



Competitor's name and surname: \_\_\_\_\_  
Supervisor's name and surname: \_\_\_\_\_  
School: \_\_\_\_\_ Municipality: \_\_\_\_\_  
Competitor's signature: \_\_\_\_\_

JURY ONLY	
Points total:	_____
Questions:	_____ Problems: _____
Checked by:	_____

I. MULTIPLE CHOICE TEST WITH ONLY ONE CORRECT ANSWER  
(Mark **only one** of the answers A, B, C, D or E)

1. A catalyst is:
  - A. A substance taking no part in chemical reaction.
  - B. An accelerator of the reaction.
  - C. A substance that accelerates the reaction, and leaves, chemically and quantitatively, unchanged.
  - D. An accelerator or decelerator of a reaction.
  - E. All of the above answers are true.
  
2. An indication that a chemical reaction takes place *might* be:
  - A. A change of the color in the system.
  - B. Hazing.
  - C. Bubbling.
  - D. A temperature change in the system.
  - E. All of the above answers.
  
3. Find the intruder:
  - A. Reaction.
  - B. Volume.
  - C. Pressure.
  - D. Mass.
  - E. Concentration.
  
4. The temperature coefficient of a rate constant is 3. Estimate the increase of the reaction rate upon a temperature increase of 40 °C:
  - A. 3 times.
  - B. 12 times.
  - C. 40 times.
  - D. 80 times.
  - E. 120 times.
  
5. The reaction between  $\text{CuSO}_4(\text{aq})$  and  $\text{NH}_3(\text{aq})$  is possible due to:
  - A. Formation of a precipitate.
  - B. Formation of a stable complex.
  - C. Formation of a gaseous product.
  - D. Formation of a colored product.
  - E. None of the above.
  
6. The corrosion of which metal is expected to be the fastest one?
  - A. Magnesium.
  - B. Iron.
  - C. Aluminum.
  - D. Sodium.
  - E. Copper.
  
7. The pH value of pure water at 0 °C is 7,5. That means:
  - A. The system is slightly acidic.
  - B. The system is neutral.
  - C. The system is slightly basic.
  - D. The system is heterogeneous.
  - E. There aren't enough data to answer.
  
8. Which salt will be subject to hydrolysis?
  - A. Potassium carbonate.
  - B. Potassium acetate.
  - C. Ammonium chloride.
  - D. Ammonium sulfate.
  - E. All above mentioned salts.
  
9. The compound  $\text{H}_6\text{TeO}_6$  is telluric acid. What might  $\text{H}_6\text{TeO}_3$  be?
  - A. Pyrotelluric acid.
  - B. Pertelluric acid.
  - C. Tellurous acid.
  - D. Hypotellurous acid.
  - E. Nothing of the above.
  
10.  $\text{Cr}(\text{OH})_2\text{HCO}_3$  is:
  - A. Chromium hydroxide hydrogencarbonate.
  - B. Chromium dioxide trihydrogencarbonate.
  - C. There is no such compound.
  - D. Chromium perhydro-hydroxocarbonate.
  - E. Chromium oxide hydrocarbonate.
  
11. Upon dilution of concentrated sulfuric acid, it is important that:
  - A. A weak stream of water is added to the acid, and the liquid is stirred permanently.
  - B. A weak stream of acid is added to the water, and the liquid is stirred permanently.
  - C. For best results, weak streams of acid and water are added in an empty vessel, upon permanent stirring.
  - D. It makes no difference, as long as it is stirred.
  - E. The dilution is impossible; this acid is immiscible with water.
  
12. In the experiment where diluted hydrogen peroxide is added to manganese(IV) oxide, a reaction occurs that could be summarized with the equation:
  - A.  $\text{H}_2\text{O}_2(\text{aq}) = \text{H}_2\text{O}(\text{l}) + \frac{1}{2}\text{O}_2(\text{g})$ .
  - B.  $\text{MnO}(\text{s}) + \text{H}_2\text{O}_2(\text{aq}) = \text{H}_2\text{MnO}_3(\text{aq})$ .
  - C.  $\text{MnO}_2(\text{s}) + \text{H}_2\text{O}_2(\text{aq}) = \text{H}_2\text{MnO}_4(\text{aq})$ .
  - D.  $\text{MnO}_4(\text{aq}) + \text{H}_2\text{O}_2(\text{aq}) = \text{H}_2\text{MnO}_4(\text{aq}) + \text{O}_2(\text{g})$ .
  - E.  $2\text{MnO}_2(\text{s}) + \text{H}_2\text{O}_2(\text{aq}) = 2\text{HMnO}_3(\text{aq})$ .

