Students' Misconceptions on Acid-Base Chemistry

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أخطاء الطلاب حول الكيمياء الحمضية المفتوحة

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الملخص

هذه المقالة درست مسألة سوء الفهم في درس كيمياء الأحماض المفتوحة لدى طلّاب الثانويات في محافظة أذربيجان الغربية. شملت عينة الدراسة ٢٦٤ طالباً في الصف الثاني عشر من ستّ مدارس مختلفة في أذربيجان الغربية بناءً على التحقق من صحتها. تهدف هذه الدراسة إلى تحديد سوء فهم الطلّاب في معرفة كيمياء الأحماض المفتوحة. من أجل تحقيق هذا الهدف ، تم استخدام الأسئلة التشخيصية المفتوحة والمقابلات شبه المنظمة. تم تعيين استبيانات تشخيصية على ٢٦٤ طالبا في الصف الثاني عشر في فرع العلوم التجريبية. بالإضافة إلى ذلك، تمت المقابلة مع ٣٦ طالبًا. تمّت مناقشة المفاهيم وتصوّرات الطلاب المطروحة في الاختبار والمقابلات. تشير النتائج إلى أن الطلاب يحفظون بكل قوتهم قدرًا كبيرًا سوء الأفهام، وأن هذه الأخطاء لا تتأثر بمناهج التدريس التقليدية، فلهذا يلزم التغيير في المناهج التدريسية. يجب على المعلمين أن يكونوا على دراية بسوء أفهام الطلاب على صعيد الأحماض المفتوحة. لا يتعلم الطلاب المفاهيم الجديدة إذا لم يتم تصحيح الأخطاء. والخلاصة هي أنّ استخدام الأساليب الملائمة في التدريس خاصة في تدريس الأحماض المفتوحة، قضي بشكل كبير على قسم من أخطاء الطلاب وسوء أفهامهم.

الكلمات المفتاحية: المفاهيم الخاطئة لدى الطلاب ، تعليم الكيمياء ، كيمياء القاعدة الحمضية ، التعلم النشط.

Abstract

In current study , Students' misconceptions were investigated on acid-base chemistry at senior high schools in West Azerbaijan. The study involved ٢٦٤ of XII grade students from six different schools in west Azerbaijan selected based on their accreditation. This study is aimed at determining students' misconceptions about acids and bases. In order to fulfill this aim, open-ended diagnostic questions and semi-structured interviews were used. The diagnostic questions were administered to ٢٦٤ students experimental science field senior high schools in Iran. In addition 36 students were interviewed in order to clarify their written responses and to further probe students' conceptual understandings of the questions asked in the test. The findings revealed a number of misconceptions. The results have implications for education acid-base chemistry, suggesting that a substantial review of teaching strategies is needed. Teachers should be aware of students' prior knowledge and misconceptions on acids and bases, because they are strong predictors of student achievement. In short, when suitable strategies are used in the teaching of the unit acids and bases', they are more likely to cause a significantly better removal of misconceptions and acquisition of scientifically sound concepts.

Key words: students' misconceptions, chemistry education , acid- base chemistry, active learning .

Introduction

Studies has indicated that students often construct their own theories about how the natural world works, prior to formal science education, but their theories are frequently contrary to those of scientists (Osborne et al., 1985). Students' self-constructed conceptions have been referred to in the literature as misconceptions, alternative conceptions, preconceptions, naive conceptions etc (Driver et al., 1987;

Krishnan et al., 1994; Demircioğlu et al., 2001). Throughout this article, the term 'misconceptions' has been used to refer to these ideas that are not in agreement with accepted scientific ideas. Many factors can be considered as the sources of students' misconceptions. Previous experiences of the student, common use of some terms in scientific and non-scientific languages, not paying attention to the terms used in the class, contexts and images in the textbooks, teaching method, etc. are all effective in forming misunderstandings in the students (Muchtar , Z & Harizal, 2012). In science classroom, students bring their prior knowledge from the outside and sometimes relate their prior knowledge to what teacher explains improperly. Therefore, the concepts they construct cannot correctly explain the scientific phenomena and, finally, deviate from scientific concepts. These differences between the students' views and the scientifically accepted views are called misconceptions (Ozmen, 2004; Barke et al., 2009), traditional instructional language (Bergquist et al., 1990), teachers, mismatches between teacher and student knowledge of science (Hodge, 1993), chemical terms that have changed their meaning (Schmidt, 1999; Schmidt et al., 2003) and textbooks (Stake et al., 1978). Misconceptions are resistant to change, persistent, and difficult to extinguish even with instruction designed to address them. Also, the misconceptions learners may hold generally hinder their subsequent learning (Ben-Zvi et al., 1986; de Vos et al., 1987; Haidar et al., 1991; de Posada, 1997). So, learners' misconceptions should be taken into consideration in the developing of science curricula. Unfortunately, many of the current science curricula and textbooks have not addressed the persistence of any misconceptions. Because misconceptions is helping students about their environment , they can hardly be changed, thus they interfere with the learning process. Whatever teachers have more information about students' misconceptions , they can better prepare them for learning . It can argued that the identification of the students' misconceptions is a fundamental and important step in avoiding of students' misconceptions scientific topics particularly chemistry field .Bodner (1986), in his discussion of the constructivist approach to chemical education, suggested that knowledge cannot simply be handed down from instructor to students must actively construct knowledge from new information and their existing experiences and knowledge.Students use their existing knowledge base to evaluate new information; if the new information is consistent with this existing knowledge base, it can be assimilated. However, if the new information contradicts it, the knowledge base must be changed to accommodate the new information. Because knowledge is constructed by the student (Resnick, 1983; Jonassen, 1991), any erroneous information that is part of the student's knowledge base may adversely affect subsequent learning.Researches show that students can develop scientifically incorrect conceptions as labeled "misconceptions" during the traditional lessons (Jonassen, 1991).Because active learning is based on constructivism and constructivist learning theory clearly states that every learner actively builds or constructs their own private understanding, it has a great role on preventing misconceptions (Bodner, 1986). Chemistry is sometimes viewed as a difficult subject by students. The chemistry concepts itself are really complex and abstract (Stieff & Wilensky, 2003). Chemistry also makes students go between macroscopic representations, submicroscopic (or molecular) representations, and symbolic (or iconic) epresentations simultaneously (Johnstone, 2000; Chandrasegaran et al., 2007). In order to get deep and comprehensive understanding in learning chemistry, students need to comprehend those three representations of chemistry. Any chemistry teaching that cannot relate these three chemistry representation properly will have great possibility to create misconceptions in students and make them cannot fully understand the concept.In general term, misconceptions could be defined as any conceptions that are in disagreement or different with currently accepted scientific view. Various sources of misconceptions have been found and explained such as students (Suparno, 2005), teachers (Suparno, 2005; Drechsler & Schmidt, 2005), textbooks (Pedrosa & Dias, 2000; Chiu, 2005; Sanger & Greenbowe, 1999), teaching method (Tasker & Dalton, 2006), and internet (Sesen & Ince, 2010). Talanquer (2006) had also explained how the way students think about chemical substances and phenomena underlying the misconceptions based on commonsense explanatory framework.Some of these misconceptions can be removed easily, but most of them are strongly held by students and

usually not affected by regular classroom teaching because these are something students believe. If the misconceptions are not corrected, new concepts would be difficult to be learnt (Gonen & Kocakaya, 2010).The objective of this research was to identify senior high school students' misconceptions about concepts of acid-base chemistry and to determine which misconceptions in basic chemistry concepts causing difficulties in learning the concepts of acid-base chemistry at senior high schools in West Azerbaijan. because Identifying misconception of students is the first step for preventing misconceptions in chemistry.

Method

The research was conducted qualitatively by using questionnaire in form Acid-Base Chemistry Misconception Test as the instrument to obtain and indentify misconceptions in acid-base chemistry topic.A diagnostic test composed of ten open-ended questions was specifically developed for this study (see Appendix). Question 1 required students to predict the pH of pure water at two different temperatures. Students' understanding of neutral solution was questioned by the second question. Question 3 was used to find out whether students predict the pH of excessively diluted solution of a strong acid. Question 4 tested students' understanding of neutralization of a strong base and a weak acid. Question 5 tested students' understanding At the end of all neutralization reactions .Question 6 tested students' misconception about strong acid and concentrated acid .Question 7 was about misconception " Polyprotic acid behaves as strong monoprotic acid " Question 8 was about the chemical formula of acids and bases .

