FILTERING SOLUTIONS

Occasionally, one has to remove solid crystals or precipitates from a solution. The process used to accomplish this is filtration. There are two types of filtration used in the laboratory, *gravity filtration* and *vacuum filtration*. Gravity filtration is usually used when fine particles of solid need to be separated from a solution and vacuum filtration is used when coarse particles or crystals of solid need to be separated.

In **gravity filtration**, a piece of filter paper is folded into a cone and placed in a funnel. The solution is poured into the funnel and it then flows through the filter paper by gravitational pull. Most fine solid particles will not pass through the paper leaving a clear solution, called the *filtrate*, and a *residue* in the filter paper.

To filter a mixture using gravity filtration:

Obtain a round piece of filter paper, of a size appropriate to the funnel.

The filter paper is folded in half and then into quarters.

A corner is torn off one side, and the paper is opened into a cone with the torn corner on the outside.

The cone is placed in a funnel and moistened with a small amount of water. (See Figure F-1)

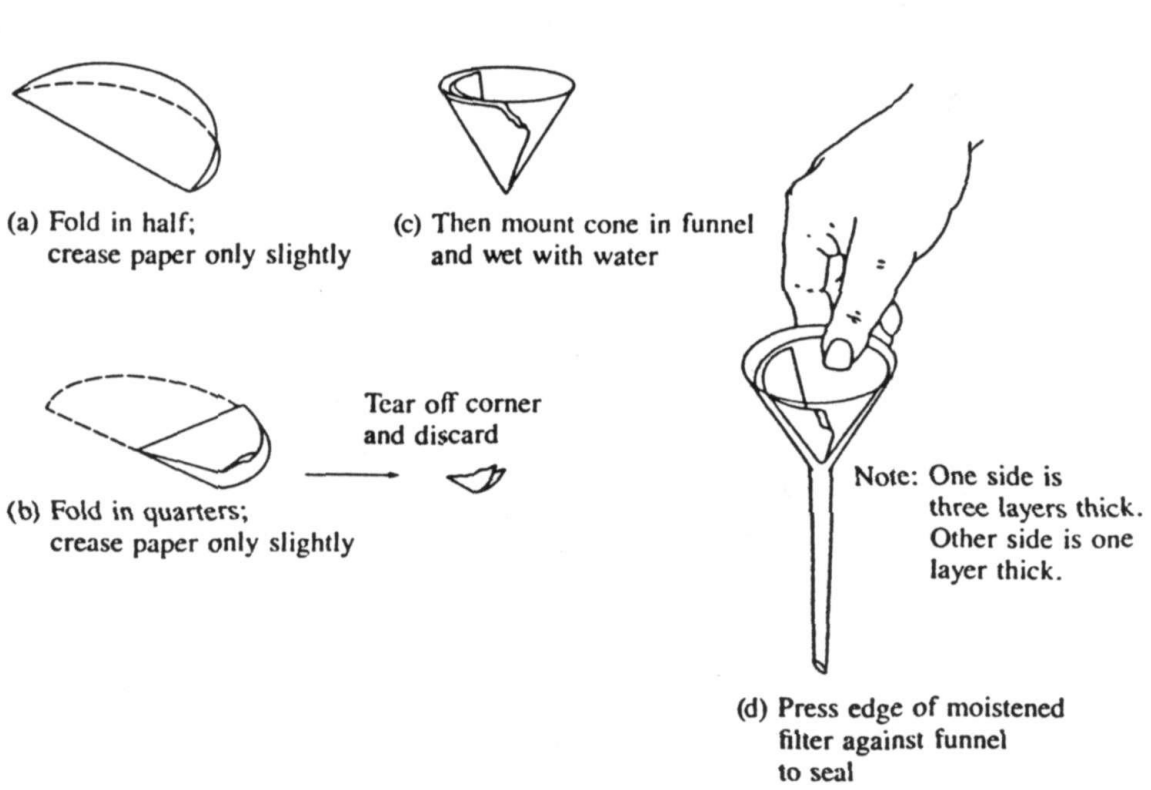

Figure F-1. Folding filter paper for gravity filtration.

The funnel is placed in a funnel support or on a ring support. If the ring support is too large to hold the funnel, then a clay triangle can be used to support the funnel. (See Figure F-2) A clean beaker, or other appropriate container, is placed under the funnel.

The solution, to be filtered, is poured down a stirring rod into the funnel. (See Figure F-2)

The filtrate or the residue will be saved, as directed in your experiment.

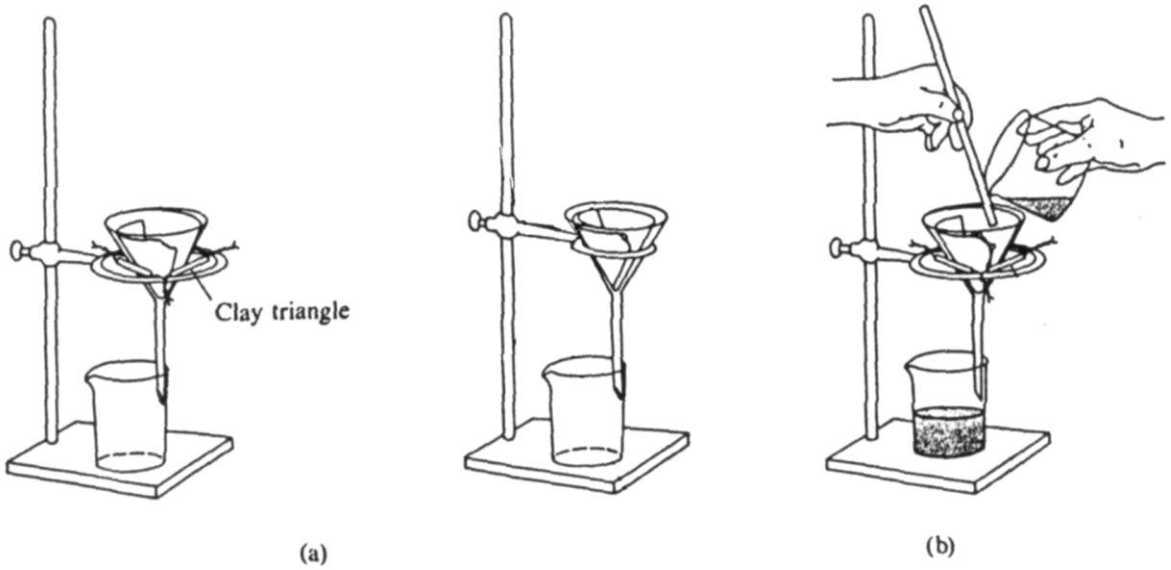

Figure F-2. (a) A funnel supported by either a metal support ring or a ring and clay triangle combination. (b) Pouring a solution into the funnel using a glass stirring rod.

In **vacuum filtration**, a heavy wall vacuum flask is used along with a Büchner funnel and attached to a vacuum source, often a water aspirator. A piece of filter paper is placed into the funnel so that it lays flat on the bottom of the funnel, it is moistened with water, or an appropriate solvent, the vacuum is turned on and the solution is poured into the funnel. The vacuum causes the solution to be pushed (by air pressure) through the filter paper. Coarse particles or small crystalline solids will not flow through the filter paper, but fine particles often do. Again, the clear solution is called the *filtrate* and the material on the filter paper is the *residue*.

Vacuum filtration apparatus is assembled as shown in Figure F-3. The flask must be clamped to some sort of support to prevent it from falling over and possibly imploding. The hose from the side arm of the flask is attached to the vacuum source, usually the side arm of a water aspirator.

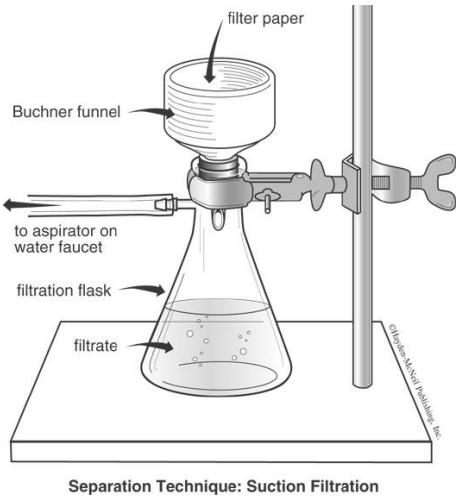

Figure F-3. Apparatus for vacuum filtration.

To filter a mixture using vacuum filtration:

Place a piece of filter paper into the Büchner funnel. It should lay flat and cover the bottom of the funnel.

Pour a small amount of water (about 1 to 2 mL), or an appropriate solvent as called for in your experiment, into the funnel.

Turn on the vacuum. The liquid in the funnel will be pushed through the filter paper and the paper will be pushed against the funnel bottom.

Slowly pour the mixture, to be filtered, into the funnel. The liquid should be pushed through the filter paper fairly rapidly. (See Figure F-4)

If directed, in your experiment, the residue can be rinsed with an appropriate solvent.

If the residue is the desired product and if directed, in your experiment, the apparatus can be left in place with the vacuum on to air dry the residue.

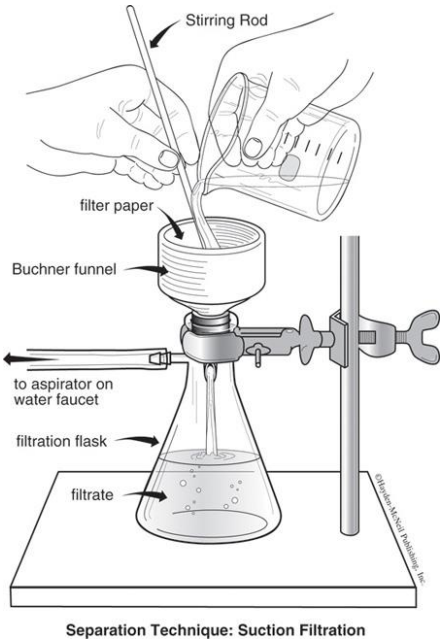

Figure F-4. Pouring solution into a Buchner funnel

Filter Paper

There are different grades of filter paper available. Generally, filter papers are classified as *qualitative* and *quantitative*. Within both types of filter papers, there are a variety of porosities making them applicable for use with precipitates ranging from fine to coarse. Once a mat of precipitate is formed on the paper, the effectiveness of the pore size will be affected, usually slowing the rate of filtration.

Qualitative filter paper is generally used for rapid filtration to retain precipitates or to remove solid impurities from a solution. The residue, or precipitate, if it is to be retained, is usually dried, collected, and weighed and any material sticking to the paper is usually considered part of the acceptable loss accounted for in the percent yield calculations.

Quantitative filter papers are used to retain precipitates that are to be precisely weighed, usually in analytical procedures. Quantitative filter papers are usually finer porosity to retain the maximum amount of precipitate and are classified as *ashless*, in that the filter paper is removed from the precipitate by burning before the precipitate is weighed. These papers are manufactured with a hydrochloric acid treatment that removes most of the non-volatile components so they burn away leaving less than 0.1 mg of residue or ash. The average mass of ash that remains after burning is normally listed on the filter paper package.

Manufacturers of filter papers provide a listing of the types and porosities their papers to allow experimenters to select the proper types and grades for their specific applications.

Understanding Precipitates

Precipitates form as a result of formation of an insoluble substance from a chemical reaction or when there is deceased solubility and nucleation produced by evaporating solvent or lowering temperature for a pure substance. In either case, a precipitate is not always ready for filtration immediately after formation. In some cases, the particles formed are so small that the filter paper will be unable to retain them. Such precipitates will pass through the paper with the mother liquor leaving a cloudy solution as the filtrate. To minimize this problem, or error, the precipitate must be allowed to stand for a period of time, in contact with the liquid it was precipitated from. This process is known as **digestion**. Generally, digestion is carried out at elevated temperatures, but is sometimes carried out at room temperature.

In the digestion process, smaller particles tend to form aggregates or small crystals will dissolve and recrystallize on larger crystals. In both cases, larger particles are formed that will be better retained by the filter paper. The digestion process will vary with the types or precipitates formed and can range from a few minutes, to an hour (the most common length of time for digestion), or even as long as a day of two. For any digestion period longer than a few minutes, the container should be covered to prevent contamination by dust

or other airborne particles, but it should not be sealed so that free access to the air can be maintained. There is no general rule for determining the time needed for digestion of a precipitate, unless there is some data in an analytical book or handbook, the digestion period for each substance must be determined experimentally.