Basic 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 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. School, location:

3. Year group:

4. Email:

3. Lattice structures in solids 10 p.

Select the correct lattice structure for each solid from the drop-down menu options. All substances are in a solid state.

Substance	Lattice structure	
Water	ionic lattice / atomic lattice (giant covalent structure) / metallic lattice / polar molecular lattice / nonpolar molecular lattice / no lattice structure (non-crystalline solid)	1 p.
Strontium	ionic lattice / atomic lattice (giant covalent structure) / metallic lattice / polar molecular lattice / nonpolar molecular lattice / no lattice structure (non-crystalline solid)	1 p.
Ethanal	ionic lattice / atomic lattice (giant covalent structure) / metallic lattice / polar molecular lattice / nonpolar molecular lattice / no lattice structure (non-crystalline solid)	1 p.
Silicon dioxide	ionic lattice / atomic lattice (giant covalent structure) / metallic lattice / polar molecular lattice / nonpolar molecular lattice / no lattice structure (non-crystalline solid)	1 p.
Potassium chloride	ionic lattice / atomic lattice (giant covalent structure) / metallic lattice / polar molecular lattice / nonpolar molecular lattice / no lattice structure (non-crystalline solid)	1 p.
Diethyl ether	ionic lattice / atomic lattice (giant covalent structure) / metallic lattice / polar molecular lattice / nonpolar molecular lattice / no lattice structure (non-crystalline solid)	1 p.

Diamond	ionic lattice / atomic lattice (giant covalent structure) / metallic lattice / polar molecular lattice / nonpolar molecular lattice / no lattice structure (non-crystalline solid)	1 p.
Hydrogen fluoride	ionic lattice / atomic lattice (giant covalent structure) / metallic lattice / polar molecular lattice / nonpolar molecular lattice / no lattice structure (non-crystalline solid)	1 p.
Polypropene (polypropylene)	ionic lattice / atomic lattice (giant covalent structure) / metallic lattice / polar molecular lattice / nonpolar molecular lattice / no lattice structure (non-crystalline solid)	1 p.
Copper Sulphate pentahydrate	ionic lattice / atomic lattice (giant covalent structure) / metallic lattice / polar molecular lattice / nonpolar molecular lattice / no lattice structure (non-crystalline solid)	1 p.

4. 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.

4.1 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.**

4.2 Determine the molecular formula of the compound using the spectrum shown below **2 p.**

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>
> 4.2.A Mass spectrum of the unknown compound

4.3 An IR spectrum of the compound was also measured. 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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4.3.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 (or 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.

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

5. Density of diamond 10 p.

The lattice structure of diamond was studied with an X-ray diffractometer. It was found that in diamond's structure there are eight atoms in a 0.357 nm × 0.357 nm × 0.375 nm cube.

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5.A The diamond packs into a regular lattice structure

5.1 Calculate the volume of the cube **2 p.**

5.2 Calculate the mass of the cube. **6 p.**

5.3 Calculate the density of diamond. **2 p.**

6. Determination of caffeine content by UV spectrometer 15 p.

Caffeine is one of the world's most used intoxicants that affects the central nervous system by reducing fatigue. Caffeine is naturally found in many different plants that can be used to prepare foods and drinks. The most well-known of these are probably coffee and tea, which, depending on the variety, contain about 20 to 110 mg of caffeine per 2.0 dl cup.

The students wanted to investigate whether the brewing time of the tea affects the caffeine content of the tea. Measuring the caffeine content with a UV spectrometer was chosen as the research method.

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6.A The structure of caffeine, or 1,3,7-trimethylpurine-2,6-dione

6.1 Students first prepared the standard solutions using the instructions below. Calculate the caffeine concentrations of the standard solutions in mg/l. **4 p.**

Solution	Instructions
c_1	Weigh 0.0250 grams of caffeine with an analytical balance and dilute with water up to 1000.0 ml in a volumetric flask.
c_2	Measure 80.0 ml of solution c_1 with a volumetric pipette and dilute with water up to 100.0 ml in a volumetric flask.
c_3	Measure 60.0 ml of solution c_1 with a volumetric pipette and dilute with water up to 100.0 ml in a volumetric flask.
c_4	Measure 40.0 ml of solution c_1 with a volumetric pipette and dilute with water up to 100.0 ml in a volumetric flask.
c_5	Measure 20.0 ml of solution c_1 with a volumetric pipette and dilute with water up to 100.0 ml in a volumetric flask.

