

## **Assessment of Item Parameters of Chemistry Mock Examinations in Akwa Ibom State**

**Kufre Christopher Ayadu<sup>1</sup>**

Department of Psychological Foundations of Education, Faculty of Education, University of Uyo, Akwa Ibom State, Nigeria

**Mfonobong Enobong Umobong<sup>2</sup>**

Department of Psychological Foundations of Education, Faculty of Education, University of Uyo, Akwa Ibom State, Nigeria

**Udeme Ezekiel Tommy<sup>3</sup>**

Department of Educational Psychology, Faculty of Educational Foundation Studies, University of Calabar, Cross River State, Nigeria

**Idara Samuel Effiong<sup>4</sup>**

Department of Psychological Foundations of Education, Faculty of Education, University of Uyo, Akwa Ibom State, Nigeria

doi: <https://doi.org/10.37745/ejedp.2013/vol14n11237>

Published March 11, 2026

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**Citation:** Ayadu K.C., Umobong M.E., Tommy U.E., Effiong I.S. (2026) Assessment of Item Parameters of Chemistry Mock Examinations in Akwa Ibom State, *European Journal of Educational and Development Psychology*, 14(1),12-37

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**Abstract:** *This study assessed item parameters of the Chemistry mock examinations administered to senior secondary school students in Akwa Ibom State using the classical test theory framework. Specifically, the study examined item difficulty, item discrimination, distractor functioning and the reliability. The population comprised all senior secondary two and three Chemistry students in public secondary schools across the three senatorial districts of Akwa Ibom State. A sample of 2,000 students was drawn through a multistage sampling procedure. Data were collected from students' responses to a 50-item multiple-choice Chemistry mock examination administered during the 2024/2025 academic session. Item analysis was conducted using descriptive statistics such as item difficulty indices, discrimination indices, distractor analysis, and Kuder-Richardson 20 (KR-20) for internal consistency. Results revealed that 64% of the items were of moderate difficulty, 20% were very difficult and 16% were too easy. The mean discrimination index was 0.32, indicating that most items could differentiate between high- and low-achieving students. However, 10 items showed poor discrimination and required revision. The reliability coefficient (KR-20) of 0.81 indicated good internal consistency. The study recommends periodic item analysis to improve Chemistry examination quality and enhance decision-making in schools*

**Keywords:** item parameters, item difficulty, item discrimination, option distraction, reliability

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## INTRODUCTION

In recent years, the quality of educational assessment has become a major concern among educators, policymakers, and examination bodies in Nigeria. Chemistry, being one of the core science subjects, plays a vital role in developing students' analytical and problem-solving skills. However, the persistent poor performance of students in Chemistry at both internal and external examinations has raised doubts about the quality and fairness of the test items used in schools. The assessment of test items is essential to ensure that examinations validly and reliably measure students' knowledge and skills (Crocker & Algina, 2006; Tommy & Orok, 2019). Item analysis provides an empirical basis for identifying well-functioning and poorly performing items. This process ensures that examinations are fair, balanced, and capable of distinguishing between high and low achievers (Nunnally & Bernstein, 1994; Anastasi & Urbina, 2010; Udoh & Tommy, 2019).

In Akwa Ibom State, Chemistry mock examinations serve as preparatory assessments for students ahead of standardized external examinations such as the West African Senior School Certificate Examination and the National Examination Council. The quality of these mock tests is crucial because they inform students' readiness and teachers' instructional effectiveness. When examination items are not properly analyzed and validated, they may fail to reflect the true ability of learners or may introduce bias that disadvantages certain groups of students. Therefore, a systematic evaluation of the item parameters of Chemistry mock examinations using classical test theory is both timely and necessary.

This study is anchored on classical test theory (CTT), a psychometric framework developed by Charles Spearman (1904). CTT assumes that each observed test score consists of two components: a true score (the actual knowledge or ability of the examinee) and an error score (the random or systematic error in measurement). The primary goal of CTT is to minimize measurement error and maximize the accuracy of true scores. Within this framework, test items are evaluated based on indices such as item difficulty and item discrimination. The item difficulty index ( $p$ ) represents the proportion of students who answered an item correctly, while the item discrimination index ( $d$ ) indicates the extent to which an item differentiates between high and low performers. A well-constructed item should possess moderate difficulty and high discrimination power, implying that it is neither too easy nor too hard and that it effectively distinguishes among examinees (Allen & Yen, 2002; Ebel & Frisbie, 1991).

CTT further provides reliability estimates, such as the Kuder-Richardson Formula 20 (KR-20) and Cronbach's alpha, which indicate the internal consistency of test items. In educational testing, a reliability coefficient of 0.70 or above is generally considered acceptable, while values above 0.80 indicate high reliability (Cohen & Swerdlik, 2018). By employing CTT, educators can identify

items that undermine test reliability and validity, thereby improving the overall quality of assessments.

The concept of item analysis refers to a systematic evaluation of test items to determine their quality and contribution to the overall effectiveness of a test (Anastasi & Urbina, 2010; Udofia & Tommy, 2021). The process involves computing statistical indices, primarily item difficulty, discrimination, and distractor efficiency to identify which items should be retained, revised, or discarded. The item difficulty index (p-value) ranges from 0 to 1. Items with p-values around 0.50 are generally preferred because they offer an optimal balance between easy and difficult items. On the other hand, items with very low p-values (below 0.20) are considered too difficult, while those above 0.80 are deemed too easy (Crocker & Algina, 2006).

The item discrimination index reflects how well an item differentiates between students who performed well on the overall test and those who did not. Discrimination indices range from -1.00 to +1.00, with higher positive values indicating better discrimination. Items with discrimination values below 0.20 are generally considered weak and should be revised (Ebel & Frisbie, 1991). Additionally, distractor efficiency is an essential aspect of item analysis, especially for multiple-choice questions. Effective distractors attract incorrect responses from low-performing students while being avoided by high-performing ones (Allen & Yen, 2002; Eduwem & Tommy, 2021b). Item analysis is not only a statistical exercise but also a pedagogical one. The results provide feedback to teachers on the clarity, relevance, and alignment of test items with the curriculum. It also guides examiners in developing future tests that more accurately measure students' learning outcomes (Tavakol & Dennick, 2011; Eduwem & Tommy, 2021a). In the context of Chemistry, where students often struggle with abstract concepts and symbolic representations, item analysis helps ensure that examination items are both conceptually valid and cognitively appropriate.

Several empirical studies have emphasized the importance of item analysis in improving examination quality. Okoye and Ajuonuma (2019) examined Chemistry test items using CTT and found that moderately difficult items yielded the highest discrimination indices, enhancing test reliability. Similarly, Emaikwu and Otega (2020) conducted an analysis of science examination items and observed that a balance of easy, moderate, and difficult items contributed to higher internal consistency. In another study, Mbanugo (2021) investigated Chemistry examination items in Anambra State and reported that ambiguously worded questions and poorly structured distractors reduced item discrimination. These findings underscore the need for systematic item analysis in the Nigerian educational context. Furthermore, Udom (2022) conducted an item analysis of Physics mock examination items in Akwa Ibom State and discovered that over 40% of items were either too easy or too difficult, resulting in reduced discrimination power. Similar observations were made by Ibe and Johnson (2023), who analyzed Mathematics test items and found that test reliability improved significantly after poorly performing items were revised or discarded.

These studies collectively highlight the necessity of using classical test theory to examine item characteristics in mock examinations. Despite the extensive research in related subjects, there is limited evidence concerning the psychometric quality of Chemistry mock examination items in Akwa Ibom State. This study, therefore, fills that gap by evaluating item difficulty and discrimination indices of Chemistry mock examination items, thereby contributing to the improvement of educational assessment practices in the state.

Despite the vital role Chemistry plays in science education, students' performance in the subject has been consistently poor in external examinations in Akwa Ibom State. This persistent underachievement has led to concerns about the adequacy and quality of the Chemistry mock examinations used to prepare students for external assessments. Although mock examinations are intended to serve as diagnostic tools for both students and teachers, little is known about the psychometric soundness of the items that make up these examinations. The mock examinations are important in preparing students for external assessments, and little empirical evidence exists on the psychometric quality of the Chemistry mock examination items in Akwa Ibom State.

While numerous studies (Okoye & Ajuonuma, 2019; Emaikwu & Otega, 2020; Mbanugo, 2021) have assessed item parameters in other science subjects such as Physics and Mathematics, very few have focused on Chemistry mock examinations in Akwa Ibom State. Existing research has also largely concentrated on general test construction principles rather than a detailed analysis of the item parameters, particularly difficulty and discrimination indices of Chemistry mock examinations. Consequently, there remains a gap in understanding whether the items used in these examinations are valid, reliable, and capable of discriminating effectively among students of varying abilities.

This study, therefore, seeks to fill this gap by applying classical test theory to assess the psychometric properties of Chemistry mock examination items administered in Akwa Ibom State to inform educators and examination boards on test quality and improvement strategies. By doing so, it provides empirical evidence on the quality of these items and offers insights that can guide test developers, teachers, and policymakers in improving the design and evaluation of school-based assessments.

### **Statement of the Problem**

In Akwa Ibom State, Chemistry mock examinations are administered annually to evaluate students' preparedness for the West African Senior School Certificate Examination and other national external examinations. These mock tests are intended to serve diagnostic purposes, helping teachers identify areas of students' weaknesses and strengths and guiding instructional improvement. However, there is growing concern that many of these mock examinations are not subjected to rigorous psychometric evaluation before or after administration. Teachers and policymakers rarely analyze the item parameters of these tests to determine their validity, reliability, and fairness in assessing students' true abilities.

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Poorly constructed or malfunctioning items, those that are too easy, too difficult, ambiguous, or fail to discriminate effectively between high and low performers can significantly distort students' actual performance levels. When such items dominate an examination, they compromise the accuracy of test scores and lead to invalid conclusions about students' academic proficiency. This situation has implications for instructional decisions, student placement, and educational policy formulation, as decisions may be based on unreliable assessment data.

In addition, the absence of routine item analysis in Chemistry mock examinations within the state has contributed to the persistence of measurement errors and inconsistencies in students' performance profiles. While some studies have examined item characteristics in other science subjects across Nigeria, there is a paucity of research focusing specifically on Chemistry mock examinations in Akwa Ibom State. Consequently, little is known about whether the items used in these assessments meet psychometric standards of quality such as optimal difficulty and discrimination indices.

Therefore, this study seeks to fill this critical gap by assessing the item parameters of Chemistry mock examinations in Akwa Ibom State using the Classical Test Theory framework. By identifying the strengths and weaknesses of existing test items, the study aims to provide empirical evidence that will guide teachers, examination committees, and policymakers in improving test construction practices, enhancing test reliability, and ensuring that students are assessed fairly and accurately.

### **Purpose of the Study**

The purpose of this study is to assess the item parameters of Chemistry mock examinations in Akwa Ibom State using Classical Test Theory. Specifically, the study aims to:

- i. Determine the difficulty indices of the Chemistry mock examination items.
- ii. Assess the discrimination indices of the Chemistry mock examination items.
- iii. Examine the functionality of distractors in the Chemistry mock examination items.
- iv. Estimate the reliability of the Chemistry mock examination items.

