Mystery Substance Identification

The Identification of Unlabeled Laboratory Chemicals Found on School Premises

Perhaps the most commonly posed question we encounter is, "I have a container of chemical on my shelf. I do not know what it is. Can you help me?"

The following text and suggested procedures are an effort to provide the willing science teacher the means to classify such substances for disposal. No, it is not our intent to identify the material for use. It is our intent to classify the material for disposal.

It is likely that your mystery substance was inherited. In order to avoid leaving someone else such a legacy we urge you to be rigorous in your labeling activities.

If you wish to postpone the identification process, then assume the chemical is severely hazardous and treat it accordingly. This suggests that you would want to protect the container from fire, being dropped, etc. Turn to the index of your *Flinn Scientific Catalog/Reference Manual.* Find the section dedicated to Chem-Saf® Bags and Saf-Stor® Cans. A pictorial presentation located in the Safety Supplies and Equipment section takes you through the step-by-step process of "packaging" the substance. Once packaged it is likely the material will be safer while it remains on your premises.

We feel it is unnecessary to completely identify the item, an undertaking that will involve both qualitative and quantitative analysis. Our goal is not to salvage but to help the science teacher rid himself or herself of this mystery substance. Yes, we assume the chemical has no value. Since we do not know what the chemical is this "no value" assumption appears reasonable. Should you have been able to identify the chemical you are still faced with possible chemical contamination. Salvage is not the goal. Identification for disposal—that is our goal.

These procedures will help you segregate the mystery substance into a category or class. Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. Each category or class will have a disposal procedure. These disposal procedures are listed at the back of the *Flinn Scientific Catalog/ Reference Manual.*

You will probably not know that a mystery bottle or flask contains, for example, 0.15 molar hydrochloric acid (aqueous) when you complete the identification procedure. You would have identified the material as a strong acid. You would dispose of a strong acid using Flinn Disposal Method #24b.

You may not plan to dispose of the material. It may be your plan to store the material while you examine your disposal options. You may wish to have a professional and licensed disposal firm handle the material. You now know the material is a strong acid and you should label the material accordingly. You may want to accompany the now semi-identified chemical with a brief narrative describing how you conducted your investigation and the conclusion you reached. A disposal firm would appreciate this information and may bill you for less.

You will take your mystery chemical through a series of tests. These tests attempt to be systematic. Often you can get clues without being completely systematic. Frequently there are negative clues. Such negative clues will tell you something about what the substance is not.

For this reason—the value of negative clues—we exhort you to completely read through this series of procedures. You will find that a complete reading of the procedures will provide the basis for a more thorough understanding of the process. You will see a bigger picture and not simply be following "recipe-like," step-by-step procedures. You will have a better understanding of what will happen next.

PRELIMINARY EXAMINATION

A lot can be learned about a mystery substance just by examining its container. If the container is not a commercial container then this step may not be significant. We mean the container may be a flask, beaker, etc., as opposed to a chemical company's original container.

If the container appears to be a commercial container, is any part of the label intact? Clues can be gained from a partial label. Perhaps a catalog number or a lot number is intact. These clues—catalog number or lot number—may be all that is required for immediate identification. Contact Flinn Scientific with this information. We may be able to be helpful with just those clues. Even if only portions of an original label remain, valuable clues may be learned which will solve the mystery.

Is the container glass? If yes, is it clear glass or amber glass? Amber glass can be an indicator that the substance is light sensitive. We know that the substance would not be hydrofluoric acid since that acid dissolves glass. Is the container a heat sealed glass ampule? Such an ampule may be a significant clue since a relatively few substances are ever packaged in such a container. Examples might be bromine or adipoyl chloride. There are solution concentrates packaged in sealed ampules. Frequently such concentrates are not hazardous. Ampule-type packaging is also used to assure product quality or concentration. Such packaging is also used to hold very volatile or air-reactive substances.

Describe your glass container's closure or cap. Is it a metal cap? Is it a plastic cap? How would you describe the condition of the closure? A badly corroded metal cap may reflect the external environment in which the container was stored rather than the contents of the container. Today, metal caps are almost never used on glass bottles. A metal cap may only tell us that the substance is more than two decades old. Describe the condition of the plastic cap. Does it appear to be intact or does it show signs of destruction from within? Such cap destruction may be the result of contact with a very strong oxidizer.

Perhaps the closure is not a cap at all but is rather a rubber stopper, a cork or even some kind of unique closure. Ethyl ether (diethyl ether) is commonly packaged in a metal can with a soft metal hood. The user must cut away the soft metal hood to open the container.

The cap or closure can give meaningless, somewhat meaningful, or very meaningful clues about the contents of the container. Even the cap color may play a role. As you know, common acids and ammonium hydroxide are packaged in glass containers with color-coded caps. The color codes are as follows:

Substance	Cap Color
Acetic acid	Brown
Ammonium hydroxide	Green
Hydrochloric acid	Blue
Nitric acid	Red
Phosphoric acid	White
Sulfuric acid	Yellow

Do not accept cap color as a guarantee of the bottle contents. There are cases of budget conscious science teachers switching caps on acid bottles. Given enough exposure time, nitric acid will slowly destroy the plastic cap. Rather than rid themselves of the substance, teachers may use another available cap from an empty bottle. We will have to take our qualitative detective work further. We hope you can begin to see the strong reason for reviewing this whole procedure before you start reaching conclusions.

Any container that appears to have been professionally sealed likely contains substances that react with air or water vapor in the air. Such professional sealing may be a strong enough indicator that you should proceed no further but will have to depend on professional assistance. Some examples of materials in sealed containers might be:

Bromine	Sodium, metal
Ethyl ether	Sodium peroxide
Hydrofluoric acid	Adipoyl chloride
Lithium, metal	Butyric acid
Phosphorus (white/yellow)	Pyridine
Potassium, metal	Sebacoyl chloride

However, just because a container is *not* sealed is not a guarantee that one of the above substances is not inside. Anything is possible!

The condition of the external surface of your mystery substance container or cap is not a very good indicator of what is inside. The storage conditions surrounding the container (particularly if it is metal) may be more responsible for the container's condition than its contents. A metal container stored near iodine, for example, may reflect the strong corrosion characteristics of a neighboring container. If it is obvious that the substance is leaking from the container, then that is another matter. A good example of a substance that appears to have frothed out of its metal container is sodium peroxide. This substance is frequently packaged in a metal can (like a small paint can). Over long storage periods the sodium peroxide will take on water from its environment and form sodium hydroxide. The sodium hydroxide will slowly destroy the metal container. In this example it is the container's contents that have damaged the container.

Years ago corks were used as bottle closures. We still see such containers on school science department shelves. Teachers will also use corks or rubber stoppers to close a container. Is the cork badly discolored or crumbly? Many strong acids or strong bases will have that effect on cork. To our knowledge rubber stoppers were never used by any chemical packager. It is possible that the use of a rubber stopper would provide some clues. Has the stopper swelled, lost its shape or is it out of proportion? Many halogenated organic compounds, and even vinegar (acetic acid) will have that effect on rubber. Few inorganic substances will so deteriorate rubber.

Is your mystery chemical container transparent? Is the substance solid or liquid?

Does the substance appear to be both solid and liquid? Can you characterize the substance's color? Is the substance homogeneous or heterogeneous? If the substance is a solid can you characterize its form, e.g., powder, crystal, granular, etc.? If a liquid, has it about the same viscosity as water or would it be more viscous—like honey?

A colorless liquid or a white powder could be any one of millions of substances. However, a blue, granular solid is likely to be one of only a few copper-containing ionic compounds.

Such a simple inspection (color, consistency, form, etc.) coupled with a little chemical knowledge might be just enough information for the identification process to move along with some speed.

Take a few moments now to review the color table that is included as part of these procedures. Almost all of the substances (dry chemicals, organic and inorganic; solutions; etc.) found in the *Flinn Scientific Catalog/Reference Manual* are incorporated into this list. This list represents substances most likely found in elementary, middle/junior or senior high school science departments.

Remember, if the chemical color is clear, white, milky, buff or none, and the chemical does not have an odor, it will not appear on this list.

Please note that our list includes information about the liquid or solid character of each substance.

The color of every substance listed in the *Flinn Scientific Catalog/ Reference Manual* is provided in the individual product listing for that substance. Included also is information about odor.

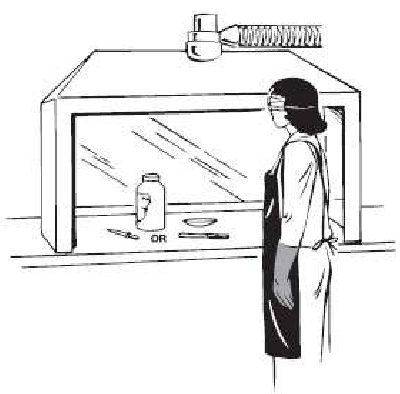
Color can be a very helpful clue in identifying your mystery substance. Sometimes color plus a simple confirming test is all that is required for classification.

There are a very small number of chemical substances that are shock sensitive. An example of such a substance is picric acid. Picric acid is a yellow or yellow/white crystalline material. When the substance contains as little as ten percent or more of water the material is safe. In its dry state it is a shock-sensitive explosive. Please read Flinn disposal suggestion #4a in the *Flinn Scientific Catalog/Reference Manual* before proceeding. **If you have any indication or even a suspicion that you are dealing with picric acid, proceed no further. You will need professional assistance.** That help may have to come from a local bomb squad. Picric acid is not likely to be found on school premises—but the possibility always exists.

