

# The Effectiveness Of The Refutation Text To Improve Understanding Of The Acid-Base Concepts For High School Students

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**A EFICÁCIA DO TEXTO DE REFUTAÇÃO PARA MELHORAR A COMPREENSÃO DOS CONCEITOS DE ÁCIDO-BASE PARA ESTUDANTES DO ENSINO MÉDIO****THE EFFECTIVENESS OF THE REFUTATION TEXT TO IMPROVE UNDERSTANDING OF THE ACID-BASE CONCEPTS FOR HIGH SCHOOL STUDENTS****ANALISIS HASIL REMEDIASI PEMAHAMAN KONSEP MENGGUNAKAN BAHAN BACAAN REFUTATION TEXT PADA MATERI ASAM BASA**HARYANI, Sri<sup>1\*</sup>; DEWI, Siti Herlina<sup>2</sup>; HARJITO<sup>3</sup>.<sup>1,2,3</sup> Semarang State University, Mathematics and Sains Faculty, Chemistry Department. Indonesia

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**RESUMO**

Ácido-base é um assunto difícil de aprender. Inclui palavras conceitualmente complicadas para os alunos. O assunto também é considerado difícil pelos professores e futuros professores, tanto em termos de ensino quanto em termos de avaliação do domínio do aluno. O não entendimento em tópicos de química é um dos maiores desafios para o professor. Isso faz com que muitos alunos não atinjam o objetivo de aprendizado. O tópico ácido-base é considerado um dos assuntos mais difíceis e existem muitos conceitos mal compreendidos acerca desse tema. A falta de compreensão pode ser reduzida ao fornecer uma fonte de aprendizado simples e fácil de entender, como texto de refutação. O objetivo deste estudo foi determinar a eficácia do texto de refutação para melhorar a compreensão dos conceitos e reduzir o mal entendimento na aprendizagem corretiva no tópico ácido-base para o ensino médio. Existem seis subtópicos sobre o conteúdo de ácido-base para o ensino médio. O método de teste utilizado foi o pré e pós-projeto de um grupo, com um número limitado de sujeitos. O instrumento de teste usado foi composto por três camadas de várias opções para material ácido-base (teste de entendimento do conceito). O resultado da análise mostrou que 17 dos 19 alunos estavam aumentando a compreensão de conceitos e diminuindo os conceitos errôneos. A mudança de conceito foi significativa de acordo com o teste de Mc Nemar. O valor do tamanho do efeito (ES) baseado no teste Crohan-Q foi 4,12, que é uma categoria alta. Pode-se concluir que o texto de refutação é eficaz o suficiente para melhorar a compreensão dos conceitos dos alunos e aplicável à aprendizagem corretiva.

**Palavras-chave:** texto de refutação; equívoco; materiais à base de ácido; aprendizagem corretiva.

**ABSTRACT**

Acid-base is a difficult subject to learn. It includes conceptually tricky words for the students. The theme is also considered difficult by teachers and prospective teachers in teaching and assessing student mastery. A misconception in chemistry topics is one of the biggest challenges for the teacher. This means that many students do not reach the learning objective. The acid-base question is considered one of the most challenging subjects, and there are many misunderstood concepts on this topic. Lack of understanding can be reduced by providing a simple and natural source of learning, such as a refutation text. This study aimed to determine the effectiveness of the refutation text to improve understanding of concepts and reduce misunderstanding in corrective learning on the acid-base topic for high school. There are six subtopics on acid-base content for high school. The test method used was the pre and post-project of a group, with a limited number of subjects. The test instrument used was the three-tiers of multiple choices for acid-base material (concept understanding's test). The analysis result showed that 17 of 19 students had increased knowledge of concepts and decreased misconceptions. The concept change was significant, according to Mc Nemar Test. The value of effect size (ES) based on the Crohan-Q test was 4.12, a high category. It could be concluded that refutation text is effective enough to improve students' concepts and apply them to remedial learning.

**Keywords:** refutation text; misconception; acid-base materials; remedial learning.

## ABSTRAK

Asam basa adalah mata pelajaran yang sulit dipelajari. Ini mencakup kata-kata yang secara konseptual rumit bagi siswa. Tema tersebut juga dianggap sulit oleh guru dan calon guru baik dalam hal pengajaran maupun dalam hal menilai penguasaan siswa. Kesalahpahaman dalam topik kimia adalah salah satu tantangan terbesar bagi guru. Artinya banyak siswa yang belum mencapai tujuan pembelajaran. Pertanyaan asam basa dianggap sebagai salah satu mata pelajaran yang paling menantang, dan ada banyak konsep yang disalahpahami tentang topik ini. Kurangnya pemahaman dapat dikurangi dengan menyediakan sumber belajar yang sederhana dan alami, seperti teks sanggahan. Tujuan penelitian ini adalah untuk mengetahui keefektifan teks sanggahan dalam meningkatkan pemahaman konsep dan mengurangi kesalahpahaman dalam pembelajaran korektif topik asam basa di SMA. Ada enam subtopik tentang kandungan asam basa untuk SMA. Metode tes yang digunakan adalah pra dan pasca proyek suatu kelompok, dengan jumlah mata pelajaran yang terbatas. Instrumen tes yang digunakan adalah tiga tingkatan pilihan ganda untuk bahan asam basa (tes pemahaman konsep). Hasil analisis menunjukkan bahwa 17 dari 19 siswa mengalami peningkatan pengetahuan konsep dan penurunan miskonsepsi. Perubahan konsep itu signifikan menurut Mc Nemar Test. Nilai effect size (ES) berdasarkan uji Cochran-Q sebesar 4.12 dan termasuk kategori tinggi. Dapat disimpulkan bahwa teks sanggahan cukup efektif untuk meningkatkan pemahaman konsep siswa dan dapat diterapkan pada pembelajaran remedial.

