

2000/2001 õa keemiaolümpiaadi lõppvoorü ülesannete lahendused
12. klass

1. a) Kuningvees lahustub Au, Ag ei saa lahustuda, sest see kattub AgCl kihiga

$$\text{Au} + \text{HNO}_3 + 3\text{HCl} = \text{AuCl}_3 + \text{NO}\uparrow + 2\text{H}_2\text{O}$$

$$\text{HCl} + \text{AuCl}_3 = \text{H}[\text{AuCl}_4]$$
- b) HNO_3 konts + 3HCl konts = $\text{NOCl} + 2\text{Cl}^* + 2\text{H}_2\text{O}$
 Kulda lahustavaks komponendiks on atomaarne kloor
- c) i) katoodil: tetrakloroauraat(III)ioonide ebastabiilsusest tekivad Au^{3+} – ioonid, mis redutseeruvad

$$\text{Au}^{3+} + 3\text{e}^- = \text{Au}$$
 Summaarselt $[\text{AuCl}_4]^- + 3\text{e}^- = \text{Au} + 4\text{Cl}^-$
- ii) anoodil: $2\text{Cl}^- - 2\text{e}^- = \text{Cl}_2\uparrow$
 Samad elektroodireaktsioonid toimuvad, kui lahuses on AlCl_3 .
- d) $0,9 \cdot 20 \text{ A} \cdot 4 \text{ h} \cdot 3600 \text{ s/h}$

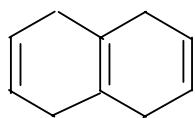
$$\text{Au} \Leftrightarrow 3\text{e}^-$$

$$196,97 \quad 96485 \text{ A}\cdot\text{s/mol}$$

$$m(\text{Au, elektrolüüdis}) = \frac{1}{3} \cdot 20 \text{ A} \cdot 4 \cdot 3600 \text{ s} \cdot 0,9 \cdot \frac{1 \text{ mol}}{96485} \cdot 196,97 \text{ g/mol} = 176,38 \text{ g}$$

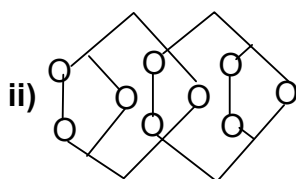
$$m(\text{medal}) = \frac{176,38 \text{ g}}{0,9} \cdot \frac{24}{23} = 204,50 \text{ g}$$

2. a) i)



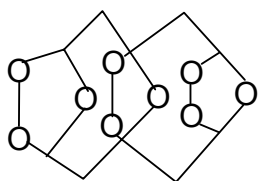
A

ii)

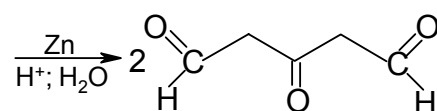


B

b) i)

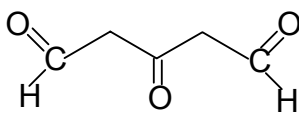


B

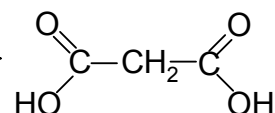
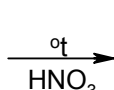


C

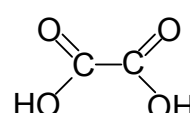
ii)



C

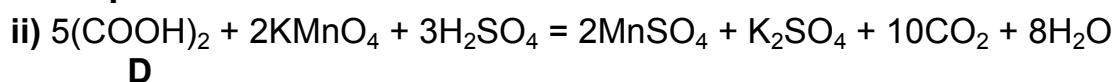
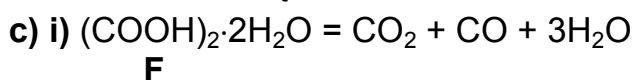


