

Keemia lahtine võistlus

Ülesannete lahendused

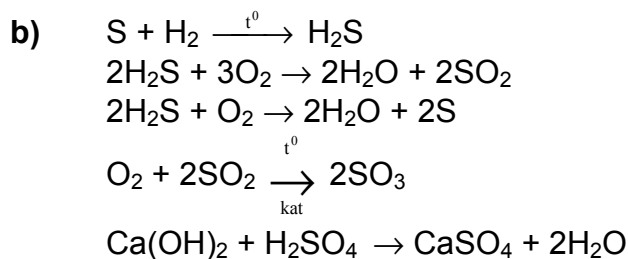
1. november 1997. a.

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Noorem aste (9. ja 10. klass)

- 1.
- 1) $\text{CaCO}_3 \xrightarrow{t^0} \text{CaO} + \text{CO}_2 \uparrow$
 - 2) $\text{CaO} + 2\text{HCl} + 5\text{H}_2\text{O} \rightarrow \text{CaCl}_2 \cdot 6\text{H}_2\text{O}$
 - 3) $\text{CaCl}_2 \cdot 6\text{H}_2\text{O} \xrightarrow{t^0} \text{CaCl}_2 + 6\text{H}_2\text{O} \uparrow$
 - 4) $\text{CaCl}_2 \xrightarrow[\text{suland}]{\text{elektrolüüs}} \text{Ca} + \text{Cl}_2 \uparrow$
 - 5) $\text{Ca} + \text{S} \rightarrow \text{CaS}$
 - 6) $\text{CaS} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2\text{S} \uparrow$
 - 7) $\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2$
 - 8) $\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 \downarrow + \text{H}_2\text{O}$
 - 9) $\text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{Ca(HCO}_3)_2$

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 väävliseppe lahus (H_2SO_3).



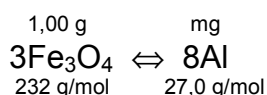
c)

$$\%(\text{Ca}) = \frac{40,1}{136,2} \cdot 100 = 29,4 \qquad \%(\text{O}) = \frac{64}{136,2} \cdot 100 = 47,0$$
$$\%(\text{S}) = \frac{32,1}{136,2} \cdot 100 = 23,6 \qquad \mathbf{29,4 + 47,0 + 23,6 = 100}$$

3. a) 1) $\text{Fe}_3\text{O}_4 + 4\text{CO} \rightarrow 3\text{Fe} + 4\text{CO}_2$
2) $3\text{Fe}_3\text{O}_4 + 8\text{Al} \rightarrow 9\text{Fe} + 4\text{Al}_2\text{O}_3$

b)

$$\begin{array}{l} 1,00 \text{ g} \qquad V \text{ dm}^3 \\ \text{Fe}_3\text{O}_4 \Leftrightarrow 4\text{CO} \\ 232 \text{ g/mol} \qquad 22,4 \text{ dm}^3/\text{mol} \\ V(\text{CO}) = \frac{4}{1} \cdot \frac{1,00 \text{ g}}{232 \text{ g/mol}} \cdot 22,4 \text{ dm}^3/\text{mol} = 0,3862 \text{ dm}^3 \approx \mathbf{0,386 \text{ dm}^3} \end{array}$$



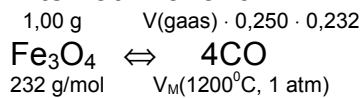
c) $m(\text{Al}) = \frac{8}{3} \cdot \frac{1,00 \text{ g}}{232 \text{ g/mol}} \cdot 27,0 \text{ g/mol} = 0,3103 \text{ g} \sim \mathbf{0,310 \text{ g}}$

- d) $V(\text{gaas}) \cdot 0,250 \cdot 0,300 = v(\text{CO})$.
Normaaltingimustel: $1 \text{ atm} \cdot 0,386 \text{ dm}^3 = n \cdot R \cdot 273 \text{ K}$ (I)
temperatuuril 1200°C ja 1 atm : $1 \text{ atm} \cdot V(\text{CO}; 1200^\circ\text{C}) = n \cdot R \cdot 1473 \text{ K}$ (II)
Jagades II võrrandi I-ga saame:

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

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

Alternatiivvariant



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

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

4. a) $2\text{K} + 2\text{H}_2\text{O} \rightarrow 2\text{KOH} + \text{H}_2$
 b) $\text{CuSO}_4 + 2\text{KOH} \rightarrow \text{Cu}(\text{OH})_2 \downarrow + \text{K}_2\text{SO}_4$

