THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATION COUNCIL OF TANZANIA
DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

732 **CHEMISTRY TEACHING METHODS**

Time: 3 Hour. **ANSWERS** **Year: 2003**

Instructions

1. This paper consists of sections **A**, **B** and **C.**
2. Answer all questions in sections **A** and **B**, and **two (2)** questions from section **C.**
3. Section **A** carries **36 marks**, section **B** carries **40 marks** and section **C** carries **24 marks**.
4. Cellular phones and other unauthorized materials are **not** allowed in the examination room.
5. Write your **Examination Number** on every page of your answer booklet(s).

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SECTION A (36 marks)

Answer all questions in this section.

1. Discuss four (4) fundamental pedagogical implications of introducing the mole concept to students at Form III level.

Introducing the mole concept requires a shift from qualitative to quantitative reasoning. This transition demands that the teacher scaffolds abstract thinking, starting with relatable comparisons such as using the mole to represent “a chemist’s dozen” before moving to Avogadro’s number.

The teacher must ensure mathematical competence. Since mole calculations involve proportional reasoning and algebraic manipulation, the Chemistry teacher should assess and reinforce relevant mathematical skills before teaching the topic.

It is important to integrate laboratory experiences such as molar volume of gases or empirical formula determination. This hands-on approach helps students link abstract calculations with physical observations.

The concept demands spiral learning. Teachers should plan to revisit mole-related ideas like stoichiometry, concentration, and titration across different topics to reinforce understanding and reduce cognitive load.

2. Describe four (4) challenges a Chemistry teacher may face when integrating inquiry-based learning (IBL) into experimental topics like rates of reaction or electrolysis.

Time management becomes a major issue. IBL is exploratory and time-consuming, often requiring several lessons to complete tasks that could be done in a single lecture.

Some students may lack the independence or motivation to explore effectively, especially if they are used to teacher-directed instruction. This makes group engagement inconsistent.

IBL depends on resource availability. Experiments like electrolysis need functioning power supplies, electrodes, and accurate stopwatches, which may be limited in many schools.

Assessment is difficult to standardize. Inquiry-based work produces diverse outputs, and Chemistry teachers may struggle to design fair marking schemes that reward both process and outcome.

3. Explain the didactic significance of balancing redox equations by the ion-electron method and why it should be emphasized in Form IV Chemistry.

Balancing redox reactions using the ion-electron method helps students develop an analytical understanding of electron transfer, rather than just memorizing reactions. This deepens their grasp of oxidation and reduction processes.

It reinforces conservation laws, both of mass and charge. This is critical in Chemistry education as students must appreciate that matter and electric charge are not lost in reactions.

The method forms a foundation for electrochemistry. Understanding redox balancing is essential before discussing cells, electroplating, and electrolysis.

It develops systematic problem-solving skills. The procedural nature of ion-electron balancing fosters a disciplined thinking style useful in tackling advanced Chemistry topics and in examinations.

4. With specific reference to Form II learners, outline four (4) learner-centered approaches you would apply to introduce the concept of the reactivity series.

I would use guided discovery through controlled displacement experiments. Learners would test combinations of metals and salt solutions, observe reactions, and arrange metals by reactivity based on evidence.

Role play could be used where students act as different elements reacting in a competition, helping them personify and internalize the reactivity order.

Interactive digital simulations showing metal reactivity trends can reinforce observations visually and cater to diverse learning styles, especially for schools with limited chemicals.

Group discussion and peer teaching, where each group investigates a particular metal's reactivity and presents findings, ensures active participation and collaborative learning.

5. (a) What is meant by the term "construct validity" in the context of Chemistry assessment?
   (b) Give three (3) practical strategies to improve construct validity in Chemistry test items.

Construct validity refers to the extent to which a test or assessment accurately measures the intended concept or skill. In Chemistry, this means ensuring that test items evaluate actual chemical understanding rather than unrelated abilities like language proficiency.

One strategy is aligning questions closely with instructional objectives. Each test item should be traceable to a clear syllabus or lesson objective to ensure relevance.

Avoiding ambiguous language and unnecessary complexity improves construct validity by ensuring that language does not become a barrier to demonstrating chemical knowledge.

Using a range of question types, practical, theoretical, and data-based, ensures that diverse aspects of chemical understanding are measured fairly and comprehensively.

6. Identify four (4) specific laboratory scenarios where procedural errors can lead to misinterpretation of empirical data and suggest appropriate preventive strategies.

In titration, failing to read the burette at eye level causes parallax error. This can be prevented by training students to maintain eye level when taking measurements.

During filtration, pouring the mixture too quickly may cause unfiltered solids to pass through. Teachers should emphasize pouring slowly and using folded filter papers.

In calorimetry, neglecting to insulate the apparatus leads to heat loss and inaccurate enthalpy values. Using polystyrene cups and lids can improve insulation.

In gas collection over water, if the delivery tube is not submerged properly, gas may escape. Students must be shown correct apparatus setup during demonstrations.

