

1997/98 õa keemiaolümpiaadi piirkondliku vooru ülesannete lahendused
8. klass

- 1) 1) keeduklaas 1) химический стакан
2) lehter 2) воронка
3) mensuur 3) мензурка
4) tiiglitangid 4) щипцы
5) Kippi aparaat 5) аппарат Киппа
6) gaasipõleti 6) газовая горелка
7) seisukolb 7) плоскодонная колба
8) ümarkolb 8) круглодонная колба
9) kooniline kolb 9) коническая колба
10) mõõtkolb 10) мерная колба

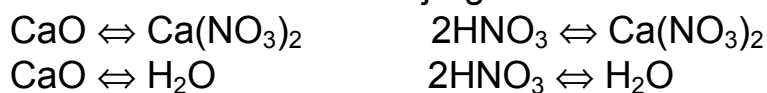
2. a) $4\text{Al} + 3\text{O}_2 = 2\text{Al}_2\text{O}_3$
b) $2\text{SO}_2 + \text{O}_2 = 2\text{SO}_3$
c) $2\text{Al}(\text{OH})_3 + 3\text{H}_2\text{SO}_4 = \text{Al}_2(\text{SO}_4)_3 + 6\text{H}_2\text{O}$
d) $3\text{Fe} + 4\text{H}_2\text{O} = \text{Fe}_3\text{O}_4 + 4\text{H}_2$
e) $4\text{H}_3\text{BO}_3 + 2\text{NaOH} = \text{Na}_2\text{B}_4\text{O}_7 + 7\text{H}_2\text{O}$

3. a) $\text{C}_8\text{H}_{10} \rightarrow 8\text{CO}_2 + 5\text{H}_2\text{O}$
b) $M_r(\text{CO}_2) = 44 \quad m(\text{CO}_2) = 44 \frac{\text{amü}}{\text{molekul}}$
 $M_r(\text{H}_2\text{O}) = 18 \quad m(\text{H}_2\text{O}) = 18 \frac{\text{amü}}{\text{molekul}}$
c) $m(\text{CO}_2) = 8 \text{ molekuli} \cdot \frac{44 \text{ amü}}{\text{molekul}} = 352 \text{ amü}$
 $m(\text{H}_2\text{O}) = 5 \text{ molekuli} \cdot \frac{18 \text{ amü}}{\text{molekul}} = 90 \text{ amü}$
d) $\frac{352 \text{ amü}}{90 \text{ amü}} = 3,91 \text{ korda} \sim \mathbf{3,9 \text{ korda}}$
e) $2\text{C}_8\text{H}_{10} + 21\text{O}_2 = 16\text{CO}_2 + 10\text{H}_2\text{O}$

4. a): 1) CuO 2) NaOH 3) H₂SO₄ 4) HNO₃ 5) Fe₂O₃
b): 1) tsinkkloriid 2) kaltsiumkarbonaat 3) raud(III)kloriid
4) fosforhape 5) diboortrioksiid

5. a) $\text{CaO} + 2\text{HNO}_3 = \text{Ca}(\text{NO}_3)_2 + \text{H}_2\text{O}$
b) $M(\text{CaO}) = \mathbf{56 \text{ g/mol}}$; $M[\text{Ca}(\text{NO}_3)_2] = \mathbf{164 \text{ g/mol}}$
 $M(\text{HNO}_3) = \mathbf{63 \text{ g/mol}}$; $M(\text{H}_2\text{O}) = \mathbf{18 \text{ g/mol}}$
c) $n(\text{CaO}) = 11,2 \text{ g} \cdot \frac{1 \text{ mol}}{56 \text{ g}} = \mathbf{0,20 \text{ mol}}$
 $n(\text{HNO}_3) = 25,2 \text{ g} \cdot \frac{1 \text{ mol}}{63 \text{ g}} = \mathbf{0,40 \text{ mol}}$

d) Lähteained on ekvivalentsses vahekorras. Saadusainete massi võib leida nii esimese kui teise lähteaine järgi.



$$n(\text{Ca(NO}_3)_2) = n(\text{CaO}) \cdot \frac{1 \text{ Ca(NO}_3)_2}{1 \text{ CaO}}$$

$$m(\text{Ca(NO}_3)_2) = \frac{1}{1} \cdot 0,20 \text{ mol} \cdot 164 \text{ g/mol} = 32,8 \text{ g} \sim \mathbf{33 \text{ g}}$$

$$m(\text{H}_2\text{O}) = \frac{1}{2} n(\text{HNO}_3) \cdot 18 \text{ g/mol} = \frac{1}{2} \cdot 0,40 \text{ mol} \cdot 18 \text{ g/mol} = \mathbf{3,6 \text{ g}}$$

Märkus: Vastus $m[\text{Ca(NO}_3)_2] = 32,8 \text{ g}$ lugeda õigeks.

6. a) $n(\text{C}_2\text{H}_5\text{OH}) = 60,3 \text{ g} \cdot \frac{1 \text{ mol}}{46,0 \text{ g}} = \mathbf{1,31 \text{ mol}}$

b) 250 cm^3 (lahus) \Leftrightarrow $1,31 \text{ mol}$ (piiritus)

$$n(\text{C}_2\text{H}_5\text{OH}) = 1,00 \text{ liitrit} \cdot \frac{1000 \text{ cm}^3}{1 \text{ liiter}} \cdot \frac{1,31 \text{ mol}}{250 \text{ cm}^3} = \mathbf{5,24 \text{ mol}}$$

c) $m(\text{lahus}) = 341,5 \text{ g} - 100,5 \text{ g} = 241,0 \text{ g}$

$$\rho(\text{lahus}) = \frac{241,0 \text{ g}}{250,0 \text{ cm}^3} = \mathbf{0,9640 \text{ g/cm}^3}$$

d) massiprotsent % (piiritus) = $\frac{60,3 \text{ g}}{241 \text{ g}} \cdot 100 = \mathbf{25,0}$

e) I variant:

$$m(\text{H}_2\text{O}) = 241,0 \text{ g} - 60,3 \text{ g} = 180,7 \text{ g}$$

$250,0 \text{ cm}^3$ (lahus) \Leftrightarrow $60,3 \text{ g}$ (piiritus)

$$m(\text{C}_2\text{H}_5\text{OH}) = 850 \text{ cm}^3 \text{ (lahus)} \cdot \frac{60,3 \text{ g (piiritus)}}{250,0 \text{ cm}^3 \text{ lahus}} = \mathbf{205 \text{ g}}$$

