Competitor's name and surname: _____
Supervisor's name and surname: _____
School: _____ Municipality: _____
Competitor's signature: _____

JURY ONLY
Points total: _____
Mult. choice:_____ 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. Elementary substances are:
A. built of different atoms.
B. built of identical atoms.
C. built of ions.
D. isomers.
E. isotopes.

2. Dew formation is a:
A. chemical process.
B. biological process.
C. physical process.
D. sociological process.
E. none of the above.

3. Mark the intruder!
A. Oxidation.
B. Combustion.
C. Corrosion.
D. Melting.
E. Reduction.

4. Which substances are, at standard conditions, built of free atoms?
A. Halogen elements.
B. Diamond.
C. Metals.
D. Noble gases.
E. None of the above.

5. The chemical symbol of iodine is:
A. J
B. J_2
C. I
D. I_2
E. Jo

6. The formula $Ca_3(PO_4)_2$ means that:
A. the mole ratio of calcium, phosphorus and oxygen in the compound is 3:1:4.
B. the mole ratio of calcium, phosphorus and oxygen in the compound is 3:2:2.
C. the mole ratio of calcium, phosphorus and oxygen in the compound is 3:2:8.
D. the mass ratio of calcium, phosphorus and oxygen in the compound is 3:2:8.
E. None of the above is true.

7. In the compound NO_2, the nitrogen is:
A. monovalent.
B. bivalent.
C. tetravalent.
D. hexavalent.
E. eight-valent.

8. In 1 mol of NO there are:
A. $6{,}02\cdot10^{23}$ molecules of nitrogen monoxide.
B. $6{,}02\cdot10^{23}$ atoms of nitrogen.
C. $6{,}02\cdot10^{23}$ atoms of oxygen.
D. All 3 statements (A, B, C) are true.
E. All 3 statements (A, B, C) are false.

9. Which stoichiometric coefficients should be put to balance the chemical equation:
$AgNO_3 + AlCl_3 \rightarrow AgCl + Al(NO_3)_3$
A. 1,1,1,1
B. 3,1,1,1
C. 3,3,3,1
D. 3,1,3,1
E. None of the above is correct.

10. What does a balanced chemical equation express?
A. Which reactants are transformed to products, without considering their quantities.
B. The mass ratio of the participants in the reaction.
C. The mass ratio of the participants in the reaction.
D. All 3 statements (A, B, C) are true.
E. None is true.

11. Mark the correct statement!
A. There are neutrons and equal number of protons and electrons in every nucleus.
B. The number of protons in every nucleus is equal to the number of neutrons.
C. The number of protons in the nucleus of the atom is equal to the number of electrons in the electronic shells.
D. The sum of the number of neutrons and protons in the nucleus of the atom is equal to the number of electrons in the electronic shells.
E. The number of neutrons in the nucleus of the atom is called an atomic number.

12. Nuclides with equal mass number and different atomic number are called:
A. isotopes.
B. isobars.
C. isohores.
D. isomers.
E. isohypses.

13. The nuclide $^{122}_{50}Sn$:
A. has 122 neutrons and 50 protons.
B. has 72 neutrons and 50 protons.
C. has 72 protons and 50 neutrons.
D. is an isotope to the nuclide $^{122}_{52}Te$.
E. is an isobar to the nuclide $^{120}_{50}Sn$.

14. The following combination of quantum numbers $n = 4$, $l = 2$, $m_l = 0$ refers to:
A. one of the 4*p* orbitals.
B. one of the 4*d* orbitals.
C. one of the 4*f* orbitals.
D. all 4*d* orbitals.
E. This combination is not possible.

15. Sodium is the first, and chlorine the one before-the-last element in the third period. Mark what is true!
A. The first ionization energy of sodium is greater than the one of chlorine.
B. The first ionization energy of sodium is smaller than the one of chlorine.
C. The first ionization energy of sodium and chlorine are similar.
D. The electronegativity of sodium and chlorine are similar.
E. The electronegativity of sodium is greater than the one of chlorine.

16. All substances are built of:
A. atoms.
B. ions.
C. molecules.
D. all particles given in A, B or C.
E. only atoms and molecules.