Question 9 was about properties of acids and bases . Finally, question 10 aimed to explore students' understanding of the hydrolysis concept. All questions were piloted and required modifications were made prior to the administration of the test. The content validity of the test questions was assessed by six chemistry lecturers. The questions were administered to 264 of XII grade students from six different schools in west Azerbaijan.The test was conducted under normal class conditions without previous warning. The students were confirmed that the results of the test would be used for research purposes and would be kept confidential. Students' responses to the diagnostic questions were analyzed. Misconceptions were determined and percentages were calculated. In addition, 36 students were interviewed in order to clarify their written responses and to further probe students' conceptual understandings of the ideas tested in the questions asked in the test. Interviewees were selected on the basis of their responses given to the test. If a student presented a misconception and did not provide detailed or clear explanation to his/her response was requested to interview. Interview time was varied between 20 minutes and half an hour. All interviews were tape recorded after taking the interviewees' consent and transcribed for analysis. The interviews were not submitted to detailed analysis, instead they were used in order to exemplify the misconceptions throughout the results section during discussion. As the interviews were conducted in Iran, the quotations reported in the paper were translated into English by the author.

Results and Discussion

Table 1. Students' misconceptions identified through students' written responses. (N=264)

Students' misconceptions		f	%
1	Equilibrium system in acidic or basic solution is not affected by the temperature :	-	↓
1a	pH of pure water is always equal to 7	164	62
1b	Neutral solution is equivalent with pH = 7 (Halstead, 2009)	145	55
1c	K_w water equals to 1.0×10^{-14}	172	65
2	In calculation of pH using the formula pH = -log[H3O+], [H3O+] is just from the solute (A solution of 10^{-8} M HCl has a pH of 8)	185	70
3	Neutralization of acid and base always gives a neutral product	106	40

4	In a neutralization reaction, when one of the reactants (acid or base) is weak,the neutralization does not completely take place	137	52
5	All salts are neutral	158	60
6	Hydrolysis is to being separated of a matter into its ions by water	195	74
7	A strong acid is always a concentrated acid	172	65
8	At the end of all neutralization reactions ,there are neither H^+ nor OH^- ions in the resulting solutions	111	42
9	As the number of hydrogen atoms increases in the formula of an acid, its acidity becomes stronger	153	58
10	Species having formulas with hydrogen are acids and those having formulas with hydroxyl are bases :	-	↓
10a	PH_3 is an acidic compound	116	44
10b	NaH is an acidic compound	95	36
10c	$B(OH)_3$ is an basic compound	180	68
11	Acids burn and melt everything	145	55
12	The only way to test a sample whether it is an acid or a base is to see if it eats something away	106	40
13	Bubbles or bubbling is a sign of chemical reaction or strength of an acid or a base	127	48
14	Bronsted-Lowry theory can explain all acid-base reaction	180	68

The results of the students' written responses to question 1 (see Table 1) revealed that 62% of the students considered that pure water always has a pH of 7. In other words, they believed that the pH of pure water is the same (7) at different temperatures, although the pH of pure water is 7 only at 25oC. This kind of reasoning of the students suggests that they did not consider the temperature effect on ionic product of water and of course, on its pH. The following excerpt from a student's interview exemplifies this notion (T and S used for Teacher researcher and student, respectively):

T: What can you say about the value of the pH of pure water?
S: It is 7.
T: Could you please explain, why?
S: I know that pure water is neither basic nor acidic, it is neutral. To be neutral, the pH should be 7… Yeah I said, if water has a pH of 7, it is neutral.
T: OK. What would you say about the pH of pure water at different temperatures?
S: …must be same. It is 7.
T: … should water have different degree of dissociation at different temperatures?
S: I don't think so. At any temperature, water would dissociate so that the concentrations of H+ and OH^- will be same, 10^{-7} M.
T: Why do you think so?
S: Because, in order for water to be neutral, its pH must be 7.

