CHEM 231

Experiment 1

Chemistry of household products

Introduction

In this experiment, you will be observing reactions of several household products with some common laboratory reagents. You will relate your observations to certain chemical properties of these products. Finally, you will look up the active ingredients of these products and – with whatever chemistry knowledge you have at this point – relate these properties to your observations in the lab. The purpose of the experiment is learn some of the common laboratory tests used in the laboratory and to use these to identify the important chemical properties of some household products.

The products you will be examining are the following:

Baking soda (a solid)

Washing soda (a solid)

Ordinary sugar (a solid)

Household ammonia (a liquid solution)

Lysol toilet bowl cleaner (a liquid solution)

Vinegar (a liquid solution)

Salt (a solid)

(Your instructor may choose others or make substitutions.)

The reagents for the chemical tests (contained in convenient dropper bottles) are the following:

Silver nitrate ($AgNO_3$; 0.1 **M** solution)

Thymol blue indicator (0.1% solution)

Hydrochloric acid (HCl; 6 **M** solution)

Calcium chloride ($CaCl_2$; 1 **M** solution)

Phenolphthalein indicator

Background information

A very important chemical property of any substance, but particularly solids, is that of water solubility. A substance that dissolves in water mixes completely to form a completely homogenous liquid mixture, called a solution. It is important to distinguish between a solution and a so-called solid suspension which may appear homogeneous but actually consists of very fine solid particles. A solution is clear and, unless it has a color, appears indistinguishable from pure water. In a solid suspension, the solid particles give the liquid a cloudy appearance.

Another important chemical property is the ionic or nonionic nature of a substance. Some substances are composed of positive and negative ions and others of neutral molecules. (Some are more difficult to classify in that although they may be nonionic, they form ions in water solution.)

A very important feature of water solutions is that called “acidity” – and its opposite “alkalinity” or “basicity”. Substances classified as acids form positively charged hydrogen ions (H_+) when mixed with water and those classified as bases form negatively charged hydroxide ions (OH_-). Acids and bases may be classified strong or weak depending upon the extent to which they form these ions. Also, acidic and basic solutions will “neutralize” one another as these two ions combine to form water molecules. Note that a substance need not necessarily itself be ionic to be acidic or basic in water.

The reagents

Silver nitrate

The silver nitrate solution provided to you is 0.1 **M** solution. Silver nitrate has the formula $AgNO_3$ and in water consists of silver (Ag^+) and nitrate (NO_3^-) ions. Many ionic compounds of the silver ion are insoluble. When a solution containing one of these negative ions is mixed with silver nitrate, a precipitate forms. A precipitate is a solid formed from a reaction in solution. This is a common test for the chloride (Cl^-) ion which is forms an AgCl precipitate when silver nitrate is added to it. However, many negative ions also form precipitates with silver ion.

Calcium chloride

This solution is also a solution of an ionic compound containing the calcium (Ca^{2+}) and chloride (Cl^-). Just like silver chloride solutions, it can form precipitates if mixed with something that causes an insoluble substance to form. This would most often occur with the calcium ion as most ionic compounds of chloride are soluble. The two most common precipitates seen with calcium ion are with the hydroxide (OH^-) ion and with the carbonate (CO_3^{2-}) ion. Calcium hydroxide is slightly soluble; therefore, a precipitate may or may not be seen when calcium is mixed with a basic solution. It depends upon how basic it is. Calcium carbonate is very insoluble. A very distinct precipitate can be seen whenever solutions containing the calcium ion and the carbonate ion are mixed.

Thymol blue indicator

There are a number of substances which change color depending upon how acidic or basic a solution is. Thymol blue is one of these. This particular indicator is red if the solution is very acidic. If the solution is only moderately acidic or neutral, it is yellow. Finally, thymol blue will turn blue in the presence of a solution that is moderately or strongly basic.

Phenolphthalein

This is another very common acid-base indicator. It is clear in acidic, neutral, or very weakly basic solutions. In stronger basic solutions, it turns pink.

Hydrochloric acid

This is the most common laboratory acid. It is a strong acid and, as such, has a significant concentration of hydrogen (H^+) ions. Two common reactions are worth mentioning. First, as a strong acid, it will neutralize bases. It ordinarily does so with the generation of a significant amount of heat. Second, it will react with substances containing the carbonate ion (CO_3^{2-}) or the hydrogen carbonate ion (HCO_3^-). (Hydrogen carbonate ion is also called bicarbonate.) The reaction produces carbon dioxide gas which is evidenced by vigorous fizzing.

Procedure

Record in your notebook the household products available in your lab for testing. Be certain to include brand names where appropriate.

Water solubility

> Use four small test tubes. In the bottom of each one place a small amount of one of the four solid household products. The solid should just barely fill the rounded bottom of the tube, but the exact amount is not critical. Label the tubes and add distilled water so that each is about half full. Stopper each one and shake vigorously for about a minute. Write down what you observe in your notebook. Draw a conclusion about the water solubility of each solid. Note: Often a water soluble solid might take some time to completely dissolve. Thus, a considerable amount of suspended solid might remain after a minute of shaking even if the solid is soluble. If you see the amount of visible solid decreasing as you shake, you can conclude that the substance is soluble even if some cloudiness remains.

If you conclude that any of these solids are water soluble, save the test tube with the liquid solution for subsequent testing.

Testing solutions with the laboratory reagents

You have up to four solutions of household products in labeled test tubes from Part A. Obtain samples of the three other products (liquid ammonia cleaner, Lysol toilet bowl cleaner and vinegar) in three additional test tubes. Each of these (up to) seven solutions is to be tested with each of the five chemical reagents listed above. Use a well plate (or plates) to carry out the tests. For the sake of keeping track of the many combinations, it may be convenient to arrange the combinations in a grid format on the well plates with each column corresponding to one of the chemical reagents and each row to one of the household products.

To carry out the tests, simply place a few drops of the solution to be tested and a few drops of the testing reagent into the appropriate well. Observe what happens and write down your observations in your notebook with as much detail as possible. Particularly record any colors observed, visible reactions such as fizzing, or the appearance of precipitates. It is also possible that a particular combination produces no reaction. If so, indicate this as well. If you have doubts about any particular combination, repeat that test in a test tube in order to better observe the results.

Conclusion and follow-up

On the basis of your observations, you are to draw whatever conclusions that you can about the contents of the household products. In doing so, make use of the background information given in this procedure. You may also find the following link to the solubility rules for ionic compounds useful:

http://www.csudh.edu/oliver/chemdata/solrules.htm

For example, your conclusion might be something like this: "___ is a solid which is water-soluble. ___ contains ions in solution because ___. A solution of this product is basic because ___." Report as much as you can reasonably conclude based upon the chemical tests but no more than that. You may or may not have information about the specific ions present. Be careful not to conclude something more specific than you are entitled to on the basis of your observations.