17. The ionic bond is formed by exchange of electrons in the way that:
A. the atoms are electrostatically attracted to each other.
B. both partners in the bond formation give electrons that are then shared.
C. both partners in the bond formation give electrons that are then shared, but one of atom attracts the electrons more that the other.
D. one partner gives electron/s and the other accepts the electron/s and the ions formed attract each other.
E. ionic molecules are formed.

18. The atoms of hydrogen and oxygen are bonded in the water molecule by a:
A. ionic bond.
B. non-polar covalent bond.
C. polar covalent bond.
D. hydrogen bond.
E. oxygen bond.

19. The double bond is formed by:
A. overlapping of two atomic orbitals.
B. sharing two common electrons.
C. sharing two common protons.
D. forming a common pair of electrons.
E. forming two common electron pairs.

20. Diamond is an example of a crystal built of:
A. ions.
B. atoms.
C. molecules.
D. radicals.
E. It does not have a crystal structure.

21. What is true for the *s*-elements!
A. They easily accept electrons.
B. They easily give electrons.
C. They have high ionization energy.
D. They have high electronegativity values.
E. They are not reactive.

22. The formula of the hexavalent chromium is:
A. Cr_3O
B. Cr_2O_3
C. CrO_2
D. CrO_3
E. CrO_4

23. The name of the following acid H_2SeO_4 is:
A. hydrogen selenide.
B. seleneous acid.
C. selenic acid.
D. perselenic acid.
E. superselenic acid.

24. The formula of barium perchlorate is:
A. $BaClO_3$
B. $Ba(ClO_3)_2$
C. $BaClO_4$
D. $Ba(ClO_4)_2$
E. $Ba(ClO_5)_2$

25. In a just opened bottle of sparkling water there is a:
A. true solution.
B. homogeneous system.
C. coarse dispersed system.
D. colloid dispersed system.
E. emulsion.

II. PROBLEMS

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

1. Calculate the number of water molecules in 1 g of copper(II) sulfate pentahydrate?

   Result: ☐

2. The chemical analysis of one component of the thyme essential oil gave the following results for the mass percent of the elements: 79.88 % carbon, 9.32 % hydrogen; the rest is oxygen. Another type of analysis revealed the relative molecular mass of 150.22. This compound is called carvacrol. Find its molecular formula.

   Result: ☐

3. Find the amount of substance of sulfur in 15 g of $Al_2(SO_4)_3 \cdot 18H_2O$?

   Result: ☐

4. The industrial production of baking soda can be written by the following chemical equation:

   $$NaCl + CO_2 + NH_3 + H_2O \longrightarrow NaHCO_3 + NH_4Cl$$

   What is the mass of sodium chloride (expressed in kg) needed for producing 1 t of sodium hydrogencarbonate?

   Result: ☐

5. Calculate the volume of carbon dioxide (in liters, at standard conditions) that is liberated in reaction of 7 g calcium carbonate with 30 g aqueous solution of hydrochloric acid (the mass fraction of hydrochloric acid is 18 %)?

   Result: ☐

Data that might be needed:

$A_r(H) = 1.01$; $A_r(C) = 12.0$; $A_r(O) = 16.0$; $A_r(Cu) = 63.5$; $A_r(S) = 32.1$;
$A_r(Al) = 27.0$; $A_r(Na) = 23.0$; $A_r(Cl) = 35.4$; $A_r(Ca) = 40.1$; $A_r(N) = 14.0$.

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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. A reactant is:
A. The substance standing strictly on the left-hand side of the chemical equation.
B. The substance that is oxidized.
C. The substance that is reduced.
D. The substance the quantity of which decreases.
E. All offered answers are correct.

2. What is true at equilibrium, for a chem. reaction described by the equation $2HI \rightleftharpoons H_2 + I_2$:
A. There is no chemical reaction whatsoever.
B. HI is a reactant.
C. The rates of the direct and inverse reactions are equal.
D. In fact, the reactants are H_2 and I_2.
E. The question is not posed correctly.

3. Find the intruder:
A. Reaction of decomposition.
B. Reaction of pyrolysis.
C. Reaction of polymerization.
D. Displacement reaction.
E. Synthesis reaction.

