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Development of an achievement test on the eighth-grade "acids and bases" topic*

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Highlights:

- The Acids and Bases Achievement Test (ABAT) was developed as a valid and reliable assessment tool aligned with middle school eighth-grade instruction.
- Exploratory and confirmatory factor analyses supported a two-factor structure consisting of 24 items and explaining 40% of the total variance.
- The test demonstrated strong internal consistency (KR-20 = 0.87) and acceptable item difficulty and discrimination indices.
- The ABAT provides a practical instrument for educators and researchers to measure student achievement and identify learning gaps in the topic of acids and bases.

Abstract

This study aimed to develop an achievement test specifically for eighth-grade middle school students on the topic of 'Acids and Bases' (ABAT). The research process followed standard test development procedures, focusing on creating a practical achievement test. The sample included 282 eighth-grade students from various middle schools. Data were analyzed using SPSS 27.00, Factor 11.02.04 software, and Microsoft Excel. Both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were conducted using the Factor 11.02.04 program. The EFA revealed a two-factor structure with 24 items, a KMO value of 0.82, and explained 40% of the total variance. The CFA confirmed the two-factor model for the ABAT. Additionally, the independent-samples t-test supported the construct validity of the ABAT, demonstrating its ability to distinguish between lower and higher groups. The difficulty and discrimination indices of the ABAT were moderate, and the KR-20 reliability coefficient was 0.87. Overall, this study developed a reliable and valid assessment tool that educators and researchers can use to evaluate middle school students' achievement in 'Acids and Bases' or to identify learning gaps.

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1. Introduction

Science education encompasses a set of practices designed to foster students' research and inquiry skills, enable them to connect events and phenomena, and enhance their ability to communicate acquired knowledge effectively through various methods. Science courses cover a broad spectrum, incorporating societal, social, and economic dimensions. Uyanık (2019) emphasized the significance of science education in the information age, noting that scientific knowledge is encountered in nearly all aspects of life. Although science remains a subject of great curiosity among students, it is also considered one of the most challenging disciplines to learn due to time constraints and the extensive range of concepts to be covered. Additionally, the abstract and complex nature of science contributes to students' difficulties in understanding the subject (Ayvacı & Durmuş, 2016). Therefore, the goal of science education extends beyond the mere transmission of predefined knowledge; it should also take into account students' interests and preferences, equipping them with the skills necessary to comprehend scientific phenomena they encounter in daily life. To determine whether these educational goals are being achieved and tailor instruction accordingly, it is essential to assess students' learning outcomes effectively.

Accurately assessing students' achievement levels is critical to fulfilling this educational goal. Assessment and evaluation, as fundamental components of education, should be conducted using valid and reliable measurement tools. Such assessments help determine students' achievement levels, identify and address learning deficiencies, and evaluate the effectiveness of instructional activities (Adom, Mensah & Dake, 2020). One of the most widely used and practical methods in assessment and evaluation is the multiple-choice achievement test (Tsui & Treagust, 2009). In multiple-choice tests, the correct answer is embedded among distractors, requiring students to identify it. In science education, achievement tests serve as practical tools for detecting conceptual misconceptions (Demir et al., 2016). Beyond identifying misconceptions, these tests are also instrumental in evaluating the extent to which learning objectives have been attained. When used effectively, it can serve as a valuable tool in enhancing students' conceptual understanding (Chang et al., 2009; Şahin & Çepni, 2011). Achievement tests provide a comprehensive assessment of students' knowledge (Saraç, 2018). To accurately measure the extent to which objectives in science education are achieved, it is essential to develop valid and reliable achievement tests (Sontay & Karamustafaoğlu, 2017). Moreover, in the Turkish education system, not only high school entrance exams but also university entrance exams and various national assessments predominantly consist of multiple-choice questions (Uçar & Aktamış, 2019). This widespread use can be attributed to several advantages of multiple-choice tests, such as their practicality in large-scale assessments, ease of scoring, and ability to cover a broad range of content in a limited time. However, these tests also have limitations, including their restricted capacity to assess higher-order thinking skills and students' reasoning processes. Despite these shortcomings, the multiple-choice format remains the most preferred assessment method in Turkey due to its standardization, efficiency, and objective scoring.

A review of the literature reveals that achievement tests have been developed for various science topics and units. For instance, tests have been designed for subjects such as "Solutions" (Demir et al., 2016), "States of Matter and Heat" (Divarcı & Kaya, 2019), "Elements and Compounds" (Eren et al., 2020), "Simple Machines" (Özcan et al., 2021), "Matter and Heat" (Kaplan et al., 2022), "Chemical Bonds" (Boz et al., 2022), "Properties of Matter" (Aydın Gürler & Akgün, 2023; Dağ & Karamustafaoğlu, 2023), "Structure and Properties of Matter" (Köroğlu et al., 2023), and "Pure Substances and Mixtures" (Pazar & Karamustafaoğlu, 2023). These examples demonstrate an increasing focus on developing valid and reliable assessment tools tailored to specific science concepts. Such studies highlight both the diversity of content areas being addressed and the growing recognition of the need to evaluate students' conceptual understanding through well-constructed instruments.

Achievement tests allow students to assess their own learning processes and increase their motivation to achieve specific goals, ultimately enhancing overall learning performance. This study aims to develop a multiple-choice achievement test specifically for the eighth-grade "Acids and Bases" topic. Acids and bases are among the fundamental concepts in chemistry education and play a crucial role not

only in academic success but also in understanding numerous real-world phenomena (MEB, 2018). These concepts are essential in various branches of chemistry and industrial applications. A thorough understanding of acids and bases is, therefore, a key indicator of success in chemistry education (Edwards & Head, 2016; Elham et al., 2019; Holme et al., 2015).

The topic of acids and bases serves as an ideal foundation for teaching basic chemistry concepts for several reasons: Everyday Relevance: Acids and bases are commonly encountered in daily life. For instance, lemon juice is acidic, while soap is basic. Understanding their properties helps explain various chemical reactions in everyday contexts. Acids and bases play a significant role in industrial processes. For example, sulfuric acid is used in battery production, and hydrochloric acid is employed in metal cleaning. Their proper use is essential for efficiency and safety in industrial production. Learning about acids and bases is closely related to fundamental topics such as the pH scale, neutralization reactions, and real-world applications. For these reasons, the topics of acids and bases are not only fundamental in chemistry education but also play a central role in understanding everyday life, industry, environmental science, and biological systems. However, due to its abstract nature, students often struggle to grasp and apply acid-base concepts correctly (Cetin-Dindar & Geban, 2017; Chiu, 2007; Ross & Munby, 1991). Misconceptions about acids and bases persist even after instruction, highlighting the need for carefully designed teaching interventions (Nakhleh, 1992; Smith & Metz, 1996). Therefore, an effective teaching process is essential to facilitate students' conceptual understanding and encourage meaningful engagement in chemistry learning (Demirci, 2003; Demircioglu et al., 2005; Üce & Ceyhan, 2019).

