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DIAGNOSIS OF GRADE 12 STUDENTS' ALTERNATIVE CONCEPTIONS ON THE CONCEPTS OF CHEMICAL THERMODYNAMICSUSING A FOUR TIER DIAGNOSTIC INSTRUMENT: THE CASE OF ANSHO SECONDARY SCHOOL IN SNNPR, ETHIOPIA

MSc thesis

By

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EXAMINERS' APPROVAL SHEET

We the undersigned certify that the thesis prepared by **Demeke Habte Mugoro** entitled "Diagnosis of grade 12 students' alternative conceptions on the concepts of chemical thermodynamics using a four tier diagnostic instrument: the case of Ansho secondary school in SNNPR, Ethiopia" and submitted in partial fulfillment of the requirements for the degree of Master of **Science in Chemistry** (General) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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AUTHOR’S DECLARATION

I declare that this thesis entitled “diagnosis of grade 12 students’ alternative conceptions on the concepts of chemical thermodynamics using a four tier diagnostic instrument: the case of Ansho secondary school in SNNPR, Ethiopia” is a result of my original work and that all sources of materials used for writing it have been duly acknowledged. This thesis has been submitted to the Department of Chemistry, Dilla University in partial fulfillment of the requirements for Masters of Science Degree and is deposited at the University’s library to be made available to readers under the rules and regulations of the library. I solemnly declare that this thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate. Brief quotations from this thesis are allowed without requiring special permission on condition that an accurate acknowledgement of source is made. Requests for permission for extended quotations from or reproduction of this thesis in whole or in part may be approved by the Head of the Department of Chemistry or the Director of the Postgraduate School when in his or her judgment the proposed use of the material is for academic interest. In all other circumstances, however, permission must be obtained from the author.

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ACRONYMS AND ABBREVIATIONS

NUC	Not Understand Concept
UC	Understand Concept
ACs	Alternative Conceptions
R-tier	Reason-tier
A-tier	Answer-tier
2TMC	Two-tier Multiple Choice
3TMC	Three-Tier Multiple Choice
4TMC	Four-tier Multiple Choice
4T CTDI	Four-tier Chemical Thermodynamics Diagnostic Instrument
MCQ	Multiple choice Question

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Abstract

Thermodynamics is fundamental to physical science to understand the concept of energy and associated properties. Despite the importance of chemical thermodynamics as the foundation for chemistry, most students hold several misconceptions about these concepts. Therefore, the aim of this study was to identify the common misconceptions of grade 12 natural science steam students held on the concept of chemical thermodynamics (first law and second law of chemical thermodynamics) using four-tier diagnostic test and to determine the level of their misconceptions. The data were collected from 120 grade 12 students joined natural science streams in 2021/2022 academic year. To identify students' misconceptions four-tier diagnostic test which consists 14 multiple choice questions were prepared from first law and second law of chemical thermodynamics. The analysis of results showed that Grade 12 Natural science students hold misconceptions about the concepts of chemical thermodynamics predominantly on enthalpy, heat, entropy, open system, closed system and open system are some major areas'. Besides, the misconception level of Grade 12 Natural science students' level of misconception ranged from low level misconception to high level misconception (27.50%- 72.50%).

Keywords: diagnostic instruments, misconceptions, chemical thermodynamics, confidence level, ordinary multiple choice

CHAPTER ONE

INTRODUCTION

The students learn about the world around them formally through school education or informally through their everyday experiences, they often tend to form their own views. Because of this concern, several studies have been conducted to depict students' understanding.

1.1. Back ground of the Study

Chemistry plays a fundamental role in everyone's lives and touches .Almost every aspect of our existence or to meet our basic needs such as: food, clothing, shelter, health, energy, and clean air, water, and soil. Chemical thermodynamics our quality of life in numerous ways by providing new solutions to problems in health, materials, and energy usage. Thus, studying chemistry is useful in preparing us for the real world and knowing something about chemistry is worthwhile because it provides an excellent basis for understanding the physical universe we live in. However, some researchers reported that students have difficulty in understanding fundamental concepts of chemistry such as chemical thermodynamics (Bordogna, *et* al., 2012); Electrochemistry (Lin, *et al*., 2002); chemical equilibrium (Yamtinah and Shidiq, 2019); symbols, formulae and equations, acids, bases and salts, organic chemistry, structure and energy level of atom, quantitative analysis, chemical equation, non-metal and their compounds, thermo chemistry, metals and their compounds, applied chemistry, nuclear chemistry and Astronomical chemistry (Uzezi, *et al.,* and Chou, 2002). Besides (Treagust, *et al.*, 2000) reported that most students have superficial understanding of chemical thermodynamics and chemical kinetics concepts and their understandings do not go beyond algorithmic problem solving with concepts associated thermodynamics.

Thermodynamics is the study of how heat can be transformed into useful energy in the form of work thermodynamics gives the foundation for heat engines, power plants, chemical reactions, refrigerators, and many more important concepts that the world we live in today relies on. However, many science education researchers reported that chemical thermodynamics is one of the most difficult chemistry concepts for chemistry students faced at high schools as well as at tertiary levels (Sokrat, *et al.*, 2014) .According to (Sokrat, *et al.,* and Radid, 2014) report chemical thermodynamics is difficult to students because of understanding of chemical thermodynamics requires prior knowledge of mathematics and physics. Furthermore a number of researchers in the field of science education reported students' learning difficulties associated with thermodynamics. For instance; students conceptions of heat and temperature (Winarti, *et al.,* 2017); phase changes, equilibrium (Akkus and Atasoy, 2011); differentiating thermodynamic data such as: solubility, equilibrium constant, equilibrium, Gibbs free energy, enthalpy, and kinetic data such as: dissolution rate, equilibrium constant, reaction rate (Sözbilir, and Canpolat, 2010); and the second law of thermodynamics (Baran, & Sözbilir, 2018).

The main challenge for students is that the abstract level of thermodynamic concepts (Ayyildiz and Tarhan, 2012). Besides, Pathare and Pradhan, (2010) reported that because of some selected chemistry concepts are not part of learners' everyday experiences, students lead to misinterpret the topics when they are introduced in science classes. Students learn enthalpy generally in upper secondary school or at higher level. In secondary school, students are mainly taught the concepts 'heat' and 'chemical energy' instead of enthalpy. One of the problems is that many students cannot distinguish the concepts of heat and temperature and they consider "heat" and "temperature" to have the same meaning and use them interchangeably (Kartal, Ozturk, and Yalvac, 2011).Further study conducted by (Cotignola, and Cappannini, 2012) revealed that students confused to differentiate heat and energy concepts and they often have misconception in learning such chemical thermodynamics concepts. Besides, enthalpy is one of the fundamental thermodynamic concept which students confused to understand the concept (Costu, Ayas, and Niaz, *et al*, 2010).

Few researches carried out in order to find out students' understandings of enthalpy change or energy changes in a chemical reaction and bond energies (Kolomuç, and Tekin, 2011).Students' ideas and misunderstandings about enthalpy and related chemical thermodynamics concepts have received relatively little attention from science educators and researchers (Tatar and Oktay, 2011). Therefore, this study focused on diagnosis of grade 12 students' alternative conceptions of chemical thermodynamics.

