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Abstract. The enthalpy concept and its change were introduced to describe the forms of internal energy transfer in chemical reactions. Likewise, the concepts of exothermic and endothermic reactions introduced as a consequence of heat transfer form. In the heat measurement process at constant pressure, work is often ignored. The exothermic or endothermic reactions, usually only based on the increase or decrease of the reaction temperature, without associated with the internal energy. Depictions of enthalpy and its change assumed closely related to students' problem-solving ability. Therefore, the study to describe pre-service chemistry teacher student's conceptions and problem-solving ability on topic chemical thermodynamics has been done. This research was a case study of chemical education course in Provinsi Lampung. The subjects of this study were students who attend the chemical thermodynamics course. Questions about exothermic and endothermic reactions, enthalpy and its change, as well as internal energy and its change were given in the form of an essay exam questions. Answers related to conception qualitatively categorized, while problem solving answers were scored and assessed. The results showed that, in general, students were having problems in enthalpy and describe the changes in the form of heat and work. The highest value of problem solving ability obtained 26.67 from the maximum value of 100. The lowest value was 0, and the average value was 14.73. These results show that the problem-solving ability of pre-service chemistry teacher students was low. The results provide insight to researchers, and educators to develop learning or lab work on this concept.

INTRODUCTION

World economy comptetition on twenty-first century will be increasingly stringent. Therefore, the national expert analysis and commentary on the state of education has referred to the need to develop the problem solver. Therefore, the impotanta role of an educator is to help students become a problem solver[1].

Problem solving is a mental and intellectual process in finding a problem and solve it based on accurate data and information; knowledge, understanding and skills that have been held; as well as combining the rules, knowledge, and skills to produce precise and accurate conclusion, understanding or new knowledge, and solve the problem[2,3,4]. The process of problem solving gives learners the opportunity to play an active role in studying, searching, and founding the information to processed into concepts, principles, theories, or conclusions. In other words, problem solving requires the ability to be processed information to make a decision[2].

During solve the problem, requires a combination of basic knowledge and basic skills. The basic knowledge is a set of knowledge and experience that are stored in long-term memory, while the basic skills can be used to solve problems, which include the skills to problems analyze, to connect its knowledge with encountered problems, and plan appropriate strategies to solve problems. Body of knowledge consists of related concepts, which is very important in problem solving. Thus, to solve the problem, students must have the correct conceptions.

Conceptions are often viewed as mental model[5,6,7]. Saptono, defines conception as the ability to understand the concepts, obtained through interaction with the environment as well as from formal education[8]; while Berg defines conception as the interpretation of a concept[9]. Calik, and Ayas used the term "alternative conceptions" to describe conceptual difficulties, so definition of concept is different or inconsistent with accepted scientific definition[10].

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Students's conceptions, either individually[11] and group[12], about single concepts, single tasks, or phenomena has been investigated. Different methods and techniques have been used, and the tradition is mostly cognitive or constructive whereby individuals have parallel conceptions[13], a conceptual profiles[14], misconceptions and preconceptions[15] or intermediate conceptions[16].

Many students in high school and college have difficulties with fundamental concepts in chemical thermodynamics[5,11] and that a gap exists at the tertiary level[17], related to more specific chemistry concepts such as enthalpy. Many students leave introductory thermodynamics courses with only a "dim understanding of this subject"[12]. Many students consider the physical chemistry course, in which chemistry majors perform more advanced concepts in thermodynamics, to be one of the most difficult courses[12].

Only a few studies in higher education focused on understanding of enthalpy and its change, and its related with the internal energy, heat and work[5,18,19,20]. The previous research has studied conception of heat and work around the same ages; and conception of enthalpy, enthalpy change, heat and work; and related concepts[5].

Furthermore, no one has examined related between problem-solving ability and conception of chemical thermodynamics. In this study, researchers construct the real problems questions based on concepts of chemical thermodynamics. Furthermore, it was studied how the students' ability to solve the problem. Development of students' ability in problem solving is the important objectives of science education. Problem-solving ability can be interpreted as an ability to reason analytically, think critically, and create productively, that involve quantitative, manual, critical-response, and communication skills[21]. Developing problem-solving ability being important because not only needed in learning processes, but in working world, family, and society.

