# Keemia lahtine võistlus
# Ülesannete lahendused
# 1. november 1997. a.
# Tallinn, Tartu, Kuressaare, Narva, Ahtme
# Noorem aste (9. ja 10. klass)

**1.**

**1)** $CaCO_3 \xrightarrow{t^0} CaO + CO_2\uparrow$

**2)** $CaO + 2HCl + 5H_2O \rightarrow CaCl_2 \cdot 6H_2O$

**3)** $CaCl_2 \cdot 6H_2O \xrightarrow{t^0} CaCl_2 + 6H_2O\uparrow$

**4)** $CaCl_2 \underset{\text{suland}}{\overset{\text{elektrolüüs}}{\rightarrow}} Ca + Cl_2\uparrow$

**5)** $Ca + S \rightarrow CaS$

**6)** $CaS + 2H_2O \rightarrow Ca(OH)_2 + H_2S\uparrow$

**7)** $CaO + H_2O \rightarrow Ca(OH)_2$

**8)** $Ca(OH)_2 + CO_2 \rightarrow CaCO_3\downarrow + H_2O$

**9)** $CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

**2.**

**a)** **X** on väävel (S), **B** on divesiniksulfiid ($H_2S$), **C** on vääveldioksiid ($SO_2$), **D** on vääveltrioksiid ($SO_3$), **E** on väävelhape ($H_2SO_4$), **F** on kaltsiumsulfaat ($CaSO_4$), **M** on väävlishappe lahus ($H_2SO_3$).

**b)**

$S + H_2 \xrightarrow{t^0} H_2S$

$2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$

$2H_2S + O_2 \rightarrow 2H_2O + 2S$

$O_2 + 2SO_2 \underset{\text{kat}}{\overset{t^0}{\rightarrow}} 2SO_3$

$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$

**c)**

$$\%(Ca) = \frac{40,1}{136,2}\cdot 100 = 29,4 \qquad \%(O) = \frac{64}{136,2}\cdot 100 = 47,0$$

$$\%(S) = \frac{32,1}{136,2}\cdot 100 = 23,6 \qquad \mathbf{29,4 + 47,0 + 23,6 = 100}$$

**3.** **a)**

**1)** $Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$

**2)** $3Fe_3O_4 + 8Al \rightarrow 9Fe + 4Al_2O_3$

**b)**

$$\underset{232\ \text{g/mol}}{\overset{1,00\ \text{g}}{Fe_3O_4}} \Leftrightarrow \underset{22,4\ \text{dm}^3\text{/mol}}{\overset{V\ \text{dm3}}{4CO}}$$

$$V(CO) = \frac{4}{1}\cdot\frac{1,00\,\text{g}}{232\,\text{g/mol}}\cdot 22,4\,\text{dm}^3/\text{mol} = 0,3862\,\text{dm}^3 \approx \mathbf{0,386\ dm^3}$$

$$\underset{232\ \text{g/mol}}{\overset{1,00\ \text{g}}{3Fe_3O_4}} \Leftrightarrow \underset{27,0\ \text{g/mol}}{\overset{m\ \text{g}}{8Al}}$$

**c)**

$$m(Al) = \frac{8}{3}\cdot\frac{1,00\,\text{g}}{232\,\text{g/mol}}\cdot 27,0\,\text{g/mol} = 0,3103\,\text{g} \sim \mathbf{0,310\,g}$$

**d)** V(gaas) · 0,250 · 0,300 = v(CO).

Normaaltingimustel: 1 atm · 0,386 $dm^3$ = n · R · 273 K (I)

temperatuuril $1200^0$C ja 1 atm: 1 atm · V(CO; $1200^0$C) = n · R · 1473 K (II)

Jagades II võrrandi I-ga saame:

V(CO; 1200$^0$C) = $\frac{1473\,\text{K}}{273\,\text{K}} \cdot 0{,}386\,\text{dm}^3 = 2{,}0827\,\text{dm}^3$

$$V(\text{gaas}) = 2{,}0827\,\text{dm}^3 \cdot \frac{1}{0{,}250} \cdot \frac{1}{0{,}300} = 27{,}77\,\text{dm}^3 \sim \mathbf{27{,}8\,dm^3}$$