7. Justify the inclusion of cross-cutting issues like climate change and industrial pollution in Chemistry curriculum content, giving four (4) academic or ethical reasons.

Understanding climate change requires comprehension of chemical principles like combustion, greenhouse gases, and atmospheric reactions, linking academic content to real-world issues.

It promotes scientific literacy. Learners can make informed decisions on environmental matters when they understand the chemistry behind pollution and sustainability.

It fosters environmental responsibility. Teaching pollution effects instills values of conservation and accountability among young learners.

It aligns Chemistry with national and global priorities such as sustainable development goals (SDGs), making the subject socially and ethically relevant.

8. Propose four (4) principles to guide a Chemistry teacher in selecting content for a revision lesson two weeks before national examinations.

Relevance should be the first principle. The teacher must prioritize high-weight topics from the examination syllabus and past paper trends.

Difficulty level is important. Topics that learners have consistently performed poorly on should receive more attention during revision.

Content should be organized by conceptual clusters. Grouping related concepts together (e.g., acid-base and titration) helps reinforce connections and retention.

Active recall methods like quizzes, peer questioning, and timed drills should be emphasized to strengthen memory and exam readiness.

9. A Chemistry teacher decides to integrate a flipped classroom approach in Form IV classes. Explain four (4) critical preparatory steps necessary to implement this pedagogical innovation effectively.

The teacher must prepare quality instructional content such as videos, readings, or slide presentations that clearly explain concepts and can be accessed outside of class.

Students must be oriented on the flipped model and trained to engage with material independently before class. This may involve showing them how to take notes or summarize key points.

ICT infrastructure must be checked. The teacher needs to ensure all students have access to the materials via phones, computers, or printed copies where necessary.

The teacher must design in-class activities that build upon the pre-class learning. These include problem-solving sessions, experiments, and discussions that deepen understanding.

SECTION B (40 marks)

Answer both questions in this section.

10. During a teaching practice, a trainee teacher decided to use project-based learning (PBL) to teach the sub-topic "Water and its Composition."
(a) Propose a comprehensive project outline, including the aim, student activities, duration, and mode of assessment.
(b) Highlight four (4) pedagogical strengths and three (3) limitations of using project-based learning in this context.
(c) Suggest three (3) criteria that should be used to evaluate students' learning outcomes from this project.

(a) The aim of the project is to help students investigate the sources, purification, and chemical composition of water and present findings in a report.
Student activities include: collecting water samples from different local sources, performing simple purification processes (like filtration and boiling), conducting tests for hardness and pH, and presenting their findings.
Duration: Two weeks.
Assessment mode: Rubric-based evaluation of written report, oral presentation, and practical execution.

(b) One pedagogical strength is that PBL promotes active learning and real-life application of Chemistry, making lessons more relevant.
It enhances teamwork and communication, as students must work together to gather data and solve problems.
PBL encourages creativity and autonomy, helping learners develop research and presentation skills.
It supports cross-subject integration, linking Chemistry with geography, biology, and ICT.

One limitation is that it is time-consuming and may conflict with syllabus coverage.
There may be unequal participation within groups, causing assessment bias.
Limited access to resources like testing kits or clean sampling tools may hinder project quality.

(c) Evaluation criteria include:
Depth and accuracy of scientific content, did the student correctly test and describe the water's chemical properties?

Quality of presentation, was the report well-organized, clearly written, and supported by data?
Level of participation and collaboration, did the student contribute meaningfully in planning and executing the project?

SECTION B (continued)
Answer both questions in this section.

11. In an electrochemical experiment, a current of 0.25 A was passed through a copper (II) sulphate solution using copper electrodes for 32 minutes and 10 seconds.
    (a) Calculate the total quantity of electricity used in coulombs.
    (b) Calculate the number of moles of electrons transferred.
    (c) Determine the mass of copper deposited at the cathode. (1 Faraday = 96,500 C/mol, Molar mass of Cu = 63.5 g/mol, n = 2)
    (d) Identify and explain two (2) classroom management challenges that may arise during this experiment and how to mitigate them.

(a) First convert time to seconds:
32 minutes 10 seconds = (32 × 60) + 10 = 1920 + 10 = 1930 seconds
Charge (Q) = Current (I) × Time (t) = 0.25 A × 1930 s = **482.5 C**

(b) Moles of electrons (n) = Charge ÷ Faraday
= 482.5 ÷ 96,500 = **0.005 mol**

(c) Copper requires 2 moles of electrons to deposit 1 mole of Cu (n = 2)
So, moles of copper deposited = 0.005 ÷ 2 = **0.0025 mol**
Mass = moles × molar mass = 0.0025 × 63.5 = **0.15875 g**

(d) One classroom challenge is monitoring group activity. With multiple setups, students may mishandle wires or overheat the power source. To manage this, the teacher should divide the class into fewer groups and circulate frequently for supervision.

Another challenge is equipment failure or confusion with electrode polarity. The teacher should give a clear demonstration first and provide labeled apparatus to minimize errors during setup.