Understanding the topic of "Acids and Bases" is crucial for students' success in chemistry courses. Well-structured achievement tests provide an effective means to evaluate students' comprehension of these fundamental concepts. A review of the literature indicates that multiple-choice tests are the most frequently used tools for diagnosing students' misconceptions about acids and bases (Yaşa & Koçak, 2022). This underscores the need for alternative assessment tools that can be employed during the teaching process. Achievement tests are essential for measuring students' learning levels, evaluating instructional effectiveness, and enhancing educational programs (Bloom, 1956). Developing an achievement test specifically for the "Acids and Bases" topic will provide teachers and students with valuable insights into the learning process, enabling a more accurate assessment of students' conceptual understanding and learning deficiencies. This study aimed to develop a valid and reliable achievement test to assess eighth-grade students' knowledge of "Acids and Bases." The research addressed the following sub-questions:

1) Are the results obtained from the "Acids and Bases" Achievement Test (ABAT) developed in the study valid?
2) What are the item difficulty and discrimination indices of the ABAT developed in the study?
3) Are the results obtained from the ABAT developed in the study reliable?

2. Method

Since the ABAT was developed in this study, the research process was conducted in accordance with standard test development procedures. In most studies in the literature, it is stated that the test development process generally consists of three basic stages: "preparation, application, and reporting" (Haslam & Treagust, 1987; Peterson et al., 1989). In this study, the focus first was on preparing test questions; a pilot application was then conducted, and a detailed test development process was followed, including validity and reliability analyses. The test development process is not limited to collecting data from a large sample; instead, it involves multiple stages. Specifically, when constructing an achievement test, it is essential to define its purpose and content, formulate and refine test items based on expert feedback, analyze item performance following a pilot study, and ultimately finalize the test.

2.1. Participants, Procedure, and Ethical Considerations

The participants of this study comprise all eighth-grade students enrolled in schools across Giresun province during the 2022-2023 academic year. The study sample consists of 282 eighth-grade students

from five middle schools, three of which are located in the central district of Giresun and two in the Dereli district, during the same academic year. The sample was selected using convenience sampling, which involves selecting individuals or units that are most readily accessible to the researcher. This method is widely utilized in research due to its advantages in terms of time, cost, and effort efficiency (Canbazoğlu Bilici, 2019).

In the sampling process, various criteria are considered, including selecting 10% of the accessible population, obtaining a sample size ten times the number of test items, or determining the sample size using G*Power analysis (Pallant, 2020). The literature presents different approaches to sample size determination in test development studies. While some studies have adopted the criterion of selecting a sample size ten times the number of test items (Bolat & Karamustafaoğlu, 2019), others have used 10% of the accessible population as a reference (Kaplan et al., 2022; Nacaroğlu et al., 2020; Tüncaz & Şahin Çakır, 2024). In the present study, the target sample size was determined based on the principle of selecting several eighth-grade students, equivalent to 10 times the number of ABAT items, resulting in a total sample of 282 students.

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2.2. Data Collection Instruments

The study's data were collected using the ABAT.

2.2.1. The ABAT Development Process

In this study, the ABAT test development process followed the stages outlined by Treagust (1988). These stages were systematically presented in Figure 1 below:

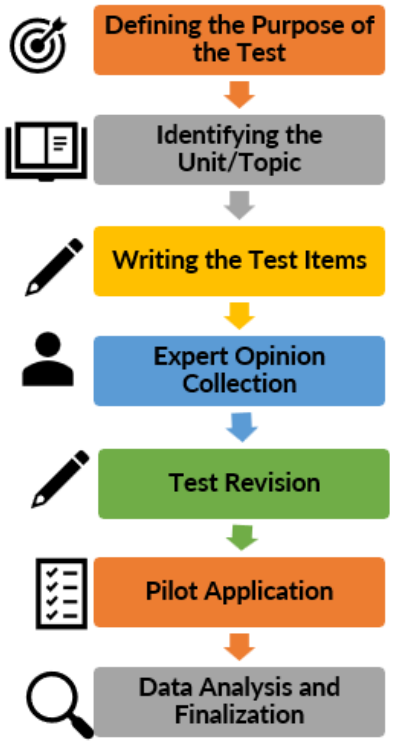


Figure 1. Development stages of the ABAT

Defining the Purpose of the Test: The primary objective of this research was to develop a valid and reliable achievement test to assess eighth-grade students' understanding of the "Acids and Bases" topic.

Identifying the Unit/Topic: The content of the items in the ABAT was determined by the learning objectives specified in the eighth-grade Science Course Curriculum (SCC) (Ministry of National Education (MoNE), 2018). The corresponding learning objectives are presented in Table 1.

Table 1. Objectives determined for the ABAT

Objectives for the ABAT
F.8.4.4.1. Explains the general properties of acids and bases.
F.8.4.4.2. Provides examples of acids and bases from daily life.
F.8.4.4.3. Uses readily available materials as acid-base indicators in daily life.
F.8.4.4.4. Makes inferences about the acidity and basicity of substances using pH values.
Students are encouraged to make inferences through experiments related to the topic.
F.8.4.4.5. Observes the effects of acids and bases on various materials.
F.8.4.4.6. Takes necessary precautions regarding potential hazards when using acids and bases as cleaning agents.
F.8.4.4.7. Proposes solutions to prevent acid rain.
The causes and consequences of acid rain are addressed.

Writing the Test Items: A literature review on the topic of acids and bases was conducted to identify common misconceptions found in previous studies (Baybutoğlu, 2011; Bradley & Mosimege, 1998; Çökelez, 2010; Elham et al., 2019; Eyceyurt Türk & Güngör Seyhan, 2022; Feng & Tuan, 2005; Karslı & Ayas, 2013; McClary & Bretz, 2012; Pabuçcu & Geban, 2015; Sheppard, 2006; Ültay & Çalık, 2016; Wandersee et al., 1994; Zoller, 1990). The literature review revealed that participants in studies on acids and bases held misconceptions related to the definition of acids and bases, their properties, acid and base strength, acid-base reactions, pH and pOH in acids and bases, indicators in acids and bases, and contemporary concepts related to acids and bases (Yaşa & Koçak, 2022). The identified misconceptions from the literature were incorporated into the distractors of the test items. For example, some common misconceptions are as follows: “acids are only harmful, corrosive, and dangerous substances” (Sheppard, 2006); “bases are used solely for cleaning purposes” (Demircioglu et al., 2004); “pH is a fixed and unique value for each substance” (Ross & Munby, 1991); and “litmus paper only changes color according to the rule 'red = acid, blue = base” (McClary & Talanquer, 2011).

