Investigating misconceptions about acids and bases among pre-service science teachers

Nur Farha Shaafi[1], Mohammad Mubarrak Mohd Yusof[2], Ellianawati Ellianawati[3], Bambang Subali[3], Muhammad Haziq Hazim Raji'e[2]
[1]Department of Science, Faculty of Psychology and Education, Universiti Malaysia Sabah, Sabah, Malaysia
[2]Department of Science, Faculty of Education, Universiti Teknologi MARA, Selangor, Malaysia
[3]Department of Physics, Faculty of Mathematics and Natural Science, Universitas Negeri Semarang, Semarang, Indonesia

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ABSTRACT

This study examines prevalent misconceptions among students regarding the fundamental concepts of acids and bases, which often arise during the learning process. This study aims to pinpoint misconceptions held by pre-service science teachers in the realm of acids and bases; 117 university students from diverse educational backgrounds, enrolled in three distinct courses: Biology, Chemistry, and Physics from the Faculty of Education, participated in the study. Using a structured questionnaire, the research identified 11 misconceptions out of 26 items related to acid and base concepts among pre-service teachers, while 15 items showed a correct understanding. Notably, three misconceptions exhibit the highest prevalence, namely the universal indicator of strong alkali (71.7%), the calculation-related concentration of acids and bases (69.3%), and the procedural steps for preparing a solution with a specified concentration using the dilution method (65.8%). The analysis indicates that although pre-service teachers generally understand acid and base concepts well, some misconceptions persist. Additionally, correlations between gender, university major, and understanding of these concepts were found. Further global research is recommended to identify misconceptions among university students. Comprehensive research in Malaysia could help educators and students address these misconceptions in Chemistry education.

Corresponding Author:

Mohammad Mubarrak Mohd Yusof
Department of Science, Faculty of Education, Universiti Teknologi MARA
Puncak Alam, Selangor, Malaysia
Email: mubarrak@uitm.edu.my

1. INTRODUCTION

Comprehensive and coherent instruction in acid-base concepts is essential in Chemistry, as these concepts play a pivotal role in a broad spectrum of reactions [1]. Proficient understanding of acid-base principles empowers students to anticipate and elucidate the outcomes of seemingly disparate reactions. They can establish connections and unify diverse phenomena, including proton-transfer, transition metal coordination complexes, and nucleophilic/electrophilic organic reactions [2]. However, students encounter challenges when learning acid-base concepts, such as misconceptions, reliance on superficial characteristics for identifying acids and bases, and difficulties in fluidly navigating between acid-base models. Misconception, defined as the supposition and erroneous descriptions formed by individuals based on their experiences, can impede true understanding of concepts [3]. In the realm of science education, misconceptions persist due to students' creative nature and their predisposition to biased ideas stemming from personal experiences, teacher influences, or parental guidance [4]. This constructivist attitude impedes the assimilation of new knowledge and fosters the defense of unrealistic notions as truth, ultimately leading to misconceptions about scientific concepts. Recognizing and documenting these misconceptions, particularly among pre-service teachers, becomes imperative. These misconceptions arise from a lack of well-articulated prior knowledge during the processing of new information, leading to confusion and flawed reasoning [5]. Causes of misconceptions include inadequate information, incorrect instructional strategies, and memorization of concepts [6]. The mental structures underlying students' ideas about related concepts contribute to the formation of misconceptions [7]. Background, experiences, and the learning environment further shape students' unique knowledge, sometimes deviating from accepted scientific norms and hindering the assimilation of new concepts. The brain tends to assimilate new information by connecting it to existing knowledge. If the new information doesn't align with established thought patterns, it is reshaped to fit, inadvertently reinforcing misconceptions in learners' explanations [8]. Studies indicate that learners across all educational levels harbor misconceptions [9]–[11]. Chemistry, with its abstract concepts, poses challenges for students in grasping and internalizing these ideas. Difficulties in understanding acid-base concepts stem not only from their abstract and complex nature but also from challenges in comprehending the three levels of representation (macroscopic, submicroscopic, and symbolic) and deviations from scientific conceptions [3].

A study conducted by Safo-Adu [12] at the University of Education, Winneba in Ghana, explored acid-base concept misconceptions among pre-service Integrated Science teachers. Findings revealed that approximately 49.0% of student teachers held misconceptions about acid-base models. This contrasts with research in Tai and Indonesia, indicating lower percentages of misconceptions among grade 12 students. The study affirms that acid–base models pose challenges for students, manifesting alternative conceptions. Similarly, a study conducted among undergraduate science teacher trainees at a Turkish state university indicated that these trainees held misconceptions regarding acid-base Chemistry concepts [13]. It is crucial to recognize the initial conceptions of pre-service integrated science teachers concerning acid-base concepts, as these conceptions play a pivotal role and must be addressed. The interpretations of observations and concepts by students can be influenced by their prior experiences, background, and environment. Consequently, students may bring misconceptions into the classroom, hindering their accurate understanding of scientific concepts [14]. Erroneous knowledge among learners can lead to faulty reasoning and the formation of incorrect concepts [15]. In the context of pre-service integrated science teachers, these misconceptions may impede their comprehension of acid-base concepts. Nearly half of Ghanaian students entering tertiary teacher education harbored misconceptions about chemical phenomena [7]. Despite this, a study investigating misconceptions held by student teachers about acid-base concepts found their understanding to be generally disappointing [16].

Many undergraduate students develop their own concepts of basic chemistry during high school before university studies [17]. This prior chemical knowledge can result in students inaccurately relating to current chemical concepts, creating misleading concepts compared to those of experts. The link provided offers further insights into addressing and remediating these misconceptions among pre-service integrated science teachers using cognitive conflict instructional strategies [18]. Research objectives serve as the compass guiding a study, articulating its aim and purpose. According to Kothari [19], research objectives unveil hidden truths and aid in understanding phenomena, portraying characteristics accurately, and testing causal relationships [19]. This research aims to identify misconceptions about acids and bases among pre-service science teachers in the faculty of education. The specific objectives include identifying acid and base misconceptions among pre-service science teachers, investigating differences in acid and base misconceptions between male and female pre-service science teachers, and identifying variances in respondents' major subjects and their understanding of acid-base concepts. Therefore, the aim of the study to i.e., i) identify the acid and base misconception among pre-service science teachers in the faculty of education, ii) investigate the acid and base misconception between male and female pre-service science teachers, and iii) identify between respondent's major subject and acid-base concept understanding.

2. METHOD

2.1. Research design

The research design outlines how the study will be carried out. This study employs a quantitative approach, utilizing questionnaires to identify pre-service science teachers' misconceptions on acid and base concepts. The chosen research design focuses on quantitative methods, specifying the value to gather data in addressing the highlighted research problems. The findings are then interpreted, allowing the researcher to delve into the problem in depth and obtain more detailed information regarding respondents' understanding and misconceptions about acid and base concepts. Additionally, this design enhances the validity and reliability of the findings [20], [21]. The study employs the questionnaire method to gather data, chosen for its efficiency in collecting necessary information within a short timeframe directly from respondents [22].