Therefore, the purpose of this study was to describe the profile of pre-service chemistry teacher student's conceptions and problem-solving ability on topic chemical thermodynamics. This study was a preliminary research. The future will conduct advanced research to develop learning and lab work on this concept to changed the conception that refers to correct conceptuals.

RESEARCH METHODOLOGY

Research subjects

The research has been conducted on Program Studi Pendidikan Kimia in Provinsi Lampung. The subjects in this study were 42 college students in 2013 who take basic chemistry course.

Methods, data collection and analysis techniques

This research methods was a case study. Data collection technique used was tests and interviews. Tests conducted to reveal the conception and measure the students' problem-solving ability on topic chemical thermodynamics. The questions related conceptions refer to Nilsson & Niedderer[5], while the questions related to problems-solving developed based on these conceptions. Interviews were conducted to confirm the students' answers on the conception test. Conception test result data, compiled, then coded, reduced, and categorized to building conception. Problem-solving ability data, analyzed by scoring techniques, subsequently converted into value. The average score of problem-solving ability obtained by the following formula: $s_{ave} = s/n$, where s_{ave}, s, and n are the average score, the number of score, and the number of students, respectively. Then, the average value of problem solving ability is determined using the following formula: $v_{ave} = \left(s_i/m\right) \times 100\%$, where v_{ave}, s_i, and m are the average value, the score obtained, and the maximum score, respectively.

RESULTS AND DISCUSSION

The students' conception profile shown in **Table 1**.

TABEL 1. Concepts and student's conceptions pattern on topic chemical thermodynamics

Concepts	Conceptions Pattern (CP)
1. a. *Apparatus A: closed system, constant pressure. At constant pressure allows the work. b. *Apparatus B: closed system, constant volume. At a constant volume, no work is done.	1.1 Apparatus A is an open system since the valve is opened. Constant pressure not expressed. 1. 2 Apparatus B is a closed system since the valve is closed. Constant volume not expressed. 1.3 Apparatus B is an isolated system.
2. At constant volume, all internal energy change was released as heat ($\Delta E = q_v$)	The most heat is given to the surroundings in the apparatus: 2.1 A. Since it open system which allows the heat flow from system to surroundings. 2.2 B. Since it isolated system. 2.3 B. Since the mass in B is constant, and decreased in A. 2.4 B. Since the heat trapped in the system.
3. Enthalpy change as heat at a constant pressure	Enthalpy change is the heat in apparatus: 3.1 B. 3.2 B. Since it closed system, did not allow transfer of energy. 3.3 A and B. 3.4 A and B. Since the same amount of reactants. 3.5 A and B. Since the chemical reaction heat measurement the same as enthalpy change. 3.6 A. Since the heat out of the system.
4. In glass 1 $H_{products}<H_{reactants}$, ΔH will be negative. In this case the overall decrease in enthalpy is achieved by the generation of heat, and the reaction is exothermic. In glass 2 $H_{products}<H_{reactants}$, ΔH will be positive. Thus heat will be absorbed by the system, and the reaction is endothermic.	4.1 In glass 1 the heat released by the system, so temperature rise occurs, the value of ΔH is negative (-) and the reaction is exothermic. In glass 2 the heat absorbed by the system, so temperature decreased occurs, the value of ΔH positive (+) and the reaction is endothermic. 4.2 In glass 1 the initial reaction temperature is lower than the final, $\Delta H_{initial} < \Delta H_{final}$, so the reaction is exothermic. In glass 2 the initial reaction temperature is higher than the final, $\Delta H_{initial} > \Delta H_{final}$,, so the reaction is endothermic. 4.3 Only the term heat of reaction is used for the reaction studied at a constant pressure, whereas, the term enthalpy change is not.