For each objective in the "Acids and Bases" topic, three questions were developed. To ensure the content validity of the draft ABAT, a test blueprint (Table 2) was created. This blueprint was structured according to the cognitive domains of Bloom’s Taxonomy. To validate the content of the test, expert opinions were sought from three specialists: two in science education and one in chemistry education. One science education expert provided feedback in a face-to-face meeting, while the other science education expert and the chemistry education expert shared their opinions via email. Necessary revisions were made based on expert feedback.

For instance, one expert noted that the test contained too many negatively worded question stems. In response, negatively worded questions were identified, and five of them were revised to have positive wording. Additionally, some experts pointed out that certain objectives were underrepresented in the test. To address this issue, a minimum of three questions per objective was ensured, and missing items were added. Another expert indicated that there were too many questions assessing knowledge and comprehension levels. In light of this feedback, additional questions targeting higher-order cognitive skills, such as application, analysis, and synthesis, were included in the test according to Bloom’s Taxonomy.

The revised ABAT, modified in response to feedback from science and chemistry education experts, was then reviewed by a Turkish-language expert for linguistic and grammatical accuracy. Furthermore, a science teacher evaluated the test to ensure it was appropriate for eighth-grade students. The final version of the test blueprint for the developed ABAT is presented below.

Table 2. Objectives determined for the ABAT

Bloom's Taxonomy (Cognitive Domain)	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Questions
Objectives' no							
F.8.4.4.1.	X					-	1, 2, 11, 16, 17, 19
F.8.4.4.2.		X				-	5, 7, 8, 18, 20
F.8.4.4.3.			X			-	21, 22, 25
F.8.4.4.4.				X		-	9, 10,19
F.8.4.4.5.					X	-	3,4,12
F.8.4.4.6.					X	-	6, 13, 15
F.8.4.4.7.				X	X	-	14, 23, 24,26, 27

In Table 2, the objective F.8.4.4.1 is stated as "Expresses the general properties of acids and bases." In this objective, students are expected to achieve learning at the knowledge level. Therefore, the questions related to the F.8.4.4.1 objective were prepared at the knowledge level. The objective F.8.4.4.2 states, "Gives examples of acids and bases from daily life." In this objective, students are expected to achieve learning at the comprehension level. Therefore, the questions related to this objective were prepared at the comprehension level. The objective F.8.4.4.3 is stated as "Uses materials accessible in daily life as acid-base indicators." In this objective, students are expected to achieve learning at the application level. Accordingly, the questions related to this objective were prepared at the application level. The objective F.8.4.4.4 is stated as "Draws conclusions about the acidity and basicity of substances using their pH values," and "Students are encouraged to make inferences through experiments related to the topic." In this objective, students are expected to achieve learning at the analysis level. Therefore, the questions related to this objective were prepared at the analysis level. The objective F.8.4.4.5 is stated as "Observes the effects of acids and bases on various materials." In this objective, students are expected to achieve learning at the synthesis level. Therefore, the questions related to this objective were prepared at the synthesis level. The objective F.8.4.4.6 states, "Takes necessary precautions regarding potential hazards when using acids and bases as cleaning materials." In this objective, students are expected to achieve learning at the synthesis level. Therefore, the questions related to this objective were prepared at the synthesis level. The objective F.8.4.4.7 is stated as "Proposes solutions for the prevention of acid rain," and "The causes and consequences of acid rain are addressed." In this objective, students are expected to achieve learning at both the analysis and synthesis levels. Therefore, the questions related to this objective were prepared at the analysis and synthesis levels.

Expert Opinion Collection: To determine the content validity of the ABAT, the opinions of two experts in science education and one expert in chemistry education were obtained. Based on their feedback, some revisions were made to the ABAT.

Test Revision: The ABAT questions were revised in light of the expert opinions. Some of the revisions are as follows:

(1) Rewording of Negative Question Stems: Five questions with negative stems were revised to positive wording. For example:

- The question stem "Which of the following is not sufficient to distinguish an acid from a base?" was revised to "Which of the following is sufficient to distinguish an acid from a base?"
- The question stem "Which of the following is not the formula of the acid described above?" was changed to "Which of the following is the formula of the acid described above?" and the answers were also revised accordingly.

(2) Addition of Questions from Higher Cognitive Levels: Based on the feedback regarding the excess of factual-level questions, questions targeting higher cognitive levels in Bloom's Taxonomy—application, analysis, and synthesis—were added. Some of the new questions are as follows: Analysis-level question: The students have prepared a fishbone diagram outlining measures to prevent acid rain. Based on this, which of the measures listed in the fishbone diagram are correct?

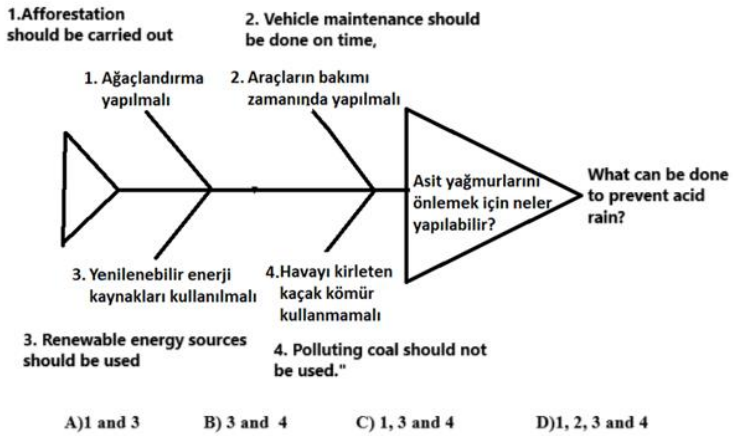


Figure 2. Analysis-level question

This process ensures that the test is more balanced and includes a range of cognitive levels as per Bloom's Taxonomy, enhancing its overall validity and effectiveness.

A question written for the synthesis level was presented in Figure 3.

The teacher is conducting an experiment on acids and bases in the classroom. The teacher asks Ahmet to pass the plastic bottle in front of him. Ahmet hands over the bottle to the teacher. Noticing that Ahmet is curious about the liquid inside the bottle, which of the following pieces of information would most effectively satisfy Ahmet's curiosity?

A) This bottle is plastic, so the liquid inside is definitely neutral.
B) This bottle is plastic, so the liquid inside could be acidic.
C) The type of bottle doesn't matter; the liquid inside is any type of liquid.
D) The bottle is plastic, so the pH of the liquid inside is greater than 7.

Figure 3. Synthesis level question

Based on the feedback obtained, the final version of the ABAT was prepared. Prior to the pilot implementation, the test was administered to a group of 10 eighth-grade students. During this process, feedback regarding the clarity of the questions, spelling errors, and content density was collected. The students reported that the ABAT questions were clear and understandable, and they did not encounter any difficulties understanding or reading them.

Pilot Application and Subsequent Procedures: Following the pilot application, item analyses and reliability estimates for the ABAT were calculated, and the final version of the ABAT was prepared. The data collected from the pilot applications were analyzed, and the KR-20 reliability coefficient was calculated. To ensure the construct validity of the ABAT, an independent-samples t-test was performed. This analysis helped determine whether the ABAT could distinguish between students in the upper and

lower groups. Additionally, to test the construct validity of the ABAT, both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were conducted.

2.4. Data Analysis

Because the draft ABAT developed in the research had an ordered structure and was coded with '1' for correct answers and '0' for incorrect answers, factor validity was tested using a tetrachoric correlation analysis in the Factor 11.02.04 program (Lorenzo-Seva & Ferrando, 2022). Both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were conducted in the Factor program. In the "Configure Analysis" section, "Polychoric correlations" was selected, the number of factors was set to 2, and the 'Raw Varimax' rotation method was chosen, considering the factors to be correlated. When the unit objectives were examined, the number of factors was limited to 2, as they generally focused on basic information and their association with daily life. Within the scope of EFA, the Kaiser-Meyer-Olkin (KMO) value and the significance value of Bartlett's test were calculated. The KMO value obtained from the EFA indicates that the sample size was sufficient and that the data follow a normal distribution. A KMO value of 0.60 or higher is required (Büyüköztürk, 2012).

Furthermore, to test the validity of the draft ABAT, both expert opinions (for content validity) and hypothesis testing techniques (for construct validity) were used. The independent-samples t-test was used to compare the scores of students in the bottom and top 27% groups. Thus, the significance of the difference between the average scores of the bottom and top groups was identified. One of the techniques used to assess the construct validity of tests is hypothesis testing (Büyüköztürk, 2012, p.168). The independent-samples t-test was carried out using SPSS 27.00. Since items in the draft ABAT do not have the same difficulty level, the KR-20 reliability coefficient was used to assess internal consistency (Can, 2017).

To determine the difficulty and discriminative power of the items in the draft ABAT, item analysis was conducted using the Excel program. For this purpose, the ABAT scores obtained by students were arranged in descending order, and the bottom and top groups were determined as the bottom 27% and the top 27% of the total student population, respectively. Then, item difficulty analysis for the ABAT was calculated using the formula: "(p = (Number of correct responses in the top group + Number of correct responses in the bottom group) / Total number of participants in the top and bottom groups)" and item discrimination analysis was calculated using the formula: "(d = (Number of correct responses in the top group - Number of correct responses in the bottom group) / Number of participants in the top or bottom group)" (Sontay & Karamustafaoğlu, 2020). Items with a discrimination value of 0.30 or higher were considered discriminatory; items with values between 0.20 and 0.29 were considered needing modification; and items with values below 0.19 were removed from the test. If the average difficulty value of the ABAT items is 0.50, it was interpreted as a test of medium difficulty (Sontay & Karamustafaoğlu, 2020).

3. Results

In this section, the findings obtained from the validity, reliability, and item analysis studies of the ABAT were presented.

3.1. Findings Regarding the Validity of the ABAT

For the content validity of ABAT, the opinions of two science education experts and one chemistry education expert were obtained. Based on expert opinions, the final version of ABAT was created, ensuring that it entirely covered all the learning objectives of the eighth-grade SCC "acids and bases" topic.

To test the construct validity of ABAT, both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were conducted, and the mean scores of the upper and lower groups were compared using an independent samples t-test. The results of the EFA, CFA, and independent-samples t-test are presented below.

Factor analysis conducted to determine the factor structure of the draft ABAT revealed a two-factor structure. The KMO value for EFA was calculated as 0.83, and Bartlett's test was found to be significant (3121.9 (df = 351; p = 0.000010); p < 0.05).

It was observed that the factor loadings of items 1 and 3 were below 0.30. In the first analysis, the CFA findings indicated that the NNFI (0.98), GFI (0.93), AGFI (0.91), and RMSEA (0.04) were excellent. For NNFI, values above 0.95; for GFI and AGFI, values above 0.90; and for RMSEA, values between 0.00 and 0.05 were interpreted as an excellent fit (Kaplan et al., 2022). Additionally, when examining the factor loadings for each test item, it was determined that items 1 and 3 had loadings below 0.30. Therefore, items 1 and 3 were removed from the ABAT, and the factor analysis was repeated. As a result of the repeated factor analysis, the KMO value was 0.82, and Bartlett's test was significant (p < 0.05).

The repeated factor analysis was conducted with a two-factor structure. For the repeated factor analysis, the KMO value was 0.82, and Bartlett's test was significant (p<0.05). The results of the repeated EFA and CFA after the removal of item 2 from the two-factor structure of the draft ABAT, as well as the results of the third factor analysis, are presented below.

Table 3. EFA findings for the two-factor structure of the ABAT after the removal of items 1, 2 and 3

Variable	Eigenvalue	Variance Ratio	Total Variance Ratio
1	7,30412	0,30434	0,30434
2	2,26904	0,09454	0,39888
3	1,79275	0,07470	
4	1,26976	0,05291	
5	1,20042	0,05002	
6	1,12825	0,04701	
7	1,06619	0,04442	
8	1,00562	0,04190	
9	0,94829	0,03951	
10	0,81991	0,03416	
11	0,73556	0,03065	
12	0,71678	0,02987	
13	0,68141	0,02839	
14	0,53662	0,02236	
15	0,50711	0,02113	
16	0,39736	0,01656	
17	0,38408	0,01600	
18	0,34736	0,01447	
19	0,26856	0,01119	
20	0,25335	0,01056	
21	0,20086	0,00837	
22	0,09936	0,00414	
23	0,06724	0,00280	
24	0,00001	0,00000	

When examining Table 3, it was observed that, after removing item 2, the repeated factor analysis showed that Factor 1 explained 30% of the variance, while Factor 2 explained 9%.

Table 4. Factor loadings for the two-factor structure of the ABAT after the removal of item 2

Item	Factor 1 Loading Value	Factor 2 Loading Value
4		0,38
5		0,50
6		0,48
7		0,46
8		0,71
9		0,67
10		0,48
11		0,46
12		0,43
13		0,81
14		0,62
15		0,72
16		0,32
17		0,33
18		0,52
19		0,39
20	0,40	
21	0,54	

22	0,59
23	0,57
24	0,72
25	0,67
26	0,59
27	0,52

When examining Table 4, it was observed that all items in the ABAT have factor loadings above 0.30, ranging between 0.38 and 0.81. Therefore, after the sequential removal of items 1, 3, and 2, the final draft of the ABAT consists of 24 questions.

