ANALITIČKA KEMIJA - SEMINAR

- osnove statistike
- kemija vodenih otopina
- **gravimetrijske metode analize**

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1. Napišite gravimetrijske faktore:

Zadatak	Traženo	Vagano
a)	CuS	CuO
b)	SO_3	$BaSO_4$
c)	Fe	$Fe_2(SO_4)_3$
d)	MgO	$Mg_2P_2O_7$
e)	Al	Al_2O_3
f)	P_2O_5	$Mg_2P_2O_7$
g)	Li	Li_3PO_4
h)	$Nb(OH)_5$	Nb_2O_5

a)

$$\mathrm{CuS} \rightarrow \mathrm{CuO}$$

$$n(\mathrm{CuS}) : n(\mathrm{CuO}) = 1:1$$

$$n(\mathrm{CuS}) = n(\mathrm{CuO})$$

$$a = b$$

$$f_g = \frac{a}{b} \cdot \frac{M_t}{M_v}$$

$$f_g(\mathrm{CuS};\mathrm{CuO}) = \frac{1}{1} \cdot \frac{M(\mathrm{CuS})}{M(\mathrm{CuO})} = \frac{95{,}611}{79{,}546} = 1{,}202$$

b) $$\mathrm{SO_3} \rightarrow \mathrm{BaSO_4}$$

$$n(\mathrm{SO_3}) : n(\mathrm{BaSO_4}) = 1:1$$

$$n(\mathrm{SO_3}) = n(\mathrm{BaSO_4})$$

$$a = b$$

$$f_g = \frac{a}{b} \cdot \frac{M_t}{M_v}$$

$$f_g(\mathrm{SO_3};\mathrm{BaSO_4}) = \frac{1}{1} \cdot \frac{M(\mathrm{SO_3})}{M(\mathrm{BaSO_4})} = \frac{80{,}065}{233{,}392} = 0{,}343$$

c) $$2\,\mathrm{Fe} \rightarrow \mathrm{Fe_2(SO_4)_3}$$

$$n(\mathrm{Fe}) : n(\mathrm{Fe_2(SO_4)_3}) = 2:1$$

$$n(\mathrm{Fe}) = 2n(\mathrm{Fe_2(SO_4)_3})$$

$$a = 2b$$

$$f_\mathrm{g} = \frac{a}{b} \cdot \frac{M_\mathrm{t}}{M_\mathrm{v}}$$

$$f_\mathrm{g}(\mathrm{Fe; Fe_2(SO_4)_3}) = \frac{2}{1} \cdot \frac{M(\mathrm{Fe})}{M(\mathrm{Fe_2(SO_4)_3})} = 2 \cdot \frac{55{,}845}{399{,}885} = 0{,}279$$

d)

$$2\ \mathrm{MgO} \rightarrow \mathrm{Mg_2P_2O_7}$$

$$n(\mathrm{MgO}) : n(\mathrm{Mg_2P_2O_7}) = 2:1$$

$$n(\mathrm{MgO}) = 2n(\mathrm{Mg_2P_2O_7})$$

$$a = 2b$$

$$f_\mathrm{g} = \frac{a}{b} \cdot \frac{M_\mathrm{t}}{M_\mathrm{v}}$$

$$f_\mathrm{g}(\mathrm{MgO; Mg_2P_2O_7}) = \frac{2}{1} \cdot \frac{M(\mathrm{MgO})}{M(\mathrm{Mg_2P_2O_7})} = 2 \cdot \frac{40{,}305}{222{,}558} = 0{,}362$$

e)

$$2\ \mathrm{Al} \rightarrow \mathrm{Al_2O_3}$$

$$n(\mathrm{Al}) : n(\mathrm{Al_2O_3}) = 2 : 1$$

$$n(\mathrm{Al}) = 2n(\mathrm{Al_2O_3})$$

$$a = 2b$$

$$f_\mathrm{g} = \frac{a}{b} \cdot \frac{M_\mathrm{t}}{M_\mathrm{v}}$$

$$f_\mathrm{g}(\mathrm{Al};\ \mathrm{Al_2O_3}) = \frac{2}{1} \cdot \frac{M(\mathrm{Al})}{M(\mathrm{Al_2O_3})} = 2 \cdot \frac{26{,}982}{101{,}964} = 0{,}529$$

f)