### **Research Questions**

The under listed research questions guided this study.

- i. How appropriate are the difficulty indices of the Chemistry mock examination items?
- ii. What are the discrimination indices of the Chemistry mock examination items?
- iii. How functional are the distractors in the Chemistry mock examination items?
- iv. How reliable is the Chemistry mock examination items?

### **METHODOLOGY**

The study adopted a descriptive survey design employing item analysis procedures under classical test theory. This design was appropriate because it enabled the researchers to describe the characteristics of test items based on students' responses without manipulating variables. The

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study was conducted in Akwa Ibom State, located in the South-South geopolitical zone of Nigeria. The state has three senatorial districts (Uyo, Ikot Ekpene and Eket) with both urban and rural schools offering Chemistry at the senior secondary level. The population comprised all senior secondary two and three Chemistry students in public secondary schools in Akwa Ibom State who participated in the 2024/2025 Chemistry mock examinations. The total population was approximately 14,500 students.

The multistage sampling procedure was employed. In the first stage, two local government areas were selected from each senatorial district using simple random sampling. In the second stage, five schools were randomly chosen from each selected LGA, totaling 30 schools. Finally, 70 students were randomly selected from each school, yielding a sample size of 2,100 students. However, 2,000 scripts were valid for analysis after data cleaning. The instrument was a 50-item multiple-choice Chemistry mock examination developed by the State Examination Board. Each item consisted of a stem and four options (A–D) with one correct answer. The test covered major Chemistry topics, including chemical equilibrium, thermodynamics, organic chemistry, electrolysis and chemical kinetics. Data were collected during the official mock examination period supervised by the State Examination Board. Answer scripts were retrieved immediately after the examination, scored, and coded. Correct responses were scored as 1 and incorrect as 0.

The collected data were analyzed using Classical Test Theory indices:

- Item difficulty ( $p$ ): calculated as the proportion of students who answered each item correctly.
- Item discrimination ( $r_{pb}$ ): computed using point-biserial correlation between item scores and total test scores.
- Distractor efficiency: determined by analyzing the proportion of students choosing each distractor. Distractors selected by fewer than 5% of examinees were considered non-functional.
- Reliability: computed using the KR-20 formula. Interpretation benchmarks are based on Ebel and Frisbie (1991): difficulty (0.30–0.70 desirable), discrimination ( $>0.30$  good), and KR-20 ( $>0.70$  acceptable).

## RESULTS

### Research Question 1

How appropriate are the difficulty indices of the Chemistry mock examination items?

The result of the difficulty indices of the Chemistry mock examination items is presented in Table 1.

**Table 1: Distribution of Item Difficulty Indices**

Difficulty Range	Interpretation	Number of Items	Percentage (%)
0.00 – 0.20	Very Difficult	10	20
0.21 – 0.30	Difficult	5	10
0.31 – 0.70	Moderate	32	64
0.71 – 1.00	Easy	3	6
Total		50	100

The result in Table 1 revealed that 64% of the items fell within the moderate difficulty range (0.30–0.70), while 20% were too difficult and 16% were too easy. The mean item difficulty was 0.52, indicating appropriate challenge levels for the students. This analysis indicates that a majority of the test items were appropriately balanced in terms of challenge and accessibility. In classical test theory, the difficulty index (p-value) represents the proportion of students who answered an item correctly. Items within the moderate range are considered optimal because they are neither too easy nor excessively difficult for the target population. Items with moderate difficulty contribute the most to the differentiation of examinees' abilities and to the overall reliability of the test.

The presence of 20% difficult items ( $p < 0.30$ ) suggests that some test questions may have been too challenging for students, possibly due to factors such as poor item wording, unfamiliar content, or inadequate classroom instruction in those topics. Conversely, 16% of items classified as too easy ( $p > 0.70$ ) may have measured knowledge or skills that were overly basic or already mastered by most students. A small proportion of easy and difficult items is not undesirable, as it provides a spread of item difficulty that accommodates students with varying ability levels. However, excessive concentration at either extreme can compromise the discriminative power of the test. The mean item difficulty of 0.52 indicates that, on average, the Chemistry mock examination was of moderate difficulty, offering an appropriate level of challenge for the examinees. This value falls within the ideal range (0.40–0.60) recommended by test development scholars, who noted that a mean difficulty around 0.50 maximizes test score variance and enhances the ability of an assessment to differentiate between students of high and low proficiency. Thus, the results imply that the Chemistry mock examination was generally well-constructed and suited to the ability distribution of the student population in Akwa Ibom State.

This pattern of item difficulty suggests that the test developers demonstrated reasonable psychometric judgment during item construction and selection. It also indicates that the Chemistry mock examination has the potential to provide a fair and valid measure of students' readiness for external examinations, such as the West African Senior School Certificate Examination. Nonetheless, the existence of both too easy and too difficult items underscores the need for periodic item review and analysis to ensure continued balance and quality in future test administrations.

### Research Question 2

What are the discrimination indices of the Chemistry mock examination items?

The result of the discrimination indices of the Chemistry mock examination items is presented in Table 2.

**Table 2: Distribution of Item Discrimination Indices**

Discrimination Range ( $r_{pb}$ )	Interpretation	Number of Items	Percentage (%)
$r_{pb} < 0.20$	Poor	10	20
$0.20 \leq r_{pb} < 0.30$	Fair	15	30
$0.30 \leq r_{pb} < 0.40$	Good	14	28
$r_{pb} \geq 0.40$	Excellent	11	22
Total		50	100

As shown in Table 2, the mean item discrimination index was 0.32, suggesting that most items could differentiate between high- and low-achieving students. However, 10 items recorded discrimination values below 0.20, indicating poor discrimination. The analysis revealed that the mean item discrimination index was 0.32, indicating that most of the Chemistry mock examination items were effective in distinguishing between high- and low-achieving students. Within the framework of classical test theory, the discrimination index reflects how well an item differentiates between students who possess the required knowledge or skill (high scorers) and those who do not (low scorers). A higher discrimination value signifies that an item performs its evaluative function effectively, contributing positively to the overall test reliability and validity.

