



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

Вариант _____

Место проведения Красноярск
город

ПИСЬМЕННАЯ РАБОТА

Олимпиада школьников Ломоносов 2024
наименование олимпиады

по химии
профиль олимпиады

Ахметовой Екатерины Михайловны
фамилия, имя, отчество участника (в родительном падеже)

Дата
« 3 » марта 2024 года

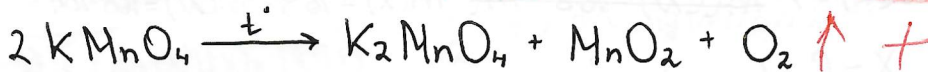
Подпись участника
Ахметова

71-36-99-88
(64.2)

Чистовик

Задание 1

1	2	3	4	5	6	7	Σ
4	8	12	15	16	6	21	82

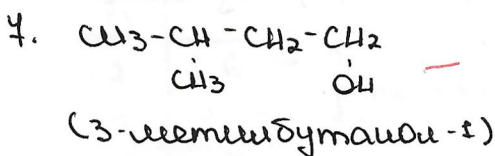
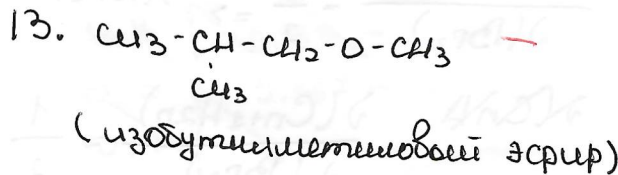
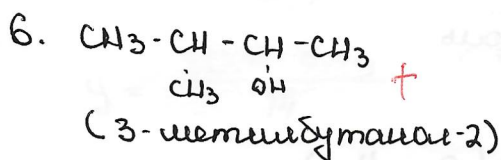
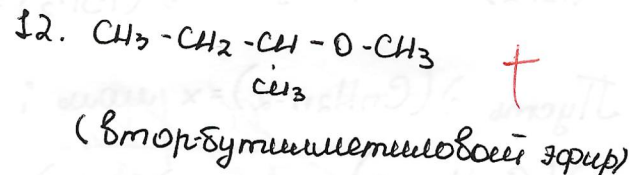
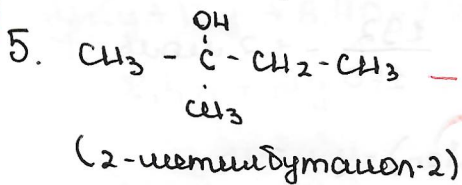
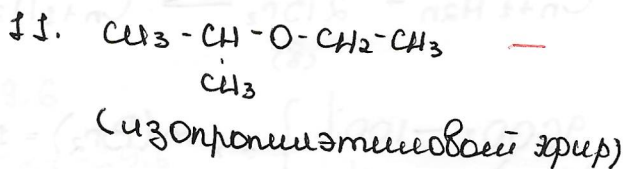
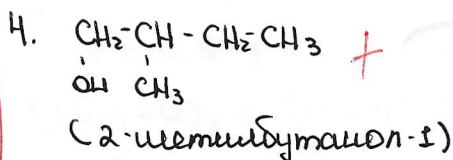
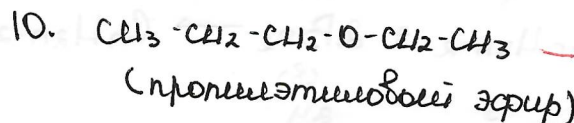
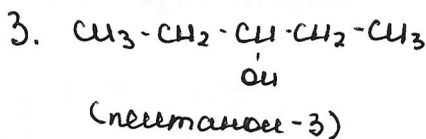
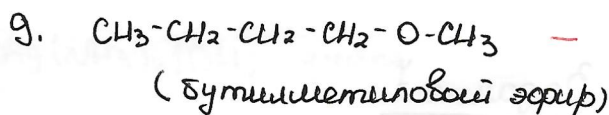
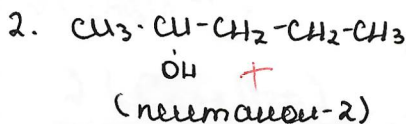
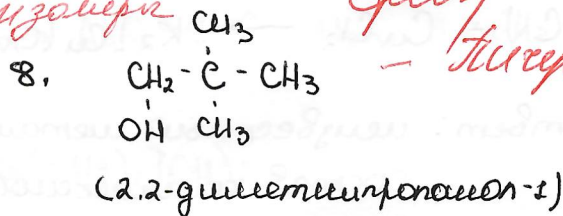
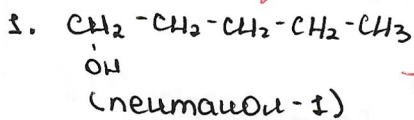


Задание 2

Изомеры:

В задании требовалось привести оптич. изомеры

*Борзенко
Женя
- Писарен*



14.

