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# CHEMISTRY:

## GENERAL, MEDICAL, AND PHARMACEUTICAL,

INCLUDING

THE CHEMISTRY OF THE U. S. PHARMACOPŒIA.

## A MANUAL

ON THE GENERAL PRINCIPLES OF THE SCIENCE, AND THEIR APPLICATIONS IN MEDICINE AND PHARMACY.

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# PREFACE.

THE short title on the back of a book, and even the words on the title-page, are generally, and even necessarily, imperfect descriptions of the contents, and hence not unfrequently induce at the outset misconceptions in the minds of readers. The author of *Chemistry: General, Medical, and Pharmaceutical*, would at once state, therefore, that his chief aim is to teach the general truths of chemistry to medical and pharmaceutical pupils. So far as laws and principles are concerned, the book is a work on General Chemistry; but, inasmuch as those laws and principles are elucidated and illustrated by that large portion of Chemistry which is directly interesting to medical practitioners and pharmacists, the book may be said to be a work on Medical Chemistry and Pharmaceutical Chemistry. Only in this conventional sense would the author speak of Medical and Pharmaceutical Chemistry, for the truths of chemistry are the same for all students—crystalline verities which cannot be expanded or compressed to suit any class of workers. The leading principles of the science, however, can as easily be illustrated by or deduced from those facts which have interest as from those which have little or no special interest to the followers of medicine and pharmacy. The grand and simple leading truths of chemistry, the lesser truths or principles, and nearly all the interesting relationships of elements and compounds—in a word, the *science* of chemistry—can be taught to medical and pharmaceutical students with little other aid than that afforded by the materials which lie in rich abundance all around these workers. Such a mode of teaching "the general principles of the science, and their applications in medicine and pharmacy," is adopted in this volume. It is a mode which

greatly increases the usefulness of the science to the class chiefly addressed, while it in no way diminishes the value of chemistry as an instrument of mental culture—an instrument which sharpens and expands the powers of observation, which enlarges and strengthens memory and imagination, which gives point to the perceptive faculties, and which develops and elaborates the powers of thought and of reason.

This manual is intended, then, as a systematic exponent of the general truths of chemistry, but is written mainly for the pupils, assistants, and principals engaged in medicine and pharmacy. It is essentially a manual of applied chemistry, but it is first of all a manual of chemistry. The book will be found equally useful as a reading-book for gentlemen having no opportunities of attending lectures or performing experiments, or, on the other hand, as a text-book for college pupils; while its comprehensive Index, containing nearly nine thousand references, will fit the work for after-consultation in the course of business or professional practice.

From other chemical text-books it differs in three particulars: first, in the exclusion of matter relating to compounds which at present are only of interest to the scientific chemist; secondly, in containing more or less of the chemistry of every substance recognized officially or in general practice as a remedial agent; thirdly, in the paragraphs being so cast that the volume may be used as a guide in studying the science experimentally.

The order of subjects is that which, in the author's opinion, best meets the requirements of medical and pharmaceutical students in Great Britain, Ireland, America, India, and the English colonies. Introductory pages are devoted to a few leading properties of the elements. A review of the facts thus unfolded affords opportunity for stating the views of philosophers respecting the manner in which these elements influence each other as components of terrestrial matter. The consideration in detail of the relations of the elementary and compound radicals follows, synthetical and analytical bearings being pointed out, and attention frequently directed to connecting or underlying truths or general principles. The chemistry of substances met with in vegetables and animals, or similar substances artificially produced (the so-called Organic Chemistry), is next considered. Practical toxicology, and the chemical as well as microscopical characters of morbid urine, urinary sediments, and calculi, are then given. The concluding sections form a laboratory-guide to the chemical and physical study of quantitative analysis. In the Appendix is a long table of tests for impurities in medicinal preparations; also a short one of the saturating powers of acids and alkalies, designed for use in prescribing and dispensing.



