A drug is considered to be any substance used as a medicine internally or externally. It can have an effect on the function or structure of living tissue through various chemical reactions. Some drugs are habit-forming and are classified as narcotics. Narcotics are regulated by Federal law. All drugs that are covered by law and are restricted in some manner are called “controlled drugs”. Whenever a drug of any type is taken in excessive amounts and causes illness or death, i.e. exhibits toxic properties and is then classified as a poison.

When a person is arrested for possession or sale of illegal drugs, analysis is needed to determine if the confiscated material is a controlled drug, and not just an over-the-counter drug. Analysis is also needed for any apparent deliberate poisoning, a homicide, an accidental death or suicide can all involve drug consumption. If a victim is found unconscious at the scene of an incident, it is important to determine as quickly as possible if a drug or poison was administered to the victim and what the substance was! Thus, the crime scene needs to be carefully searched for evidence: empty glasses, milk or wine bottles, or medicine containers; traces of powder or liquids on the victim’s body, clothes or possession or on the carpet or floor nearby; and suspicious material in the trash. It is easier to determine what poisoned a victim by examining an empty container than to have to examine the victim’s remains.

How does one analyze an unknown compound? Chemists must continuously develop new methods for analyzing drugs and poisons to keep up with the modern drug industry and with the criminals who make and sell their own drugs. These methods involve looking at the chemical reactions that occur with different compounds. As soon as a pharmaceutical company produces a new drug, it sends a sample to the FBI Crime Lab. Tests are developed to identify both large and minute quantities of the substance and results are placed on file for use as a reference when unknown samples are analyzed. Many techniques are used to test drugs and poisons, including chromatography (gas, paper and thin layer; see in last week’s laboratory), spectrophotometer (ultraviolet and infrared), mass spectrophotometer, and spot tests using certain chemical reagents. The last method is the one we will employ in this lab.

An unknown sample may be one of over a thousand or more common over-the-counter drugs. It may be a powerful illegal narcotic. Specific analysis techniques, often involving thin layer chromatography (TLC), or other sophisticated laboratory apparatus, are undertaken.

Often drugs sold illicitly are not pure. They are often “cut” with other inert materials known as additives—e.g., sugar, starch and quinine. At times, other poisonous substitutes are incorporate within these illicit drug samples. This “filler” material must also be identified, in that it is used to dilute the drug’s potency and stretch its value when sold on the illicit market.

A complete analysis must leave no error. The sample examined is either a drug or it is not. If it is found to be a drug, it then must be determined whether it is of the legal over-the-counter type, or illegal. Depending upon the accuracy of the forensic evidence, legal charges might be brought against a drug pusher or a charge of first degree murder might be brought against someone charged in the poisoning of a victim.

**Over-the-Counter (OTC) Drugs**

Many sociably accepted over-the-counter drugs can cause accidental poisoning or even death, especially to children. These drugs include alcohol, antacids, nicotine, aspirin, and other pain relievers. It is important to identify these substances as soon as possible so measures can be taken to help save the victim’s life.
An acidified solution of iron(III) (Fe\(^{3+}\)) nitrate can be used to detect the presence of aspirin in an unknown powder. The aspirin is split apart by water to form salicylic acid and acetic acid, and the iron(III) ion reacts with the salicylic acid to form a compound with a specific purple color.

**Acetaminophen**, available as Tylenol®, is also a good pain reliever. It is not acidic and can be used by those who are allergic to aspirin or have asthma.

Antacids are slightly basic compounds that are used to treat a condition of hyper-acidity; too much hydrochloric acid (HCl) in the stomach. Many of these products contain carbonates (CO\(_3^{2-}\)), which react with or neutralize the acid in the stomach to produce a salt, water and carbon dioxide (CO\(_2\)) gas. Bicarbonate of Soda (NaHCO\(_3\)), also known as sodium bicarbonate or sodium hydrogen carbonate, reacts in the following manner:

\[
\text{NaHCO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2
\]

This produces a salt (NaCl), water, and carbon dioxide. Alka-Seltzer®, which contains sodium bicarbonate, citric acid and a very small amount of aspirin, reacts with water to produce carbon dioxide gas and a buffer (resists change in pH).

The citric acid-sodium citrate buffer reacts with the excess stomach acid to relieve hyperacidity. If too great an amount of antacid is taken, severe stomach disorders may result.

**Controlled Drugs**

Some of the drugs that have been making headlines in the news over the last forty years include the so-called “hallucinogenic” drugs: LSD (lysergic acid diethylamide), marijuana, heroin, cocaine, etc. With the exception of marijuana, these are classified as alkaloids: basic nitrogen containing plant products having marked physiological action when given to animals. Marijuana is not a drug, but the dried parts of the hemp plant, Cannabis sativa. The active component in marijuana is tetrahydrocannabinol. Most are white powders.

The first step in screening a suspicious hallucinogenic sample is to examine it under **ultraviolet light**. Most hallucinogens show up as fluorescent areas. The substance can be dissolved in an appropriate solvent and tested with the appropriate chemical reagent. Thin layer chromatography can be used to detect micrograms of the material.

Many alkaloids can be identified by the colored precipitates (solids) they form with specific reagents. Observation under various types of lighting and the results of chromatography scan also can be used to identify an unknown drug.

One of the first steps in the examination of suspected marijuana is the visual identification under a microscope. At the base of the leaf hairs you should be able to observe small crystals of calcium carbonate. If a drop of hydrochloric acid is added to the material, bubbles of carbon dioxide gas, water and calcium chloride will be produced. Other tests involve adding various known reagents to see if a predetermined result is observed (color change, bubbling, etc.).

**Identification of Heavy Metal Poisons**

Although there are very few homicides nowadays that involve poisoning, there still are many suicides and accidental deaths that do. The poisons can come from a wide range of sources: car exhausts, pesticides, medicines, alcohol, industrial wastes, etc. Our environment is full of materials that contain **lead**, arsenic, cadmium and **mercury ions**. Lead and its ions are found in storage batteries, industrial paint, leaded gasoline (airplanes), solder, ceramic glazes, and artist’s paint pigments. Mercury and its ions are found in
electric apparatus, thermometers, batteries, medicines, fungicides for seeds, industrial waste, and contaminated fish. Both of these metals can build up in the body and cause damage. Lead ions affect the functioning of the blood, liver, kidney, and brain. It will be deposited in the bones over a period of time. A dose of 0.5 gram can be fatal. Whatever the poison, the ultimate effect is the same: It withholds the oxygen necessary for life processes to continue from the tissues.

**Theory:**

We will react the powders in this lab with various chemicals to see how each will respond. This will test the chemical properties of the various known compounds. We can then compare the properties of the known compounds to some unknown compounds. This can help us to identify what the unknown compound is. These tests do not conclusively prove what the compound is, but rather can eliminate what the compound is not.

We will be using universal indicator in the first column (look at Data Table 1). This will help us to determine if the compound is acidic, basic or neutral. The colors of the Universal indicator are:

- a red color (low pH) which is characteristic of acids
- a violet/blue color (high pH) which is characteristic of bases
- an olive/yellow color which is characteristic of neutral solutions (pH=7) (not acidic or basic)

In the second column of Data Table 1, we are adding HCl (hydrochloric acid). This can cause CO₂ (carbon dioxide) to be released from certain compounds. If CO₂ is present, bubbles will form when you add HCl.

In the final two columns of Data Table 1, iron(III) (Fe⁺³) and potassium chromate (K₂CrO₄) are reacted with each of your samples. These compounds will react with your samples to form new compounds, some of which are clear, others of which are opaque and brightly colored.
Procedure

You will be given a plate already loaded with samples and unknowns, as shown on Data Table 1. The unknowns will be one of the knowns. Unknowns 1 and 2 will be white powders (labeled A-F) and unknown 3 will be a liquid (labeled I or II).

Be very careful not to contaminate the other wells!

**Put a white piece of paper under the plate; this helps to visualize the color**

1. Add 3-4 drops of DI water to each of the wells in the first column (labeled indicator).

2. Add 1-2 drops of universal indicator to each of these wells. Stir each well with a clean toothpick. You can use the opposite end of the toothpick. What happened? Record your results on Data Table 1.

3. Add 3-4 drops of HCl to each of the wells in the column labeled HCl. What happened? Record your results on Data Table 1.

4. Add 3-4 drops of Iron(III) ion to each of the wells in the column labeled Fe$^{3+}$. Stir with a clean toothpick. What happened? Record your results on Data Table 1.

5. Add 3-4 drops of Potassium Chromate to each of the wells in the column labeled K$_2$CrO$_4$. What happened? Record your results on Data Table 1.

**When you are finished with your lab, please rinse out your plates in the waste container and set them aside to dry. DO NOT remove the tape.**
Experiment 4: Analysis of Drugs and Poisons: Chemical Reactions

PRELABORATORY EXERCISES

Name: __________________________  Lab Day and Time: _________________________

1. Write the balanced chemical reaction described earlier in the laboratory, “At the base of the leaf hairs you should be able to observe small crystals of calcium carbonate. If a drop of hydrochloric acid is added to the material, bubbles of carbon dioxide gas, water and calcium chloride will be produced.”

2. If the pH indicator shows that the pH of a solution is 5.93, is this acidic, basic or neutral?

3. Given the compounds that you will be working with in lab, identify each as an acid, base, or neither:
   (alka seltzer) sodium bicarbonate ______________ and citric acid ______________
   calcium hydroxide __________________
   aspirin, HC9H7O4 ______________________
   HCl ______________________________
   K2CrO4 ___________________________
# Experiment 4: Analysis of Drugs and Poisons: Chemical Reactions

**Name:** ______________________  **Partner:** ______________________

## Data Table 1

<table>
<thead>
<tr>
<th>Well Plate number (for identifying the unknowns)</th>
<th>Indicator</th>
<th>HCl</th>
<th>Fe$^{+3}$</th>
<th>K$_2$CrO$_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tylenol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alka Seltzer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium Hydroxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD (simulated)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercury(II) Nitrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead(II) Nitrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Be sure to record enough observations (color, bubbling, got cloudy, etc.) here so you can determine the identity of your unknown compound! (See next page).
Data Sheet/Results

Name______________________________________________________
Partner’s Name_______________________________________________

1. Record all of your results on Data Table 1, including, but not limited to:
   color change
   CO₂ produced (bubbles)
   (and anything else that happens).

2. On Data Table 1, note which wells contain:
   acids
   bases
   neutral compounds

3. What could Unknown 1 be? Support your answer.

4. What could Unknown 2 be? Support your answer.

5. What could Unknown 3 be? Support your answer.

Post Lab Question

Name:_______________________

Why is it important not to contaminate the other wells with your samples? What might happen?