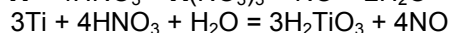
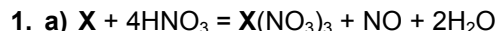


2010/2011 õ.a. keemiaolümpiaadi lõppvooru ülesannete lahendused
12. klass



b) Kui võtame metalli X moolide arvuks x (mmol ning g/mol) ja titaani moolide arvuks y (mol), siis:

$$\frac{x}{1000} + \frac{4}{3}y = \frac{pV}{RT} \text{ ning } \frac{x}{1000} \cdot x + 47,87y = 4,01$$

avaldame y:

$$y \text{ mol} = \frac{3}{4} \cdot \frac{101,325 \text{ kPa} \cdot 1,94 \text{ dm}^3}{8,314 \frac{\text{J}}{\text{K} \cdot \text{mol}} \cdot 293 \text{ K}} - \frac{x}{1000} \text{ mol} = \left(0,0605 - \frac{3}{4} \cdot \frac{x}{1000} \right) \text{ mol}$$

siis

$$x^2 - \frac{3}{4} \cdot 47,87x + 0,0605 \cdot 47,87 \cdot 1000 = 4,01 \cdot 1000$$

$$x^2 - 35,90x - 1110 = 0$$

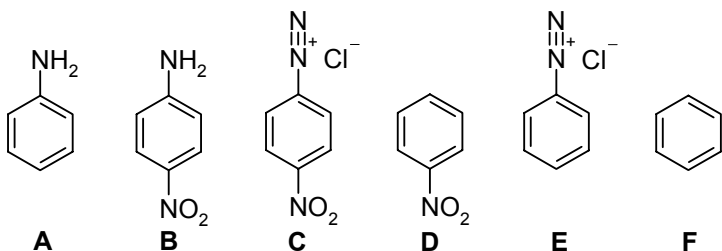
Lahendame ruutvõrandi vastavalt toodud valemile:

$$x = \frac{35,90 + \sqrt{35,90^2 + 4 \cdot 1110}}{2} = 55,9$$

$$x = 55,9 \Rightarrow M(X) = 55,9 \text{ g/mol} \Rightarrow X - \text{Fe}$$

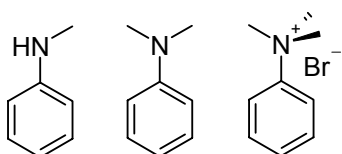
$$\frac{x}{y} = \frac{0,05585 \text{ mol}}{(0,08069 - 0,05585) \text{ mol}} \cdot \frac{4}{3} = 3, \text{ intermetalliidi valem} - \text{Fe}_3\text{Ti}$$

2. a)



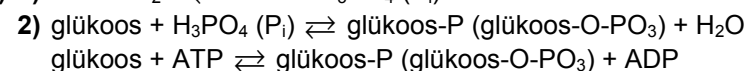
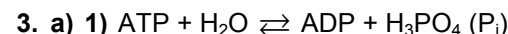
b) Kõige tugevam nukleofiil on A.

c)



d) $m/z = 136$ – vastab trimetüülfeniüülammoniumioonile

$m/z = 79$ ja 81 – vastavad Br^- ioonile (looduslik broom on ^{79}Br ja ^{81}Br isotoopide segu).



b) $\Delta_r G^\circ = (-30,5 + 14,0) \text{ kJ/mol} = -16,5 \text{ kJ/mol}$

c) $K = \exp\left(-\frac{\Delta G}{RT}\right) = \exp\left(\frac{16500 \text{ J} \cdot \text{mol}^{-1}}{8,314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \cdot 298 \text{ K}}\right) = 780$

d) $K = \exp\left(-\frac{\Delta G}{RT}\right) = \exp\left(\frac{16500 \text{ J} \cdot \text{mol}^{-1}}{8,314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \cdot 310 \text{ K}}\right) = 603$

$$K = \frac{[\text{ADP}][\text{glükoos-P}]}{[\text{ATP}][\text{glükoos}]} \Rightarrow \frac{[\text{glükoos-P}]}{[\text{glükoos}]} = 603 \cdot 12 = 7230$$

4. a) $E_1 = -\frac{-11600 \text{ J}}{3 \cdot 96485 \text{ C} \cdot \text{mol}^{-1}} = 0,04 \text{ V}$

$$E_2 = -\frac{-154000 \text{ J}}{4 \cdot 96485 \text{ C} \cdot \text{mol}^{-1}} = 0,40 \text{ V}$$

EMJ = 0,40 V + 0,04 V = 0,44 V

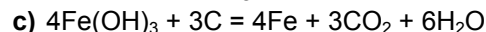
b) $\text{pH} = 7,00$ $[\text{OH}^-] = 10^{-7} \text{ M}$
 $4\text{Fe} + 3\text{O}_2 + 6\text{H}_2\text{O} = 4\text{Fe}(\text{OH})_3$ $n = 12$

$$E = E^\circ + \frac{RT}{12F} \cdot \ln \frac{p^3(\text{O}_2)}{([\text{Fe}^{3+}][\text{OH}^-]^3)^4} =$$

$$= 0,44 \text{ V} + \frac{0,0244 \text{ V}}{12} \cdot \ln \frac{0,2^3}{(6 \cdot 10^{-5} \cdot 10^{-7,3})^4} = 0,90 \text{ V}$$