$250,0 \text{ cm}^3$ (lahus) \Leftrightarrow $180,7 \text{ g}$ (H_2O)

$$m(\text{H}_2\text{O}) = 850 \text{ cm}^3 \text{ (lahus)} \cdot \frac{180,7 \text{ g (H}_2\text{O)}}{250,0 \text{ cm}^3 \text{ (lahus)}} = 614,38 \text{ g} \sim \mathbf{614 \text{ g}}$$

II variant:

$$m(\text{lahus}) = 850 \text{ cm}^3 \cdot 0,9640 \text{ g/cm}^3 = 819,4 \sim \mathbf{819 \text{ g}}$$

$$m(\text{C}_2\text{H}_5\text{OH}) = 819 \text{ g} \cdot 0,250 = 204,75 \text{ g} \sim \mathbf{205 \text{ g}}$$

$$m(\text{H}_2\text{O}) = 819 \text{ g} \cdot 0,750 = 614,25 \text{ g} \sim \mathbf{614 \text{ g}}$$

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1. Lähtume ühest moolist

a) $M(\text{FeS}_2) = 120 \text{ g/mol}$

$$m(\text{S}) = 2 \text{ mol} \cdot 32,1 \text{ g/mol} = 64,2 \text{ g}$$

$$m(\text{püriit}) = 120 \text{ g (FeS}_2) \cdot \frac{100 \text{ (püriit)}}{80,0 \text{ (FeS}_2)} = 150 \text{ g}$$

$$\%(\text{S}) = \frac{64,2 \text{ g (S)}}{150 \text{ g (püriit)}} \cdot 100 = \mathbf{42,8}$$

b) $M(\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}) = 248 \text{ g/mol}$ $m(\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}) = 1 \text{ mol} \cdot 248 \text{ g/mol} = 248 \text{ g}$

$$m(\text{S}) = 2 \text{ mol} \cdot 32,1 \text{ g/mol} = 64,2 \text{ g}$$

$$\%(\text{S}) = \frac{64,2}{248} \cdot 100 = \mathbf{25,9\%}$$

c) $m(\text{lahus}) = 25,0 + 100 = 125 \text{ g}$

$$\%(\text{S}) = \frac{25,0 \text{ g (Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O})}{125 \text{ g (lahus)}} \cdot \frac{25,9 \text{ g (S)}}{100 \text{ g (Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O})} \cdot 100 = \mathbf{5,18}$$

2. a) $\text{H}_2\text{SO}_4 + 2\text{NH}_3 = (\text{NH}_4)_2\text{SO}_4$

b) $m(\text{H}_2\text{SO}_4) = V(\text{lahus}) \text{ cm}^3 \cdot 1,34 \text{ g/cm}^3 \cdot 0,440$

$$m(\text{NH}_3) = 0,220 \text{ dm}^3 \cdot \frac{1000 \text{ cm}^3}{1 \text{ dm}^3} \cdot 0,935 \text{ g/cm}^3 \cdot 0,170$$

c) $M(\text{H}_2\text{SO}_4) = \mathbf{98,1 \text{ g/mol}}$

$M(\text{NH}_3) = \mathbf{17,0 \text{ g/mol}}$

d) $V \text{ cm}^3 \cdot 1,34 \text{ g/cm}^3 \cdot 0,440$ $220 \text{ cm}^3 \cdot 0,935 \text{ g/cm}^3 \cdot 0,170$

H_2SO_4	\Leftrightarrow	2NH_3
$98,1 \text{ g/mol}$		$17,0 \text{ g/mol}$

$$1,34 \cdot 0,440 V = \frac{1}{2} \cdot 220 \cdot 0,935 \cdot 0,170 \cdot \frac{1}{17,0} \cdot 98,1$$

$$V(\text{H}_2\text{SO}_4 \text{ lahus}) = \frac{1}{2} \cdot 220 \text{ cm}^3 \cdot 0,935 \text{ g/cm}^3 \cdot 0,170 \cdot \frac{1 \text{ mol}}{17,0 \text{ g}} \cdot 98,1 \text{ g/mol} \cdot \frac{1}{0,440} \cdot \frac{1 \text{ cm}^3}{1,34 \text{ g}} = \mathbf{171 \text{ cm}^3}$$

3. a) Lähtume 100-st grammist

$$n(\text{Cu}) = 100 \text{ g} \cdot 0,254 \cdot \frac{1 \text{ mol}}{63,5 \text{ g}} = 0,40 \text{ mol}$$

$$n(\text{S}) = 100 \text{ g} \cdot 0,129 \cdot \frac{1 \text{ mol}}{32,1 \text{ g}} = 0,40 \text{ mol}$$

$$n(\text{O}) = 100 \text{ g} \cdot 0,256 \cdot \frac{1 \text{ mol}}{16,0 \text{ g}} = 1,6 \text{ mol}$$

$$n(\text{H}_2\text{O}) = 100 \text{ g} \cdot 0,361 \cdot \frac{1 \text{ mol}}{18 \text{ g}} = 2,0 \text{ mol}$$

$n(\text{Cu}) : n(\text{S}) : n(\text{O}) : n(\text{H}_2\text{O})$

$\mathbf{0,4 : 0,4 : 1,6 : 2}$

b) Valemis peavad aatomid suhtuma nagu täisarvud. Lihtsaima täisarvudega suhte saame olemasolevate moolide arvu korrutamisel 2,5-ga - $\mathbf{Cu_1S_1O_4 \cdot 5H_2O}$

c) Vaadeldud soolaks on **vasksulfaat-5-vesi**, mille rahvapärane nimetus on vasevitriol - $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$

4. Tähistame anuma ruumala sümboliga V_a .

a) $V_M = 1 \text{ mol} \cdot 0,0820 \frac{\text{atm} \cdot \text{dm}^3}{\text{mol} \cdot \text{K}} \cdot 277 \text{ K} \cdot \frac{1}{5,00 \text{ atm}} = \mathbf{4,54 \text{ dm}^3/\text{mol}}$

$$\text{b) } n(\text{HCl}) = \frac{4}{5} V_a (\text{dm}^3) \cdot \frac{1 \text{ mol}}{4,54 \text{ dm}^3} = \mathbf{0,1762 \cdot V_a \text{ (mol)}}$$

$$m(\text{HCl}) = 0,1762 \cdot V_a (\text{mol}) \cdot 36,5 \text{ g/mol} = \mathbf{6,43 V_a \text{ (g)}}$$

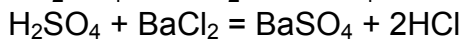
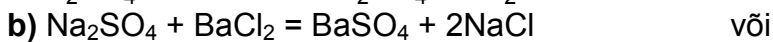
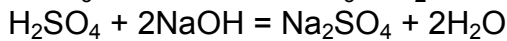
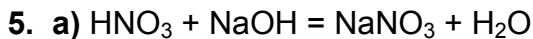
$$\text{c) } m(\text{lahus}) = m(\text{H}_2\text{O}) + m(\text{HCl})$$

$$m(\text{H}_2\text{O}) = V_a (\text{dm}^3) \cdot 1000 \text{ g/dm}^3 = 1000 V_a \text{ (g)}$$

$$m(\text{lahus}) = \mathbf{1006,43 V_a \text{ (g)}}$$

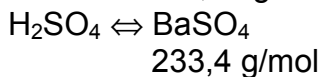
$$\text{d) } \%(\text{HCl}) = \frac{6,43 V_a \text{ (g)}}{1006,43 V_a \text{ (g)}} \cdot 100 = 0,63889 \approx \mathbf{0,639}$$

Märkus: 4 °C juures ei ole vee tihedus neljast tüvenumbrist täpsem. Kui lahuse massi tüvenumbrite arv on ümardatud neljani, siis lugeda see õigeks.



$$\text{c) } \Sigma n(\text{NaOH}) = 36,0 \text{ g} \cdot 0,300 \cdot \frac{1 \text{ mol}}{40,0 \text{ g}} = \mathbf{0,270 \text{ mol}}$$

$$\text{d) } \quad \quad \quad 7,00 \text{ g}$$



$$233,4 \text{ g/mol}$$

$$n(\text{H}_2\text{SO}_4) = \frac{1}{1} \cdot 7,00 \text{ g} \cdot \frac{1 \text{ mol}}{233,4 \text{ g}} = 0,02999 \text{ mol} \approx \mathbf{0,0300 \text{ mol}}$$

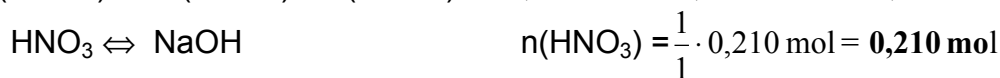
e) Vävelhappe neutraliseerimiseks kulub n' mooli NaOH



$$n'(\text{NaOH}) = \frac{2}{1} \cdot 0,0300 \text{ mol} = 0,0600 \text{ mol}$$

HNO₃ neutraliseerimiseks jääb:

$$n(\text{NaOH}) = \Sigma n(\text{NaOH}) - n'(\text{NaOH}) \Rightarrow 0,270 \text{ mol} - 0,0600 \text{ mol} = 0,210 \text{ mol}$$



$$\text{6. a) } m(\text{etanool}) = 1 \text{ L(lahus)} \cdot \frac{1000 \text{ cm}^3}{1 \text{ L}} \cdot \frac{40,0 (\text{etanool})}{100 (\text{lahus})} \cdot 0,794 \text{ g/cm}^3 = 317,6 \text{ g} \approx \mathbf{318 \text{ g}}$$

$$\text{b) } m(\text{etanool } 40,0 \% \text{ Vol.}) = 1 \text{ L (lahus)} \cdot \frac{1000 \text{ cm}^3}{1 \text{ L}} \cdot 0,950 \text{ g/cm}^3 = \mathbf{950 \text{ g}}$$

$$\%(\text{etanool}) = \frac{317,6}{950} \cdot 100 = 33,43 \approx \mathbf{33,4}$$

$$\text{c) } m(\text{etanool } 40,0 \% \text{ Vol.}) = 1 \text{ L(etanool)} \cdot \frac{1000 \text{ cm}^3}{1 \text{ L}} \cdot \frac{100 (\text{lahus})}{40,0 (\text{etanool})} \cdot 0,950 \text{ g/cm}^3 = 2375 \text{ g} \approx \mathbf{2380 \text{ g}}$$

$$\text{d) } V(\text{etanool } 40,0 \% \text{ Vol}) = 1 \text{ kg (etanool)} \cdot \frac{1000 \text{ g}}{1 \text{ kg}} \cdot \frac{1 \text{ cm}^3}{0,794 \text{ g}} \cdot \frac{1 \text{ L}}{1000 \text{ cm}^3} \cdot \frac{100 (\text{lahus})}{40,0 (\text{etanool})} = 3,149 \text{ L} \approx \mathbf{3,15 \text{ L}}$$

e) Ühest liitrist etanoolist sai valmistada 2375 g lahust (punkt c)

$$m(\text{etanool}) = 1 \text{ L (etanool)} \cdot \frac{1000 \text{ cm}^3}{1 \text{ L}} \cdot 0,794 \text{ g/cm}^3 = 794 \text{ g}$$

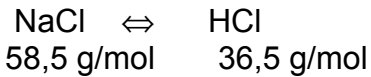
$$m(\text{H}_2\text{O}) = 2375 \text{ g} - 794 \text{ g} = 1581 \text{ g}$$

$$V(\text{H}_2\text{O}) = 1581 \text{ g (H}_2\text{O)} \cdot \frac{1 \text{ cm}^3}{1,00 \text{ g}} \cdot \frac{1 \text{ L}}{1000 \text{ cm}^3} = 1,581 \text{ L} \approx \mathbf{1,58 \text{ L}}$$

$$Q = \frac{2}{1} \cdot \frac{6,54 \text{ g}}{65,4 \text{ g/mol}} \cdot 96500 \text{ A} \cdot \text{s/mol} = 19300 \text{ A} \cdot \text{s}$$

$$Q = 19300 \text{ A} \cdot \text{s} \cdot \frac{1 \text{ h}}{3600 \text{ s}} = \mathbf{5,36 \text{ A} \cdot \text{h}}$$