4. The rate of a reaction *does not* depend on:
A. The temperature.
B. The concentration.
C. The nature of the reacting substances.
D. The volume of the vessel used.
E. None of the above answers is true.

5. Upon dissolving in water, the number of ions from the solute will significantly increase in case of:
A. Table salt.
B. Hydrogen chloride.
C. Potassium iodide.
D. Sodium hydroxide.
E. All of the above compounds.

6. What material/s is/are subject to corrosion?
A. Glass.
B. Iron.
C. Cement.
D. Marble.
E. All of the above.

7. At 60 °C pure water has pH ≈ 6.5, which means:
A. The solution is slightly acidic.
B. The solution is neutral.
C. The solution is slightly basic.
D. The solution is contains some other substances.
E. There aren't enough data to answer the question.

8. Which substance will be subject to hydrolysis?
A. Sodium hydrogen carbonate.
B. Potassium sulfate.
C. Calcium chloride.
D. Lithium bromide.
E. All of the above mentioned salts.

9. The compound $HClO_3$ is chloric acid. What is HClO?
A. Pyrochloric acid.
B. Oxyhydrogenchloridic acid.
C. Chlorous acid.
D. Hypochloric acid.
E. Hypochlorous acid.

10. What is the chemical name of $BiCl_2(OH)$?
A. Bismuth hydroxyl chloride.
B. Bismuth(III) hydroxide chloride.
C. Bismuth(V) oxido-hydrido-chloride.
D. Bismuth(V) oxido-hydrido-dichloride.
E. Bismuth(III) hydroxochloride.

11. In the historical experiment that led to discovery of electricity, of key significance were:
A. Frog legs.
B. Chicken wings.
C. Cat claws.
D. Horse hair and tail.
E. Eel intestines.

12. Which ions can be considered as both acids and bases (in a Brönsted sense)?
A. NO_3^-.
B. SO_4^{2-}.
C. H_3O^+.
D. NH_4^+.
E. HSO_4^-.

13. Which formulae correspond to correctly written salts of nitric acid?

A. $NaNO_3$ $BaNO_3$
B. $Ca(NO_3)_2$ NH_4NO_3
C. $KHNO_3$ $Al(NO_3)_3$
D. $Ca(NO_2)_2$ $Ba(NO_3)_2$
E. $NH_4(NO_3)_2$ $Ba(NO_3)_2$

14. A chemical reaction is represented by the equation:

$$2Al + 3H_2SO_4 = Al_2(SO_4)_3 + 3H_2$$

What is true regarding the above equation?

A. Aluminum has been reduced.
B. H_2SO_4 is an oxidation agent.
C. The charge of sulfur changes from +6 to +2.
D. The hydrogen is being oxidized.
E. Aluminum is an oxidation agent.

15. Mark the intruder:

A. Univalent copper.
B. Divalent sulfur.
C. Trivalent nitrogen.
D. Tetravalent iron.
E. Pentavalent phosphorus.

16. Which of the simple substances *will not* displace hydrogen from the acids?

A. Gold and iron.
B. Calcium and sodium.
C. Silver and copper.
D. Copper and zinc.
E. Platinum and aluminum.

17. The chemical composition of baking soda is:

A. $NaHCO_3$.
B. $NaCO_3$.
C. Na_2O.
D. NaOH.
E. Na_2CO_3.

18. Quantities (left: 1, 2, 3, 4) should be related to their units (right: A, B, C, D):

1. amount of substance	A. 1/mol
2. mass	B. kg mol^{-1}
3. Avogadro's constant	C. mol
4. molar mass	D. kg

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–C, 2–D, 3–A, 4–B.
E. 1–B, 2–D, 3–C, 4–A.

19. Which elementary substance has nothing to do with the industrial production of NaOH?

A. Mercury.
B. Chlorine.
C. Oxygen.
D. Hydrogen.
E. Sodium.

20. Mark the chemical equation that is important for copper production from chalcocite:

A. $2CuS + 3O_2 = 2CuO + 2SO_2$.
B. $2Cu_2S + 3O_2 = 4Cu + 2SO_3$.
C. $2Cu_2S + 3O_2 = 2Cu_2O + 2SO_2$.
D. $2CuFeS_2 + 5O_2 = Cu + 2FeO + 4SO_2$.
E. $2Cu_2O + S = 4Cu + SO_2$.