2.2. Population and sampling

The purposive sampling method will be employed in this study. This non-probability sampling technique is not random, as all individuals have the opportunity to be selected as study samples. This type of sampling is easier to use, quick, and cost-effective for conducting assessments [23]. The target population comprises all pre-service science teachers at the Faculty of Education in one of the public universities in Malaysia. To focus on scientific concepts, three courses' Physics, Chemistry, and Biology were selected, specifically fourth-year students. The choice of these seniors in the Science Education course is based on their imminent teaching roles, emphasizing the need for a solid understanding of acid and base concepts before entering the teaching profession. The study employs random sampling, ensuring selected samples meet criteria related to science subjects, either in their current or past studies. The selected samples are individuals on the brink of completing their studies and transitioning into teaching roles.

2.3. Instrumentation

The instrument format consists of 26 items, encompassing multiple-choice questions. The first section, a demographic survey, collects information on gender and major subject in university. The second section, the Acid and Base Concepts survey, comprises 26 multiple-choice items assessing pre-service teachers' understanding and misconceptions. Respondents choose the best answer from options A, B, C, and D. The instrument, adopted and adapted from the acids-bases chemistry achievement test (ABCAT), has demonstrated validity and reliability in previous studies, instilling confidence in its use for this research.

2.4. Validity

In research, the analysis of data based on theories and approachable research questions needs to yield results advantageous to others and must be described in a comprehensible language [24]. Therefore, for this study, the researcher emphasized several content criteria, including the use of English as it is the most comprehensible language globally, and ensuring the validity and reliability of the items used to assess the soundness of the study. In this study, the instrument is adopted and adapted from the ABCAT. All the items had previously demonstrated an appropriate level of validity and reliability in prior studies. Consequently, the survey instrument was used with confidence.

2.5. Data collection procedure

The questionnaire was distributed to 117 pre-service teachers through the electronic medium, specifically Google Forms. Respondents were requested to complete and submit the questionnaire within a given period. The absence of the researcher during the questionnaire completion allowed respondents to take adequate time to provide precise answers, enhancing the study's accuracy in understanding the topics under investigation.

2.6. Data analysis

After collecting all questionnaire sheets, the answers for each respondent were analyzed. The quantitative data obtained were statistically analyzed using the Statistical packages for social science (SPSS) version 23.0. Descriptive statistical analysis, including frequency and percentage, was performed on all data provided by respondents. In the data analysis, if a pre-service teacher chose the incorrect answer, the respondent was considered to have a misconception. Each analyzed data point was accompanied by detailed explanations as stated in Table 1.

Table 1. Data analysis procedure

Unit	Section	Statistical tool (s)
1	Demographic data	Descriptive analysis
2	The misconception held by pre-service science teachers in Faculty of Education on acid and base concepts.	Descriptive analysis
3	The difference in misconception of acid and base between male and female pre-service science teacher.	Independent t-test
4	The difference between university subject major and acid and base concepts understanding among pre-service science teachers.	ANOVA test

3. RESULTS AND DISCUSSION

3.1. Analysis of identification of acid and base misconception among pre-service science teachers in the faculty of education

A total of 117 respondents, selected from pre-service teachers, completed the acid and base questionnaire. As a rule, a pre-service teacher is considered to have a good understanding of acid and base concepts if they select the correct answers in the questionnaire, which consists of multiple-choice items. Conversely, if a pre-service teacher selects incorrect answers for multiple-choice items, it indicates a lack of understanding or misconceptions about the acid and base concepts. The detail of percentage of pre-service teachers who provided responses to multiple choice questions of acid and base survey instrument has been shown in Table 2 (see in Appendix).

In general, the overall results revealed that the level of understanding of acid and base concepts among pre-service teachers is still at a high level. At least 15 out of 26 items were answered correctly by pre-service teachers, while only 11 items were answered incorrectly. The highest percentage of correct responses was 91.5%, observed in Item 4. Therefore, it can be concluded that pre-service teachers' understanding of acid and base concepts is at a high level, indicating a low level of misconception among them.

Item 1 as shown in Table 3 assessed pre-service teachers' understanding on a property of acid. Most of the respondents selected the correct answer which is 80.3% (*n*=94). The rest select the wrong answer which is one of it 1.7% (*n*=2) respondents thought that an acid displays its properties when it ionises in propane to produce OH^- ions.

Table 3. Pre-service teachers' response for item 1

No.	Item	Response option		Response answer	
1	An acid displays its properties when it…	A	ionises in propane to produce H^+ ions	*n*	11
				%	9.4
		B	ionises in propane to produce OH^- ions	*n*	2
				%	1.7
		C**	ionises in water to produce H^+ ions	*n*	94
				%	80.3
		D	ionises in water to produce OH^- ions	*n*	10
	**correct answer			%	8.5

Item 2 as shown in Table 4 assessed pre-service teachers' understanding on properties of bases. Most of the respondents selected the correct answer which is 77.8% (*n*=91). The rest select the wrong answer which is one of it 3.4% (*n*=4) respondents thought that base displays its properties when it ionises in propane to produce OH^- ions.

Table 4. Pre-service teachers' response for item 2

No.	Item	Response option		Response answer	
2	Base displays its properties when it……	A	ionises in propane to produce H^+ ions	*n*	7
				%	6.0
		B	ionises in propane to produce OH^- ions	*n*	4
				%	3.4
		C	ionises in water to produce H^+ ions	*n*	15
				%	12.8
		D**	ionises in water to produce OH^- ions	*n*	91
	**correct answer			%	77.8

Item 3 as shown in Table 5 addressed what is chemical X based on the properties given. The results showed that out of 117 respondents, 50 respondents selected the correct answer which is 42.7% that chemical X is aqueous calcium hydroxide. The rest of the respondents selected wrong answer which is 35.9% (*n*=42) selected the sodium hydroxide dissolved in propane, 17.1% (*n*=20) respondents selected dry ammonia gas and 4.3% (*n*=5) respondent selected glacial acetic acid. Item 4 as shown in Table 6 assessed pre-service teachers' understanding of the properties of citrus fruits based on their taste. Evidently, the majority of the respondents, 91.5% (*n*=107), believed that citrus fruits like oranges and lemons are acidic. Only a small number of respondents, 10 out of 117, selected the wrong answer.

Item 5 as shown in Table 7 addressed a question related to problem-solving based on the given situation. Among the 117 respondents, 59% (*n*=69) selected the correct answer, identifying lime as a substance with basic properties. The remaining 41% (*n*=48) of respondents believed that caustic soda, common salt, and vinegar are chemicals that can be added to the soil to promote the growth of grass when the soil is too acidic.

Table 5. Pre-service teachers' response for item 3

No	Item		Response option	Response answer	
3	Chemical X shows the following properties:	A**	Aqueous calcium hydroxide	*n*	50
	Tastes bitter and feels soapy.			%	42.7
	Turns red litmus paper blue.	B	Dry ammonia gas	*n*	20
	Reacts with an acid to produce a salt and water.			%	17.1
	Produces ammonia gas when heated with an ammonium salt.	C	Glacial acetic acid	*n*	5
	Reacts with an aqueous salt solution to produce a metal			%	4.3
	hydroxide.	D	Sodium hydroxide dissolved in	*n*	42
	**correct answer		propane	%	35.9

Table 6. Pre-service teachers' response for item 4

No	Item		Response option	Response answer	
4	What is a property of citrus fruits like oranges and lemons?	A**	Acidic	*n*	107
				%	91.5
		B	Basic	*n*	7
				%	6.0
		C	Neutral	*n*	2
				%	1.7
		D	None of the above answers could be	*n*	1
	**correct answer		right	%	0.9

Table 7. Pre-service teachers' response for item 5

No	Item		Response option	Response answer	
5	If soil is too acidic, it is not likely to support the healthy growth of grass. What chemical would you add to the soil to promote the growth of grass?	A	Caustic soda	*n*	25
				%	21.4
		B	Common salt	*n*	15
				%	12.8
		C**	Lime (Calcium Oxide)	*n*	69
				%	59.0
		D	Vinegar	*n*	8
	**correct answer			%	6.8

Item 6 as shown in Table 8 assessed why respondents think water is needed to demonstrate the acidic properties of an acid. It appears that the majority of respondents, 73.5% (*n*=86), selected the correct answer, which is that ionization of acid occurs in water. A smaller percentage of respondents, 12% (*n*=14), believed that neutralization of acid occurs in water, 8.5% (*n*=10) thought water oxidizes the acid, and 6% (*n*=7) believed water dissolves the acid.

Table 8. Pre-service teachers' response for item 6

No	Item		Response option	Response answer	
6	Which statement explains why water is needed to show the acidic properties of an acid?	A**	Ionisation of acid occurs in	*n*	86
			water	%	73.5
		B	Neutralisation of acid occurs in	*n*	14
			water	%	12.0
		C	Water dissolves the acid	*n*	7
				%	6.0
		D	Water oxidises the acid	*n*	10
	**correct answer			%	8.5

Item 7 as shown in Table 9 assessed respondents on their knowledge about the strength of acids and bases, particularly focusing on the example of a strong acid. It appears that the majority of respondents, 72.6% (*n*=85), correctly identified sulphuric acid as an example of a strong acid. The remaining respondents, 27.4% (*n*=32), did not know the example of a strong acid.

Item 8 as shown in Table 10 inquired about weak alkaline solutions. Among the 117 respondents, 51.3% (*n*=60) demonstrated a correct understanding, stating that weak alkaline solutions can partially ionize in water. Conversely, 21.4% (*n*=25) of respondents provided incorrect responses, with some stating that weak alkaline solutions have a pH value of 13, and others suggesting that the concentration of the solution is slow. Additionally, only 7 respondents answered that weak alkaline solutions do not react with acids.

Table 9. Pre-service teachers' response for item 7

No	Item	Response option		Response answer	
7	Which of the following is strong acids?	A	Acetic acid	*n*	9
				%	7.7
		B	Ethanoic acid	*n*	10
				%	8.5
		C	Phosphoric acid	*n*	13
				%	11.1
		D**	Sulphuric acid	*n*	85
	**correct answer			%	72.6

Table 10. Pre- service teachers' response for item 8

No	Item	Response option		Response answer	
8	Which of the following is correct about weak alkaline solution?	A	Concentration of the solution is low	*n*	25
				%	21.4
		B	Have pH value of 13	*n*	25
				%	21.4
		C**	Partially ionised in water	*n*	60
				%	51.3
		D	Solution does not react with acid	*n*	7
	**correct answer			%	6.0

Item 9 as shown in Table 11 evaluated respondents' knowledge of pH values. As anticipated, the majority of respondents, 71.8% (*n*=84), believed that X is a strong alkali. Additionally, 12% (*n*=14) answered that X dissociates partially in water, 11.1% (*n*=13) believed X is a weak acid, and 5.1% (*n*=6) of respondents thought that X has a high concentration of hydrogen ions. Item 10 as shown in Table 12 evaluated respondents' knowledge about pH values, similar to Item 9. The majority of respondents, 88% (*n*=103) out of 117, provided the correct answer. The remaining respondents indicated that they were unsure whether a low pH value corresponds to a strong acid.

Item 11 as shown in Table 13 assessed respondents on the uses of sodium hydroxide. The results show that 48.7% (*n*=57) of the respondents selected the correct answer, which is the use of sodium hydroxide in making soaps. The remaining respondents chose incorrect answers, such as using sodium hydroxide to make fertilizers, neutralize acidic soil, and preserve fruits and vegetables. Item 12 (Table 14) assessed respondents on pH value and degree of dissociation for a strong acid. As anticipated, the majority of respondents, 61.5% (*n*=72), provided the correct answer, stating that sulfuric acid has a pH value of 2 and a high degree of dissociation. The remaining respondents selected incorrect answers.

Table 11. Pre- service teachers' response for item 9

No	Item	Response option		Response answer	
9	0.1 mol dm^{-3} solution of X has a pH value of 13. Which statement is correct about the solution?	A	X dissociates partially in water	*n*	14
				%	12.0
		B	X has a high concentration of hydrogen ions	*n*	6
				%	5.1
		C**	X is a strong alkali	*n*	84
				%	71.8
		D	X is a weak acid	*n*	13
	**correct answer			%	11.1

Table 12. Pre- service teachers' response for item 10

No	Item	Response option		Response answer	
10	Solution M has a pH value of 2. What is solution M?	A**	Strong acid	*n*	103
				%	88.0
		B	Strong alkali	*n*	4
				%	3.4
		C	Weak acid	*n*	1
				%	0.9
		D	Weak alkali	*n*	9
	**correct answer			%	7.7

Table 13. Pre- service teachers' response for item 11

No	Item	Response option		Response answer	
11	Which of the following is the uses of sodium hydroxide?	A	Making fertilisers	*n*	21
				%	17.9
		B**	Making soaps	*n*	57
				%	48.7
		C	To neutralise acidic soil	*n*	18
				%	15.4
		D	To preserve fruits and vegetables	*n*	21
	**correct answer			%	17.9

