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# Analysis of students' mental models using the flipped classroom learning model

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**Abstract:** This research analyses the flipped classroom learning model on students' mental model on salt hydrolysis material. This research was conducted at SMAN 1 Ulu Barumun, Padang Lawas Regency. The research subjects were 11th-grade science students, totalling 20 students. The study used a two-tier test instrument, student observation, and in-depth interviews. The results showed that most students achieved the scientific mental model (38.33%), which reflects deep understanding and the ability to connect concepts with phenomena scientifically. In addition, 31.52% of students were at the synthesis mental model, where they began to understand the concept, but there were still misconceptions. Meanwhile, 30.13% of students were in the initial mental model, with limited and inaccurate understanding. Factors such as teacher explanation, learning experience, and learning resources used play an important role in achieving the scientific mental model. Overall, flipped classrooms are proven to be an effective learning strategy and are worth applying to improve the quality of learning and form students' mental models on salt hydrolysis material.

**Keywords:** flipped classroom learning model, salt hydrolysis, mental model.

## INTRODUCTION

Chemistry is an abstract learning material, meaning that it has the meaning of something that does not exist or is only a picture of the mind. Chemistry is one of the science families that studies the composition, structure, arrangement, properties and changes in matter, as well as the energy that accompanies these material changes. Learning chemistry is a scientific attitude which is a product and a series of processes in the form of concepts, laws, and theories (Hilda, 2020). Chemical concepts are divided into three representations, namely symbolic representation, macroscopic representation, and sub-microscopic representation (Dewi Melina et al., 2018). The three concepts have a very strong attachment and cannot be separated. Students' understanding of the three chemical representations and their relationship is expressed as a mental model (Handayanti et al., 2015).

Student mental models are ideas that represent images that build understanding and imaginative visualizations in the minds of students and are used to describe and explain phenomena (Pikoli et al., 2022). The chemical mental model is a term that is often used to describe the understanding of the three levels of chemical representation. Students who can connect the three levels of chemical representation to an idea have an intact mental model, while students who cannot connect them have an incomplete mental model (Agung et al., 2018). The formation of mental models is influenced by the experience and prior knowledge of learners, their attitudes and beliefs and the problems they face (Suja, 2015).

Flipped Classroom is one way to find out students' understanding of learning concepts. The flipped classroom is a pedagogical strategy that provides opportunities for students to learn on their own before meeting in class face-to-face (Paristiowati et al., 2022). Flipped Classroom is a blended learning model, where learning activities are carried out outside the classroom or virtually, and vice versa homework is done in class (Hartandi & Mawardi, 2022). It aims to train students to be active and able to learn independently. Flipped Classroom provides a lot of time for students to discover, learn, and understand the concepts of subject matter in class. Students are required to be able to manage time by discussing with friends, practising, and also being able to receive from the teacher regarding the development and progress in learning. The purpose of this study is to determine the mental model of students with the application of the flipped classroom learning model.

## METHOD

This research was conducted in 11th Grade high school at SMAN 1 Ulu Barumun in Padang Lawas Regency with a subject of 20 students consisting of 7 boys and 13 girls. The method used in the research is a qualitative method that describes the description of students' mental models in chemistry lessons on hydrolysis material and how the application of flipped classrooms to the formation of students' mental models. Data sources were obtained through observation, the use of two-tier tests that have been validated by lecturers and teachers, and completed in-depth interviews with students. Student observations were conducted to obtain student responses to Flipped Classroom learning and the process of forming student mental models. The Two-tier Test was conducted to identify the full picture of students' thinking patterns related to the material. Interview to confirm the results of the two-tier test. Flipped Classroom implementation is conducted through three stages, namely before class, activities during class, and after class which can be seen in Figure 1.

## RESULTS AND DISCUSSION

### Flipped Classroom Learning Model

The flipped classroom is an instructional model where students learn subject matter outside the classroom through learning videos, learning activities in the classroom are carried out in collaborative learning that emphasizes student activity in groups (Yuni & Edy, 2019). This learning model is divided into three stages, namely learning activities before class activities during class, and activities after class (Fitriani, 2022). The scheme of the learning stages with the flipped classroom learning model can be seen in Figure 1.

