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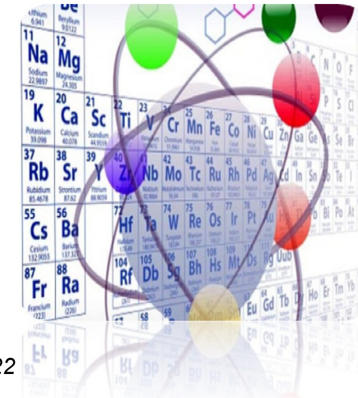

Understanding the Difference Between Chemical Changes and Physical Changes

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ABSTRACT

The purpose of this study is to distinguish physical changes and chemical changes. This study uses an experimental method, in which this experiment is carried out to prove data and hypotheses regarding changes in physics and chemical changes. The hypotheses and data that will be proven are the factors that influence physical changes and chemical changes, examples of physical changes and also chemical changes, as well as significant differences between physical and chemical changes. In this research, I used some tools and I need some materials. For the tools that used in this research were test tube holders, measuring pipettes, droppers, spirits lamp, clay triangle and gauze, beaker glass, test tubes and also the rack of test tubes, watch glass. While for the materials that needed are I_2, $CuSO_4$, Mg, HCl, CCl_4, KI, wax, H_2O

Keywords: physical changes, chemical changes

I. INTRODUCTION

Physical change is the process of changing the physical properties of a substance. The changes that occur, such as changes in shape, size, color, volume, phase (solid, liquid, gas), etc[1]. Which is, without making any changes in the composition of the molecule. We can see these changes directly, and these changes can also be reversed using simple physical methods. It means, the changes in physics are reversible changes. The same element or composition, before or after the change, that is, the original characteristics of the object remain or unchanged. For example, melting of wax, dissolving sugar in water, cutting wood, squeezing paper, etc[2].

Chemical change is a process that can produce a new substance, or chemical change is a process in which the atoms of one or more substances are rearranged or combined to make a new substance. When a substance changes chemically, the chemical properties of this substance change and then it converted into substances which is different with different chemical compositions[4]. Energy evolution, bubble formation, odor change, temperature change are some of the signs of chemical change. Alternately, it is known as a chemical reaction, where the substance involved is known as a reactant, and the reaction product is called a product. Energy changes are one of the characteristics of chemical change, due to the formation of new products. After a chemical change has taken place, the substance cannot return to normal. This means that chemical changes are irreversible changes. Examples of chemical changes, namely rotten fruit, paper burned to ash, stale rice, rusty iron[3].

In physical changes and chemical changes, there are some differences that make it easy for us to determine what changes occur in a substance that is being observed. To facilitate understanding, a comparison of the process of changing physics and chemistry is presented in table 1.

Table 1. Comparison of physical change and chemical change

BASIS FOR COMPARISON	PHYSICAL CHANGE	CHEMICAL CHANGE
Meaning	Physical change refers to a change in which the molecules are rearranged but their internal composition remains same.	Chemical Change is a process in which the substance transforms into a new substance, having different chemical composition.
Example	Tearing of paper, melting/freezing of water, cutting of trees, etc.	Burning of wood/trees/paper, rusting of iron, setting of curd, etc.
Nature	Reversible	Irreversible
Original matter	Can be recovered	Cannot be recovered
Involves	Change in physical properties of the substance, i.e. shape, size, color etc.	Change in chemical properties and composition of the substance.
Product Formation	No new product is formed.	New product is formed.
Energy	Absorption and evolution of energy do not take place.	Absorption and evolution of energy take place, during reaction.

II. Research Method

2.1. Tools and Materials

The tools and materials used in this research are beaker glass, test tube, heater, drop pipette, KI, magnesium, $CuSO_4$, HCl, H_2O, wax, iodine crystal, and CCl_4.

2.2. Research Procedure

A. Procedure 1

Put in 3 grams of iodine crystal in first beaker glass and then put in 10 grams of wax in second beaker glass. Heat both of beaker glasses and see the changes that occurred in each glass. Note the changes occurred. After that, cooling down both of beaker glasses and note the change ocured after cooling process.

B. Procedure 2

In the first test tube, put in 2 grains of iodine crystals and then add 2 ml of $KI_{(aq)}$ 0.1 M and then stir it slowly. In the second test tube, put in 2 grams of iodine crystals and then add 2 ml of $CCl_{4(aq)}$ and stir it slowly. In the third test tube, put in 2 grams of iodine crystals and then add 2 ml of $H_2O_{(l)}$ and stir it slowly.

