## I. MULTIPLE CHOISE QUESTIONS WITH A SINGLE CORRECT ANSWER

(Answer by circling **just one** of the options A, B, C or D)

1. What is the number of possible acyclic structural isomers with an unbranched carbon chain having the formula $C_4H_8O$?

A. 4.
B. 5.
C. 6.
D. More than 6.

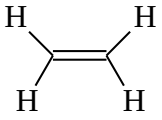
2. Which of the following particles represent Lewis acids?

I. $Li^+$ II. $TiCl_4$ III. $CH_3SCH_3$

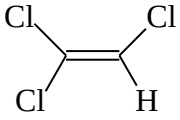
IV. $AlCl_3$ V. $CH_3CHO$

A. Only I, II and IV.
B. Only II and IV.
C. Only I, III, IV and V.
D. None of the above.

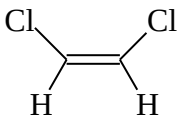
3. Which of the following molecules have a dipole moment?



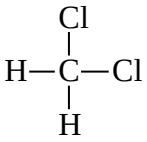
I.



II.



III.



IV.

A. Only I and III.
B. Only II and III.
C. Only II, III andIV.
D. Only II and IV.

4. Heterolytic cleavage of a covalent bond in a molecule produces which of the following?

A. Only cations
B. Two free radicals.
C. Only anions.
D. One cation and one anion.

5. Which of the following statements about the ethylene (ethene) molecule is **NOT** true?

I. Its structure is linear.
II. It is a polar molecule.
III. It shows optical and geometric isomerism.
IV. When it reacts with hydrogen halides, alkyl halides (haloalkanes) are formed.

A. I, II and III
B. I and IV
C. III and IV
D. None of the above statements.

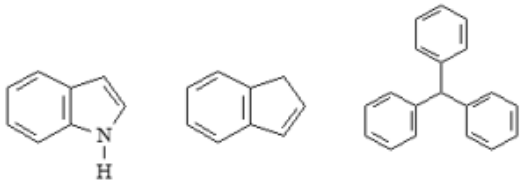
6. What is the product of the reaction between hydrogen bromide and 4-methylhept-1ene?

A. 4-methyl-7-bromoheptaten.
B. 2-bromo-4-methylheptane.
C. 1-bromo-4-methylheptane.
D. 2-bromo-2-methylheptane.

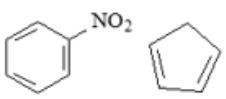
7. In which of the following compounds does optical isomerism occur?

A. 2-bromopentane.
B. 3-bromohex-2-ene.
C. 1-bromobut-1-yne.
D. 2,2-dichloropropane.

8. Which of the following structures represent aromatic compounds according to Hickel's rule of aromaticity?



I. II. III.



IV. V.

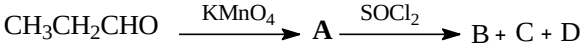
A. Only I, II and V.
B. Only II, III and IV.
C. Only I, III and IV.
D. Only II and IV.

9. Which of the following pairs of compounds react with/on:

I. Ammoniacal solution of silver nitrate.
II. Oxidation in the presence of potassium permanganate.
III. Aldol addition.

A. Benzaldehyde and acetophenone (methyl phenyl ketone).
B. Butan-2-on and butanal.
C. Acetaldehyde and propanal.
D. Propan-1-ol and propanal.

10. Below you will find the reaction equation for a reaction in which propanal reacts with potassium permanganate to form product A. The resulting product reacts with $SOCl_2$ to form the products B, C, and D. Which products are formed in these two subsequent reactions?




A. A- propandic acid; B- propanoic acid; C- $SO_2$; D- HCl.
B. A- propan-1-ol; B- propanoyl chloride; C-$SO_2$; D-HCl.
C. A- propanoic acid; B- propanoyl chloride; C- $SO_3$; D-$Cl_2$.
D. A- propanoic acid; B- propanoyl chloride; C- $SO_2$; D-HCl.

11. Mark the intruder!
A. Pyrrole.
B. Thiophene.
C. Pyrrolidine.
D. Furan.

12. Which of the following is **NOT** true of 2,4,6-trinitrophenol?
A. It is formed by nitration of various natural substances of plant and animal origin..
B. The salts formed are called nitrophenolates.
C. It dissolves well in water.
D. It can also be obtained by complete nitration of phenol.

13. When ethyl acetate is heated in the presence of KOH, the following is obtained:
A. $CH_3CHO$ and $CH_3CH_2OK$.
B. $CH_3COOH$ and $CH_3CH_2OK$.
C. $CH_3COOH$ and $CH_3CH_2OH$.
D. $CH_3COOK$ and $CH_3CH_2OH$.

14. In which of the following compounds does geometric isomerism not occur?
A. Oct-4-en.
B. Pent-2-ene.
C. Hex-3-ene.
D. 2-methylhex-2-ene.

15. Which of the following compounds are isomers?

I. methylbenzene;
II. *m*-diethylbenzene;
III. propylbenzene;
IV. 1,2-diethylbenzene;
V. *p*-diethylbenzene

A. I and IV.
B. I, III and IV.
C. II, IV and V.
D. II and V.

## II. TASKS

**(In the assigned tasks, write the method of solving and the answer in the provided place)**

1. Methanol, also known as wood alcohol, is the simplest aliphatic alcohol. It is a light, volatile, colorless and flammable liquid that has a specific odor. Methanol was given the name wood alcohol because in the past it was mainly produced by destructive (dry) distillation of wood. Methanol can also be generated by reaction of carbon monoxide and hydrogen under high pressure and in the presence of a catalyst. What mass of methanol is obtained when 52 g of carbon monoxide and 4.1 g of hydrogen enter into a reaction?

