



МОН, ЛГВ НАЦИОНАЛНА ОЛИМПИАДА ПО ХИМИЯ
И ОПАЗВАНЕ НА ОКОЛНАТА СРЕДА

Областен кръг, 12 февруари 2022 г.

Учебно съдържание XI - XII клас

Примерни решения и оценка на задачите

Важно за проверителите! Освен представените примерни решения, за вярно се приема и всяко друго решение, което е логично обосновано и води до същия (числов или фактологичен) резултат.

При непълни отговори (например неизравнени уравнения) могат да се присъждат и по-малко от предвидените точки.

Задача 1 (25 точки)



$$\frac{n(\text{H}_3\text{PO}_4)}{n(\text{Ca}(\text{NO}_3)_2)} = \frac{2,39M(\text{Ca}(\text{NO}_3)_2)}{1,00M(\text{H}_3\text{PO}_4)} = \frac{2,39 \text{ g} \times 164,074 \text{ g/mol}}{1,00 \text{ g} \times 97,994 \text{ g/mol}} = \frac{4,00}{1,00} \quad \mathbf{1 \text{ т.}}$$



От реакция (*): (КТ – комбиниран тор)

$$\begin{aligned} m(\text{КТ})_1 &= M(\text{CaHPO}_4) + 2 \text{ mol} \times M(\text{NH}_4\text{NO}_3) + 3 \text{ mol} \times M((\text{NH}_4)_2\text{HPO}_4) = \\ &= 1 \text{ mol} \times 136,058 \text{ g/mol} + 2 \text{ mol} \times 80,043 \text{ g/mol} + 3 \text{ mol} \times 132,056 \text{ g/mol} \\ &= 692,31 \text{ g} \quad \mathbf{1 \text{ т.}} \end{aligned}$$

$$m(\text{N-КТ})_1 = n(\text{N}) \times M(\text{N}) = 10 \text{ mol} \times 14,007 \text{ g/mol} = 140,07 \text{ g} \quad \mathbf{1 \text{ т.}}$$

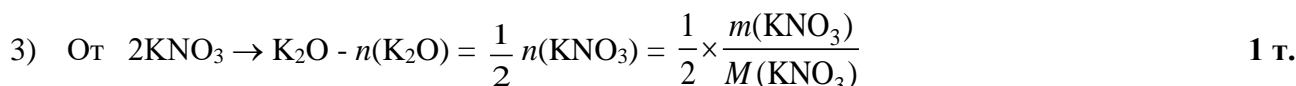
$$(\text{N-ind.})_1 = \frac{m(\text{N-КТ})_1}{m(\text{КТ})_1} = \frac{140,07 \text{ g}}{692,31 \text{ g}} = 0,2023 \rightarrow 20\% \quad \mathbf{1 \text{ т.}}$$



$$m(\text{P-КТ})_1 = \frac{1}{2} n(\text{P}) \times M(\text{P}_2\text{O}_5) = 0,5 \times 4 \text{ mol} \times 141,943 \text{ g/mol} = 283,89 \text{ g} \quad \mathbf{1 \text{ т.}}$$

$$(\text{P-ind.})_1 = \frac{m(\text{P-КТ})_1}{m(\text{КТ})_1} = \frac{283,89 \text{ g}}{692,31 \text{ g}} = 0,4101 \rightarrow 41\% \quad \mathbf{1 \text{ т.}}$$

$$\Rightarrow \text{NPK за (КТ)}_1: 20 - 41 - 00 \quad \mathbf{1 \text{ т.}}$$



$$\text{и } n(\text{N}) = n(\text{N-КТ})_1 + n(\text{KNO}_3): \quad \mathbf{1 \text{ т.}}$$

$$\begin{aligned}
 (\text{K-ind.})_2 &= \frac{\frac{1}{2} \times \frac{m(\text{KNO}_3)}{M(\text{KNO}_3)} \times M(\text{K}_2\text{O})}{m(\text{KT})_1 + m(\text{KNO}_3)} = \frac{\frac{1}{2} \times \frac{m(\text{KNO}_3)}{101,102 \text{ g/mol}} \times 94,195 \text{ g/mol}}{m(\text{KT})_1 + m(\text{KNO}_3)} = & \mathbf{1 \text{ т.}} \\
 &= \frac{0,4658m(\text{KNO}_3)}{m(\text{KT})_1 + m(\text{KNO}_3)} & \mathbf{1 \text{ т.}}
 \end{aligned}$$