21. Which oxide is not an acidic anhydride:

A. SO_3.
B. N_2O.
C. N_2O_5.
D. CO_2.
E. N_2O_3.

22. Which of the chemical reactions (sketched by *unbalanced* equations) is *impossible*:

A. $K_2Cr_2O_7 \rightarrow K_2O + Cr_2O_3 + O_2$.
B. $K_2Cr_2O_7 + HCl \rightarrow KCl + CrCl_3 + Cl_2 + H_2O$.
C. $K_2Cr_2O_7 + CO_2 \rightarrow K_2CO_3 + Cr_2O_3$.
D. $K_2Cr_2O_7 + CO_2 \rightarrow K_2CO_3 + CrO_3$.
E. $K_2Cr_2O_7 + SO_2 \rightarrow K_2SO_4 + Cr_2O_3 + SO_3$.

23. For certain reaction the temperature coefficient of a rate constant is 4. Estimate the increase of the reaction rate upon a temperature increase of 50 °C?

A. 4 times.
B. 20 times.
C. 50 times.
D. 200 times.
E. 1000 times.

24. The efficiency of the oxidation of SO_2 to SO_3 with air and NO_2 as a ctalyst *does not* depend on the:

A. Temperature.
B. Quantity of NO_2.
C. Pressure.
D. Quantity of SO_2.
E. Contact surface of the catalyst.

25. Mark the strongest reducing agent:

A. Iron.
B. Zinc.
C. Calcium.
D. Aluminum.
E. Copper.

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!

$$P_4 + HNO_3 + H_2O \rightarrow H_3PO_4 + NO$$

In this equation, oxcidazing agent is_____, while reducing agent is_____.

2. Determine the amount of heat that is being released during the reaction presented with the equation:

$$S(s) + O_2(g) = SO_2(g)$$

if 2 g pure sulfur and 0.1 mol pure oxygen are taken. The reaction enthalpy of the process of sulfur combustion is –296.8 kJ/mol. [A_r(S) = 32.066; A_r(O) = 15.999]

Solution:

3. Two vessels with volumes of 1.5 L and 0.5 L that contain 0.16 mol nitrogen and 1.68 mol hydrogen respectively are connected and the system is heated to 1000 °C. Then, chemical equilibrium shown with the equation:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

takes place. It was determined that the equilibrium amounts of the reactants are 0.088 mol for nitrogen and 1.464 mol for hydrogen, while the equilibrium mass of ammonia is 2.448 g. Calculate the equilibrium constant of the reaction! [A_r(H) = 1.008; A_r(N) = 14.007]

Solution:

4. Calculate the pH value of the solution obtained by dissolving 0.4209 g solid NaOH with mass fraction of 95 % so the total volume of the solution is 100 mL. Consider that the temperature of the solution is 25 °C. [A_r(Na) = 23; A_r(O) = 16; A_r(H) = 1]

Solution:

5. During the process described with the equation:

$$CO(g) + H_2O(g) = CO_2(g) + H_2(g)$$

that takes place in a 10 L vessel it was found out that the initial amount of CO that was 2.05 mol decreased to 1.75 mol after 2 min. Determine the rate of the reaction and the rate of consumption of carbon monoxide.

Solution:

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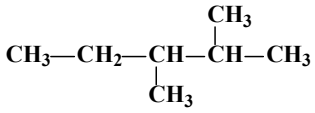
I. MULTIPLE CHOICE TEST WITH ONLY ONE CORRECT ANSWER

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

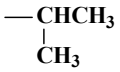
1. By homolytic cleavage of C–C bond the following species are obtained:
A. Two carbocations.
B. Carbocation and carbanion.
C. Two free radicals.
D. Two carbanions.
E. Free radical and carbocation.

2. How many primary, secondary, tertiary and quaternary C-atoms are there in the following compound?



A. 3, 2, 1, 0
B. 4, 1, 2, 0
C. 2, 2, 0, 1
D. 0, 2, 1, 4
E. 4, 1, 1, 1

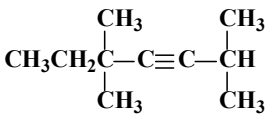
3. What is the name of the following alkyl group?



