

his special knowledge tells him has been newly introduced to, or is rare in, pharmacy.

In the case of liquids the solvents as well as the dissolved matters claim attention. A few drops are evaporated to dryness on platinum-foil to ascertain if solid matter of any kind is present; the liquid is tested by red and blue litmus-paper to ascertain if free alkalies, free acids, or neither are present; a few drops are heated in the test-tube and the odor of any vapor noticed, a piece of glass tubing bent to a right angle being, if necessary, adapted to the test-tube by a cork, and some of the distilled liquid collected and examined; finally, the usual group-reagents for the several basylous and acidulous radicals are consecutively applied.

Proceeding in this way, the student who has already had some experience in pharmacy will not be likely to overlook such solvents as water, acids, alkalies, alcohol, glycerin, ether, chloroform, benzene, fixed oils, and essential oils, or to miss the substances which these menstrua may hold in solution. He will probably also recognize such liquids as carbolic acid, formic acid, lactic acid, methylic alcohol, aldehyde, aniline, nitrobenzol. He must not, however, suppose that he will always be able to qualitatively analyze, say, a bottle of medicine; for the various infusions, decoctions, tinctures, wines, syrups, liniments, confections, extracts, pill-masses, and powders contain vegetable matters most of which at present are quite beyond the reach of the analyst. Neither the highest skill in analysis nor the largest amount of experience concerning the odor, appearance, taste, and uses of drugs is sufficient for the detection of all these vegetable matters. Skill and experience combined, however, will do much, and in most cases even so difficult a task as the one just mentioned be accomplished with reasonable success. Obviously, qualitative analysis alone will not enable the experimenter to produce a mixture of substances similar to that analyzed; to this end recourse must be had to quantitative analysis, a subject reserved for subsequent consideration.

Natural fluids, as "Milk" and "Urine" (*vide* Index), admit of special analytical treatment.

Gas-analysis, or *Eudiometry* (from *eidia*, *eudia*, calm air, and *μέτρον*, *metron*, a measure, in allusion to the *eudiometer*, an instrument used in measuring the proportion and, as the early chemists thought, the salubrity of the gases of the air), is a branch of experimental investigation, chiefly of a quantitative character, concerning which information must be sought in other treatises. The analysis of atmospheric air from various localities, coal-gas, and gases obtained in chemical researches, involves operations which are scarcely within the sphere of Chemistry applied to Medicine. Beyond the recognition, therefore, of oxygen, hydrogen, nitrogen, carbonic, sulphurous, and hydrosulphuric acid gases, the experimental considerations of the chemistry of gaseous bodies may be omitted. Their study, however, should not be neglected, as existing conceptions of the constitution of chemical substances are largely dependent on the observed relations of the volumes of gaseous compounds to their elements. (See previous paragraphs, pp. 16 to 29, 42 to 45,

52 to 54, and 128.) The best single work on this latter part of the subject is a small book by Hofmann, *Introduction to Modern Chemistry*.

Spectrum Analysis.—It may be as well to state here that the preliminary and final examinations of minute quantities of solid matter may, in certain cases, profitably include their exposure to a temperature at which they emit light, the flame being physically analyzed by a spectroscope. A spectroscope consists essentially of a prism to decompose a ray of light into its constituent colors, with tubes and lenses to collect and transmit the ray or rays to the eye of an observer. The material to be examined is placed on the end of a platinum wire, which is then brought within the edge of a spirit-lamp or other smokeless flame; volatilization, attended usually in the case of a compound by decomposition, at once occurs, and the whole flame is tinged with a characteristic hue. A flat ribbon of rays is next cut off by bringing near to the flame a brass tube, the cap of which is pierced by a narrow slit. At the other end of the tube, at focal distance for parallel rays, is a lens through which the ribbon of light passes to a prism; the prism decomposes the ribbon, spreading out its constituent colors like a partially-opened fan, and the colored beam or *spectrum* thus produced is then examined by help of a telescope attached by a movable joint to a stand which carries the prism and the object-tube. It is this combination of tubes, lenses, and prism or prisms which constitutes the spectroscope. Sodium compounds under the circumstances give yellow light only, indicated by a double band of light in a position corresponding to a portion of the yellow part of an ordinary solar spectrum. The potassium spectrum is mainly composed of a red and violet band; lithium, a crimson, and, at very high temperatures, a blue, band. Most of the other elements give equally characteristic spectra.

