

2002/2003 õa keemiaolümpiaadi lõppvooru ülesannete lahendused

9. klass

1. a) IV periood VIII B alarühm (VIII kõrvalalarühm)

b) i) ${}_{27}^{59}\text{Co}$

ii) ${}_{28}^{58}\text{Ni}$; ${}_{28}^{60}\text{Ni}$; ${}_{28}^{61}\text{Ni}$; ${}_{28}^{62}\text{Ni}$; ${}_{28}^{64}\text{Ni}$

c) i) $A_r(\text{Co}) = 59 - 0,1 = 58,9$

ii) $A_r(\text{Ni}) = 57,9 \cdot 0,681 + 59,9 \cdot 0,262 + 60,9 \cdot 0,0114 + 61,9 \cdot 0,0363 +$
 $+ 63,9 \cdot 0,00926 = 39,43 + 15,69 + 0,69 + 2,25 + 0,59 = 58,65 \approx \mathbf{58,7}$

d) Koobalt peab olema eespool, sest tema järjenumbr (tuumalaeng) on väiksem.

e) **A** on koobalt ja **B** on nikkel, sest aatomite arv on võrdne ja suurema massi annavad suurema aatommassiga aatomid.

2. a) $n(\text{HCO}_3^-) = 1 \text{ l} \cdot 100 \text{ mg/l} \cdot \frac{1 \text{ mol}}{61 \text{ g}} = 1,64 \text{ mmol} \approx \mathbf{1,6 \text{ mmol}}$

$n(\text{SO}_4^{2-}) = 1 \text{ l} \cdot 40 \text{ mg/l} \cdot \frac{1 \text{ mol}}{96 \text{ g}} = 0,417 \text{ mmol} \approx \mathbf{0,4 \text{ mmol}}$

$n(\text{Cl}^-) = 1 \text{ l} \cdot 1200 \text{ mg/l} \cdot \frac{1 \text{ mol}}{35,5 \text{ g}} = \mathbf{33,8 \text{ mmol}}$

$n(\text{Ca}^{2+}) = 1 \text{ l} \cdot 120 \text{ mg/l} \cdot \frac{1 \text{ mol}}{40 \text{ g}} = \mathbf{3,0 \text{ mmol}}$

$n(\text{Mg}^{2+}) = 1 \text{ l} \cdot 50 \text{ mg/l} \cdot \frac{1 \text{ mol}}{24 \text{ g}} = 2,08 \text{ mmol} \approx \mathbf{2,1 \text{ mmol}}$

$n(\text{ühelaenguliste anioonidena}) = 1,6 \text{ mmol} + 2 \cdot 0,4 \text{ mmol} + 33,8 \text{ mmol} =$
 $= 36,2 \text{ mmol}$

$n(\text{Ca}^{2+} + \text{Mg}^{2+}) \cdot 2 = (3,0 \text{ mmol} + 2,1 \text{ mmol}) \cdot 2 = 10,2 \text{ mmol}$

$n(\text{ühelaengulised katioonid}) = 36,2 \text{ mmol} - 10,2 \text{ mmol} = 26,0 \text{ mmol}$

b) $n(\text{Na}^+) = n(\text{K}^+) = 26,0 : 2 = 13,0 \text{ mmol}$

$m(\text{Na}^+) = 13 \text{ mol/l} \cdot 23 \text{ g/mol} = 299 \text{ mg/l} \approx \mathbf{300 \text{ mg/l}}$

$m(\text{K}^+) = 13 \text{ mol/l} \cdot 39 \text{ g/mol} = 507 \text{ mg/l} \approx \mathbf{510 \text{ mg/l}}$
 $\mathbf{810 \text{ mg/l}}$

$\Sigma m = 100 \text{ mg/l} + 40 \text{ mg/l} + 1200 \text{ mg/l} + 120 \text{ mg/l} + 50 \text{ mg/l} + 810 \text{ mg/l} = \mathbf{2320 \text{ mg/l}}$

c)

100 mg

$2\text{HCO}_3^- = \text{CO}_3^{2-} + \text{H}_2\text{O} + \text{CO}_2$

61 g/mol

$\underbrace{\hspace{10em}}_{62 \text{ g/mol}}$

$\Delta m = \frac{1}{2} \cdot 100 \text{ mg/l} \cdot \frac{1 \text{ mol}}{61 \text{ g}} \cdot 62 \text{ g/mol} = 51 \text{ mg/l}$

$$\Sigma m = 2320 \text{ mg/l} - 51 \text{ mg/l} = 2269 \text{ mg/l} \approx \mathbf{2270 \text{ mg/l}}$$