13. The compound  $\text{Na}[\text{Au}(\text{CN})_4]$  is:

- A. Sodium gold cyanide.
- B. Sodium gold(III) cyanide.
- C. Tetracyanogolden sodium.
- D. Sodium tetracyanoaurate(III).
- E. Sodium tetracyanogoldate(III).

14. Find the intruder:

- A. Cuprite.
- B. Galena.
- C. Sphalerite.
- D. Quartz.
- E. Malachite.

15. Upon electrolysis of copper(II) chloride, at the anode is separated:

- A. Copper.
- B. Copper(I) chloride.
- C. Oxygen.
- D. Chlorine.
- E. Hydrogen.

16. Which two elementary substances will displace hydrogen from diluted acids?

- A. Sulfur and iron.
- B. Iron and sodium.
- C. Sodium and copper.
- D. Copper and zinc.
- E. Zinc and silver.

17. Which of the oxides is also a plumbate?

- A.  $\text{Pb}_2\text{O}_3$ .
- B.  $\text{Pb}_3\text{O}_4$ .
- C.  $\text{Pb}_2\text{O}_4$ .
- D.  $\text{Na}_2\text{PbO}_2$ .
- E.  $\text{Pb}_2\text{O}_2$ .

18. The quantities (left: 1, 2, 3, 4) are related to their units (right: a, b, c, d):

1. rate of reaction	a. $\text{mol s}^{-1}$
2. pressure	b. kJ
3. reaction enthalpy	c. Pa
4. energy	d. kJ/mol

Which of the offered answers is correct?

- A. 1-a, 2-d, 3-b, 4-c.
- B. 1-b, 2-c, 3-a, 4-d.
- C. 1-c, 2-d, 3-b, 4-a.
- D. 1-d, 2-c, 3-a, 4-b.
- E. None of the above.

19. If a process can be described by the equation  $2\text{HA} \rightleftharpoons \text{H}_2\text{A}^+ + \text{A}^-$ , it is actually:

- A. Electrolysis.
- B. Autoprotolysis.
- C. Catalysis.
- D. Hydrolysis.
- E. Monalysis.

20. Which diluted acid is capable to act on copper, in the presence of oxygen:

- A.  $\text{H}_2\text{SO}_4(\text{aq})$
- B.  $\text{HCl}(\text{aq})$ .
- C.  $\text{CH}_3\text{COOH}(\text{aq})$ .
- D. Any of the above three.
- E. None mentioned.

21. Which oxide does not exist?

- A.  $\text{S}_2\text{O}$ .
- B.  $\text{N}_2\text{O}$ .
- C.  $\text{SO}_2$ .
- D.  $\text{NO}_2$ .
- E.  $\text{SO}_3$ .

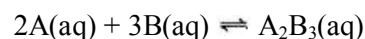
22. Which is *the only* chemical reaction (represented by an *unbalanced* equation) that is feasible:

- A.  $\text{KMnO}_4 \rightarrow \text{K}_2\text{O} + \text{Mn}_2\text{O}_7 + \text{O}_2$ .
- B.  $\text{KMnO}_4 + \text{HCl} \rightarrow \text{KCl} + \text{MnCl}_2 + \text{Cl}_2 + \text{H}_2\text{O}$ .
- C.  $\text{KMnO}_4 + \text{CO}_2 \rightarrow \text{K}_2\text{CO}_3 + \text{MnO}_2$ .
- D.  $\text{KMnO}_4 + \text{CO}_2 \rightarrow \text{K}_2\text{CO}_3 + \text{MnO}_3$ .
- E.  $\text{KMnO}_4 + \text{SO}_2 \rightarrow \text{K}_2\text{SO}_4 + \text{Mn}_2\text{O}_7$ .

23. A chemical reaction taking place in aqueous solution *does not* depend on:

- A. The temperature.
- B. The concentration.
- C. The nature of the reacting substances.
- D. The magnitude of atmospheric pressure.
- E. Any of the above.

