

2001/2002 õa keemiaolümpiaadi lõppvooru ülesannete lahendused
9. klass

1. a) $M(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = 250 \text{ g/mol}$
 $m(\text{CuSO}_4) = 5,0 \text{ kg} \cdot 0,040 = 0,20 \text{ kg}$
 $m(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = 0,20 \text{ kg} (\text{CuSO}_4) \cdot \frac{250 (\text{CuSO}_4 \cdot 5\text{H}_2\text{O})}{160 (\text{CuSO}_4)} = 0,312 \text{ kg} \approx$
» 0,31 kg

$m(\text{H}_2\text{O}) = 5,0 \text{ kg} - 0,31 \text{ kg} = 4,69 \text{ kg} \approx \mathbf{4,7 \text{ kg}}$

b) $M(\text{FeSO}_4 \cdot 7\text{H}_2\text{O}) = 278 \text{ g/mol}$

Olgu $m(\text{FeSO}_4 \cdot 7\text{H}_2\text{O}) = x$

$$0,050 = \frac{9,0 \text{ kg} \cdot 0,030 + x \cdot \frac{152}{278}}{9,00 \text{ kg} + x}$$

$$0,45 \text{ kg} + 0,05 x = 0,27 \text{ kg} + x \cdot 0,547$$

$$0,18 \text{ kg} = 0,497x$$

$$x = 0,362 \text{ kg} \approx 0,36 \text{ kg}$$

$m(\text{FeSO}_4 \cdot 7\text{H}_2\text{O}) = \mathbf{0,36 \text{ kg}}$

2. a) i) **X** – Al, alumiinium

ii) Alumiinium on kaetud oksiidiga Al_2O_3 tiheda kihiga.

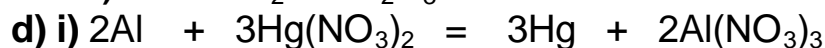
b) i) **Y** – Hg, elavhõbe

ii) Al_2O_3 kaitsekiht eemaldati

iii) Lusika pinnale moodustus alumiiniummalm (alumiiniumi lahus elavhõbedas).

iv) Tilgakesed **C** on metalliline elavhõbe.

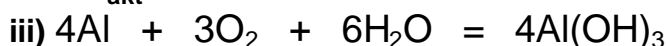
c) i) Alumiinium kattub tiheda Al_2O_3 kaitsekihiga.



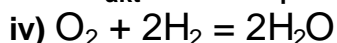
X A – elavhõbe(II)nitraat



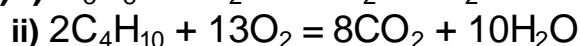
X_{akt} D – vesi **B** – alumiiniumhüdroksoid **F** – vesinik



X_{akt} E – hapnik **D B**



E F D



b) i) $n(\text{C}_3\text{H}_8) = 21,0 \cdot 10^3 \text{ g} \cdot \frac{1 \text{ mol}}{44,1 \text{ g}} = 4,76 \cdot 10^2 \text{ mol}$

$$\text{DH}(\text{C}_3\text{H}_8) = 4,76 \cdot 10^2 \text{ mol} \cdot (-2221 \text{ kJ/mol}) = -1,06 \cdot 10^6 \text{ kJ} = -1,06 \cdot 10^3 \text{ MJ} = \mathbf{-1,06 \text{ GJ}}$$

ii) $n(\text{C}_4\text{H}_{10}) = 21,0 \cdot 10^3 \text{ g} \cdot \frac{1 \text{ mol}}{58,1 \text{ g}} = 3,61 \cdot 10^2 \text{ mol}$

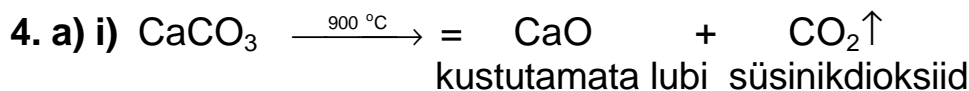
$$DH(C_4H_{10}) = 3,61 \cdot 10^2 \text{ mol} \cdot (-2,889 \cdot 10^3 \text{ kJ/mol}) = -1,04 \cdot 10^6 \text{ kJ} = -1,04 \cdot 10^3 \text{ MJ} = \mathbf{-1,04 \text{ GJ}}$$

c) Sama raha eest saadud energia hulk on antud juhul energiaühiku hinnaga pöördvõrdelises seoses.

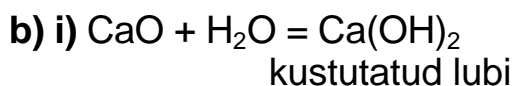
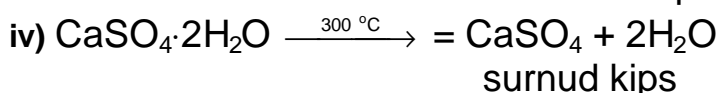
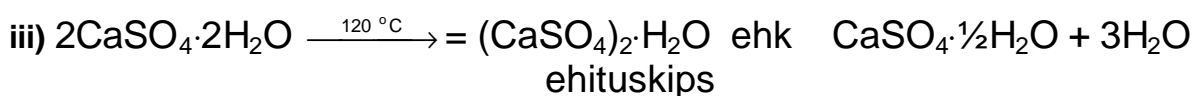
i) Propaani põletamisel saame sama energia väiksema raha eest. Propaan on odavam.

ii) Ühe ballonitäie ükskõik kumma gaasi põletamisel saame keskmiselt 1,05 GJ energiat (tarbija seisukohalt märk +).

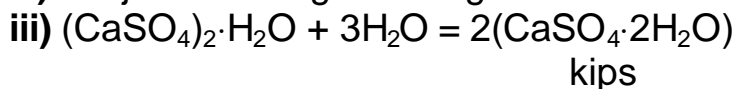
$$\text{Hind} = \frac{250 \text{ krooni}}{1,05 \text{ GJ}} = \mathbf{238 \text{ krooni/GJ}}$$



ii) 300 °C juures lubjakivi ei lagune.

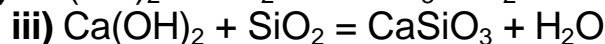
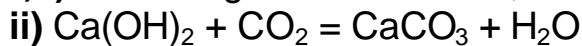


ii) Lubjakivi ei reageeri veega.

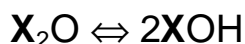


iv) Surnud kips ei reageeri veega.

c) i) Krohvisegu saadakse liiva, kustutatud lubja ja vee segamisel.



5. a) Leelismetalli oksidi **D** valem on X_2O .



D **B**

$$n(\text{XOH}) = \frac{2}{1} \cdot 0,100 \text{ mol} = 0,200 \text{ mol}$$

$$M(\text{XOH}) = \frac{8,00 \text{ g}}{0,200 \text{ mol}} = 40,0 \text{ g/mol}$$

$$M_r(\text{X}) = 40,0 - 16,0 - 1,0 = 23$$

X – Na, naatrium

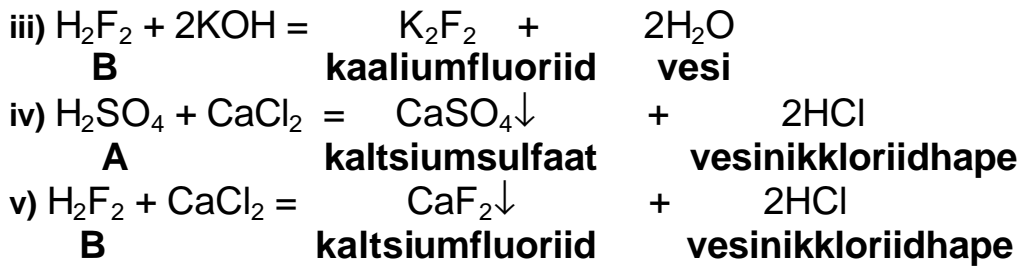
B – NaOH, naatriumhüdroksoid

b) Gaas **C** saab olla CO_2 , sest see on kolmeatomiline, värvitu ja lõhnatu. CO_2 reageerimisel süsihappe normaalsoolaga **A** moodustub vesiniksool **E**. Vesiniksool **E** laguneb vee keemistemperatuurist madalamal temperatuuril normaalsoolaks **A**. CO_2 (**C**) juhtimisel NaOH (**B**) vesilahusesse moodustub alguses normaalsool **A** ja seejärel vesiniksool **E**.

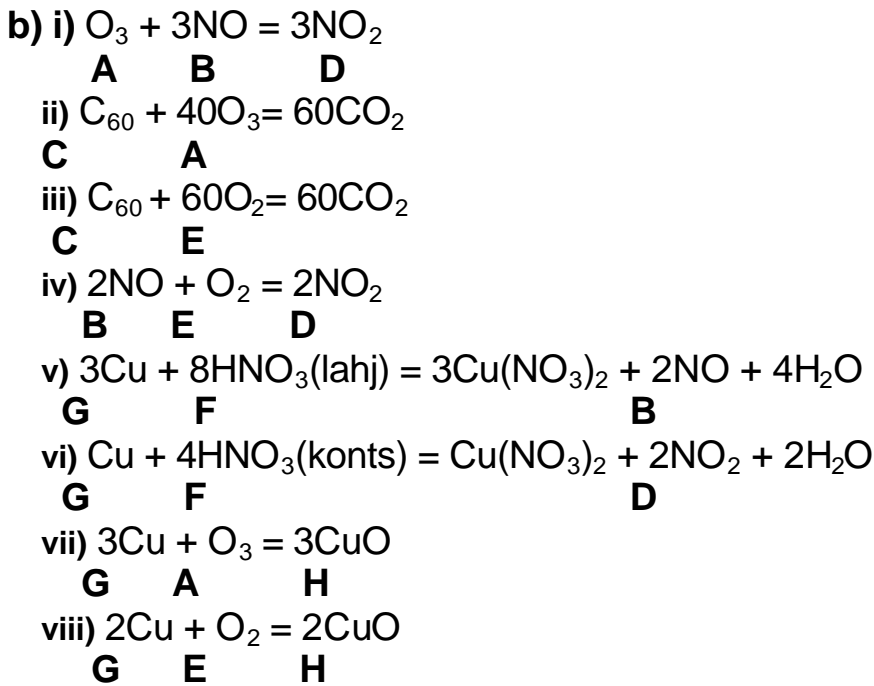
c) i) $\overset{\text{A}}{\text{Na}_2\text{CO}_3} + \overset{\text{B}}{\text{H}_2\text{O}} = 2\overset{\text{B}}{\text{NaOH}} + \overset{\text{C}}{\text{CO}_2}$

