $M(\text{H}_2) = 2,016 \text{ g/mol}$

$$V_m(\text{H}_2) = 22,4 \text{ dm}^3/\text{mol}$$

$$r(\text{H}_2) = 2,016 \text{ g/mol} \cdot \frac{1 \text{ mol}}{22,4 \text{ dm}^3} = 0,0900 \text{ g/dm}^3 = \mathbf{9,00 \times 10^{-2} \text{ g/dm}^3}$$

b) $\rho(\text{H}_2) = 9,00 \cdot 10^{-2} \text{ g/dm}^3 \cdot 1 \text{ dm}^3/1000 \text{ cm}^3 = 9,00 \cdot 10^{-5} \text{ g/cm}^3$

$$r(\text{Li}) = 9,00 \cdot 10^{-5} \text{ g/cm}^3 \cdot 5,93 \cdot 10^3 = 0,5337 \text{ g/cm}^3 \approx \mathbf{0,534 \text{ g/cm}^3}$$

c) $1 \text{ dm}^3 \cdot \frac{1000 \text{ cm}^3}{1 \text{ dm}^3} = 1000 \text{ cm}^3$

$$m(\text{Li}, 1 \text{ dm}^3) = 1000 \text{ cm}^3 \cdot 0,534 \text{ g/cm}^3 = 534 \text{ g}$$

$$n(\text{Li}, 1 \text{ dm}^3) = 534 \text{ g} \cdot \frac{1 \text{ mol}}{6,941 \text{ g}} = \mathbf{76,9 \text{ mol}}$$

$$c(\text{Li}) = 76,9 \text{ mol/dm}^3$$

6. a) **C₂₇H₁₇Cl₂NO₁₁**

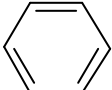
b) i) alkohol – CH₃OH, metanool

ketoon – H₃CCOCH₃, propaan-2-oon

eeter – CH₃OCH₃, dimetüüleeter

karboksüülhape – HCOOH, metaanhape

alküün – HC≡CH, etüün

areen – , benseen

primaarne amiin: CH₃NH₂, metüülamiin

ii) Antud fluorestseini derivaat kuulub järgmistesse aineklassidesse:

ketoon, eeter, karboksüülhape, areen.

c) 1000 krooni eest saab $\frac{1000 \text{ EEK}}{700000 \text{ EEK/g}} = 1,43 \text{ mg ainet} \sim \mathbf{1 \text{ mg}}$

$$M_r(\text{aine}) = 27 \cdot 12 + 17 + 2 \cdot 35,5 + 14 + 11 \cdot 16 = 602$$

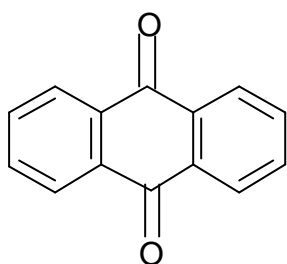
$$n(\text{aine}) = \frac{1,43 \cdot 10^{-3} \text{ g}}{602 \text{ g/mol}} = 2,38 \cdot 10^{-6} \text{ mol} \sim \mathbf{2 \times 10^{-6} \text{ mol}}$$

Keemia lahtise võistluse ülesannete lahendused

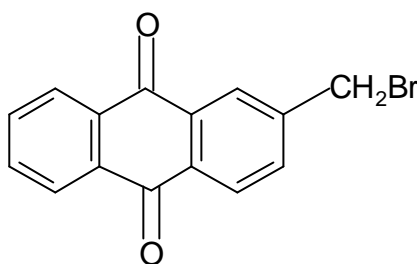
Vanem rühm (11. ja 12. klass)

16. november 2002. a.

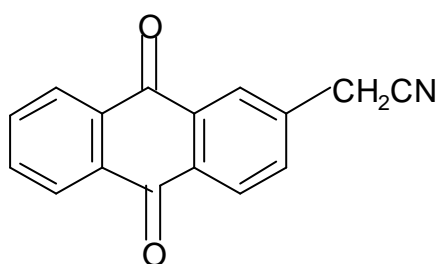
1. a) b)