6.2 The absorbances of the standard solutions were measured with a UV spectrometer at the wavelength of 272 nm. Draw a graph of the results and determine the equation of the standard line. **3 p.**

Solution	Absorbance at 272 nm
c_1	2.087
c_2	1.651
c_3	1.216
c_4	0.780
c_5	0.345

6.3 The students prepared the tea samples by steeping a tea bag in 2.00 deciliters of 80 degree water 0.5, 1.0 and 2.0 minutes. For sample analysis, caffeine was extracted from the tea into dichloromethane. In the extraction phase, a 5.0 ml sample was taken from the brewed tea, which was extracted into dichloromethane in a separatory funnel. After extraction, the dichloromethane was collected and diluted in a 50.0 milliliter volumetric flask. The absorbances of the prepared samples were measured with an UV spectrometer at the wavelength of 272 nm. Calculate how many milligrams of caffeine the 2.00 dl tea samples contained. **4 p.**

Brewing time	Absorbance at 272 nm
0.5 min	0.875
1.0 min	1.198
2.0 min	1.421

6.4 Did the brewing time have an effect on the caffeine content of the tea sample? **1 p.**

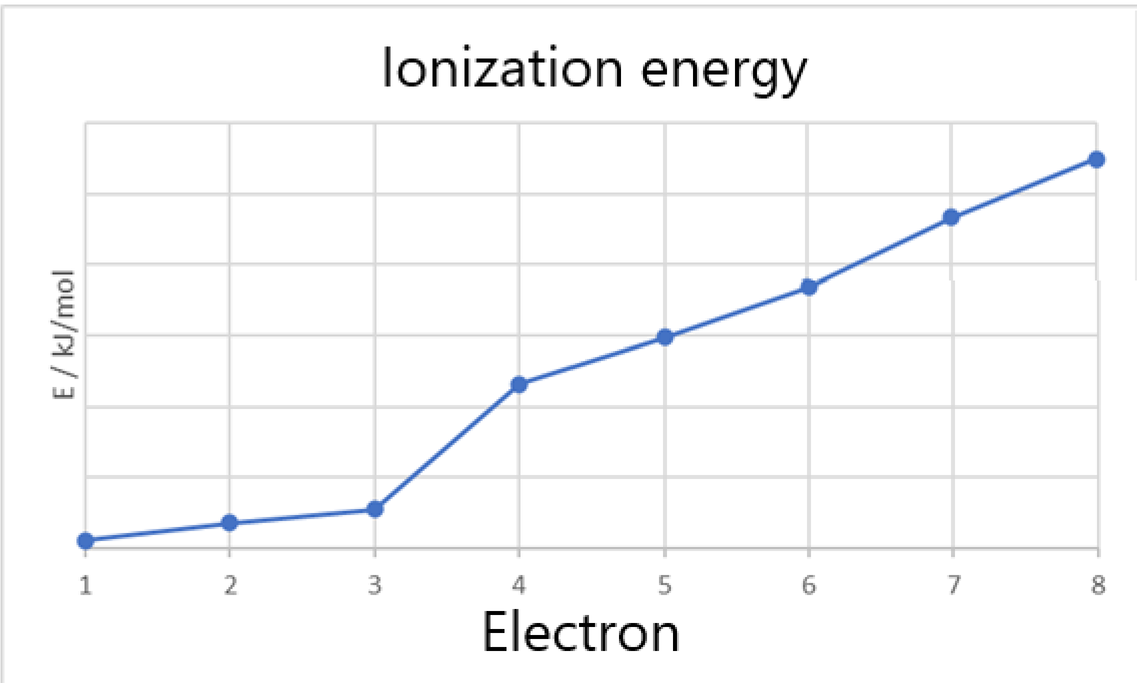
6.5 Based on the research results, can it be said how much caffeine is extracted into the tea when the brewing time is 4.0 minutes? **1 p.**

6.6 How could students evaluate the reliability of their research method? In other words, how could students evaluate whether their research method gives the right results? **1 p.**

6.7 How could the reliability of the research result be improved? **1 p.**

7. A coctail of elements 8 p.

7.1 The ionization energies of an element in the 3rd period are shown in the attached picture. What element is it? **1 p.**



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7.1.A Ionization energies of an element in the third period

7.2 Electron affinity describes the energy released when one electron is attached to a gaseous atom or ion. The higher the electron affinity, the more favorable is the attachment of an electron to an atom or ion. This 4th period element has the highest electron affinity of the period. What element is it? **1 p.**

7.3 The most famous oxide minerals of this transition metal are called hematite and magnetite. What element is it? **1 p.**

7.4 This element is the lightest element that does not have any stable isotopes (i.e. it only has radioactive isotopes). What element is it? **1 p.**

7.5 What ions are found in an aqueous solution of aluminum chloride? Give your answer using chemical symbols. **2 p.**

7.6 What is the formula of the sparingly soluble yellow salt that precipitates when aqueous solutions of lead(II) nitrate and potassium iodide are combined? **2 p.**

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7.6.A Sparingly soluble, yellow salt

Kokeen tehtävät loppuvat tähän.

Siirry tarkastelemaan vastauksiasi

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