A – naatriumkarbonaat **B** **C**





3. a) **A** – O₃, osoon, gaas, lihtaine, mürgine
B – NO, lämmastikmonooksiid, gaas, mürgine
C – C₆₀, fullereen, tahke, lihtaine
D – NO₂, lämmastikdioksiid, gaas, mürgine
E – O₂, hapnik, gaas, lihtaine
F – HNO₃, lämmastikhape
G – Cu, vask
H – CuO, vask(II)oksiid



b) i) $n(\text{N}) = 35 \text{ g} \cdot \frac{1 \text{ mol}}{14 \text{ g}} = 2,5 \text{ mol}$

$n(\text{O}) = 60 \text{ g} \cdot \frac{1 \text{ mol}}{16 \text{ g}} = 3,75 \text{ mol}$

$n(\text{H}) = 5 \text{ g} \cdot \frac{1 \text{ mol}}{1 \text{ g}} = 5 \text{ mol}$

Väikseimad täisarvud saame siis, kui moolide arvud jagame arvuga

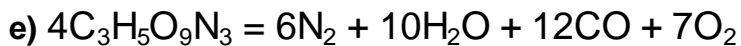
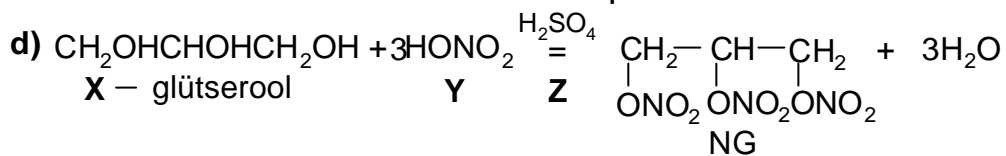
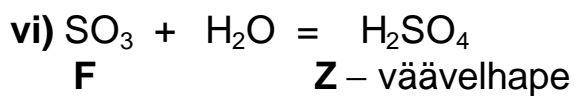
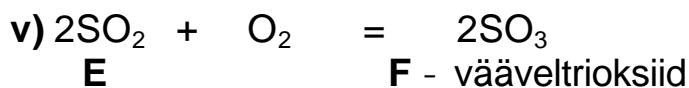
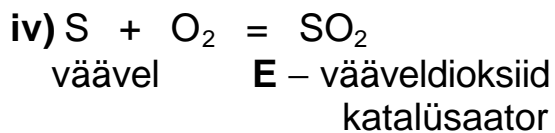
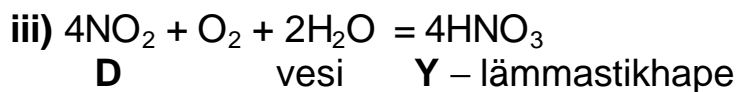
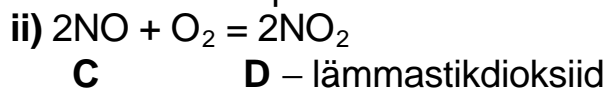
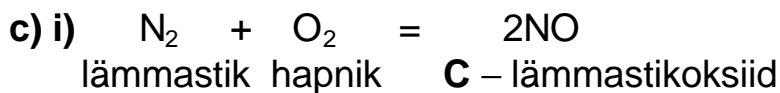
1,25.

Lihtsaim brutovalem on seega N₂H₄O₃.

A - NH₄NO₃

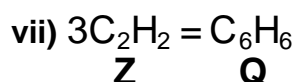
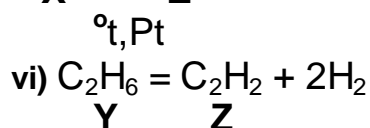
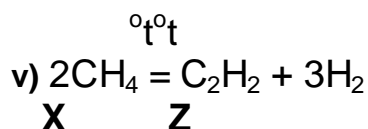
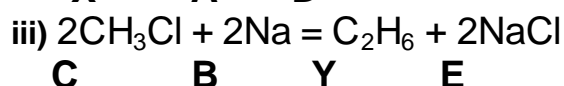
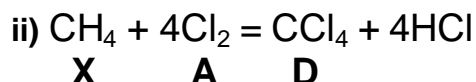
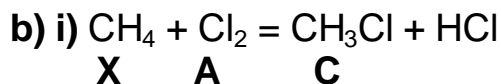
ii) ammooniumnitraat

ii) **B** – seep; (rasvhappe) sool
elektrikaar



2001/2002 õa keemiaolümpiaadi lõppvoorü ülesannete lahendused
11. klass

1. a) **X** – CH₄, metaan **B** – Na, naatrium
Y – C₂H₆, etaan **C** – CH₃Cl, klorometaan e metüülkloriid
Z – C₂H₂, etüün **D** – CCl₄, tetraklorometaan
Q – C₆H₆, benseen **E** – NaCl, naatriumkriid
A – Cl₂, kloor



c) i) M_r(CCl₄) = 154
M_r(CH₄) = 16

$$D(\text{CCl}_4)_{\text{CH}_4} = \frac{154}{16} = \mathbf{9,6}$$

ii) M_r(C₂H₂) = 26
M_r(C₂H₆) = 30

$$D(\text{C}_2\text{H}_6)_{\text{C}_2\text{H}_2} = \frac{26}{30} = \mathbf{0,867}$$

