



Сојуз на хемичарите и технолозите на Македонија  
Напревари по хемија за ученици од основно и средно образование

## NATIONAL CHEMISTRY COMPETITION

May 26, 2023

- 1) The tests are stapled with an envelope on the top. In the envelope there is piece of paper on which you should fill in the requested data: name and surname, school, supervisor etc. and then close and **seal the envelope!**
- 2) Do not put any signature, or a mark on the envelope and on the test (the code should be filled in by the jury). If any signature or mark is found on the test or envelope, the competitor will be disqualified.
- 3) You should write on the test using a **blue pen**, answers written with pencil will not be considered.
- 4) It is not allowed to use textbooks, any other book, notebook, paper, the periodic table, cell phone etc. Cell phones should be left on the teacher's desk or out of the test room.
- 5) Any conversation between the competitors is forbidden. If you have any question, then the teacher in the room should call the responsible person for the competition..
- 6) Read the test carefully and answer the questions following the instructions by writing down the solution and answer in the designated space in the test. The jury **will evaluate only the answers written in the designated space for it**, and the procedures for solving the problems will be checked. The back of every page of the test, that is empty, can be used for free writing and it will not be checked and evaluated!
- 7) The maximal number of points is **50**: 40 from the theoretical problems and 10 from the experimental problem.
- 8) The competition lasts **150 minutes**. The tests that are handed after the given time will not be considered for scoring.

**We wish you success!**

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### For the jury only

Теориски проблеми: \_\_\_\_\_

Замислен експеримент: \_\_\_\_\_

Вкупно поени: \_\_\_\_\_

Прегледал (Име и презиме)

\_\_\_\_\_



**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. How many millilitres of hydrochloric acid solution with a concentration of  $0.1 \text{ mol/dm}^3$  must be mixed with a second solution of hydrochloric acid solution with a concentration of  $0.5 \text{ mol/dm}^3$  to obtain  $2 \text{ dm}^3$  hydrochloric acid solution with a concentration of  $0.2 \text{ mol/dm}^3$ ?

(7 points)

2. What volume of ammonia (expressed in  $\text{dm}^3$ ) is obtained from  $300 \text{ dm}^3$  of hydrogen and  $300 \text{ dm}^3$  of nitrogen under standard conditions?

(6 points)

3. Complete dehydration of a sample of  $\text{CrF}_3 \times \text{H}_2\text{O}$  reduces its mass by half. How many water molecules does the formula unit of the crystalline hydrate contain?

(7 points)

4. Proteins are macromolecular organic compounds that constitute the main mass of cell protoplasm and account for 10-20% of the total mass in the body (i.e., up to 50% of the dry mass). They have numerous functions: structural, regulatory (hormones), protective (antibodies), transporting (haemoglobin), driving force (myosin and actin), role of biocatalysts (enzymes), etc.

Complete hydrolysis of proteins yields the monomeric units of which they are composed - amino acids. (10 points)

Complete the statements below:

a) \_\_\_\_\_ reagent is used to prove the presence of peptide bonds. This reagent is a mixture of an aqueous solution of \_\_\_\_\_ and \_\_\_\_\_. In the case of a positive test, \_\_\_\_\_ coloring of the solution is obtained.

b) Some proteins are soluble in water or aqueous solutions of salts, while others are not soluble in water. The solubility of proteins depends on:

- I. \_\_\_\_\_ ;
- II. \_\_\_\_\_ ;
- III. \_\_\_\_\_ ;
- IV. \_\_\_\_\_ .

c) Draw the structural formula of the following peptide: Gly-Ser-Phe-Lys



d) Name the peptide Gly-Ser-Phe-Lys. \_\_\_\_\_

5. Monosaccharides can enter into different types of reactions and form different derivatives. One of the most important derivatives that are constituents of monosaccharides are glycosides.