**Kata kunci:** teks sanggahan/ refutation text; miskonsepsi; konsep asam-basa; pembelajaran remedial.

## 1. INTRODUCTION:

Acid-base is a difficult subject to learn. It includes conceptually tricky words for the students. The subject is also considered difficult by teachers and prospective teachers in teaching and assessing student mastery (Haryani, T. P., and Saptarini, 2014). The students difficulties in learning the acid-base subject can be seen from the many misconceptions about it. The problems include delusions in the acid-base theory and acid-base examples (Muchtar, Sciences, and Iskandar, 2012), the nature of acids and bases (Demircioğlu, 2009; Effendi, 2012; Sesen, 2011), acid-base equilibrium, and the concept of pH (Halstead, 2009; Metin, 2011; Sheppard, 2006).

A misconception in the acid-base topic could affect student learning outcomes. The traditional passing grade value for the material ranges from 40-50%. Based on these data, the teacher should do remedial learning (Kemendikbud, 2019). Remedial learning can be interpreted as an improvement program directed at overcoming students' learning difficulties by changing, correcting, or clarifying students' frame of mind to achieve teaching goals to the maximum extent possible, effectively and efficiently (Buna'i, 2007). Besides, with the existence of this remedial program, the teacher can make improvements to his teaching mistakes or deliver learning material that is felt to be lacking and / or late (Dole, 2011; Hastuti, 2000; Margolis, McCabe, Margolis, and McCabe, 2016).

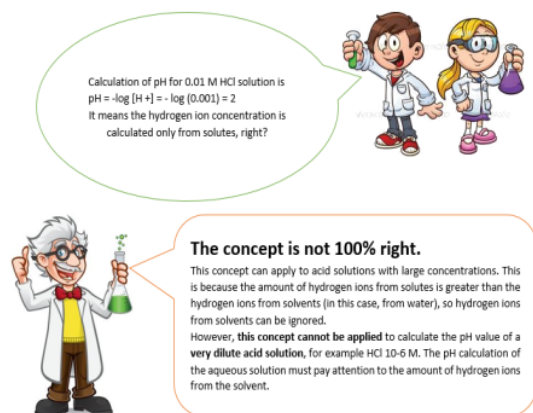
The implementation of remedial learning was only in the form of a re-test with the same or different questions. It is influenced by several factors, including limited learning time, the burden

of teaching the teacher, and the significant learning burden of students and other extracurricular activities. It is less possible to do re-learning to improve student understanding. Remedial misconception can be done by using conceptual change text (CCT) or meaningful learning involving reorganizing or replacing students' initial conception by accommodating ideas called conceptual change (Brix, 2017; Chambers and Andre, 1997; Chi, 2008). One type of remedial learning with CCT with a high effect size is an alternative reading by refutation text.

<sup>29</sup> Refutation text is the text that generally consists of three components. The first component is a statement that is usually a misconception about a concept. The second component is a refutation statement, such as "incorrect, it is not right...". The third component is the correct and scientifically acceptable statement of misconception in the first component (Tippett, 2010). Some studies related to remedial in the form of reading material in the way of refutation text, among others, on the content of Light on Mirror (Physics), refutation text could reduce student errors by 42.92% with effect size 1.47 (Apeng, 2009). Refutation text for Vibration (Physics) material also shows effect size, a relatively large of 1,170 with a contribution of reducing student errors by 37.90% (Hardiansyah, 2009).

Refutation text can also improve understanding of concepts, and read refutation text is more pleasing than reading ordinary textbooks to overcome misconceptions (Danielson, Sinatra, and Kendeou, 2016; Kendeou, Walsh, Smith, and O'Brien, 2014; Tippett, 2010). A study with the solubility content

employing refutation text showed that the refutation text can reduce misconception up to 49.20% compared to ordinary textbooks (Figure 1) (Regita, Enawaty, Harun, and Text, 2015).



**Figure 1.** The refutation text (Regita, Enawaty, Harun, and Text, 2015).

<sup>30</sup> This study aimed to determine the effectiveness of remedial teaching materials in refutation text in improving students' conceptual understanding, especially in acid-base content.

## <sup>23</sup> 2. MATERIALS AND METHODS:

### 2.1. Method of the study

The method of this study was a descriptive experiment with one group pre-and-post-design. The purpose of the study was to analyze the effect of refutation text on acid-base remedial learning. The effect was known by measuring the student's understanding of the acid-base topic.

### 2.2. Sample and Ethics

The research sample were students of 11-grade science class who had not to pass at the acid-base topic. The sample was limited to one class because the refutation text is still in development research (limited test). There were 30 students between the ages of 15-16 who were involved, consisting of 9 boys and 21 girls. A total of 19 students did not pass on the topic of acid-base, then the analysis of remedial learning results only focused on these 19 students, consisting of 8 boys and 11 girls. There are no exceptions in the analysis process. All participants consciously and voluntarily agreed to be involved in the research. The research results can be published, but the identity of the participant was not explicitly

mentioned.

### 2.3. The study content

<sup>13</sup> There are six subtopics in acid-based for senior high school in Indonesia. (1) development of the concept of acids and bases; (2) identification of acid-base; (3) acid strength (weak acid pH, weak base, and strong base acid pH strong); (4) calculation of pH; (5) the concept of pH in the environment; and (6) acid and base reactions or neutralizing reactions. The research samples were classified into three categories based on their daily test scores, namely the upper group (A), consisted of 7 students; the middle group (B), consists of 8 students, and the lowest group (C), consists of 4 students. The grouping aimed to facilitate the analysis of understanding concepts in students. The effectiveness of teaching materials can be known from the pretest and posttest (Appendix 1) (Creswell, 2015).

### 2.4. Instruments

The instruments used were in the form of conceptual understanding tests of three-tiers multiple choices (Appendix 1) that were adapted from other studies (Halstead, 2009; Ilmah, 2017; Milenković, Hrin, Segedinac, and Horvat, 2016; Modell, H., Michael, J., and Wenderoth, 2005; Muchtar *et al.*, 2012; Nurpialawati, 2017; Pohan, 2017; Treagust, 1988; Tuysuz, 2009). The concept of understanding test questions consists of 20 items. The detail of the test can be seen at Appendix 1.

