A Relation Between the Fluidity and the Temperature of Liquids.—By Henry Jermain Maude Creighton,

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Some years ago it was shown by Ramsay and Young[1] that for any pair of closely related substances—such as methyl acetate and ethyl acetate, or propyl propionate and propyl butyrate—the ratio of the absolute temperatures (T) corresponding to equal vapour pressures is constant, *i. e.*, $\frac{T'_A}{T'_B} = \frac{T_A}{T_B} =$ constant. For substances not closely related it was found that the relation was less simple, but that it might be expressed by the equation, $R' = R + c(t' - t)$, where R' is the ratio of the absolute temperatures of the two substances corresponding to any vapor pressure, the same for both; R is the ratio of the absolute temperatures at any other vapor pressure, again the same for both; c is a constant; and t' and t are the temperatures of one of the substances corresponding to the two vapour pressures. This relationship was tested by Ramsay and Young for 23 pairs of substances, and has also been found to hold up to the critical point. The method has been employed by Ramsay and Travers[2] to calculate the vapor pressure of the inert gases argon, krypton and xenon.

At the suggestion of Ramsay, Findlay[3] showed that a precisely similar equation to that of Ramsay and Young connects the absolute temperatures at which two substances have equal solubilities, and also the two absolute temperatures at which two chemical equilibria have equal equilibrium constants.

The writer has recently found that the two absolute temperatures at which two substances have the same value for other of their physical constants are related by an equation having this same form. In this paper the relation between the fluidity (reciprocal of viscosity) and the absolute temperature of liquids is presented briefly.

The constant c in the equation $R' = R + c(t' - t)$, where R' and R are the ratios of the absolute temperatures of two

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[1] Phil. Mag., (5), *20*, 515 (1885); *21*, 33 (1886).
[2] Phil. Trans., A., *197*, 47 (1901).
[3] Proc. Roy. Soc., *69*, 471 (1902).

liquids A and B corresponding to two values of the fluidity (∅) and t' and t are the temperatures of liquid B corresponding to the two fluidities, is determined as follows: The ratios $\frac{T_A}{T_B}$ corresponding to a number of different fluidities are plotted as abscissae against the absolute temperatures, T_B, of one of the liquids as ordinates. A straight line is then drawn through the series of points obtained and "smoothed ratios" read off, corresponding to the temperatures T_B. The values of the smoothed ratios are substituted in the equation $R' = R + c(t' - t)$, and the equation solved for the constant *c*.

The success with which fluidities can be calculated by means of the equation $R' = R + c(t' - t)$ is shown by the examples contained in Tables I and II. In these tables, the asterisk indicates the temperature ratio R from which the other temperature ratios (R') and the corresponding temperatures (T_A) have been calculated.

TABLE I.

Calculation of the Fluidity of Methyl Alcohol (A) from the Fluidities of Water (B).

$c = 0.000568.$

Observed Fluidity ∅	Observed absolute Temperature		Ratio of observed Temperature $T_A \div T_B$	Calculated absolute Temperature T_A	Calculated Fluidity ∅	Difference ∅calc. *minus* ∅ obs.
	Methyl Alcohol[4] T_A	Water[5] T_B				
170.5	293.1	319.0	0.9189	293.7	170.8	+0.3
182.4	298.1	323.0	0.9221*	298.1	182.4	0.0
195.1	303.1	327.6	0.9252	302.9	194.9	-0.2
209.9	308.1	332.5	0.9266	308.3	210.2	+0.3
223.7	313.1	336.6	0.9302	313.0	223.5	-0.2
238.0	318.1	341.0	0.9328	317.9	237.6	-0.4
253.7	323.1	345.6	0.9349	323.1	253.7	0.0
269.5	328.1	350.0	0.9374	328.1	269.5	0.0
286.5	333.1	354.4	0.9399	333.2	286.7	+0.2

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[4] Bingham, E. C. and J. L. Cadwell, *Zeitschr. physik. Chem.*, *83*, 649-50 (1913).

[5] Bingham, E. C. and G. F. White, *ibid.*, *83*, 646 (1913).

TABLE II.

Calculation of the Fluidity of Octane (A) from the Fluidities of Benzene (B).

c = 0.000354.

Observed Fluidity	Observed absolute Temperature		Ratio of observed Temperatures	Calculated absolute Temprature	Calculated Fluidity	Difference
	Octane[6]	Benzene[7]				Ø calc. *minus* Ø obs.
Ø	T_A	T_B	$T_A \div T_B$	T_A	Ø	
142.2	273.1	287.6	0949.7	273.4	142.6	+0.4
163.2	283.1	296.8	0954.0*	283.1	163.2	0.0
174.8	288.1	301.5	0955.7	288.1	174.8	0.0
185.9	293.1	306.1	0957.6	293.0	185.7	−0.2
197.4	298.1	310.8	0959.1	298.0	197.2	−0.2
209.0	303.1	315.5	0960.5	303.2	209.2	+0.2
233.7	313.1	324.9	0963.7	313.1	233.7	0.0
259.4	323.1	334.1	9967.3	322.8	258.8	−0.6
286.1	333.1	343.3	0970.1	333.2	286.3	+0.2

[6] Landolt-Bŏrnstein, "Physikalisch-Chemische Tabellen," S. 78, Berlin 1912.

[7] Ibid., S. 80

The preceding examples are only a few of those that have been studied. In most cases the agreement between the calculated fluidity values and those determined by experiment is closer than the fluidity values determined by two different investigators. This agreement indicates that this method can be applied to the calculation of the fluidity or viscosity of liquids with a close approximation of the truth.

In order to calculate the fluidity of a liquid A from the known values of another liquid B, the fluidity of the former is determined at any two temperatures T'_A and T_A. The ratios $\frac{T'_A}{T'_B} = R'$ and $\frac{T_A}{T_B} = R$ are then obtained, the values plotted as abscissae against the absolute temperatures T'_B and T_B as ordinates, and a straight line drawn through the two points.

By multiplying a particular temperature T_B by the corresponding temperature ratio (read off from the curve), the absolute temperature T_A is obtained at which the fluidity of liquid A is equal to that of liquid B at the absolute temperature T_B. In this way the fluidity of liquid A over the whole range of known fluidities of liquid B may be calculated.

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