ELEMENTARY MODERN CHEMISTRY

OSTWALD AND MORSE

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PREFACE

The beginner in the study of chemistry finds interest and pleasure, first of all, in the remarkable new facts which are placed before him, and this is both natural and desirable. No one can master the science without much study of properties and reactions, and minute acquaintance with as many phenomena as possible is a fundamental requisite. Modern chemistry has, however, a number of general laws which appear everywhere through it, connecting various facts in the most interesting way. Before study has gone very far it becomes necessary to begin the statement of these laws and to indicate how the facts already learned group themselves about them. Two purposes are served by this method of presentation. First, a real *science* of chemistry begins to unfold itself to the student, and second, the acquisition of more new facts is made easier and more interesting.

We have planned in this book to present a sufficient number of facts and experiments to fill the time usually devoted to a first course, and at the same time we have endeavored to fit these facts, as far as possible, to the simpler of the general laws now firmly established as the basis of the science of chemistry.

It is not to be expected or desired that every teacher will wish to follow exactly the order we have chosen. Each teacher of a science must find the individual best way of presenting it. We believe, however, that the experiments chosen and the general laws explained will serve as a fitting introduction, and that they will lead naturally to the desired development of scientific methods of thought by the student.

The drawings illustrating this book were made, in nearly every instance, in the laboratory from apparatus actually set up and tested for performing the experiment described. The successful achievement of this laborious task is due to the scientific training and artistic skill of Miss Elizabeth D. Gray, of Lynn, Mass.

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MODERN CHEMISTRY

CHAPTER I

SUBSTANCES AND PROPERTIES

1. Properties. If a body is shown to you with the question, What is this? the answer is to be found by investigating the body in various ways and finding out what its *properties* are. It may be white and made up of little grains with shining surfaces; it may taste sweet and dissolve readily in water, giving a sweet taste to the water; it may make moist fingers sticky when it is handled. From the evidence thus obtained you would conclude that the body is *sugar*.

This conclusion was reached after an examination of the properties of the body. It was observed *by the eye* and found to have a white color and shining surfaces. It was examined by the *taste* and found to be sweet. It was touched and found to be a solid, and by holding it in the hand it could be shown to have weight. When brought into contact with another body, water, it lost its visible properties, disappearing as far as the eye was concerned. But it still retained the properties which belonged to taste, since the liquid formed tasted like the original body.

2. Specific properties. In the study of chemistry we learn all we can about the properties of bodies, but we pay special attention to such properties as are independent of the shape or size of the piece studied. These are called the *specific* properties of the body. *Color* is easy to see — we can apply this test even when we are not very near; *luster* is another such property, and still another is the *state* in which it exists — whether it is a solid, a liquid, or a gas. Our other tests — the taste of the body and its solubility — are harder to apply, and involve the use of other bodies.

3. Substances. A body which is studied with reference to its specific properties is called a *substance.* Sugar is the same substance, whether we mean a large or a small piece.

Experiment 1. Examine a lump of sugar with the eye alone and then with a magnifying glass. Can you find any difference in the specific properties at different points?

Experiment 2. Examine a piece of granite carefully, first with the eye alone and then with a magnifying glass.

The granite evidently consists of more than one substance. The reddish parts with smooth plane surfaces are feldspar, the white parts are quartz, and the black, shiny bits are thin plates of mica.

4. Mixtures. Bodies which have different properties are evidently different substances and we give them different names. If a body consists of several substances which can be distinguished from each other, it is called a *mixture.* Granite is a mixture, since it consists of three substances, — quartz, feldspar, and mica. Sugar is not a mixture but a simple substance, since all the pieces are the same in all of their specific properties. Very often the parts of a mixture are so small that they cannot be distinguished by the eye alone. A magnifying glass or a microscope may then be used in examining them.

Experiment 3. *Demonstration.* An enlarged picture of a section of granite as seen through the microscope should be shown; if possible, as seen by polarized light.

Figure 1 shows the appearance of a section of granite as seen through the microscope. Figure 2 shows the same section illuminated by polarized light.

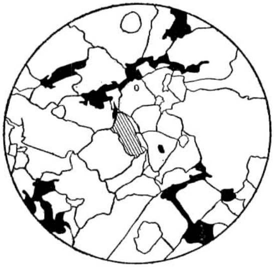

FIG. 1. Section of granite (ordinary light)

FIG. 2. Section of granite (polarized light)

Many bodies which to the eye are not mixtures are found to consist of several substances when examined with a microscope. The stronger the magnifying power the greater the number of bodies which are found to be mixtures, but even under the most powerful microscope many substances show no parts which are different from one another.