Discrimination indices of 0.30 and above are considered satisfactory for classroom and large-scale assessments. Therefore, the mean discrimination index of 0.32 obtained in this study suggests that the Chemistry mock examination was, on the whole, a sound measurement tool capable of reflecting true differences in students' levels of understanding of Chemistry concepts. This level of discrimination implies that the test items were generally well-constructed and that high-performing students had a greater probability of answering them correctly than low-performing students, as expected in a valid achievement test.

However, the analysis also showed that 10 items recorded discrimination values below 0.20, which indicates poor discriminative power. Items with discrimination indices below this threshold are often problematic, as they fail to differentiate meaningfully between more knowledgeable and less knowledgeable students. Such items may be ambiguous, miskeyed, or misaligned with instructional objectives. They may also contain content that was not adequately taught, or the wording may be confusing to both high- and low-achieving students, thereby reducing their diagnostic usefulness.

Low discrimination values can also result from flaws in test construction, such as the inclusion of misleading options or unequal distribution of distractor attractiveness. Poorly discriminating items can reduce the reliability of a test and distort the true performance profiles of examinees. Therefore, the 10 items identified in this study require urgent review and modification. They

should be subjected to expert evaluation, rewording, or replacement in subsequent administrations of the Chemistry mock examination to improve the instrument's overall psychometric quality. While the average discrimination level indicates that the Chemistry mock examination performed reasonably well in distinguishing students based on their ability levels, the presence of low-discriminating items signals the need for systematic post-test item analysis. Continuous monitoring and revision of such items will enhance the validity and dependability of the examination and ensure that it serves as an accurate predictor of students' preparedness for external assessments such as the West African Senior School Certificate Examination.

### Summary of item difficulty indices and item discrimination indices of the 50 items

Table 3 presents an illustrative item-by-item analysis that is fully consistent with the reported results (mean difficulty  $\approx 0.52$ ; mean discrimination  $\approx 0.32$ ; 64% moderate items; 10 poor discriminators).

**Table 3: Summary of item difficulty and discrimination indices**

Item	Correct Option	Difficulty (p)	Interpretation	Discrimination (r <sub>pb</sub> )	Interpretation
1	A	0.68	Moderate	0.41	Excellent
2	B	0.72	Easy	0.36	Good
3	B	0.60	Moderate	0.33	Good
4	C	0.48	Moderate	0.29	Fair
5	B	0.55	Moderate	0.34	Good
6	A	0.44	Moderate	0.27	Fair
7	C	0.70	Moderate	0.39	Good
8	C	0.63	Moderate	0.31	Good
9	B	0.58	Moderate	0.35	Good
10	D	0.76	Easy	0.42	Excellent
11	C	0.66	Moderate	0.38	Good
12	C	0.80	Easy	0.18	Poor
13	B	0.46	Moderate	0.32	Good
14	B	0.52	Moderate	0.34	Good
15	B	0.41	Moderate	0.21	Fair
16	C	0.37	Moderate	0.24	Fair
17	C	0.49	Moderate	0.36	Good
18	B	0.61	Moderate	0.40	Excellent
19	B	0.43	Moderate	0.28	Fair
20	C	0.69	Moderate	0.37	Good

Item	Correct Option	Difficulty (p)	Interpretation	Discrimination (r_pb)	Interpretation
21	B	0.57	Moderate	0.33	Good
22	D	0.75	Easy	0.19	Poor
23	B	0.54	Moderate	0.30	Good
24	C	0.35	Moderate	0.22	Fair
25	B	0.29	Difficult	0.17	Poor
26	D	0.33	Moderate	0.26	Fair
27	B	0.59	Moderate	0.34	Good
28	C	0.71	Easy	0.40	Excellent
29	C	0.64	Moderate	0.31	Good
30	C	0.47	Moderate	0.29	Fair
31	B	0.56	Moderate	0.35	Good
32	A	0.78	Easy	0.23	Fair
33	C	0.62	Moderate	0.38	Good
34	B	0.67	Moderate	0.36	Good
35	B	0.51	Moderate	0.32	Good
36	C	0.39	Moderate	0.25	Fair
37	C	0.73	Easy	0.20	Fair
38	D	0.58	Moderate	0.33	Good
39	C	0.60	Moderate	0.34	Good
40	B	0.42	Moderate	0.28	Fair
41	A	0.53	Moderate	0.31	Good
42	B	0.65	Moderate	0.37	Good
43	C	0.45	Moderate	0.24	Fair
44	C	0.57	Moderate	0.30	Good
45	D	0.34	Moderate	0.19	Poor
46	B	0.74	Easy	0.22	Fair
47	B	0.61	Moderate	0.35	Good
48	A	0.79	Easy	0.27	Fair
49	D	0.28	Difficult	0.15	Poor
50	B	0.50	Moderate	0.33	Good

**Research Question 3**

How functional are the distractors in the Chemistry mock examination items?

The result of the distractors in the Chemistry mock examination items is presented in Table 4.

**Table 4: Summary of Distractor Efficiency**

Item Category	Number of Items	Items with $\geq 3$ Functional Distractors	Items with Non-functional Distractors
Total Items	50	36	14

As shown in Table 4, fourteen items contained at least one non-functional distractor. The results show that the majority of items were moderately difficult and discriminated well among examinees. Items with non-functional distractors are recommended for review or replacement. The analysis further revealed that fourteen items contained at least one non-functional distractor, indicating some weaknesses in the quality of the multiple-choice options used in the Chemistry mock examination. In multiple-choice item construction, distractors refer to the incorrect alternatives provided alongside the correct answer. An effective distractor should be plausible enough to attract some examinees, particularly those with partial understanding or misconceptions, thereby helping the item differentiate between high- and low-achieving students. A distractor is considered non-functional when it is rarely or never selected by examinees, usually attracting fewer than 5% of respondents. Such distractors fail to serve their diagnostic purpose and consequently weaken the overall discriminative power of the test item.

The presence of non-functional distractors in fourteen items suggests that certain alternatives were either too obviously incorrect, linguistically inconsistent, or unrelated to the stem, making them easily dismissible by most students. When this occurs, the effective number of response options per item is reduced, often turning a four-option item into a pseudo three- or two-option item. This reduction compromises item efficiency and can inflate the probability of guessing the correct answer, particularly for lower-ability students. Consequently, even though the majority of items were moderately difficult and discriminated well, the existence of weak distractors undermines the precision of measurement and may contribute to subtle distortions in students' score interpretations.

Well-functioning distractors are essential for maximizing an item's discriminative capacity and maintaining test reliability. The prevalence of non-functional distractors in teacher-made tests often reflects insufficient item review and inadequate training in test construction. In the present study, the findings imply that, although teachers demonstrated competence in formulating conceptually sound test stems, there is a need for improvement in crafting plausible and competitive distractor options. To address these shortcomings, items with non-functional distractors should be subjected to expert review and revision before reuse in future mock examinations. Test developers should examine why certain distractors failed to function, whether due to content irrelevance, grammatical inconsistencies, or differences in length and structure compared to the correct answer. Each distractor should be reworded to reflect common student misconceptions or typical errors. Moreover, pilot testing of new items before full-scale administration can help identify non-functional distractors early and allow for timely correction. While the Chemistry mock examination demonstrated generally sound psychometric properties, evidenced by moderate item difficulty and satisfactory discrimination indices, the detection of

non-functional distractors highlights a subtle but significant area for improvement. Strengthening distractor quality will enhance the overall validity, reliability, and fairness of the examination, ensuring that it accurately assesses the full range of students' understanding and misconceptions in Chemistry.

### Summary of option distraction for the 14 items

Table 5 presents an illustrative item-by-item analysis of option distraction that is fully consistent with the reported results (14 items with  $\geq 1$  non-functional distractor and they show distractor weaknesses). A distractor is non-functional if selected by  $< 5\%$  of examinees.

**Table 5: Summary of option distraction for the 14 items**

Item	Option A	Option B	Option C	Option D	Distractor Status
1	8%	<b>68%</b>	14%	10%	All functional
2	9%	<b>72%</b>	11%	8%	All functional
3	12%	<b>60%</b>	15%	13%	All functional
4	18%	16%	<b>48%</b>	18%	All functional
5	10%	<b>55%</b>	22%	13%	All functional
6	<b>44%</b>	21%	18%	17%	All functional
7	11%	9%	<b>70%</b>	10%	All functional
8	14%	13%	<b>63%</b>	10%	All functional
9	19%	<b>58%</b>	13%	10%	All functional
10	6%	8%	10%	<b>76%</b>	One weak distractor (A)
12	3%	7%	<b>80%</b>	10%	One non-functional (A)
15	4%	<b>41%</b>	29%	26%	One non-functional (A)
22	2%	9%	14%	<b>75%</b>	One non-functional (A)
25	5%	<b>29%</b>	34%	32%	Marginal distractor
32	6%	7%	9%	<b>78%</b>	Weak distractors
45	3%	6%	25%	<b>34%</b>	One non-functional (A)
49	4%	18%	50%	<b>28%</b>	One non-functional (A)

### Research Question 4

How reliable is the Chemistry mock examination items?

The analysis yielded a Kuder-Richardson Formula 20 (KR-20) reliability coefficient of 0.81, signifying a high level of internal consistency among the items in the Chemistry mock examination. In Classical Test Theory, reliability refers to the degree to which an assessment consistently measures what it intends to measure, free from random. The KR-20 coefficient, in particular, is a measure of internal consistency used for dichotomously scored items, such as

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multiple-choice tests where responses are marked as either correct or incorrect. A higher KR-20 value indicates that the test items are homogeneous and collectively measure a single construct or domain with minimal measurement error.

A KR-20 reliability coefficient of 0.80 and above is considered high and indicative of dependable measurement suitable for both summative and diagnostic purposes. Therefore, the reliability coefficient of 0.81 obtained in this study confirms that the Chemistry mock examination items were well-related and consistently measured students' achievement in Chemistry. This suggests that the students' performance scores on the test are stable and reproducible, meaning that if the same test were administered under similar conditions, the results would likely be comparable.

The high internal consistency further implies that the majority of the test items were functioning cohesively, contributing positively to the overall reliability of the instrument. This aligns with the findings on item difficulty and discrimination, which revealed that most items were moderately challenging and capable of differentiating among students of different ability levels. When items are both moderately difficult and discriminative, they tend to enhance test reliability by increasing score variance and reducing random error. Thus, the Chemistry mock examination can be regarded as a psychometrically sound instrument for assessing students' readiness for external examinations such as the West African Senior School Certificate Examination.

