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Secondary School Students' Conceptual Understanding of Physical and Chemical Changes

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Abstract

In recent years, researchers have shown an interest in understanding students' own ideas about basic chemical principles and guiding them through innovative ways to gain conceptual understanding where necessary. This research was a case study designed to assess 50 first year high school students' conceptual understanding about changes in matter, with interpretive underpinnings. A diagnostic probe was administered to find out if discrete particles could be used to differentiate chemical changes from physical changes and to unravel the different conceptual interpretations that students had. Submissions obtained from the students were classified on levels of conceptions, and analysed using frequency counts and percentages, after which an interview was conducted to gain a deeper insight into their unscientific submissions. Findings from the study indicated that only a few students had difficulties in distinguishing between physical and chemical changes. These few did not associate the changes in states with associated physical and chemical properties, as was expected at their level. Neither did they base their explanation on the breaking nor formation of bonds, nor with changes in the constitutions of entities. They overwhelmingly intimated that physical changes were reversible whilst chemical changes were not. About 38% of participants who provided correct definitions for physical and chemical changes in two of the probes could not assign reasons for them. However, almost 79% of the participants showed an appreciable knowledge of types of changes that occur in chemistry. The adopted diagnostic probe and interview were useful in identifying students' alternative conceptions about changes in chemistry. Diagnostic probes are recommended as a pre-requisite for conceptual change strategies.

Keywords: Chemical change, Chemical property, Conceptual change, Physical change, Physical property.

Contents

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1. Introduction

Chemistry is an active discipline which involves principles that are important to both the realms of nature and society. It deals with the composition of matter and its principles (Mailumo *et al.*, 2009). In addition, it is seen as a central science that unifies the other science subjects (Agogo and Otor, 2013). It therefore implies that chemistry is needed for the development of human life and societies. This also suggests that chemistry education should be emphasised at the secondary school so that students can understand and apply chemical principles that are taught in their daily lives. Interestingly, there has been a consistent decline in the performance of students in national chemistry examinations conducted by the West African Examinations Council (WAEC) (Samba and Eriba, 2012; West African Examinations Council, 2012). The reports surmise that Ghanaian students are not acquiring the necessary requisite skills and knowledge required for life from their chemistry studies. A presumptive inference to be made from this knowledge could be that Ghanaian students may be having conceptual difficulties in acquiring chemical principles and phenomena.

Several studies have identified conceptual difficulties that students express in their study of basic chemistry (Kind, 2004; Horton, 2007). Concepts are formed when ideas or thoughts are developed upon common properties of objects or events by abstraction. Duit (2007) found in a study that students hesitate to answer questions set on concepts that are difficult for them. Perhaps avoidance of some test items based on conceptual challenges could be a reason for students' poor performance in chemistry assessments. The concept of change in matter, for example, is an area of study which has been found to be difficult for students at secondary schools (Kind, 2004). Changes in matter are broadly classified into chemical and physical changes. 'Chemical change' is any change that results in the formation of new chemical substances. At the molecular level, a chemical change involves making or breaking of bonds between atoms. It often takes 'extraordinary' means to separate the changed product into the starting or original materials. Here, chemical reactions are implied. 'Physical change' is about the rearrangement of particles in matter without affecting their individual internal structures (Senese, 2016). In effect, as no bonds are broken, changes could affect only colour, density, volume or mass, without a change in the chemical nature of the substance. Changes in matter (that is physical and chemical changes) are important and fundamental topics in science from as early as the primary level to the undergraduate level. Often teachers teach the differences between chemical and physical changes shallowly and incorrectly, with very few examples to substantiate assertions they make. Thus, their distinctions are not absolute and lead learners to develop misconceptions about them.

Hanson *et al.* (2011) in a similar study on bonding in matter found out that, undergraduate students in most cases could not give correct reasons to explain processes that were physical and chemical. The missing gap was students' inabilities to understand and differentiate between physical and chemical properties of matter. They noted that introductory concepts on matter and its changes were not mastered effectively by Junior High School (JHS) students before entry into the Senior High School (SHS), and subsequently to the university. In order to fully understand changes in matter, students must be familiar with fundamental concepts such as those associated with physical properties, chemical properties, the particulate nature of matter and chemical bonding.

Students' misconceptions regarding changes in matter appear to be worldwide (Taber, 2002). We live and operate within the macro and micro world of matter but cannot follow shifts between these levels logically (Harrison and Treagust, 2000; Robinson, 2003). Consequently, we tend to build alternative conceptions and non-scientific metal models (Taber and Coll, 2002) as a result of improper and uncoordinated linkages. Ahetee and Varjola (1998) interviewed students from the 7th and 8th grades at the upper stage of senior secondary school and first year general chemistry course at a university and asked them to describe the concept of chemical reactions. Their responses indicated that students at various levels of education have alternative concepts about changes in matter. They showed difficulties in the usage of terms such as 'substance', 'molecule' and 'atom'. Only 6% of their 7th and 8th graders and 14% of the university students in their study were able to describe some changes in chemical reactions. Ahetee and Varjola attributed their students' difficulties to instructional incompetence.

