

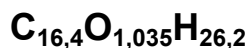
2002/2003 õa keemiaolümpiaadi lõppvooru ülesannete lahendused

11. klass

1. a) $n(\text{C}) = 240 \cdot 0,82 \cdot \frac{1}{12,01} = 16,38 \approx 16,4$

$n(\text{O}) = 240 \cdot 0,069 \cdot \frac{1}{16,00} = 1,035$

$n(\text{H}) = 240 \cdot 0,11 \cdot \frac{1}{1,008} = 26,19 \approx 26,2$

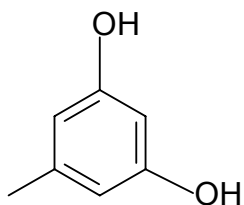


b) Küllastumata ühendile $\text{C}_{16}\text{H}_{26}\text{O}$ vastab küllastunud ühend

i) $\text{C}_{16}\text{H}_{32}\text{O}$ - ketoon;

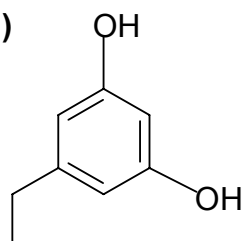
ii) $\text{C}_{16}\text{H}_{34}\text{O}$ - alkohol.

c) i)



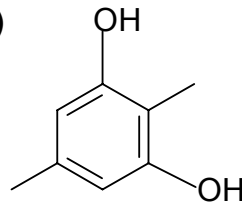
5-metüülresortsiin

ii)



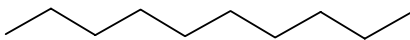
5-etüülresortsiin

iii)



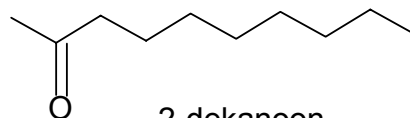
2,5-dimetüülresortsiin

d) i)



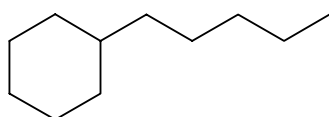
dekaan

ii)



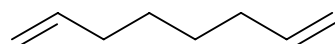
2-dekanoon

iii)



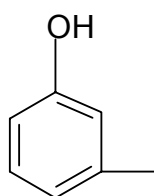
pentüülsükloheksaan

iv)



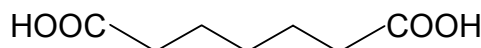
1,7-oktadieen

v)



3-metüülfenool

vi)



heptaandihape

2. a) X – C, süsinik

Y – O, hapnik

E – CO, süsinikmonooksiid, vingugaas

F – CO₂, süsinikdioksiid, süsihappegaas

b) i) Kui molekulis on hapniku aatomeid kaks ja süsiniku aatomeid kolm, siis on hapniku sisaldus 47%.

$$n(\text{C}) = 2 \cdot 16 \cdot \frac{1}{47\%} \cdot 53\% \cdot \frac{1}{12} = 3$$

Kõik ülejäänud kombinatsioonid ei vasta ülesande tingimustele.

ii) O=C=C=C=O (süsinikul on 4 sidet, hapnikul on 2 sidet)

c) M(-COOH) = 45 g/mol

$$\text{Kui } \mathbf{D} \Leftrightarrow \text{NaOH, siis } m(\mathbf{D}) = 2,080 \text{ g} \cdot \frac{1}{0,04 \text{ mol}} = 52 \text{ g/mol}$$

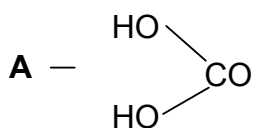
$$52 - 45 = 7$$

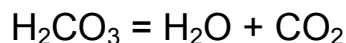
Ei sobi, sest sellise molekulmassiga fragmenti pole.

$$\text{Kui } \mathbf{D} \Leftrightarrow 2\text{NaOH, siis } M(\mathbf{D}) = \frac{1}{2} \cdot 2,080 \text{ g} \cdot \frac{1}{0,04 \text{ mol}} = 104 \text{ g/mol}$$