Table 14. Pre- service teachers' response for Item 12

No	Item	Response option		Response answer	
12	Which pair shows pH value and the degree of dissociation for sulphuric acid?	A**	pH value=2, Degree of dissociation=High	*n*	72
				%	61.5
		B	pH value=2, Degree of dissociation=Low	*n*	20
				%	17.1
		C	pH value=6, Degree of dissociation=High	*n*	12
				%	10.3
		D	pH value=6, Degree of dissociation=Low	*n*	13
	**correct answer			%	11.1

Item 13 as shown in Table 15 assessed respondents on how to determine the number of hydrogen ions in a strong acid. The correct method for determining the number of hydrogen ions in an acid is based on the chemical formula of the acid. For example, H_2SO_4 is the chemical formula of sulfuric acid, indicating it has two hydrogen ions. The results showed that 46.2% (*n*=54) of respondents answered correctly, identifying sulfuric acid as having the highest number of hydrogen ions compared to other acids. Additionally, 35% (*n*=41) chose hydrochloric acid, HCl; 15.4% (*n*=18) selected ethanoic acid, CH_3COOH; and 3.4% (*n*=4) opted for nitric acid, HNO_3.

Table 15. Pre- service teachers' response for item 13

No	Item	Response option		Response answer	
13	Which strong acid contains the highest number of hydrogen ions?	A	25cm^3 of 1 mol dm^{-3} ethanoic acid	*n*	18
				%	15.4
		B	25cm^3 of 1 mol dm^{-3} hydrochloric acid	*n*	41
				%	35.0
		C	25cm^3 of 1 mol dm^{-3} nitric acid	*n*	4
				%	3.4
		D**	25cm^3 of 1 mol dm^{-3} sulphuric acid	*n*	54
	**correct answer			%	46.2

Item 14 as shown in Table 16 inquired about strong alkali from the respondents. The results revealed that the majority of respondents, 54.7% (*n*=64), incorrectly selected 'blue color in universal indicator' as the characteristic of strong alkali. The correct answer for this question is that strong alkali will show a purple color in the universal indicator. Only a minority of respondents, 28.2% (*n*=33), provided the correct response.

Table 16. Pre- service teachers' response for item 14

No	Item	Response option		Response answer	
14	Which of the following is correct about a strong alkali?	A	show blue colour in universal indicator	*n*	64
				%	54.7
		B	show green colour in universal indicator	*n*	10
				%	8.5
		C**	show purple colour in universal indicator	*n*	33
				%	28.2
		D	show red colour in universal indicator	*n*	9
	**correct answer			%	7.7

Item 15 as shown in Table 17 inquired about strong acid from the respondents. The results showed that the majority of respondents, 76.9% (*n*=90), correctly selected the answer that strong acid will show a red color in the universal indicator. However, 27 respondents chose the incorrect option, with only 5 respondents stating that strong acid will show a green color in the universal indicator.

Table 17. Pre- service teachers' response for item 15

No	Item	Response option		Response answer	
15	Which of the following is correct about a strong acid?	A	show blue colour in universal indicator	*n*	8
				%	6.8
		B	show green colour in universal indicator	*n*	5
				%	4.3
		C	show purple colour in universal indicator	*n*	14
				%	12.0
		D**	show red colour in universal indicator	*n*	90
	**correct answer			%	76.9

Item 16 as shown in Table 18 is the last item that asks about the strength of acid and base. It inquires about which one is an example of a weak alkali. The findings show that 55 respondents (47%) have the correct understanding, identifying aqueous ammonia. The remaining respondents provided different answers: 18.8% (*n*=22) chose aqueous potassium hydroxide, 17.9% (*n*=21) selected sodium hydroxide, and 16.2% (*n*=19) opted for calcium hydroxide.

Table 18. Pre- service teachers' response for item 16

No	Item	Response option		Response answer	
16	Which of the following is weak alkali?	A**	Aqueous ammonia	*n*	55
				%	47.0
		B	Aqueous potassium hydroxide	*n*	22
				%	18.8
		C	Calcium hydroxide	*n*	19
				%	16.2
		D	Sodium hydroxide	*n*	21
	**correct answer			%	17.9

Item 17 as shown in Table 19 inquired about which step is not part of the procedure to prepare a solution with a specified concentration using the dilution method. Out of the four response options, 40 respondents (34.2%) correctly identified that adding a few drops of universal indicator solution into the volumetric flask is not a step. However, the majority, 77 respondents (65.8%), answered incorrectly. There are two possible explanations for the incorrect responses: first, the respondents might genuinely not know the correct step, and second, they may have overlooked the word 'not' in the question. Item 18 as shown in Table 20 inquired about the apparatus that might not be needed for a titration experiment. The majority of respondents answered this question correctly, with 59% (*n*=69) selecting the accurate option, which is the test tube. Conversely, 12.8% answered pipette, 24.8% chose a white tile, and 3.4% selected a retort stand as the apparatus, all of which are incorrect.

Item 19 as shown in Table 21 inquired about the main apparatus used in the preparation of a standard solution. Essentially, the majority of respondents, 67.5%, selected the correct answer for this question, which is the volumetric flask. The remaining respondents chose incorrect options: 15.4% answered beaker, 12.8% chose a measuring cylinder, and 4.3% selected 'none of the above answers could be right.

Table 19. Pre- service teachers' response for item 17

No	Item	Response option		Response answer	
17	Which of the following is not a step in the procedure to prepare a solution with a specified concentration using the dilution method?	A**	A few drops of universal indicator solution are added into the volumetric flask	*n* %	40 34.2
		B	Distilled water is added to the volumetric flask until the graduation mark	*n* %	26 22.2
		C	The required volume of stock solution is transferred into the volumetric flask using a pipette	*n* %	15 12.8
	**correct answer	D	The volume of stock solution required is calculated	*n* %	36 30.8

Table 20. Pre- service teachers' response for item 18

No	Item	Response option		Response answer	
18	Which of the following apparatus might not be needed for a titration experiment?	A	Pipette	*n*	15
				%	12.8
		B	Retort stand	*n*	4
				%	3.4
		C**	Test tube	*n*	69
				%	59.0
		D	White tile	*n*	29
	**correct answer			%	24.8

Table 21. Pre- service teachers' response for item 19

No	Item	Response option		Response answer	
19	What is the main apparatus that is used in the preparation of a standard solution?	A	Beaker	*n*	18
				%	15.4
		B	Measuring cylinder	*n*	15
				%	12.8
		C	None of the above answers	*n*	5
			could be right	%	4.3
		D**	Volumetric flask	*n*	79
	**correct answer			%	67.5

Item 20 as shown in Table 22 inquired about the condition of concentration of solution and the number of moles of solute present when a standard solution of specific concentration is diluted. Only 38.5% answered this question correctly. The accurate response is that when a standard solution of specific concentration is diluted, the concentration of the solution will decrease while the number of moles of solute present will remain constant. The majority of respondents (61.5%) selected the wrong answer for this question.