### 2.5. Lessons

<sup>39</sup> All participants took regular lessons on the topic of acid and base and took an exam at the end of the lesson. Based on exam results, classical passing grade rates have not yet been reached. Therefore, remedial learning is done by using refutation text. After remedial learning, all participants took a conceptual understanding test. Remedial learning consisted of two parts. Activities in the first part, beginning with conducting activities pretest. Then proceed with the provision of teaching materials part 1 in the form of refutation text. After that, continue to posttest. All the activities were done in one meeting (about 120 minutes). The second part is almost the same as the first part, by giving teaching materials part 2 and doing posttests with the same research subject. The different stages of implementation between the first and second part were in the second part, 1) the provision of teaching materials carried out with additional

discussion for 2 lesson hours (about 80 minutes); 2) students are also given a reading control card; 3) posttest is carried out 2 days after giving teaching materials so that there is more time to read refutation text than in first part.

### 2.6. Results presentation and statistics

The results of the pre and posttest answers were analyzed by grouping the answers of each student based on the categories in Table 1. The answer pattern analysis results was then converted into a percentage to determine the changes that occur. Mc Nemar Test and Cochran-Q Test were conducted to determine whether the data was significant or not (Yarnold, 2015). Recapitulation of results data is pre, and posttest frequency in the form of 2x2 tables is based on the categories in Table 2. In contrast, the determination of changes in the answer category is based on Table 3. The data analyzed are only data "a" and "d" (Table 2). The code in Table 3 was based on Table 1, e.g., U-LK has meant the answer in the pretest include in 'understanding (U)'. Then in the posttest, it changes into 'lack knowledge (LK)'. Then, it includes changing the concept from positive to negative categories.

The Mc-Nemar statistical test was conducted to determine whether the change in number was significant or not. The Mc-Nemar test selection was based on the fact that the study sample was less than 25, so nonparametric tests were used; besides that, the data were not normally distributed. The test can be used to test whether there are significant differences between 2 pairs of samples. The purpose of 2 paired samples can be 1 sample measured 2 times, for example, 1 person measured his understanding by giving pre and posttest. The paired sample in question can also be in the form of 2 samples measured together, i.e., 1 sample is treated, and the other is not treated. The statistical result using Mc-Nemar test (in metode) is given in terms of  $\chi^2$ . It is same with the t test, to determine the data signification but for nonparametric data (Creswell, 2015).

The Q-Cochran test is a non-parametric test, which is similar to repeated ANOVA measures and is used to detect differences in multiple sets of matching numerical responses. This procedure also calculates a two-sided pairwise multiple comparison test, making it possible to determine which groups of individuals differ if the null hypothesis in the Q-Cochran test is rejected. The Cochran's Q test is an extension of the McNemar test to situations where there are

more than two suitable samples (Creswell, 2015).

### 3. RESULTS AND DISCUSSION:

In general, in group A, six of seven students have an increased understanding of the concept and decrease misconceptions. Although there were students who have not concept change and have grown in misunderstanding. The result of group B was six of eight students has increased in the understanding of concepts and has decreased in misconceptions. A total of 4 students in group C have increased in understanding concepts and have decreased in misconceptions. The planned improvement was given a time lag between giving teaching materials and posttest. Besides, students are also given a reading control card to control students to read teaching materials seriously.

The results posttest in part 2 showed that all students (groups A, B, and C) have increased in understanding concepts. Although all students experienced an increase in understanding of concepts, some students also have increased in misconceptions. For group A, one of seven students experienced an increase in misunderstandings occurring in item number 16 (about the relationship between Ka's value and pH strength). Misunderstandings for the same number of questions in group B occurred in 4 of the 8 students who initially did not understand the concept as a misconception. In comparison, the other 4 students did not experience changes in conceptual understanding. Whereas in group C, misconceptions still occur in items number 12, 14, 17, and 18 of Appendix 1.

8 Question number 12 (Appendix 1) is related to the concept of acid strength. There were three of four students has a misconception about the degree of dissociation. They have not been able to distinguish strong acids and weak acids. Item number 14 deals with the use of the acid-base theory. As many as 1 in 4 students still answer Arrhenius's acid-base theory can explain all acid-base concepts. Items number 17 and 18 relate to the concept of pH calculation and neutralization reaction. As many as 1 out of 4 students (different people) who initially did not understand became a misconception. The misconception found is that students still think that the pH of weak acids and strong acids is always different, and the results of neutralization reactions are always neutral.

The second posttest result was combined with data first posttest to be analyzed with indicators of understanding concepts and learning

achievement indicators and the results pretest. In general, the number of students who understand the concept increases, and those who experience misconceptions decrease. This applies to the six sub-concepts in acid-base material. The complete change can be seen in Figures 2 and 3. Sub-concepts in acid-base material based on syllabus surgery namely (1) development of the concept of acids and bases, (2) identification of acid-base, (3) acid strength (weak acid pH, weak base, and strong base acid pH strong), (4) calculation of pH, (5) the concept of pH in the environment and (6) acid and base reactions or neutralizing reactions.

The 1st sub-conception is the development of the theory of acid-base. The theories discussed include the theory of acid-base Arrhenius, Brønsted-Lowry, and Lewis. One of the misconceptions in this sub-concept is that students cannot understand the use of acid-base theory. Most students think that using one of these theories can explain all acid-base reactions. Also, some students had difficulty understanding the theory of the Brønsted-Lowry acid-base. This difficulty is evidenced by some students still being wrong in answering the 9th question item.

The second sub-conception material includes a discussion of acid-base characteristics, various indicators, and how to identify acid bases with indicators. The misconception in this sub-concept is that students assume that acidic compounds are more dangerous than alkaline compounds. The pretest and posttest results also show that the number of students who understand this concept is quite high.

