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Die Schule der Chemie. Erste Einführung in die Chemie für Jedermann. By Wilhelm Ostwald. Part i., General Considerations. Pp. vii+186. (Braunschweig: Friedrich Vieweg und Sohn, 1903.) Price 4.80 marks.

PROF. OSTWALD is an ingenious man; in his own language, the attribute might be expressed by the adjective "schlau." Having, as he tells us in his preface, published volumes of the greatest importance, and of the widest range, on physical chemistry for the use of investigators in the domains of chemistry and physics, and having next written his work on elementary chemistry for the ordinary student commencing the study of the subject in universities or Polytechnika (a work of which an excellent English translation by Dr. Findlay has been brought out), he now makes an attempt in this very elementary work to reach a larger public, and has written this most amusing book for the use of youngsters about ten to thirteen years of age. The plan adopted is to introduce by means of dialogue some chemical facts concerning hydrogen, oxygen, water, nitrogen, air, and carbon and its oxides, and incidentally to consider the nature of pure substances and mixtures, including solutions, the phenomena relating to change of state, and the behaviour of gases with alteration of pressure and temperature. All these subjects are treated in a philosophical manner, and his own views are incidentally, and one might almost say insidiously, introduced, so as to set the young mind on what he considers to be the right track.

Beginning with the notion of a "Stoff," or "stuff"—a convenient word, inasmuch as the word "Substanz," or "substance," from its derivational point of view, by no means accords with the views of the author—the properties of a stuff—sugar—are considered, and the pupil is made to reject the idea of a "substance" by subtracting properties, and recognising that there is no underlying entity. "You must rid yourself of the idea," the pupil is told, "that there is anything underlying the properties of a thing, which is more real or important than the properties themselves. Formerly, before science had progressed, people held such notions, and our language still retains expressions which almost force us to accept the notions. But when once that error is recognised, it can be avoided." To which the pupil replies that he is afraid that he will have difficulty in getting rid of the old views. "But," replies the teacher, "when you know more chemistry, you will see that you have to do only with the properties of stuffs, and never with their real nature; so that you will forget the incorrect method of expression."

Later on, in talking about the melting point of ice, the teacher defines it as "that temperature at which solid and liquid can exist beside each other"; and the

pupil asks, "Then, who made this law?" The teacher answers, "The word *law* is only a way of speaking. It has been found that stuffs behave like this, and they have been compared to obedient pupils who always do what they are told. In science the word *law* means only that we find that things are related to each other in a certain way; and that is expressed in a general form."

In discussing change of state, the teacher refers to the term "state of aggregation," and explains it by the conception of atoms. He elucidates the word "hypothesis," but declines to accept the atomic hypothesis as an "explanation" of states of aggregation, and suggests the word "Formarten," and this leads to the consideration of differences between the states of solid, liquid, and gas. Having got the pupil to infer that liquids when cooled become solid, and solids when heated melt at definite temperatures, the pupil asks, "What determines these temperatures?" "That is a stupid question. You should rather ask: To what other properties do they show that they are related? It is just as if you were to ask: why are there camels? All that you can ask is, what are the properties of these animals, and how are these properties connected with those of other animals?"

Talking of the combustion of a candle and its disappearance, the pupil says, "But it really vanishes before my eyes." "Yes," says the teacher, "it becomes invisible. But can't it change into something invisible?" "There are no invisible things," says the pupil. "Oho!" replies the teacher. "No," says the pupil, "ghosts and goblins don't exist." "Even they are said to be sometimes visible," answers the teacher. "But can you see the air?" "Hum—no," says the pupil. "But the air is changed by burning. I don't see how." And so the formation of an invisible gas is brought out, and the method of determining its weight.

In considering heat and light produced by combustion, their absence of weight is remarked, and the pupil guesses that they are "forces." The teacher corrects, and explains that what used to be known as force is now known as energy, and that it is defined as "what causes things to change." Stuffs contain chemical energy when they can act on each other and form new stuffs, and part of their chemical energy takes the form of heat or light, and sometimes of electrical or mechanical energy. The pupil is made to throw out suggestions on the conversion of one form of energy into another, and his own energy is traced to the chemical energy he takes in as food. "But I am often hungry, even when I do nothing," says the pupil. And it is explained that his temperature has to be maintained, and that if he likes he can produce light by rubbing two pieces of sugar together, and electricity by rubbing sealing-wax with a cloth. In this way an idea is given of transformation and equivalence of energy.

Compounds and elements are next considered, and the pupil asks the natural question, "Are the constituents actually in the compound or not?" "You haven't considered your question. A compound is not a bag or a box in which something can be contained.

If you mean by 'in' that the constituents can be got out again by appropriate means, then they are 'in.' But you mustn't suppose that the constituents are locked up in the compound, somehow or other, with all their properties."