Задание 3



$w(\text{X}) = 38,1\% \Rightarrow w(\text{лиганда}) = 100 - w(\text{X}) = 100 - 38,1 = 61,9\%$

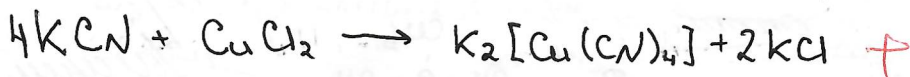
$w(\text{лиганда}) = \frac{m(\text{CN})}{m(\text{CN}) + m(\text{X})} \cdot 100 \Rightarrow 0,619 = \frac{26,4}{M(\text{частицы})}$

1

$$M(\text{гастцыцы}) = \frac{m(\text{CN})}{\omega(\text{Лиганда})} = \frac{104}{0,619} = 168 \text{ г/моль}$$

$$168 = m(\text{CN}) + m(\text{X}) \Rightarrow m(\text{CN}) = 168 - m(\text{X}) \quad M(\text{X}) = 168 - m(\text{CN}) = 168 - 104 = 64 \text{ г/моль} \Rightarrow \text{X} - \text{Cu} (\text{шөгө}) +$$

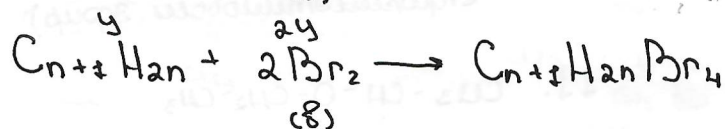
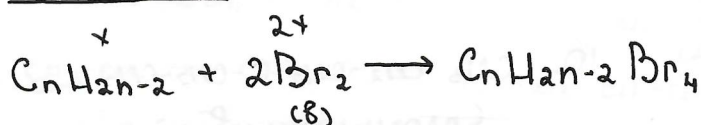
состав комплексной гастцыцы: $[\text{Cu}(\text{CN})_4]^{2-}$ +



Ответ: неизвестный металл - Cu (шөгө)

состав комплексной гастцыцы: $[\text{Cu}(\text{CN})_4]^{2-}$
заряд: 2-

Задача 4



$$\left. \begin{array}{l} 9600\% - 100\% \\ m(\text{Br}_2) - 2\% \end{array} \right\} \Rightarrow m(\text{Br}_2) = 192 \text{ г} \\ \nu(\text{Br}_2) = \frac{m}{M} = \frac{192}{160} = 1,2 \text{ моль} +$$

Пусть $\nu(\text{C}_n\text{H}_{2n-2}) = x$ моль; $\nu(\text{C}_{n+1}\text{H}_{2n}) = y$ моль

$$\frac{\nu(\text{C}_n\text{H}_{2n-2})}{\nu(\text{Br}_2)} = \frac{1}{2} \Rightarrow \nu(\text{Br}_2) = 2x \text{ моль}$$

$$\frac{\nu(\text{C}_{n+1}\text{H}_{2n})}{\nu(\text{Br}_2)} = \frac{1}{2} \Rightarrow \nu(\text{C}_{n+1}\text{H}_{2n}) = 2y \text{ моль}$$

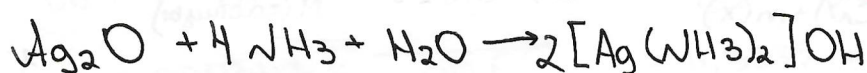
$$2x + 2y = 1,2$$

$$29,6 = m(\text{C}_n\text{H}_{2n-2}) + m(\text{C}_{n+1}\text{H}_{2n})$$

$$m(\text{C}_n\text{H}_{2n-2}) = (14n-2)x \text{ г}$$

$$m(\text{C}_{n+1}\text{H}_{2n}) = (14n+12)y \text{ г}$$

$$(14n+12)y + (14n-2)x = 29,6$$

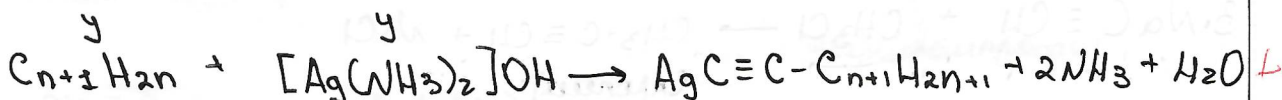
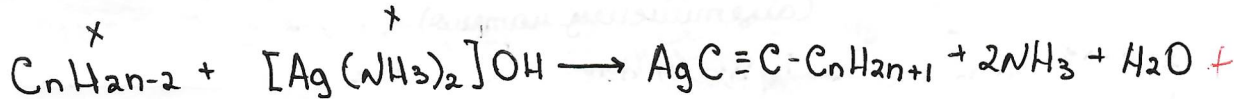


2

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(64.2)

$$\nu(\text{Ag}_2\text{O}) = \frac{m}{M} = \frac{69.6}{232} = 0.3 \text{ моль}$$

$$\frac{\nu(\text{Ag}_2\text{O})}{\nu([\text{Ag}(\text{NH}_3)_2]\text{OH})} = \frac{1}{2} \Rightarrow \nu([\text{Ag}(\text{NH}_3)_2]\text{OH}) = 0.6 \text{ моль}$$



$$\frac{\nu(\text{C}_n\text{H}_{2n-2})}{\nu([\text{Ag}(\text{NH}_3)_2]\text{OH})} = \frac{1}{1} \Rightarrow \nu([\text{Ag}(\text{NH}_3)_2]\text{OH}) = x \text{ моль}$$

$$\frac{\nu(\text{C}_{n+1}\text{H}_{2n})}{\nu([\text{Ag}(\text{NH}_3)_2]\text{OH})} = \frac{1}{1} \Rightarrow \nu([\text{Ag}(\text{NH}_3)_2]\text{OH}) = y \text{ моль}$$