Shock-sensitive chemicals were mentioned at this point in our narrative because the next step in the examination process is to smell the mystery substance. If you have any reason whatever to think you are dealing with a shock-sensitive material you would, of course, never want to handle the container. Yes, we realize you have absolutely no way of knowing what you are dealing with since the substance is a mystery. You can understand that it is incumbent upon us to call such a circumstance to your attention. Not to do so would be irresponsible. This alert may also cause you not to want to handle a substance at all.

Our next step involves an attempt to characterize odor. Please note that in addition to color, odor is now also listed in the body of the description of each chemical substance found in the *Flinn Scientific Catalog/Reference Manual.*

Many chemical reference books make a stab at listing odor. Unfortunately, odor is frequently described with words like "characteristic odor." An example might be acetone. If you are familiar with acetone, perhaps the definition "characteristic odor" is adequate. If you are unfamiliar with the odor of acetone, we have chosen to use more real-life characterizations. In the case of acetone, the *Flinn Scientific Catalog/Reference Manual* defines its odor as "like nail polish remover." Throughout the entire chemical listings odor characterizations like: "smells like new leather"; "smells like vanilla" are used instead of meaningless terminology.



You would, of course, have equipped yourself with the necessary safety aids like chemical splash goggles, gloves, an apron, etc. Container opening and small sample removal would best be done inside your properly operating fume hood. If a hood is not available, then be certain to work in a very well ventilated area. We are not trying to be alarmists, but there are many substances that can create a surprise when opened. A good example might be the common material, anhydrous aluminum chloride. If the environment is warm and humid, the container of anhydrous aluminum chloride may puff and form a cloud of hydrochloric acid vapor. Since you have no idea what you are dealing with, you can, we are sure, quickly sense the need for a hood or—at the very least—good ventilation.

Open your container of mystery substance. Open and close it very quickly. Remove a very small amount of material.

Use a plastic spoon or spatula for dry material or a dropper for liquids. Place about a 0.1 (1/10th) of a gram or two drops of the material on a watch glass. Close the container quickly until this phase of the examination is complete.

The material removed may surprise you by smoking or igniting on brief exposure to air. Such a reaction is unlikely but possible. White/yellow phosphorus is an example of such a substance. This material is normally in stick form and is stored under water. Other than stick form has been encountered and thus our warnings. If you discover the substance is air-reactive, stop the examination process. You will need expert advice. Please call (800-452-1261) or email (flinn@flinnsci.com) Flinn Scientific. If your mystery substance is not air-reactive, then please continue. Don't act quickly. Sometimes very, very old material will be slow to react. Patience is an important safety consideration. Take time to watch before you act.

We want to check and see if an odor is present. Again open your container and wave your hand over its mouth toward your nose and sniff cautiously. Odor is very much a subjective call but these guidelines may be helpful:

- Most solid substances with strong odors are organic compounds. We will discuss this in more detail a little later.
- Liquids with strong odors can be organic or inorganic but most inorganic liquids have little odor. There are certainly exceptions and some might be, but are not limited to, hydrochloric acid, ammonia, sulfides, bromine and chlorine. Solid, elemental sulfur is yellow and has a faint odor. Sulfur does not have the rotten egg odor that characterizes some sulfur compounds. Solid, elemental iodine usually appears as dark gray flakes with a metallic sheen. Iodine's odor has, sort of, the smell of medicine or a hospital. Iodine emits a vapor that is violet in color.

Summary of Preliminary Examination

- Examine the container for clues.
- What type of container is it?
- Does the closure or cap reveal anything?
- Describe the condition of the container and its closure.
- What form is your mystery substance, i.e., solid, liquid?
- Color?
- Odor?
- Is there evidence of air-reactivity?

PREPARATION FOR CHEMICAL TESTS

By this time you should have sensed that our identification procedure is a series of steps that is not necessarily systematic. Rather, we are gathering as much information as possible in our attempt to reach a conclusion. Now it is time to do some testing as part of our chemical detective work.

A very helpful tool that users of chemicals should have in their libraries would be the current edition of the CRC Handbook of Chemistry and Physics. Other resources such as chemical indexes and dictionaries would also be useful.

Title	Catalog Number
CRC Handbook of Chemistry and Physics	AP4205

Next you will need to accumulate some common laboratory apparatus and an appropriate place to work. You are again reminded (if you can) to work under a fume hood or, at the very least, in a very well ventilated lab space.

Working alone is not a good practice. Try to have a lab partner with you during these investigative sessions. Another science teacher would be preferable to asking a student to aid you.

You are again reminded to have all the necessary safety aids available for your personal use and that of your lab partner.

The following lab apparatus should be accumulated for these procedures. Most of this material is already probably available to you. We list the material showing the Flinn catalog number simply as a reference and so you can easily identify the item if you are uncertain about what is needed.

Important...For Your Protection!

Read this ENTIRE article on identifying a mystery substance before you are tempted to start the process. Why? Your mystery substance may threaten your life or health unless handled correctly. Just this once...READ IT ALL BEFORE PROCEEDING!

APPARATUS

Description	Catalog Number
Spatula	**AP8338**
Test Tubes, 100 x 13 mm	**GP6010**
Watch Glasses, 65 mm	**GP8006**
pH Paper	**AP1107**
Stirring Rods, plastic	**AP8150**
Labeling Tape	**AP1370**
Droppers or Beral-type Pipets	**AP5102** **AP1718**
Micro Bunsen Burner	**AP1024**
Spoon, metal, micro	**AP1323**
Crucible Cover, porcelain	**AP8247**
Triple Beam Balance, 610 g Capacity, 0.1 g Sensitivity	**OB1040**
Cylinder, Graduated, 10 mL	**GP2005**
Cylinder, Graduated, 25 mL	**GP2010**
Plates, glass, cobalt, 3″ x 3″	**AP1058**

CHEMICALS/SOLUTIONS

Description	Catalog Number
Sodium Hydroxide Solution, 0.1 M, Aqueous	**S0149**
Calcium Chloride Solution, 0.1 M, Aqueous	**C0234**
Hydrochloric Acid Solution, 6 M	**H0056**
Hydrochloric Acid Solution, 0.1 M	**H0042**
Potassium Iodide Solution, 1 M, Aqueous ***Note:*** The potassium iodide solution must be fresh and colorless. If your solution has yellowed it will not do for our application here. Do not buy this solution. Make it as needed to be sure it is fresh.	Prepare as needed.
Potassium Iodide Solution, 1 M, Acetic Acid ***Note:*** The solvent used to make this solution is acetic acid, not water. Make this solution only when needed to assure that it is fresh.	
Distilled Water	**W0001**

EXPOSURE TO WATER

Place about 3 mL of distilled water in a test tube. Throughout our procedures we will use water. Distilled water should be used—not tap water.

Add 2 drops (if liquid) of your unknown. If your unknown is a solid add about 0.1 (1/10th) of a gram of the solid to the test tube of water.

Note the reaction (if any). Is the reaction violent? Does flame appear? Is the reaction heat generating? Cautiously touch the exterior of the test tube. Go slowly! Take your time. Wait for a reaction (if any).

The unknown could be one of the alkali metals, calcium carbide, anhydrous aluminum chloride, acetyl chloride or concentrated sulfuric acid (if liquid).

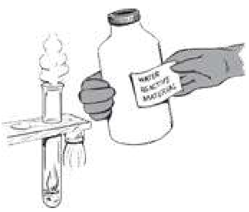
Let's talk about water-reactive metals like sodium, potassium and lithium. These metals are stored under oil to avoid moisture contact. Sodium and potassium are commonly sold as chunks or sticks. The sticks of potassium are 3″–6″ long and about ½″ in diameter. As potassium ages, it develops a spongy yellow-looking exterior that almost looks like tallow or yellow fat. The material has no metallic look about it at all unless you take a knife and cut through this exterior coating to expose the metal. Since old potassium develops peroxides, it is very unwise to cut into such a piece of potassium metal. Peroxides may react with the oil or other organic liquid in which the potassium was stored and an explosion may result. If your mystery substance appears to be sticks or chunks of material under oil or kerosene there is a very good possibility that what is present in the container is one of these metals.

Another substance sold in stick form is white/yellow phosphorus. Phosphorus would be stored under water, not oil. If the phosphorus has been stored under the same water for an extended period, it is likely that the water has been converted to phosphoric acid. This liquid is hazardous. We mention phosphorus at this point only because phosphorus and potassium have the single common characteristic of being sold commercially in stick form. Do not confuse the two—that could be a terrible mistake. Old phosphorus (under water) appears to be white in color. Old potassium (very old potassium) has a yellow, spongy-looking exterior surface.

Sodium is also sold in sticks but sometimes it has been sold in large ball bearing size balls. It is also sold as rectangular sticks. Sodium does not develop explosive peroxides, nor does it develop that yellow, spongy look as does potassium.

Lithium has been sold as sticks but is usually sold in wire form.

We took the time to go into this discussion of sodium, potassium and lithium at this point since their forms (sticks, chunks, wire) do not lend themselves to being extracted from the container with a spatula or dropper. Here are examples where the physical shape of the substance and the medium in which it is normally stored (oil or kerosene) will deliver a lot of information about the mystery substance.



Back to the reaction (if any) of our mystery substance with water. If a vigorous reaction occurs between your unknown and water, immediately label the container "Water-Reactive Material." Label your container RIGHT NOW!

