splint of wood. The wood will instantly take fire and burn with great brilliancy. Hence the gas has the same characteristic as that obtained by heating mercuric oxide and is therefore *Oxygen*.

The above process is called *electrolysis* and is frequently employed in decomposing chemical compounds.

When the above experiment is carefully made, it is found that the only substance that undergoes permanent change is the water. The weight of the water is diminished in exact proportion to the amount of gas evolved. Besides, if the operation is continued the water will be *completely* resolved into the two gases.

Exp. 17.—Take a strong glass tube, about thirty centimetres long and one centimetre in diametre. Choose a good, sound cork, pass two short copper wires through it, connecting their extremities within the tube with fine platinum wire. Insert the cork tightly in the tube and cover it with sealing wax. Such a tube is called a *Eudiometer*, of which there are many forms. Now, fill the tube with acidified water, and place it over the platinum strips, taking care that they do not touch each other. When the tube is about two-thirds full of water, press it firmly against an india rubber or paper pad on the bottom of the tumbler, wrapping a towel loosely round the tube, and connect wires in the cork with the battery. The fine platinum wire will soon become red-hot and explode the gases. On raising the tube from the pad, the water will rush up and fill the tube, showing that the two gases have united to form water which appears as vapor on the tube before it is raised from the pad.

Water is, therefore, composed of two gases, Oxygen and Hydrogen, in the proportion of one volume of the former to two volumes of the latter.

Combination by Volume.—In the preceding experiment if the union of the oxygen and hydrogen be effected in an apparatus so arranged that the gases before explosion are heated beyond the temperature of boiling water and kept at the same temperature after explosion, it is found that the two volumes of hydrogen and one volume of oxygen which were mixed together have become chemically united into *two volumes* of steam. It is found in other cases also that **Whatever the number of volumes which enter into combination, the resulting compound is two volumes.**

Exp. 18.—Take two glass tubes, about one metre in length and five millimetres in diameter. Close one end of each and bend so that the short limb may be about twenty centrimetres long. Fill one of them with acidulated water, colored with litmus or cochineal, and place it over the pole from which the hydrogen is escaping, until enough is collected to half fill the short limb of the tube. Turn the short limb uppermost and the gas will pass into it. Half fill the short limb of the other tube with oxygen in the same manner.

(1). Observe that when both limbs are full of water the gases are equally compressed.

(2). By means of a pipette, to which a piece of rubber tubing or a piece of fine glass tubing is attached, adjust the water in each tube so that it may stand at various heights, but always at the same height in each tube. Observe that the gases expand equally as the water is removed.

(3). If you have mercury pour an equal quantity into each tube, and observe that the gases contract to the same extent.

(4). Plunge the tubes into boiling water. Observe that the gases expand equally.

(5). Plunge the tubes into ice-cold water or a freezing mixture, and the gases contract to the same extent.

Hence we infer that *Oxygen and Hydrogen gases when compared under the same conditions are affected in the same way and to the same extent by equal alterations of pressure and temperature.*

When the same mode of investigation is applied to other gases, whether elementary or compound, the following important characteristics are observed:

(1). All true gases obey the same law of compressibility.

(2.) Equal volumes of all true gases expand equally on the same increase of temperature.

The conlusion that must necessarily be drawn from the preceding facts is, that all gases, however different chemically, must be physically constituted alike. Upon these facts an Italian chemist, Avogadro, based a most important hypothesis. He assumed that all substances, solid, liquid, and gaseous, are made up of an innumerable number of little particles which he called *molecules*, and was thence led to the enunciation of the following law

AVOGADRO'S LAW. **When in the condition of a perfect gas, all substances under like conditions of temperature and pressure contain in equal volumes the same number of molecules.**

Relative Weight of Molecules. The above law, enunciated by Avogadro, in 1811, is considered one of the most impo tant in the whole range of chemical science. It is to the chemist what the law of gravitation is to the astronomer. We have indicated only one of the evidences in its favor. It is in reality a generalization from a large mass of facts, and the best proof of its validity is to be found in the circumstance that it not only explains the known facts of chemistry, but also, that it is constantly leading to new discoveries. It gives at once the means of determining directly the relative weight of the molecules of all substances that can exist in the state of gas. For it is obvious that **The ratio of the weight of volumes of gases, compared at the same pressure and temperature, must represent the relative weight of the molecules of these gases.** Now it is found by experiment that given volume of oxygen is sixteen times heavier than an equal volume of hydrogen, under the same conditions; therefore, *the molecule of oxygen is sixteen times heavier than the molecule of hydrogen.*

Atomic Weight of Elementary Gases.—It has been shown that two volumes of hydrogen unite with one volume of oxygen to form two volumes of steam; and by Avogadro's Law we know that the two volumes of steam contain the same number of molecules as the two volumes of hydrogen, hence we have—

2 vols. hydrogen + 1 vol. oxygen = 2 vols. steam,
or 2 mols. " +1 mol. " = 2 mols. "

Now, in the two molecules of steam there is but one molecule of oxygen; therefore in one molecule of steam there can only be half a molecule of oxygen, and the weight of the oxygen corresponding to the semi-molecule is the smallest quanity of that gas that can take part in any chemical change, and as it cannot be further divided by any chemical means it is called an *atom*. We shall find that the molecule of hydrogen can also be divided into two parts, and that one of these parts is the least quantity of hydrogen known to take part in any chemical action, and is, therefore, called an *atom* of hydrogen. It has been found convenient to take 1 as the *atomic weight*, or weight of a semi-molecule of hydrogen. The weight of the molecule of hydrogen is, therefore, 2; and since oxygen is sixteen times heavier than hydrogen, the molecule of oxygen is 32, and consequently its atomic weight is 16.

Hence, **To find the atomic weight of an elementary gas, it is only necessary to find its weight compared with hydrogen as the unit.**

Specific Gravity of a Compound Gas.—Suppose that in a given volume of steam there is a certain number of molecules, then by Avogadro's Law the same volume of hydrogen will contain the same number of molecules. Therefore, the weight of a given volume of steam has the same ratio to the weight of an equal volume of hydrogen that a molecule of steam has to a molecule of hydrogen. But the molecule of steam is made up of two atoms of hydrogen and one atom of oxygen; its *molecule weight* is therefore, 18, and the molecule weight of hydrogen is 2, or the ratio is 9 to 1. Therefore, the specific gravity of steam compared with hydrogen as the unit is 9.

Hence, **The specific gravity of a compound gas compared with hydrogen as the unit is found by taking half its molecular weight.**

Conversely, **To find the molecular weight of a gas it is only necessary to find its specific gravity referred to hydrogen as unity, and then multiply it by 2.**

Definitions.—From the preceding paragraphs we have the following definitions:—

Molecule.—*A molecule is the smallest particle of a compound or element that can exist in a free state.*

Atom.—*An atom is the smallest portion of a chemical element that is known to take part in a chemical change, and is almost invariably the semi-molecule.*

Atomic Weight.—*The atomic weight of an element is the smallest proportion, by weight, in which it enters into or is expelled from a chemical compound, the weight of hydrogen being taken as unity.*