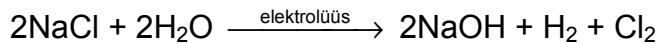
5. a) m tonn 1 tonn · 0,365



$$m(\text{NaCl}) = \frac{1}{1} \cdot \frac{1 \text{ tonn} \cdot 0,365}{36,5 \text{ g/mol}} \cdot 58,5 \text{ g/mol} = \mathbf{0,585 \text{ tonni}}$$

b,c) $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ katoodprotsess (-)

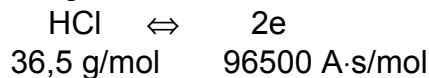
$2\text{Cl}^- - 2\text{e}^- \rightarrow \text{Cl}_2$ anoodprotsess (+)



d) Eralduv kloor disproportsieerub: $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + \text{HClO}$

e) $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$

f) $10^6 \text{ g} \cdot 0,365$ Q · A · s



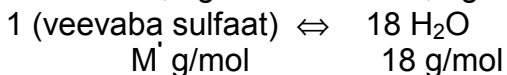
$$Q = \frac{2}{1} \cdot \frac{10^6 \cdot 0,365}{36,5} \cdot 96500 = 9,65 \cdot 10^8 \text{ A} \cdot \text{s}$$

$$n(\text{kW} \cdot \text{h}) = 9,65 \cdot 10^8 \text{ A} \cdot \text{s} \cdot \frac{1 \text{ h}}{3600 \text{ s}} \cdot 3 \text{ V} \cdot \frac{1 \text{ kW}}{1000 \text{ A} \cdot \text{V}} = \mathbf{804}$$

6. a) $m(\text{veevaba sulfaat}) = 111 \cdot 0,154 = 17,1 \text{ g}$

$$m(\text{H}_2\text{O}) = 33,3 - 17,1 = \mathbf{16,2 \text{ g}}$$

b) 17,1 g 16,2 g



Avaldame kas veevaba sulfaadi või vee massi

$$m(\text{veevaba sulfaat}) \Rightarrow 17,1 = \frac{1}{18} \cdot \frac{16,2}{18} \cdot M'$$

$$M' = 17,1 \text{ g} \cdot \frac{18 \text{ g/mol}}{16,2 \text{ g}} \cdot \frac{18}{1} = \mathbf{342 \text{ g/mol}}$$

Alternatiiv

$$m(\text{H}_2\text{O}) \Rightarrow 16,2 \text{ g} = \frac{18}{1} \cdot \frac{17,1 \text{ g}}{M' \text{ g/mol}} \cdot 18 \text{ g/mol, millest } M' = \mathbf{342 \text{ g/mol}}$$

c) Olgu sulfaadi valem $\text{X}_2(\text{SO}_4)_n$

$$342 = 2X + n \cdot 96$$

$$X = \frac{342 - n \cdot 96}{2}$$

Kui $n=1$, siis $X=123$;

kui $n=2$, siis $X=75$;

kui $n=3$, siis $X=27$ Element X on alumiinium

d) $\text{Al}_2(\text{SO}_4)_3 + 3\text{K}_2\text{S} + 6\text{H}_2\text{O} \rightarrow 3\text{H}_2\text{S} + 2\text{Al}(\text{OH})_3 + 3\text{K}_2\text{SO}_4$

e) $2\text{Al}_2\text{S}_3 + 9\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3 + 6\text{SO}_2$

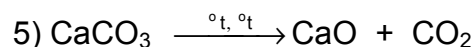
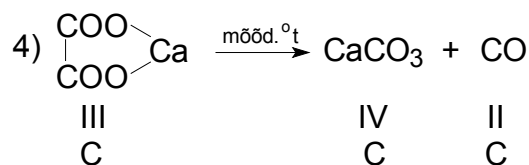
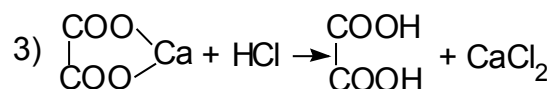
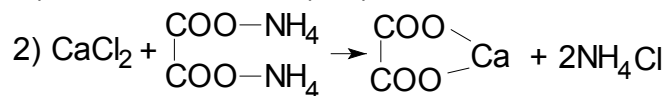
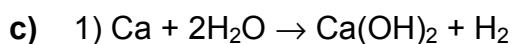
**1997/98 õa keemiaolümpiaadi piirkondliku vooru ülesannete lahendused
11. klass**

1. a) $M(A^+) = 35,5 \text{ g/mol} \cdot \frac{1}{63,9} \cdot 36,1 = 20,1 \text{ g/mol}$

$M(A^{2+}) = 71,0 \text{ g/mol} \cdot \frac{1}{63,9} \cdot 36,1 = 40,1 \text{ g/mol}$

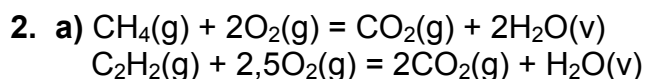
$M(A^{3+}) = 106,5 \text{ g/mol} \cdot \frac{1}{63,9} \cdot 36,1 = 60,2 \text{ g/mol}$

b) Ainsana sobib molaarmass 40,1, mis kuulub kaltsiumile. Kaltsium reageerib toatemperatuuril veega.



d) Disproportsioneerumisreaktsioonil tekib süsinikmonooksiid CO ja kaltsiumkarbonaadi lagunemisel tekib süsinikdioksiid CO₂.

e) **A** – Ca, kaltsium; **B** – CaCl₂, kaltsiumkloriid; **C** – CaO₄C₂, kaltsiumoksalaat; **D** – CaCO₃, kaltsiumkarbonaat; **E** – CaO, kaltsiumoksiid.



b) $V_M = 1 \text{ mol} \cdot 0,0820 \frac{\text{atm} \cdot \text{dm}^3}{\text{mol} \cdot \text{K}} \cdot 298 \text{ K} \cdot \frac{1}{1 \text{ atm}} = 24,436 \text{ dm}^3 / \text{mol} \approx \mathbf{24,4 \text{ dm}^3 / \text{mol}}$

c) $\frac{2}{1} \cdot V(\text{CH}_4) \text{ dm}^3 \cdot \frac{1 \text{ mol}}{24,4 \text{ dm}^3} \cdot 18 \text{ g/mol} + \frac{1}{1} [12,0 - V(\text{CH}_4)] \text{ dm}^3 \cdot \frac{1 \text{ mol}}{24,4 \text{ dm}^3} \cdot 18 \text{ g/mol} = 14,0 \text{ g}$