3. a) i) **C** – A₂O
G – HB

$$\text{ii) } A_r(\mathbf{A}) = 16 \cdot \frac{1}{0,258} \cdot 0,742 \cdot \frac{1}{2} = \mathbf{23}$$

$$A_r(\mathbf{B}) = 1,008 \cdot \frac{1}{0,0276} \cdot 0,9724 = \mathbf{35,5}$$

$$\text{b) } N(\mathbf{A}) = 2 \cdot 16 \cdot \frac{1}{0,41} \cdot 0,59 \cdot \frac{1}{23} = \mathbf{2}$$

c) **A** – Na, naatrium

B – Cl, kloor

C – Na₂O, naatriumoksiid

D – Na₂O₂, naatriumperoksiid

E – Na₂CO₃, naatriumkarbonaat

F – O₂, hapnik

G – HCl, vesinikkloriid

d) i) $2\text{Na} + \text{Cl}_2 = 2\text{NaCl}$

ii) $4\text{Na} + \text{O}_2 = 2\text{Na}_2\text{O}$

iii) $2\text{Na}_2\text{O}_2 + 2\text{CO}_2 = 2\text{Na}_2\text{CO}_3 + \text{O}_2$

iv) $\text{Cl}_2 + \text{H}_2 = 2\text{HCl}$

4. a) i) Neeldunud gaasiks saab olla ainult CO₂, sest lähtesegu sisaldas kahte keemilist elementi.

$$\text{ii) } V(\text{CO}_2) = 1,375 \text{ g} \cdot \frac{1 \text{ mol}}{44,0 \text{ g}} \cdot 22400 \text{ cm}^3/\text{mol} = \mathbf{700 \text{ cm}^3}$$

b) Lähtesegus peavad olema CO, O₂ ja CO₂, sest neeldunud CO₂ ruumala on suurem, kui O₂ reageerimisel süsinikmonooksiidiga moodustunud CO₂ ruumala. Lähtesegu ruumala saab väheneda ainult reageerinud O₂ arvelt.

c) i) $2\text{CO} + \text{O}_2 = 2\text{CO}_2$

$$V(\text{O}_2, \text{reageeris}) = \mathbf{100 \text{ cm}^3}$$

$$V(\text{CO}, \text{reageeris}) = \frac{2}{1} \cdot 100 \text{ cm}^3 = \mathbf{200 \text{ cm}^3}$$

d) Lõpp- ja lähtesegs on mõlema variandi korral CO₂ ruumala ühesugune: vastavalt 700 cm^3 ja $700 \text{ cm}^3 - 200 \text{ cm}^3 = 500 \text{ cm}^3$

	<i>Lähtesegu</i>		<i>Lõppsegu</i>	
I variant	CO ₂	500 cm ³	CO ₂	700 cm ³
	CO	200 cm ³	CO	–
	O ₂	300 cm ³	O ₂	200 cm ³
II variant	CO ₂	500 cm ³	CO ₂	700 cm ³
	CO	400 cm ³	CO	200 cm ³
	O ₂	100 cm ³	O ₂	–

5. a) $M(\mathbf{B}) = 28,0 \text{ g/mol} \cdot 9,07 \approx \mathbf{254 \text{ g/mol}}$

$M(\mathbf{C}) = 2,0 \text{ g/mol} \cdot 32 = \mathbf{64 \text{ g/mol}}$

b) i) X – I, jood

ii) A – KI, kaaliumjodiid

B – I₂, jood

C – SO₂, vääveldioksiid

D – KHSO₄, kaaliumvesiniksulfaat

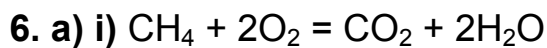
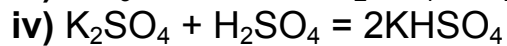
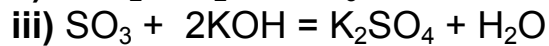
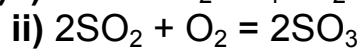
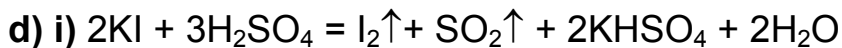
E – SO₃, vääveltrioksiid

F – K₂SO₄, kaaliumsulfaat

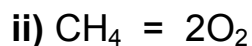
c) i) $n(\mathbf{A}) = n(\text{KI}) = 3,32 \text{ g} \cdot \frac{1 \text{ mol}}{166 \text{ g}} = \mathbf{0,02 \text{ mol}}$

ii) $n(\mathbf{C}) = n(\text{SO}_2) = 0,224 \text{ dm}^3 \cdot \frac{1 \text{ mol}}{22,4 \text{ dm}^3} = \mathbf{0,01 \text{ mol}}$

iii) $n(\mathbf{D}) = n(\text{KHSO}_4) = 2,72 \text{ g} \cdot \frac{1 \text{ mol}}{136 \text{ g}} = \mathbf{0,02 \text{ mol}}$



$$V \cdot 0,21$$



$$V(\text{õhk}) = \frac{2}{1} \cdot \frac{1}{0,21} = 9,5$$

$$V(\text{CH}_4) : V(\text{õhk}) = 1 : 9,5$$

iii) Ei teki tahkeid jääke (tuhk) ega tekita happevihma. Kivisüsi sisaldab väävlit, mis paiskab atmosfääri vääveldioksiidi.

b) $V(\text{CH}_4) = 10^9 \text{ J} \cdot \frac{1 \text{ mol}}{8,9 \cdot 10^5 \text{ J}} \cdot 0,0224 \text{ m}^3 / \text{mol} = 25,17 \text{ m}^3 \approx \mathbf{25,2 \text{ m}^3}$

c) $V(\text{CH}_4) = 2,3 \cdot 10^7 \text{ J} \cdot \frac{1 \text{ mol}}{8,9 \cdot 10^5 \text{ J}} \cdot 0,0224 \text{ m}^3 / \text{mol} = 0,579 \text{ m}^3 \approx \mathbf{0,58 \text{ m}^3}$

