

## VOLUMETRIC ASSAY OF BULLION, ALLOYS, ETC.

Probably no quantitative analytical process is susceptible of a higher degree of accuracy than that by which the quantity of silver in bullion, coin, plate, etc., is now usually determined, and in point of simplicity as well as accuracy is a good illustration of the volumetric method as applied to the analysis of many other substances.

When a neutral or acid solution containing silver is brought into contact with a solution containing a sufficient quantity of sodium chloride (common table salt) the whole of the silver is precipitated as silver chloride.

A given quantity of pure salt always thus precipitates a certain definite quantity of silver (1 grain of salt corresponding to  $1\frac{1}{10}$  grains, nearly, of silver.)

If one grain of salt, silver, or any other substance is dissolved in a quart of liquid, and the quart is then divided into ten, one hundred, or one thousand equal parts or volumes, each of these will contain just one-tenth, one-hundredth, or one-thousandth, as the case may be, of a grain of the dissolved substance. So that, in the case of silver, if it is known just how much salt is dissolved in a given quantity of water it is easy to calculate how much there is in any volume of the solution, and just how much dissolved silver any volume of it will precipitate.

The several pieces of apparatus necessary in preparing, standardizing, and applying this liquid measurer are shown annexed. The glass burette, A, is secured in position by the wooden clamp, B, adjustable on the iron rod of the stand, C. The ground glass stop-cock, *a*, controls the flow of the liquid from the tube. The burette is accurately graduated to one-fifth or one-tenth cubic centimeter by an etched scale.

In the burette, D, the expensive glass stop-cock is dispensed with, a piece of pure gum rubber tubing and a brass wire clamp, *b*, being substituted. The small delivery neck of the burette is joined by the tubing to a small piece of glass tube drawn out at one end to a fine delivery. The wire clamp (quetchon or pinch-cock) retains the liquid by pinching the rubber tube. E and F are pipettes. In using them the lower end is dipped in the liquid, the mouth applied to the upper end, and the liquid drawn up until the tube is nearly full. The mouth is then removed, the finger quickly placed over the end, as shown at G, and a small portion of the liquid allowed to escape until the liquid fills the tube just to the containing mark, *c*. When the finger is removed the liquid runs out. The flask is used where larger quantities of the liquid are to be measured. The containing mark is at *e* on the neck.

The titration bottle, H, is of fine thin glass, the glass stopper being ground to accurately fit the neck, and terminates in a point. These bottles usually have a capacity of about 250 c.c.

In analytical work of this kind the decimal or French system of weights and measures is nearly always used, as they are much more convenient than other systems. The gramme equals  $15\frac{1}{2}$  grains, nearly; the milligramme (mg.)  $\frac{1}{1000}$  of a gramme; the liter about  $1\frac{3}{4}$  pints; the cubic centimeter (c.c.)  $\frac{1}{1000}$  of a liter.

In preparing the salt solution  $5\frac{1}{2}$  grammes of chemically pure, dry salt is dissolved in a small quantity of distilled water, the solution diluted to one liter with cold distilled water, and put into a clean glass bottle labeled "Salt No. 1." Fifty c.c. of this solution is drawn off with a pipette, diluted with cold distilled water to 500 c.c. (half liter), and put into another clean bottle marked "Salt No. 2."

These solutions are then *standardized*—that is, tested to determine just how much silver a given measure of the liquid will precipitate.

One-half gramme of pure silver is dissolved, by aid of gentle heat, in about 3 c.c. of pure nitric acid, and the solution is then diluted to one-half liter with cold distilled water; so that 1 c.c. of the liquid contains just 1 mg. of silver. Fifty c.c. of this solution, drawn off with a pipette, is placed in the titration bottle, and the burette (A or D) is filled to zero with the salt solution No. 2. This solution is then allowed to drop from the burette into the silver solution in the bottle, the flow being discontinued from time to time and the bottle closed and agitated to facilitate the subsidence of the flocculent precipitate. A little experience enables the operator to tell when the silver solution is nearly saturated, and then the contents of the bottle is shaken and allowed to subside between the addition of every two or three drops, so that when at last the drops of salt solution fail to produce any more precipitate in the silver solution, then the total quantity or volume of salt solution used may be accurately read off on the scale of the burette. To avoid any error the test is duplicated, and the results of the two tests, when

compared, should agree very closely. If it is found, for instance, that 50 c.c. of the salt solution corresponds to 50 c.c. of the silver solution, then the solution in bottle No. 2 is marked "1 c.c. = 1 mg. silver;" and bottle No. 1, "1 c.c. = 10 mg. silver," as its contents contain ten times as much salt.

