SAMPLE EXAMINATION QUESTIONS FOR THE CHEMISTRY GLOBAL FINAL - CATEGORY 1 (GRADES 9-10)

Q1. In the series of chemical elements P → Si → Al:
A) The number of protons in the nucleus increases.
B) Electronegativity increases.
C) Non-metallic properties weaken.
D) The atomic radius decreases.

Q2. To determine Fe^{2+}, the following is used:
A) Copper sulfate
B) Sodium hydroxide
C) Barium chloride
D) Sulfuric acid

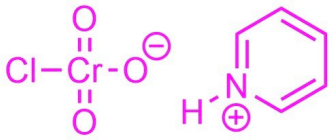
Q3. The volume of hydrogen at STP produced from the reaction of 0.6 mol of hydrochloric acid with 0.5 mol of metallic sodium is:
A) 11.2 L
B) 44.8 L
C) 5.6 L
D) 22.4 L

Q4. Which of the following is NOT a structural isomer of butanol?
A) 1-butanol
B) 2-butanol
C) 2-methyl-2-propanol
D) 2-butanone.

Q5. An isotope of element X has an atomic number of 17 and a mass number of 37. If this isotope undergoes beta decay, what will be the atomic number and mass number of the resulting isotope?
A) 16, 37
B) 18, 37
C) 17, 36
D) 18, 36

Q6. A reaction between a metal M and dilute nitric acid produces hydrogen gas and a nitrate salt. However, when concentrated HNO_3 is used, no H_2 is produced, and nitrogen dioxide is formed instead. Which metal M is most likely responsible for this behavior, and why?
A) Magnesium, due to its high reactivity and ability to reduce both dilute and concentrated HNO_3
B) Copper, because it reacts with dilute HNO_3 to produce H_2 but is oxidized by concentrated HNO_3 to form NO_2
C) Zinc, as it produces H_2 with dilute HNO_3 but forms NO_2 due to the oxidizing nature of concentrated HNO_3

D) Sodium, because it reacts violently with both forms of HNO_3, producing H_2 and NO_2 respectively



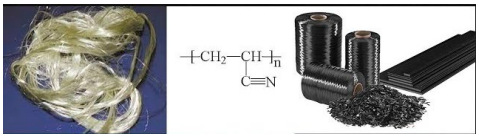
Q7. An alcohol with the molecular formula $C_5H_{11}OH$ is oxidized stepwise using pyridinium chlorochromate (PCC) followed by potassium permanganate under acidic conditions. The final product is a dicarboxylic acid with the formula $C_5H_8O_4$. What is the structure of the original alcohol, and why?

A) Pentan-1-ol, because it oxidizes to pentanal (with PCC) and then to pentanedioic acid (with $KMnO_4$)

B) 2-Methylbutan-1-ol, because it oxidizes to an aldehyde and then a dicarboxylic acid with cleavage

C) Pentan-2-ol, because it oxidizes to pentan-2-one (with PCC) and then to a dicarboxylic acid via cleavage

D) 3-Methylbutan-1-ol, because it forms an aldehyde and then a dicarboxylic acid with two carboxyl groups



Q8. A polymer is synthesized from the monomer CH_2=CH-CN (acrylonitrile) via free radical polymerization, and its structure shows alternating double bonds and nitrile groups in the backbone. If this polymer is hydrolyzed under acidic conditions, what functional group is most likely introduced, and how does this affect its solubility in water?

A) Amine groups, increasing solubility due to protonation in water

B) Carboxylic acid groups, increasing solubility due to ionization in water

C) Hydroxyl groups, slightly increasing solubility due to hydrogen bonding

D) Ester groups, decreasing solubility due to nonpolar character

Q9. A 0.1 M solution of $NaHCO_3$ reacts with 0.05 M HCl in a 1:2 molar ratio, producing CO_2, H_2O, and NaCl. If 50 mL of $NaHCO_3$ solution is used, what volume of CO_2 at STP is produced?

A) 0.56 L

B) 1.12 L

C) 2.24 L

D) 0.28 L

Q10. A factory releases a mixture of CO_2 and NO_2 into the atmosphere, contributing to both greenhouse effects and acid rain. If 100 kg of CO_2 and 50 kg of NO_2 are emitted daily, which gas contributes more significantly to acid rain formation, and why?