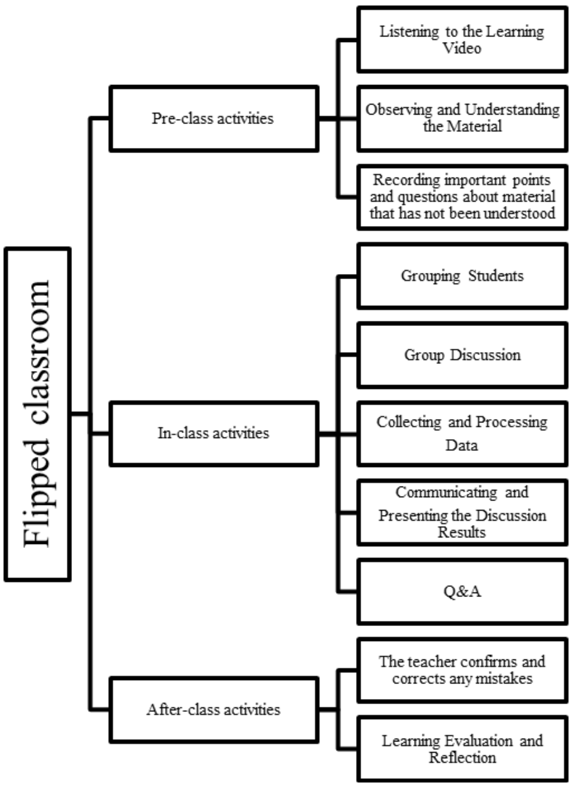



**Figure 1.** Schematic of the learning stages of the flipped classroom model.

The flipped classroom learning model is an effective and efficient learning model to use in learning conditions in line with the development of science and technology. With this model, the teacher's goal is to equip students' ability to think critically, cooperation, communication skills and creative and innovative thinking can be carried out well (Paristiowati et al., 2022).

*Activity stage before classroom learning*

At this stage, students learn independently at home by studying the material that has been sent by the teacher in the Google Classroom. Students are trained to observe and understand the material independently. During this stage, students respond well. The flipped classroom learning model uses learning videos as the initial stage. The purpose of providing learning videos is so that students have an overview of the material that will be learned in class. In addition, so that students do not feel guessing and feel afraid when learning chemistry in class. This is by the results of interviews with students below.

"I feel excited about learning because I have gotten a picture of learning so when I'm in class I'm not confused or asking my friends anymore and I also feel a little more confident".

Students watch the learning video provided by the teacher on Google Classroom and note the important points on salt hydrolysis material. This is in line with the following student interview results.

"I always watch the learning videos given by the teacher and note down the points that I think are important. Because otherwise, I am a typical person who has to take notes to remember."

The implementation of pre-class learning follows previous research that this stage is asynchronous (Yuni & Edy, 2019). At this stage, students are expected to learn independently which is guided through teaching materials that have been provided by the teacher and students already understand the material before learning in class directly.

*Stage of learning activities during class*

At this stage, group discussions are held. In the discussion, students develop an attitude of appreciation and respect for the opinions of group mates and establish cooperation to achieve good results. The implementation of the discussion looks quite active, with the formation of two-way communication. Students make presentations, ask questions, answer questions, foster confidence, and increase interaction between students and students and students and teachers.

"I like learning with discussion. Because during the discussion I can exchange ideas with other friends. When discussing, I can give ideas and responses, and I can respect each other's opinions".

The implementation of the activity stage during class is under several previous studies that during class there is cooperative-based learning, group discussions, and discussing new concepts synchronously (Fitriani, 2022). In this stage, students are trained to work together, respect each other and be active

*After-class activity stage*

At this stage, the teacher reviews the material learned. Then the teacher conveys the material that will be learned at the next meeting. The implementation of the after-class activity stage follows several previous studies that in the after-class stage students repeat what has been learned at the activity stage during class (Fitriani, 2022). In this case, students responded positively to the flipped classroom learning model. Here are some student responses regarding the flipped classroom learning model.

"This learning model is very effective in learning. I can learn independently first at home so that when in class I already understand the material even though it is not completely".

Other students also gave positive responses to the flipped classroom learning model.

