2002/2003 õa keemiaolümpiaadi lõppvooru ülesannete lahendused

12. klass

1. a) **X** – SiO_2, ränidioksiid, liiv

b) i) $n(CO_2) = 45{,}1\ g \cdot \frac{1\ mol}{44{,}0\ g} = 1{,}025\ mol$

$n(FeO) = 0{,}2\ g \cdot \frac{1\ mol}{71{,}9\ g} = 0{,}00278\ mol \approx 0{,}003\ mol$

$n(CaO) = 48{,}1\ g \cdot \frac{1\ mol}{56{,}1\ g} = 0{,}857\ mol$

$n(\mathbf{Y}) = 1{,}025\ mol - 0{,}003\ mol - 0{,}857\ mol = 0{,}165\ mol$

$M(\mathbf{Y}) = 6{,}6\ g \cdot \frac{1}{0{,}165\ mol} = \mathbf{40\ g/mol}$

Ühend **Y** ei saa olla Me_2O, sest siis oleks $A_r(Me) = 12$. Kui ühend **Y** on MeO, siis $A_r(Me) = 40 - 16 = 24$, mis vastab magneesiumile.

ii) **Y** – MgO, magneesiumoksiid

c) Happelised mullad vajavad põlevkivituhka. CaO neutraliseerib mulla happesuse.

d) CaO ja Al_2O_3

e) SO_2 – kerogeeni ja savi–liiva koostisse
H_2O – kerogeeni koostisse
CaO – karbonaatide koostisse

f) i) $SO_2 + H_2O = H_2SO_3$

ii) $2H_2SO_3 + O_2 = 2H_2SO_4$

iii) $H_2SO_4 + CaO + H_2O = CaSO_4 \cdot 2H_2O$

2. a) Ühend **A** peab olema $\mathbf{X}O_2$, sest sellest saadakse viieaatomiline binaarne ühend $\mathbf{X}Cl_4$

$M_r(\mathbf{A}) = 16 \cdot 2 \cdot \frac{1}{0{,}40} = 80$

$A_r(\mathbf{X}) = 80 - 32 = 48$

X – Ti, titaan

b) **A** – TiO_2, titaan(IV)oksiid

B – C, süsinik

C – Cl_2, kloor

D – $TiCl_4$, titaan(IV)kloriid

E – CO, süsinikoksiid

F – H_2, vesinik

G – $TiCl_3$, titaan(III)kloriid

H – $Ti_2O_3 \cdot H_2O$, titaan(III)oksiid monohüdraat

c) i) $TiO_2 + 2C + 2Cl_2 = TiCl_4 + 2CO$

ii) $TiCl_4 + 2H_2O = TiO_2 + 4HCl$

iii) $TiCl_4 + 2Mg = Ti + 2MgCl_2$

iv) $2TiCl_4 + H_2 = 2TiCl_3 + 2HCl$

v) $2TiCl_3 + 6NaOH = Ti_2O_3 \cdot H_2O + 6NaCl + 2H_2O$

vi) $TiO_2 + CaO = CaTiO_3$ (kaltsiummetatitanaat
vii) $TiO_2 + 4NaOH = Na_4TiO_4 + 2H_2O$ (naatriumortotitanaat)

3. a) $n(H) \Leftrightarrow 2n(H_2O)$

$n(H) = 2 \cdot 216{,}2 \text{ mg} \cdot \frac{1 \text{ mol}}{18{,}02 \text{ g}} = 24 \text{ mmol}$

$n(C) \Leftrightarrow n(BaCO_3)$

$n(C) = 1{,}973 \text{ g} \cdot \frac{1 \text{ mol}}{197{,}3 \text{ g}} = 10 \text{ mmol}$

$24 \text{ mmol} \cdot 1{,}008 \text{ g/mol} + 10 \text{ mmol} \cdot 12{,}01 \text{ g/mol} = 144{,}3 \text{ mg}$

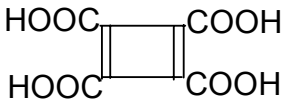
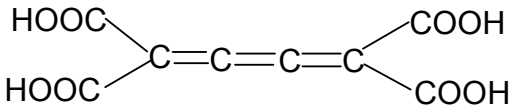
$n(O) = (176{,}3 \text{ mg} - 144{,}3 \text{ mg}) \cdot \frac{1 \text{ mol}}{16 \text{ g}} = 2 \text{ mmol}$