Alternatiivvariant

1,00 g  V(gaas) · 0,250 · 0,232

$Fe_3O_4 \Leftrightarrow 4CO$

232 g/mol  $V_M$(1200$^0$C, 1 atm)

$$V_M(1200^0\,\text{C}, 1\,\text{atm}) = 1\,\text{mol} \cdot 0{,}0820 \frac{\text{atm} \cdot \text{dm}^3}{\text{mol} \cdot \text{K}} \cdot 1473\,\text{K} \cdot \frac{1}{1\,\text{atm}} \cdot \frac{1}{1\,\text{mol}} = 120{,}78 \frac{\text{dm}^3}{\text{mol}} \approx 120{,}8 \frac{\text{dm}^3}{\text{mol}}$$

$$V(\text{gaas}) = \frac{4}{1} \cdot \frac{1{,}00\,\text{g}}{232\,\text{g/mol}} \cdot 120{,}8 \frac{\text{dm}^3}{\text{mol}} \cdot \frac{1}{0{,}250} \cdot \frac{1}{0{,}300} = 27{,}77\,\text{dm}^3 \sim \mathbf{27{,}8\,dm^3}$$

**4.** **a)** $2K + 2H_2O \rightarrow 2KOH + H_2$

$CuSO_4 + 2KOH \rightarrow Cu(OH)_2 \downarrow + K_2SO_4$

**b)**

$$m(\text{KOH}) = \frac{2}{2} \cdot \frac{1{,}00\,\text{g}}{39{,}1\,\text{g/mol}} \cdot 56{,}1\,\text{g/mol} = 1{,}4348\,\text{g} \sim 1{,}43\,\text{g}$$

$$m(CuSO_4) = 0{,}500\,\text{g}\,(CuSO_4 \cdot 5H_2O) \cdot \frac{160\,\text{g}(CuSO_4)}{250\,\text{g}(CuSO_4 \cdot 5H_2O} = 0{,}320\,\text{g}$$

$3{,}2\,\text{g}\,CuSO_4$ reageerimiseks kulub KOH – d

$$m(\text{KOH kulub}) = \frac{2}{1} \cdot \frac{0{,}320\,\text{g}}{160\,\text{g/mol}} \cdot 56{,}1\,\text{g/mol} = 0{,}224\,\text{g} \sim 0{,}22\,\text{g}$$

m(KOH lõpplahuses) = 1,43 g - 0,22 g = **1,21 g**

$$m[Cu(OH)_2\downarrow] = \frac{1}{1} \cdot \frac{0{,}320\,\text{g}}{160\,\text{g/mol}} \cdot 97{,}5\,\text{g/mol} = \mathbf{0{,}195\,g}$$

$$m(K_2SO_4) = \frac{1}{1} \cdot \frac{0{,}320\,\text{g}}{160\,\text{g/mol}} \cdot 174\,\text{g/mol} = \mathbf{0{,}348\,g}$$

$$V(H_2) = \frac{1\,\text{g} \cdot 22{,}4\text{dm}^3\text{/mol}}{39\,\text{g/mol} \cdot 2} = \mathbf{0{,}287\ dm^3}$$

**c)** Lahuse mass määratakse lähteainete masside summa ja lahusest väljunud ainete ($H_2$ ja $Cu(OH)_2$ masside vahega.

m (lähteained) = 50,0 g + 1,00 g + 0,500 g = 51,5 g, sest

$$m(H_2O) = 50{,}0\,\text{cm}^3 \cdot \frac{1\,\text{g}}{\text{cm}^3} = 50{,}0\,\text{g}$$

$$m(H_2) = \frac{1}{2} \cdot \frac{1{,}00\,\text{g}}{39{,}1\,\text{g/mol}} \cdot 2\,\text{g/mol} = 0{,}0256\,\text{g}$$

$$m(H_2 \text{ ja } Cu(OH)_2) = 0{,}0256\,\text{g} + 0{,}195\,\text{g} = 0{,}2206\,\text{g} \sim 0{,}22\,\text{g}$$

$$m(\text{lahus}) = 51{,}5\,\text{g} - 0{,}22\,\text{g} = 51{,}28\,\text{g} \sim 51{,}3\,\text{g}$$

$$\%(\text{KOH}) = \frac{1{,}21\,\text{g}}{51{,}3\,\text{g}} \cdot 100 = \mathbf{2{,}35}$$

$$\%(K_2SO_4) = \frac{0{,}348\,\text{g}}{51{,}5\,\text{g}} \cdot 100 = 0{,}6757 \sim \mathbf{0{,}676}$$

