# INORGANIC CHEMISTRY, FOR SCIENCE CLASSES

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# PREFACE.

This work has been provided for the use of beginners in the study of Chemistry more especially for students of Science Classes. It has therefore been made an especial object to avoid technicalities as far as possible, and to afford a plain and brief description of the preparation and properties of the elementary bodies, and their principal compounds. A complete enumeration of these bodies would have occupied much space, and might distract the attention of the learner from those properties with which it is important he should first become acquainted; nevertheless, the present volume exhibits a comprehensive view of the latest improvements and discoveries of modern chemical science.

The author is not acquainted with any elementary work in which the new system of molecular equivalents and systematic notation has been adopted, and where the various Rules are

the data for calculating the equivalent by weight of the compound, but also gives him the proportion by volume in which the elements are united. The formula in common use, HO, does not represent the proportion by volume in which the elements exist.

3rd. The chemical equivalents usually adopted do not represent uniform combining quantities. "In the first place, let us observe that the composition of the poly acid bases, such as alumina and ferric oxide, has almost always been expressed by molecular formula, and not by equivalent formula. It was known that one molecule of alumina would saturate three molecules of sulphuric acid, and this quantity was wrongly termed an equivalent of alumina. The true equivalent of alumina—that is to say, the quantity of alumina which corresponds to one molecule of potash or oxide of silver—is the quanity of alumina which contains an equivalent of oxygen. It is this quantity which saturates an equivalent of sulphuric acid. The general formula used, $Al_2O_3$, 3 $SO_3$, did not express an equivalent of sulphate of alumina, but a molecule of sulphate of alumina." . . "It is seen from the above that after having pointed out the difference between atoms and equivalents, the progress of science leads to the separation of the idea of molecule from that of equivalent of a compound body."*

*An atom* is the smallest quantity of an element, indivisible by chemical means, which can exist in a compound body.

*A molecule* is the smallest quantity of an element—radical, acid, base, salt, or other compound—which is supposed to exist in the free state.

"Molecules, in fact, are not always equivalent among each other. One equivalent of phosphoric acid is not equivalent to one molecule of acetic acid, and one molecule of alumina is not equivalent to one equivalent of oxide of silver."*

One atomic equivalent of citric acid will neutralise three atomic equivalents of sodium, and one atomic equivalent of oxide of bismuth require three atomic equivalents of nitric acid to form ternitrate of bismuth.

4th. The recent researches in organic chemistry of our most distinguished chemists tend to establish the molecular

* A. Wurtz, *Chemical News*, vol. 11, page 119.

equivalents of carbon as 12 and oxygen as 16. The limits of this work will not admit of any lengthy arguments in favour of the new notation; let it suffice that, after examining the question of specific heat, isomorphism, &c., and the principal arguments *pro* and *con*, the author considers that the weight of evidence is in favour of the new molecular equivalents.

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*Chemical Affinity* is the affinity of one substance for another. After combination the compound usually possesses new characters and properties. The following are a few examples:—

Ex. 1. The metal sodium is a powerful alkaline base; when introduced into a jar of chlorine gas, the affinity of the sodium and chlorine cause them to enter into combination forming chloride of sodium, common salt.

Ex. 2. When a mixture of oxygen and hydrogen are caused to unite (by an electric spark), an explosion takes place, the gases disappear, and water is formed by the chemical affinity of oxygen for hydrogen.

Ex. 3. If to a solution of chloride of barium sulphuric acid be added, the affinity of sulphuric acid for barium being greater than the affinity of chlorine for that base, sulphate of barium is formed, and chlorine in combination with hydrogen (HCl) remains in solution.

Ex. 4. When water is added to quicklime (oxide of calcium), great heat is generated from the chemical union of the oxide of calcium with water forming hydrated oxide of calcium.

Ex. 5. If a piece of potassium be thrown on water, the affinity of the potassium for the oxygen of the water causes its decomposition, oxide of potassium is formed, and hydrogen set free. The heat generated is sufficient to spontaneously ignite the hydrogen gas.

Ex. 6. When a few grains of iodine are brought in contact with phosphorus, the affinity which exists between these elements causes them to combine with the spontaneous combustion of a portion of the phosphorus.