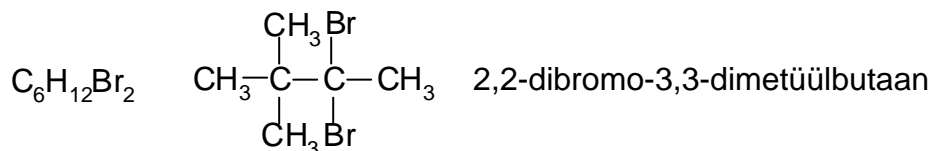
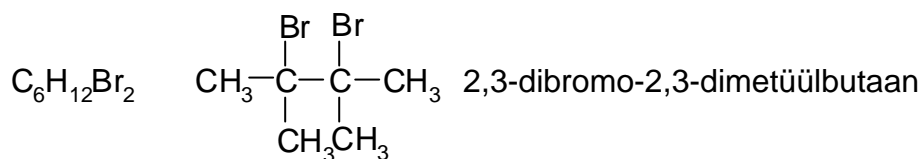
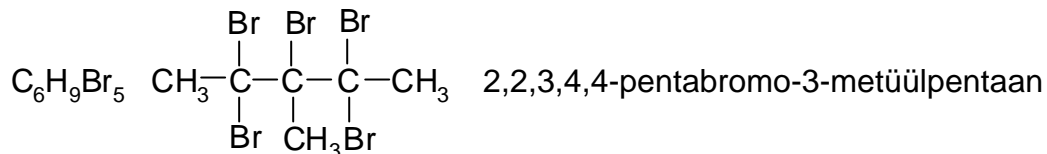
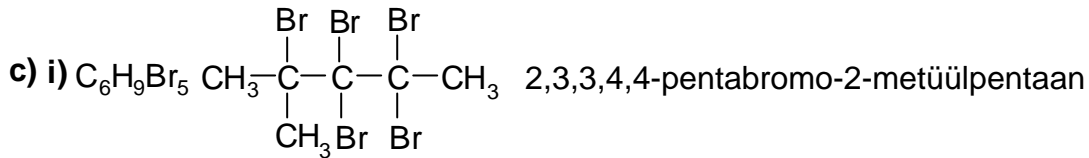
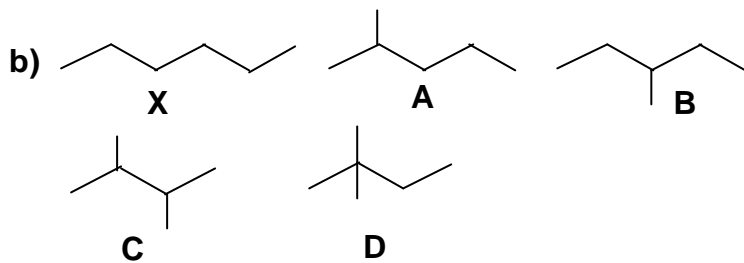
iii) **M(C₆H₆) = 78 g/mol**

2. a) i) $\frac{n(\text{H})}{n(\text{C})} = \frac{2 \cdot 8,95 \text{ g}}{18,0 \text{ g/mol}} \cdot \frac{22,4 \text{ dm}^3 / \text{mol}}{9,55 \text{ dm}^3} = 2,333 \approx \mathbf{2,33}$

ii) 2,333n = 2n + 2

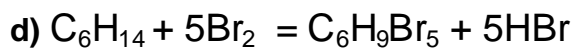
$$n = \frac{2}{0,333} = 6,006 \approx 6$$





$$\text{ii) } \frac{M(C_6H_9Br_5)}{M(C_6H_{14})} = \frac{81 + 5 \cdot 80}{86} = 5,59$$

$$\frac{M(C_6H_{12}Br_2)}{M(C_6H_{14})} = \frac{84 + 2 \cdot 80}{86} = 2,84$$



3. a) i) $N(O) = \frac{47,1}{16} = 2,94$ $N(Al) = \frac{52,9}{27,0} = 1,96$

Kui $N(Al) = 1$, siis $N(O) = \frac{2,94}{1,96} = 1,5$



ii) $N(O) = \frac{50,4}{16} = 3,15$ $N(Al) = \frac{42,5}{27} = 1,57$

$N(Be) = \frac{7,1}{9,01} = 0,788$

Kui $N(Be) = 1$, siis $N(Al) = \frac{1,57}{0,788} \approx 2$ ja $N(O) = \frac{3,15}{0,788} = 4$



$$\text{iii) } N(\text{O}) = \frac{53,6}{16} = 3,35 \quad N(\text{Si}) = \frac{31,4}{28} = 1,12$$

$$N(\text{Al}) = \frac{10}{27} = 0,37 \quad N(\text{Be}) = \frac{5,0}{9,01} = 0,555$$

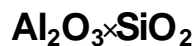
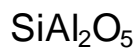
$$\text{Kui } N(\text{Al}) = 1, \text{ siis } N(\text{O}) = \frac{3,35}{0,37} \approx 9,$$

$$N(\text{Si}) = \frac{1,12}{0,37} \approx 3 \quad N(\text{Be}) = \frac{0,555}{0,37} \approx 1,5$$



$$\text{iv) } N(\text{O}) = \frac{49,4}{16} = 3,09 \quad N(\text{Si}) = \frac{17,3}{28} = 0,618 \quad N(\text{Al}) = \frac{33,3}{27} = 1,23$$

$$\text{Kui } N(\text{Si}) = 1, \text{ siis } N(\text{Al}) = \frac{1,23}{0,618} \approx 2 \quad \text{ja} \quad N(\text{O}) = \frac{3,09}{0,618} = 5$$

