lous paper, and afterward at a temperature between 55° and 60° C. (131° to 140° F.). Weigh the crystals in the inner filter, counterbalancing by the outer filter. The weight of the crystals in grammes, multiplied by *twenty*, equals the percentage of morphine in the opium taken." [At 110° C. morphine is anhydrous.]

"On exhausting 100 parts of opium previously dried at a temperature of 105° C. (221° F.), with cold water, and evaporating the solution to dryness, an extract is obtained which should weigh between 55 and 60 parts."—U. S. P.

The foregoing process yields results almost exactly comparable amongst themselves; therefore is medically reliable. It has been generally recognized as involving some loss of morphine, the loss being, however, fairly constant. Messrs. Teschemacher and Smith, after working for many years on the subject, have devised such a combination of known morphiometric methods as to enable them to obtain more morphine from a given sample of opium than they formerly obtained, and about 2 or 2¼ per cent. more morphine from a given sample than they can obtain by the official method. They hope to so extend their improvements as to obtain still higher results. Meanwhile, they claim for their method not only the important medical desideration that like other trustworthy methods it yields constant results, but that it necessarily yields results at all events nearer to truth than the results hitherto obtained. The minimum contents by the official process is to be 9 per cent. of morphine or 10.3 from the dried opium. This corresponds to a yield by the annexed process of 12½ per cent. from dried opium.

*Teschemacher and Smith's Method.*—Thoroughly exhaust 200 grains of opium with warm distilled water. Concentrate this water extract to a thin syrup in a shallow dish, over a water-bath, the water of which should not quite boil. Transfer this thin syrup to a suitable flask, which permits the use of a soft cork, using a few drops of water successively to wash out the dish. Add to the contents of the flask 50 fluidgrains of alcohol, sp. gr. about 0.820, and about 600 fluidgrains of ether. Mix gently, but thoroughly, and then add some 50 fluidgrains of ammonia, sp. gr. 0.935. Shake the contents of the flask well to precipitate the alkaloids in arenaceous crystals, with occasional agitation during the ensuing eighteen hours. Transfer the contents of the flask to a vacuum filter, and permit all the adherent liquid to be drawn away, washing out the flask



with morphinated spirit* and continue its use till the liquid passes colorless. Then wash the morphinated water† till this also passes colorless. Now dry, slowly at first, finishing at 212° F. Transfer the dried substance to a mortar, reduce it to a very fine powder, and digest it thoroughly in benzene to dissolve the narcotine and such of the opium alkaloids, other than morphine, which may be present. Transfer this mixture to a vacuum filter, wash out the mortar carefully with benzene, which use to wash the powder thoroughly. This, then, will be morphine, free from other opium alkaloids and narcotine, but still containing coloring and possibly other organic matters to the extent of 3 to 10 per cent. Dry and weigh this powder. Now ascertain the percentage of crystallized morphine by titration of this powder with standard hydrochloric acid and litmus as the indicator, by weight. This acid is so made that 1000 grains by weight shall exactly neutralize 100 grains of pure morphine crystallized from water, washed with ether, and gently dried finally at 212° F.

## SUGAR.

The qualitative test of sugar by means of an alkaline copper solution (*vide* p. 470) may be applied in the estimation of sugar in saccharifierous substances.

*Process 1.*—34.65 grammes of pure dry crystals of ordinary sulphate of copper are dissolved in about 250 c.c. of distilled water, and 173 grammes of pure crystals of the double tartrate of potassium and sodium are dissolved in 480 c.c. of solution of caustic soda of sp. gr. 1.14. The solutions are only mixed when required, water being then added to form one litre, smaller quantities of the fluids being proportionately diluted. 100 c.c. of this solution represent 3.464 grammes of sulphate of copper, and correspond to 0.5 of a gramme of pure anhydrous grape-sugar, 0.475 of cane-sugar, 0.82 of maltose, or 0.45 of starch. The solutions must be preserved in a well-stoppered bottle to prevent absorption of carbonic acid, and be kept in a dark place. Should the mixture give a precipitate on boiling, a little solution of soda may be added when making experiments. A solution of this strength is officially (U. S. P.) termed "Test-Solution of Potassio-cupric Tartrate," or "Fehling's Solution."