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10. klass

1. a) i) **A** – CO₂, süsinikdioksiid

B – H₂, vesinik

C – Na, naatrium

ii) **D** – H₂SO₄, väävelhape

E – NH₃, ammoniaak

b) CO₂ täidetud õhupall on ohutu, H₂ on plahvatusohtlik ja NH₃ on hingamist ärritav.

c) $M_r(\text{õhk}) = 29 < M_r(\text{CO}_2) = 44$, langeb põrandale
 $M_r(\text{õhk}) = 29 > M_r(\text{H}_2) = 2$, tõuseb lakke
 $M_r(\text{õhk}) = 29 > M_r(\text{NH}_3) = 17$, tõuseb lakke

d) **F** – NaOH, naatriumhüdroksiid

G – NaHCO₃, naatriumvesinikkarbonaat

H – NH₄HCO₃, ammooniumvesinikkarbonaat

I – (NH₄)₂SO₄ ammooniumsulfaat

J – Na₂SO₄, naatriumsulfaat

e) i) $2\text{Na} + 2\text{H}_2\text{O} = 2\text{NaOH} + \text{H}_2\uparrow$

ii) $2\text{NaOH} + \text{H}_2\text{SO}_4 = \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$

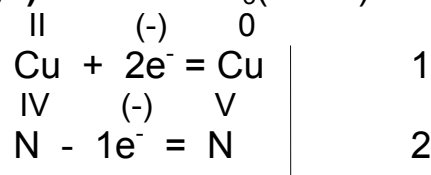
iii) $\text{NaOH} + \text{CO}_2 = \text{NaHCO}_3$

iv) $2\text{NaHCO}_3 + \text{H}_2\text{SO}_4 = \text{Na}_2\text{SO}_4 + 2\text{CO}_2 + 2\text{H}_2\text{O}$

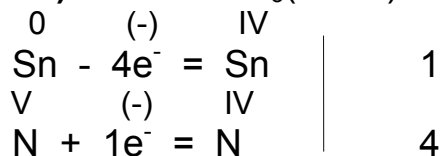
v) $\text{CO}_2 + \text{NH}_3 + \text{H}_2\text{O} = \text{NH}_4\text{HCO}_3$

vi) $2\text{NH}_4\text{HCO}_3 + \text{H}_2\text{SO}_4 = (\text{NH}_4)_2\text{SO}_4 + 2\text{CO}_2 + 2\text{H}_2\text{O}$

2. a) i) $\text{Cu} + 4\text{HNO}_3(\text{konts}) = \text{Cu}(\text{NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$



ii) $\text{Sn} + 4\text{HNO}_3(\text{konts}) = \text{H}_2\text{SnO}_3 \cdot \text{H}_2\text{O} + 4\text{NO}_2$

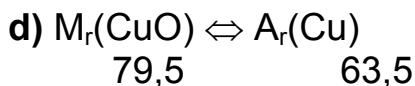


b) Sn(OH)₄, tina(IV)hüdroksiid

c) $m(\text{H}_2\text{SnO}_3 \cdot \text{H}_2\text{O}) = 32,61 \text{ g} - 5,08 \text{ g} = 27,53 \text{ g}$

$M_r(\text{H}_2\text{SnO}_3 \cdot \text{H}_2\text{O}) \Leftrightarrow A_r(\text{Sn})$
186,6 118,6

$$\%(\text{Sn}) = 27,53 \text{ g} \cdot 118,6 \cdot \frac{1}{186,6} \cdot \frac{1}{139,88 \text{ g}} \cdot 100 = \mathbf{12,51}$$



$$m[\text{Cu, vask(II)oksiidis}] = 0,636 \text{ g} \cdot 63,5 \cdot \frac{1}{79,5} = 0,508 \text{ g}$$

$$m(\text{Cu, saadud sulamis}) = (5,08 \text{ g} - 0,508 \text{ g}) \cdot 0,0556 = 0,254 \text{ g}$$

$$\%(\text{Au}) = (5,08 \text{ g} - 0,508 \text{ g} - 0,254 \text{ g}) \cdot \frac{1}{5,08 \text{ g}} \cdot 100 = \mathbf{85,0}$$

3. a) Mineraalsest osast lendub põletamisel sama kogus CO_2 , nagu eraldub seda soolhappega reageerimisel.

$$m(\text{CO}_2) = 6,74 \text{ dm}^3 \cdot \frac{1 \text{ mol}}{22,4 \text{ dm}^3} \cdot 44 \text{ g/mol} = 13,2 \text{ g}$$

$$\text{i) } \%(\text{kerogeen}) = (100 \text{ g} - 13,2 \text{ g} - 53,0 \text{ g}) \cdot \frac{1}{100 \text{ g}} \cdot 100 = \mathbf{33,8}$$

$$\text{ii) } \%(\text{mineraalne osa}) = (100 \text{ g} - 33,8 \text{ g}) \cdot \frac{1}{100 \text{ g}} \cdot 100 = \mathbf{66,2}$$