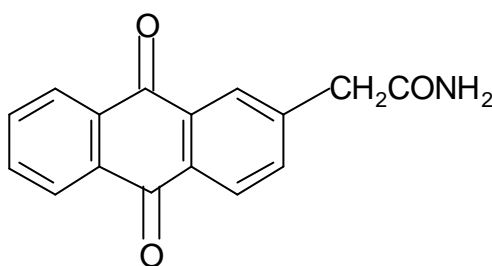
A



C

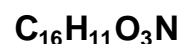


D



E

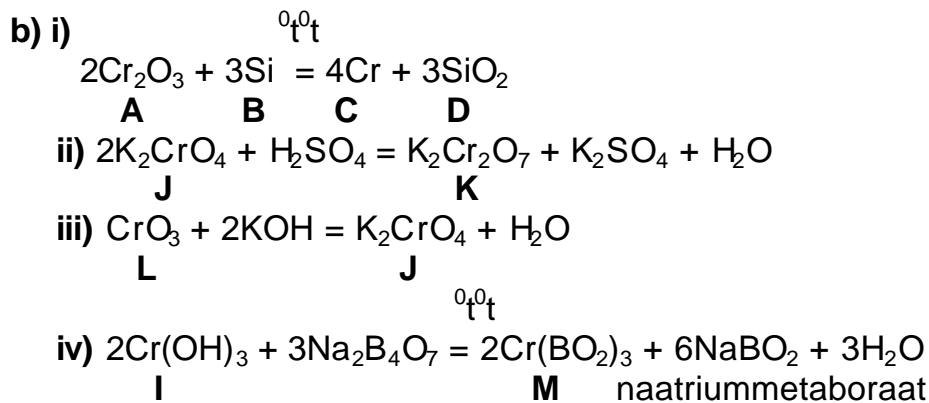
$$\text{b) } M(\text{E}) = 14 \text{ g/mol} \cdot \frac{1}{0,0528} = 265 \text{ g/mol};$$



c) NaOH liia lisamisel toimub mitte ainult HCl, vaid ka happe X neutraliseerimine ning soola RCOONa tekkimine. Sool on iooniline (polaarne) ühend ning seetõttu lahustub paremini vees. Diklorometaaniga ekstraheerimisel läks orgaanilisse lahustisse ainult vähepolaarne mitteioniseeruv lisand - amiid E.

d) Reaktsioonisegule tuleb lisada NaOH, seejuures tekib happest RCOONa ning diklorometaaniga ekstraheeruvad vähepolaarsed lisandid (ülesande tingimustes on öeldud, et aine E ei ioniseeru) - nii nagu üliõpilane esialgu tegi. Siis tuleb lisada veefaasile HCl, et viia RCOONa happeks RCOOH ning ekstraheerida veefaasi veelkord diklorometaaniga.

2. a)
- A - Cr₂O₃, kroom(III)oksiid
 - B - Si, räni
 - C - Cr, kroom
 - D - SiO₂, ränidioksiid
 - E - Na₂SiO₃, naatriummetasilikaat
 - F - Na₄SiO₄, naatriumortosilikaat
 - G - CrSO₄, kroom(II)sulfaat
 - H - Cr(OH)₂, kroom(II)hüdrosiid
 - I - Cr(OH)₃, kroom(III)hüdrosiid
 - J - K₂CrO₄, kaaliumkromaat
 - K - K₂Cr₂O₇, kaaliumdikromaat
 - L - CrO₃, kroom(VI)oksiid
 - M - Cr(BO₂)₃, kroom(III)metaboraat

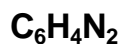


3. a) i) $N(\text{C}) = 104 \text{ g/mol} \cdot 0,6921 \cdot \frac{1 \text{ mol}}{12 \text{ g}} = 6$

$N(\text{N}) = 104 \text{ g/mol} \cdot 0,2692 \cdot \frac{1 \text{ mol}}{14 \text{ g}} = 2$

$\%(\text{H}) = 100 - 69,21 - 26,92 = 3,87$

$N(\text{H}) = 104 \text{ g/mol} \cdot 0,0387 \cdot \frac{1 \text{ mol}}{1 \text{ g}} = 4$



ii) $n(\text{nikotiin}) = 0,729 \text{ g} \cdot \frac{1 \text{ mol}}{162 \text{ g}} = 0,00450 \text{ mol}$



$n(\text{C}) = \frac{1}{1} \cdot 8,86 \text{ g} \cdot \frac{1 \text{ mol}}{197 \text{ g}} \approx 0,0450 \text{ mol}$