E



D

t^0



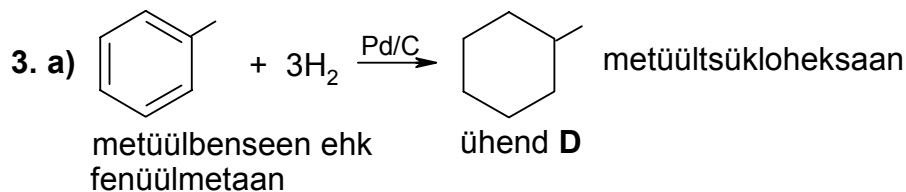
- d) $0,153 \text{ dm}^3$
 $5(\text{gaasid}) \Leftrightarrow \text{F}$

$$22,4 \text{ dm}^3 / \text{mol} \cdot \frac{373}{273}$$

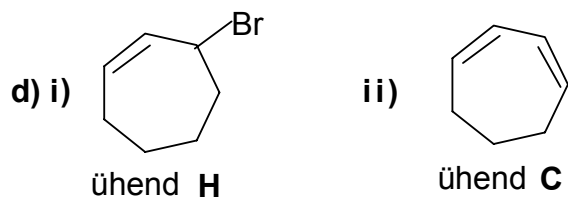
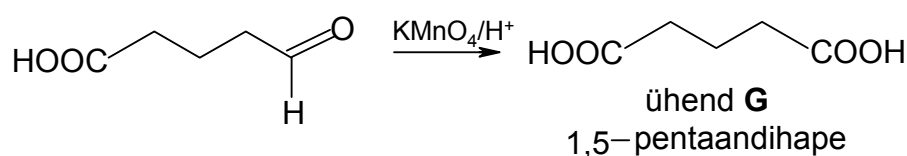
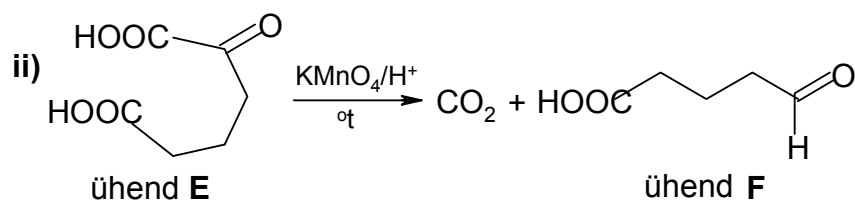
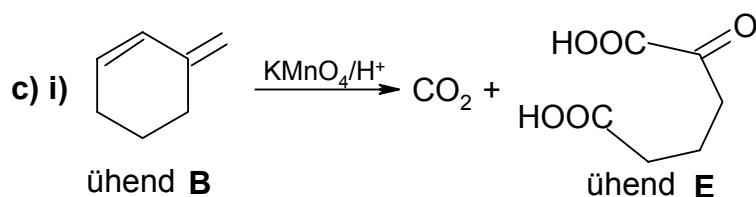
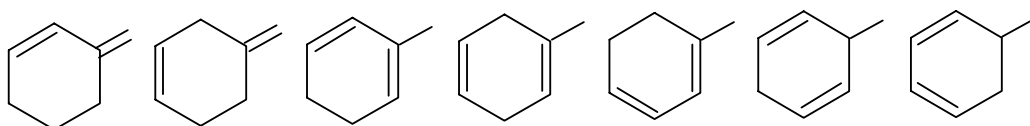
$$n(\text{F}) = \frac{1}{5} \cdot 1,53 \text{ dm}^3 \cdot \frac{1 \text{ mol}}{22,4 \text{ dm}^3 \cdot \frac{373}{273}} = 0,009998 \text{ mol} \approx 0,0100 \text{ mol}$$

$$\text{e) } 0,0100 \text{ mol} \cdot \frac{1}{0,1 \text{ dm}^3} \cdot 10 \text{ cm}^3 \quad 5(\text{F}) = 2(\text{KMnO}_4) \quad \text{c} \cdot 13,2 \text{ cm}^3$$

$$c(\text{KMnO}_4) = \frac{2}{5} \cdot 0,100 \text{ mol} / \text{dm}^3 \cdot 10 \text{ cm}^3 \cdot \frac{1}{13,2 \text{ cm}^3} = \mathbf{0,0303 \text{ mol/dm}^3}$$



b) Ühendite **A**, **B** ja **C** brutovalem (isomeerid) peab olema C_7H_{10} . Ühendile **B** vastavas 7 isomeeris peab olema süsiniku aatomite paigutus sama nagu metüülsükloheksaanis (C_7H_{14}). Järelikult kõik need molekulid peavad olema dienid.