$$\begin{aligned}
 (\text{N-ind.})_2 &= \frac{m(\text{N-KT})_2}{m(\text{KT})_1 + m(\text{KNO}_3)} = \frac{m(\text{N-KT})_1 + \frac{m(\text{KNO}_3)}{M(\text{KNO}_3)} \times M(\text{N})}{m(\text{KT})_1 + m(\text{KNO}_3)} = & \mathbf{1 \text{ т.}} \\
 &= \frac{m(\text{N-KT})_1 + \frac{m(\text{KNO}_3)}{101,102 \text{ g/mol}} \times 14,007 \text{ g/mol}}{m(\text{KT})_1 + m(\text{KNO}_3)} = \frac{140,07 \text{ g} + 0,1385m(\text{KNO}_3)}{m(\text{KT})_1 + m(\text{KNO}_3)} & \mathbf{1 \text{ т.}}
 \end{aligned}$$

$$\begin{aligned}
 \text{От } (\text{K-ind.})_2 &= \frac{1}{3} (\text{N-ind.})_2: \quad 0,4658m(\text{KNO}_3) = \frac{1}{3} (140,07 + 0,1385m(\text{KNO}_3)) & \mathbf{1 \text{ т.}} \\
 &\Rightarrow m(\text{KNO}_3) = 111,26 \text{ g} & \mathbf{1 \text{ т.}}
 \end{aligned}$$

$$\frac{m(\text{KT})_1}{m(\text{KNO}_3)} = \frac{692,31 \text{ g}}{111,26 \text{ g}} = 6,22 : 1,00 \quad \mathbf{1 \text{ т.}}$$

$$4) (\text{N-ind.})_2 = \frac{140,07 \text{ g} + 0,1385 \times 111,26 \text{ g}}{692,31 \text{ g} + 111,26 \text{ g}} = \frac{155,48 \text{ g}}{803,57 \text{ g}} = 0,1935 \rightarrow 19\% \quad \mathbf{1 \text{ т.}}$$

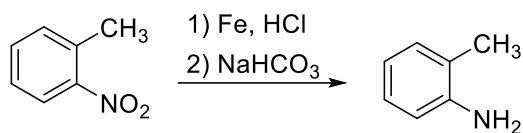
$$(\text{P-ind.})_2 = \frac{m(\text{P-KT})_1}{m(\text{KT})_2} = \frac{283,89 \text{ g}}{803,57 \text{ g}} = 0,3533 \rightarrow 35\% \quad \mathbf{1 \text{ т.}}$$

$$(\text{K-ind.})_2 = \frac{0,4658m(\text{KNO}_3)}{m(\text{KT})_1 + m(\text{KNO}_3)} = \frac{0,4658 \times 111,26 \text{ g}}{803,57 \text{ g}} = 0,0645 \rightarrow 6\% \quad \mathbf{1 \text{ т.}}$$

$$[3(\text{K-ind.})_2 : 3 \times 0,0645 = 0,1935 (\text{N-ind.})_2]$$

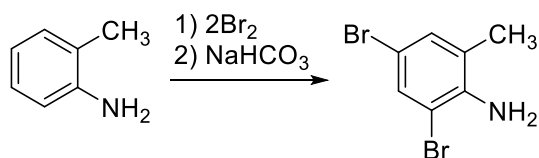
$$\Rightarrow \text{NPK за } (\text{KT})_2: \quad 19 - 35 - 06 \quad \mathbf{1 \text{ т.}}$$

Задача 2 (25 точки)



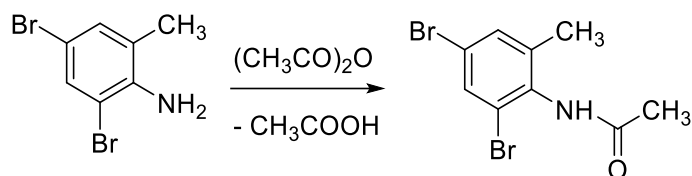
2 т.