A. Propyl.
B. Ethyl.
C. Isobutyl .
D. Methylethyl.
E. Isopropyl.

4. The following alkanes are given:
I. $C_{12}H_{26}$ II. $C_{33}H_{68}$ III. C_7H_{16} IV. $C_{55}H_{112}$
Which is the correct order of these alkanes based on their boiling points (from lowest to highest)?
A. III < I < II < IV
B. IV < II < III < I
C. IV > I > II > III
D. III > II > IV > I
E. I > III > II > IV

5. What is IUPAC name of the following compound?

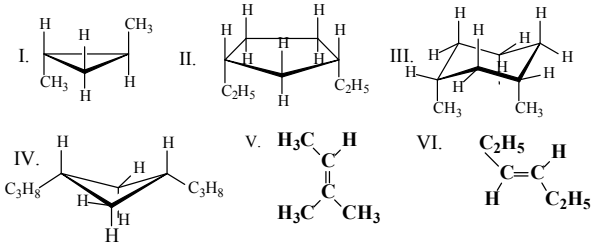


A. 3,3,6-trimethylhept-4-yne.
B. 1,1,4,4-tetramethylhex-2-yne
C. 3,3-dimethyloct-2-yne.
D. 2,5,5-trimethylhept-3-yne.
E. 3,3,6,6-tetramethylhex-4-yne.

6. How many positional isomers does octyne have?
A. 4
B. 3
C. 7
D. 5
E. 1

7. What is the molecular formula of cycloalkane with 28 hydrogen atoms?
A. $C_{12}H_{28}$
B. $C_{13}H_{28}$
C. $C_{14}H_{28}$
D. $C_{15}H_{28}$
E. $C_{28}H_{56}$

8. Which of the following compounds are *cis,* and which are *trans* isomers?

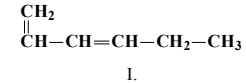


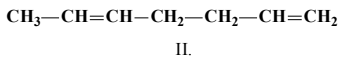
A. *cis*: II, III, V	*trans*: I, IV, VI
B. *cis*: I, II, III, IV	*trans*: IV, VI
C. *cis*: II, III, IV	*trans*: I, V, VI
D. *cis*: I, VI	*trans*: II, III, IV
E. *cis*: II, III, IV	*trans*: I, VI

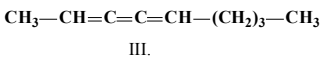
9. What product is obtained by addition of water to propene?
A. Propanone
B. Propan-1-ol.
C. Propanoic acid.
D. Propan-2-ol.
E. Propanal.

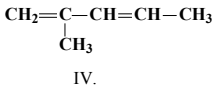
10. Which of the following compounds cannot form acetylides?
A. Pent-1-yne.
B. Etyne.
C. 4-methylhept-1-yne
D. 4-methylpent-2-yne.
E. 3-methylhex-1-yne

11. Which of the following compounds are conjugated and which are isolated dienes?


I.


II.

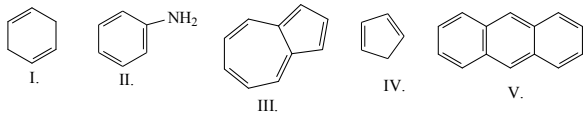

III.


IV.

A. conjugated: I, II and IV isolated: III.
B. conjugated: II and IV isolated: III.
C. conjugated: I and IV isolated: III and II.
D conjugated: I and IV isolated: II
E. conjugated: all isolated: none

12. Which reaction is characteristic for benzene?
A. Electrophilic aromatic supstitution.
B. Nucleophilic aromatic supstitution.
C. Addition.
D. Elimination.
E. Isomerization.

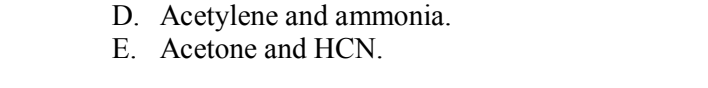
13. Which of the following compounds are aromatic?