C : H : O = 10 : 24 : 2 ehk 5 : 12 : 1, millele vastab brutovalem
$C_5H_{12}O$

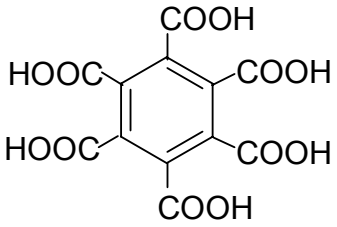
b) **X** – $(CH_3)_3COCH_3$
A – CH_3OH
B – $(CH_3)_2C=CH_2$
C – $CH_3OSO_2OCH_3$
D – CH_3I
E – $(CH_3)_3COH$
F – $(CH_3)_3CONa$

c) i) $CO + 2H_2 \xrightarrow{\text{katal}} CH_3OH$
ii) $2CH_3OH + H_2SO_4 = CH_3OSO_2OCH_3 + 2H_2O$
iii) $CH_3OSO_2OCH_3 + KI = CH_3OSO_2OK + CH_3I$
iv) $(CH_3)_2C=CH_2 + H_2O \xrightarrow{H^+} (CH_3)_3COH$
v) $2(CH_3)_3COH + 2Na = 2(CH_3)_3CONa + H_2$
vi) $CH_3OSO_2OCH_3 + (CH_3)_3CONa = (CH_3)_3COCH_3 + CH_3OSO_2ONa$
vii) $CH_3OH + (CH_3)_2C=CH_2 = (CH_3)_3COCH_3$

4. a) $\mathbf{M} = \frac{1{,}71 \text{ g}}{0{,}025 \text{ dm}^3 \cdot 1{,}20 \text{ mol/dm}^3} = \mathbf{57{,}0 \text{ g/mol}}$

b) Üheprootonilise karboksüülhappe valem on R–COOH
M(–COOH) = 45 g/mol
M(R) = 12 g/mol
Tiitrimise andmeid rahuldavad kõik karboksüülhapped, mille valem on $(CCOOH)_n$
n = 1 sellist hapet ei ole
n = 2 HOOCC≡CCOOH
n = 3 pole võimalik
n = 4  või 
n = 5 pole võimalik

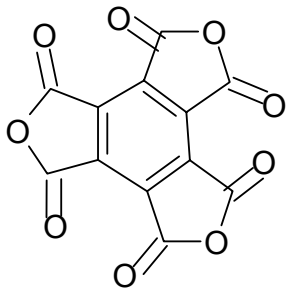
n = 6



c) Karboksüülhappe kuumutamisel tekib anhüdriid.

d) i) Bensoolheksakarboksüülhape, samuti haped, kus n=4 ja n=2;

ii)



$M_r(C_{12}O_9) = 144 + 144 = 288$

5. a) i) $2H_2O_2 = 2H_2O + O_2$

ii) $2KMnO_4 + 5H_2O_2 + 3H_2SO_4 = K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$

iii) $2KMnO_4+10FeSO_4+8H_2SO_4 = K_2SO_4+2MnSO_4 +5Fe_2(SO_4)_3+8H_2O$

b) $k = \frac{1}{5\ \text{min}} \cdot \ln\frac{46,1}{37,1} = 0,04344\ \text{min}^{-1}$

$k = \frac{1}{10\ \text{min}} \cdot \ln\frac{46,1}{29,8} = 0,04363\ \text{min}^{-1}$

$k = \frac{1}{20\ \text{min}} \cdot \ln\frac{46,1}{19,3} = 0,04354\ \text{min}^{-1}$

$k = \frac{1}{30\ \text{min}} \cdot \ln\frac{46,1}{12,5} = 0,04350\ \text{min}^{-1}$

$k(\text{keskmine}) = 0,0435\ \text{min}^{-1}$

c) $\tau = \frac{\ln 2}{0,0435\ \text{min}^{-1}} = 15,9\ \text{min} = 15\ \text{min}\ 54\ \text{sek} \approx$ **15 min 50 sek**

d) $\frac{c_o}{c_t} = e^{kt}$ $\quad c_t = c_o \cdot e^{-k\cdot t}$

$n(KMnO_4) = 46,1\ \text{mmol} \cdot e^{-0,0435\text{min}^{-1}\cdot\ 50\ \text{min}} \approx$ **5,2 mmol**

6. a) $4\,{}^1H = {}^4He + 2\beta^+ + 2\upsilon + 2\gamma$

b) $\Delta\mathbf{m} = 4m({}^1H) - m({}^4He) - 2m(\beta^+) = 4 \cdot 1,00727 - 4,00273 - 2\cdot 0,0005486 =$
= 0,02525 amü

c) $\Delta m = \frac{5,0\ \text{g}}{1000\ \text{g/kg}} \cdot \frac{-0,02525\ \text{amü}}{4,02908\ \text{amü}} = -3,134\cdot10^{-5}\ \text{kg}$

$\mathbf{E} = -3,134\cdot10^{-5} \cdot (3,0\cdot10^8\ \text{m/s})^2 =$ **$-2,82\cdot10^{12}$ J**

d) $H_2 + 1/2\ O_2 = H_2O$

Reaktsioonikäigus eralduv energiahulk $\frac{-286\ \text{kJ/mol}}{2,0\ \text{g/mol}} \cdot 1000\ \text{J/kJ} \cdot 5,0\ \text{g} = -7,1\cdot10^5\ \text{J}$

Suhe= $\frac{-2,82\cdot10^{12}}{-7,1\cdot10^5} =$ **$3,9\cdot10^6$**