Acid-base strength (3rd sub-conception) is a reasonably tricky concept. This is evidenced by most students not yet understanding the difference between strong/weak acids/bases. As many as 6 out of 19 experienced misconceptions based on the results of the pretest. The misconception is that the pH shows the strength of the acid. The smaller the pH the stronger the acid. Another difficulty in this concept is that students do not understand the concept of acid/base constant. Based on the answers to item number 12, some students still answered that  $K_a$ 's value for acetic acid was equal to 1. The results of the posttest showed that there was an increase in understanding and a decrease in misconceptions. As many as 2 out of 19 people still experience misconceptions, especially regarding the concept of  $K_a / K_b$ . The two students understood that the value of  $K_a$  for weak acids was less than one, but they still did not understand the reason.

The fourth sub-concept, namely the

calculation of pH, is the most difficult, as evidenced by 11 of 19 students experiencing misconceptions based on the pretest results. A common misconception is that they think that the pH value of a strong and weak acid / base compound is different. They also still have difficulty understanding the calculation of weak and strong acid / base pH (difficulty in reducing equations).

The fifth sub-concept discusses the influence of pH in everyday life, one of which is on the environment. Many students still know that pH can affect river water quality, but they are still not right in answering the reason. Students think that acidic chemical plant wastes only cause the change in pH in river water without connecting whether the river water pH increases or decreases (4 out of 19 students). After conducted refutation text was, only 1 in 4 students still experienced misconceptions.

The final sub-conception in acid-base material is an acid-base reaction known as neutralization reaction. This sub-concept introduces students to writing and equalizing acid-base reactions. This sub-concept is very important because it relates to further materials such as hydrolysis and buffer solutions. The neutralization reaction in the concept of acid-base is the number of moles of acids and bases that react equally or both react precisely. Still, the pH of the resultant reaction is not necessarily neutral. There were 8 of the 19 students still did not understand, and 9 of them had misconceptions. They think that neutralization reactions always produce a neutral solution. After remedial learning, 7 of 19 students were had conceptual understanding while 6 students keep has misconceptions. The reason is probably that students are more focused on learning concepts related to calculations.

The recapitulation of the Mc-Nemar test can be seen in Figure 4. The value of the degree of freedom is equal to 1, and the alpha value is 5%, obtained  $\chi^2_{\text{standard}}$  is 3.85. Based on this result, the results of 14 items experienced a significant change, while 6 items were not significant. The six items that are not significant changes are numbers 1, 2, 9, 12, 14 and 16. Items number 1, 2 and 14 are not significant because the students who already understand the pretest and posttest results are almost equal. For item number 9, 12, and 16, it occurs because the number of students who experience change from negative to positive is the same as from positive to negative.

Analysis of the results of further implementation to test the increase in understanding concepts in the first and second

parts was significantly or not, carried out by the Crochan-Q Test. Q value obtained is 18.32 for part 1 and 12.7 for part 2 with the value of  $x_{\text{standard}}$  9.49. It means that the increased understanding of concepts occurs significantly. The effect size (ES) obtained at each part is 5.94 and 4.12. The ES value of part 1 is more significant than part 2, probably because the sub-concept on part 1 is more accessible than part 2.

The research results were appropriate with the opinions of other researchers that refutation text has effect size high enough in improving understanding of concepts (Broughton and Reynolds, 2010; Hardiansyah, 2009; Hardigaluh, B. and Djudin, n.d.; Regita *et al.*, 2015). Also, it can minimize the adverse effects of learning distortions (misconceptions) (Ariasi, Hyönä, Kaakinen, and Mason, 2017; Broughton and Reynolds, 2010; Diakidoy, Mouskounti, and Fella, 2016). Refutation text also requires less time to be understood than ordinary explanatory texts (Broughton and Reynolds, 2010; Van Boekel, Lassonde, O'Brien, and Kendeou, 2017). Other studies have also found that refutation text is more effective with the presentation of analogies and images. Refutation text can be modified and integrated with other media such as posters, comics (Lassonde, Kolquist, and Vergin, 2017; Modell, H., Michael, J., and Wenderoth, 2005).

<sup>34</sup> The reader, refutation text, remembers more scientific facts than non-refutation text readers (Ariasi *et al.*, 2017). Refutation text is suitable for remedial programs as a corrective action. The refutation sentence in refutation text helps increase integrative processing at the end of the paragraph. The process helps readers connect the reading contents and the concept of faith more quickly (Kendeou *et al.*, 2014; Lassonde *et al.*, 2017; Van Boekel *et al.*, 2017).

The shortcomings of this study are the number of research subjects used is still very limited. Classical completeness was not achieved because only 11 were completed from 19 students who attended the remedial program. Classical completeness is said to have been achieved if at least 12 of the 19 students completed the re-test conducted at the end of this remedial study.

#### 4. CONCLUSIONS:

There were improvements in the understanding of concepts even though there were some students who had increased in misconceptions. Some factors might have influenced them. The distance between the time of taking pretest and posttest which were very close;

the distance between the provision of teaching materials and the execution of the posttest which were also very close; students were still unfamiliar with the teaching material working time of questions; the lack of control of students' sincerity in learning the teaching materials given. It can be concluded that the use of refutation text can improve students' conceptual understanding of the acid-base topic. Nevertheless, there are still students who have an increase in misconceptions. Further research with a more significant sample must be done to gain more valid data.

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16

**Table 1.** Patterns of grouping to analyze the answers of the three-tiers test

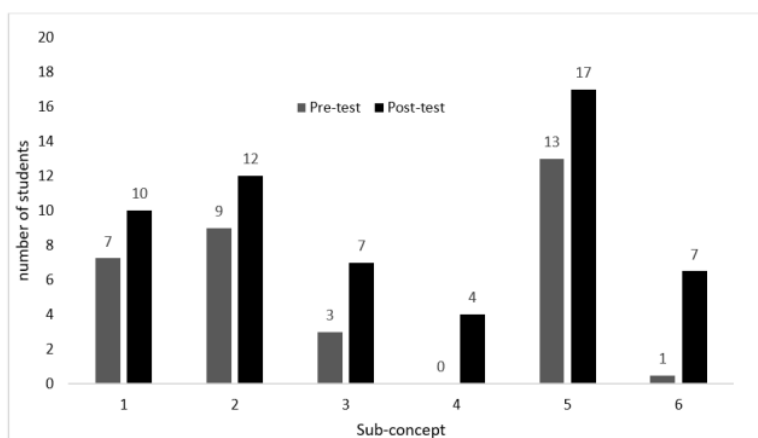
Tier -1	Tier 2	Tier 3	Category
True	True	Sure	Understanding (U)
True	True	Not Sure	Less Understood (GL)
False	True	Not Sure	Guess (G)
True	False	Not sure	Guessing ( G)
False	False	Not sure	Leak Knowledge (LK)
False	True	Sure	Misconception (M)
True	False	Sure	Misconception (M)
One	One	Sure	Misconception (M)

**Table 2.** The answer change's categories

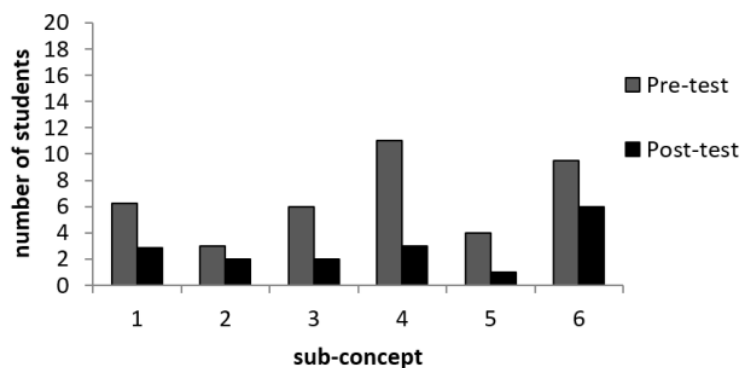
Pretest	Posttest	
	Negative	Positive
Positive	a	b
Negative	c	d

**Table 3.** Pattern for Determining Changes to Answers

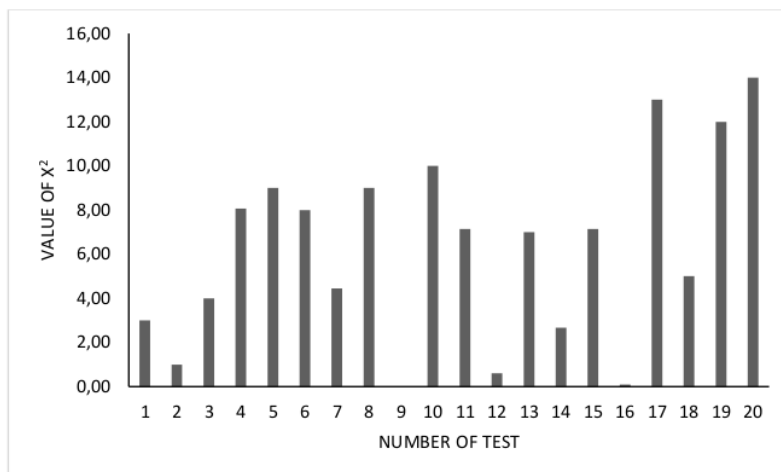
Pretest	Posttest	The Answer Change
Positive	Negative	U-LK; U-M; U-GL; U-G; GL-G; GL-M; GL-LK; G-M; G-LK; M-LK
Positive	Positive	U-U; GL-GL; G-G
Negative	Negative	LK-LK; M-M
Negative	Positive	LK-G; LK-GL; LK-U; M-G; M-GL; M-U; G-GL; G-U; GL-U



**Figure 2.** Changes in concept understanding



**Figure 3.** Changes in misconception



**Figure 4.** The Mc-Nemar Test's result

## APPENDIX 1

### • THREE-TIERS MULTIPLE CHOICES TESTS OF ACID-BASE TOPIC FOR SENIOR HIGH SCHOOL STUDENTS

#### WORK INSTRUCTIONS:

- Fill in the complete identity, including Name, No. Absent, and Class Name.
- The questions consist of 15 questions with three tiers of answers  
 Tier 1: Answer  
 Tier 2: Reason  
 Tier 3: Confidence level
- Write your answer by crossing (X) on the answer sheet according to your answer
- Scoring rules
 

a. if level 1 and 2 are correct, and you are sure	: 4
b. if level 1 and 2 are correct, and you are not sure	: 3
c. if level 1 or 2 is wrong, and you're not sure	: 2
d. if level 1 or 2 is wrong and you are sure	: 1
e. if level 1 and 2 are wrong and you are not sure	: 0
f. if level 1 and 2 are wrong and you are sure	: -1
g. if not answer either part or all	: -2
- It is permissible to bring periodic tables and calculators, but it is **forbidden** to use communication devices or computer

#### THREE-TIERS MULTIPLE CHOICES TESTS:

- The nature of pure water based on Arrhenius's theory is ...

**Answer Choice:**

- A. Neutral
- B. Weak acid
- C. Strong acid
- D. Weak base
- E. Strong bases

**Choice of Reason:**

1. Nonpolar
2. water is colorless
3. Is a universal solvent
4. Water molecules do not break down easily
5. The amount of  $H^+$  and  $OH^-$  ions in pure water is equal.

**Confidence Level**

- I. Sure
- II. Not sure

2. Pay attention to Table 1!

Table 1. Definition of acids and bases

Acid	Base
1. Ionized acid in water produces $H^+$ ions	a. Bases are substances that can bind to $H^+$ ions
2. Acid is a substance that can donate $H^+$	b. The $OH^-$ ion in water is a characteristic of bases
3. Acid is a compound that has an H atom	c. Bases are all compounds containing the $-OH$ group

The exact statement according to Arrhenius's acid-base theory is...

