



**МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
имени М.В. ЛОМОНОСОВА**

ОЛИМПИАДНАЯ РАБОТА

Наименование олимпиады школьников: **«Ломоносов»**

Профиль олимпиады: **Химия**

ФИО участника олимпиады: **Шевелева Богдана Михайловна**

Класс: **11**

Технический балл: **97**

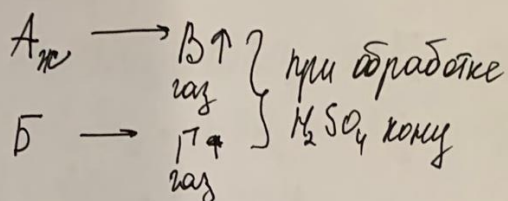
Дата проведения: **27 февраля 2022 года**

9142796	8	16	16	20	17(неправильно рассчитана масса CO ₂ , отсюда арифметическая ошибка при расчете массы карбоната	20	97
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Буданова А.А.

Задача №6

Источники 1 из 7

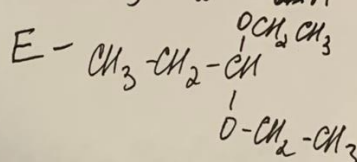
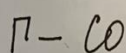
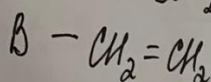
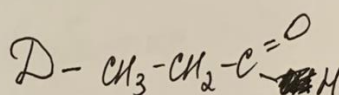
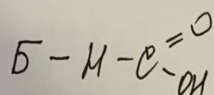
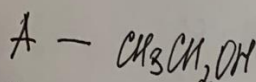


$$B + \Gamma = D_{O_2} = 0,875$$

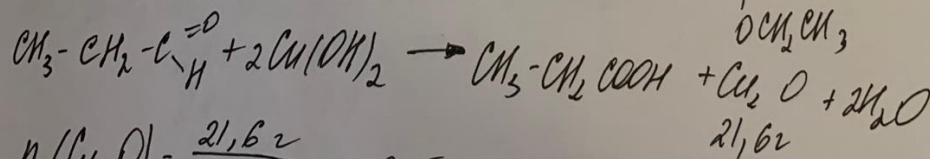
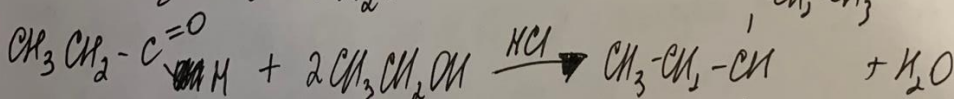
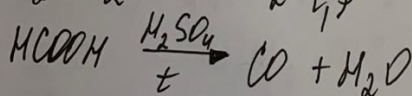
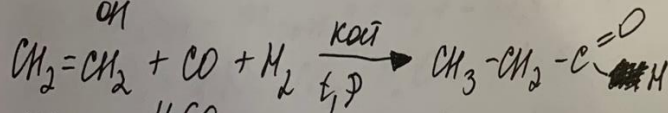
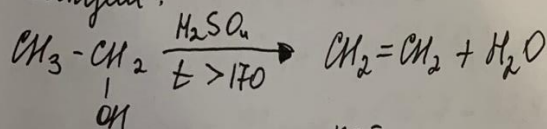
(возможные газы: CO, C₂H₄, NH₃)

$$D = \frac{x^2 / \text{моль}}{16 \cdot 2} = 0,875 \Rightarrow x = 28^2 / \text{моль} \Rightarrow$$

Соответственно:



Реакции:

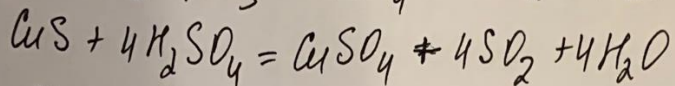
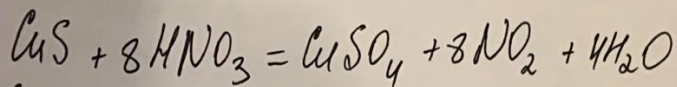


$$n(\text{Cu}_2\text{O}) = \frac{21,62}{144 \text{ моль}} = 0,15 \text{ моль}$$

$$n(\text{CH}_3\text{CH}_2-\text{C}(=\text{O})\text{H}) = 0,15 \cdot 58 = \underline{\underline{8,72}}$$