C. Procedure 3

Put in a little piece of Magnesium in 3 different test tube. In the first test tube, heat it until there is a change or reaction. In the second test tube, add 2 mL of $HCl_{(aq)}$ 0.1 M slowly and then heat it. In the third test tube, add 2 mL of $H_2O_{(l)}$ and then heat it. Note the entire changes occurred.

D. Procedure 4

Put some grains of $CuSO_4$ in two different test tube. In the first test tube, heat it until the color changes to white. After that add 2 drops of H_2O using drop pipette and then heat it again. In the second test tube, heat it until the color changes to white. After that, add2 drops of CCl_4 using drop pipette and then heat it again. Note the entire changes occurred.

III. Result and Discussion

3.1. Physical Changes

A. Heating Iodine Crystal

Iodine is a dark grey crystalline solid. Iodine is very slightly soluble in water and freely soluble in organic solvents. Its melting point is 114°C and boiling point is 184°C. The properties of molecules within a **compound** are responsible for their structure, melting point, boiling point, etc. There are many forces acting between the molecules of a compound. They could be physical, chemical or electrostatic in nature. They could be attractive or repulsive forces. The total sum of these attractive or repulsive forces between the molecules (intermolecular forces) is collectively called as van der walls force. The iodine atoms within one molecule are pulled closely to each other by a covalent bond. Between the molecules, there exist weak Van Der Waals Forces.

When Iodine crystals are heated, the van der waals are easily overcome and the molecule breaks into gas phase. They sublime and form a purple colored dense vapor. The sublimation of iodine is used to stain chromatography plates and in the detection of finger prints in forensic science. Iodine sublimates and forms iodine fumes when it comes in contact with air. As you cannot bring back Iodine (solid) back from the fumes, it is a physical process. As iodine is sublimating in presence of air (O_2, N_2) it is a chemical process. So it can be said that Iodine Sublimation is a Physio-Chemical (or mostly physical) process.

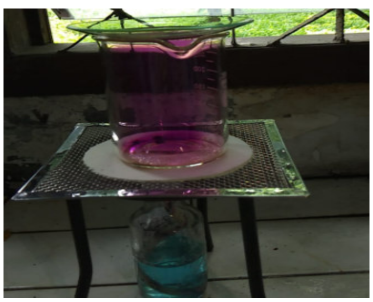

Figure 1. Result of heating the iodine crystal

B. Heating Wax

When you burn a candle, you end up with less wax after burning than you started with. This is because the wax oxidizes, or burns, in the flame to yield water and carbon dioxide, which dissipate in the air around the candle in a reaction that also yields light and heat.

A popular chemical compound that often requires heating is wax, which is an organic compound that has a plastic texture at room temperature. Wax begins to melt at 44 degrees celsius resulting in a low viscosity rating. In a burning candle, there are both physical and chemical changes. The melting of the solid wax to form liquid wax and the evaporation of liquid wax to form wax vapour are physical changes. The burning of the wax vapour is a chemical change. The wax vapour reacts with oxygen in the air to form new substances including carbon dioxide and ash[5].

Physical Changes in Burning Candle: On heating, candle wax melts and form liquid wax. It is a physical change. Since it again turns into solid wax on cooling. This is a reversible change.

Chemical Changes in Burning Candle: When you light the candle, the wax present near the wick will melt. Wick absorbs the liquid wax. The liquid wax vaporizes due the heat produced by the flame. This wax vapor near to flame burns and gives new substances like Carbon Dioxide, Carbon soot, water vapours, heat and light. This is an irreversible change[19].

The heat of the flame vaporizes the wax molecules and they react with the oxygen in the air. As wax is consumed, capillary action draws more liquid wax along the wick. As long as the wax doesn't melt away from the flame, the flame will consume it completely and leave no ash or wax residue. Both light and heat are radiated in all directions from a candle flame. About one-quarter of the energy from combustion is emitted as heat. The heat maintains the reaction, vaporizing wax so that it can burn, melting it to maintain the supply of fuel. The reaction ends when there is either no more fuel (wax) or when there isn't enough heat to melt the wax[6].