Fortunately very few substances are water-reactive or air-reactive.

Do not dump your test tube of water and unknown. There is more to be done with this sample. Let the material sit in water for several minutes. Agitate the mixture from time to time using a stirring rod. Continue to observe the mixture until all obvious activity (if any) ceases.

The major purpose of our mixing your unknown with water was to learn as much as we could about water solubility. We can reach some major conclusions about organic and inorganic materials based on water solubility.

Much more information will follow about distinguishing between inorganic and organic substances. At this point, let's pursue water solubility.

If an organic material is soluble in water it is probably an:

- Alcohol
- Acid
- Amine

or something like one of the above. The substance would, most likely, have no more than 5 or 6 carbon atoms in it and, more than likely, it is a liquid.

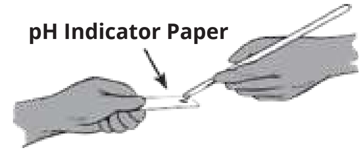
If it is inorganic and soluble in water it is very likely to be:

- A salt with an alkali metal or the ammonium ion as the cation.
- A salt with the anion being a nitrate, chloride, bromide, iodide or sulfate.
- A salt having both of the above characteristics.

If your mystery substance is both soluble and colored, the possibilities become even clearer.

Refer back now to our color chart. Compare your solution's color with the color chart. If you added a colored solid to the water, and the resulting color of the solution is very *intense*, the material is likely to be a pH indicator, a biological stain or dye, or potassium permanganate.

We are not through with your test tube yet so don't dump it. Next we want to check the pH of the solution.



Place a drop of your solution on a strip of pH indicator paper. If the pH of your solution is below 3 or above 11 your solution should be considered corrosive. Label your container with an appropriate designation like: CORROSIVE LIQUID, ACID, pH = 2 or, if a solid, CORROSIVE SOLID, BASE, pH = 13. It is quite likely that your mystery substance is, in fact, a strong acid or a strong base or a material that reacts with water to form a strong acid or base.

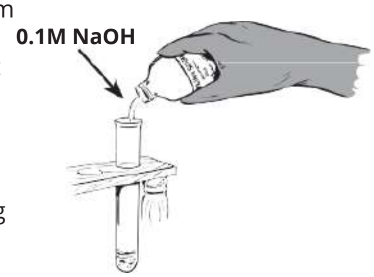
You may dispose of materials that test acidic using Flinn suggested disposal procedures #1a, #1b, #24b or #27c. Materials that test basic would call for use of suggested procedures #3, #10, or #25.

Other identification data gathered during our investigation will enable you to more closely identify the substance. Based on that additional information you will be better able to choose from the above suggested disposal procedures.

If your solution tests between pH 3 and pH 5 you most likely have:

- A weak acid
- A highly dilute strong acid
- A salt formed from the cation of a weak base combined with the anion of a strong acid.

Ordinary tap water will usually have a pH of about 5.6. Many think water has a pH of 7.0. This is usually only true with very pure, freshly distilled, or recently boiled water. Distilled water that has been stored for some time would contain dissolved carbon dioxide.



Add some dilute (0.1M) sodium hydroxide to your mystery solution. If nothing happens it is likely to be one of the first two above, i.e., a weak acid or a highly diluted strong acid. These weak or highly diluted acids can be disposed of using the Flinn suggested disposal procedure #24a or #24b depending on whether the material is organic or inorganic.

In our example of a weak or dilute acid, nothing happened on the addition of 0.1 M sodium hydroxide solution. Let's assume now that something does happen. If activity occurs, your unknown is very likely a salt as described above, i.e., a salt formed from the cation of a weak base combined with the anion of a strong acid.

You may get a precipitate on the addition of the sodium hydroxide solution. Note the color. Now combine this new knowledge with what you learned previously. The combination of information may help you to more closely identify your unknown. An example: A white solid that dissolves in water; has the pH of a weak acid; and precipitates with a small quantity of base is likely to be a salt of aluminum, cadmium, lead or zinc.

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If you get no precipitate but an odor of ammonia is obvious, you no doubt have an ammonium salt.

If the pH of your unknown is between 8 and 11 the unknown is likely to be:

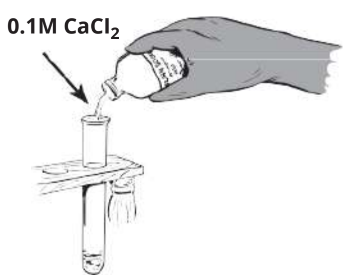
- A weak base
- A very dilute strong base
- The salt of a weak acid combined with a strong base

Care is needed as we proceed here. Even though there are many, many harmless substances which fit into these aforementioned categories *you cannot simply add acid to your unknown solution* as we added base in our previous tests. An example of a very dangerous material that fits into the third category listed above is potassium cyanide. Adding acid to potassium cyanide would release the very poisonous gas hydrogen cyanide, HCN.

It would be irresponsible and, perhaps, deadly to acidify "just a little" to see if you can detect the well-known "bitter almond" smell of HCN. Many people are insensitive to this smell. Don't discover your insensitivity by making such a fatal mistake. There is no unambiguous, quick and easy test for cyanide ion.

Another potentially dangerous material in this category is sodium sulfide. You will, most likely, recognize this or other soluble sulfides by the characteristic rotten egg odor. This odor results from small amounts of hydrogen sulfide always present with soluble sulfides. Adding acid to any sulfide can release large quantities of hydrogen sulfide. *Hydrogen sulfide is even more hazardous than hydrogen cyanide.*

If you can eliminate the possibility of dealing with cyanide or sulfide in this category you are on much safer ground. Let's try to do this by adding a very dilute (0.1M) calcium chloride to the mystery solution in your test tube. If a white precipitate forms, you most likely have a phosphate or carbonate as an anion in a salt, not cyanide or sulfide. If your unknown was originally a liquid and smells like ammonia, it is probably a solution of ammonia in water or the first of our base categories, i.e., a weak base.



If you cannot eliminate cyanide as a possibility then you cannot proceed further. You need expert help for testing and ultimately disposing of soluble substances in this pH range. Please review Flinn suggested disposal procedure #14 which discusses cyanide disposal. Our warnings may appear to be hyper-cautious but the risks of not being cautious are great. For those of you who are a little more chemically curious as well as chemically adept, later on a test (more complex than any we have dealt with so far) will be given for cyanide and sulfide compounds.

If your material is not soluble in your test tube of water, a lot of knowledge has also been gained. Is your unknown more or less dense than water? Is it a liquid that is insoluble and also sinks to the bottom of your test tube? If yes, the likelihood is that you have an organic compound containing at least one halogen atom, e.g., bromine, chlorine, fluorine or iodine.

If it is an insoluble liquid floating on top of the water, the chances are that it is an organic compound with at least five carbon atoms and does not contain a:

- Halogen atom
- Hydroxyl
- Acid
- Amine group

This leaves mostly hydrocarbons and fats.

If it's a solid that is insoluble in water, we have not learned a lot except to combine this knowledge with other information you have so far developed about your unknown.

Most insoluble solids will be more dense than water. If your unknown floats, it is most likely an organic substance.

DENSITY

From the previous work you have already done you have some idea of the density of your unknown. If the material is a liquid it is going to be very helpful to get a more accurate measure of the liquid's density.

Making density measurements of soluble solids is very difficult unless the substance is monolithic. The space between particles of granular materials is the problem. For insoluble solids, you already know (to a degree) if your unknown is more or less dense than water.

Using a balance and a graduated cylinder, determine the weight of a measured volume of the liquid. It is important to measure as accurately as you can.

If the density is very close to 1.00 and the unknown dissolves in water, it is most likely a dilute aqueous solution of something or, alternatively, an:

- Organic acid
- Low molecular weight amine

Pure acetic acid has a density of 1.05. An organic acid or an amine will have a definite odor. An aqueous solution of an unknown probably will not have an odor.

If the density is less than 1.00 and the material dissolves in water, the unknown is very probably a low molecular weight alcohol, e.g., ethyl alcohol has a density of 0.79. If the density is less than 1.00 and the liquid doesn't dissolve in water, it is probably a:

- Hydrocarbon (gasoline 0.72; benzene 0.88)
- Fat (cooking or mineral oil)
- High molecular weight alcohol or amine

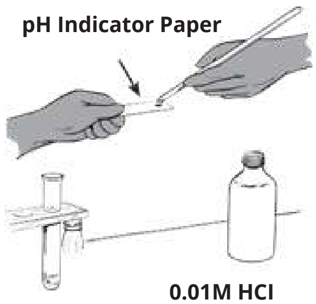
If the density is greater than 1.00 and the liquid is soluble in water, then the unknown could be concentrated nitric (d = 1.5) or sulfuric acid (d = 1.86).

If the density is greater than 1.00 and the liquid is insoluble in water, the unknown is most likely to be a halogenated hydrocarbon of some kind, e.g., carbon tetrachloride (d = 1.59).

Now would be the best and first opportunity you might have to use the handbooks you have available as a resource. Refer to the tables of organic compounds for density and solubility information.

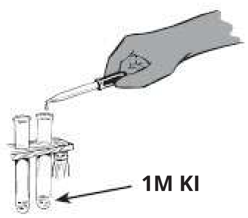
AN OXIDIZING AGENT?

Some materials found to be oxidizing agents may be unpredictably explosive, e.g., organic compounds like ethyl ether and, as we have learned most recently, even isopropyl alcohol can develop explosive peroxides on aging and long exposure to air.



