



THEORETICAL PROBLEMS

(Write down the solutions and answers to the problems at the designated places!
Results/solutions out of the frame will not be checked!)

1. Starting from the main product of the reaction between calcium carbide and water (write down the equation of this reaction first), write down the chemical equations of the reactions for obtaining the following compounds as products:
- A) Ethanol
 - B) Vinyl chloride
 - C) Benzene
 - D) Acetic acid

2. I. The molar mass of a carboxylic acid is 100 g/mol. The mass fraction of carbon in it is 60 %, and the mass fraction of hydrogen is 8 %. Find the molecular formula of the acid.

I.

- II. The acid can exist as two geometrical isomers A1 and A2. Write down the structures of the two geometrical isomers.

II.

- III. Upon complete hydrogenation (Pt/H_2) of a mixture of the two geometrical isomers, a mixture of two optical isomers is obtained. Write down the structural formulas of the two optical isomers and denote the chiral C-atoms.

III.

3. Compounds A and B are two consecutive members of the homologous series of aldehydes. To 100 g aqueous solution of A, in which the mass fraction of a is 23%, 19 g of B are added. Then, 2 g of this solution have been subjected to the Tollens' reaction and it was found that 0.0202 mol Ag^+ have been consumed for oxidation of the total amount of both aldehydes.

I. Calculate the mass of each compound, A and B, present in 2 g of the reaction mixture.

I.

II. Find the molar mass of A and B.

II.

III. Write down the structural formulas of A and B and their names.

III.

4. Upon nitration of phenol with diluted nitric acid a product is obtained that contains 51.8 % carbon, 3.6 % hydrogen and 10 % nitrogen (*m/m*). It was found that 3 moles of the product have a mass of 420 g.

I. Find the molecular formula of the product.

I.

II. Write down the structural formulas of the possible structural isomers.

II.

III. The study of the product with a method known as ^{13}C NMR have shown that there are four different types of carbon atoms in the product. Consequently, which is the formula of the obtained product?

III.

IV. Further nitration of phenol gives picric acid. Calculate the volume of a solution of NaOH with concentration $c(\text{NaOH}) = 0.5 \text{ mol/dm}^3$ that is needed for complete neutralization of 2.29 g picric acid?

IV.

5. An aliphatic dicarboxylic acid was subjected to esterification with propan-2-ol and 0.14 mol of diester were obtained as a product. The yield of the reaction was 70 %. The same mass of the acid was neutralized with KOH and a salt was obtained that has a molar mass of 192.3 g/mol. Upon heating to 150 °C the acid forms an intra-molecular anhydride.
- I. Find the molar mass of the acid!
 - II. What is the theoretical mass of the reacted acid in the reaction of esterification?
 - III. Write down the molecular formula and the structural formulas of the two geometrical isomers of the acid.
 - IV. Which of these two isomers enters the reaction that gives the anhydride as a product?
 - V. Write down the equation of the reaction for obtaining the diester.
 - VI. Write down the equation of the reaction of forming the anhydride.

I.

II.

III.

IV.

V.

VI.

IMAGINED EXPERIMENT

(10 points)

In separate laboratory bottles without labels with compound names, the following pairs of substances are combined:

- a) Butane- 1-ol and 2-methylbutan-2-ol
- b) Acetaldehyde and acetone
- c) Acetophenone and benzophenone

Describe the experiments that you would perform to distinguish the substances within each pair. For that purpose, you have the following reagents: CuSO_4 , solution of NaOH , $\text{K}_2\text{Cr}_2\text{O}_7$, diluted H_2SO_4 and solution of I_2 .

a)

b)

c)

Data you need:

$A_r(\text{H}) = 1,0$; $A_r(\text{C}) = 12,0$; $A_r(\text{N}) = 14,0$; $A_r(\text{O}) = 16,0$; $A_r(\text{Na}) = 23,0$; $A_r(\text{P}) = 31,0$; $A_r(\text{K}) = 39,1$