"I think this flipped classroom learning model is very good and makes it easier for me to understand the material. Because the material can be repeated until I understand so I already have an idea of the material that will be learned in class and I also feel more confident when learning in class. In addition, discussions also make it easier for me to learn and I can exchange ideas with other friends"

**Students' Mental Model**

Analysis of students' explanations resulted in three different categories of mental models, namely initial mental models, synthetic mental models, and scientific mental models. In the initial mental model, students can identify phenomena but the conceptual understanding of the material is still lacking or even inappropriate. The synthetic mental model is one level above the initial model where students can understand the concept but are still lacking in linking the concept received with the given phenomenon. Scientific mental models are mental models where students can identify chemical phenomena, understand concepts, and relate them according to scientific knowledge (Pikoli et al., 2022). Student mental models can be distributed divided into initial mental models consisting of 30.13%, 31.52% synthesis mental models, and 38.33% scientific mental models. The distribution of students' mental model formation both initial, synthetic, and scientific can be seen in Figure 2.

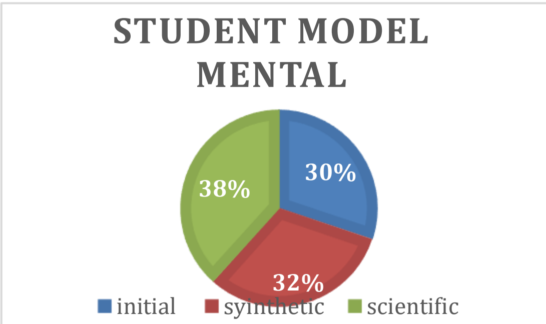



**Figure 2.** Percentage of mental models

*Initial mental model*

The percentage of initial mental models in the study had an average of 41.25%. In the initial mental model, students' understanding is only limited to macroscopic representations or only to symbolic representations. In some cases, students were not able to accurately answer the questions asked. For example, at the sub-microscopic level, some students could not answer accurately about the event that occurred between table salt and water by analyzing the pictorial question as in Figure 3.

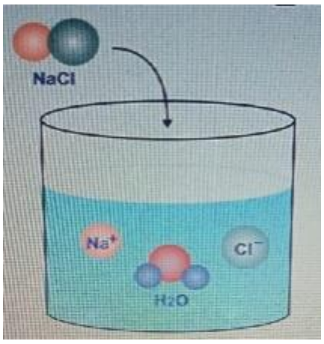



**Figure 3**. Reaction of table salt with water

Students answered that the reaction between table salt and water is cation hydrolysis because hydrolysis is the reaction between salt ions and water molecules that produce new ions. This hydrolysis is called cation hydrolysis because it involves positive ions (cations) from salt. The students' answers, show that students' understanding of hydrolysis material is not correct. This happens because students do not have a good understanding of salt hydrolysis material so the mental models built by students regarding hydrolysis events are not correct. In addition, the sub-microscopic level requires careful observation and analysis. This statement is in line with Anisa Umayah's research which states that the initial mental model can only represent macroscopically and symbolically, not sub-microscopically (Umayah et al., 2023). This is in line with the results of interviews with students below.

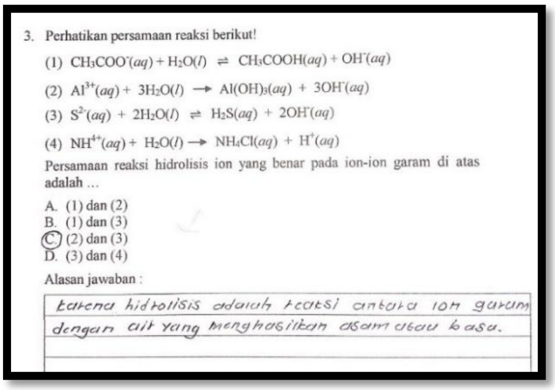
"If table salt is mixed with water, partial hydrolysis will occur because it will produce H + ions so that the solution will be acidic."

In addition to the sub-microscopic representation level, the initial mental model at the symbolic level is also limited because students cannot answer the questions accurately. This is evidenced in the student answer sheet on the salt hydrolysis equation in Figure 4.

In Figure 3, it can be identified that students have not been able to explain that the reaction of anions and cations in a hydrolyzed salt compound forms an equilibrium solution. Students only know that a salt will produce acid or base. This student's understanding is formed from the teacher's explanation at the initial meeting that salt is formed from acids and bases.

*Model mental sintesis*

At the synthesis mental model stage, students can already understand at the macroscopic level but some misconceptions are still found. The synthesis mental model has an average of 31.52% of the overall level of representation on salt hydrolysis material. For example, in the question about the application of salt hydrolysis in clothes bleach. This can be seen from the students' answers in Figure 5.