5. Homogeneous substances. Substances which are not mixtures are said to be *homogeneous*. Sugar is a homogeneous substance and so are water and air. The name "substance" is applied to liquids like water and gases like air, as well as to solid bodies like sugar and quartz. All substances have the property of *weight*, which can be felt by holding them in the hand and which can be exactly measured by a balance. As we shall see later, gases have weight also, although they are very much lighter — usually a thousand times lighter — than the same volume of liquids or solids.

In chemistry we study the specific properties of homogeneous substances only. Mixtures, of course, consist of homogeneous substances too, but of two or more different ones; and if a mixture is given to us for study, we separate it into its homogeneous parts and study each separately. We can then add up the properties of the various parts and the sum will be the properties of the mixture.

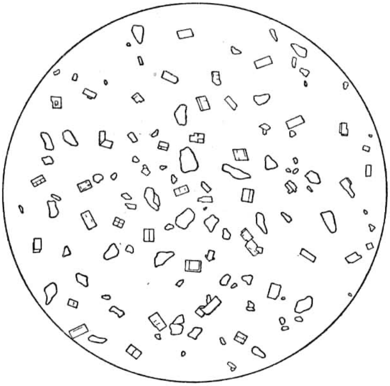

FIG. 3. A mixture of sand and sugar under the microscope

The grains with sharp edges and corners are sugar and the rounded grains are sand

6. The properties of a mixture. Suppose we have a mineral which is composed of equal parts by volume of a black substance and a white one. The color of the mineral will be gray. If the specific gravity of the white substance is 5.0 and that of the black substance is 7.0, the specific gravity of the mineral will be 6.0, for each cubic centimeter of it consists of half a cubic centimeter of a substance of specific gravity 5.0 (that is, 2.5 gm. of it), and half a cubic centimeter of a substance of specific gravity 7.0 (that is, 3.5 gm.), and so the total weight of one cubic centimeter of the mixture will be

$$2.5 \text{ gm.} + 3.5 \text{ gm.} = 6.0 \text{ gm.}$$

7. Phases. The different parts of a mixture (each a homogeneous substance by itself) are called its *phases*. Granite is a mixture of three phases, — quartz, feldspar, and mica. A homogeneous substance consists of only one phase, for every part of it has the same specific properties. Different phases have different specific properties, and when different solid phases are brought together they form a mixture whose properties can be calculated as already shown from the properties of the various phases. With liquids it is not always as simple as this, for they very often act on each other to form a new phase — one which has properties different from those calculated by the simple rule given above. Gases never form mixtures, but unite in every case to form one single new phase. The changes which take place when gases unite are the very simplest of all *chemical processes*, and we shall study about them soon.

QUESTIONS

1. What is a body?
2. What is the distinction between a body and a substance?
3. What is a mixture?
4. What is a homogeneous substance?
5. What is a phase?
6. How can the properties of a mixture be calculated from those of its parts?

CHAPTER II

MELTING AND SOLIDIFICATION

8. Melting point and freezing point. Any solid whatever can be changed into a liquid if its temperature is raised to a high enough point, and any liquid can be changed to a solid if it is cooled to a sufficiently low temperature. Water changes into ice at the freezing point, and ice melts back into water again at the *same temperature.* Water and ice are two phases of the same substance, and when they are mixed together the temperature of the mixture very soon becomes 0° C. This is the freezing point of water and the melting point of ice, and it is the temperature at which ice and water can exist together.

Experiment 4. Place some finely crushed ice in a beaker and watch the temperature on a thermometer placed in the ice. Warm the beaker with the hand. Warm it slightly with a Bunsen burner. At what temperature can water and ice exist in the same vessel?

9. The freezing point of water. A piece of ice always has the same temperature while it is melting, without regard to the amount of water or ice which is present. In the same way, water always has the same temperature while it is freezing. If we keep on cooling it, the water will all change to ice at 0° C. and the solid body, "ice," can then be cooled as far as we choose. If we heat it and keep on adding heat, the ice will all melt at 0° C. and we can then cause the water to rise in temperature; but not indefinitely, since at 100° C. the water will boil away.