Задача 5

Учетовик 2 из 7



$$n(\text{CuS}) = \frac{9,6}{96} = 0,1 \text{ моль}$$

$$m(\text{HNO}_3) = \text{в избытке} \quad n(\text{HNO}_3) = \frac{75,6}{63} = 1,2 \text{ моль}$$

$$n(\text{NO}_2) = 8n(\text{CuS}) = 8 \cdot 0,1 = 0,8 \text{ моль} \quad m(\text{HNO}_3) = 0,63 \cdot 120 = 75,62$$

$$m(\text{NO}_2) = 0,8 \cdot 46 = 36,82$$

$$m_1 \text{ остатка} = m(\text{CuS}) + m_p(\text{HNO}_3) - m(\text{NO}_2) = 9,6 + 120 - 36,8 = 92,82$$

$$m(\text{H}_2\text{SO}_4) = 0,92 \cdot 142,7 = 139,82 \quad \left. \begin{array}{l} \\ \end{array} \right\} \text{H}_2\text{SO}_4 \text{ в избытке}$$

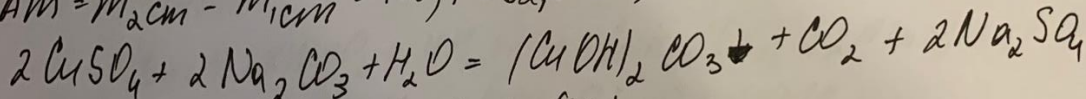
$$n(\text{H}_2\text{SO}_4) = \frac{139,8}{98} = 1,43 \text{ моль}$$

$$n(\text{SO}_2) = 4 \cdot n(\text{CuS}) = 4 \cdot 0,1 = 0,4 \text{ моль}$$

$$m(\text{SO}_2) = 0,4 \cdot 64 = 25,62$$

$$m_2 \text{ см} = m(\text{CuS}) + m_p(\text{H}_2\text{SO}_4) - m(\text{SO}_2) = 9,6 + 142,7 - 25,2 = 126,72$$

$$\Delta m = m_2 \text{ см} - m_1 \text{ см} = 126,72 - 92,8 = 33,92$$



$$\Delta m = m(\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}) - m(\text{CO}_2)$$

Пусть $n(\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}) = x$, тогда $n(\text{CO}_2) = 0,5x$

$$m(\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}) = 286x, \quad m(\text{CO}_2) = 22x$$

$$286x - 22x = 33,9$$

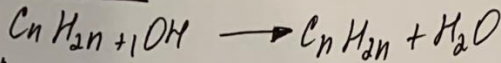
$$264x = 33,9$$

$$x = 0,1284$$

$$m(\text{Na}_2\text{CO}_3) = 0,1284 \cdot 286 = \underline{\underline{36,72}}$$

Задача 4

Чистовик 3 из 7



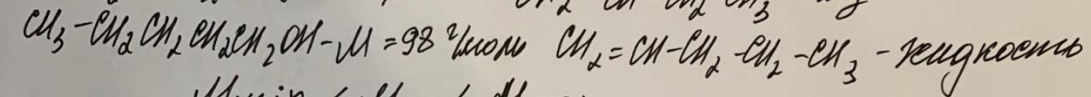
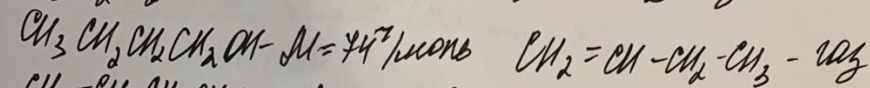
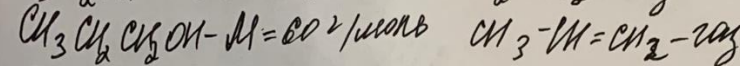
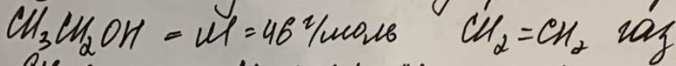
$$m(\text{смеси}) = 15,92$$

$$pV = nRT \Rightarrow n(\text{моль}) = \frac{pV}{R \cdot T} = \frac{101,3 \cdot 11,15}{8,31 \cdot 453} = 0,3 \text{ моль}$$

$$M(\text{ср}) = \frac{m}{n} = \frac{15,92}{0,3} = 53 \text{ г/моль}$$

Передпр:

C_3H_7OH - не вступает во внутримолекулярную циклизацию;

