PROBLEMS OF PHYSICAL CHEMISTRY.*

By Prof. R. B. Warder.

We may distinguish, at least, four stages or kinds of scientific work, which may or may not be accomplished by the same investigator:

I. The observation and recording of facts; these may be quantitative, as the density of a gas, or qualitative, as the liquefaction of a vapor.

II. The compilation of related facts for further use (tables of constants, for example), together with the critical examination of the discrepancies and trustworthiness of observations.

III. Comparison and discussion of related facts. The observed facts may require reduction or computation in order to make them comparable; as when specific gravities are referred to water at different temperatures, or boiling points are observed under various pressures. Many determinations of speed of chemical action are on record, which have not yet been reduced to a uniform system of units.

IV. The tracing of generalized facts to their cause; first, by scientific use of the imagination in devising an hypothesis, then by subjecting it to the rigorous test of known facts or further experiments. Such was the brilliant work of O. E. Meyer on the kinetic theory of gases.

These various kinds of scientific activity demand very different degrees and kinds of ability; the field is broad and varied enough for all willing workers, even with quite moderate laboratories and libraries, if the work could be properly distributed.

The subject matter of physical chemistry may include all physical properties or phenomena of all kinds of matter in all possible

* Abstract of paper read at the Pittsburgh meeting.

conditions, either passive or active. It includes also the relations of these facts to one another, and the generalizations to be deduced, setting forth the unity of science.

Among the topics in which some progress has been made are:

Nature of matter in general.	Theory of vortex atoms. Kinetic theory of gases. Deviations of actual from the ideal or "perfect" gas. Continuity of gaseous and liquid conditions, as in critical temperature and pressure. Kinetic theory of liquids, especially of solutions. Continuity of liquid and solid conditions, as in viscosity.
Properties of the several chemical bodies.	Periodic law of elements. Mutual attraction, as in capilarity. Freedom of motion, as in viscosity and diffusion. Volume, under varying conditions of temperature and pressure. Refraction, with correction for waves of infinite length. Polarization, in non-isotropic solids. Rotation of plane of polarization, traced to geometrical asymmetry. Simple and harmonic vibrations, as indicated by spectra. Melting and boiling points. Vapor tensions. Solubility. Electrical conductivity and electrolysis. Electro-motive force.

Phenomena of chemical action.	Influence of mass. Speed of reactions. Manifestation of energy; as heat, light and electricity. Temperature required for limited or complete reaction. Conditions of equilibrium.

The foregoing scheme is tentative only; closely related matter being placed under different heads. Still it may help to direct attention to the broader and the subsidiary problems. Among the former are:

I. What is the real nature of matter in atoms and molecules, in elements and compounds, and in the several states of aggregation?

II. How far can the properties of each kind of matter be expressed as a function of the atoms (or other constituents) of which it consists?

III. What are the mechanical possibilities and limitations of chemical change?

If it were possible that physical chemistry should ever become a completed science, we should not only understand the nature of each kind of atom, but we should be able to predict the properties of any possible compound and the manifestations of energy with the conditions of equilibrium in any possible reaction.

Howard University, Washington, D. C.