

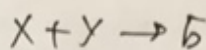
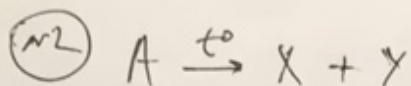
Часть 1

Олимпиада: **Химия 11 класс (1 часть)**

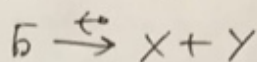
Шифр: **21300031**

ID профиля: **877425**

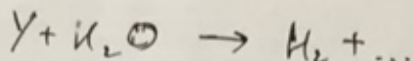
Вариант 2



$$\rho(X) = 1,251 \cdot 10^{-3} \text{ г/см}^3$$



$$m(A+B) = 50 \text{ г}$$

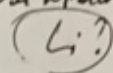


~ м. карм. красн

$$M_{\text{допп}} = 10 \text{ г/м}$$

$$D(H_2) = 44$$

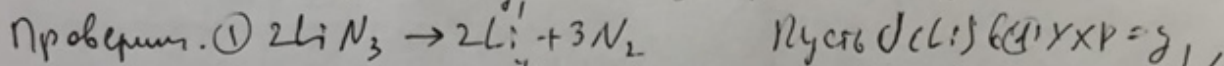
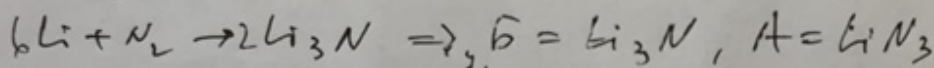
$$pV = nRT$$



$$V = \frac{pV}{RT} = \frac{10 \text{ г} \cdot 44,01 \text{ г/м}^3}{2,016 \text{ г/м}^3 \cdot 293 \text{ К}} = 1,87 \text{ моль}$$

Судя по прописке, X - газ; Li дает карм. красн. окраску пламени, $Li + H_2O \rightarrow \frac{1}{2}H_2 + LiOH$ $Y = Li?$ $X = N_2?$

Li_3N и LiN_3 - ионные соединения азота и лития содержат одинаковое число атомов



$$\Rightarrow D(LiN_3) = g_1, D(Li_3N) = \frac{1}{3} g_2$$

$$\begin{cases} g_1 + g_2 = 2 D(H_2) = 2 \cdot 1,87 = 3,74 \text{ моль} \\ m(Li_3N) + m(LiN_3) = 50 \text{ г} \Rightarrow \frac{1}{3} g_1 \cdot 35 + g_2 \cdot 49 = 50 \end{cases}$$

$$g_2 = 3,74 - g_1$$

$$\frac{35}{3} g_1 + 49(3,74 - g_1) = 50$$

$$\frac{35}{3} g_1 + 183,26 - 49g_1 = 50$$

$$183,26 = 37,3 g_1$$

$$g_1 = 3,573 \text{ моль} \Rightarrow$$

$$g_2 = 0,167 \text{ моль}$$

$$D(Li_3N) = \frac{1}{3} g_2 = \frac{1}{3} \cdot 0,167 \text{ моль} = 0,056 \text{ моль}$$

$$D(LiN_3) = g_1 = 3,573 \text{ моль} = 3,573 \text{ моль}$$

$$m(\text{Li}_3\text{N}) = m\omega = 1,19 \cdot 35 = 41,65$$

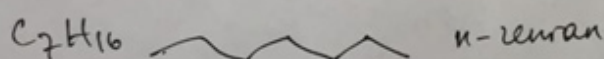
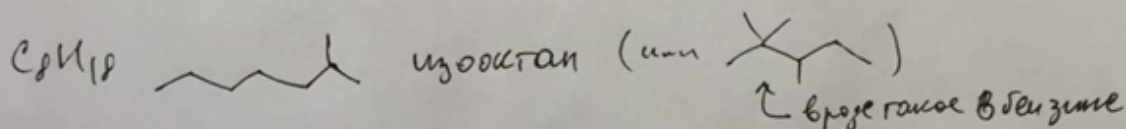
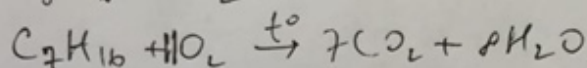
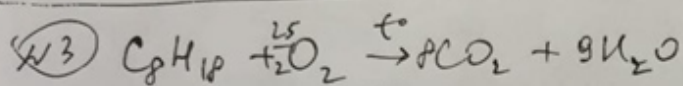
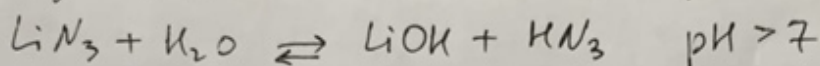
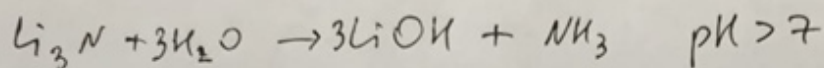
Чистовик (3)

$$m(\text{LiN}_3) = m\omega = 0,167 \cdot 99 = 16,7$$

$$\omega(\text{Li}_3\text{N}) = \frac{41,65}{50} = 83,3\%$$

$$\omega(\text{LiN}_3) = 100 - 83,3 = 16,7\%$$

Омберг:	$\omega(\text{Li}_3\text{N}) = 83,3\%$	$A = \text{LiN}_3$	$X = \text{N}_2$
	$\omega(\text{LiN}_3) = 16,7\%$	$B = \text{Li}_3\text{N}$	$Y = \text{Li}$