$$\mathrm{P_2O_5} \rightarrow \mathrm{Mg_2P_2O_7}$$

$$n(\mathrm{P_2O_5}) : n(\mathrm{Mg_2P_2O_7}) = 1 : 1$$

$$n(\mathrm{P_2O_5}) = n(\mathrm{Mg_2P_2O_7})$$

$$a = b$$

$$f_\mathrm{g} = \frac{a}{b} \cdot \frac{M_\mathrm{t}}{M_\mathrm{v}}$$

$$f_\mathrm{g}(\mathrm{P_2O_5};\ \mathrm{Mg_2P_2O_7}) = \frac{1}{1} \cdot \frac{M(\mathrm{P_2O_5})}{M(\mathrm{Mg_2P_2O_7})} = \frac{141{,}948}{222{,}558} = 0{,}638$$

g)

$$3\,\mathrm{Li} \rightarrow \mathrm{Li_3PO_4}$$

$$n(\mathrm{Li}) : n(\mathrm{Li_3PO_4}) = 3 : 1$$

$$n(\mathrm{Li}) = 3n(\mathrm{Li_3PO_4})$$

$$a = 3b$$

$$f_\mathrm{g} = \frac{a}{b} \cdot \frac{M_\mathrm{t}}{M_\mathrm{v}}$$

$$f_\mathrm{g}(\mathrm{Li}; \mathrm{Li_3PO_4}) = \frac{3}{1} \cdot \frac{M(\mathrm{Li})}{M(\mathrm{Li_3PO_4})} = 3 \cdot \frac{6{,}941}{115{,}797} = 0{,}180$$

h)

$$2\,\mathrm{Nb(OH)_5} \rightarrow \mathrm{Nb_2O_5}$$

$$n(\mathrm{Nb(OH)_5}) : n(\mathrm{Nb_2O_5}) = 2 : 1$$

$$n(\mathrm{Nb(OH)_5}) = 2n(\mathrm{Nb_2O_5})$$

$$a = 2b$$

$$f_\mathrm{g} = \frac{a}{b} \cdot \frac{M_\mathrm{t}}{M_\mathrm{v}}$$

$$f_\mathrm{g}(\mathrm{Nb(OH)_5}; \mathrm{Nb_2O_5}) = \frac{2}{1} \cdot \frac{M(\mathrm{Nb(OH)_5})}{M(\mathrm{Nb_2O_5})} = 2 \cdot \frac{177{,}947}{265{,}813} = 1{,}339$$

2. Odvagano je 2,0450 g uzorka koji sadrži magnezij. Nakon otapanja uzorka, magnezij je istaložen otopinom amonijeva fosfata heksahidrata. Analizom je dobiveno 0,9284 g $Mg_2P_2O_7$. Koliki je maseni udio magnezija u uzorku?

$m(\text{uzorak}) = 2{,}0450\,\text{g}$ $\qquad$ $m(Mg_2P_2O_7) = 0{,}9284\,\text{g}$

$$2\,Mg^{2+} \rightarrow 2\,MgNH_4PO_4 \cdot 6\,H_2O \rightarrow Mg_2P_2O_7$$

$$n(Mg_2P_2O_7) = \frac{m(Mg_2P_2O_7)}{M(Mg_2P_2O_7)} = 4{,}17 \cdot 10^{-3}\ \text{mol}$$

$$n(Mg) : n(Mg_2P_2O_7) = 2:1 \quad \Rightarrow \quad n(Mg) = 2\,n(Mg_2P_2O_7) = 8{,}34 \cdot 10^{-3}\ \text{mol}$$

$$m(Mg) = n(Mg) \cdot M(Mg) = 0{,}2028\,\text{g}$$

$$w(Mg) = \frac{m(Mg)}{m(\text{uzorak})} \cdot 100\% = 9{,}92\%$$

3. Otopljeno je 1,6942 g uzorka nečistog željezovog karbonata. Otopina je prebačena u odmjernu tikvicu od 500,00 mL i dopunjena do oznake. Uzet je alikvot volumena 100,0 mL i, nakon oksidacije, istaložen je hidroksid, koji je dalje preveden u oksid. Dobiveno je 0,3254 g Fe_2O_3. Ako sadržaj željeza u uzorku izrazimo kao masu FeO odnosno Fe_3O_4, koji maseni udio a) FeO odnosno b) Fe_3O_4, će biti u uzorku?

