Analysis of students difficulties based on respondents ability test on the topic of factors affecting reaction rate

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Abstract. Reaction rate is one of the essential topic in the chemistry because of the results of the final exam analysis for the last 5 years (2012-2016), the question of reaction rate always appear. The purpose of this research is to obtain information about students difficulties and level of students’ understanding on the topic of factors affecting reaction rate. This research was conducted at one high school in Bandung with 60 students of grade XI IPA. This study uses a test method that is pencil based test. Analysis of test results using quantitative and descriptive qualitative analysis. Based on the results of the analysis of responses of respondents’ test. It was found that only 33 students who can do respondents ability test with good results. The results of the descriptive analysis show that students know about factors affecting reaction rate but students do not understand how these factors work to accelerate a reaction. These results shown that students still do not understand how these factors affect the reactions rate, so that it is required further investigation to find out how to overcome student learning difficulties on the topic of factors affecting reaction rate.

1. Introduction
Chemistry is a field of science that emphasizes the mastery of concepts. In the learning process, concepts are things that need to be understood, studied and mastered by students. Chemical concepts form within students gradually through their experiences and interactions with the natural surroundings [1]. Chemistry is the study of the structure of matter, the properties of matter, the transformation of matter into other matter, and the energy that accompanies the change of matter [2]. Chemistry is classified as a difficult subject. Kean and Middlecamp say that one of the characteristics of chemistry is abstract, sequential and tiered. This means that understanding more complex chemical concepts requires a correct understanding of the underlying concepts. If students have difficulty on one of the basic concepts, then there is the possibility of students having difficulty with more complex concepts. Understanding improper concepts can lead to students misconceptions [3].

Based on the results of interview with chemistry teacher of one high school in Bandung found that one of the chemical topics that are considered difficult is a factor affecting reaction rate. Factor affecting reaction rate topic is an essential material because based on the analysis of the last 5 years final exam from 2012-2016, the question of factors affecting the reaction rate always appears. Students understand what factors influence reaction rate but students do not understand how these factors can accelerate reaction rate. In addition, students cannot explain the relationship between reaction rate factors, collision theory, and activation energy.
Chemical reaction rates and the factors that affect them constitute an important area of the chemistry curriculum. Research on learning difficulties associated with chemical kinetics is investigated and documented by some researchers. The results showed that chemical kinetics was considered as a difficult concept to understand by both school and undergraduate students [4]. Chemical reaction rate covers lots of fundamental chemistry concepts. The topics in the unit are the rate of reaction, activation energy, and factors affecting the rate of reaction, collision theory, catalysts, enthalpy, and reaction mechanism. These concepts are most importance in order to understand the relations between chemical change and energy, the types of chemical reactions, and the chemical change processes [5]. According to Kirik in studying the reaction rates of many students who experienced misconceptions and difficulties [6]. Furthermore, Cakmakci mentioned that the reaction rate material has many abstract concepts. This makes students feel difficult to learn. Reaction rate is part of abstract chemical concepts, which often makes students difficult to understand this concept [7].

Research about reaction rate has been done by many researchers. The results of research conducted by Sinaga showed that almost half of the students had difficulty in understanding the concept of catalyst and temperature influence on reaction rate [8]. Kurt and Ayas examine students' understanding of reaction rate in everyday life. From the research found the difficult concepts that are concept of catalysts, effects of temperature, effects of concentration, and the effect of surface area on the reaction rate [9]. Based on the above description, it is necessary to know the concept of student understanding on the subject matter affecting reaction rate. The purpose of this research is to know the students difficulties in understanding the concept of factors affecting reaction rate and to describe the factors that influence students' difficulties in learning the factors affecting reaction rate.

2. Method
The research was conducted at one of the high schools in Bandung, Indonesia. The subject is 64 students of grade XI MIPA. The subject selection is based on input from the chemistry teacher. This study uses a test method that is pencil based test to determine the difficulties of students in learning the factors affecting the reaction rate. The respondent's test consists of 4 problems. Data analysis of research result is done quantitatively and descriptive qualitative. Quantitative analysis is done by assessing student test result with scoring system 1-100. Quantitative analysis is done to know the students understanding about the concept of factors influence the reaction rate. Scores of each student are then incorporated into the appropriate criteria, there are 5 criteria of student understanding that is very good, good, fair, low, and very low. While qualitative descriptive analysis done to know which part of problems that student got difficult.

3. Result and discussion

3.1. Student understanding of factors affecting reaction rate
Respondents ability test consists of 4 problems that is 1) Explain why the difference of surface area result in different reaction rate 2) Explain the effect of concentration on the reaction rate 3) Explain the effect of temperature on the reaction rate 4) Explain the effect of the catalyst on the reaction rate. The analysis results of student answers are presented in table 1.

| Criteria    | Score  | Number of student | Percentage (%) |
|-------------|--------|-------------------|----------------|
| Very good   | 80-100 | 14                | 21,9           |
| Good        | 61-80  | 19                | 29,7           |
| Fair        | 41-60  | 26                | 40,6           |
| Low         | 21-40  | 3                 | 4,7            |
| Very low    | 1-20   | 2                 | 3,1            |
Based on table 1 it is found that most students (40.6%) have fair understanding, 29.7% have good understanding, 21.9% have very good understanding and 4.7% students have low understanding and 3.1% students have very low understanding. This shows that most students have been familiar with the concept of factors affecting reaction rate. Students can mention any factors that can accelerate the reaction rate. However, students cannot explain how these factors can accelerate reaction rate, this is in line with the results of interviews with teachers in the school who stated that students know what factors affect reaction rate but students cannot explain how these factors accelerate reaction rate. The students' understanding of the factors affecting the reaction rates is detailed in table 2.

Based on table 2 it is found that students' understanding of the concept of factors that influence reaction rate is sufficient, the students' understanding of the smallest percentage is about the influence of surface area and temperature. In understanding the influence of surface area and temperature of students still encountered many confusion.

3.2. Surface area
The influence of surface area in accelerating the reaction rate is enough to make students confused. From the results of the experiments, students know that the reaction between egg shell powder with 1M HCl solution will be faster than the reaction between the egg shell pieces with 1M HCl solution. However students difficult to explain why the reaction with the powder is faster.

Based on table 3 it is found that most students assume that small particle size will have small surface are so it will faster. There are also students who think that the egg shell pieces have a large surface area so that the reaction rate is slow. This is one of the difficulties students are identified in studying the topic of factors affecting reaction rate. This result is in accordance with the research results conducted by Gunarti, et al in which students incorrectly define the surface area on the reaction rate material because most students are still confused with the definition of surface area on the subject of mathematics [10].

The concept of a true surface area is a material or particles of smaller size having a larger touch surface area so that the reaction is faster. The influence of the surface area can be explained by the concept of collision theory, the same mass of large size of reactant (small surface area) will have less frequent of collision than small size of reactant (large surface area). On the other hand, small size of reactant (large surface area) will have more frequent of collision than large size (small surface area) [2].
3.3. Concentration
Students are still confused about the effect of concentration in accelerating the reaction rate. Students answer for concentration problem are presented in table 4.

Table 4. Student answer for concentration problem.

| Student answer                                                                 | Percentage (%) |
|--------------------------------------------------------------------------------|----------------|
| The greater the concentration the faster the reaction rate                     | 56.25          |
| The greater the concentration then the collisions between particles more frequent occurs so that the reaction rate faster | 23.43          |

Based on table 4 students understand if the concentration of a reactant is higher, the reaction rate is faster. Students also understand if the reactant concentration is high then the number of particles is high. But students do not understand and cannot explain why high concentrations can lead to faster reaction rates. Yalcinkaya et al say that he majority of students from both groups could state that reaction rate increases by increasing the concentrations of the reactants; however, they could not provide the reason for this [11]. The students' difficulty in understanding the concept of the effect of concentration on the reaction rate is that students cannot explain the relation between reactant concentration and collision theory. Cakmakci, et al said that one of the distinctions between secondary and undergraduate students’ responses was related to the epistemological assumptions made [12]. Many school students gave explanations based upon taken for granted everyday knowledge. For example, such students might respond more concentrated acid removes limestone faster in the kettle, because it is stronger. By contrast, undergraduates typically provided explanations based upon theoretical models and entities within established chemical ideas. For instance, such students argue that reaction rate is proportional to the concentration of reactants. A higher concentration of reactants raises the probability of collisions among reactant molecules, which leads to an increase in the reaction rate.

