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CHEMISTRY

BY
RAPHAEL MELDOLA
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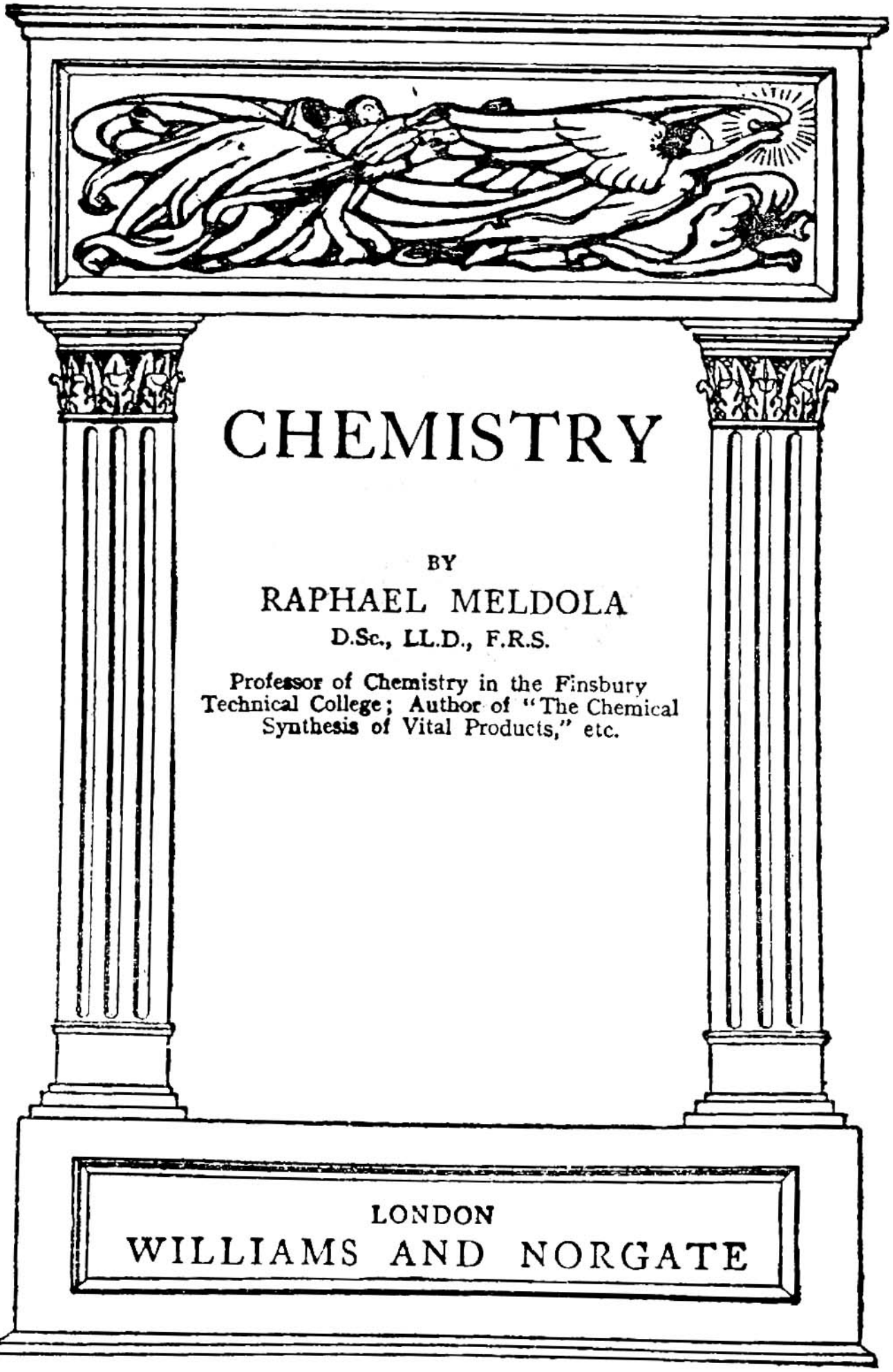