Table 22. Pre- service teachers' response for item 20

No	Item	Response option		Response answer	
20	When a standard solution of specific concentration is diluted, the concentration of the solution will _____, while the number of moles of solute present will be _____	A**	decrease;	*n*	45
			constant	%	38.5
		B	decrease;	*n*	18
			decrease	%	15.4
		C	increase;	*n*	24
			constant	%	20.5
		D	increase;	*n*	30
	**correct answer		decrease	%	25.6

Item 21 as shown in Table 23 inquired about the number of moles when the molarity and volume of the acid were given. To answer this question, respondents were supposed to use the formula $n=MV$, where 'n' is the number of moles, 'M' is for molarity, and 'V' stands for volume. Respondents could calculate the answer using a calculator. Only 30.8% (n=36) of respondents answered this question correctly, while the majority (69.2%) selected the wrong answer.

Table 23. Pre- service teachers' response for item 21

No	Item	Response option		Response answer	
21	What is the number of moles in 100cm^3 of 1.5 mol dm^{-3} of nitric acid?	A	0.015 mol	*n*	45
				%	38.5
		B	0.100 mol	*n*	25
				%	21.4
		C**	0.150 mol	*n*	36
				%	30.8
		D	1.500 mol	*n*	11
	**correct answer			%	9.4

Item 22 as shown in Table 24 inquired about the possibilities of element Z when it combines with acid to produce salt and water. The majority of respondents, 59% (n=69), correctly answered this question. Element Z is, in fact, an alkali. Therefore, when acid combines with alkali, it will produce salt and water a process known as neutralization. However, 41% (*n*=48) of respondents had misconceptions about this question.

Table 24. Pre- service teachers' response for Item 22

No	Item	Response option		Response answer	
22	Acid+Z to be salt+water. What is Z?	A** alkali	alkali	*n*	69
				%	59.0
		B	ammonia	*n*	20
				%	17.1
		C	Hydrogen chloride	*n*	21
				%	17.9
	**correct answer	D	Oxygen	*n*	7
				%	6.0

Item 23 as shown in Table 25 inquired about the substance that neutralizes alkaline wasp stings. Based on the results, only 41.9% (*n*=49) of respondents knew about the substance that can neutralize alkaline wasp stings, which is vinegar. The majority of respondents selected the wrong answer for this question.

Table 25. Pre- service teachers' response for item 23

No	Item	Response option		Response answer	
23	Which of the following substance are neutralising the alkaline wasp stings?	A	Ammonia	*n*	9
				%	7.7
		B	Baking powder	*n*	34
				%	29.1
		C	Lime	*n*	25
				%	21.4
		D**	Vinegar	*n*	49
	**correct answer			%	41.9

Item 24 as shown in Table 26 inquired about the situation when a piece of sodium metal is put into a beaker containing 30 cm3 of water to form a solution. It asked which of the following substances can react with the solution. Only 34.2% (*n*=40) answered this question correctly, identifying hydrogen chloride solution as the substance that can react with the solution. The majority answered incorrectly, with 29.9% (*n*=35) selecting potassium carbonate solution, 19.7% (*n*=23) choosing aqueous ammonia, and 16.2% (*n*=19) opting for lithium hydrogen carbonate solution.

Table 26. Pre- service teachers' response for item 24

No	Item	Response option		Response answer	
24	A piece of sodium metal is put into a beaker which contains 30cm^3 of water to form a solution. Which of the following can react with the solution?	A	Aqueous ammonia	*n*	23
				%	19.7
		B**	Hydrogen Chloride solution	*n*	40
				%	34.2
		C	Lithium hydrogen carbonate solution	*n*	19
				%	16.2
		D	Potassium carbonate solution	*n*	35
	**correct answer			%	29.9

Item 25 as shown in Table 27 also inquired about a neutralization question. It asked about what substance aqueous potassium hydroxide can react with to produce a salt and water. The majority of respondents answered this question incorrectly. Only 42.7% (*n*=50) answered correctly, stating that aqueous potassium hydroxide can react with dilute nitric acid to produce a salt and water. The remaining 57.3% (*n*=67) selected the other options.

Item 26 as shown in Table 28 is the last item in the questionnaire. This item asks about the correct reaction between acid and magnesium hydroxide. The majority of respondents answered this question correctly, with 52.1% (*n*=61). The remaining 47.9% (*n*=56) selected the wrong answer.

Table 27. Pre-service teachers' response for item 25

No	Item	Response option		Response answer	
25	Aqueous potassium hydroxide reacts with _____ to produce a salt and water	A	Aqueous magnesium hydroxide	*n*	12
				%	10.3
		B	Aqueous sodium chloride	*n*	29
				%	24.8
		C**	Dilute nitric acid	*n*	50
				%	42.7
		D	Glacial acetic acid	*n*	26
	**correct answer			%	22.2

Table 28. Pre-service teachers' response for item 26

No	Item	Response option		Response answer	
26	Which of the following equations most accurately describes the neutralisation reaction between the acid, HA, and magnesium hydroxide?	A	Option 1	*n*	26
				%	22.2
		B**	Option 2	*n*	61
				%	52.1
		C	Option 3	*n*	12
				%	10.3
		D	Option 4	*n*	18
	**correct answer			%	15.4

The initial research question sought to understand pre-service teachers' misconceptions about the concepts of acids and bases. Analysis of their responses revealed that 15 out of 26 items were answered correctly by the respondents, while 11 items indicated misconceptions. Items 1 to 6 focused on the pre-service teachers' comprehension of the characteristics and properties of acids and bases, with only item 3 showing a majority of incorrect responses. The remaining five items indicated no misconceptions, suggesting that most pre-service teachers have a clear understanding of these concepts. Moving on to items 7 to 16, which addressed the strength of acids and bases, there were a total of 10 questions. Six questions received a majority of correct responses, while four questions had a majority of incorrect answers. Specifically, items 11, 13, 14, and 16 had the highest instances of incorrect responses. Notably, item 10, which inquired about the strength of solution M with a pH value of 2, showed that 88% of respondents correctly identified it as a strong acid. Similarly, item 15 revealed that 76.9% of respondents knew that a strong acid would display a red color in a universal indicator. Item 7, asking for an example of a strong acid, showed that 72.6% of respondents correctly identified sulfuric acid. Overall, it appears that the majority of respondents have a good understanding of the strength of acids and bases. Items 17 to 21 focused on the concentration of acids and bases, incorporating questions related to calculations and facts. For instance, item 18 asked about the apparatus not needed in titration, with the majority correctly identifying the test tube. Item 19 questioned the main apparatus used to prepare a standard solution, with the majority correctly identifying the volumetric flask. This result suggests that respondents, in general, share a similar understanding of the necessary apparatus for experiments. Items 22 to 26 centered around neutralization, with 2 out of 5 questions receiving a majority of correct responses. Notably, item 22, inquiring about the possibility of element Z combining with acid to produce salt and water, received a correct response from 59% of the respondents. Element Z was correctly identified as an alkali, and the process was recognized as neutralization.