$$\begin{cases} x + y = 0.6 \\ (14n + 12)y + (14n - 2)x = 29.6 \end{cases}$$

$$x = 0.6 - y$$

$$(14n + 12)y + (0.6 - y)(14n - 2) = 29.6$$

$$14ny + 12y + 8.4n - 1.2 - 14ny + 2y = 29.6$$

$$8.4n + 14y = 30.8$$

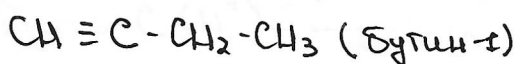
$$n = \frac{30.8 - 14y}{8.4}$$

$$y = \frac{30.8 - 8.4n}{14}$$

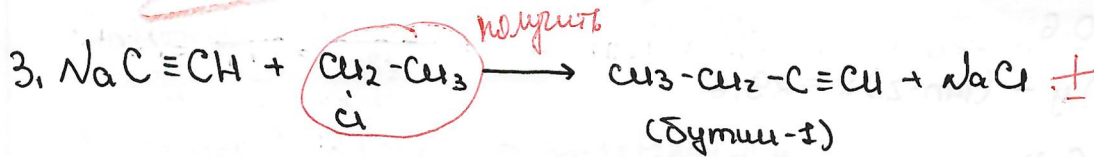
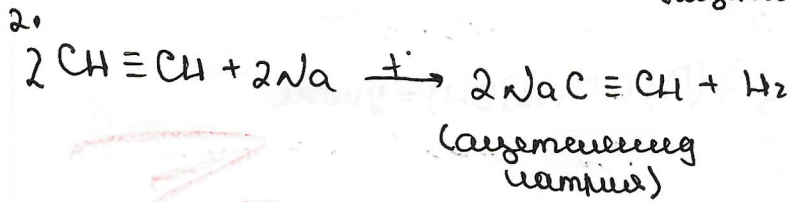
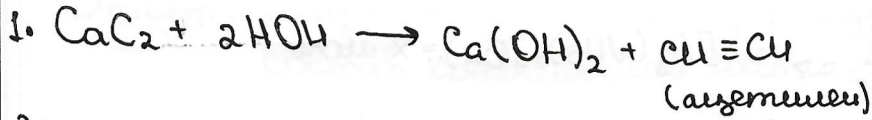
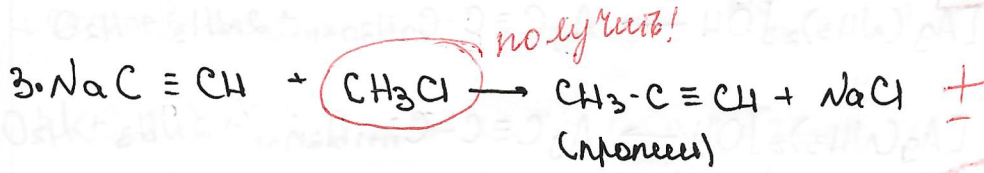
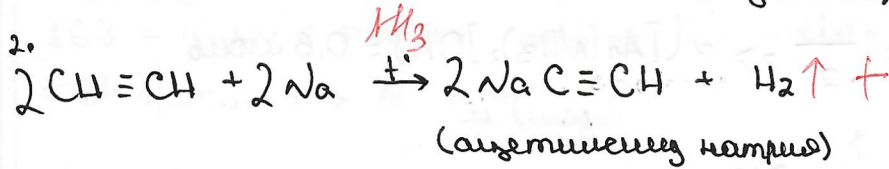
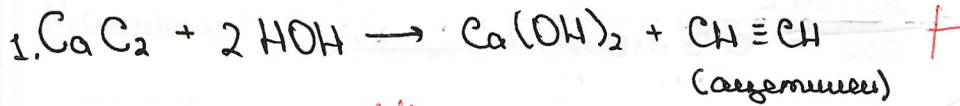
n	y
1	3.6 -
2	1 -
3	0.4 +
4	-0.2 -

} мк $x + y = 0.6$

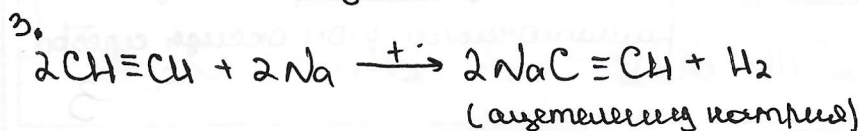
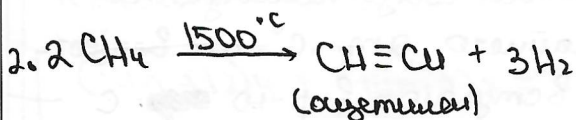
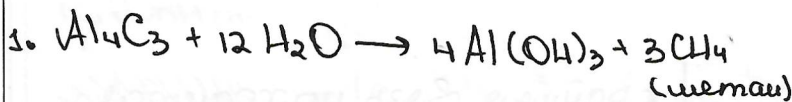
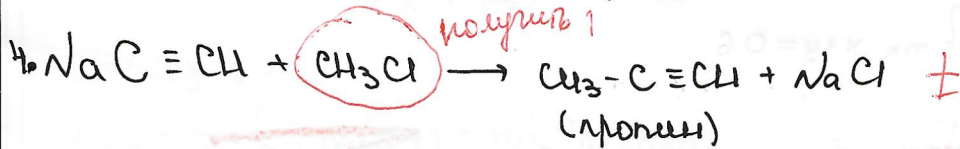
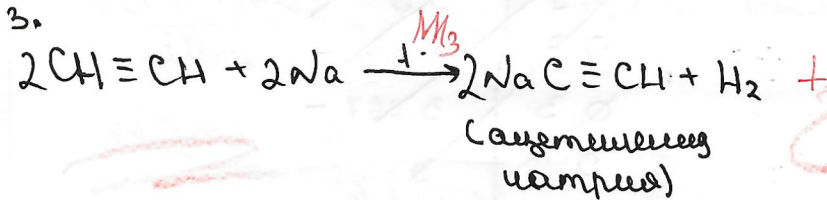
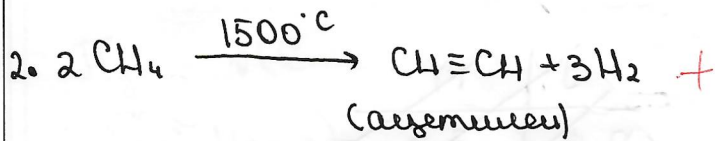
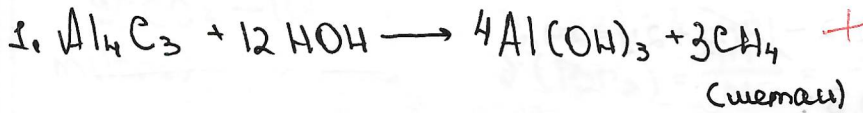
y	n
0.1	3.5
0.2	3.333 -
0.3	3.167 -
0.4	3