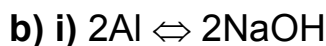
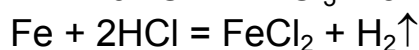
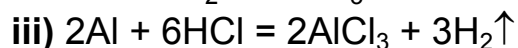
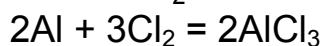
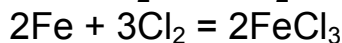
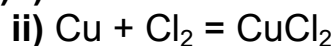
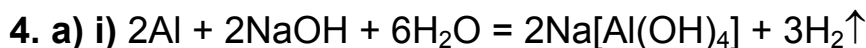
$$\text{ehk } \text{mineraalne osa} = 100\% - 33,8\% = 66,2\%$$

$$\text{b) } \%(\text{saagis}) = 0,338 \cdot 0,66 \cdot 100 = \mathbf{22,3}$$

$$\text{c) } m(\text{tahke jääk põlevkivi utmisel}) = 100 \text{ g} - 1,9 \text{ g} - 5,6 \text{ g} - 22,3 \text{ g} = 70,2 \text{ g}$$

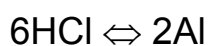
$$\text{i) } \%(\text{poolkoks}) = (70,2 \text{ g} - 66,2 \text{ g}) \cdot \frac{1}{100 \text{ g}} \cdot 100 = \mathbf{4,0}$$

$$\text{ii) } \%(\text{poolkoks, kerogeenist}) = 4 \text{ g} \cdot \frac{1}{33,8 \text{ g}} \cdot 100 = 11,8 \approx \mathbf{12}$$



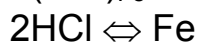
$$m(\text{Al}) = \frac{2}{2} \cdot 40,0 \text{ g} \cdot \frac{1 \text{ mol}}{40,0 \text{ g}} \cdot 26,98 \text{ g/mol} = 26,98 \text{ g} \approx \mathbf{27,0 \text{ g}}$$

$$\text{ii) } n(\text{HCl, lähte}) = 1035 \text{ cm}^3 \cdot 1,10 \text{ g/cm}^3 \cdot 0,100 \cdot \frac{1 \text{ mol}}{36,5 \text{ g}} = 3,12 \text{ mol}$$



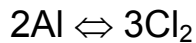
$$N(\text{HCl})_{\text{Al}} = \frac{6}{2} \cdot 1,00 \text{ mol} = 3,00 \text{ mol}$$

$$n(\text{HCl})_{\text{Fe}} = 3,12 \text{ mol} - 3,00 \text{ mol} = 0,12 \text{ mol}$$



$$m(\text{Fe}) = \frac{1}{2} \cdot 0,12 \text{ mol} \cdot 55,85 \text{ g/mol} = 3,35 \text{ g} \approx \mathbf{3,4 \text{ g}}$$

$$\text{iii) } n(\text{Cl}_2, \text{ lähte}) = 37,4 \text{ dm}^3 \cdot \frac{1 \text{ mol}}{22,4 \text{ dm}^3} = 1,6696 \text{ mol} \approx \mathbf{1,67 \text{ mol}}$$

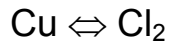


$$n(\text{Cl}_2)_{\text{Al}} = \frac{3}{2} \cdot 1,00 \text{ mol} = 1,50 \text{ mol}$$



$$n(\text{Cl}_2)_{\text{Fe}} = \frac{3}{2} \cdot 0,060 \text{ mol} = 0,090 \text{ mol}$$

$$n(\text{Cl}_2)_{\text{Cu}} = 1,67 \text{ mol} - 1,50 \text{ mol} - 0,090 \text{ mol} = 0,08 \text{ mol}$$



$$m(\text{Cu}) = 0,08 \text{ mol} \cdot 63,55 \text{ g/mol} = 5,08 \text{ g} \approx \mathbf{5,1 \text{ g}}$$

5. a) i) **A** – H_2O_2 , vesinikperoksiid

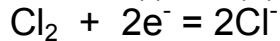
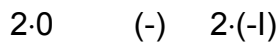
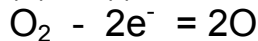
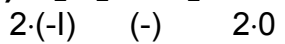
B – Cl_2 , kloor

C – KMnO_4 , kaaliumpermanganaat

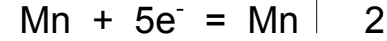
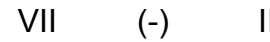
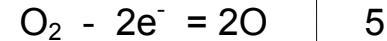
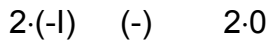
$$\text{ii) } \%(\text{O}_2, \text{H}_2\text{O}_2) = \frac{32}{34} \cdot 100 = \mathbf{94,1}$$

$$\%(\text{O}_2, \text{KMnO}_4) = \frac{64}{158} \cdot 100 = \mathbf{40,5}$$

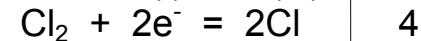
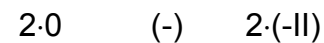
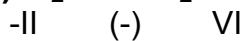
b) i) $\text{H}_2\text{O}_2 + \text{Cl}_2 = 2\text{HCl} + \text{O}_2$