In the course of the treatment outlined in the preceding paragraph it will be observed that the whole of the elements are first noticed very shortly, to give the pupil a general view of his course of study, and afterward at length and thoroughly; that the chemistry of the common metallic radicals precedes that of the rarer, and that the sections on the acidulous radicals are similarly divided; while the basylous radicals are arranged according to analytical relations, the common acidulous according to exchangeable value or quantivalence, and rarer acidulous radicals alphabetically. By this plan the more important facts and principles are repeatedly brought under consideration, the points of view, however, differing according as interest is concentrated on physical, synthetical, analytical, or quantitative properties. This arrangement of matter was adopted, also, partly from the belief that the separate and general truths of Chemistry never enter the mind in the order of any scientific classification at present possible. Chemical facts are not yet united by any single, consistent theory. In the current state of chemical knowledge consistency in the methodical arrangement even of elements can only be carried out in one direction, and is necessarily accompanied by inconsistencies in other directions—a result most perplexing to learners, and hence totally subversive of the chief advantage of classification. For this reason the writer has preferred to lead up to, rather than follow, scientific classification—has allowed analogies and affinities to suggest, rather than be suggested by, classification. Among

the acidulous radicals, especially, any known system of classification would have given undue prominence to one set of relations and undeserved obscurity to others. Then, by separating more important from less important matter, instruction is adapted to the wants of gentlemen whose opportunities of studying chemistry vary greatly, and are unavoidably insufficient to enable them to gain a knowledge of the detail of the science. One great advantage of the mode of treatment is that difficulties of nomenclature, notation, chemical constitution, and even those arising from conventionality of language, are explained as they arise, instead of being massed under the head of "Introductory Chapters," "Preliminary Considerations," or "General Remarks," which are not unfrequently too difficult to be understood by a beginner, too voluminous to be remembered except by the aid of subsequent lessons, and are consequently the cause of much trouble and confusion. For an illustration of this treatment the reader is referred to the various notes on chemical constitution. (See "Constitution of Salts" in the Index.) This plan has also admitted of greater prominence being given to "The General Principles of Chemical Philosophy," the only section to which the student is asked frequently to return until he finds himself naturally employing those principles in the interpretation of the phenomena obtained by experiment.

An elementary knowledge of the subjects of Gravitation, Heat, Light, Sound, Electricity, and Magnetism cannot be too strongly recommended to the student of Chemistry. The first portion of this manual would have been devoted to an exposition of these branches of physics, so far as they bear on chemistry, did not the many special books on physics render such a course unnecessary. Quantitative chemical analysis frequently involving determinations of temperature, specific gravity, and atmospheric pressure, a few paragraphs on these subjects are made introductory to the sections on quantitative operations.

The theories that matter consists of molecules and that molecules consist of atoms are freely adopted in this book, the author believing that in the present state of knowledge and education philosophic conceptions regarding chemistry can only be taught to medical, pharmaceutical, and the great majority of general students by such objective aid.



The chemical notation of the work is in accordance with modern theories. Equations illustrative of pharmacopœial processes have a name to each formula.

In the first edition of this Manual, in 1867, chemical nomenclature was modernized to the extent of defining the alkali-metal salts and the earthy compounds as those of potassium, sodium, ammonium, barium, calcium, magnesium, and aluminium, instead of potash, soda, ammonia, baryta, lime, magnesia, and alumina. The author confidently believes that this change, founded on views now adopted by all prominent writers on chemistry, will be accepted and become popular with all the followers of medicine and pharmacy. It is a step in the direction of simplicity and consistency, and involves far less hypothesis than is contained in the old system. The name "nitrate of potash," for example, was based on the pure assumption that nitre contained oxide of potassium or potash and nitric anhydride, then erroneously termed nitric acid. By the modern name, "nitrate of potassium," all that is intended to be conveyed is that nitre contains the element common to all potassium compounds and the group of elements common to all nitrates. Under the old method students always experienced difficulty in distinguishing salts of the metal from salts of its oxide—salts of potassium, for instance, from salts of potash; under the new view no such difficulty arises. Names such as potassium nitrate or potassic nitrate are also consistent with modern views, but for general adoption are too unlike the original. The contractions in Latin for names like "nitrate of potassium" are identical with the contractions for names resembling "nitrate of potash"—an accidental circumstance that will much facilitate the general introduction of the former among the older medical practitioners and pharmacists, and a practical advantage that must determine the choice over

