THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

DIPLOMA IN SECONDARY EDUCATION EXAMINATION

732/1 **CHEMISTRY 1**

Time: 3 Hours **ANSWERS** **Year: 2010**

Instructions

1. This paper consists of section A, B and C.
2. Answer all questions in section A and two questions from section B and C.

1. What is meant by the following terms:

(a) Order of reaction

(b) Hybridization

(c) Ionization energy

(d) Covalent bond

(a) Order of reaction: The order of reaction is the sum of the exponents in the rate law, indicating how the reaction rate depends on reactant concentrations. For example, a first-order reaction depends on one reactant, guiding kinetic studies and reaction predictions.

(b) Hybridization: Hybridization is the mixing of atomic orbitals to form new hybrid orbitals (e.g., sp^2 in ethene) with specific geometries, explaining molecular shapes and bond angles in organic compounds.

(c) Ionization energy: Ionization energy is the energy needed to remove an electron from a gaseous atom, reflecting nuclear attraction, which increases across a period and decreases down a group in the periodic table.

(d) Covalent bond: A covalent bond forms by sharing electron pairs between atoms, stabilizing molecules like H_2O, and serves as a cornerstone for understanding molecular structure and reactivity.

2. Explain why it is not recommendable to do the following in the laboratory:

(a) To prepare primary standard solution of sulphuric acid from commercial sample.

(b) To prepare primary standard solution of sodium hydroxide from sodium hydroxide pellets.

(c) To add water into a concentrated acid.

(d) To leave a container of sodium hydroxide solution uncovered.

(a) To prepare primary standard solution of sulphuric acid from commercial sample: Commercial H_2SO_4 is impure and variable in concentration, making it unsuitable as a primary standard, which requires high purity and stability for accurate volumetric analysis.

(b) To prepare primary standard solution of sodium hydroxide from sodium hydroxide pellets: NaOH pellets are hygroscopic, absorbing moisture and CO_2, leading to inconsistent composition, unsuitable for a primary standard needing precise molarity.

(c) To add water into a concentrated acid: This causes rapid heat generation and splashing due to exothermic dilution, risking burns, whereas adding acid to water controls the reaction safely.

(d) To leave a container of sodium hydroxide solution uncovered: NaOH absorbs atmospheric CO_2, forming carbonates and altering concentration, which compromises solution integrity for experiments.

3. (a) Define the term pH of a solution.

(b) Calculate the molar concentration of H^+ ions in the solution which has 2.5×10^{-7} M of OH^- ions.

(c) What will be the pH value of the solution in 3(b) above?

(a) Define the term pH of a solution: pH is a measure of the hydrogen ion concentration in a solution, defined as $pH = -\log_{10}[H^+]$, indicating acidity ($pH < 7$), neutrality ($pH = 7$), or alkalinity ($pH > 7$), crucial for chemical equilibrium studies.

(b) Calculate the molar concentration of H^+ ions in the solution which has 2.5×10^{-7} M of OH^- ions: Using the water ionization constant ($K_w = 1.0 \times 10^{-14}$ at 25°C), where $[H^+][OH^-] = K_w$, $[H^+] = K_w / [OH^-] = 1.0 \times 10^{-14} / 2.5 \times 10^{-7} = 4.0 \times 10^{-8}$ M.

(c) What will be the pH value of the solution in 3(b) above?: Applying the pH definition: $pH = -\log_{10}[H^+] = -\log_{10}(4.0 \times 10^{-8}) \approx 7.4$, indicating a slightly basic solution, consistent with the given $[OH^-]$.

4. (a) What do you understand by the following terms as they are used in organic chemistry?

(i) Cracking

(ii) Isomerism

(b) Name the following organic compounds:

(i) CH_3-CH_2-CH_2-OH

(ii) CH_3-CH=CH-CH_3

(a) (i) Cracking: Cracking is the thermal or catalytic breakdown of large hydrocarbons into smaller molecules (e.g., breaking octane into ethene and butane), vital for producing fuels and alkenes in the petroleum industry.