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CHEMISTRY

INTRODUCTORY

THE history of civilization reveals the fact that all highly developed nations in the course of their evolution have passed through phases characterised by the culmination of various human activities, physical and intellectual. Not that it is implied by this statement that the manifestation of extreme activity of a particular kind at one period was accompanied by a decline, or was developed at the expense of all other forms of activity. The lesson of history is that, concurrently with the general national activity, certain ages have witnessed special activities or have attained particular maxima of development which have served to stamp the age with some general characteristic. Thus, there was an age of Philosophy in ancient Greece, of Militarism in ancient Rome, of Sacred Art in mediæval Italy, and of Dramatic Poetry in England during the Elizabethan period. The influence of such epochs has extended perceptibly or imper-

ceptibly from a remote past down to the present time ; the recognition of this influence is embodied in the familiar adage that we are the heirs of all the ages. The special activity of the present time, Science, is one that we believe is destined to influence the future more profoundly than any of those activities which reached their culminating points in former ages.

In stating that we are now living in an age of Science, it is meant that we are getting into closer communion with Nature than has hitherto been possible. From the time when man became an observing and thinking being, he must have been impressed by natural phenomena ; but at no former period, so far as history has preserved records, has there been such intense activity in the questioning of Nature—in the systematized observation of facts, and in the endeavour to arrive at a knowledge of causes. It may be said that, among the more advanced nations, mankind is gradually beginning to grasp that great truth which in former ages was realized only by a few specially gifted individuals—the truth that the human race, although the intellectual crown and summit of terrestrial life, is not detached from and independent of its surroundings. The anthropocentric notions

which dominated thought in early times are slowly being replaced by that broader view which makes man a part of Nature—an organism adapted to his environment just like any other organism, but having the supreme advantage of practically unlimited adaptability by virtue of his intellectual development. It is now beginning to be perceived that this power of adaptation is synonymous with a knowledge of Nature's methods—in other words, that the present well-being and the future progress of the human race is dependent upon the development of Natural Science.

The recognition of the principle that man's dominion is inseparably bound up with scientific progress is embodied in Tennyson's lines :—" The crowning race ; Of those that eye to eye shall look on knowledge ; Under whose command is Earth and Earth's ; And in their hand is Nature like an open book."

This recognition has been brought about in modern times by the labours of those who have devoted and are devoting their lives to the study of Nature at first hand. It is the active army of original investigators who, in the first place, have become cognizant of the supreme importance of their work to the present and future welfare of the race. The

realization of the truth that Nature is to the earnest student "an open book" has become the trumpet call of the present age. The worker in the domain of Science is prompted by the knowledge that his results, directly or indirectly, immediately or prospectively, may be utilized for the benefit of humanity. His achievements, although strictly humanitarian in their ultimate bearing, cannot, however, be weighed and measured by a narrowly practical standard. The level of natural knowledge which has now been reached, and which is annually being raised, is the result of patient and laborious research, often extending over many years, sometimes over a lifetime. But only a small proportion of the work accomplished is of immediate utility; and that which is obviously useful to man is but the final stage of a long series of antecedent gropings after truth. The popular appreciation of Science, to be of real value to the nation, should, therefore, be independent of the spirit of narrow utilitarianism, for no investigator who enters upon a definite line of work can foresee when or how his results may become of practical value, or whether they will ever lead to any practical applications. If the progress of the nation is dependent—as we are now beginning to

realize—upon its general appreciation of Science, that appreciation must be of the highest and broadest character—it is Science in the abstract, and not purely utilitarian concrete knowledge, which must be raised to the level of one of the most exalted branches of human culture.

The modern awakening of the spirit of scientific inquiry has resulted in an activity which is in itself responsible in some measure for the slow progress towards the attainment of that high standard of popular scientific culture which we desire to see established. The active workers are a numerous and ever growing body, and the boundaries of knowledge are being extended with such rapidity in every direction that the educated layman who can follow with intelligence the various developments of Literature or of Art finds himself unable to cope with the progress of Science. Nor is this surprising when we find that even the workers themselves, having necessarily to specialize in order to achieve results of value, are unable to keep pace with the progress of discovery in domains outside their own field of research. Moreover, the constant discovery of new facts and principles, and the concurrent revision or extension of scientific doctrine is apt to discourage the would-be

learner who, without any special scientific training, has had his mind deprived of plasticity by an inelastic education in subjects for which the materials are gathered entirely from books and not directly from Nature's records.