the other chemically equivalent names just mentioned. The author ventures to express some gratification that his use and advocacy of this system since 1867 has resulted in its adoption, in 1873, in the "Pharmacopœia of the United States," and, in 1885, in the "British Pharmacopœia." Pharmacy among English-speaking nations will thus sooner or later, in the important matter of chemical nomenclature, be in accord with the current state of chemical science.

The Metric System of Weights and Measures (that which, doubtless, is destined to supersede all others) is alone used in the sections on Quantitative Analysis. In other parts of the manual avoirdupois weights and imperial measures are employed.

It is hoped that the numerous etymological references scattered throughout the following pages will be found useful. Words in Greek have been rendered in English characters, letter for letter. The word "official" is used throughout for things recognized officially by the compilers of Pharmacopœias; "officinal" in its original application to the officina or shop.

Students are strongly recommended to test their progress by frequent examination. To this end appropriate questions are appended to each subject.

The author's ideal of a manual of chemistry for medical and pharmaceutical students is one in which not only the *science* of chemistry is taught, but in which the chemistry of every substance having interest for the followers of medicine and pharmacy is noticed at more or less length in proportion to its importance, and at least its position in relation to the leading principles of chemistry set forth with all attainable exactness. The extent to which he has realized this ideal he leaves to others to decide. Such a work will doubtless in certain parts partake of the character of a dictionary; but this is by no means a fault, especially if a good index be appended; for the points of contact between pure and applied chemistry are thus multiplied, and abundant outlets supplied by which a lover of the science may pass into other chemical domains by aid of other guides, or even into the regions of original research.



Among the rarer alkaloids, bitter bodies, glucosides, salts of organic radicals, solid fats, fixed oils, volatile oils, resins, oleo-resins, gum-resins, balsams, and coloring-matters, mentioned in this volume, will be found many such points whence the ardent student may start for the obscure or untrodden paths of scientific chemistry.

Within twenty-two years a demand has arisen for twelve large editions of this Manual. The First, in 1867, was intended as a handbook of practical chemistry only; but the notes and remarks made respecting most of the experiments were found to be so useful by students that this portion of the volume was in the Second Edition (1869) sufficiently extended to render the book more fairly complete in itself. In response to a call from professional friends in the United States in 1870, the work was revised by the author for the followers of medicine and pharmacy in America, the chemistry of the Preparations and Materia Medica of the United States Pharmacopœia being introduced, and such other adaptations included as to form a Third Edition. A Fourth was presented to English workers in the autumn of 1872, and, founded on the Fourth, a Fifth Edition for American students in 1873. A very large Sixth Edition was published in England in 1875, a Seventh in America in 1876, an Eighth in 1879, a Ninth in England in 1881, a Tenth in America in 1883, and an Eleventh in England in 1885.

The present (Twelfth) edition contains such alterations and additions as seemed necessary for the demonstration of the latest developments of chemical principles and the latest applications of chemistry in pharmacy. The work now includes the whole of the chemistry of the United States Pharmacopœia and nearly all the chemistry of the British and Indian Pharmacopœias.

But the chief new feature is the section on Organic Chemistry, an elaboration of that written for the last British edition early in 1885. It has grown out of the section which, in previous editions, was termed "The Chemistry of Certain Substances of Animal and Vegetable Origin." These sub-

stances are in the eleventh and twelfth editions of this Manual classified according to the system now adopted by most authorities, for which followers of chemistry have largely to thank the enthusiasm and labors and lucid literary work of a former colleague of the author at St. Bartholomew's Hospital—Professor Auguste Kekulé.