An analysis of the ABAT items indicates that the items in Factor 1 pertain to the relationship between acids and bases in daily life, while the items in Factor 2 relate to the properties of acids and bases. Accordingly, Factor 2 was named "Properties of Acids and Bases", and Factor 1 was named " Acids and Bases in Daily Life."

Table 5. CFA Fit Indices for the Two-Factor Structure of the Draft ABAT after the Removal of Item 2

Fit Index	Value for the Scale	Comment on the Fit of the Scale	Fit Indices in the Literature
NNFI	0,98	Perfect	Acceptable Fit (NNFI≥0.80) (Hooper Coughlan & Mullen, 2008)
GFI	0,94	Perfect	GoodFit (GFI≥0.85) (Weizmann-Henelius et al., 2010)
AGFI	0,93	Perfect	GoodFit (AGFI≥0.80) (Weizmann-Henelius et al., 2010)
RMSEA	0,04	Perfect	Perfect Fit (RMSEA≤0.06, 0.08, 0.10) (Hu & Bentler, 1999; Kline, 2013)

When examining the CFA findings in Table 5, it was observed that the NNFI (0.98), GFI (0.94), AGFI (0.93), and RMSEA (0.04) values indicated a perfect fit. The conducted factor analyses also indicated that the ABAT has construct validity. The results of the independent-samples t-test, one of the hypothesis-testing techniques used to assess the construct validity of the draft ABAT, are presented in Table 6.

Table 6. Findings from the independent samples t-test based on the ABAT mean scores of the lower and upper groups

Test	Group	N	$\bar{X}$	SS	Standard Error	t	df	p	Cohen's d
ABAT	Upper	76	18.68	1.34	.15	34.36	150	.000	5.574
	Lower	76	8.03	2.35	.27				

When examining Table 6, a significant difference in mean ABAT scores was observed between the upper and lower groups, favoring the upper group. The Cohen's d value also indicates that the difference between the ABAT scores of the upper and lower groups falls within the large effect size category. The item analysis results of the ABAT were presented in Table 7.

Table 7. Results of item analysis for the ABAT

Item	Group	True Answer	False Answer	Item Difficulty Index (p)	Item Discrimination Index (d)
I1	Upper	69	7	0,86	0,09
	Lower	62	14		
I2	Upper	69	7	0,82	0,18
	Lower	55	21		
I3	Upper	68	8	0,82	0,14
	Lower	57	19		
I4	Upper	73	3	0,68	0,55
	Lower	31	45		
I5	Upper	68	8	0,69	0,41
	Lower	37	39		
I6	Upper	62	14	0,55	0,53
	Lower	22	54		
I7	Upper	70	6	0,72	0,41
	Lower	39	37		
I8	Upper	76	0	0,73	0,54
	Lower	35	41		
I9	Upper	75	1	0,81	0,36
	Lower	48	28		
I10	Upper	72	4	0,55	0,80

	Lower	11	65		
I11	Upper	68	8	0,68	0,43
	Lower	35	41		
I12	Upper	59	17	0,53	0,50
	Lower	21	55		
I13	Upper	75	1	0,70	0,57
	Lower	32	44		
I14	Upper	75	1	0,74	0,49
	Lower	38	38		
I15	Upper	68	8	0,56	0,67
	Lower	17	59		
I16	Upper	64	12	0,47	0,74
	Lower	8	68		
I17	Upper	71	5	0,63	0,61
	Lower	25	51		
I18	Upper	69	7	0,59	0,63
	Lower	21	55		
I19	Upper	74	2	0,70	0,55
	Lower	32	44		
I20	Upper	69	7	0,57	0,67
	Lower	18	58		
I21	Upper	62	14	0,50	0,63
	Lower	14	62		
I22	Upper	64	12	0,55	0,58
	Lower	20	56		
I23	Upper	72	4	0,63	0,63
	Lower	24	52		
I24	Upper	74	2	0,72	0,50
	Lower	36	40		
I25	Upper	61	15	0,49	0,62
	Lower	14	62		
I26	Upper	41	35	0,36	0,36
	Lower	14	62		
I27	Upper	61	15	0,52	0,57
	Lower	18	58		
Mean				0,61	0,56

When Table 7 was examined, it was observed that the discrimination values for Items 1, 2, and 3 were below 0.19. These items should be removed from the test. After removing these items from the ABT, the mean difficulty index (p) value of the remaining 24 items was 0.61, indicating that the ABAT is a test of medium difficulty. The item discrimination index (d) is 0.56, suggesting that it is a discriminative test.

3.2. Findings Regarding the Reliability of the ABAT

The findings obtained from the internal consistency analysis of the ABAT were presented in Table 8. In the internal consistency analysis to assess the reliability of the ABAT, the KR-20 value was 0.87.

Table 8. Internal Consistency Analysis Data of the ABAT

Internal Consistency Reliability Analysis	N	Number of Items	Calculated Values
KR-20	282	24	0.87

4. Discussion

In this section, the validity and reliability findings of the ABAT developed in the research were discussed in light of the literature. Based on these discussions, some conclusions have been drawn and suggestions made.

For a test to adequately measure the targeted quality, it must have content validity (Büyüköztürk, 2012). To ensure content validity, expert opinions are consulted (Büyüköztürk, 2012). In the literature, to determine the content validity of achievement tests, a blueprint table has been prepared, and expert opinions have been sought (Ayvacı & Durmuş, 2016; Bolat & Karamustafaoğlu, 2019; Özkan & Yadigaroğlu, 2020; Dağ & Karamustafaoğlu, 2023; Demir et al., 2016; Pazar & Karamustafaoğlu, 2023). To ensure the content validity of the ABAT, a blueprint table was prepared, and the opinions of two science education experts and one chemistry education expert were sought. These experts stated that

the ABAT contains questions that cover all the unit's learning objectives and that content validity has been ensured. Based on these opinions, it can be concluded that the ABAT has achieved content validity.