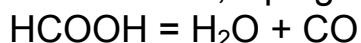
$$104 - 2 \cdot 45 = 14$$

Selline molekulmass on fragmendil –CH₂–
HOOCCH₂COOH

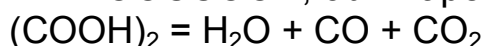
d)  , süsihape



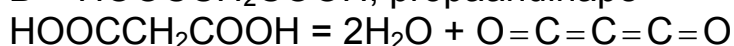
B – HCOOH, sipelghape



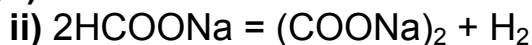
C – HOCCOOH, oblikhape



D – HOOCCH₂COOH, propaandihape



e) i) CO + NaOH = HCOONa



3. a) i) 2Ca₃(PO₄)₂ + 3SiO₂ + 10C = P₄ + 10CO + 3Ca₂SiO₄

ii) A – Ca₃(PO₄)₂, kaltsiumfosfaat

B – P₄, valge fosfor

C – P_n, punane fosfor

F – PH₃, fosfiin

1) Vee all puudub hapnik, mis oksüdeeriks fosfori. Helendumine on tingitud reaktsioonist



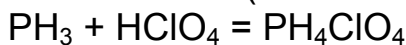
2) 2M soolhappe lahjendamisel 2 korda saadakse 1 M happe lahus

$$\text{pH} = -\log[\text{H}^+] \Rightarrow -\log 1 \Rightarrow -\log 10^0 = 0$$

3) $\text{P}_4 + 3\text{NaOH} + 3\text{H}_2\text{O} = 3\text{NaH}_2\text{PO}_2 + \text{PH}_3$

Reaktsioonil tekib ka P_2H_4 , mille jälgede tõttu PH_3 sütib õhus.

4) Fosfiinil pole aluselisi omadusi, kuid väga tugevate hapetega annab see fosfooniumisooli (neutraliseerib happe, mis suurendab lahuse pH-d).



5) $\text{Ca}_3(\text{PO}_4)_2 + 2\text{H}_2\text{SO}_4 = \text{Ca}(\text{H}_2\text{PO}_4)_2 + 2\text{CaSO}_4$

Moodustub vees lahustuv väetis superfosfaat.

4. a) **A** – $(\text{CuOH})_2\text{CO}_3$, vaskhüdrosiidkarbonaat, sest lagunemisel eraldus ka vesi.

B – CO_2 , süsinikdioksiid

C – CuO , vask(II)oksiid

b) i) $2\text{CuSO}_4 + 4\text{NaHCO}_3 = (\text{CuOH})_2\text{CO}_3 + 2\text{Na}_2\text{SO}_4 + \text{H}_2\text{O} + 3\text{CO}_2$

ii) $(\text{CuOH})_2\text{CO}_3 \xrightarrow{\text{tõtt}} 2\text{CuO} + \text{CO}_2 + \text{H}_2\text{O}$

iii) $\text{Ca}(\text{OH})_2 + \text{CO}_2 = \text{CaCO}_3 + \text{H}_2\text{O}$

iv) $\text{Ca}(\text{OH})_2 + \text{CO}_2 + \text{CO}_2 = \text{Ca}(\text{HCO}_3)_2$

v) $3\text{CuO} + 2\text{NH}_3 = \text{N}_2 + 3\text{Cu} + 3\text{H}_2\text{O}$

c) i) $0,13 = m \cdot \frac{160}{250} \cdot \frac{1}{27,8 \text{ g}}$

$$m(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = 0,13 \cdot 27,8 \text{ g} \cdot \frac{250}{160} = 5,646 \text{ g} \approx \mathbf{5,6 \text{ g}}$$

ii) $m(\text{H}_2\text{O}) = 27,8 \text{ g} - 5,6 \text{ g} = \mathbf{22,2 \text{ g}}$