$$\rho(\text{C}_8\text{H}_{18}) = 0,692/\text{cm}^3 \quad \rho(\text{C}_7\text{H}_{16}) = 0,684/\text{cm}^3 \quad (1\text{cm}^3 = 1\text{мл})$$

$$V(\text{см}^3) = 100\text{мл} \quad Q = 9333, \text{ Дж/кг}$$

$$\varphi(\text{C}_8\text{H}_{18}) = ? \quad \text{— определяем массу} \quad V_{\text{C}_8\text{H}_{18}} + V_{\text{C}_7\text{H}_{16}} = V_{\text{смесь}} = 100$$

$$\text{Пусть } V_0 \text{ — общее количество вещества} \quad \frac{m_{\text{C}_8\text{H}_{18}}}{\rho_{\text{C}_8\text{H}_{18}}} + \frac{m_{\text{C}_7\text{H}_{16}}}{\rho_{\text{C}_7\text{H}_{16}}} = 100$$

$$\text{То есть } V(\text{C}_8\text{H}_{18}) = \varphi V_0$$

$$V(\text{C}_7\text{H}_{16}) = (1 - \varphi) V_0$$

$$\frac{m_{\text{C}_8\text{H}_{18}} \cdot V_{\text{C}_8\text{H}_{18}}}{\rho_{\text{C}_8\text{H}_{18}}} + \frac{m_{\text{C}_7\text{H}_{16}} \cdot V_{\text{C}_7\text{H}_{16}}}{\rho_{\text{C}_7\text{H}_{16}}} = 100$$

$$\frac{104 \varphi V_0}{0,69} + \frac{100}{0,684} (1 - \varphi) V_0 = 100$$

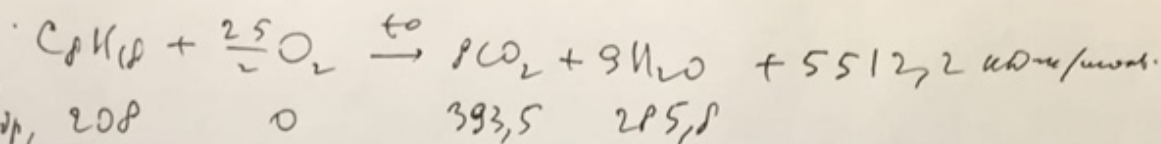
$$165,22 \varphi V_0 + 146,2 (1 - \varphi) V_0 = 100$$

$$165,22 \varphi - 146,2 \varphi = \frac{100}{V_0} - 146,2$$

$$\varphi = \frac{5,26}{V_0} - 7,69 = \frac{5,26 - 7,69 V_0}{V_0} ; \quad V_0 = V(\text{C}_8\text{H}_{18}) + V(\text{C}_7\text{H}_{16})$$

Условие

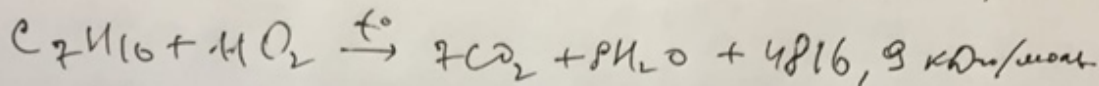
(4)



$$Q_{01}, 208 \quad 0 \quad 393,5 \quad 285,8$$

кДж/моль

$$Q_{p1} = 9 \cdot 285,8 + 8 \cdot 393,5 - 208 = 5512,2 \text{ кДж/моль}$$



$$Q_{02}, 224 \quad 0 \quad 393,5 \quad 285,8$$

кДж/моль

$$Q_{p2} = 8 \cdot 285,8 + 7 \cdot 393,5 - 224 = 4816,9 \text{ кДж/моль}$$

$$Q_{p1} \cdot \nu(C_8H_{18}) + Q_{p2} \cdot \nu(C_7H_{16}) = 3333,8 \text{ кДж}$$

$$\nu(C_8H_{18}) + \nu(C_7H_{16}) = \nu_0 - ?$$

$$5512,2 \cdot \nu_{C_8H_{18}} + 4816,9 \cdot \nu_{C_7H_{16}} = 3333,8$$

$$(5512,2 \cdot \nu_{C_8H_{18}} + 4816,9 (\nu_0 - \nu_{C_8H_{18}})) = 3333,8$$

$$5512,2 \cdot \nu_{C_8H_{18}} + 4816,9 \nu_0 - 4816,9 \nu_{C_8H_{18}} = 3333,8$$

$$695,3 \nu_{C_8H_{18}} = 3333,8 - 4816,9 \nu_0$$

$$\left\{ \begin{array}{l} 5512,2 \nu_{C_8H_{18}} + 4816,9 \nu_{C_7H_{16}} = 3333,8 \\ \frac{114}{9,69} \nu_{C_8H_{18}} + \frac{100}{0,684} \nu_{C_7H_{16}} = 100 \end{array} \right.$$