3. Perhatikan persamaan reaksi berikut!

(1) $CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$

(2) $Al^{3+}(aq) + 3H_2O(l) \rightarrow Al(OH)_3(aq) + 3OH^-(aq)$

(3) $S^{2-}(aq) + 2H_2O(l) \rightleftharpoons H_2S(aq) + 2OH^-(aq)$

(4) $NH^{4+}(aq) + H_2O(l) \rightarrow NH_4Cl(aq) + H^+(aq)$

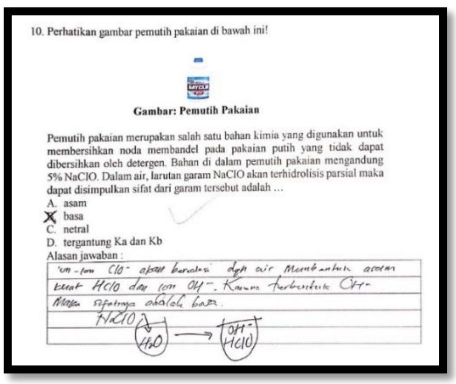
Persamaan reaksi hidrolisis ion yang benar pada ion-ion garam di atas adalah ...

A. (1) dan (2)
B. (1) dan (3)
C. (2) dan (3)
D. (3) dan (4)

Alasan jawaban :

karena hidrolisis adalah reaksi antara ion garam dengan air yang menghasilkan asam atau basa.

**Figure 4**. Salt hydrolysis reaction equation



10. Perhatikan gambar pemutih pakaian di bawah ini!

**Gambar: Pemutih Pakaian**

Pemutih pakaian merupakan salah satu bahan kimia yang digunakan untuk membersihkan noda membandel pada pakaian putih yang tidak dapat dibersihkan oleh detergen. Bahan di dalam pemutih pakaian mengandung 5% NaClO. Dalam air, larutan garam NaClO akan terhidrolisis parsial maka dapat disimpulkan sifat dari garam tersebut adalah ...

A. asam
B. basa
C. netral
D. tergantung Ka dan Kb

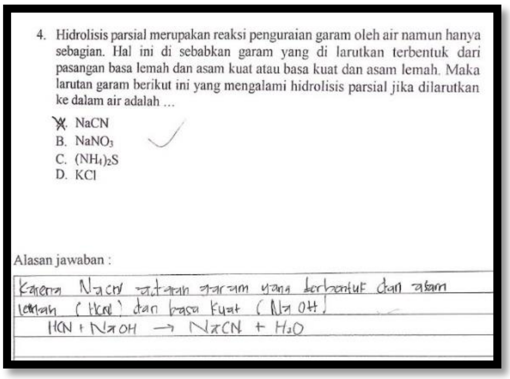
Alasan jawaban :

**Figure 5**. Application of salt hydrolysis

From the student's answer above Figure 4. shows that in terms of the sub-microscopic representation level, students visualize the reaction that occurs between NaClO and water by writing the names of compounds and ions directly. In addition, students have been able to know the nature of the clothes bleach which is alkaline. However, students experience misconceptions by answering that HClO is a strong acid whereas HClO is a weak acid. Students assume that if a salt produces OH ions, it will be basic. The student's answer arises because, in the acid and base material, the teacher explains that bases have OH groups, so students assume that any compound that produces $OH^-$ ions will be basic. This statement is by the student's answers during the interview as follows:

"When learning acid and base materials, the teacher said that one of the signs of a base is the presence of $OH^-$ ions."

The synthesis mental model of the symbolic representation level can be seen from the students' answers in Figure 5. Students' understanding of the types of hydrolysis already knows the concept but students have not been able to explain how the reaction of partial hydrolysis. Students have not been able to write the reaction of NaCN salt hydrolysis perfectly. Students only know that partial hydrolysis is formed from weak acids and strong bases or strong acids and bases.

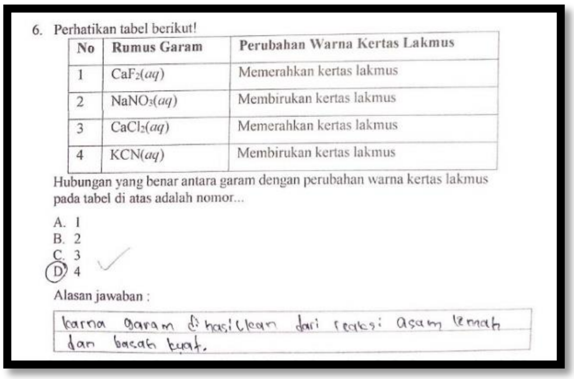

4. Hidrolisis parsial merupakan reaksi penguraian garam oleh air namun hanya sebagian. Hal ini di sebabkan garam yang di larutkan terbentuk dari pasangan basa lemah dan asam kuat atau basa kuat dan asam lemah. Maka larutan garam berikut ini yang mengalami hidrolisis parsial jika dilarutkan ke dalam air adalah ...