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

$$m(\text{CuSO}_4) = 0,500 \text{ g} (\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) \cdot \frac{160 \text{ g}(\text{CuSO}_4)}{250 \text{ g}(\text{CuSO}_4 \cdot 5\text{H}_2\text{O})} = 0,320 \text{ g}$$

3,2 g CuSO_4 reageerimiseks kulub KOH – d

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

$$m(\text{KOH lõpplahuses}) = 1,43 \text{ g} - 0,22 \text{ g} = \mathbf{1,21 \text{ g}}$$

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

$$m(\text{K}_2\text{SO}_4) = \frac{1}{1} \cdot \frac{0,320 \text{ g}}{160 \text{ g/mol}} \cdot 174 \text{ g/mol} = \mathbf{0,348 \text{ g}}$$

$$V(\text{H}_2) = \frac{1 \text{ g} \cdot 22,4 \text{ dm}^3/\text{mol}}{39 \text{ g/mol} \cdot 2} = \mathbf{0,287 \text{ dm}^3}$$

- c) Lahuse mass määratakse lähteainete masside summa ja lahusest väljunud ainete (H_2 ja $\text{Cu}(\text{OH})_2$) masside vahega.

$$m(\text{läheteained}) = 50,0 \text{ g} + 1,00 \text{ g} + 0,500 \text{ g} = 51,5 \text{ g, sest}$$

$$m(\text{H}_2\text{O}) = 50,0 \text{ cm}^3 \cdot \frac{1 \text{ g}}{\text{cm}^3} = 50,0 \text{ g}$$

$$m(\text{H}_2) = \frac{1}{2} \cdot \frac{1,00 \text{ g}}{39,1 \text{ g/mol}} \cdot 2 \text{ g/mol} = 0,0256 \text{ g}$$

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

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

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

$$\%(\text{K}_2\text{SO}_4) = \frac{0,348 \text{ g}}{51,5 \text{ g}} \cdot 100 = 0,6757 \sim \mathbf{0,676}$$

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

5. a)

$$n(\text{CaCO}_3) = 1,00 \text{ tonni} \cdot \frac{10^6 \text{ g}}{\text{tonn}} \cdot \frac{1 \text{ mol}}{100 \text{ g}} = 1,00 \cdot 10^4 \text{ mol}$$

Ühe mooli CaCO_3 lagunemisel

$$\Delta H(\text{CaCO}_3) = \frac{1,78 \text{ GJ}}{1,00 \cdot 10^4 \text{ mol}} \cdot \frac{10^6 \text{ KJ}}{1 \text{ GJ}} = 178 \text{ kJ/mol}$$

Selle reaktsiooni termokeemiline võrrand: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ ($\Delta H = 178 \text{ kJ/mol}$)

Ühe mooli CaO "kustutamisel"

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

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

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

b) $\text{CaCO}_3 \Leftrightarrow \text{CaO}$

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

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

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

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

6. a) $\text{KCr}(\text{SO}_4)_2 + 2\text{Ba}(\text{NO}_3)_2 \rightarrow 2\text{BaSO}_4 + \text{KNO}_3 + \text{Cr}(\text{NO}_3)_3$

b) $n(\text{SO}_4^{2-}) = \frac{2}{1} \cdot 9,98 \text{ g} \cdot \frac{1 \text{ mol}}{499 \text{ g}} = \mathbf{0,0400 \text{ mol}}$,

sest $M(\text{KCr}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}) = 499 \text{ g/mol}$

c) $m(\text{lahus}) = 9,98 + 50,0 = 60,0 \text{ g}$, sest liitmisel ümardatakse madalaima ühise järguni.

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

$$c(\text{SO}_4^{2-}) = \frac{0,0400 \text{ mol}}{0,05714 \text{ dm}^3} = \mathbf{\sim 0,700 \text{ M ehk } 0,700 \frac{\text{mol}}{\text{dm}^3}}$$

d) $\frac{1}{261 \text{ g/mol}} \text{Ba}(\text{NO}_3)_2 \Leftrightarrow 1 \text{SO}_4^{2-}$

$$m[\text{Ba}(\text{NO}_3)_2 \text{ lahus}] = \frac{1}{1} \cdot 0,0400 \text{ mol} \cdot 261 \text{ g/mol} \cdot \frac{1}{0,0500} = 208,8 \text{ g} \sim \mathbf{209 \text{ g}}$$