Yan and Talanquer (2015) also found from review studies that students encounter difficulties in their studies about transformations in matter. They attributed their observations of these student behaviours to difficulties that could have stemmed from under-developed concepts about substances. In a related study, Johnson (2000) found that students do not often consider chemical reactions as complete transformations of matter, but only as change in appearance or state of matter. This suggests that students make misguided distinctions between physical and chemical changes. In teachers' attempts to help, they sometimes introduce chemical reactions as rearrangement of atoms without explaining that it implies changes in the discrete and constituent particles that result from the formation of new substances which emerge as a result of 're-bonding'. They fail to link this new concept to students' own understanding about chemical and physical properties of matter.

These findings from literature on students' difficulties in their understanding of changes in matter led the researchers to find out whether Ghanaian Senior High School students also experience these difficulties, or that it was peculiar to a part of the world.

1.1. Aim of the study

The aim of this study was to investigate students' own conceptual interpretations and applications of changes in matter.

2. Research Design

The research was a case study Cohen *et al.* (2011) to assess first year Senior High School (SHS) students' conceptual understanding about changes of matter in Chemistry. A validated diagnostic concept probe titled 'changes in chemistry' was extracted from the Royal Society of Chemistry (RSC) Resources and administered to students for 20 minutes. The probe (Appendix A) contained five items. In the first two items, students were asked to explain what they thought about the terms, 'physical' and 'chemical changes'. The next three items contained particle diagrams for 'before activity' and 'afterwards' to further probe the application of their understanding of changes in chemistry. They were to decide whether the change in each diagram was a physical or chemical change and to explain their reasons for whatever choice that they made. The written responses from the students were scored and classified on levels of conception. Probes provide evidence of students' thoughts. The criterion for classifying levels of conceptual understanding is presented in Table 1.

Table-1. Criteria for classifying levels of conception

Degree of conceptual understanding	Criteria for selecting responses
Sound conception	Responses that include all components of the validated responses.
Partial conception	Responses that include at least one of the components of the validated response, but not all the components.
Alternative conception	Responses that include illogical, incorrect, irrelevant or unclear responses, no response or blank space.

Source: Hanson *et al.* (2015)

After analysing students' responses to the diagnostic probes, 20 of the participants were interviewed individually for 5 minutes each to get their in-depth understanding about some of the unscientific answers that they provided in the probes. The interview protocol was culled from the probe. The selection of interviewees was purposive as five students were selected from the sound conception group, 10 from the partial conception group, and another five from the high alternative conception group.

2.1. Sample and Sampling Procedure

The target population for the study comprised all science students in Senior High Schools in the Agona West Municipality of Central Region, Ghana. A random sampling method was used to select an experimentally accessible population for the study. First year science students in a Senior High School in the Agona West Municipality who numbered 50, were all selected to participate in the study, which they willingly obliged to. This sample was an intact class and everyone participated in the study. Whole class effects have significant influence on the strategies for conceptual change used by teachers.

2.2. Data Analysis

The numbers of respondents possessing various degrees of conceptual understanding were determined using frequency counts and percentages.

3. Results

Based upon the developed criterion for distinguishing levels of comprehension as described in Table 1, the percentage distribution of students' conceptual understanding based on the set criteria are presented in Table 2.

Table-2. Distribution of levels of conceptions about changes in chemistry through a diagnostic probe

Item	Sound conception (%)	Partial conception (%)	Alternative conception (%)
1	32.0	32.0	36.0
2	32.0	38.0	30.0
3	62.0	20.0	18.0
4	76.0	20.0	04.0
5	58.0	24.0	18.0

Source: Fieldwork Data (2016)

Table 2 was translated graphically for clarity and shown as Figure 1.

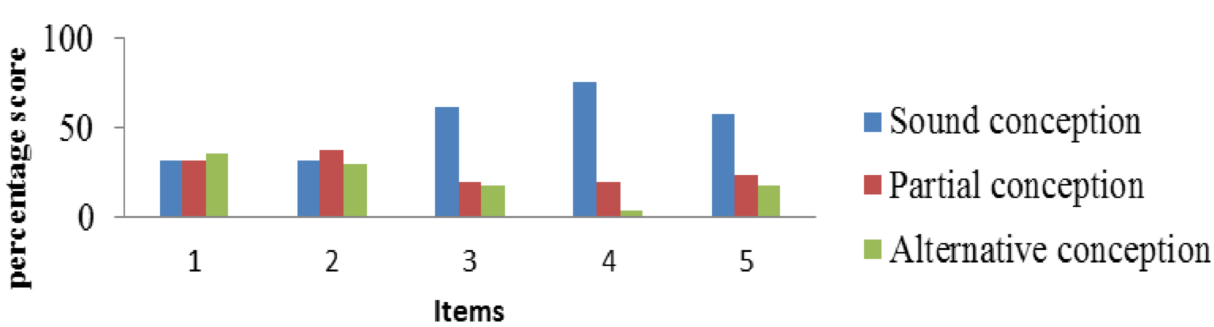

Figure-1. A bar graph indicating the percentage distribution of students' conceptual understanding of changes in chemistry
Source: Graphical Field Data from Table 2.