(10 points)

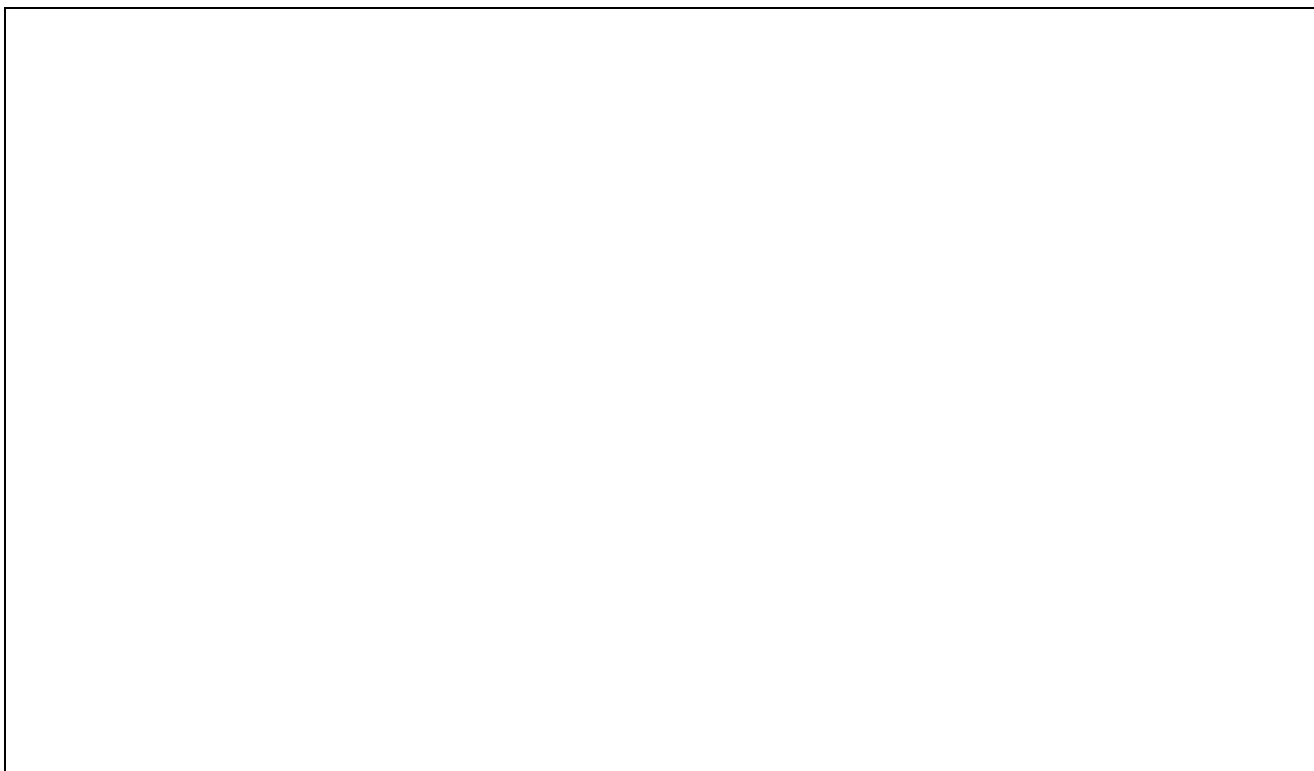
a) Draw the structure of  $\alpha$ -D-glucopyranose

b) Label the anomeric C atom

c) Draw the glycoside obtained in the reaction of  $\alpha$ -D-glucopyranose with ethanol

d) Mark the glycosidic bond

e) The sugar component in the structure of glycosides is generally referred to as \_\_\_\_\_, while the non-sugar component is referred to as \_\_\_\_\_.



## IMAGINARY EXPERIMENT

(10 points)

Meteors are small solid bodies in space that, upon entering the atmosphere, heat up and burn before falling to Earth's surface. As they burn up, they leave a bright trail in the sky, which is why they are also called "falling stars." Light is emitted in different colors depending on the chemical composition of the meteors, their speed and their interaction with the atmosphere.