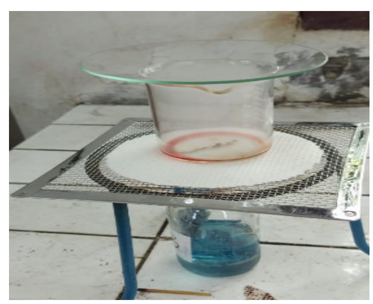

Figure 2. Result of heating wax

C. Heating Magnesium

When magnesium is in its metal form it will burn very easily in air. However, in order to start the reaction (the burning) the magnesium metal needs a source of energy. The flame provides a source of heat so that the magnesium metal atoms can overcome their activation energy. Activation energy is the minimum energy required in order for a chemical reaction to proceed. When the magnesium metal burns it reacts with oxygen found in the air to form Magnesium Oxide. A compound is a material in which atoms of different elements are bonded to one another. Oxygen and magnesium combine in a chemical reaction to form this compound. After it burns, it forms a white powder of the magnesium oxide. Magnesium gives up two electrons to oxygen atoms to form this powdery product. This is an exothermic reaction. An exothermic reaction is a term that describes a chemical reaction in which there is a net release of energy (heat).

$$2Mg_{(s)} + O_{2\,(g)} \rightarrow 2MgO_{(s)} + \text{energy}$$

Magnesium is also capable of reducing water to the highly-flammable hydrogen gas, which will be ignited by the excess heat given by the reduction reaction.

$$Mg_{(s)} + 2H_2O_{(l)} \rightarrow Mg(OH)_{2(s)} + H_{2(g)}$$

Magnesium also reacts with carbon dioxide to form magnesium oxide and carbon:

$$Mg_{(s)} + CO_{2\,(g)} \rightarrow 2MgO_{(s)} + C_{(s)}$$

Hence, carbon dioxide fire extinguishers **can not** be used for extinguishing magnesium fires either. Burning magnesium is usually quenched by using a Class D dry chemical fire extinguisher, or by covering the fire with sand to remove its air source[7].

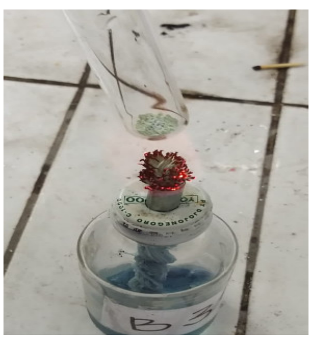

Figure 3. Result of heating magnesium

D. Heating $CuSO_4$

This is an example of a physical change. Copper sulfate is a very hygroscopic material. This means that it absorbs and coordinates with water very readily. Note that this coordination with water is *not* a chemical bond formed between the copper and the water. Copper sulfate pentahydrate is a blue solid but when you heat it you evaporate the water from the sample and are left with anhydrous copper sulfate (no water present) which is white in color. Upon cooling, the white copper sulfate absorbs water from the atmosphere to become the pentahydrate again. Also, when you added water the last of the anhydrous material converted to the pentahydrate. Since no chemical bonds were broken or formed (the definition of a chemical change), this is an example of a physical change[8].

Figure 4. Result of heating $CuSO_4$

3.2. Chemical Changes

A. Crystal Iodine + KI 0.1 M

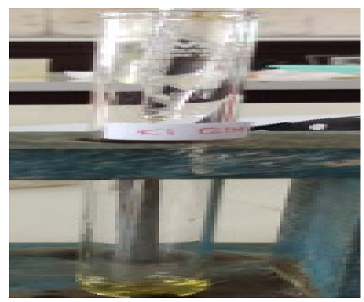

Figure 5. Reaction of crystal iodine with KI 0.1 M

Potassium iodide is used to be able to attain much higher concentrations of iodine in aqueous solution without having to use organic solvents. A solution of iodine (I_2) and potassium iodide (KI) in water has a light orange-brown color. The colors are caused by so-called charge transfer (CT) complexes. Molecular iodine (I_2) is not easily soluble in water, which is why potassium iodide is added. Together, they form polyiodide ions of the type I_n^-, for example, I_3^-, I_5^-, or I_7^-. The negatively charged iodide in these compounds acts as charge donor, the neutral iodine as a charge acceptor. Electrons in such charge-transfer complexes are easy to excite to a higher energy level by light. The light is absorbed in the process and its complementary color is observed by the human eye.