А



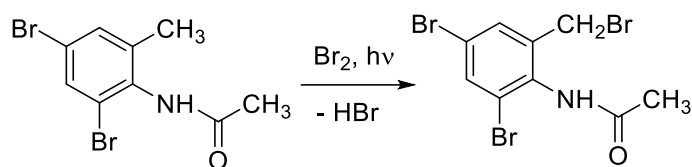
2 т.

Б



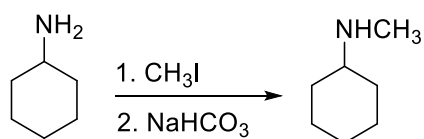
3 т.

В



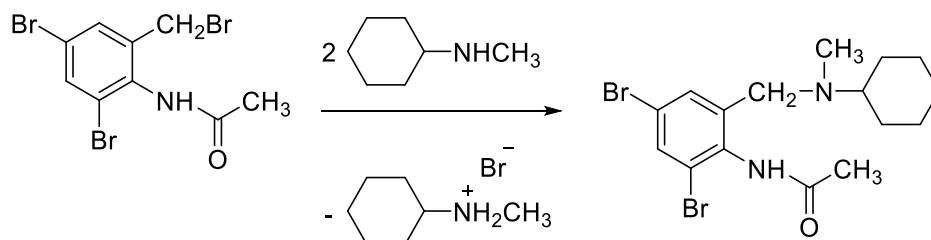
2 т.

Г



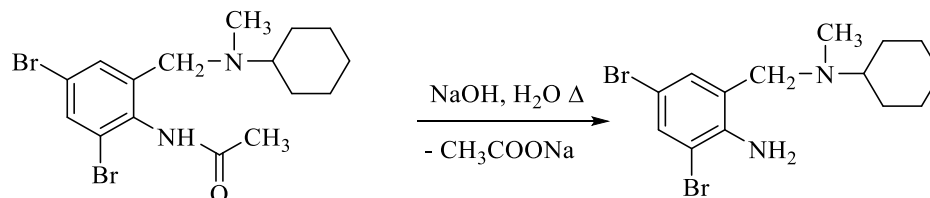
2 т.

Д



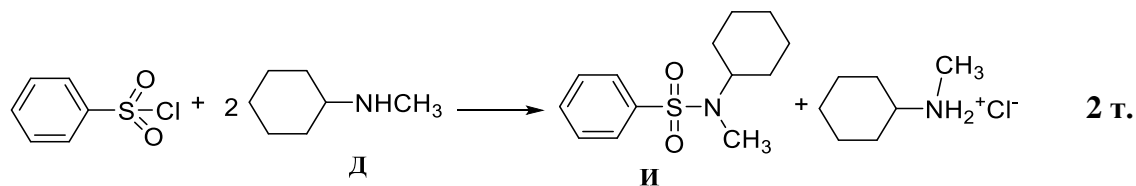
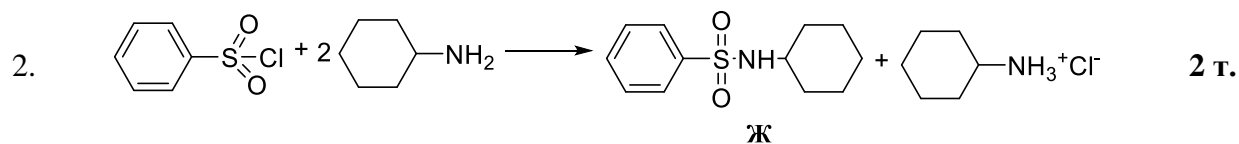
3 т.

Е

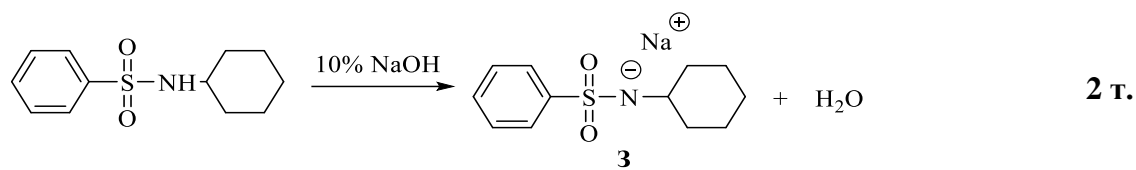


3 т.

(I)



Съединението **Ж** проявява NH кисели свойства – при взаимодействие с NaOH се получава разтворим във вода продукт.



В съединението **И** няма такъв тип водородни атоми и няма възможност за протичане на аналогично взаимодействие. **2 т.**

Задача 3 (25 точки)



$$n(\text{NO}_2 + \text{O}_2) = V/V_m = 26,9/22,4 = 1,2 \text{ mol} \quad 1 \text{ т.}$$

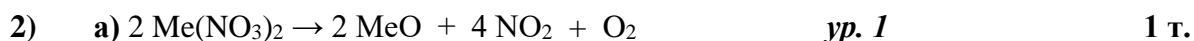
Азотният диоксид реагира с натриевата основа и в газовата фаза остава само кислород:

$$n(\text{O}_2) = V/V_m = 1,2/6 = 0,2 \text{ mol} \quad 1 \text{ т.}$$

$$n(\text{NO}_2) = 1,2 - 0,2 = 1,0 \text{ mol} \quad 1 \text{ т.}$$

$$\chi(\text{NO}_2) = (n(\text{NO}_2)/n(\text{NO}_2 + \text{O}_2)) \times 100 = (1,0/1,2) \times 100 = \mathbf{83,3 \text{ мол. \%}} \quad 1 \text{ т.}$$

$$\chi(\text{O}_2) = (n(\text{O}_2)/n(\text{NO}_2 + \text{O}_2)) \times 100 = (0,2/1,2) \times 100 = \mathbf{16,7 \text{ мол. \%}} \quad 1 \text{ т.}$$



$$\mathbf{83,5 \text{ g}} \quad \mathbf{1,0 \text{ mol}}$$

б) Ако и двата оксида имат състав $\text{Me}^{+2}\text{O}^{-2}$, от ур. 1 следва:

$$n(\text{NO}_2) : n(\text{O}_2)_{\text{ур.}} = 4 : 1 = \mathbf{1,0 : 0,25} \quad 1 \text{ т.}$$

От изчисленията, направени по експерименталните данни във в. 1):

$$n(\text{NO}_2) : n(\text{O}_2)_{\text{експ.}} = \mathbf{1,0 : 0,2} = 5 : 1 \quad 1 \text{ т.}$$

$$\Rightarrow n(\text{O}_2)_{\text{ур.}} - n(\text{O}_2)_{\text{експ.}} = \mathbf{0,05 \text{ mol}} \quad 1 \text{ т.}$$

Следователно $\mathbf{0,05 \text{ mol}}$ отделен кислород по ур. 1 окисляват оксида BO

до $\text{B}_2^{+x}\text{O}_x^{-2}$, където $+x$ е степента на окисление на B . 1 т.

в) *Означаваме:* $M_{\text{ср.}}(\text{Me}(\text{NO}_3)_2)$ - средна молна маса на сместа от двата нитрата.

От молно отношение, съставено по ур. 1, следва:

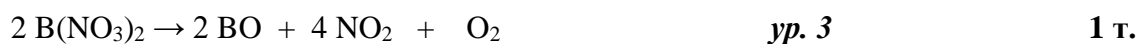
$$83,5/M_{\text{ср.}}(\text{Me}(\text{NO}_3)_2) = 1,0/2 \quad 1 \text{ т.}$$

$$\Rightarrow M_{\text{ср.}}(\text{Me}(\text{NO}_3)_2) = \mathbf{167 \text{ g/mol}} \quad \mathbf{0,5 \text{ т.}}$$

$$\Rightarrow M_{\text{ср.}}(\text{Me}) = 167 - 2 \times 62 = \mathbf{43 \text{ g/mol}} \quad \mathbf{0,5 \text{ т.}}$$



$$\mathbf{a \text{ mol}} \quad \mathbf{a \text{ mol}} \quad \mathbf{2a \text{ mol}} \quad \mathbf{0,5a \text{ mol}}$$