$M(\text{gaas}) = 24,0 \text{ dm}^3/\text{mol} \cdot 1,167 \text{ g/dm}^3 = 28 \text{ g/mol}$, so N₂

$n(\text{N}) = \frac{2}{1} \cdot 0,108 \text{ dm}^3 \cdot \frac{1 \text{ mol}}{24,0 \text{ dm}^3} = 0,00900 \text{ mol}$

$m(\text{H}_2) = 0,729 \text{ g} - 0,045 \text{ mol} \cdot 12 \text{ g/mol} - 0,0045 \text{ mol} \cdot 28 \text{ g/mol} =$
 $= 0,729 \text{ g} - 0,540 \text{ g} - 0,126 \text{ g} = 0,063 \text{ g}$

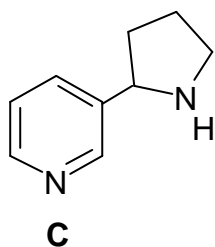
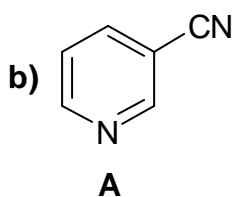
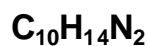
$n(\text{H}) = 0,063 \text{ g} \cdot \frac{1 \text{ mol}}{1 \text{ g}} = 0,063 \text{ mol}$

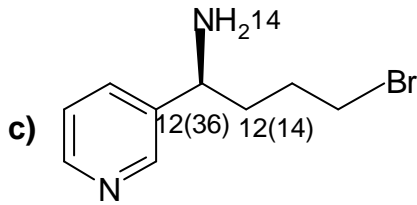
Nikotiini molekulide, süsiniku, lämmastiku ja vesiniku aatomite moolide arvud suhtuvad nagu 0,0045 : 0,045 : 0,090 : 0,063.

Ühes molekulis nikotiinis on süsinikku $\frac{0,045}{0,0045} = 10$ aatomit

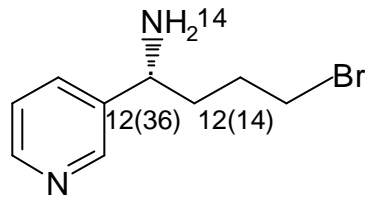
lämmastikku $\frac{0,0090}{0,0045} = 2$ aatomit

vesinikku $\frac{0,063}{0,0045} = 14$ aatomit





S-isomeer



R-isomeer

4. a) i) $M(\text{gaaside segu}) = 1,674 \text{ g/dm}^3 \cdot 22,4 \text{ dm}^3/\text{mol} = 37,5 \text{ g/mol}$
 $0,75 \cdot M(\text{F}) + 0,25 \cdot 30 \text{ g/mol} = 37,5 \text{ g/mol}$
 $M(\text{F}) = 40,0 \text{ g/mol}$

ii) $N(\text{C}) = 40,0 \text{ g/mol} \cdot 0,90 \cdot \frac{1 \text{ mol}}{12 \text{ g}} = 3$

b) A – CuCl_2 , vask(II)kloriid

B – $\text{H}[\text{CuCl}_2]$, vesinikdiklorokupraat(I)

C – CuCl , vask(I)kloriid

D – $[\text{Cu}(\text{NH}_3)_2]\text{Cl}$, diammiinvask(I)kloriid

E – CuO , vask(II)oksiid

F – $\text{CH}_3\text{C}\equiv\text{CH}$, propüün

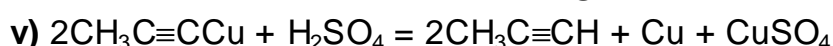
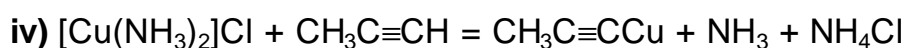
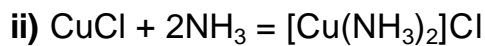
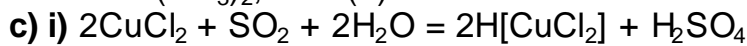
G – $\text{CH}_3\text{C}\equiv\text{CCu}$, 1-vask(I)propüün

H – Cu_2SO_4 , vask(I)sulfaat

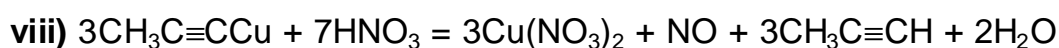
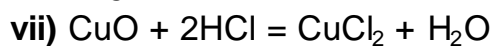
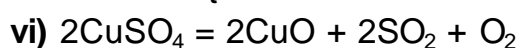
I – Cu , vask