A) CO_2, because it forms carbonic acid in water

B) NO_2, because it forms nitric acid in the presence of water and oxygen

C) CO_2, because it has a higher molar mass and greater solubility

D) NO_2, because it reacts faster with atmospheric moisture

Q11. To a 3.5 M NH_4Cl solution with a volume of 80 mL and a density of 1.05 g/mL, water with a volume of 40 mL (density of water taken as 1 g/mL) was added. Determine the mass fraction of the salt in the resulting solution.
A) 15%
B) 18.5%
C) 22.3%
D) 12.1%

Q12. In a steel cylinder with a volume of 5 L, ammonia is present at a temperature of 22°C and a pressure of 620 kPa. What mass of ammonium hydrosulfate can be obtained if all the ammonia is passed through an excess of sulfuric acid solution?
A) 145g
B) 150g
C) 155g
D) 160g

Q13. From 4 g of technical calcium carbide, reacting with an excess of water, a gas with a volume of 1.12 L at STP can be obtained. What mass of technical calcium carbide should be taken to produce 19.6 g of ethanol, in which the mass fraction of water is 6%?
A) 25g
B) 30g
C) 28g
D) 32g

Q14. Upon partial reduction of cobalt(II) oxide with a mass of 30 g using hydrogen, a mixture of the oxide and metal with a mass of 26.8 g was obtained. What amount of substance (in moles) of hydrogen reacted?
A) 0.1 mole
B) 0.3 mole
C) 0.4 mole
D) 0.2 mole

Q15. What mass of formalin with a mass fraction of formaldehyde of 40% can be formed if the aldehyde obtained from the catalytic oxidation of 336 L of methane at STP with oxygen from the air is used? The yield of products in the oxidation reaction is 60%.
A) 585g
B) 675g
C) 743g
D) 372g

Q16. Combustion is defined as a reaction characterized by the spontaneous release of heat and light, during which more than 1.5 kJ of heat is liberated per 1 g of the initial mixture of reactants. The complete chlorination of 1 mole of carbon releases 133 kJ, while the complete chlorination of 1 mole of magnesium releases 645 kJ. Can magnesium burn when doused with carbon tetrachloride, a liquid formerly used to fill fire extinguishers? Provide the equations of possible reactions and the corresponding calculations.

Q17. A piece of metallic sodium with a mass of **B** g was placed into an excess of water with a mass of **A** g. Subsequently, **V** mL of hydrogen chloride at STP was passed into the solution until complete neutralization (without excess). Only one dissolved substance remained in the solution. Determine its mass fraction ω (%), expressed in terms of **A**, **B**, and **V**. Write the equations of the reactions.

Q18. The sodium salt of a carboxylic acid **A** was heated at 300°C in the presence of NaOH. Upon acidification of the reaction product, acid **X** was obtained. For the complete neutralization of 2.25 g of acid **X**, 40.0 g of a NaOH solution with a mass fraction of 5.0% is required. Upon strong heating of acid **X**, in addition to water vapor, a mixture of gases **B** and **C** is formed, which has a density relative to hydrogen of 18.

Q19. A mixture of two solid substances with a total mass of 10.00 g was carefully calcined at 1100 °C (reaction 1), during which gas **A** with a volume of 1.792 L at STP was released. The solid residue, weighing 7.76 g, was dissolved in water—the insoluble black portion, weighing 4.38 g, was filtered off, and an excess of copper(II) nitrate solution was added to the filtrate, resulting in the formation of 1.92 g of a black precipitate **B** (reaction 2).

a) Determine the composition of the initial mixture, given that no visible signs of reaction are observed when an excess of hydrochloric acid solution is added to it. Provide the necessary calculations.

b) Identify substances **A** and **B**.

c) Write the equations for reactions 1 and 2.

Q20. An unknown organic compound **A** ($C_5H_{10}O$) undergoes the following transformation chain:

1.**A** reacts with $NaBH_4$ in ethanol, yielding compound **B**.

2.**B** is treated with concentrated H_2SO_4 at 140°C, producing compound **C**, which decolorizes Br_2 in CCl_4.

3.**C** is subjected to ozonolysis followed by reductive workup (Zn/H_2O), yielding two carbonyl compounds: **D** and **E**.

4.**E** is oxidized with Tollens' reagent, forming compound **F**, which upon heating with soda lime (NaOH/CaO) at 300°C produces compound **G**.

5.**D** is treated with HCN followed by hydrolysis, yielding compound **H.**

Using the molecular formulas and reaction conditions, determine the structure of the compound **A-H**, and provide the reaction for the entire transformation chain.

Answer key

1) C
2) B
3) C
4) D
5) B
6) B
7) A
8) B
9) A
10) B
11) D
12) A
13) D
14) D
15) B

Open ended problem's solutions

Q16.