$V(\text{CH}_4) = \mathbf{7,0 \text{ dm}^3}$
 $V(\text{C}_2\text{H}_2) = \mathbf{5,0 \text{ dm}^3}$

d) $\text{CH}_4 \Leftrightarrow 2\text{O}_2$ $V(\text{O}_2) = \frac{2}{1} \cdot 7,0 \text{ dm}^3 = 14,0 \text{ dm}^3$

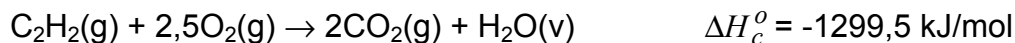
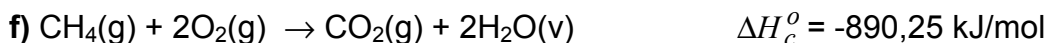
$\text{C}_2\text{H}_2 \Leftrightarrow 2,5\text{O}_2$ $V(\text{O}_2) = \frac{2,5}{1} \cdot 5,0 \text{ dm}^3 = 12,5 \text{ dm}^3$

26,5 dm³

$$V(\text{>hk}) = 26,5 \text{ dm}^3 \cdot \frac{1}{0,209} = 126,8 \text{ dm}^3 \approx \mathbf{127 \text{ dm}^3}$$

e) $\Delta H_c^\circ(\text{CH}_4) = 2 \cdot (-285,8) + (-393,5) - (-74,85) - 2 \cdot (0) = \mathbf{-890,25 \text{ kJ/mol}}$

$\Delta H_c^\circ(\text{C}_2\text{H}_2) = (-285,8) + 2 \cdot (-393,5) - 226,7 - 2,5 \cdot (0) = \mathbf{-1299,5 \text{ kJ/mol}}$



g) $\Delta H_c^\circ(\text{CH}_4) = 7,0 \text{ dm}^3 \cdot \frac{1 \text{ mol}}{24,4 \text{ dm}^3} \cdot (-890,25 \text{ kJ/mol}) = -255,4 \text{ kJ} \approx -260 \text{ kJ}$

$\Delta H_c^\circ(\text{C}_2\text{H}_2) = 5,0 \text{ dm}^3 \cdot \frac{1 \text{ mol}}{24,4 \text{ dm}^3} \cdot (-1299,5 \text{ kJ/mol}) = -266 \text{ kJ} \approx -270 \text{ kJ}$

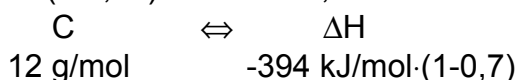
$\Sigma \Delta H_c^\circ = -255 + (-266) = -521 \text{ kJ} \approx \mathbf{-520 \text{ kJ}}$

3. a) $1,00 \cdot 10^6 \text{ g}$



$\Delta H = \frac{1}{1} \cdot 1,00 \cdot 10^6 \cdot \frac{1 \text{ mol}}{122 \text{ g}} \cdot 123 \text{ kJ/mol} = 1,008 \cdot 10^6 \text{ kJ} \approx \mathbf{1,01 \cdot 10^6 \text{ kJ}}$

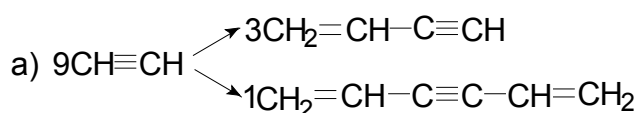
b) $m(1-0,05) \quad -1,008 \cdot 10^6 \text{ kJ}$



Märkus: Saagise % võib kirjutada ka süsiniku kohale: 30 % süsinikust kulub kasuliku energia saamiseks. (-) märk näitab, et süsinik eraldab vajaliku energia. Silikaadi tekkimine tarbib energiat (+).

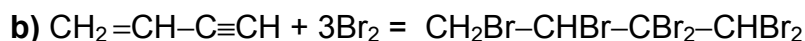
$m(\text{süsinik}) = \frac{1}{1} \cdot (-1,008 \cdot 10^6) \text{ kJ} \cdot \frac{1 \text{ mol}}{-394 \text{ kJ} \cdot 0,3} \cdot 12 \text{ g/mol} \cdot \frac{1}{0,95} = 1,077 \cdot 10^5 \text{ g} \approx \mathbf{108 \text{ kg}}$

4.

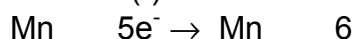
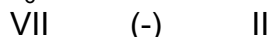
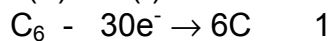
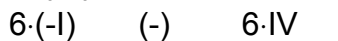


$n(\text{dimeer}) = \frac{3}{9} \cdot 0,200 \text{ mol} \cdot 0,900 = 0,0600 \text{ mol}$

$n(\text{trimeer}) = \frac{1}{9} \cdot 0,200 \text{ mol} \cdot 0,900 = 0,0200 \text{ mol}$



c) $\text{Dimeer} \Leftrightarrow 3\text{Br}_2 \quad n(\text{Br}_2) = \frac{3}{1} \cdot 0,0600 \text{ mol} = 0,180 \text{ mol}$



5. a) $n(\text{H}_2\text{SO}_4) = 20,0 \text{ g} \cdot 0,200 \cdot \frac{1 \text{ mol}}{98,1 \text{ g}} = \mathbf{0,0408 \text{ mol}}$

b) $n[\text{Ca}(\text{OH})_2] = 10,90 \text{ g} \cdot \frac{1 \text{ mol}}{74,10 \text{ g}} = \mathbf{0,1471 \text{ mol}}$

c) $n[\text{Ca}(\text{OH})_2] = 0,1471 \text{ mol} - 0,0408 \text{ mol} = \mathbf{0,1063 \text{ mol}}$

d) $\text{H}_2\text{SO}_4 \Leftrightarrow \text{Ca}(\text{OH})_2 \quad n(\text{H}_2\text{SO}_4) = 0,1063 \text{ mol}$