The peroxides developed in some substances are strong oxidizers. We need to perform a test for oxidizing agents before we heat any unknowns.

If the unknown was found to be water soluble, you should have already determined its pH. Unless it is already acidic, lower the pH to 5–7 with a small quantity of acid. Please keep in mind our previous exhortations about cyanides and sulfides. This pH adjustment can be made by adding very small quantities of dilute (0.01M) hydrochloric acid. Be careful and see what small additions of this acid will produce in terms of pH change. Larger quantities of a stronger acid (0.1M) may be necessary. Now add a drop of this pH-adjusted solution to about 1 mL of an aqueous potassium iodide solution. We earlier alerted you to make fresh potassium iodide solution that was clear in color.

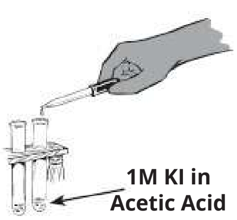


If a yellow or brown color develops, you have a water soluble oxidizing agent. This could be a compound with one of the following anions:

- hypochlorite
- chlorate
- chromate
- perchlorate
- persulfate
- peroxide
- permanganate
- hydrogen peroxide
- organic peroxide
- hydro peroxide

It might be best at this point to review the materials with Flinn suggested disposal procedures #12a, #22a and #22b.

If your substance is insoluble in water, it may be tested for its oxidizing power by adding a drop (if a liquid) or about 0.1 gram (if a solid) to a solution of potassium iodide in acetic acid. Here again we alerted you earlier to make this solution up fresh and on an as-needed basis. The development of a yellow or brown color is a positive test for an oxidizing agent.



In either case, if the material tests positive using the potassium iodide test, label the material NOW as an oxidizing agent.

See Flinn suggested disposal procedure #12a for disposal information unless it is very clear you have a fairly pure peroxide. Refer to Flinn suggested disposal procedure #22a or #22b.

ORGANIC OR INORGANIC?

Perhaps you have been wondering when we would address this question. It is now time.

Place several drops (if a liquid) or about 0.1 g (if a solid) of your unknown on a spoon or a porcelain crucible cover. Bring the flame of a Bunsen burner up to your small sample VERY SLOWLY!

If your sample was a solid does it begin to melt? Will it burn—perhaps like candle wax? Does it give off sparks when it burns?

If a liquid, does it burn or merely boil? Is the flame rather sooty? What color is the flame—yellow, blue, invisible...what? If your liquid boils, does it markedly change the color of your burner flame?

If your unknown is a liquid, is there a residue remaining after all the liquid boils away? Heat the material gently, then strongly. This kind of heating (gentle, then strong) can give an indication of the volatility of a substance.

If your substance is a solid, does it appear to change form or color as you heat it strongly? Is there a residue remaining after the solid cools?

What have we learned from these observations?

Most burning is good evidence that you have an organic (carbon containing) compound. This is particularly true if your solid appeared to melt first.

If you have a fine dust-like solid that burned, it could be a metal powder. Metal powders will give off sparks when they burn.

A sooty, yellow flame is a good indication of little or no oxygen in the organic compound. An example, please. Gasoline burns and produces lots of soot. When gasoline is burned in your car engine the carburetor adds lots of oxygen which prevents the creation of soot. Ethyl alcohol, which contains combined oxygen, burns cleanly with an almost invisible flame. Of the few organic compounds that don't burn or at least char when strongly heated, the common ones are the halogenated hydrocarbons (that are mostly water insoluble liquids and are heavier than water).

So, the burning test, coupled with the prior tests, should be a very good indicator of whether or not the material is organic or inorganic.

Label anything that burns "Flammable Liquid" or "Flammable Solid." Label the material NOW!

Do you wish to dispose of these materials yourself? If yes, review Flinn suggested disposal procedures #18a or #18b.

Please note that these two procedures, i.e., #18a and #18b are quite similar to Flinn suggested disposal numbers 2, 4b, 4c, 5, 9, 13, 15, 20 and 27j. Burning or simple evaporation is appropriate for small quantities of a large variety of organic compounds.

Certainly water and solutions that are mostly water don't burn. Such substances will boil away easily. Solutions that boil away easily may leave a residue. Concentrated aqueous solutions of sulfuric acid will leave an oily liquid as a residue. Aqueous solutions of gases like hydrogen chloride and ammonia will not leave a residue. You will probably have already identified these substances by their acid–base (pH) characteristics or odor.

If you find that you have a non-burning liquid that leaves a solid residue, the odds are high that you have an aqueous solution of some salt.

If you see a strong color in the flame as you are heating a liquid (suspected to be aqueous) or a non-burning solid, that can give you a clue as to the identity of the material. What you are seeing is the common flame test for many metallic ions.

Following is a brief list of the common colors observed in flame tests:

Color of Flame	Element Indicated
BLUE	
Azure	Lead, selenium, $CuCl_2$ (and other copper compounds when moistened with HCl); $CuBr_2$ appears azure blue, then is followed by green
Light blue	Arsenic and some of its compounds; seleniun
Greenish-blue	$CuBr_2$; arsenic; lead; antimony
GREEN	
Emerald green	Copper compounds other than halides (when not moistened with HCl); thallium compounds
Blue-green	Phosphates moistened with sulfuric acid; B_2O_3
Pure green	Thallium and tellurium compounds
Yellow-green	Barium; possibly molybdenum; borates (with H_2SO_4)
Faint green	Antimony and ammonium compounds
Whitish green	Zinc
RED	
Carmine	Lithium compounds (masked by barium or sodium), are invisible when viewed through green glass, appear violet through cobalt glass
Scarlet	Calcium compounds (masked by barium), appear greenish when viewed through cobalt glass and green through green glass
Crimson	Strontium compounds (masked by barium), appear violet through cobalt glass, yellowish through green glass
VIOLET	Potassium compounds other than silicates, phosphates, and borates; rubidium and cesium are similar. Color is masked by lithium and/or sodium, appears purple-red through cobalt glass and bluish-green glass
YELLOW	Sodium, even the most minute amounts; is invisible when viewed through cobalt glass

A change in form or color when heating a solid that does not burn gives clues aside from the flame test discussed above. Carbonates, upon heating, often give off carbon dioxide, and the residue will be an oxide. If you have a salt which has water in a hydrate structure, heating the salt will often drive off most or all of the water, and this may lead to a change in color or structure. Heating pink cobalt chloride hydrate will turn it blue. Heating blue copper sulfate will turn it white.

Important...For Your Protection!

Read this ENTIRE article on identifying a mystery substance before you are tempted to start the process. Why? Your mystery substance may threaten your life or health unless handled correctly. Just this once...READ IT ALL BEFORE PROCEEDING!

Up to this point we have described several simple chemical and physical tests:

- Exposure to air
- Visual examination
- Water exposure
- pH test
- Density
- Oxidizing power
- Heating

If you have the facilities, the equipment and a fair degree of organization the whole process may take less than an hour.

You may not need to know more than these tests have told you. In many cases you may have been able to learn enough to follow one of the Flinn suggested disposal procedures or to provide a professional disposal firm with the results of your work which will enable them to classify the substance for disposal. Professional disposal firms frequently charge much less for a substance which has been generally classified—as opposed to a complete unknown.

FURTHER TESTING

You have gained a lot of information about your unknown substance. It is likely that you now know if the material is organic or inorganic. Further testing will build on the valuable information you have already developed.

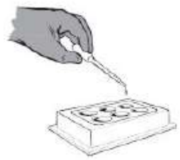
Organic? If it is organic you probably do not need to know more about it for disposal. Either burn it or evaporate it according to the suggested Flinn disposal techniques with which you have become familiar and that were previously listed in this narrative.

Perhaps you are interested in finding out more about your unknown compound. There are several fairly easy tests you can do. An additional reference book you should have is *The Systematic Identification of Organic Compounds* by Shriner and Fuson. Any edition of this reference book will be satisfactory.

Among the simple tests you can do are solubility and flame tests. These are not exhaustive, but rather, are intended to be illustrative of the kind of testing and thinking needed for further identification.

More materials will be needed as follows:

- Ethyl ether (diethyl ether) less than 100 mL
- A length of copper wire (approximately 6" long) bent at one end to form a small loop. The opposite end will be held by a pair of pliers or other appliance used to hold a hot copper wire.
- 0.5 molar aqueous hydrochloric acid solution
- 1.0 molar aqueous sodium bicarbonate solution
- 1.0 molar aqueous sodium hydroxide solution
- Small quantity of concentrated 18 molar sulfuric acid
- Bunsen burner



Test the solubility of your unknown in each of the five solvents listed above. This might be a fine time to consider performing these solubility tests in micro reaction plates using Beral-type pipets. You already have information about your substance insofar as water solubility is concerned.

If your substance is insoluble in water but soluble in ether and aqueous sodium hydroxide solution, it is very likely that your unknown is:

- An organic acid of moderate to high molecular weight
- A phenol

An acid will be soluble in aqueous sodium bicarbonate solution while a phenol will not be soluble.

Insolubility in:

- Water
- Sodium hydroxide solution
- Sodium bicarbonate solution
- Hydrochloric acid solution

But solubility in ether and concentrated sulfuric acid suggests the substance may be:

- An ether
- Alcohol
- Ketone (of moderate to high molecular weight)
- A compound having double or triple bonds

If a substance is insoluble in any of these aforementioned solvents you will get some information about your substance's density if it has not already been determined.

