

THURSDAY, MARCH 17, 1898.

## THE CHEMISTRY OF THE METALS.

*A Treatise on Chemistry.* By H. E. Roscoe and C. Schorlemmer. Vol. ii. The Metals. New edition completely revised by Sir H. E. Roscoe, assisted by Drs. H. G. Colman and A. Harden. Pp. 1192. (London: Macmillan and Co., Ltd., 1897.)

NEARLY twenty years have elapsed since the appearance of this part of Roscoe and Schorlemmer's well-known treatise, and as in the interval much important work has been done in connection with the classification of the elements, with metallurgical processes, with chemical manufactures and new theories bearing upon our views of the constitution of salts, the condition of dissolved substances and other important questions have been proposed, it is obvious that the time has come when a new edition is urgently needed. It may at once be said that the revision has been accomplished with great care, with full knowledge, and, speaking generally, with a great measure of success.

The introductory chapters, which occupy 150 pages, naturally contain the most debateable matters, concerning which, probably, there will always be considerable differences of opinion, relating as they do to such subjects as the characteristics of metals, to valency, to classification and other subjects which are less matters of fact—for there is usually not much dispute about the facts—than of inference, and must therefore assume different aspects according to the degree of importance with which they are invested in different minds.

Take, for example, the consideration of those properties of the metals which seem to some people to mark off these substances very clearly from the remaining elements, which are commonly referred to as non-metals. Of course any attempt to arrange natural things into groups, the members of every one of which are distinguishable sharply from the members of other groups, fails hopelessly when such attempt is carried too far; but this need not prevent such attempts from reaching that measure of partial success which is practically useful. It is, in fact, impossible to avoid classification, for no sooner does a series of facts or phenomena become known than the mind involuntarily proceeds to arrange them into groups, and the pretence on the part of a few modern chemists that *no* scientific distinction can be drawn between metals and non-metals is not likely to be permanently maintained. The want of definiteness on this point in the book before us is to be regretted. We are told (pp. 5, 6) that "although the division into metals and non-metals is thus seen to be one which does not admit of exact definition, it is none the less true that the metals as a class do possess certain generic properties which the non-metals either do not possess at all or exhibit only in a very slight degree," and it is a little surprising to find that "among these properties that of metallic lustre may be specially mentioned." What then about iodine, graphite and tellurium, which most people agree to place among non-metals?

NO. 1481, VOL. 57]

Undoubtedly any attempt to provide a definition which shall be comprehensive enough to include not only the seven ancient metals, but such things as arsenic, antimony, titanium, as well as the true metals—sodium and the rest which have been made known in modern times—must fail; but that is not a reason for refusing to recognise in the great majority of those elements which show a disposition to form oxides of more or less pronounced basic character, certain other characters, chemical and physical, which, taken together, afford a useful criterion of the true metal, while for those elements which only imitate the metals in one character or more and fail in the rest, the term "metalloid," so long misapplied, might be appropriately retained. The true metal is malleable, with a good conducting power for heat and electricity, and forms no gaseous or vaporisable compound with hydrogen. The semi-metal or metalloid is brittle, a bad conductor, and in many cases produces a gaseous hydride.

The general adoption of Mendeléeff's scheme of classification of the elements has no doubt served to increase the difficulty felt as to the distinction of metal from non-metal; but even in the periodic table the non-metals are confined to the top right-hand corner, and display amid great physical diversity an assemblage of chemical characters which marks them off as a class.

Naturally there are elements which recall in respect to one set of relations the features of a metal, and in respect to another those of a non-metal, and these of course stand between; but to refuse to recognise these distinctions would be as inconvenient as a proposal to do without "orders" in botany because all botanists are not agreed about the diagnostic characters of every order in the vegetable world.

The authors have made a change of some importance in the sequence in which the metallic elements are taken for study in this volume. In the first edition they were grouped into families more or less entitled to be regarded as "natural"; but are now taken in the order of the periodic system. There is, however, a sort of acknowledgment of the inconvenience of this plan for the arrangement of matters for study, inasmuch as it is departed from at the very outset, sodium and not lithium being the metal first described. It must, however, be admitted that the authors have dealt with this difficult question in the liberal spirit proper to scientific men. They point out that while the arrangement of the elements in the order of their atomic weights has brought into view the remarkable relations among their properties which are formulated in the so-called "periodic law," and that this system stands upon a very firm basis of fact,

"the system will doubtless undergo modification as our knowledge increases, for difficulties occur which cannot at present be explained. Thus elements sometimes occur in the same group between which only a limited amount of analogy can be traced and, on the other hand, elements which have a good deal in common are sometimes separated widely."

This being admitted, it is a very doubtful advantage to have adopted the system, interesting and suggestive as it is, as the order for the contents of the book. This, however, is not of serious consequence inasmuch as the

X

volume is provided with a good index, and old-fashioned people who might be disposed to look for copper, silver and gold elsewhere will have no difficulty in finding a good and clear account of them, notwithstanding that they are sandwiched in between the metals of the alkalis and the metals of the alkaline earths.