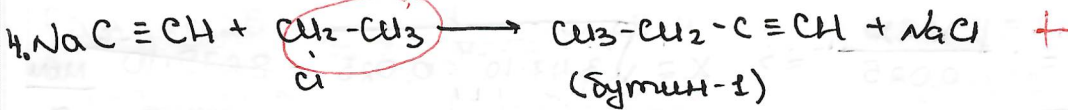
крайняя связь находится у крайнего ат. "С", тк вещество вступает в р-ю с аммиачным р-ом оксида серебра.



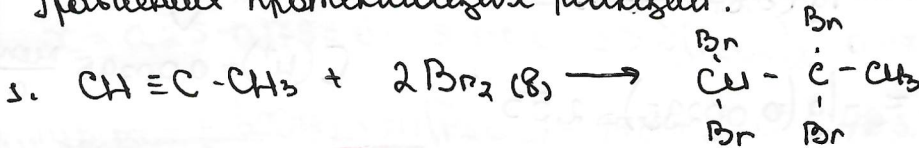
из карбида алюминия:



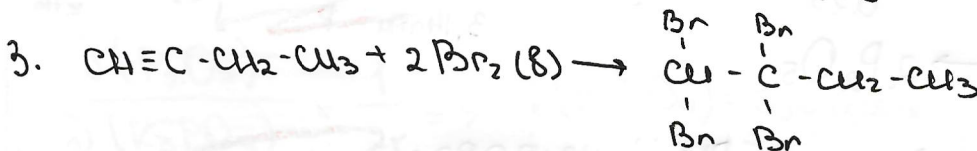
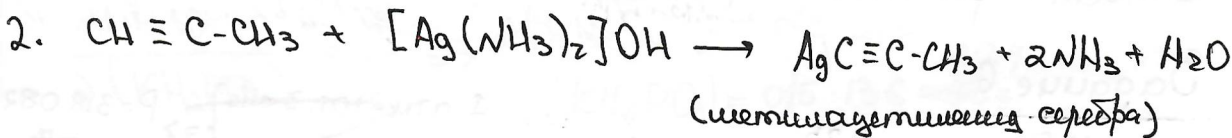
получить



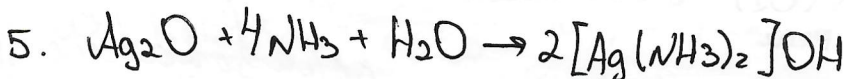
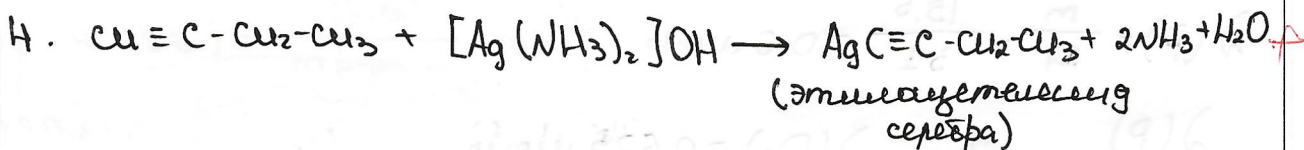
Уравнения протекающих реакций:



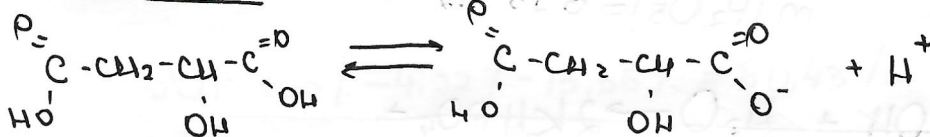
(1,1,2,2-тетрабромпропан)



(1,1,2,2-тетрабромбутан)



Задача 4



$$K_1 = \frac{[\text{H}^+] \cdot [\text{HO}-\text{C}(\text{R})-\text{CH}_2-\text{CH}(\text{OH})-\text{C}(=\text{O})\text{O}^-]}{[\text{HO}-\text{C}(\text{R})-\text{CH}_2-\text{CH}(\text{OH})-\text{C}(=\text{O})\text{OH}]}$$

$$\lambda(\text{кислоты}) = \frac{m}{M} = \frac{0.67}{134} = 0.005 \text{ моль}$$

$$C = \frac{\lambda}{V} \Rightarrow C(\text{кислоты}) = \frac{0.005}{0.2} = 0.025 \text{ моль/л}$$