**Answer choices:**

- A. 1 and a
- B. 1 and b
- C. 2 and a
- D. 3 and b
- E. 3 and c

*A. Choice of reasons:*

1. According to Arrhenius, acids and bases will ionize into cation and anion
2. According to Arrhenius, the nature of acids or bases is based on the handover of protons ( $H^+$ )
3. According to Arrhenius the nature of acids or bases is based on the transfer of lone pairs
4. According to Arrhenius, acidic or basic compounds are electron and proton donors ( $H^+$ )
5. According to Arrhenius, the  $H^+$  ion is the carrier of acidic properties, and the  $OH^-$  ion is the carrier of basic properties

**Confidence level**

- I. Sure
- II. Not sure

3. The following theory statement, which is following the Brønsted-Lowry acid-base theory, is ...

*B. Answer choices:*

- A. The acid in water releases  $H^+$  ions
- B. Alkaline in water releases  $OH^-$  ions
- C. A base is a substance that can receive protons ( $H^+$ )
- D. Acids and bases in water can receive protons
- E. An acid is a substance that can be bound to a pair of free electrons in a base

*C. Choice of reasons:*

- 1)  $H^+$  and  $OH^-$  ions as conjugate acid-base pairs
- 2) According to Brønsted-Lowry, the acidic or basic nature is based on electron handover
- 3) Brønsted-Lowry substances that are acidic or basic are only dissolved in water solvents
- 4) Substances which act as acids will form conjugate acids because they provide donor protons

(H<sup>+</sup>)

- 5) Substances that act as bases will form into conjugate acids because they receive a donor proton (H<sup>+</sup>)

**Confidence level**

- I. Sure  
II. Not sure

4. The following reaction is an acid-base reaction, except ...

**Answer choices**

- A.  $\text{Al}(\text{OH})_3(\text{aq}) + \text{OH}^-(\text{aq}) \rightleftharpoons \text{Al}(\text{OH})_4^+(\text{aq})$   
B.  $\text{H}_2\text{O}(\text{l}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq})$   
C.  $\text{BF}_3(\text{g}) + \text{NH}_3(\text{g}) \rightleftharpoons \text{NH}_3\text{-BF}_3(\text{s})$   
D.  $2\text{NH}_3(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{l}) + \text{NH}_2^-(\text{l})$   
E.  $3\text{Ni}^{2+}(\text{aq}) + 2\text{Cr}(\text{OH})_3(\text{aq}) + 10\text{OH}^-(\text{aq}) \rightleftharpoons 3\text{Ni}(\text{s}) + 2\text{CrO}_4^{2-}(\text{aq}) + 8\text{H}_2\text{O}(\text{l})$

**Choice of reasons**

- 1) Every acid-base reaction must involve OH<sup>-</sup> and or H<sup>+</sup> ions  
2) the phase of reagents not in water solvents  
3) is a reduction-oxidation reaction  
4) is a depositional reaction  
5) the product produced is not salt and water

**Confidence level**

- I. Sure  
II. Not sure

5. The reactions in question number 4, which are acid-base reactions, according to Brønsted-Lowry, are ...

**Answer choices:**

- A. Reactions A and B  
B. Reactions A and C  
C. Reactions A and E  
D. Reactions B and C  
E. Reaction B and D

*D. Choice of reasons:*

- 1) The ions are ionized into cations and anions  
2) Acid and base compounds dissolved in water solvents  
3) Ionized acid compounds produce hydrogen ions  
4) Co-existence with a pair of free electron pairs  
5) Acid and base compounds undergo proton (H<sup>+</sup>) handover

**Confidence level**

- I. Sure  
II. Not sure

6. The reactions in question number 4, which are acid-base reactions, according to Lewis, are ...

*E. Answer choices:*

- A. Reactions A and B  
B. Reactions A and C  
C. Reactions A and E  
D. Reactions B and C  
E. Reaction B and D

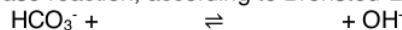
*F. Choice of reasons:*

- 1) Base compounds involve hydroxide ions in their reaction
- 2) Acid and base compounds do not depend on water solvents
- 3) Base compounds donate lone pairs to acidic compounds
- 4) Acid compounds donate lone pairs to base compounds
- 5) Base compounds provide free electron pairs for acid compounds to be used together

**Confidence level**

- I. Sure
- II. Not sure

7. Consider the following acid-base reaction, according to Brønsted-Lowry!



The right compound to complete the acid-base reaction in succession if  $\text{HCO}_3^-$  as a base and  $\text{OH}^-$  as a conjugate base is ...

*G. Answer choices:*

- A.  $\text{OH}^-$  and  $\text{H}_2\text{O}$
- B.  $\text{OH}^-$  and  $\text{CO}_3^{2-}$
- C.  $\text{OH}^-$  and  $\text{H}_2\text{CO}_3$
- D.  $\text{H}_2\text{O}$  and  $\text{CO}_3^{2-}$
- E.  $\text{H}_2\text{O}$  and  $\text{H}_2\text{CO}_3$

*H. Choice of reasons:*

- 1)  $\text{H}_2\text{CO}_3$  accepts protons ( $\text{H}^+$ ) from  $\text{H}_2\text{O}$
- 2)  $\text{OH}^-$  gives protons ( $\text{H}^+$ ) to  $\text{HCO}_3^-$
- 3)  $\text{H}_2\text{O}$  gives protons ( $\text{H}^+$ ) to  $\text{HCO}_3^-$
- 4)  $\text{H}_2\text{CO}_3$  gives protons ( $\text{H}^+$ ) to  $\text{HCO}_3^-$
- 5)  $\text{HCO}_3^-$  receives protons ( $\text{H}^+$ ) from  $\text{H}_2\text{O}$  to  $\text{CO}_3^{2-}$

**Confidence level**

- I. Sure
- II. Not sure

8. Consider the following acid-base reaction!



The conjugate acid-base pair, according to Brønsted-Lowry from the above reaction, is...