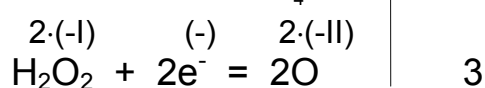
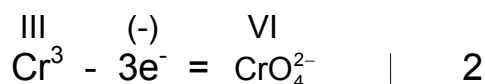
d) $V \cdot 1,22 \text{ mol/dm}^3 \quad 27,8 \text{ g} \cdot 0,13$
 $4\text{NaHCO}_3 \Leftrightarrow 2\text{CuSO}_4$
 160 g/mol

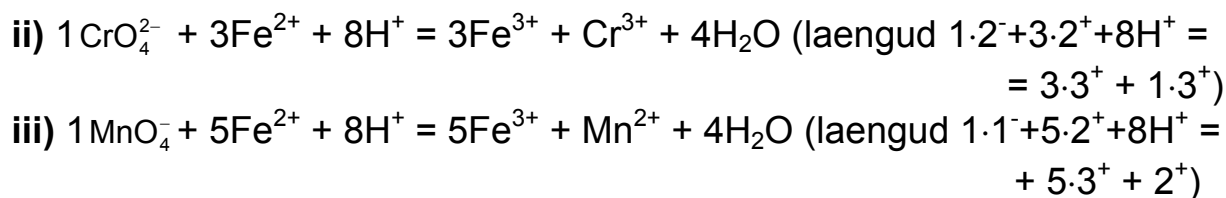
$$V(\text{NaHCO}_3) = \frac{4}{2} \cdot 27,8 \text{ g} \cdot 0,130 \cdot \frac{1 \text{ mol}}{160 \text{ g}} \cdot \frac{1 \text{ dm}^3}{1,22 \text{ mol}} \cdot 1000 \text{ cm}^3 / \text{dm}^3 = \mathbf{37,0 \text{ cm}^3}$$

e) $27,8 \text{ g} \cdot 13\% \quad 2,4 \text{ g}$
 $2\text{CuSO}_4 \Leftrightarrow (\text{CuOH})_2\text{CO}_3$
 $160 \text{ g/mol} \quad 221 \text{ g/mol}$

$$\%[\text{saagis}, (\text{CuOH})_2\text{CO}_3] = \frac{2}{1} \cdot 2,4 \text{ g} \cdot \frac{1 \text{ mol}}{221 \text{ g}} \cdot 160 \text{ g/mol} \cdot \frac{1}{27,8 \text{ g}} \cdot \frac{1}{0,13} \cdot 100 = \mathbf{96}$$

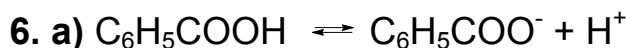
5. a) i) $2\text{Cr}^{3+} + 3\text{H}_2\text{O}_2 + 10\text{OH}^- = 2\text{CrO}_4^{2-} + 8\text{H}_2\text{O}$ (laengud $2 \cdot 3^+ + 10\text{OH}^- = 2 \cdot 2^-$)





b) $n(\text{Fe}^{2+}) = 0,02400 \text{ l} \cdot 0,1500 \text{ mol/l} = 0,003600 \text{ mol}$
 $n(\text{MnO}_4^-) = 0,03100 \text{ l} \cdot 0,0195 \text{ mol/l} = 0,0006045 \text{ mol}$
 $n(\text{Fe}^{2+}, \text{ox MnO}_4^-) = \frac{5}{1} \cdot 0,0006045 \text{ mol} = 0,003023 \text{ mol}$
 $n(\text{Fe}^{2+}, \text{ox CrO}_4^-) = 0,003600 - 0,003023 = 0,000577 \text{ mol}$
 $m(\text{Cr}) = 25 \cdot \frac{1}{3} \cdot 0,000577 \text{ mol} \cdot 52,0 \text{ g/mol} = \mathbf{0,250 \text{ g}}$