In summary, the data obtained from the acid-base survey instruments indicate that pre-service teachers generally have a satisfactory understanding of acid and base concepts, with all twenty-six items exceeding a 50% correct response rate. Despite this overall positive trend, there were still eleven misconceptions among the pre-service teachers, indicating areas where further clarification or teaching may be needed. The most prevalent misconceptions were related to the universal indicator of strong alkali (71.7%), concentration of acid and base involving calculations (69.3%), and the steps in the procedure to prepare a solution with a specified concentration using the dilution method (65.8%).

3.2. Analysis of investigation of the acid and base misconception between male and female pre-service science teachers

In this study, 24% of the chosen participants are male, while 76% are female. Tables 29 and 30 provides the analysis of an independent sample t-test on misconceptions in gravity between male and female students. The results of the study indicate a significant difference in the misconceptions of acids and bases between male and female pre-service science teachers (p-value=0.044, which is less than $\alpha = 0.05$). The role of gender was also examined in the context of this research. In science education, the dominance of boys in the scientific learning process has been a concern, with the argument that girls are not adequately trained to respond to questions in a scientific manner compared to boys. This inadequacy may lead to an inability to explain phenomena, resulting in misconceptions in scientific theory [25].

Table 29. Group statistic

	Gender	*N*	Mean	Std. Deviation	Std. error mean
Knowledge in acid and base	Male	28	13.2143	5.45933	1.03172
	Female	89	15.2584	4.33414	.45942

Table 30. Independent sample t-test on misconception in acid base between male and female students

		Levene's test for equality of variances		T-test for equality of means		
		F	Sig.	t	df	Sig. (2-Tailed)
Knowledge in acid and base	Equal variances assumed	5.160	.025	-2.041	115	.044
	Equal variances not assumed			-1.810	38.307	.078

Contrary to the findings of Gruber *et al*. [26], who identified a gender gap in understanding scientific concepts, this study challenges such notions. In their research, a questionnaire revealed that male students had higher mean scores than female students, suggesting a better understanding among males. The researchers discussed that male respondents provided accurate scientific answers confidently, even when incorrect, while female students hesitated despite having mostly accurate concepts. The girls may struggle to verbalize their ideas and often rely on group teamwork to articulate their thoughts, as they may lack confidence in expressing their answers [27]. The challenge of adapting to the scientific world needs specific attention for both genders because traditional learning methods appear to favor boys over girls [28].

Overcoming misconceptions in both genders proves difficult. Boys tend to retain misconceptions developed during active learning and vigorously defend them, while girls, despite achieving good grades in science, may lack confidence. Girls also seem to be less engaged in hands-on activities, indicating a disconnection with active learning [29]. Therefore, it is crucial for future research to highlight gender issues and explore the relationship between gender and knowledge understanding in science. This will ensure that steps and instructions are introduced equitably to both genders, addressing any potential disparities in learning outcomes.

3.3. Analysis of identification between respondent's major subject and acid-base concept understanding

A cross-tabulation between the level of understanding of acid and base concepts among pre-service science teachers and their major subjects taken in university is presented in Table 31. The statistics indicate that pre-service teachers majoring in Chemistry achieved higher scores, with 17 respondents obtaining high scores, followed by 20 respondents with moderate scores and 1 respondent with low scores. In contrast, respondents majoring in Biology had 10 respondents with high scores, 32 with moderate scores, and 3 with low scores. For those majoring in Physics, only one respondent achieved a high score, while 18 respondents had moderate scores and 15 respondents had low scores. The results suggest that Chemistry respondents obtained higher scores compared to Physics and Biology respondents. To assess the significance of differences in the understanding levels of pre-service science teachers, an ANOVA test was conducted. The mean scores for the three majors have been tabulated, as shown in Tables 32 and 33.

Table 31. Crosstab of major subject for pre-service science teacher against level of understanding in acid and base concepts

		Scores			
		High	Moderate	Low	Total
Major courses	Biology	10	32	3	45
	Physic	1	18	15	34
	Chemistry	17	20	1	38
	Total	28	70	19	117

Table 32. Mean score of pre-service science teachers

Major	*N*	Mean	Std. deviation
Biology	45	15.3111	4.01034
Physic	34	10.8235	3.83343
Chemistry	38	17.6579	3.65599
Total	117	14.7692	4.68561

Table 33. ANOVA test of respondents' faculties and acid base concept understanding

	Sum of squares	df	Mean square	F	Sig
Between Groups	859.631	2	429.815	29.043	.000
Within Groups	1687.138	114	14.799		
Total	2546.769	116			

The test revealed that the mean score for Chemistry majors is slightly higher than the mean score for Biology majors, and the mean score for Physics majors is the lowest. It can be concluded that there is a significant difference between the levels of understanding among pre-service science teachers and their major subjects, as indicated by $F(2,114) = 29.043$, $p=0.00<0.05$. Therefore, we reject the null hypothesis. Given the significant difference between the levels of understanding among pre-service science teachers and their major subjects, a post hoc test was conducted, and the results are presented in Table 34.

Table 34. Post hoc test

Dependent variable: total_score
LSD

(I)Class	(J)Class	Mean difference (I-J)	Std. Error	Sig.	95% confidence interval	
					Lower bound	Upper bound
Biology	Physic	4.48758*	.87416	.000	2.7559	6.2193
	Chemistry	-2.34678*	.84755	.007	-4.0258	-.6678
Physic	Biology	-4.48758*	.87416	.000	-6.2193	-2.7559
	Chemistry	-6.83437*	.90815	.000	-8.6334	-5.0353
Chemistry	Biology	2.34678*	.84755	.007	.6678	4.0258
	Physic	6.83437*	.90815	.000	5.0353	8.6334

The ANOVA test revealed a significant difference among majors in Biology, Chemistry, and Physics. The mean score for Chemistry majors was slightly higher at 17.6579, compared to Physics majors (10.8235) and Biology majors (15.3111). The difference between Chemistry and Biology majors was not substantial, as it was influenced by the number of respondents participating in the research. Since the acid and base concepts have been introduced to students since the lower forms of secondary school (Form 2) and continue through the science stream in Form 4, students who pursue science majors are expected to have exposure to these concepts throughout their academic journey.

Results of the analysis revealed a significant difference between respondents' major subjects and their understanding of the acid-base concept. This finding aligns with research conducted by Shtulman and Walker (2020), who observed that science students explore scientific evidence systematically and easily construct correct inferences about their initial misconceptions [30]. In contrast, students not actively involved in scientific studies tend to develop their understanding of scientific concepts based on personal experiences [31]. The most challenging task for teachers lies in correcting misconceptions when students have a history of successfully proving those misconceptions. Therefore, experiences and observations both inside and outside the classroom play crucial roles in helping students gain a deeper understanding of the acid-base concept.