$$\mathbf{b \text{ mol}} \quad \mathbf{b \text{ mol}} \quad \mathbf{2b \text{ mol}} \quad \mathbf{0,5b \text{ mol}}$$



$$\mathbf{b \text{ mol}} \quad \mathbf{0,05 \text{ mol}}$$



$$\Rightarrow n(\text{A}) = \mathbf{a}; \quad n(\text{B}) = \mathbf{b}$$

От ур. 3 и извода във в. 2б, че $\mathbf{0,05 \text{ mol}}$ отделен кислород окисляват оксида BO до $\text{B}_2^{+x}\text{O}_x^{-2}$ следва:

$$0,5b = 0,05 \quad \Rightarrow \mathbf{b = 0,1 \text{ mol}} \quad 1 \text{ т.}$$

От ур. 2 и ур. 3 и изчисленията във в. 1:

$$n(\text{NO}_2) = 2a + 2b = 1,0 \quad \Rightarrow \mathbf{a + b = 0,5}$$

$$\Rightarrow \mathbf{a = 0,5 - 0,1 = 0,4 \text{ mol}} \quad 1 \text{ т.}$$

$$\chi(\text{A}(\text{NO}_3)_2) = (0,4/0,5) \times 100 = \mathbf{80 \text{ мол \%}} \quad \mathbf{0,5 \text{ т.}}$$

$$\chi(\text{B}(\text{NO}_3)_2) = (0,1/0,5) \times 100 = \mathbf{20 \text{ мол \%}} \quad \mathbf{0,5 \text{ т.}}$$

От молно отношение, съставено по *ур. 4*, следва:

$$2/b = (x-2)/(2 \times 0,05) \Rightarrow x = 4 \quad 1 \text{ т.}$$

5) $M_{\text{cp.}}(\text{Me}) = (M(\text{A}) \times a + M(\text{B}) \times b)/(a+b) = 43$

$$M(\text{A}) \times 0,8 + M(\text{B}) \times 0,2 = 43 \quad 2 \text{ т.}$$

A е s-елемент от втора група и степен на окисление +2. 1 т.