Thus standardized the salt solutions become, when properly used, accurate measures of the amount of silver in a liquid.

In the actual assay of a silver alloy from half to one



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gramme of the metal is weighed out, put into the titration bottle with 4 or 5 c.c. of nitric acid (of sp. gr. 1.2), and the contents heated by placing the bottle obliquely in a hot water bath. From time to time the nitrous fumes are blown out and the bottle frequently shaken to promote their expulsion. When solution is complete the bottle is removed and its contents allowed to cool. If the alloy contains gold, a small quantity of pure sulphuric acid is added, and the liquid boiled until all the gold has separated. The liquid adhering to the stopper and neck of the bottle having been rinsed down with a small jet of distilled water, salt solution No. 1 is gradually let in from a burette until the silver solution is, as before described, nearly saturated; then salt solution No.

distilled water to about ten times its volume, and well shaken. About 50 c.c. of standardized salt solution is mixed with just enough of a strong aqueous solution of pure potassium chromate solution to distinctly color it. Then the dilute silver solution is gradually let in from the burette, the mixture being agitated after every few drops. As long as there is an excess of salt the orange-red silver chromate is formed when the drops of silver solution strike the salt liquid is quickly decomposed and decolorized. When the point of complete saturation is reached this decomposition no longer takes place, and the solution assumes a distinct orange-red color.

The quantity of silver solution required to saturate 50 c.c. of the standardized salt solution is then read off on the burette. As the quantity of silver this volume of salt solution corresponds to is known, the rest of the calculation is easy.

## DYNAMIC ELECTRICITY.

BY GEO. M. HOPKINS.

## GENERATION OF THE ELECTRIC CURRENT.

When two dissimilar metals, such as pure copper and pure zinc, are placed in contact in acidulated water, evidences of activity immediately appear in the form of a cloud of microscopic bubbles constantly rising to the surface of the water. If the metals are individually capable of resisting the action of the acid solution, it will be noticed that on separating the metals the action ceases, but it will commence again as soon as the metals are brought into contact. The same action is noticed if the two metals are connected by a wire, which may be either wholly within or partly out of the acidulated water.

The bubbles which are noticed in this experiment are hydrogen resulting from the decomposition of the water and escape from the copper, and the oxygen resulting from the analysis unites with the zinc, forming zinc oxide.

The copper is scarcely attacked while the zinc slowly wastes away. If the wire connecting the zinc and copper be cut and the two ends placed on the tongue, a slight but peculiar biting sensation is experienced, which will not be felt when the wires are disconnected from the metals.

A piece of paper moistened with a solution of iodide of potassium and starch placed between the ends of the wires exhibits a brown spot, showing that between the ends of the wires there is a species of energy capable of effecting chemical decomposition. If a wire joining the copper and zinc is placed parallel with and near a delicately suspended magnetic needle, it will be found that it is endowed with properties capable of affecting the needle in the same manner as a magnet. This form of energy is dynamic or current electricity, generated in this case by chemical action and confined to, and following a continuous conductor, of which the two metallic elements and the acid solution form a part, the whole comprising a complete electric circuit.

For the purpose of studying the generation and behavior of dynamic electricity the elements referred to may be formed into an electric generator or battery, and the magnetic needle and conducting wire may be combined to form an electrical indicator or galvanometer.

The engraving shows convenient apparatus for making the primary experiments in dynamic electricity. The glass tank or cell is built with special reference to projecting the visible manifestations of the phenomena exhibited in the cell, upon a screen, by means of the lantern, to enable a number of persons to observe simultaneously.