c) $Q = I \cdot t = 2,36 \text{ A} \cdot 575 \text{ sek} = 1357 \text{ A}\cdot\text{s}$
 $Q(\text{Cr}^{3+}) = \frac{0,250 \text{ g}}{5} \cdot \frac{1 \text{ mol}}{52,0 \text{ g}} \cdot 3 \cdot 96485 \text{ A}\cdot\text{s/mol} = 278,3 \text{ A}\cdot\text{s} \approx 278 \text{ A}\cdot\text{s}$
 $Q(\text{Ag}^+ + \text{Cu}^{2+}) = 1357 \text{ A}\cdot\text{s} - 278 \text{ A}\cdot\text{s} = 1079 \text{ A}\cdot\text{s}$
Olgu $Q(\text{Cu}^{2+}) = 1079 \text{ A}\cdot\text{s} - Q(\text{Ag}^+)$
 $2,50 \text{ g} - 0,250 \text{ g} = m(\text{Ag}^+) + m(\text{Cu}^{2+})$
 $m(\text{Ag}^+) = 5 \cdot Q(\text{Ag}^+) \cdot \frac{1 \text{ mol}}{96485 \text{ A}\cdot\text{s}} \cdot 108 \text{ g/mol} = 0,00559 Q(\text{Ag}^+)/\text{A}\cdot\text{s}$
 $m(\text{Cu}^{2+}) = 5 \cdot [1079 \text{ A}\cdot\text{s} - Q(\text{Ag}^+)] \cdot \frac{1}{2} \cdot \frac{1 \text{ mol}}{96485 \text{ A}\cdot\text{s}} \cdot 63,5 \text{ g/mol} =$
 $= 0,001645 \text{ g/A}\cdot\text{s} [1079 \text{ A}\cdot\text{s} - Q(\text{Ag}^+)] = 1,775 \text{ g} - 0,00165 \text{ g } Q(\text{Ag}^+)/\text{A}\cdot\text{s}$
 $2,250 \text{ g} = 0,00559 \text{ g/A}\cdot\text{s} \cdot Q(\text{Ag}^+) + 1,775 \text{ g} - 0,00165 \text{ g/A}\cdot\text{s} \cdot Q(\text{Ag}^+)$
 $0,475 = 0,00394 Q(\text{Ag}^+) \cdot 1/\text{A}\cdot\text{s}$
 $Q(\text{Ag}^+) = 120,55 \text{ A}\cdot\text{s} \approx 121 \text{ A}\cdot\text{s}$
 $Q(\text{Cu}^{2+}) = 1079 \text{ A}\cdot\text{s} - 121 \text{ A}\cdot\text{s} = 958 \text{ A}\cdot\text{s}$
 $m(\text{Ag}) = m(\text{Ag}^+) = 5 \cdot 121 \text{ A}\cdot\text{s} \cdot \frac{1 \text{ mol}}{96485 \text{ A}\cdot\text{s}} \cdot 108 \text{ g/mol} = 0,677 \text{ g} \approx \mathbf{0,68 \text{ g}}$
 $m(\text{Cu}) = 2,250 - 0,677 = 1,573 \text{ g} \approx \mathbf{1,57 \text{ g}}$



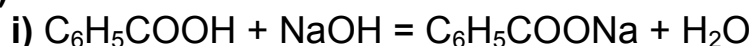
$$K_h = \frac{[\text{C}_6\text{H}_5\text{COO}^-][\text{H}^+]}{[\text{C}_6\text{H}_5\text{COOH}]}$$

