1997/98. õa 9. klassi vabariikliku vooru ülesannete lahendused

1. **a**) II peaalarühma karbonaatide kuumutamisel tekivad oksiidid MeO ja CO_2

$M(CO_2) = 44$ g/mol

Olgu kumbagi karbonaati üks mool

$$M(Me^{I}O + Me^{II}O) = 2 \cdot 44 \text{ g/mol} \cdot \frac{1}{38} \cdot 62 \approx 144 \text{ g/mol}$$

b) $M(M^{I} + M^{II}) = 144$ g/mol - 32 g/mol = 112 g/mol

II peaalarühm	Be	Mg	Ca	Sr	Ba	Ra
M(g/mol)	9	24,3	40,1	87,6	137	226

M(Mg+Sr) = 24,3 g/mol + 87,6 g/mol = 111,9 ~112 g/mol

c) $MgCO_3 \xrightarrow{^0t} MgO + CO_2$

$SrCO_3 \xrightarrow{^0t} SrO + CO_2$

2. **a**) $3Cu + 2PH_3 \rightarrow Cu_3P_2 + 3H_2$

$H_2 + CuO \rightarrow Cu + H_2O$

b) *I torus* 4,96 g = $m(Cu_3P_2) - m(3Cu) \Leftrightarrow m(P_2)$

$2PH_3 \Leftrightarrow P_2$

$$n(PH_3) = \frac{2}{1} \cdot 4{,}96 \text{ g} \cdot \frac{1 \text{ mol}}{2 \cdot 31{,}0 \text{ g}} = 0{,}160 \text{ mol}$$

II torus 5,76 g = $m(CuO) - m(Cu) \Leftrightarrow m(O)$

$H_2 \Leftrightarrow O$

$$n(H_2 \text{ kokku}) = 5{,}76 \text{ g} \cdot \frac{1 \text{ mol}}{16{,}0 \text{ g}} = 0{,}360 \text{ mol}$$

$$n(H_2 \text{ fosfaanist}) = \frac{3}{2} \cdot 0{,}160 \text{ mol} = 0{,}240 \text{ mol}$$

$n(H_2$ lähte) = 0,360 mol - 0,240 mol = 0,120 mol

c) $V_{st} = 22{,}4 \text{ dm}^3/\text{mol} \cdot \frac{298}{273} = 24{,}45 \approx 24{,}5 \text{ dm}^3/\text{mol}$

d) $M(PH_3) = 34{,}0$ g/mol; $m(H_2) = 2{,}02$ g/mol

m(lähtesegu) = 0,16 mol·34 g/mol + 0,12 mol·2,02 g/mol = 5,44 g + 0,24 g = 5,68 g

$V=(0{,}16+0{,}12)$ mol·24,45 dm^3/mol = 6,846 dm^3

$$\rho = \frac{5{,}68 \text{ g}}{6{,}846 \text{ dm}^3} = 0{,}820 \text{ g/dm}^3$$

Märkus: Arvutustes pole vajalik murdarvule nulle taha kirjutada, küll aga tuleb lõppvastuses lähteandmete tüvenumbritega arvestada. Vahetehetes on kasulik säilitada lisanumber.

3. **a**) $KMnO_4 + HCl \rightarrow KCl + MnCl_2 + Cl_2 + H_2O$
$Cl_2 + Ca(OH)_2 \rightarrow CaCl_2 + Ca(ClO)_2 + H_2O$

b) Kloori saamise reaktsiooni võrrandi kordajate leidmist on ratsionaalsem alustada saadustest, sest Cl_2 kõik aatomid muudavad oksüdatsiooni- astet

$2\cdot 0 \quad (-) \quad 2\cdot(-I)$
$Cl_2 + 2e \rightarrow 2Cl \qquad 5$
$II \quad (-) \quad VII \quad 10$
$Mn - 5e \rightarrow Mn \qquad 2$
$2KMnO_4 + 16HCl = 2KCl + 2MnCl_2 + 5Cl_2 + 8H_2O$

Ka Cl_2 disproportsioneerumise reaktsiooni võrrandi kordajate leidmist on mugavam alustada saadustest

$2\cdot(-I) \quad (-) \quad 2\cdot 0$
$2Cl - 2e \rightarrow Cl_2 \qquad 1$
$2\cdot I \quad (-) \quad 2\cdot 0 \quad 2$
$2Cl + 2e \rightarrow Cl_2 \qquad 1$
$2Cl_2 + 2Ca(OH)_2 \rightarrow 1CaCl_2 + 1Ca(ClO)_2 + 2H_2O$

c) $5Cl_2 \Leftrightarrow 16HCl$
$1(\text{kloorlubi}) \Leftrightarrow 2Cl_2$
$M[CaCl_2\cdot Ca(ClO)_2] = 254\ g/mol$

$$m(\text{kloorlubi}) = \frac{1}{2}\cdot\frac{5}{16}\cdot 69{,}8\ cm^3\cdot 1{,}189\ g/cm^3\cdot 0{,}365\cdot 0{,}26\cdot \frac{1\ mol}{36{,}5\ g}\cdot 254\ g/mol = 8{,}56\ g$$

4. **a**) 1) $Cu + HCl$ ei reageeri
2) $Cd + 2HCl \rightarrow CdCl_2 + H_2\uparrow$
3) $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$
4) $CdCl_2 + K_2S \rightarrow CdS + 2KCl$
kollane

b) A - Cu (vask); B - Cd (kaadmium); C - $CdCl_2$ (kaadmiumkloriid); D - Cu (vask); E - $Cu(NO_3)_2$ (vasknitraat); F - NO_2 (lämmastikdioksiid); G - CdS (kaadmiumsulfiid)

c) $1CdS \Leftrightarrow 1CdCl_2$ $M(CdS) = 144{,}5\ g/mol$; $M(CdCl_2) = 183{,}3\ g/mol$

$$m(CdCl_2) = \frac{1}{1}\cdot 14{,}45\ g\cdot\frac{1\ mol}{144{,}5\ g}\cdot 183{,}3\ g/mol = 18{,}33\ g$$