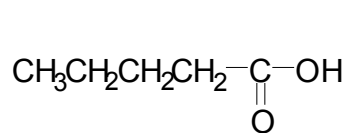
$$\frac{x \text{ g} (\text{SO}_3)}{80,1 \text{ g/mol}} + \frac{(10,0 - x) \text{ g} (\text{H}_2\text{SO}_4)}{98,1 \text{ g/mol}} = 0,1063 \text{ mol}$$

$$0,01248x + 0,1019 - 0,01019x = 0,1063$$

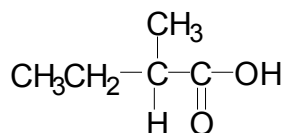
$$0,00229x = 0,0044 \quad m(\text{SO}_3) = 1,9 \text{ g}$$

$$\%(\text{SO}_3) = \frac{1,9 \text{ g}}{10,0 \text{ g}} \cdot 100 = \mathbf{19}$$

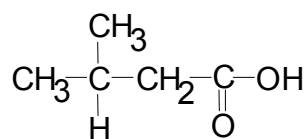
6. a)



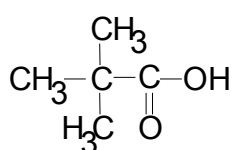
pentaanhape



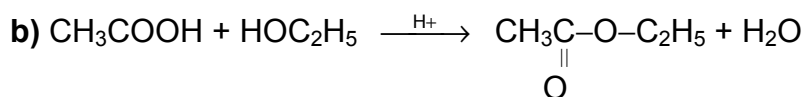
2-metüülbutaanhape



3-metüülbutaanhape



2,2-dimetüülpropaanhape



etaanhape

etanool

etüületanaat

vesi

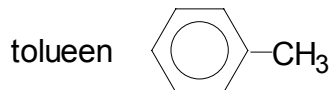
1997/98 õa keemiaolümpiaadi piirkondliku vooru ülesannete lahendused

12. klass

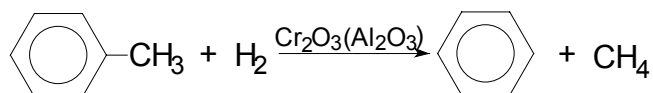
1. a) Lähtume täpselt 100 grammist

$$n(\text{C}) = 100 \text{ g} \cdot 0,913 \cdot \frac{1 \text{ mol}}{12,0 \text{ g}} = 7,61 \text{ mol}; \quad n(\text{H}) = 100 \text{ g} \cdot 0,087 \cdot \frac{1 \text{ mol}}{1,01 \text{ g}} = 8,61 \text{ mol}$$

Üldvalem C_nH_{n+1} . Aromaatse ühendina sobib metüülbenseen ehk



b)



c) $M(\text{C}_6\text{H}_6) = 78 \text{ g/mol}$ $M(\text{CH}_4) = 16 \text{ g/mol}$
 et $\rho = M \cdot \frac{1}{V_M}$, siis $\frac{\rho(\text{C}_6\text{H}_6)}{\rho(\text{CH}_4)} \Rightarrow \frac{78}{16} = 4,87 \approx \mathbf{4,9}$

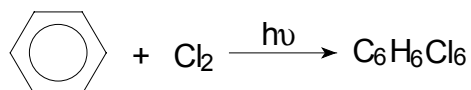
d) $n(\text{C}) = 100 \text{ g} \cdot 0,247 \cdot \frac{1 \text{ mol}}{12,0 \text{ g}} = 2,06 \text{ mol}$

$$n(\text{H}) = 100 \text{ g} \cdot 0,0208 \cdot \frac{1 \text{ mol}}{1,01 \text{ g}} = 2,06 \text{ mol}$$

$$n(\text{Cl}) = 100 \text{ g} \cdot 0,732 \cdot \frac{1 \text{ mol}}{35,5 \text{ g}} = 2,06 \text{ mol}$$

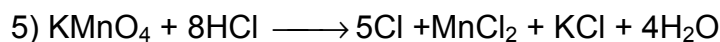
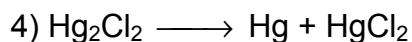
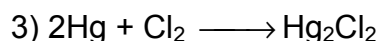
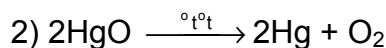
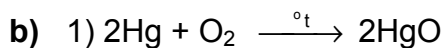
$\text{C}_n\text{H}_n\text{Cl}_n$ on $\text{C}_6\text{H}_6\text{Cl}_6$ - heksaklorotsükloheksaan

e)

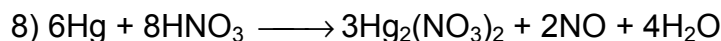
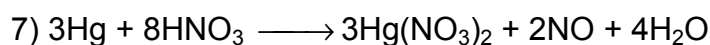
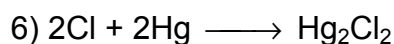


f) **A** - $\text{C}_6\text{H}_5\text{CH}_3$, metüülbenseen; **B** - C_6H_6 , benseen; **C** - CH_4 , metaan; **D** - $\text{C}_6\text{H}_6\text{Cl}_6$, heksaklorotsükloheksaan.

2. a) **A** - Hg, elavhõbe; **B** - HgO, elavhõbe(II)oksiid; **C** - Hg_2Cl_2 , elavhõbe(I)kloriid, kalomel; **D** - HgCl_2 , elavhõbe(II)kloriid, sublumaat; **E** - $\text{Hg}(\text{NO}_3)_2$, elavhõbe(II)nitraat; **F** - $\text{Hg}_2(\text{NO}_3)_2$, elavhõbe(I)nitraat.