Figure 1 is a display of students' performance in their interpretation of some changes in chemistry.

3.1. Findings

A general overview of the graph shows that Items 1 and 2 had the highest partial and alternative conceptions of 32%, altogether. The least sound conceptions were observed here. Incidentally, in Items 3 to 5, where knowledge of changes had to be applied, very high sound conceptions (over 50%) were recorded. Students had no problem identifying and interpreting changes in matter at different levels. Levels of partial conceptions were highest for Item 2 (38%), as a few of the students could not explain what a chemical change was, with the appropriate chemical language or descriptive terms. It was clear that they had problems in using appropriate scientific language in describing changes in phenomena; no wonder they scored poorly in items 1 and 2, where a display of appropriate descriptive chemical terms were required. The highest level of sound conception was recorded with Item 4 (76%). From Figure 1 (Table 2) it was observed that 32%, 32% and 36% of the respondents gave sound conception, partial conception and alternative conception respectively on the definition of ‘physical change’. Altogether, 64% demonstrated had fair ideas about what physical and chemical changes were. Also, 32%, 38% and 30% of the respondents gave sound conception, partial conception and alternative conceptions respectively on the definition of ‘chemical change’.

The respondents who had alternative conceptions about ‘chemical change’ were less than those with sound and partial conceptions put together. Students who failed to explain the concept of physical change said that it was a change that was accompanied by physical observations such as the evolution of gas or a kind of scent, instead of stating that physical changes involved change in state or form of matter which did not cause any change in the chemical composition of the combining elements or particles. They could also have explained the event on the basis of physical properties; that an aspect of matter was being observed or measured without change to it. Their answers showed no inclinations towards the physical properties of matter. In a similar manner some students defined chemical change without linking it to a change in chemical composition of the combining substances due to the breaking and formation of new bonds. Some of their responses are presented as Appendix D. Majority of students who held ACs about changes, used the words ‘reversible’ and ‘irreversible’ indiscriminately in their definitions.

In Item 3 students were asked to state and explain whether cooling liquid nitrogen until it froze was a chemical or physical change. The results showed that 62%, 20%, and 18% of them respectively had sound, partial and alternative conceptions about the phenomenon. Most of the students explained their observations as being that of a physical change. Those who showed partial understanding were able to identify the phenomenon as a physical change but could not give logical reasons for their choices. They failed to relate the change to a permanence or otherwise of an original state. Students who showed alternative conceptions based their explanations on the spaces in the given diagram as it appeared before and after freezing. Their explanations were not linked to any scientific theory such as a change in state, the breaking and creating of bonds or permanence of entities after an ‘apparent’ change as was expected. Neither were changes interpreted with respect to differences in energy. One student wrote that a chemical change has occurred because a new substance has resulted, though it contains the same molecule. He added that only arrangement was changed.

Students were asked to state and explain whether burning of magnesium in oxygen was a physical or chemical change in Item 4. Data gathered indicated that 66%, 20% and 14% respectively had sound, partial and alternative conceptions about the phenomenon. Most of them were able to state and justify the reason why they considered it a chemical change. Perhaps their knowledge about reversible and irreversible changes were successfully applied here. Some of them were able to state that burning magnesium ribbon to ash was a chemical change but were not able to assign reasons to their initial choice. A student with an alternative conception wrote that the phenomenon was a physical change as magnesium would scatter in oxygen due to its physical properties and that after heating the magnesium became attracted to oxygen to form a uniform substance. The last Item (5) required students to state whether the dissolution of sodium chloride in water would demonstrate a physical or chemical change and to write supporting reasons. Their answers indicated that 58%, 24% and 18% respectively gave sound, partial and alternative conceptions about the phenomenon. Although a higher percentage of the students gave sound reasons for the change, a few had challenges in making choices; thus, no supporting reasons were given.

3.2. Interviews

In order for appropriate remediation to be given to the students, 40% of the participants, from across the various conceptual levels, were interviewed individually for 5 minutes each, in order to identify the root cause of their unscientific answers in the probe. The semi-structured interview questions are presented as Appendix C. Results gathered from the interview sessions showed that only few students’ understanding about changes in chemistry were shallower than deduced from written responses. They were able to soundly and logically explain and classify changes in dissolution processes and change of states during solidification, melting and burning of substances.