1.2. Statement of the problem

The study of misconceptions attracted the considerable interest of science educators because of it is essential for a successful teaching and learning interplay. Misconception is erroneous beliefs or alternative views of scientific principles or wrong notions about certain scientific concepts agreed that students do not grasp fundamental ideas covered in classroom teaching instructions (Çalık, and Cobern, 2017). It might also be referred to as preconceived notions, non-scientific beliefs, naïve theories, mixed conceptions or conceptual misunderstandings. Basically, in science, there are the ideas in the mind of individuals may be different from what is scientifically correct (Sani, 2010).What is of great concern about misconceptions is that individuals continue to build knowledge on their current understanding which may have negative impact on future learning. Previous studies revealed that students hold misconceptions in chemistry. Some areas of chemistry students frequently in misconceptions are chemical equilibrium (Yamtinah, *et al*., 2019); acid-base and chemical bonding (Smith and Nakhleh, 2011); nuclear chemistry (Pidgeon, and Demski, 2012); solutions and their components (Adadan, and Savasci, 2012, and electrochemistry (Sanger, and Greenbowe, 1997); and chemical thermodynamics (Malaku et.al, 2015).

Alternative conceptions about chemical thermodynamics might be transferred from teacher to students (Kolomuç and Tekin, 2011).Some of the earlier reported misconceptions was identified in chemical thermodynamics; Bond breaking release energy, conversely bond making requires energy, a spontaneous reaction is always exothermic, enthalpy change is the energy transfer at constant volume, exothermic reactions occur fast, endothermic reactions occur fast (Baran, & Sözbilir, 2018) and they were conducted at university level (Malaku et.al, 2015).

In addition to review of literature report, from his teaching experiences of secondary schools teaching chemistry, the researcher noted that many grade 12 natural science students were confused and difficulty in solving the problems related chemical thermodynamics (first law and second law of chemical thermodynamics) in their examinations. They didn't express their answers clearly and logically in the chemical thermodynamics. However, there was no study conducted to identify grade 12 students' misconception about chemical thermodynamics using four-tier test on these secondary schools while the problems are still observed in Ansho secondary schools. Therefore, this study was aimed to identify grade 12 natural science students' misconceptions on the chemical thermodynamics using four-tier diagnostic test, and level of students' misconception in Ansho secondary school of SNNPR, Ethiopia.

Research questions

1. What are the common misconceptions grade 12 natural science stream students hold in the thermodynamic concepts?
2. What are the levels of misconceptions of grade 12 natural science steam students

on the concept of chemical thermodynamics?

1.3. The Objective of the Study

1.3.1The General objective of the Study

The general objective of this study is:

- To identify grade 12 natural science stream students' alternative conceptions on the concept of chemical thermodynamics using four-tier test and determine the level of their misconception.

1.3.2. Specific Objectives of the Study

The specific objective of the study will be:

- To identify the common misconceptions of grade 12 natural science stream students on the concept of chemical thermodynamics (first law and second law of chemical thermodynamics)using four-tier test to prove learning and teaching process.
- To determine the level of misconceptions of grade 12 natural science stream students on the concept of chemical thermodynamics.

1.4. Significant of the Study

Information about the development of misconceptions is particularly useful for science teaching community in order to develop curriculum materials and design better instructional approach to minimize the challenge. Therefore, this study is important in helping teachers and curriculum developers in addressing and designing teaching and learning process. It will be expected to reduce the existing gaps in learning chemical thermodynamics conceptions such as enthalpy, spontaneous process, non-spontaneous process, and entropy. It will be also used as a starting point for the development of subsequent learning activities based on some common and key misconceptions. Moreover, this study lays a foundation for future studies that aim at investigating the causes of misconceptions and appropriate to bring conceptual change. Therefore, to ensure meaningful learning, exploring students' misconceptions are great importance.

1.5. Scope of the Study

This study identified the major alternative concepts on grade 12 natural science stream students of Ansho Secondary School held on the concept of Chemical thermodynamics. Hence, generalizing the finding of this study into other disciplines or topics or contextualize to related specific discipline may lead to causes difficulty. Therefore, it focused only on selected chemistry concepts of chemical thermodynamics covered in grade 12 natural science students textbook.

CHAPTER TWO

2. RELATED LITERATURE REVIEW

2.1. Misconceptions in Chemistry

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 (Barke et al., 2009), alternative conceptions and commonsense reasoning (Talanquer, 2006),preconceptions (Barke et al., 2009), alternative framework (Maskill & de Jesus, 1997), or naïve conception (Reiner et al., 2000) (misconception term is used in this paper for simplicity.) 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). A number of research studies in the area of misconception showed that students' prior experiences, back ground, environment, world view affect their interpretation of observations, scientific concepts etc. As a result, students may come to the classroom with some misconceptions toward to be taught. But, traditional textbooks and instructional strategies are not helpful in removing these misconceptions because simply presenting material, giving out problems and accepting answers back is not an efficient way of meaningful learning and instruction. If you understand which pre-instructional conceptions are forming students current thinking, you might be able to strategize ways for students to first question those pre-instructional conceptions before introducing new ideas (Muchtar, and Hariza, 2012). Thus, considering the science education, there are extensive literature about the incorrect scientific understandings of students which focus on the identification of them, classification of them and evaluation of instructional strategies to change them. This process of changing the existing conception (i.e., belief, idea, or way of thinking) of students is called as conceptual change. In fact, many misconceptions stem from oversimplifying scientific concepts in order to introduce information at a level that more accurately represents the intellectual capacity of students in a particular classroom (Li & Li, 2008). Some misconceptions can be attributed to the age and maturity of the students, while others can be attributed to the scientific language and vocabulary that are often used by both textbooks and teachers in the classroom. In conceptual change, existing conceptions become a conceptual framework that students use to solve problems, explain phenomena, and function in their world. The first and most significant step in teaching for conceptual change is to make students aware of their own ideas about the topic or phenomenon under study. As students become aware of their own conceptions through presentation to others and by evaluation of those of their peers, they become dissatisfied with their own ideas; conceptual conflict begins to build (Barke et al., 2009; Muchtar, and Hariza, 2012). By recognizing the inadequacy of their conceptions, students need to become more open to changing them.

Introducing high Schhol students to complex scientific ideas and terminology requires a simplification of topics to accommodate the ability level of the students. There is a surprisingly large amount of chemistry material found in elementary textbooks due to the potential to relate many chemistry topics (such as states of matter) to a young student's everyday experiences (Gabel, 1999). While introducing topics at a young age can be beneficial in the construction of a conceptual framework, it can also hinder a student's understanding when teachers use words from their everyday language, such as heat or theory, to explain scientific phenomena where the words have very specific meanings (Özmen, 2004). Student understanding is also affected by the amount of time spent on each topic. The less time a student spends exploring a topic, the more likely a misconception will form and affect future learning experiences. This lack of understanding carries over to more advanced material as well, creating a vicious cycle of learning, connecting and restructuring a conceptual framework that was incorrect from the very beginning (Nakhleh, 1992).