$m(Cu) = (37{,}99 - 18{,}33)\ g = 19{,}66\ g$

d) $m(Cd) = 14{,}45\ g \cdot \frac{1\ mol}{144{,}5\ g} \cdot 112{,}4\ g/mol = 11{,}24\ g$

$$\%(Cd) = \frac{11{,}24}{11{,}24 + 19{,}66} \cdot 100 = 36{,}38$$

$$\%(Cu) = \frac{19{,}66}{30{,}90} \cdot 100 = 63{,}62$$

5. **a**) $2KMnO_4 + 3H_2O_2 \rightarrow 2KOH + 2MnO_2 + 2H_2O + 3O_2$

$^{2\cdot 0}O_2 + 2e \rightarrow {}^{2\cdot(-I)}2O$ 3

$^{IV}Mn - 3e \rightarrow {}^{VII}Mn$ 6 2

$$2H_2O_2 \xrightarrow{MnO_2} 2H_2O + 1O_2$$

$^{-II}O - 1e \rightarrow {}^{-I}O$ 2

$^{2\cdot 0}O_2 - 2e \rightarrow {}^{2\cdot(-I)}2O$ 2 1

b) $n(O_2) = 2{,}016\ dm^3 \cdot \frac{1\ mol}{22{,}4\ dm^3} = 0{,}0900\ mol = 9{,}00 \cdot 10^{-2}\ mol$

c) $n(KMnO_4) = 20{,}0\ cm^3 \cdot \frac{1\ dm^3}{1000\ cm^3} \cdot 0{,}100\ mol/dm^3 =$

$= 0{,}00200\ mol = 2{,}00 \cdot 10^{-3}\ mol$

$2KMnO_4 \Leftrightarrow 3(O_2)$

$n(O_2) = \frac{3}{2} \cdot 0{,}002\ mol = 0{,}00300\ mol = 3{,}00 \cdot 10^{-3}\ mol$

d) $2KMnO_4 \Leftrightarrow 3(H_2O_2)$

$n(H_2O_{2\ r\text{-}n}) = \frac{3}{2} \cdot 0{,}002 = 0{,}00300\ mol = 3{,}00 \cdot 10^{-3}\ mol$

$n(O_2\ katal) = 0{,}09\ mol - 0{,}003\ mol = 0{,}0870\ mol$

$1O_2 \Leftrightarrow 2H_2O_2$

$n(H_2O_2) = \frac{2}{1} \cdot 0{,}087 = 0{,}174\ mol$

e) $M(H_2O_2) = 34{,}0\ g/mol$

$n(H_2O_2) = (0{,}174 + 0{,}003)\ mol = 0{,}177\ mol$

$m(H_2O_2) = 0{,}177\ \text{mol} \cdot 34{,}0\ \text{g/mol} = 6{,}02\ \text{g}$

$$\%(H_2O_2) = \frac{6{,}02\ \text{g}}{100\ \text{cm}^3 \cdot 1{,}02\ \text{g/cm}^3} \cdot 100 = 5{,}90\ \%$$

6. **a**) $2HCl + Zn \rightarrow ZnCl_2 + H_2\uparrow$

b) $$V = 100\underline{0}\ \text{cm}^3 - 10\underline{0}\ \text{g} \cdot \frac{1\ \text{cm}^3}{1{,}180\ \text{g}} - 9{,}00\ \text{g} \cdot \frac{1\ \text{cm}^3}{7{,}14\ \text{g}} =$$

$$= 1000\ \text{cm}^3 - 84{,}75\ \text{cm}^3 - 1{,}26\ \text{cm}^3 = 914\ \text{cm}^3$$

$$n(\text{õhk}) = 0{,}914\ \text{dm}^3 \cdot \frac{1\ \text{mol}}{22{,}4\ \text{dm}^3} = 0{,}0408\ \text{mol}$$

c) Kontrollime, millise lähteaine järgi vesiniku hulka arvutada

$$m(Zn) = 100\ \text{g} \cdot 0{,}365 \cdot \frac{1\ \text{mol}}{36{,}5\ \text{g}} \cdot 65{,}4\ \text{g/mol} = 65{,}4\ \text{g}$$

Järelikult HCl-i on ülehulgas

$$n(H_2) = \frac{1}{1} \cdot 9{,}00\ \text{g} \cdot \frac{1\ \text{mol}}{65{,}4\ \text{g}} = 0{,}1376\ \text{mol}$$

n(gaasid)=0,0408 mol + 0,1376 mol = 0,178 mol

d) $$p = 0{,}178\ \text{mol} \cdot 0{,}0820 \frac{\text{atm} \cdot \text{dm}^3}{\text{mol} \cdot \text{K}} \cdot 293\ \text{K} \cdot \frac{1}{0{,}914\ \text{dm}^3} = \approx 4{,}68\ \text{atm}$$

1997/98. õa 10. klassi vabariikliku vooru ülesannete lahendused

1. **a**) A - Cr_2O_3 (kroom(III)oksiid); B - $Na_2Cr_2O_7$ (naatriumdikromaat) C - Na_2SO_4 (naatriumsulfaat); D - NaOH (naatriumhüdroksiid); E - $NaCrO_2$ (naatriumkromit); F - $Cr(OH)_3$ (kroom(III)hüdroksiid); K = $Na_3[Cr(OH)_6]$ (naatriumheksahüdroksükromaat(III)); G - CrO(OH) (kroom(III)hüdrok-süoksiid); H - Cr (kroom); I - Na_2CrO_4 (naatriumkromaat).