4. a) i) $M(\text{B}) = 44,01 \text{ g/mol} \cdot 1,611 = 70,90 \text{ g/mol}$
B – Cl_2

ii) Et ühest moolist ühendist **A** moodustub 1,5 mooli Cl_2 , siis peab metalli **X** oksüdatsiooniaste ühendis **A** olema III. Ühendi valemiks peab olema XCl_3

$$M(\text{X}) = 3 \cdot 35,45 \text{ g/mol} \cdot 20,24/79,76 = 26,99 \text{ g/mol}$$

X – Al

iii) **C** – LiH

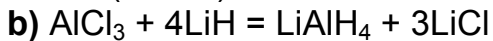
iv) **E** – LiCl. Ülesande tingimuste kohaselt on ühendis **E** metalli oksüdatsiooniaste I.

v) **D** – LiAlH_4

$$M(\text{AlCl}_3) = 133,35 \text{ g/mol}$$

$$M(\text{D}) = 133,35 \text{ g/mol} \cdot 0,285 = 38,0 \text{ g/mol}$$

$$M(\text{LiAlH}_4) = 6,94 + 26,98 + 4 \cdot 1,008 = 37,95 \text{ g/mol} \approx 38,0 \text{ g/mol}$$



A **C** **D** **E**

c) $\text{LiAlH}_4 + \text{Me}_3\text{COH}$ reaktsioonil eraldub vesinik ja tekivad saadused, kus ühendis LiAlH_4 on asendatud erinev arv vesiniku aatomeid

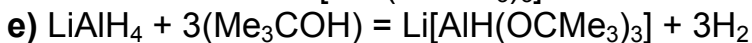


d) $n(\text{H}_2) = 0,0112 \text{ dm}^3 \cdot \frac{1 \text{ mol}}{22,4 \text{ dm}^3} = 0,0005 \text{ mol} = 0,5 \text{ mmol}$



$$n(\text{C}) = 1,20 \text{ g} \cdot \frac{1 \text{ mol}}{100 \text{ g}} = 0,012 \text{ mol} = 12 \text{ mmol}$$

Ühendiks **H** on $\text{Li}[\text{AlH}(\text{OCMe}_3)_3]$



D

H

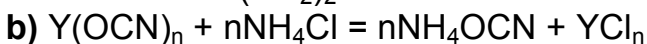


J

g) i) $\text{Li}[\text{Al}(\text{OCMe}_3)_4]$, ii) Kuumutamise saab ületada Me_3C –rühmadest põhjustatud steerilist takistust.

5. a) Loodetud sool **A** pidi andma iseloomuliku lõhna (NH_3) kustutatud lubja toimet. Sellest võib järeldada, et ühendis **X** on neljandaks elemendiks vesinik, mida on 6,66%.

$$\text{N} : \text{C} : \text{O} : \text{H} = \frac{46,67}{14,0} : \frac{20,00}{12,0} : \frac{26,67}{16,0} : \frac{6,66}{1,01} = 3,33 : 1,67 : 1,67 : 6,60 = 2 : 1 : 1 : 4$$



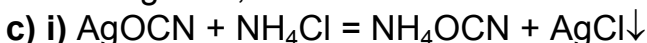
$$M(\text{NH}_4\text{OCN}) = M(\text{X}) = 60,0 \text{ g/mol}$$

$$M(\text{A}) = 60,0 \text{ g/mol} \cdot 2,50 = 150 \text{ g/mol} = M[\text{Y}(\text{OCN})_n]$$

$$\text{Kui } n=1, \text{ siis } M(\text{Y}) = 150 - 42 = 108 \text{ g/mol}$$

Y – Ag

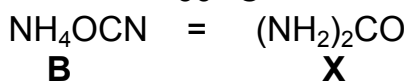
A – AgOCN , hõbetsüanaat



A

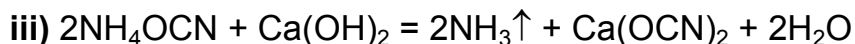
B

ii) $>60^\circ\text{C}$



B

X

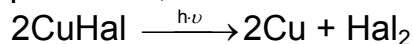


d) i) Friedrich Wöhler

ii) Isomeeria

iii) Esmakordselt saadi anorgaanilisest ühendist orgaaniline ühend.