(ii) Isomerism: Isomerism refers to compounds with the same molecular formula but different structural arrangements (e.g., butane and isobutane), affecting physical and chemical properties.

(b) (i) CH_3-CH_2-CH_2-OH: Naming involves identifying the longest carbon chain and functional groups; this is propan-1-ol, a primary alcohol.

(ii) CH_3-CH=CH-CH_3: Naming is based on the double bond position; this is but-2-ene, an alkene with the double bond between the second and third carbons.

5. (a) State Faraday's second Law of electrolysis.

(b) By passing a current of 0.65A for 35 minutes through water, Copper and Silver coulometers, respectively 0.014g of H_2 gas, 0.114g of O_2 gas and 1.542g of Ag were liberated. Show that these results agree with Faraday's second Law of electrolysis.

Calculating the charge passed: $Q = I \times t = 0.65\ A \times (35 \times 60\ s) = 1{,}365$ C. Faraday's constant (F = 96,485 C/mol) relates charge to moles.

Determining moles liberated: For H_2, $2H^+ + 2e^-$ ----> H_2, 1 mol H_2 = 2 F, moles = 0.014 / (2 × 0.001) ≈ 7 × 10^{-3} mol (molar mass 2 g/mol); for O_2, $2H_2O$ -----> $O_2 + 4H^+ + 4e^-$, moles = 0.114 / 32 ≈ 3.56 × 10^{-3} mol; for Ag, $Ag^+ + e^-$ -----> Ag, moles = 1.542 / 108 ≈ 0.0143 mol.

Evaluating the ratio of equivalents: Equivalent weight = molar mass / n (n = electrons); H_2 (n=2) = 1 g/equiv, O_2 (n=4) = 8 g/equiv, Ag (n=1) = 108 g/equiv. Mass ratio = 0.014 : 0.114 : 1.542, equivalent ratio = 0.014/1 : 0.114/8 : 1.542/108 ≈ 0.014 : 0.01425 : 0.0143, showing proportionality, confirming Faraday's second law.

6. (a) What is chemical kinetics?

(b) The decomposition of hydrogen peroxide to the reaction $2H_2O_2(t) \rightarrow 2H_2O(t) + O_2(g)$ is a first order reaction with a rate constant of $0.041 min^{-1}$.

(i) If its initial concentration is 0.50M, calculate its concentration after 10 minutes.

(ii) How long will it take for the concentration of hydrogen peroxide to drop from 0.50M to 0.10M?

(a) What is chemical kinetics?: Chemical kinetics is the study of reaction rates and the factors affecting them, such as concentration, temperature, and catalysts, enabling prediction of reaction progress.

(b) (i) If its initial concentration is 0.50M, calculate its concentration after 10 minutes:

Applying the first-order rate law: $[A] = [A]_0e^-kt$, where $[A]_0$ = 0.50 M, k = 0.041 min^{-1}, t = 10 min. [A] = $0.50e^-(0.041\times10) = 0.50e^-0.41$ ≈ 0.33 M, showing exponential decay.

(ii) How long will it take for the concentration of hydrogen peroxide to drop from 0.50M to 0.10M?

Solving $t = (1/k) \ln([A]_0/[A])$, where $[A]_0$ = 0.50 M, [A] = 0.10 M, k = 0.041 min^{-1}. t = (1/0.041) ln(0.50/0.10) ≈ 24.4 min, indicating the time for concentration reduction.

7. (a) Define the terms:

(i) Titration

(ii) Standard solution

(b) Describe briefly how to prepare sodium hydroxide solution for volumetric analysis purpose.

8. (a) What do you understand by the following terms?

(i) Period

(ii) Electronegativity

(b) How does the electronegativity of elements behaves

(i) down a group

(ii) across the period

9. (a) State the Le Chatelier's Principle.

(a) (i) Titration: Titration is a volumetric method to determine the concentration of an unknown solution by reacting it with a standard solution, using an indicator to detect the endpoint, essential for acid-base analysis.