J – CuSO_4 , vask(II)sulfaat

K – $\text{Cu}(\text{NO}_3)_2$, vask(II)nitraat



0_t

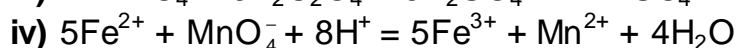
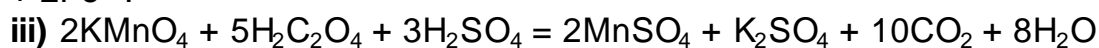


K



ii) Tsingi reaktsioonil väävelhappega tekib atomaarne vesinik, mis redutseerib raud(III) raud(II)-ks: $\text{Fe}^{3+} + \text{H} = \text{Fe}^{2+} + \text{H}^+$

Peale selle redutseerib rauda ka tsink, kui aktiivne metall: $\text{Zn} + 2\text{Fe}^{3+} = \text{Zn}^{2+} + 2\text{Fe}^{2+}$.



$$\text{b) i) } c(\text{H}_2\text{C}_2\text{O}_4) = 1,0860 \text{ g} \cdot \frac{1 \text{ mol}}{126,05 \text{ g}} \cdot \frac{1}{0,1000 \text{ dm}^3} = 0,086156 \text{ mol/dm}^3 \approx$$

$$\approx \mathbf{0,08616 \text{ M}}$$

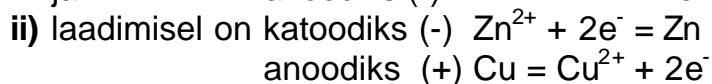
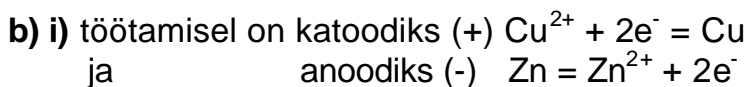
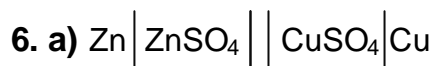
$$\text{ii) } c(\text{KMnO}_4) = \frac{2}{5} \cdot 0,01000 \text{ dm}^3 \cdot 0,08616 \text{ mol/dm}^3 \cdot \frac{1}{0,02225 \text{ dm}^3} =$$

$$= 0,015488 \text{ mol/dm}^3 \approx \mathbf{0,01549 \text{ M}}$$

$$\text{c) } \%(\text{Fe}) = \frac{5}{1} \cdot \frac{0,250 \text{ dm}^3}{0,0100 \text{ dm}^3} \cdot 0,01775 \text{ dm}^3 \cdot 0,01549 \text{ mol/dm}^3 \cdot$$

$$\cdot 55,847 \text{ g/mol} \cdot \frac{1}{2,09276 \text{ g}} \cdot 100 = 91,658\% \approx \mathbf{91,8\%}$$

*Andmed Kaali meteoriidi kohta on pärit leheküljelt <http://www.muinas.ee/ecp/kaali/index.html>



c) i) $E_{\text{Zn}^{2+}/\text{Zn}} = -0,736 \text{ V} + \frac{0,059 \text{ V}}{2} \lg 0,1 = \mathbf{-0,766 \text{ V}}$

$$E_{\text{Cu}^{2+}/\text{Cu}} = 0,337 \text{ V} + \frac{0,059 \text{ V}}{2} \lg 0,5 = \mathbf{0,328 \text{ V}}$$

ii) $\text{EMJ} = 0,328 \text{ V} - (-0,766) \text{ V} = \mathbf{1,094 \text{ V}}$

d) i) Elemendi EMJ saab suurendada Zn^{2+} kontsentratsiooni vähendamise või Cu^{2+} kontsentratsiooni suurendamisega, sest sel juhul $E_{\text{Zn}^{2+}/\text{Zn}}$ väheneb ja $E_{\text{Cu}^{2+}/\text{Cu}}$ suureneb.

ii) Elemendi EMJ väheneb, kui anoodprotsessi saadusaine (Zn^{2+}) kontsentratsioon suureneb ja katoodprotsessi lähteaine (Cu^{2+}) kontsentratsioon väheneb.