

## CHANGES, PHYSICAL AND CHEMICAL.

BY CREIG S. HOYT,

*Grove City College, Grove City, Pa.*

When a material system is acted upon by some form of energy, we observe a change. That change may be slight and, on the other hand, it may be deep-seated. We have, for convenience in teaching, arbitrarily classified these changes, which we observe in a material system, as physical and chemical. Those changes in matter which are so slight that the energy change is by comparison very great are treated under the subject of physics. Similarly, those changes in matter which are so deep-seated that the energy change is by comparison unimportant are treated under the subject of chemistry.

Such a classification can be considered in no sense categorical. The criteria on which we base our classification are such that a single change might be classified as either chemical or physical, depending on the viewpoint of the observer. At best, the classification is simply an endeavor to roughly divide phenomena, and cannot be considered as fundamental to the science. Its justification lies not in the nature of the science, but in the necessity of the teacher.

From this arbitrary classification, several errors have arisen. Some of these are scientific, some pedagogical. They are due, first, to misconception of the criteria on which the classification is based; and, second, to the habit of considering the classes as categorical and mutually exclusive.

In many texts, the criterion by which one judges whether a change be physical or chemical is evidently the reversibility of the reaction, or, in other words, whether the material be permanently or temporarily altered by the energy change which it has undergone.

"When we notice the things about us, we see that they undergo changes: a piece of wood bends under a weight or warps when wet; a rod lengthens when heated; a piece of iron placed near a magnet attracts another piece of iron. If we remove the weight from the stick, it straightens; the iron removed from the magnet loses its power of attraction. In such changes, although the object may be considerably altered, we still recognize the pieces of the stick as wood, as we do the fragments of a broken tumbler as glass; that is, the material has not lost or changed those peculiar properties or characteristics by which we identify

it. Such changes are called physical changes; they result usually in a change of such properties as size, shape or color."<sup>1</sup>

It is evident that such a standard would bar from chemical changes some reactions which are easily reversible. It is possible to bring about a chemical change in matter by an application of a form of energy, which can be reversed by the removal of the source of energy. For example, on heating the white solid, ammonium chloride, two gases, ammonia and hydrogen chloride, are formed, but a return to the original temperature causes a reversal of the dissociation with the formation of ammonium chloride. Reversibility affords no criterion of the nature of a change. The polymerization of water on freezing would be physical if viewed from the ease of its reversibility and chemical if viewed from its radical change in properties.

Another standard by which it is judged whether a change be physical or chemical is the loss or gain of distinctive properties. Such a standard might be scientifically correct, provided one chose the right properties. The usual test, however, is that the final substance be recognized as the original material after the application of the energy change. Since distinctive properties may easily be lost or gained without a change in the composition of a substance, the observer may easily be led astray. To conclude that the beginning student will choose the most fundamental properties of a substance rather than the most obvious properties is a mistake pedagogically.

Again, it is a mistake to assume that all changes are either physical or chemical. The phenomenal growth of the relatively new science of physical chemistry is evidence for that statement. The classification of reactions into physical and chemical can not be as rigid as one would be led to believe from the teaching of elementary chemistry. A large portion of chemistry is a refined study in physics. There are many changes taking place as important in their energy aspect as in their material side.

Physical changes are sometimes defined as changes in condition, while chemical changes are changes in composition. We should resort to analysis to establish differences in composition. Yet an analysis would fail to show any change in composition when sodium chloride goes into solution, although two new materials are formed in that process, the sodium and chloride ions. These have properties which differ both from sodium chloride and from the sodium and chlorine of which it is composed.

<sup>1</sup>*First Principles of Chemistry*, Brownlee, Fuller, Hancock, Sohn, Whitsitt.

Molecular association in liquids is another phenomenon which could not be classed as chemical by an analysis, since strictly no change in composition has occurred. Our evidence of it is obtained through surface tension, a physical phenomenon.

An analysis of the content of physics and of chemistry reveals that the systems studied are in most cases identical. The distinction is principally that in physics we are primarily interested in the energy change, as such, while in chemistry we are interested in the change in the material system produced by energy with less attention focused on the energy change itself. The physicist, as a rule, avoids a study of an energy change in a material system where the material change is great, since it tends to make the formulation more difficult. The treatment accorded the Voltaic cell and the new science of radio activity in the physics course shows need for the physicist to abandon his strict classification, and consider material as well as energy change. The older chemistry ignored the energy change and concerned itself altogether with the material change. To such a chemistry, the strict classification might be applicable. The newer chemistry is concerned not so much with tabulating properties and unallied reactions, but with formulating chemical changes according to the energy cause or accompaniment. The change in mass has ceased to be our prime interest. The student of elementary chemistry should be introduced to the modern chemistry and early learn the importance of energy in chemical reactions. Otherwise, chemistry becomes cookery. The present introduction to the science is, then, altogether inappropriate to the subject matter. It has failed to advance as has the rest of chemistry.

Is there need for such a classification? It is not necessary to the science. It is not a true generalization. It confuses rather than aids the student. And, finally, we have no real criterion by which to judge to which category a particular change should be assigned.

---

#### ONE OF TYNDALL'S "LIGHT" EXPERIMENTS.

One part gum mastic is dissolved in eighty-seven parts grain alcohol, and a few drops of this solution are added to a vessel of water, while the vessel is vigorously stirred. The gum mastic, being insoluble in water, forms a very fine precipitate which remains in suspension in the water. If the vessel is now viewed against a black background, with the light coming from the side or above, the water can be seen to give a very fair sky blue color, while transmitted light (shown best by placing the vessel between an arc light and a white screen) is a rich golden yellow, like sunlight.