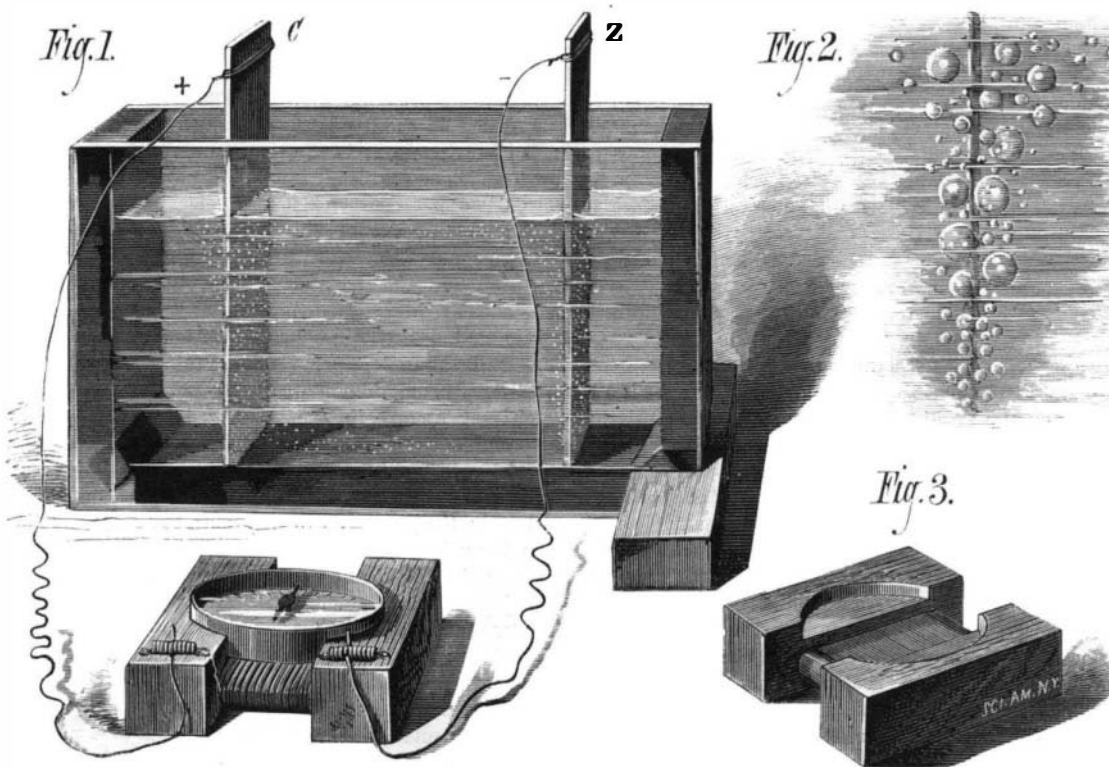
The cell consists of two plates of transparent glass 4 by 6 inches, separated by a half inch square strip of soft rubber, which is cemented to both glasses by means of a cement composed of equal parts of pitch and gutta percha. The cell is nearly filled with the exciting liquid, consisting of dilute sulphuric acid (acid 1 part, water 15 parts), in which are placed two plates, the positive plate consisting of a strip of zinc about one-sixteenth of an inch thick, the negative plate being a strip of copper.

As commercial zinc is so impure as to be violently attacked by the exciting liquid, it is well to dip the zinc strip into the solution, and then apply to it a drop or so of

mercury, which amalgamates the surface of the zinc and prevents local action.

When these two plates are brought into contact with each other in the exciting liquid, hydrogen gas is given off copiously at the copper or negative plate, while the action at the zinc or positive plate is almost unnoticeable. If the plates are connected together by a conductor outside of the solution, the same phenomenon is observed.

The plane flat surfaces of the cell offer facilities for the



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2, from another burette, is added until the exact point of saturation is noted. The readings from the two burettes properly reduced will then indicate how much pure silver the alloy contains.

Tests of this kind should always be made in duplicate to avoid error.

In testing photographic silver baths the total quantity of bath is measured, and a clean burette is filled to the zero mark with a definite portion of it, previously diluted with