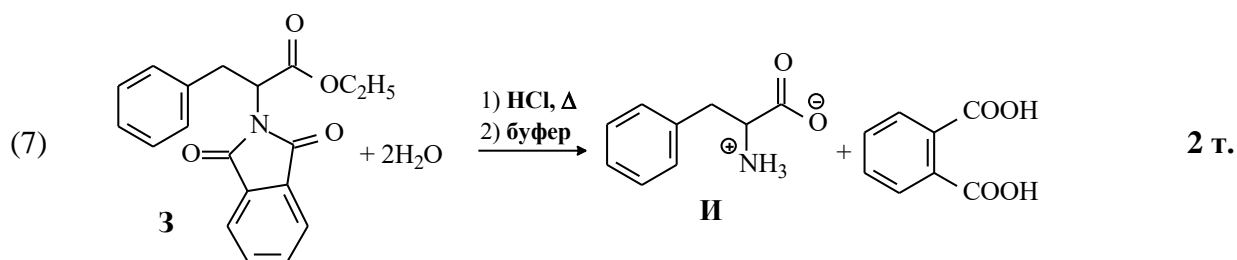
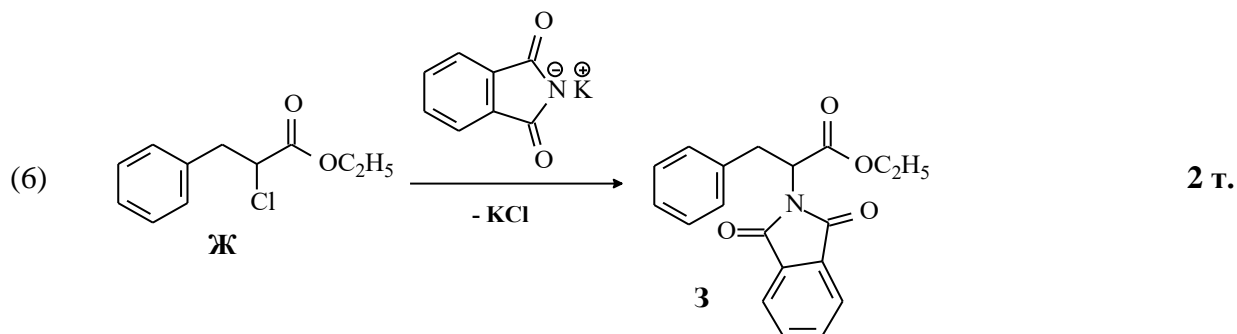
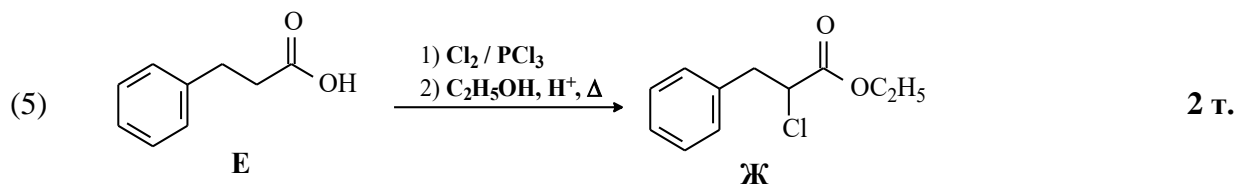
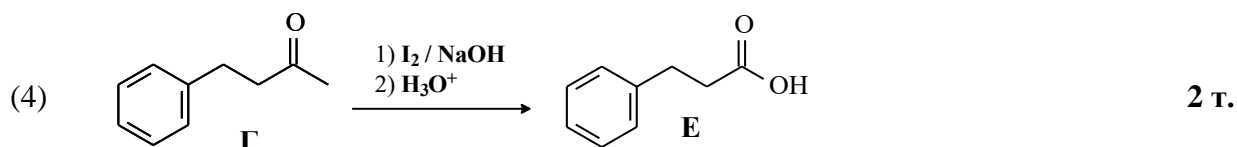
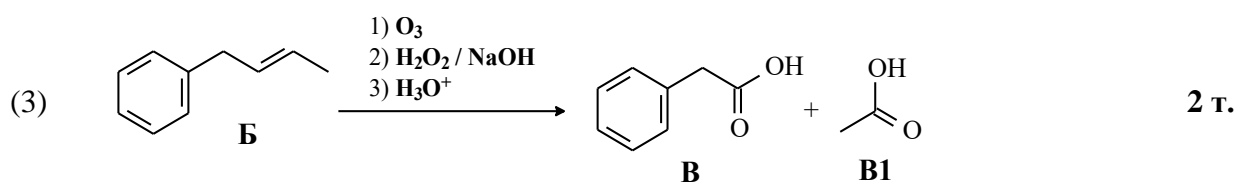
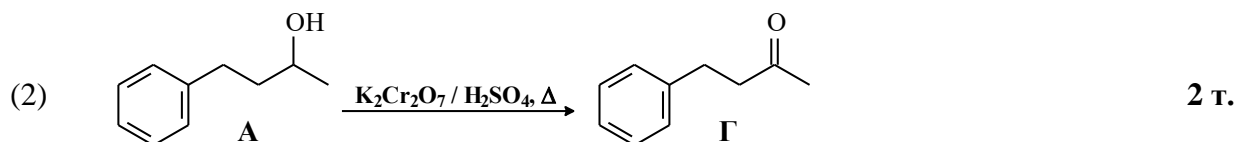
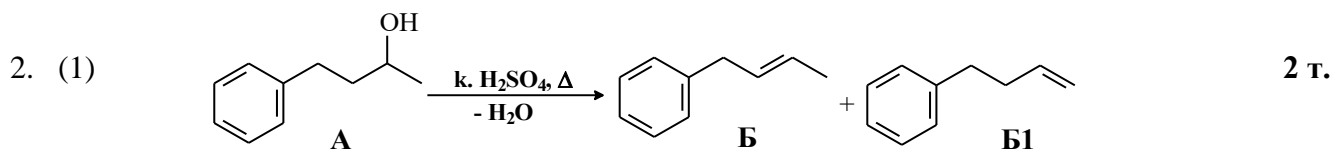
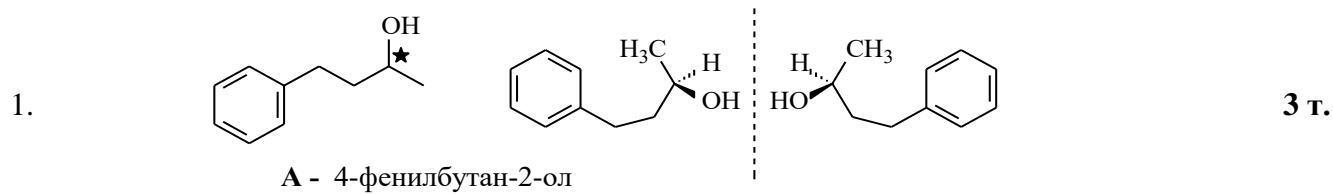
От $M_{\text{cp.}}(\text{Me}) = 43 \text{ g/mol}$ и $\chi(\text{A}) = 80 \text{ mol \%}$ следва, че **A** не е **Sr** и **Ba**. 0,5 т.

