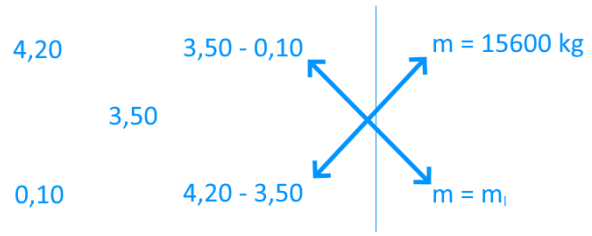
**2021/2022. õa keemiaolümpiaadi lahtise võistluse ülesanded**
**Noorem rühm (9. ja 10. klass)**
**2. oktoober 2021**
**Lahendused**

**1. Kaaliumi ja kaltsiumi keemia** **Kokku 10 p**

$K + O_2 \rightarrow KO_2$ või $4K + O_2 \rightarrow 2K_2O$ (1)
$12K + P_4 \rightarrow 4K_3P$ (1)
$2K + MgCl_2 \rightarrow 2KCl + Mg$ (1)
$2K + 2H_2O \rightarrow 2KOH + H_2$ (1)
$16K + S_8 \rightarrow 8K_2S$ (1)
$2Ca + O_2 \rightarrow 2CaO$ (1)
$Ca + 2C \rightarrow CaC_2$ (1)
$3Ca + 2LaCl_3 \rightarrow 3CaCl_2 + 2La$ (1)
$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ (1)
$6Ca + P_4 \rightarrow 2Ca_3P_2$ (1)

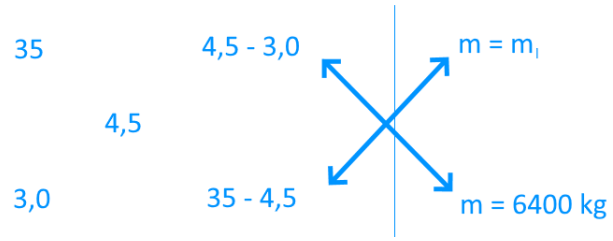
**2. Piima standardiseerimine** **Kokku 10 p**

**a)** Toorpiima rasvasisaldus on 4,20%, lisatava komponendi rasvasisaldus on 0,10%. Standardiseeritud piima jaoks saame Pearsoni ruudu järgi avaldada:
$(3{,}50 - 0{,}10)/(4{,}20 - 3{,}50) = 15600/m_l$.



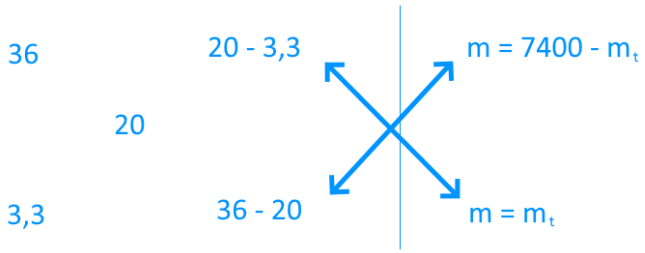

$m_l = 15600 \cdot (4{,}20 - 3{,}50)/(3{,}50 - 0{,}10) =$ **3210 kg**

**b)** Toorpiima rasvasisaldus on 3,0%, lisatava komponendi rasvasisaldus on 35%. Standardiseeritud piima jaoks saame Pearsoni ruudu järgi avaldada:
$(4{,}5 - 3{,}0)/(35 - 4{,}5) = m_l/6400$.