17 Bloomsbury Square, London,
February 22, 1889.

# ADVICE TO STUDENTS

## RESPECTING THEIR OBJECT IN STUDYING.

It is unnecessary to advise you to avoid studying chemistry, or indeed any subject, *merely* by way of "preparation for examination." You will not so mistake the means for the end. You are studying to fit yourself for your position in the world. Work diligently, study thoughtfully and deliberately—above all, be thorough; otherwise your knowledge will be inaccurate and transient, and will be unaccompanied by that enlightenment of the understanding, that mental training, mental discipline, and general elevation of the intellect which constitute, in a word, education. When you are thus educated, you will with ease and pleasure pass any examination in the knowledge you have thus acquired.

All authorities on education, whether statesmen, teachers, or examiners, regard "examination," even by the most highly skilled "Board," with ample time at its disposal and a wide area from which to select questions, as but a partial test of knowledge and an extremely imperfect test of education. It is the best, however, that has been devised, and is especially useful when, following instead of leading education, it is restricted to the subjects of a well-defined, earnestly-followed, compulsory curriculum of study—a curriculum defined and directed by a competent representative body, wisely administered by properly qualified teachers, and earnestly followed by pupils possessing sound preliminary training.

Students! in all honor and in the highest self-interest take care that any inefficiencies inseparable from "examination" are abundantly compensated by the extent and precision of your knowledge and by the soundness and thoroughness of your whole education.

### List of Apparatus for Experiments in Analysis.

List of Apparatus suitable for a three months' course of practical chemistry in the summer session of medical schools or for any similar series of lessons—including the preparation of elementary gases, analytical reactions of common metals and acidulous radicals, analysis of single salts, chemical toxicology, and the examination of urine, urinary sediments, and calculi:—

- One dozen test-tubes.
- Test-tube stand.
- Test-tube cleaning-brush.
- A few pieces of glass tubing, 8 to 16 in. long, with a few inches of India-rubber tubing to fit.
- Small flask.
- Two small beakers.
- Two small funnels.
- Two watch-glasses.
- Two or three glass rods.
- Wash-bottle.
- Test-paper.
- Filter-paper.
- Small pestle and mortar.
- A 2-pint earthenware basin.
- A 2-inch and a 3-inch evap. basin.
- Two porcelain crucibles.
- Blowpipe.
- Crucible tongs.
- Round file.
- Triangular file.
- Small retort-stand.
- Sand-tray.
- Wire triangles.
- Platinum wire and foil.
- Towel.
- Two dozen corks.

(*This set, packed in a deal box, can be obtained of any chemical apparatus maker for about seven dollars.*)

### Apparatus for Experiments in Synthesis and Analysis.

A larger set, suitable for the performance of most of the synthetical as well as analytical experiments described in this manual:—

- A set of evaporating-basins, of the following sizes:—
  - One 8½-inch.
  - One 7¼-inch.
  - One 6½-inch.
  - One 4-inch.
  - Two 3-inch.
- One retort-stand and three rings.
- Two test-glasses.
- One half-pint flask.
- One half quire of filter-paper.
- Two porcelain crucibles.
- One measure-glass, 5 oz.
- Blowpipe, 8-inch, Black's.
- Two glass funnels.
- One doz. test-tubes (German glass).
- One test-tube brush.
- One pair of 8-inch brass crucible tongs.
- Two soup-plates.
- One flat plate.
- Two spatula-knives.
- One pair of scissors.
- One round file.
- One triangular file.
- One half pound of glass rod.
- One half pound of glass tubing.
- One ft. small India-rubber tubing.
- Three dozen corks of various sizes.
- Platinum wire and foil.
- Test-papers.
- A nest of three beakers.

