Сојуз на хемичарите и технолозите на Македонија
Натпревари 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!

For the jury only

Теориски проблеми: _____

Замислен експеримент: _____

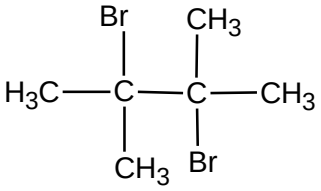
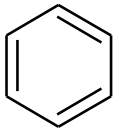
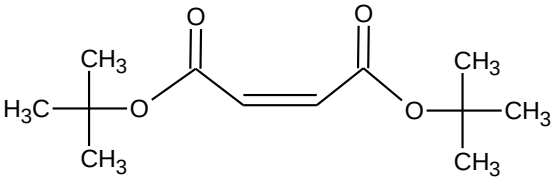
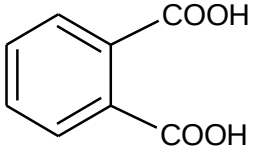
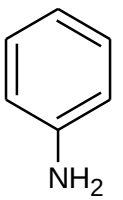
Вкупно поени:_____ Прегледал (Име и презиме)

_____

Write down the solution, including the method of solving and the answer in the appropriate place for it!
Only the part within the marked frame will be checked by the jury!)
The Periodic table of the elements can be found on the last page!

Problem 1. **(10 p)**

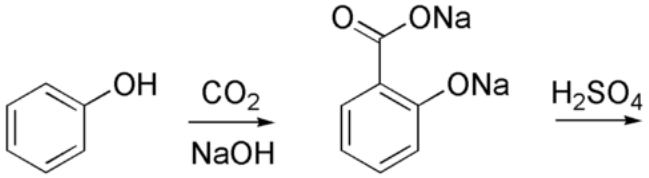
Fill in the missing part (reactant/s or product/s), write the names of the reactants and products and balance the equations.

	→	 _____
 + Cl_2 _____	$\xrightarrow[p,\ t]{h\nu}$	
	→	 _____
 _____	$\xrightarrow{t}$	
 + H_2SO_4 _____	→	

Problem 2. **10 p.**

Aspirin is a very often used medicine against pain, fever and/or inflammation. First data for the discovery of aspirin are from England in 1763 and describe the use of bark from willow trees in reducing pain and fever. The active ingredient in willow bark was later found to be salicylic acid (from salix, the Latin name for willow).

A. Until 1860 the chemists Kolbe and Schmitt managed to synthesize salicylic acid starting from phenol and sodium hydroxide by heating with carbon dioxide under pressure, and the reaction mixture was subsequently acidified to yield salicylic acid according to the following reaction scheme (write the formula and the IUPAC name of a salicylic acid as the final product):



_____ 1 p.

Б. Due to its acidity, salicylic acid irritated the mucous membranes of the mouth, esophagus, and stomach, and this problem has been solved by a simple substitution of the "acidic" hydrogen from the phenolic group with an acetyl group. Write the equation of this reaction that is carried out with anhydride of acetic acid giving aspirin as a product.

2 p.

B. During synthesis of aspirin from salicylic acid, the excess of anhydride of acetic acid is removed by adding water. Write the equation of this reaction:

1 p.

Г. Then aspirin is precipitated and separated by vacuum filtration and its purity has to be tested, especially for the presence of salicylic acid that was not consumed in the reaction. How can the final product be checked for the presence of unconsumed salicylic acid?

2 p.

Д. If the starting material for aspirin synthesis is phenol with 95 % purity and the yield of the final product is 80%, calculate how much phenol (95 % purity) is needed to obtain 1 kg of aspirin?

4 p.

Problem 3. **(8 p)**

One liquid A reacts with aqueous sodium hydroxide and the obtained product is the alcohol B (the product is not an alkene neither a salt of a carboxylic acid).

In the reaction of 1.80 g of compound A with aqueous silver nitrate, 2.71 g of a yellow precipitate is obtained that is not soluble in ammonia. Do the necessary calculations and write down the formulae of compounds A and B.

A= ______6 p**.** **B=** _____2 p.

Problem 4. **12 p.**

Compound X is an unsaturated acyclic hydrocarbon with seven carbon atoms in the molecule, one of them being chiral, and only one primary, one secondary and one tertiary carbon being present, and no quaternary carbon.

After a complete catalytic hydrogenation of the compound X, the compound Y is obtained that does not have a chiral carbon atom. The relative molecular mass of the compound Y is 100.23.

A. Write the structural formula and the name of compound X following IUPAC rules.

6 p.

Б. Write the structural formula and the name of compound Y following IUPAC rules

2 p.

B. Write the rational structural formulae and names of all possible monochlorinated products that could be obtained by reaction of halogenation of compound Y.

2 p.

Г. How many of the monochlorinated products obtained by halogenation of compound Y have a chiral carbon atom? Write down their names according to IUPAC rules.

2 p.

Problem 5. IMAGINARY EXPERIMENT (10 p)

A chemist got an assignment to separate 3 substances from a mixture consisting from the following 3 substances: **A. benzoic acid, B. 1,4-dibromobenzene and C. 4-chloroaniline.**

He had the following chemicals at disposal: water, diethyl ether, aqueous hydrochloric acid, aqueous sodium hydrogencarbonate and anhydrous sodium sulfate. From labware, he had Erlenmeyer flasks, a separatory funnel and a rotary evaporator (apparatus for evaporation of solvent at lowered pressure).

To do the job he worked as follows:

I. He dissolved the mixture in diethyl ether in an Erlenmeyer flask and transferred it to the separatory funnel. Then he added aqueous HCl in the separatory funnel, mixed it thoroughly and left it for the two layers to separate well, and then he collected the lower (aqueous) layer in a clean Erlenmeyer flask. He repeated the same procedure, once again with aqueous HCl and one more time with distilled water and collected the lower layer of all three times in the same **Erlenmeyer flask No. 1**.

II. Then, in the separatory funnel with the remaining solution in diethyl ether he added aqueous $NaHCO_3$ solution and repeated the same steps: thorough mixing, separation of the lower aqueous layer (2 times) and the third time with distilled water. This time he collected the three aqueous layers in the clean **Erlenmeyer flask No. 2**.

III. Finally, he collected the remaining solution in diethyl ether from the separatory funnel by draining it into the clean **Erlenmeyer flask No. 3**.

Explain:

I. Why did he add aqueous HCl and which substance and in which form was separated into the aqueous phase in this step? How can this substance be then turned back in its original form? 4 p.

Erlenmeyer flask No. 1: substance _____

II. Why did he add aqueous $NaHCO_3$ solution and which substance and in which form was separated into the aqueous phase in this step? How can this substance be then turned back in its original form? 4 p.

Erlenmeyer flask No. 2: substance _____

III. Which substance and in which form was separated in the organic phase in this step? 2 p.

Erlenmeyer flask No. 3: substance _____

PERIODIC TABLE

1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 181.0	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.0	89 **Ac** 227.0	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Ds** (281)	111 **Uuu** (272)	112 **Uub** (285)	113 **Uut** (284)	114 **Uuq** (289)	115 **Uup** (288)			

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)