So far, it might be supposed that this system does not differ from the "heuristic" system which has been so much in evidence lately. But that is not so. There is no attempt made to prove anything exhaustively, or to let the pupil do so; as a rule, the experiment is made by the teacher, and the pupil is sometimes allowed to repeat it. A little later, in considering the classification of certain elements, the pupil remarks, "But it appears to me not very scientific to take anything on trust that I can't prove." To which the teacher answers, "You will be able to prove this, when you know more chemistry."

Teleological "explanations" are conspicuous by their absence. Yet when the pupil inquires, "Why have most chemical stuffs such a nasty smell?" he is told, "If they hadn't, we shouldn't notice them, and we should have our skin hurt and get a cold in the head." This is not quite consistent.

That the cost of an article depends on the amount of work put into it is illustrated in the case of aluminium, the compounds of which, such as clay, have almost no value, while the metal is costly. The pupil inquires, "Can the work be got out of the aluminium again?" "Yes," says the teacher, and shows the pupil the reduction of iron oxide by means of powdered aluminium.

The pupil is constantly afraid that he will not be able to retain in his head all that he is taught. But he is comforted by being assured that he will have to go over the subject again, and that he really knows a good deal. These little remarks are very natural, and the answers are most judicious. But we agree with the pupil when he says "Chemistry is a frightfully big subject!" Indeed, he is told that no one man knows all about oxygen, in reply to a remark, flattering to the teacher, "But surely you know all about this!" Much is in writing, however; and he then asks, "Is everything in these books right?" "Most of it," he is assured; and what is best about scientific books is that no one intentionally tries to deceive.

The action of iron oxide in accelerating the evolution of oxygen from potassium chlorate is likened to that of oil on a rusty machine, or of a whip on a horse. And so catalytic phenomena are introduced. There are many such digressions, and often the teacher lets them go on to a certain point, and then harks back to the actual subject of the lesson.

The pupil is introduced to the idea of mass-action after he has made the natural remark, "But iron is stronger than hydrogen, and takes the oxygen from it." "First iron was stronger than hydrogen, and afterwards, hydrogen stronger than iron. That's surely a contradiction." "The contradiction is owing to your looking at the reason of chemical changes as a mechanical power or force; such a force has never been proved to exist or measured." And when pressed,

the teacher fences thus, "A man can carry a good lot of water; but a larger quantity of water can carry a man." "So you mean, chemical change depends on which stuff is present in largest quantity." "That's about it; but we must go back to hydrogen." And the digression closes.

The laws of recurrence and of continuity are illustrated and formulated; the existence of allotropic forms of carbon is referred to the difference in their content of energy, and the source of all terrestrial energy, except that of the tides, is traced to the sun, due attention being paid to the reciprocal action of plants and animals.

One admirable feature of the work is that the pupil is allowed to fall into all kinds of traps. For example, he calculates the conversion of the Fahrenheit into the centigrade scale in every conceivable wrong manner before he finds the right use of the "32"; and after he has seen experiments on the compressibility of air and the observations have been written down, he is made to find the law. The method is so good that it is worth quoting. "Suppose you have ten apples: some in your pocket, some in your hand. Call the number of apples in your pocket t , and those in your hand h . Now you know you can calculate t if you know h , and h if you know t . Why is that?" "Because I know that together they make 10." "You see then $t+h=10$; and you can calculate t if you know h , and *vice versa*." "That's neat. But I could have done that without a formula." "Yes; but only because the formula is so simple. Now try if your pressures and volumes can be calculated as simply." "Let me see:— $75+100=175$; $62.5+120=182.5$; $60+150=210$. No; the sum is always getting bigger." "The sum formula doesn't fit, then. You might have seen that you can only add like things, such as apples to apples: you can't add a pressure to a volume." "What sort of formula can it be, then?" "If p gets bigger, v gets smaller. What kind of combination of p and v will give that result?" "Probably a whole lot." "Quite true; but not many simple combinations. Try the simplest you can think of, besides the sum." "Perhaps the product. If one factor gets smaller, the other must get larger, so as to make the same product." And so he gets it out.

It must be allowed that this is excellent teaching. The whole book is so lively and conversational, and withal so amusing, that it well deserves reading by those of an older generation. It is probably likely to be more useful to teachers than to pupils, for it will serve them as a guide. As the publishers say in their preface, the standpoint from which the book is written is the most modern one; some, perhaps, may consider it too modern, and that some of the doctrines expounded are as yet not in general circulation, and perhaps never will attain universal consent. That is a matter of opinion, and, of course, the author believes that they will. Anyhow, he has taken advantage of the lessons of all missionaries—get hold of the children, and the doctrines will spread. And if an attractive book can help their dissemination, this is one.

W. R.