$$\left\{ \begin{array}{l} \frac{4816,9}{146,2} (100 - 165,22 \nu_{C_8H_{18}}) + 5512,2 \nu_{C_8H_{18}} = 3333,8 \\ \nu_{C_7H_{16}} = \frac{100 - 165,22 \nu_{C_8H_{18}}}{146,2} \end{array} \right.$$

$$32,95 (100 - 165,22 \nu_{C_8H_{18}}) + 5512,2 \nu_{C_8H_{18}} = 3333,8$$

$$3295 - 5443,99 \nu_{C_8H_{18}} + 5512,2 \nu_{C_8H_{18}} = 3333,8$$

$$68,201 \nu_{C_8H_{18}} = 3,8$$

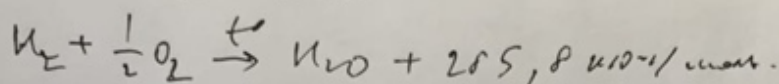
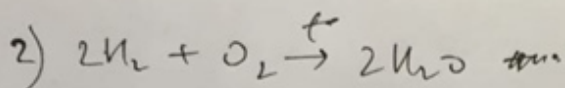
$$\nu_{C_8H_{18}} = 0,57 \text{ моль}$$

$$V_{C_{2H_6}} = \frac{100 - 165,22 \cdot 0,57}{146,2} = 0,04 \text{ моль} \quad \text{Углекисл. (5)}$$

$$V_0 = 0,04 + 0,57 = 0,61 \text{ моль}.$$

$$\psi = \frac{V_{C_{2H_6}}}{V_0} = \frac{0,57}{0,61} = 0,9344 \quad (93,44\%)$$

Ответ: $\psi = 93,44\%$ - окислительное число



$$\frac{40 \text{ л}}{0,1 \text{ м}} = \frac{x}{333,8 \text{ кДж/моль}}; \quad x = 1333520 \text{ кДж}.$$

$$V(H_2) = \frac{1333520}{285,8} \approx 4666 \text{ моль}.$$

$$V(H_2) = \frac{4666}{22,4} = 208,3 \text{ л (н.у.)}$$

$$3) \quad 40 \text{ л}, \quad p = 19,6 \cdot 10^6 \text{ Па} = 19,6 \cdot 10 \cdot 10^5 \text{ Па} \quad T = 298 \text{ К}$$

$$p = \frac{19,6 \cdot 10^6}{101325} = 193,44 \text{ атм} \quad m = 76,5 \text{ кг}$$

$$pV = nRT$$

$$V = \frac{pV}{pT} = \frac{19,6 \cdot 10^6 \cdot 40 \cdot 10^{-3}}{101325 \cdot 298} = 0,3164 \cdot 10^3 = 316,44 \text{ моль}.$$

$$m(H_2) = 2 \cdot 316,44 = 632,88 \text{ г}$$

$$m_{\text{газа}} = 76,5 - 0,63288 = 75,867 \text{ кг}$$

$$40 \text{ л газа} = 1333,520 \cdot 10^3 \text{ кДж}$$

$$q_{\text{газа}} = \rho_{\text{газа}} \psi + \rho_{C_2H_6} (1 - \psi) =$$

$$= 0,9344 \cdot 0,57 \cdot 114 + 0,0656 \cdot 0,04 \cdot 100 = 60,72 + 0,2624 =$$

$$= 60,9824 \text{ л}. \quad V = 100 \text{ м}^3$$

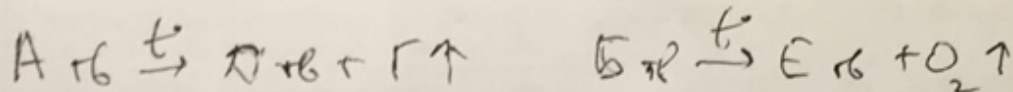
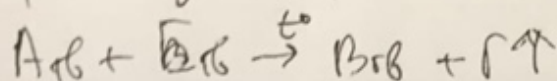
$$\rho_{\text{газа}} = 0,609 \text{ г/см}^3$$

№

Угрюбук Чистобук

①

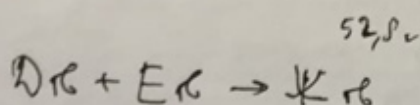
№1 A, B - окис. м., $w(O) = 48\%$



$$V(A) = V(B) = \frac{40}{M}$$

$$V(O) = \frac{496}{22,4} = 0,4 \text{ моль.}$$

$$V(O_2) = \frac{6,72}{22,4} = 0,3 \text{ моль} \quad m(O_2) = M \cdot V = 9,6$$



$$\Rightarrow m(E) = m(B) - m(O_2) =$$

$$= 40 - 9,6 = 30,4$$

$$m(D) = m(B) - m(E) = 52,8 - 30,4 = 22,4$$

$$m(O) = m(A) - m(D) = 40 - 22,4 = 17,6$$

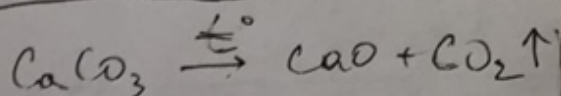
$$M(O) = \frac{m}{V} = \frac{17,6}{0,4} = 44 \text{ г/моль} \quad (CO_2?)$$

$$A - \text{карбонат?} \quad M(A) = \frac{40}{0,4} = 100 \text{ г/моль} \quad CaCO_3$$

$$\text{Допустим, } V(A) = V(O)$$

$$M(B) = M(A) = 100 \text{ г/моль.}$$

ответ:



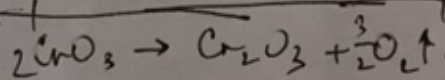
$$O = CO_2$$

$$D = CaO$$

$$A = CaCO_3$$

A - основный оксид,

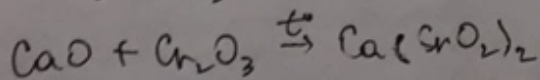
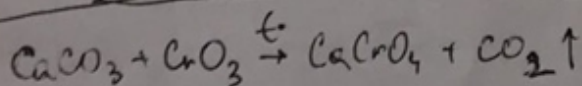
B - амфотер или кислотный
(CrO₃) + гидроксид-ионный
ион (CrO₄²⁻)



$$B = CrO_3$$

$$E = Cr_2O_3$$

$$w(O) = \frac{48}{100} = 48\%$$



$$* = Ca(CrO_2)_2$$

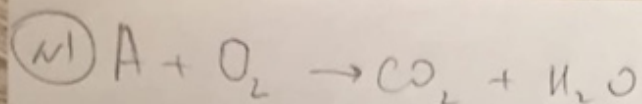
Часть 2

Олимпиада: **Химия 11 класс (2 часть)**

Шифр: **21300031**

ID профиля: **877425**

Вариант 2



числовик

1

$m(A) = 10,2$

$V(CO_2) = 11,2$ л (н.у.) $V(CO_2) = V(C) = \frac{V}{V_m} = \frac{11,2}{22,4} = 0,5$ моль.

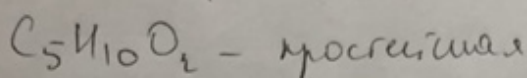
$V(H_2O) = 9$ л $m(H_2O) = \rho V = 9 \cdot 1 = 9$ г

$V(H) = 2V(H_2O) = 2 \cdot \frac{m}{M} = 2 \cdot \frac{9}{18} = 1$ моль.

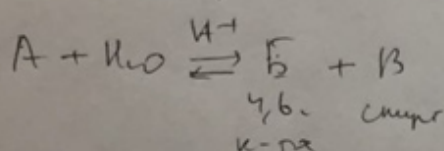
$m(C) = MW = 0,5 \cdot 12 = 6$ г $m(H) = MW = 1$ г

$m(O) = 10,2 - 7 = 3,2$ г $V(O) = \frac{3,2}{16} = 0,2$ моль.

$C:H:O = 0,5:1:0,2 = 5:10:2$

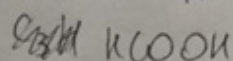


молекулярная формула

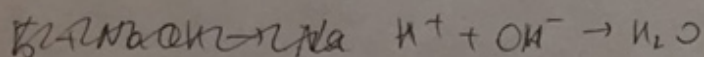
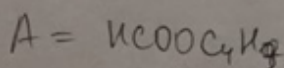
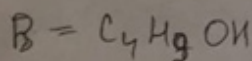
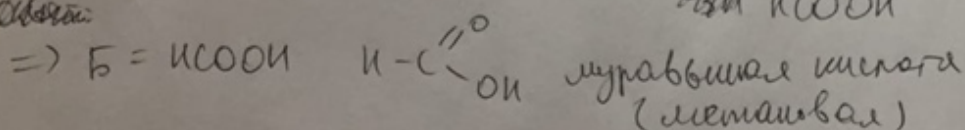


$V(B) = V(A) = \frac{10,2}{102} = 0,1$ моль.

$M(B) = \frac{46}{0,1} = 46$ г/моль.



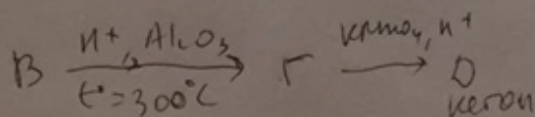
ответ:



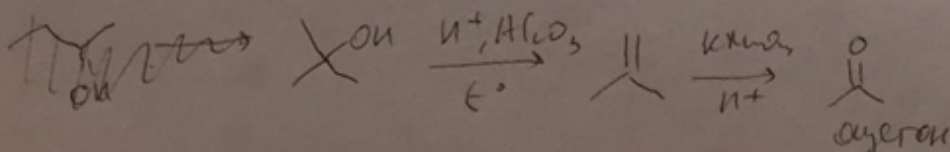
$C(OH^-) = 2$ м $V = 50$ мл = $50 \cdot 10^{-3}$ л

Бромирование $V(OH^-) = CV = 2 \cdot 50 \cdot 10^{-3} = 0,1$ моль = $V(B)$

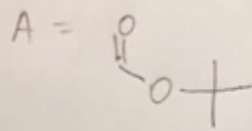
$M(B) = 46$ г/моль.



