**Background:**

 A drug is a chemical used medicinally for treating disease and injuries. The term “drug” however carries with it a connotation of narcotics, addition and crime. Many drugs or medicines are entirely legal, readily available and re-sold as over –the-counter- medications without the need for a prescription. Over-the-counter (OTC) drugs include categories of drugs such as pain relievers, antacids, alcohol, caffeine and vitamins. While these OTC drugs are sold legally, they like controlled or prescription drugs have the ability to cause accidental or purposeful poisoning and even death if taken improperly. Thus it is important that dosage information and precautions printed on the label are strictly followed in order to prevent accidental injury or harm.

**Pain relievers** – Analgesic and Antipyretic medicines

Aspirin is the common or trade name for acetylsalicylic acid and is today’s leading pain reliever. Aspirin acts as an analgesic (pain reliever) and an antipyretic (fever reducer) as well as an anti-inflammatory agent (reducing swelling/inflammation). Aspirin is a fairly acidic compound which reacts slowly with moisture from the air to undergo hydrolysis forming salicylic acids and acetic acid; shown below.

  

 H2O

acetylsalicylic acid water salicylic acid acetic acid

**Figure 1**

If aspirin is to be stored for several months, it should be kept dry. If the tablets picks up moisture they may begin to smell like vinegar and become even more acidic. This increase in acidity can be very irritating to the lining of the stomach and intestines, causing side effects such as upset stomach, gastrointestinal bleeding, and various allergic reactions. Furthermore, aspirin, as with any drug, must get into the bloodstream in order to do its work. The time it takes for acetylsalicylic acid in tablet form to enter the blood is limited by the rate at which the tablet disintegrates in the stomach, which is dependent on pH. The high the pH (less acidic) the fast the tablet will disintegrate.

Some people opt to take a buffered aspirin, which contains aspirin and one or more weak bases. The weak bases such as, calcium carbonate, magnesium oxide or magnesium carbonate coat the aspirin and this raise the pH in the stomach when ingested. Since the pH in the stomach is increased it allows the aspirin to break down quicker and enter the bloodstream to begin work.

  

Acetylsalicylcic acid Acetominophen Ibuprofen

**Figure 2 Figure 3 Figure 4**

The acetylsalicylic acid has an ester side chain (), the R on the left represents the CH3 and the R on the right represents the 6 sided benzene ring attached to the O. In the presence of water the ester group hydrolyzes and breaks down into a phenol complex (benzene ring with –OH attached) and acetic acid, as seen in Figure 1. A chemical test to detect the presence of the phenol group is seen in a reaction with iron (III) nitrate. If a phenol group is present a distinct violet-colored complex is formed. Iron (III) nitrate is commonly used as a positive presumptive indicator test.

Acetaminophen, which is an acylate atomatic amine, is a non-aspirin headache remedy and the active ingredient in Tylenol. Compare figures 2 & 3 and notice the similarities and differences between the chemical structures of the two pain relievers. Acetaminophen has an alcohol (-OH) group on the benzene ring as well, just like Aspirin after it undergoes hydrolysis (refer to figure 1). Therefor, in the presence of iron (III) nitrate a distinct violet- colored complex will also be produced. Acetaminophen is a mild analgesic and antipyretic but lacks the anti-inflammatory properties which aspirin has. Acetaminophen is also less acidic and makes a good alternative for those who have a stomach that can not tolarate aspirin or are allergic. Exedrin is a combination of OTC pain relievers, consisting of equal amounts of aspirin, acetaminophen and a small amount of caffeine. The caffeine is added as a stimulant to the nervous system and heart, providing a heightened sense of awareness, which some people like in a pain reliever. The caffeine also helps to dilate your blood vessels to allow the active ingredients to work quicker.

Ibuprofen, another commonly used pain reliever, is the active ingredient in Advil and Motrin. The structure for ibuprofen can be seen in figure 4 and is another non-aspirin OTC drug. However, like aspirin, ibuprofen acts as an analgesic, antipyretic as well as an anti-inflammatory agent. Compare figure 4, with figures 2 and 3 and see what similiarities you notice.

**Antacids**

 Antacids are chemical that relieve over-acidity by neutralizing excess acid in the stomach. The excess acid can produce discomfort commonly called ‘acid indigestion’ or ‘heartburn’ and possibly gastric ulcers. Antacids promise to provide “prompt relief” of the unpleasant effects of these stomach distresses. Most antacids will dossolve completely in water and are made to dissolve slowly in the acid juices of the stomach so that carbon dioxide will be given off gradually as the antacid nuetralizes excess acid.

The stomach’s digestive juices, or gastric juices, contain hydrochloric acid (HCl), which serves to promote digestion of food protiens by the enzyme pepsin in the gastric juices and kill bateria that enters our digestive system. The stomach lining of a normal adult produced 2 – 3 liters of dilute HCL each day to aid in digestion, which a normal stomach pH ranging from 1.0 – 3.0. While the stomach produces a small amount of acid all the time, it can be stimulated to produce more acid in the presence of food. Too much food, certain types of food, or high levels os stress may cause the stomach to respond with an outpouring of acid, thus lowering the stomach pH to the point of discomfort.

Most common antacids contain weak bases such as sodium bicarbonate (NaHCO3), calcium carbonate (CaCO3), magnesium hydroxide (Mg(OH)2), aluminum hydroxide (Al(OH)3) or some combination of these. The basic compounds in the antacids serve to neutralize the excess HCL as well as to affect the functioning of the enzyme pepsin (which breaks down protiens). An acid-base neutralization reactions occurs between the base and the acid in the stomach. An effective antacids does not bring the pH of the stomach to complete acid-base neutrality (pH 7) as this would completely shut down digestion and promote “acid rebound” (an automatic response which flood the stomach with fresh acid). Instead, an effective antacid neutralizes some of the HCl in thr gastic juices, which is enough to relieve pain and discomfort.

Carbonate- containing atacids, such as sodium bicarbonate and calcium carbonate, react with stomach acid to produce a neutral salt and carbonic acid.

**Figure 5**  NaHCO3 + HCl 🡪 NaCl + H2CO3  CO2 + H2O

 Sodium bicarbonate + hydrochloric aicd 🡪 salt + carbonic acid carbon dioxide + water

Carbonic acid is much weaker than hydrochloric acid so it is less abrasive on the stomach.

Hydroxide – containing compounds such as magnesium hydroxide or aluminum hydroxide produce neutral salts as well as water when they are broken down in the stomach.

**Figure 6**

Mg(OH)2 + 2HCl 🡪 MgCl2 + 2H2O

 Magnesium hydroxide + hydrochloric acid 🡪 magnesium chloride + water

Common antacids are Tums, Rolaids, and Alka-Seltzer. Alka- Seltzer is very popular because not only does it bring antacid relief it also contains aspirin for pain relief as well. When the tablet is dropped into water the sodium bicarbonate produces the familiar “fizz” from the chemical release of carbon dioxide. Rolaids is another common antacid containing a combination of calcium carbonate and magnesium hydroxide. The generic antacids provided in theis lab are similar to Tums and have formulated with only calcium carbonate. Individuals with high blood pressure are advised to avoid excess sodium and may choose to use an antacid without sodium bicarbonate. People with osteophorosis or those who need a calcium supplement may choose to use an antacid formulated with calcium carbonate. Calcium carbonate, however, if used over long periods of time tends to cause constipation. Due to this, some antacids contain a combination of calcium carbonate and magnesium hydroxide which acts as a laxative effect. Magnesium hydroxide, whil effective in controlling ulcer pain has a lower-neutralizing capacity and can cause trouble if taken too frequently by people with kidney impairment.

In any case, each OTC drug must e taken with caution, and dosage information printed on the label should be followed strictly. In this lab we will analyze 2 classes of drugs, pain relievers and antacids. Known samples will be test and then unknown samples will be identified by comparison with the known samples. This process is purely qualitative, since we are only determinining what is in each sample, not how much.

**Please answer the following pre-lab questions on a separate piece of paper, in complete sentences.**

1. Over the counter drugs can be classified into what categories?

2. Aspirin (acetylsalicylic acid) is the leading pain-reliever in the U.S. what properties does it have to reduce pain?

3. Why must aspirin be stored in a dry place? What are the side effects that can be increased due to no storing in a dry location?

4. What is buffered aspirin and how does it differ from regular aspirin? Discuss the digestion process

5. What chemical test will we perform in the lab to test for the presence of a phenol group (-OH)? What color with the substance turn if the phenol group is present?

6. Acetaminophen is the active ingredient in what OTC pain reliever?

7. What pain relieving properties does acetaminophen possess and what does it lack?

8. What are the active ingredients in Excedrin?

9. Why is a small amount of caffeine added to Excedrin?

10. Ibuprofen is the active ingredient in what OTC pain reliever?

11. What pain relieving properties does Ibuprofen possess and/or lack?

12. What function do antacids perform?

13. Our stomachs digestive juices contain what chemical? What does it aid in digesting and killing?

14. When or How can you end up with more gastric acid in your stomach?

15. What weak basic chemicals are commonly found in antacids?

16. Upon taking an antacid explain the reaction that takes place in your stomach.

17. Why might someone choose to take Alka-Seltzer as opposed to Rolaids?

18. What are some other factors what individuals may take into account when choosing an antacid supplement?