The volume concludes with the history of those two remarkable substances argon and helium, and winds up by pointing out that "the existence of two substances having the properties of argon and helium is not in any way indicated in the periodic classification of the elements, and it is probable that their discovery will lead to modifications of that hypothesis," a statement with which even the most fanatical of periodic chemists will find it difficult to disagree.

One is tempted to think that, if we were not so familiar with it, *hydrogen* is the element upon which, in connection with any system of classification, wonder must be concentrated. Undoubtedly a positive element, similar in general chemical character to a metal, yet its volatility removes it far from any acknowledged metal, and its low atomic weight separates it in the periodic scheme from all the other gaseous elements. Its nearest allies are the metals of the alkalis, and towards them it stands, so far as physical character is concerned, much in the same relation as nitrogen to arsenic and antimony or oxygen to selenium and tellurium. And even as to chemical relations its position is analogous to that of nitrogen or of oxygen, notwithstanding that among the negative elements chemical activity generally diminishes as atomic weight increases; while in the series Li, Na, K, Rb, Cs, chemical activity increases with atomic weight.

The question of the molecular weights of the metals is one of great interest. It has been known for a long time, from the vapour densities of mercury, cadmium, and zinc, that the molecules of these metals are monatomic, while the semi-metal arsenic forms in the state of vapour a molecule composed of four atoms. Potassium and sodium are unmanageable, and no other metal is volatile enough to afford by this process any trustworthy results. But attempts have been made to estimate the molecular weights of a great many metals by observation of the depression of the freezing points of certain fusible metals—for example, of tin, lead, or bismuth (Heycock and Neville), or of the lowering of the vapour pressure of mercury (Ramsay) by solution in these fluids of determinate quantities of the metals under consideration. The general result of these experiments tends to the conclusion that in nearly all such cases the molecules are composed of one atom only. There is evidently room for further experimental inquiry in this direction, for there seems at present to be some conflict of testimony. The molecule of arsenic in the vaporous state is undoubtedly  $As_4$ , and its chief oxide is also admittedly  $As_4O_6$ . In like manner the molecule of antimonious oxide is  $Sb_4O_6$ , and by analogy one must conclude that the vapour of antimony, although not actually observable, must be tetratomic or  $Sb_4$ . When these vapours condense, either to the liquid or solid state, it would be contrary to all experience in other cases to suppose that they dissociate, and that the four atoms part company from each other. Yet this is what the results derived

from freezing point or vapour pressure experiments would lead to. There is also the curious fact that the theory of Dulong and Petit, which states that specific heat in the solid elements is inversely as the atomic weight, points to the atom, and not any congeries of atoms, as the physical unit in the solid. So that, for example, arsenic and cadmium, so different as regards vapour density, agree in atomic heat; thus—

	Specific Heat × Atomic Weight = Atomic Heat	
Arsenic	·0814 (Regnault)	74·4 = 6·05
Cadmium	·0542 (Kopp)	111·3 = 6·03

Probably in the solid the molecules settle down into some tactical relation to one another, in consequence of which the atoms of neighbouring molecules are brought as near together by cohesion as the atoms in any one molecule are by chemical attraction.

Turning again to the volume before us, there is much that must be interesting to readers of all classes, and especially in connection with the metallurgy of such metals as sodium and aluminium, concerning which Sir Henry Roscoe is in a position to give trustworthy information. As is well known, sodium was first obtained in 1807 by Sir Humphry Davy, who got it by the electrolysis of caustic soda. Subsequently Gay-Lussac and Thénard succeeded in decomposing that compound by means of metallic iron at a high temperature, but up to quite recent times it has been usual to manufacture it by distilling a mixture of dry sodium carbonate and charcoal, the metal passing over accompanied by the escaping carbonic oxide. But even in well-conducted operations the yield of metal corresponded to not more than about one-third of the theoretical amount.

A great improvement was introduced by Mr. Castner some fifteen years ago when he replaced sodium carbonate by caustic soda, and employed an intimate mixture of iron and carbon as the reducing agent. It is now interesting to learn that he has accomplished another great advance which consists in adapting the original method to manufacturing purposes, and we are told that whereas—

"in the year 1807 Davy, with his battery of 100 cells, found it impossible to produce the effects of decomposition on pieces of soda of more than fifteen or twenty grains in weight, the process has now been so amended that the plant at the works of the Aluminium Company, Limited, at Oldbury, manufactures about five tons of sodium per week."

What becomes of so large a quantity of this strange metal, considering that the Aluminium Company no longer makes aluminium, and sodium is no longer used for this purpose anywhere, is a question which naturally arises. And the answer is supplied pretty well by the book. Sodium is used for the manufacture of cyanides, the consumption of which in the process of extracting gold from poor ores and tailings must be now enormous. It is also used for the manufacture of sodium peroxide, for the production of metallic magnesium, and in the preparation of certain complex carbon compounds, of which the most important commercially is antipyrine.