$M(O) = \frac{16}{58} = 27,59\%$



Отвѣтъ:

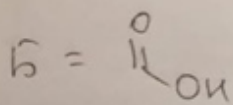


ацетон

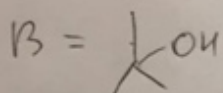
(2)

третбутиловый эфир
муравьиной (метановой кислоты)

(третбутилоформиат)

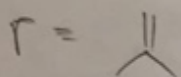


метановая (муравьиная) кислота

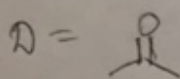


2-метилпропанол-2

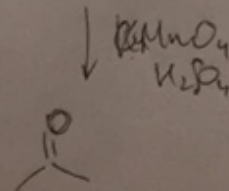
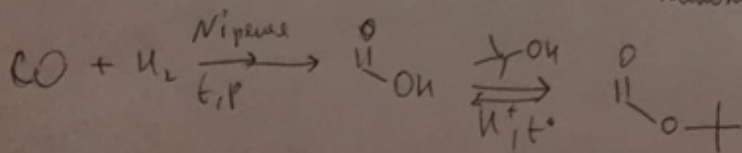
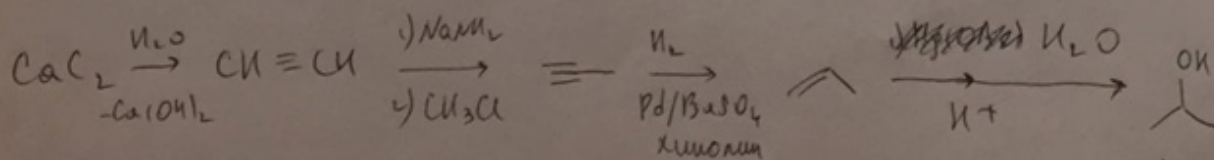
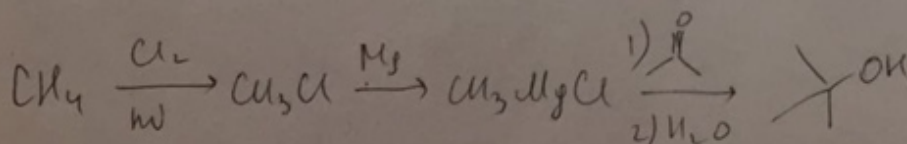
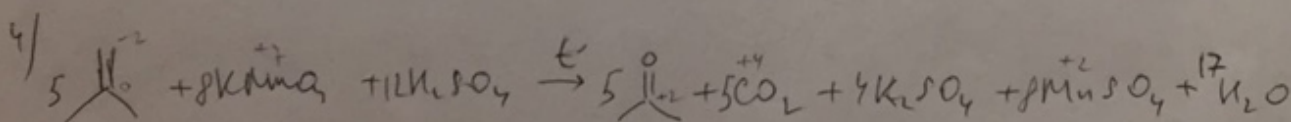
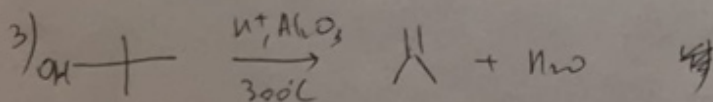
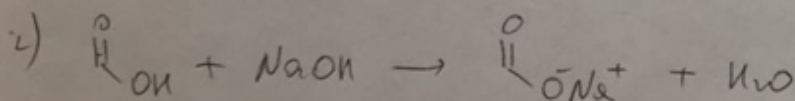
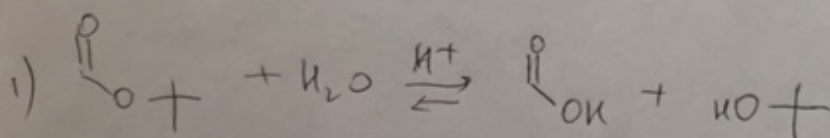
(третбутанол)



2-метилпропен

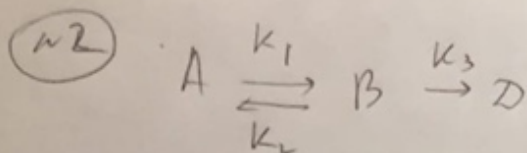


пропанон (ацетон)



Усложнение

(3)



$k_1 = k_3$

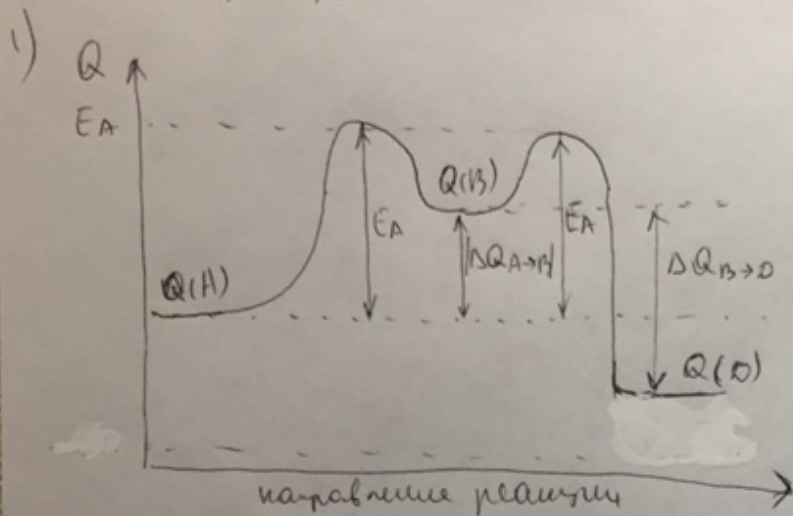
$Q_{B \rightarrow D} = 1,5 | - Q_{B \rightarrow A} |$

$Q_{A \rightarrow B} = 2/3 E_A$

$k_1 = k_3 \Rightarrow$

$A \exp(-\frac{E_{A1}}{RT}) = A \exp(-\frac{E_{A2}}{RT})$

$E_{A1} = E_{A2}$



$| \Delta Q_{A \rightarrow B} | = \frac{2}{3} E_A$

$\Delta Q_{A \rightarrow B} < 0$ экзотерм.