As can be clearly seen from the above dialogue, without considering the temperature effect on ionization constant of water, the respondent stated that at every temperature, the degree of dissociation of water would be the same. One possible reason for holding this misconception could be attributed to the fact that during instruction, when the related topics were being presented, no or insufficient emphasis of the temperature effect was placed on the pH value of water. Also, in solutions of related exercises and problems, only saying that a pH of 7 means neutrality could cause the above misconception for the students, as can be seen in the following excerpt from a student's interview:

"…from all exercises and problems I have experienced, I know that pure water has a pH of 7"

The above situation is not different also for chemistry textbooks. The following statement from a chemistry textbook (Fine and Beall, 1990, p.422) reflects this:

"pure (neutral) water has a pH of 7; pH values lower than 7 represent acidic solutions; and pH Values higher than 7 represent basic solutions"

without referring to the temperature effect on pH values.

In addition, one possible reason for omitting temperature effect on equilibrium constant of water can be attributed to the use of different terms, in different examples, for naming the same concept. In other words, the students could probably be unaware that "ionic product of water" stands for the "equilibrium constant for dissociation of water". As indicated by Selvaratnam (1993), terms such as ionic product, solubility product, dissociation constant…etc should be used in terms of the equilibrium constant. This would help simplify learning, emphasizing that the same principles are involved in all types of equilibria, otherwise it complicates the learning of chemistry. Anecdotal evidence also supports this notion. Question 2 revealed a misconception that the pH of a neutral solution is always 7. This view held by 55% of the students supports the findings above mentioned, because it can be clearly said that also for this case, the students did not consider temperature effect on pH. A typical dialogue from an interview is representative of this notion:

T: Could you please define neutral solution?
S: It is a solution which has a pH of 7… like pure water.
T: Is it possible for the pH of a neutral solution to be higher or lower than 7?
S: No, then the solution would not be neutral. To be neutral, its pH should be 7… whatever done, it is impossible to change the value of neutral pH.

From the above dialogue, it is suggested that the students' reasoning behind this misconception is the same as that in previous misconception. The findings about the misconceptions mentioned above is consistent with those in the work of Demerouti et al (2004) with twelfth-grade students in which it was reported that the neutrality concept seemed to confuse the students so that the majority of them defined this concept in terms of the pH= 7 value.

Question 3 required students to predict the pH of a solution of 10^{-8} M HCI. The majority of the students (70%) reasoned that the pH of the solution would be 8. The students' written responses about this question showed that they simply used the equation of $pH = -Log\ [H^+]$ to find out the pH of the solution, as indicated in the following excerpt from one of the written responses:

" $HCI \rightarrow H^+ + C\ l^-$ pH=-Log $[H^+]$ => pH=-Log [10-8] and so, pH= 8 "
$[H^+] = 10^{-8}$

The analysis of the students' written responses showed that many students tended to leave the explanation section of this question blank rather than giving reasoning for their answers. This is similar in the interviews in which they repeated some of the statements from their written responses. The following excerpt from one interview confirms this rationale:

S: …according to pH=-Log [H+], pH will be 8.
T: but, this is an acid solution, isn't it?
S: yeah…but the equation says that its pH is 8.
T: then, in this case, how can you explain that an acid solution has a pH of 8?
S: I don't know…

However, the results of interviews and written responses revealed that few students reasoned that the pH of the solution is 8, because it is too dilute. In addition, the students stated that if an acid solution was getting dilute, the pH of the solution would be over 7. The following excerption taken from one of the students' responses best exemplifies this approach:

S: …its pH would be 8.
T: but, this is an acid solution, isn't it?
S: Yeah.

T: then, in this case, how can you explain that an acid solution has a pH of 8?
S: for example…let's… consider a solution of 10-5M HCI. If we diluted it ten times, the pH would be 6; again diluted ten times, the pH would be 7; again diluted ten times, the pH would be 8.
A quotation from another student's interview is similar:

"…If we added a large amount of water into this solution, we can make the pH of 8"

This misconception had been also revealed in a previous work in which it was reported that the students holding the misconception assume that the strong acid determines the pH and some took into account only the acid ionization (Demerouti et al. 2004). As they said, in the case of low acid concentration, the ionization equilibrium of water is important and should be taken into account. Two common misconceptions relating to the neutralization concept were determined from students' responses to Question 4. The one held by 40% of the students was that the neutralization of acid and base always gives a neutral product. This misconception suggests that the students thought that all salts are neutral. The following excerpt from a student's interview best exemplifies this notion:
S: all neutralization reactions result in neutral solution.
T: Please explain why.
S: the products are water and salt…and we know water is neutral… also salt is neutral because its structure contains no H+ or OH- which can ionize and so, the resulting solution would be neutral.
T: for a salt, is it possible to be acidic or basic?
S: No, because it is only a salt. If it was acidic or basic, then we should call acid or base, not salt.