Another validity technique is construct validity (Büyüköztürk, 2012). The independent samples t-test results used to evaluate the construct validity of the ABAT show that the mean scores of the upper group are significantly higher than those of the lower group. This indicates that the ABAT can distinguish between those who know and those who do not know. Similarly, in the literature, hypothesis testing methods have been used to ensure the validity of developed tests (Demir et al., 2016; Kaplan et al., 2022; Orduhan & Şahin Çakır, 2023; Sontay & Karamustafaoğlu, 2020; Tüncaz & Şahin Çakır, 2024). Moreover, for multiple-choice tests scored as 1 and 0, tetrachoric correlation analysis (factor analysis) should be performed to verify construct validity (Kaplan et al., 2022; Köroğlu et al., 2023; Lorenzo-Seva & Ferrando, 2022; Özkılıç et al., 2023). Tetrachoric correlation analysis reveals the factor structure of the test and confirms the identified factors. In this context, it is believed that the tetrachoric correlation analysis conducted for the construct validity of the ABAT developed in this study will contribute to the literature. The analysis showed that the ABAT has a two-factor structure, named “Characteristics of Acids and Bases” and “Relationship of Acids and Bases with Daily Life.” Compared to other tests developed on acids and bases, the ABAT shares some similarities and differences. Both aim to assess students' knowledge, comprehension, application, and higher-order thinking skills regarding acids and bases. Additionally, item writing procedures and expert reviews are common features. However, there are notable differences. First, this test was developed following a more detailed process based on Treagust’s (1988) stages, including pilot testing and item analysis. Second, the ABAT emphasizes daily life connections and problem-solving skills more than many existing tests, which mainly focus on factual knowledge. Furthermore, items were carefully revised based on expert feedback and statistical analysis to enhance validity and reliability.

Thus, while the ABAT shares a similar purpose with other tests, it offers a more comprehensive and practical approach to assessing students' understanding of acids and bases. Similarly, Özkan and Yadigaroğlu (2020) used tetrachoric correlation analysis to determine the construct validity of the ABAT they developed. The achievement test on acids and bases developed by Özkan and Yadigaroğlu (2020) has a one-factor structure. Both studies employed a similar methodological approach to validate their tests, particularly through tetrachoric correlation analysis and expert review. However, there are also important distinctions between the two tests. While Özkan and Yadigaroğlu’s (2020) test exhibited a one-factor structure focused mainly on conceptual understanding, the ABAT developed in the present study revealed a two-factor structure, encompassing both the conceptual characteristics of acids and bases and their applications in daily life. Furthermore, the present study emphasizes a more balanced distribution of questions across cognitive levels in Bloom’s taxonomy, particularly by including items that assess higher-order thinking skills such as analysis and application. In this sense, the ABAT developed in this study provides an alternative and more comprehensive measurement tool that not only evaluates students’ conceptual understanding but also their ability to relate scientific concepts to real-world contexts. The ABAT developed in this study, which consists of a two-factor structure, provides an alternative to the literature. The results of hypothesis testing and tetrachoric correlation analysis indicate that the ABAT is a valid test.

Through item analysis, detailed information about each test item can be obtained (Hasançebi et al., 2020). The item difficulty index indicates how easy or difficult the test questions are for respondents. As the item difficulty index approaches 0.00, the question becomes more difficult, and as it approaches 1.00, the question becomes easier. Ideally, questions of medium difficulty are preferred (Adom et al., 2020; Kaplan et al., 2022). Büyüköztürk (2012) states that the difficulty index in measurement tools should be between 0.30 and 0.70 (Kaplan et al., 2022). The item discrimination index indicates that a question is answered more correctly by those in the upper group of the test, while it is answered less correctly by those in the lower group, thus distinguishing between those who know and those who do not know. This index ranges from -1 to +1; as it approaches 0.00, the item’s discrimination is low, and as it approaches -1 or +1, the discrimination is high. In the draft ABAT, the discrimination indices of items

1, 2, and 3 were below 0.19, so these items were removed from the test. Additionally, the results of the tetrachoric correlation analysis support removing items 1, 2, and 3 from the ABAT due to their factor loadings being below 0.30. After the removal of these items, the average difficulty index (p) value of the remaining 24 items in the ABAT was 0.61, indicating that the ABAT is a moderately difficult test, and the item discrimination index (d) value is 0.56, indicating that it is a discriminative test.

The reliability of a measurement tool can be defined as the consistency of participants' responses to test items (Büyüköztürk, 2012) or as the stability of the scores obtained from the measurement tool. From this perspective, if a test's results are both consistent and valid, it can be concluded that the test is meaningful (Göncü, 2013). To determine the reliability of multiple-choice tests, the Kuder-Richardson 20 and 21 (KR-20 and KR-21) coefficients are used. When the difficulty levels of test items differ, the KR-20 reliability coefficient is calculated (Büyüköztürk, 2012). Since the item difficulty values in the ABAT developed in this study differ, the KR-20 reliability coefficient was calculated and found to be 0.87. For multiple-choice tests, the KR-20 reliability coefficient should be at least 0.80 (Aydın & Faydaoğlu, 2022). Given the ABAT's KR-20 reliability coefficient, the test is reliable.

In summary, the ABAT developed in this study is a valid and reliable test. Therefore, the ABAT can serve as a data collection tool in scientific research. Teachers can implement it in their classrooms to assess students' prior knowledge and learning progress. Similarly, achievement tests can be created for other grade levels and units. Additionally, it is recommended to conduct tetrachoric correlation analysis to verify construct validity in the development of achievement tests.

5. Conclusion

As a result, an achievement test with valid and reliable results has been developed. Different analysis methods have been used to present the validity and reliability evidence of the achievement test.

5.1. Implications For Theory and Practice

This study contributes to the body of knowledge by providing an alternative to existing achievement tests in the context of acids and bases. The two-factor structure of the ABAT offers a more nuanced understanding of students' conceptual understanding, dividing it into "Characteristics of Acids and Bases" and "Relationship of Acids and Bases with Daily Life." This could pave the way for the development of more specialized tests that more accurately assess students' knowledge. Moreover, the use of tetrachoric correlation analysis to assess construct validity adds value to the field, highlighting the importance of sophisticated statistical methods in test validation. These findings challenge previous models that relied on one-dimensional tests, offering a theoretical basis for more complex, multifaceted assessment designs.

The ABAT developed in this study has practical implications for educators. It can be used as a diagnostic tool to assess eighth-grade students' prior knowledge and learning status in science classrooms, specifically in the unit on acids and bases. Teachers can utilize the test to identify areas where students struggle, enabling them to tailor their instructional approaches to address specific misconceptions. Additionally, the process of developing the ABAT through expert validation and statistical analysis provides a framework for educators looking to create or modify achievement tests in other scientific disciplines. The use of tetracoric correlation analysis also demonstrates a methodological approach that can be replicated for other educational assessment designs. Furthermore, the test's reliability (KR-20 coefficient of 0.87) provides educators with confidence in its consistency, making it a trustworthy tool for future assessments.