a) $m(\text{uzorak}) = 1{,}6942\,\text{g}$ $\qquad$ $m(Fe_2O_3)_{100\,\text{mL}} = 0{,}3254\,\text{g}$

$$2\,FeO \rightarrow Fe_2O_3$$

$$n(Fe_2O_3) = \frac{m(Fe_2O_3)_{100\,\text{mL}}}{M(Fe_2O_3)} = 2{,}04 \cdot 10^{-3}\ \text{mol}$$

$$n(FeO) : n(Fe_2O_3) = 2:1 \quad \Rightarrow \quad n(FeO) = 2\,n(Fe_2O_3) = 4{,}08 \cdot 10^{-3}\ \text{mol}$$

$$m(FeO)_{100\,\text{mL}} = n(FeO) \cdot M(FeO) = 0{,}2928\,\text{g}$$

$$m(\mathrm{FeO})_{500\,\mathrm{mL}} = m(\mathrm{FeO})_{100\,\mathrm{mL}} \cdot 5 = 1{,}4640\,\mathrm{g}$$

$$w(\mathrm{FeO}) = \frac{m(\mathrm{FeO})_{500\,\mathrm{mL}}}{m(\mathrm{uzorak})} \cdot 100\% = 86{,}41\%$$

b)

$$2\,\mathrm{Fe_3O_4} \rightarrow 3\,\mathrm{Fe_2O_3}$$

$$n(\mathrm{Fe_3O_4}) : n(\mathrm{Fe_2O_3}) = 2:3 \quad \Rightarrow \quad n(\mathrm{Fe_3O_4}) = \frac{2}{3} n(\mathrm{Fe_2O_3}) = 1{,}36 \cdot 10^{-3}\ \mathrm{mol}$$

$$m\,(\mathrm{Fe_3O_4})_{100\,\mathrm{mL}} = n\,(\mathrm{Fe_3O_4})\,M\,(\mathrm{Fe_3O_4}) = 0{,}3145\,\mathrm{g}$$

$$m(\mathrm{Fe_3O_4})_{500\,\mathrm{mL}} = m(\mathrm{Fe_3O_4})_{100\,\mathrm{mL}} \cdot 5 = 1{,}5727\,\mathrm{g}$$

$$w(\mathrm{Fe_3O_4}) = \frac{m(\mathrm{Fe_3O_4})}{m(\mathrm{uzorak})} \cdot 100\% = 92{,}83\%$$

4. 1,0000 g neke rude, koja između ostalih sastojaka sadrži i krom, otopljeno je i u otopini je krom oksidiran u kromat koji je istaložen kao Ag_2CrO_4. Isprani talog srebrova kromata otopljen je u dušičnoj kiselini, pa je Ag^+ ion istaložen u obliku AgCl. Dobiveno je 0,3124 g AgCl. Izračunajte: a) maseni udio kroma; b) maseni udio Cr_2O_3 u uzorku.

a) $m(\text{ruda}) = 1{,}0000\,\text{g}$ $m(\text{AgCl}) = 0{,}3124\,\text{g}$

$$Cr^{3+} \rightarrow CrO_4^{2-} \rightarrow Ag_2CrO_4 \rightarrow 2\,AgCl$$

$$n(\text{AgCl}) = \frac{m(\text{AgCl})}{M(\text{AgCl})} = 2{,}18 \cdot 10^{-3}\ \text{mol}$$

$$n(Cr^{3+}) : n(\text{AgCl}) = 1:2 \quad \Rightarrow \quad n(Cr^{3+}) = \frac{1}{2} n(\text{AgCl}) = 1{,}09 \cdot 10^{-3}\ \text{mol}$$

$$m(\text{Cr}) = n(\text{Cr}) \cdot M(\text{Cr}) = 0{,}0567\,\text{g}$$

$$w(\text{Cr}) = \frac{m(\text{Cr})}{m(\text{ruda})} \cdot 100\% = 5{,}67\%$$

b) $\mathrm{Cr_2O_3} \rightarrow 2\,\mathrm{Cr^{3+}} \rightarrow 2\,\mathrm{CrO_4^{2-}} \rightarrow 2\,\mathrm{Ag_2CrO_4} \rightarrow 4\,\mathrm{AgCl}$

$$n(\mathrm{Cr_2O_3}) : n(\mathrm{AgCl}) = 1 : 4$$

$$n(\mathrm{Cr_2O_3}) = \frac{1}{4} \cdot n(\mathrm{AgCl}) = 5{,}45 \cdot 10^{-4}\ \mathrm{mol}$$

$$m(\mathrm{Cr_2O_3}) = n(\mathrm{Cr_2O_3}) \cdot M(\mathrm{Cr_2O_3}) = 0{,}0828\,\mathrm{g}$$

$$w(\mathrm{Cr_2O_3}) = \frac{m(\mathrm{Cr_2O_3})}{m(\mathrm{ruda})} \cdot 100\% = 8{,}28\%$$

5. Iz uzorka aluminijeva sulfata mase 1,200 g aluminij se istaloži s amonijakom kao $Al_2O_3 \cdot xH_2O$. Nakon filtracije, talog se žari na 1000 °C dajući 0,1798 g bezvodnog Al_2O_3. Izrazite rezultat analize kao udio $NH_4Al(SO_4)_2$ u uzorku.