By aid of a combined microscope and spectroscope (micro-spectroscope) the color of colored fluids can be analyzed.

CHEMICAL TOXICOLOGY.

In cases of criminal and accidental poisoning the substances presented to the chemical analyst for examination are usually articles of food, medicines, or vomited matters, or the liver, kidneys, intestines, stomach and contents, removed in course of post-mortem examination. In these cases some special operations are necessary before the poison can be isolated in a state of sufficient purity for the application of the usual tests; for in most instances the large quantity of animal and vegetable—or, in one word, organic—matter present prevents or masks the characteristic reactions on which the tests are founded. These operations will now be described;* they form the

* Materials for these experiments are readily obtained for educational purposes by dissolving the poison in infusions of tea or coffee, in porter or in water, to which some mucilage of starch or linseed meal, pieces of bread, potato, and fat have been added.

chemical part of the subject of Toxicology (τοξικὸν, *toxicon*, poison, and λόγος, *logos*, discourse).

Substances occurring in the form of an apparently definite salt or unmixed with organic matter need no special treatment. They are analyzed by the ordinary methods already given, attention being restricted to poisonous compounds only.

EXAMINATION OF AN ORGANIC MIXTURE SUSPECTED TO CONTAIN—MERCURY, ARSENIUM, ANTIMONY, LEAD, COPPER, OR ZINC; SULPHURIC ACID, NITRIC ACID, HYDROCHLORIC ACID, OXALIC ACID, OR HYDROCYANIC ACID; CAUSTIC ALKALIES; PHOSPHORUS; STRYCHNINE, MORPHINE, OR OTHER POISONOUS ALKALOIDS.

Preliminary Examination.

Odor, Appearance, Taste.—Smell the mixture, with the view of ascertaining the presence or absence of any notable quantity of free hydrocyanic acid. Look carefully for any small solid particles, such as arsenic, corrosive sublimate, or verdigris, and for any appearance which may be regarded as abnormal, any character unusual to the coffee, tea, beer, medicine, vomit, coats of stomach, kidney, liver, or other organ, tissue, or solid matter under examination.

Poisonous Quantity of Acid.—Add to a small portion some solution of carbonate of sodium, with the view of ascertaining by strong effervescence the presence of any large, poisonous quantity of sulphuric, nitric, or hydrochloric acid (p. 549).

Poisonous Quantity of Alkali.—If so excessively alkaline as to require the addition of a very large quantity of acid before neutralization is effected, a noxious quantity of a corrosive or caustic alkali is present. Whether soda or potash, etc., is ascertained by the usual tests.

Special instructions may induce the operator to suspect the presence of one particular poison. Direct examination for the latter may then be made, either at once if the substance has an aqueous character, or when filtration or treatment with warm hydrochloric or acetic acid has afforded a more or less colorless liquid.

Fluids.—A vomit or the contents of a stomach, if set aside in a long narrow vessel (test-glass or ale-glass), or, better, exposed on a filter during a night, will often yield a more or less clear, limpid portion at the bottom or top of the solid matter. This fluid (separated by a pipette or otherwise) will sometimes respond to tests without further preparation, and always requires less preparatory treatment than a semi-solid mixture.

If none passes through a filter, a portion often collects in the upper part.

General Procedure.—If the preliminary examination does not indicate the method to be pursued, proceed as follows, treating a portion (not more than one-fourth) of the mixture for the poisonous metals, another for the acids, and a third for alkalis, reserving the remainder for any special experiments which may suggest themselves in the course of analysis.

Examination for Mercury, Arsenium, Antimony, Lead, Copper, Zinc.

If a liquid, acidulate with hydrochloric acid and boil for a short time. If solid or semi-solid, cut up the matter into small pieces, add enough water to form a fluid mixture, stir in 10 or 20 per cent. of ordinary liquid hydrochloric acid, and boil until, from partial aggregation and solution of the solid matter, filtration can easily be effected.