5.2. Limitations and Directions for Future Research

One limitation of the study is that the ABAT was developed explicitly for eighth-grade students in the context of acids and bases. Therefore, its applicability to other grade levels or science units is yet to be determined. The test's validity and reliability may differ when applied to other student groups or topics, and the generalizability of the findings could be limited to the specific context of this research. Additionally, although the test showed good reliability (KR-20 = 0.87), further research could examine its

stability over time, particularly through test-retest reliability measures. Another limitation is the potential bias in the expert opinions used for content validation, as the experts' backgrounds in science and chemistry education may influence their perspectives on the test's content.

Future studies could explore the use of the ABAT across different educational settings and with diverse student populations, including those from various socio-cultural backgrounds and with different academic abilities. Comparative studies could examine whether the two-factor structure of the ABAT holds across diverse groups. Another direction for future research could be the further refinement of the test items to ensure they are equally challenging for all students, as some items may still be too easy or too tricky for specific learners. Additionally, future research could examine how test results correlate with other measures of student achievement, such as classroom assessments or national standardized tests. Finally, researchers could develop similar achievement tests for other scientific topics and use the methods from this study, including expert validation and tetrachoric correlation analysis, to build a larger body of reliable and valid tools for science education assessment.

The ABAT developed within the scope of this research was prepared in accordance with the objectives of the "Acids and Bases" topic in the 2018 Science Curriculum. With the 2024 curriculum update, the learning outcomes have been revised. When comparing the objectives of both curricula, it is observed that the 2018 curriculum focuses more on knowledge-based and directly observable outcomes. In contrast, the 2024 curriculum emphasizes higher-order cognitive skills, such as scientific inquiry, reasoning, prediction, and evidence-based inference. The number of objectives decreased in 2024; while there were 7 outcomes in 2018, this number was reduced to 4 in 2024. However, the sub-skills of each outcome have been elaborated in more detail. This change requires the test items to measure not only factual knowledge but also process and thinking skills. Furthermore, some outcomes have been removed from the curriculum. For instance, the objective related to "acid rain" and the outcome regarding safety precautions in the use of cleaning products have been excluded from the 2024 Science Curriculum. To ensure the ABAT can be used in the future, it is recommended to revise the test by including items aligned with the 2024 Science Curriculum and removing those related to outcomes no longer included. Additionally, a review of the ABAT's cognitive level is advised. The 2024 Science Curriculum particularly focuses on higher cognitive levels, such as inductive reasoning, prediction based on observation, and scientific reasoning. Therefore, knowledge-based multiple-choice items in the ABAT should be revised to align with these cognitive demands.

Statement of Researchers

Researchers' contribution rate statement:
ÖB and ÇŞÇ planned the study and conducted the literature review. ÖB contributed to data collection and data transfer. ÇŞÇ performed the statistical analysis. ÖB and ÇŞÇ contributed to the writing of the article and read and approved the final version of the study.
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The authors declare that they have no conflict of interest.
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APPENDIX 1. The ABAT

1. Aşağıda verilen özelliklerden hangisi sadece asitlere ait bir özelliktir?
A) Elektrik akımını iletir
B) Ayraçlara etki ede.
C) Sulu çözeltileri H+ iyonu verir
D) Tatları acıdır

2. Aşağıdakilerden hangisi bazlara ait bir özelliktir?
A) Ciltte yakıcı bir his uyandırır
B) Mavi turnusol kâğıdını kırmızıya dönüştürür
C) Sulu çözeltileri OH− iyonu verir
D) Bazı metallerle birleşince H2 gazı açığa çıkarır.

3. Asit ve Bazların zararlı etkilerinden korunmak için aşağıdakilerden hangisi yapılmamalıdır?
A) Kimyasal madde içeren deterjanları kullanırken eldiven takmak
B) Kimyasal maddelerle temizlik yapılan ortamlarda uzun süre kalmamak
C) Asitli içecekler içtikten sonra kuvvetli baz içerek asidin etkisini azaltmak
D) Kimyasal maddelerle deney yaparken koruyucu maske ve eldiven kullanmak.

4. Aşağıdakilerden hangisi bir asit ile bir bazı birbirinden ayırt etmemizi sağlamaya yeterlidir?
A) pH değerinin bilinmesi.
B) Yakıcı ve tahriş edici olması.
C) Turnusol kağıdına etki etmesi.
D) Sulu çözeltisinin elektriği iletmesi

5. Aşağıdakilerden kaç tanesinin sulu çözeltisi baz özellik gösterir?
- Limon -Şampuan
- Mide ilacı - Kan
- Aspirin - Mayonez

A) 2 B) 3 C) 4 D) 5

6. Öğretmen sınıfta öğrencilerine asit baz konusunda deney yapıyor. Ahmet'e önünde bulunan şişelerden plastik olanı uzatmasını istiyor. Ahmet, öğretmenine şişeyi uzatıyor. Ahmet'in şişenin içindeki sıvıyı merak ettiğini fark eden öğretmen hangi bilgiyi verirse Ahmet'in merakını en doğru şekilde gidermiş olur?

A) Bu şişe plastik olduğu için içindeki kesin olarak nötr bir sıvıdır.
B) Bu şişe plastik olduğu için içindeki asit olabilir.
C) Şişenin cinsinin önemi yoktur, içindeki sıvı herhangi bir sıvıdır
D) Şişe plastik olduğu için içindeki sıvının pH'ı 7'den büyüktür

7.



1. Yoğurt 2. Elma 3. Limon

Yukarıda verilen maddelerde bulunan asitler aşağıdakilerden hangisinde doğru olarak verilmiştir?

	Yoğurt	Elma	Limon
A	Laktik asit	Malik asit	Sitrik asit
B	Malik asit	Sitrik asit	Laktik asit
C	Laktik asit	Sitrik asit	Malik asit
D	Sitrik asit	Laktik asit	Malik asit

8. Öğretmen asit-baz konusunu işledikten sonra öğrencilerden günlük yaşamda kullanılan asit ve bazlara birer örnek vermelerini istemiştir.

Hangi öğrencinin verdiği örnek doğrudur?

A) Ayşe: Sofra tuzu, saf su
B) Mustafa : Çamaşır suyu, şampuan
C) Mirkelam: Sirke, saf su
D) Hasan: Tuz ruhu, çamaşır suyu

9. Esra pH metre kullanarak bir çözeltinin pH'ını ölçüyor. pH metredeki değer 2'yi gösteriyor. Buna göre bu madde ne özelliği taşır?

A) Asit B) Baz C) Tuz D) Su

10.
Hidroklorik asittir adım.
Tuz ruhu olarak adlandırılırım.
Banyo ve tuvaletlerde her an yanınızdayım.
Eldivensiz dokunmayın yakarım ve pH'ım 7'den küçüktür."

Yukarıda kendini tanıtan asidin formülü aşağıdakilerden hangisidir?