$m(\text{uzorak}) = 1{,}200\,\text{g}$ $\qquad$ $m(Al_2O_3) = 0{,}1798\,\text{g}$

$$2\,NH_4Al(SO_4)_2 \rightarrow Al_2(SO_4)_3 \rightarrow Al_2O_3 \cdot xH_2O \rightarrow Al_2O_3$$

$$n(Al_2O_3) = \frac{m(Al_2O_3)}{M(Al_2O_3)} = 1{,}76 \cdot 10^{-3}\ \text{mol}$$

$$n(NH_4Al(SO_4)_2) : n(Al_2O_3) = 2:1$$

$$n(NH_4Al(SO_4)_2) = 2\,n(Al_2O_3) = 3{,}53 \cdot 10^{-3}\ \text{mol}$$

$$m(NH_4Al(SO_4)_2) = n(NH_4Al(SO_4)_2)M(NH_4Al(SO_4)_2) = 0{,}8364\,\text{g}$$

$$w(NH_4Al(SO_4)_2) = \frac{m(NH_4Al(SO_4)_2)}{m(\text{uzorak})} \cdot 100\% = 69{,}7\%$$

6. Uzorak nečistog magnezita, $MgCO_3$, mase 0,7406 g razori se s HCl. Oslobođeni CO_2 skupi se na kalcijevu oksidu i izmjeri se da ima masu 0,1881 g. Izračunajte udio magnezija u uzroku.

$m(\text{uzorak}) = 0{,}7406\,\text{g}$ $\qquad$ $m(CO_2) = 0{,}1881\,\text{g}$

$$MgCO_3 + 2\,HCl \rightarrow Mg^{2+} + 2\,Cl^- + CO_2 + H_2O$$

$$CaO + CO_2 \rightarrow CaCO_3$$

$$n(CO_2) = \frac{m(CO_2)}{M(CO_2)} = 4{,}27 \cdot 10^{-3}\ \text{mol}$$

$$n(Mg^{2+}) : n(CO_2) = 1:1 \quad \Rightarrow \quad n(Mg^{2+}) = n(CO_2)$$

$$m(Mg) = n(Mg) \cdot M(Mg) = 0{,}1039\,\text{g}$$

$$w(Mg) = \frac{m(Mg)}{m(\text{uzorak})} \cdot 100\% = 14{,}03\%$$

7. Uzorak pesticida mase 5,000 g razori se s metalnim natrijem u alkoholu, a oslobođeni kloridni ion istaloži kao AgCl. Izrazite rezultat ove analize kao postotak 1,1,1-trikloro-2,2-bis(paraklorfenil)etana (DDT, $C_{14}H_9Cl_5$), ako je nađeno 0,1606 g AgCl.

$m(\text{uzorak}) = 5{,}0000\,\text{g}$ $\qquad$ $m(\text{AgCl}) = 0{,}1606\,\text{g}$

$$C_{14}H_9Cl_5 \rightarrow 5\,Cl^- \rightarrow 5\,AgCl$$

$$n(\text{AgCl}) = \frac{m(\text{AgCl})}{M(\text{AgCl})} = 1{,}12 \cdot 10^{-3}\ \text{mol}$$

$$n(C_{14}H_9Cl_5) : n(\text{AgCl}) = 1:5 \quad \Rightarrow \quad n(C_{14}H_9Cl_5) = \frac{1}{5} n(\text{AgCl}) = 2{,}24 \cdot 10^{-4}\ \text{mol}$$

$$m(C_{14}H_9Cl_5) = n(C_{14}H_9Cl_5) \cdot M(C_{14}H_9Cl_5) = 0{,}0794\,\text{g}$$

$$w(C_{14}H_9Cl_5) = \frac{m(C_{14}H_9Cl_5)}{m(\text{uzorak})} \cdot 100\% = 1{,}59\%$$

8. Iz uzorka mase 0,7152 g živa se istaloži s paraperjodnom kiselinom, H_5IO_6. Talog se odfiltrira, ispere od taložnog reagensa, suši i važe. Izračunajte udio Hg_2Cl_2 u uzorku ako je izvagano 0,3408 g taloga.

