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.

MULTIPLE CHOICE QUESTIONS TEST WITH ONE CORRECT ANSWER
(Select just one answer A, B, C or D)

A periodic table is included on the last page of the test!

1. There is a single stable isotope of fluorine (^{19}F). How many protons, neutrons and electrons are present in one molecule of deuterium fluoride?

A. 11 protons, 10 neutrons and 11 electrons.

B. 10 protons, 11 neutrons and 10 electrons.

C. 10 protons, 21 neutrons and 10 electrons.

D. 10 protons, 17 neutrons and 10 electrons.

2. A sample of some element Z contains $4.61 \cdot 10^{21}$ atoms. Its mass is 0.815 g. What is the chemical identity of Z?

A. Fe B. Cd

C. Pd D. Na

3. Oxidation numbers of tin in $[Sn(OH)_6]^{2-}$, $SnHPO_3$ and $NaSn_2F_5$ are correspondingly:

A. +4, +2, +2

B. +2, +2, +2

C. +4, +2, +4

D. +2, +2, +4

4. The dissolving of $CaCl_2$ in water is a very exothermic process. The most logical answer about dissolving of $CaCl_2 \cdot 6H_2O$ would be:

A. the process is very exothermic.

B. the process is followed by unsignificant (endothermic) heat change.

C. the process is very endothermic.

D. there are no enough data to predict the heat change.

5. It is known that arsenic(III) bromide melts at 31.1 °C and the obtained melt does not conduct electricity. Its solid phase is:

A. amorphous B. molecular

C. ionic D. structure based on network of covalently bonded atoms

6. Some industrial process for removal of sulfur from natural gas and oil includes the reaction between hydrogen sulfide and sulfur dioxide:

$2H_2S(g) + SO_2(g) \rightarrow 3S(s) + 2H_2O(l)$

Which of the following statements is NOT correct?

A. This is a redox reaction.

B. The number of lost and gained electons, when the extent of the chemical reaction changes by 1 mole, must be equal.

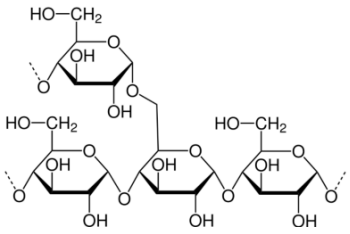
C. SO_2 is an oxidizing agent, H_2S is a reducing agent.

D. H_2S is an oxidizing agent, SO_2 is a reducing agent.

7. Which of the following oxides: N_2O_5, P_4O_{10}, N_2O_3, Sb_2O_3 is amphoteric?

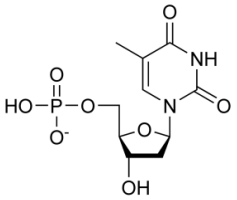
A. N_2O_5
B. P_4O_{10}
C. N_2O_3
D. Sb_2O_3

8. The following structure represents a part of a molecule of:



A. Amylose
B. Amylopectin
C. Cellulose
D. Maltose

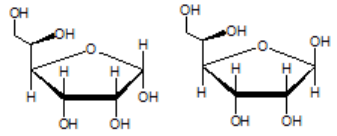
9. The following figure represents the structure of:

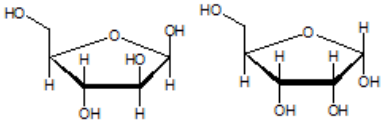


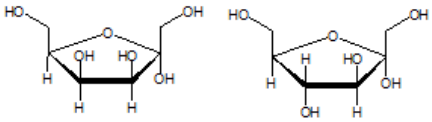
A. Adenosine-5-diphosphate.
B. Cytidine-5-monophosphate.
C. Thymidine-5-monophosphate.
D. Guanidine-5-monophosphate.

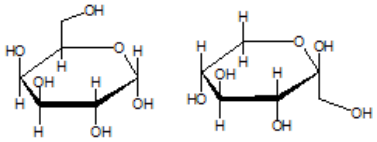
10. Which of the following statements is NOT true for enzyme-catalyzed reactions?
A. Enzyme reactions are stereospecific.
B. The optimum temperature for enzyme-catalyzed reactions is about 80 °C.
C. Substances that affect on enzyme activity are called effectors.
D. According to Michaelis-Menten theory, the enzyme and the substrate form an enzyme-substrate complex.

11. Which of the following pairs of carbohydrates are anomers?

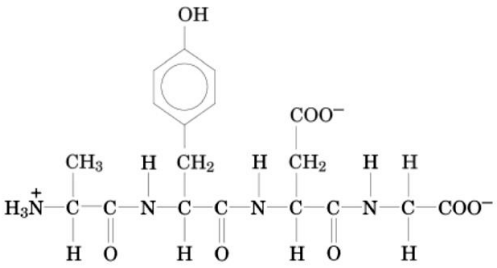
A. 

B. 

C. 

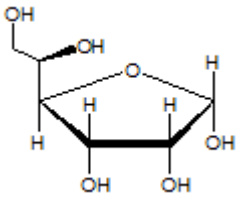
D. 

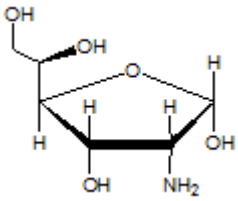
12. Which of the following statement is true for the peptide represented in the figure??

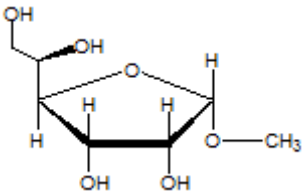


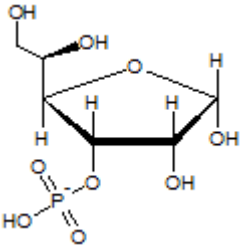
A. It is a tripeptide.
B. The molecule contains four amino acids and three peptide bonds.
C. Complete hydrolysis of one molecule of it produces four molecules of amino acids and three molecules of H_2O.
D. The peptide contains only polar amino acids.

13. Which compound is NOT a derivative of monosaccharides?

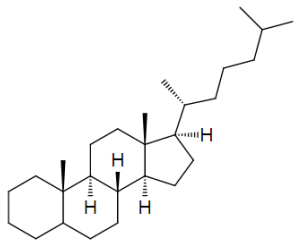
A. 

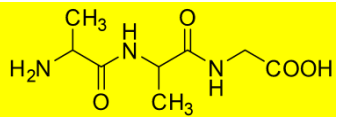
B. 

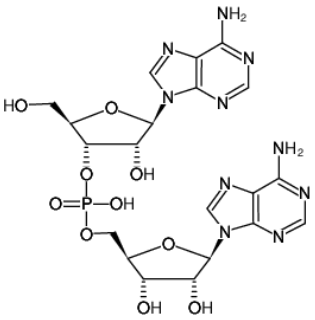
C. 

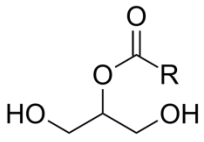
D. 

14. Which of the following compounds will give a positive Biuret reaction?

A. 

B. 

C. 

D. 

15. Hydrogenation of oleic acid yields:

A. Stearic acid.

B. Lauric acid.

C. Linolenic acid.

D. Palmitic acid

PROBLEMS:

(Write down the way of solving and the answer in the marked place)
A periodic table is included on the last page of the test!

1. A copper wire having a mass of 2.196 g, reacted with sulfur. The exess sulfur was then burned yielding SO_2 gas. The mass of produced copper sulfide was 2.748 g.

a) What is the percent composition (by mass) of obtained copper sulfide?

b) What is its empirical formula?

c) Calculate the number od copper ions per cubic centimeter if the density of the copper sulfide is 5.6 g/cm^3.

а) $\omega(\mathrm{Cu}) = \dfrac{m(\mathrm{Cu})}{m(\mathrm{Cu_xS_y})} = \dfrac{2{,}196\ \mathrm{g}}{2{,}748\ \mathrm{g}} = \boxed{79{,}91\ \%}$

$\omega(\mathrm{S}) = (100 - 79{,}91)\% = \boxed{20{,}09\ \%}$

б) $\dfrac{n(\mathrm{Cu})}{n(\mathrm{S})} = \dfrac{x}{y}$

$\dfrac{\dfrac{m(\mathrm{Cu})}{M(\mathrm{Cu})}}{\dfrac{m(\mathrm{S})}{M(\mathrm{S})}} = \dfrac{x}{y}$

$m(\mathrm{S}) = (2{,}748 - 2{,}196)\ \mathrm{g} = 0{,}552\ \mathrm{g}$

$\dfrac{x}{y} = \dfrac{2}{1} \Rightarrow \boxed{\mathrm{Cu_2S}}$

в)

$$\rho(\mathrm{Cu_2S}) = \frac{m(\mathrm{Cu_2S})}{V(\mathrm{Cu_2S})} = \frac{n(\mathrm{Cu_2S})\,M(\mathrm{Cu_2S})}{V(\mathrm{Cu_2S})} = \frac{N(\mathrm{Cu_2S})\,M(\mathrm{Cu_2S})}{N_A\,V(\mathrm{Cu_2S})}$$

$$N(\mathrm{Cu_2S}) = \frac{\rho(\mathrm{Cu_2S})\,N_A\,V(\mathrm{Cu_2S})}{M(\mathrm{Cu_2S})} = 2{,}1\cdot10^{22}$$

$N(\mathrm{Cu^+}) = \boxed{4{,}2\cdot10^{22}}$

2. a) Element X, a member of the 15th group, forms two chlorides, XCl_3 and XCl_5. Reaction of an exess of Cl_2 with 8.729 g XCl_3 yields 13.233 g XCl_5. What is the identity of the element X!

b) A mixture of XCl_3 and XCl_5, with mass of 10.00 g, contains 81.04 % Cl by mass. How many grams of each chloride are present in the mixture?