* *For Morphinated Spirit.*—Digest a large excess of morphine in rectified spirit of 80 per cent., for several days, with frequent agitation; filter for use.

† *For Morphinated Water.*—As above, substituting distilled water for spirit.

Dissolve 0.475 of pure dry powdered cane-sugar in about 50 c.c. of water, convert into grape-sugar by acidulating with sulphuric acid and heating for an hour or two on a water-bath, make slightly alkaline with carbonate of sodium, and dilute to 100 c.c. Place 10 c.c. of the copper solution in a small flask, dilute with three or four times its bulk of water, and gently boil. Into the boiling liquid drop the solution of sugar from a burette, one cubic centimetre or less at a time, until, after standing for the precipitate to subside, the supernatant liquid has just lost its blue color; 10 c.c. of the solution of the sugar should be required to produce this effect = 0.0475 of cane-sugar, 0.082 of maltose, or 0.05 of grape-sugar. Experiments on pure cane-sugar must be practised until accuracy is attained; syrups, diabetic urine, and saccharated substances containing unknown quantities of sugar may then be analyzed.

*Starch* is converted into grape-sugar by gentle ebullition with dilute acid for eight or ten hours, the solution being finally diluted so that one part of starch, or rather sugar, shall be contained in about 150 of water.

If instead of Fehling's Solution, Pavy's Ammoniated Solution be used (*Proceedings of the Royal Society of London*, vol. xxviii., p. 260, and vol. xxix., p. 272), one-fifth more of the copper salt will be required to do the same amount of work.

In cases in which loss of blue color cannot be relied on as indicating the termination of the reaction, the suboxide of copper should be rapidly filtered out, washed, dried, and, after adding the filter ash, ignited, and the resulting black oxide of copper weighed. One gramme of black oxide (or of suboxide or of metallic copper) indicates the subjoined amounts of the respective sugars:—

| One gramme of— | Glucose. | Cane-sugar. | Milk-sugar. | Malt-sugar. |
|---|---|---|---|---|
| Black oxide . . . . . | .4535 | .4308 | .6153 | .7314 |
| Suboxide . . . . . | .5042 | .4790 | .6843 | .8132 |
| Metallic copper . . . | .5634 | .5395 | .7707 | .9089 |

*Process 2.—Roberts' Method for the Estimation of Sugar in Urine.*—About four ounces of saccharine urine are put into a twelve-ounce bottle, and a lump of German yeast about the size of a cob-nut or small walnut is added. This excess of yeast hastens fermentation, and does no harm. The bottle is then covered with a grooved cork (to allow of the escape of carbonic acid gas) and set aside in a warm place to ferment. By the side of it is placed a tightly corked four-ounce phial filled with the same urine without any yeast. In about twenty-four hours the fermentation will have ceased and the scum cleared off or subsided. The fermented urine is then decanted



and its specific gravity taken. At the same time the specific gravity of the unfermented urine in the companion phial is observed. The *density lost* is thus ascertained. Each degree of density lost represents a grain of glucose per fluidounce.

Sugar is often estimated by the measurement of the carbonic acid gas evolved during fermentation.

*Saccharimetry.*—A generic term for certain volumetric operations undertaken with the view of ascertaining the quantity of sugar present in any matter in which it may be contained.

Saccharimetry is frequently performed upon common syrup (*Syrupus*, B. P.) and solutions which are known to contain nothing but cane- (ordinary) sugar, the object being merely to ascertain the amount present. In such a case it is only necessary to take the specific gravity of the liquid at 60° F., and then refer to a previously prepared Table of density and percentages:—