*I. Answer choices:*

- A.  $\text{SO}_4^{2-}$  and  $\text{H}_2\text{O}$
- B.  $\text{HSO}_4^-$  and  $\text{H}_2\text{O}$
- C.  $\text{HSO}_4^-$  and  $\text{SO}_4^{2-}$
- D.  $\text{H}_3\text{O}^+$  and  $\text{SO}_4^{2-}$
- E.  $\text{H}_3\text{O}^+$  and  $\text{HSO}_4^-$

*J. Choice of reasons:*

- 1)  $\text{H}_2\text{O}$  accepts protons ( $\text{H}^+$ ) from  $\text{H}_3\text{O}^+$
- 2)  $\text{H}_2\text{O}$  gives protons ( $\text{H}^+$ ) to  $\text{HSO}_4^-$
- 3)  $\text{H}_3\text{O}^+$  gives protons ( $\text{H}^+$ ) to  $\text{SO}_4^{2-}$
- 4)  $\text{SO}_4^{2-}$  acts as a conjugate acid and  $\text{H}_2\text{O}$  as a base
- 5)  $\text{HSO}_4^-$  acts as an acid and  $\text{SO}_4^{2-}$  as its conjugate base

**Confidence level**

- I. Sure
- II. Not sure

9. Sulfide acid solution ( $\text{H}_2\text{S}$ ) has two ionization constant values namely  $K_{a1} = 8.9 \times 10^{-8}$  and  $K_{a2} = 1.2 \times 10^{-13}$ . Species in sulfide acid ( $\text{H}_2\text{S}$ ) solution are ...

**Answer choices:**

- A.  $\text{H}_2\text{S}$ ,  $\text{HS}^-$ ,  $\text{S}^{2-}$ ,  $\text{H}^+$ ,  $\text{OH}^-$ ,  $\text{H}_2\text{O}$
- B.  $\text{HS}^-$ ,  $\text{H}^+$ ,  $\text{OH}^-$ ,  $\text{H}_2\text{O}$
- C.  $\text{S}^{2-}$ ,  $\text{H}^+$ ,  $\text{OH}^-$ ,  $\text{H}_2\text{O}$
- D.  $\text{H}_2\text{S}$ ,  $\text{S}^{2-}$ ,  $\text{H}^+$ ,  $\text{OH}^-$ ,  $\text{H}_2\text{O}$
- E.  $\text{H}_2\text{S}$ ,  $\text{HS}^-$ ,  $\text{H}^+$ ,  $\text{S}^{2-}$ ,  $\text{H}_2\text{O}$

**Choice of reasons:**

- A.  $\text{H}_2\text{S}$  solution is a strong polyprotic acid so that it will ionize completely in one stage
- B.  $\text{H}_2\text{S}$  solution is a polyprotic weak acid so that it will ionize completely in one step
- C.  $\text{H}_2\text{S}$  solution is a polyprotic weak acid so that it will ionize partially in one stage
- D.  $\text{H}_2\text{S}$  solution is a polyprotic weak acid so that it will ionize partially in 2 stages
- E.  $\text{H}_2\text{S}$  solution is a weak acid so it has no base species in the solution.

**Confidence level**

- I. Sure
- II. Not sure

10. A 0.1 grams of  $\text{NaOH}$  solids were dissolved in water to 100 mL at  $25^\circ \text{C}$ . The nature of the solution is ....

11.

**K. Answer choices:**

- A. neutral
- B. bases
- C. acid
- D. can be acidic or basic
- E. can be basic or neutral

**L. Choice of reasons:**

- 1) neutral because the solution has a  $\text{pH} = 7$
- 2) acidic because the solution has a  $\text{pH} > 7$
- 3) acidic because the solution has a  $\text{pH} < 7$
- 4) alkaline because the solution has a  $\text{pH} > 7$
- 5) alkaline because the solution has a  $\text{pH} < 7$

**Confidence level**

- I. Sure
- II. Not sure

12. Valid acid solution with a concentration of 0.01 M turned out to have a  $\text{pH}$  value above 2. The degree of ionization ( $\alpha$ ) of the acid is.....

**M. Answer choices:**

- A. more than 1
- B. less than 1
- C. is equal to 1
- D. is less than equal to 1
- E. More than equal to 1

**N. Choice of reasons:**

- 1) is a monoprotic strong acid and completely dissociated
- 2) is a monoprotic strong acid and partially dissociated
- 3) is acidic weak monoprotic and fully dissociated

- 4) is acidic weak monoprotic and partially dissociated
- 5) is a strong but dilute acid, so the pH value of the solution is high

**Confidence level**

- I. Sure
- II. Not sure

13. Two 150 mL glass bottles, each containing 0.01 M HCl solution and 0.01 M CH<sub>3</sub>COOH solution. Do the two solutions have different acid strengths?

*O. Answer choices:*

- A. Yes                      B. Not

*P. Choice of reasons:*

- 1) Both are acidic solutions with the same acid strength
- 2) The number of binding atoms affects the strength of acids
- 3) The ability to ionize in different waters affects the strength of the acid
- 4) The concentration of the same solution results in the same acid strength
- 5) Acetic acid has more hydrogen atoms compared to hydrochloric acid

**Confidence level**

- I. Sure
- II. Not sure

14. Is the theory of acid-base according to Arrhenius sufficient to explain all substances that are acidic or basic?

*Q. Answer choices:*

- A. Yes                      B. Not

*R. Choice of reasons:*

- 1) Not limited to solvents
- 2) Not to include the smallest things
- 3) Limited to free electron handover
- 4) Limited to the reaction of H<sup>+</sup> and OH<sup>-</sup> in water
- 5) Take and give H<sup>+</sup> occurs in a water solvent

**Confidence level**

- I. Sure
- II. Not sure

15. The researchers found that the pH of mountain water was 6.8 - 7, while in the low region which is a downstream area of the river the pH value of the river was obtained to 9. Based on the illustration, does the change in pH affects the river's water quality?