2.1 Alternative conceptions in Chemical thermodynamics

Chemical thermodynamics study mainly aimed to determine high school students' conceptual understanding levels of common thermodynamics subjects such as heat, temperature, bond breaking, bond formation, enthalpy and energy changes in chemical reaction. Chemical thermodynamics problem involves not only the concepts that are unique to, it but also other concepts of first law chemical thermodynamics, second law of chemical thermodynamics, heat of energy, bond broken energy and bond formation energy, enthalpy, and entropy. It is not then surprising that students encountered numerous difficulties in solving such problems was addressed by (Ozturk, and Yalvac, 2011). Some researchers reported students misconceptions in area of chemical thermodynamics like; bond breaking release energy, conversely bond making requires energy, a spontaneous reaction is always exothermic, enthalpy change is the energy transfer at constant volume, exothermic reactions occur fast, endothermic reactions occur fast (Sozbilir, 2001). Moreover, other problems are many students cannot distinguish the concepts of heat and temperature and they consider “heat” and “temperature” to have the same meaning and use them interchangeably (Schönborn, *et al.*, & Xie, 2014).

Science education researchers reported that students have misconceptions on the energy is released when chemical bonds formed. Ross (1993) notes that many students think energy are released when chemical bonds break. He believes this misconception is a barrier to learning which begins when students develop a strong association between fuels and energy, learning the phrase "fuels contain energy" by rote. Development of the idea continues when students associate “fuel is an energy store" with chemical bonds. For example, they will learn that each methane molecule involves forming four covalent bonds between carbon and hydrogen. It is easier to imagine that the energy associated with burning methane is generated when these bonds break, rather than is “leftover” when new bonds form. Students' ideas about burning were discussed earlier and many of them do not know where the heat produced in burning comes from. Chemical bonding provides them with an answer. Ross (1993) suggests that to assist students, teachers should present the reactions between fuels and oxygen as a "fuel - oxygen system" and help them to develop ideas about the relative strengths of covalent bonds in different molecules. Moreover, Brook and Driver (1984) found that students have misconception about conservation of energy. When asked more directly about this principle, two-thirds of the students said, "Energy is used up or lost" (Finegold and Trumper, 1989) found similar difficulties in their study and they report that 80% of their students did not conserve energy in responding to basic questions. Energy being "used up" was commonplace (Ross, 1993) notes that students acquire this idea from everyday experience of batteries going flat, petrol tanks needing refilling and electricity being "used up" in providing heat and light. For this question some students described energy as being "caused" by something. This student seems to suggest that energy is made by something.

The essential principle of the Second Law of Thermodynamics is that disorder, or entropy, increases when a chemical reaction occurs. An alternative statement is that "heat will not flow spontaneously from a colder to a warmer body" (Freemantle, 1987), (Duit and Kesidou, 1988) studied understanding of students about the Second Law of Thermodynamics and they reported that "Most students have intuitively the correct idea that temperature differences tend to equalize and that the processes will not totally run back after equalization." The principle embodied in the Second Law does not seem to run against students' everyday experiences, so perhaps this idea is less problematic. The First Law is more problematic because the energy transfers included in a system are frequently invisible; for example, a toy car when wound up will only run for a limited period of time and to a child it seems that the energy has simply "run out" or has been "used up". That the energy has done work in making the car move against the environment is not obvious. In contrast, students are more likely to think that heat can only go in one direction, since again this fits with their every day.

2.2. Methods of investigating students' Alternative Conceptions

By investigating the conceptual understanding Test (CUT) used in the pilot study will includes multiple choice questions (MCQs) tend to be a popular choice questions. Multiple choice questions are versatile, efficiency, easy to use and less influenced by an individual tendency to respond in a particular way. Students' understanding of chemical thermodynamics concepts, especially misunderstandings and alternative concepts cannot be fully identified by a simple instrument such as a multiple-choice test. Such one-dimensional tools cannot distinguish between a lack of knowledge, an alternative concept or indeed guesswork.

Multiple choice tests, have been used to a ascertain students' conceptions. The validity evidence for this format is strong (Treagust, & Lilia, 2011). From the point of view of teachers' usage, valid and reliable, easy-to-score, easy-to-administer, paper-and-pencil instruments enable teachers to effectively assess students' understanding of science. A science teacher can get information about students' knowledge and misconceptions by use of the diagnostic instruments. Once the student misconceptions are identified, teachers can work to remedy the faulty conceptions with appropriate instructional approaches. Advantages of using multiple-choice tests over other methods have been discussed by several authors (Caleon & Subramaniam, 2010a). To sum up, some of the advantages of multiple-choice tests are: (1) They permit coverage of a wide range of topics in a relatively short time. (2) They are easily and quickly scored. (3)They are suitable for item analysis by which various attributes can be determined. (4) They provide valuable diagnostic information and are viable alternatives to interviews and other qualitative tools in gauging students' understanding and in determining the prevalence and distribution of misconceptions across a population. The chief difficulty in these tests, however, is in interpreting students' responses if the items have not been constructed carefully. Researchers developed test items with distracters based on students' answers to interviews (Dibattista, and Kurzawa, 2011) suggested the combination of the strengths of interviewing technique and multiple-choice exams as an ideal course of action in order to investigate students' understanding in Chemistry. In spite of the advantages of multiple-choice tests mentioned above, there are some criticisms of them. (Yeh and Barufaldi, 2010) stated that certain limitations and drawbacks of multiple-choice questions, such as: (1) Student guessing contributes to the error variance and reduces the reliability of the test. (2) Selected choices do not provide deep insights into student ideas or conceptual understanding. (3) Students being forced to choose each answer from among a very limited list of options, which is preventing them from constructing, organizing and presenting their own answers. (4) It is extremely difficult to write good multiple-choice questions. Another very common criticism that was described that ordinary multiple-choice tests cannot differentiate correct answers due to correct reasoning from those that are due to incorrect reasoning (Caleon & Subramaniam, 2010a; Eryılmaz, 2010), so they may overestimate student scores (Kaltakç, 2012; Peşman & Eryılmaz, 2010). To overcome the limitations of multiple-choice tests, tests with multiple-tiers have been developed.

A two-tier diagnostic instruments which are the most popular form of multi-tier instruments. The first tier consists of multiple-choice questions with one correct answer and several controlled distracters. The second tier is a reason tier which can be in two different formats. In one format the second tier consists of choices for a reason for the chosen answer in multiple-choice question (MCQ) form. This tier includes one correct scientific reason and several incorrect or unscientific reasons.(Chandrasegaran, *at al.*, & Mocerino, 2007).All options in both tiers are derived from students' actual misconceptions and misunderstandings as determined by preliminary tests, interviews and the literature. A two-tier instrument of this type cannot distinguish between a guessed reason and a real misconception. In addition, a two-tier instrument could only detect a small proportion of students' alternative concepts. In addition TTMC instrument is effective to determine students‟ conceptual understanding and may used as an alternative instrument to determine students‟ achievement (Winarti, *et al.*, 2017). TTMC instrument is developed to investigate the students‟ concept understanding because TTMC instrument consists of conceptual question with two level or two tier. The first level (first tier) is the main answer to evaluate students‟ conceptual, and the second level (second tier) is the reason of students‟ answer in first tier.4Thus, two-tier tests might overestimate or underestimate students' scientific conceptions or overestimate the proportions of the misconceptions since the gap in knowledge could not be determined by two tier tests (Caleon & Subramaniam, 2010a, 2010b; Peşman & Eryılmaz, 2010). To sum up, two-tier tests have advantages over ordinary multiple-choice tests. The most important of them is that those tests provide students' reasoning or interpretation behind their selected response. However, these tests have some limitations in discriminating lack of knowledge from misconceptions, mistakes, or scientific knowledge. For this reason, three-tier tests become crucial in order to determine whether the answers given to the first two tiers are due to a misconception or a mistake due to lack of knowledge.