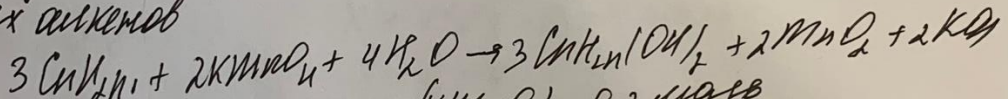


$$M_{\text{min}} < M_{\text{ср}} < M_{\text{max}}$$

$$C_3H_7OH \quad 46 < 53 < 60 \text{ или } 74$$

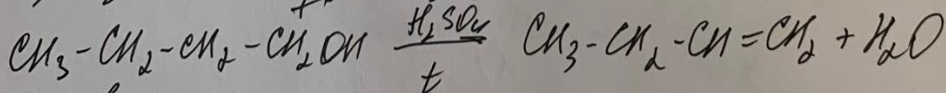
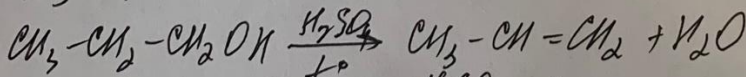
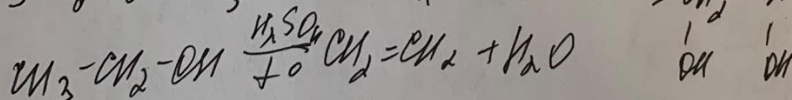
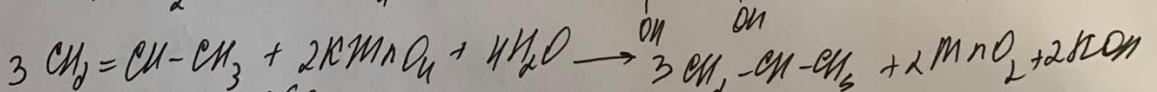
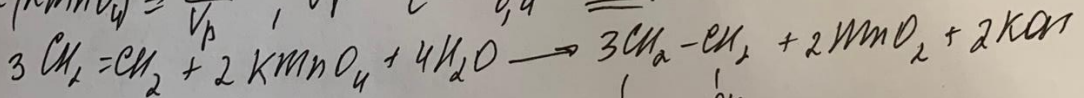
Возможный состав: C_2H_5OH и C_3H_7OH / или C_3H_7OH и C_3H_7OH

Реакция алкенов с $KMnO_4$ протекает одинаково для всех алкенов



$$n(C_n H_{2n}) = 0,3 \text{ моль} \quad n(KMnO_4) = 0,2 \text{ моль}$$

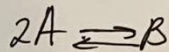
$$c(KMnO_4) = \frac{n}{V_p}; \quad V_p = \frac{n}{c} = \frac{0,2}{0,4} = 0,5 \text{ л}$$



Массовые доли:

смотреть продолжение на стр 57

Задача №3



B - газ, значит $M(B) = 2M(A)$

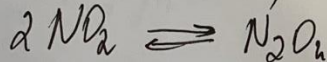
Пусть $n(A) = 1$ моль, $n(B) = 1,86$ моль

$$M_{\text{ср}} = \frac{n(A) \cdot M(A) + n(B) \cdot M(B)}{n(A) + n(B)} = 75,9$$

$$\frac{1 \cdot M(A) + 1,86 \cdot 2 \cdot M(A)}{1 + 1,86} = 75,9$$

$$4,72 M(A) = 217$$

$$M(A) = 46 \Rightarrow \text{NO}_2 \leftarrow A ; B - \text{N}_2\text{O}_4$$



$$PV = nRT \quad n = \frac{PV}{RT} = \frac{101,3 \cdot 1,0}{8,31 \cdot 303} = 0,04 \text{ моль}$$

$$n(A) = x$$

$$n(B) = 1,86x$$

$$x + 1,86x = 0,04 \text{ моль}$$

$$x = 0,014$$

$$n(A) = 0,014$$

$$n(B) = 0,026$$

$$[A] = \frac{0,014}{1} = 0,014 \text{ моль/л}$$

$$[B] = \frac{0,026}{1} = 0,026 \text{ моль/л}$$

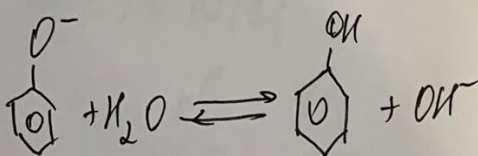
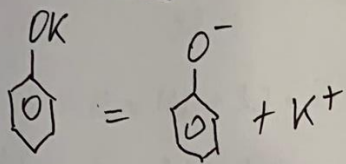
$$K_p = \frac{[B]^1}{[A]^2} = \frac{0,026}{0,014^2} = 132,7$$

$$K_p = \frac{K_{\text{кр}}}{K_{\text{обп}}}$$

$$K_{\text{обп}} = \frac{K_{\text{кр}}}{K_p} = \frac{5,00 \cdot 10^{-3}}{132,7} = 3,77 \cdot 10^{-5} \text{ моль/л}$$