Märkus: Hg oksüdeerijaks on kloor tekkimise momendil. Cl_2 tekkimine lugeda õigeks.



c) $\%(\text{N}) = \frac{28,0}{525} \cdot 100 = \mathbf{5,33}$

d) Metallide lahuseid elavhõbedas nimetatakse amalgaamideks.

$$3. \text{ a) } n(\text{O}) = 1 \text{ kg} \cdot \frac{1000 \text{ g}}{1 \text{ kg}} \cdot 0,700 \cdot 0,430 \cdot \frac{1 \text{ mol}}{16 \text{ g}} = 18,8 \text{ mol}$$

$$n(\text{H}) = 1000 \text{ g} \cdot 0,700 \cdot 0,060 \cdot \frac{1 \text{ mol}}{1,01 \text{ g}} = 41,6 \text{ mol}$$

$$\text{Hapnikuga reageerib: } n(\text{H}) = \frac{2}{1} \cdot 18,8 \text{ mol} = 37,6 \text{ mol}$$

$$\text{Energiaat andev: } n(\text{H}) = 41,6 \text{ mol} - 37,6 \text{ mol} = \mathbf{4,0 \text{ mol}}$$

$$n(\text{C}) = 1000 \text{ g} \cdot 0,700 \cdot 0,500 \cdot \frac{1 \text{ mol}}{12,0 \text{ g}} = 29,17 \text{ mol} \approx \mathbf{29,2 \text{ mol}}$$

$$\text{b) Süsiniku põlemine: } \Delta H(\text{C}) = 29,17 \text{ mol} \cdot (-394) \text{ kJ/mol} \approx -11493 \text{ kJ}$$

$$\text{Vesiniku põlemine: } \Delta H(\text{H}_2) = 1/2 \cdot 4,0 \text{ mol} \cdot (-242) \text{ kJ/mol} = -484 \text{ kJ}$$

Vee aurustumine:

$$\Delta H(\text{H}_2\text{O}) = 1000 \text{ g} \cdot 0,300 \cdot \frac{1 \text{ mol}}{18 \text{ g}} \cdot (-242 \text{ kJ/mol} - (-286 \text{ kJ/mol})) = +733 \text{ kJ}$$

$$\Delta H = -11493 \text{ kJ} + (-484) \text{ kJ} + 733 \text{ kJ} = -11244 \text{ kJ} \approx \mathbf{-11200 \text{ kJ}}$$

$$\text{c) } m(\text{puit}) = 3,60 \text{ MJ} \cdot \frac{1}{0,300} \cdot \frac{1 \text{ kg}}{11200 \text{ kJ}} \cdot \frac{1000 \text{ kJ}}{1 \text{ MJ}} = \mathbf{1,07 \text{ kg}}$$

$$\text{d) } \text{C} \Leftrightarrow \text{CO}_2$$

$$m(\text{CO}_2) = \frac{1}{1} \cdot 1070 \text{ g} \cdot 0,700 \cdot 0,500 \cdot \frac{1 \text{ mol}}{12,0 \text{ g}} \cdot \frac{44,0 \text{ g}}{1 \text{ mol}} = 1296 \text{ g} \approx 1,37 \text{ kg}$$

$$V(\text{CO}_2) = \frac{1}{1} \cdot 1070 \text{ g} \cdot 0,700 \cdot 0,500 \cdot \frac{1 \text{ mol}}{12,0 \text{ g}} \cdot \frac{22,4 \text{ dm}^3}{1 \text{ mol}} = 699 \text{ dm}^3 \approx \mathbf{0,70 \text{ m}^3}$$

$$4. \text{ a) } \text{D}_2(\text{g}) + 1/2\text{O}_2(\text{g}) \rightarrow \text{D}_2\text{O}(\text{g}) \quad \Delta H_f^\circ = -249,20 \text{ kJ/mol}$$

$$\text{H}_2(\text{g}) + 1/2\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g}) \quad \Delta H_f^\circ = -241,82 \text{ kJ/mol}$$

$$\text{b) } V_M = \frac{1 \text{ mol} \cdot 0,08201 \text{ atm} \cdot \text{dm}^3 \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \cdot 298,15 \text{ K}}{1,000 \text{ atm}} = 24,45 \text{ dm}^3 / \text{mol}$$

$$V(\text{H}_2) \text{ dm}^3 \cdot \frac{1 \text{ mol}}{24,45 \text{ dm}^3} \cdot (-241,82) \text{ kJ/mol} + [2,722 - V(\text{H}_2)] \text{ dm}^3 \cdot \frac{1 \text{ mol}}{24,45 \text{ dm}^3} \cdot (-249,20) \text{ kJ/mol} = 27,154 \text{ kJ}$$

$$-241,82 V(\text{H}_2) + 249,20 V(\text{H}_2) = -663,91 + 678,32$$

$$7,38 V(\text{H}_2) = 14,41$$

$$V(\text{H}_2) = 1,953 \text{ dm}^3 \approx \mathbf{1,95 \text{ dm}^3}$$

$$V(\text{D}_2) = 2,722 \text{ dm}^3 - 1,953 \text{ dm}^3 = 0,769 \text{ dm}^3 = \mathbf{0,77 \text{ dm}^3}$$

$$\text{c) } m(\text{H}_2\text{O}) = \frac{1}{1} \cdot 1,953 \text{ dm}^3 \cdot \frac{1 \text{ mol}}{24,45 \text{ dm}^3} \cdot 18,0 \text{ g/mol} = 1,4378 \text{ g} \approx 1,44 \text{ g}$$

$$V(\text{H}_2\text{O}) = 1,44 \text{ g} \cdot \frac{1 \text{ cm}^3}{1,00 \text{ g}} = 1,44 \text{ cm}^3$$

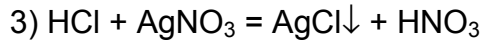
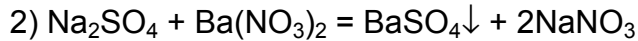
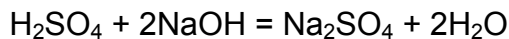
$$V(\text{D}_2\text{O}) = 2,00 \text{ cm}^3 - 1,44 \text{ cm}^3 = 0,56 \text{ cm}^3$$

$$m(\text{D}_2\text{O}) = \frac{1}{1} \cdot 0,769 \text{ dm}^3 \cdot \frac{1 \text{ mol}}{24,45 \text{ dm}^3} \cdot 20,0 \text{ g/mol} = 0,629 \text{ g} \approx 0,63 \text{ g}$$

$$\rho(D_2O) = \frac{0,63 \text{ g}}{0,56 \text{ cm}^3} = 1,125 \text{ g/cm}^3 \approx \mathbf{1,1 \text{ g/cm}^3}$$