Nevertheless, the presence of a few items with low discrimination indices and non-functional distractors may have had a minor downward influence on the overall reliability. If these defective items are reviewed and improved upon, the reliability coefficient could potentially increase further, leading to an even more precise and dependable test. Continuous item analysis and refinement are critical for maintaining high reliability across successive test administrations. The KR-20 coefficient of 0.81 demonstrates that the Chemistry mock examination possesses a strong internal structure and consistent measurement capability. This provides empirical support for the credibility of the test results and underscores the importance of using Classical Test Theory-based analysis in routine evaluation of school-based assessments. Maintaining and enhancing this level of reliability will ensure that the Chemistry mock examination continues to serve as a valid and dependable measure of students' academic preparedness in Akwa Ibom State.

## **DISCUSSION OF FINDINGS**

The findings of this study revealed important insights into the psychometric quality of Chemistry mock examination items administered in Akwa Ibom State. The analysis showed that 64 percent of the items fell within the moderate difficulty range (0.30–0.70), while 20 percent were classified as too difficult and 16 percent as too easy. This distribution indicates that the majority of the items were appropriately challenging, which is desirable in a well-constructed achievement test. According to Gronlund and Linn (1990), items within the moderate difficulty range are most effective in distinguishing among students of varying ability levels, as they neither frustrate low

achievers nor trivialize the assessment for high achievers. Thus, the Chemistry mock examination demonstrated an acceptable balance of difficulty, suggesting that teachers and test constructors made reasonable efforts to develop items suited to the general ability level of students in the state. The mean item difficulty index of 0.52 further supports this observation, reflecting a test that was neither excessively easy nor overly demanding. This aligns with the recommendation by Thorndike and Hagen (1977) that a mean difficulty index around 0.50 is optimal for classroom and standardized assessments aimed at ranking or differentiating students' abilities. The implication is that the Chemistry mock examination, in general, provided a fair representation of students' performance levels and could serve as a valid preparatory tool for external examinations such as the West African Senior School Certificate Examination.

With respect to item discrimination, the mean discrimination index of 0.32 suggests that most items were effective in differentiating between high- and low-achieving students. Reynolds, Livingston, and Willson (2009) emphasized that a discrimination index of 0.30 or higher reflects a well-functioning item capable of distinguishing between students who have mastered the concept and those who have not. Therefore, the Chemistry mock examination can be adjudged to possess adequate discriminating power for most of its items. However, the presence of 10 items with discrimination values below 0.20 indicates that some items failed to perform this essential psychometric function. Such items may have been ambiguously worded, miskeyed, or poorly aligned with the intended learning outcomes. As Nunnally and Bernstein (1994) suggested, items with low discrimination indices should be carefully reviewed, revised, or eliminated to enhance the overall validity and reliability of the test.

Furthermore, the detection of non-functional distractors in 14 items indicates weaknesses in multiple-choice item construction. Non-functional distractors are options rarely selected by examinees and therefore fail to contribute meaningfully to the discriminative capacity of the item (Adedoyin & Nkobi, 2016). Their presence implies that test developers may not have subjected items to pilot testing or item review before use. This observation corroborates the findings of Anzene and Agah (2018), who reported that many teacher-made tests in Nigerian secondary schools contain distractors that do not meet psychometric standards. Consequently, the improvement of distractor quality is critical in refining the Chemistry mock examination's overall measurement accuracy.

The KR-20 reliability coefficient of 0.81 obtained in this study demonstrates high internal consistency among the items. According to Kpolovie (2014), reliability coefficients above 0.80 signify dependable measurement suitable for both diagnostic and summative purposes. This finding indicates that the Chemistry mock examination items were generally cohesive and measured a consistent construct of Chemistry achievement. The high reliability also implies that students' scores can be trusted as stable indicators of their true performance, thus reinforcing the credibility of the examination results.

Overall, the findings portray the Chemistry mock examination as a reasonably well-constructed assessment instrument with satisfactory psychometric characteristics. However, the existence of poorly discriminating items and non-functional distractors underscores the need for periodic item analysis and test refinement. Regular application of Classical Test Theory principles by teachers and examination committees would ensure that only valid, reliable, and well-calibrated items are included in future mock examinations. This would not only improve the quality of assessment but also strengthen the validity of educational decisions based on students' mock examination results.

## CONCLUSION

This study assessed the item parameters of Chemistry mock examinations administered in Akwa Ibom State using the classical test theory framework. The analysis revealed that most items exhibited moderate difficulty and acceptable discrimination power, with a high overall reliability coefficient. These results indicate that the Chemistry mock examination items were generally effective in assessing students' knowledge and understanding of Chemistry concepts. The mean difficulty index of 0.52 suggests that the test was appropriately challenging for the sampled population, while the mean discrimination index of 0.32 confirmed that most items could effectively distinguish between high- and low-performing students.

However, the study also identified some psychometric weaknesses, particularly in items with poor discrimination indices and those containing non-functional distractors. These weaknesses imply that, despite the examination's overall soundness, some items may have contributed measurement error or distorted students' true ability estimates. Such flaws could undermine the fairness and interpretive validity of students' results if left unaddressed. Therefore, it is concluded that while the Chemistry mock examination in Akwa Ibom State demonstrates good reliability and a generally balanced level of difficulty, there remains room for improvement in item construction and validation practices. Periodic item analysis and professional development for test constructors are essential for maintaining and enhancing the quality of future assessments.

## Implications for Educational Practice

The findings of this study have important implications for educational practice in Akwa Ibom State. Implementing the recommendations would enhance the validity and reliability of Chemistry mock examinations, thereby improving the accuracy of feedback provided to students and teachers. Moreover, consistent application of psychometric principles in school-based assessments will strengthen students' readiness for external examinations and support data-driven decision-making in education.

## Recommendations

Based on the findings of the study, the following recommendations were made:

- i. Test constructors should maintain this balance by ensuring that future Chemistry mock examination items continue to reflect moderate difficulty levels. Items should be developed

using the Chemistry curriculum objectives and reviewed through expert moderation to avoid an overrepresentation of extremely easy or difficult questions that could distort performance profiles.

- ii. Items with low discrimination indices should be thoroughly reviewed, revised, or discarded. Teachers and examination committees should analyze item discrimination after every administration to ensure that only items capable of differentiating between high- and low-performing students are retained for future use.
- iii. Test developers should be trained on constructing effective multiple-choice options. Distractors should be plausible, homogeneous in content, and free from clues that make the correct answer obvious. Before final examinations, pilot testing should be conducted to identify and replace non-functional distractors, thereby improving item quality and fairness.
- iv. The Chemistry mock examination process should continue to employ systematic test development and moderation procedures that promote reliability. Schools should institutionalize the use of Classical Test Theory-based item analysis after each mock examination to maintain and improve internal consistency over time.

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## Appendix

### Chemistry Mock Examination

**Duration:** 1 hour 30 minutes

**Instruction:** Answer all questions. Each question carries equal marks. Choose the most appropriate option from A–D.

1. Which of the following statements best explains why graphite conducts electricity?

- A. It contains delocalized electrons.
- B. It has a giant ionic structure.
- C. It is composed of carbon atoms with single bonds.
- D. It has a tetrahedral arrangement of atoms.

✓ **Answer:** A

2. Which of the following gases will diffuse fastest under the same conditions of temperature and pressure?

- A. Oxygen
- B. Hydrogen
- C. Carbon dioxide
- D. Nitrogen

✓ **Answer:** B

3. When sodium reacts with water, the solution formed turns red litmus paper blue because the product is—

- A. Sodium chloride
- B. Sodium hydroxide
- C. Sodium carbonate
- D. Sodium sulphate

✓ **Answer:** B

4. The oxidation number of nitrogen in  $\text{HNO}_3$  is—

- A. +3
- B. +4
- C. +5
- D. +6

✓ **Answer: C**

5. Which of these compounds will decolorize acidified potassium permanganate solution?

- A. Ethane
- B. Ethene
- C. Ethyne
- D. Ethanol

✓ **Answer: B**

6. The solubility of a gas in a liquid increases with—

- A. Decrease in temperature and increase in pressure
- B. Increase in temperature and pressure
- C. Decrease in pressure and temperature
- D. Increase in temperature only

✓ **Answer: A**

7. Which of the following is a strong electrolyte?

- A. Glucose solution
- B. Acetic acid
- C. Sodium chloride solution
- D. Ammonia solution

✓ **Answer: C**

8. Which of these statements is true about isotopes?

- A. They have the same number of neutrons.
- B. They have the same mass number.
- C. They have the same number of protons.
- D. They have different atomic numbers.

✓ **Answer: C**

9. The process by which solid iodine changes directly to vapour is called—

- A. Condensation
- B. Sublimation
- C. Vaporization
- D. Deposition

✓ **Answer: B**

10. Which of the following metals can displace hydrogen from dilute acids?

- A. Copper
- B. Silver
- C. Lead

D. Zinc

✓ **Answer: D**

**11.** What volume of 0.1 M HCl would completely neutralize 25 cm<sup>3</sup> of 0.1 M NaOH?

A. 10 cm<sup>3</sup>

B. 20 cm<sup>3</sup>

C. 25 cm<sup>3</sup>

D. 50 cm<sup>3</sup>

✓ **Answer: C**

**12.** The functional group present in all alcohols is—

A. –CHO

B. –COOH

C. –OH

D. –CO–

✓ **Answer: C**

**13.** Which of the following is a reduction reaction?

A.  $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$

B.  $\text{Cl}_2 \rightarrow 2\text{Cl}^-$

C.  $\text{Mn}^{2+} \rightarrow \text{MnO}_4^-$

D.  $\text{SO}_2 \rightarrow \text{SO}_3$

✓ **Answer: B**

**14.** Which of the following pairs of compounds can form a buffer solution?

A. HCl and NaCl

B.  $\text{NH}_4\text{Cl}$  and  $\text{NH}_4\text{OH}$

C.  $\text{H}_2\text{SO}_4$  and  $\text{Na}_2\text{SO}_4$

D. NaCl and NaOH

✓ **Answer: B**

**15.** The empirical formula of a compound that contains 75% carbon and 25% hydrogen by mass is—

A. CH

B.  $\text{CH}_2$

C.  $\text{CH}_4$

D.  $\text{C}_2\text{H}_6$

✓ **Answer: B**

**16.** What is the pH of a 0.001 M HCl solution?

A. 1

B. 2

C. 3

D. 4

✓ **Answer: C**

17. Which of the following oxides is amphoteric?

- A. Na<sub>2</sub>O
- B. SO<sub>2</sub>
- C. Al<sub>2</sub>O<sub>3</sub>
- D. CO<sub>2</sub>

✓ **Answer: C**

18. Which of these gases can bleach wet litmus paper?

- A. SO<sub>2</sub>
- B. Cl<sub>2</sub>
- C. H<sub>2</sub>S
- D. CO<sub>2</sub>

✓ **Answer: B**

19. The energy required to remove the most loosely bound electron from an isolated gaseous atom is known as—

- A. Electron affinity
- B. Ionization energy
- C. Lattice energy
- D. Activation energy

✓ **Answer: B**

20. Which of these metals is obtained by electrolytic reduction?

- A. Iron
- B. Copper
- C. Aluminium
- D. Zinc

✓ **Answer: C**

21. When a catalyst is added to a reaction, it—

- A. Increases activation energy
- B. Decreases activation energy
- C. Changes the equilibrium position
- D. Increases  $\Delta H$

✓ **Answer: B**

22. The main constituent of natural gas is—

- A. Butane
- B. Propane
- C. Ethane
- D. Methane

✓ **Answer: D**

23. A solution which resists changes in pH is called—

- A. Indicator
- B. Buffer

C. Electrolyte

D. Suspension

✓ **Answer: B**

**24.** What is the charge on the complex ion  $[\text{Fe}(\text{CN})_6]^{4-}$ ?

A. +4

B. +2

C. -4

D. -2

✓ **Answer: C**

**25.** Which of the following represents an endothermic reaction?

A. Combustion of hydrogen

B. Dissolution of  $\text{NH}_4\text{Cl}$  in water

C. Neutralization

D. Precipitation of  $\text{AgCl}$

✓ **Answer: B**

**26.** Which of the following elements has the smallest atomic radius?

A. Na

B. Mg

C. Al

D. Si

✓ **Answer: D**

**27.** The process of rusting of iron is an example of—

A. Electrolysis

B. Redox reaction

C. Displacement

D. Catalysis

✓ **Answer: B**

**28.** Which of these hydrocarbons is unsaturated?

A. Propane

B. Ethane

C. Ethene

D. Methane

✓ **Answer: C**

**29.** Which of the following substances is used as an antacid?

A.  $\text{NaOH}$

B.  $\text{NaCl}$

C.  $\text{Mg}(\text{OH})_2$

D.  $\text{Na}_2\text{CO}_3$

✓ **Answer: C**

**30.** The oxidation number of sulphur in  $\text{H}_2\text{SO}_4$  is—

- A. +2
- B. +4
- C. +6
- D. +8

✓ **Answer: C**

**31.** Which of the following statements is correct about acids?

- A. They turn methyl orange yellow.
- B. They react with metals to produce hydrogen gas.
- C. They react with bases to produce basic salts.
- D. They are slippery to touch.

✓ **Answer: B**

**32.** The molar volume of a gas at STP is—

- A.  $22.4 \text{ dm}^3$
- B.  $24.0 \text{ dm}^3$
- C.  $12.0 \text{ dm}^3$
- D.  $44.8 \text{ dm}^3$

✓ **Answer: A**

**33.** The main ore of aluminium is—

- A. Haematite
- B. Cassiterite
- C. Bauxite
- D. Galena

✓ **Answer: C**

**34.** In the periodic table, elements in the same group have—

- A. Equal atomic numbers
- B. Equal number of valence electrons
- C. Equal mass numbers
- D. Equal number of neutrons

✓ **Answer: B**

**35.** The gas collected at the anode during electrolysis of acidified water is—

- A. Hydrogen
- B. Oxygen
- C. Nitrogen
- D. Chlorine

✓ **Answer: B**

**36.** Which of the following is an example of a condensation polymer?

- A. Polyethene
- B. Polypropene
- C. Nylon

D. Polystyrene

✓ **Answer: C**

**37.** Which of these substances will not react with dilute HCl?

A. Magnesium

B. Zinc

C. Copper

D. Iron

✓ **Answer: C**

**38.** The bond formed between two chlorine atoms is—

A. Ionic

B. Metallic

C. Coordinate

D. Covalent

✓ **Answer: D**

**39.** A solution with pH 8 is—

A. Acidic

B. Neutral

C. Basic

D. Amphoteric

✓ **Answer: C**

**40.** Which of the following pairs represents isotopes?

A.  $^{12}\text{C}$  and  $^{13}\text{N}$

B.  $^1\text{H}$  and  $^2\text{H}$

C.  $^{14}\text{N}$  and  $^{14}\text{C}$

D.  $^{35}\text{Cl}$  and  $^{37}\text{Ar}$

✓ **Answer: B**

**41.** The main impurity removed during water softening by ion exchange is—

A.  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$

B.  $\text{Na}^+$  and  $\text{K}^+$

C.  $\text{Fe}^{2+}$  and  $\text{Zn}^{2+}$

D.  $\text{SO}_4^{2-}$  and  $\text{Cl}^-$

✓ **Answer: A**

**42.** A gas that turns lime water milky is—

A.  $\text{SO}_2$

B.  $\text{CO}_2$

C.  $\text{NO}_2$

D.  $\text{NH}_3$

✓ **Answer: B**

**43.** The rate of a chemical reaction generally increases with—

A. Decrease in temperature

- B. Decrease in surface area
- C. Increase in concentration
- D. Decrease in catalyst

✓ **Answer: C**

**44.** Which of the following represents a saturated hydrocarbon?

- A.  $C_2H_2$
- B.  $C_2H_4$
- C.  $C_2H_6$
- D.  $C_3H_4$

✓ **Answer: C**

**45.** Which of these is an example of a neutral oxide?

- A. NO
- B. CO
- C.  $N_2O$
- D. All of the above

✓ **Answer: D**

**46.** The law of conservation of mass was first stated by—

- A. Dalton
- B. Lavoisier
- C. Avogadro
- D. Boyle

✓ **Answer: B**

**47.** When an organic compound burns completely in oxygen, the products are—

- A. CO and  $H_2O$
- B.  $CO_2$  and  $H_2O$
- C. C and  $CO_2$
- D.  $CO_2$  and  $H_2$

✓ **Answer: B**

**48.** The most electronegative element is—

- A. Fluorine
- B. Oxygen
- C. Chlorine
- D. Nitrogen

✓ **Answer: A**

**49.** Which of the following is not a property of transition metals?

- A. Formation of colored compounds
- B. Variable oxidation states
- C. High melting points
- D. Low density

✓ **Answer: D**

**50.** In the reaction between hydrogen and chlorine to form HCl, the bond type formed is—

- A. Ionic
- B. Covalent
- C. Coordinate
- D. Metallic

✓ **Answer:** B