Recently, instrument asks students for their mean confidence level in both tiers while the three-tier and four-tier instruments have been used in science education research to overcome the drawbacks of the two-tier instrument. In both types of instrument, the first two tiers are exactly the same as the tiers in the two-tier instrument. However, the three-tier instrument asks for the confidence level in both tiers separately (Caleon & Subramaniam, 2010). Confidence levels are rated on a scale from 1(not at all confident) to 5 or 6 (absolutely confident).As the confidence level in the three-tier instrument relates to mean confidence in both answer and reason, such an instrument cannot determine whether students are confident about both their answer and their reason or whether they are sure about their answer but unsure about their reason and vice versa. This creates difficulties when grading and categorizing the responses. To overcome this disadvantage, the three-tier instrument and the four-tier instrument has been developed. These instruments will provide both theoretical and practical advantages. Theoretically, this instrument will enrich chemistry education literature and will be transferable to related research. Practically, this instrument will help High school teachers in their general and physical chemistry classes as it can be used to identify students' preconceptions and so assist in planning to teach. So far, studies using a four-tier instrument have only been published in physics education in chemical thermodynamics (Sreenivasulu,& Subramaniam, 2013) and transition-metal chemistry (Sreenivasulu & Subramaniam, 2014). Generally, multiple choices have a fundamental weakness; they cannot differentiate scientific answer or correct answer from those which are due to incorrect reasoning;

i. A two tier multiple choice (2TMC) item includes content based alternative in the first tier (A-tier or Answer tier) and relevant principles justifying A-tier response in the second tier (R-tier or reason-tier) . 2TMC tests relative to MCQs is better to explore students' ACs as they measure not only the students' ability to select correct responses regarding, but also the reasoning based on their choices.

ii. A three-tier Multiple choice test item includes confidence-rate refers to the judgments and appraisals by an individual regarding the quality or accuracy of their own performance.

iii. A Four-tier Multiple Choice Test (4TMC) test is similar with version of the two-tier multiple choice (2TMC) tests. As in 2TMCs its answer and reason-tier measure students' concept knowledge, respectively. Moreover the two additional tier measure the level of confidence of the students in correctness of their chosen options for the reason and answer.

CHAPTERTHREE

RESEARCH METHODOLOGY

3.1 Area and Population of the study

The study was conducted grade 12 students in 2014 at Ansho high school which is capital city of the Duna Woreda. It is found in Hadya Zone, SNNPR/, Ethiopia at a distance of 277 km from Addis Ababa, 211 km from Hawassa, 42km from Hosanna. The sample population of the study was grade 12 natural science students in Ansho secondary school.

3.2 Sample and sampling techniques

The study was conducted at Ansho secondary school and the all grade 12 students in 2014 E.C were considered. Accordingly, 120 grade 12 natural science students (60 male and 60 female) were participated in this study. The researcher selected Ansho secondary school purposively due to the researcher worked at this school its physical accessibility to the researcher, and he was experienced students misconception in chemistry class in general and chemical thermodynamics in particular which makes the data more valid and reliable.

3.3.1 Research design and data collection instrument

To diagnosis grade 12 students' misconceptions on chemical thermodynamics, multiple-choice test was commonly used in science education research in order to identify misconceptions. However, each tool has some advantages as well as disadvantages over the others as discussed in several studies. In this study the researcher developed and used Four-tier diagnostic instrument on chemical thermodynamics (FTDICTD) of students to obtain a general overview about the concepts that are not generally understood; collecting and categorizing students' unscientific ideas and misconceptions based on initial questionnaire results. The researcher collected and categorized students' unscientific ideas and misconceptions and then validated the prototype FTDICTD after piloted the data from with sampled students; and refined the final FTDICTD based on the findings of pilot study. In this study the targeted area include first law chemical thermodynamics (enthalpy, internal energy, the systems and spontaneous and non-spontaneous process); the relation b/n temperature; and entropy in second law of chemical Thermodynamics.

In order to construct the questions, various sources were exploited including textbooks, exam papers and other literature. All diagnostic questions were developed from the concept of chemical thermodynamics from Grade 12 chemistry text book and evaluated by the experienced chemistry teachers. The questions were then scrutinized by experienced chemistry teachers who have been teaching grade 12 natural science students. Accordingly, some questions were adjusted followed experts comments and suggestions. In this way 14 FTDICTD which were evaluated by experts were selected and distributed to the students. Each item consisted one correct answer and 3 distractors. The students were asked to give their level of confidence in their chosen answer using a 6 part Liker scale from just guessing to absolutely confident. Students were then asked to select the appropriate reasons for their answers given in the first tier and then assign a level of confidence to the reasons, again using a six-part Liker scale.

3.3.2 Data Collection Process

In this study, four-tier multiple choice chemical thermodynamics diagnostic (FTDICTD) was developed by the researchers by considering the misconceptions reported in the literature, and administered to the students to collect data. The collected data were recorded for further analysis. The sample of FTDICTD is given on the Appendix 1. There were 14 multiple choice questions with one correct answer and three distractors which reflect the students' common misconceptions in chemical thermodynamics concept. Content validity of the instrument was determined by considering the experts' ideas in the department of chemistry Dilla University and experienced high school Chemistry teachers. The data collection process was taken two weeks.

3.4. Data Analysis

In order to measure students' conceptions on chemical thermodynamics concepts, four-tier multiple choice chemical thermodynamics diagnostic (FTDICTD was administered by the researcher. The administration and collection of the research instruments was done in second term of the school calendar and took two weeks. The collected data was recorded and analyzed by SPSS/PC 11.0 version.

Four-tier multiple-choice tests

In this study a four-tier diagnostic instrument were conducted as main data gathering instruments. Four-tier multiple choice (4TMCs) diagnostic questions were developed (Kaltakçı, 2012) on the concept of chemical thermodynamics from Grade 12 students' chemistry text book, university entrance examination, and other literatures. The 4TMCs were carefully examined by Dilla University, chemistry department lecturers and experienced high school chemistry teachers of selected schools.

Table 1 below provides the decisions for four-tier test in determining the lack of knowledge based on the possible student rating of confidence in four-tier tests. For instance, in a four tier test, if a student gives a correct answer to the main question in the first tier and is high about his answer for this tier, then gives a correct answer to the reasoning question in the third tier but is low about his answer for this tier, then the researcher's decision about the student's answer for this item is "lack of knowledge" because there is doubt about at least one tier of the student's answer, the student may select "high" or "low" since he is not sure for at least one of the tiers. If he chooses "low" the researcher's decision would be that student has a "lack of knowledge", but if the student chooses "high" then the researchers' decision for that student's answer for this item would be he has a "scientific knowledge" on this item. No understanding: the student answered both tiers incorrectly (Sreenivasulu & Subramaniam, 2013). Hestenes et al. (1992) proposed False positive and false negative concepts in order to emphasize the importance of accuracy of measures in a multiple-choice test. False positive is defined as a Newtonian answer chosen with non-Newtonian reasoning; whereas false negative is a non-Newtonian answer with Newtonian reasoning. False negatives are considered unproblematic and are attributed to carelessness or inattention. The minimization of false positive answers, on the other hand, is difficult. The authors stated that the major problem in a multiple-choice test development is to minimize false positives and negatives (Kaltakçı, 2012; Peşman & Eryılmaz, 2010)

The analysis part of four- tier multiple question has five categories based on the students' response on each tier of four-tier diagnostic test of chemical thermodynamics. The five categories consist of, false positives, false negative, lack of knowledge, scientific conceptions and misconception.