$\Delta Q_{B \rightarrow D} > 0$ эндотерм.

$\Delta Q_{B \rightarrow A} = \frac{3}{2} | \Delta Q_{A \rightarrow B} | = \frac{3}{2} \cdot \frac{2}{3} E_A = E_A$

~~$Q_{A \rightarrow B} = Q(D) - Q(B)$~~

2) $\Delta Q = \Delta Q_{A \rightarrow B} + \Delta Q_{B \rightarrow D} = -\frac{2}{3} E_A + E_A = \frac{1}{3} E_A > 0$

$\Delta Q > 0$

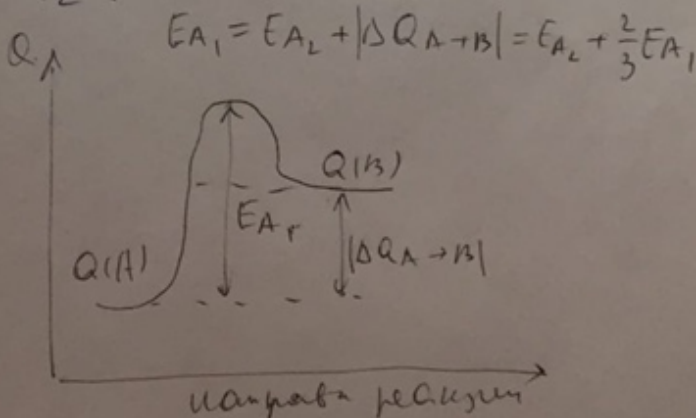
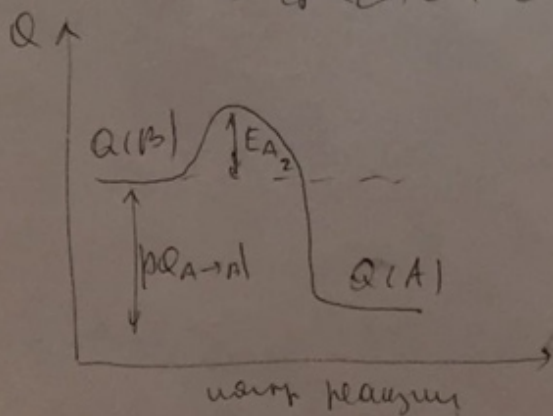
3) $k_1 = A \exp(-\frac{E_{A1}}{RT})$ $k_2 = A \exp(-\frac{E_{A2}}{RT})$

$W_B = k_1 C_A - k_2 C_B = k_1 (C_A - C_B)$
($k_1 = k_2$)

$W_A = +k_1 C_A + k_2 C_B$

$\frac{k_2}{k_1} = \exp(-\frac{E_{A2}}{RT} + \frac{E_{A1}}{RT}) = \exp(\frac{E_{A1} - E_{A2}}{RT})$

$\exp(\frac{E_{A1} - E_{A2}}{RT}) = 1 \Rightarrow E_{A1} = E_{A2}$



$E_{A1} = E_{A2} + | \Delta Q_{A \rightarrow B} | = E_{A2} + \frac{2}{3} E_A$

Учробу

$$E_{A_1} = E_{A_2} + \frac{2}{3} E_{A_1} \quad \cancel{E_{A_2}}$$

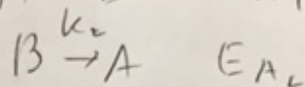
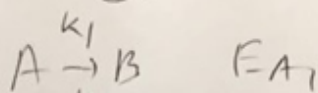
$$\frac{1}{3} E_{A_1} = E_{A_2}$$

$$\boxed{\frac{E_{A_1}}{E_{A_2}} = \frac{3}{1}}$$

Order:

$$\boxed{\frac{E_{A(A \rightarrow B)}}{E_{A(B \rightarrow A)}} = 3}$$

(4)



$$\frac{E_{A_1} - 1}{E_{A_2}}$$

$$\frac{k_2}{k_1} = \exp\left(\frac{E_{A_1} - E_{A_2}}{R\tau}\right) = \exp\left(\frac{2E_{A_2}}{R\tau}\right) \quad \checkmark$$

$$E_{A_1} = R\tau \ln(k_1/A) \quad E_{A_2} = -R\tau \ln\left(\frac{k_2}{A}\right)$$

$$\frac{E_{A_1}}{E_{A_2}} = \frac{3}{1} = \frac{\ln(k_1/A)}{\ln(k_2/A)} \quad \text{cancel}$$

$$\ln\left(\frac{k_1}{A}\right) = \ln\left(\frac{k_2}{A}\right)^3 \quad \frac{k_1}{A} = \frac{k_2^3}{A^3} \quad ?$$