Условие 5 из 7

Задача №2



$$\text{pH} = 11$$

$$\text{pH} + \text{pOH} = 14$$

$$\text{pOH} = 3$$

$$[\text{OH}^-] = 10^{-\text{pOH}} = 10^{-3}$$

$$K_m = \frac{[\text{C}_6\text{H}_5\text{OH}][\text{OH}^-]}{[\text{C}_6\text{H}_5\text{O}^-]} \cdot \frac{[\text{H}^+]}{[\text{OH}^-]} = \frac{K_w}{K_{\text{OH}}}$$
$$= \frac{10^{-14}}{10^{-10}} = 10^{-4}$$

$$K_m = \frac{[\text{C}_6\text{H}_5\text{OH}][\text{OH}^-]}{[\text{C}_6\text{H}_5\text{O}^-]} = \frac{[\text{OH}^-]^2}{c_{\text{OH}^-}}$$

$$[\text{OH}^-] = [\text{C}_6\text{H}_5\text{OH}]$$

$$\frac{(10^{-3})^2}{c_{\text{OH}^-} - 10^{-3}} = 10^{-4}$$

$$c_{\text{OH}^-} - 10^{-3} = 10^{-2}$$

$$c_{\text{OH}^-} = 10^{-2} + 10^{-3}$$

$$c_{\text{OH}^-} = \underline{\underline{0,011 \text{ моль/л}}}$$

Условие 6 ц 7

Задача №1

$$42 e^- \quad 32 n$$

12^C

16^O

$1H$

$$M = p + n = 42 + 32 = 74 \text{ /моль}$$

$$N(p) = N(e^-)$$

$6^C \quad 8^O \quad 1H$

$6e^- \quad 8e^- \quad 1e^-$

$$C_x H_y O_z \quad M(C_x H_y O_z) = 12x + y = 162$$

$$6x + y + 8z = 42$$

$$12x + y + 16z = 74$$

1 уравнение умножаем на 2 и от него вычитаем
2 уравнение

$$y = 10$$

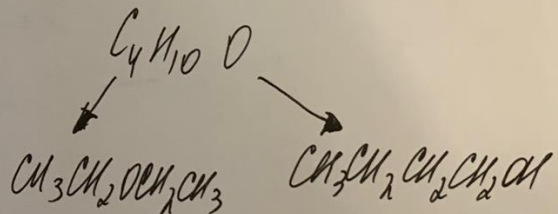
$$6x + 10 + 8z = 42$$

$$6x + 8z = 32$$

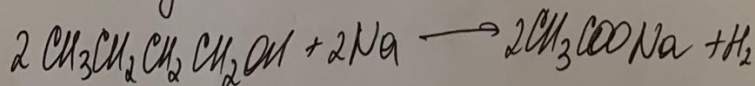
$$z_1 = 1 \quad x = 4$$

$$z_2 = 2 \quad x = \frac{16}{8}$$

$$z_3 = 3 \quad x = \frac{8}{6}$$



Реакция:



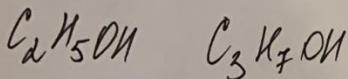
Числовое 7 из 7

Задача №4 (процентная)

Массовые доли:

$$m(\text{сиртов}) = 15,92$$

$$n = 0,3 \text{ моль}$$



$$46$$

$$60$$

$$\frac{X \cdot 46 + (0,3 - X) \cdot 60}{0,3} = 53$$

$$46X + 18 - 60X = 15,9$$

$$14X = 2,1$$

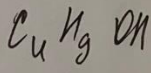
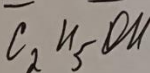
$$X = 0,15$$

$$m(C_2H_5OH) = 0,15 \cdot 46 = 6,92$$

$$m(C_3H_7OH) = 9,2$$

$$W(C_2H_5OH) = \frac{6,9}{15,9} \cdot 100\% = 43,4\%$$

$$W(C_3H_7OH) = 56,6\%$$



$$46$$

$$74$$

$$X$$

$$0,3 - X$$

$$46X + (0,3 - X) \cdot 74 = 15,9$$

$$46X + 22,2 - 74X = 15,9$$

$$28X = 6,3$$

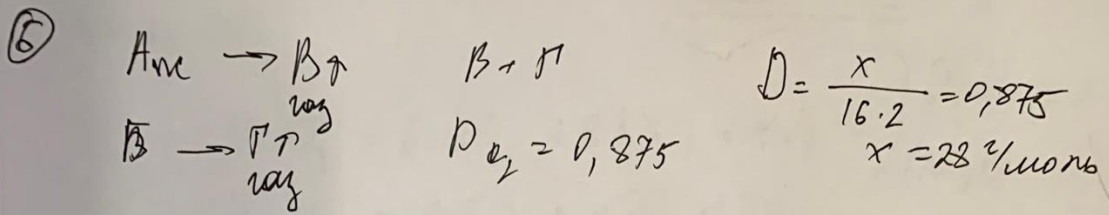
$$X = 0,225$$

$$m(C_2H_5OH) = 0,225 \cdot 46 = 10,352$$

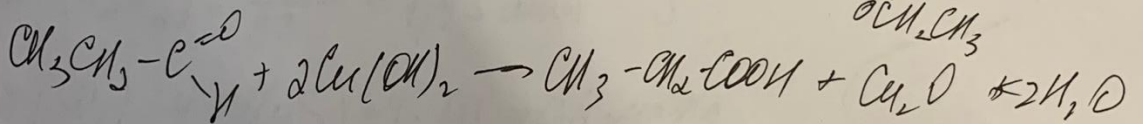
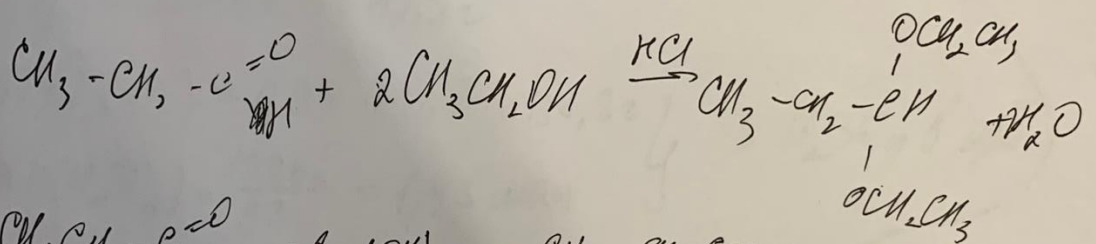
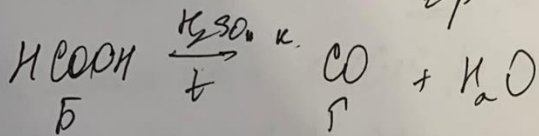
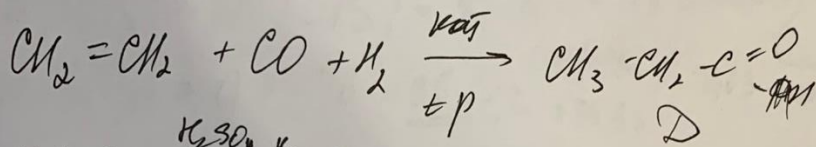
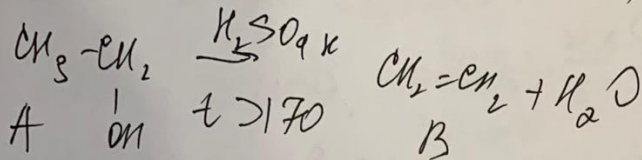
$$m(C_4H_9OH) = 5,552$$

$$W(C_2H_5OH) = \frac{10,35}{15,9} \cdot 100\% = \underline{\underline{65,1\%}}$$

$$W(C_4H_9OH) = \underline{\underline{34,9\%}}$$



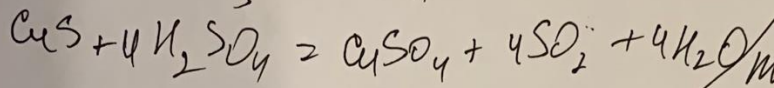
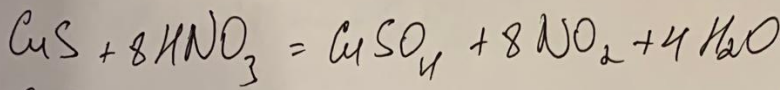
$M = 28 \text{ \% моль}$ (газы $\Rightarrow \text{CO}, \text{C}_2\text{H}_4, \text{N}_2$) \leftarrow возможно



$$n(\text{Cu}_2\text{O}) = \frac{21,6}{144} = 0,15 \text{ моль}$$

$$n(\text{CH}_3\text{-CH}_2\text{-C}(=\text{O})) = 0,15 \cdot 58 = \underline{\underline{8,72}}$$

Задача 15



Пусть n
 $(\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}) = x$

тогда $n(\text{CO}_2) = 0,5x$

$$m(\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}) = 286x$$

$$m(\text{CO}_2) = 22x$$

$$286x - 22x = 33,9$$

$$264x = 33,9$$

$$x = 0,1284$$

$$m(\text{Na}_2\text{CO}_3) =$$

$$0,1284 \cdot 286$$

$$= 36,72$$

$$n(\text{CuS}) = \frac{9,6}{96} = 0,1 \text{ моль}$$

$$m(\text{HNO}_3) \text{ в моль} \quad n(\text{HNO}_3) = \frac{75,6}{63} = 1,2 \text{ моль}$$

$$n(\text{NO}_2) = 8n(\text{CuS}) = 8 \cdot 0,1 = 0,8 \text{ моль}$$

$$m(\text{NO}_2) = 98 \cdot 0,8 = 78,4 \text{ г}$$

$$m(\text{HNO}_3) = 0,63 \cdot 120 = 75,6$$

$$m_1 \text{ смеси} = m(\text{CuS}) + m_p(\text{HNO}_3) - m(\text{NO}_2) = 9,6 + 120 - 36,8 = 92,8$$