SECTION C (24 marks)
Answer two (2) questions from this section.

12. (a) Define the term “cognitive overload” as applied in Chemistry instruction.
    (b) Identify and explain three (3) Chemistry topics where students are prone to cognitive overload.
    (c) Describe three (3) instructional strategies a teacher can apply to minimize cognitive overload in senior Chemistry classes.

(a) Cognitive overload occurs when the amount of information or complexity in a lesson exceeds the learner's ability to process it effectively. This leads to confusion, fatigue, or failure to retain content.

(b) Stoichiometry causes overload due to complex calculations and multiple conceptual layers such as moles, ratios, and chemical equations.
Organic Chemistry overwhelms students with structural formulas, nomenclature rules, and reaction mechanisms.
Electrolysis presents too many new concepts at once, including ions, electrodes, redox reactions, and apparatus setup, making it difficult to process without clear scaffolding.

(c) One strategy is chunking breaking lessons into smaller segments. Instead of teaching an entire titration calculation in one go, start with balanced equations, then moles, and finally volumes.
Use visual aids such as flowcharts or labeled diagrams to reduce working memory load and improve conceptual clarity.
Incorporate retrieval practice through short quizzes or peer-teaching to reinforce concepts without overwhelming students with new material.

13. Using examples and balanced equations, discuss six (6) key principles of Green Chemistry that can be incorporated into the Tanzanian secondary Chemistry curriculum.

Prevention: Instead of cleaning up pollution, avoid generating waste. Example: Use microscale experiments in class to reduce chemical waste.

Atom economy: Reactions should maximize the incorporation of all materials into the final product. For example, addition reactions are preferred over substitution reactions.

Less hazardous synthesis: Choose safer reagents. Instead of using concentrated acids for reactions, opt for milder alternatives where possible.

Design for energy efficiency: Use reactions that proceed at room temperature or pressure to save fuel. In schools, favor experiments that do not require extensive heating.

Use of renewable feedstocks: Where possible, derive reagents from renewable sources. For example, ethanol from sugarcane rather than petroleum-based solvents.

Safer solvents: Avoid volatile organic solvents. Water and ethanol can often replace toxic solvents in school experiments.

14. A Form III teacher conducted a midterm evaluation where the mean score was 42, standard deviation was 8, and a student scored 58.
(a) Calculate the z-score for the student.
(b) Interpret the meaning of the score in terms of performance.
(c) Discuss the implications of using norm-referenced interpretations in assessing Chemistry learning outcomes.

(d) Suggest two (2) alternative models of interpreting learner performance and explain their benefits in Chemistry teaching.

(a) z = (X - mean) ÷ standard deviation = (58 - 42) ÷ 8 = 16 ÷ 8 = **2.0**

(b) A z-score of 2.0 means the student performed two standard deviations above the class average, indicating significantly higher achievement than most peers.

(c) Norm-referenced assessment ranks students relative to one another. While useful for identifying top performers, it can demotivate lower achievers even when they have improved, and it does not show whether a learning objective was met.

(d) Criterion-referenced assessment compares performance to predefined standards. It tells whether students understood a concept regardless of how others performed.
Mastery learning emphasizes achieving complete understanding before moving on, ensuring foundational skills are solid, crucial in Chemistry where concepts build progressively.

15. Construct a marking guide for the following question and award marks out of 20:
"Explain the processes and reactions involved in the extraction of iron from its ore in a blast furnace. Use equations and diagrams to support your explanation."
(a) Outline marking points including chemical reactions, diagram features, physical changes, and temperature zones.
(b) State four (4) common misconceptions students have when answering such a question and explain how a teacher should address them during instruction.

(a) **Diagram** (4 marks):

- Correct labeling of furnace zones (1)
- Arrows showing input (coke, limestone, hematite) (1)
- Labeling outputs (molten iron, slag, waste gases) (1)
- Temperature gradient from top (200°C) to base (1900°C) (1)

Reactions (8 marks):

- Combustion: $C + O_2 \rightarrow CO_2$ (1)
- Reduction: $CO_2 + C \rightarrow 2CO$ (1)
- Main iron reduction: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ (2)
- Thermal decomposition: $CaCO_3 \rightarrow CaO + CO_2$ (1)

- Slag formation: $CaO + SiO_2 \rightarrow CaSiO_3$ (1)
- Physical change of iron melting and collecting (2)

Explanation and Sequence (6 marks):

- Order of processes explained clearly (2)
- Role of each substance: coke, limestone, iron ore (2)
- Gaseous movement and function of CO as reducing agent (2)

(b) One misconception is that oxygen is the reducing agent; teachers should emphasize that carbon monoxide reduces iron oxide.

Another is confusing slag and molten iron. Teachers must reinforce that slag is waste (calcium silicate) while iron is the useful product.

Students may think iron is extracted as Fe_2O_3 directly. Teachers should stress the importance of chemical reduction to get elemental iron.

Some think limestone reduces iron. Teachers must clarify that limestone is used to remove impurities, not for iron extraction itself.