Next, take your copper wire loop and pick up a small quantity of your unknown. Place the copper loop with its unknown directly in the flame of your burner. Halogenated compounds (those containing bromine, chlorine or iodine) will impart a very distinct green color to the flame.

Compounds containing double bonds and aldehyde groups will decolorize very dilute, aqueous potassium permanganate solution. Acid halides will give a white precipitate with a dilute, alcoholic solution of silver nitrate. You really must, at this point, spend some time with your copy of Shriner and Fuson's *The Systematic Identification of Organic Compounds* since the possible permutations are extensive.

INORGANIC?

Further inorganic identification for safe disposal of your unknown is directed at creating information as to whether your unknown contains:

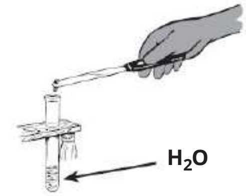
- Cyanide
- Sulfide
- Toxic heavy metals
- Reducing agents

Cyanide, sulfide and toxic heavy metals are all very dangerous materials even in very small quantities and low concentrations. If you even remotely suspect that you might be dealing with such materials, all appropriate and responsible safety steps must be taken.

Water soluble cyanides and sulfides are more dangerous than those which are insoluble in water. Many cyanides and sulfides that are insoluble in water are, in fact, soluble in acid. The process of placing such materials into solution in acids releases very dangerous hydrogen cyanide or equally dangerous hydrogen sulfide. Both are very, very poisonous gases.

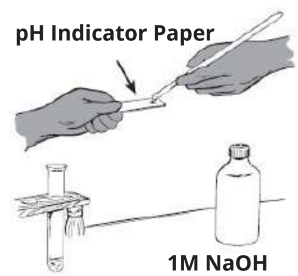
Does your unknown contain cyanide?

We do not recommend trying to prove a water insoluble substance contains cyanide. The test involves generating and trapping a potentially dangerous quantity of hydrogen cyanide gas.

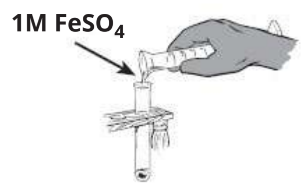


However, to test a water soluble substance for cyanide is much less hazardous; it is known as the Prussian Blue test. The name, Prussian Blue, comes from the insoluble blue artist's pigment and is chemically known as iron (III) ferrocyanide.

To perform the Prussian Blue procedure:

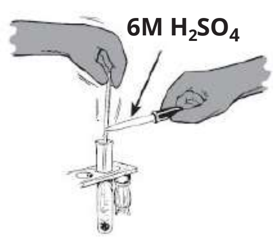


- Dissolve a very small amount of the water soluble material in about 10 mL of water.
- Adjust the pH of this solution to 12–13 pH using 1 molar, aqueous sodium hydroxide solution. As long as your solution is strongly basic, hydrogen cyanide gas can't be released.



- Add approximately 1 mL of 1 molar, aqueous iron(II) sulfate solution which will cause an orange/brown precipitate of iron hydroxide to form.

- Boil this mixture for about 30 seconds above a Bunsen burner.
- Now add 6 molar sulfuric acid drop-wise to the mixture while stirring. The goal is to *just dissolve* the iron hydroxide with the acid.



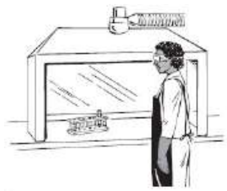
As the iron hydroxide dissolves, a blue suspension or precipitate remains. It is the presence of this blue material that confirms that your unknown substance contains cyanide.

If your test confirms the presence of cyanide, label your unknown "solid cyanide mixture" or "aqueous cyanide mixture" at once. Don't delay!

Label it now. You would also be wise to package the material using a plastic bag and can as depicted in this catalog/reference manual under product listings for Chem-Saf® bags and Saf-Stor® cans.

Please review Flinn suggested disposal procedure #14. This procedure involves oxidizing the cyanide ion to carbon dioxide and nitrogen using calcium hypochlorite solution. Heed all of the hazard alerts and other exhortations that are a part of this suggested procedure. In our opinion cyanide disposal should only be handled by professionals experienced and equipped to deal with such substances.

Does it contain sulfide?

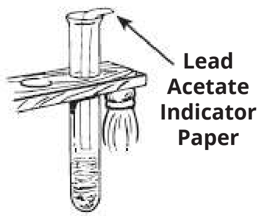


This test should only be done on a sample which tests negative for cyanide ion.

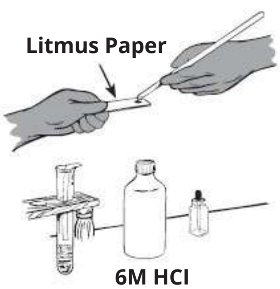
If a substance tests positive for cyanide, it should be disposed of as a cyanide without any further testing for other ions.

This test will release small amounts of poisonous hydrogen sulfide gas. The amount released is judged to be small and inconsequential if the testing is done under a reliable, operating fume hood using only very small amounts of sample (about ½ gram).

The procedure is as follows:



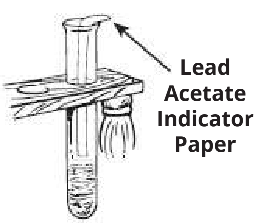
- If the sample is water soluble, dissolve about 0.5 grams in 10 mL of water in a test tube.
- Place a piece of moist lead acetate indicator paper just above the solution and allow it to adhere to the inside wall of the test tube.



- Slowly add, dropwise, 6 molar hydrochloric acid to your sample solution until the solution is acidic to litmus or about pH 5.
- Heat the acidified solution. Note any darkening of the lead acetate test paper caused by the possible formation of black lead sulfide.

This preceding test, if positive, confirms that you have a water soluble sulfide.

If your unknown is water insoluble then proceed as follows:



- Suspend about 0.5 grams in 10 mL of a 6 molar hydrochloric acid solution. Locate the moistened lead acetate test paper just above the solution level on the inside wall of the test tube.
- Boil the mixture gently over your Bunsen burner.

- Darkening of the lead acetate paper indicates your unknown contains a water insoluble sulfide.

If you get a positive test, immediately label the unknown substance "solid metal sulfide mixture" if it is a solid.

Important...For Your Protection!

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If your unknown is a liquid (most likely an aqueous solution), make it basic to a pH of at least 12 with 1 molar sodium hydroxide, aqueous solution. Label this mixture "Basic Sulfide Ion Mixture."

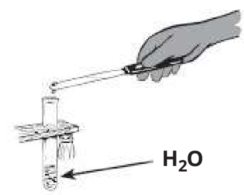
Does your unknown contain toxic, heavy metal ions?

Justifiable concern is focused on appropriate and responsible disposal of substances containing heavy metals. The consequences of irresponsible acts involving mercury are well publicized. A good deal is also known about lead but many less well publicized heavy metals present equally serious problems. A few local governments are now even prohibiting the introduction of copper ions into wastewater.

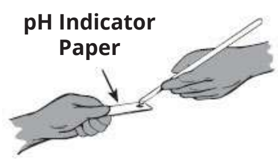
Our concern extends beyond the well-being of you and your students and includes the environment. Heavy metals must be disposed of responsibly.

Materials testing positive for either cyanide or sulfide should not be tested for heavy metals.

Almost all materials in the general category of heavy metals will form insoluble sulfide compounds. Since this generalization is true we can use this test for heavy metals:



- Dissolve about 0.5 grams of your unknown in 10 mL of water. If solution does not occur, place 0.5 g of your unknown in about 10 mL of 6 molar hydrochloric acid and boil it for several minutes.



- Cool if necessary, and adjust pH of the solution to 7.0. Use 1 molar sodium hydroxide solution and pH indicator paper to determine the pH.

- Add, dropwise, a very small quantity of a 0.1 molar sodium sulfide solution. This will most likely raise the pH, so readjust the pH to 7.0 using a 1 molar hydrochloric acid solution. The 7.0 pH is important since some sulfides will dissolve in acid and others will dissolve in base. This is true if excess sodium sulfide is present. Neutral pH 7.0—is important.
- Any precipitate that forms, usually dark colored, indicates the presence of heavy metal ions. Cadmium sulfide forms a bright yellow precipitate.

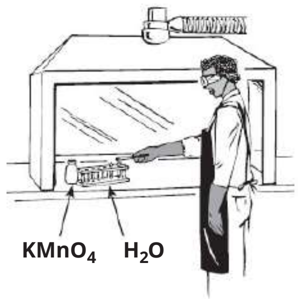
Label your unknown either “solid heavy metal mixture” or “aqueous heavy metal mixture” as appropriate. In our experience this is acceptable for disposal purposes.

If you wish to consider disposal yourself, please review Flinn suggested procedures #27f and #27h.

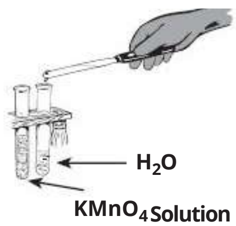
If you wish to more closely identify your unknown, we would suggest a good qualitative analysis test. One such fine publication is Sorum’s *Introduction to Semimicro Qualitative Analysis.* There are several editions of this text, any of which will serve you well.

Is your unknown a reducing agent?

Most reducing agents don’t carry the same hazard alerts as do oxidizers. You may have an unknown that has not tested positive to any of our tests. Perhaps it is a reducing agent. Here is a simple confirming test:



- Make a very dilute solution of potassium permanganate by dissolving enough in water to give a medium pink-purple color. Such a solution will be about 0.0001 molar, but in this case accuracy is not critical.
- Make a solution, if necessary, of 0.5 grams of your unknown (but suspected) reducing agent in about 10 mL of water in a test tube.