$A_r$(C) = 12.00; $A_r$(H) = 1.00; $A_r$(O) = 16.00. (**5 points**)

$m(CO) = 52$ g
$m(H_2) = 4.1$ g
$m(CH_3OH) = ?$

$CO + 2H_2 \rightarrow CH_3OH$

$$n(CO)_0 = \frac{m\ (CO)}{M\ (CO)} = \frac{52\ g}{28{,}01\ \frac{g}{mol}} = 1{,}856\ mol$$

$$n(H_2)_0 = \frac{m(H_2)}{M(H_2)} = \frac{4{,}1\ g}{2{,}02\ \frac{g}{mol}} = 2{,}030\ mol$$

$$n(H_2)_{потр.} = 2 \cdot n(CO) = 2 \cdot 1{,}856\ mol = 3{,}712\ mol$$

$$\frac{n(CH_3OH)}{n(H_2)} = \frac{1}{2}$$

$$m(CH_3OH) = 0{,}5 \cdot n(H_2) \cdot M(CH_3OH) = 0{,}5 \cdot 2{,}030\ mol \cdot 32{,}082\ \frac{g}{mol} = 32{,}563\ g$$

- **1 point for every step; Molar mass calculation does not bring any point.**

2. The substance that gives bananas their characteristic smell is formed when acetic acid reacts with 3-methylbutan-1-ol. What is the theoretical mass of the product if you take 69 g of 3-methylbutan-1-ol and 46 g of acetic acid? Write down the reaction equation! What type of reaction is involved? Name the resulting product! Calculate the yield of the reaction if you know that 82.532 g of the product of this reaction was obtained experimentally.
$A_r$(C) = 12.00; $A_r$(H) = 1.00; $A_r$(O) = 16.00. (**10 points**)

$CH_3COOH + C_5H_{11}OH \rightarrow CH_3COOC_5H_{11} + H_20$ **(1 point)**

- Esterification reaction **(1 point)**
- $CH_3COOC_5H_{11}$(to accept: isopentyl acetate, isoamyl acetate, 3-methylbutyl ethanoate, 3-methylbutyl acetate) **(1 point)**

$M$ (оцет. к-на)= 2 · $A_r$(C) + 4 · $A_r$(H) + 2 · $A_r$(O)= 2 · 12 + 4 · 1 + 2 · 16 = 60 g/mol **(1 point)**

$$n\,(\text{оцет.к}-\text{на}) = \frac{m(\text{оцет.к}-\text{на})}{\text{M}(\text{оцет.к}-\text{на})} = \frac{46\ \text{g}}{60\ \frac{\text{g}}{\text{mol}}} = 0{,}766\ \text{mol}$$

**(1 point)**

$M$ (алкох.) = 5 · $A_r$(C) + 12 · $A_r$(H) + 1 · $A_r$(O)= 5 · 12 + 12 · 1 + 1 · 16 = 88 g/mol **(1 point)**

$$n\,(\text{алкох.}) = \frac{m(\text{алкох.})}{\text{M}(\text{алкох.})} = \frac{69\ \text{g}}{88\ \frac{\text{g}}{\text{mol}}} = 0{,}784\ \text{mol}$$

**(1 point)**

$$\frac{n(\text{естер})}{n(\text{оцет.к}-\text{на})} = \frac{1}{1}$$

$M$(естер)= 7 · $A_r$(C) + 14 · $A_r$(H) + 2 · $A_r$(O)= 7 · 12 + 14 · 1 + 2 · 16 = 130 g/mol **(1 point)**

$m$(естер)= $n$(оцет.к-на) · $M$(естер) = 0,766 mol · 130 g/mol = 99,58 g **(1 point)**

$$y = \frac{m(\text{естер})_{\text{експ}}}{m(\text{естер})_{\text{теор}}} = \frac{82{,}532\ \text{g}}{99{,}58\ \text{g}} \cdot 100 = 82{,}88\ \%$$

**(1 point)**

**Molar mass calculation does not bring any point.**

3. In a reaction between acetyl chloride and ethanol, the main product is ethyl acetate. Set up the reaction equation, balance it and calculate the yield of the reaction using the information below!

*m*(acetyl chloride) = 2.31 g
*V*(EtOH) = 1.66 mL
$\rho$(EtOH) = 0.789 g/mL
*m*(ethyl acetate)exp =1.8 g
*Ar*(C) = 12.00; $A_r$(H) = 1.00; $A_r$(O) = 16.00; $A_r$(Cl) = 35,45. (**5 points**)

$$CH_3COCl + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + HCl$$

$$n(\text{ац.х.}) = \frac{m(\text{ац.х.})}{M(\text{ац.х.})} = \frac{2{,}31\text{g}}{78{,}49\frac{\text{g}}{\text{mol}}} = 0{,}0294\text{mol}$$

$$n(EtOH) = \frac{\rho(\text{EtOH}) \cdot V(\text{EtOH})}{M(\text{EtOH})} = \frac{0{,}789\frac{\text{g}}{\text{mL}} \cdot 1{,}66\text{mL}}{46{,}068\frac{\text{g}}{\text{mol}}} = 0{,}028\text{mol}$$

$$\frac{n(\text{ет.ац.})}{n(\text{EtOH})} = \frac{1}{1}$$

$$m(\text{ет.ац.}) = n(\text{EtOH}) \cdot M(\text{ет.ац.}) = 0{,}284\text{mol} \cdot 88{,}11\frac{\text{g}}{\text{mol}} = 2{,}502\text{g}$$

$$y = \frac{m(\text{ет.ац.})_{\text{експ}}}{m(\text{ет.ац.})_{\text{теор}}} = \frac{1{,}8\text{g}}{2{,}502\text{g}} \cdot 100 = 71{,}94\%$$