Table 1 Confidence level decisions in four-tier tests

First-tier (A-tier)	**Second-tier (C-Rating)**	**Third-tier (R-tier)**	**Fourth-tier (C-Rating)**	**Decision for four-tier test**
Correct	High	Correct	High	SC
correct	High	correct	Low	LK
correct	Low	correct	High	LK
correct	Low	correct	Low	LK
Correct	High	Incorrect	High	FP (M)
correct	High	incorrect	Low	LK
correct	Low	incorrect	High	LK
correct	Low	incorrect	Low	LK
Incorrect	High	Correct	High	FN (M)
incorrect	High	correct	Low	LK
incorrect	Low	correct	High	LK
incorrect	High	correct	Low	LK
Incorrect	High	Incorrect	High	M
incorrect	High	incorrect	Low	LK
incorrect	Low	incorrect	High	LK
incorrect	Low	incorrect	Low	LK

True response (correct) High confidence rating ≥ 4 (4 5 6)

False response (incorrect) Low confidence rating < 4 (1 2 3)

SC = Scientific Conceptions M = Misconception

FN = False Negative FP = False Positive

LK = Lack of Knowledge

The level of misconception

The level of misconception was calculated followed Kaltakci*et al*, (2015) as follows:

$$\% = \frac{\Sigma Student\ with\ misconception}{\Sigma Sample} \times 100\%$$

The decision on the level of misconceptions present among the students was decided based on the work of Kaltakci et al, (2015) presented in table 2.

Table 2: Criteria to determine level of misconception

S.No	Percentage (%)	Level of Misconception
1.	$0 \leq LM \leq 20$	Very low
2.	$21 \leq LM \leq 40$	Low
3.	$41 \leq LM \leq 60$	Moderate
4.	$61 \leq LM \leq 80$	High
5.	$81 \leq LM \leq 100$	Very high

CHAPTER FOUR

RESULTS AND DISCUSSIONS

In this part, students' level of conceptual understanding on heat energy, temperature, enthalpy, spontaneous and non-spontaneous process and entropy, in chemical reactions were analyzed. The study investigated the level of conceptual understanding in three categories: completely wrong or no answer, partially understanding or misconceptions and full understanding.

4.1. Students Misconception on concept of chemical thermodynamics

Table 3: Frequency and Percentage of Scientific Concept, Lack of knowledge, misconception false positive, misconception false negative and all misconception on each area (N = 120).

Items	Frequency and Percentage (f (%))					
	FP	FN	LK	M	SC	FPM+FPN+M
1.	20(16.67)	13(10.8)	65(54.17)	9(7.50)	13(10.80)	42(35.00)
2.	12(10.00)	11(9.17)	76(63.33)	13(10.8)	8(6.67)	36(30.00)
3.	23(19.17)	27(22.50)	48(40.00)	9(7.50)	13(10.80)	59(49.17)
4.	47(39.17)	26(21.67)	30(25)	10(8.33)	6(5.00)	84(70.00)
5.	6(5.00)	12(10.00)	67(55.83)	15(12.50)	20(16.67)	33(27.50)
6.	45(37.5)	29(24.17)	26(21.67)	13(10.83)	7(8.83)	87(72.50)
7.	16(13.33)	9(7.50)	55(45.83)	21(17.50)	19(15.83)	46(38.33)
8.	12(10.00)	12(10.00)	57(47.50)	16(13.33)	23 (19.17)	40(33.33)
9.	48(40.00)	20(16.67)	22(18.33)	15(12.50)	15(12.50)	83(69.17)
10.	10(8.33)	14(11.67)	59(49.17)	11(9.17)	26(21.67)	35(29.17)
11.	24(20.00)	23(19.17)	20(16.67)	20(16.67)	33(27.50)	67(55.83)
12.	23(19.17)	10(8.33)	51(42.50)	20(16.67)	16(13.33)	53(44.17)
13.	30(25.00)	21(17.5)	20(16.67)	21(17.50)	28(23.33)	72(60.00)
14.	18(15.00)	12(10.00)	39(32.50)	27(22.5)	24(20)	57(47.50)

False Positive = FP, False negative = FN, Lack of Knowledge = LK, Misconception = M, Scientific Conceptions = SC, False Positive + False negative + Misconception = FP+ FN +M, frequency = f, Percentage = %

In item 1, students were requested to identify t he relationship between intermolecular forces of attraction of gas particles with pressure. Accordingly, about 42(35%) of students have misconception in identifying the relationship between intermolecular forces of attraction of gas particles with pressure. Many students believed that the frequency of collisions of the molecules with the walls of the container increases when gas molecules further away from each other. For this question, majority 65(54.17%) of grade E 12 natural science stream students of Ansho secondary school have lack of knowledge while only 13(10.8%) of students gave correct answer or have scientific concepts. To answer this question the students' should have concrete understanding of real gas law concept.When intermolecular force of attraction disappears suddenly the gas molecules velocities would increase and consequently, the observed pressure will also increase.

In item 2, students were asked to identify the effect of catalyst on chemical reaction. Accordingly, majority or 76 (63.33%) of students have lack of knowledge while about 36(30%)of students have misconception. Majority of students believed that using catalysts make the reactions faster without requiring energy. However, the presence of catalyst lowers the energy of the transition state of the reaction since the activation energy is the difference between the transition state energy and the reactant energy, lowering the transition state energy also lowers the activation energy. For this question about 8 (6.7%) of students gave correct scientific concepts. They believed that by using catalyst didn't affect the amount of products and reactants and only it have effect on the activation energy.

In item 3, students were requested to identify the relationship among heat, temperature, specific heat and mass when compared the amount of heat of Pacific Ocean and the amount of heat in the glass from Pacific Ocean that is heated up at a fixed point. Accordingly, about 59(49.2%) students have misconception in identifying the relationship between heat, temperature, mass & specific heat. They believed that heat is only connected with temperature and mass without distinguishing specific heat capacity. Others believed that absorbed heat depends only on specific heat, and if temperature is high, the heat is absolutely high and it is not connected with mass. However, 13(10.8) % of students have correct scientific idea who identified there is the relationship between temperature, heat, mass and specific heat when temperature increases. As the amount of heat energy gained or lost by a substance is equal to the mass of the substance multiplied by its specific heat capacity multiplied by the change in temperature (final temperature - initial temperature:Δt) $Q = mc\Delta t$.

In item 4, students were requested to identify between the given substance of water and ice become freeze to below temperature 0^0c after waiting until their temperature equals the freezer temperature, which eventually lose the greatest amount of heat. Accordingly, about 84(70%) of students have misconception in identifying the greatest amount of heat lost. They believed that when they put water and ice into a freezer, both of them at 0ºC, they lost the same amount of heat because both of them have the same initial temperature. The alternative concept was so predominant that they did not consider the phase change. Some students believed that in terms of heat and temperature having a cause-effect relationship. Students with this idea used only temperature to think about the amount of heat transfer into or out of the object. However, 6(5%)of students have correct scientific idea the students identified the amount of heat energy gained or lost by a substance is equal to the mass of the substance multiplied by its specific heat capacity multiplied by the change in temperature (final temperature - initial temperature: Δt) $Q = mc\Delta t$.