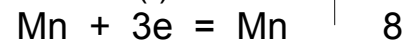
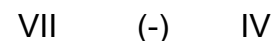
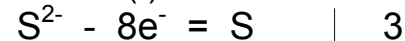
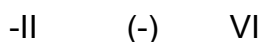
ii) $5\text{H}_2\text{O}_2 + 2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 = 1\text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 5\text{O}_2 + 8\text{H}_2\text{O}$



c) i) $\text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{Cl}_2 = 8\text{HCl} + 1\text{H}_2\text{SO}_4$

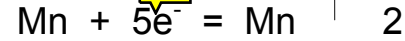
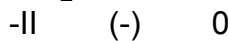


ii) $3\text{S}^{2-} + 8\text{KMnO}_4 + 4\text{H}_2\text{O} = 3\text{SO}_4^{2-} + 8\text{MnO}_2 + 8\text{KOH}$

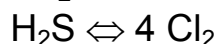


iii) $\text{H}_2\text{S} + \text{H}_2\text{O}_2 = \text{S} + 2\text{H}_2\text{O}$

iv) $5\text{H}_2\text{S} + 2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 = 5\text{S} + \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 8\text{H}_2\text{O}$

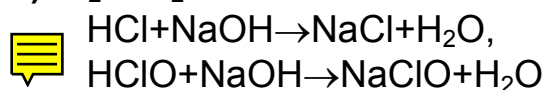


d) $1\text{H}_2\text{S} \Leftrightarrow 10\text{H}^+ \Leftrightarrow 10\text{NaOH}$; ja võrrandi c) i) järgi



$$n(\text{NaOH}) = \frac{10}{1} \cdot \frac{1}{4} \cdot 1\text{mol} = \mathbf{2,5\text{mol}}$$

e) $\text{Cl}_2 + \text{H}_2\text{O} = \text{HCl} + \text{HClO}$



6. a) $\text{C}_{12}\text{H}_{22}\text{O}_{11}(\text{t}) + 12\text{O}_2(\text{g}) = 12\text{CO}_2(\text{g}) + 11\text{H}_2\text{O}(\text{v})$ $\Delta\text{H}(\text{sahh, põlem})$

b) $\Delta\text{H}(\text{sahh, põlem}) = \Sigma\Delta\text{H}(\text{tekke, saad}) - \Sigma\Delta\text{H}(\text{tekke, lähte}) =$

$$= 12 \text{ mol} \cdot (-393,5 \text{ kJ/mol}) + 11 \text{ mol} \cdot (-285,8 \text{ kJ/mol}) - \text{mol} \cdot (-2222,0 \text{ kJ/mol}) - 12 \text{ mol} \cdot 0 \text{ kJ/mol} = - \mathbf{5643,8 \text{ kJ/mol}}$$

c) $\Delta\text{H} [\text{H}_2\text{O}(\text{v}) \rightarrow \text{H}_2\text{O}(\text{g})] = -241,8 \text{ kJ/mol} - (-285,8 \text{ kJ/mol}) = 44,0 \text{ kJ/mol}$

Plussmärk on seetõttu, et süsteem saab energiat

$M(\text{sahharoos}) = 342 \text{ g/mol}$

Ühe grammi suhkru oksüdeerumisel saame $+5643,8 \text{ kJ/mol} \cdot \frac{1 \text{ mol}}{342 \text{ g}} =$

$$= 16,502 \text{ kJ/g} \approx 16,5 \text{ kJ/g}$$

Ühe liitri vee aurustamiseks kulub

$$+44,0 \text{ kJ/mol} \cdot 1000 \text{ cm}^3 \cdot 1,00 \text{ g/cm}^3 \cdot \frac{1 \text{ mol}}{18,0 \text{ g}} = 2444 \text{ kJ} \approx 2440 \text{ kJ}$$

$$\mathbf{m(\text{sahharoos}) = 2444 \text{ kJ} \cdot \frac{1 \text{ g}}{16,5 \text{ kJ}} = 148 \text{ g}}$$

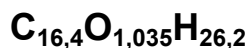
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11. klass

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

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

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

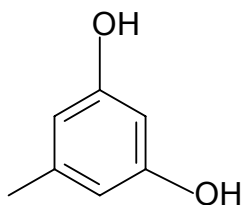


b) Küllastumata ühendile $\text{C}_{16}\text{H}_{26}\text{O}$ vastab küllastunud ühend

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

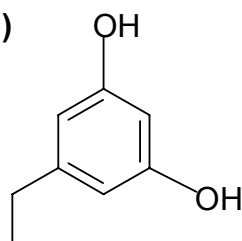
ii) $\text{C}_{16}\text{H}_{34}\text{O}$ - alkohol.

c) i)



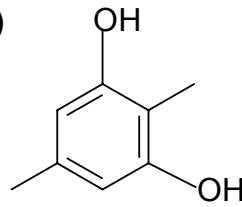
5-metüülresortsiin

ii)



5-etüülresortsiin

iii)



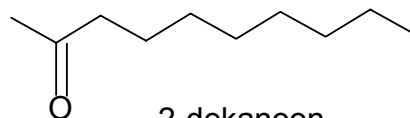
2,5-dimetüülresortsiin

d) i)