The history of the metal aluminium has also many points of interest. The discovery of the metals sodium and potassium by Davy placed in the hands of chemists

new and very powerful agents, by which it became possible to isolate from their compounds several elements the existence of which was well recognised, but which had previously resisted all attempts to obtain them in a separate state. Among these was aluminium, which was seen for the first time in 1828 by Wöhler, who succeeded in decomposing the chloride by potassium. With the substitution of the cheaper sodium for potassium, and the occasional replacement of the chloride by the fluoride of aluminium, this was practically the method adopted by the experimentalist and manufacturer alike down to quite recent years. The Aluminium Company, already referred to, was formed for the purpose of working such a process with the use of sodium obtained more abundantly and cheaply than before by Castner's process. All this is now changed. So long ago as 1854 aluminium was deposited in the metallic state by the electrolysis of the fused chloride of aluminium and sodium according to the method introduced by Bunsen. It was also stated to have been obtained by the electrolysis of aqueous solutions of certain aluminium compounds, but this appears to have been a mistake. The method now adopted consists in subjecting to the electric current pure alumina in a fluid state, that is fused alone or dissolved in melted cryolite.

Now that the energy of falling water is being turned to account on a large scale, works have been established at Neuhausen near the falls of the Rhine, at Niagara, and at Foyers in Scotland, for the production of the current by means of vast dynamo machines, and its application, among other chemical manufactures, to the reduction of aluminium.

Little else remains to be said of the book except by way of commendation. A few minor matters have been passed over rather slightly. Thus the solubility of calcium sulphate in water containing chlorides is a matter of some importance from a technical point of view; and the simple statement of the text (p. 437), that "according to Anton 1 part of gypsum dissolves in 122 parts of a saturated solution of sodium chloride," is neither very precise, nor is it of much practical use. A long series of determinations of the solubility of calcium sulphate in chlorides is provided by the work of Lunge (*J. Soc. Chem. Ind.*, 4, 31), and by that of Tilden and Shenstone (*Proc. R. S.*, 38, 331). As regards the temperatures supposed to be indicated by the colours developed upon the surface of steel in the process of tempering, it has been shown, more especially by Turner, that these colours can be *successively* developed by protracted heating to the same temperature, and under any circumstances are not to be interpreted to within a considerable range of degrees. As the interesting lead tetrachloride has been properly mentioned, the more stable tetracetate (Hutchinson and Pollard) should have been noticed at the same place.

The whole of such a volume as this should be read attentively by every serious student of chemistry; and if this treatise does not displace all other English text-books devoted to mere description, it will be solely on account of the unfortunate but unavoidable high price, a consideration which necessarily influences so many students in their choice.

W. A. T.

#### SUBMARINE CABLE TESTING.

*Student's Guide to Submarine Cable-Testing.* By H. K. C. Fisher and J. C. H. Darby. Pp. 165. (London: *The Electrician* Printing and Publishing Co., 1897.)

THIS practical and useful little book is designed as its title indicates, and, as its authors state in their preface, to meet the requirements of young students in this particular branch of submarine cable engineering, and to endeavour to place before them in as concise and lucid a manner as possible, not only the practical problems involved in the study of cable-testing, but also the simple algebraical formulæ necessary for their solution.

Many of the large submarine cable companies now demand that their employés shall qualify themselves in electrical subjects, and shall pass certain examinations before being considered eligible for promotion from the lower to the higher grades of the service.

This very proper requirement on the part of the companies has resulted in stimulating their staffs to greater exertions; but it has been found that the ordinary text-books in circulation are either too theoretical and advanced for beginners, or fail to deal with and thoroughly explain just those particular points upon which they seek instruction.

The authors of the little work under review—practical electricians and cable engineers themselves—were constantly being asked for information upon these points, and their first effort to meet this demand upon their time and patience took the form of a small pamphlet entitled "Notes on Practical Cable-Testing," of which a small number was printed and issued privately.

This first effort was so far appreciated, as to encourage them to hope that a more ambitious work, carried out on the same lines, might be found still more useful; and although, as the authors modestly remark in their preface, "the scope of the present work is bounded by the requirements of the electrical examinations for supervisors, and the ordinary electrical outfit of all the company's stations," we venture to think they have so far succeeded in their purpose, that this book will be found of practical value, not only to those for whom it was originally written, but to all desirous of studying and understanding this most interesting subject.

As we have already observed, too many of the existing text-books are the works of theorists who do not concern themselves with the practical features of the matters upon which they write; in fact, who do not possess the necessary practical experience themselves, which would enable them to do so satisfactorily; and we think, therefore, that this little book will be accepted, and rightly so, as a useful contribution not only to our knowledge, but also to submarine cable bibliography.

The work is divided into two parts: the first dealing with simple testing, such as the measurements of resistances and of electrostatic capacity, together with the testing of batteries for electromotive force and internal resistance; and the second, with the various known methods which are adopted for the localisation of faults in submarine cables.