In item 5 the students were requested to indicate the amount of heat transfer. About 33(27.5%) of students have misconception while about 67(55.83%) of the students shown lack of knowledge. Majority of students considered temperature as an indicator for the amount of heat transfer, or they thought that if two bodies have the same temperature or have the same changes in temperature then they have the same energy or heat. But the amount of heat energy gained or lost by a substance is equal to the mass of the substance multiplied by its specific heat capacity multiplied by the change in temperature (final temperature - initial temperature: ΔT) $Q = mc\ \Delta T$ by considering the phase change. Only, 20(16.7)% of the students answered correct answer or have scientific concept.

In item 6, students were requested to identify the final temperature of the water in the container from the same substances at different masses and temperature. Accordingly, about 87(72.5%) of students have misconception who believed that the substances have higher temperature also has greater volume. And on the other hand some students considered as the substances which that have lower temperature also smaller volume. Some students believed that substances do not have any heat and temperature at zero degrees Celsius. However, some students understood the scientific idea that the heat transfer is normally from a higher to a lower temperature object alternatively by differentiating between extensive properties (heat transfer) and intensive properties (temperature).

In item 7, students were requested to identify the entropy at different states. However, 46(38.3%) of students have misconception and they believed that an increase in entropy means anyways an increase in temperature. Entropy increases in the gaseous molecules than liquid b/c the particle of the gaseous molecule become disordered. However, 19(15.8%) of students have scientific knowledge. They described that there is no constraint on the change in entropy of particles order, so the entropy may not be increase or decrease in temperature dependence (that considering only the enthalpy change of a process is not enough). But the factor which makes the spontaneity of a process is also depends on how the disorder of the system changes during the process.

In item 8, students were requested to determine the entropy of the system (S_{system}) increase, decrease, or remain the same. Accordingly, 40(33.3%) of students have misconceptions in identifying entropy of the system according to the second law of thermodynamics. Entropy of a system increases as temperature of the system increases and the entropy of a system decrease as temperature of the system decrease. This is because of randomness (entropy) decreases as the motion of particles decreases and their velocity decreases so they have less entropy at a lower temperature. In another word, an increase in temperature causes increase in particles collision which brings greater kinetic energy of the system and enhances entropy of the system. However, 23(19.2%) of students have scientific knowledge that the entropy of the surroundings must increase as based on the consequence of the second law chemical thermodynamics which stated that the entropy of the universe increases in a spontaneous process and remains unchanged in an equilibrium process. Because the universe is made up of the system and its surroundings, the entropy change in the universe ($\Delta S_{universe}$) for any process is the sum of the entropy changes in the system (ΔSsys)and the surroundings (ΔSsur). This is Mathematically expressed as:

For a spontaneous process: $\Delta S\text{univ} = \Delta S\text{sys} + \Delta S\text{sur} > 0$

For an equilibrium process: $\Delta S\text{univ} = \Delta S\text{sys} + \Delta S\text{sur} = 0$

For a spontaneous process, the second law says that ΔS_{un} must be greater than zero.

In item 9, students were asked to determine the entropy of the surroundings ($\Delta S_{surrounding}$) increase, decrease, remain the same or this is not determinable. Accordingly, 83(69.2%) of students have misconception about the entropy of the surrounding decreases because temperature decreases. Some students believed that no information is provided about energy transfer between system and surroundings increasing or decreasing. However, 15(12.5%) of students have scientific idea that the entropy of the surrounding decreases when the temperature of the system decreases, the kinetic energy or the internal energy decreases, so the molecules in the system could not move more freely, which indicates an decrease in disorder of the system.

In item 10, students were asked to differentiate what happen to the system when the entropy of the system plus the entropy of the surroundings (System+ Surroundings). Accordingly, 35(29.17%) of students have misconception about the entropy of the surrounding decreases because temperature decreases. They believed zero energy transfer between system and surroundings. However, 15(12.5%) of students have scientific idea that the entropy of the surrounding decreases when the temperature of the system decreases.

Item 11 the students wereasked to differentiate what is happen when the ice melts and some drops of water is observed at the outer wall of the battle. Accordingly, 67(55.83%)of students have misconceptions that predicts students always think that the entropy of a system must increase without considering the processes in that system. However, 33(27.50%)of the students have scientific concepts according to the 2nd law of chemical thermodynamics states that the total entropy of a real process has to be zero.

In item 12, students were requested to observe different reactions occurred in the different beaker. Accordingly, 53(44.2%) of students have misconceptionthe students understood that if the temperature is increased the substance takes heat, but they failed to understand that if the temperature is decreased the substance releases heat. Some said that the substances take cold instead of giving heat. Moreover, some students believed that certain substances give heat steadily because of their nature. However, 16(13.3%) of students have scientific ideas there is the relationship between heat and temperature. When a temperature is increased in a given substance the reaction will be increased because the kinetic collision of particle is increased.

In item 13 students were requested to identify temperature of isolated system when subsystem A is thermal contact with its surroundings which together comprises an isolated system. The position before the reaction & after the reaction is seen below for each beaker.Accordingly, about 72(60%) of students have misconception in identifying an isolated system when students asked about an isolated system, students with this ACs answered that the system entropy has to increase and the total entropy has to be zero because the system is isolated. However, about 28(23.3%) of students have scientific ideathat is a system in which neither the transfer of mass nor that of energy takes place across its boundary with the surroundings.

In item 14, students were requested to identify asubsystem is in thermal contact with its a given surroundings and they together comprise an isolated system that is undergoing an irreversible process. Accordingly, about 57(47.5%) of students have misconception in identify the relationship between irreversible reaction and isolated system. They confused the entropy of the system with the total entropy, or the entropy of the system plus surroundings. However, 24(30%) have scientific idea isolated system is a system in which neither the transfer of mass nor that of energy takes place across its boundary with the surroundings.

The results of this study showed that Ansho secondary school students have a number of common misconceptions in the chemical thermodynamics. These can be summarized as:

- Endothermic reactions cannot be spontaneous.
- Entropy of surrounding decreases because its temperature decreases.
- The entropy of the system has to always increase.
- Total entropy has to be zero because the system is isolated.
- Catalysts make the reactions faster without requiring energy.
- The substance that lower temperature has smaller volume where as higher temperature also has larger volume.
- Temperature is the amount of heat contained in a body since heat and temperature are the same
- Heat is affected just by temperature but not by mass and specific heat.
- Heat transfer does not depend on the mass of the object. Heat transfer is the same only if they are the same type of substance, such as water
- The entropy of the system must increase for any spontaneous process

4.2. The level of misconceptions

The decision on the level of misconceptions present among the students was decided based on the work of Kaltakci et al, (2015) which is presented in table 4.