24. In a reaction represented by the equation:



The units for the equilibrium constant,  $K_c$  are:

- A.  $\text{mol}^{-1} \text{dm}^3$ .
- B.  $\text{mol}^{-2} \text{dm}^6$ .
- C.  $\text{mol}^{-3} \text{dm}^9$ .
- D.  $\text{mol}^{-4} \text{dm}^{12}$ .
- E.  $\text{mol}^{-5} \text{dm}^{15}$ .

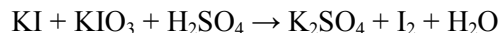
25. Which compound is not an ionic one?

- A. HOH.
- B. NaOH.
- C. KOH.
- D. RbOH.
- E. CsOH.

## II. PROBLEMS

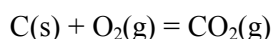
(Write the final result in the rectangle, placed under the posed problem)

1. Balance the given equation of the redox reaction using electronic scheme. For the final balanced equation use the smallest possible stoichiometric coefficients!



In this equation, oxidizing agent is \_\_\_\_\_, while reducing agent is \_\_\_\_\_.

2. Calculate the mass of the anthracite (with 94 % mass fraction of carbon), that needs to be combusted in order to obtain  $10^5$  kJ heat. The enthalpy of carbon combustion described with the equation:

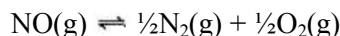


is  $-393.5$  kJ/mol. Consider that the rest 6 % of the anthracite do not react.

$[A_r(\text{C}) = 12; A_r(\text{O}) = 16]$

Solution:

3. For the chemical equilibrium, represented by the equation:



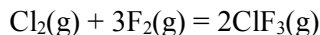
The equilibrium constant,  $K_c$ , equals 0.1414 at 25 °C. Calculate the equilibrium masses of the products knowing that the equilibrium concentration of NO equals  $2 \cdot 10^{-3}$  mol/dm<sup>3</sup>. The volume of the reaction vessel is 2 L. In the beginning there is only NO present in the system.  $[A_r(\text{N}) = 14.0; A_r(\text{O}) = 16.0]$

Solution:

4. Calculate the pH value of the solution obtained by mixing 20 mL sodium hydroxide solution with molar concentration of the solute equal to 0.0021 mol/L and 15 mL sodium hydroxide solution with molar concentration of the solute equal to 0.0205 mol/L?

Solution:

5. Determine the molar concentration of the ClF<sub>3</sub> obtained during the chemical reaction represented by the equation:



after the twentieth second from its start, if no ClF<sub>3</sub> was present at the beginning. From the literature data it is known that the rate of formation of the product is  $0.074$  mol L<sup>-1</sup> s<sup>-1</sup>. Consider that the amount of the reactants is big enough so the reaction can proceed for a long period of time.

Solution:



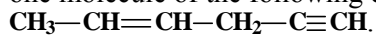
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I. MULTIPLE CHOICE TEST WITH ONLY ONE CORRECT ANSWER  
 (Mark **only one** of the answers A, B, C, D or E)

1. How many  $sp^2$ -hybridized C-atoms are there in one molecule of the following compound?



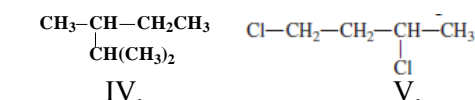
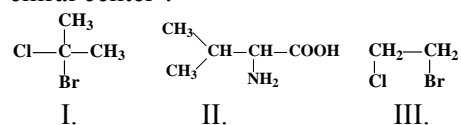
- A. 4  
 B. 6  
 C. 2  
 D. 1  
 E. 0

2. Which of the following species are electrophiles?



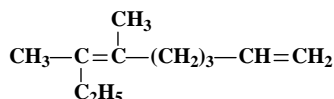
- A. All  
 B. I and III  
 C. IV  
 D. None  
 E. II and V

3. Which of the following compounds have a chiral center?



- A. II, IV and V.  
 B. I only.  
 C. II and V.  
 D. II only.  
 E. I and III.