In this research, the results indicate that Chemistry majors achieved higher scores in the high-level category, with 17 respondents, while Biology and Physics majors had 10 and 1 respondent(s), respectively. At the moderate level, Biology majors had higher respondent numbers than Chemistry and Physics majors, while at the low level, Physics majors had more respondents than Chemistry and Biology. The higher number of Chemistry majors at the high level suggests that these students, having studied acid and base concepts since secondary school, are more adept at mastering the topic compared to their counterparts in Biology and Physics.

4. CONCLUSION

In conclusion, the investigation into acid and base misconceptions among pre-service science teachers in the Faculty of Education yielded valuable insights. Overall, the majority of pre-service teachers demonstrated a high level of understanding in the acid and base concept, as revealed by the questionnaire responses. Notably, 15 out of the 26 items showed correct answers selected by more than half of the respondents. However, specific misconceptions were identified, with the highest percentages related to the universal indicator of strong alkali, concentration calculations, and the dilution method procedure. Furthermore, the study explored gender differences in misconceptions, contradicting previous research on a gender gap in scientific understanding. The findings highlighted the need for tailored approaches to address challenges faced by both male and female pre-service science teachers. Additionally, the research revealed a significant correlation between the respondents' major subject and their understanding of acid-base concepts, aligning with previous studies emphasizing the role of active scientific involvement in shaping students' comprehension. These findings underscore the importance of targeted interventions to enhance the conceptual understanding of acid and base concepts among pre-service science teachers, taking into account gender dynamics and academic backgrounds.

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APPENDIX

Table 2. Percentage of pre-service teachers who provided responses to multiple choice questions of acid and base survey instrument

No	Item	Response option		Courses		
				Bio (%)	Chem (%)	Phy (%)
1	An acid displays its properties when it…	A	Ionises in propane to produce H^+ ions	3.42	-	5.98
		B	Ionises in propane to produce OH^- ions	-	-	1.71
		C**	Ionises in water to produce H^+ ions	34.19	31.62	14.53
		D	Ionises in water to produce OH^- ions	0.85	0.85	6.84
2	Base displays its properties when it……	A	Ionises in propane to produce H^+ ions	0.85	-	5.13
		B	Ionises in propane to produce OH^- ions	3.42	-	-
		C	Ionises in water to produce H^+ ions	1.71	0.85	10.26
		D**	Ionises in water to produce OH^- ions	32.48	31.62	13.68
3	Chemical X shows the following properties: - Tastes bitter and feels soapy. - Turns red litmus paper blue. - Reacts with an acid to produce a salt and water. - Produces amonia gas when heated with an ammonium salt. - Reacts with an aqueous salt solution to produce a metal hydroxide.	A**	Aqueous calcium hydroxide	16.24	16.24	10.26
		B	Dry ammonia gas	8.55	2.56	5.98
		C	Glacial acetic acid	2.56	-	1.71
		D	Sodium hydroxide dissolved in propane	11.11	13.68	11.11
4	What is a property of citrus fruits like oranges and lemons?	A**	Acidic	36.75	31.62	23.08
		B	Basic	1.71	0.85	3.42
		C	Neutral	-	-	1.71
		D	None of the above answers could be right	-	-	0.85
5	If soil is too acidic, it is not likely to support the healthy growth of grass. What chemical would you add to the soil to promote the growth of grass?	A	Caustic soda	12.82	4.27	4.27
		B	Common salt	1.71	5.13	5.98
		C**	Lime (calcium oxide)	23.08	22.22	13.68
		D	Vinegar	0.85	0.85	5.13
6	Which statement explains why water is needed to show the acidic properties of an acid?	A**	Ionisation of acid occurs in water	28.21	28.21	17.09
		B	Neutralisation of acid occurs in water	3.42	1.71	6.84
		C	Water dissolves the acid	2.56	0.85	2.56
		D	Water oxidises the acid	4.27	1.71	2.56
7	Which of the following is strong acids?	A	Acetic acid	1.71	0.85	5.13
		B	Ethanoic acid	2.56	1.71	4.27
		C	Phosphoric acid	4.27	5.13	1.71
		D**	Sulphuric acid	29.91	24.79	17.95

Table 2. Percentage of pre-service teachers who provided responses to multiple choice questions of acid and base survey instrument (*continued*)

No	Item	Response option		Courses		
				Bio (%)	Chem (%)	Phy (%)
8	Which of the following is correct about weak alkaline solution?	A	Concentration of the solution is low	7.69	1.71	11.97
		B	Have pH value of 13	6.84	5.98	8.55
		C**	Partially ionised in water	22.22	21.37	7.69
		D	Solution does not react with acid	1.71	3.42	0.85
9	0.1 mol dm^{-3} solution of X has a pH value of 13. Which statement is correct about the solution?	A	X dissociates partially in water	3.42	6.84	1.71
		B	X has a high concentration of hydrogen ions	2.56	-	2.56
		C**	X is a strong alkali	29.06	24.79	17.95
		D	X is a weak acid	3.42	0.85	6.84
10	Solution M has a pH value of 2. What is solution M?	A**	Strong acid	35.90	32.48	19.66
		B	Strong alkali	-	-	3.42
		C	Weak acid	-	-	0.85
		D	Weak alkali	2.56	-	5.13
11	Which of the following is the uses of sodium hydroxide?	A	Making fertilisers	6.84	2.56	8.55
		B**	Making soaps	21.37	18.80	8.55
		C	To neutralise acidic soil	4.27	6.84	4.27
		D	To preserve fruits and vegetables	5.98	4.27	7.69
12	Which pair shows pH value and the degree of dissociation for sulphuric acid?	A**	pH value = 2, Degree of dissociation = High	25.64	23.08	12.82
		B	pH value = 2, Degree of dissociation = Low	5.13	5.98	5.98
		C	pH value = 6, Degree of dissociation = High	5.13	0.85	4.27
		D	pH value = 6, Degree of dissociation = Low	2.56	2.56	5.98
13	Which strong acid contains the highest number of hydrogen ions?	A	$25cm^3$ of 1 mol dm^{-3} ethanoic acid	3.42	3.42	8.55
		B	$25cm^3$ of 1 mol dm^{-3} hydrochloric acid	16.24	11.97	6.84
		C	$25cm^3$ of 1 mol dm^{-3} nitric acid	0.85	1.71	0.85
		D**	$25cm^3$ of 1 mol dm^{-3} sulphuric acid	17.95	15.38	12.82
14	Which of the following is correct about a strong alkali?	A	show blue colour in universal indicator	23.08	16.24	15.38
		B	show green colour in universal indicator	0.85	2.56	5.13
		C**	show purple colour in universal indicator	11.97	11.11	5.13
		D	show red colour in universal indicator	2.56	2.56	3.42
15	Which of the following is correct about a strong acid?	A	show blue colour in universal indicator	1.71	2.56	2.56
		B	show green colour in universal indicator	1.71	0.85	1.71
		C	show purple colour in universal indicator	1.71	5.13	5.13
		D**	show red colour in universal indicator	33.33	23.93	19.66
16	Which of the following is weak alkali?	A**	Aqueous ammonia	19.66	19.66	7.69
		B	Aqueous potassium hydroxide	8.55	6.84	3.42
		C	Calcium hydroxide	4.27	3.42	8.55
		D	Sodium hydroxide	5.98	2.56	9.40
17	Which of the following is not a step in the procedure to prepare a solution with a specified concentration using the dilution method?	A**	A few drops of universal indicator solution are added into the volumetric flask	11.11	14.53	8.55
		B	Distilled water is added to the volumetric flask until the graduation mark	5.98	5.13	11.11