The above finding was similar to that of Schmidt (1991), and Ross and Munby (1991), in which it was stressed that most of the students misunderstood the concepts of neutralization and neutrality, and they suggested that the reason of this misconception was that students failed to realize the central role of water in neutralization reactions. The results also indicated that some of the students of this study showed semantic understanding in their explanation of neutralization concept; in a neutralization process, a neutral product will occur. Schmidt (1997) also pointed out the negative influence of the term "neutralization" which described reactions that leave neither acid nor base and indicated that students have difficulties in understanding neutralization of a strong acid by a weak base. The following quotation from an interview dialogue supports this notion.

"…this is neutralization, and it is clear that this causes neutral products."

The misconception indicated that the students had the idea that acid and base consumes each other completely in all neutralizations namely every neutralization yields a neutral solution. As reported by Schmidt (1991), the reason for this can probably be attributed to introducing students to eutralization reactions through examples where strong acids react with strong bases to give a neutral solution. The other misconception revealed by question 4 is that in a neutralization reaction, when one of the reactants (acid or base) was weak, the neutralization does not completely take place and the strong one (acid or base) determines the pH of the resulting medium. Relating to the question 4. 52% of the students stated that the pH would be over 7, indicating that after sodium hydroxide neutralized the initially ionized part of the weak acid, there will be excess hydroxide ions in medium and this causes basic pH. This view clearly suggests that the students consider that after the initially ionized part was neutralized, the weak acid will not ionize any more. The following quotation from an interview dialogue emphasis this kind of view:
S: ... here acid and base cannot completely consume each-other. Because, we know that the acid partly ionizes and the ionized part will be neutralized. After this, there still will be acid and base.
T: OK. Will neutralization stop after the initially ionized part of the acid was consumed?
S: Yeah… because, there is no H^+ any more.
T: What you think, will the rest of the acid dissociate to give more H^+?
S: No... I don't think so.
...
T: Could you please explain why the pH will be over 7?

S: There will be plenty of OH^- ions from potassium hydroxide. This causes the basic pH of the solution.

The above dialogue demonstrates leads us to suggest that the student had possibly failed to extend the application of the principles of chemical equilibrium to the ionization equilibrium of a weak acid. However, some of the students did not provide logical explanations, but only said that the pH will be determined by the stronger between the acid and the base. The following written response of a student indicates this notion:

"…acid is weak, base is strong. So, the solution will have basic pH "

With regard to the above misconception, Demerouti et al. (2004) reported similar findings. They found out that the respondents believed that for its neutralization, a strong base requires more moles of a weak acid than that of a strong acid.

The other misconception revealed by question 5 is that in a neutralization reaction, At the end of all neutralization reactions, there are neither H^+ nor OH^- ions in the resulting solutions .

T: what is happening At the end of all neutralization reactions?

S: At the end of all neutralization reactions, there are neither H^+ nor OH^- ions in the resulting solutions

The misconception indicated that most of the students,failed to realize the central role of water in neutralization reactions. The concentration of $H3O^+$ and OH^- ions in the neutral aqueous solution is about 10^{-7} mol/l. Therefore, neutral doesn't mean that the two are not present in the medium. In the literature, Schmidt' s (1991, 1997) suggestion for the reason of this misconception was that students misunderstood the concepts of neutralization and neutrality.

The other misconception revealed by question 6 is that in A strong acid is always a concentrated acid

T: Is A strong acid always a concentrated acid ?

S: yes because concentrated acid is more hydrogen .

The other misconception revealed by question 7 is that in Polyprotic acid behaves as strong monoprotic acid

T: Are all Polyprotic acids stronger then monoprotic acids?

S: yes , As the number of hydrogen atoms increases in the formula of an acid, its acidity becomes Stronger and Polyprotic acid is ionized in one step ionization reaction also Polyprotic acid is ionized in one step ionization reaction .