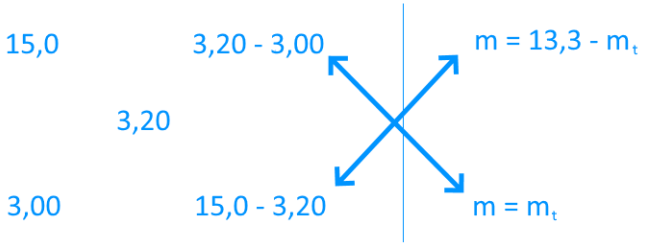

$m_l = 6400 \cdot (4{,}5 - 3{,}0)/(35 - 4{,}5) =$ **310 kg**

**c)** Toorpiima rasvasisaldus on 3,3%, lisatava komponendi rasvasisaldus on 36%.
Tähistame toorpiima massi $m_t$-ga. Kui standardiseeritud piima (hapukoore) mass on 7400 kg, siis lisatava komponendi mass on 7400 kg – $m_t$. Pearsoni ruudu järgi avaldame:
$(20 - 3{,}3)/(36 - 20) = (7400\text{ kg} - m_t)/m_t$



$m_t \cdot (20 - 3{,}3)/(36 - 20) = 7400 - m_t$
$m_t \cdot [1 + (20 - 3{,}3)/(36 - 20)] = 7400$ kg
$m_t = 7400 \cdot (36 - 20)/(36 - 3{,}3) = 3600$ kg
$m$(koor) = 7400 − 3600 = **3800 kg**

**d)** Toorpiima rasvasisaldus on 3,00%, lisatava komponendi rasvasisaldus on 15,0%. Tähistame toorpiima massi $m_t$-ga. Kui standardiseeritud piima (keefiri) mass on 13,3 t, siis lisatava komponendi mass on 13,3 t − $m_t$. Pearsoni ruudu järgi avaldame:
$(3{,}20 - 3{,}00)/(15{,}0 - 3{,}20) = (13{,}3\text{ t} - m_t)/m_t$




$m_t \cdot (3{,}2 - 3{,}0)/(15 - 3{,}2) = 13{,}3 - m_t$
$m_t \cdot [1 + (3{,}2 - 3{,}0)/(15 - 3{,}2)] = 13{,}3$ t
$m_t = 13{,}3 \cdot (15 - 3{,}2)/(15 - 3{,}0) = 13{,}1$ t
$m$(koor) = 13,3 − 13,1 = **0,2 t**

## 3. Katalüsaatorid — Kokku 10 p

**a)** $n(NiO) = 2(WO_3) = 200000\text{ g}/(74{,}7\text{ g·mol}^{-1} + ½ \cdot 231{,}8\text{ g·mol}^{-1}) = 1049$ mol (1)
$M((NH_4)_2W_4O_{13}\cdot 8H_2O) = 1123{,}6$ g·mol$^{-1}$ ja $M(Ni(NO_3)_2\cdot 6H_2O) = 290{,}8$ g·mol$^{-1}$ (1)
$m((NH_4)_2W_4O_{13}\cdot 8H_2O) = ½ \cdot 1049\text{ mol} \cdot 1123{,}6\text{ g·mol}^{-1} \cdot 1\text{ lb}/453{,}59237\text{ g} =$ **1300 lb** (2)
$m(Ni(NO_3)_2\cdot 6H_2O) = 1049\text{ mol} \cdot 290{,}8\text{ g·mol}^{-1} \cdot 1\text{ lb}/453{,}59237\text{ g} =$ **673 lb** (2)

**b)** **i)** $2NiS + 3O_2 \rightarrow 2NiO + 2SO_2$ (1)
**ii)** $NiO + 6NH_3 + 2HCl \rightarrow Ni(NH_3)_6Cl_2 + H_2O$ (1)
**iii)** $Ni(NH_3)_6Cl_2 + 2NaOH \rightarrow Ni(OH)_2 + 2NaCl + 6NH_3$ (1)
**iv)** $Ni(OH)_2 + 2HNO_3 + 4H_2O \rightarrow Ni(NO_3)_2\cdot 6H_2O$ (1)

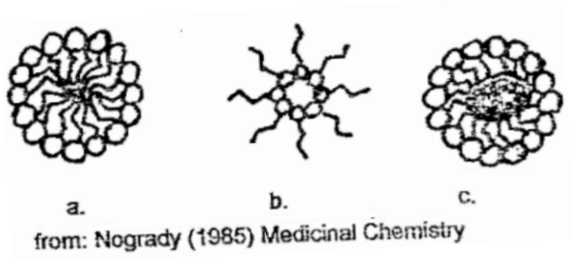
## 4. Jodomeetriline tiitrimine (IChO PP 1995) — Kokku 10 p