In the case of the aqueous solution of polyiodides, the absorptions of the different species lead to an overall brownish color. Once amylose is added, it forms another CT complex, Here, the amylose acts as a charge donor and the polyiodide as an acceptor. This complex absorbs light of a different wavelength than polyiodide, and the color turns dark blue. The I_2 molecules in iodine are not very soluble in water because they are not alike. I_2 is non-polar whereas H_2O is polar. But KI solution contains I^- ions which combine with the I_2 to form I_3^- ions because these are charged they dissolve in the water which is a polar solvent[9,10,11].

B. Crystal Iodine + CCl_4

Figure 6. Reaction of crystal iodine with CCl_4

Iodine is more likely to dissolve in $CCl_{4\,(aq)}$. $I_{2\,(s)}$ and $CCl_{4\,(aq)}$ are both nonpolar molecular compounds, whereas water is a polar molecular compound. There are no significant attractions between the non-polar I_2 molecules and polar water molecules that would cause molecules of I_2 to separate.

Iodine does not react with CCl_4, it dissolves in it. Solutions of Iodine in non-polar solvents, like CCl_4, are purple in color. CCl_4 used as a solvent because it has no C-H bonds, carbon tetrachloride does not easily undergo free-radical reactions. The CCl_4 molecule wouldn't be polar, because it has a symmetrical shape in which the four chlorine atoms point toward the corners of a tetrahedron, as shown in the figure 7 below. CCl_4 is therefore best described as a nonpolar solvent[12,13].

C. Crystal Iodine + H_2O

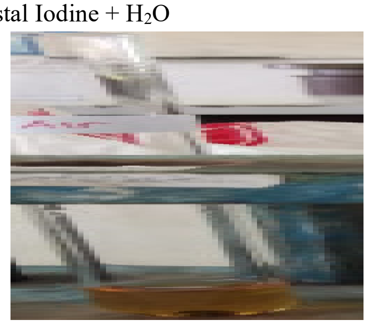

Figure 7. Reaction of crystal iodine with H_2O

A solution of iodine in water is yellow-brown . When Iodine (I_2) is mixed with water, the water dissolves some iodine by forming a temporary charge. The oxygen from water bonds with the iodine. Iodine and water can have **dipole-induced dipole** interactions, in which either end of the water dipole can induce a temporary dipole in the iodine molecule. The interaction with the oxygen end of water becomes more important, because the lone pair electrons on water make it a Lewis base. The molecules can form a loosely bound Lewis-type **charge transfer complex**, in which there is a partial transfer of electrons from the water to the iodine[14].

The difference between the electronegativities of the hydrogen and oxygen atoms in water is much larger (EN = 1.24), and the H — O bonds in this molecule are therefore polar. If the H_2O molecule was linear, the polarity of the two O — H bonds would cancel, and the molecule would have no net dipole moment. Water molecules are not linear, however, they have a bent, or angular shape. As a result, water molecules have distinct positive and negative poles, and water is a polar molecule, as shown in the figure below. Water is therefore classified as a **polar solvent**[15].

Because water molecules are bent, or angular, they have distinct negative and positive poles. H_2O is therefore an example of a polar solvent[16].

D. Magnesium + HCl (Heated)

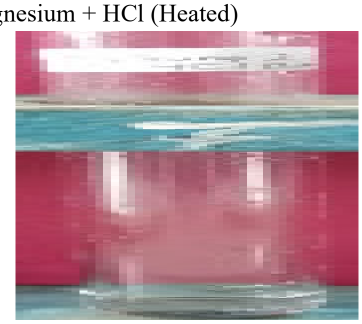

Figure 8. Reaction of heating magnesium with HCl

When magnesium metal reacts with hydrochloric acid, hydrogen gas and magnesium chloride are formed. This characteristic reaction of metals with acid, a single replacement reaction, or to demonstrate the generation of hydrogen gas[17].

E. Magnesium + H_2O (Heated)

Magnesium metals are not affected by water at room temperature. Magnesium generally is a slow-reacting element, but reactivity increases with oxygen levels. Magnesium fires cannot be extinguished by water.Furthermore, magnesium reacts with water vapor to magnesium hydroxide and hydrogen gas.

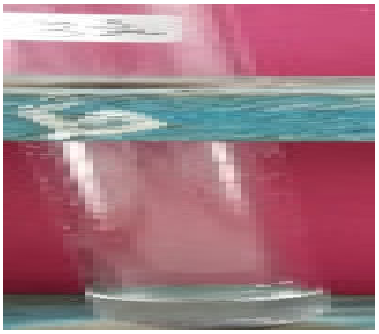

Figure 9. Reaction of heating Mg with H_2O

Magnesium oxide reacts with ionised water to produce magnesium hydroxide. This is a combination reaction. This reaction takes place at a temperature much higher than room temperature, around 120°C and can be reversed by reheating magnesium hydroxide[18].

F. $CuSO_4$ + H_2O (Heated)

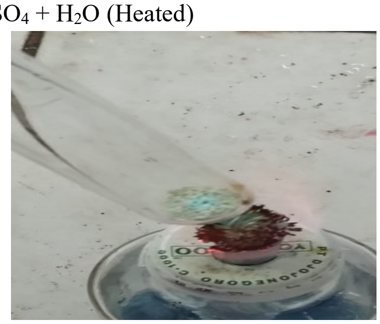

Figure 10. Reaction of heating $CuSO_4$ with H_2O

According to one text, a change in color, release of a gas (and some other changes), are indications of a chemical reaction. Since water vapor is released and the solid changes color, this should be considered as a chemical reaction, not a physical change. By heating copper(II) sulfate pentahydrate until it was white and contained no more water, you undergo a chemical change. The chemical makeup of $CuSO_4{\cdot}5H_2O$, changed to $CuSO_4$. The change in color in this situation also indicates a chemical change, but a change in color doesn't always entail a chemical change[20,21].

The crystal structure shows that the copper is six coordinated and has four oxygen atoms from water molecules in a plane and the other two octahedral positions are each occupied by one oxygen from an SO_4 group.

The fifth water molecule has its oxygen bridging two $CuSO_4$ molecules, see the sketch, and is bonded to four oxygens, two from water and two to sulphate oxygens, presumably by hydrogen bonds. The H atoms scatter x ray so weakly that these are not seen.

As these bonds from this oxygen will be weaker than those of other oxygens bonded to the cation they should be broken first on heating so this should be considered to be a chemical reaction. Breaking the other bonds Cu−OH_2 bonds will follow on further heating to form the anhydrous solid.

G. $CuSO_4$ + CCl_4 (Heated)

Figure 11. Reaction of heating $CuSO_4$ with CCl_4

High CCl_4 conversions (63% – 83%) were found in the mineralization process performed at 513 K – 603 K for 10 – 30 min. Using X-ray-absorption near edge structure (XANES) and X-ray photoelectron spectroscopies, we found that most $CuCl_2$ was encapsulated in the CCl_4-mineralized product solid (mineralization at 513 K for 30 min). At higher mineralization temperatures (563 K – 603 K), $CuCl_2$ was found to be predominant on the surfaces of the mineralization product. Speciation of copper in the mineralization product solid was also studied by extended X-ray absorption fine structure (EXAFS) spectroscopy. Bond distances of Cu-O and Cu-Cl in the CCl_4-mineralized product solid were 1.93-1.94 and 2.10-2.12 respectively, which were greater than those of normal CuO and $CuCl_2$ by 0.03-0.07 A. The increase of the bond distances for Cu-O and Cu-Cl might be due to Cl insertion and concomitant structural perturbation of unreacted CuO in the mineralization process. For the second shell around copper atom, bond distances of Cu-(O)-Cu also increased by 0.03-0.05 A, and the coordination numbers of Cu-O and Cu-(O)-Cu decreased, as expected, in the mineralization process. In addition, stoichiometrically excess oxygen atoms were found on the solid surfaces, and they might play an important role in the mineralization of CCl4, leading to the formation of CO_2 and Cl. Chloride atoms might be further captured by CuO, yielding $CuCl_2$ in the mineralization process. This work exemplifies the utilization of X-ray spectroscopies (XANES, EXAFS and XPS) to reveal the speciation and possible reaction pathway in a very complex mineralization process in detail[12,22].

IV. Conclusion

Physical changes is the process of changing the physical properties of a substance but not making any changes in the composition of the molecule. Changes in physics are reverrsible. Which includes changes in physics in this journal, namely heating the iodine crystal, heating the wax, heating the magnesium, heating the $CuSO_4$. Whereas chemical changes is a process that can produce a new substance, and the chemical properties of this substance change and then it is converted into substances which are different with different chemical compositions. Chemical changes are ireverrsible. Which includes chemical changes in this journal, namely crystal iodine + KI 0.1 M, crystal Iodine + CCl_4, crystal iodine + H_2O, magnesium + HCl (heated), magnesium + H_2O (heated), $CuSO_4$ + H_2O (heated), $CuSO_4$ + CCl_4 (heated).

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