(Elektromotoorjõu avaldises on esitatud aktiivsused. Seega 0,2 bar hapniku aktiivsus, eeldusel et tegemist on ideaalse gaasiga, on 0,2 ehk 0,2 bar / 1 bar. 1 bar on rõhk standardolekus)

$$\Delta G = -12 \cdot \frac{96490 \text{ C}}{1 \text{ mol}} \cdot 0,90 \text{ V} = 1,04 \cdot 10^6 \text{ J} = 1,04 \text{ MJ}$$



d) $\Delta_r G = [3 \cdot (-394,4) + 6 \cdot (-237,2) - 4 \cdot (-3 \cdot 96,485 - 0,90)] \text{ kJ/mol} = -1560 \text{ kJ/mol}$

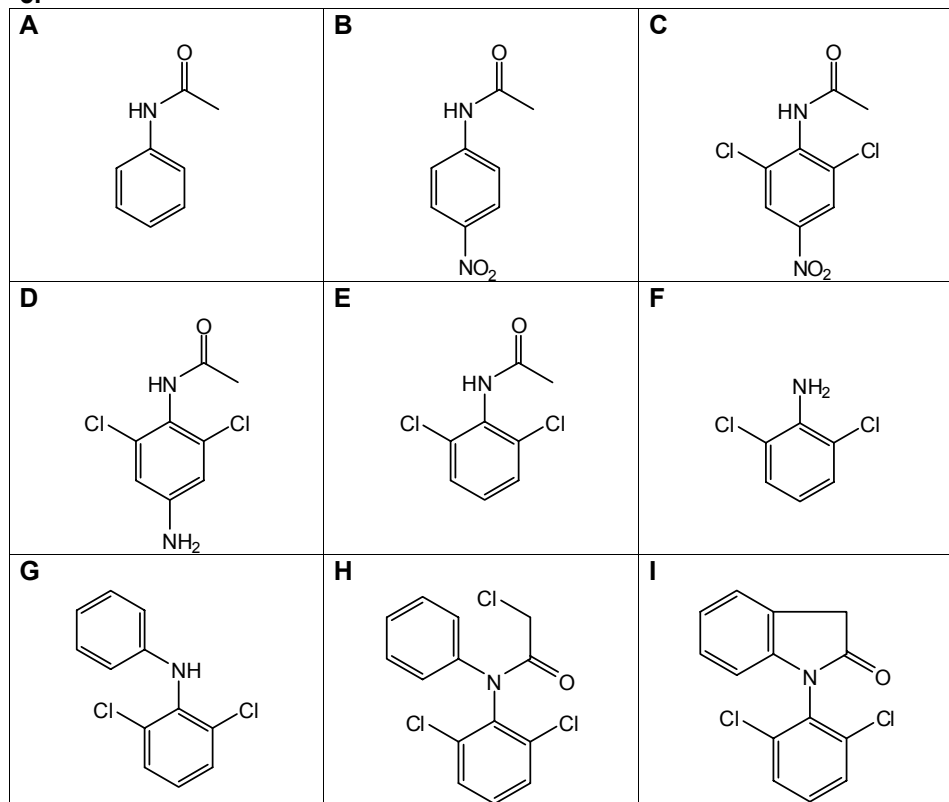
Kuna reaktsiooni $\Delta_r G$ on piisavalt negatiivne, siis toimub redutseerimine isevooluliselt.

$$e) m(C) = 1,35 \cdot 10^{15} \text{ g} \cdot 0,2 \cdot \frac{12,0 \text{ g} \cdot \text{mol}^{-1}}{55,85 \text{ g} \cdot \text{mol}^{-1}} \cdot \frac{3}{4} = 4,4 \cdot 10^{13} \text{ g}$$

$$\text{Hind} = 4,4 \cdot 10^{13} \text{ g} \cdot \frac{1 \text{ kg}}{1000 \text{ g}} \cdot 0,10 \frac{\text{€}}{\text{kg}} \approx \mathbf{4,4 \text{ mlrd €}}$$

f) Reaktsioon kineetika on aeglane. Raua saamisel rauamaagist oksüdeeritakse süsi algset CO-ks, mis järgnevalt kiiresti redutseerib raua.

5.



6. a) anoodil: $\text{Zn} = \text{Zn}^{2+} + 2e^-$
 katoodil: $2\text{H}^+ + 2e^- = \text{H}_2$

$$b) E = E^\circ(\text{H}^+/\text{H}_2) - E^\circ(\text{Zn}^{2+}/\text{Zn}) = 0 \text{ V} - (-0,76 \text{ V}) = 0,76 \text{ V}$$

$$n(\text{Zn}) = 5 \cdot \frac{5 \cdot 10^{-4} \text{ cm} \cdot 9 \text{ cm} \cdot 5 \text{ cm} \cdot 7,1 \text{ g} \cdot \text{cm}^{-3}}{65,4 \text{ g} \cdot \text{mol}^{-1}} = 0,0122 \text{ mol}$$

$$A = 0,0122 \text{ mol} \cdot 2 \cdot 96485 \frac{\text{A} \cdot \text{s}}{\text{mol}} \cdot 0,76 \text{ V} \cdot \frac{1 \text{ h}}{3600 \text{ s}} = \mathbf{0,5 \text{ W} \cdot \text{h}}$$

$$c) P = EI = 2 \text{ V} \cdot 0,005 \text{ A} = 0,01 \text{ W}$$

$$t = \frac{0,5 \text{ W} \cdot \text{h}}{0,01 \text{ W}} = \mathbf{50 \text{ h}}$$