Table 4: The level of misconceptions

Items	FM	PM	LM
1.	42	35.00	Low
2.	36	30.00	Low
3.	59	49.17	Moderate
4.	84	70.00	High
5.	33	27.50	Low
6.	87	72.50	High
7.	46	38.33	Low
8.	40	33.33	Low
9.	83	69.17	High
10.	35	29.17	Low
11.	67	55.83	Moderate
12.	53	44.17	Moderate
13.	72	60.00	Moderate
14.	57	47.50	Moderate

FM= Frequency of Misconception, PM = Percentage of misconception, LM = Level of Misconception

Based on the Table 4, the level of misconception among grade 12 natural science stream students of Ansho secondary school is ranged from low level misconception to high level misconception level (27.50%-72.50%). In this research, the highest levels of misconception are the subtopic of identifying the final temperature of the water in the container from the same substances at different masses and temperature (72.50%), distinguish between the given substance of water and ice to become freeze below temperature 0^0C after waiting until their temperature equals the freezer temperature (70 %) and about the entropy of the surroundings (69.17%). As for chemical thermodynamics topic, the high percentage of misconceptions of chemical thermodynamics shows that students unable to differentiate the relationship between temperature, entropy or first law and second law of chemical thermodynamics. At the moderate level of misconceptions the subtopic are differentiate the heat and temperature indifferent context(49.17%), entropy of a system (55.83%), temperature exchange in the system (44.17%), temperature of isolated system (60.00%), and about irreversible reaction and isolated system (47.50%).

The overall analysis of the level of students misconceptions indicates that grade 12 students were experienced a moderate level of misconception or 47.26 % which is found on the range 41-60%. The study revealed that grade 12 students faced moderate level of misconception on the concept of chemical thermodynamics.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

This section summary the finding of this study the core concern of this study is the exploration of the misconceptions of the grade 12 natural science stream students about the chemical thermodynamics using a Four-tier diagnostic instrument comprising of 14 questions. The proposed research problems were:1, to identify the common misconceptions of grade 12 students on the concept of chemical thermodynamics (first law and second law of chemical thermodynamics)using four-tier test to prove learning and teaching process 2, to identify the level of misconceptions of grade 12 students on the concept of chemical thermodynamics. One hundred twenty grade 12 male and female students from Ansho secondary school. The instrument used in the study was FTCTDT which consisted of four-tier multiple-choice items. The first-tier consisted of content questions with four alternatives. The second tier consisted of a confidence scale with 1 to 6 corresponding to "Just Guessing" to "'Absolute Confidence" respectively on content question, respectively. The third consists of reason questions with four alternatives including three alternative reasons and one scientifically accepted reason. The fourth tier students to express their confidence in their response to the third tiers by using a confidence scale with 1 to 6 corresponding to "Just Guessing" to"' Absolute Confidence" respectively. The collected data was recorded and analyzed by SPSS. The analysis of results showed that Grade 12 Natural science students hold misconceptions about the concepts of chemical thermodynamics predominantly on enthalpy, heat, entropy, open system, closed system and open system are some major areas'. Besides, the misconception level of Grade 12 Natural science students' level of misconception ranged from low level misconception level to high level misconception (27.50%-72.50%).

5.2. Conclusion

The aim of this study was to identify the common misconceptions grade 12 natural science steam students held on the concept of chemical thermodynamics (first law and second law of chemical thermodynamics) using four-tier diagnostic test and to determine the level of their misconceptions. Accordingly, the analysis of results showed that Grade 12 natural science students of Ansho secondary school hold misconceptions about the concepts of chemical thermodynamics predominantly on the area of enthalpy, heat, entropy, open system, closed system and open system are some major areas’. Generally, the following misconceptions were identified in the area of chemical thermodynamics:

- Endothermic reactions cannot be spontaneous.
- Entropy of surrounding decreases because its temperature decreases.
- The entropy of the system has to always increase.
- Total entropy has to be zero because the system is isolated.
- Catalysts make the reactions faster without requiring energy.
- The substance that lower temperature has smaller volume where as higher temperature also has larger volume.
- Temperature is the amount of heat contained in a body since heat and temperature are the same
- Heat is affected just by temperature but not by mass and specific heat.
- Heat transfer does not depend on the mass of the object. Heat transfer is the same only if they are the same type of substance, such as water
- The entropy of the system must increase for any spontaneous process

Besides, the misconception level of Grade 12 Natural science students’ level of misconception ranged from low level misconception to high level misconception (27.50%- 72.50%).The overall analysis of the level of students misconceptions indicates that grade 12 students were experienced a moderate level of misconception or 47.26 % which is found on the range 41-60%.

5.3. Recommendations

In line with the findings of this study, the researcher recommend that;

- Curriculum designers should consider students misconception in the area of chemical thermodynamics when they design the curriculum. If so it will reduce students' misconception on the concept of chemical thermodynamics and enhance their understanding.
- The teaching and learning of chemical thermodynamics in secondary schools should be strengthening to provide a good foundation for students.
- The teachers should have the concept about students' misconceptions on the area of chemical thermodynamics when they start to teach chemical thermodynamics concepts.
- Teaching chemical thermodynamics concepts should be carried out by experienced chemistry teacher and to reduce students' misconception in the area.

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APPENDIX

Appendix: Sample items of misconception diagnostic methods and their analysis

Question - 1

1.1 Consider a real gas placed in a container. If intermolecular attractions were to disappear suddenly, which one of the following is likely to occur?

A. The pressure decreases
B. The pressure increases
C. The pressure remain the same
D. The gas expands

1.2 The confidence rating;

A. Just guessing,
A. Very unconfident,
B. Unconfident,
C. Confident
D. Very confident,
E. Absolutely confident

1.3 The Scientific reason;

A. The gas molecules are further away from each other
B. The frequency of the collisions of the molecules with the wall of the container
C. Increases
D. The gas molecule will have more freedom to move around
E. It will behave more like an ideal gas

1.4 Confidence rating:

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

Question-2

2.1 Under the same conditions (temperature, pressure and amount), the same reaction is occurred with catalyst in the first and without catalyst in the second beaker. According to this, which of the following is true?

A. The reaction needs less energy to occur
B. The first beaker has higher temperature after the reaction
C. We can’t make any comment about the temperature of beakers
D. The amount of the products are the same for both beakers

2.2 Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

2.3 The scientific reason;

A. Using catalyst decreases the enthalpy
B. Using catalyst effects the enthalpy of different reaction in a different way
C. Using catalyst increases the efficiency of the reaction
D. Using catalyst decreases activation energy

2.4 Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

Question - 3

3.1 Which statement is correct about the pacific ocean at 5^0c and a glass of water from the pacific that is heated up to 95^0c ?

A. Heat of water in the glass is higher
B. The heat of the pacific ocean is higher
C. We cannot compare the heat of pacific ocean and the heat of water in the glass
D. The heat of pacific ocean and heat of water in the glass are the same

3.2 The confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

3.3 The Scientific reason;

A. substances with higher temperature also have heat
B. There is no connection b/n heat, temperature & mass; heat increases when mass Increases
C. The heat is the same for both the water in the glass and pacific ocean, b/c they are the same substances
D. There is no connection b/n heat, temperature & mass

3.4 The confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

Question-4

4.1 If 100 grams of ice at 0°C and 100 grams of water at 0°C are put into a freezer which has a temperature below 0°C. After waiting until their temperature equals the freezer temperature, which one will eventually lose the greatest amount of heat?

