

Open series - MAOL Chemistry contest - 30.10.2024

The time allowed for open series is 100 minutes.

If you compete in both basic and open series, the basic series exam should be done first within 100 min and after returning the answers you can start doing the open series exam. The time allowed for open series is then only 80 minutes, since you do not have to answer the same question which you already did in the basic series exam. Please write to that answer box "the answer is in the basic series exam". You are allowed to use a calculator and a data booklet. Remember to answer with clear reasoning. Answer all the questions.

Good luck to the contest!

Sisällys

1. Consent for the privacy statement	Aineisto	1 p.
2. Competitor information		1 p.
3. Identify the compound made from wood	Aineisto	15 p.
4. Preparation of silane		12 p.
5. The chemistry of sunscreen	Aineisto	13 p.
6. Synthesis of an anti-asthma drug	Aineisto	14 p.
7. Yield of propyl benzoate		20 p.

Koe yhteensä **76 p.**

1. Consent for the privacy statement 1 p.

By participating in the competition, you give permission to publish the results in MAOL's communication channels. If you wish that your results are not published you must prohibit it separately.

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1.A [Privacy statement](#)

1.1 Do you consent to the processing of your data in accordance with the privacy statement? 1 p.

- ☐ Yes - I will participate in the competition.
- ☐ No - I will not participate in the competition.

2. Competitor information 1 p.

Competitor information (please write on separate rows):

1. Name:

2. Gender:
3. School, location:
4. Year group:
5. Email:
6. Home adress, postal code, town:
7. Phone:
8. Teacher's name and email:

3. Identify the compound made from wood 15 p.

Forests are Finns' most important natural resource. The estimated growth rate of the Finnish forest is approximately 103 million cubic meters annually. Forests have many important tasks, from recreational use to the exportation, and many different products can be made from Finnish wood.

(If you already answered to this question in the basic series exam, please write to all answer boxes that "the answer is in the basic series exam".)

- 3.1 A compound made from a tree was analysed in a laboratory. 5.010 grams of this compound was found to contain 1.977 grams of carbon, 0.398 grams of hydrogen, and 2.633 grams of oxygen. Calculate the empirical formula of the compound. 4 p.

- 3.2 Determine the molecular formula of the compound using the spectrum shown below 2 p.

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3.2.A Mass spectrum of the unknown compound

- 3.3 An IR spectrum of the compound was also taken. See Appendix (Liite) 4.B. IR spectrum of the unknown compound. Based on the available information, what functional groups does the compound contain? 5 p.

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3.3.A IR spectrum of the unknown compound

Functional group	Does the unknown compound contain the functional group in question?	
Carbonyl group	Yes, it does. This functional group is in the structure of the compound. No, it doesn't. This functional group is not in the structure of the compound. Can't be said based on the available data.	p.
Carboxyl group	Yes, it does. This functional group is in the structure of the compound. No, it doesn't. This functional group is not in the structure of the compound. Can't be said based on the available data.	p.
Hydroxy group (hydroxyl group)	Yes, it does. This functional group is in the structure of the compound. No, it doesn't. This functional group is not in the structure of the compound. Can't be said based on the available data.	p.
Amino group	Yes, it does. This functional group is in the structure of the compound. No, it doesn't. This functional group is not in the structure of the compound. Can't be said based on the available data.	p.
Alkenyl group	Yes, it does. This functional group is in the structure of the compound. No, it doesn't. This functional group is not in the structure of the compound. Can't be said based on the available data.	p.

3.4 What compound could it be? Also draw the structural formula of the compound. **4 p.**

4. Preparation of silane **12 p.**

Silane i.e. SiH_4 is a colorless, foul-smelling gas used in the manufacture of silicon. Silane can be prepared by a reaction where magnesium silicide i.e. Mg_2Si reacts with hydrogen chloride. Magnesium chloride is formed as a byproduct. Magnesium silide, on the other hand, is produced by a reaction in which silicon dioxide and metallic magnesium react with each other. Magnesium oxide is formed as a byproduct of this reaction.

4.1 Balance the reaction equations that describe the production of magnesium silicide and the production of silane from magnesium silicide (two reaction equations in total). **4 p.**

4.2 What is the maximum volume of silane that can be formed if 50.0 g of silicon dioxide, 40.0 g of metallic magnesium and 500.0 ml of a 2.50 mol/l aqueous solution of hydrogen chloride are available for the reactions? You can assume a temperature of 50.0 °C and a pressure of 101.325 kPa for the silane formation reaction. **6 p.**

4.3 Silane is a very reactive gas. Give your best estimate of what products can be formed if silane reacts with the oxygen in air. **2 p.**

5. The chemistry of sunscreen 13 p.

5.1 BP-3 is an organic compound that has been widely used in sunscreens. It has been found to damage water bodies, which is why sunscreens containing it have been banned in, for example, Hawaii. The structure of BP-3 is shown below. Identify the functional groups of BP-3. **4 p.**

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5.1.A Structural formula of BP-3

5.2 Physical sunscreens use titanium dioxide or zinc oxide instead of organic UV filter molecules. On a laboratory scale, zinc oxide can be produced in a reaction where metallic zinc is electrolyzed in an aqueous solution, resulting in a white zinc-containing precipitate and some gas. When the white precipitate is heated, zinc oxide is formed. Write two balanced reaction equations describing the production of zinc oxide. Identify the element being oxidized and reduced in the first reaction. **6 p.**

5.3 How big of a mass of zinc oxide can be formed when a current of 150 mA is used in electrolysis for 30 minutes? **3 p.**

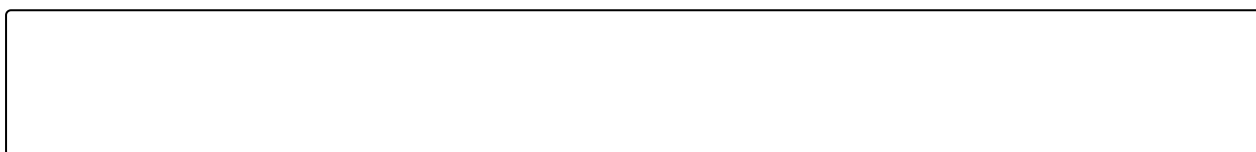
6. Synthesis of an anti-asthma drug 14 p.

