

Making and Testing the Carhart-
Clark Standard Cell.

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The materials necessary to the construction are —

- (1) a glass specimen or test tube about three-fourths inch in diameter and three inches long;
- (2) a piece of platinum wire about two or three inches long;
- (3) a rod of pure zinc about two inches long;
- (4) two six-inch pieces of copper wire;
- (5) pure mercury;
- (6) mercurous sulphate;
- (7) zinc carbonate;
- (8) zinc sulphate;
- (9) few odds and ends.

In constructing the cell, first seal the platinum wire into the closed end of the specimen or test tube so that about one inch of it is within the tube. A piece of glass tubing of proper diameter and length may be used instead of the specimen or test tube, by closing one end in the blow pipe flame. In this case the platinum wire may be sealed in at the time of closing the end. This sealing in of the platinum wire may be avoided by using a piece of capillary tubing three inches long and sealing the wire into

one end of it. Then fasten the capillary tube to the inside of the cell chamber with cement or by covering it fast when in a plastic condition from heating. The wire should project about an inch from the end of the capillary tube and bottom of tube should be within one-half inch of bottom of cell chamber.

One piece of the copper wire is soldered to the external end of the platinum wire and the other to one end of the rod of zinc. The zinc is fitted into a cork about three eighths of an inch thick and of the size to fit the cell chamber.

The mercurous sulphate, zinc carbonate and zinc sulphate are made into a paste. The mercurous sulphate must be free from acid and from mercuric sulphate but may contain free mercury without harm. It may be obtained commercially or by treating pure mercury with an excess of sulphuric acid under a heat below the boiling point of the acid. It is nearly insoluble in water and so can be washed thoroly to free it from acid and from mercuric sulphate. The paste is made by using the ingredients

in the proportion of 150 grams of mercurous sulphate to 5 grams of zinc carbonate and enough of the saturated solution of zinc sulphate to make a thick paste. Mix well in a mortar and let it stand for a few days, rubbing thoroly occasionally, to allow what carbonic oxide may form to escape. The zinc sulphate solution must not be supersaturated. This can be avoided if in making the solution only very slight heat is used and if care is taken to keep crystals of the sulphate in the bottom of the flask when the solution is made.

To form the cell from its component parts.

(1). Wash the cell chamber well with distilled water and dry it.

(2). Pour in the pure mercury, best if it has been distilled in vacuo, till about three-fourths of an inch deep in the chamber. Internal portion of the platinum wire should all be below the surface of the mercury.

(3) Put in about three-fourths inch layer of paste upon the mercury.

(4) Pour in saturated solution of zinc

sulphate till about one-half inch layer is upon the paste. This layer of solution may be omitted with but slight decrease in the E. M. F. of the cell.

(5). Place in the cork holding the zinc rod till no air space is left above the zinc sulphate solution. The zinc rod should be pushed down far enough to extend into the paste some little distance but should not touch the mercury below.

(6). Fill the cell chamber full above the cork with Le Page's or Marine glue - not with paraffine.

(7). The cell is then placed within some sort of a support. One may be made by boring a hole of proper size to receive cell, into a block of wood and by making a small hole at one side of the large one thru which the wire leading from the mercury electrode is brought from the bottom of the cell.

The cell is now ready for testing as soon as it has stood a few minutes.

The testing was done with a standardized galvanometer of 6600 ohms resistance. The cell soon depreciates in E. M. F. if in a low resistance circuit. To determine the electro-

motive force of a cell in volts the deflection of the galvanometer needle, in divisions upon the dial, is multiplied by the horizontal intensity of the earth's magnetism and this product is divided by the number at which the galvanometer is set upon its stage.

Three different Carhart-Clark standard cells were made and tested in this case. In all the platinum wire was sealed into the bottom of the cell chamber. In all the paste was the same, containing some free mercury in the mercurous sulphate thus making it dark in color.

Cell No. I.

In this the mercury used was pure, distilled in vacuo. No layer of zinc sulphate solution was put upon the paste.

Cell No. II.

The mercury used in this cell had been used for the various experiments in physics and so contained some impurities. No zinc sulphate solution layer used in this cell.

Cell No. III.

In this cell the pure mercury was used and also the one-half inch layer of zinc sulphate solution on top of paste.

The results of the testings are as follows. The deflections to the right (R) and to the left (L) are expressed in the divisions upon the dial of the galvanometer.

No. I.		No. II.		No. III.	
One set of measurements.					
R	L	R	L	R	L
24.3	23.9	20.2	21.	24.5	24.7
24.3	24.3	20.3	20.5	24.3	24.7
24.5	23.9	20.2	20.	24.5	24.8
—	—	19.8	20.5	24.8	24.8
—	—	20.1	20.5	24.5	24.8
—	—	20.2	20.	24.3	24.8
—	—	—	20.2	24.6	24.9
Mean 24.2		Mean 20.27		Mean 24.6	
E.M.F. 1.42 volts		E.M.F. 1.19 volts		E.M.F. 1.445 volts	
Another set of measurements.					
23.8	23.9			24.5	24.9
23.7	23.7			24.8	24.8
23.8	23.7			24.5	24.8
23.7	23.7			24.6	24.9
23.7	23.7			24.4	24.7
23.8	23.7			24.4	24.7
—	23.8			24.7	24.8
Mean 23.74				Mean 24.7	
E.M.F. 1.395 volts				E.M.F. 1.45 volts	

Another set of measurements.

23.3	23.	16.	16.9	24.8	24.8
23.3	23.	16.4	16.7	24.7	24.7
23.	23.2	16.3	16.5	24.8	24.9
23.	23.5	16.5	16.8	24.8	24.7
23.2	23.	16.7	16.5	24.7	24.9
23.3	23.2	16.7	16.5	24.9	24.7
23.2	23.	16.4	16.7	24.7	24.9
Mean 23.16		Mean 16.55		Mean 24.8	
E.M.F. 1.335 volts		E.M.F. .9668 volts		E.M.F. 1.457 volts	

Mean E.M.F.

$$No. I. = 1.388 \text{ volts}$$

$$No. II = 1.0784 \text{ "}$$

$$No. III = 1.4507 \text{ "}$$

In these computations for the E.M.F. the horizontal intensity of the earth's magnetism is taken at .235 dyne, which is as near it as has been ascertained both by mathematical calculation and by the standard Raoult cell.

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