4. What is the IUPAC name of the following compound?



- A. 7-ethyl-6-methylocta-1,6-diene  
 B. 2-ethyl-3-methylocta-2,7-diene  
 C. 6,7-dimethylocta-1,6-diene  
 D. 3,4-dimethylhepta-3,8-diene  
 E. 6,7-dimethylnona-1,6-diene

5. By heterolytic cleavage of C-F bond of  $\text{CH}_3\text{CH}_2\text{F}$  the following species are obtained:

- A.  $\cdot\text{CH}_3\text{CH}_2$  and  $\cdot\text{F}$  radicals  
 B.  $\cdot\text{CH}_3$ ,  $\text{CH}_2^+$  and  $\text{F}^-$   
 C.  $\cdot\text{CH}_3\text{CH}_2$  and  $\text{F}^-$   
 D.  $\text{CH}_3\text{CH}_2^+$  and  $\text{F}^-$   
 E.  $\text{CH}_3\text{CH}_2^-$  and  $\text{F}^+$

6. Which compound is obtained from the reaction between cyclopropane and bromine?

- A. 1-bromocyclopropane  
 B. 1,2-dibromocyclopropane  
 C. 1,3-dibromopropane  
 D. 1,2-dibromopropane  
 E. 1,1-dibromocyclopropane

7. How many positional isomers are possible for pentadiene?

- A. 6  
 B. 2  
 C. 3  
 D. 4  
 E. 5

8. Which compound is obtained by addition of hydrogen to 2,4,4-trimethylpent-2-ene?

- A. 2,4,4-trimethylpentane  
 B. 2,4,4-trimethyloctane  
 C. Octane  
 D. 2,2,4-trimethyloctane  
 E. 2,2,4-trimethylpentane

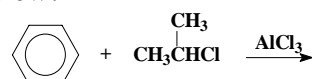
9. For which of the following compounds geometrical isomerism is not possible?

- A. Hept-3-ene.  
 B. 2-methyl-but-2-ene.  
 C. 4-methylpent-2-ene.  
 D. 6-ethyloct-3-ene.  
 E. 1-chlorobut-2-ene.

10. Which compound is obtained by water addition on pent-1-yne, according to Markovnikov's rule?

- A. Pentan-2-one.  
 B. Pentan-2-ol.  
 C. Pentanal  
 D. Pentan-1-ol.  
 E. Pentan -3- one

11. What is the product of the reaction which is sketched below?

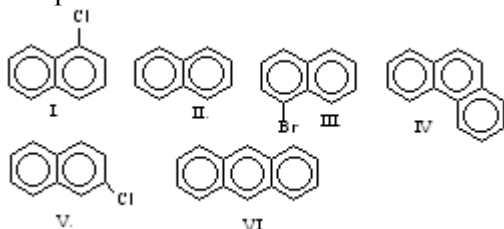


- A. p-Xylene  
 B. 2-methyl-propylbenzene.  
 C. Toluene.  
 D. Chlorobenzene.  
 E. Isopropylbenzene.

12. Which organic reactant and which catalyst is needed to obtain *o*-chlorotoluene?

- A. Benzene and sulfuric acid
- B. Toluene and sulfuric acid.
- C. Toluene and iron(III) chloride.
- D. Benzene and iron(III) chloride.
- E. Xylene and sulfuric acid.

13. Find the isomeric pairs from the following compounds?

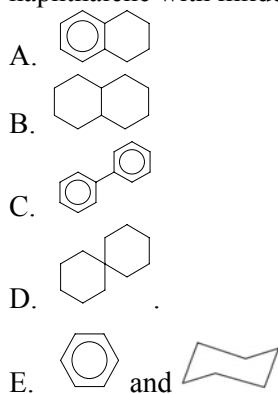


- A. I, II and V.
- B. Only I and V.
- C. I and III; II and VI
- D. I and V; IV and VI.
- E. Only I and III.

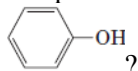
14. How many monosubstituted derivatives can be obtained from the electrophilic aromatic substitution of naphthalene?

- A. 1
- B. 2
- C. 4
- D. 8
- E. 10

15. Which compound is obtained by reduction of naphthalene with milder reducing agents?



16. What is the pH of aqueous solutions of the



following compound ?

- A. Weakly basic.
- B. Strongly basic.
- C. Neutral.
- D. Weakly acidic.
- E. Strongly acidic.