Heat a portion of the clear liquid with a thin piece of bright pure copper or copper gauze, about an inch long and a quarter of an inch broad, for about ten or twenty minutes; metallic *mercury*, *arsenium*, or *antimony* will be deposited on the copper, darkening it considerably in color. Pour off the liquid from the copper, carefully rinse the latter with a little cold water, dry the piece of metal by holding it over or near a flame (using fingers, not tongs, or it may become sufficiently hot for loss of mercury or arsenium to occur by volatilization); introduce it into a narrow test-tube or piece of glass tubing closed at one end, and heat the bottom of the tube in a flame, holding it horizontally, that the upper part of the tube may be kept cool, and partially closing the mouth with the finger to prevent escape of vapor. Under these circumstances any *mercury* will volatilize from the copper and condense on the cool part of the tube in a ring or patch of white sublimate, readily aggregating into visible globules on being pressed by the side of a thin glass rod inserted into the tube; *arsenium* will volatilize from the copper, and, absorbing oxygen from the air in the tube, condense on the cool part of the glass in a ring or patch of white sublimate of arsenic (gray or even darker if much arsenium as well as arsenic be present), not running into globules when rubbed, but occurring in small crystals, the characteristic octahedral form of which (*vide* p. 169) is readily seen by aid of a good hand lens or the low power of a microscope; *antimony* volatilizes from the copper if strongly heated,

and, absorbing oxygen, immediately condenses as a slight white deposit close to the metal.

Confirmatory Tests.—1. Nothing short of the production of globules should be accepted as evidence of the presence of mercury. It will usually have existed as corrosive sublimate.—2. To confirm indications of the presence of arsenium, a portion of the acid liquid may be subjected to the hydrogen tests (pp. 170–172), or the tube containing the white crystalline arsenic may be broken, and the part on which the sublimate occurs boiled for some time in water, and the hydrosulphuric-acid, ammonio-nitrate-of-silver, and ammonio-sulphate-of-copper tests (pp. 173–175) applied to the aqueous solution.—3. For antimony, a portion of the acid liquid must always be introduced into the hydrogen-apparatus with the usual precautions. (*Vide* p. 170.)—4. Any sulphur present may darken the copper, and such stained copper may subsequently yield a whitish sublimate of sulphur on the sides of the subliming tube; such appearances, therefore, are consistent with the entire absence of mercury, arsenium, and antimony.

Note.—Before finally concluding that arsenium is absent from a fluid the latter should be warmed with a little sulphurous acid, and ordinary tests then again applied, for arsenic acid and other arseniates are not readily affected by the usual reagents for arsenium.

For *Lead* and *Copper*, pass hydrosulphuric acid gas through the clear acid liquid for some time, warming the liquid if no precipitate is produced, or diluting and partially neutralizing the acid by ammonia if much acid has been added. Collect on a filter any black precipitate that may have formed; wash, dissolve in a few drops of aqua regia, dilute, and apply tests, such as ammonia for copper, sulphuric acid for lead, or any other of the ordinary reagents (pp. 190, 211).

Copper may often be at once detected in a small quantity of acidulated liquid by immersing the point of a penknife or a piece of bright iron wire—a deposit of copper in its characteristic color quickly or slowly appearing according to the amount present (p. 189).

Zinc.—To the acid liquid through which sulphuretted hydrogen has been passed, add excess of ammonia (or to the original acid fluid add excess of ammonia, and then sulphhydrate of ammonium); a precipitate falls which may contain alumina, phosphates, and zinc—it is usually blackish, from the presence of sulphide of iron. Collect the precipitate on a filter, wash, dissolve in a little hydrochloric acid, add a few drops of nitric acid, boil, pour in excess of ammonia, filter, and test the filtrate with sulphhydrate of ammonium; a white precipitate indicates zinc.

Examination for Mineral Acids, Oxalic Acid, or Hydrocyanic Acid.

To detect *Hydrochloric*, *Nitric*, or *Sulphuric Acid* in any liquid containing organic matter, dilute with water and apply to small portions the usual tests for each acid, disregarding indications of small quantities. (*Vide* pp. 265, 287, 309.)

Excessive sourness, copious evolution of carbonic acid gas on the addition of carbonate of sodium, and abundant evidence of acid on applying the various tests to small portions of the fluid presented for analysis, collectively form sufficient evidence of the occurrence of a poisonous amount of either of the three common mineral acids. Small quantities of the hydrochloric, nitric, and sulphuric radicals, occurring as metallic salts or acids, are common normal constituents of food; hence the direction to disregard insignificant indications. If the fluid under examination be a vomit or the contents of a stomach, and an antidote has been administered, free acid will not be found, but, instead, a large amount of the corresponding salt.

For *Oxalic Acid*, filter or strain a portion of the liquid, if not already clear, and add solution of acetate of lead so long as a precipitate occurs; collect the precipitate—which in any case is only partly oxalate of lead—on a filter, wash, transfer it to a test-tube or test-glass, add a little water, and pass hydrosulphuric gas through the mixture for a short time; the lead is thus converted into the insoluble form of sulphite, while any oxalic acid is set free in the solution. Filter, boil to get rid of hydrosulphuric gas, and apply the usual tests for oxalic acid (see p. 315) to the clear filtrate.

The contents of a stomach containing oxalic acid is often of a dark-brown color with a tinge of green (altered blood and mucus), and the viscid mixture generally, though slowly, affords some clear limpid, almost colorless, liquid by filtration on standing.

For *Hydrocyanic Acid*, the three chief tests may be applied at once to the liquid or semi-liquid organic mixture, whether it has an odor of hydrocyanic acid or not. First: Half fill a small porcelain crucible with the material, add eight or ten drops of strong sulphuric acid, stir gently with a glass rod, and invert over the mouth of the crucible a watch-glass moistened with a small drop of solution of nitrate of silver; a white film on the silver solution is probably cyanide of silver, formed by the action of the gaseous hydrocyanic acid on the nitrate of silver. Second: Prepare a small quantity of the organic mixture as before, slightly moistening the centre of the watch-glass with solution of potash; here, again, the heat generated by the

action of the strong acid is sufficient to volatilize some of the hydrocyanic acid, which, reacting on the potash, forms cyanide of potassium. On removing the watch-glass and stirring into it successively solution of a ferrous salt, a ferric salt, and hydrochloric acid, flocks of Prussian blue are produced if hydrocyanic acid is present. Third: Proceed as before, moistening the watch-glass with sulphhydrate of ammonium; after exposure to the hydrocyanic gas for five or ten minutes, add a drop of solution of ammonia, evaporate to dryness at a low temperature, and add a drop of hydrochloric acid and of solution of perchloride of iron; a blood-red color, due to sulphocyanate of iron, is produced if cyanogen is present.

If the above reactions are not well marked, the organic mixture may be carefully and slowly distilled in a small retort, the neck of which passes into a bottle and dips beneath the surface of a little water at the bottom of the bottle, and the reagents then applied to separate portions of the distillate.

The examination of organic mixtures for hydrocyanic acid must be made without delay, as the poison soon begins to decompose, and in a day or two is usually destroyed.

Examination for Phosphorus.

A paste containing phosphorus is commonly employed for destroying vermin. In cases of poisoning the phosphorus is generally in sufficient quantity to be recognized by its characteristic unpleasant smell. A stomach in which it occurs not unfrequently exhibits slight luminosity if opened in a dark room. When the phosphorus is too small in quantity or too much diffused to afford this appearance, a portion of the material is placed in a flask, water acidulated by sulphuric acid added, a long wide glass tube fitted to the neck of the flask by a cork, and the mixture gently boiled. If phosphorus is present (even 1 part in 2,000,000, according to De Vrij), the top of the column of steam as it condenses in the tube will appear distinctly phosphorescent when viewed in a dark room. From its liability to oxidation, phosphorus cannot be detected after much exposure of an organic mixture to air.

Examination for Strychnine and Morphine.

Strychnine.—If solid or semi-solid, digest the matter with water and about 10 per cent. of hydrochloric acid till fluid; filter, evaporate to dryness over a water-bath. If the organic mixture is already liquid, it is simply acidulated with hydrochloric acid and evaporated to dryness. The acid residue is

next treated with spirit of wine as long as anything is dissolved, the filtered tincture evaporated to dryness over the water-bath, and the residue digested in water and filtered. This slightly acid aqueous solution must now be rendered alkaline by ammonia, and well shaken in a closed bottle or long tube with about half an ounce of chloroform, and set by till the chloroform has subsided. The chloroform (which contains the strychnine) is then removed by a pipette, the presence of any aqueous liquid being carefully avoided, and evaporated to dryness in a small basin over a water-bath, the residue moistened with concentrated sulphuric acid, and the basin kept over the water-bath for several hours. (It is highly important that the sulphuric acid used in this operation should be free from nitrous compounds. Test the acid, therefore, by adding powdered sulphate of iron, which becomes pink if nitrous bodies are present. If these are found, the acid should be purified by strongly heating with sulphate of ammonium, seventy or eighty grains to a pint.) The charred material is exhausted with water, filtered, excess of ammonia added, the filtrate shaken with about a quarter of an ounce of chloroform, the mixture set aside for the chloroform to separate, and the chloroform again removed. If on evaporating a small portion of this chloroform solution to dryness, adding a drop of sulphuric acid to the residue, and warming, any darkening in color or charring takes place, the strychnine is not sufficiently pure for chemical detection; in that case the rest of the chloroform must be removed by evaporation, and the residue redigested in warm sulphuric acid for two or three hours. Dilution, neutralization of acid by ammonia, and agitation with chloroform are again practised, and the residue of a small portion of the chloroform solution once more tested with sulphuric acid. If charring still occurs, the treatment must be repeated a third time. Finally, a part of the chloroform solution is taken up by a pipette and drop after drop evaporated on one spot of a porcelain crucible-lid until a fairly distinct dry residue is obtained. A drop of sulphuric acid is placed on the spot, another drop placed near, a minute fragment of red chromate of potassium placed in the second drop, and, when the acid has become tinged with the chromate, one drop drawn across the other; the characteristic evanescent purple color is then seen if strychnine is present. Other tests (*vide* p. 391) may be applied to similar spots.

This is Girdwood and Rogers's method for the detection of strychnine when mixed with organic matter. It is tedious but trustworthy,

and, though apparently complicated, very simple in principle, thus: strychnine is soluble in acidulated water or alcohol or in chloroform, readily removed from an alkaline liquid by agitation with chloroform, and not charred or otherwise attacked when heated to 212° F. with sulphuric acid; much of the organic matter of the food is insoluble in water; of that soluble in water, much is insoluble in alcohol; and of that soluble in both menstrua, all is charred and destroyed by warm sulphuric acid in a shorter or longer time. (See also Stas's general process, p. 553.)

Morphine and the Meconic Acid with which it is Associated in Opium.—To the liquid or the semi-fluid mixture warmed for some time with a small quantity of acetic acid, filtered, and concentrated if necessary, add solution of acetate of lead until no further precipitate is produced. Filter and examine the precipitate for meconic acid, reserving the filtrate for the detection of morphine.

The Precipitate.—Wash the precipitate (meconate of lead, etc.) with water, place it in a test-tube or test-glass with a small quantity of water, pass hydrosulphuric acid gas through the mixture for a short time, filter, slightly warm in a small basin, well stirring to promote removal of excess of the gas, and add a drop of neutral solution of perchloride of iron; a red color, due to the formation of meconate of iron, is produced if meconic acid is present. This color is not destroyed on boiling the liquid after the addition of one drop of diluted hydrochloric acid, as is the case with ferric acetate, nor is it bleached by solution of corrosive sublimate, thus distinguishing it from ferric sulphocyanate. It is discharged by hydrochloric acid.

The Filtrate.—The solution from which meconic acid has been removed by acetate of lead is evaporated to a small bulk over a water-bath, excess of carbonate of potassium added, and evaporation continued to dryness. The residue is then treated with alcohol, which dissolves the morphine. The alcoholic solution evaporated similarly may leave the morphine sufficiently pure for the application of the usual tests (*vide* p. 384) to small portions of the residue. If no reaction is obtained, add a drop of sulphuric acid and a little water to the residue, and shake with ether, in which the salt of morphine is insoluble. The treatment with ether may be repeated until nothing more is removed, the acid aqueous liquid saturated with carbonate of potassium, the mixture evaporated to dryness, the residue digested in alcohol, filtered, and portions of the alcoholic liquid evaporated to obtain spots of morphine for the application of the ordinary tests.

If much organic matter is believed to remain in the filtrate after the acetate-of-lead treatment, or if a considerable excess of acetate of lead has been employed, the filtered liquid should be subjected to a current of sulphuretted hydrogen until no more sulphide of lead is precipitated, the mixture filtered, and the filtrate, with the washings from the sulphide of lead, evaporated to a small bulk, excess of carbonate of potassium added, and the whole well mixed and agitated with twice or thrice its bulk of a mixture of ether and acetic ether (ether alone might not dissolve the morphine). On standing, the ethereal liquid rises to the surface; it is carefully removed, evaporated to dryness, and the residue tested or further purified in the manner described in the preceding paragraph.

The examination for morphine must be conducted with great care, and with as large a quantity of material as can be spared; for its isolation from other organic matter is an operation of considerable difficulty, especially when only a minute proportion of alkaloid is present. Fortunately, the detection of meconic acid does not include similar difficulties; and, as its reactions are quite characteristic, its presence is held to be strong evidence of the existence of opium in an organic mixture.

Examination for Other Poisonous Alkaloids.

Stas's Process.—Minutely subdivide any solid matter; to this and the liquid portion of the vomit, etc. add about twice their weight of the strongest spirit of wine containing sufficient tartaric acid to fairly acidify the mixture. Digest the whole in a flask at a temperature of 150° or 160° F.; set aside to cool; filter. The solution, which will contain the whole of the alkaloid, should then be evaporated nearly to dryness *in vacuo*, or at all events at a temperature not exceeding 100° F., lest volatile alkaloids should be dissipated. The residue is next exhausted with cold anhydrous alcohol, filtered, and the filtrate evaporated to dryness with the precautions already stated. The extract is dissolved in a very small quantity of water, treated with excess of powdered bicarbonate of sodium or potassium, and well shaken with five or six times its volume of pure ether (with perhaps a little acetic ether). This ethereal liquid contains the alkaloid. Small portions should be evaporated in watch-glasses and tasted, or tested physically and chemically, according as the knowledge of collateral circumstances by the operator, or his experience, or such reactions as are recorded on pp. 392–399, may suggest.

If a volatile alkaloid (conine, nicotine, lobeline) is indicated,

the ethereal solution, which may still contain animal matter, is removed, agitated with aqueous solution of potash, decanted, and shaken with pure diluted sulphuric acid. On standing, the aqueous portion, containing the alkaloid as acid sulphate, subsides; the upper ethereal portion containing the animal matter is rejected; the acid aqueous liquid is made alkaline with caustic potash or soda; ether added; well shaken; the ethereal liquid decanted, evaporated to dryness *in vacuo* or at a low temperature, and (to get rid of all traces of ammonia) again moistened with ether and dried. The residue is now tested for the suspected alkaloid by taste, smell, and the application of appropriate reagents (pp. 392-399).

If a non-volatile alkaloid (aconitine, atropine, brucine, colchicine, emetine, physostigmine, solanine, veratrine, as well as morphine, codeine, and strychnine) is indicated, further purification is effected by decanting the ethereal liquid from the lower aqueous solution of bicarbonate of sodium, removing the ether by evaporation, digesting the residue in alcohol, filtering, evaporating the alcohol, treating the residue with diluted sulphuric acid, setting aside for a few hours, filtering, concentrating, adding powdered carbonate of potassium, and finally anhydrous alcohol. The alcoholic liquid, on evaporation, yields the alkaloid in a fit state for testing in the manner already stated.

Sonnenschein's Process.—Digest with diluted hydrochloric acid, evaporate to the consistence of syrup, dilute, set aside for some hours, filter. Add solution of phosphomolybdic acid so long as any precipitate falls or cloudiness occurs; collect the precipitate on a small filter; wash it with water containing phosphomolybdic and nitric acids, and, while still moist, place it in a flask. Decompose this compound of phosphomolybdic acid and alkaloid by adding caustic baryta until the stirred mixture is distinctly alkaline. Distil off volatile alkaloids, condensing and collecting by help of a long tube so bent that the apparatus shall act as a retort, the end of the tube being attached to a bulb or a series of bulbs containing diluted hydrochloric acid. The acid liquid evaporated gives a residue of hydrochlorates of alkaloids. The latter will afford characteristic reactions with the tests for the suspected alkaloid, and on being moistened with baryta-water and warmed will afford fumes of volatile alkaloids whose odor is usually characteristic. The residue in the flask will contain non-volatile alkaloids. It is treated with carbonic acid gas to neutralize and precipitate the excess of baryta as insoluble carbonate of barium; the mix-

ture is evaporated to dryness over a water-bath, and the residue digested in alcohol. The alcoholic solution evaporated generally yields the alkaloids in a fit state for testing.

Reagents for Alkaloids.

Phosphomolybdic acid forms with ammonia, in acid solutions, a remarkably insoluble compound, and it comports itself in a similar manner with those compounds which are analogous to ammonia—the nitrogenized organic bases—consequently forming an excellent reagent for their detection. It may be prepared in the following manner: Molybdate of ammonium is precipitated by phosphate of sodium; the yellow precipitate, having been washed, is diffused through water and heated with sufficient carbonate of sodium to dissolve it. The solution is then evaporated to dryness, and calcined to drive off the ammonia. In case any of the molybdic compound be reduced by this operation, the residue must be moistened with nitric acid and again calcined. The dry mass is then dissolved in cold water, the solution strongly acidulated with nitric acid, and water added until ten parts of the solution contain one of the dry salt. The liquid, which is of a golden-yellow color, must be preserved from ammoniacal fumes. It precipitates all the alkaloids (with the exception of urea) when a mere trace only is present. The precipitates are yellow, generally flocculent, insoluble in water, alcohol, ether, and the diluted mineral acids, with the exception of phosphoric acid.—Nitric, acetic, and oxalic acids, concentrated and boiling, dissolve them. These compounds are decomposed by the alkalis, certain metallic oxides, and the alkaline salts, which separate the alkaloid. To give an idea of the sensitiveness of this reagent, it may be stated that the 0.000071 gramme of strychnine gives an appreciable precipitate with one cubic centimetre of the solution of phosphomolybdic acid.

Phosphoantimonic and phosphotungstic acids are also precipitants of alkaloids. The chlorides of platinum, iridium, palladium, and gold are occasionally serviceable. Tannic and picric acids may, too, be used, and a solution of iodine and iodide of potassium.

Other special reagents for alkaloids are "Meyer's" and "Nessler's" (see Index), the double iodide of potassium and cadmium, and a solution of the double "Iodide of Bismuth and Potassium." The latter is made (by Thresh) on adding together one ounce of *Liquor Bismuthi*, B. P., 90 grains of iodide of potassium, and 90 grains of strong hydrochloric acid. This orange-colored solution gives a red precipitate with dilute cold solutions containing alkaloids.

Plomaines (πτομα, a corpse) have already been alluded to as including poisonous alkaloids producible from putrefying animal matters, even the human body itself, during the ordinary processes of decay. They are distinguished, according to Brouardel and Boutmy, by a drop or two of a solution of their sulphate converting a drop of solution of ferrocyanide of potassium into ferricyanide, the mixture then giving a dark-blue precipitate with a ferric salt.

Unfortunately, some other substances also possess this converting power.