Considering only the chemical composition, what metal can a meteor contain if it emits light when it burns?

a) yellow color \_\_\_\_\_

b) blue-green color \_\_\_\_\_

A small sample of meteorite was taken, crushed, and dissolved in nitric acid at a concentration of 6 mol/L. Explain how would you make 100 mL of this acid if you have concentrated nitric acid ( $w = 68\%$ ,  $\rho = 1.42\text{ g/mL}$ ,  $M_r = 63.01$ ) at your disposal?

Ammonium hydroxide was then added to make the medium basic. The basicity test of the medium is performed using litmus paper. How could you conclude that the medium is basic?

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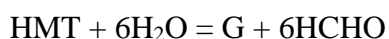
After adding ammonium hydroxide, a red-brown precipitate appeared – that is a compound of a trivalent element. According to this, what element is probably present in the meteor? Write the equation for the chemical reaction that takes place!

If the element has reacted completely with  $\text{NH}_4\text{OH}$  and the mass of the resulting reddish-brown precipitate is 700 mg, calculate the mass fraction of the element in the meteor?

The precipitate is separated from the solution. A few drops of dimethylglyoxime are added to the separated solution and a red, voluminous precipitate is formed. According to this, what other element could be present in the meteor? \_\_\_\_\_

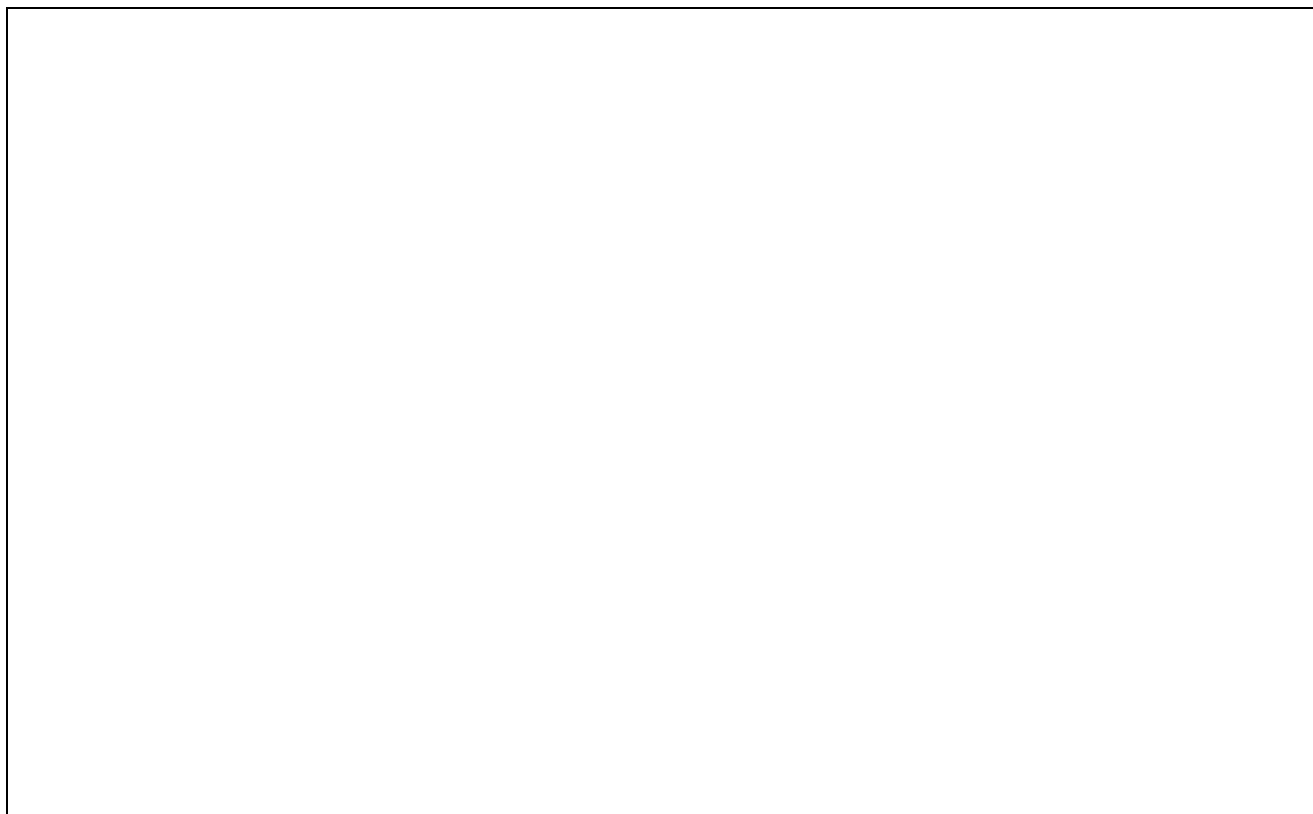
In addition to inorganic components, organic compounds are also found in the composition of meteors. A compound called HMT was found in the studied meteor, which is believed to play an important role in the formation of organic compounds in interstellar space. HMT contains carbon, hydrogen, and an element E. When heated, HMT decomposes into formaldehyde and the colorless gas G with a pungent odor, which dissolves in water and turns red litmus paper blue. The gas G contains the element E.