3.4. Temperature
Based on table 2 students' understanding of the effect of temperature in accelerating the reaction rate into fair category. The result of student’s answer analysis shows that students understand that a reaction done at higher temperature will accelerate the reaction rate. The result of student answer are presented in table 5.

Table 5. Student answer for temperature problem.

| Students answer                                                                 | Percentage (%) |
|--------------------------------------------------------------------------------|----------------|
| The higher the temperature the faster the reaction rate                       | 59.37          |
| High temperatures cause the particles to move faster so that the reaction rate is faster | 26.56          |

Based on table 5 it is found that students also understand that when there is a rise in temperature then collisions among particles are more frequent and the reaction takes place more quickly. The students' difficulties in studying the effect of temperature on the reaction rate is that students do not understand why when the temperature is increased collisions among particles are more frequent. There are also students who answered if the temperature increased then the activation energy is greater so that the reaction rate becomes faster. This is in line with the research result by Nazar et al. in his research also found that 57.89% of students who have misconceptions regarding the effect of temperature on reaction rate with regard increase in temperature may affect the activation energy so the reaction rate increase [13]. In understanding the concept of the influence of temperature on the reaction rate, students do not relate to the kinetic energy of particles. The average kinetic energy of the reactant molecules is
proportional to temperature, when the temperature increases then the kinetic energy of the reactant also increases so that the reaction rate becomes faster [14].

3.5. Catalyst
According to table 2 students' understanding of the effect of the catalyst on the reaction rate reaches 70%, but this understanding is only limited to the knowledge of which substance acts as the catalyst and what is the function of the catalyst based on the experiments performed. However, students were unable to explain how the catalyst can accelerate reaction rate. The student answer for catalyst problem are presented in table 6.

| Students Answer                                      | Percentage (%) |
|------------------------------------------------------|----------------|
| Catalyst accelerates the reaction rate                | 60.93          |
| Catalyst raises the activation energy so that the reaction rate is faster | 7.81          |
| Catalyst decreases the activation energy so that the reaction rate is faster | 10.93          |

Based on table 6 it is found that students' difficulties in understanding the role of catalyst in accelerating reaction rate is that students are wrong in understanding the relationship between catalyst and activation energy. Students understand that the addition of the catalyst can increase the activation energy so that the reaction rate is faster. Though the correct concept is the addition of a catalyst can decrease the activation energy of the reactant so that the reaction takes place more quickly and more reactants react to form the product [4]. The data above are consistent with the findings of Sinaga in which nearly half of the students have errors in understanding the concept of catalyst influence on reaction rate. In terms of the effect of the catalyst addition on the reaction rate, most students understand that the addition of the catalyst can increase the activation energy of the reactant so that the faster reaction rate takes place [8]. This is happen because students confuse about activation energy and kinetic energy. Some student understand that activation energy is equal to kinetic energy. This result is in accordance with the research results conducted by Cakmakci, in which many of students viewed activation energy as the kinetic energy of reactant molecules reached a conclusion that the bigger the activation energy is, the faster a reaction occurs [4].

4. Conclusion
Based on the results of the study it can be concluded that students understand the factors that influence reaction rate but have difficulty in explaining how these factors can accelerate reaction rate. Student difficulties that found are: students cannot explain the relationship between particle shape, surface area and collisions between particles; students have difficulty in explaining why the higher concentration of the reactant can accelerate the reaction rate; students cannot explain why the higher temperature the reaction rate is faster; student cannot explain how the catalyst can accelerate reaction rate.

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