

## Some Lab Activities in Chemical Analysis

### A Combination to Avoid!

NH<sub>3</sub> dissolved in water is ammonia solution, a common household cleaning agent (e.g. Windex for windows). Clorox is 3-6% solution of sodium hypochlorite (NaClO) in water, also used for cleaning. If an overeager person decides to mix these two cleaners, they are creating a chemical reaction that produces a mixture of three toxic compounds: NH<sub>2</sub>Cl, NHCl<sub>2</sub> and NCl<sub>3</sub>. An additional reaction produces hydrazine N<sub>2</sub>H<sub>2</sub>, a poisonous and powerful oxidizer used in some rocket fuels. Hence the admonition: "**Don't mix ammonia and bleach!!!**"

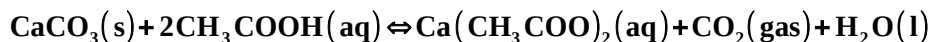
We will use a variety of chemical tests to identify a collection of "unknown" white powders that are common household chemicals.

### Calcium carbonate (chalk) CaCO<sub>3</sub>

The White Cliffs of Dover in England are composed of chalk from parts of ancient single-cell algae.

Chalk is not soluble in water (only 0.0015 g/100 mL at 25 °C).

The reaction of calcium carbonate with acetic acid in vinegar produces calcium acetate, carbon dioxide and water:



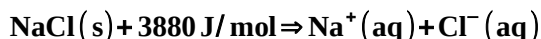
For more about calcium acetate, see [https://en.wikipedia.org/wiki/Calcium\\_acetate](https://en.wikipedia.org/wiki/Calcium_acetate)

### Sucrose C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>

Sucrose is ordinary sugar that is soluble in water (200 g/100 mL at 25 °C). It is a disaccharide composed of glucose and fructose.

### Sodium chloride (table salt) NaCl

It is soluble in water (36 g/100 mL at 20 °C and 40 g/100 mL at 100 °C) and absorbs energy as it dissolves.

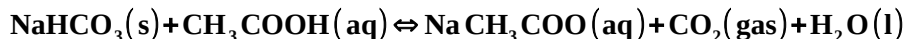


### Sodium hydrogen carbonate (baking soda) NaHCO<sub>3</sub>

This is also called sodium bicarbonate, but that name is deceptive since there is only one carbonate ion (CO<sub>3</sub><sup>2-</sup>). When used in baking, baking soda reacts with any acidic components in the batter to produce bubbles of carbon dioxide. It also gives off carbon dioxide upon being heated while baking.

Baking soda is also commonly used to neutralize acid or base spills. I have used it on car battery terminals.

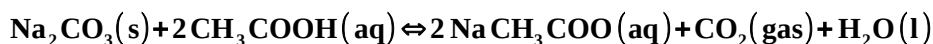
It is soluble in water (9.6 g/100 mL at 20 °C and 23.6 g/100 mL at 100 °C).



### Sodium carbonate (washing soda) Na<sub>2</sub>CO<sub>3</sub>

As explained in your text in Section 16.6, washing soda is used to "soften" water by binding with Ca<sup>++</sup> and Mg<sup>++</sup> ions in the "hard" water. These doubly-ionized atoms, commonly found in well water, can tie together pairs of soap molecules and prevent their useful action.

It is soluble in water (21.6 g in 100 mL at 20 °C and 45.0 g/100 mL at 100 °C).



## **Cornstarch (starch containing amylose and amylopectin) polysaccharide of glucose**

Cornstarch is used as a thickening agent in foods such as soups and gravies. The amylose polysaccharide curls into a helical shape within which  $I_3^-$  ions tend to accumulate.

The amylopectin in starch is soluble in water, but the amylose is not. As a result, cornstarch is not very soluble in water.

## **Magnesium sulfate (Epsom salt) $MgSO_4$**

We used Epsom salt to aid in the conductivity of water in our production of  $H_2$  and  $O_2$  by electrolysis. Because of its high molecular weight and high solubility in water, it is used in baths for flotation therapy. It is also used in gardens that are deficient in  $Mg^{++}$ , the metal at the center of chlorophyll molecules.

It is soluble in water (25.5 g in 100 mL at 20 °C).

## **Chemical Tests**

### **Solubility in Room Temperature Water**

Place a small amount of unknown (about the volume of a pencil eraser) into a test tube and add 5 mL of water. Shake for a few minutes and see if the unknown dissolves.

All unknowns should dissolve except for chalk and cornstarch.

Save all solutions (even those that did not dissolve) for later tests with a pH indicator and vinegar.

### **Solubility in Isopropyl Alcohol**

Performed in a similar manner to the water solubility test.

Only Epsom salt should dissolve.

### **Iodine Test**

Add a small amount of tincture of iodine (2-7%  $I_2$  dissolved in a mixture of water and ethanol along with some KI or NaI) to unknowns that were not soluble in water and see which are stained blue or brown. Blue means that the unknown has amylose starch helices within which  $I_3^-$  ions are held.

### **Indicator Test using pH Test Paper Strips**

Use a pH indicator strip to test the pH of your successful water solutions. Determine what happens to the blue and red strips when dipped in vinegar (a weak acid) or ammonia (a weak base). Then, see what happens with washing soda.

### **White Vinegar Test**

Vinegar is a water and acetic acid ( $CH_3COOH$ ) solution with typically few percent acetic acid. When added to a solution that has carbonate ions (baking soda, washing soda, and chalk), carbon dioxide bubbles will be released.

1 L of vinegar can dissolve 49.5 g of chalk,  $CaCO_3$ . Ocean acidification from dissolved atmospheric  $CO_2$  is a threat to the shells of marine animals.

### **Solubility in Hot Water**

Most substances that are soluble in water at room temperature, double or triple their solubility when tested in water at 100 °C.  $NaCl$  is an exception; its solubility increases by only about 10%.