$$= 9,6 + 120 - 36,8 = 92,8$$

$$m(\text{H}_2\text{SO}_4) = 0,98 \cdot 142,7 = 139,82$$

$$n(\text{H}_2\text{SO}_4) = \frac{139,82}{98} = 1,43 \text{ моль}$$

$\Rightarrow \text{H}_2\text{SO}_4 \text{ в моль}$

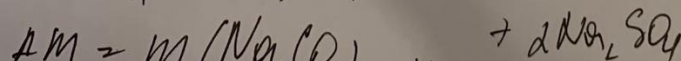
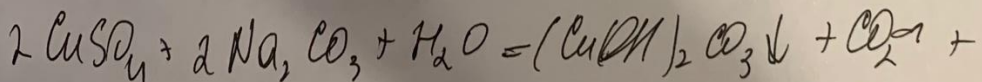
$$n(\text{SO}_2) = 4 \cdot n(\text{CuS}) = 4 \cdot 0,1 = 0,4 \text{ моль}$$

$$m(\text{SO}_2) = 0,4 \cdot 64 = 25,6$$

$$m_{2\text{см}} = m(\text{CuS}) + m_p(\text{H}_2\text{SO}_4) - m(\text{SO}_2) = 9,6 + 142,7 -$$

$$- 25,6 = 126,7$$

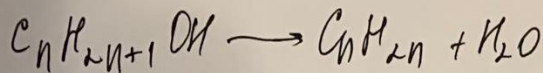
$$\Delta m = m_{2\text{см}} - m_{1\text{см}} = 126,7 - 92,8 = 33,9 \text{ г}$$



$$\Delta m = m(\text{Na}_2\text{CO}_3 + 10\text{H}_2\text{O}) - m(\text{CO}_2)$$

Черновик 3 из 7

Задача №4



$$M(\text{смеси}) = 15,92$$

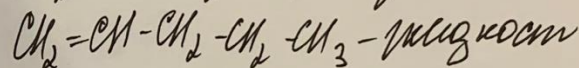
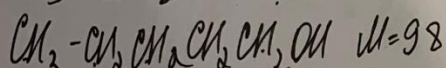
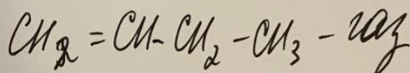
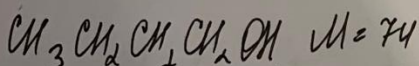
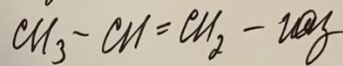
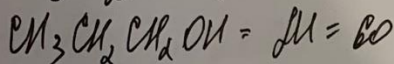
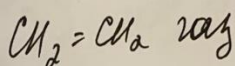
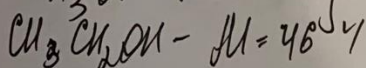
$$PV = nRT$$

$$n(\text{газов}) = \frac{PV}{R \cdot T} = \frac{101,3 \cdot 11,15}{8,31 \cdot 453} = 0,3 \text{ моль}$$

$$M_{cp}(\text{средней}) = \frac{m}{n} = \frac{15,92}{0,3} = 53,2 / \text{моль}$$

Перебор:

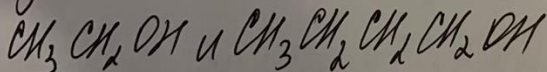
$C_n H_{2n+1} OH$ - не вступает во внутримолекулярную дегидратацию



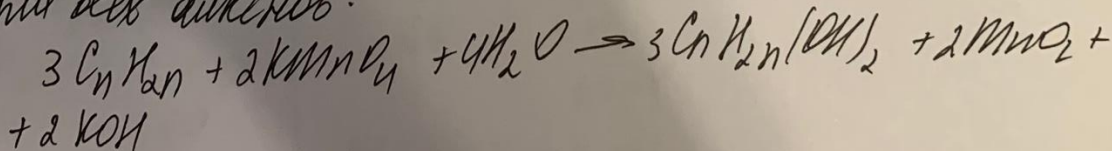
$$M_{mix} < M_{cp} < M_{max}$$

$$C_3 H_7 OH \quad 46 < 53 < 60 \text{ или } 74$$

Возможный состав $C_3 H_7 OH$ и $C_4 H_9 OH$ / или



Реакция алкенов с $KMnO_4$ протекает одинаково для всех алкенов:



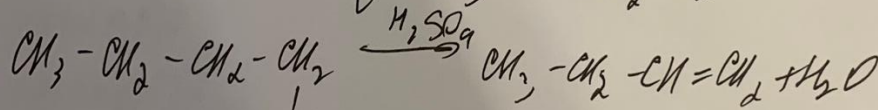
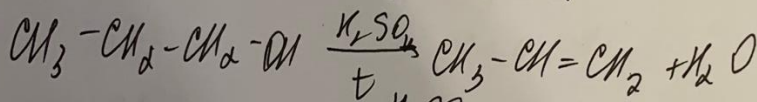
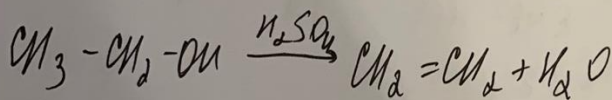
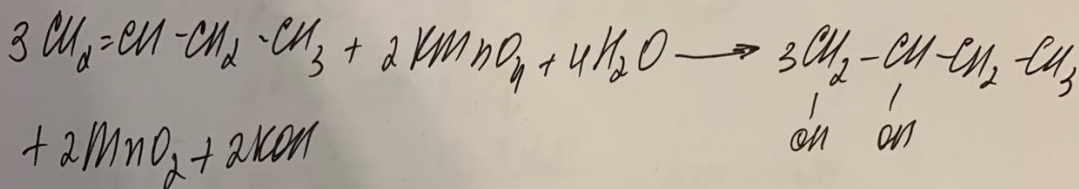
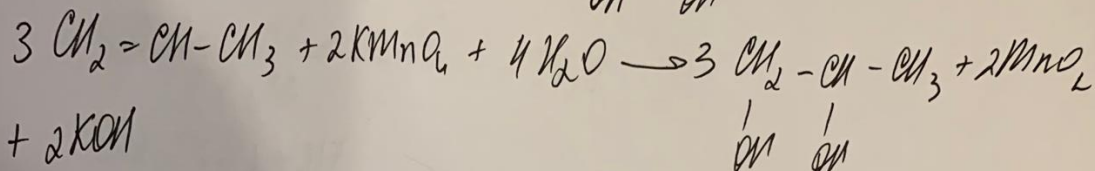
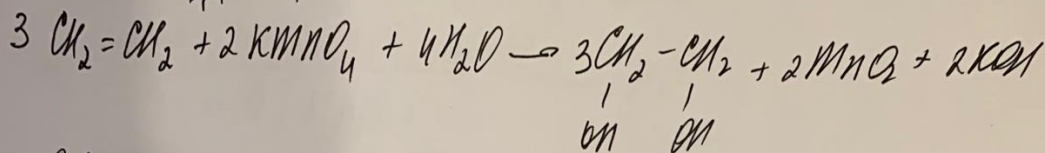
$$n(C_n H_{2n}) = 0,3 \text{ моль}$$

$$n(KMnO_4) = 0,2 \text{ моль}$$

Черновик 4 из 7

$$e(\text{KMnO}_4) = \frac{n}{V_p}$$

$$V_p = \frac{n}{c} = \frac{0,2}{0,4} = 0,5 \text{ л}$$

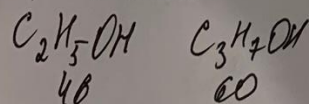


$$w(\text{C}_2\text{H}_5\text{OH}) = \frac{6,9}{15,9} \cdot 100\% = 43,4\%$$

Массовые доли:

$$m(\text{смешан}) = 15,92$$

$$n_1 = 0,3 \text{ моля}$$



$$\frac{x \cdot 46 + (0,3 - x) \cdot 60}{0,3} = 53$$

$$46x + 18 - 60x = 15,9$$

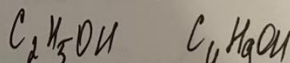
$$14x = 2,1$$

$$x = 0,15$$

$$m(\text{C}_2\text{H}_5\text{OH}) = 0,15 \cdot 46 = 6,9 \text{ г}$$

$$m(\text{C}_3\text{H}_7\text{OH}) = 9,0$$

$$w(\text{C}_3\text{H}_7\text{OH}) = 56,6\%$$



$$x$$

$$0,3 - x$$

$$46x + (0,3 - x) \cdot 74 = 15,9$$

$$46x + 22,2 - 74x = 15,9$$

$$28x = 6,3$$

$$x = 0,225$$

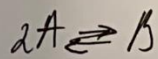
$$m(\text{C}_2\text{H}_5\text{OH}) = 0,225 \cdot 46 = 10,35 \text{ г}$$

$$m(\text{C}_4\text{H}_9\text{OH}) = 5,55 \text{ г}$$

$$w(\text{C}_4\text{H}_9\text{OH}) = 43,5\%$$

$$w(\text{C}_2\text{H}_5\text{OH}) = \frac{10,35}{15,9} \cdot 100\% = 65,1\%$$

103



Термобокс 5 м³ F

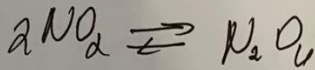
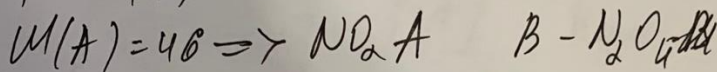
B - газ, значит $M(B) = 2M(A)$