A. NaCN
B. $NaNO_3$
C. $(NH_4)_2S$
D. KCl

Alasan jawaban :

Karena NaCN adalah garam yang terbentuk dari asam lemah (HCN) dan basa kuat (NaOH)

$HCN + NaOH \rightarrow NaCN + H_2O$


6. Perhatikan tabel berikut!

| No | Rumus Garam | Perubahan Warna Kertas Lakmus |
|---|---|---|
| 1 | $CaF_2(aq)$ | Memerahkan kertas lakmus |
| 2 | $NaNO_3(aq)$ | Membirukan kertas lakmus |
| 3 | $CaCl_2(aq)$ | Memerahkan kertas lakmus |
| 4 | $KCN(aq)$ | Membirukan kertas lakmus |

Hubungan yang benar antara garam dengan perubahan warna kertas lakmus pada tabel di atas adalah nomor...

A. 1
B. 2
C. 3
D. 4

Alasan jawaban :

karna garam dihasilkan dari reaksi asam lemah dan basah kuat.

**Figure 6.** Partial hydrolysis **Figure 7**. Relationship between salt and litmus paper colour change

Seen from the macroscopic representation level of the synthesis mental model, students can analyze the salt formula with the colour change of litmus paper correctly but students are still not accurate in explaining the relationship between the salt formula and the colour change of litmus paper. The answers above show that students already know the formation of salt is produced from acids or bases but students are still unable to explain how KCN salt can be basic. Students only know that salts formed from strong bases and weak acids will be basic so that they can turn litmus paper blue.

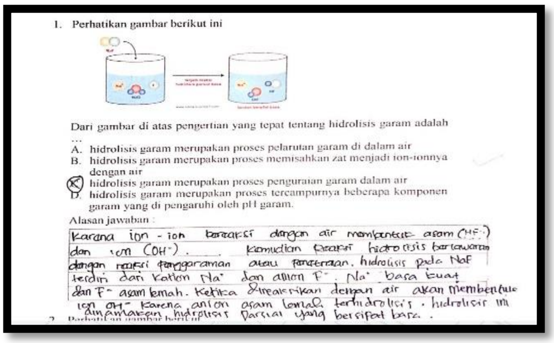
This synthesis mental model arises because during discussions students tend to look for definitions from the internet. The development of this synthesis mental model is influenced by the teacher's explanation and everyone's perception during learning (Umayah et al., 2023). This synthesis mental model arises because during discussions students tend to look for definitions from the internet that provide brief explanations so that students' understanding is not complete. The development of this synthesis mental model is influenced by the teacher's explanation and everyone's perception during learning, in line with research (Melina et al., 2018) which states that the synthesis mental model arises because of student misconceptions that are influenced by the conditions of students, teachers, chemical materials, and contexts.

*Scientific mental model*

In this study, the scientific mental model is superior to other mental models. The scientific mental model itself has an average percentage of 38.33% of the total percentage of all mental models. In this scientific mental model, students' understanding has been able to connect three levels of representation (Umayah et al., 2023). In this scientific mental model, students have been able to accurately explain the concept of salt hydrolysis, the process of salt hydrolysis, and the calculation of pH in salt hydrolysis. This can be seen from the students' answers during the interview as follows:

> "Salt hydrolysis is the process of decomposition between salt cations or anions with water. For example, $NH_4Cl$ will decompose into a weak base cation $NH_4^+$ and a strong acid anion $Cl^-$ which is then reacted with water ($H_2O$) then the cation of the weak base $NH_4^+$ will hydrolyze and produce $H_3O^+$ ions."

Based on the findings of the student interview, it shows that students have been able to distinguish between anions and cations. In addition, students are also able to estimate the results of the reaction produced before the reaction. Students answered that salt hydrolysis is the process of breaking down salt in water. Because ions react with water to form acid (HF) and ions ($OH^-$). Where the hydrolysis reaction is opposite to the salting or neutralizing reaction. Hydrolysis in NaF consists of strong base cations $Na^+$ and weak acid anions $F^-$. when reacted with water will form ions ($OH^-$) because weak acid anions are hydrolyzed. This hydrolysis is called partial hydrolysis with basic properties. This can be seen from the students' answers in Figure 8.