$C + 2Cl_2 \rightarrow CCl_4 + 133\ kJ$

$Mg + Cl_2 \rightarrow MgCl_2 + 645\ kJ$

$2Mg + CCl_4 + 2Cl_2 \rightarrow 2MgCl_2 + C + 2Cl_2 + 2 \times 645 - 1332$

$Mg + CCl_4 \rightarrow 2MgCl_2 + C + 1157$ kJ

Alternatively, this results in 1157 kJ released per 202 g of the mixture, i.e., 5.73 kJ per 1 g.The energy is released in a significant excess, so combustion will occur.

Q17.

$$\begin{array}{cccccc} & B & & & X & Y \\ 2\,Na & + & 2\,H_2O & = & 2\,NaOH & + & H_2 \\ 46 & & & & 80 & 2 \end{array}$$

$$\begin{array}{cccccc} & X & & & Z & \\ NaOH & + & HCl & = & NaCl & + & H_2O \\ 40 & & & & 58,5 & \end{array}$$

Mass of HCl: 36.5(V/22400)
Final mass of the solution: A + B - (1/23)B + 36.5(V/22400)
Mass of the dissolved substance (NaCl):Z = (58.5/40)X = (40/23)B × (58.5/40) = (58.5/23)B
Answer: ω (%) = 100% × (58.5/23)B / [A + B - (1/23)B + 36.5(V/22400)]

Q18.
The amount of alkali is 0.05 mol.If the acid is monobasic, its molar mass would be 2.25 / 0.05 = 45, which corresponds to the molar mass of a carboxyl group. This means the acid is dibasic and contains only carboxyl groups, i.e., oxalic acid $H_2C_2O_4$.X = oxalic acid

$2HCOONa \rightarrow Na_2C_2O_4 + H_2$,i.e., acid A is formic acid.$H_2C_2O_4 \rightarrow H_2O + CO + CO_2$

Other reactions mentioned in the problem:$H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$

$Na_2C_2O_4$ + dilute $H_2SO_4 \rightarrow H_2C_2O_4 + Na_2SO_4$

Q19.
The total mass of the calcined mixture is:m(A) = 10.00 - 7.76 = 2.24 gv(A) = 0.08 mol, calculated,M(A) = 28 g/mol, this may correspond to N_2 and CO (assuming the molar mass of A). the calcination of the mixture at 1100°C (reagent 1) /mol (N_2 and CO) resulted in a yield, the mass of the calcined substance was 28 g, net calcination of the mixture at 1100°C (reagent 1) /mol (N_2 and CO). A = this CO

The mass of the calcined substance 4.38 g – this calcined yield, total,m(Me_2Sn) = 7.76 - 4.38 = 3.38g (CuS) = 0.02 mol

$Me_2Sn + nCu(NO_3)_2 \rightarrow nCuS + 2Me(NO_3)_n$v($Me_2Sn$) = 0.02/n mol, totalM($Me_2Sn$) = 169n = 2M + 32n, calculated,M(Me) = 68.5n, with n = 2, M = 137 g/mol, this corresponds to barium (Ba) (assuming barium)

$BaS + Cu(NO_3)_2 \rightarrow CuS + Ba(NO_3)_2$

$BaSO_4 + 4C \rightarrow BaS + 4CO$

($BaSO_4$) = v(BaS) = 0.02 mol, total,m($BaSO_4$) = 4.66 g, calculated, the net product mass corresponds:ω($BaSO_4$) = 46.6%ω(C) = 53.4%

Q20.
Reaction Scheme:

1. Reduction:$CH_3COCH_2CH_2CH_3 + NaBH_4 \rightarrow CH_3CH(OH)CH_2CH_2CH_3$(A: pentan-2-one → B: pentan-2-ol)
2. Dehydration:$CH_3CH(OH)CH_2CH_2CH_3 \rightarrow CH_3CH{=}CHCH_2CH_3 + H_2O$ (H_2SO_4, 140°C)(B → C: pent-2-ene)
3. Ozonolysis:$CH_3CH{=}CHCH_2CH_3 + O_3 \rightarrow [CH_3CH{=}O + O{=}CHCH_2CH_3] \rightarrow CH_3CHO + CH_3CH_2CHO$ (Zn/H_2O)(C → D: acetaldehyde + E: propanal)
4. Oxidation:$CH_3CH_2CHO + [Ag(NH_3)_2]^+ + OH^- \rightarrow CH_3CH_2COOH + Ag$(E → F: propanoic acid)
5. Decarboxylation:$CH_3CH_2COOH + NaOH/CaO \rightarrow C_2H_6 + CO_2$ (300°C)(F → G: ethane)
6. HCN Addition and Hydrolysis:$CH_3CHO + HCN \rightarrow CH_3CH(OH)CN \rightarrow CH_3CH(OH)COOH$ (H_2O, H^+)(D → H: lactic acid)