Keemia lahtise võistluse ülesannete lahendused

Noorem rühm (9. ja 10. klass)

13. november 2004. a.

1. a) i) *Kaur* $Cu + 4HNO_3 = Cu(NO_3)_2 + 2NO_2\uparrow + 2H_2O$

Sander $2Cu + O_2 = 2CuO$

$CuO + 2HNO_3 = Cu(NO_3)_2 + H_2O$

Jasper $3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 2NO\uparrow + 4H_2O$

Õhuga kokku puutudes $2NO + O_2 = 2NO_2\uparrow$

ii) *Kaur* $n(HNO_3) = \frac{4}{1} \cdot 3000\ g \cdot \frac{1\ mol}{187,5\ g} = 64\ mol$

Sander $n(HNO_3) = \frac{2}{1} \cdot 3000\ g \cdot \frac{1\ mol}{187,5\ g} = 32\ mol$

Jasper $n(HNO_3) = \frac{8}{3} \cdot 3000\ g \cdot \frac{1\ mol}{187,5\ g} = 42,7\ mol \approx 43\ mol$

b) Nii Kauri kui Jasperi kasutatud meetodil moodustub lõpptulemusena keskkonda reostav NO_2.

Kaur $n(NO_2) = \frac{2}{1} \cdot 3000\ g \cdot \frac{1\ mol}{187,5\ g} = 32\ mol$

Jasper $n(NO_2) = n(NO) = \frac{2}{3} \cdot 3000\ g \cdot \frac{1\ mol}{187,5\ g} = 10,7\ mol \approx 11\ mol$

Sanderi meetodis mürgiseid gaase ei eraldunud.

c) Kõik vennad lähtusid samast vase hulgast, lämmastikhapet kulus aga Sanderil kõige vähem. Temal ei tekkinud ka keskkonda saastavat gaasi. Sanderi meetod on kõige odavam ja keskkonnasõbralikum.

2. a) elektroni laeng $e^- = \frac{F}{N_A} = \frac{9,648456 \cdot 10^4\ C \cdot mol^{-1}}{6,022045 \cdot 10^{23}\ mol^{-1}} = 1,602189 \cdot 10^{-19}\ C$

b) $m(elektron) = \frac{e^-}{e^-/m} = \frac{1,602189 \cdot 10^{-19}\ C}{1,7588047 \cdot 10^{11}\ C \cdot kg^{-1}} = 9,109535 \cdot 10^{-31}\ kg =$

$= 9,109535 \cdot 10^{-28}\ g$

c) $M(e^-) = m \cdot N_a = 9,109534 \cdot 10^{-28}\ g \cdot 6,022045 \cdot 10^{23}\ mol^{-1} = 5,485803 \cdot 10^{-4}\ g \cdot mol^{-1}$

d) $m(H) = m(prooton) + m(elektron) = 1,6726485 \cdot 10^{-27}\ kg + 0,00091095 \cdot 10^{-27} kg =$

$= 1,673560 \cdot 10^{-27}\ kg$

e) i) $\frac{m(H)}{m(e^-)} = \frac{1,6735595 \cdot 10^{-27}\ kg}{9,109534 \cdot 10^{-31}\ kg} = 0,1837151 \cdot 10^4 = 1837,151$

ii) $\frac{\mathbf{m(Maa)}}{\mathbf{m(e^-)}} = \frac{5{,}976 \cdot 10^{24}\ \text{kg}}{9{,}109534 \cdot 10^{-31}\ \text{kg}} = 0{,}6560 \cdot 10^{55} = 6{,}560 \cdot 10^{54}$

3. a) i) A – MeS

B – Me_2O_3

C – $Me_2(SO_4)_3$

ii) $4MeS + 7O_2 = 2Me_2O_3 + 4SO_2$

II III

$Me - 1e^- \rightarrow Me$ | 7

-II IV

$S - 6e^- \rightarrow S$ |

$2 \cdot 0$ $2 \cdot (-II)$

$O_2 + 4e^- \rightarrow 2O$

iii) $Me_2O_3 + 3H_2SO_4 = Me_2(SO_4)_3 + 3H_2O$

b) $n(Me) = n(MeS) \Rightarrow \frac{176\ \text{g}}{[A_r(Me) + 32]\ \text{g/mol}}$ = b(tundmatu)

$m(H_2SO_4,\text{lahus}) = \frac{3}{2} \cdot b \cdot 98 \cdot \frac{1}{0{,}376} = b \cdot 391\ \text{g/mol}$

$m(Me_2O_3) = \frac{b}{2} \cdot [2A_r(Me) + 48] = b[A_r(Me) + 24]\ \text{g/mol}$

m(saadud lahus) = $m(H_2SO_4,\text{lahus}) + m(Me_2O_3)$ = 391 g/mol · b + $+b \cdot [A_r(Me) + 24]\ \text{g/mol} = b[Ar(Me) + 415]\ \text{g/mol}$

$m[Me_2(SO_4)_3] = \frac{b}{2}[2A_r(Me) + 288]$ = $b[A_r(Me) + 144]$ g/mol

$0{,}425 = \frac{b[A_r(Me) + 144]\ \text{g/mol}}{b[A_r(Me) + 415]\ \text{g/mol}} \Rightarrow \frac{A_r(Me) + 144}{A_r(Me) + 415}$

$A_r(Me) = 56$ Me – Fe, raud

c) $n(Fe) = n(FeS) = \frac{1{,}76\ \text{g}}{88\ \text{g/mol}} = 0{,}020$ mol

m(lahus peale jahutamist) =0,020 mol·(56+415) g/mol – 2,75 g = 6,67 g

$m[Fe_2(SO_4)_3,\text{lõpplahuses}] = 6{,}67\ \text{g} \cdot 0{,}306 = 2{,}04\ \text{g}$

$m[Fe_2(SO_4)_3,\text{kristallhüdraadis}] = 0{,}020\ \text{mol} \cdot (56+144)\ \text{g/mol} - 2{,}04\ \text{g} =$

$= 1{,}96\ \text{g}$

$m(H_2O,\text{kristallhüdraadis}) = 2{,}75\ \text{g} - 1{,}96\ \text{g} = 0{,}79\ \text{g}$

$n[Fe_2(SO_4)_3] = \frac{1{,}96\ g}{400\ g/mol} = 0{,}0049\ mol$

$n(H_2O) = \frac{0{,}79\ g}{18\ g/mol} = 0{,}0439\ mol$

$\frac{n(H_2O)}{n[Fe_2(SO_4)_3]} = \frac{0{,}0439}{0{,}0049} = 8{,}96 \approx 9$

Kristallhüdraadi **D** valem on $Fe_2(SO_4)_3 \cdot 9H_2O$

4. a) A – N_2, lämmastik

B – O_2, hapnik

C – NO, lämmastik(mono)oksiid

D – NO_2, lämmastikdioksiid

E – HNO_3, lämmastikhape

F – NH_4NO_3, ammooniumnitraat

G – N_2O, dilämmastik(mono)oksiid

b) i) $N_2 + O_2 = 2NO$

ii) $2NO + O_2 = 2NO_2$

iii) $4NO_2 + O_2 + 2H_2O = 4HNO_3$

iv) $HNO_3 + NH_3 = NH_4NO_3$

^0t

v) $NH_4NO_3 = N_2O + 2H_2O$

c) $n(HNO_3) \Leftrightarrow n(NO)$

$n(HNO_3) = \frac{1}{1} \cdot 1{,}0 \cdot 10^9\ J \cdot 0{,}05 \cdot \frac{1\ mol}{9{,}037 \cdot 10^4\ J} = 553\ mol \approx 550\ mol$

5. a) i) CaO – kaltsiumoksiid

PbO_2 – plii(IV)oksiid

CrO_3 – kroom(VI)oksiid

OsO_4 – osmium(VIII)oksiid

Na_2O – naatriumoksiid

Al_2O_3 – alumiiniumoksiid

V_2O_5 – vanaadium(v)oksiid

Mn_2O_7 – mangaan(VII)oksiid

ii) CO – süsinikmonooksiid

CO_2 – süsinikdioksiid

SO_3 – vääveltrioksiid

N_2O – dilämmastik(mono)oksiid

N_2O_3 – dilämmastiktrioksiid

N_2O_5 – dilämmastikpentaoksiid

Cl_2O_7 – dikloorheptaoksiid

b) i) X_2O_2 näiteks Na_2O_2, naatriumperoksiid

ii) XO_2 näiteks KO_2, kaaliumhüperoksiid

iii) IA rühm, leelismetallid

iv) -I -½

Na_2O_2, KO_2

6. a) V(96,50%vol etanooli lahus) = $\frac{40{,}00\text{ml}}{0{,}965}$ = 41,45 ml ~ 41,5 ml