Учебник

№ 3

5

$$m_{\text{при электролизе}} = 1250,6.$$

$$I = 3 \text{ A.}$$

$$m(\text{FeSO}_4) = 69,8.$$

$$\Delta t = 10 \text{ ч } 43 \text{ мин} = 643 \text{ мин} = 38580 \text{ с}$$

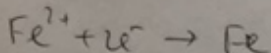
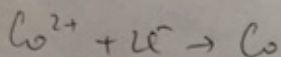
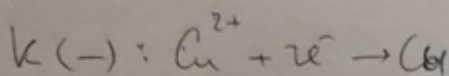
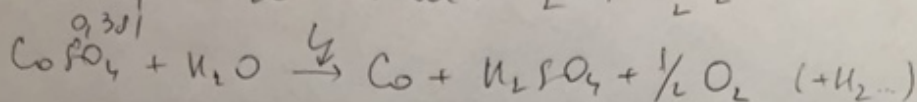
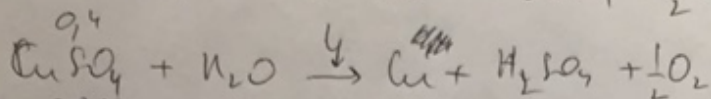
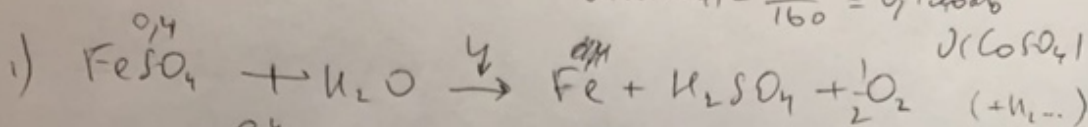
$$m(\text{CuSO}_4) = 64.$$

$$j(\text{FeSO}_4) = \frac{69,8}{152} = 0,46 \text{ моль}$$

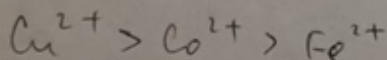
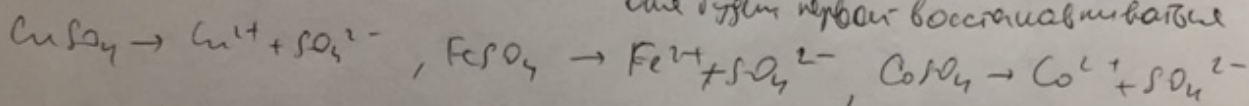
$$j(\text{CuSO}_4) = \frac{64}{160} = 0,4 \text{ моль}$$

$$m(\text{CoSO}_4) = 62.$$

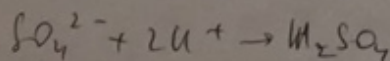
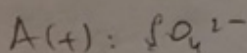
$$j(\text{CoSO}_4) = \frac{5,9}{155} = 0,38 \text{ моль}$$



последовательность восстановления ие катоды
(в порядке увеличения активности ие)
Cu - наименее активный ие $\Rightarrow$
он будет первым восстанавливаться



увеличение окислительных свойств $\Rightarrow$ в такой последовательности
(увеличение восстанов. св) восстановления



2) Закон Фарадея

$$m = \frac{I \cdot \Delta t \cdot M}{z \cdot F}$$

$$F = 96500 \text{ Кл/моль}$$

$$z = 2$$

$$\Delta m_{\text{max}}(\text{Cu}) = 0,4 \cdot 64 = 25,6$$

$$\Delta t = \frac{\Delta m \cdot z \cdot F}{I \cdot M} = \frac{25,6 \cdot 2 \cdot 96500}{64 \cdot 3} =$$

$$= 25733 \text{ с.}$$

$$t_{\text{ост}} = 38580 - 25733 = 12847 \text{ с}$$

Cu ↓ по катоду

$$\Delta m(\text{Co}) = 0,4 \cdot 58 = 22, \quad 0,381 \cdot 59 = 22,479. \quad \text{⑥}$$

$$\Delta t = \frac{\Delta m \cdot z \cdot F}{I \cdot \eta} = \frac{59 \cdot 0,381 \cdot 2 \cdot 96500}{59 \cdot 3} = \frac{24511 \text{ c}}{t_{\text{продв}}} < \frac{12847 \text{ c}}{t_{\text{ост.}}}$$

$$\Delta t = 12847 \text{ c.}$$

$$\Delta m(\text{Co}) = \frac{\Delta t \cdot I \cdot z}{z \cdot F} = \frac{12847 \cdot 59 \cdot 3}{2 \cdot 96500} = 11,782 \text{ c}$$

$$\Delta V(\text{Co}) = \frac{11,782}{59} \approx 0,2 \text{ моль} \quad \text{Co} \downarrow$$

$$V_{\text{ост}}(\text{Co}) = 0,381 - 0,2 = 0,181 \text{ моль} \approx 0,18 \text{ моль}$$