**d)** Lahus on **aluseline,** sest lahuses on KOH.

**5.** **a)**

$$n(CaCO_3) = 1{,}00\,\text{tonni} \cdot \frac{10^6\,\text{g}}{\text{tonn}} \cdot \frac{1\,\text{mol}}{100\,\text{g}} = 1{,}00 \cdot 10^4\,\text{mol}$$

Ühe mooli $CaCO_3$ lagunemisel

$$\Delta H(CaCO_3) = \frac{1{,}78\,\text{GJ}}{1{,}00 \cdot 10^4\,\text{mol}} \cdot \frac{10^6\,\text{KJ}}{1\,\text{GJ}} = 178\,\text{kJ/mol}$$

Selle reaktsiooni termokeemiline võrrand: $CaCO_3 \rightarrow CaO + CO_2$ ($\Delta H$ = 178 kJ/mol)

Ühe mooli CaO "kustutamisel"

$$\Delta H(CaO) = -\frac{1{,}15\,\text{GJ}}{1\,\text{tonn}} \cdot \frac{1\,\text{tonn}}{10^6\,\text{g}} \cdot \frac{56{,}1\,\text{g}}{1\,\text{mol}} \cdot \frac{10^6\,\text{kJ}}{1\,\text{GJ}} = -64{,}5\,\text{kJ/mol}$$

$CaO(t) + H_2O(v) \rightarrow Ca(OH)_2$ ($\Delta H$ = -64,5 kJ/mol)

Märkus: Et reaktsioonivõrrandites osaleb 1 mool, siis tuleb mõlemat ühikut (kJ ja kJ/mol) õigeks lugeda.

**b)** $CaCO_3 \Leftrightarrow CaO$

$$m(CaO) = \frac{1}{1} \cdot \frac{1\,\text{tonn}}{100\,\text{g/mol}} \cdot 56{,}1\,\text{g/mol} = \mathbf{0{,}561\,tonni}$$

Märkus: Tonne pole vaja grammideks teisendada, sest g/mol taandub.

**c)** $$n(CaO) = 0{,}561\,\text{tonni} \cdot \frac{10^6\,\text{g}}{1\,\text{tonn}} \cdot \frac{1\,\text{mol}}{56{,}1\,\text{g}} = 1{,}00 \cdot 10^4\,\text{mol}$$

$\sum\Delta H = 1{,}00 \cdot 10^4\text{mol} \cdot 178\ \text{kJ/mol} + 1{,}00 \cdot 10^4\text{mol} \cdot (-64{,}5\ \text{kJ/mol}) =$
$= 1{,}78\ \text{GJ} - 0{,}645\ \text{GJ} =$ **~1,135 GJ**

**6.** **a)** $KCr(SO_4)_2 + 2Ba(NO_3)_2 \rightarrow 2BaSO_4 + KNO_3 + Cr(NO_3)_3$

**b)** $$n(SO_4^{2-}) = \frac{2}{1} \cdot 9{,}98\,\text{g} \cdot \frac{1\,\text{mol}}{499\,\text{g}} = \mathbf{0{,}0400\ mol},$$

sest $M(KCr(SO_4)_2 \cdot 12H_2O$ = 499 g/mol

**c)** m(lahus)=9,98 + 50,0 = 60,0 g, sest liitmisel ümardatakse madalaima ühise järguni.

$$V(\text{lahus}) = 60{,}0\,\text{g} \cdot \frac{1\,\text{cm}^3}{1{,}05\,\text{g}} = 57{,}14 \sim 57{,}1\,\text{cm}^3 \sim 0{,}0571\,\text{dm}^3$$

$$c(SO_4^{2-}) = \frac{0{,}0400\,\text{mol}}{0{,}05714\,\text{dm}^3} = \sim \mathbf{0{,}700\,M\ ehk\ 0{,}700\,\frac{mol}{dm^3}}$$

**d)** $\underset{261\ \text{g/mol}}{\underline{1}\ Ba(NO_3)_2} \Leftrightarrow 1SO_4^{2-}$ (m(lahus) · 0,0500)

$$m[Ba(NO_3)_2\ \text{lahus}] = \frac{1}{1} \cdot 0{,}0400\,\text{mol} \cdot 261\,\text{g/mol} \cdot \frac{1}{0{,}0500} = 208{,}8\,\text{g} \sim \mathbf{209\,g}$$