Answer by encircling the letter in front of one of the offered answers. Each correct answer is worth 2 points. A wrong answer is penalized by –0,25 points. Unanswered questions do not alter the score. Using a pencil, encircling of two or more answers or drawing over the answer is penalized by –0.25 points. Each problem is worth a total of 5 points.

JURY ONLY

Total points:_____

Checked by:

_____

I. MULTIPLE CHOICE TEST WITH A SINGLE CORRECT ANSWER

(Encircle **only one** of the answers A, B, C, D or E)

1. What is the value of Gibbs energy in equilibrium?
A) Higher than before the equilibrium.
B) Lower than before the equilibrium.
C) The least possible under the actual conditions.
D) The highest possible under the actual conditions.
E) B and C are the correct answers.

2. In a reaction of thermal decomposition, the sign of ΔH is:
A) Positive.
B) Negative.
C) There is no sign.
D) Positive or negative.
E) It cannot be answered.

3. The quantity defined as a sum of the internal energy and the product of the pressure and volume is known as:
A) Enthalpy.
B) Affinity.
C) Entropy.
D) Activation energy.
E) Potential energy.

4. Upon combination of hydrogen and oxygen (in a presence of a catalyst) water steam is formed. What is correct:
A) The reaction needs heat in order to proceed.
B) The reaction is endothermic.
C) Heat is evolved during the reaction.
D) Heat is neither evolved nor needed for this reaction to proceed.
E) It is not a reaction, but a physical process.

5. Consider an endothermic reaction, A → B, with activation energy E_o and $E_д$ of the reverse and the direct reaction, respectively. In that case:
A) $E_o < E_д$.
B) $E_o = E_д$.
C) $E_o > E_д$.
D) One could not say in advance.
E) A calculation/simulation is needed.

6. A catalyst is a substance that:
A) Brings energy to the reaction.
B) Increases the value of the equilibrium constant of the reaction.
C) Shortens the time needed for reaching equilibrium.
D) Increases the equilibrium concentration of the product.
E) Increases the equilibrium concentration of the reactant.

7. What is the relation between ΔH and ΔU in a system at constant pressure, where there is no change of volume during the transit between two states:
A) $\Delta H < \Delta U$.
B) $\Delta H > \Delta U$.
C) $\Delta H = \Delta U$.
D) ΔH is independent of ΔU.
E) Such a system does not exist.

8. The reaction described by the equation: $ZnSO_4(aq) + Ni(s) = NiSO_4(aq) + Zn(s)$:
A) Is a spontaneous one.
B) Is not a spontaneous one.
C) Sometimes it is spontaneous, sometimes it isn't.
D) One cannot answer without knowing the concentrations.
E) None of the above is true.

9. In the unbalanced equation, $As_2S_3 + HNO_3 = H_3AsO_4 + H_2SO_4 + NO_2 + H_2O$, the number of elements that change their oxidation number is:
A) One.
B) Two.
C) Three.
D) Four.
E) Five

10. During oxidation-reduction reaction of displacement of a metal from its salt by another one, it is true that:
A) The metal that displaces the other one is reduced, while the metal being displaced is oxidized.
B) The metal that displaces the other one is oxidized, while the metal being displaced is reduced.
C) Both metals are oxidized, while the non-metals are reduced.
D) Both metals are reduced, while the non-metals are oxidized.
E) No answer is correct.

11. In an elementary act of chemical transformation it is possible to have:
A) One particle.
B) Two particles.
C) Three particles.
D) B) and C) are the correct answers.
E) A), B) and C) are correct answers.

12. The rate of a reaction between hydrogen and iodine (a reversible reaction) is proportional to the concentrations of both reactants. By how many times will the rate of reaction of HI synthesis [$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$] increase, if the concentration of iodine increases 4 times:
A) 4 times.
B) 2 times.
C) Other important data is missing.
D) It will not increase at all.
E) Such a reaction is hypothetical and will not proceed at all.

13. The temperature coefficient of the rate of an irreversible reaction is 3. At 50 °C the reaction completes in 5 min. How long will it last at 30 °C:
A) 15 min
B) 30 min
C) 45 min
D) 60 min
E) 90 min

14. The reaction profile of a given reaction gives the dependence of the:
A) Energy of the activated complex as a function of time.
B) Activation energy as a function of the reactants.
C) Activation energy as a function of the products.
D) Energy as a function of the reaction coordinate.
E) Temperature of the activated complex as a function of time.

15. In a heterogeneous reaction, when solid and gaseous constituents are in equilibrium, the expression for the equilibrium constant K_c deals with the equilibrium:
A) Concentrations of all solids.
B) Quantities of all constituents.
C) Concentrations of all gases present.
D) Concentrations of all constituents.
E) Quantities of all gases present.

Write the procedure and the result in the rectangle under each problem and only the written in the rectangles will be checked. You may freely use the other side of the paper, but that will not be checked nor will points be assigned, unless written as advised.

II. PROBLEMS

1. Balance the equation by electron schemes and least possible integral coefficients:

Solution:

$$\_\_HNO_3 + \_\_Cu_2O \rightarrow \_\_Cu(NO_3)_2 + \_\_NO + \_\_H_2O$$

The oxidizing agent is _____, while the reducing one is _____.

2. A vessel of 0.874 L, contains gaseous sulfur and hydrogen. After equilibrium was reached at 954 °C, the following values for the equilibrium quantities were found: $n(H_2)_e$ = 0.0665 mol, $n(S)_e = 1.398 \cdot 10^{-6}$ mol and $n(H_2S)_e$ = 0.0815 mol. Write the chemical equation of this reaction and calculate the equilibrium constant.

Solution:

Write the procedure and the result in the rectangle under each problem and only the written in the rectangles will be checked. You may freely use the other side of the paper, but that will not be checked nor will points be assigned, unless written as advised.

3. Evaluate the pH value of a solution obtained by mixing 0.3 g sodium hydroxide and 0.1 g potassium hydroxide in a volumetric flask of 100 mL. The purity of both substances is 95 %. T = 298 K. A_r(H) = 1.008; A_r(O) = 15.999; A_r(Na) = 22.990; A_r(K) = 39.098.

Solution:

4. Determine the concentration of NO_2 generated according to the equation:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

one minute after the reaction started, knowing that the initial quantity of NO_2 was 0.1 mol, while the vessel volume was 0.5 L. It is known from literature that the reaction rate is 0.06 mol L^{-1} s^{-1}. Assume that the quantity of the reactant is large enough, so that the reaction can proceed for a long time.

Solution: