

LABORATORY USES OF THERMOS BOTTLES.¹

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The thermos bottle may be used to great advantage as a calorimeter in a large number of experiments in the laboratory. The losses due to radiation and conduction are very small when the temperature of the contents of the bottle is not too far above or below that of the surrounding medium. Even with a thermos bottle, it is necessary to keep the contents at a temperature as close as possible to that of the surrounding medium, to avoid appreciable errors. The value of results obtained will depend entirely upon the accuracy with which the thermal capacity of the bottle and contents is determined.

The water equivalent or thermal capacity may be measured very accurately, if care is taken to get the temperatures of the contents and all inner parts of the bottle well equalized. This may seem simple at first, but in reality it takes care to get consistent results.

If a mercury-glass thermometer is used, it must not be raised or lowered, but remain fixed in one position throughout the experiment. The thermometer must be and remain in the same position as above when the thermal capacity of the bottle is determined.

In order to get all the inner parts and contents of the bottle at equal temperatures, it is absolutely necessary to turn it upside down several times. A rubber washer at the neck will prevent liquids from leaking out.

If it is necessary to put a liquid into the bottle without a change of temperature, it must be brought very nearly to room temperature before pouring in. To get accurate weights of liquids, weigh them after they are poured into the bottle and subtract the weight of the bottle.

If the above precautions are taken into consideration during a series of observations, very consistent results may be obtained. Otherwise, all the advantages of the thermos bottle over the ordinary laboratory calorimeter may be lost.

Let me explain the case of a pint thermos bottle in which all the precautions were taken into consideration, with the exception of turning it upside down. The water equivalent was

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sought for by two methods, as follows: 1. Method of mixtures.
2. Method of electrical heating.

The first method is known to all. The second method made use of a heating coil of resistance 1.037 ohms, an ammeter, which reads to 1/100 amperes, a thermometer which reads to 1/100 degrees Centigrade, and a stop watch which reads to one-fifth of a second. Distilled water was used in the bottle. Mechanical equivalent of heat used was 4.187 joules per calorie.

METHOD.	
First.	Second.
16.9	18.3
15.3	13.7
17.0	21.0
23.5	25.6
14.9	17.2
13.5	16.9
21.7	19.8
21.3	20.5
13.4	19.7
—	19.5
Average17.5	21.3
	24.8
	24.3
	27.3
	24.5
	22.4
	20.0
	19.5
	21.0
	—
	Average20.8

Average of 1 and 2 = 19.1

The results show the same range of values by both methods, but nothing consistent about them by either.

By observing all the precautions named above, the following values were obtained:

Water Equivalent.	
1	2
19.2	18.7
17.2	19.5
18.6	18.1
19.0	17.2
18.4	17.3
18.7	17.2
	17.0
	17.2
	18.0
—	—
Average.....18.4	Average.....17.7
Average of 1 and 2 = 18.05.	
Grand total average, 18.5.	

With the water equivalent of the bottle so accurately measured, it is possible to use the bottle for a number of purposes in the laboratory.

The calorimeter measures energy, and, therefore, if the resistance of the heating coil is accurately determined, we may use the thermos bottle to measure power, current, voltage, and even magnetic field strength as well as specific heat, latent heat, etc. It is quite an easy matter to check Rowland's value of the mechanical equivalent, 4.187 within two- or three-tenths of one per cent with the above apparatus.

TABULATED DATA AND RESULTS.

J = Mechanical equivalent of heat, 4.187 joules per cal.

H = Calories of heat.

m = Mass of water in grams.

T = Time in seconds.

R = Resistance in ohms, 1.037 ohms.

I = Current in amperes.

Q = Quantity of electricity.

t = Temperature change degrees Centigrade.

c = Water equivalent in gram calories per degree.

W = Power in watts.

Law of heating: $JH = I^2RT$.

$$H = (m + c) t.$$

$$J = \frac{I^2RT}{H}.$$

$$I = \sqrt{(JH/RT)}.$$

$$R = \frac{JH}{I^2T}.$$

$$W = I^2R = \frac{JH}{T}.$$

$$E = IR = W/I = \frac{JH}{IT} = \frac{\sqrt{(JHR)}}{T}$$

$$Q = IT = T\sqrt{(JH/RT)} = \sqrt{(JHT/R)}.$$

By using more water than above, and allowing for the change in the specific heat of water at different temperatures, errors could easily be reduced to two- or three-tenths of one per cent.

The resistance of the coil can be found in this way about as accurately as with a Wheatstone's bridge. The current and voltage are determined from reading the instrument scales.

If a tangent galvanometer be placed in the circuit so that the current and deflection are known, the reduction factor may be calculated accurately.

$$I = K \tan \theta,$$

$$K = 1/\tan \theta = \frac{\sqrt{(JH/RT)}}{\tan \theta},$$

$$\text{also} \quad K = \frac{10F}{2\pi n/r} = 10F/G.$$

F = Horizontal component of the earth's magnetic field.

n = Number of turns of wire.

R = Radius of turns of wire.

$$F = KG/10 = \frac{2\pi n \sqrt{(JH/RT)}}{10r \tan \theta}.$$

The value of G can be calculated from the number of turns used on the galvanometer and their radius.

We see then that from the value of the current determined by the calorimeter, it is possible to find the value of F accurately.

It seems possible, from the above considerations, to use the thermos bottle together with a heating coil whose resistance is known, for purposes in the laboratory as follows: To determine specific heats and latent heats, to calibrate ammeters, voltmeters and wattmeters, to find the reduction factor of a tangent galvanometer and the earth's magnetic field.

Data Including J and R.						Calorimeter Results.				Correct Values.			
M	T	t	C	J	R	I	W	E	O	I	W	E	O
150	420	5.60	18.4	4.187	1.037	3.01	9.43	3.12	1267	3.00	9.33	2.11	1260
150	480	6.35	18.4	4.187	1.037	3.00	9.36	3.11	1442	2.99	9.33	3.11	1435
150	420	5.60	18.4	4.187	1.037	3.01	9.43	3.12	267	3.00	9.33	3.11	1260
150	840	11.15	18.4	4.187	1.037	3.00	9.38	3.11	2522	3.00	9.33	3.11	2520

Data Including J and I.						Calorimeter Results.		Correct Values.	
M	T	t	C	J	I	R		R	
150	420	5.60	18.4	4.187	3.00	1.042		1.037	
150	480	6.35	18.4	4.187	2.99	1.045		1.037	
150	420	5.60	18.4	1.187	3.00	1.042		1.037	
150	840	11.15	18.4	4.187	3.00	1.039		1.037	

Data Including I and R.						Calorimeter Results.		Correct Values.	
M	T	t	C	I	R	J		J	
150	420	5.60	18.4	3.00	1.037	4.155		4.187	
150	480	6.35	18.4	2.99	1.037	4.160		4.187	
150	420	5.60	18.4	3.00	1.037	4.155		4.187	
150	840	11.15	18.4	3.00	1.037	4.180		4.187	

Later, a student performed this experiment in the laboratory, using a thermos bottle as a calorimeter. Data and results are as follows:

Data Including I and R.						Calorimeter Results.		Correct Values.	
M	T	t	C	I	R	J		J	
288.70	480	6.16	17.5	4.00	1.025	4.1734		4.187	
259.14	480	6.80	17.5	4.00	1.025	4.1906		4.187	
248.25	480	7.13	17.5	4.00	1.025	4.1654		4.187	
249.07	480	7.11	17.5	4.00	1.025	4.1643		4.187	

Average—4.1734.

Per cent error—0.32 per cent.

Sgd.: H. D. Draper.