Colterol hydrochloride is a muscle relaxant that is mainly used to treat asthma. The industrial production route of colterol hydrochloride is shown below.

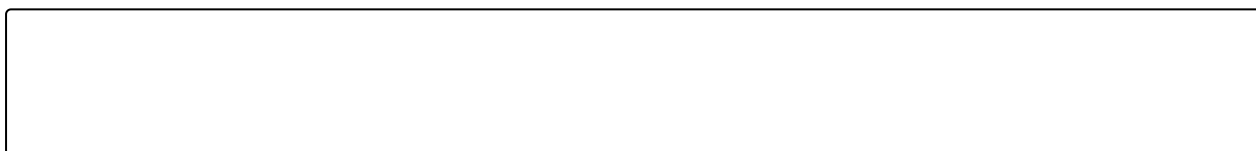
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6.A Industrial production route of colterol hydrochloride

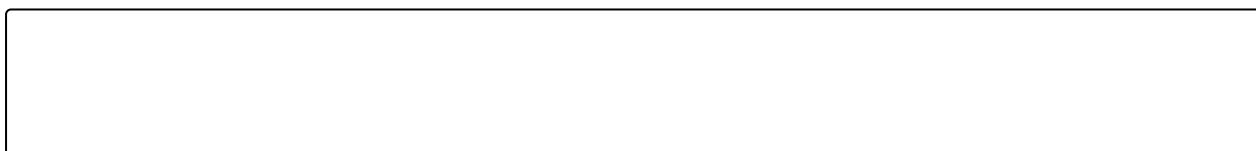
6.1 Draw the structure of A 2 p.



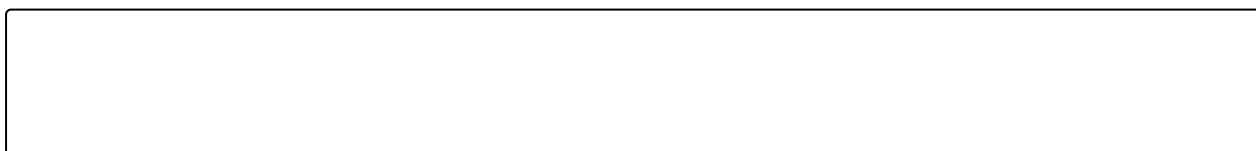
6.2 Draw the structure of B 2 p.



6.3 Draw the structure of C 2 p.



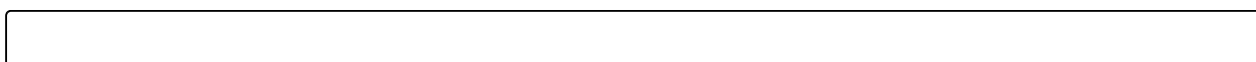
6.4 Draw the structure of D 2 p.



6.5 Draw the structure of E 2 p.



6.6 Draw the structure of F 2 p.



6.7 Suggest an alternative reagent with which step d) could be carried out. 2 p.

7. Yield of propyl benzoate 20 p.

7.1 The aim was to produce an ester named propyl benzoate. 1.00 mol of benzoic acid and 1.50 mol of propanol and a small amount of concentrated sulfuric acid were added to the reaction mixture. However, something went wrong, as the percentage yield for the desired ester was only 10.0%. In addition, percentage yield for dipropyl ether was 64.5%.

How much substance (in moles) of benzoic acid and propanol was left?

5 p.

7.2 After reconsidering the conditions, the synthesis was carried out again with the same amounts of starting materials. This time, the oily product was collected dry (without possible easily volatile propanol and dipropyl ether and without sulfuric acid residues) and the yield was 140.0 g. However, the raw product could have contained benzoic acid as the only remaining impurity, which was decided to be removed (= final purification of the product) only if the mixture contained more than 70.0% of the theoretical maximum amount of ester at this stage.

25.0 mg of the product mixture was dissolved in 5.00 ml of deuteriochloroform and measured by NMR. Based on the integral of the phenyl hydrogens, it was found that the sum of the concentrations of benzoic acid and propyl benzoate in this sample was 79.4% of the concentration of benzoic acid in a sample in which 25.0 mg of benzoic acid had been dissolved in 5.00 ml of deuteriochloroform.

Did the raw product contain significantly (more than 1 m-%) benzoic acid? Justify with calculations. It is possible to answer this question well, even if one does not solve point 7.3. If you solve point 7.3 even just barely, it is enough to answer this question too.

2 p.

7.3 What is the mass percentage of the ester in the raw product? If you can't solve this part exactly, you can get partial points for a good estimate. **10 p.**

7.4 Is the stated criterion for removing benzoic acid from the product met? Justify with calculations. If you were unable to solve question 7.3, answer this question assuming that the answer to question 7.3 is 74.5%. **3 p.**

Kokeen tehtävät loppuvat tähän.

Siirry tarkastelemaan vastauksiasi

Tarkastelun jälkeen voit vielä palata muokkaamaan vastauksia, tai päättää kokeen.