1 л = 1000 мл => 200 мл = 0.2 л

Пусть $C(\text{H}^+) = x \text{ моль/л} \Rightarrow$

$$\Rightarrow \frac{\lambda(\text{H}^+)}{\lambda(\text{HO}-\text{C}(\text{R})-\text{CH}_2-\text{CH}(\text{OH})-\text{C}(=\text{O})\text{O}^-)} = \frac{1}{1} \Rightarrow \text{их кол-ва равны, и concentra-ция также равны, тк объемы одинаковы (200 мл)}$$

$$3,47 \cdot 10^{-4} = \frac{x \cdot x}{0,025} \Rightarrow x = \sqrt{3,47 \cdot 10^{-4} \cdot 0,025} = 8,675 \cdot 10^{-6} \frac{\text{моль}}{\text{л}}$$

~~$$\text{pH} = -\lg [H^+] = -\lg(8,675 \cdot 10^{-6})$$~~

$$0,00295$$

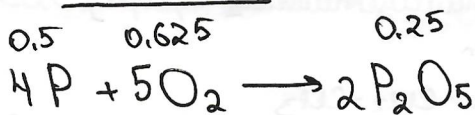
$$C(H^+) = 0,00295 \frac{\text{моль}}{\text{л}}$$

$$\text{pH} = -\lg [H^+] = -\lg(0,00295) = 2,53$$

Ответ: pH = 2,53

мет объяснения, почему при расчёте $C_{H^+} = [Cu^{2+}]$ ← равновесная конц. K_{sp}

Задача 6



$$\left. \begin{array}{l} 1 \text{ атм} = 101,3 \text{ кПа} \\ 3,14 \text{ атм} = P \end{array} \right\} \Rightarrow P = 318,082 \text{ кПа}$$

$$PV = R\nu T \Rightarrow \nu(O_2) = \frac{PV}{RT} = \frac{318,082 \cdot 7}{8,314 \cdot (25+273)} = 0,9 \text{ моль} \quad +$$

(избыток)

$$\nu(P) = \frac{m}{M} = \frac{15,5}{31} = 0,5 \text{ моль} \quad +$$

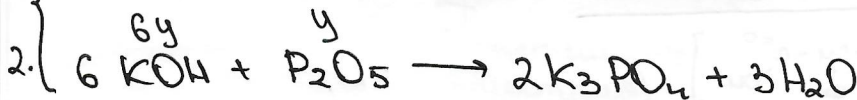
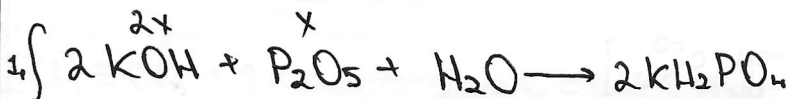
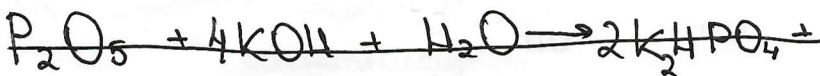
$$\frac{\nu(P)}{\nu(O_2)} = \frac{4}{5} \Rightarrow \nu(O_2) = 0,625 \text{ моль}$$

реак

не учитывается образование P_2O_3 !

$$\frac{\nu(P)}{\nu(P_2O_5)} = \frac{4}{2} \Rightarrow \nu(P_2O_5) = 0,25 \text{ моль}$$

$$m(P_2O_5) = 0,25 \cdot 142 = 35,5 \text{ г}$$



$$\left. \begin{array}{l} 448 - 100\% \\ m(KOH) - 15\% \end{array} \right\} \Rightarrow \begin{array}{l} m(KOH) = 67,2 \text{ г} \\ \nu(KOH) = 67,2 / 56 = 1,2 \text{ моль} \end{array}$$

Пусть $\nu(KOH)_1 = 2x$ моль ; $\nu(KOH)_2 = 6y$ моль

$$\frac{\nu(KOH)_1}{\nu(P_2O_5)_1} = \frac{2}{1} \Rightarrow \nu(P_2O_5)_1 = x \text{ моль} \quad \left| \quad \frac{\nu(KOH)_2}{\nu(P_2O_5)_2} = \frac{6}{1} \Rightarrow \nu(P_2O_5)_2 = y \text{ моль}$$

$$\begin{cases} x+y=0,25 \\ 2x+6y=1,2 \end{cases} \Rightarrow \begin{cases} x=0,25-y \\ x=\frac{1,2-6y}{2} \end{cases} \Rightarrow \begin{cases} 0,25-y=0,6-3y \\ 2y=0,35 \\ y=0,175 \text{ моль} \end{cases}$$

$$x=0,25-0,175=0,075 \text{ моль} \Rightarrow \nu(\text{P}_2\text{O}_5)_1=0,075 \text{ моль}; \nu(\text{P}_2\text{O}_5)_2=0,175 \text{ моль}$$

$$m_{\text{р-ра}} = m(\text{KOH})_{\text{р-р}} + m(\text{P}_2\text{O}_5) = 448 + 35,5 = 483,5 \text{ г}$$