The other misconception revealed by question 8 is that in Species having formulas with hydrogen are

acids and those having formulas with hydroxyl are bases . (Halstead, 2009)

T: NaH , CH_4 , $B(OH)_3$ and PH_3 acidic compounds are or basic compounds ?

S: NaH , CH_4 and PH_3 The compounds are acidic because they have hydrogen in their structure

But $B(OH)_3$ is an base because there is a hydroxyl in the formula .

The other misconception revealed by question 9 what is acid ? what is base ?

T: What do you know about acids and bases ? Explain your answer as carefully as you can.

S : Acids burn and melt everything also All acids and bases are harmful and poisonous .

Bubbles or bubbling is a sign of chemical reaction or strength of an acid or a base .

The results of the final question revealed a common misconception about the hydrolysis concept. 74% of the students considered that in hydrolysis, water causes the separation of substance ions. This suggests that these students regard hydrolysis as the ionic dissolution of substances in water. The following excerpt shows this view:

S: …hydrolysis is a compound to be separated of into its ions by water.

T: Could you please give an example?

S: like, KCI + Water ? K^+ + CI^-

T:This is dissolution, isn't it?

S: Yeah...but please pay attention that in that case, the solvent is water.

T: What do you mean? Please, explain more.

S: Yeah…I mean that it is a specific situation of dissolution… I think dissolution in water is specifically
called hydrolysis.

In the above dialogue it can be seen that the student consider hydrolysis as a sub-concept of dissolution concept. Because, the students holding this view used the term hydrolysis only in the case of dissolution of an ionic matter in water, excluding molecular dissolution, as clearly indicated in the following quotation:

S: … if ionization takes place in water, this is called hydrolysis.
T: What about dissolving of sugar in water? Is that also a hydrolysis?
S: No, there is no ionization in dissolving of sugar, so no hydrolysis.

Conclusions and Implications

The results of this study showed that Iranian students senior high schools have a number of common misconceptions in the topic of acids and bases. These can be summarized as:

- pure water (or a neutral solution) has always a pH of 7;
- the pH of an acid solution that is excessively diluted can be over 7;
- all salts are neutral in terms of acidity-basicity;
- the neutralization of a strong base by a weak acid (and vice versa) does not proceed to completion (even if the reactants are in stoichiometric amounts), hence the resulting solution is basic (or acidic);
- At the end of all neutralization reactions, there are neither H_3O^+ nor OH^- ions in the resulting solutions .
- At the end of all neutralization reactions ,there are neither H^+ nor OH^- ions in the resulting solutions
- A strong acid is always a concentrated acid
- Polyprotic acid behaves as strong monoprotic acid
- Species having formulas with hydrogen are acids and those having formulas with hydroxyl are bases
- The only way to test a sample whether it is an acid or a base is to see if it eats something away
- Bubbles or bubbling is a sign of chemical reaction or strength of an acid or a base
- Bronsted-Lowry theory can explain all acid-base reaction
- hydrolysis is considered as being the separation of a substance into ions by water.

Teachers should be aware of students' prior knowledge and misconceptions on acids and bases, because they are strong predictors of student achievement. In short, when suitable strategies are used in the teaching of the unit 'acids and bases', they are more likely to cause a significantly better removal of misconceptions and acquisition of scientifically sound concepts. In addition, chemistry teachers should be encouraged to prepare teaching materials related to the other chemistry topics in the light of the models of Context-based approach and conceptual change . We have concluded that the Students' misconceptions of the concepts of the acids and bases generally originated from their experiences in everyday life. So, when preparing a teaching program and student-activities on the concepts, it is very important to include everyday substances in the activities. The written responses given by the students revealed several misconceptions that probably affect the quality of their learning in typical chemistry classes. In addition, the data from the students' nterviews showed that in many cases their understanding of basic concepts is limited,distorted, wrong, or missing entirely. In the light of this evidence, chemistry instructors may sometimes overestimate their students' understanding of basic acid-base concepts. It is clear that instructors should consider supplementing the lecture format with a variety of activelearning teaching strategies that would encourage the students to become aware of their misconceptions. Instructors also would benefit from knowing their students' misconceptions and by making efforts at remediating them.