(*This set, packed in a case, can be obtained of any chemical-apparatus maker for about twelve dollars.*)

A sponge, towels, and note-book may be included.



### List of Furniture of a Chemical Laboratory.

The following apparatus should be ready to the hands of students following an extended course of practical chemistry in a room set apart for the purpose:—

- A bench or table and stool.
- Water-supply and waste-pipe.
- A cupboard attached to a chimney with an outward draught.
- A furnace fed with coke; tongs, hot-plate, or sand-bath, etc.
- A waste-box.
- Shelves for chemicals and other materials in jars or bottles.
- Gas-supply and lamp with flexible tube (or a spirit-lamp and spirit).
- Test-tube rack, two dozen holes.
- Iron stand or cylinder for supporting large dishes.
- Iron adapters for fitting dishes to cylinder.
- Pestle and mortar, 5 or 6 inches.
- One 6-inch funnel.
- Brown pan, 1- or 2-gallon.
- White jug, 1-gallon.
- Water-bottle, quart.
- Twenty-eight test-bottles, 6-oz.

Other articles, such as flasks, retorts, receivers, condensers, large evaporating-dishes, may be obtained as wanted. In Quantitative Analysis the apparatus described in the sections on that subject will be required.

### List of Reagents.

Certain chemical substances are used so frequently in analytical processes that it is desirable to have small quantities placed in bottles in front of the operator. As these "reagents" or "test-solutions" are generally employed in a state of solution, nearly all the solid salts may at once be dissolved (in distilled water). The bottles employed should be well stoppered, and of five or six ounces capacity. The bottles should not be more than three-quarters full; single drops, if required, can then be poured out with ease and precision. The following list of test-solutions is recommended; directions for methods of preparing those not readily purchasable will be found by referring to the Index:—

- Sulphuric Acid, strong.
- Nitric Acid, strong.
- Hydrochloric Acid, strong.
- Acetic Acid, strong.
- Sol. of Potash, 5 per cent. or B. P.
- " Soda, 5 to 15 per cent.
- " Ammon., 10 per ct. or B. P.
- Lime-water, saturated.

The next nine may contain about 10 per cent. of solid salt:—

- Carbonate of Ammonium, with a little solution of Ammonia added.
- Chloride of Ammonium.
- Phosphate or Arseniate of Ammonium.
- Sulphydrate of Ammonium.
- Chloride of Barium.
- Chloride of Calcium.
- Phosphate of Sodium.
- Neutral Chromate.

The succeeding seven may have a strength of about 5 per cent.:—

- Ferrocyanide of Potassium.
- Ferridcyanide of Potassium.
- Iodide of Potassium.
- Oxalate of Ammonium.
- Perchloride of Iron.
- Nitrate of Silver.
- Perchloride of Platinum.

### List of Solid Chemical Substances for Study.

List of chemical substances necessary for the practical study of the non-metallic elements mentioned on pp. 13 to 31. The quantities are sufficient for several experiments.

| | | | |
|---|---|---|---|
| Chlorate of Potassium | 1 oz. | Phosphorus | ½ oz. |
| Black Oxide of Manganese | 1 oz. | Hydrochloric Acid | 1 oz. |
| Zinc | 1 oz. | Sulphur | ½ oz. |
| Oil of Vitriol | 2 oz. | Iodine | ¼ oz. |

List of chemical substances necessary for the *analytical* study of the metallic and acidulous radicals (pp. 60 to 378). The quantities will depend on the frequency with which experiments are repeated or analyses performed; those mentioned are sufficient for one or two students. The articles are given in the order in which they will be required. The eight substances mentioned in the above list are included:—