4. Discussion

Students in this study were asked to explain in their own words the meaning of chemical and physical changes and to classify some changes in matter through probes. It demonstrates that they process knowledge and sometimes improve on their process skills, as they think before they justify their observations. In this study, the researchers found that most students were able to identify both the chemical and physical changes but had difficulties in giving correct reasons for identifications. The study further revealed that students had challenges with the use of appropriate chemical terms. They also had limited conceptual frameworks about matter and its changes. For example, the words ‘reversible’ and ‘irreversible’ were over used in their descriptions of chemical and physical changes. Most students stated that all chemical changes in matter were irreversible while all physical changes could be reversed (Appendix B). This was clearly an over generalisation of the terms as well as the concept of change. They showed a bias towards the complete disappearance of a substance as being a chemical change while they intimated that the substances would remain unchanged for physical changes. They defined a chemical change as ‘a change which occurs when substances combine chemically’ while physical change according to them, ‘occurs when substances combine physically’. It was expected that at their level, they would use descriptions such as ‘a change that did not involve the breaking or formation of strong chemical bonds’, or ‘where atoms, molecules or ions were merely arranged’, in the latter case. Again, they were expected to know that a chemical change ‘involved the breaking or formation of strong chemical bonds which resulted in the formation of new molecules’.

Changes in reversibility were not observable in the diagnostic probes and so were not expected to be used in their answers. Change in energy ($Mg + 1/2O_2$ to form MgO) was not very explicit. Thus, not much was expected from students either. Nevertheless, a few were able to figure this out. They intimated that a new substance, MgO was formed. Bonds had been broken and new ones formed, at the molecular level. They added that the new substance formed was going to require 'extraordinary' means to separate the various 'ingredients' out into their original forms. Other responses associated chemical combination with processes in which heat was applied while physical changes were not affected by heat. Most changes in real life go through various steps, some of which involve both changes and can be quite confusing to students when asked to make choices between physical and chemical changes. However, the probes used in this study were common examples of changes which should have posed no interpretative challenges.

Furthermore, some students' written responses indicated that they did not yet know that in a chemical change there was an alteration in the chemical composition of the substance in question through the breakage and formation of new bonds, and that in a physical change there was only a difference in the appearance of the sample matter without change in chemical composition. Such fundamental reasons, which indicate a deeper and more permanent understanding of the chemical procedures, were not assigned to the changes that they were probed on. Their overall performance was quite encouraging, though some remediation was required. In order for an appropriate remediation to be given to the students, 40% (20) of the participants were interviewed. The semi-structured interview questions are presented as Appendix C. Results from the interview showed that the Ghanaian students had appreciable knowledge about changes that occurred in chemistry and life in general and could distinguish between them appropriately.

Findings from this study differed from that of Ahetee and Varjola (1998) which showed that about 80% of their 18 pupils interviewed could not make a clear distinction between physical and chemical changes. In Ahtee and Varjola's study, pupils approved both melting of ice, dissolving of salt, fermentation of berry juice and rusting of iron as examples of chemical change. Interview results from this current study placed the Ghanaian students in a higher level of conceptual understanding about changes in chemistry. About 60% (12) of the interviewees in our study clearly distinguished between physical and chemical changes and were also able to explain that solvation was a physical process. They further added that if a salt solution was evaporated and the vapour collected, somehow, water would be obtained while pure dry salt would be retained in the beaker. It was however obvious that they lacked both everyday English and the appropriate chemical language to express themselves appropriately. Again, this current study contradicts findings from review by Yan and Talanquer (2015) that students struggle to understand transformations in matter. In our study 52% of our sample demonstrated sound conceptions about transformations in matter in their written probes, while 65% of the interviewees (especially those from the partial conception bracket) were able to explain these transformations orally. About 26.8% demonstrated close to sound conception, herein termed partial conception. Thus in all, about 78.8% of the sample had a good understanding about these changes in chemistry, per the probes. Only 21.2% of the students who participated demonstrated alternative conceptions in their definitions and explanations of the changes.

An in-depth analysis of students' descriptions of the diagnostic probes revealed that some definitions of physical changes were associated with processes in which there was colour change, smell and evolution of gas. From our findings 18% of students did not know that any reaction that involved burning was a chemical process. They were unable to identify the change of oxygen to its oxide and neutral magnesium atoms in the metallic state to magnesium ions. This could have been because the symbolic forms of the species were used. In addition, students failed to recognise the new ionic states. Perhaps they only recognised the symbols Mg and O in the 'after' state. They could not perceive that the new ionic dispositions were a change. Besides, they failed to take note of the word 'heat' which suggested that energy changes were involved. Though energy changes are not the best way to characterise changes, in this particular example different particles were obtained after the change. Students mixed up concepts related to observations made in the real world with the theoretical concepts needed in the explanations. A compilation of misconceptions gathered in this study demonstrated that they did not consider chemical reactions as a complete transformation of matter, but only as a change in appearance or as a change in its state, which is not the true case. These interpretations led to the few observed warped distinctions between physical and chemical changes. It must be remembered that the distinction between some changes are not absolute and so teachers themselves sometimes find it difficult to decipher between the two main changes, which could be sources of teacher-made misconceptions. The undue emphasis on reversibility and non-reversibility could also pose a problem for students in their study of chemical equilibrium.