5. a) **A** - HCl, H₂SO₄, H₂O; **B** - HCl; **C** - H₂SO₄, H₂O

b) 1) HCl + NaOH = NaCl + H₂O



c) $n(H^+) \Leftrightarrow n(NaOH)$

$$\text{Vedelikus A on: } n(H^+) = \frac{1}{1} \cdot 122,5 \text{ cm}^3 \cdot \frac{1 \text{ dm}^3}{1000 \text{ cm}^3} \cdot 0,09820 \text{ mol/dm}^3 = \mathbf{0,01203 \text{ mol}}$$

d) Vedelikus C on: $2H^+ \Leftrightarrow BaSO_4$

$$n(H^+) = \frac{2}{1} \cdot 0,9018 \text{ g} \cdot \frac{1 \text{ mol}}{233,4 \text{ g}} = \mathbf{0,00773 \text{ mol}}$$

e) HCl-i hulk ja mass gaasis **B** ja vedelikus A on:

$$n(HCl) = 0,01203 - 0,00773 = 0,00430 \text{ mol}$$

$$m(HCl) = 0,00430 \text{ mol} \cdot 36,45 \text{ g/mol} = 0,157 \text{ g}$$

H₂SO₄ mass vedelikus **C** ja vedelikus **A** on:

$$n(H_2SO_4) \Leftrightarrow n(BaSO_4)$$

$$m(H_2SO_4) = \frac{1}{1} \cdot 0,9018 \text{ g} \cdot \frac{1 \text{ mol}}{233,4 \text{ g}} \cdot 98,1 \text{ g/mol} = 0,379 \text{ g}$$

$$m(\text{vedelik C}) = 1,000 \text{ g} - 0,157 \text{ g} = 0,843 \text{ g}$$

Vedelikus **C** on:

$$\%(H_2SO_4) = \frac{0,379 \text{ g}}{0,843 \text{ g}} \cdot 100 = 44,958 \approx \mathbf{45,0}$$

$$\%(H_2O) = \frac{0,843 - 0,379}{0,843} \cdot 100 = \frac{0,464}{0,843} \cdot 100 \approx \mathbf{55,0}$$

Vedelikus **A** on:

$$\%(H_2SO_4) = \frac{0,379}{1,000} \cdot 100 = \mathbf{37,9}$$

$$\%(HCl) = \frac{0,157}{1,000} \cdot 100 = \mathbf{15,7}$$

$$\%(\text{H}_2\text{O}) = \frac{0,464}{1,000} \cdot 100 = \mathbf{46,4}$$

6. a) Täpselt 100 grammis ühendis oleksid elementide hulgad järgmised:

$$n(\text{C}) = 65,20 \text{ g} \cdot \frac{1 \text{ mol}}{12,01 \text{ g}} = 5,429 \text{ mol}$$

$$n(\text{H}) = 8,75 \text{ g} \cdot \frac{1 \text{ mol}}{1,008 \text{ g}} = 8,68 \text{ mol}$$

$$n(\text{O}) = (100,00 - 65,20 - 8,75) \text{ g} \cdot \frac{1 \text{ mol}}{16,00 \text{ g}} = 1,628 \text{ mol}$$

b) Leiame sellise $n(\text{O})$ väärtuse, mille korral ka vesiniku ja süsiniku hulk moolides oleks täisarv. Tegur x on kordajaks esialgsele moolide arvule

$n(\text{C})$	$n(\text{H})$	$n(\text{O})$	x
5,429	8,68	1,628	1
3,3	5,3	1	$1/1,628 = 0,61$
6,6	10,6	2	$2/1,628 = 1,22$
10,0	16,0	3	$3/1,628 = 1,843$

Ühendi **Q** lihtsaim empiiriline valem on $\mathbf{C_{10}H_{16}O_3}$

$$\text{c) } n(\text{NaOH}) = 23,7 \text{ cm}^3 \cdot \frac{1 \text{ dm}^3}{1000 \text{ cm}^3} \cdot 1,00 \cdot 10^{-2} \text{ mol/dm}^3 = 2,37 \cdot 10^{-4} \text{ mol}$$

$$43,7 \text{ mg} \cdot \frac{1 \text{ g}}{1000 \text{ mg}} = 4,37 \cdot 10^{-2} \text{ g}$$

$$4,37 \cdot 10^{-2} \text{ g (Q)} \Leftrightarrow 2,37 \cdot 10^{-4} \text{ mol (NaOH)}$$

$$m(\text{Q}) = 1 \text{ mol (NaOH)} \cdot \frac{4,37 \cdot 10^{-2} \text{ g (Q)}}{2,37 \cdot 10^{-4} \text{ mol (NaOH)}} = 184,4 \text{ g} \approx 184 \text{ g}$$

d) Et ühendi **Q** molaarmass on väiksem kui 200 ja lihtsaima empiirilise valemi korral tuleb ühe mooli massiks

$$100 \text{ g} \cdot 1,843 = 184,3 \text{ g}, \text{ siis peavad empiiriline ja molekulvalem olema samad.}$$

$$M(\text{C}_{10}\text{H}_{16}\text{O}_3) = 10 \cdot 12,01 \text{ g/mol} + 16 \cdot 1,008 \text{ g/mol} + 3 \cdot 16,00 \text{ g/mol} = 184,2 \text{ g/mol}$$

Märkus: Tegurite 10,16 ja 3 ühikuks on mol/mol, mis taanduvad välja.

e) Molekulis **Q** sisaldub üks $-\text{COOH}$ rühm, sest ühe mooli neutraliseerimiseks kulub üks mool naatriumhüdroksiidi. Molekulis **Q** peab sisalduma süsiniku aatomite vahel üks kahekordne side, $-\text{CH}=\text{CH}-$, sest üks mool ühendit **Q** valastab ühe mooli Br_2 -te. Molekulis olevast kolmest hapnikuaatomist üks jääb üle, mis peab moodustama karbonüülrühma, $-\text{CO}-$. Karbonüülrühm saab olla seotud ainult süsinikkudega, sest ta ei saa moodustada aldehüüdrühma (ei anna hõbepeegli reaktsiooni). Kõnealune kolmas hapniku aatom ei saa moodustada hüdroksüülrühma ega ka eetrit, sest sellisel juhul jääks molekulis kaks vesiniku aatomit puudu. *Tsis-trans*-isomeeria olemasolu viitab kaksiksidemele süsiniku aatomite vahel, kuid ta ei määra kaksiksidemete arvu. Selle määras Br_2 ekvimolaarsus.