*S. Answer choices:*

- A. Yes                      B. Not

*T. Choice of reasons:*

- 1) Changes in pH value experienced by the river water does not affect the quality of river water
- 2) Changes in the pH value of river water may be caused by acid rain, thereby reducing water quality
- 3) Changes in the pH value of river water may be caused by household soap waste, thereby reducing water quality
- 4) The change in pH value is due to the pH changing by itself due to differences in water level, thereby improving water quality



- 5) Changes in the pH value of river water may be caused by chemical plant waste containing hydrochloric acid compounds, which is high enough to reduce water quality

**Confidence level**

- I. Sure  
II. Not sure

16. Sulfonic acid solution ( $\text{H}_2\text{SO}_3$ ) and sulfuric acid ( $\text{H}_2\text{SO}_4$ ) in concentrated conditions can cause serious injury if it affects the skin / other body parts. The  $K_{a2}$  values of each acid were  $1.2 \times 10^{-2}$  and  $6.43 \times 10^{-8}$ . A laboratory assistant makes a solution of sulphonic acid with a concentration of 0.1 M and 0.5 M sulfuric acid with the same volume. Is the sulfuric acid solution made by the laboratory assistant stronger than sulfonic acid?

**Answer Choice:**

- A. Yes B. No

**Choice of Reason:**

- 1) The strengths of sulfuric acid and sulfonic acid are the same or almost the same because they are strong acids.
- 2) Sulfuric acid is stronger than sulfonic acid because the value of  $K_a$  sulfuric acid is greater than sulfonic acid.
- 3) Sulfuric acid is stronger than sulfonic acid because there are more O atoms in sulfuric acid.
- 4) Sulfuric acid is stronger than sulfonic acid because of its greater concentration.
- 5) Sulfuric acid is stronger than sulfonic acid because the pH of sulfuric acid is greater than the pH of sulfonic acid.

**Confidence level:**

- I. Sure  
II. Not sure

17. A total of 10 mL of 0.1 M cyanide acid ( $\text{HCN}$ ) solution ( $K_a = 4.9 \times 10^{-10}$ ) mixed with 10 mL of pyridine ( $\text{C}_2\text{H}_5\text{N}$ ) 0.1 M ( $K_b = 1.7 \times 10^{-9}$ ) produce saline solution. Is the pH of the salt solution equal to 7?

**Answer Choice:**

- A. Yes  
B. Not

**Choice of Reasons**

- A. Both of these solutions react appropriately (both equivalent moles are the same)
- B. The salt solution comes from weak acids and weak bases
- C.  $K_a$  and  $K_b$  values do not affect the nature of the solution
- D. The salt solution is acidic because the value of  $K_a$  cyanide acid is smaller than the pyridine base
- E. The salt solution is basic because the value of  $K_a$  cyanide acid is smaller than the pyridine base

**Confidence level:**

- I. Sure  
II. Not sure

18. There are two acid solutions, acetic acid ( $\text{CH}_3\text{COOH}$ ) solution of 200 mL ( $K_a = 1 \times 10^{-5}$ ) has a dissociation degree of 1% and 200 mL of  $5 \times 10^{-4}$  M sulfuric acid ( $\text{H}_2\text{SO}_4$ ) solution. Are both of the solutions have the same pH value?

**Answer choices**

- A. Yes
- B. Not

**Choice of reasons**

- 1) both of these solutions have the same concentration
- 2) the concentration of acetic acid is greater than sulfuric acid
- 3) sulfuric acid is diprotic acid so that the acid pH value is lower
- 4) The pH of weak acids and strong acids is always different
- 5) the amount of  $H^+$  and  $OH^-$  ions in the two solutions is the same

**Confidence level:**

- I. Sure
- II. Not sure

19. The following compounds in water that provide the most powerful alkaline properties are....

**Answer choices**

- A.  $CH_3CH_2CHO$
- B.  $CH_3CH_2CH_2OH$
- C.  $CH_3CH_2CO_2H$
- D.  $CH_3CH_2CH_2NH_2$
- E.  $CH_3COCH_3$

**Choice of reasons**

- 1) Base compounds are compounds that have the -OH group
- 2) The less the number of H atoms the more alkaline
- 3) The -NH<sub>2</sub> group gives the basicity of nature stronger than the -OH group
- 4) The -NH<sub>2</sub> group gives basic properties weaker than the -OH group
- 5) Cluster =O gives a stronger nature than the -OH group

**Confidence level:**

- I. Sure
- II. Not sure

20. Hydrogen fluoride (HF) compounds in water are weak acids. A 0.1 mol of HF was dissolved in 500 mL of solution and the  $K_a$  value was  $6.5 \times 10^{-4}$ , was the pH of the solution less than 2?

**Answer choices:**

- A. Yes
- B. Not

**Choice of reasons**

- 1)  $K_a$  HF is more than  $10^{-4}$  so the pH value of HF is always more than 2
- 2) The concentration of the solution is 0.1 M
- 3) The concentration of the solution is 0.2 M
- 4) The higher the pH the weaker an acid, and HF is a weak acid
- 5) Volume does not affect the pH value

**Confidence level:**

- I. Sure
- II. Not sure

21. A total of 100 mL of 0.1 M NaOH solution was reacted with 100 mL of 0.1 M  $H_2SO_4$  solution, was the resulting solution neutral?

**Answer choices**

- A. Yes
- B. Not

**Choice of reasons:**

- 1) The reaction is an acid and base reaction which produces a neutral solution
- 2) The reaction is a reaction of strong acids and strong bases and produces a neutral solution
- 3) The concentrations of the two reactants are the same so the solution will be neutral
- 4) In this reaction, the number of moles of acid and base reacting is equivalent
- 5) In this reaction, the number of moles of acid and base that reacts is not equivalent

**Confidence level:**

- I. Sure
- II. Not sure

# The Effectiveness Of The Refutation Text To Improve Understanding Of The Acid-Base Concepts For High School Students

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## GRADEMARK REPORT

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FINAL GRADE

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GENERAL COMMENTS

**Instructor**

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