themselves. The chemist examines the circumstances under which such changes occur, and attempts to discover the laws upon which they are based. Experiment is the fountain-head of all our chemical knowledge, and every student of the science should strive to acquire an accurate acquaintance with the experimental method of investigation and a clear idea of the method of induction founded upon it. Practical Chemistry explains the various experimental methods and appliances used, and Theoretical Chemistry discusses the truths which may be deduced from the results. We have to learn how to conduct our experiments successfully, and secondly, we have to learn to study the experiments so carefully that we may observe everything about them, and find out all that can be known by correct reasoning from what they teach us.

5. It is the distinctive character of the chemical force to produce a permanent change in the properties of bodies, while their weight continues exactly the same. Weight is the only property in which the compound is identical with its constituents. It is the peculiar and characteristic mark of chemical combination that substances acquire new properties on combining with one another, their weight remaining unchanged. Thus we may by heat convert ice into water, and water into steam. But as soon as the heat is removed, the steam relapses into water, and the water is frozen into ice. The changes are only temporary. There is no alteration of chemical properties. Each minute particle of ice, water, or steam has retained all the same essential properties, has contained the same substance, each molecule made up of the same three atoms, namely—two atoms of hydrogen firmly bound by the chemical force to one atom of oxygen. The heat has varied the physical form of the water without altering its chemical qualities. It has merely driven the molecules farther apart, in opposition to cohesion; the molecules themselves have been entirely unchanged. But when the chemical force comes into play, as when fine iron filings are heated along with finely powdered sulphur, a change of unique character ensues. There is a complete change of chemical properties and atomic constitution. The former properties of the constituents disappear, and with the advent of the new compound, new properties make their appearance. The metallic lustre, magnetism, malleability, etc., of the iron vanish, along with the pale yellow color, the crystalline appearance, glassy aspect, etc., of the sulphur. The dark, porous mass formed by their union, resembles neither iron nor sulphur, and has a set of properties distinctly its own, not borrowed from either of its constituents. Notice carefully, however, that its weight is the sum of those of the iron and the sulphur, also that though we grind it into the finest powder, we cannot by mechanical means recover the iron and sulphur again in the separate state. Similarly, if white mercury and yellow sulphur be heated together, they combine and produce bright scarlet vermillion totally different from either in properties and appearance, but precisely the same in weight. No way is yet known of predicting what these new properties will be. We can only ascertain them by our method of experiment. No amount of abstract reasoning before the actual trial could inform us that two intensely poisonous substances like chlorine and sodium would produce common salt, not only harmless but actually necessary to life; that the air we are breathing would contain the elements of a deadly poison, namely, nitric acid; that sugar would be found to be entirely composed of charcoal and the elements of water; or that three harmless elements like carbon, hydrogen, and nitrogen would combine to form prussic acid (HCN, hydric cyanide), one of the most formidable poisons known.

6. The chemical force frequently alters the physical properties, as color, taste, smell, temperature, or volume. It often changes the physical form. Two gases may produce a liquid or a solid, two solids a liquid or a gas, two liquids a gas or a solid, etc. The only property which chemists have found absolutely unchangeable is the weight. In every instance the weight of the compound is the same as that of all its materials weighed together. Thus we see the first-rate importance of the *Chemical Balance*, the best of which are now constructed so as to turn with less than one millionth part of the substance weighed. By combining the methods of reversal and substitution, with the method of vibration or oscillation, by which the excursions of the moving beam are accurately observed, the chemist can determine the true weight of a body with a very close approximation to accuracy. Light and electricity are often evolved as the result of chemical union or disunion. Heat is also commonly evolved or absorbed, that is the body grows hotter or colder than its constituents were previously to their combination.

7. The chemical force acts only at imperceptibly small distances and between minute particles of different kinds of matter. This distinguishes it from the physical forces, which act through considerable spaces, as gravitation, between masses of matter, and matter either of the same kind or of different kinds, as cohesion and capillary attraction. It plainly follows that chemical action will be promoted by all circumstances and conditions that tend to bring the constituents together in a very fine state of subdivision, to shake the molecules and atoms apart, to bring molecule to molecule, or atom to atom. Hence pulverisation, solution, fusion, vaporisation, percussion, high temperature, and a powerful current of electricity, are means commonly employed to bring about a desired chemical combination or decomposition.

8. Chemical union takes place with the greatest ease and energy between those bodies which have the least chemical resemblance, which possess the most widely different propeities, as sulpher and mercury, nitric acid and copper. It always takes place between fixed, definite, unchangeable proportions by weight of the elements. This serves to distinguish a chemical compound from a *Mechanical Mixture*, in which any ingredients may be chosen, and their proportions varied within all conceivable limits. The mixture will acquire no new chemical properties but will partake of all the its constituents, for example its specific gravity or comparative weight, and its color will lie intermediate between those of the ingredients. Fine sand mixed with pulverised sugar is both gritty and sweet. Brass, type-metal, solder, german-silver, bell-metal, fusible-metal, bronze, gun-metal, pewert, and our common coins are mechanical mixtures. They are alloys or mixtures of similar metals, not untied in any fixed, definite and invariable proportions by weight. Gunpowder is a mixture of nitre, sulpher and charcoal. It is characteristic of mechanical mixtutes that their ingredients can be separated by such simple means as solution, filtration, diffusion, and crystallisation. Thus take a little gunpower and place it in warm water; the water will dissolve out all the nitre. Filter the liquid and evaporate; the nitre will be deposited at the bottom of the evaporating dish. Now take the black powder left in the filter paper and put it in some carbon disulphide, a volatile liquid which will dissolve all the sulpher. Again filter and the charcoal alone will now be deposited on the paper, and in a few minutes the carbon disulphide will vaporise (N. B. The vapor is poisonous) and leave the sulpher on the dish. Again, take two or three grains of gunpowder and reduce to a fine flour. Place a little of this under the microscope, and the separate particles of carbon, nitre, and sulpher will be seen lying side by side, and not chemically combined. The explosion of gunpowder is the result of rapid chemical union. When iron filings and sulpher are ground togother to a find powder, the mixture assumes a greenish tinge, and the elements are no longer separately visible to the naked eye. But a lens showes them lying disunited; a magnet stirred through the mixture will draw out the iron; carbon disulphide will dissolve the sulpher and let the iron fall to the bottom.

(To be continued.)