(ii) Standard solution: A standard solution has a precisely known concentration, prepared from a primary standard (e.g., Na_2CO_3), ensuring accuracy in quantitative measurements.

(b) Describe briefly how to prepare sodium hydroxide solution for volumetric analysis purpose:

Using a primary standard approach, dissolve a weighed amount of pure NaOH (e.g., 20 g) in distilled water, transfer to a 1 L volumetric flask, and dilute to the mark, standardizing with HCl to confirm concentration. This ensures precision for volumetric use.

(c) (a) (i) Period: A period is a horizontal row in the periodic table, representing elements with increasing atomic number and similar outer electron configurations.

(ii) Electronegativity: Electronegativity measures an atom's ability to attract electrons in a bond, influencing bond polarity and reactivity.

(b) (i) down a group: Electronegativity decreases due to increasing atomic size and shielding, reducing electron attraction (e.g., F > Cl > Br).

(ii) across the period: Electronegativity increases due to stronger nuclear pull with less shielding (e.g., C < N < O).

(c) State the Le Chatelier's Principle: A system at equilibrium adjusts to counteract changes in temperature, pressure, or concentration, shifting to restore balance (e.g., increasing pressure favors fewer gas moles).

8. (a) What do you understand by the term standard solution?

(b) Outline six (6) apparatus commonly used in volumetric analysis.

(a) What do you understand by the term standard solution?

A standard solution is a solution with a precisely known concentration, typically prepared from a primary standard like Na_2CO_3, ensuring accuracy in quantitative experiments such as titrations.

(b) Outline six (6) apparatus commonly used in volumetric analysis:

Burette: Delivers precise volumes of a solution, such as a titrant, during titration, ensuring accurate endpoint determination.

Pipette: Measures and transfers a fixed volume of solution, like an analyte, for consistent sample sizes in experiments.

Volumetric flask: Prepares standard solutions by allowing precise dilution to a specific volume, ensuring concentration accuracy.

Conical flask: Serves as the reaction vessel during titration, providing space for mixing and observing color changes with indicators.

Indicator: Detects the endpoint of a titration, such as phenolphthalein, by changing color at a specific pH, guiding the reaction's completion.

Analytical balance: Weighs chemicals accurately for preparing standard solutions, ensuring the correct mass for molarity calculations.

11. The following are scores of form two students in one of the secondary schools: 56, 54, 52, 50, 65, 67, 72, 81, 84, 86.

(a) Obtain the standard score for each student.

(b) Assume the national average is 50 and 10 is standard marks of each lesson.

(a) Obtain the standard score for each student:

Standard score (z-score) is calculated using $z = (x - \mu) / \sigma$, where μ is the mean and σ is the standard deviation. Mean = (56 + 54 + 52 + 50 + 65 + 67 + 72 + 81 + 84 + 86) / 10 = 66.7. Variance = $\Sigma(x - \mu)^2 / n$ = $[(56-66.7)^2 + (54-66.7)^2 + ... + (86-66.7)^2] / 10 \approx 160.41$, so $\sigma = \sqrt{160.41} \approx 12.66$. Z-scores: 56: (56-66.7)/12.66 ≈ -0.85; 54: (54-66.7)/12.66 ≈ -1.00; 52: (52-66.7)/12.66 ≈ -1.16; 50: (50-66.7)/12.66 ≈ -1.32; 65: (65-66.7)/12.66 ≈ -0.13; 67: (67-66.7)/12.66 ≈ 0.02; 72: (72-66.7)/12.66 ≈ 0.42; 81: (81-66.7)/12.66 ≈ 1.13; 84: (84-66.7)/12.66 ≈ 1.36; 86: (86-66.7)/12.66 ≈ 1.52.

