INEXPENSIVE CHEMICAL INSTRUMENTATION: Y-TUBE STANDARD CELL

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ABSTRACT.—Instructions are presented for construction of an inexpensive Weston standard cell, suitable as an internal voltage reference (1.019±0.001 volt) for student potentiometers.

The operation of any student-type potentiometer, such as the Valco model described by Van Atta, Linnenbom, and Coleman (1967), requires standardization of the instrument against a reference voltage source. A reference cell of the Weston, saturated cadmium sulfate type can be easily constructed, by students, from very inexpensive components; it is small enough so that it may be incorporated internally in the Valco potentiometer, making that instrument "self-contained".

MATERIALS

Chemicals required include analytical reagent grade cadmium sulfate, $3CdSO_4\cdot 8H_2O$, mercury, and mercurous sulfate, Hg_2SO_4. Cadmium shavings may be cut from discs of the metal prepared from pure stick cadmium by the technique described by Vosburgh and Derr (1941). About 4 cm. of B & S 25- gauge platinum or nichrome wire are required for electrical contacts and a 5/16-inch O.D. shell glass Y-tube (about 30 cents each) is used as the cell vessel. The cell may be sealed with commercial epoxy cement.

CONSTRUCTION DETAILS

Seal 2-cm. lengths of the nichrome or platinum wire in the ends of the diagonal arms of the Y-tube, as shown in Figure 1; alternatively, the wire may be cemented in place with epoxy cement. Score the remaining (upper) end of the Y-tube about 1 cm. above the joint; break off and fire polish the cut end.

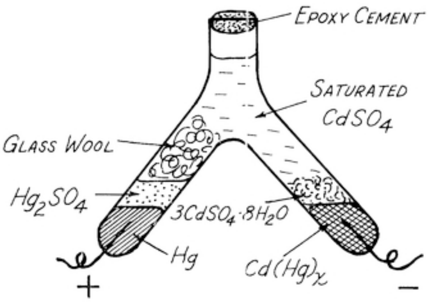

FIGURE 1.—Y tube standard cell.

Prepare the cadmium amalgam by placing a ½-cm. layer of cadmium metal shavings in the bottom of a 13x100 mm. test tube; add enough pure mercury to just cover the metal, then add about 2 ml. of dilute H_2SO_4 over the mixture. Shake tube and contents in a hot-water bath for one minute, then decant off the excess acid; wash the resulting amalgam thoroughly with distilled water, then transfer a 1-cm. layer of the product into one leg of the Y-tube. Place mercury in the other leg to a similar depth.

Using a small spatula, transfer about 0.5 gram of finely ground Hg_2SO_4 into the mercury leg of the Y-tube; similarly, place about 0.5 gram of finely ground $3CdSO_4\cdot 8H_2O$ into the amalgam leg. Introduce saturated $CdSO_4$ solution into the Y-tube until the liquid level is just up to the common joint in both legs. With the aid of a stiff wire, force a small wad of glass wool into the mercury leg, as shown (this will prevent the contents of the two legs from mixing, should the cell be tipped inadvertently). Make certain that there are no large air bubbles in either leg of the Y-tube, then add an additional 0.5 gram of solid cadmium sulfate to the cell.

Seal the top of the Y-tube with epoxy cement and allow the cell to stand for a day or so, after which it is ready for calibration and use.

Performance

More than twenty Y-tube cells have been prepared by high-school and college students in the authors' laboratory. When properly built, these cells have been found to yield potentials of 1.019 ± 0.002 volt immediately after the addition of the saturated cadmium sulfate solution, stabilizing within a few hours to 1.019 ± 0.001 volt. Voltages were measured with a Valco student potentiometer, standardized against an Eppley unsaturated cadmium standard cell. Several of the cells have been randomly inverted and shaken from time to time and found to remain stable (within 0.001 volt) over the several months elapsed since their construction. Some have been installed inside the cases of Valco potentiometers and have been found to render highly satisfactory performance as internal reference standards for these instruments.

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Literature Cited

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