

**THE ELEMENTS OF CHEMICAL
ARITHMETIC, WITH A SHORT
SYSTEM OF ELEMENTARY
QUALITATIVE ANALYSIS**

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The Elements of Chemical Arithmetic, with a Short System of Elementary Qualitative Analysis
by J. Milnor Coit

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CHEMICAL ARITHMETIC
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QUALITATIVE ANALYSIS.

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PREFACE.

THIS little manual is intended to supplement the teaching of the text-books of descriptive chemistry, and to be used as a companion to them, by those who desire to make the whole subject more practical. It is the result of the author's experience after several years of elementary science teaching.

Part I. contains some of the more important rules and principles of chemical arithmetic, followed by a series of problems, which will not be found to be above the comprehension of the average student in the schools. The matter relating to chemical theory, and the rules, have been collected from the best authorities.

Part II. is devoted to an elementary system of qualitative analysis, and the best methods have been adopted. This part of the book can be used separately, and can be taught together with any good work in descriptive chemistry, such as Eliot & Storer's, Shepard's, Remsen's, or Avery's Chemistry. An intelligent student can, with the occasional supervision of his instructor, work out by himself the reactions and the separations as given in

the tables. The tables are those generally in use. Tests are given for the more common metals and acids only, and the reagents indicated are those which almost any school laboratory will afford.

J. M. C.

St. PAUL'S SCHOOL,
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PART I.

CHEMICAL ARITHMETIC.

CHAPTER I.

INTRODUCTION.

1. Matter is anything that occupies space.

2. Divisions of Matter. Three divisions of matter are recognized in science, — masses, molecules, and atoms.

A *mass* of matter is any portion of matter appreciable by the senses.

A *molecule* is the smallest particle of matter into which a body can be divided without losing its identity; or it is the smallest portion of matter which can exist by itself.

An *atom* is a still smaller particle produced by the division of a molecule; or it is the smallest portion of matter that can go into combination.

EXAMPLES. The sun and a grain of sand are masses of matter. The smallest particle of salt which can exist and which exhibits the properties of salt is a molecule. The minute particles of chlorine and sodium which compose the molecule of salt are atoms.

A mass is made up of molecules, and a molecule is composed of atoms.

3. Attractions of Matter. The three forms of attraction admitted in science are:—

First. *Gravitation*, or the attraction between masses.

Second. *Cohesion*, or the attraction between like molecules; adhesion between unlike molecules.

Third. *Chemical attraction*, or the attraction between unlike atoms.

EXAMPLES. The attraction between the sun and the planets, or between the earth and all bodies upon it, is *gravitation*. The attraction between the molecules of a piece of marble is *cohesion*. The attraction between a liquid and solid,—as, for instance, when you dip your hand into water it becomes wet,—or between two different solids at the surface, as shown by the action of cements, is *adhesion*. The attraction between the unlike atoms of chlorine and sodium by means of which we have an entirely different substance, salt, is *chemical attraction*.

4. Province of Physics. Physics is that department of physical science which studies the results which come from the molar and molecular conditions of matter.

5. Province of Chemistry. Chemistry studies matter in its atomic condition. It investigates the laws and conditions of chemical changes, and seeks to account for some of the phenomena connected therewith.

6. Physical Changes. Physical changes are those which take place outside the molecule; they have no effect upon the molecule itself nor alter the identity of the matter operated on. The study of physics is a study of physical changes.

7. Chemical Changes. Chemical changes take place through the atoms and within the molecule. They alter the character of the molecule, and hence destroy the

identity of the matter itself. The study of chemistry is a study of chemical changes.

EXAMPLES. The change of water into ice and steam, or the change of any solid into a liquid, or of any liquid into a vapor, are *physical changes*. But when water is subjected to the influence of the electric current, it undergoes a more radical change; the water disappears, and in its place appear two gaseous substances, oxygen and hydrogen, entirely different from the water from which they were derived. This is a *chemical change*.

8. Physical Properties. Physical properties are those properties which bodies possess in virtue of their molar or molecular condition.

9. Chemical Properties. Chemical properties are those which result from the atomic composition of the molecule.

10. Chemistry defined. Chemistry is that branch of physical science which treats of the atomic composition of bodies, and of those changes in matter which result from an alteration in the kind, the number, or the relative position of the atoms which compose the molecule.

11. Analysis and Synthesis. The two processes by which the chemist seeks to find out the composition of matter are analysis and synthesis.

Analysis consists in separating the molecule into its constituent atoms.

Synthesis consists in putting together constituent atoms to form the molecule.

CHAPTER II.

MOLECULES AND ATOMS.

12. Chemical Definition of the Molecule. A molecule is the smallest particle of any substance which can exist in a free state in nature.

Molecules classified. Molecules are of two classes:—

First. *Elementary molecules*, or those whose atoms are alike.

Second. *Compound molecules*, or those whose atoms are unlike.

13. Simple Substances are those whose molecules contain like atoms.

14. Compound Substances are those whose molecules contain unlike atoms.

15. Number of Simple Substances. There are sixty-eight elementary substances, as far as has been investigated by chemical science; that is, sixty-eight substances whose molecules contain like atoms. Therefore it is obvious that there are sixty-eight different kinds of atoms. From combinations of these sixty-eight kinds of atoms all the different varieties of matter result. We cannot resolve a simple substance into any other substances or atoms.

16. Ampère's Law. "Equal volumes of all gases, simple as well as compound, under like conditions of temperature and pressure, contain the same number of molecules."