Пусть $n(A) = 1$ моль, $n(B) = 1,86$ моль

$$M_{\text{ср}} = \frac{n(A) \cdot M(A) + n(B) \cdot M(B)}{n(A) + n(B)} = 75,9$$

$$\frac{1 \cdot M(A) + 1,86 \cdot 2 \cdot M(A)}{1 + 1,86} = 75,9$$

$$4,72 M(A) = 217$$



$$PV = nRT \quad n = \frac{PV}{RT} = \frac{101,3 \cdot 1,0}{8,31 \cdot 303} = 0,04 \text{ моль}$$

$$n(A) = x$$

$$x + 1,86x = 0,04 \text{ моль}$$

$$n(B) = 1,86x$$

$$x = 0,014$$

$$n(A) = 0,014$$

$$n(B) = 0,026$$

$$[A] = \frac{0,014}{1} = 0,014 \text{ моль/л}$$

$$[B] = \frac{0,026}{1} = 0,026 \text{ моль/л}$$

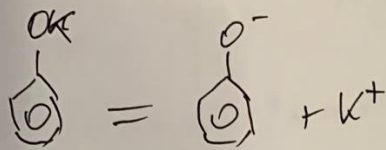
$$K_p = \frac{[B]}{[A]^2} = \frac{0,026}{0,014^2} = 132,7$$

$$K_p = \frac{K_{\text{кр}}}{K_{\text{ср}}}$$

$$K_{\text{ср}} = \frac{K_{\text{кр}}}{K_p} = \frac{5,00 \cdot 10^{-3}}{132,7} = 3,77 \cdot 10^{-5} \text{ л/моль}$$

Черновик 6 из 7

②



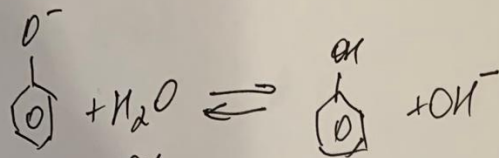
$$pK = 11$$

$$pK + pOH = 14$$

$$pOH = 3$$

$$pOH = 3$$

$$[OH^-] = 10^{-pOH} = 10^{-3}$$



$$K_p = \frac{[\text{C}_6\text{H}_5\text{OH}][\text{OH}^-]}{[\text{C}_6\text{H}_5\text{O}^-]} \cdot \frac{[\text{H}^+]}{[\text{H}^+]} = \frac{K_w}{K_{\text{дис}}} = \frac{10^{-14}}{10^{-10}} = 10^{-4}$$

$$K_p = \frac{[\text{C}_6\text{H}_5\text{OH}][\text{OH}^-]}{[\text{C}_6\text{H}_5\text{O}^-]} = \frac{[\text{OH}^-]^2}{C_{\text{соль}} - [\text{OH}^-]}$$

$$[\text{OH}^-] = [\text{C}_6\text{H}_5\text{OH}]$$

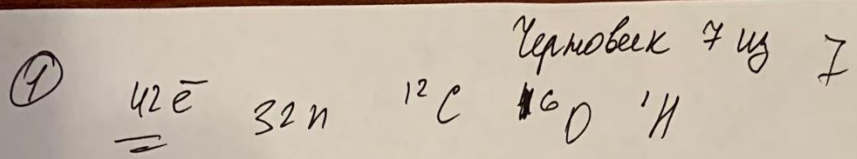
$$[\text{C}_6\text{H}_5\text{O}^-] = C_{\text{соль}} - [\text{OH}^-]$$

$$\frac{(10^{-3})^2}{C_{\text{соль}} - 10^{-3}} = 10^{-4}$$

$$C_{\text{соль}} - 10^{-3} = 10^{-2}$$

$$C_{\text{соль}} = 10^{-2} + 10^{-3}$$

$$C_{\text{соль}} = \underline{0,011 \text{ моль/л}}$$



$M = p + n = 42 + 32 = 74$ число

$N(p) = N(e)$

6^C	$8O_2$	$1H$
$6e$	$8e$	$1e$

$C_x H_y O_z \quad M(C_x H_y O_z) = 12x + y + 16z$

$6x + y + 8z = 42$

$12x + y + 16z = 74$

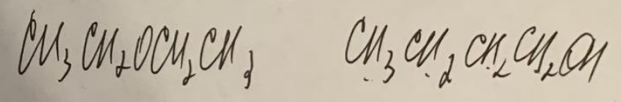
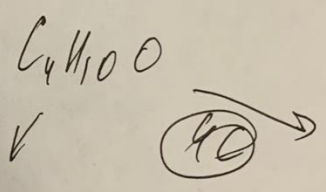
1 ур-ня уменьшаем на 2 и от него вычитаем 2 уравнения

$y = 10$

$6x + 10 + 8z = 42$

$6x + 8z = 32$

- $Z_1 = 1 \quad x = 4$
- $Z_2 = 2 \quad x = \frac{16}{8}$
- $Z_3 = 3 \quad x = \frac{6}{6}$



Реакция:

