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.

1. The following equation is given:

$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$
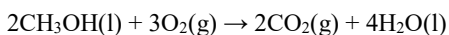
What is correct?
A) The corresponding reaction is endothermic, as the methanol must burn.
B) The changes in the reaction enthalpy are the same, no matter whether the water is obtained in gaseous or liquid state.
C) If the water is in gaseous state, the released heat will be smaller.
D) If the water is in gaseous state, the released heat will be larger, as the vapour temperature is higher of that of the liquid.

2. What is the rate of change of $c(HNO_3)$ with respect to the rate if change of $c[Al(OH)_3]$, for the reaction described by the equation:

$Al(OH)_3 + 3HNO_3 = Al(NO_3)_3 + 3H_2O$
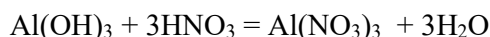
A) The rate of change of $c(HNO_3)$ will be thrice the rate of change for $c[Al(OH)_3]$.
B) The rate of change of $c(HNO_3)$ will be three times smaller of the rate of change for $c[Al(OH)_3]$.
C) The rate of change of $c(HNO_3)$ will be smaller by 3 than the rate of change for $c[Al(OH)_3]$.
D) The rate of change of $c(HNO_3)$ will be larger by 3 than the rate of change for $c[Al(OH)_3]$.

3. The energy of the activated complex is:
A) smaller than the activation energy.
B) equal to the activation energy.
C) equal to the reactants energy.
D) larger than the activation energy.

4. What is the exact expression for the concentration equilibrium constant, for a reaction described by the following equation?
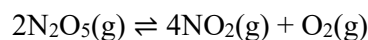
$$2C(s) + 3H_2(g) \rightleftharpoons C_2H_6(g)$$
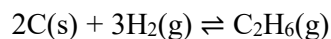
A) $K_c = \dfrac{c(C_2H_6)_e}{c(C_e)^2 \cdot [c(H_2)_e]^3}$

B) $K_c = \dfrac{c(C_2H_6)_e}{[c(H_2)_e]^3}$

C) $K_c = \dfrac{c(C_2H_6)_e}{[c(C)_e]^2 + [c(H_2)_e]^3}$

D) $K_c = \dfrac{[c(C)_e]^2 \cdot [c(H_2)_e]^3}{c(C_2H_6)_e}$

5. The following reaction equation is given for a system in equilibrium:

$$2N_2O_5(g) \rightleftharpoons 4NO_2(g) + O_2(g)$$

What is going to happen if the preasure is increased in the reaction system?
A) Nothing, as all constituents in the reaction are gases.
B) There will be a decrease in the concentrations of all constituents.
C) The equilibrium will move to the right, towards generation of NO_2 and O_2.
D) The equilibrium will move to the left, towards generation of N_2O_5.

6. Which of the following particles could be amphiprotolytes?
I. HSO_4^- II. S^{2-} III. H_2O IV. $H_2PO_4^-$
A) Only II.
B) Only III and IV.
C) I, III and IV.
D) Only I and III.

7. At temperatures lower than 25 °C:
A) $K_w < 1 \cdot 10^{-14}$ mol^2/dm^6.
B) $K_w > 1 \cdot 10^{-14}$ mol^2/dm^6.
C) $K_w = 1 \cdot 10^{-14}$ mol^2/dm^6.
D) One cannot say.

8. The pH value of a NaOH solution equals 11. What is the value of $c(OH^-)$?
A) $c(OH^-) = 10^{-11}$ mol/dm^3
B) $c(OH^-) = 10^{-3}$ mol/dm^3
C) $c(OH^-) = 3$ mol/dm^3
D) $c(OH^-) = 11$ mol/dm^3

9. What solution(s) show pH < 7 at 25 °C?
I. $NaHCO_3$ II. $(NH_4)_2SO_4$ III. CsOH IV. KCN
A) All.
B) Only I, III and IV.
C) Only III and IV.
D) Only II.

10. The oxidation number of phosphorus in H_3PO_2 is:
A) +3.
B) +1.
C) +5.
D) –1

11. During some redox reaction, the nitric acid gives ammonia as a product. That means:
A) The nitric acid is a reducing agent.
B) The oxidation number of nitrogen has increased.
C) The nitric acid is an oxidazing agent.
D) The nitric acid is being oxidized.

12. Which of the following can be both oxidazing and reducing agent, depending on the substances it reacts with?
A) F_2
B) Na_2S
C) $KMnO_4$
D) KNO_2

13. Which of the following equations does not correspond to a redox process?
A) $3KClO = KClO_3 + 2KCl$
B) $CoO + H_2SO_4 = CoSO_4 + H_2O$
C) $Ca + 2H_2O = Ca(OH)_2 + H_2$
D) $2Ba + O_2 = 2BaO$

14. Which of the following substances cannot be oxidizer?
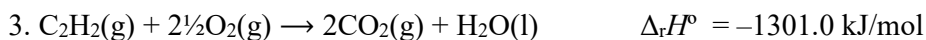A) Cs
B) Cl_2
C) H_2O
D) H_2SO_4

15. Which of the following is the strongest reducing agent?
A) Zinc.
B) Lithium.
C) Silver.
D) Magnesium.

PROBLEMS
(Write down the way of solving and the answer/solution, where appropriate)
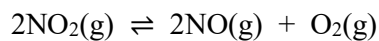
1. The following thermochemical equations are given:

1. $C(graphite) + O_2(g) \longrightarrow CO_2(g)$ $\qquad\qquad$ $\Delta_r H^o = -393.5$ kJ/mol

2. $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$ $\qquad\qquad$ $\Delta_r H^o = -285.8$ kJ/mol

3. $C_2H_2(g) + 2\frac{1}{2}O_2(g) \longrightarrow 2CO_2(g) + H_2O(l)$ $\qquad$ $\Delta_r H^o = -1301.0$ kJ/mol

Calculate the enthalpy of formation of acetylene (C_2H_2).

SOLUTION:

2. In a vessel with volume of 8 L there are 12 mol NO$_2$. At certain temperature NO$_2$ is pyrolyzed according to the equation:

$$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$$

After equilibrium is reached, it has been discovered that there are 6 mol of NO. Calculate the equilibrium concentration constant of chemical equilibrium for this reaction:

SOLUTION:

3. What volume (in mL) of a HNO_3 solution with concentration $c(HNO_3) = 10$ mol/L and what volume of water are needed to prepare 2000 mL solution of HNO_3 with pH = 1.3.

SOLUTION:

4. Nitrogen can be generated by passing gaseous ammonia over cobalt (II) oxide at high temperature, giving elemental cobalt and water vapour.
A) Write down the reaction equation and balance it using electron balance scheme?
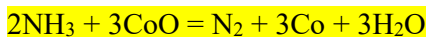Б) Which reactant is an oxidizer, and which is the reducing one?
B) What is the mass of nitrogen obtained from 9 g of NH_3?
Г) What is the volume of the used mass of ammonia at standard conditions?

$A_r(N) = 14.0$; $A_r(H) = 1.0$

SOLUTION:

$2NH_3 + 3CoO = N_2 + 3Co + 3H_2O$

NH_3 – reducing agent CoO – oxidizer