The reaction proceeds according to the following equation:



a) Identify the gas X that is obtained during the decomposition and write down its Lewis formula!

Determine the true molecular formula of this compound if it is known that the molecular weight is 140.186 and that it contains 51.4 % carbon, 8.6 % hydrogen, and the remainder the element E



1 <b>H</b> 1.008																	2 <b>He</b> 4.003
3 <b>Li</b> 6.941	4 <b>Be</b> 9.012											5 <b>B</b> 10.81	6 <b>C</b> 12.01	7 <b>N</b> 14.01	8 <b>O</b> 16.00	9 <b>F</b> 19.00	10 <b>Ne</b> 20.18
11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31											13 <b>Al</b> 26.98	14 <b>Si</b> 28.09	15 <b>P</b> 30.97	16 <b>S</b> 32.07	17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95
19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.88	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.39	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.61	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80
37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.1	45 <b>Rh</b> 102.9	46 <b>Pd</b> 106.4	47 <b>Ag</b> 107.9	48 <b>Cd</b> 112.4	49 <b>In</b> 114.8	50 <b>Sn</b> 118.7	51 <b>Sb</b> 121.8	52 <b>Te</b> 127.6	53 <b>I</b> 126.9	54 <b>Xe</b> 131.3
55 <b>Cs</b> 132.9	56 <b>Ba</b> 137.3	57 <b>La</b> 138.9	72 <b>Hf</b> 178.5	73 <b>Ta</b> 181.0	74 <b>W</b> 183.8	75 <b>Re</b> 186.2	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.2	78 <b>Pt</b> 195.1	79 <b>Au</b> 197.0	80 <b>Hg</b> 200.6	81 <b>Tl</b> 204.4	82 <b>Pb</b> 207.2	83 <b>Bi</b> 209.0	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
87 <b>Fr</b> (223)	88 <b>Ra</b> 226.0	89 <b>Ac</b> 227.0	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (263)	107 <b>Bh</b> (262)	108 <b>Hs</b> (265)	109 <b>Mt</b> (266)	110 <b>Ds</b> (281)	111 <b>Uuu</b> (272)	112 <b>Uub</b> (285)	113 <b>Uut</b> (284)	114 <b>Uuq</b> (289)	115 <b>Uup</b> (288)			
58 <b>Ce</b> 140.1	59 <b>Pr</b> 140.9	60 <b>Nd</b> 144.2	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.4	63 <b>Eu</b> 152.0	64 <b>Gd</b> 157.3	65 <b>Tb</b> 158.9	66 <b>Dy</b> 162.5	67 <b>Ho</b> 164.9	68 <b>Er</b> 167.3	69 <b>Tm</b> 168.9	70 <b>Yb</b> 173.0	71 <b>Lu</b> 175.0				
90 <b>Th</b> 232.0	91 <b>Pa</b> 231.0	92 <b>U</b> 238.0	93 <b>Np</b> (237)	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (262)				