*see appendix

The problem-solving ability data presented in **Figure 1**. The average score of problem-solving ability related concepts 1 and 3 was 1.35 for maximum score 7; related concepts 1b and 2 was 0.91 to maximum score 8; and related concept 4 was 0.98 to maximum score 7. Then, average value of problem-solving ability related concepts 1 and 3 was 19.29; related concepts 1b and 2 was 11.38; related concepts 4 was 14.00. The highest value of problem-solving ability obtained 26.67 to maximum value 100, and overall average value of problem-solving ability was 14.73.

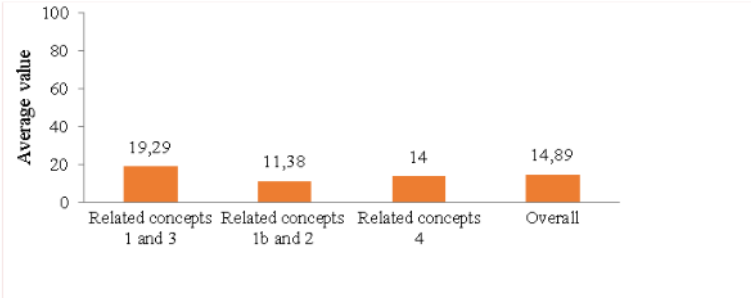

FIGURE 1. Students' problem-solving ability

Conceptions. The conceptions constructed by the students are presented in **Table 1** and the elaboration of the conception described below.

Conception pattern 1. This conception related to the question based on Nilsson and Niedderer [5]. This conception is the basis for the conception 2 and 3, where the apparatus A and B are at constant volume and constant pressure, respectively. At constant pressure allows the work, while in constant volume, no work is done. In this case, the student considers the same between the open and closed valve with the open and closed system, while the constant volume and pressure not expressed. Students also stated that the two apparatus both A and B are isolated system. This means that the students describe the closed system as an isolated system.

Conception pattern 2. This conception is deepening conception 1, in which in the constant volume, no work is done. Apparatus B is a constant volume, for a constant-volume process, the change in volume V is equal to zero. Thus, the work (which is -PΔV) is also equal to zero. Therefore, $\Delta E=q+w=q=q_v$ [22]. This means that all the internal energy change was released as heat. So, apparatus B gives the most heat to the surroundings. In this case, there are several patterns of conception constructed by students. Some students describe apparatus A gives the most heat to the surroundings (2.1); other students describe apparatus B gives the most heat to the surroundings (2.2, 2.3, 2.4). All the patterns that emerge, no one associated with state of constant volume. There are varies arguments for the choice of apparatus A or B. The argument for the choice of apparatus A since opened system allows the heat flow from system to surroundings. The argument for the choice of apparatus B since the constant mass in B, and decreased in A (2.3); the heat trapped in the system (2.4); the system is isolated (2.2). The arguments are consistent with the conception 1. Related to this case, Nielsson and Niedderer found that students considered most of heat given out in apparatus B, since the volume is constant, thus no work is done and all energy is heat. In this case, the enthalpy change is related to constant volume instead of constant pressure[5].

Conception pattern 3. This conception, also a deepening conception 1, in which at constant pressure (only PV work allowed), the enthalpy change (ΔH) of the system is equal to the energy flow as heat[22], therefore $\Delta H=\Delta E + P\Delta V = q_p$. Apparatus A is a constant pressure, so the apparatus A provides heat measurement equal to the change in enthalpy. In this case, there are several patterns of conception constructed by students. Some students describe apparatus A give the heat measurements equal to the change in enthalpy (3.6); another student described the apparatus B (3.1, 3.2), and apparatus A and B (3.3, 3.4, 3.5). All the patterns that emerged, no one associated with the state of constant pressure; while Nilsson and Niedderer found that the required demand for constant pressure is explicitly expressed but disregarded as the answeris given, whereby students explicitly state that enthalpy change is heat at constant pressure[5]. There are varies arguments for the choice of apparatus A or B.The argument for the choice of apparatus A since the heat out of the system (3.6). The argument for the choice of apparatus B since closed system does not allow transfer of energy (3.2). The argument for apparatus options A and B, because the same amount of reactants (3.4); measurement of chemical reaction heat equal to the change in enthalpy (3.5). The arguments are consistent with the conception 1.