$m(\text{uzorak}) = 0{,}7152\,\text{g}$ $\qquad$ $m(Hg_5(IO_6)_2) = 0{,}3408\,\text{g}$

$$5\,Hg^{2+} + 2\,H_5IO_6 \rightarrow Hg_5(IO_6)_2(s) + 10\,H^+$$

$$5\,Hg_2Cl_2 \rightarrow 2\,Hg_5(IO_6)_2$$

$$n(Hg_5(IO_6)_2) = \frac{m(Hg_5(IO_6)_2)}{M(Hg_5(IO_6)_2)} = 2{,}35 \cdot 10^{-4}\ \text{mol}$$

$$n(Hg_2Cl_2) : n(Hg_5(IO_6)_2) = 5:2 \quad \Rightarrow \quad n(Hg_2Cl_2) = \frac{5}{2} n(Hg_5(IO_6)_2) = 5{,}88 \cdot 10^{-4}\ \text{mol}$$

$$m(Hg_2Cl_2) = n(Hg_2Cl_2) \cdot M(Hg_2Cl_2) = 0{,}2776\,\text{g}$$

$$w(Hg_2Cl_2) = \frac{m(Hg_2Cl_2)}{m(\text{uzorak})} \cdot 100\% = 38{,}82\%$$

9. Iz pročišćenog NaCl mase 2,5683 g dobiveno je 6,2971 g AgCl. Izračunajte relativnu atomsku masu natrija.

$m(\mathrm{NaCl}) = 2{,}5683\,\mathrm{g}$ $\qquad$ $m(\mathrm{AgCl}) = 6{,}2971\,\mathrm{g}$

$$\mathrm{NaCl} + \mathrm{Ag}^+ \rightarrow \mathrm{AgCl(s)} + \mathrm{Na}^+$$

$$n(\mathrm{NaCl}) : n(\mathrm{AgCl}) : n(\mathrm{Na}) = 1 : 1 : 1$$

$$n(\mathrm{NaCl}) = n(\mathrm{AgCl}) = n(\mathrm{Na})$$

$$\frac{m(\mathrm{NaCl})}{M(\mathrm{NaCl})} = \frac{m(\mathrm{AgCl})}{M(\mathrm{AgCl})} \quad \Rightarrow \quad M(\mathrm{NaCl}) = M(\mathrm{AgCl})\frac{m(\mathrm{NaCl})}{m(\mathrm{AgCl})}$$

$$M(\mathrm{NaCl}) = 58{,}4549\ \mathrm{g\,mol^{-1}} \quad \Rightarrow \quad M_\mathrm{r}(\mathrm{NaCl}) = 58{,}4549$$

$$A_\mathrm{r}(\mathrm{Na}) = M_\mathrm{r}(\mathrm{NaCl}) - A_\mathrm{r}(\mathrm{Cl}) = 23{,}0019$$

10. Niz uzoraka sulfata analizira se taloženjem u obliku $BaSO_4$. a) Ako je poznato da masa barijeva sulfata odgovara udjelu između 20 i 55%, koja se najmanja masa uzorka mora uzeti ako želimo da masa taloga ne bude manja od 0,300 g? b) Koja se najveća masa taloga može očekivati ako se uzme ta količina uzorka?

a) $m(\mathrm{BaSO_4})_{\min} = 0{,}300\,\mathrm{g}$ $\qquad$ $\mathrm{Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4(s)}$

$$20\% \le w(\mathrm{BaSO_4}) \le 55\% \quad \Rightarrow \quad w(\mathrm{BaSO_4})_{\min} = 0{,}20$$

$$w(\mathrm{BaSO_4}) = \frac{m(\mathrm{BaSO_4})}{m(\mathrm{uzorak})}$$

$$m(\mathrm{uzorak})_{\min} = \frac{m(\mathrm{BaSO_4})_{\min}}{w(\mathrm{BaSO_4})_{\min}} = 1{,}500\,\mathrm{g}$$

b) $w(\mathrm{BaSO_4})_{\max} = 55\%$ $\qquad$ $m(\mathrm{uzorak}) = 1{,}500\,\mathrm{g}$

$$m(\mathrm{BaSO_4})_{\max} = w(\mathrm{BaSO_4})_{\max}\, m(\mathrm{uzorak}) = 0{,}825\,\mathrm{g}$$