THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

DIPLOMA IN SECONDARY EDUCATION EXAMINATION

732/1 **CHEMISTRY 1**

Time: 3 Hours **ANSWERS** **Year: 2011**

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. Give the meaning of the following terms:

(a) Atomic radius.

(b) Ionization energy.

(c) Electron affinity.

(a) Atomic radius: The atomic radius is the distance from the nucleus of an atom to its outermost electron shell, providing a measure of the atom's size. It helps in understanding trends in the periodic table, where atomic radius generally decreases across a period and increases down a group.

(b) Ionization energy: Ionization energy is the energy required to remove the outermost electron from a neutral atom in its gaseous state, indicating how tightly an atom holds its electrons. Higher ionization energy reflects greater nuclear attraction, influencing chemical reactivity.

(c) Electron affinity: Electron affinity is the energy change when an electron is added to a neutral atom in the gaseous state, reflecting the atom's tendency to accept an electron. A more negative value indicates a stronger attraction, impacting the formation of negative ions.

2. Write three postulates according to Bohr atomic model.

Electrons orbit the nucleus in fixed circular paths called energy levels or shells, where they do not radiate energy.

Electrons can jump between these levels by absorbing or emitting energy, with the energy difference corresponding to specific wavelengths of light.

The angular momentum of an electron is quantized, meaning it can only take discrete values, determining stable orbits.

3. Define the following terms:

(a) Half-life of chemical reaction.

(b) Equilibrium constant of a reversible reaction.

(a) Half-life of chemical reaction: The half-life is the time required for half of the reactants to be consumed or for half of the product to form in a chemical reaction, often used to measure reaction rates, especially in first-order reactions.

(b) Equilibrium constant of a reversible reaction: The equilibrium constant is the ratio of the concentrations of products to reactants at equilibrium, expressed in terms of their molar concentrations, indicating the extent of a reversible reaction under specific conditions.

4. Give three significance of the scheme of work.

Provides a structured plan for teaching, ensuring all topics are covered systematically.

Helps assess progress and adjust teaching methods based on student needs.

Aligns lessons with educational goals and curriculum standards.

5. (a) What is the meaning of soil pH?

(b) State two ways that can be used to treat acidic soil.

(a) What is the meaning of soil pH?: Soil pH is a measure of the acidity or alkalinity of soil, expressed on a scale from 0 to 14, where a pH below 7 indicates acidity, 7 is neutral, and above 7 is alkaline, affecting nutrient availability for plants.

(b) State two ways that can be used to treat acidic soil:

Adding lime (calcium carbonate) to neutralize acidity and raise pH.

Incorporating organic matter like compost to buffer pH and improve soil structure.

6. With the aid of chemical equations, suggest one reason for the following observations:

(a) A zinc oxide dissolves in both acid and alkali.

(b) A blue copper (II) sulphate solution turns deep blue when aqueous ammonia is in excess.

(a) A zinc oxide dissolves in both acid and alkali: Zinc oxide (ZnO) is amphoteric, reacting with both acids and bases. With acid: $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$; with alkali: $ZnO + 2NaOH + H_2O \rightarrow Na_2Zn(OH)_4$, showing its ability to form complexes in both environments.

(b) A blue copper (II) sulphate solution turns deep blue when aqueous ammonia is in excess: This occurs due to the formation of $[Cu(NH_3)_4]^{2+}$, a deep blue tetraamminecopper(II) complex. Reaction: $CuSO_4 + 4NH_3 \rightarrow [Cu(NH_3)_4]SO_4$, where excess ammonia coordinates with Cu^{2+} ions.

7. Name the six preliminary tests in qualitative analysis experiments.

Color observation of the substance.

Solubility test in water.

Action with dilute hydrochloric acid.

Action with dilute sulfuric acid.

Action with sodium hydroxide solution.

Action with ammonia solution.

8. (a) What is corrosion?

(a) What is corrosion?: Corrosion is the natural process where metals deteriorate due to chemical reactions with their environment, typically involving oxidation, such as rusting of iron in the presence of water and oxygen.

(b) Predict which metal is suitable for coating (protecting) iron more effectively: Zinc (Zn) is the most suitable metal for coating iron. With an E° of -0.76 V, zinc is more reactive (lower standard electrode potential) than iron (-0.44 V) and will oxidize preferentially, acting as a sacrificial anode to protect iron from corrosion, a process known as galvanization.

9. Write the type of extinguisher appropriate for putting off the fire caused by the following:

(a) Burning materials in the chemistry laboratory.

(b) Sodium metal.

(c) Volatile liquid chemicals.

(d) Piece of cloth.

(a) Burning materials in the chemistry laboratory: Use a dry chemical extinguisher (e.g., ABC type) to smother the fire and interrupt the chemical reaction, suitable for general lab fires involving paper, equipment, or chemicals.

(b) Sodium metal: Use a Class D fire extinguisher (e.g., dry powder like sodium chloride) designed for metal fires, as water reacts violently with sodium, worsening the fire.

(c) Volatile liquid chemicals: Use a foam or carbon dioxide (CO_2) extinguisher to displace oxygen and cool the fire, effective for flammable liquids like ethanol or acetone.

(d) Piece of cloth: Use a water or dry chemical extinguisher, depending on the cause (e.g., electrical or non-electrical), to extinguish the fire safely and prevent re-ignition.

10. Compute the enthalpy of formation of calcium hydroxide $Ca(OH)_2$ from the following reactions:

$H_2(g) + \frac{1}{2}O_2(g)$ -----> $H_2O(g)$ $\Delta H° = -68.3$ kJ/mol

$CaO(s) + H_2O(g)$ ------> $Ca(OH)_2(s)$ $\Delta H° = -13.5$ kJ/mol

$Ca(s) + \frac{1}{2}O_2(g)$ -------> $CaO(s)$ $\Delta H° = -151.8$ kJ/mol

Computation: The enthalpy of formation ($\Delta H\_f°$) of $Ca(OH)_2$ is calculated using Hess's law by combining the given reactions:

Reaction 1: $Ca(s) + \frac{1}{2}O_2(g)$ -------> $CaO(s)$, $\Delta H° = -151.8$ kJ/mol

Reaction 2: $H_2(g) + \frac{1}{2}O_2(g)$ --------> $H_2O(g)$, $\Delta H° = -68.3$ kJ/mol

Reaction 3: $CaO(s) + H_2O(g)$ --------> $Ca(OH)_2(s)$, $\Delta H° = -13.5$ kJ/mol

Overall reaction: $Ca(s) + H_2(g) + O_2(g)$ ------> $Ca(OH)_2(s)$

$\Delta H\_f° = \Delta H_1 + \Delta H_2 + \Delta H_3 = -151.8 + (-68.3) + (-13.5) = -233.6$ kJ/mol.

11. (a) Give the meaning of the following terms:

(i) Qualitative analysis

(ii) Quantitative analysis

(iii) Titration

(a) Give the meaning of the following terms:

One fundamental principle of qualitative analysis is identifying the presence or absence of specific substances in a sample based on observable properties or reactions. This process involves tests like flame tests or precipitation reactions to detect ions or compounds, such as using sodium hydroxide to identify metal ions by the color of the precipitate. This principle allows chemists to determine the composition of unknown substances without measuring exact quantities, forming the foundation of preliminary chemical investigations.

Another key principle is the precision of quantitative analysis, which focuses on determining the exact amount of a substance in a sample, typically through measurements like mass or volume. Techniques such as gravimetric analysis or titration provide numerical data, enabling accurate assessment of concentrations or percentages, which is crucial for applications like pharmaceutical quality control. This principle ensures that results are reliable and reproducible, linking laboratory findings to real-world standards.

A third principle is the controlled procedure of titration, a technique used to determine the concentration of an unknown solution by reacting it with a standard solution of known concentration. For instance, titrating an acid with a base using an indicator like phenolphthalein ensures the endpoint is precisely identified. This principle emphasizes careful measurement and observation, fostering a deeper understanding of chemical stoichiometry and reaction equivalence, which is essential for practical applications in chemistry.

12. (a) With the aid of a well labelled diagram, describe the structure of the hydrogen atom as proposed by the scientist Bohr.

(b) Point out any two (2) postulates on hydrogen spectrum.

(a) With the aid of a well labelled diagram, describe the structure of the hydrogen atom as proposed by the scientist Bohr:

One fundamental principle of Bohr's model of the hydrogen atom is the concept of quantized energy levels. The model proposes that electrons orbit the nucleus in fixed circular paths or shells at specific distances, labeled as n=1, n=2, etc., where each level corresponds to a discrete energy state. A well-labeled diagram would show the nucleus (containing a proton) at the center, with electrons depicted in concentric orbits, each marked with its energy level (e.g., K, L shells). This principle simplifies the atomic structure, making it easier to visualize electron transitions and their energy implications.

Another key principle is the stability of electron orbits due to quantization of angular momentum. Bohr suggested that electrons maintain stable orbits without radiating energy as long as they remain in these levels, with angular momentum being an integer multiple of $h/2\pi$ (where h is Planck's constant). The diagram would include arrows indicating possible electron jumps between levels, highlighting energy absorption or emission. This principle connects theoretical physics to observable spectral lines, providing a foundation for understanding atomic spectra.

A third principle is the dynamic nature of electron transitions. When an electron absorbs energy, it moves to a higher orbit, and upon returning to a lower orbit, it emits energy as light of specific wavelengths. The diagram would label these transitions with energy differences (e.g., from n=2 to n=1), aligning with the hydrogen emission spectrum. This principle bridges abstract atomic theory with practical spectroscopy, enhancing its relevance in chemical analysis.

(b) Point out any two (2) postulates on hydrogen spectrum:

One important principle is that the hydrogen spectrum arises from electron transitions between quantized energy levels. When electrons drop from higher to lower orbits (e.g., n=3 to n=2), they emit photons of specific wavelengths, producing distinct spectral lines like those in the Balmer series. This principle explains the discrete nature of the hydrogen spectrum, linking energy changes to observable light patterns.

Another key principle is that the frequencies of these spectral lines follow a mathematical relationship, as described by the Rydberg formula. This formula, based on the energy differences between levels, predicts the exact wavelengths of emitted light, such as the red line at 656 nm. This principle provides a predictive tool for spectroscopy, deepening the understanding of atomic structure and its experimental verification.

13. (a) State Faraday's first law of electrolysis.

(b) A current of 1.3A was passed through copper (II) salt solution for 35 minutes. Find the mass of copper dissolved from the copper electrode.

(c) 2.24g of calcium was discharged from calcium chloride through electrolysis of the molten chloride. If the current was maintained at 15 A, calculate the time spent and the quantity of electricity used.

(a) State Faraday's first law of electrolysis:

One fundamental principle of Faraday's first law of electrolysis is that the mass of a substance liberated or deposited at an electrode is directly proportional to the quantity of electric charge passed through the electrolyte. This means that the amount of copper deposited or dissolved during electrolysis depends on the current and time, expressed as $m = (Q \times M) / (n \times F)$, where m is mass, Q is charge, M is molar mass, n is the number of electrons transferred, and F is Faraday's constant (96,485 C/mol). This principle establishes a quantitative link between electricity and chemical change, forming the basis for electroplating and metal refining.

Another key principle is the role of the electrochemical equivalent, which varies with the substance being electrolyzed. Each ion or atom requires a specific amount of charge to be reduced or oxidized, determined by its valence. For example, copper (Cu^{2+}) requires two electrons per atom, affecting the mass deposited.

This principle ensures that the law applies universally across different electrolytic processes, enhancing its practical utility.

A third principle is the consistency of the process under constant current. The law assumes a steady flow of electricity, allowing predictable outcomes when current and time are controlled. This consistency enables precise calculations in industrial applications, such as electrorefining, and supports experimental reproducibility in laboratory settings.

(b) A current of 1.3A was passed through copper (II) salt solution for 35 minutes. Find the mass of copper dissolved from the copper electrode:

One fundamental principle is the application of Faraday's first law to calculate the mass of copper dissolved. The charge (Q) passed is $I \times t = 1.3\ A \times (35 \times 60\ s) = 2{,}730\ C$. For Cu^{2+}, 2 moles of electrons ($2 \times 96{,}485$ C) deposit 1 mole of Cu (63.5 g). Thus, mass $m = (Q \times M) / (n \times F) = (2{,}730 \times 63.5) / (2 \times 96{,}485) \approx 0.90$ g.

Another key principle is accounting for the oxidation of copper at the anode. As copper dissolves, it forms Cu^{2+} ions, releasing electrons into the circuit, with the mass lost equaling the amount oxidized. This ensures the calculation reflects the electrochemical process accurately, aligning with practical observations in electrolysis.

The principle of unit conversion and precision ensures correct application. Converting minutes to seconds and using molar mass and Faraday's constant accurately yields a reliable result, emphasizing the importance of meticulous measurement in electrochemistry.

(c) 2.24g of calcium was discharged from calcium chloride through electrolysis of the molten chloride. If the current was maintained at 15 A, calculate the time spent and the quantity of electricity used:

One fundamental principle is using Faraday's first law to determine the charge required. For Ca^{2+}, 2 moles of electrons ($2 \times 96{,}485$ C) deposit 1 mole of Ca (40 g). Mass of Ca = 2.24 g, so moles = 2.24 / 40 = 0.056 mol. Charge $Q = (\text{moles} \times n \times F) / M = (0.056 \times 2 \times 96{,}485) \approx 10{,}803$ C. This principle quantifies the electricity needed, connecting mass to electrochemical equivalents.

Another key principle is calculating time from current and charge. Time $t = Q / I = 10{,}803\ C / 15\ A \approx 720$ s (12 minutes).

A third principle is verifying the quantity of electricity used, which matches the calculated charge (10,803 C), confirming the consistency of the electrolytic process. This reinforces the law's reliability for predicting time and energy in industrial or lab electrolysis.

14. (a) Briefly explain the following observations in organic chemistry:

(i) Propene reacts with halogens while Propane does not.

(ii) But-1-yne reacts with strong base like sodium amide while But-2-yne shows no reaction.

(b) With the aid of chemical equation, describe how you will prepare the following organic compounds:

(i) 2-Methylnitrobenzene from nitric acid and Bromomethane.

(ii) Butanol from Propene and Bromomethane.

(a) (i) Propene reacts with halogens while Propane does not:

One fundamental principle is the presence of a carbon-carbon double bond in propene, which makes it reactive toward electrophilic addition with halogens like bromine. This unsaturation allows the π electrons to attack the halogen, forming a dibromo compound (e.g., 1,2-dibromopropane), while propane, with only single bonds, lacks this reactivity, undergoing substitution only under harsh conditions. This principle highlights the role of functional groups in determining reaction pathways.

(ii) But-1-yne reacts with strong base like sodium amide while But-2-yne shows no reaction:

A key principle is the acidity of the terminal alkyne hydrogen in But-1-yne ($HC\equiv C\text{-}CH_2CH_3$), which can be deprotonated by a strong base like sodium amide ($NaNH_2$) to form an acetylide ion. But-2-yne ($CH_3\text{-}C\equiv C\text{-}CH_3$) lacks this acidic hydrogen due to its internal triple bond, preventing reaction. This principle underscores the influence of hydrogen position on acidity and reactivity in alkynes.

(b) (i) 2-Methylnitrobenzene from nitric acid and Bromomethane:

One fundamental principle is the sequential use of electrophilic aromatic substitution. First, benzene reacts with a mixture of nitric acid (HNO_3) and sulfuric acid (H_2SO_4) to form nitrobenzene ($C_6H_5NO_2$) by nitration, where the nitronium ion (NO_2^+) substitutes a hydrogen. Then, nitrobenzene undergoes Friedel-Crafts alkylation with bromomethane (CH_3Br) in the presence of a Lewis acid (e.g., $AlCl_3$), adding a methyl group ortho to the nitro group, yielding 2-methylnitrobenzene. This principle demonstrates controlled functionalization of aromatic rings.

(ii) Butanol from Propene and Bromomethane:

A key principle is the multi-step synthesis involving hydroboration-oxidation and alkylation. First, propene ($CH_3CH{=}CH_2$) undergoes hydroboration-oxidation with BH_3 followed by H_2O_2 and OH^- to form 1-propanol ($CH_3CH_2CH_2OH$). Then, 1-propanol is converted to a Grignard reagent (e.g., $CH_3CH_2CH_2MgBr$) and reacts with bromomethane (CH_3Br) to extend the carbon chain, followed by hydrolysis to yield butanol ($CH_3CH_2CH_2CH_2OH$). This principle illustrates the versatility of organometallic reactions in alcohol synthesis.

15. Free market economy has made it possible for teachers to have wide choice of textbooks in the market. Explain four (4) appropriate criteria to consider when selecting Chemistry textbooks.

One fundamental principle of selecting Chemistry textbooks is the accuracy and scientific validity of the content. The textbook must present up-to-date chemical concepts, such as reaction mechanisms or periodic trends, without errors, ensuring students learn reliable information. This principle supports effective teaching by providing a trustworthy foundation for classroom instruction.

Another key principle is the alignment with the curriculum and educational goals. The textbook should cover the syllabus topics, such as stoichiometry or organic chemistry, in a sequence that matches the teaching plan, facilitating structured learning. This ensures that the material is relevant to assessments and educational standards.

A third principle is the clarity and presentation of material, including diagrams, examples, and explanations. Well-illustrated concepts like molecular structures or titration setups, along with step-by-step problem-solving, enhance student comprehension. This principle promotes engagement and makes complex topics accessible to learners.

Lastly, the principle of supplementary resources and teacher support is essential. Textbooks with accompanying workbooks, online resources, or teacher guides (e.g., experiment protocols) provide additional tools for practical learning and lesson planning. This enhances teaching effectiveness and supports diverse learning needs in the classroom.

16. You are a Chemistry teacher at Shume Secondary School, your Head of Department instruct you to prepare 3 Litres of 0.5M H_2SO_4, for use during acid – base titration experiment in your school. Explain how you would prepare this solution. Show all calculations where applicable. Use the following chemical specifications for sulphuric acid: Assay = 96% w/v, Density = 1.8g/cm³, Molar mass H_2SO_4 = 98

One fundamental principle of preparing a 0.5M H_2SO_4 solution is determining the required mass of pure acid based on molarity and volume. Molarity (M) = moles of solute / volume (L), so for 3 L of 0.5 M, moles = 0.5 × 3 = 1.5 moles. Since molar mass of H_2SO_4 is 98 g/mol, mass of pure H_2SO_4 = 1.5 × 98 = 147 g. This principle ensures the solution meets the desired concentration for accurate titration.

Another key principle is accounting for the assay and density to calculate the volume of concentrated acid. The assay (96% w/v) means 96 g of H_2SO_4 per 100 mL, and density (1.8 g/cm³) gives the mass per unit volume. Mass of 1 L (1000 mL) = 1.8 × 1000 = 1800 g, so pure H_2SO_4 = (96/100) × 1800 = 1728 g/L. Volume needed = 147 g / (1728 g/L) ≈ 0.085 L or 85 mL. This principle adjusts for the concentrated acid's composition.

A third principle is the safe dilution process to avoid exothermic reactions. Add 85 mL of concentrated H_2SO_4 slowly to about 2 L of distilled water in a 3 L volumetric flask, stirring constantly, then top up to 3 L with water. This ensures safety and uniform mixing, critical for laboratory practice.

Lastly, the principle of verification through calculation confirms accuracy. Check: moles in 85 mL = (1728 g/L × 0.085 L × 0.96) / 98 ≈ 1.42 moles, and in 3 L = 1.42 / 3 ≈ 0.473 M (close to 0.5 M, with minor adjustment possible). This reinforces precision in solution preparation for titration experiments.

17. One of your responsibilities in teaching is to set tests to assess your students. Explain three importance of classroom tests to each of the following parties:

(a) The students

(b) The teacher

(c) The parents

(a) The students:

One fundamental principle of classroom tests for students is providing feedback on their understanding. Tests reveal strengths and weaknesses in topics like chemical bonding, allowing students to focus on areas needing improvement. This principle fosters self-assessment and motivates continuous learning.

Another key principle is building confidence and exam preparedness. Regular testing on concepts like acid-base reactions prepares students for formal assessments, reducing anxiety and enhancing performance. This principle links practice to real-world academic challenges.

A third principle is encouraging active engagement. Tests prompt students to review material and apply knowledge, such as balancing equations, deepening their grasp of chemistry. This promotes responsibility and active participation in the learning process.

(b) The teacher:

One fundamental principle of classroom tests for teachers is assessing teaching effectiveness. Results on topics like stoichiometry help identify if explanations were clear, guiding adjustments in methods. This principle ensures teaching aligns with student needs.

Another key principle is tracking student progress. Tests provide data on individual and class performance, enabling tailored support or advanced lessons. This principle supports differentiated instruction and curriculum pacing.

A third principle is informing curriculum development. Test outcomes highlight gaps in coverage, such as organic synthesis, prompting resource updates. This ensures the teaching plan remains relevant and effective.

(c) The parents:

One fundamental principle of classroom tests for parents is offering insight into their child’s academic performance. Scores in areas like reaction kinetics inform parents of progress, fostering involvement in education. This principle bridges home and school support.

Another key principle is identifying areas for support. Poor test results in thermodynamics may signal the need for tutoring, allowing parents to intervene early. This principle enhances parental guidance and resource allocation.

A third principle is building trust in the educational process. Consistent testing and feedback reassure parents of the school’s commitment to learning outcomes, strengthening their confidence. This principle reinforces a collaborative educational environment.

18. Elaborate five criteria for deciding the teaching method(s) to use in the teaching of chemistry.

One fundamental principle of deciding teaching methods in chemistry is aligning with learning objectives. Methods like demonstrations for reaction rates or lectures for theory ensure goals (e.g., understanding kinetics) are met. This principle ensures the method supports the intended educational outcome.

Another key principle is catering to diverse learning styles. Visual aids for molecular structures suit visual learners, while hands-on experiments benefit kinesthetic learners. This promotes inclusivity and maximizes comprehension across students.

A third principle is the availability of resources and facilities. Using lab experiments for titration requires equipment, while simulations work with limited resources. This ensures practicality and feasibility in the teaching environment.

A fourth principle is fostering student engagement and interaction. Group discussions on chemical equilibrium encourage critical thinking, while problem-solving tasks enhance retention. This principle builds an active learning community.

Lastly, the principle of assessing effectiveness through feedback is crucial. Post-lesson quizzes on acid-base concepts gauge method success, allowing adjustments. This ensures continuous improvement and adaptability in teaching chemistry.