$$\frac{\nu(\text{P}_2\text{O}_5)}{\nu(\text{KH}_2\text{PO}_4)} = \frac{1}{2} \Rightarrow \nu(\text{KH}_2\text{PO}_4) = 0,15 \text{ моль} \quad 20,4$$

$$m(\text{KH}_2\text{PO}_4) = 0,15 \cdot 136 = 20,4 \text{ г}$$

$$\frac{\nu(\text{P}_2\text{O}_5)}{\nu(\text{K}_3\text{PO}_4)} = \frac{1}{2} \Rightarrow \nu(\text{K}_3\text{PO}_4) = 0,35 \text{ моль}$$

$$m(\text{K}_3\text{PO}_4) = 0,35 \cdot 212 = 74,2 \text{ г}$$

$$\omega(\text{р-ра}) = \frac{m(\text{р-ра})}{m_{\text{р-ра}}} \cdot 100\%$$

$$\omega(\text{KH}_2\text{PO}_4) = \frac{20,4}{483,5} \cdot 100\% = 4,22\%$$

$$\omega(\text{K}_3\text{PO}_4) = \frac{74,2}{483,5} \cdot 100\% = 15,35\%$$

$$\omega(\text{H}_2\text{O}) = 100\% - 4,22\% - 15,35\% = 80,43\%$$

Ответ: $\omega(\text{KH}_2\text{PO}_4) = 4,22\%$; $\omega(\text{K}_3\text{PO}_4) = 15,35\%$; $\omega(\text{H}_2\text{O}) = 80,43\%$

Задача 5

$$C_1 V_1 = C_2 V_2$$

$$C_2 = 0,05 \text{ моль/л}$$

(NaOH)

$$V_2(\text{NaOH}) = 4 \text{ мл}$$

$$V_1(\text{HCl}) = 20 \text{ мл}$$

$$C_1(\text{HCl}) = ?$$

$$\text{Пусть } C_1(\text{HCl}) = x \text{ моль/л}$$

$$20x = 0,05 \cdot 4$$

$$x = 0,01 \text{ моль/л}$$

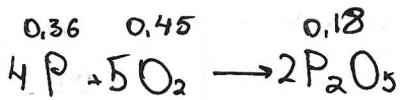
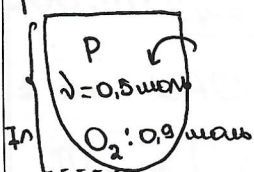
$$\left. \begin{array}{l} 200 \text{ мл (p-p HCl)} = 0,2 \text{ л} \\ 4 \text{ мл (HCl к)} = 0,004 \text{ л} \end{array} \right\} \Rightarrow C \cdot V (\text{p-p HCl}) = C \cdot V (\text{HCl к}) +$$

$$0,2 \cdot 0,02 = 0,004y \Rightarrow y = 2 \text{ моль/л}$$

Пусть $C (\text{HCl к}) = y \text{ моль/л}$

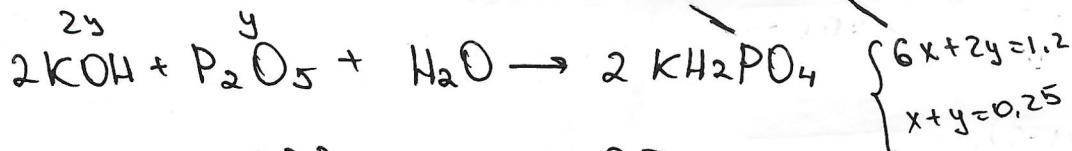
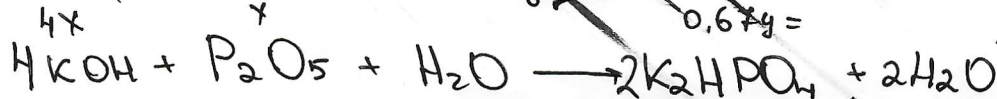
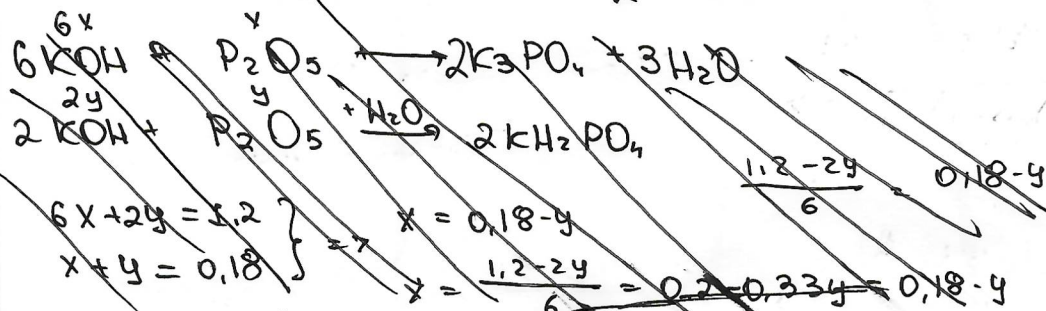
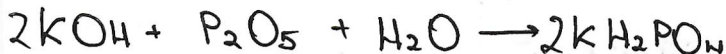
Ответ: $C (\text{HCl к})_{\text{исход.}} = 2 \text{ моль/л}$ +