1. Perhatikan gambar berikut ini

Dari gambar di atas pengertian yang tepat tentang hidrolisis garam adalah …

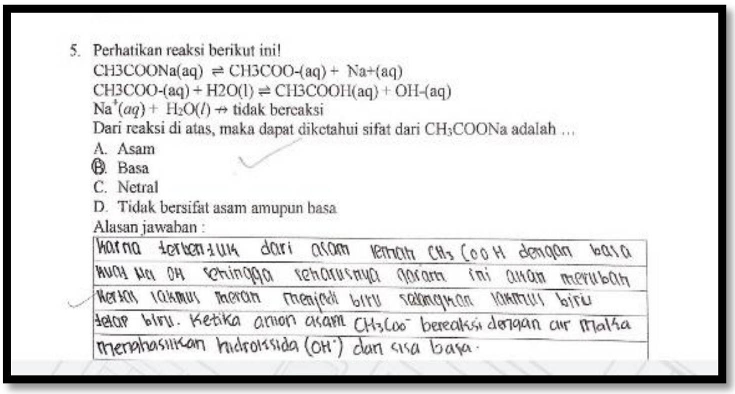
A. hidrolisis garam merupakan proses pelarutan garam di dalam air
B. hidrolisis garam merupakan proses memisahkan zat menjadi ion-ionnya dengan air
C. hidrolisis garam merupakan proses penguraian garam dalam air
D. hidrolisis garam merupakan proses tercampurnya beberapa komponen garam yang di pengaruhi oleh pH garam.

Alasan jawaban :

Karena ion - ion bereaksi dengan air membentuk asam (HF) dan ion (OH⁻). Kemudian reaksi hidrolisis berlawanan dengan reaksi penggaraman atau penetralan. hidrolisis pada NaF terdiri dari kation Na⁺ dan anion F⁻. Na⁺ basa kuat dan F⁻ asam lemah. Ketika direaksikan dengan air akan membentuk ion OH⁻ karena anion asam lemah terhidrolisis. hidrolisis ini dinamakan hidrolisis parsial yang bersifat basa.

**Figure 8**. Definition of salt hydrolysis

From the student's answer, the student has been able to understand the concept of hydrolysis at the sub-microscopic level. The symbolic representation arising from students in the scientific mental model can be seen in Figure 9.


5. Perhatikan reaksi berikut ini!
CH3COONa(aq) ⇌ CH3COO-(aq) + Na+(aq)
CH3COO-(aq) + H2O(l) ⇌ CH3COOH(aq) + OH-(aq)
Na⁺(aq) + H₂O(l) ↛ tidak bereaksi

Dari reaksi di atas, maka dapat diketahui sifat dari CH₃COONa adalah …

A. Asam
B. Basa
C. Netral
D. Tidak bersifat asam amupun basa

Alasan jawaban :

Karna terbentuk dari asam lemah CH₃COOH dengan basa kuat Na OH sehingga seharusnya garam ini akan merubah kertas lakmus merah menjadi biru sedangkan lakmus biru tetap biru. Ketika anion asam CH₃COO⁻ bereaksi dengan air maka menghasilkan hidroksida (OH⁻) dan sisa basa.

**Figure 9.** Reaction equations and their properties

Students answered that $CH_3COONa$ salt is basic because it is formed from the weak acid $CH_3COO^-$ and the strong base NaOH so this salt should be able to turn red litmus paper blue while blue litmus remains blue. When the anion of the weak acid $CH_3COO^-$ reacts with water, it produces ($OH^-$) and the remaining base. This shows that students' understanding at the symbolic representation level is good where students can connect the properties that $CH_3COONa$ salt will produce from a hydrolysis reaction equation. The students' answers above are in line with the results of interviews with students when students are asked to make and explain the hydrolysis reaction of salt from $NH_4F$ as follows in Figure 10.