Another obstacle in the way of the general diffusion of scientific culture is the technical language which every branch of science has found it necessary to invent in order to give precision to the description of new facts, and for the formulation of new principles. But, while admitting that the technicalities of modern scientific language from the popular point of view interpose difficulties, it must be borne in mind that for the actual workers they are labour-saving contrivances. Although the terminology may appear formidable to the uninstructed, it must not be forgotten that every term and every symbol corresponds with some natural reality, or with what according to existing knowledge is believed to be a reality. The reality is generally capable of being expressed in simpler terms than would appear from its symbolical expression; the underlying idea is generally less complex than the language which has been found necessary to define it with scientific precision.

But, apart from all such difficulties, in view

of the daily increasing importance of Science as a prime factor of national development, the educated layman can no longer afford to ignore the achievements of that great international army which is waging perpetual warfare against ignorance of Nature's methods. In this quest for knowledge, there is no distinction of race, or creed, or country—all workers are co-operating for the general cause; a truth wrested from Nature becomes the common property of mankind. Such truths cannot be lightly set aside, or crushed out of existence by the older learning; they are revelations to man as distinct, as eternal, and as far reaching in their consequences as any proclaimed by the seers and prophets of former ages.

Granting, therefore, that the reader wishes to be put in possession of the existing state of scientific knowledge, it must at the outset be realized that Science never pauses on her onward march; there is no "existing state" of knowledge in the sense of finality. She has no dogmatic creed to proclaim; she is aware of her fallibility; and her strength lies in her knowledge that it is Nature which is infallible, and man but an interpreter with limited power of observation and reasoning. The ground covered by Science is, moreover,

so vast that it must also be recognized that, for the practical purposes of study and research, sub-division into departments is absolutely necessary. Not that these sub-divisions are representative of any natural reality; they are expressive rather of the imperfect state of our knowledge. In view of the limitations of human faculty, it is both necessary and expedient that the worker should confine himself to some particular department; but, in accepting this principle as a matter of convenience, the student must not commit himself to the belief that this sub-division indicates a want of unity in Nature. On the contrary, the most advanced thinkers have come to believe in the unity of Nature and to recognize that the ideal towards which research is tending is the unification of knowledge into one general Science or system of Philosophy. There may be work for countless generations before this ideal is reached, but even now there are indications in every direction that natural knowledge cannot be confined in water-tight compartments; the barriers, confessedly artificial, are being broken down, and the inter-relations between the various sciences are becoming both more numerous and more intimate with the progress of discovery. The tendency towards coales-

cence is shown by the creation in modern times of such subjects as thermodynamics, astrophysics, chemical physics and physical chemistry, electrochemistry, thermochemistry, biochemistry, and biophysics.

CHAPTER I

THE SCOPE OF CHEMISTRY—THE NATURE OF CHEMICAL CHANGE—CHEMISTRY AN EXPERIMENTAL SCIENCE

The Scope of Chemistry.—The Science of Chemistry, as is, no doubt, already known to the reader in a general way, is essentially a materialistic science in so far as it deals with matter. It belongs to a division known as the physical sciences, a designation applied in order to distinguish such subjects from those which, like Zoology, Botany, Physiology, etc., deal with life, and which are, therefore, grouped as the biological sciences. This classification is convenient as representing the existing state of knowledge; whether such sub-division corresponds with some underlying fundamental reality is a debateable question concerning which no dogmatic pronouncement can at present be made. But as with all attempts at rigid classification, so here it will be found that no absolute barrier can be erected between the two

groups. Living matter, whether lowly or highly organized, is as subject to physical and chemical conditions as non-living matter. The Physics and Chemistry of the living organism are no longer regarded as impenetrable mysteries beyond the scope of legitimate scientific investigation. Modern Chemistry does not recognize that rigid definition which in former times restricted its scope to "dead matter"; in that borderland between the two main groups of sciences, there is now at work a new school of investigators who are attacking the mysteries of vital chemistry in the same spirit as that which has prompted research into every other department of science. It is realized that the living organism has solved chemical problems which we have as yet been unable to approach by our known methods—but this is regarded as an incentive, and no longer as a deterrent, to further inquiry. On the other side, the biologist deals with living organisms not only from the point of view of classification, distribution, bionomics, evolution, etc., but he also concerns himself with their physical and chemical activities, with the inner mechanism of the life processes. Physiology, in the broad sense, has now become the meeting-ground of the physical and biological sciences.