Чертовик

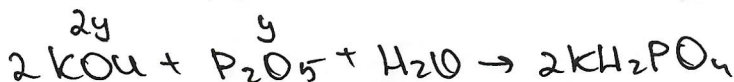
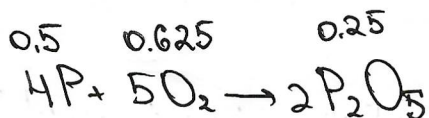


$$\left. \begin{array}{l} n(O_2)_{\text{пер}} = 0,9 \text{ моль} \\ n(O_2)_{\text{ост}} = 0,45 \text{ моль} \end{array} \right\} \Rightarrow n(O_2)_{\text{реак}} = 0,45 \text{ моль}$$

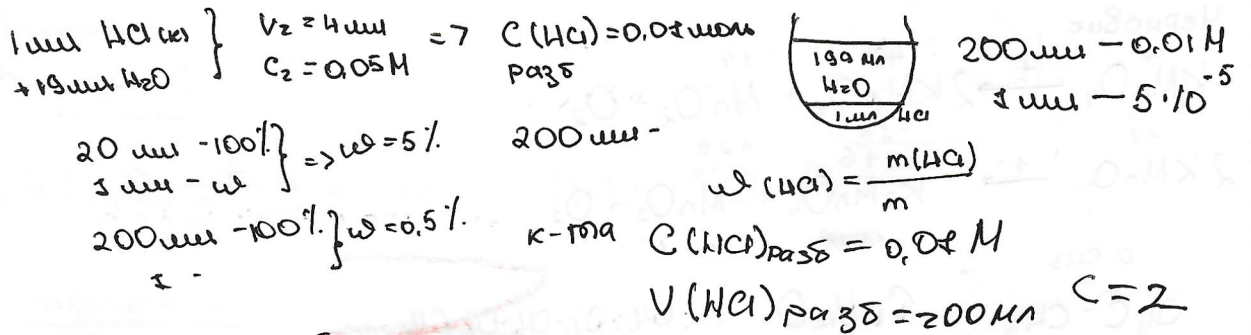
$$n(P)_{\text{ост}} = 0,5 - 0,36 = 0,14 \text{ моль}$$



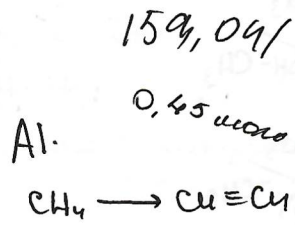
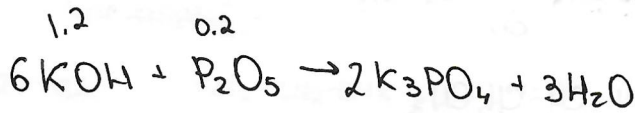
$$\left. \begin{array}{l} 4x + 2y = 1,2 \\ x + y = 0,25 \end{array} \right\} \Rightarrow \left. \begin{array}{l} x = 0,3 - 0,5y \\ 0,3 - 0,5y = 0,25 - y \\ -0,5y + y = 0,18 - 0,3 \end{array} \right\} \Rightarrow \left. \begin{array}{l} 0,667y = 0,05 \\ y = 0,075 \\ x = 0,175 \end{array} \right\}$$



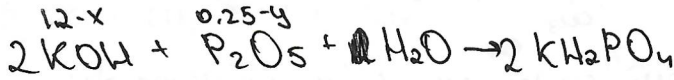
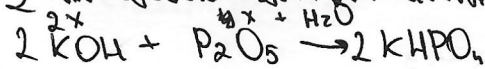
$$\left. \begin{array}{l} 6x + 2y = 1,2 \\ x + y = 0,25 \end{array} \right\} \Rightarrow \left. \begin{array}{l} x = 0,2 - 0,6y \\ y = 0,25 - y \\ -0,6y + y = 0,25 - 0,2 \end{array} \right\} \Rightarrow \left. \begin{array}{l} 0,4y = 0,05 \\ y = 0,125 \\ x = 0,125 \end{array} \right\}$$



$\Delta(\text{O}_2) = \frac{PV}{RT} = \frac{318,082 \cdot \cancel{10^5}}{298 \cdot 8,314} = 0,899 \text{ моль}$



~~2 KOH + P2O5 + H2O -> 2 KHPO4~~



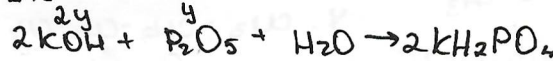
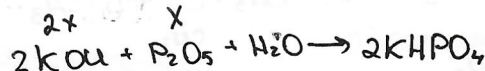
$P = 159,04$

$[\text{H}^+] = \sqrt{K \cdot [\text{к-та}]}$

$3,47 \cdot 10^{-4} \cdot 0,25$

$[\text{H}^+] = 0,0093$

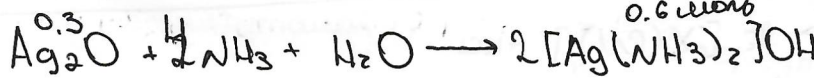
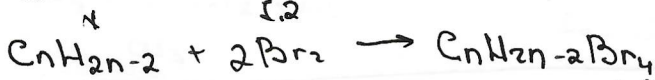
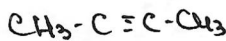
~~0,25 + x + y = 1,2~~