a) $XCl_3 + Cl_2 = XCl_5$

$$\frac{n(XCl_3)}{n(XCl_5)} = 1$$

$$\frac{m(XCl_3)}{M(XCl_3)} = \frac{m(XCl_5)}{M(XCl_5)}$$

$$M_r(XCl_3) = A_r(X) + 3\,A_r(Cl)$$

$$M_r(XCl_5) = A_r(X) + 5\,A_r(Cl)$$

$$\frac{8{,}729\ \text{g}}{(a + 3 \cdot 35{,}45)\ \text{g/mol}} = \frac{13{,}233\ \text{g}}{(a + 5 \cdot 35{,}45)\text{g/mol}}$$

$$a = A_r(X) = 31{,}06$$

$$\Rightarrow \boxed{X = P}$$

b) $\omega(Cl) = \frac{m(Cl)}{m(\text{смеса})} = 0{,}8104 \cdot 10{,}00\ \text{g} = 8{,}104\ \text{g}$

$$m(Cl) = m(Cl)_{PCl_3} + m(Cl)_{PCl_5}$$

$$\frac{n(Cl)}{n(PCl_3)} = \frac{3}{1}$$

$$\frac{n(Cl)}{n(PCl_3)} = \frac{5}{1}$$

$$\begin{cases} m(Cl) = \left[3\frac{m(PCl_3)}{M(PCl_3)} + 5\frac{m(PCl_5)}{M(PCl_5)}\right] M(Cl) \\ m(PCl_5) = m(\text{смеса}) - m(PCl_3) \end{cases}$$

$$\boxed{\begin{aligned} m(PCl_3) &= 5{,}32\ \text{g} \\ m(PCl_5) &= 4{,}68\ \text{g} \end{aligned}}$$

3. Strongly heating 1000 g of mixture of $KClO_3$, $KHCO_3$, K_2CO_3 and KCl leads to formation of a gas mixture which contains 18 g water vapor, 132 g carbon dioxide and 40 g oxygen. The equations of the reactions taking place in the course of the heating process of the mixure are:

$KClO_3 \rightarrow KCl + O_2$

$KHCO_3 \rightarrow K_2O + H_2O + CO_2$

$K_2CO_3 \rightarrow K_2O + CO_2$

Calculate the mass fraction (in percentage) of the initial mixture if thermal decomposition of substances is completed!

(1) $2\,KClO_3 \rightarrow 2\,KCl + 3\,O_2$

$$\frac{n(KClO_3)}{n(O_2)} = \frac{2}{3}$$

$$m(KClO_3) = \frac{2}{3}\frac{m(O_2)}{M(O_2)}M(KClO_3)$$

$$m(KClO_3) = \frac{2}{3}\frac{40\text{ g}}{32\text{ g/mol}}122{,}55\text{g/mol}$$

$$m(KClO_3) = \boxed{102{,}12\text{ g}}$$

(2) $2\,KHCO_3 \rightarrow K_2O + H_2O + 2\,CO_2$

$$\frac{n(KHCO_3)}{n(H_2O)} = \frac{2}{1}$$

$$m(KHCO_3) = 2\frac{m(H_2O)}{M(H_2O)}M(KHCO_3)$$

$$m(KHCO_3) = 2\frac{18\text{ g}}{18{,}02\text{ g/mol}}100{,}12\text{g/mol}$$

$$m(KHCO_3) = \boxed{200{,}22\text{ g}}$$

(3) $K_2CO_3 \rightarrow K_2O + CO_2$

$$\frac{n(K_2CO_3)}{n(CO_2)} = 1$$

$$n(CO_2)_{BK.} = n(CO_2)_{K_2CO_3} + n(CO_2)_{KHCO_3}$$

$$n(CO_2)_{BK.} = n(K_2CO_3) + n(KHCO_3)$$

$$n(K_2CO_3) = n(CO_2)_{BK.} - n(KHCO_3)$$

$$m(K_2CO_3) = \left[\frac{m(CO_2)_{BK.}}{M(CO_2)} - \frac{m(KHCO_3)}{M(KHCO_3)}\right]M(K_2CO_3)$$

$$m(K_2CO_3) = \left[\frac{132\text{ g}}{44{,}01\text{ g/mol}} - \frac{200{,}02\text{ g}}{100{,}12\text{ g/mol}}\right]138{,}21\frac{\text{g}}{\text{mol}}$$

$$m(K_2CO_3) = \boxed{138{,}21\text{ g}}$$

(4)

$$\omega(KClO_3) = \frac{m(KClO_3)}{1000\text{ g}} = \frac{102{,}12\text{ g}}{1000\text{ g}} = \boxed{10{,}21\ \%}$$

$$\omega(KHCO_3) = \frac{m(KHCO_3)}{1000\text{ g}} = \frac{200{,}22\text{ g}}{1000\text{ g}} = \boxed{20{,}02\ \%}$$

$$\omega(K_2CO_3) = \frac{m(K_2CO_3)}{1000\text{ g}} = \frac{138{,}21\text{ g}}{1000\text{ g}} = \boxed{13{,}82\ \%}$$

$$\omega(KCl) = [100 - (10{,}21 + 20{,}02 + 13{,}82)]\% = \boxed{55{,}95\ \%}$$

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)