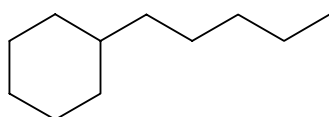
dekaan

ii)



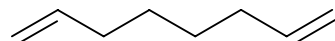
2-dekanoon

iii)



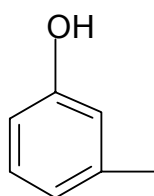
pentüülsükloheksaan

iv)



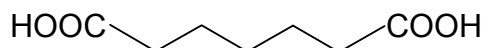
1,7-oktadieen

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

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

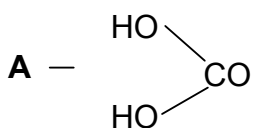
$$52 - 45 = 7$$

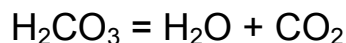
Ei sobi, sest sellise molekulmassiga fragmenti pole.

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

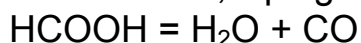
$$104 - 2 \cdot 45 = 14$$

Selline molekulmass on fragmendil –CH₂–
HOOCCH₂COOH

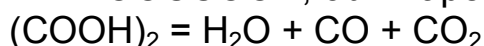
d)  , süsihape



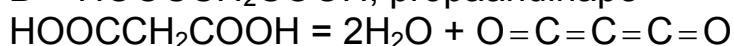
B – HCOOH, sipelghape



C – HOCCOOH, oblikhape



D – HOOCCH₂COOH, propaandihape



e) i) CO + NaOH = HCOONa

ii) 2HCOONa = (COONa)₂ + H₂

iii) O=C=C=C=O + 2CH₃OH = CH₃OOCCH₂COOCH₃

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



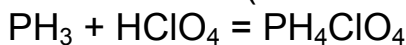
2) 2M soolhappe lahjendamisel 2 korda saadakse 1 M happe lahus

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

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

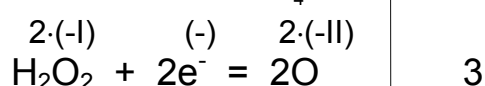
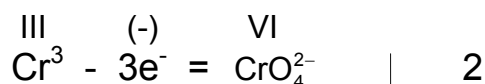
d) $V \cdot 1,22 \text{ mol/dm}^3 \quad 27,8 \text{ g} \cdot 0,13$
 $4\text{NaHCO}_3 \Leftrightarrow 2\text{CuSO}_4$
 160 g/mol

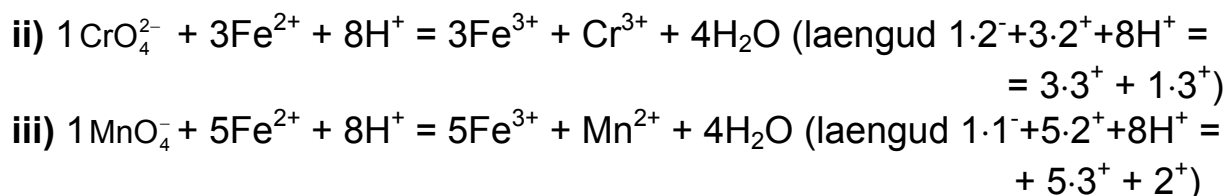
$$V(\text{NaHCO}_3) = \frac{4}{2} \cdot 27,8 \text{ g} \cdot 0,130 \cdot \frac{1 \text{ mol}}{160 \text{ g}} \cdot \frac{1 \text{ dm}^3}{1,22 \text{ mol}} \cdot 1000 \text{ cm}^3 / \text{dm}^3 = \mathbf{37,0 \text{ cm}^3}$$

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

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

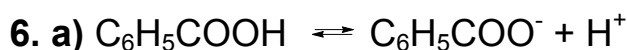
5. a) i) $2\text{Cr}^{3+} + 3\text{H}_2\text{O}_2 + 10\text{OH}^- = 2\text{CrO}_4^{2-} + 8\text{H}_2\text{O}$ (laengud $2 \cdot 3^+ + 10\text{OH}^- = 2 \cdot 2^-$)





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



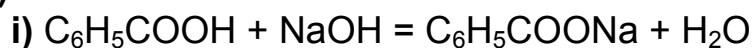
$$K_h = \frac{[\text{C}_6\text{H}_5\text{COO}^-][\text{H}^+]}{[\text{C}_6\text{H}_5\text{COOH}]}$$

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

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

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

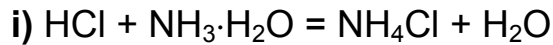
$$n(\text{C}_6\text{H}_5\text{COONa, l\"opp}) = \frac{1}{1} \cdot 0,0024 \text{ mol} = 0,0024 \text{ mol}$$

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

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

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

B



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

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

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

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

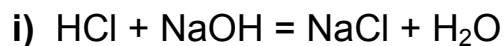
$$n(\text{HCl, l\"opp}) = n(\text{NH}_4\text{Cl, alg}) = 0$$