**a)** 1. $XO_3^- + 5X^- + 6H^+ = 3X_2 + 3H_2O$ (2)
2. $X_2 + 2S_2O_3^{2-} = 2X^- + S_4O_6^{2-}$ (1)
3. $3ClO^- + X^- = 3Cl^- + XO_3^-$ (1)

**b)** $c(\text{KI}) = \frac{(0{,}01700\text{ M}\cdot 6\cdot 25{,}00\text{ cm}^3 - 0{,}1000\text{ M}\cdot 23{,}60\text{ cm}^3)}{25{,}00\text{ cm}^3} \cdot \frac{5}{6} \cdot \frac{166{,}0\text{ g·mol}^{-1}}{1000\text{ cm}^3\cdot\text{dm}^3} =$ **1,05 · 10$^{-3}$ g·cm$^{-3}$** (3)

$c(\text{KBr}) = \frac{(0{,}1000\text{ M}\cdot 30{,}17\text{ cm}^3 - 1{,}051\text{ g·dm}^{-3}\cdot 10\cdot 6/166{,}0\text{ g·mol}^{-1})}{10{,}00\text{ cm}^3} \cdot \frac{1}{6} \cdot \frac{199{,}0\text{ g·mol}^{-1}}{1000\text{ cm}^3\cdot\text{dm}^3} =$ **5,23 · 10$^{-3}$ g·cm$^{-3}$** (3)

## 5. Seebi mitsellid (IChO PP 1995) — Kokku 10 p




**a)** (3)
**b)** $N_{seep} = \pi\cdot(10^{-4}\text{ m})^2/(10^{-9}\text{ m})^2 = 3{,}14\cdot 10^{10}$ (1)
$N_{tilk} = 1\text{ g}/(0{,}92\text{ g/cm}^3)/(4/3\cdot\pi\cdot(0{,}5\cdot 10^{-2}\text{ cm})^3) = 2{,}08\cdot 10^6$ (1)
$m_{seep} = 306{,}5\text{ g/mol}/(6{,}022\cdot 10^{23}\text{ mol}^{-1})\cdot 3{,}14\cdot 10^{10}\cdot 2{,}08\cdot 10^6 =$ **3,32·10$^{-5}$ g** (2)
**c)** $r_{mull} = (1{,}0\text{ dm}^3\cdot 3/4/\pi)^{1/3} = 0{,}062$ m (1)
$m_{seep} = 306{,}5\text{ g/mol}/(6{,}022\cdot 10^{23}\text{ mol}^{-1})\cdot 2\cdot 4\cdot\pi\cdot(0{,}062\text{ m})^2/(10^{-9}\text{ m})^2 =$ **4,92·10$^{-5}$ g** (2)

**6. Hou protsess** **Kokku 10 p**

**a)** $2NH_3 + 2NaCl + H_2O + CO_2 = 2NH_4Cl + Na_2CO_3$ (1)

**b)** **i)** $NH_4Cl$ kasutatakse väetisena ja NaCl lisand on soovimatu kuna võib tekitada taimedele kahju. **(õige)** (1)

**c)** **i)** $m(-10\ °C) = 434\ g - 263\ g =$ **171 g** (1)
**ii)** $m(0\ °C) = 434\ g - 294\ g =$ **140 g** (1)
**iii)** $m(20\ °C) = 434\ g - 375\ g =$ **59 g** (1)

**d)** **i)** $m(-10\ °C) = 215\ g - 122\ g =$ **93 g** (1)
**ii)** $m(0\ °C) = 215\ g - 143\ g =$ **72 g** (1)
**iii)** $m(20\ °C) = 215\ g - 215\ g =$ **0 g** (1)