*Equivalents* are the proportions by weight or volume in which one element or compound unites with another to form

a definite chemical salt or compound. The following are a few examples :—

EQUIVALENT BY WEIGHT.

Ex. 1. The equivalent of hydrogen is 1, and that of chlorine is 35·46. These elements combine forming hydrochloric acid gas, the equivalent of which is 36·46.

Ex. 2. The equivalent of sodium is 23, and that of chlorine 35·46. These elements combine forming chloride of sodium, equivalent 58·46.

Ex. 3. The equivalent of nitrate of silver is 169·97, and that of chloride of sodium 58·46. If these salts are dissolved (in equivalent quantities) in water and mixed, one equivalent of chloride of silver, 143·43, and one equivalent of nitrate of sodium, 85·00 are formed.

Ex. 4. The equivalent of hydrochloric acid is 36·46, and that of hydrate of potassium is 56·11. If these compounds be mixed, one equivalent of chloride of potassium, 74·57, and one equivalent of water, 18·00 are formed.

Ex. 5. One equivalent of zinc, 65·06, when dissolved in one equivalent of sulphuric acid, 98·00, forms one equivalent of sulphate of zinc, 161·06, and two equivalents of hydrogen, 2·00 are evolved.

EQUIVALENT BY VOLUME.

Ex. 1. The volume of hydrogen is 1, and that of oxygen is also 1. Water, $H_2O$, is formed when two volumes of hydrogen are united with one volume of oxygen.

Ex. 2. The volume of nitrogen is 1, and that of hydrogen is 1. Ammonia, $NH_3$, is formed when one volume of nitrogen is exploded with three volumes of hydrogen.

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*Elements or simple substances* are forms of matter that we are unable to resolve into any simpler condition. Thus, oxygen, hydrogen, sulphur, &c., are termed elements. Water or air are not elements, being resolvable, the former (water) into oxygen and hydrogen gases; the latter (air) into oxygen, nitrogen, gases, &c. The number of elementary bodies at present recognised are 65, of which about 50 are metals, the rest are termed the non-metallic or metalloid elements. Arsenic and Tellurium, though possessing the properties of metals, are yet intimately connected with the metalloids.

*Acid.*—Solutions of acids and all acid substances have the property of changing (most) vegetable blue colouring matters red. Example: Blue litmus papers are used extensively in the laboratory for the purpose of detecting the presence of acids, which immediately turn the blue colour red. All acids unite with bases to form compounds named salts.

*Alkali.*—Solutions of alkalis and all alkaline substances possess the property of changing red litmus blue, and yellow turmeric of a reddish brown colour. Red litmus papers and yellow tumeric test papers are employed for the detection of alkalis in solution. All alkalis unite with acids to form salts, which are usually neutral.

*Base.*—Bases, alkaline or otherwise, unite with acids to form neutral, acid, or alkaline salts.

### EXAMPLES OF SALTS.

A neutral salt, sulphate of potassium $K_2SO_4$, is formed when one equivalent of sulphuric acid, $H_2SO_4$, unites with one equivalent of oxide of potassium, $K_2O$.

An acid salt, bi-sulphate of potassium K, H, $SO_4$ is formed when two equivalents of sulphuric acid, $H_2SO_4$, unite with one equivalent of oxide of potassium, $K_2O$; two equivalents of the acid sulphate are formed.

An alkaline salt, carbonate of potassium, $K_2CO_3$, is formed when one equivalent of a feeble acid, carbonic acid $CO_2$, unites with one equivalent of oxide of potassium.

*Rational Formulæ* express the arrangement or grouping of elements according to their supposed affinities for each other, thus: Potash alum, a crystalline double salt, is considered to be sulphate of aluminium and sulphate of potassium in combination with twenty-four equivalents of water of crystallisation. The rational formula is therefore

$$Al_2\ 3(SO_4),\ K_2SO_4,\ 24(H_2O).$$

Chloride of platinum and ammonium, a crystalline double salt, is considered to be a chloride of platinum in combination with chloride of ammonium. The rational formula is therefore

$$PtCl_4,\ 2(NH_4Cl)$$

*Empirical Formulæ* simply expresses the number of atoms of each element in a compound without conveying any idea