b) m(etanool) = 40 ml · 0,78924 g/cm^3 = 31,5696 g

m(40,00%vol etanooli lahus) = 100 cm^3 · 0,94805 g/cm^3 = 94,805 g

V(H_2O) = $\frac{94{,}805\text{ g} - 31{,}5696\text{ g}}{0{,}99820\text{ g/cm}^3}$ = 63,349 cm^3 ≈ 63,35 cm^3

c) Teada peab olema 96,5%vol etanooli lahuse tihedus.

Keemia lahtise võistluse ülesannete lahendused
Vanem rühm (11. ja 12. klass)
13. november 2004. a.

1. a)

i) K_2SiO_3 (**B**)+$K[Al(OH)_4]$ (**C**)+6HCl = H_4SiO_4 (**D**)+3KCl (**E**)+$AlCl_3$(**Q**) +$3H_2O$
ii) H_4SiO_4 (**D**) + 6HF = H_2SiF_6 (**G**) + $4H_2O$
iii) H_2SiF_6 (**G**) + 2KOH = K_2SiF_6 (**H**) + $2H_2O$
iv) K_2SiF_6 (**H**) + $4H_2O$ = H_4SiO_4 (**D**) + 4HF + 2KF

b) Reaktsioonivõrrandist **v)** saame vastavuse
Si $\Leftrightarrow$ 4HF

%(Si) = $\frac{1}{4} \cdot 0{,}09296\ \text{mol} \cdot 28{,}09\ \text{g/mol} \cdot \frac{1}{3{,}000\ \text{g}} \cdot 100$ = **21,76**

c) Võttes aluseks täpselt 100 g savi saame
m(H) = 100 – 20,90 – 21,76 – 55,78 = 1,56 g

n(Al) = $\frac{20{,}90}{26{,}98} = 0{,}7746\ \text{mol}$

n(Si) = $\frac{21{,}76}{28{,}09} = 0{,}7747\ \text{mol}$

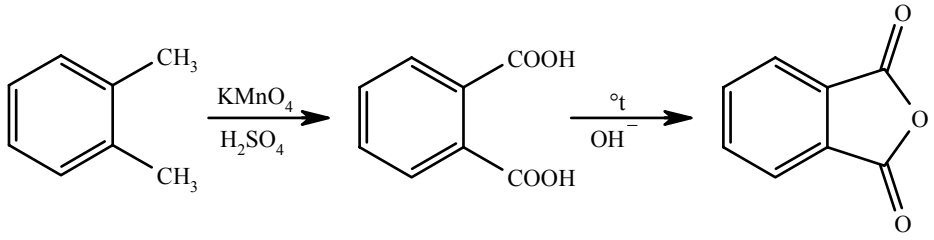
n(H) = $\frac{1{,}56}{1{,}008} = 1{,}55\ \text{mol}$

n(O) = $\frac{55{,}78}{16{,}00} = 3{,}486\ \text{mol}$

n(Al):n(Si):n(H):n(O) = 0,7746:0,7747:1,55:3,486 ≈1:1:2 :4,5 ≈ 2 : 2 : 4 : 9
Brutovalem on $Al_2Si_2H_4O_9$, esitatuna oksiidide kaudu
$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$

d) $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ + 6KOH = $2K_2SiO_3$ (**B**) + $2K[Al(OH)_4]$ (**C**) + H_2O

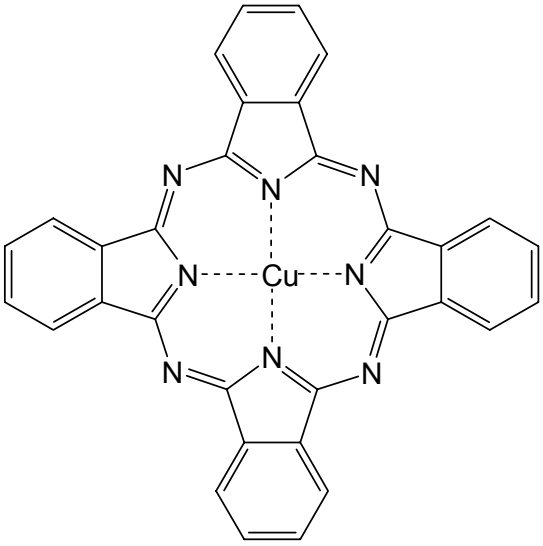
2. a)



b) %(H) = 100 – 66,7 – 19,5 – 11,0 = 2,8

C : H : N : Cu = $\frac{66{,}7}{12{,}0} : \frac{2{,}8}{1{,}0} : \frac{19{,}5}{14{,}0} : \frac{11{,}0}{63{,}5}$ = 32 : 16 : 8 : 1

Vaskftalotsüaniini brutovalem – $C_{32}H_{16}N_8Cu$



c) A – 2-tsüanobensamiid
B – benseen-1,2-dikarboksüülhappe anhüdriid

3. a) $M = \frac{m}{n}$; $n = \frac{V}{V_M}$; $V_M = \frac{R \cdot T}{p}$

$M(\mathbf{K}) = 2{,}86\ kg/m^3 \cdot 8{,}314\ N \cdot m/(K \cdot mol) \cdot 298\ K \cdot \frac{1 m^2}{10^5\ N} = 7{,}086 \cdot 10^3 \cdot \frac{1}{10^5} kg/mol \approx$
$\sim 0{,}0709\ kg/mol \approx 70{,}9\ g/mol$

K – kloor (Cl_2)

b) A – Au
B – NO
C – $H[AuCl_4]$
D – $H[AuCl_2]$
E – $Au(OH)_3$
F – Au_2O_3
G – AuOH
H – Au_2O
I – $[NH_3AuCl_3]$
J – **[**NH_3AuCl]
K – Cl_2
L – $[Au(NH_3)_2]Cl$
M – tert-BuC≡CAu
N – $Au(NO_3)_3$
O – NO

c) i) $Au + 4\ HCl + HNO_3 = H[AuCl_4] + NO + 2\ H_2O$
ii) $H[AuCl_4] + SO_2 + 2H_2O = H[AuCl_2] + H_2SO_4 + 2HCl$
iii) $H[AuCl_4] + 4KOH = Au(OH)_3 + 4KCl + H_2O$
iv) $2Au(OH)_3 = Au_2O_3 + 3H_2O$
v) $H[AuCl_2] + 2KOH = AuOH + 2KCl + H_2O$
vi) $2AuOH = Au_2O + H_2O$
vii) $H[AuCl_4] + 2NH_3 = [NH_3AuCl_3] + NH_4Cl$
viii) $[NH_3AuCl_3] = [NH_3AuCl] + Cl_2$
ix) $[NH_3AuCl] + NH_3 = [Au(NH_3)_2]Cl$
x) $[NH_3AuCl]$ + tert-BuC≡CH = tert-BuC≡CAu + NH_4Cl
xi) 3tert-BuC≡CAu +$11HNO_3$=$3Au(NO_3)_3$+2NO+ 3tert-BuC≡CH + $4H_2O$

4. a) $Zn + 4HNO_3 = Zn(NO_3)_2 + 2NO_2\uparrow + 2H_2O$
$Cu + 4HNO_3 = Cu(NO_3)_2 + 2NO_2\uparrow + 2H_2O$

b) $n(Zn + Cu) = 10 \cdot 9{,}69\ mL \cdot 0{,}02015\ mol/L \cdot \frac{1L}{1000\ mL} \cdot \frac{1000\ mmol}{1\ mol} = 1{,}9525\ mmol$

Maskeeritakse Cu^{2+}, sest $Cu^{2+} \rightarrow Cu^{+}$

n(Zn) = $\frac{100}{25} \cdot 5{,}93\ mL \cdot 0{,}02015\ mol/L = 0{,}47796\ mmol \approx$ **0,478 mmol**

n(Cu) = 1,9525 mmol – 0,47796 mmol = 1,4749 mmol ≈ **1,47 mmol**

c) %(Zn) = $\frac{0{,}47796\ mmol \cdot 65{,}37\ g/mol}{125{,}0\ mg} = 24{,}99 \approx$ **25,0**

%(Cu) = 100 – 25,0 = **75,0**

5. a) v = $N \cdot \ln 2/\tau = \frac{1g}{238\ g/mol} \cdot 6{,}022 \cdot 10^{23}\ \frac{aatomit}{mol} \cdot \frac{\ln 2}{87{,}2\ aastat} =$