b) 1) $Na_2Cr_2O_7 + S \rightarrow Cr_2O_3 + Na_2SO_4$

2) $Cr_2O_3 + 2NaOH \rightarrow 2NaCrO_2 + H_2O$

3) $NaCrO_2 + 2H_2O + 2NaOH \rightarrow Na_3[Cr(OH)_6]$

4) $Na_3[Cr(OH)_6] + 3H^+ \rightarrow 3Na^+ + Cr(OH)_3\downarrow + 3H_2O$

5) $Cr(OH)_3 \rightarrow CrO(OH) + H_2O$

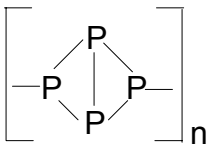
6) $2CrO(OH) \xrightarrow{150\ ^0C} Cr_2O_3 + H_2O$

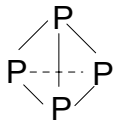
7) $Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr$

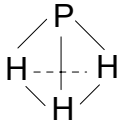
8) $2Cr + 2Na_2CO_3 + 3O_2 \rightarrow 2Na_2CrO_4 + 2CO_2$

2.

a)

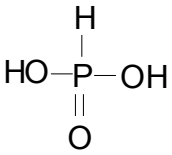
A 

B 

H 

b) aine C: $M(P_4O_{10}) = 284$ g/mol; aine F: $M(P_4O_6) = 220$ g/mol

$$\frac{284}{220} = 1{,}29$$

c) 

d) 1) $4P + 5O_2 \rightarrow P_4O_{10}$

2) $P_4O_{10} + 2H_2O \rightarrow 4HPO_3$

3) $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$

4) $P_4 + 3O_2 \rightarrow P_4O_6$

5) $P_4O_6 + 6H_2O \xrightarrow{\text{madal } ^0t} 4H_3PO_3$

6) $P_4O_6 + 6H_2O \xrightarrow{\text{korge } ^0t} 3H_3PO_4 + PH_3$

e) A - P (punane fosfor); B - P_4 ehk P (valge fosfor); C - P_4O_{10} (tetrafosfordekaoksiid); D - HPO_3 (metafosforhape); E - H_3PO_4 (ortofosforhape); F - P_4O_6 (tetrafosforheksaoksiid); G - H_3PO_3 (fosforishape); H - PH_3 (fosfiin ehk fosfaan).

3. **a**) 16/3 IV IV
U_3O_8 (triuraanoktaoksiid); UO_2 (uraandioksiid); UF_4 (uraan(IV)fluoriid);

VI VI VI
UF_6 (uraan(VI)fluoriid); $(NH_4)_2U_2O_7$ (ammooniumdiuranaat(VI); UO_3 (uraantrioksiid).

b) $U_3O_8 + 2H_2 \xrightarrow{^0t} 3UO_2 + 2H_2O$

$UO_2 + 4HF \xrightarrow{400-700\ ^0C} UF_4 + 2H_2O$

$UF_4 + F_2 \xrightarrow{300\ ^0C} UF_6$

$2UF_6 + 7H_2O + 14NH_3 \xrightarrow{\text{sadenemine}} (NH_4)_2U_2O_7 + 12\ NH_4F$

$(NH_4)_2U_2O_7 \xrightarrow{^0t} 2UO_3 + 2NH_3 + H_2O$

$UO_3 + H_2 \xrightarrow{800-900\ ^0C} UO_2 + H_2O$

c) $U_3O_8 \Leftrightarrow UO_2 \cdot 2UO_3$

4. **a**) katoodil $2H_2O + 2e \rightarrow H_2\uparrow + 2OH^-$
anoodil $2Cl^- - 2e \rightarrow Cl_2$

b) $Cl_2 + H_2O \rightarrow HCl + HClO$
$3HClO \rightarrow HClO_3 + 2HCl$

c) $K_2Cr_2O_7 + 14HCl \rightarrow 2KCl + 2CrCl_3 + 3Cl_2 + 7H_2O$

d) $KClO_3 \Leftrightarrow 3HClO$; $1HClO \Leftrightarrow 2e$

$$m(KClO_3) = \frac{1}{3} \cdot \frac{1}{2} \cdot \frac{0{,}35\ A \cdot 3600\ s}{96500\ A \cdot s} \cdot 123\ g/mol = 0{,}27\ g$$

5. **a**) $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$
$3Ni + 8HNO_3 \rightarrow 3Ni(NO_3)_2 + 2NO + 4H_2O$
$8Al + 30HNO_3 \rightarrow 8Al(NO_3)_3 + 3NH_4NO_3 + H_2O$
$Cu(NO_3)_2 + 2NaOH \rightarrow Cu(OH)_2\downarrow + 2NaNO_3$
$Ni(NO_3)_2 + 2NaOH \rightarrow Ni(OH)_2\downarrow + 2NaNO_3$
$Al(NO_3)_3 + 6NaOH \rightarrow Na_3[Al(OH)_6] + 3NaNO_3$ või
$Al(NO_3)_3 + 4NaOH \rightarrow Na[Al(OH)_4] + 3NaNO_3$
$2Ni(NO_3)_2 + Br_2 + 6NaOH \rightarrow 2Ni(OH)_3\downarrow + 2NaBr + 4NaNO_3$

b) $m[Cu(OH)_2] + m[Ni(OH)_2] = 21{,}310\ g$
$m[Cu(OH)_2] + m[Ni(OH)_3] = 21{,}395\ g$

$$n(Ni) = \Delta n(OH^-) = (21{,}395 - 21{,}310)\ g \cdot \frac{1\ mol}{17\ g} = 0{,}0050\ mol$$

c) $m(Ni) = 0{,}0050\ mol \cdot \frac{2{,}92}{14{,}60} \cdot 58{,}7\ g/mol = \ 0{,}0587\ g\ \approx 0{,}059\ g$