Tyrotaxon.—This ptomaine (p. 519) may be isolated and tested as follows: Prepare an aqueous extract of the cheese or filter the coagulated milk, etc. No heat should be applied, and undue exposure to air should be avoided by using stoppered bottles. Make the filtered fluid faintly alkaline with carbonate of sodium, and well shake with half its bulk of ether. Allow the perfectly clear ethereal solution to evaporate spontaneously. If necessary, again extract the aqueous residue with water, shaking with ether and evaporating as before. The aqueous residue may be tested in two or three ways. A little placed on the tongue and swallowed will cause more or less of nausea, vomiting, purging, and headache. The aqueous residue is either characteristically crystalline or will become so after standing in a vacuum over sulphuric acid. Mix two or three drops of sulphuric acid and carbolic acid on a white plate, and add a few drops of the aqueous residue just mentioned; if an orange-red or purple color results, the presence of tyrotaxon may be suspected, but any nitrate or nitrite present may cause a similar color. To some of the aqueous residue add an equal volume of a saturated solution of caustic potash; the double hydrate of potassium and diazobenzene is then formed, and appears in six-sided plates, whereas any nitrate of potassium appears in prisms. This residue may be treated with absolute alcohol, filtered, and the filtrate evaporated, when the plates may again be observed, or the color reaction again obtained with this now purified product (Vaughn).

Obscure Poisons.—Many substances, the active principles of which are at present beyond the reach of the chemical analyst, are poisons of a more or less active character. (See the *Pharmaceutical Journal* for Sept. 6, 1879, p. 195, and for Dec. 20, 1879, p. 481.)

ANTIDOTES.

Vide "Antidotes" in the Index.

QUESTIONS AND EXERCISES.

890. In examining food and similar matter for poison, why must not the ordinary tests for the poison be at once applied?

891. What preliminary operations should be performed on a vomit in a case of suspected poisoning?

892. How would you proceed in searching for corrosive sublimate in wine?

893. By what series of operations would you satisfy yourself of the presence or absence of arsenic in the contents of the stomach?

894. Describe the treatment to which decoction of coffee should be subjected in testing it for tartar emetic.

895. State the method by which the occurrence of lead in water is demonstrated.

896. Give a process for the detection of copper in jam.

897. How would you detect zinc in a vomit?

898. How may the presence of a poisonous quantity of sulphuric acid in gin be proved?

899. In examining ale for free nitric acid, what reactions would be selected?

900. Show how you would conclude that a dangerous quantity of hydrochloric acid had been added to cider.

901. Describe the manipulations necessary in testing for hydrocyanic acid in the contents of a stomach.

902. By what method is oxalic acid discovered in infusion of coffee?

903. How is phosphorus detected in organic mixtures?

904. Give the process by which strychnine is isolated from partially digested food.

905. Mention the experiments by which the presence of laudanum in porter is demonstrated.

906. Name the appropriate antidotes in cases of poisoning by—*a*, alkaloids; *b*, antimonials; *c*, arsenic; *d*, barium salts; *e*, copper compounds; *f*, hydrochloric acid; *g*, hydrocyanic acid; *h*, preparations of lead; *i*, corrosive sublimate; *j*, nitric acid; *k*, oxalic acid; *l*, salts of silver; *m*, oil of vitriol; *n*, tin liquors; *o*, zinc solutions; *p*, carbolic acid.

EXAMINATION OF MORBID URINE AND CALCULI.

THE various products of the natural and continuous decay of animal tissue and the refuse matter of food are eliminated from the system chiefly as feces, urine, and expired air. Air exhaled from the lungs carries off from the blood much carbon (about 8 ounces in twenty-four hours) in the form of carbonic acid gas, and some aqueous vapor—the latter, together with a small amount of oily matter, also escaping by the skin. Directing the breath to a cold surface renders moisture evident, and breathing through a tube into lime-water demonstrates the presence of a considerable quantity of carbonic acid gas. The feces consist mainly of the insoluble *débris* of the system, the soluble matters and water forming the urine. These excretions vary considerably, according to the food and general habits of the individual and external temperature. But in disease the variations become excessive; their detection by the medical practitioner, or by the pharmacist for the medical practitioner, is therefore a matter of importance.

A complete analysis of feces, urine, or expired air cannot be performed in the present state of our knowledge. Nor can even a partial analysis of feces or air be made with sufficient ease and rapidity to be practically available in medical diagnosis. But with regard to urine, certain abnormal substances and abnormal quantities of normal constituents may be chemically detected in the course of a few minutes by any one having already some knowledge of chemical manipulation.