2007/2008 õ.a. keemiaolümpiaadi lõppvooru ülesannete lahendused
12. klass

1. 1. $(Cu,Zn)O + KHSO_4 = (Cu,Zn)SO_4 + KOH$

$Fe_2O_3 + 3KHSO_4 = Fe_2(SO_4)_3 + 3KOH$

2. **i)** $2CuSO_4 + 2NH_4OH = (CuOH)_2SO_4\downarrow + (NH_4)_2SO_4$

$ZnSO_4 + 2NH_4OH = Zn(OH)_2\downarrow + (NH_4)_2SO_4$

$Fe_2(SO_4)_3 + 6NH_4OH = 2Fe(OH)_3 + 3(NH_4)_2SO_4$

ii) $(CuOH)_2SO_4 + (NH_4)_2SO_4 + 6NH_4OH = 2[Cu(NH_3)_4]SO_4 + 8H_2O$

$Zn(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH = 2[Zn(NH_3)_4]SO_4 + 4H_2O$

3. $[(Zn,Cu)(NH_3)_4]SO_4 + 4HCl = (Cu,Zn)SO_4 + 4NH_4Cl$

4. $Fe(OH)_3 + (NH_4)_2HPO_4 = FePO_4\downarrow + 2NH_4OH + H_2O$

5. $2CuSO_4 + 2Na_2S_2O_3 + 2H_2O = Cu_2S\downarrow + S\downarrow + 2H_2SO_4 + 2Na_2SO_4$

$ZnSO_4 + Na_2S_2O_3 \neq$

6. $3ZnSO_4 + 2K_4[Fe(CN)_6] = \mathbf{K_2Zn_3[Fe(CN)_6]_2}\downarrow + 3K_2SO_4$

7. $Cu_2S + 6$ konts. $HNO_3 = 2Cu(NO_3)_2 + H_2S\uparrow + 2NO_2\uparrow + 2H_2O$

8. $2Cu(NO_3)_2 + K_4[Fe(CN)_6] = \mathbf{Cu_2[Fe(CN)_6]}\downarrow + 4KNO_3$

9. $FePO_4 + 3HCl = FeCl_3 + H_3PO_4$

10. $4FeCl_3 + 3K_4[Fe(CN)_6] = \mathbf{Fe_4[Fe(CN)_6]_3}\downarrow + 12KCl$

2. a) i) $Ag^+ + KSCN = AgSCN + K^+$

$Fe^{3+} + 3KSCN = Fe(SCN)_3 + 3K^+$

$$\mathbf{n(Ag)} = (\frac{1}{1}\cdot 100\ cm^3 \cdot \frac{0{,}01\ mol}{1\ dm^3} - \frac{3}{1}\cdot 9{,}69\ cm^3 \cdot \frac{0{,}01\ mol}{1\ dm^3})\frac{1\ dm^3}{1000\ cm^3} = \mathbf{0{,}00709\ mol}$$

$$\mathbf{m(Ag)} = 0{,}007093\ mol \cdot \frac{107{,}9\ g}{1\ mol} = \mathbf{0{,}765\ g}$$

ii) $SO_2 + Ba(OH)_2 = BaSO_3\downarrow + H_2O$

$$\mathbf{n(S)} = \frac{1}{1}\cdot 1{,}156\ g \cdot \frac{1\ mol}{217{,}4\ g} = \mathbf{0{,}00532\ mol}$$

$$\mathbf{m(S)} = 0{,}005317\ mol \cdot \frac{32{,}06\ g}{1\ mol} = \mathbf{0{,}171\ g}$$

b) Leiame Ag_2S hulga argürodiidis ja järgi jäänud väävli hulga:

$$n(Ag_2S) = \frac{n(Ag)}{2} = \frac{0{,}007093\ mol}{2} = 0{,}003547\ mol$$

$$n(S,\ jääk) = 0{,}005317\ mol - 0{,}003547\ mol = 0{,}001770\ mol$$

Otsitav element peab olema positiivse oa-ga.

$$m(X) = 1\ g - 0{,}7653\ g - 0{,}1705\ g = 0{,}06420\ g$$

Elemendi X aatommass ühendis XiSj on leitav:

$$A(X) = \frac{m(X)}{i/j \cdot n(S,\ jääk)} = \frac{j}{i}\cdot\frac{0{,}06420\ g}{0{,}001770\ mol} = 36{,}27\frac{j}{i}\ g/mol$$

Võimalikes ühendites on $\mathbf{X}_2S$, $\mathbf{X}S$, $\mathbf{X}_2S_3$, $\mathbf{X}S_2$ jne on j/i suhtes 0,5, 1, 1,5, 2 jne. Võimalikud **X** aatommassid on 18,1 (oa = I), 36,3 (II), 54,4 (III), 72,5 (IV), 90,6 (V) jne. Sobib vaid neljavalentne Ge so GeS_2.

$$n(GeS_2) = \frac{0{,}001770\ mol}{2} = 0{,}0008850\ mol$$

$Ag_2S : GeS_2 = 0{,}003547 : 0{,}0008850 = 4 : 1$

Argürodiidi valem on Ag_8GeS_6.

c) i) $GeO_2 + 4HCl = GeCl_4 + 2H_2O$

ii) $GeO_2 + 2NaOH = Na_2GeO_3 + H_2O$

Germaanium (nimetusest Germany) sarnanes omadustelt Mendelejevi poolt ennustatud elemendi ekaräniga ja see kinnitas lõplikult perioodilisusseaduse olemasolu.

3. a) $\mathbf{N} = 6\cdot\frac{1}{2} + 8\cdot\frac{1}{8} = 3 + 1 = \mathbf{4}$

b) $\mathbf{V_{ühikrakk}} = a^3 = (3{,}62\cdot 10^{-8}\ cm)^3 = \mathbf{4{,}70\cdot 10^{-23}\ cm^3}$

Leiame seose võrekonstandi a ja aatomi raadiuse r vahel:

$$(r + 2r + r) = \sqrt{a^2 + a^2} = \sqrt{2a^2} = \sqrt{2}a \quad \Rightarrow \quad r = \frac{\sqrt{2}a}{4}$$

$$\mathbf{V_{aatom}} = 4\cdot\frac{4}{3}\pi r^3 = \frac{16}{3}\pi(\frac{\sqrt{2}a}{4})^3 = \frac{16}{3}\cdot\frac{2\sqrt{2}}{64}\pi a^3 = \frac{\sqrt{2}}{6}\pi a^3 =$$

$$= \frac{\sqrt{2}}{6}\pi\cdot 4{,}70\cdot 10^{-23}\ cm^3 = \mathbf{3{,}48\cdot 10^{-23}\ cm^3}$$

$$\mathbf{\%_{hõivatud}} = \frac{\sqrt{2}}{6}\pi a^3\cdot\frac{1}{a^3}\cdot 100 = \mathbf{74{,}0\ \%}$$

c) $m_{ühikrakk} = V_{ühikrakk}\cdot\rho \qquad M = \frac{m_{ühikrakk}}{n_{ühikrakk}} = \frac{m_{ühikrakk}}{N/N_A}$

$$M = 4{,}7\cdot 10^{-23}\ cm^3\cdot\frac{8{,}92\ g}{cm^3}\cdot\frac{1}{4}\cdot\frac{6{,}02\cdot 10^{23}}{1\ mol} = 63{,}1\ g/mol$$

Element on **vask**. Kaheksajala veri on **sinist värvi**.

