Experiment 4

Physical and Chemical Changes

INTRODUCTION

Matter is frequently undergoing change. These changes can be classified as either physical or chemical changes. A physical change is a change in the size, state, or structure of matter. Physical changes involve "actions" which do not change the composition of the compound. The individual atoms are not rearranged in a different order after such an "action" takes place. Physical changes may alter the state of matter (gas, liquid or solid). For example, when ice (H_2O) melts, it becomes liquid water (also H_2O).

$$H_2O\ (l) \xrightarrow{\Delta} H_2O\ (g)$$

If that water is boiled it becomes a vapor or gas (H_2O). The chemical composition has not changed. A chemical change is a change in the composition of matter. Chemical changes involve "actions" which change the composition of the compound. If the compound was initially water, H_2O, and after an "action" it changed to H_2 and O_2 gases, then a chemical change has occurred.

$$2H_2O\ (l) \rightarrow 2H_2\ (g) + O_2\ (g)$$

The atoms of the compound water have been rearranged. Chemical changes involve two basic methods, analysis and synthesis. Analysis is the breakdown of a material for the purpose of uncovering what compounds or elements make up that material and synthesis is the construction of materials from smaller or different starting materials. In this experiment various laboratory operations will be performed on substances and the products observed. If no new substance is produced, a physical change took place. If a new substance with new properties results, the change was chemical. Writing an equation that describes the changes substances undergo is a brief but vital method used to communicate the discovery. All equations in chemistry have certain characteristics in common. The Table below lists some basic symbols commonly used in equations. Although equations are usually used to describe chemical changes (thus the complete name is "chemical equations") these equations can also be used to describe physical changes.

Symbol	Meaning	Symbol	Meaning
(g)	gas	Δ	heat
(l)	liquid	$\rightarrow$	produces
(s)	solid	+	combines with

The starting materials are generally called "reactants" and the ending materials are called "products". The importance of chemical equations is it informs the reader of all the materials used in an experiment. Compounds or elements can not "magically" appear or disappear so chemical equations is also a way of keeping track of all of the components, its the bookkeeping of the chemistry world.

Part 1: ANALYSIS OF METAL IONS BY THE FLAME TEST

The purpose of this section is to become familiar with the characteristic color associated with different metallic ions and then use this information to analyze the metallic ion present in some everyday chemicals. If energy is applied to an atom in the form of heat or electrical discharge, the atom can emit light. This process is responsible for the light of neon signs and fluorescent light bulbs. If the emitted light is passed through a prism or a diffraction grating, the light can be split into its components wavelengths and is called a spectrum. When gases are made to emit light in this way, the spectrum consists of a series of lines and is called an emission spectrum. The observed spectrum is characteristic of the element, and is considered a "fingerprint" of the element. A number of salts can produce this "fingerprint" emission spectra when exposed to high temperatures. The kind of color given off by each atom is so exact that it can be used to identify that atom. In the samples studied here, only the metallic ions, when excited by the flame of the Bunsen burner, produce observable colors. The non-metallic ions do not produce radiation in the visible region, and hence they do not interfere with the analysis.

PROCEDURE

1. Fill a 250 or 400 mL beaker about 2/3 full with distilled water and place 10 wooden applicator sticks in it.
2. Procure pea-size solid samples of each of the following samples including an unknown:

LiCl	NaCl	KCl	$CaCl_2$	$SrCl_2$	$BaCl_2$
salt substitute	Alka-seltzer	baking powder	cream of tartar	Rolaids	sugar

   Be careful not to contaminate the samples with each other by accidental mixing.

3. Light the Bunsen burner and set it to a very hot flame (light blue inner cone).
4. Dip the wet end of the applicator stick in one end of the solid samples to pick up a few crystals of the solid.
5. Place the applicator stick in the flame, just at the upper tip of the inner blue cone. Observe and record the color of the flame.
6. Discard the applicator stick after each test and use a new stick for each new test. If the household chemicals provided are bulky, grind the pieces into a powder before heating.

Part 2: THE CHANGES OF MAGNESIUM

Magnesium (Mg) is a metal, which, like most metals, is a solid at room temperature. When oxidized, magnesium always has an oxidation number of +2, which means that the oxide is MgO and the chloride is $MgCl_2$. Hydrogen (H_2), in contrast, will have an oxidation number of +1, so its oxide is H_2O (water!) and its chloride is HCl. The purpose of this section is to observe chemical reactions of magnesium (and hydrogen) and to identify reaction products.

PROCEDURE

1. Examine a piece of magnesium ribbon about 3 inches in length. Note the color, luster, and flexibility of the metal.
2. Either hold the strip of Mg with tongs in the bluest part of the flame and watch it ignite or a safer method would be to bend the strip and place it in an evaporating dish so that part of it protrudes above the dish. Ignite the magnesium with a burner.

CAUTION: DO NOT LOOK DIRECTLY AT THE MAGNESIUM WHILE IT IS BURNING!

3. Compare the ash with the original metal.
4. Obtain a new piece of magnesium (Mg) and place it into a medium test tube. Carefully add about 2 mL of dilute hydrochloric acid (HCl). Quickly place a watch glass over the opening of the test tube. Near the end of the reaction, remove the watch glass and place a lit splint into the mouth of the test tube. Flammability is one property of a gas called hydrogen (H_2). When a mixture of hydrogen and oxygen is ignited, the explosion can be heard as a whistle or "pop".

Part 3: THE CHANGES OF CARBON

Part A

In the hood, light a small birthday candle and fix it such that it will stand upright. Hold a watch glass over the flame for about 20 seconds and watch what happens.

Did you observe any moisture forming on the glass? Yes ____ No _____

Did you observe the deposition of a dark substance on the underside of the watch glass? Yes ____ No _____

What state of matter(s) do you think each product exists in?

What substance is given off by the burning of the candle to account for these observations?

When a candle burns down, it appears to disappear into nothing. Is this true? Yes ___ No _____

Did the candle undergo a physical or chemical change? ____

Part B

In the hood, you will find some toluene (a gasoline type substance). Take 1 mL of toluene and place it in an evaporating dish. Ignite it under the hood by carefully bringing a lit match or splint to the dish. Observe the flame and any soot that forms.

Color of flame: _________________________________ color of residue: _____________________________

What element is the soot? _______________

This substance is produced when the gasoline is burned incompletely, a condition that happens when there is not enough oxygen present.

In a different evaporating dish, pour about 1 mL of ethanol (a gasoline type substance containing oxygen). Ignite it in the hood. Observe the color of the flame and any soot that forms.

Color of flame: ______________________________ color of residue (if any): __________________________

What compound would be formed from the complete burning of gasoline? That is when oxygen is in abundance? ____________________

Did the toluene & ethanol undergo a physical or chemical change? ____________________________

Explain you answer:

Part 4: T HE CHANGES OF COMPOUNDS

Part A: Analysis of Rust

Pour 1 mL of iron(III) chloride (FeCl3) solution into a small beaker. Add several drops of sodium hydroxide (NaOH) solution and observe.

What happened?

Write an equation describing the reaction between iron(III) chloride and sodium hydroxide if the products are iron(III) hydroxide and sodium chloride.

What color is iron (III) hydroxide? ____________________

Now add dilute hydrochloric acid until something happens, gently shake occasionally.

Describe what happened.

Write an equation describing the reaction between iron(III) hydroxide and hydrochloric acid if the products are iron(III) chloride and water.

Was this a physical or chemical change? _________________________

Many times reversibility of the state of matter can be used to determine whether or not a change is physical. In this experiment you started and ended with iron(III) chloride so the change was reversible. Does reversibility mean the change must be physical? Yes ____ No _____

What criteria should be used to distinguish between physical or chemical changes?

Obtain a rusty nail. Place half of it in a beaker containing dilute HCl. Wait a few minutes then describe what happens.

Rust is a form of iron oxide. Does this experiment suggest a way to get rid of rust stains? _____

If rust has the formula Fe_2O_3, write an equation describing the "ridding" of rust with HCl. Remember it should be similar to previous reactions.

Part B: Analysis of a hydrated salt

Weigh a clean dry test tube (in a small beaker) and record your answer below. Place 1.00 g of copper sulfate pentahydrate (CuSO4·5H2O) in a test tube and re-weight. Set up a bunsen burner. The test tube should be handle at a 45^{o} angle using the test tube holder. Gently heat using the hottest portion of the Bunsen burner flame. After 1 minute or so carefully observe the inside walls of the test tube. Note what happened to the crystals as the substance was being heated.

Weight of test tube: ________________ g

Weight of $CuSO_4$. $5H_2O$ and test tube: ________________ g

Weight of $CuSO_4$. $5H_2O$: ________________ g

What color were the crystals originally? __________________

What do you observe on the test tube walls? (see further tests below)

What do you think is the substance on the wall?

Where do you think the substance on the wall came from?

To what color did the crystals change as the compound was being heated? __________________

Once the color change is complete, remove the heat from the test tube. Allow the test tube to cool to room temperature. Once cooled, weigh the crucible and remaining substance.

Weight of residue and test tube: ______________________ g

Weight of residue: ______________________ g

Weight of H2O driven off: ______________________ g

Calculate the percent of water found in the hydrated salt. ______________________ % H2O

Show work:

Add a few drops of water to the residue in the test tube. Describe any changes that happened.

Did the original substance undergo a physical or chemical change? Yes ___ No _____

Write an equation describing the dehydration of copper sulfate pentahydrate, read the bottle label for the formula.

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Part 1: FLAME TESTS

Sample test	Color observed	Metallic ion present
LiCl		
NaCl		
KCl		
CaCl2		
SrCl2		
BaCl2		
Salt substitute		
Alka seltzer		
Baking powder		
Rolaids		
Cream of tartar		
Sugar		

Did the salts undergo a physical or chemical change? ________________________

Part 2: MAGNESIUM

1. Describe the physical properties of magnesium metal.

2a) Describe what happens when the magnesium is burned.

2b) Describe the physical appearance of the ash.

2c) Was heat given off or was it absorbed in this reaction? Yes ____ No _____

2d) What is the chemical term describing the heat transfer for this reaction?

2e) Which type of change, physical or chemical, did the magnesium undergo?

3a) What state of matter is being produced when the Mg reacts with HCl?

3b) What happened when the burning splint was placed in the mouth of the test tube?

3c) What substance was produced when the "pop" occurred?

3d) Which type of change, physical or chemical, did the magnesium undergo?

3e) If the solution left over contained magnesium chloride ($MgCl_2$), write an equation that describes the reaction.