Results from this study further indicated that few students had difficulties in distinguishing between physical and chemical changes that matter undergo. Some provided correct definitions for physical and chemical changes but could not apply them in subsequent probes; an indication of a superficial understanding of the concepts. They intimated that physical changes could be seen physically and were reversible but added that the composition sometimes altered. There was clearly a mix of concepts here. Most of the students who provided partially correct answers failed to use the appropriate chemical language as was expected. In an interview session with 10 of these students, it was obvious that they had a good understanding of the concepts but had challenges in using scientific terms to construct logical statements. It is therefore important to teach conceptual terms associated with topics to enable students build scientific frameworks. During the interview session, they recognised that a mixture was formed in item 5 as there were the same particles of salt and water entities before and after dissolution. Answers from Items 4 and 5 also showed that the participants had adequate conceptions about solvation, combustion, and change of state. Only one student intimated that a chemical change occurs when a substance changes due to dilution or concentration. He added that a deformity had occurred and the process was irreversible. It was clear that this student clearly had conceptual problems which were non-scientific. On the average, over 60% of students had fair conceptions about the concepts under study in all the five probes, and this is a good start for teaching and learning.

5. Conclusion

The study sought to implicitly make students aware of concepts about changes in matter which are necessary for building conceptual frameworks through the use of a diagnostic probe. The diagnostic probe was useful in identifying students’ alternative conceptions. Besides unearthing their misconceptions, it exposed their inadequate scientific vocabulary especially that required for useful discussions about chemical changes. Diagnostic assessments must be encouraged as a pre-requisite for conceptual change approach as it gives a lead to especially young teachers in identifying areas to strengthen in their teaching. If learners engage in learning by investigating, inquiring, collaborating, discussing and forming mental models they will learn more meaningfully.

5.1. Recommendations

From the findings, it is recommended that:

1. Teachers should be encouraged to use conceptual change approaches in their teaching.
2. In their use of conceptual change approaches, they must purposefully use directed methods in instances where students need to make distinctions between chemical terms.
3. Appropriate science or chemical language must be used clearly for students to build up authentic conceptual frameworks.
4. It is suggested that video animations of the formation of compounds and mixtures be shown and discussed at length with students with similar problems.

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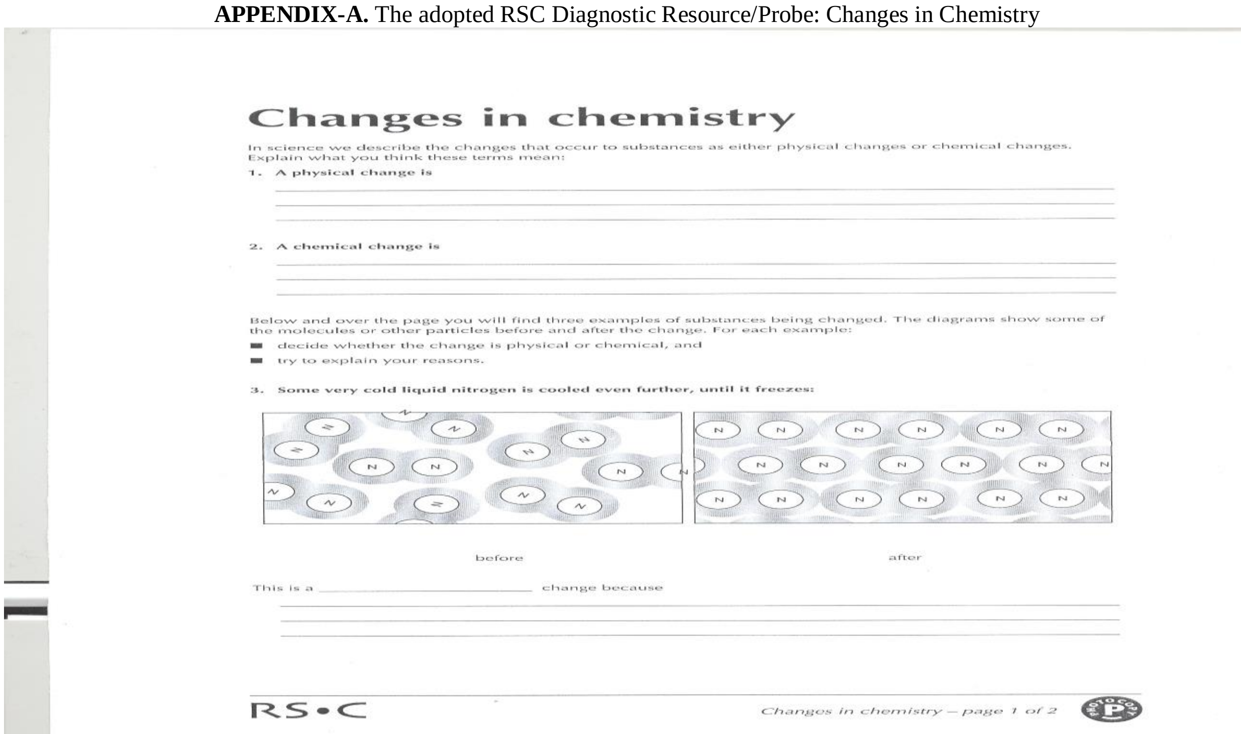
APPENDIX-A. The adopted RSC Diagnostic Resource/Probe: Changes in Chemistry