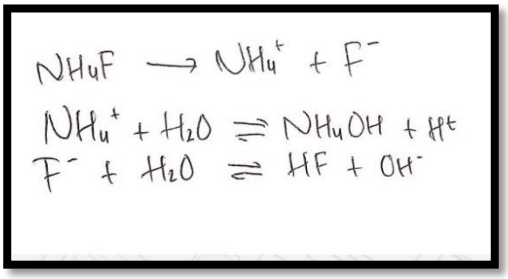



**Figure 10.** Salt Hydrolysis Reaction of $NH_4F$

"Based on the first reaction $NH_4F$ will decompose into $NH_4^+$ as a weak base cation and F- as a weak acid anion. Then completely hydrolyzed because the $NH_4F$ salt is formed from weak acids and weak bases. The nature of this salt is determined by the price of Ka and Kb. If Ka>Kb then the salt is acidic and if Ka<Kb then the salt is basic and if Ka=Kb then the salt is neutral."

From the student's answer, it can be stated that students already have a scientific mental model at the symbolic representation level because students have been able to distinguish between cations and anions and students are also able to analyze the nature of a salt from a reaction equation. In addition, the scientific mental model at the macroscopic representation level is shown in Figure 11. At the macroscopic representation level, students can analyze the concept of salt hydrolysis and can connect it with the calculation of the pH value of the mixture.

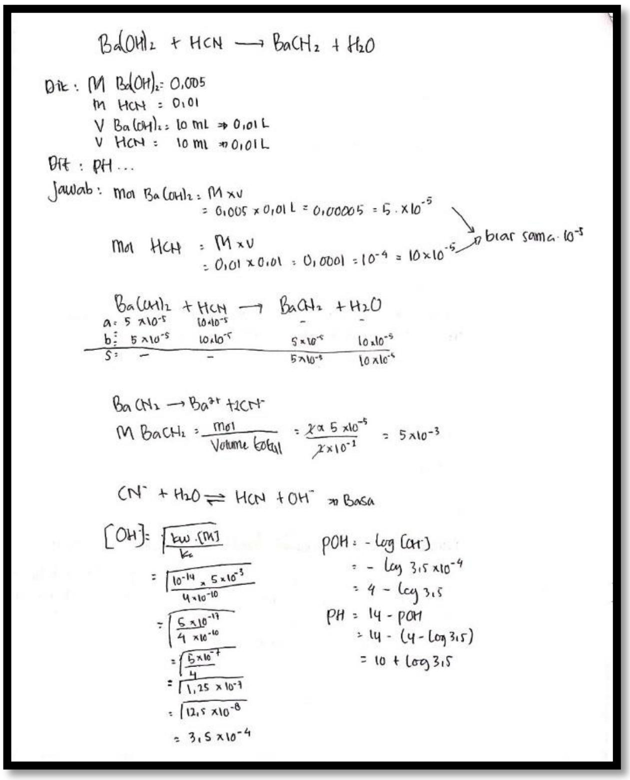


**Figure 11.** Calculation of pH value

Based on the student's answer, shows that students have been able to analyze the nature of the salt mixture so that they can understand the use of the formula to determine the pH of a salt mixture.

In mathematical calculations, students do not experience problems. Based on previous research, students build mental models based on students' understanding and experience which is influenced by student characteristics and the environment around students (Andina et al., 2017). The development of scientific mental models during salt hydrolysis learning comes from a combination of several factors such as the application of the flipped classroom learning model, guidance provided by teachers, student creativity, textbooks and learning videos. This is in line with research conducted by (Pikoli et al., 2022) which states that the factors that influence the level of student understanding are explanations from teachers and learning resources used by students in understanding the material. The flipped classroom learning model can help students improve their understanding of salt hydrolysis material. This is in line with previous research which states that the flipped classroom learning model is effective in improving concept understanding ability (Meldatia, 2023).

## CONCLUSIONS

Based on the research conducted by the author, it can be concluded that the flipped classroom learning model is effective in improving students' concept understanding and developing scientific mental models in salt hydrolysis material. Students who learn through flipped classrooms prepare themselves independently before class, actively participate in group discussions and presentations during class, and reinforce their understanding through post-class reviews. The results showed that most students achieved the scientific mental model (38.33%), which reflects deep understanding and the ability to connect concepts with phenomena scientifically. In addition, 31.52% of students were at the synthesis mental model, where they began to understand the concept but there were still misconceptions. Meanwhile, 30.13% of students were in the initial mental model, with limited and inaccurate understanding. Factors such as teacher explanation, learning experience, and learning resources used play an important role in this process. Overall, the flipped classroom is proven to be an effective learning strategy and worth applying to improve the quality of learning and able to shape students' mental models on salt hydrolysis material.

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