В море: в к-те есть $\text{FeSO}_4, \text{CoSO}_4, \text{H}_2\text{O}, \text{H}_2\text{SO}_4$
после
электролиза

$$V(\text{FeSO}_4) = 0,4 \text{ моль.}$$

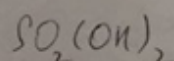
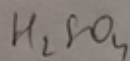
$$V(\text{CoSO}_4) = 0,18 \text{ моль}$$

$$V(\text{H}_2\text{SO}_4) = 0,4 + 0,2 = 0,6 \text{ моль.}$$

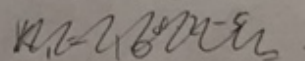
$$3) \Delta t_{\text{мехар}} = t_{\text{пр}} - t_{\text{ост}} = 24511 - 12847 = 11664 \text{ c} = 194,4 \text{ мин.}$$

Ответ: на 194,4 мин

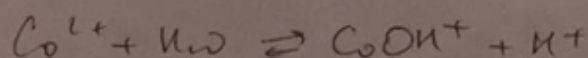
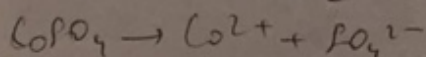
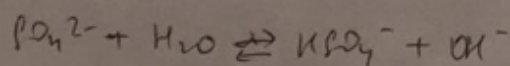
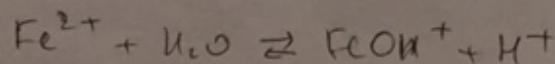
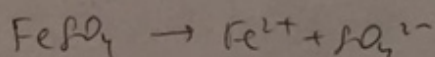
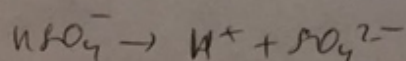
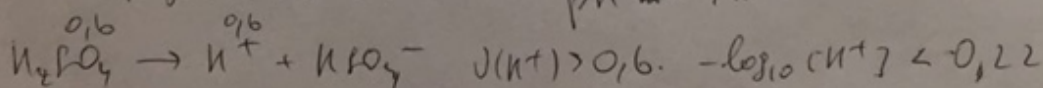
$$4) m_{\text{ост}} = 20 \text{ c.}$$



используем по 1 ступени,
среднее по 2.

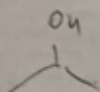
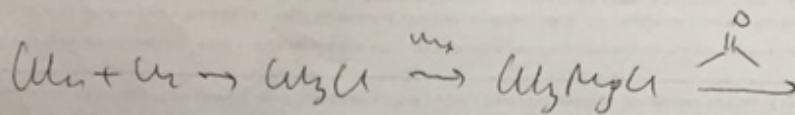
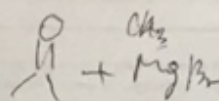
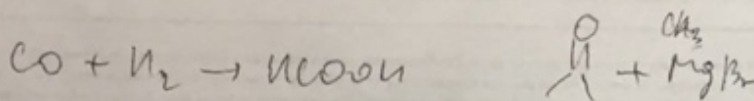
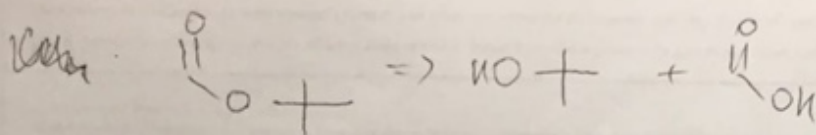


pH < 7.

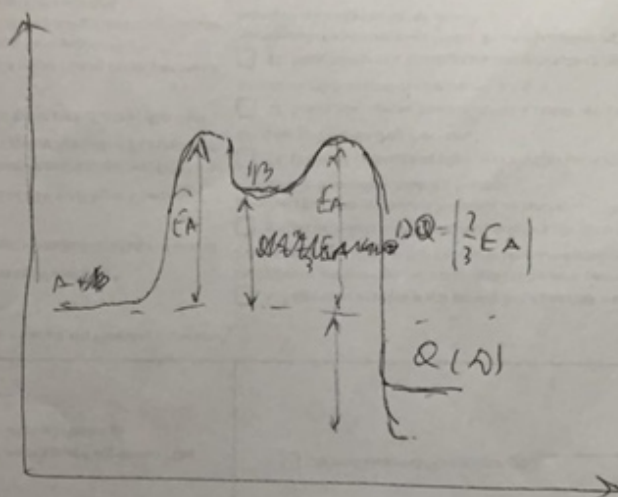
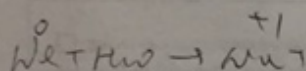


Черновик

①



$$\frac{2}{3} \cdot \frac{3}{2} = 1$$



$$k_1 = k_3 = A \exp\left(-\frac{EA}{RT}\right)$$

$$W_B = k_1 (C_A - C_B)$$

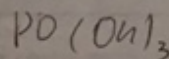
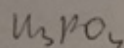
$$EA_1 = EA_3 ?$$

$$C_A - C_B = \frac{W_B}{k_1}$$

$$C_A = \frac{W_B}{k_1} + C_B$$

$$W_A = k_2 C_B - k_1 C_A = k_2 C_B - W_B - k_1 C_B = C_B (k_2 - k_1) - W_B$$

$$\frac{W_A}{W_B} = \frac{k_2 C_B - k_1 C_A}{k_1 (C_A - C_B)}$$



$$15 - 15 = 10$$