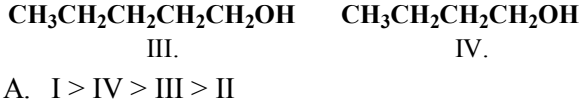


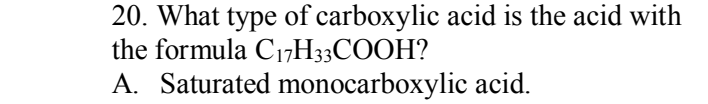
A. I, II and V.
B. All of them.
C. I, III, IV and V.
D. Only I.
E. II, III and V.

14. Order the following compounds according to their water solubility (from lowest to highest solubility)?


I.


II.

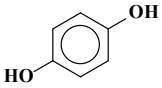

III.


IV.

A. I > IV > III > II
B. II > IV > III > I
C. IV > III > II > I
D. I < II < IV < III
E. I > III > IV > II

15. What is the product obtained from oxidation of butan-2-ol?
A. Butene.
B. Butane.
C. Butanedioic acid.
D. Butanal.
E. Butanone.

16. What is the name of the following compound?



A. Hydroquinone.
B. Quinone
C. Phenol.
D. Phenyl alcohol.
E. Catechol.

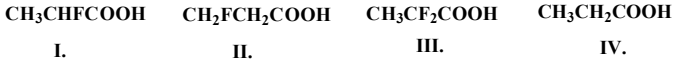
17. The electrophilic aromatic substitution of phenol:
A. Takes place more readily when compared with benzene.
B. Takes place less readily when compared with benzene
C. Does not take place at all.
D. Takes place less readily when compared with nitrobenzene
E. Takes place at equal extent when compared with benzene

18. Which of the following statements are true?
A. Ketones are easier to oxidize than aldehydes.
B. Ketones cannot be oxidized .
C. Ketones are more difficult to oxidize than aldehydes.
D. Ketones are oxidized to secondary alcohols.
E. Ketones are oxidized to alkenes.

19. Acetals are obtained from which of the following reactants ?
A. Acetic acid and methanol.
B. Aldehyde and alcohols.
C. Acetylene and alcohols.
D. Acetylene and ammonia.
E. Acetone and HCN.

20. What type of carboxylic acid is the acid with the formula $C_{17}H_{33}COOH$?
A. Saturated monocarboxylic acid.
B. Unsaturated monocarboxylic acid with one triple bond.
C. Unsaturated monocarboxylic acid with two double bonds.
D. Unsaturated monocarboxylic acid with only one double bond.
E. Aromatic saturated monocarboxylic acid.

21. Order the following carboxylic acids according to their strength (from least acidic to the most aciding) .

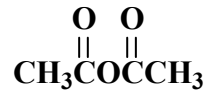

I. II. III. IV.

A. IV > II > I > III.
B. IV < III < I < II.
C. III < I < IV < II.
D. IV < II < I < III.
E. IV > I > II > III.

22. The reaction between formic acid and barium hydroxide is a reaction of:
A. Esterification.
B. Neutralization.
C. Oxidation.
D. Hydrolysis.
E. Saponification.

23. Amides are:
A. Cyclic amines.
B. Inorganic compounds.
C. Organic ammonium salts.
D. Amino derivatives of alkanes.
E. Derivatives of carboxylic acids.

24. What product is obtained from the hydrolysis of the following compound?



A. Ethanal.
B. Ethanol.
C. Ethanoic acid.
D. Methanoic acid.
E. Methanal.

25. Amines are:
A. Acidic.
B. Neutral.
C. Basic.
D. Amphoteric.
E. Aromatic.

II. PROBLEMS

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

1. Calculate the mass fraction of chlorine in dichloromethane?

Solution:

2. How many moles are there in 177.39 g trimethylamine?

Solution:

3. The mass fractions of the elements in one organic compound are: w(C) = 85.60 %; w(H) = 14.40 %; What is the empirical formula of this compound?

Solution:

4. What volume of CO_2 (measured at standard conditions) will be released upon combustion of 3 moles of propane?

Solution:

5. Consider the reaction between methane and chlorine. Calculate what mass of chlorine is needed in order to obtain 1.5 mol of trichloromethane (chloroform).

Solution: