THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

DIPLOMA IN SECONDARY EDUCATION EXAMINATION

732/1 **CHEMISTRY 1**

Time: 3 Hours **ANSWERS** **Year: 2018**

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. As a chemistry teacher, justify the relevance of the chemistry subject in daily life to your Form I students. Give four points.

Chemistry helps students understand the composition and behavior of matter, which is essential for making sense of everyday materials such as water, air, food, and clothing. This enables them to make informed decisions in real-life situations such as food preservation and hygiene.

Chemistry promotes awareness of environmental issues such as pollution, acid rain, and waste management. Through this knowledge, students learn to conserve natural resources and adopt sustainable practices in their surroundings.

The subject equips learners with knowledge about chemical products used in homes like detergents, disinfectants, fertilizers, and medicines. This knowledge ensures proper usage and enhances safety and health in domestic environments.

Chemistry develops practical skills that can be applied in different careers and entrepreneurship. Students can learn basic laboratory procedures and techniques that are useful in industries such as agriculture, pharmaceuticals, and food processing.

2. (a) What is a transition metal?

A transition metal is a metallic element found in the d-block of the periodic table, which has partially filled d-orbitals either in its elemental form or in at least one of its oxidation states. These elements typically exhibit variable oxidation states, form colored compounds, and act as catalysts in chemical reactions.

(b) Briefly explain the observation that copper (I) compounds are colored whereas copper (II) are not.

The coloring of copper compounds arises due to electronic transitions in d-orbitals. Copper (II) has a d^9 electronic configuration, which allows d-d transitions that absorb visible light, resulting in colored compounds. However, copper (I) has a d^{10} configuration with completely filled orbitals, so it does not allow such transitions easily, leading to colorless or less intense colored compounds.

3. Briefly describe four criteria for choosing a chemistry textbook.

The textbook should be aligned with the national curriculum and syllabus, ensuring that the content corresponds with the learning objectives of the level being taught.

It should have clear language and illustrations that enhance understanding for students of different abilities. Concepts should be explained step by step with appropriate examples.

A good textbook must include exercises and questions at the end of each topic to test learners' understanding and help teachers in assessment and revision.

It should be updated and accurate, reflecting current scientific knowledge and technological advancements to keep students in touch with modern science.

4. State four amendments on atomic theory against the ones proposed by Dalton.

Dalton's idea that atoms are indivisible was modified after the discovery of subatomic particles—electrons, protons, and neutrons.

Dalton proposed that atoms of the same element are identical, but it was later discovered that atoms of the same element can have different masses, called isotopes.

Dalton's theory did not include the idea of energy levels or orbitals; this was added later with the quantum mechanical model of the atom.

Dalton did not account for nuclear reactions or radioactive decay, which later revealed that atoms can indeed change from one type to another.

5. (a) List down four gases which cause global warming.

Carbon dioxide
Methane
Nitrous oxide
Chlorofluorocarbons (CFCs)

(b) Differentiate between greenhouse gases and photochemical smog.

Greenhouse gases are atmospheric gases that trap heat from the sun, causing an increase in global temperature. They include carbon dioxide and methane.

Photochemical smog is a type of air pollution formed when sunlight reacts with nitrogen oxides and volatile organic compounds, producing ozone and other harmful chemicals near the ground level.

6. (a) Define standard solution.

A standard solution is a solution whose concentration is accurately known. It is prepared by dissolving a known amount of solute in a fixed volume of solvent, typically used in titrations and quantitative analysis.

(b) With specific example in each case, state four characteristics of primary standard reagents.

They should be highly pure, such as anhydrous sodium carbonate. Impurities would affect concentration and accuracy.

They should be stable in air, meaning they do not absorb moisture or carbon dioxide, like potassium hydrogen phthalate.

They must have a high molar mass to minimize weighing errors, for example oxalic acid dihydrate.

They should dissolve easily and completely in water to form a clear solution, such as sodium tetraborate.

7. Briefly describe four stages of the lesson development in the chemistry lesson plan.

Introduction involves engaging learners by linking the new topic with their previous knowledge or presenting a stimulus.

Presentation stage involves delivering the new content using teaching methods such as explanations, demonstrations, or practical activities.

Practice stage allows learners to apply what they have learned through guided activities like problem-solving or experiments.

Conclusion involves summarizing key points, assessing students' understanding, and giving assignments for further study.

8. Outline four characteristics of a good chemistry test.

It should be valid by measuring what it intends to measure and be aligned with the lesson objectives.

It should be reliable and give consistent results when administered under similar conditions.

It must be comprehensive by covering all important areas of content and skills taught.

It should be clear, with unambiguous questions that match students' level of understanding and language ability.

9. Briefly describe four types of manures.

Farmyard manure is composed of decomposed animal waste and bedding materials. It improves soil fertility and structure.

Compost manure is formed from decayed plant materials and kitchen waste. It is rich in organic matter and micronutrients.

Green manure involves growing specific crops like legumes and plowing them into the soil to enhance nitrogen content.

Vermicompost is manure produced using earthworms to decompose organic waste, resulting in a nutrient-rich product for crop production.

10. (a) Mention two uses of benzene.

Benzene is used as a solvent in industries for dissolving resins, oils, and rubber.

It is also used in the synthesis of other organic chemicals such as styrene, phenol, and aniline.

(b) (i) Give the meaning of electrophilic substitution.

Electrophilic substitution is a reaction where an electrophile replaces a hydrogen atom in an aromatic compound, usually in the benzene ring, without breaking the aromaticity.

(ii) Using relevant reaction equation; show how aromatic compounds undergo electrophilic substitution.

An example is nitration of benzene:
$C_6H_6 + HNO_3 \text{ ---> } C_6H_5NO_2 + H_2O$ (in presence of H_2SO_4 as catalyst)
In this reaction, NO_2^+ is the electrophile which replaces a hydrogen atom on the benzene ring.

11. The experiment to investigate the factors affecting rate of chemical reaction was conducted by reacting 0.02M potassium permanganate solution and 0.05M oxalic acid in dilute sulphuric acid. The experiment was repeated four times using different temperatures and the data were collected as shown in Table 1.

(a) What is the role of sulphuric acid in this experiment?

Sulphuric acid plays a crucial role in providing the acidic medium necessary for the redox reaction between potassium permanganate and oxalic acid. The presence of hydrogen ions from sulphuric acid ensures proper ionization of oxalic acid and facilitates the reduction of permanganate ions. Sulphuric acid also prevents the formation of manganese dioxide precipitate by stabilizing manganese ions in solution. Without an acidic medium, the reaction would proceed very slowly or not at all.

(b) Of the factors affecting rate of chemical reaction, which one was being investigated? Give a reason.

The factor being investigated in this experiment is temperature. This is evident from the experimental design in which the reaction was repeated under different temperature conditions (50°C, 60°C, 70°C, and 80°C) while other factors such as concentration of reactants and volume remained constant. The change in reaction time observed at different temperatures demonstrates the effect of temperature on reaction rate.

(c) Write
(i) The half reaction for the oxidized and reduced species.

Oxidation half-reaction:

$(COOH)_2$ ----> $2CO_2 + 2H^+ + 2e^-$

Reduction half-reaction:
$MnO_4^- + 8H^+ + 5e^-$ -----> $Mn^{2+} + 4H_2O$

(ii) Overall reaction equation:
$2MnO_4^- + 5(COOH)_2 + 6H^+$ ----> $2Mn^{2+} + 10CO_2 + 8H_2O$

(d) Use equation: log(1/t) = log A - Ea / (2.3RT) in the form of y = mx + c to calculate the activation energy. Take the value of m = -9.112×10^3.

From the equation, slope m = -Ea / 2.303R
Rearranging the equation: Ea = $-m \times 2.303 \times R$
Substitute values: Ea = $-(-9.112 \times 10^3) \times 2.303 \times 8.314$
Ea = $9.112 \times 10^3 \times 19.147 = 174561.3$ J/mol
Ea = 174.6 kJ/mol

12. Compound A, C_4H_8, and compound B, C_5H_{10}, give C_4H_{10} and C_5H_{12} respectively upon hydrogenation. When compound A reacts with water under acidic medium, it gives compound C, a primary alcohol. When C_5H_{12} reacts with nitric acid under heat, it gives D, $C_5H_{11}NO_2$.

(a) Write the chemical reactions for the formation of A, B, C and D.

Compound A, C_4H_8, is an alkene such as but-1-ene or but-2-ene. Upon hydrogenation, it reacts with hydrogen gas in the presence of a catalyst (such as nickel) to form C_4H_{10}, which is butane:
$C_4H_8 + H_2$ ----> C_4H_{10}

When compound A undergoes hydration under acidic conditions (acid-catalyzed addition of water), it forms an alcohol. If A is but-1-ene, it forms butan-2-ol or butan-1-ol depending on Markovnikov or anti-Markovnikov addition:
$C_4H_8 + H_2O$ ----> C_4H_9OH (Compound C)

Compound B, C_5H_{10}, is another alkene such as pent-1-ene or pent-2-ene. Upon hydrogenation with hydrogen gas, it forms C_5H_{12}, which is pentane:
$C_5H_{10} + H_2$ ---> C_5H_{12}

When pentane reacts with nitric acid under heat, it undergoes nitration to give nitropentane, which is a nitroalkane (compound D):
$C_5H_{12} + HNO_3$ ------> $C_5H_{11}NO_2 + H_2O$

(b) Name the structures of A, B, C and D.

A can be But-1-ene or But-2-ene depending on the structure.

B can be Pent-1-ene or Pent-2-ene depending on the position of the double bond.
C is Butan-1-ol or Butan-2-ol depending on the position of the hydroxyl group formed during hydration.
D is Nitro-pentane, which can be either 1-nitropentane or 2-nitropentane depending on the position of the nitro group on the carbon chain.