4. $E(Eesti) = 10000\ GWh\cdot\frac{10^9\ Wh}{1\ GWh}\cdot\frac{3600\ s}{1\ h}\cdot\frac{1\ J}{1\ W\cdot 1\ s} = 3{,}6\cdot 10^{16}\ J$

a) $\mathbf{h} = 3{,}6\cdot 10^{16}\ J\cdot\frac{1\ m\ kg}{9{,}8\ J}\cdot\frac{1}{25\ km^3}\cdot\frac{km^3}{10^9\ m^3}\cdot\frac{1\ m^3}{10^3\ kg} = 147\ m = \mathbf{150\ m}$

b) $\mathbf{\Delta T} = 3{,}6\cdot 10^{16}\ J\cdot\frac{1\ kg\ K}{4181\ J}\cdot\frac{1}{25\ km^3}\cdot\frac{km^3}{10^9\ m^3}\cdot\frac{1\ m^3}{10^3\ kg} = \mathbf{0{,}34\ K}$

c) $H_2 + 1/2O_2 = H_2O$

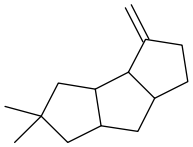
$$\mathbf{m(H_2)} = 3{,}6 \cdot 10^{16}\ \text{J} \cdot \frac{1\,\text{mol}}{286{,}6\,\text{kJ}} \cdot \frac{1\,\text{kJ}}{10^3\,\text{J}} \cdot \frac{2\,\text{g}}{1\,\text{mol}} \cdot \frac{1\,\text{kg}}{10^3\,\text{g}} = \mathbf{2{,}5 \cdot 10^8\ kg}$$

d) $^3\text{H} + {}^2\text{H} = {}^4\text{He} + {}^1\text{n} \qquad E = \Delta mc^2$

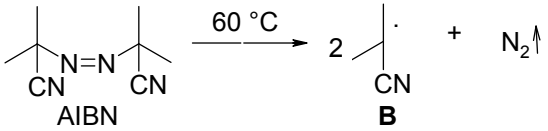
$$\Delta m = 3{,}6 \cdot 10^{16}\ \text{J} \cdot \frac{1\,\text{s}^2}{(3 \cdot 10^8\ \text{m})^2} = 0{,}4\ \text{kg}$$

$$\mathbf{m(^3H + {}^2H)} = 0{,}4\ \text{kg} \cdot \frac{2{,}0141 + 3{,}0160}{2{,}0141 + 3{,}0160 - 4{,}0026 - 1{,}0087} = 107\ \text{kg} = \mathbf{110\ kg}$$

5. a)



b)



6. a) $C_nH_{2n+2}O \rightarrow C_nH_{2n}O \rightarrow C_nH_{2n}O_2$

$n(C_nH_{2n}O) = n(C_nH_{2n}O_2) \qquad \frac{75}{14n+16} = \frac{115}{14n+32} \qquad \Rightarrow \qquad n = 1$

A – CH_3OH, metanool

$RCOOH + NaOH = RCOONa + H_2O$

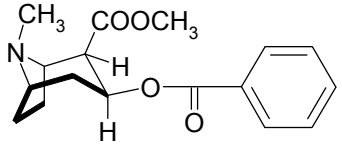
$$n(\text{RCOOH}) = \frac{1}{1} \cdot 20\ \text{g} \cdot 0{,}3 \cdot \frac{1\,\text{mol}}{40\ \text{g}} = 0{,}15\ \text{mol}$$

$$M(\text{RCOOH}) = \frac{18{,}3\ \text{g}}{0{,}15\ \text{mol}} = 122\ \text{g/mol}$$

$M(R) = (122 - 45)\ \text{g/mol} = 77\ \text{g/mol}$ R on benseeni tuum (C_6H_5-)

B – C_6H_5COOH, bensoehape

Kokaiini võib vaadelda ekoniini kahekordse esterdamise saadust: metanool reageerib karboksüülrühmaga ja bensoehape hüdroksüülrühmaga.

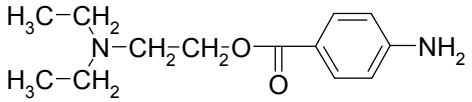


b) $R_2NCH_2CH_2OH \qquad \%(N) = \frac{14}{2M(R) + 59} = 0{,}12 \quad \Rightarrow \quad M(R) = 29$

R on etüülrühm (C_2H_5-)

$(C_2H_5)_2NCH_2CH_2OH$

Aminoalkoholi reageerimisel aminobensoehappega saadakse novokaiin



c) Kokaiini ja novokaiini struktuuri võrdlemine näitab, et tõenäoline anestesiofoori struktuur on