| | | | |
|---|---|---|---|
| The set of test-solutions described on the previous page. | | Black Oxide of Manganese | ½ lb. |
| | | Chloride of Manganese | ¼ oz. |
| Carbonate of Potassium | 1 oz. | Chloride of Cobalt | 50 grs. |
| Tartaric Acid | 1 oz. | Nitrate of Nickel | ¼ oz. |
| Litmus | ¼ oz. | Chloride of Chromium | ¼ oz. |
| Sulphate of Magnesium | 1 oz. | Gold leaves | 2 or 3 |
| Sulphate of Zinc | 1 oz. | Chloride of Cadmium | ¼ oz. |
| Alum | 1 oz. | Nitrate of Bismuth | ¼ oz. |
| Sulphide of Iron | 1 lb. | Bromide of Potassium | ¼ oz. |
| Oak-galls | 1 oz. | Starch | 1 oz. |
| Sulphocyanate of Potassium | ¼ oz. | Nitrate of Potassium | 1 oz. |
| White Arsenic | ½ oz. | Copper borings or turnings | 1 oz. |
| Zinc | ½ lb. | Indigo | ¼ oz. |
| Charcoal | ½ lb. | Chlorate of Potassium | 1 oz. |
| Sulphate of Iron | 1 oz. | Iodine | ½ oz. |
| Copper foil | 1 oz. | Spirit of Wine | 1 oz. |
| Sulphate of Copper | 1 oz. | Sulphur | 1 oz. |
| Tartar Emetic | ½ oz. | Acid Oxalate of Potassium | 1 oz. |
| Mercury | 1 oz. | Citric Acid | 1 oz. |
| Corrosive Sublimate | ½ oz. | Phosphorus | 1 oz. |
| Calomel | ½ oz. | Borax | 1 oz. |
| Tin | 1 oz. | Turmeric | 1 oz. |
| Bicarbonate of Sodium | 1 oz. | Benzoic Acid | 50 grs. |
| Acetate of Lead | 1 oz. | Fluor Spar | 1 oz. |
| Cyanide of Potassium | ½ oz. | Tannic Acid | 50 grs. |
| Hyposulphite of Sodium | 1 oz. | Gallic Acid | 50 grs. |
| A Lithium Salt | 10 grs. | Pyrogallic Acid | 50 grs. |
| Nitrate of Strontium | ¼ oz. | | |

The quantities of materials required for the study of Chemistry *synthetically* will necessarily vary with the desires and tastes of the operator, or according to the number and requirements of students working together.

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# CHEMISTRY:

## GENERAL, MEDICAL, AND PHARMACEUTICAL.

### INTRODUCTION.*

The infinite variety of solid, liquid, and gaseous substances of which our earth and atmosphere are composed, may be resolved with more or less difficulty into distinct forms of matter appropriately termed Elements, for by no known means can they be further decomposed. Some seventy or more elements have been proved to exist. A few (such as gold) occur naturally in the uncombined state, but the greater number are combined in so subtle a manner as to conceal them from ordinary methods of observation. Thus none of the common properties of water indicate that it is composed of two elements, both gases, but differing much from each other: nor can the senses of sight, touch, and taste, or other common means of examination, detect in their concealment the three elements of which sugar is composed. The art by which these and all other compound substances are resolved into their elements is termed Chemistry, a name derived possibly from the Arabic word *kamai*, to conceal.† The *art* of chemistry also includes the construction of compounds from elements, and the conversion of substances of one character into those of another. The general principles

* Students using this book as a guide in following chemistry practically should read the first three pages, and then commence work by preparing oxygen. All students should read the prefatory pages, especially the page of "Advice to Students."

† The idea that common metals contained valuable metals concealed within them was the one seed from which mainly sprung chemical knowledge. The men who endeavored to find the secret of such concealment were appropriately termed *alchemists*, and their efforts spoken of as *alchemy* (*al kimia*, from *kamai*, to conceal). Their persistent labors, generation after generation, were unsuccessful so far as the transmutation of baser metals into gold was concerned, yet were invaluable to posterity. For new substances were discovered and truths of nature unveiled; from these discoveries multiplication of discoveries resulted, and thus grew the still-growing branch of knowledge called Chemistry.