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

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

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

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

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

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

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

2002/2003 õa keemiaolümpiaadi lõppvoorü ülesannete lahendused

12. klass

1. a) X – SiO₂, ränidioksiid, liiv

$$\text{b) i) } n(\text{CO}_2) = 45,1 \text{ g} \cdot \frac{1 \text{ mol}}{44,0 \text{ g}} = 1,025 \text{ mol}$$

$$n(\text{FeO}) = 0,2 \text{ g} \cdot \frac{1 \text{ mol}}{71,9 \text{ g}} = 0,00278 \text{ mol} \approx 0,003 \text{ mol}$$

$$n(\text{CaO}) = 48,1 \text{ g} \cdot \frac{1 \text{ mol}}{56,1 \text{ g}} = 0,857 \text{ mol}$$

$$n(\text{Y}) = 1,025 \text{ mol} - 0,003 \text{ mol} - 0,857 \text{ mol} = 0,165 \text{ mol}$$

$$M(\text{Y}) = 6,6 \text{ g} \cdot \frac{1}{0,165 \text{ mol}} = \mathbf{40 \text{ g/mol}}$$

Ühend Y ei saa olla Me₂O, sest siis oleks A_r(Me) = 12. Kui ühend Y on MeO, siis A_r(Me) = 40 - 16 = 24, mis vastab magneesiumile.

ii) Y – MgO, magneesiumoksiid

c) Happelised mullad vajavad põlevkivituhka. CaO neutraliseerib mulla happesuse.

d) CaO ja Al₂O₃

e) SO₂ – kerogeeni ja savi-liiva koostisse

H₂O – kerogeeni koostisse

CaO – karbonaatide koostisse

f) i) SO₂ + H₂O = H₂SO₃

ii) 2H₂SO₃ + O₂ = 2H₂SO₄

iii) H₂SO₄ + CaO + H₂O = CaSO₄·2H₂O

2. a) Ühend A peab olema XO₂, sest sellest saadakse viieaatomiline binaarne ühend XCl₄

$$M_r(\mathbf{A}) = 16 \cdot 2 \cdot \frac{1}{0,40} = 80$$

$$A_r(\mathbf{X}) = 80 - 32 = 48$$

X – Ti, titaan

b) A – TiO₂, titaan(IV)oksiid

B – C, süsinik

C – Cl₂, kloor

D – TiCl₄, titaan(IV)kloriid

E – CO, süsinikoksiid

F – H₂, vesinik

G – TiCl₃, titaan(III)kloriid

H – Ti₂O₃·H₂O, titaan(III)oksiid monohüdraat

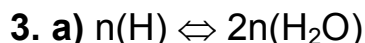
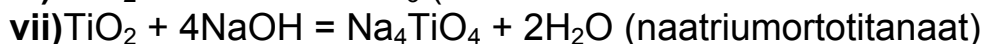
c) i) TiO₂ + 2C + 2Cl₂ = TiCl₄ + 2CO

ii) TiCl₄ + 2H₂O = TiO₂ + 4HCl

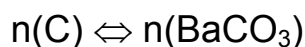
iii) TiCl₄ + 2Mg = Ti + 2MgCl₂

iv) 2TiCl₄ + H₂ = 2TiCl₃ + 2HCl

v) 2TiCl₃ + 6NaOH = Ti₂O₃·H₂O + 6NaCl + 2H₂O



$$n(\text{H}) = 2 \cdot 216,2 \text{ mg} \cdot \frac{1 \text{ mol}}{18,02 \text{ g}} = 24 \text{ mmol}$$

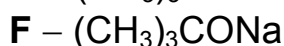
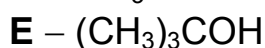
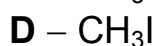
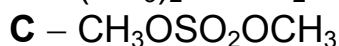
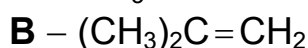
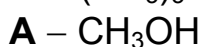
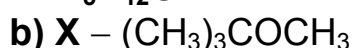


$$n(\text{C}) = 1,973 \text{ g} \cdot \frac{1 \text{ mol}}{197,3 \text{ g}} = 10 \text{ mmol}$$

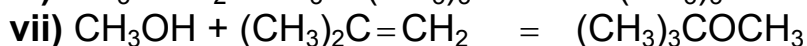
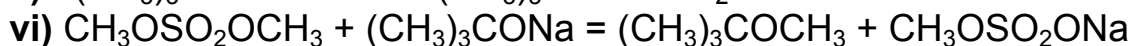
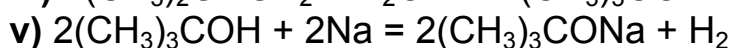
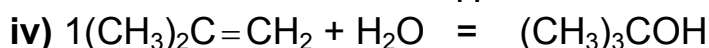
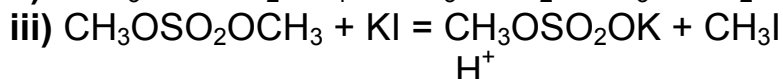
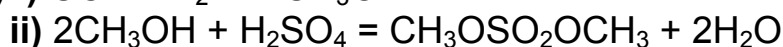
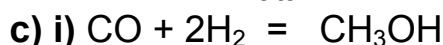
$$24 \text{ mmol} \cdot 1,008 \text{ g/mol} + 10 \text{ mmol} \cdot 12,01 \text{ g/mol} = 144,3 \text{ mg}$$

$$n(\text{O}) = (176,3 \text{ mg} - 144,3 \text{ mg}) \cdot \frac{1 \text{ mol}}{16 \text{ g}} = 2 \text{ mmol}$$

C : H : O = 10 : 24 : 2 ehk 5 : 12 : 1, millele vastab brutovalem $\text{C}_5\text{H}_{12}\text{O}$



katal



4. a) $M = \frac{1,71 \text{ g}}{0,025 \text{ dm}^3 \cdot 1,20 \text{ mol / dm}^3} = 57,0 \text{ g/mol}$

b) Üheprotonilise karboksüülhappe valem on R–COOH

$M(-\text{COOH}) = 45 \text{ g/mol}$

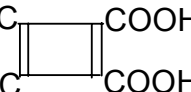
$M(\text{R}) = 12 \text{ g/mol}$

Tiitrimise andmeid rahuldavad kõik karboksüülhapped, mille valem on $(\text{CCOOH})_n$

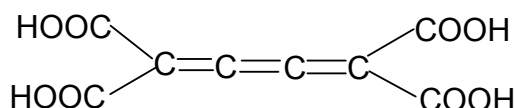
n = 1 sellist hapet ei ole

n = 2 $\text{HOOC}\equiv\text{CCOOH}$

n = 3 pole võimalik

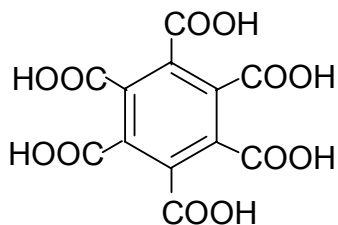
n = 4 HOOC  COOH

või



n = 5 pole võimalik

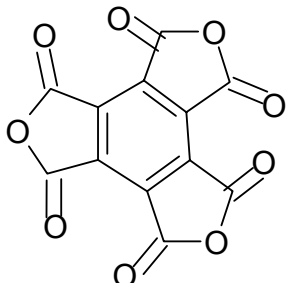
n = 6



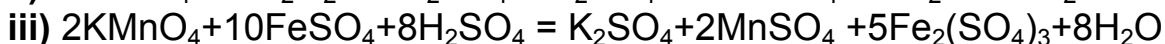
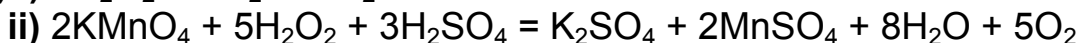
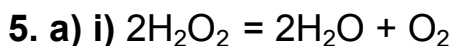
c) Karboksüülhappe kuumutamisel tekib anhüüriid.

d) i) Bensoolheksakarboksüülhappe, samuti haped, kus n=4 ja n=2;

ii)



$$M_r(C_{12}O_9) = 144 + 144 = 288$$



b) $k = \frac{1}{5 \text{ min}} \cdot \ln \frac{46,1}{37,1} = 0,04344 \text{ min}^{-1}$

$$k = \frac{1}{10 \text{ min}} \cdot \ln \frac{46,1}{29,8} = 0,04363 \text{ min}^{-1}$$

$$k = \frac{1}{20 \text{ min}} \cdot \ln \frac{46,1}{19,3} = 0,04354 \text{ min}^{-1}$$

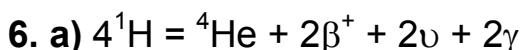
$$k = \frac{1}{30 \text{ min}} \cdot \ln \frac{46,1}{12,5} = 0,04350 \text{ min}^{-1}$$

$$k(\text{keskmine}) = 0,0435 \text{ min}^{-1}$$

c) $\tau = \frac{\ln 2}{0,0435 \text{ min}^{-1}} = 15,9 \text{ min} = 15 \text{ min } 54 \text{ sek} \approx \mathbf{15 \text{ min } 50 \text{ sek}}$

d) $\frac{C_o}{C_t} = e^{kt} \quad C_t = C_o \cdot e^{-k \cdot t}$

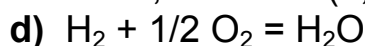
$$n(KMnO_4) = 46,1 \text{ mmol} \cdot e^{-0,0435 \text{ min}^{-1} \cdot 50 \text{ min}} \approx \mathbf{5,2 \text{ mmol}}$$



b) $\Delta m = 4m(^1H) - m(^4He) - 2m(\beta^+) = 4 \cdot 1,00727 - 4,00273 - 2 \cdot 0,0005486 = \mathbf{0,02525 \text{ amü}}$

c) $\Delta m = \frac{5,0 \text{ g}}{1000 \text{ g/kg}} \cdot \frac{-0,02525 \text{ amü}}{4,02908 \text{ amü}} = -3,134 \cdot 10^{-5} \text{ kg}$

$$E = -3,134 \cdot 10^{-5} \cdot (3,0 \cdot 10^8 \text{ m/s})^2 = \mathbf{-2,82 \cdot 10^{12} \text{ J}}$$



Reaktsioonikäigus eralduv energiahulk $\frac{-286 \text{ kJ/mol}}{2,0 \text{ g/mol}} \cdot 1000 \text{ J/kJ} \cdot 5,0 \text{ g} = -7,1 \cdot 10^5 \text{ J}$

$$\mathbf{Suhe = \frac{-2,82 \cdot 10^{12}}{-7,1 \cdot 10^5} = 3,9 \cdot 10^6}$$