$m[Ni(OH)_2] = 0{,}0050\ mol \cdot 92{,}7\ g/mol = 0{,}4635\ g$

$m[Cu(OH)_2] = 21{,}310 - 0{,}4635 = 20{,}846\ g$

$m(Cu) = \frac{1}{1} \cdot 20{,}846\ g \cdot \frac{63{,}54}{97{,}55} \cdot \frac{2{,}92}{14{,}60} = 2{,}716\ g \approx 2{,}72\ g$

$m(Al) = 2{,}92\ g - 0{,}059\ g - 2{,}716\ g = 0{,}145\ g$

d) $\%(Ni) = \frac{0{,}059}{2{,}92} \cdot 100 = \ \approx 2$

$\%(Cu) = \frac{2{,}72}{2{,}92} \cdot 100 = \ \approx 93$

$\%(Al) = \frac{0{,}145}{2{,}92} \cdot 100 = \ \approx 5$

6. **a**) $n(CH_4) = 3{,}60\ MJ \cdot \frac{1}{0{,}300} \cdot \frac{1\ mol}{802\ kJ} \cdot \frac{1000\ kJ}{1\ MJ} \approx 15{,}0\ mol$

Märkus: Elektri tootmine tarbib energiat, mistõttu märk on +.

b) $m(CO_2) = \frac{1}{1} \cdot 15{,}0\ mol \cdot 44{,}0\ g/mol = 658\ g = 0{,}658\ kg$

c) $n(maagaas) = 14{,}96\ mol \cdot \frac{100}{99} = 15{,}11\ mol$

$V(maagaas\ suvel) = 15{,}11\ mol \cdot 22{,}4\ dm^3/mol \cdot \frac{293}{273} = 363{,}2\ dm^3 \approx$

$\approx 0{,}363\ m^3$

$V(maagaas\ talvel) = 15{,}11\ mol \cdot 22{,}4\ dm^3/mol \cdot \frac{253}{273} = 313{,}7\ dm^3 \approx$

$\approx 0{,}314\ m^3$

1997/98. õa 11. klassi vabariikliku vooru ülesannete lahendused

1. **a**) $SO_2Cl_2 \rightleftharpoons SO_2 + Cl_2$

$$K_c = \frac{[SO_2][Cl_2]}{[SO_2Cl_2]}$$

b) *Tasakaaluolek I* $0{,}0811 = \frac{x \cdot x}{0{,}0200 - x}$, kus x on nii SO_2 kui Cl_2 tasakaaluline kontsentratsioon

$$x^2 + 0{,}0811x - 0{,}001622 = 0$$

$$x = \frac{-0{,}0811 \pm \sqrt{0{,}00658 + 0{,}00648}}{2} \Rightarrow 0{,}0166$$

$$[SO_2] = [Cl_2] = 0{,}0166 \text{ mol/dm}^3 \qquad [SO_2Cl_2] = 0{,}0034 \text{ mol/dm}^3$$

Tasakaaluolek II $0{,}0811 = \frac{y^2}{0{,}0200}$, kus y on nii SO_2 kui Cl_2 tasakaaluline kontsentratsioon

$y^2 = 0{,}001622$; $y = 0{,}04027$

$$[SO_2] = [Cl_2] = 0{,}04027 \text{ mol/dm}^3, \qquad [SO_2Cl_2] = 0{,}02 \text{ mol/dm}^3$$

c) $K_c' = \frac{[SO_2Cl_2]}{[SO_2][Cl_2]} = \frac{0{,}0034}{0{,}0166^2} = 12{,}3 \text{ dm}^3/\text{mol}$ ehk

$$K_c' = \frac{1}{K_c} = \frac{1}{0{,}0811} = 12{,}3 \text{ dm}^3/\text{mol}$$

d) $K_p = \frac{p(SO_2) \cdot p(Cl_2)}{p(SO_2Cl_2)}$

$$p = \frac{n}{V} \cdot R \cdot T \Rightarrow c(R \cdot T)$$

$$K_p = \frac{\left[SO_2\right]\cdot RT\cdot\left[Cl_2\right]\cdot RT}{\left[SO_2Cl_2\right]\cdot RT} \Rightarrow K_cRT =$$

$$= 0{,}0811\ \text{mol/dm}^3 \cdot 0{,}0820\,\frac{\text{atm}\cdot\text{dm}^3}{\text{mol}\cdot\text{K}}\cdot 446\ \text{K} = 2{,}97\ \text{atm}$$

2. **a**) $k\cdot t = \ln\frac{c_o}{c_t}$, millest $k = \frac{\ln 2}{\tau} = 0{,}0861\ \text{päeva}^{-1}$

b) $t = \frac{1}{0{,}0861}\cdot\ln\frac{100}{0{,}01} = 107\ \text{päeva}$

c) jood

d) 1) $I_2 + H_2 \rightleftharpoons 2HI$
2) $KI + AgNO_3 \rightarrow AgI\downarrow + KNO_3$

e) Lähtume arvutustes 1,000 grammist

$1(KI) \Leftrightarrow 1\ AgNO_3$

$$n(KI) = \frac{1}{1}\cdot 1{,}000\ \text{g}\cdot\frac{1\ \text{mol}}{169{,}9\ \text{g}} = 0{,}005886\ \text{mol}$$

$$m(K) = 0{,}005886\ \text{mol}\cdot\frac{39{,}1\ \text{g}}{1\ \text{mol}} = 0{,}230\ \text{g}$$

$$M(I) = \frac{(1{,}000 - 0{,}230)\ \text{g}}{0{,}005886\ \text{mol}} = 130{,}8\ \text{g/mol} \approx 131\ \text{g/mol}$$

Märkus: Radioaktiivsete isotoopide aatommassid antakse massiarvuna (täisarv). Näiteks $^{131}_{53}I$.

f) $^{131}_{53}I - e^- \rightarrow {}^{131}_{54}Xe$

3. **i**) $K_{diss} = \frac{c\cdot\alpha\cdot c\cdot\alpha}{c(1-\alpha)} = c\cdot\alpha^2$, millest $\alpha = \sqrt{\frac{K_{diss}}{c}}$

$$\left[H^+\right] = c\cdot\alpha = \sqrt{K_{diss}\cdot c}$$

või $K_{diss} = \frac{[A^-]\cdot[H^+]}{[AH]} \approx \frac{[H^+]^2}{c_h}$; $[H^+] = \sqrt{c \cdot K_{diss}}$

ii) $[OH^-] = \sqrt{K_{diss} \cdot c}$

$[H^+] = \frac{10^{-14}}{[OH^-]}$

iii) **a**) $[H^+] = 10{,}00\ cm^3 \cdot \frac{1\ dm^3}{1000\ cm^3} \cdot \frac{0{,}0100\ mol}{dm^3} \cdot \frac{1}{100\ cm^3} \cdot \frac{1000\ cm^3}{1\ dm^3} =$

$= 1{,}00 \cdot 10^{-3}\ mol/dm^3$

pH = -lg $1{,}00 \cdot 10^{-3}$ = 3,00

b) $[H^+] = \sqrt{5{,}01 \cdot 10^{-8} \cdot 2{,}00 \cdot 10^{-2}} = \sqrt{10{,}02 \cdot 10^{-10}} = 3{,}17 \cdot 10^{-5}$

pH = -lg $3{,}17 \cdot 10^{-5}$ = 4,50

c) $[OH^-] = \sqrt{1{,}79 \cdot 10^{-5} \cdot 6{,}00 \cdot 10^{-2}} = \sqrt{1{,}074 \cdot 10^{-6}} = 1{,}04 \cdot 10^{-3}$

$[H^+] = \frac{10^{-14}}{1{,}04 \cdot 10^{-3}} = 9{,}61 \cdot 10^{-12}$

pH = -lg $9{,}61 \cdot 10^{-12}$ = 11,0

d) $[OH^-] = 5{,}00 \cdot 10^{-3}\ mol/dm^3 \cdot \frac{1}{100} = 5{,}00 \cdot 10^{-5}\ mol/dm^3$

$[H^+] = \frac{10^{-14}}{5{,}00 \cdot 10^{-5}} = 2{,}00 \cdot 10^{-10}$

pH = -lg $2{,}00 \cdot 10^{-10}$ = 9,70

e) Etanool on neutraalse keskkonnaga amfolüüt, mistõttu tema vesilahuse pH on ~7. Süsihappegaasi lahustumise tõttu võib lahus olla nõrgalt happelise reaktsiooniga.

iv) No 1 MO - punane, seega lahus a
No 2 FF - punane, kas d või c
TF - sinine, seega lahus c

No 3 MP - kollane, kas e või d
FF - värvitu, seega lahus e
No 4 FF - punane
TF - värvitu, seega lahus d
No 5 MP - oranzikas punane (pöördealas), seega lahus b

4. **a**) A – NH_3 (ammoniaak); B – CH_3NH_2 (metüülamiin);

D – $(CH_3)_3N$ (trimetüülamiin);

E — $CH_2—CH_2$ (etüleenoksiid)
$\backslash O /$

b) 1) $3CH_3OH + NH_3 \xrightarrow{t^o\ Al_2O_3} (CH_3)_3N + 3H_2O$

2) $2C_2H_4 + O_2 \xrightarrow{Ag} 2\ CH_2—CH_2$
$\backslash O /$

3) $CH_2—CH_2 + (CH_3)_3N + H_2O \longrightarrow HO—CH_2—CH_2—\overset{\overset{O}{\|}}{N}(CH_3)_3—\overset{\overset{O}{\|}}{O}H$
$\backslash O /$

c) $CH_2{=}CH–\overset{\overset{O}{\|}}{N}(CH_3)_3–\overset{\overset{O}{\|}}{O}H + 2HBr = Br–CH_2–CH_2–\overset{\overset{O}{\|}}{N}(CH_3)_3–\overset{\overset{O}{\|}}{O}Br + H_2O$

5. **a**) Lähtume 100-st grammist

$$n(Cl) = 100\ g \cdot 0{,}722 \cdot \frac{1\ mol}{35{,}5\ g} = 2{,}03\ mol$$

$$n(C) = 100\ g \cdot 0{,}163 \cdot \frac{1\ mol}{12{,}0\ g} = 1{,}36\ mol$$

$$n(O) = 100\ g \cdot 0{,}1082 \cdot \frac{1\ mol}{16{,}0\ g} = 0{,}676\ mol$$

$$n(H) = 100\ g \cdot 0{,}0687 \cdot \frac{1\ mol}{1{,}008\ g} = \approx 0{,}677\ mol$$

Kui molekulis on vesiniku ja hapniku aatomeid üks, siis

$$n(C) = \frac{1}{0{,}677} \cdot 1{,}36\ mol = 2{,}0\ mol \quad \text{ja} \quad n(Cl) = \frac{1}{0{,}677} = 3{,}0\ mol$$

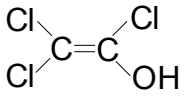
Cl_3C_2OH

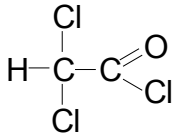
b) $M(\text{monohüdraat}) = 1{,}86 \frac{K \cdot kg}{mol} \cdot \frac{1}{0{,}372\ K} \cdot 3{,}31\ g \cdot \frac{1}{0{,}100\ kg} = 165{,}5\ g/mol$

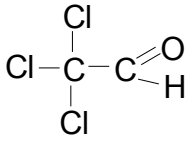
M(A) = 165,5 g/mol - 18,0 g/mol = 147,5 g/mol

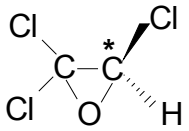
Aine A brutovalem vastab aatomite minimaalsele täisarvulisele suhtele.

c)









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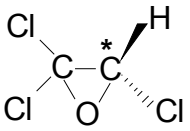

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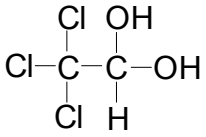
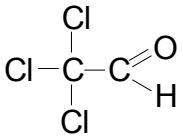
d)  2,2,2-trikloroetaan-1,1-diool

e)  2,2,2-trikloroetanaal

6. **a**) $m(\text{antratsiit}) = \frac{1\ \text{kg}}{28{,}5\ \text{MJ} \cdot 0{,}3} \cdot \frac{3{,}60\ \text{MJ}}{1\ \text{kW}} = 0{,}421\ \text{kg/kW}$

$m(\text{põlevkivi}) = \frac{1\ \text{kg}}{10{,}5\ \text{MJ} \cdot 0{,}3} \cdot \frac{3{,}60\ \text{MJ}}{1\ \text{kW}} = 1{,}14\ \text{kg/kW}$

b) $S \Leftrightarrow SO_2 \Leftrightarrow CaO \Leftrightarrow CaSO_3$

$n(\text{S seotud}) = 1140\ \text{g} \cdot 0{,}88 \cdot 0{,}018 \cdot 0{,}8 \cdot \frac{1\ \text{mol}}{32\ \text{g}} = 0{,}451\ \text{mol}$

$m(CaO) = 0{,}451\ \text{mol} \cdot 56{,}1\ \text{g/mol} = 25{,}3\ \text{g} \sim 25{,}0\ \text{g}$

c) Antratsiidist $m(CO_2) = 421\ \text{g} \cdot 0{,}94 \cdot 0{,}85 \cdot \frac{44}{12} = 1233\ \text{g} \approx 1200\ \text{g}$

Põlevkivist $m(CO_2) = 1140\ \text{g} \cdot 0{,}88 \cdot 0{,}27 \cdot \frac{44}{12} = 993\ \text{g} \approx 990\ \text{g}$

+ $CaCO_3$ lagunemisest $1140\ \text{g} \cdot 0{,}88 \cdot 0{,}41 \cdot 0{,}95 \cdot \frac{44}{100} = 172\ \text{g}$

Kokku: 1162 g

d) $CaCO_3 \rightarrow CaO + CO_2$

ΔH(r-n) = -636 kJ - 394 kJ - (-1207 kJ) = +177 kJ

ΔH (CaO saamiseks) = 0,451 mol $\cdot$ 177 kJ/mol = 79,8 kJ

$S + O_2 \rightarrow SO_2$

ΔH (SO_2 saamiseks) = 0,451 mol $\cdot$ (-297 kJ/mol) = -133,9 kJ

$CaO + SO_2 \rightarrow CaSO_3$

ΔH(r-n) = -1346 kJ - (-636 kJ - 297 kJ) = -413 kJ

ΔH($CaSO_3$ saamiseks) = 0,451 mol $\cdot$ (-413 kJ/mol) = -186,3 kJ

$\Sigma\Delta H$(väävli (80 %) sidumiseks)=79,8 kJ-133,9 kJ-186,3 kJ = -240,4 kJ $\approx$ $\approx$ -240 kJ

e) Antratsiidist $m(SO_2) = 421\text{ g} \cdot 0{,}94 \cdot 0{,}015 \cdot \frac{64}{32} = 11{,}87 \approx 12\text{ g}$

Põlevkivist $m(SO_2) = 1140\text{ g} \cdot 0{,}88 \cdot 0{,}018 \cdot 0{,}2 \cdot \frac{64}{32} = 7{,}22\text{ g} \approx 7{,}2\text{ g}$

1997/98. õa keemiaolümpiaadi vabariikliku vooru ülesannete lahendused
12. klass

1. **a**) $2CH_3COOH \xrightarrow[2e]{\text{elektrolüüs}} CH_3{-}CH_3 + 2CO_2 + H_2$

$2H_2O \xrightarrow[4e]{\text{elektrolüüs}} 2H_2 + O_2$

$$M(C_2H_6 \cdot 2CO_2 \cdot H_2) = (1\ \text{mol} \cdot 30{,}0\ \text{g/mol} + 2\ \text{mol} \cdot 44{,}0\ \text{g/mol} + 1\ \text{mol} \cdot 2{,}02\ \text{g/mol}) \cdot \frac{1}{4\ \text{mol}} = 30{,}0\ \text{g/mol}$$

$$M(2H_2 \cdot 1O_2) = (2\ \text{mol} \cdot 2{,}02\ \text{g/mol} + 1\ \text{mol} \cdot 32{,}0\ \text{g/mol}) \cdot \frac{1}{3\ \text{mol}} = 12{,}0\ \text{g/mol}$$

b) katoodil $2H_3O^+ + 2e \rightarrow H_2 + 2H_2O$

anoodil $2CH_3COO^- - 2e \rightarrow C_2H_6\uparrow + 2CO_2\uparrow$

$6H_2O - 4e \rightarrow O_2 + 4H_3O^+$

c) $$n(\text{gaasid}) = \frac{761}{760}\text{atm} \cdot 40{,}0\ \text{dm}^3 \cdot \frac{1\ \text{mol} \cdot \text{K}}{0{,}082\ \text{atm} \cdot \text{dm}^3} \cdot \frac{1}{298\ \text{K}} = 1{,}64\ \text{mol}$$

d) M(gaasid) = 29,0 g/mol · 0,476 = 13,8 g/mol

Olgu veest tekkinud gaasisegu moolide arv x, siis äädikhappest tekkinud gaasisegu moolide arv on 1,64 mol-x

x · 12,0 g/mol + (1,64 mol - x) · 30,0 g/mol = 1,64 mol · 13,8 g/mol

12,0x g/mol + 49,2 g - 30,0x g/mol = 22,6 g

18x g/mol = 26,6 g

$$x = 26{,}6\ \text{g} \cdot \frac{1\ \text{mol}}{18\ \text{g}} = \approx 1{,}48\ \text{mol}$$