(b) Assume the national average is 50 and 10 is standard marks of each lesson:

Using $\mu = 50$ and $\sigma = 10$, z-scores for each score: 56: (56-50)/10 = 0.6; 54: (54-50)/10 = 0.4; 52: (52-50)/10 = 0.2; 50: (50-50)/10 = 0; 65: (65-50)/10 = 1.5; 67: (67-50)/10 = 1.7; 72: (72-50)/10 = 2.2; 81: (81-50)/10 = 3.1; 84: (84-50)/10 = 3.4; 86: (86-50)/10 = 3.6. This compares individual performance to the national standard.

12. (a) What are the advantages of involving pupils in chemistry lesson preparation?

(b) Outline steps involved in modern scientific methods of teaching Chemistry.

(c) What problems are likely to occur if the teacher executes lesson without preparations?

(a) What are the advantages of involving pupils in chemistry lesson preparation?

Involving pupils fosters ownership and engagement, as they contribute ideas or materials, enhancing their interest in topics like chemical reactions. It encourages teamwork, developing collaboration skills while preparing for experiments. Students gain a deeper understanding by researching concepts beforehand, such as acid-base properties, making lessons more meaningful. It builds confidence, as they take active roles, like setting up equipment, improving their practical skills. It promotes critical thinking, as they plan and predict outcomes, strengthening their scientific inquiry abilities.

(b) Outline steps involved in modern scientific methods of teaching Chemistry:

Identify learning objectives, such as understanding reaction rates, to guide the lesson's focus. Engage students with a hook, like a demonstration of a color-changing reaction, to spark curiosity. Facilitate inquiry-based learning by posing questions or problems, encouraging students to hypothesize and experiment. Use hands-on activities, such as titrations, to apply concepts practically, reinforcing theoretical knowledge. Encourage analysis and discussion of results, helping students draw conclusions and connect to real-world applications. Assess understanding through quizzes or reflections, ensuring concepts are grasped and addressing misconceptions.

(c) What problems are likely to occur if the teacher executes lesson without preparations?

Lack of preparation leads to disorganized lessons, causing confusion as topics like stoichiometry are poorly explained. Time management issues arise, with insufficient coverage of key concepts, leaving students unprepared. Unavailability of materials, such as reagents for experiments, disrupts hands-on learning, reducing engagement. Inaccurate or incomplete explanations occur, leading to misconceptions about concepts like equilibrium. Inability to address student questions effectively diminishes confidence and hinders learning, impacting overall lesson effectiveness.

13. Being a Head of Chemistry department, you have been given exactly 24 hours advance examination instructions asking you to prepare 5 Litres of 0.119M sulphuric acid from commercial sulphuric acid with the following information: 96%, Density 1.82g/cm^3, Mwt 98.

(a) What precautions will you take in handling commercial sulphuric acid?

(b) Explain the procedures you will adopt to prepare the required concentration.

(c) How much distilled water will you mix with concentrated acid given to get the required concentration?

(d) What volume of the dilute acid will neutralize exactly 25cm^3 of 0.125M sodium carbonate solution?

(a) What precautions will you take in handling commercial sulphuric acid?

Wear protective gear, including gloves, goggles, and a lab coat, to prevent burns or eye damage from splashes. Work in a well-ventilated area or fume hood to avoid inhaling harmful fumes. Always add acid to water, not the reverse, to control exothermic reactions and prevent splashing. Handle containers carefully to avoid spills, ensuring they are securely closed when not in use. Have a neutralizing agent, like sodium bicarbonate, and water nearby for emergency spill response.

(b) Explain the procedures you will adopt to prepare the required concentration:

Calculate the mass of H_2SO_4 needed: 5 L of 0.119 M requires moles = 0.119 × 5 = 0.595 moles; mass = 0.595 × 98 = 58.31 g. Determine the volume of commercial acid: density 1.82 g/cm^3, so 1 L weighs 1820 g, with 96% H_2SO_4 = 1747.2 g/L; volume = 58.31 / 1747.2 ≈ 0.0334 L (33.4 mL). Measure 33.4 mL of commercial H_2SO_4 using a graduated cylinder. Add this slowly to about 4 L of distilled water in a 5 L volumetric flask, stirring constantly, then dilute to the 5 L mark, ensuring a uniform 0.119 M solution.

(c) How much distilled water will you mix with concentrated acid given to get the required concentration?

From (b), 33.4 mL of commercial H_2SO_4 is needed. Since the final volume is 5 L (5000 mL), the volume of distilled water = 5000 mL - 33.4 mL = 4966.6 mL. Practically, add the acid to about 4 L of water and adjust to 5 L, ensuring the total volume includes the acid.

(d) What volume of the dilute acid will neutralize exactly 25cm³ of 0.125M sodium carbonate solution?

Reaction: $Na_2CO_3 + H_2SO_4 \text{ ----> } Na_2SO_4 + H_2O + CO_2$. Moles of $Na_2CO_3 = 0.125 \times 0.025 = 0.003125$ moles; 1 mole Na_2CO_3 reacts with 1 mole H_2SO_4, so moles of $H_2SO_4 = 0.003125$. Volume of 0.119 M $H_2SO_4 = 0.003125 / 0.119 \approx 0.02626$ L = 26.26 cm³.

14. Although chemistry laboratory is potentially a dangerous place, accidents do occur than elsewhere. Discuss the possible causes of accidents in the chemistry laboratory and how to prevent

Improper handling of chemicals, such as mixing incompatible substances like acids with bases, can lead to explosions or the release of toxic gases. For instance, combining hydrochloric acid with sodium hydroxide without proper control can generate excessive heat and splatter. To prevent this, students and staff should be thoroughly trained on the properties of chemicals they are working with, ensuring they understand potential reactions. Additionally, all chemicals should be clearly labeled with their names and hazard warnings, and safety data sheets should be readily available for reference to avoid accidental misuse.

Lack of personal protective equipment (PPE) poses a significant risk, as not wearing goggles, gloves, or lab coats can lead to injuries like eye damage from chemical splashes. For example, a student handling sulfuric acid without eye protection might suffer severe burns if a droplet splashes into their eyes. To mitigate this, strict enforcement of PPE usage should be implemented in the laboratory at all times. Teachers and lab supervisors must ensure that all individuals are equipped with appropriate gear before starting experiments, and regular checks should be conducted to confirm compliance.

Poor laboratory organization, such as cluttered workspaces, increases the likelihood of accidents like spills or fires. A crowded bench with misplaced reagents or equipment can lead to knocking over a bottle of flammable ethanol, potentially causing a fire. To address this, the laboratory should be kept tidy, with clear pathways and designated storage areas for chemicals and equipment. Regular inspections and adherence to organization protocols can help maintain a safe working environment, reducing the risk of accidents due to clutter.

Inadequate ventilation can lead to the accumulation of harmful fumes, posing a health risk through inhalation. For instance, working with chlorine gas in a poorly ventilated space might cause respiratory irritation or more severe effects. To prevent this, laboratories should be equipped with fume hoods for experiments involving volatile substances, and general airflow should be maintained through proper ventilation systems. Regular checks on ventilation equipment ensure that it functions effectively, safeguarding the health of everyone in the lab.

Failure to follow safety protocols, such as adding water to concentrated acid instead of the reverse, can result in violent exothermic reactions. For example, adding water to sulfuric acid can cause the mixture to boil and splash, leading to burns. To prevent such incidents, students must be educated on proper laboratory procedures, such as always adding acid to water slowly while stirring. Close supervision during experiments, especially for beginners, ensures that safety protocols are followed, and regular safety drills can reinforce these practices, minimizing the risk of accidents.

15. A Table of Specification is a very important tool in the setting of tests and examinations. Discuss.

A Table of Specification ensures balanced coverage of topics, such as stoichiometry and organic chemistry, aligning questions with curriculum objectives to fairly assess all areas. This tool helps teachers create tests that reflect the breadth of the syllabus, preventing overemphasis on any single topic.

It assists in setting appropriate difficulty levels by including a mix of recall, application, and analysis questions, catering to diverse learner abilities. This ensures that the test challenges students appropriately while remaining accessible, supporting a comprehensive evaluation of their skills.

The table guides time allocation, ensuring tests are manageable within the given timeframe, enhancing fairness and reducing student stress. By planning the duration for each section, it allows for a structured assessment process that respects the constraints of the examination period.

It promotes validity by linking questions to specific learning outcomes, ensuring the test measures what it intends to, such as problem-solving in chemical equilibrium. This alignment with educational goals enhances the reliability of the assessment results.

Lastly, it provides a framework for consistency across assessments, allowing teachers to track progress over time and adjust teaching strategies. This systematic approach supports long-term planning and improvement in educational outcomes.

16. Some teachers claim that preparation of a scheme of work is like duplication of the syllabus. Do you agree or disagree? Support your answer with concrete reasons.

I disagree with the claim that preparation of a scheme of work is like duplication of the syllabus. A scheme of work is a detailed plan that breaks down the syllabus into manageable lessons, adding specifics like timelines, teaching methods, and resources, unlike the syllabus, which is a broad outline.

It ensures systematic progression by scheduling topics, such as atomic structure before chemical bonding, avoiding gaps in learning that the syllabus alone doesn't address. This structured approach helps maintain a logical flow in teaching.

The scheme incorporates practical activities, like experiments on reaction rates, tailoring teaching to student needs beyond the syllabus's general objectives. This customization enhances hands-on learning and engagement.

It allows for flexibility to adapt to the class pace, unlike the static syllabus, ensuring effective delivery based on student comprehension. This adaptability makes it a dynamic tool rather than a mere copy.

Lastly, it aids in assessment planning by scheduling tests on topics like acids and bases, providing structure that the syllabus lacks. This forward-thinking approach supports a comprehensive educational strategy.

17. After completion of your Diploma in Education course, you have been appointed by the Head of your School to be the Head of Chemistry Department. Prepare a job description for your newly employed laboratory technician.

The laboratory technician will assist in preparing chemicals and equipment for chemistry experiments, ensuring all materials, such as reagents for titrations, are ready before classes. This role supports smooth practical sessions and maintains a functional lab environment.

They will maintain and calibrate laboratory instruments, like pH meters and balances, to ensure accurate measurements during experiments. Regular upkeep prevents errors and extends equipment lifespan.

The technician will manage the safe storage and disposal of chemicals, adhering to safety protocols to prevent hazards like spills or toxic exposure. Proper handling protects both staff and students.

They will support the department by preparing solutions and maintaining inventory, tracking stock levels of essentials like sulfuric acid. This ensures continuous availability for educational activities.

Lastly, the technician will assist in supervising student experiments, providing guidance on procedures like distillation, and reporting any safety concerns to the Head of Department. This enhances learning and maintains a safe laboratory setting.

18. One of the mostly used teaching strategy is discussion. Explain its merits and demerits.

Discussion encourages active participation, allowing students to share ideas on topics like chemical reactions, fostering a deeper understanding through peer interaction. This engagement enhances critical thinking and retention.

It promotes critical thinking and problem-solving, as students debate concepts like equilibrium shifts, developing analytical skills applicable beyond the classroom. This intellectual challenge enriches the learning experience.

The strategy facilitates diverse perspectives, with students from different backgrounds contributing unique insights on subjects like organic chemistry. This diversity broadens comprehension and encourages tolerance.

However, discussion can be time-consuming, as lengthy debates on complex topics like thermodynamics may reduce coverage of the syllabus. Effective time management is essential to mitigate this drawback.

It may also favor confident students, leaving shy individuals less involved in discussions on reaction mechanisms, potentially widening participation gaps. Teachers must encourage quieter students to ensure inclusivity.

Lastly, without proper guidance, discussions can lead to misinformation, such as incorrect interpretations of stoichiometry, requiring the teacher to monitor and correct inaccuracies. Structured facilitation is crucial for maintaining accuracy.