2003/2004 õa keemiaolümpiaadi lõppvooru ülesannete lahendused
11. klass

1. a) **A** – H_2, vesinik
B – Cl_2, kloor
C – HCl, vesinikkloriid
D – F_2, fluor
E – HF, vesinikfluoriid
F – H_2SiF_6, heksafluororänihape
G – P_4, valge fosfor
H – PCl_3, fosfortrikloriid
I – PCl_5, fosforpentakloriid
J – Sb, antimon
K – $SbCl_5$, antimon(V)kloriid
L – H_3PO_4, ortofosforhape

b) i) $H_2 + Cl_2 = 2HCl$
ii) $H_2 + F_2 = 2HF$
iii) $6HF + SiO_2 = H_2SiF_6 + 2H_2O$
iv) $P_4 + 6Cl_2 = 4PCl_3$
v) $P_4 + 10Cl_2 = 4PCl_5$
vi) $2Sb + 5Cl_2 = 2SbCl_5$
vii) $PCl_5 + 4H_2O = 5HCl + H_3PO_4$

2. a)
A – N_2, lämmastik
B - NH_3, ammoniaak
C – $H_2N–NH_2$, hüdrasiin
D – HNO_2, lämmastikushape
E – HN_3, lämmastikvesinikhape, vesiniktrinitriid, vesinikasiid
F – $NaNH_2$, naatriumamiid
G – H_2, vesinik
X – NaN_3, naatriumasiid

b) i) $N_2 + 3H_2 \xrightarrow{p,\,^0t} 2NH_3$
ii) $2NH_3 + NaClO = H_2N–NH_2 + NaCl + H_2O$
iii) $H_2N–NH_2 + HNO_2 = HN_3 + 2H_2O$
iv) $2NH_3 + 2Na = 2NaNH_2 + H_2\uparrow$
v) $NaNH_2 + N_2O = NaN_3 + H_2O$
vi) $2HN_3 + 2Na = 2NaN_3 + H_2$

3. a) $C_{12}H_{22}O_{11} + 12O_2 = 12CO_2 + 11H_2O$ (v)

i) $\Delta \mathbf{H^0} = \Delta H_c^0(C_{12}H_{22}O_{11}) = 11\ mol \cdot (-286\ kJ/mol) + 12\ mol \cdot (-394\ kJ/mol) -$

$- 1\ mol \cdot (-2222\ kJ/mol) \Rightarrow -5652\ kJ \cdot \frac{1}{mol} =$ **-5652 kJ/mol**

ii) $\Delta S^0 = 11\ mol \cdot 70\frac{J}{K \cdot mol} + 12\ mol \cdot 214\frac{J}{K \cdot mol} - 12\ mol \cdot 205\frac{J}{K \cdot mol} -$

$- 1\ mol \cdot 360\frac{J}{K \cdot mol} =$ **518 J/K**

iii) $T = 36{,}85\ ^0C + 273{,}15\ ^0C = 310{,}00\ K$

$\Delta \mathbf{G} = \Delta G_c(C_{12}H_{22}O_{11}) = -5652\ kJ - 310\ K \cdot 0{,}518\ kJ/K =$

$-5652\ kJ - 160{,}58\ kJ \Rightarrow \approx -5813\ kJ \cdot \frac{1}{mol} =$ **-5813 kJ/mol**

b) n(peptiidsidemed) = $5813\ \text{kJ} \cdot 0{,}4 \cdot \frac{1\ \text{mol}}{17{,}0\ \text{kJ}} \approx$ **137 mol**

Tähelepanu: Sahharoosi oksüdeerumisel vabaneb, kuid peptiidsidemete sünteesil neeldub energia.

4. a)

$$C_4H_8 + H_2 \xrightarrow{Pt,\ ^0t} C_4H_{10}$$

56 g/mol 2 g/mol

b) $n(C_4H_8) \cdot 56\ \text{g/mol} + [2\ \text{mol} - n(C_4H_8)] \cdot 2\ \text{g/mol} = 2{,}5 \cdot 17\ \text{g/mol} \cdot 2\ \text{mol}$

$n(C_4H_8)$ = $\frac{85\ \text{mol} - 4\ \text{mol}}{56 - 2}$ = **1,5 mol**

$n(H_2)$ = 2 mol - 1,5 mol = **0,5 mol**

c) Kui reageerib y vesinikku, siis

$n(H_2,\text{lõpus}) = 0{,}5\ \text{mol} - y$

$n(C_4H_8,\text{lõpus}) = 1{,}5\ \text{mol} - y$

$n(C_4H_{10},\text{lõpus}) = y$

$0{,}5\ \text{mol} - y + 1{,}5\ \text{mol} - y + y = 2{,}0\ \text{mol}(1-0{,}2)$

$y = 0{,}4\ \text{mol}$

%(saagis) = 100, kui reageerib ära kogu vesinik

%(saagis) = $\frac{0{,}4\ \text{mol}}{0{,}5\ \text{mol}} \cdot 100$ = **80**

d) $K = \frac{[C_4H_{10}]}{[C_4H_8] \cdot [H_2]}$

Et reaktsiooninõu maht on 1 dm^3, siis kontsentratsioon on võrdne aine hulgaga.

$K = \frac{0{,}4}{0{,}1 \cdot 1{,}1} = 3{,}6\ dm^3/\text{mol}$

e) $n'(C_4H_8) \cdot 56\ \text{g/mol} + [2\ \text{mol} - n'(C_4H_8)] \cdot 2\ \text{g/mol} = 3 \cdot 17\ \text{g/mol} \cdot 2\ \text{mol}$

$n'(C_4H_8) = 1{,}81\ \text{mol}$

$n'(H_2) = 2\ \text{mol} - 1{,}81\ \text{mol} = 0{,}19\ \text{mol}$

Kui reageerib x vesinikku, siis

$3{,}6 = \frac{x}{(1{,}81 - x) \cdot (0{,}19 - x)}$

$3{,}6x^2 - 8{,}2x + 1{,}238 = 0$

$x_1 = 0{,}16$

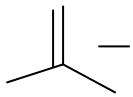
$x_2 = 2{,}11$ ei sobi, sest vesinikku on 0,19 mol

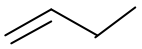
$\Sigma n'(\text{lõpus}) = (1{,}81 - 0{,}16) + (0{,}19 - 0{,}16) + 0{,}16 = 1{,}84\ \text{mol}$

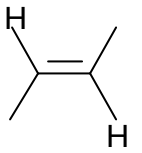
Rõhk ja hulk on omavahel võrdelises sõltuvuses.

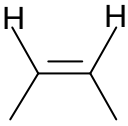
$D\mathbf{p} = \frac{2\ \text{mol} - 1{,}84\ \text{mol}}{2\ \text{mol}} \cdot 100\% \approx$ **8%**

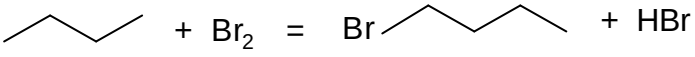
f)  — tsüklobutaan  — metüültsüklopropaan

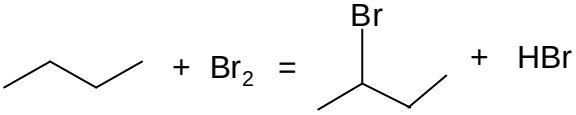
 — metüülpropeen

 — 1-buteen

 — trans-2-buteen

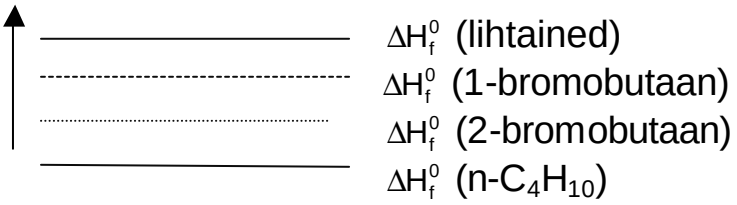
 — cis-2-buteen

5. a) i) 

ii) 

b) 

R **S**

c) 

ΔH_f^0 (lihtained)

ΔH_f^0 (1-bromobutaan)

ΔH_f^0 (2-bromobutaan)

ΔH_f^0 (n-C_4H_{10})

d) n(1-bromobutaan) = 1,6 mol · 0,375 = 0,6 mol

n(2-bromobutaan) = 1,6 mol - 0,6 mol = 1,0 mol

1 mol · ΔH(2-bromobutaan) + 0,6 mol · [ΔH(2-bromobutaan) +4kJ/mol]=

= 16,8 kJ

D**H(2-bromobutaan)** = **9,0 kJ/mol**

D**H(1-bromobutaan)** = 9,0 kJ/mol + 4,0 kJ/mol = **13,0 kJ/mol**

e) 17,2 kJ - 16,8 kJ = 0,4 kJ

$\Delta n = 0{,}4\ \text{kJ} \cdot \frac{1\ \text{mol}}{4\ \text{kJ}} = 0{,}1\ \text{mol}$

n(1-bromobutaan) = 0,6 mol + 0,1 mol = 0,7 mol

%mol(1-bromobutaan) = $\frac{0{,}7\ \text{mol}}{1{,}6\ \text{mol}} \cdot 100 = 43{,}75 \approx$ **40**

6. a) M(X) = 29,0 g/mol · 7,93 = **230 g/mol**

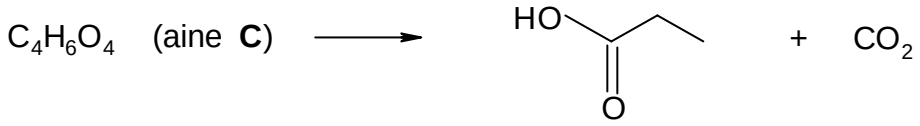
b) $n(C) \Leftrightarrow n(CO_2) \Rightarrow \frac{230\ \text{g}}{2{,}65\ \text{g}} \cdot 3{,}10\ \text{dm}^3 \cdot \frac{1\ \text{mol}}{22{,}4\ \text{dm}^3} = 12\ \text{mol}$

$n(H) \Leftrightarrow 2n(H_2O) \Rightarrow \frac{230\ \text{g}}{2{,}65\ \text{g}} \cdot 2{,}28\ \text{g} \cdot \frac{1\ \text{mol}}{18{,}0\ \text{g}} \cdot 2 = 22\ \text{mol}$

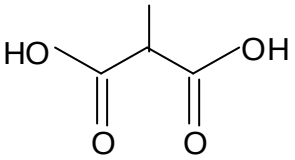
m(O)=230 g - 12 mol · 12 g/mol - 22 mol · 1 g/mol=230 g - 144 g - 22 g = 64 g

$n(O) = 64\ g \cdot \frac{1\ mol}{16\ g} = 4\ mol$

Aine **X** brutovalem on $C_{12}H_{22}O_4$

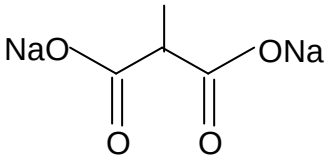


Aine **C** oli hargnenud ahelaga hape, mis dekarboksüleerus. Järelikult saab see olla dihape, sest tekkis propaanhape.



aine **C**

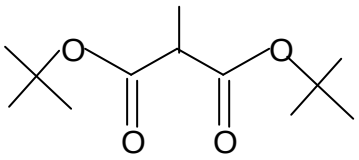
Aine **B** on järelikult dihappe sool



aine **B**

Aine **X** andis leelise toimel tertsiaarse alkoholi ja happe soola. Soola **B** aniooni brutovalem on $C_4H_4O_4$. Ainest **X** jääb järgi brutovalem C_8H_{18}. Et aine **X** on dihappe ester, siis alkoholi alküülrühma brutovalem on C_4H_9, mis vastab tert-alküülrühmale.

aine **A**



aine **X**