A) HOH B) HNO_3 C) HCl D) KOH

11. Aşağıda bazı çözeltiler verilmiştir.



1. Elma 2. Sabun 3. Tuzlu su 4. Limon

Yukarıdaki maddelere mavi turnusol kâğıdını dokundurduğumuzda hangilerinde renk değişimi olmaz?

A)1 ve 2 B) 2 ve 3 C) 3 ve 4 D) 1 ve 4

12. Aşağıdakilerden hangisi asit ve bazların olumsuz özelliklerinden kurtulmak için yapılması gerekenlerden biridir?

A) Yemekten sonra dişlerimizi fırçalamalıyız
B) Dilimlenmiş limonu mermer üzerine koymalıyız
C) Asitleri cam şişede saklamalıyız
D) Asitli içeceklerden sadece kolayı tercih etmeliyiz

13.

1.Temizlik malzemelerini birbirine karıştırma
2.Eldiven kullanma
3.Temizlik malzemelerini gıdalardan uzak tutma

Yukarıdakilerden hangisi temizlik esnasında sağlığımızı korumak içim yapılması gerekenlerdir?

A) Yalnız 1
B) 1 ve 2
C) 2 ve 3
D) 1, 2 ve 3

14. Asit yağmurları yağdıkları bölgelere çeşitli zararlar verir. Aşağıdakilerden hangisi asit yağmurlarının etkilerinden değildir?

A) Arabaların ve metal yüzeylerin aşınmasına neden olur.
B) Su ve toprak kirliliğine neden olurlar.
C) Bitki örtüsünün gelişimine olumlu yönde etki yaparlar.
D) Antik ve tarihi yapıları aşındırırlar.

15. X, Y ve Z maddelerinin pH ölçeğindeki yerleri sırasıyla 3,7 ve 13'tür. Buna göre aşağıdakilerden hangisi yanlıştır?

A) X turnusol kağıdının rengini kırmızıya çevirir.
B) Z' nin tadı ekşidir.
C) Y, X ve Z'nin tepkimesi sonucu oluşabilir.
D) X'e fenolftalein damlatıldığında renk değişimi olmaz.

16. Bazların sulu çözeltileri;

I) NaOH
II) H_2SO_4
III) NH_3

maddelerin sulu çözeltilerinden hangileri ile tepkime verir?

A) Yalnız II B) I ve III C) II ve III D) I, II ve III

17. Aşağıdakilerden hangisi bir asit ile bazları birbirinden ayırt etmemizi sağlamak için yeterlidir?

A) pH değerinin bilinmesi.
B) Yakıcı ve tahriş edici olması.
C) Turnusol kağıdına etki etmesi.
D) Sulu çözeltisinin elektriği iletmesi.

18. Aşağıdaki besinlerin içerdiği asit ile ilgili eşleştirmelerden hangisi doğrudur?

A) Süt- Sitrik Asit B) Çilek- Folik Asit C) Elma- Formik Asit D) Limon -Laktik Asit

19. HCI bileşiğinin sudaki iyonlaşma denklemi aşağıdaki gibidir:

$HCl_{(suda)} \rightarrow H^{+}_{(suda)} + Cl^{-}_{(suda)}$

Bu bileşik için verilen ifadelerden hangisi doğrudur?
A) pH 7 den büyüktür
B) Camları matlaştırır
C) Ele kayganlık hissi verir
D) Mavi turnusol kağıdını kırmızıya çevirir.

20. Aşağıda bazı çözeltiler verilmiştir.
1. Amonyak
2. Sirke
3. Tuzlu su
4. Sabun
Bu çözeltilere kırmızı turnusol kâğıdı batırıldığında hangilerinde renk değişimi olmaz?
A) 1 ve 2 B) 2 ve 3 C) 3 ve 4 D) 1 ve 4

21. Defne evde bir şişede bir madde bulur. Bu maddenin asit mi baz mı olduğunu ayırt etmek için evde bulabileceği bir malzemeden ayraç yapmak ister. Defne'nin ayraç yapması için aşağıdaki malzemelerden hangisi ya da hangilerini kullanabilir?

I) Mor lahana suyu
II) Lavanta
III) Ortanca çiçeği

A) Yalnız I
B) I ve II
C) II ve III
D) I, II ve III

22. Aşağıdaki verilen üçlülerden hangisi günlük hayatta kullanabileceğimiz asit-baz ayıraçlarına örnek olarak verilebilir?
A) Ortanca- Bitkisi-Mor Lahana- Şalgam Suyu
B) Ortanca Bitkisi-Elma Suyu- Mor Lahana
C) Şalgam Suyu- Turşu Suyu- Sirke Suyu
D) Limon- Maden Suyu- Kola

23. Aşağıdakilerden hangisi asit yağmurlarının nedenlerinden biri olabilir?
A) Tarihi eserlerin zarar görmesi.
B) Ormanların tahrip olması.
C) Karbon salımının artması.
D) Evlerin çatılarının delinmesi.

24. Aşağıdakilerden hangisi asit yağmurlarının sonuçlarından biri olabilir?
A) Karbon salımının artması.
B) Fabrikaların arttırılması.
C) Fosil yakıt kullanımının arttırılması.
D) Tarihi eserlerin zarar görmesi.

25. Eda öğretmen fen bilimleri dersinde öğrencilerini laboratuvara götürmeye karar verir. Eda öğretmen, öğrencilerine ''arkadaşlar yarın laboratuvara gideceğiz fakat elimizde yeterince asit baz ayıracı yok'' demiştir. Öğrencilerin öğretmenine verdiği cevaplardan hangisi ertesi gün laboratuvara giden öğrencilerin deney yapabilmesine yardımcı olmuştur?

A) Ayıraç olarak limon kullanabiliriz.
B) Her öğrenci evinde bulunan malzemelerden doğal ayıraç getirebilir.
C) Her öğrenci evde konuyu okuyarak gelir.
D) Dersi laboratuvarda işler fakat deney yapmayız.

26. Aşağıda verilenlerden hangisi ya da hangileri asit yağmurlarını önlemek için alınabilecek önlemlerdendir?

I. Fabrika bacalarına filtre takmak.
II. Fosil yakıt tüketimini azaltmak.
III. Toplu taşıma araçlarını kullanmak.
IV. Termik santrallerle enerji üretmek.

A) Yalnız II
B) II ve III
C) I, II ve III
D) I, II, III ve IV

27. Öğrenciler asit yağmurlarını önlemek için alınabilecek önlemlerle ilgili aşağıdaki gibi bir balık kılçığı hazırlamışlardır. Buna göre balık kılçığında yazılan önlemlerden hangisi ya da hangileri doğrudur?

A)1 ve 3 B) 3 ve 4 C) 1, 3 ve 4 D)1, 2, 3 ve 4