Table 2. Percentage of pre-service teachers who provided responses to multiple choice questions of acid and base survey instrument (*continued*)

No	Item	Response option		Courses Bio (%)	Chem (%)	Phy (%)
		C	The required volume of stock solution is transferred into the volumetric flask using a pipette	5.13	5.98	1.71
		D	The volume of stock solution required is calculated	16.24	6.84	7.69
18	Which of the following apparatus might not be needed for a titration experiment?	A	Pipette	3.42	4.27	5.13
		B	Retort stand	0.85	-	2.56
		C**	Test tube	26.50	25.64	6.84
		D	White tile	7.69	2.56	14.53
19	What is the main apparatus that is used in the preparation of a standard solution?	A	Beaker	4.27	3.42	7.69
		B	Measuring cylinder	4.27	1.71	6.84
		C	None of the above answers could be right	1.71	-	2.56
		D**	Volumetric flask	28.21	27.35	11.97
20	When a standard solution of specific concentration is diluted, the concentration of the solution will _____, while the number of moles of solute present will be _____	A**	decrease; constant	11.11	17.95	9.40
		B	decrease; decrease	6.84	5.13	3.42
		C	increase; constant	11.11	4.27	5.13
		D	increase; decrease	9.40	5.13	11.11
21	What is the number of moles in 100cm^3 of 1.5 mol dm^{-3} of nitric acid?	A	0.015 mol	16.24	10.26	11.97
		B	0.100 mol	8.55	4.27	8.55
		C**	0.150 mol	11.11	15.38	4.27
		D	1.500 mol	2.56	2.56	4.27
22	Acid + Z salt + water. What is Z?	A**	alkali	23.93	20.51	14.53
		B	ammonia	6.84	5.13	5.13
		C	Hydrogen chloride	5.98	5.98	5.98
		D	Oxygen	1.71	0.85	3.42
23	Which of the following substance are neutralising the alkaline wasp stings?	A	Ammonia	5.13	0.85	1.71
		B	Baking powder	10.26	6.84	11.97
		C	Lime	11.11	4.27	5.98
		D**	Vinegar	11.97	20.51	9.40
24	A piece of sodium metal is put into a beaker which contains 30cm^3 of water to form a solution. Which of the following can react with the solution?	A	Aqueous ammonia	10.26	4.27	5.13
		B**	Hydrogen Chloride solution	12.82	13.68	7.69
		C	Litihium hydrogen carbonate solution	7.69	4.27	4.27
		D	Potassium carbonate solution	7.69	10.26	11.97
25	Aqueous potassium hydroxide reacts with _____ to produce a salt and water	A	Aqueous magnesium hydroxide	5.13	2.56	2.56
		B	Aqueous sodium chloride	13.68	3.42	7.69
		C**	Dilute nitric acid	13.68	19.66	9.40
		D	Glacial acetic acid	5.98	6.84	9.40
26	Which of the following equations most accurately describes the neutralisation reaction between the acid, HA, and magnesium hydroxide?	A	Option 1	4.27	3.42	14.53
		B**	Option 2	20.51	21.37	10.26
		C	Option 3	5.98	3.42	0.85
		D	Option 4	7.69	4.27	3.42

Note: figures with "**" denote the percentage of respondents who provided correct answer

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BIOGRAPHIES OF AUTHORS

Nur Farha Shaafi received the Ph.D. degree from Universiti Malaysia Pahang, Malaysia. She was appointed as Senior Lecturer at the Faculty of Psychology and Education, Universiti Malaysia Sabah, Malaysia. Her current research interest includes technology in education, educational chemistry, and areas of science education. Her publication topics include advanced materials, chemistry, educational science, educational chemistry. She can be contacted at email: farhashaafi@ums.edu.my.

Mohammad Mubarrak Mohd Yusof is a Lecturer in Universiti Teknologi MARA, Malaysia. He was appointed lecturer in the university in 2012 and went on to pursue his graduate studies in physics at the Universiti Teknologi Malaysia, Skudai, Johor, Malaysia. He is passionate about raising the quality of teaching and learning of students and their development in the schools and in the higher education settings. His research interests lie in physics education, creative education, instructional technology, and heutagogy. He can be contacted at email: mubarrak@uitm.edu.my.

Ellianawati Ellianawati received Doctor of Science Education from Universitas Pendidikan Indonesia (UPI). Lecturer at Department of Physics Education (Undergraduate) as well as Physics Education, Natural Science Education, Elementary Education, and Evaluation Education Study Programs (Master Program) in Universitas Negeri Semarang (UNNES). Subjects being taught: Basic Physics, Evaluation and Assessment of Physics and Primary Education, Wave, Science Learning Innovation. She can be contacted at email: ellianawati@mail.unnes.ac.id.

Bambang Subali received Doctor of Science Education (Dr.) from Universitas Pendidikan Indonesia (UPI). Lecturer at Department of Physics Education (Undergraduate), Natural Science Education and Elementary Education (Master Programs), and Natural Science Education (Doctoral Program) of Universitas Negeri Semarang (UNNES). Subjects being taught: Basic Physics, Evaluation and Assessment of Physics Education and Primary Education, Critical Study of Natural Science Learning. He can be contacted at email: bambangfisika@mail.unnes.ac.id.

Muhammad Haziq Hazim Raji'e is a graduated Bachelor Degree Candidate, Faculty of Education, Universiti Teknologi MARA, Malaysia. He was previously under supervision of Mr. Mohammad Mubarrak Mohd Yusof for his final year project. He graduated with First Class Degree (Hons) and is currently a novice teacher at Vocational High School Raja Lumu, Pelabuhan Klang teaching Sience subject. He can be contacted at email: hmuhammadhaziqhazim@gmail.com.