| Specific gravity. | Sugar, per cent. | Specific gravity. | Sugar, per cent. | Specific gravity. | Sugar, per cent. |
|---|---|---|---|---|---|
| 1.007 . . | 1.8 | 1.100 . . | 23.7 | 1.210 . . | 46.2 |
| 1.014 . . | 3.5 | 1.108 . . | 25.6 | 1.221 . . | 48.1 |
| 1.022 . . | 5.2 | 1.116 . . | 27.6 | 1.231 . . | 50.0 |
| 1.029 . . | 7.0 | 1.125 . . | 29.4 | 1.242 . . | 52.1 |
| 1.036 . . | 8.4 | 1.134 . . | 31.5 | 1.252 . . | 54.1 |
| 1.044 . . | 10.4 | 1.143 . . | 33.4 | 1.261 . . | 56.0 |
| 1.052 . . | 12.4 | 1.152 . . | 35.2 | 1.275 . . | 58.0 |
| 1.060 . . | 14.4 | 1.161 . . | 37.0 | 1.286 . . | 60.1 |
| 1.067 . . | 16.3 | 1.171 . . | 38.8 | 1.289 . . | 62.2 |
| 1.075 . . | 18.2 | 1.180 . . | 40.6 | 1.309 . . | 64.4 |
| 1.083 . . | 20.0 | 1.190 . . | 42.4 | 1.321 . . | 66.6? |
| 1.091 . . | 21.8 | 1.199 . . | 44.3 | 1.330 (B. P.) | 66.6? |

The sp. gr. may be taken by a hydrometer, technically termed a *saccharometer*. (The above spec. gravs. = 1° to 35° Baumé.)

If a liquid contains other substances besides cane-sugar, the test of specific gravity is of little or no value. Advantage may then be taken of the fact that syrup causes right-handed twisting of a ray of polarized light to an extent exactly proportionate to the amount of sugar in solution. The saccharine fluid is placed in a long tube having opaque sides and transparent ends, and a ray of homogeneous light, polarized by reflection from a black-glass mirror or otherwise, is sent through the liquid and optically examined by a plate of tourmaline, Nicol's prism, or other polarizing eye-piece. Attached to the eye-piece is a short arm which traverses a circle divided into

degrees. The eye-piece and arm are previously so adjusted that when the ray is no longer visible the arm points to the zero of the scale of degrees. The saccharine solution, however, so twists the ray as to again render it visible; and the number of degrees which the eye-piece has to be rotated before the ray is once more invisible is exactly proportionate to the strength of the solution. The value of the degrees having been ascertained by direct experiment and the results tabulated, a reference to the Table at once indicates the percentage of sugar in the liquid under examination. Grape-sugar also possesses the property of dextro-rotation, but less powerfully than cane-sugar; moreover, the former variety does not, like cane-sugar, suffer inversion of the direction of rotation on the addition of hydrochloric acid to its solution—an operation that furnishes data for ascertaining the amounts of cane- and of grape-sugar, or of crystallizable and non-crystallizable sugar, present in a mixture. In using the polariscope-saccharometer it is convenient to employ tubes of uniform size and always to operate at the same temperature. Various modes are adopted of applying, for the purposes of quantitative analysis, the action of syrup on polarized light.

## ALCOHOL.

*Mulder's process* for the determination of the amount of alcohol in wines, beer, tinctures, and other alcoholic liquids containing vegetable matter is as follows:—Take the specific gravity and temperature of the liquid, and measure off a certain quantity (100 cubic centimetres); evaporate to one-half or less, avoiding ebullition in order that particles of the material may not be carried away by the steam. Dilute with water to the original bulk, and take the specific gravity at the same temperature as before. Of the figures representing this latter specific gravity, all over 1.000 show to what extent dissolved solid matter affected the original specific gravity of the liquid. Thus, the specific gravity of a sample of wine at 15°.5 C. is 0.9951; evaporated till all alcohol is removed and diluted with water to the original bulk, the specific gravity at 15°.5 C. is 1.0081; 0.0081 represents the gravitating effect of dissolved solid matter in 0.9951 parts of original wine. 0.0081 subtracted from 0.9951 leaves 0.987, which is the specific gravity of the water and alcohol of the wine. Or divide the sp. gr. of the wine by the sp. gr. of the wine minus alcohol, carrying out the sum to four places of decimals; the quotient shows the sp. gr. of the water and alcohol only of the wine. On referring to a Table of the strengths of diluted alcohol of different specific gravities (p. 659), 0.987 at 15°.5 C. is found to indicate a spirit containing 8 per cent. of real alcohol. Mulder's process is that adopted officially (U. S. P.) for ascertaining the strength of white wine (*Vinum Album*) and red wine (*Vinum Rubrum*). If the foregoing operation be conducted in a retort, the liquid being boiled and the steam carefully condensed, the distillate, diluted with water to the original bulk of wine operated on, will still more accurately represent the amount of water and alcohol in the wine, its specific gravity showing the percentage of real alcohol present.