Misconceptions study that have been conducted show several difficulties in learning acid-base chemistry. At least, there are four main issues that could be addressed in this analysis namely fragmentation of students' understanding, problems with symbols and mathematical formula, difficulties in understanding the context in acid-base chemistry, and problems in generalization. The

results of analysis in students' misconception could be used as references for chemistry teachers for identifying students' misconception in classroom. Teachers should be aware of students' prior knowledge and misconceptions on acids and bases, because they are strong predictors of student achievement.In short, when suitable strategies are used in the teaching of the unit 'acids and bases', they are more likely to cause a significantly better removal of misconceptions and acquisition of scientifically sound concepts. Further investigations about students' misconceptions on acid-base chemistry topic are suggested using various methods to get better data analysis. Considering the importance in collecting the data of students' misconceptions, it is also suggested for other researchers to investigate students' misconception for other topics in chemistry.

References

[1] Osborne R. and Freyberg P., (1985), Learning in Science: The Implication of Children's Science, Heinemann, London.

[2] Driver R. and Easley J., (1978), Pupils and paradigms: a review of literature related to concept development in adolescent science students, *Studies in Science Education*, 5, 61-84.

[3] Krishnan S. R. and Howe A. C., (1994), The mole concept: developing on instrument to assess conceptual understanding, *Journal of Chemical Education*, **71**, 653 . 655.

[4] Demircioğlu G., Özmen H. and Ayas A., (2001), Kimya öğretmen adaylarõnõn asitler ve bazlarla ilgili yanlõş anlamalarõnõn belirlenmesi, Yeni Binyõlõn Başõnda Türkiye' de Fen Bilimleri Eğitimi Kongresi, T.C. Maltepe University, 7-8 October 2001, İstanbul.

[5] Muchtar , Z & Harizal ., (2012), Analyzing of Students' Misconceptions on Acid-Base Chemistry at Senior High Schools in Medan, Journal of Education and Practice Vol 3, No 15.

[6] Ozmen, H. (2004), Some Student Misconceptions in Chemistry: A Literature Review of Chemical Bonding, *Journal of Science Education and Technology*, **13(2)**, 147-159.

[7] Barke, H.D., Hazari, A., & Yitbarek, S. (2009), *Misconceptions in Chemistry, Addressing Perceptions in Chemical Education*, Berlin: Springer.

[8] Bergquist W. and Heikkinen, H., (1990), Student ideas regarding chemical equilibrium, *Journal of Chemical Education*, **67**, 1000-1003.

[9] Hodge R., (1993), *Teaching as communication*, Longman, Harlow.

[10] Schmidt H.J., (1999), Should chemistry lessons be more intellectually challenging? *Chemistry Education: Research and Practice in Europe*, 1, 17-26.

[11] Schmidt H.J., Baumgartner T. and Eybe H., (2003), Changing ideas about the periodic table of elements and students. alternative concepts of isotopes and allotropes, *Journal of Research in Science Teaching*, 31, 621-637.

[12] Stake R. E. and Easley J. A., (1978), *Case studies in science education*. Urbana, IL: University of Illinois, Center for Instruction Research and Curricular Evaluation.

[13] Ben-Zvi R., Eylon B.R. and Silberstein, J., (1986), Is an atom of copper malleable? *Journal of Chemical Education*, **63**, 64-66.

[14] de Vos W., and Verdonk A.H. (1987), A new road to reaction: Part 4. The substance and its molecules, *Journal of Chemical Education*, 64, 692-694.

[15] Haidar A.H. and Abraham M.R., (1991), A comparison of applied and theoretical knowledge of concepts based on the particulate nature of matter, Journal of Research In Science Teaching, 29, 277-299.

[16] de Posada J.M., (1997). Conceptions of high school students concerning the internal structure of metals and their electric conduction: structure and evolution, *Science Education*, **81**, 445-467.

[17] Bodner, G. (1986). Constructivism: a theory of knowledge. Journal of Chemical Education, 63, 873–878.

[18] Resnick, L.B. (1983). Mathematics and science learning: a new conception. Science, 220, 477–478.

[19] Jonassen, D.H. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm? Educational Technology Research and Development, 39, 5–14.
[20] Stieff, M., & Wilensky, U. (2003), Connected Chemistry-Incorporating Interactive Simulations into the Chemistry Classroom, Journal of Science Education and Technology, 12(3), 285-302.
[21] Johnstone, A.H. (2000), Teaching of Chemistry-Logical or Psychological?, Chemistry Education: Research and Practice in Europe, 1(1), 9-15.
[22] Chandrasegaran, A.L., Treagust, D.F., & Mocerino, M. (2007), The Development of A Two-Tier Multiple-Choice Diagnostic Instrument for Evaluating Secondary School Students' Ability to Describe and Explain Chemical Reactions Using Multiple Levels of Representation, Chemistry Education Research and Practice, 8(3), 293-307. Research in Science Education, 34, 107-123.
[23] Suparno, P. (2005), Miskonsepsi dan Perubahan Konsep dalam Pendidikan Fisika, Jakarta: Grasindo.
[24] Drechsler, M., & Schmidt, H. J. (2005), Textbooks' and Teachers' Understanding of Acid-Base Models Used in Chemistry Teaching, Chemistry Education Research and Practice, 6 (1), 19-35
[25] Pedrosa, M.A., & Dias, M.H. (2000), Chemistry Textbooks Approaches to Chemical Equilibrium and Student Alternative Conceptions, Chemistry Education: Research and Practice in Europe, 1(2), 227-236.
[26]Chiu, M.H. (2005), A National Survey of Students' Conceptions in Chemistry in Taiwan, Chemical Education International, 6(1), 1-8
[27] Sanger, M.J., & Greenbowe, T.J. (1999), An Analysis of College Chemistry Textbooks as Sources of Misconceptions and Errors in Electrochemistry, Journal of Chemical Education, 76(6), 853-860.
[28] Tasker, R., & Dalton, R. (2006), Research into Practice: Visualization of the Molecular World Using Animations,Chemistry Education Research and Practice, 7(2), 141-159.
[29] Sesen, B.A., & Ince, E. (2010), Internet as A Source of Misconception: "Radiation and Radioactivity," *Turkish Online Journal of Educational Technology,* **9(4)**, 94-100.
[30] Talanquer, V. (2006), Commonsense Chemistry: A Model for Understanding Students' Alternative Conceptions,Journal of Chemical Education, 83(5), 811-816.
[31] Gonen, S., & Kocakaya, S. (2010), A Physics Lesson Designed According to 7E Model with the Help of Instructional Technology (Lesson Plan), Turkish Online Journal of Distance Education, 11(1), 98-113.
[32] Selvaratnam, M. (1993). Coherent, concise, and principle-based organization of chemical knowledge. Journal of Chemical Education, 70, 824-826.
[33] Demerouti, M., Kousathana, M. and Tsaparlis, G. (2004). Acid-base equilibria, Part I. Upper secondary students' misconceptions and difficulties. The Chemical Educator, 9, 122-131.
[34] Schmidt, H.J. (1991). A label as a hidden persuader: chemists' neutralization concept. International Journal of Science Education, 13, 459–471.
[35] Ross, B. and Munby, H. (1991). Concept mapping and misconceptions: A study of high school students' understanding of acids and bases. International Journal of Science Education, 13, 11–23.
[36] Schmidt, H.J. (1997). Students' misconceptions- Looking for a pattern. Science Education, 81, 123-135.

Appendix :

Questions	
1	Compare the pH values of pure water at 25^{o}C and 70^{o}C. Explain your answer as carefully as you can.
2	What is a neutral solution? Explain your answer as carefully as you can.
3	Predict the pH value of a solution of 10^{-8} M HCl. Explain your answer as carefully as you can.
4	At 25oC, when equal amounts of 0, 1 M KOH (aq) and 0, 1 M CH_3COOH(aq) are mixed, what about the pH of medium? a) pH > 7 b) pH = 7 c) pH < 7
5	what is happening At the end of all neutralization reactions?
6	Is A strong acid always a concentrated acid ?
7	Are all Polyprotic acids stronger then monoprotic acids?
8	NaH , CH_4 , $B(OH)_3$ and PH_3 acidic compounds are or basic compounds ?
9	What do you know about acids ? Explain your answer as carefully as you can.
10	What is hydrolysis? Explain your answer as carefully as you can.