Changes in chemistry

In science we describe the changes that occur to substances as either physical changes or chemical changes. Explain what you think these terms mean:

1. A physical change is

2. A chemical change is

Below and over the page you will find three examples of substances being changed. The diagrams show some of the molecules or other particles before and after the change. For each example:

- decide whether the change is physical or chemical, and
- try to explain your reasons.

3. Some very cold liquid nitrogen is cooled even further, until it freezes:

before

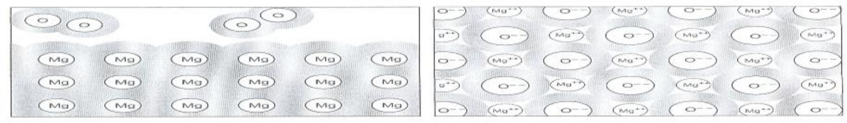
after

This is a ______________ change because

RS•C

Changes in chemistry – page 1 of 2

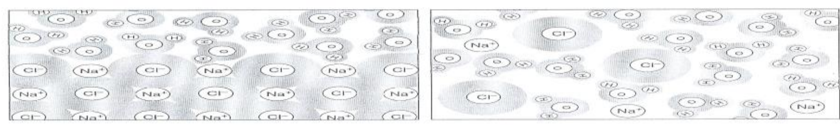
4. Some magnesium is heated in oxygen until it burns:



before after

This is a ________________ change because

5. Some sodium chloride is added to a beaker of water, and left to dissolve:



before after

This is a ________________ change because

Changes in chemistry – page 2 of 2 RS•C

Appendix-B. Evidence of students' responses

Changes in chemistry

In science we describe the changes that occur to substances as either physical changes or chemical changes. Explain what you think these terms mean:

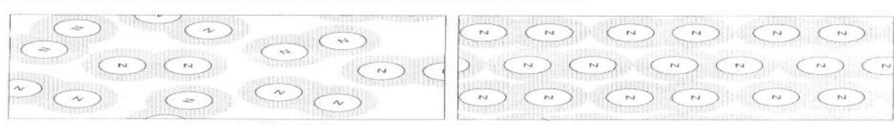
1. A physical change is
a change which causes a ~~chemi~~ a substances to change which can be seen physically thus by seeing, smelling.

2. A chemical change is
Chemical change occurs when a substances is made to change it's state as a result of diluting or concentration ~~and~~

Below and over the page you will find three examples of substances being changed. The diagrams show some of the molecules or other particles before and after the change. For each example:

- decide whether the change is physical or chemical, and
- try to explain your reasons.

3. Some very cold liquid nitrogen is cooled even further, until it freezes:

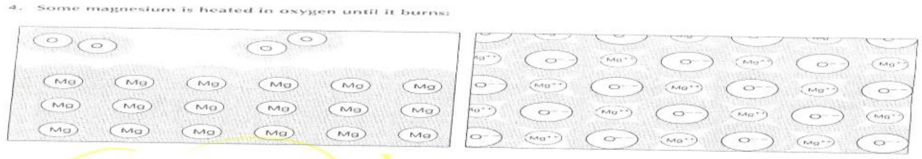


before after

This is a physical change because
This is because ~~when~~ the nitrogen was scattered when warm but when it was cooled it became uniform and was attracted to itself.

RS•C Changes in chemistry – page 1 of 2

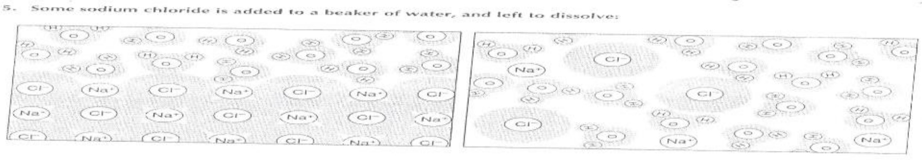
4. Some magnesium is heated in oxygen until it burns:



before after

This is a physical change because
when it wasn't heated the magnesium was scattered with the oxygen due to it's physical properties after heating the magnesium attracted the oxygen to form a uniform ~~state~~