6. a) i) $\text{A} \xrightarrow{h\nu}$ Valguse toimel lagunevad Ag^+ ja Cu^+ halogeniidid. Et kroonleht muutus punakaks, oli soolaks CuHal .



H – Cu, punane

ii) $n(\text{A}) = 2n(\text{Hal})$

$$\frac{1,00 \text{ g}}{63,5 \text{ g/mol} + M(\text{Hal})} = 2 \cdot \frac{0,667 \text{ g}}{2 \cdot M(\text{Hal})}$$

$$M(\text{Hal}) = 42,4 \text{ g/mol} + 0,667 \cdot M(\text{hal})$$

$$M(\text{Hal}) = 127,3 \text{ g/mol}$$

A – CuI, vask(I)jodiid, valge

b) 1,00 g



158 g/mol 22,4 dm³/mol

ii) $V(\text{Cl}_2) = \frac{5}{2} \cdot 1,00 \text{ g} \cdot \frac{1 \text{ mol}}{158 \text{ g}} \cdot 22,4 \text{ dm}^3 / \text{mol} = \mathbf{0,354 \text{ dm}^3}$

B – KMnO_4 , kaaliumpermanganaat, violetne; I – Cl_2 , kloor

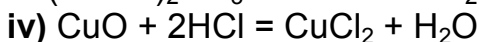
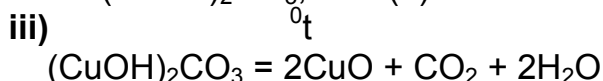
c) i) $\text{C} \xrightarrow{\text{ot}}$ J $\text{J} + \text{HCl} \rightarrow$ helesinine värvus, mis on tüüpiline Cu^{2+} – ioonile.

J – CuO, vask(II)oksiid, must

ii) kui $n(\text{C}) = n(\text{J})$, siis $M(\text{C}) = \frac{m(\text{C})}{n(\text{C})} = 1,00 \text{ g} \cdot \frac{79,5 \text{ g/mol}}{0,720 \text{ g}} = 110,4 \text{ g/mol}$

kui $n(\text{C}) = 2n(\text{J})$, siis $M(\text{C}) = 221 \text{ g/mol}$

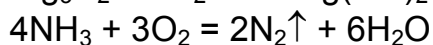
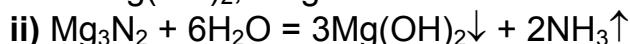
C – $(\text{CuOH})_2\text{CO}_3$, vask(II) aluseline karbonaat, roheline



K – CuCl_2 , vask(II)kloriid, helesinine

d) i) L – Mg, magneesium

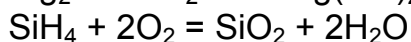
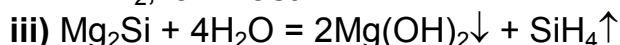
M – $\text{Mg}(\text{OH})_2$, magneesiumhüdroksiid



D – Mg_2N_3 , magneesiumnitriid, kollakasroheline

N – NH_3 , ammoniaak

P – N_2 , lämmastik



E – Mg_2Si , magneesiumsilitsiid, helesinine

O – SiH_4 , silaan

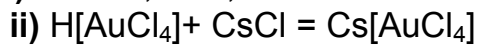
R – SiO_2 , ränidioksiid

e) i) F – Pb_3O_4 , tripliitetraoksiid, plii(II,IV)oksiid, oranžikaspunane

F – Pb_2PbO_4 , dipli(II)ortoplumbaat

$$\text{ii) \%(\text{O})} = \frac{64,0}{685} \cdot 100 = \mathbf{9,34}$$

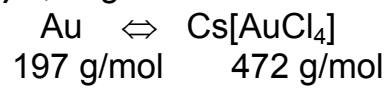
f) i) **G** – Au, kuld, kollane



Q – $\text{H}[\text{AuCl}_4]$, tetraklorokuld(III)hape

S – $\text{Cs}[\text{AuCl}_4]$, tseesiumtetrakloroauraat(III)

iii) 1,00 g



$$\mathbf{m\{Cs[AuCl_4]\}} = \frac{1}{1} \cdot 1,00 \text{ g} \cdot \frac{1 \text{ mol}}{197 \text{ g}} \cdot 472 \text{ g/mol} = \mathbf{2,40 \text{ g}}$$