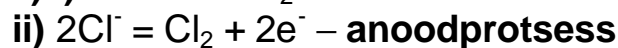
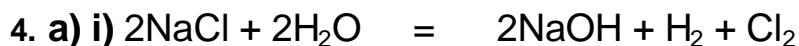


b) i) X - V, vanaadium Z - Mn, mangaan

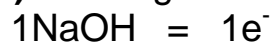
Y - Cr, kroom Q - Fe, raud

ii) Otsitavateks metallideks ei saa olla ei Ti ega Co. Nende vahele jääb neli metalli, mis sobivad ülesande tingimustega, sest raual esinevad kahe- ja kolmevalentsed ioonid. Tuntud on pruunid mangaaniühendid ja rohelised kroomiühendid.

elektrolüüs



$$\text{b) i) } 1000 \text{ g} \quad I \cdot t = 0,9$$



$$40,0 \text{ g/mol} \quad 96500 \text{ A} \cdot \text{s/mol}$$

$$I \cdot t = \frac{1}{1} \cdot 1000 \frac{\text{g}}{\text{kg}} \cdot \frac{1 \text{ mol}}{40,0 \text{ g}} \cdot 96500 \frac{\text{A} \cdot \text{s}}{\text{mol}} \cdot \frac{1}{0,9} \cdot \frac{1 \text{ kA}}{1000 \text{ A}} \cdot \frac{1 \text{ h}}{3600 \text{ s}} = 0,745 \frac{\text{kA} \cdot \text{h}}{\text{kg}}$$

$$E = 0,745 \frac{\text{kA} \cdot \text{h}}{\text{kg}} \cdot 3,80 \text{ V} \cdot \frac{1 \text{ kW}}{\text{kA} \cdot \text{V}} = 2,829 \text{ kWh/kg}$$

$$\text{Hind}(\text{NaOH}) = 2,829 \frac{\text{kWh}}{\text{kg}} \cdot 80 \frac{\text{senti}}{\text{kWh}} = 226,4 \text{ senti/kg} \approx \mathbf{226 \text{ senti/kg}}$$

ii) 40,0 g NaOH \Leftrightarrow 100 g 36,5% soolhape

$$\begin{aligned} \text{Hind}(36,5\% \text{ HCl}) &= 226,4 \text{ senti} \cdot \frac{1}{\text{kg}(\text{NaOH})} \cdot \frac{0,04 \text{ kg}(\text{NaOH})}{0,1 \text{ kg} (36,5\% \text{ soolhape})} = \\ &= 90,56 \text{ senti/kg} \approx \mathbf{90,6 \text{ senti/kg}} \end{aligned}$$

c) i) $m(\text{NaOH}) = 100 \text{ krooni} \cdot \frac{1 \text{ kg}}{2,264 \text{ krooni}} = 44,2 \text{ kg}$

ii) $m(36,5\% \text{ HCl}) = 100 \text{ krooni} \cdot \frac{1 \text{ kg}}{0,9056 \text{ krooni}} = 110 \text{ kg}$

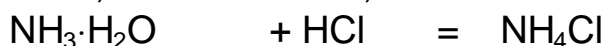
5. a) $c(\text{NaCl}) = c(\text{Cl}^-) = \frac{1,56 \cdot 10^{-10} \text{ mol}^2 / (\text{dm}^3)^2}{1,56 \cdot 10^{-9} \text{ mol} / \text{dm}^3} = 1,00 \cdot 10^{-1} \text{ mol} / \text{dm}^3$

b) $[\text{OH}^-] = 1,79 \cdot 10^{-5} \text{ mol} / \text{dm}^3 \cdot \frac{1,25 \cdot 10^{-1}}{1,00 \cdot 10^{-1}} = 2,238 \cdot 10^{-5}$

$\text{pOH} = -\lg 2,238 \cdot 10^{-5} = 4,65$

$\text{pH} = 14 - 4,65 = 9,35$

c) lähtehulk $0,009375 \text{ mol}$ $0,1875 \text{ mol}$ $0,0750 \text{ mol}$



lõpp-hulk $-$ $0,09375 \text{ mol}$ $0,169 \text{ mol}$

Lähtehulk: $n(\text{NH}_3 \cdot \text{H}_2\text{O}) = 0,750 \text{ dm}^3 \cdot 0,125 \text{ mol} / \text{dm}^3 = 0,09375 \text{ mol}$

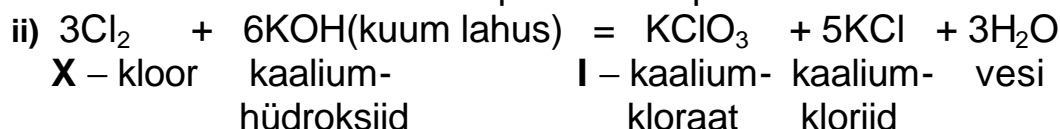
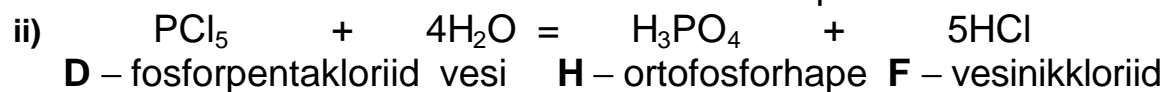
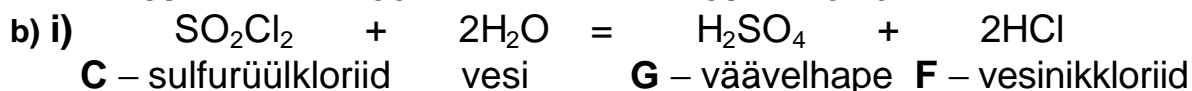
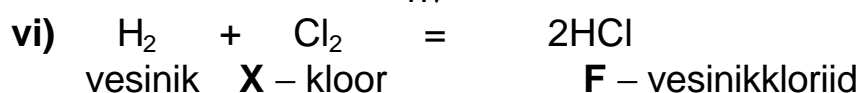
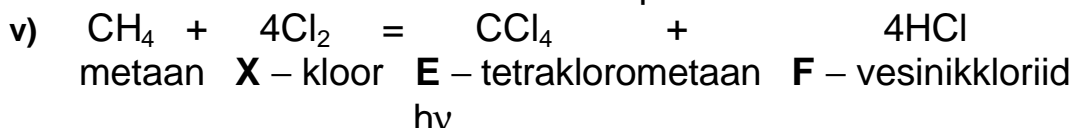
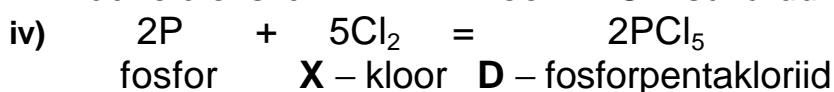
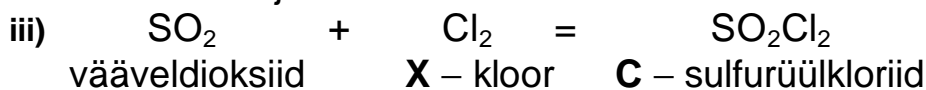
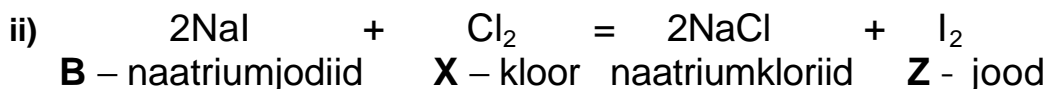
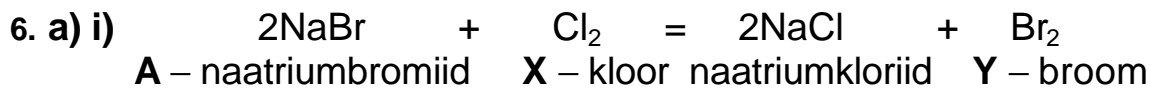
$n(\text{HCl}) = 1,50 \text{ dm}^3 \cdot 0,125 \text{ mol} / \text{dm}^3 = 0,1875 \text{ mol}$

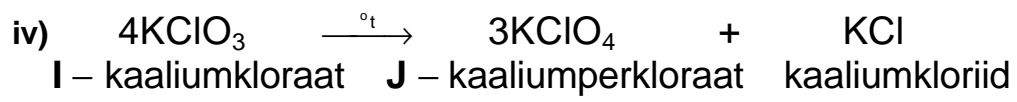
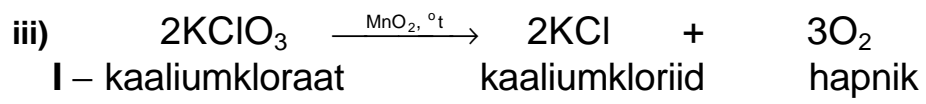
Lõpp-hulk: $n(\text{HCl}) = 0,1875 \text{ mol} - 0,09375 \text{ mol} = 0,09375 \text{ mol}$

Lahust **Z** on $1,50 \text{ dm}^3 + 1,50 \text{ dm}^3 = 3,00 \text{ dm}^3$ ja selles sisaldub $0,09375$ mooli tugevat hapet, mis nõrga aluse soolaga ei moodusta enam puhversüsteemi

$$[\text{H}^+] = \frac{0,09375 \text{ mol}}{3,00 \text{ dm}^3} = 3,125 \cdot 10^{-2} \text{ mol} / \text{dm}^3$$