Conceptions pattern 4. This conception is related to the heat of reaction and enthalpy change at constant pressure, based on task that refers to Nilsson and Niedderer[5]. In this case, the student describes chemical reaction based only on the heat of reaction, not on the change in enthalpy between reactants and products (4.1). In the pattern (4.2), students use the term of temperature to determine in enthalpy change: "In glass 1 initial reaction temperature is lower than that final, then ΔH initial < ΔH final..."; and such as in Nilsson and Niedderer results[5], students considers that the enthalpy H is equal to enthalpy change ΔH: " ΔH initial < ΔH final, not H initial < H final.

Based on the elaboration, the conception of the system state (opened, closed, isolated, constant pressure and constant temperature) is the underlying conceptions of enthalpy and its change that include heat and work.

Generally, occurs a great difference between the students' conceptions about chemical thermodynamics with accepted scientific definition[8]. Based on the interviews, it was revealed that there are difficulties in determining the state of the system since only through pictures, did not observe the process.

Problem-solving ability. Based on the data, the average score of problem-solving ability related concepts 1 and 3 was 1.35 for maximum score 7; related concepts 1b and 2 was 0.91 to score maximum 8; and related concepts 4 was 0.98 for the maximum score 7. Then, average value of problem-solving ability related concepts 1 and 3 was 19.29; related concepts 1b and 2 was 11.38; related concepts 4 was 14.00. The highest value of problem-solving ability obtained 26.67 from maximum value 100, and overall average value of problem-solving ability was 14.73. In problem solving, skills for connecting concepts is necessary to plan appropriate strategy. Concepts are depicted as conceptions possessed by students. In other words, problems in the conceptions caused students are not able to solve problem. The fact of great difference between students' conceptions about chemical thermodynamics with accepted scientific definition, confirm the lack of students' problem-solving ability. Bodner and Herron stated that the study of problem solving has provided strong evidence. However, our students were unsuccessful. They don't grasp the concepts very well. Students are lack understanding the ideas underlying problems they have answered correctly[5], because they are usually faced with algorithmic problem-solving exercises that do not promote conceptual understanding[23]. Students succeed in doing chemical thermodynamic calculations[23,24], but did not prepare them as a conceptual problem-solver[25].

Based on the results of this study, a student must have the concept accepted scientific definition to be able to solve the problem. Therefore, a lecturer should implement the learning and lab work strategy that gives a chance to student to construct the concept and develop their ability to solve the problem by real problems.

CONCLUSIONS

Based on the results and discussion, it can concluded that generally, students having problems in enthalpy and describe the changes in the form of heat and work. The existence of problems in the conceptions, causes the students are not able to connecting the concepts. Thus. it is necessary to plan great strategy in solving the problems. The results provide insight to researchers and educators to develop learning or lab work on this concept.

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Appendix

Consider the reaction

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g) \quad \Delta H^\circ = -463 kjmol^{-1}$$

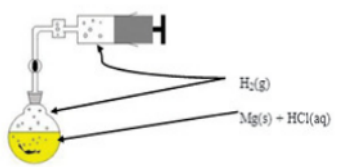
taking place in each set of apparatus shown below. In **A** the tap is open, and in **B** the tap is closed. Equal amounts of reactants are used in each case.

Consider that the reactions are completed and the systems are cooled down to their initial temperature, and you are able to measure the heat given out to the surroundings by the reaction. Based on the information given, please explain:

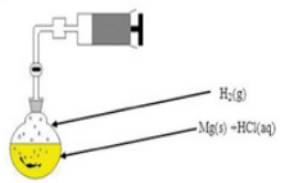
a) In which set of apparatus, **A**, **B** or both, do you think most heat is given out to the surroundings? Explain your answer as carefully as you can.

b) In which set of apparatus, **A**, **B** or both does energy transferred as heat equal the reaction enthalpy? Explain your answer as carefully as you can.

(**A**) Open tap (the pressure inside the syringe equals the pressure outside the syringe)



(**B**) Closed tap



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