$= 2{,}01 \cdot 10^{19}\ \frac{aatomit}{aastas} \cdot \frac{1\ aasta}{365\ päeva} = 5{,}51 \cdot 10^{16}\ \frac{aatomit}{päevas} \cdot \frac{1\ päev}{24\ h} \cdot \frac{1h}{3600\ s} =$

$=$ **$6{,}38 \cdot 10^{11}$ aatomit/s**

b) E = $8{,}8 \cdot 10^{-13}$ J/aatom·$6{,}38 \cdot 10^{11}$ aatomit/s = **0,56 J/s**

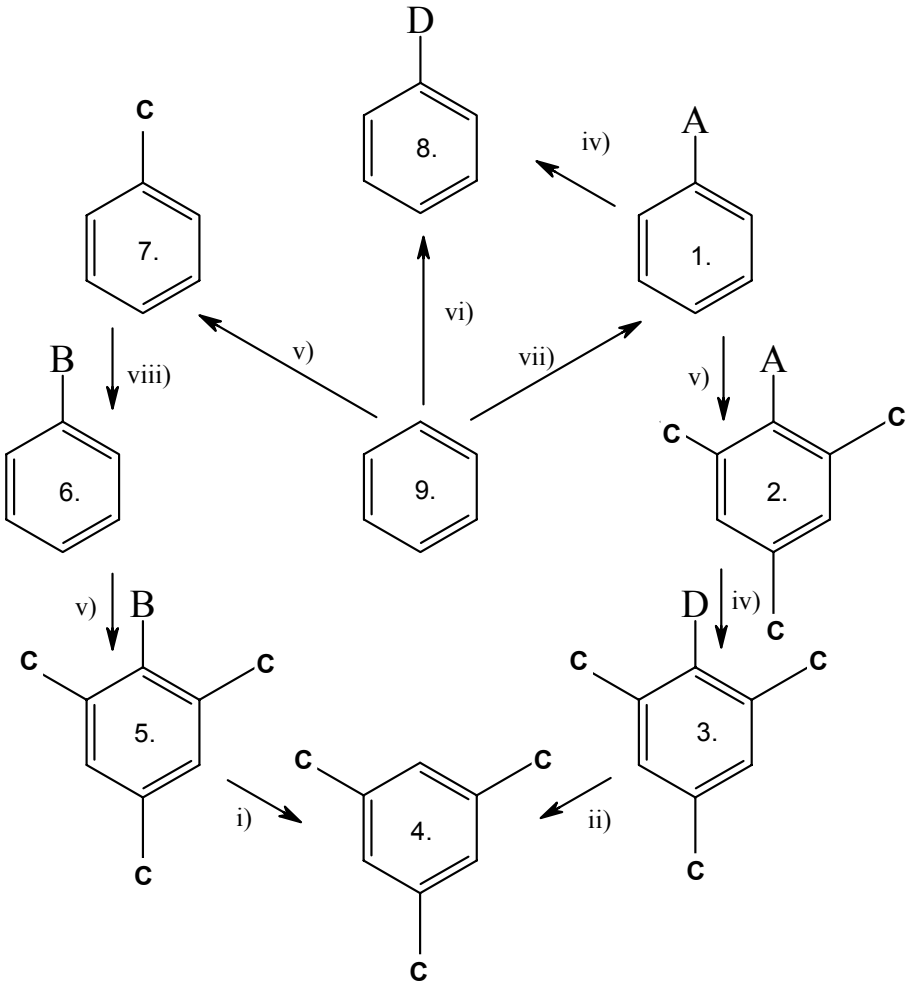
c) A_r(Pu) = 0,71·238 + 0,29·244 = 239,7 ≈ **240**

d) $\Delta N = N_0 - N_0 \cdot e^{-k \cdot t} = \frac{2{,}7\ g}{272\ g/mol} \cdot 6{,}022 \cdot 10^{23}$ aatomit/mol · $0{,}71 \cdot (1 - e^{-\ln\ 2 \cdot 10/87{,}2})$ =