## DIALYSIS.

Dialysis (from *διὰ, dia*, through, and *λύσις, lusis*, a loosing or resolving) is a term applied by Graham to a process of analysis by diffusion through a septum. The apparatus used in the process is called a *dialyzer*, and is constructed and employed in the following manner. The most convenient septum is the commercial article known as *parchment-paper*, made by immersing unsized paper for a short time in sulphuric acid; it is sold by most dealers in chemical apparatus. A piece of this material is stretched over a gutta-percha hoop and secured by a second external hoop. Dialyzers of useful size are one or two inches deep and five to ten inches wide. Liquids to be dialyzed are poured into the dialyzer, which is then floated in a flat dish containing distilled water. The portion passing through the septum is termed the *diffusate*; the portion which does not pass through is termed the *dialysate*.

The practical value of dialysis depends upon the fact that certain substances will diffuse through a given septum far more readily than others. Uncrystallizable bodies diffuse very slowly. Of such matters as starch, gum, albumen, and gelatin, the last named is perhaps least diffusive; hence substances of this class are termed *colloids*, or bodies like *collin*, which is the soluble form of gelatin. Substances which diffuse rapidly are most crystalline; hence bodies of this class are termed *crystalloids*.

*Dialyzed iron*, an aqueous solution of about 5 per cent. of highly basic oxychloride of iron, is obtained by saturating solution of perchloride of iron with ferric hydrate, by adding ammonia, or, better, carbonate of sodium, and shaking vigorously until the precipitated hydrate ceases to redissolve, filtering if necessary, placing on a dialyzer floating in distilled water, and displacing the fluid in the dish by water daily for a week or

two, or until the diffusate gives no reaction with nitrate of silver. The crystalloids (chloride of sodium or other salt) pass through the dialyzer; the colloid fluid which does not pass through the dialyzer is the highly basic oxychloride of iron, or so-called "dialyzed iron" or "dialytic iron." This fluid has very little taste of iron. Its value as a medicine has been questioned, its non-diffusibility suggesting that it never passes out of the intestinal canal, and therefore never gets into the blood.

The phenomena of dialysis show that crystalloids are superior to colloids in affinity for water.

## QUESTIONS AND EXERCISES.

1068. Carbonate of potassium is said to lose 16 per cent. of water on exposure to a red heat; give the details of manipulation observed in verifying this statement.

1069. Write a few paragraphs descriptive of the process of ultimate organic analysis.

1070. In what forms are carbon, hydrogen, and nitrogen weighed in quantitative analysis?

1071. In the combustion of .41 of a gramme of sugar, what weights of products will be obtained? *Ans.* .632 of carbonic acid gas ($CO_2$) and .237 of water ($H_2O$).

1072. How is cinchona assayed for mixed alkaloids?

1073. On what facts does De Vrij found his method for the separation and quantitative determination of all the cinchona alkaloids?

1074. Describe De Vrij's process for the assay of commercial sulphate of quinine.

1075. Give the official method for the estimation of morphine in opium.

1076. Mention the operation necessary for the estimation of the proportion of sugar in saccharated carbonate of iron or in a specimen of diabetic urine.

1077. What is understood by *Saccharimetry?*

1078. Give two processes for the estimation of the percentage of alcohol in tinctures, wines, or beer.

1079. Define dialysis.

## Conclusion.

Detailed instructions for the quantitative analysis of potable water, articles of food, general technical products, special minerals, soils, manures, air, illuminating agents (including solid fats, oils, spirits, petroleum, and gas), dyes, and tanning-materials would scarcely be in place in this volume.

The course through which the reader has been conducted



will, it is hoped, have taught the principles of the science of Chemistry, and given special knowledge concerning the applications of that science to medicine and pharmacy, as well as have imparted sufficient manipulative skill to meet the requirements of manufacture or analysis. The author would venture to suggest that this knowledge be utilized, not only in the way of personal advantage, but in experimental researches on chemical subjects connected with therapeutics and pharmacy. The discovery and publication of a new truth, great or small, is the best means whereby to aid in advancing the calling in which we may be engaged, increase our own reputation, and contribute to that ultimate end of knowledge" which Bacon defined as "employing the divine gift of reason to the use and benefit of mankind."