CXTM	**Society of Chemists and Technologists of Macedonia** Chemistry competitions for elementary and high school students **CODE:** _____ (filled in by the jury)	FOR THE JURY ONLY Total points: _____ Checked by: _____ (Name Surname)

RULES FOR THE REGIONAL CHEMISTRY COMPETITION 2022

1) The competition **starts at 12 o'clock and lasts for 90 minutes**. The tests that are handed after the given time will not be considered for scoring.
2) The maximal score is 50 points (30 points from multiple choice questions and 20 points from the problems, as given in the test)
3) The tests are stapled with an envelope on the top. In the envelope there is piece of paper on which every competitor should fill in the requested data: name and surname, school, supervisor etc. and then close (seal) the envelope.
4) **No signature, or any mark is allowed on the envelope and on the test**. The code on the test, below and on the envelope, is filled in by the jury. If any signature or mark is found on the test or envelope, the competitor will be disqualified.
5) The competitors should bring a blue pen with them. The test should be solved by this pen only. **It is not allowed to use a pencil.**
6) Each competitor should leave the **cell phone** at the teacher's desk at the beginning and take it back at the end after handing over the test.
7) A calculator can be used for the numerical problems.
8) A conversation between the competitors during the competition is forbidden as well as using books, notebooks, any other paper, the periodic table of the elements etc. All necessary data are given in the test.
9) A competitor that does not follow any of these rules/recommendations shall be eliminated from the competition.

Periodic table of elements with all the required information is given at the last page of this test!

1. Predict the geometric shape of the molecule CO_2, according to the type of hybrid orbitals of the carbon atom?

A. Tetrahedral
B. Trigonal, pyramidal
C. Trigonal, planar
D. Linear (digonal)

2. How many structural isomers can be written for a hydrocarbon molecule that contains two sp^3 and two sp hybridized C atoms?

A. one
B. two
C. three
D. four

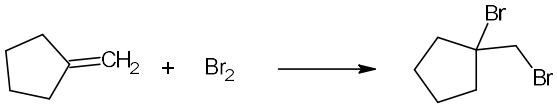
3. Which of the following compounds does NOT form a hydrogen bond between its molecules?

A. CH_3-CH_2-OH
B. CH_3COOH
C. CH_3CHO
D. HO-CH_2-CH_2-OH

4. Which of the following substances is NOT a Bronsted-Lowry acid?

A. HBr
B. NH_3
C. CCl_4
D. H_3O^+

5. The reaction shown bellow is:

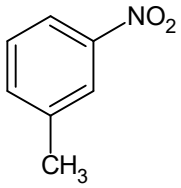


A. Addition
B. Elimination
C. Substitution
D. Regrouping

6. There are five structural isomers with molecular formula C_6H_{14}. What is the IUPAC name of compound that contains one quaternary carbon atom in its molecule?

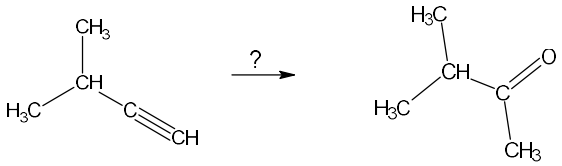
A. 2-methylpentane
B. 3-methylhexane
C. 2,3-dimethylpentane
D. 2,2-dimethylbutane

7. Name the compound:



A. *m*-nitrotoluene
B. *m*-methylnitrobenzene
C. *p*-methylnitrobenzene
D. *o*-nitrotoluene

8. What reagents are needed to synthetise the ketone in the scheme below?



A. KOH/alcohol
B. $KMnO_4/H_2O$
C. H_2O / $HgSO_4$, H^+
D. $NaNH_2$; H_2O

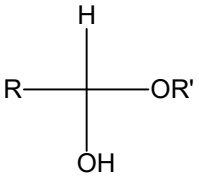
9. Which of the following compounds with molecular formula $C_5H_{12}O$ has a chiral carbon atom in the molecule and at the same time is a primary alcohol?

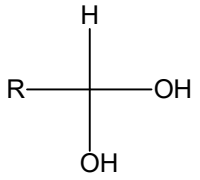
A. 3-methylbutane-2-ol
B. 2-methylbutane-2-ol
C. 3-methylbutane-1-ol
D. 2-methylbutane-1-ol

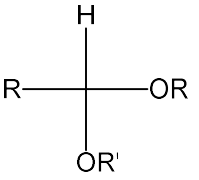
10. Which of the following alcohols (with $K_2Cr_2O_7$ in the presence of concentrated sulfuric acid), will oxidize to a ketone with the same number of carbon atoms?