**e)** **i)** Protsess on madalatel temperatuuridel liiga aeglane. **(õige)** (1)
**iii)** Temperatuuri langetamise energiakulu on liiga suur. **(õige)** (1)

**7. Soolade segu (Eesti keemia olümpiaad 1994/95 õa, 10 klass, III voor)** **Kokku 10 p**

$2AgNO_3 + MgBr_2 \rightarrow 2AgBr + Mg(NO_3)_2$ (1)

$6NaF + AlCl_3 \rightarrow Na_3[AlF_6] + 3NaCl$ (1)

$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$ (1)

$AgCl + 2(NH_4)_2CO_3 \rightarrow Ag(NH_3)_2Cl + 2NH_4HCO_3$ (1)

$m$(AgCl+AgBr) = 53,20 g, $m$(AgBr) = 18,80 g
$m$(AgCl) = 53,20 − 18,80 = 34,40 g (1)

$m(MgBr_2) = \frac{1}{2} \cdot 18{,}80\ g \cdot \frac{184{,}2\ g \cdot mol^{-1}}{187{,}8\ g \cdot mol^{-1}} = 9{,}22\ g$ (1)

$\%(MgBr_2) = \frac{9{,}22\ g}{33{,}32\ g} \cdot 100 =$ **27,67** (1)

$m(AlCl_3) = \frac{1}{3} \cdot 34{,}40\ g \cdot \frac{133{,}4\ g \cdot mol^{-1}}{143{,}3\ g \cdot mol^{-1}} = 10{,}67\ g$ (1)

$\%(AlCl_3) = \frac{10{,}67\ g}{33{,}32\ g} \cdot 100 =$ **32,02** (1)

%(NaF) = 100 − 27,67 − 32,02 = **40,31** (1)

**8. Lämmastiku keemia** **Kokku 10 p**

**a)** **A** – $NH_3$, **B** – NO, **C** – $NaNO_2$, **D** – $NaNO_3$ (2)

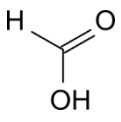
**b)** $M$(**E**) = $14{,}01 \cdot x / 0{,}874 = 16{,}0 \cdot x$, sellele vastab $(NH_2)_x$.
Kui $x$ =2, $M$(**E**) = 32, millele vastab hüdrasiin ($N_2H_4$). (2)

**c)** reaktsioon **1**: $4NH_3 + 5O_2 = 6H_2O + 4NO$ (2)
reaktsioon **2**: $NaNO_3 + 4Zn + 7NaOH + 6H_2O = 4Na_2[Zn(OH)_4] + NH_3$ (2)
reaktsioon **3**: $2NH_3 + NaOCl = H_2O + NaCl + N_2H_4$ (2)

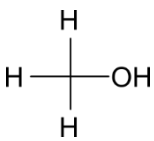
**9. Säästev keemia** **Kokku 10 p**

**a)** Märkus: hapnik tekib anoodil ning **A**–**E** produktid katoodil.
**1.** $2CO_2 + 2H_2O \rightarrow O_2 + 2CH_2O_2$ (**A**) (1)
**2.** $2CO_2 + 4H_2O \rightarrow 3O_2 + 2CH_4O$ (**B**) (1)
**3.** $2CO_2 + 4H_2O \rightarrow 4O_2 + C_2H_4$ (**C**) (1)
**4.** $4CO_2 + 2H_2O \rightarrow O_2 + 2C_2H_2O_4$ (**D**) (1)
**5.** $4CO_2 + 2H_2O + 2NH_3 \rightarrow 3O_2 + 2C_2H_5NO_2$ (**E**) (1)

**b)**



**A**



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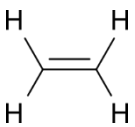
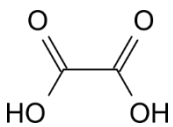
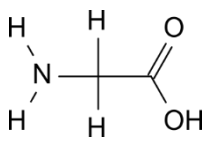


**C**



**D**



**E**