Ако **A** е **Be**, $M(\text{Be}) = 9 \text{ g/mol} \Rightarrow M(\text{B}) = 179 \text{ g/mol} \Rightarrow$ няма такъв елемент. 0,5 т.

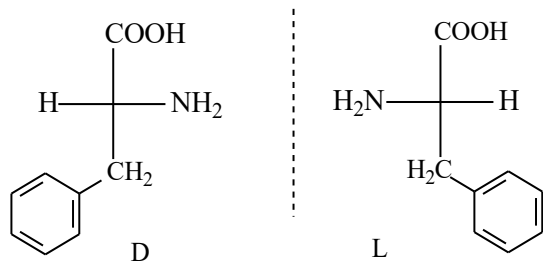
Ако **A** е **Mg**, $M(\text{Mg}) = 24 \text{ g/mol} \Rightarrow M(\text{B}) = 119 \text{ g/mol} \Rightarrow$ **B** е **Sn**, но е p-елемент 0,5 т.

Ако **A** е **Ca**, $M(\text{Ca}) = 40 \text{ g/mol} \Rightarrow M(\text{B}) = 55 \text{ g/mol} \Rightarrow$ **B** е d-елементът **Mn** 0,5 т.

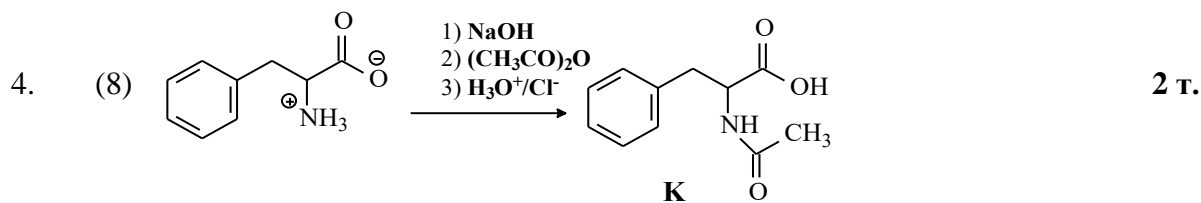
Задача 4 (25 точки)



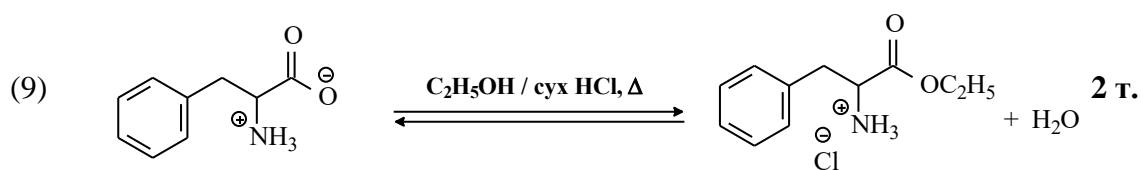
3. **И - 2-амино-3-фенилпропанова киселина** **1 т.**



2 т.



2 т.



2 т.