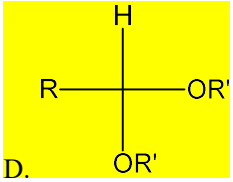
A. 1-methylcyclohexanol
B. 3,3-dimethylcyclopentanol
C. 3-methylhexane-1-ol
D. 3-ethylhexane-3-ol

11. What is the main product obtained by mixing aldehyde RCHO with an excess of alcohol R'OH, in the presence of an acid as a catalyst?

A. 

B. 

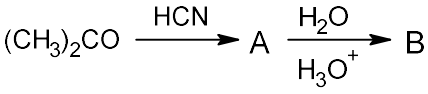
C. 

D. 

12. What type of reaction is the reaction of acetaldehyde with acetone?

A. Aldol addition
B. Oxidation
C. Hydrolysis
D. Esterification

13. What are A and B in the following sequence of reactions, correspondingly?



A. $(CH_3)_2C(OH)CN$, $(CH_3)_2C(OH)COOH$
B. $(CH_3)_2CH(OH)$, $(CH_3)_2C(OH)_2$
C. $CH_3CH(OH)CN$, $CH_3CHOHCOOH$
D. CH_3COCN, $CH_3COCOOH$

14. Which of the following statements about the electrophilic aromatic substitution of benzene is NOT true?

A. The nitration of benzene takes place in a mixture of concentrated sulfuric and nitric acid.
B. Benzene reacts as an electrophilic particle.
C. The reactions of Friedel-Kraft's alkylation and acylation take place in the presence of an $AlCl_3$ catalyst.
D. During the nitration, substitution of a hydrogen atom with an electrophilic NO_2^+ occurs.

15. How many grams of phenol will be obtained in reaction of 2 mol of potassium phenolate with hydrochloric acid?

A. 0,021 g
B. 47 g
C. 94 g
D. 188 g

PROBLEMS:

(Write the solution of these tasks in the field provided for that purpose)

The Periodic table of the elements with all the required information is given at the last page!

SEE THE SOLUTIONS IN THE MKD-VERSION OF THE TEST!

1. (**Total 3 p**) Draw the structural formula of a compound with molecular formula $C_{16}H_{10}$, which has four six-membered rings where all carbon atoms are sp^2 hybridized.

Answer:

(3)

2. (**Total 9 p**) Compound **A** is composed of carbon, hydrogen and oxygen. Its relative molecular weight is 72. This compound is non-reactive, ie it does not react with alkali metals, hydroxides, nucleophiles, oxidants and reducing agents. It is a good solvent for many organic substances. Compound **A** can be obtained by reaction with catalytic hydrogenation, where 6.22 dm^3 of hydrogen were used to synthesize 10 g of this compound under standard conditions. It can be obtained industrially by the acid-catalyzed dehydration of butane-1,4-diol. Compound **A** does not contain chiral centers.

A. In which class of oxygen compounds does the organic compound **A** belong?

Answer: _____ (1)

B. What is the molecular formula of the hydrocarbon fragment?

Answer: _____

(1)

C. How many double bonds of the starting reactant will be hydrogenated?

Answer: _____ double bonds will be hydrogenated from the starting reactant.

(2)

D. Write the structural formula of compound **A**!

Solution:

(3)

E. Write and ballance the equations (with the smallest possible integer coefficients) of the chemical reactions that describe the formation of compound **A**!

Solution:

(2)

3. (**Total 8 p**) The combustion reactions of alkanes are strongly exothermic, and the released heat is used in industry and the household. Thus, complete combustion of 11.0 g of propane releases 555 kJ of heat. Combustion of 11.5 g of a mixture of pentane and hexane releases heat of 564 kJ. In the homologous sequence of alkanes, the combustion enthalpy increases by 660 kJ/mol for each methylene group.

A. Calculate the combustion enthalpy of each of the following alkanes: propane, pentane and hexane!

Solution:

(3)

B. Calculate the mole fraction (in percentage) of pentane and hexane in the mixture!

Solution:

(4)

C. Write and ballance (with the smallest possible integer coefficients) the equation of the complete combustion reaction of pentane!

Solution:

(1)

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)