A. The 100 grams of ice
B. The 100 grams of water
C. They both lose the same amount of heat
D. There is no answer

4.2 The confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

4.3 Please indicate your reasoning:

A. Water must change to ice before it changes temperature
B. Both of them (water and ice) have the same initial temperature (0^0c)
C. Ice does not contain any heat
D. Water cannot reach 0^0c

4.4 The confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

G. **Question - 4**

H. 5.1 You want to melt ice at 0OC using hot blocks of metal as an energy source. One option is to use one metal block at a temperature of 200^0c and a second option is to use two metal blocks each at a temperature of 100^0c. All the metal blocks are made from the same material and have the same weight and surface area. Which option will melt more ice?

A. Both 100^0 blocks

B. The 200^0c block Both options

C. Not enough information

5.2 The confidence rating;

A. Just guessing

B. Very unconfident

C. Unconfident

D. Confident

E. Very confident

F. Absolutely confident

5.3 Please indicate your reasoning:

A. Two blocks have twice as much surface area as 1 block so the energy transfer rate will be higher when more blocks are used

B. Energy transferred is proportional to block mass and the change in block temperature during the process

C. The higher temperature block will melt the ice faster because the larger temperature difference will increase the rate of energy transfer

D. The temperature of the hotter block will decrease faster as energy is transferred to the ice

5.4 The confidence rating;

A. Just guessing

B. Very unconfident

C. Unconfident

D. Confident

E. Very confident

F. Absolutely confident

Question - 6

6.1 Cup A contains 100 grams of water at 0^0c but cup B contains 200 grams 0f water at50^0C. The Contents of the two caps are mixed together in an isolated container (no heat transfer occurs), when it reaches thermal equilibrium, what is the final temperature of the water in the container?

A. Between 0^0c and 25^0c

B. 25^0c

C. Between 25^0c and50^0c

D. 50^0c

6.2 Confident rating;

A. Just guessing

B. Very unconfident

C. Unconfident

D. Confident

E. Very confident

F. Absolutely confident

6.3 Scientific reason;

A. From calculation $Q_{lost} = Q_{gain}$

B. From finding an average of temperature

C. Water at temperature 50^0c has more volume

D. Water at temperature 0^0c has less volume

6.4 Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

Question -7

7.1 Predict which of the following leads to decreases in the entropy?

A. $H_2O(l) \rightarrow H_2O(g)$

B. $C_{12}H_{22}O_{11}(s) \rightarrow C_{12}H_{22}O_{11}(aq)$

C. Ag+ (aq) $^+Cl^-$ (aq) $\rightarrow$AgCl(s)

D. $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$

7.2 Confidence rating;

A. Just guessing
A. Very unconfident
B. Unconfident
C. Confident
D. Very confident
E. Absolutely confident

7.2 The Scientific reason;

A. the molecules are distributed throughout a much larger volume in the gaseous state than in the liquid state therefore; entropy increases

B. Entropy increases in the gaseous molecules than liquid b/c the particle of the gas ordered.

C. -------------

7.4 Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

QUESYION8-10

For the following questions, consider a system undergoing a naturally occurring(Spontaneous) process. The system can exchange energy with its surroundings.

8.1 During this process, does the entropy of the system (S_{system}) increase, decrease, remain the same or this is not determinable with the given information

A. Increase
B. Decrease
C. Remain the same
D. Not determinable from the given information

8.2 Confidence rating

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

8.3. Scientific reason

A. System can exchange energy with its surroundings
B. No information is provided about the entropy change of the surroundings
C. No information is provided of energy transfer between system and surroundings increasing or decreasing
D. Temperature is increasing

8.4. Confidence rating

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

Question

9.1. During this process, does the entropy of the surroundings ($S_{urrounding}$) increase, decrease, remain the same or this is not determinable with the given information

A. Increase
B. Decrease
C. No change
D. Not determinable from the given information

9.2 Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

9.3 Scientific reasoning:

A. Temperature is decreasing

B. No information is provided of energy transfer between system and surroundings increasing or decreasing
C. There is heat transfer to the surroundings
D. The entropy of the surrounding may increase or decrease

Question - 10

10.1 During this process, does the entropy of the system plus the entropy of the surroundings (System+ Surroundings) increase, decrease, remain the same or this is not determinable with the given information

A. Increase
B. Decrease
C. No change
D. Not determinable from the given information

10.2. Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

10.3. Please indicate your reasoning:

A. The entropy of the surrounding may increase
B. The sum of entropy must be zero
C. According to the law of conservation of energy
D. It is in thermal equilibrium

10.4. Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

Question - 11

11.1. An ice cube is placed in closed plastic bottle. After some time, the ice melts and some drops of water is observed at the outer wall of the battle. Defining to this phenomenon, it can be concluded that it is an/a

A. Open the system
B. Closed system

C. Isolated system

11.2. Confidence rating

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

11.3. Scientific reason

A. There is energy exchange between system and surround, but not for the matter exchange
B. Drops of water confirm the matter exchange between system and surrounds
C. The freely exchange of matter and energy between system and surroundings

11.4. Confidence rating

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

Question - 12

12.1. Two different reactions occurred in the beaker A & B. The position before the reaction & after the reaction is seen below for each beaker. According to this;

A → A   B → B

T= 20^0C   T= 30^0C   T = 20^0C   T= 10^0C

A. The reaction in the beaker A is faster than B
B. The reaction in the beaker B is faster than A
C. The energy of the products is greater after the reaction in the beaker A
D. 1We cannot make any comment about the reaction rate of beaker

12.2. Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

12.3. Scientific reasoning

A. Exothermic reactions occurs faster
B. Endothermic reaction occurs faster
C. The reaction of reactants decreases in exothermic reaction
D. There is no r/s b/n the reaction rate & enthalpy

12.4. Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

Question - 13

13.1 A subsystem A is in thermal contact with its surroundings B, which together comprises an isolated system. Consider the following situation:

I. Entropy of system increases by 5J/K; entropy of the surroundings decreases by 5 J/K.
II. Entropy of system increases by 5J/K; entropy of the surroundings t decreases by 3 J/K.
III. Entropy of system increases by 3J/K; entropy of the surroundings decreases by 5 J/K.
IV. Entropy of system decreases by 3J/K; entropy of the surroundings increases by 5 J/K.

Which of the above four situations can actually occur in the real world?

A. I only
B. II only
C. III only
D. II and IV only

13.2 Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

13.3Scientific reasoning:

A. The sum of entropy must be zero
B. The sum of entropy is more than 2J/K
C. The sum of entropy is less than 2J/K
D. The entropy of system is higher than the entropy of the surroundings

13.4 Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

Question - 14

14. A subsystem A is in thermal contact with its surroundings B and they together comprise an isolated system that is undergoing an irreversible process. Consider the following situation:

I. Entropy of system increases by 5J/K; entropy of the surroundings decreases by 5 J/K.

II. Entropy of system increases by 5J/K; entropy of the surroundings decreases by 3 J/K.

III. Entropy of system increases by 3J/K; entropy of the surroundings decreases by 5 J/K.

IV. Entropy of system decreases by 3J/K; entropy of the surroundings increases by 5 J/K.

Which of the above four situations can actually occur?

A. I only
B. II only
C. III only
D. II and IV only

14.2 Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident

14.3 Scientific reasoning:

A. The sum of entropy must be zero
B. The sum of entropy is more than 2J/K
C. The sum of entropy is less than 2J/K
D. The entropy of system is higher than the entropy of the surroundings

14.4 Confidence rating;

A. Just guessing
B. Very unconfident
C. Unconfident
D. Confident
E. Very confident
F. Absolutely confident