$3{,}24 \cdot 10^{20}$ aatomit

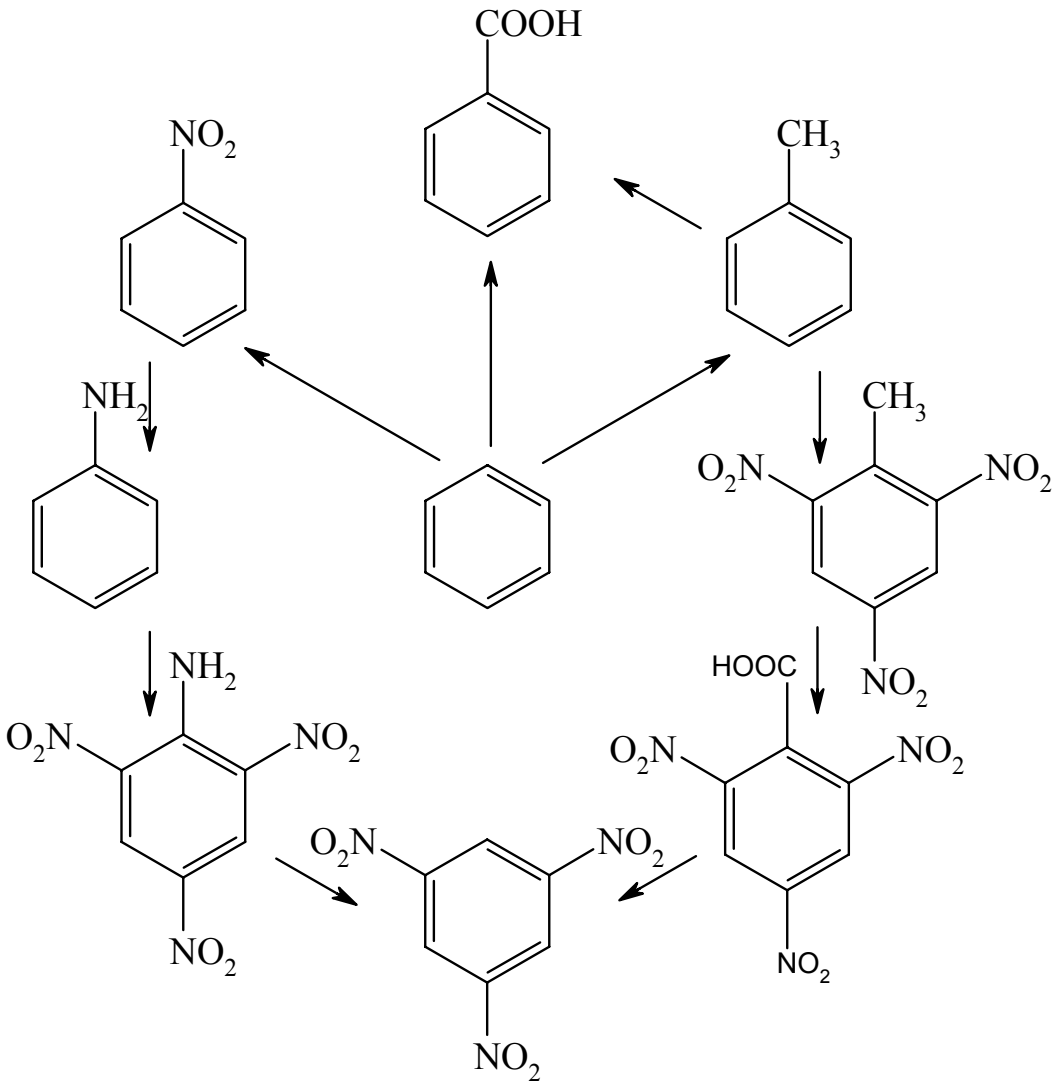
E = $8{,}8 \cdot 10^{-13}$J/aatom · $3{,}24 \cdot 10^{20}$ aatomit = $2{,}9 \cdot 10^{8}$J · $\frac{1kWh}{3{,}6 \cdot 10^{6}\ J}$ = 79,2 kWh ≈ **79 kWh**

6. a)



A - metüül
B - amiin
C - nitro
D - karboksüül

b)



1 – metüülbenseen, tolueen
2 – 2,4,6–trinitro–1–metüülbenseen
3 – 2,4,6–trinitrobensoehape
4 – 1,3,5–trinitrobenseen
5 – 2,4,6–trinitroaniliin
6 – aniliin
7 – nitrobenseen
8 – bensoehape
9 – benseen