Kui lisada naatriumbensoati, siis

$$[\text{C}_6\text{H}_5\text{COOH}] = c_{\text{hape}} \quad \text{ja} \quad [\text{C}_6\text{H}_5\text{COONa}] = c_{\text{sool}}$$

$$[\text{H}^+] = K_h = \frac{c_{\text{hape}}}{c_{\text{sool}}}$$

b) A



ii) $n(\text{C}_6\text{H}_5\text{COOH}) = 0,1 \text{ dm}^3 \cdot 0,05 \text{ mol/dm}^3 = 0,005 \text{ mol}$

$$n(\text{NaOH}) = 0,03 \text{ dm}^3 \cdot 0,08 \text{ mol/dm}^3 = 0,0024 \text{ mol}$$

$$n(\text{C}_6\text{H}_5\text{COOH, l\"opp}) = 0,005 \text{ mol} - 0,0024 \text{ mol} = 0,0026 \text{ mol}$$

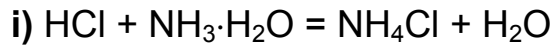
$$n(\text{C}_6\text{H}_5\text{COONa, l\"opp}) = \frac{1}{1} \cdot 0,0024 \text{ mol} = 0,0024 \text{ mol}$$

$$n(\text{NaOH, l\"opp}) = n(\text{C}_6\text{H}_5\text{COONa, alg}) = 0$$

$$\text{iii) } [\text{H}^+] = 6,5 \cdot 10^{-5} \text{ mol/dm}^3 \cdot \frac{0,0026 \text{ mol}}{0,0024 \text{ mol}} = 7,04 \cdot 10^{-5} \text{ mol}$$

$$\text{pH} = -\log 7,04 \cdot 10^{-5} = 4,14 \approx \mathbf{4,2}$$

B



$$\text{ii) } n(\text{HCl}) = 0,2 \text{ dm}^3 \cdot 0,4 \text{ mol/dm}^3 = 0,08 \text{ mol}$$

$$n(\text{NH}_3 \cdot \text{H}_2\text{O}) = 0,25 \text{ dm}^3 \cdot 0,5 \text{ mol/dm}^3 = 0,125 \text{ mol}$$

$$n(\text{NH}_4\text{Cl, l\"opp}) = \frac{1}{1} \cdot 0,08 \text{ mol} = 0,08 \text{ mol}$$

$$n(\text{NH}_3 \cdot \text{H}_2\text{O, l\"opp}) = 0,125 \text{ mol} - 0,08 \text{ mol} = 0,045 \text{ mol}$$

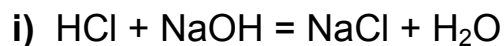
$$n(\text{HCl, l\"opp}) = n(\text{NH}_4\text{Cl, alg}) = 0$$

$$\text{iii) } [\text{OH}^-] = 1,79 \cdot 10^{-5} \cdot \frac{0,045 \text{ mol}}{0,08 \text{ mol}} = 1,01 \cdot 10^{-5}$$

$$\text{pOH} = -\log 1,01 \cdot 10^{-5} = 5,0$$

$$\text{pH} = K_v - \text{pOH} = 14 - 5,0 = \mathbf{9,0}$$

C



$$\text{ii) } n(\text{HCl}) = 0,01 \text{ dm}^3 \cdot 0,4 \text{ mol/dm}^3 = 0,004 \text{ mol}$$

$$n(\text{NaOH}) = 0,012 \text{ dm}^3 \cdot 0,4 \text{ mol/dm}^3 = 0,0048 \text{ mol}$$

$$n(\text{NaCl, l\"opp}) = \frac{1}{1} \cdot 0,004 \text{ mol} = 0,004 \text{ mol}$$

$$n(\text{NaOH, l\"opp}) = 0,0048 \text{ mol} - 0,004 \text{ mol} = 0,0008 \text{ mol}$$

$$n(\text{HCl, l\"opp}) = n(\text{NaCl, alg}) = 0$$

iii) On tugeva aluse lahus

$$[\text{OH}^-] = \frac{0,0008 \text{ mol}}{0,022 \text{ dm}^3} = 0,03636 \text{ mol/dm}^3$$

$$\text{pOH} = -\log 0,03636 = 1,44 \approx 1,4$$

$$\text{pH} = 14 - 1,4 = \mathbf{12,6}$$