(c) Give a maximum of five isomers for each of compounds A, B and C.

Isomers of compound A (C_4H_8):
But-1-ene
But-2-ene
2-Methylpropene
Cyclobutane
Methylcyclopropane

Isomers of compound B (C_5H_{10}):
Pent-1-ene
Pent-2-ene
2-Methylbut-1-ene
2-Methylbut-2-ene
3-Methylbut-1-ene

Isomers of compound C (C_4H_9OH):
Butan-1-ol
Butan-2-ol
2-Methylpropan-1-ol
2-Methylpropan-2-ol
Isobutanol (another name for 2-Methylpropan-1-ol)

13. (a) Give three differences between strong electrolyte and weak electrolyte

Ionization Degree: Strong electrolytes fully ionize in solution, like NaCl dissociating completely into Na^+ and Cl^-, while weak electrolytes partially ionize, such as acetic acid forming few H^+ and CH_3COO^- ions, critical for understanding chemical behavior.

Conductivity: Strong electrolytes conduct electricity well, like HCl in water, due to high ion concentration, whereas weak electrolytes, such as NH_3, conduct poorly due to fewer ions, essential for analyzing chemical electrical properties.

pH Impact: Strong electrolytes cause significant pH changes, like H_2SO_4 lowering pH sharply, while weak electrolytes, such as HF, cause milder pH shifts due to limited dissociation, important for studying chemical solution effects.

(b) When 25 cm^3 of aqueous ammonia is titrated with 0.17 mol/dm^3 hydrochloric acid, 20 cm^3 of the acid were needed to attain the equivalent point

(i) What is the concentration of the aqueous ammonia?

Reaction: $NH_3 + HCl \text{ ----> } NH_4Cl$ (1:1 molar ratio)

Moles of HCl = concentration × volume = 0.17 mol/dm^3 × (20/1000) dm^3 = 0.0034 moles

Moles of NH_3 = moles of HCl = 0.0034 moles

Concentration of NH_3 = moles/volume = 0.0034 / (25/1000) = 0.136 mol/dm^3

Necessary for understanding chemical stoichiometry and titration calculations.

(ii) Given that pKa for the ammonium ion is 9.3; calculate the pH of the solution equivalence point

At equivalence, NH_4^+ forms ($NH_3 + HCl \rightarrow NH_4Cl$).

$[NH_4^+]$ = 0.0034 moles / (25 + 20)/1000 dm^3 = 0.0034 / 0.045 = 0.0756 mol/dm^3

pKa = 9.3, Ka = $10^{-9.3} = 5.01 \times 10^{-10}$

NH_4^+ hydrolyzes: $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

$[H_3O^+] = \sqrt{(Ka \times [NH_4^+])} = \sqrt{(5.01 \times 10^{-10} \times 0.0756)} \approx 6.15 \times 10^{-6}$ M

pH = $-\log(6.15 \times 10^{-6}) \approx 5.21$

Essential for analyzing chemical pH changes at equivalence in titrations.

14. Chemistry laboratory is a potentially dangerous place where accidents can occur. Describe six causes of danger in the chemistry laboratory

Chemical Spills: Accidental spills, like acid on skin, cause burns due to reactive substances, critical for understanding laboratory hazards.

Fume Inhalation: Toxic gases, such as chlorine, released during reactions, harm respiratory systems, essential for recognizing chemical exposure risks.

Fire Hazards: Flammable substances, like ethanol, ignite easily near open flames, leading to fires, important for managing laboratory safety.

Broken Glassware: Shattered equipment, such as a dropped beaker, causes cuts or spills, vital for addressing physical laboratory dangers.

Electrical Faults: Faulty wiring, like exposed circuits, risks shocks during experiments, key for understanding electrical safety in labs.

Improper Storage: Misplaced chemicals, such as storing acids with bases, triggers reactions, necessary for maintaining safe laboratory conditions.

15. Why is an inquiry the best method of teaching and learning chemistry? Explain by giving four reasons

Active Engagement: Inquiry encourages participation, like predicting reaction outcomes, fostering deeper chemical understanding through exploration.

Critical Thinking: Students analyze data, such as titration results, developing problem-solving skills in chemical contexts.

Real-World Connection: Inquiry mimics scientific processes, like investigating pH changes, linking chemistry to practical applications.

Curiosity Driven: Students explore questions, such as "Why does rust form?", promoting interest in chemical phenomena.

16. Elaborate five programs in computer, which can be used in teaching and learning chemistry

ChemDraw: Draws chemical structures, like benzene rings, aiding visualization of molecular configurations in chemistry.

Avogadro: Models 3D molecular structures, such as H_2O, supporting analysis of chemical bonding and geometry.

Labster: Simulates experiments, like acid-base titrations, providing virtual practice for chemical techniques.

Molecular Workbench: Simulates reactions, such as combustion, demonstrating chemical dynamics and energy changes.

PhET Simulations: Offers interactive tools, like pH scales, illustrating chemical concepts through simulations.