$\text{pH} = -\lg 3,125 \cdot 10^{-2} \text{ mol} / \text{dm}^3 = 1,51$





2001/2002 õa keemiaolümpiaadi lõppvooru ülesannete lahendused
12. klass

1. a) $\Delta H^\circ = \Sigma \Delta H_f^\circ(\text{saadused}) - \Sigma \Delta H_f^\circ(\text{lähteained})$

$$\Delta H^\circ = 1 \text{ mol} \cdot (-110 \text{ kJ/mol}) - 1 \text{ mol} \cdot (-242 \text{ kJ/mol}) - 1 \text{ mol} \cdot (-75 \text{ kJ/mol}) = 207 \text{ kJ}$$

b) i) $\Delta G^\circ = \Delta H^\circ - T \cdot \Delta S^\circ$

$$\Delta S^\circ = \Sigma S^\circ(\text{saadused}) - \Sigma S^\circ(\text{lähteained})$$

$$\Delta S^\circ = 3 \text{ mol} \cdot 131 \text{ J/(mol}\cdot\text{K)} + 1 \text{ mol} \cdot 197 \text{ J/(mol}\cdot\text{K)} - 1 \text{ mol} \cdot 189 \text{ J/(mol}\cdot\text{K)} - 1 \text{ mol} \cdot 186 \text{ J/(mol}\cdot\text{K)} = 215 \text{ J/K} = 0,215 \text{ kJ/K}$$

$$\Delta G^\circ = 207 \text{ kJ} - 298 \text{ K} \cdot 0,215 \text{ kJ/K} = 207 \text{ kJ} - 64 \text{ kJ} = 143 \text{ kJ}$$

ii) Otsesuunaline reaktsioon ei saa toimuda.

c) $K_t = e^{-\frac{\Delta G}{RT}}$

$$K_t = e^{-\frac{143000}{8,314 \cdot 298}} = e^{-57,7} = 8,73 \times 10^{-26}$$

d) i) Tasakaalu korral $\Delta G = 0$

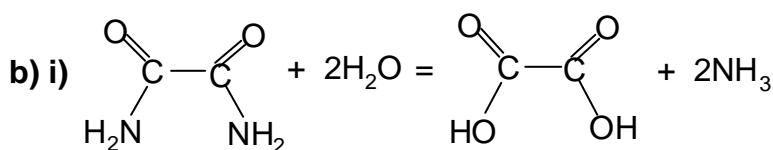
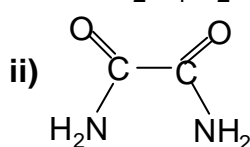
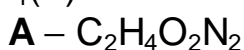
ii) $0 = \Delta H - T \cdot \Delta S$

$$T = 207 \text{ kJ} \cdot \frac{\text{K}}{0,215 \text{ kJ}} = 963 \text{ K}$$

$$t = T - 273 = 963 - 273 = 690 \text{ }^\circ\text{C}$$

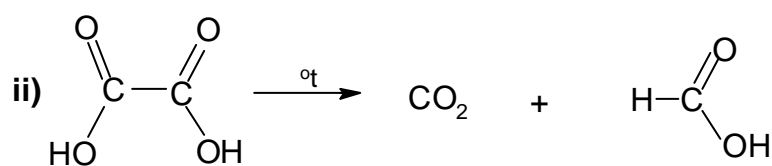
2. a) i) Elementide aatomite arv ei saa olla üks, sest siis oleks neid kõiki võrdselt ($3 \cdot 1 - 2 = 1$). Kui süsiniku, hapniku ja lämmastiku aatomite arv on kaks, siis vesiniku aatomeid peab olema neli ($3 \cdot 2 - 2 = 4$).

$$M_r(A) = 2 \cdot 12 + 4 \cdot 1 + 2 \cdot 16 + 2 \cdot 14 = 88$$



A – oksamiid

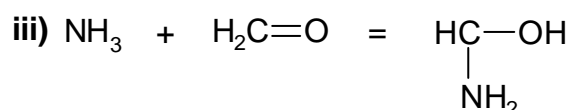
C – oblikhape **B** – ammoniaak

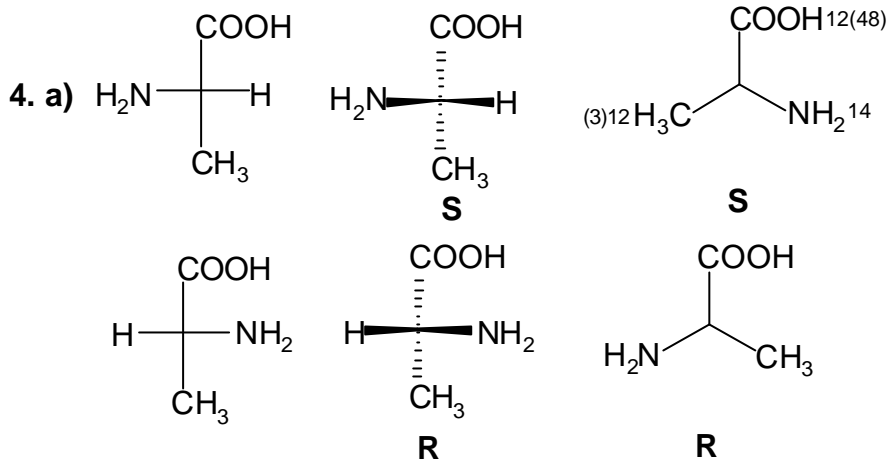


C

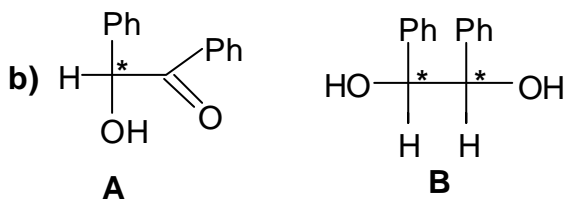
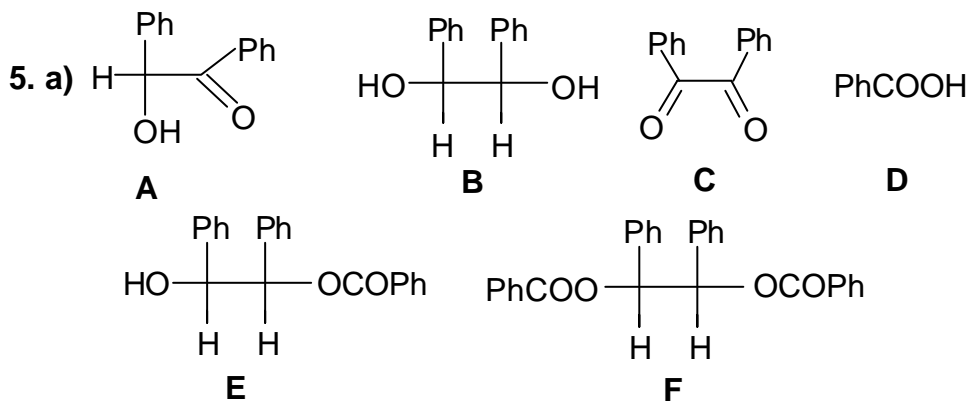
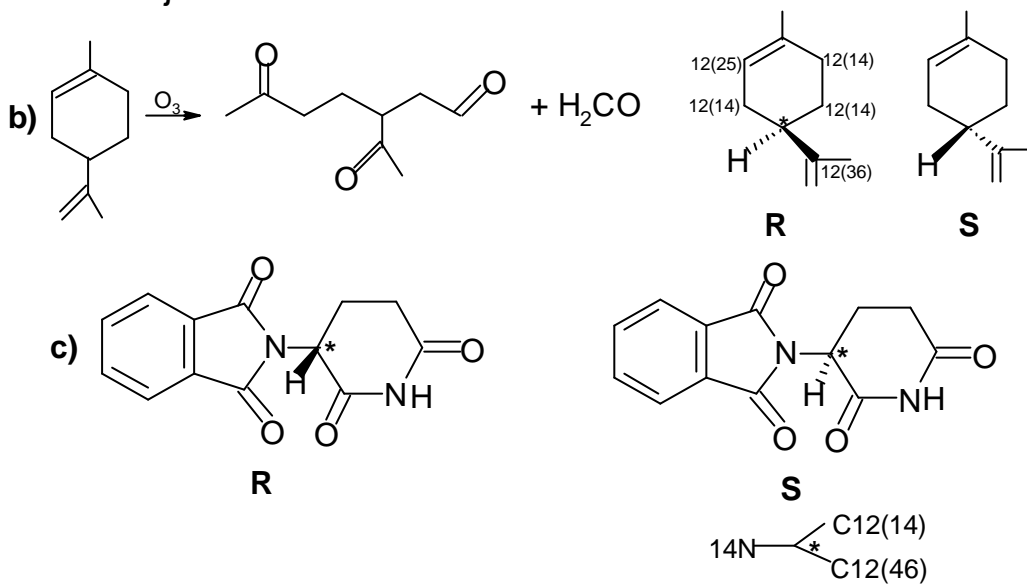
D – süsihappegaas

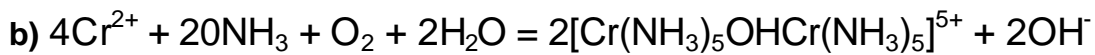
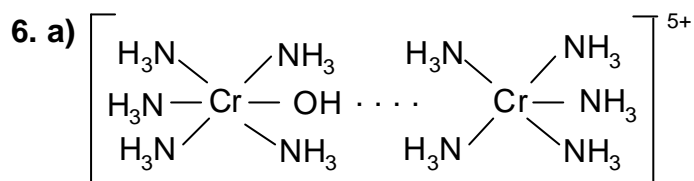
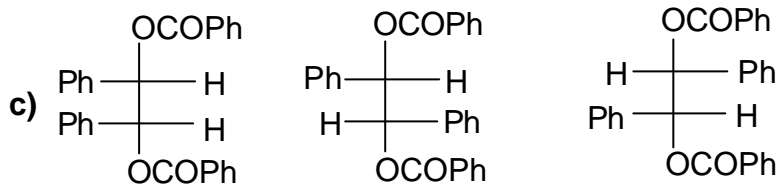
E – metaanhape



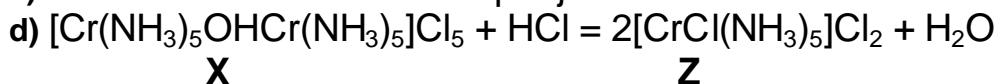


Kui on märkimata, millised rühmitused on ees, siis Fischeri projekt-sioonis ei saa **S** ja **R** enantiomeere määrata

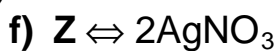




c) Kloriidioonide suur ülehulk põhjustab hüdroksiidi asemel kloriidi moodustumise.



e) Pentaammiinklorokroom(2+)kloriid.



$$V(\text{AgNO}_3) = \frac{2}{1} \cdot \frac{10 \text{ cm}^3 \cdot 0,05 \text{ mol/dm}^3}{0,1 \text{ mol/dm}^3} = 10 \text{ cm}^3$$

Komplekskatioon ei dissotsieeru.