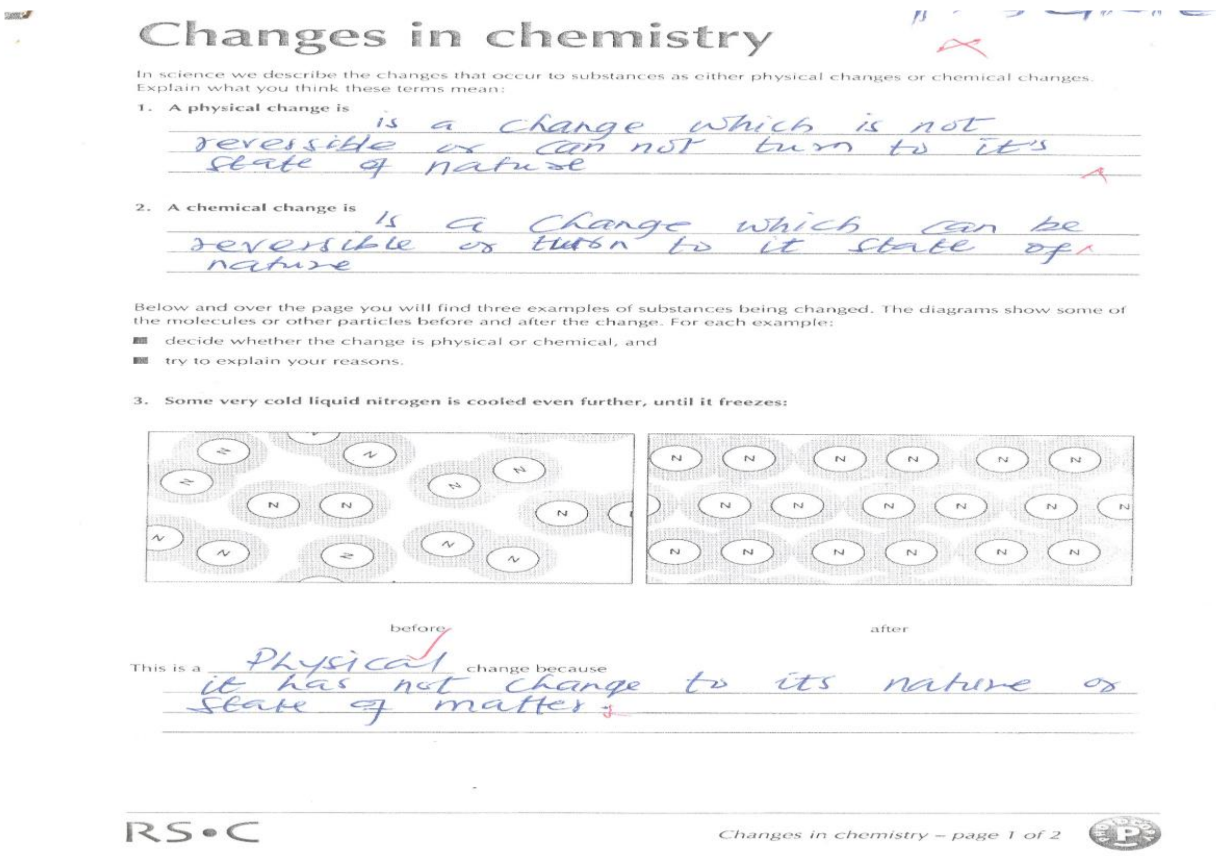
5. Some sodium chloride is added to a beaker of water, and left to dissolve:



before after

This is a chemical change because
~~The~~ of the solution was uniform but after being added to the beaker of water the water ~~was~~ diluted the sodium chloride making it's chloride content diluted and ~~left~~ leaving little trace

Changes in chemistry – page 2 of 2 RS•C



Changes in chemistry

In science we describe the changes that occur to substances as either physical changes or chemical changes. Explain what you think these terms mean:

1. A physical change is is a change which is not reversible or can not turn to it's state of nature

2. A chemical change is is a change which can be reversible or turn to it state of nature

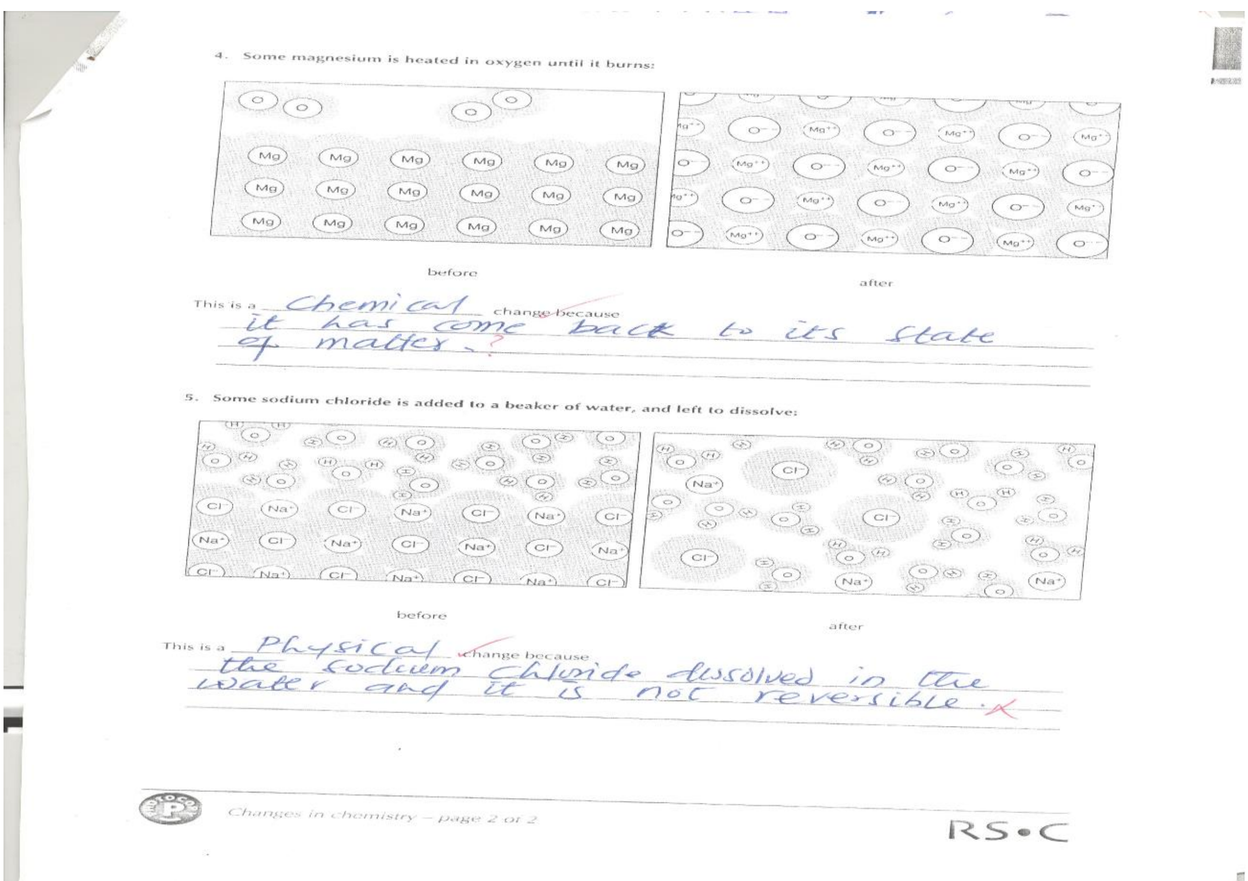
Below and over the page you will find three examples of substances being changed. The diagrams show some of the molecules or other particles before and after the change. For each example:

- decide whether the change is physical or chemical, and
- try to explain your reasons.

3. Some very cold liquid nitrogen is cooled even further, until it freezes:

This is a Physical change because it has not change to its nature or state of matter

RS•C Changes in chemistry – page 1 of 2



4. Some magnesium is heated in oxygen until it burns:

This is a Chemical ~~change because~~ it has come back to its state of matter ?

5. Some sodium chloride is added to a beaker of water, and left to dissolve:

This is a Physical change because the sodium chloride dissolved in the water and it is not reversible.

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Appendix-C. Semi-structured interview

1. How would you define a physical change?
2. When does one say that a chemical change has occurred?
3. If I freeze palm oil, will the frozen oil have undergone a chemical or physical change? Explain. How about mashed kenkey? What if I allow it to keep for three days?
4. Are you familiar with magnesium ribbon? How about wood? If we burn these two materials what would we see? Would the change be physical or chemical? Explain.
5. If I add some salt to water and I stir it, what will happen? How will you classify that change? Explain your answer further.
6. What are some terms that we can associate specifically with chemical changes?
7. Do physical changes occur in our homes and around us all the time? What are some of these changes?
8. How can you explain the process of physical change to a primary school child without using the terms 'reversible and irreversible'?

Appendix-D. Alternative conceptions

Some alternative conceptions about changes in chemistry from students' responses

1. In physical change, the change can be seen physically
2. Chemical composition is altered in a physical change
3. A physical change is a change that is experienced physically.
4. Physical change seen with the naked eye.
5. Physical change is a reversible change but chemical change is not reversible
6. Physical change is a change that occurs in a substance without any addition of chemicals to change its nature
7. In a chemical change molecules can be seen. (This was also a definition for physical change)
8. In a physical change, particles are forced in the beginning until they cling together and after that they go back.
9. Salt reacts with water to form a new substance (sometimes when it is heated).
10. Chemical change is change in concentration and mass of a substance. In N_2, new substance is formed.
11. Physical change is seen with naked eye but chemical change is not seen with the naked eye
12. In physical change, the changing process can be seen but not in chemical change.
13. Physical change is irreversible but chemical change is reversible to the original state.
14. In a physical change, there is change in state of matter after reaction but in a chemical change, there is no change in matter.
15. Physical change is a change in physical appearance of a particle but chemical change is the reaction of a particle.