1,64 mol - x $\Rightarrow$ 1,64 mol - 1,48 mol = 0,16 mol

$$n(CH_3COOH) = \frac{2}{4} \cdot 0{,}16\ \text{mol} = 0{,}080\ \text{mol}$$

$$n(H_2O) = \frac{2}{3} \cdot 1{,}48\ \text{mol} = 0{,}987\ \text{mol}$$

e) $$Q(CH_3COOH) = \frac{2}{2} \cdot 0{,}080\ \text{mol} \cdot \frac{1\ \text{F}}{\text{mol}} = 0{,}080\ \text{F}$$

$$Q(H_2O) = \frac{4}{2} \cdot 0{,}987\ \text{mol} \cdot \frac{1\ \text{F}}{\text{mol}} = 1{,}97\ \text{F}$$

$\Sigma[Q(CH_3COOH)+Q(H_2O)$= 0,080 F + 1,97 F =2, 05 F

$$U = 0{,}393\ \text{kWh} \cdot \frac{1000\ \text{A} \cdot \text{V}}{1\text{kW}} \cdot \frac{3600\ \text{s}}{\text{h}} \cdot \frac{1}{2{,}05\ \text{F}} \cdot 0{,}85 \cdot \frac{1\ \text{F}}{96485\ \text{A} \cdot \text{s}} = 6{,}08\ \text{V} \approx 6{,}1\ \text{V}$$

2. **a**) $M^{25^\circ C}(\text{gaasid}) = 0{,}499\ \text{g} \cdot 22{,}4\ \text{dm}^3/\text{mol} \cdot \frac{298}{273} \cdot \frac{1}{0{,}230\ \text{dm}^3} = 53{,}0\ \text{g/mol}$

$M^{0^\circ C}(\text{gaasid}) = 0{,}0497\ \text{g} \cdot 22{,}4\ \text{dm}^3/\text{mol} \cdot \frac{1}{0{,}024\ \text{dm}^3} = 46{,}4\ \text{g/mol}$

Gaaside segu molaarmass saab väheneda ainult ühe gaasi kondenseerumise tõttu. Järelikult madalama keemistemperatuuriga gaasi G′ molaarmass on

$M(G') = \approx 46{,}4$ g/mol

$0{,}5 \cdot [M(G') + M(G'')] = 53{,}0$ g/mol

$M(G'') = 53{,}0\ \text{g/mol} \cdot \frac{1}{0{,}5} - 46{,}4\ \text{g/mol} = \approx 59{,}6\ \text{g/mol}$

b) Et C, H ja O molaarmassid on väga lähedased täisarvudele, siis ümardame gaasi G′ molaarmassi 46,0 g/mol.

Võrrandit $12x + 14y + 16z = 46{,}0$ rahuldab süsiniku moolide arv 1 ja 2, siis on vesiniku (y) ja hapniku (z) moolide arv järgmine:

x	y	z	M(g/mol)	Valem
2	6	1	46	$C_2H_6O \rightarrow CH_3OCH_3$ või C_2H_5OH
1	2	2	46	$CH_2O_2 \rightarrow HCOOH$

Tingimust rahuldab ainult dimetüüleeter – metoksümetaan, sest etüülalkohol ja metaanhape on normaaltingimustel vedelas olekus ja nad on keemiliselt aktiivsed.

G″ on $CH_3OC_2H_5$ (metüületüüleeter e. metoksüetaan)

$M(CH_3OC_2H_5) = 60{,}0$ g/mol

c) Eetrid on kergesti lenduvad ühendid $^0t_{keem}(CH_3OC_2H_5) = 7{,}6\ ^0C$, mistõttu teda leidub gaasifaasis (n.t.) märgatavas hulgas.

3. **a**) Kui metall reageerib klooriga ja annab tetraalküülühendi, siis peab tema oksüdatsiooniaste ühendites olema +IV.

$M(A) = 4 \cdot 35{,}5\ \text{g/mol} \cdot \frac{45{,}5}{54{,}5} = 118{,}55\ \text{g/mol} \approx 119\ \text{g/mol}$

A on Sn (tina)

b) 1) $Sn + 2Cl_2 \rightarrow SnCl_4$

2) $SnCl_4 + 4CH_3MgI \rightarrow (CH_3)_4Sn + 4MgICl$

3) $(CH_3)_4Sn + 3SnCl_4 \rightarrow 4CH_3SnCl_3$, sest

$n[(CH_3)_4Sn] = 1\ \text{g} \cdot \frac{1\ \text{mol}}{179\ \text{g}} = 0{,}0056\ \text{mol}$

$n(SnCl_4) = 4{,}4\ \text{g} \cdot \frac{1\ \text{mol}}{260\ \text{g}} = 0{,}017\ \text{mol}$, millest tuleneb moolide suhe 3:1

4) $CH_3SnCl_3 + NaOH \rightarrow CH_3Sn(OH)_3 + 3NaCl$

$\downarrow$

$CH_3SnO(OH)$ ehk $CH_3SnOOH + H_2O$

5) $CH_3SnOOH + NaOH \rightarrow CH_3SnOONa + H_2O$

6) $CH_3SnOOH + 3HCl \rightarrow CH_3SnCl_3 + 2H_2O$

c) A - Sn (tina); B - $SnCl_4$ (tina(IV)kloriid), C - $(CH_3)_4Sn$ (tetrametüültina),D - CH_3SnCl_3 (metüültina(IV)kloriid), E - CH_3SnOOH (metüültinaoksühüdroksiid).

4. **a**) CuO (vask(II)oksiid); CO_2 (süsihappegaas ehk süsinikdioksiid); H_2O (vesi ehk vesinikoksiid).

b) $m^1(gaas) = 3{,}51\ dm^3 \cdot 0{,}798\ g/dm^3 = 2{,}80\ g$
$m^2(gaas) = 3{,}38\ dm^3 \cdot 0{,}910\ g/dm3 = 3{,}08\ g$

$$n^1(gaas) = 3{,}51\ dm^3 \cdot \frac{1\ mol}{22{,}4\ dm^3 \cdot 473/273} = 0{,}0904\ mol$$

$$n^2(gaas) = 3{,}38\ dm^3 \cdot \frac{1\ mol}{22{,}4\ dm^3} \cdot \frac{273}{473} = 0{,}0871\ mol$$

c) $m(MeO) = 10{,}00\ g - 2{,}80\ g = 7{,}20\ g$

$$M(MeO) = 7{,}20\ g \cdot \frac{1}{0{,}0904\ mol} = 79{,}6\ g/mol$$

$M(Me) = 79{,}6\ g/mol - 16{,}0\ g/mol = 63{,}6\ g/mol$
Metalli oksiidiks on CuO
Kontrolliks: $m(MeO) = 10{,}00\ g - 3{,}08\ g = 6{,}92\ g$

$$M(MeO) = 6{,}92\ g \cdot \frac{1}{0{,}0871\ mol} = 79{,}5\ g/mol$$

d) $$M(gaasid\ I) = 2{,}80\ g \cdot \frac{1}{0{,}0904\ mol} = \approx 31\ g/mol$$

Lagunemisel tekkivate ainete hulgad suhtuvad alati nagu täisarvud. Keskmise molaarmassi 31 g/mol annavad H_2O ja CO_2 hulkade suhe 1:1

$$(18\ g/mol + 44\ g/mol) \cdot \frac{1}{2} = 31\ g/mol$$

$$M(gaasid\ II) = 3{,}08\ g \cdot \frac{1}{0{,}0871\ mol} = 35{,}4\ g/mol$$, millele vastab H_2O ja CO_2 hulkade suhe 1:2

$$(18\ g/mol + 2 \cdot 44\ g/mol) \cdot \frac{1}{3} = 35{,}3\ g/mol$$

e) $2CuO \cdot H_2O \cdot CO_2 \Leftrightarrow CuCO_3 \cdot Cu(OH)_2$ (malahiit)
$3CuO \cdot H_2O \cdot 2CO_2 \Leftrightarrow 2CuCO_3 \cdot Cu(OH)_2$ (asuriit)

5. **a**) $$n(X) = -46{,}32\ kJ \cdot \frac{1\ mol}{-926{,}4\ kJ} = 0{,}05000\ mol$$

$$M(X) = 3{,}00\ g \cdot \frac{1}{0{,}05\ mol} = 60{,}0\ g/mol$$

Seega $12\ g/mol \cdot n(C) + 1\ g/mol \cdot n(H) + 16\ g/mol \cdot n(O) = 60{,}0\ g/mol$

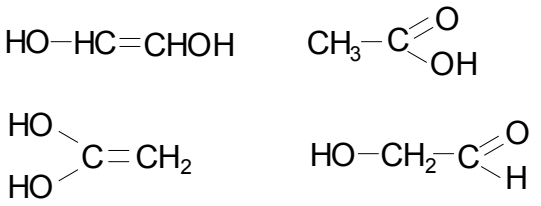
b) $$-926{,}4\ kJ/mol \cdot 1\ mol = -393{,}5\ kJ/mol \cdot n(C) -$$

$$-(-241{,}8\ kJ)/mol \cdot \frac{n(H)}{2} - (-344{,}2\ kJ)/mol \cdot 1\ mol$$

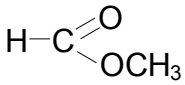
c) 12·n(C) + 1·n(H) + 16·n(O) = 60
n(O) ≤ 3
n(O) = 3 mol ei sobi, sest 60 - 48 = 12n(C), mistõttu n(H) = 0
n(O)=2 mol, siis 60 - 32 = 12n(C) + n(H), millest
n(C)= 2 mol ja n(H) = 4 mol.
Brutovalem $C_2H_4O_2$
n(O) = 1 mol ei sobi.

Kontroll:
-393,5 kJ/mol·2 mol-241,8 kJ/mol·2 mol- -344,2 kJ/mol·1 mol = -926,4 kJ

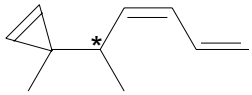
d)

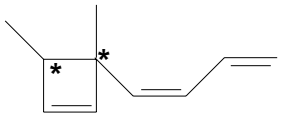


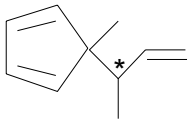
e) Ülesande tingimustele vastab ainult metüülformiaat ehk metüülmetanaat

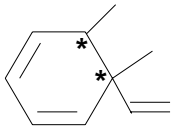


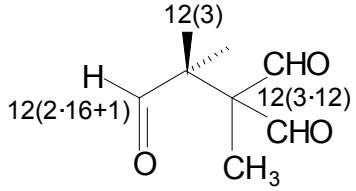
6. **a**,**b**)

1) 

2) 

3) 

4) 

c) 

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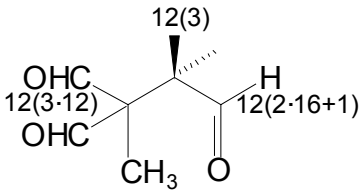

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3-2-formüül-2,3-dimetüülbutaandiaal