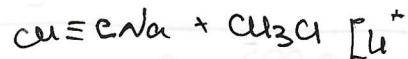
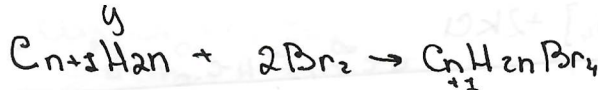
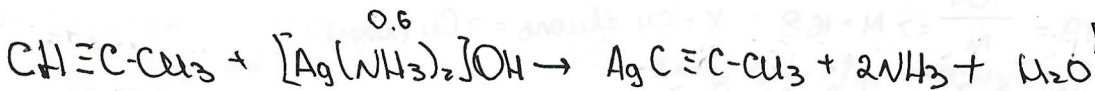
$\left. \begin{array}{l} 2x + 2y = 1,2 \\ x + y = 0,25 \end{array} \right\} \Rightarrow \begin{array}{l} x = 0,6 - y \\ x = 0,25 - y \end{array}$

$0,6 - y = 0,25 - y$
 0

$\text{pH} = -\text{p}_g[\text{H}^+] = 2$



$k = \frac{[\text{H}^+] \cdot [\text{OH}]}{[\text{к-та}]}$



$\left\{ \begin{array}{l} (14n-2)x + (14n+12)y = 29,6 \\ 2x + 2y = 1,2 \\ x + y = 0,6 \end{array} \right. \Rightarrow \begin{array}{l} x = 0,6 - y \\ x + y = 0,6 \end{array}$

$(14n-2)(0,6-y) + 8,4n - 1,2 + 2y + 12y = 29,6$

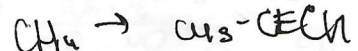
$8,4n + 14y = 30,8$

$n = \frac{30,8 - 14y}{8,4}$

y	n
0,1	3,5
0,2	
0,4	3

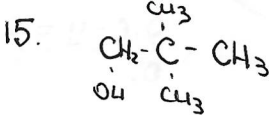
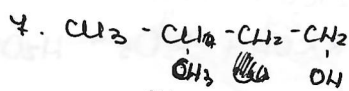
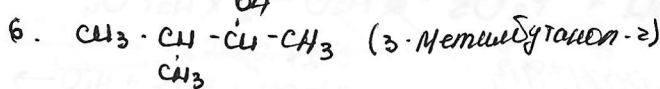
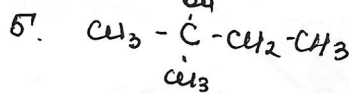
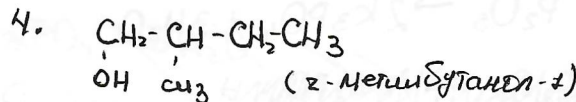
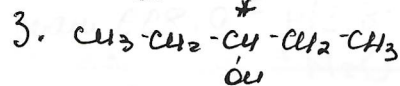
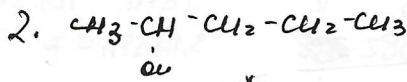
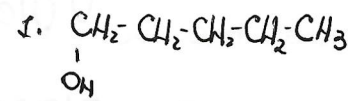
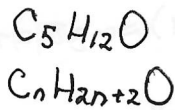
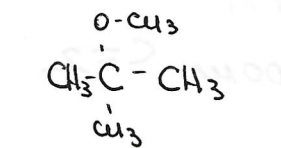
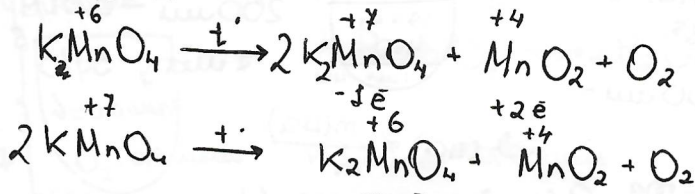
$y = \frac{30,8 - 8,4n}{14}$

$n = 3,667 - 1,667y$

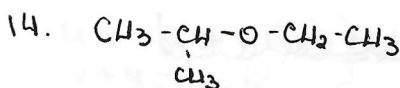
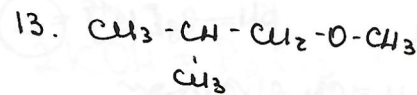
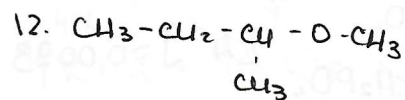
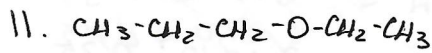
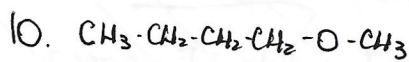


2

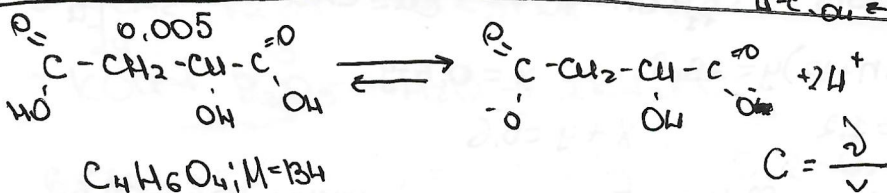
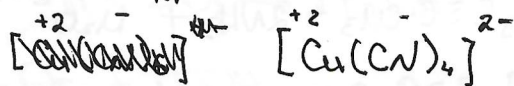
Черновик



$$\frac{P_1 \cdot V_1}{T_1} = \frac{P_2 \cdot V_2}{T_2}$$



$$0,619 = \frac{104}{M} \Rightarrow M = 168; X = 64 \text{ з/моль} \Rightarrow Cu \text{ (медь)}$$



$$C(C_4H_6O_4) = \frac{0,05}{0,2} = 0,25 \text{ моль/л}$$

$$K = \frac{[C] + [H^+]^2}{[K^+]}$$

