Rapid Gravity Determination of Solids by Means of a Differential Gravity Tube

A differential gravity tube is formed by incomplete mixing of two miscible liquids of different gravities. If it is done in a graduate cylinder or buret, the graduations are easily changed to gravity units of density. This is done by putting materials of known density in the tube, and they will assume a location in the tube according to the gravity of the liquid at the spot where they float. It can be done with test minerals of known gravities or with synthetic materials impervious to the solvent characteristics of the liquids used. Synthetic materials are more easily obtained without air entrapped within them, and also can be readily obtained in thin, flat form, which float in a horizontal plane to give accurate readings that are easy to take. Also, they are readily available in quantity at low cost.

The liquids we used were our MI-GEE Methylene Iodide of Sp.G. 3.32 for our heavy liquid and our Benzyl Benzoate of Sp.G. 1.12 for our light liquid. We used either a 100 ml. Graduated Cylinder or a 100 ml. Buret. The graduate cylinder is a little easier to prepare and has a life of about 1 month, while the buret lasts from 2 to 3 times as long. The buret is also more accurate as it is calibrated to 0.2 ml., while the graduate is calibrated to 1.0 ml. The buret we used was 1.5 cm. inside diameter and the graduate was 2.5 cm. inside diameter. Since each liquid after mixing is diffusing into the other, the useful life of the tube is governed by this rate of diffusion at the desired gravity. In general, the diffusion is greatest at the outer fringe areas. That is, the heaviest gravity and the lightest gravity are most rapidly degraded and the middle zones change less rapidly.

Since it is crucial to know how much pure liquid is at each end of the tube, it is necessary to choose boundary solids just a little bit heavier than the light liquid and just a little lighter than the heavy liquid, plus additional ones in the tube as required for intermediate gravity readings. Also, we found that in a freshly prepared tube, there could be some differential from front to back of the tube. Therefore, it was found that, except for glass, several pieces of the same material cut into squares of not over 1/16” provided a better marker than a single larger piece, which also was susceptible of trapping air bubbles. We chose the following materials for our standards:

	Sp.G.	Thickness
1. Viskon T.M. (CHICOPEE MILLS, INC.)	1.44	.006”
2. Teflon (T.M. DuPont Co.)	2.11	.005”
3. Glass	2.48	.040”
4. Aluminum	2.73	.001”
5. Silicon Carbide	3.2	grains

The tube is made up by pouring the heavy liquid in the bottom until it reaches the 50 ml. mark on the tube, and then the light liquid is poured on top of it until it reaches the zero mark. If a graduate is set up, the center area is stirred with a small spatula until a mixed zone of 30 to 40 ml. of Readings is generated. If a buret is being set up, the heavy liquid is poured in up to the 50 ml. mark and then the light liquid is poured in up to the zero mark. The mixed zone is generated by tilting the buret to about 15 degrees off the horizontal, and straightening to the vertical quite rapidly, and at the same time rotating the tube on its own axis. Ten or 15 tilts will generate a nice mixed zone. One can govern the size of the mixed zone by the exact gravities required by his own work, but a 30 to 40 ml. zone should be useful for many purposes. Now the standards are added with the heavier ones added first and allowed to settle before the next lighter one is added. In this way, they do not entangle each other in descending and find their proper location easily. Tops of the tubes are covered with a cap to slow down evaporation. Aluminum foil is handy for this purpose. Because the tube is constantly changing, it is necessary to read the standards each time an unknown is run, but this is very easy. On a certain day, we obtained the following readings on a 100 ml. graduate cylinder:

			Difference		Difference
	Sp.G.	ML Reading	ML of readings (MOR)		Gravity Unit (GU)
1. Viskon*	1.44	77.0	A. 26.5	+	.67
2. Teflon*	2.11	50.5	B. 5.5	=	.37
3. Glass	2.48	45.0	C. 3.5	=	.25
4. Aluminum	2.73	41.5	D. 19.5	=	.47
5. Silicon Carbide	3.2	Over All	E. 55.0	=	1.76

Thus, an unknown solid floating at the 60.5 ml. mark would have an interpolated gravity of 1.857.

10.0/26.5 x .67 = .253 to be subtracted from 2.11 (Teflon) or 1.857

An unknown solid floating at 43.0 would have an interpolated gravity of 2.623.

2.0/3.5 x .25 = .143 to be added to 2.48 (Glass) or 2.623

This quickly locates the gravity of the unknown, and for more accuracy, special liquids in the exact range of the unknown may be used.

Recalculating the standards readings to even gravity units, we get the following:

A. 1.0 GU = 39.5 MOR, or 0.1 GU = 3.9 MOR

B. 1.0 GU = I2.0 MOR, or 0.1 GU = 1.2 MOR

C. 1.0 GU = I3 MOR, or 0.1 GU = 1.3 MOR

D. 1.0 GU = 41.5 MOR, or 0.1 GU = 4.15 MOR

E. 1.0 GU = 3I.3 MOR, or 0.1 GU = 3.13 MOR

From the above table, it can be seen that diffusion is more at the outer limits, giving 3.9 ml. of readings (MOR) at A per 0.1 Gravity Unit (GU) and 4.15 MOR at D for each 0.1 GU. The two center differences are only 1.2 and 1.3 MOR at B and C per 0.1 GU.

Benzyl Benzoate is a chlorinated solvent in which the residual acidity has been neutralized, so that it will not act to decompose Methylene Iodide or Bromoform or any other nonaqueous heavy liquid used. These are decomposed and darkened by acid conditions. Also, the tubes should be kept out of direct sunlight or very strong fluorescent light, as this also tends to darken the tubes. Benzyl Benzoate is also non-flammable and low in toxicity.

After the tube is no longer useful, the more expensive MI-GEE can be recovered from the Benzyl Benzoate solvent by pouring the first 50 ml. into one container, and the balance into another, and separately placed in a freezer overnight after removing all solids. The first container will be mostly solvent and can be poured off any crystals that form, and the crystals allowed to melt into MI-GEE containing a little solvent. The second container, having mostly MI-GEE in it, may be solid when taken out of the freezer. It is allowed to stand at room temperature for 5-10 minutes, and the liquid portion poured into the solvent portion from above, and the remaining crystals allowed to melt and combine with the crystal portion above. These crystal portions are allowed to stand open for the residual solvent to evaporate. A few grains of Silicon Carbide placed in this recovered MI-GEE will float when it is back to proper gravity for re-use in a tube. If it has darkened, it can be cleared up according to the instructions in our Bulletin No. 30. A freezer temperature of about 15 degrees F is used, as excessive cold could crack glass containers.

If a buret with a relatively large bottom opening is used, separations of assorted solids can be affected with this method by slowly draining the buret and collecting various solids from different levels, selectively.

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