- Add, dropwise, just a few drops of your previously prepared, weak, potassium permanganate solution to your unknown.
- Decolorization of the pink-colored solution confirms that your unknown is a reducing agent.

Label your unknown (as appropriate) to show that you have determined it to be either a “solid reducing agent,” or an “aqueous reducing agent.” Please review our suggested disposal procedure #12b.

CONCLUSION

We could not be exhaustive in our description of identifying unknown substances on your school premises. A very wide spectrum of broadly applicable tests should help significantly in labeling and properly disposing of your unknown substance.

You should not assume that a substance that tests negative on all these tests is totally harmless and can be placed down the drain. You may, after all your effort, still require professional assistance.

No testing scheme can serve all purposes, nor can it solve all problems.

There is no substitute for informed judgment. If you feel you do not have enough information to make an informed judgment, then asking for more help is the next logical step.

SUBSTANCE	Physical State	Odor
BLUE		
BARFOED'S REAGENT	L	None
BENEDICT'S QUALITATIVE SOLUTION	L	None
BIURET SOLUTION	L	None
BIURET, TEST STRIPS	S	None
BIURET SOLUTION	L	None
BRILLIANT CRESYL BLUE	L	None
BROMTHYMOL BLUE	L	None
COPPER(II) ACETATE	S	None
COPPER(II) CARBONATE	S	None
COPPER(II) CHLORIDE	S	None
COPPER(II) CHLORIDE	L	None
COPPER(II) NITRATE	S	Slight Nitric Acid
COPPER(II) NITRATE	L	None
COPPER(II) SULFATE	S/L	None
COPPER(II) SULFATE STOCK SOLUTION	L	None
COPPER(II) SULFATE	L	None
CRYSTAL VIOLET	L	Alcohol
DITHIZONE	S	None
DRIERITE®	S	None
FEHLINGS SOLUTION A	L	None
LITMUS	S	Decaying Plant
LITMUS SOLUTION	L	Cabbage-like
METHYL GREEN	L	Alcohol
METHYLENE BLUE	L	None
NICKEL AMMONIUM SULFATE	S	None
NICKEL NITRATE	S/L	None
SILICA GEL	S	None
THYMOL BLUE	L	None
TOLUIDINE BLUE	L	None
BLUE VEGETABLE DYE	L	None
WRIGHT'S STAIN	L	Alcohol

SUBSTANCE	Physical State	Odor
GREEN		
AITCH-TU-ESS CARTRIDGES (H_2S)	S	None
BRILLIANT CRESYL BLUE	S	None
BRILLIANT GREEN	S/L	None
BROMCRESOL GREEN	L	None
BROMPHENOL BLUE	S	None
CHLOROPHENOL RED	S	Burnt Wood
CHROMIUM CHLORIDE	S	None
CHROMIUM OXIDE	S	None
CHROMIUM SULFATE	S/L	None
COPPER(I) CHLORIDE	S	None
CRYSTAL VIOLET	S	None
2,6-DICHLOROINDO-PHENOL SODIUM SALT	S	Throat Lozenge
GREEN—continued		
FAST GREEN SOLUTION	L	Slight Vinegar
FUCHSIN ACID	S	None
FUCHSIN, BASIC	S	None
FUCHSIN, NEW	S	None
IRON(II) AMMONIUM SULFATE	S	None
IRON(II) CHLORIDE	S	Slight Chlorine
IRON(II) SULFATE	S	None
JANUS GREEN B	S	None
MALACHITE GREEN OXALATE	S	None
MALACHITE GREEN	S/L	None
METHYL VIOLET 2B	S/L	None
METHYL VIOLET 6B	S	None
METHYLENE BLUE	S	None
NICKEL(OUS) CHLORIDE	S/L	None
NICKEL(OUS) SULFATE	S/L	None
4'-NITROACETANILIDE	S	None
RHODAMINE B	S	None
TOLUIDINE BLUE O	S	None
UNIVERSAL INDICATOR	L	Slight Alcohol
URANYL NITRATE	S	None
GREEN VEGETABLE DYE	L	None
WRIGHT'S STAIN	S	None

SUBSTANCE	Physical State	Odor
PINK TO RED, RUST, BURGUNDY		
ACETO-ORCEIN SOLUTION	L	Vinegar
ALIZARIN	S	None
ALIZARIN RED S	S/L	None
AURIN TRI CARBOXYLIC ACID	S	None
BISMARK BROWN Y	S	None
CALAMINE LOTION	L	None
CARMINE	S	None
CARMINE-ACETO SOLUTION	L	Strong Vinegar
CHROMIUM TRIOXIDE	S	None
COBALT CHLORIDE	S/L	None
COBALT NITRATE	L	None
EMB AGAR	S	Malt Like
EOSIN Y	S	None
EOSIN Y	L	None
ERYTHROSIN	S	None
FAST GREEN FCF	S	None
FLUORESCEIN	S	None
FUCHSIN ACID	L	None
FUCHSIN, BASIC	L	None
FUCHSIN, NEW	L	None
HEXAMETHYLENE-DIAMINE/ SODIUM HYDROXIDE SOLUTION	L	None
HYDRIODIC ACID	L	Slight Rotten Eggs
INDOLE-3-ACETIC ACID	S	None
3-INDOLEBUTYRIC ACID	S	None

SUBSTANCE	Physical State	Odor
PINK TO RED, RUST, BURGUNDY—continued		
IODINE (IODINE-IODIDE) SOLUTION	L	Iodine
IRON(III) OXIDE	S	None
LEAD OXIDE, TETRA	S	None
MANGANESE(II) CHLORIDE	S/L	None
MANGANESE(II) SULFATE	S	None
MERCURIC IODIDE	S	None
METHYL ORANGE	L	None
METHYL RED	L	Alcohol
4-(p-NITROPHENYLAZO) RESORCINOL	S	None
PHENOL RED	S	None
1,4-PHENYLENEDIAMINE	S	None
PHOSPHORUS, RED	S	None
RED VEGETABLE DYE	L	None
ROSE BENGAL	S	None
SAFRANIN O	S	None
SAFRANIN STAIN	L	None
SAFRANIN	L	Alcohol
SODIUM NITROFERRICYANIDE	S	None
SUDAN III	S	None
SUDAN III	L	Alcohol
SUDAN IV	L	Alcohol

SUBSTANCE	Physical State	Odor
PURPLE/VIOLET		
ANILINE BLUE	S/L	None
BROMPHENOL BLUE	L	None
CARBOL FUCHSIN	L	Strong Phenol
CHLOROPHENOL RED	L	None
CHROMIUM (IC) POTASSIUM SULFATE	S	None
COBALT CARBONATE	S	None
m-CRESOL PURPLE	L	None
COPPER(I) OXIDE	S	None
INDIGO CARMINE	S	None
IRON(III) AMMONIUM SULFATE	S	None
IRON(III) NITRATE	S	Slight Nitric Acid
METHYL VIOLET 6B	L	None
MUREXIDE	S	Slight Nitric Acid
4-(p-NITROPHENYLAZO) RESORCINOL SOLUTION	L	None
POTASSIUM PERMANGANATE	L	None
RHODAMINE B	L	None

SUBSTANCE	Physical State	Odor
YELLOW/MUSTARD		
ALBUMIN	S	Slightly Musty
ALUMINUM CHLORIDE	S	Strong Hydrochloric Acid
AMMONIUM CHROMATE	S	None
AMMONIUM METAVANADATE	S	None
YELLOW/MUSTARD—continued		
AMMONIUM SULFIDE	L	Rotten Eggs
BEESWAX	S	None
BILE SALTS	S/L	Putrid Beef
BRASS	S	None
CARNAUBA WAX	S	None
CEDARWOOD OIL	L	None
CLAYTON YELLOW	S/L	None
GLYCERIN, JELLY	L	None
IRON(III) AMMONIUM CITRATE	S	None
IRON(III) CHLORIDE	S	Slight Chlorine
LANOLIN	S	Shoe Polish
LEAD OXIDE, MONO	S	None
LEMON JUICE	L	Lemon
LUMINOL	S	None
LYCOPODIUM	S	Fresh-Cut Wood
MERCUROUS NITRATE	S/L	Faint Nitric Acid
1-NAPHTHOL	S	Slight Phenol
OLIVE OIL	L	None
PEPTONE	S	Sour Malt
PETROLATUM	S	None
PHOSPHOMOLYBDIC ACID	S	Inorganic Acid-like
POTASSIUM CHROMATE	S/L	None
POTASSIUM FERRICYANIDE	L	None
POTASSIUM NITRATE	S/L	None
RIBOFLAVIN	S	None
SOAP	S	Soap
SODIUM BISMUTHATE	S	None
SODIUM CHROMATE	S/L	None
SODIUM COBALTINITRITE	S	Medicine-like
SODIUM NITRITE	S/L	None
SODIUM PEROXIDE	S	None
SPERMACETI	S	Wax
SULFUR	S	Faint Rotten Eggs
TANNIC ACID	S	Slight Cucumber
TETRACYCLINE HYDROCHLORIDE	S	None
YELLOW VEGETABLE DYE	L	None
YEAST EXTRACT	S	Sour Malt
ZEOLITE	S	None
ZINC SULFIDE	S	None

SUBSTANCE	Physical State	Odor
ORANGE TO BROWN, AMBER		
ACRIDINE ORANGE	L	None
ALIZARIN YELLOW R	S	None
AMMONIUM DICHROMATE	S	None
BISMARK BROWN Y	L	None
BOUILLON, CUBES	S	Beef Broth
BROMINE (AMPULE)	S	Irritating, Chlorine-like
BROMINE WATER	L	Like Bromine

SUBSTANCE	Physical State	Odor
ORANGE TO BROWN, AMBER—continued		
BROMCRESOL GREEN	S	None
BROMCRESOL PURPLE	L	None
BROMTHYMOL BLUE	S	None
CERIUM (IV) AMMONIUM NITRATE	S	Slight Nitric Acid
CLOVE OIL	S	Clove
COBALT(OUS) NITRATE	S	None
COBALT(OUS) SULFATE	S/L	None
CONGO RED	L	None
COPPER	S	None
CORN OIL	L	None
COTTONSEED OIL	L	None
CRESOL RED INDICATOR	L	None
EOSIN Y	L	Alcohol
HYDROBROMIC ACID	L	Suffocating; Bromine-like
IODINE—POTASSIUM IODIDE SOLUTION	L	Iodine (Slight)
IODINE SOLUTION, GRAM	L	Iodine
ION EXCHANGE RESIN	S	None
IRON(III) CHLORIDE	L	None
IRON(III) NITRATE	L	None
LEAD DIOXIDE	S	None
LICORICE	S	Licorice Candy
LINSEED OIL	L	Oil
LYSOL®	S	Phenol
MERCURIC OXIDE	S	None
METHYL ORANGE	S	Laundry Soap
METHYL RED	S	None
MOLASSES	L	Brown Sugar
NICOTINE	S	Strong; Old, Smoked Cigarettes
NINHYDRIN SOLUTION	L	Butyl Alcohol
ORANGE G	S	None
ORANGE IV	S/L	None
PEANUT OIL	L	None
POLYURETHANE LIQUID "A"	L	Rubber-like
POLYURETHANE LIQUID "B"	L	None
POTASSIUM DICHROMATE	S/L	None
POTASSIUM FERRICYANIDE	S	None
POTASSIUM TRIIODIDE	L	Iodine-like
SESAME OIL	L	None
SODIUM DICHROMATE	S/L	None
SUCROSE (BROWN CANE SUGAR)	S	Slight Malt
SUDAN IV	S	None
VINEGAR (CIDER)	L	Acetic Acid
XANTHOPHYLL	S	Shellac
YEAST (BREWERS)	S	Malt

SUBSTANCE	Physical State	Odor
BLACK, BROWN/BLACK		
ACRIDINE ORANGE	S	None
BEEF EXTRACT	S	Putrid Beef
BROMCRESOL PURPLE	S	None
CATALASE	S	None
CHARCOAL	S	None
CHLOROPHYLLIN	S	None
COBALT(IC) OXIDE	S	None
CONGO RED	S	None
m-CRESOL PURPLE	S	None
CRESOL RED	S	Burnt Wood
COPPER(II) BROMIDE	S	Bromine-like
COPPER(II) CHLORIDE	S	Slight Vanilla
ERIOCHROME BLACK T	S	New Rubber
INK, BLACK	L	None
INVERTASE	S	Dry Dog Food
IODINE	S	Unique, Acrid
IODINE, TINCTURE	L	Iodine and Alcohol
IRON(III) CITRATE	S	None
IRON(III) OXIDE	S	None
NIGROSIN	S/L	None
THIONIN	S/L	Slight Vinegar
THYMOL BLUE	S	None

SUBSTANCE	Physical State	Odor
SILVER/GRAY		
ALUMINUM	S	None
ANTIMONY	S	None
ANTIMONY TRICHLORIDE	S	Slight Chlorine
BARIUM CARBONATE	S	None
BARIUM PEROXIDE	S	None
BENZOYL PEROXIDE	S	Faint Almond
BISMUTH	S	None
BOILING STONES	S	None
CADMIUM	S	None
CALCIUM	S	None
CALCIUM CARBIDE	S	Slight Acetylene
CALCIUM FLUORIDE	S	None
CALCIUM HYDROXIDE	S	None
CARBORUNDUM	S	None
CHROMIUM	S	None
CHROMIUM(IC) NITRATE	S/L	None
COBALT	S	None
COPPER(II) OXIDE	S	None
p-DIMETHYLAMINO BENZALDEHYDE	S	Shoe Polish
IRON(II) SULFIDE	S	None
GRAPHITE POWDER	S	None
HYDROQUINONE	S	None
IRON	S	None
IRON PYRITES	S	None

SUBSTANCE	Physical State	Odor
SILVER/GRAY—continued		
LEAD	S	None
LEAD SULFIDE	S	None
LITHIUM	S	None
MAGNESIUM	S	None
MAGNESIUM HYDROXIDE	S	None
MANGANESE	S	None
MANGANESE DIOXIDE	S	None
MERCURY	S	None
MOLYBDENUM (IV) OXIDE	S	None
NEUTRAL RED	S	None
NICHROME, WIRE	S	None
NICKEL	S	None
ONION'S FUSIBLE ALLOY	S	None
ORCEIN	S	None
PHENYLHYDRAZINE HYDROCHLORIDE	S	Strong Chlorine
PLATINUM WIRE	S	None
POTASH, SULFURATED	S	Rotten Eggs
POTASSIUM (NEW)	S	None
POTASSIUM PERMANGANATE	S	None
PUMICE	S	None
RESAZURIN	S/L	None
SILICON	S	None
SILVER	S	None
SILVER ACETATE	S	Slight Vinegar
SILVER CHLORIDE	S	Slight Chlorine
SILVER OXIDE	S	None
SODIUM	S	None or Kerosene
"dri-NA"	S	None
STEEL	S	None
THERMIT	S	None
TIN	S	None
WINKLER'S SOLUTION #1	L	None
WOOD'S METAL	S	None
ZINC	S	None

SUBSTANCE	Physical State	Odor
***CLEAR, WHITE, MILKY, BUFF, NONE**		
* Remember, if the chemical color is clear, white, milky, buff or none and the chemical does ***not*** have an odor, it will not appear on this list.		
ACACIA	S	Slightly Musty
ACETALDEHYDE	L	Pungent; Fruity
ACETAMIDE	S	Mousy; Musty
ACETIC ACID	L	Pungent Odor; Like Vinegar
ACETIC ACID, DILUTE	L	Vinegar
ACETIC ANHYDRIDE	L	Strong Vinegar
ACETONE	L	Sweetish; Like Finger-nail Polish Remover
ACETYL CHLORIDE	S	Pungent; Vinegar-like

SUBSTANCE	Physical State	Odor
***CLEAR, WHITE, MILKY, BUFF, NONE—continued**		
ACETYLCHOLINE BROMIDE	S	Strong Acetic Acid (Vinegar)
ACETYLCHOLINE BROMIDE SOLUTION	L	Slight Vinegar Odor
ACETYL SALICYLIC ACID	S	When Fresh None; As It Ages Vinegar
ADIPOYL CHLORIDE	S	Offensive Stench
ADIPOYL CHLORIDE/ HEXANE SOLUTION	S	Hexane-like
ALUMINUM NITRATE	S/L	Very Slight Ammonia
AMMONIA	L/GAS	Strong Ammonia
AMMONIUM ACETATE	S	Weak Ammonia
AMMONIUM BROMIDE	S	Faint Ammonia
AMMONIUM CARBONATE	S/L	Strong Ammonia
AMMONIUM HYDROXIDE	L	Strong Ammonia
AMYL ACETATE	L	Banana-like
n-AMYL ALCOHOL	L	Banana-like
ANILINE	L	Hard to characterize. A very slight benzene-like odor
ANTIMONY TRICHLORIDE SOLUTION	L	Slight Chlorine
ASPIRIN, TABLETS	S	Slight Vinegar
BALSAM	S	Sweet, Cedar-like
BENZALDEHYDE	L	Almond
BENZENE	L	Gasoline-like
BENZOIC ACID	S	Maple Syrup
BENZOPHENONE	S	Sweet; Rose-like
BENZYL ALCOHOL	L	Slight Floral
BISMUTH NITRATE	S	Stinging; Acid-like
BISMUTH NITRATE SOLUTION	L	Slight Nitric Acid
BIURET	S	Vomit
BLOOD AGAR BASE INFUSION	S	Putrid Beef
BISMUTH NITRATE	S/L	Slight Nitric Acid
BOUIN'S SOLUTION	L	Slight Formaldehyde
BROMOBENZENE	L	Like Moth Balls
n-BUTYL ALCOHOL	L	Like Strong Wine
sec-BUTYL ALCOHOL	L	Like Rubbing Alcohol
tert-BUTYL ALCOHOL	L	Camphor
BUTYL STEARATE	S	Faint, Fatty Odor
BUTYRIC ACID	L	Penetrating, Obnoxious Odor Like Vomit
CADMIUM NITRATE	S/L	Slight Nitric Acid
CALCIUM ACETATE	S	Slight Vinegar
CALCIUM HYPOCHLORITE	S	Chlorine-like
CALCIUM IODIDE	S	Iodine-like
CARBON DISULFIDE	L	Rotten Eggs

SUBSTANCE	Physical State	Odor
*CLEAR, WHITE, MILKY, BUFF, NONE—continued		
* Remember, if the chemical color is clear, white, milky, buff or none and the chemical does ***not*** have an odor, it will not appear on this list.		
CARBON TETRACHLORIDE	L	Sweet; Something Like Bug Spray
d-CAMPHOR	S	Penetrating, Aromatic; Like a Chest Rub
CARNOY'S SOLUTION	L	Alcohol-like
CELLULASE	S	Ginger
CETYL ALCOHOL	S	Faint; Citrus-like
CHLORETONE	S/L	Like a Chest Rub
CHLORINE	L	Pungent; Like Odor Around Swimming Pool
CHLOROFORM	L	Sweet; Anesthesia-like
CLEANER, FLINN-IT®	L	Soap-like
COLLODION	L	Strong Ether
CYCLOHEXANE	L	Rubber Cement-like
CYCLOHEXANOL	L	Camphor-like
CYCLOHEXENE	L	Paint Thinner
DECANOIC ACID	S	Fresh Paint-like
DEXTROSE AGAR	S	Dry Dog Food
DIASTASE OF MALT	S	Gingerbread
DIATOMACEOUS EARTH	S	Slightly Spicy
DIBROMACETIC ACID	S	Faint Vinegar
1,4-DICHLOROBENZENE	S	Moth Balls
DIGITONIN	S	Malt-like
DIISOPROPANOLAMINE	S	Leather
DIMETHYLGLYOXIME	S	Yogurt-like
DIMETHYLGLYOMINE	L	Alcohol
DIMETHYL SULFOXIDE	L	Smoked Oysters
1,4-DIOXANE	L	Ether-like
DIPHENYLAMINE	S	Strong Floral
DITHIZONE REAGENT	L	Slight Chloroform
DODECYL ALCOHOL	S	Flower-like
ETHER, ETHYL	L	Aromatic, Sweet
ETHYL, ACETATE	L	Strong and More Pungent than Acetone
ETHYL, ALCOHOL	L	Alcohol
ETHYLENE DIAMINE	L	Ammonia
ETHYLENE DICHLORIDE	L	Chloroform-like
ETHYLENE GLYCOL	L	Auto Anti-Freeze
FAA SOLUTION	L	Alcohol
FORMALDEHYDE	L	Formaldehyde
FORMALIN	L	Formaldehyde
FORMIC ACID	L	Penetrating; Strong Vinegar-like
D (+) GALACTOSE	S	Malt
GELATIN	S	Faint, Sour; Animal-like

SUBSTANCE	Physical State	Odor
*CLEAR, WHITE, MILKY, BUFF, NONE—continued		
GLUTARALDEHYDE	L	Distinct Chlorine
GUAR GUM	S	Freshly Cut Grass
HEMATOXYLIN	S	Slight Vinegar
n-HEPTANE	L	Paint Thinner
HEXAMETHYL-ENEDIAMINE	S	Ammonia
HEXANES	L	Paint Thinner
HEXYL ALCOHOL	L	Strong; Flower-like
HYDROCHLORIC ACID	L	Very Strong Chlorine
HYDROGEN SULFIDE SOLUTION	L	Strong Rotten Eggs
ISOBUTYL ALCOHOL	L	Strong; Alcohol-like
ISOPENTYL ALCOHOL	L	Strong; Disagreeable; Alcohol-like
ISOPROPYL ALCOHOL	L	Rubbing Alcohol
KEROSENE	L	Oil
LANTHANUM NITRATE	S/L	Slight Nitric Acid
LATEX	L	Slight Ammonia
LAURIC ACID	S	Candle Wax
LAUROYL PEROXIDE	S	Candle Wax
LEAD ACETATE	S	Strong Vinegar
LEAD ACETATE SOLUTION	L	Slight Vinegar
LEAD NITRATE	S	Slight Nitric Acid
LIPASE	S	Decaying Flesh
LULL-A-FLY®	S	Licorice
LYSOZYME	S	Sewage
MAGNESIUM ACETATE	S	Slight Vinegar
MAGNESIUM IODIDE	S	Faint Iodine
MALEIC ACID	S	Faint Tea
MALONIC ACID	S	Faint Beef Bouillon
MALTOSE	S	Fresh Cut Hay
MANGANOUS NITRATE	L	Faint Nitric Acid
MENTHOL	S	Cooling to Nasal Senses
MERCURIC NITRATE	S	Faint Nitric Acid
MERCURIC SULFATE	S	Faint Nitric Acid
DL-METHIONINE	S	Like Odorized Natural Gas
2-METHOXY ETHANOL	L	Alcohol
METHYL ALCOHOL	L	Alcohol
METHYL ETHYL KETONE	L	Nail Polish Remover
METHYL ISOBUTYL KETONE	L	Sweet; Ether-like
METHYL METHACRYLATE	L	Strong Banana Oil
POLYMETHYL METHACRYLATE	S	Plastic
METHYL SALICYLATE	L	Wintergreen
METHYLENE CHLORIDE	L	Ethyl Ether-like
MILLON REAGENT SOLUTION	L	Slight Nitric Acid

SUBSTANCE	Physical State	Odor
***CLEAR, WHITE, MILKY, BUFF, NONE—continued**		
* Remember, if the chemical color is clear, white, milky, buff or none and the chemical does ***not*** have an odor, it will not appear on this list.		
MOLISCH REAGENT	L	Alcohol-like
MONOSODIUM GLUTAMATE	S	Slight Spice
NAPHTHALENE	S	Moth Balls
NAPHTHALENE ACETIC ACID	S	Mixture of Moth Balls and Vinegar
NINHYDRIN	S	Fresh Paint
NITRIC ACID	L	Suffocating; Unique Odor
NITRIC ACID, DILUTE	L	Slight Nitric Acid
NUTRIENT AGAR	S	Strong; Putrid
NUTRIENT BROTH	S	Strong; Putrid
1-OCTADECANOL	S	Soap
2-n-OCTANOL	S	Strong; Floral
1-n-OCTANOL	L	Strong; Floral
OLEIC ACID	L	Wax-like
PALMITIC ACID	S	Wax-like
PANCREATIN	S/L	Sour Malt
PARA-FORMALDEHYDE	S	Strong Formaldehyde
PENTANE	L	Gasoline-like
PEPPERMINT OIL	L	Peppermint
PEPSIN	S	Sour Malt
PETROLEUM ETHER	L	Like Natural Gas
PHENOL	S/L	Disinfectant
PHENOLPHTHALEIN	S/L	Alcohol
PHENYL SALICYLATE	S	Disinfectant
PHENYL THIOCARBAMIDE	S	Garlic-like
POTASSIUM ACETATE	S	Slight Vinegar
POTASSIUM BISULFATE	S	Peanut Brittle
POTASSIUM BROMATE	S/L	Slight Bromine
POTASSIUM CYANIDE	S	Slight Almond
POTASSIUM IODATE	S/L	Strong Iodine
POTATO DEXTROSE AGAR	S	Sour Mash
PROPIONIC ACID	L	Rancid and Vinegar
n-PROPYL ALCOHOL	L	Alcohol
PYRIDINE	L	Unique and Entirely Disagreeable
RENNIN	S	Sour Mash
RESORCINOL	S	Strange and Unique—Floral
SABOURAUD DEXTROSE AGAR	S	Sour Malt

SUBSTANCE	Physical State	Odor
***CLEAR, WHITE, MILKY, BUFF, NONE—continued**		
SAPONIN	S	New Plastic
SCHIFF REAGENT	L	Strong Rotten Eggs
SEBACOYL CHLORIDE	L	Suffocating Acid
SILICIC ACID	S	Faint Floral
SILVER NITRATE	S	Faint Nitric Acid
SODIUM ACETATE	S	Faint Vinegar
SODIUM AMMONIUM PHOSPHATE	S	Faint Ammonia
SODIUM BISULFITE	S	Faint Sulfur
SODIUM DIPHENYL-AMINE SULFONATE	S	Flower-like
SODIUM DITHIONITE	S	Strong Sulfurous
SODIUM IODATE	S	Faint Iodine
SODIUM META-BISULFITE	S	Sulfur-like
SODIUM OLEATE	S	Soap-like
SORBIC ACID	S	Ginger
STEARIC ACID	S	Faint Wax
STYRENE, MONOMER	L	Aromatic; Rubber Cement-like
SUCROSE	S	Malt-like
SULFURIC ACID (REAGENT)	L	Sulfur; Sulfurous
l-TARTARIC ACID	S	Slight Malt
TETRAHYDROFURAN	L	Ether-like
THIOACETAMIDE	S/L	Buttered Popcorn
THYMOL	S	Liniment-like
THYMOLPHTHALEIN INDICATOR	L	Alcohol
TOLUENE	L	Benzene-like
TRICHLOROACETIC ACID	S	Vinegar-like
1,1,1-TRICHLOROETHANE	L	Chloroform-like
TRICHLOROETHYLENE	L	Chloroform-like
1,1,2-TRICHLORO TRIFLUOROETHANE	L	Carbon Tetrachloride-like
TRIPHENYL TETRAZOLIUM CHLORIDE	S	Unsalted Butter
TRYPSIN	S	Sour, Dry Urine
TRYPTONE	S	Malt
TURPENTINE	L	Paint Thinner
UREASE	S	Soy Bean-like
VINEGAR (WHITE)	L	Acetic Acid
XYLENES	L	Airplane Glue
D (+) XYLOSE	S	Brown Sugar
ZINC ACETATE	S	Faint Acetic Acid
ZINC STEARATE	S	New Leather