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

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

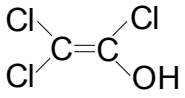
Cl_3C_2OH

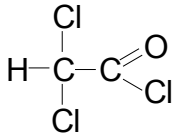
b) $M(\text{monohüdraat}) = 1{,}86 \frac{K \cdot kg}{mol} \cdot \frac{1}{0{,}372\ K} \cdot 3{,}31\ g \cdot \frac{1}{0{,}100\ kg} = 165{,}5\ g/mol$

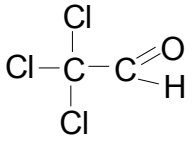
M(A) = 165,5 g/mol - 18,0 g/mol = 147,5 g/mol

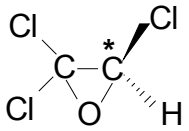
Aine A brutovalem vastab aatomite minimaalsele täisarvulisele suhtele.

c)

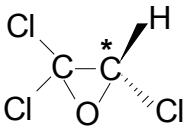




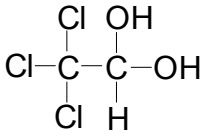


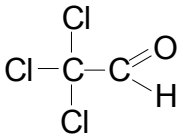


R



S

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