17. From which of the following reactions, described with the following equations, hydrogen is liberated?

- A.  $\text{CH}_3\text{OH} + \text{HCOOH} \rightarrow$
- B.  $\text{CH}_3\text{OH} + \text{Na} \rightarrow$
- C.  $\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{SO}_4 \rightarrow$
- D.  $\text{CH}_3\text{COOH} + \text{NaOH} \rightarrow$
- E.  $\text{C}_6\text{H}_5\text{OH} + \text{KOH} \rightarrow$

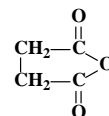
18. Which of the following compounds can react with



in nucleophilic addition reactions ?

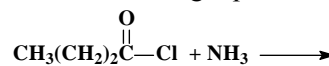
- I. HCN
- II.  $\text{C}_2\text{H}_6$
- III.  $\text{H}_2\text{O}$
- IV.  $\text{H}_3\text{C}-\text{O}-\text{CH}_3$
- V.  $\text{C}_2\text{H}_5\text{OH}$
- A. Only V.
- B. I and V.
- C. Only I.
- D. All.
- E. I, III and V.

19. The following compound is:



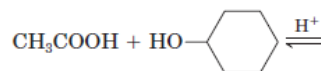
- A. Cyclopentadione.
- B. Ethanoic acid anhydride.
- C. Butanedioic acid anhydride
- D. Ester of Butanedioic acid.
- E. Tetrahydrofuraneketone.

20. What are the products from the reaction sketched with the following equation?



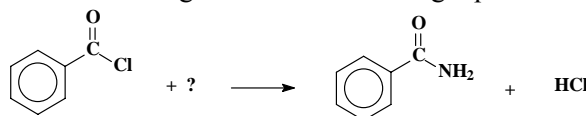
- A. Butanone and ammonium chloride
- B. 1-aminopropane and hypochloric acid.
- C. Ammonium butanoate and HCl.
- D. Butanamide and HCl.
- E. Butanoic acid and ammonium chloride.

21. What is the product products from the reaction sketched with the following equation?



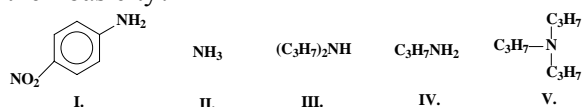
- A. Cyclohexyl acetate.
- B. Phenyl acetate.
- C. Benzophenone.
- D. *p*-hydroxybenzoic acid.
- E. *p*-methylphenol.

22. The missing reactant in following equation is:



- A. Ammonia.
- B. Ammonium bromide.
- C. Ethylamine.
- D. Ammonia and ethanol.
- E. Acetamide.

23. Order the following compounds according to their basicity?



A. I > III > IV > II > V

E. I < III < IV < V < II

C. I < II < IV < III < V

D. IV < III < V < II < I

24. What compound is obtained from the reduction of nitrobenzene?

A. Sodium benzoate.

B. Benzoyl nitrate.

C. Benzene.

D. 1,3-dinitrobenzene.

E. Aniline.

25. How many steps are there in the reaction of free radical substitution of alkanes?

A. 1

B. 3

C. 2

D. 4

E. 0

## II. PROBLEMS

(Write the final result in the rectangle, placed under the posed problem)

1. How many grams of benzoic acid will be obtained by hydrolysis of 2 moles of benzoic acid anhydride?

Answer:

2. Calculate the volume in  $\text{cm}^3$  of chlorine, measured at standard conditions, needed for reaction with 5.41 g of buta-1,3-diene in order to obtain 1,2,3,4-tetrachlorobutane?

Answer:

3. Calculate the mass of triethylamine that contains  $1.2 \cdot 10^{24}$  atoms of hydrogen.

Answer:

4. Ethanol 96 % (*m/m*) solution has density of  $0.789 \text{ g/cm}^3$ . Calculate the volume of this solution needed to prepare 100 g of 30 % (*m/m*) aqueous solution of ethanol.

Answer:

5. For bromination of benzene (with  $\text{FeBr}_3$  as a catalyst) 60 g of benzene are reacted with 135 g of bromine. Indicate the portion of which reactant will remain unreacted and express its quantity in grams.

Answer:

$$A_r(\text{Cl}) = 35,45; A_r(\text{C}) = 12,01; A_r(\text{H}) = 1,01; A_r(\text{N}) = 14,01; A_r(\text{O}) = 16,00; A_r(\text{Br}) = 79,90.$$