A VISCOSITY FORMULA FOR BINARY MIXTURES, THE ASSOCIATION DEGREES OF CONSTITUENTS BEING TAKEN INTO CONSIDERATION. SUMMARY.

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The probable values of the normal K relative to that of benzene. Before closing this series of the viscosity study,(1) we will consult as much as available data found in the literature in order to have the probable values of the normal K.

Mixtures adopted here are (1) those the viscosity curves of which are convex or quite rarely concave towards the composition axis, and (2) these both component K's of which in accord with Ishikawa's theory have already been known, although they indicate viscosity maxima or minima.

The following notations will be used:

K signifies the ratio of the characteristic constant (ka) of component 2 to that of component 1 in formula (1) for chemically indifferent mixtures:

$$\eta = \frac{\eta_1}{1+K\frac{z_m}{1-z_m}} + \frac{\eta_2}{1+\frac{1}{K}\frac{1-z_m}{z_m}} \qquad (1).$$

This normal case is simply denoted by the symbol n.

In the course of the calculation we have met with cases in which K's slightly vary as concentration, and either of the extrapolated values of K at $z_m = 0$ or $z_m = 1$ if taken much differs from the probable value of the normal K. Such anomaly is observed in the following mixtures: Acetone—*i*-propyl alcohol, carbon tetrachloride—tetrachloroethane, &c. However, further tests for these mixtures prove that they must be classified into the following case.

K' and K'' denote the ratios of the characteristic constant (ka) of component 2 to that of component 1 and that of component 1 to that of component 2 respectively, more or less differing from K and $1/K$ in formula (1) or $K'K'' > 1$ as a result of anomalous changes in molecular association:

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(1) This Bulletin, **4** (1929), 5, 25, 149, 288; **5** (1930), 47, 117; **8** (1933), 280, 293; **9** (1934), 155; **10** (1935), 153, 248; **11** (1936), 8.

$$\eta = \frac{\eta_1}{1+K'\frac{z_m}{1-z_m}} + \frac{\eta_2}{1+K''\frac{1-z_m}{z_m}} \qquad (2).$$

This formula for anomalous change in association on mixing holds true for the concentration range between the two extremities close to $z_m = 0$ and $z_m = 1$, where the numbers of molecules of one component become quite enough to change its original association into some other associations statistically at extremely low concentration and at extremely high concentration diluted with the other component. This anomalous case is abbreviated by the symbol a.

For the case in which the association degree of a component varies as dilution with the other, the extrapolated value of K at $z_m = 0$ or $z_m = 1$ gives the normal K for the mixture. The mixtures of phenol, guaiacol, or benzyl benzoate with benzene or toluene in which the former components suffer molecular dissociation are examples of this case. The formulation of the viscosity—composition curves of such mixtures cannot be generally done, since the decreasing rate of the association degree with dilution depends upon its own peculiarity of the associated component against the solventing action of the other component, yet a particular case can be solved with a particular means, say, taking K or its reciprocal at each composition for test whether they are in a linear relationship with composition or not. This variable case (3) is briefly denoted by the symbol v, and both extrapolated values at $z_m = 0$ and $z_m = 1$ are written thus: e.g. 0.087–0.227 for C_6H_6 (1)–C_6H_5OH (2).

The mixture phenol—dimethylaniline is considered as one more example of the case. The viscosity—composition curves observed by Bramley at the temperatures between 10° and 180°C. are sinuous nature as seen from Fig. 1 in which the points are the observed viscosities. Simply judging from the curves, one may imagine, as Bramley does, that the mixture appears to have a compound, but the freezing-point curve consists of two branches only, the eutectic temperature being found to be −36.0°C. according to Bramley.(2) Once when we take, however, K as ordinate and z_m as abscissa, we readily see that the points at each temperature lie on a straight line. This fact shows that there occurs the molecular dissociation of phenol but no molecular compound just as the freezing-point diagram requires. The curves in Fig. 1 are traced on thus calculated viscosities (see Table 1).

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(2) A. Bramley, *J. Chem. Soc.*, **109** (1916), 469.

Table 1. Phenol—Dimethylaniline, (Bramley).

z_m	10°C.		z_m	29.8°C.		59.9°C.	
	$\eta_{\text{obs.}}$	$\eta_{\text{calc.}}$		$\eta_{\text{obs.}}$	$\eta_{\text{calc.}}$	$\eta_{\text{obs.}}$	$\eta_{\text{calc.}}$
0.0000	0.2010	—	0.0000	0.0709	—	0.02530	—
0.0571	0.1964	0.1946	0.0537	0.0686	0.0687	0.02665	0.02473
0.1173	0.1850	0.1801	0.1116	0.0648	0.0650	0.02380	0.02387
0.1785	0.1639	0.1596	0.1726	0.06025	0.06003	0.02270	0.02274
0.2500	0.1347	0.1327	0.2409	0.05325	0.05352	0.02100	0.02124
0.3149	0.1094	0.1092	0.3046	0.04705	0.04721	0.01960	0.01972
0.3815	0.0869	0.0881	0.3778	0.0393	0.04025	0.01760	0.01790
0.4542	0.0696	0.0693	0.4452	0.0333	0.03448	0.01587	0.01627
0.5340	0.05315	0.0535	0.5231	0.0283	0.02873	0.01428	0.01451
0.6110	0.04185	0.0421	0.6151	0.02315	0.02335	0.01267	0.01268
0.7115	0.03145	0.0317	0.7042	0.01936	0.01928	0.01123	0.01118
0.7879	0.02586	0.0259	0.7960	0.01629	0.01616	0.01001	0.00992
0.8861	0.02076	0.0207	0.9001	0.01351	0.01356	0.00878	0.00881
1.0000	0.01654	—	1.0000	0.01173	—	0.00799	—

$K = 0.25 + 6.05\, z_m$. $K = 0.50 + 3.36\, z_m$. $K = 0.50 + 1.93\, z_m$.

Table 2. Acetone—Phenol, (Bramley).

z_m	9.95°C.		20.05°C.	
	$\eta_{\text{obs.}}$	$\eta_{\text{calc.}}$	$\eta_{\text{obs.}}$	$\eta_{\text{calc.}}$
0.0000	0.00360	—	0.00323	—
0.0926	0.00486	0.00486	0.00429	0.00432
0.1837	0.00635	0.00636	0.00560	0.00559
0.2749	0.00868	0.00873	0.00755	0.00752
0.3761	0.01256	0.01265	0.01055	0.01061
0.4580	0.01688	0.01683	0.01379	0.01402
0.5363	0.02358	0.02338	0.01853	0.01828
0.6340	0.03670	0.03722	0.02750	0.0273
0.6982	0.0495	0.0501	0.0359	0.0357
0.7829	0.0748	0.0736	0.0497	0.0500
0.8890	0.1193	0.1194	0.0730	0.0745
1.0000	0.2010	—	0.1104	—

$K = 0.063$ ($z_m = 0.0$–0.20);
$K = 0.0485 + 0.079\, z_m$ ($z_m = 0.20$–0.55);
$K = -0.026 + 0.228\, z_m$ ($z_m = 0.55$–1.0).

$K = 0.100$ ($z_m = 0.0$–0.20);
$K = 0.077 + 0.120\, z_m$ ($z_m = 0.20$–0.55);
$K = -0.033 + 0.316\, z_m$ ($z_m = 0.55$–1.0).

Table 2. (*Concluded*)

z_m	29.8°C.		40.1°C.		49.8°C.	
	$\eta_{obs.}$	$\eta_{calc.}$	$\eta_{obs.}$	$\eta_{calc.}$	$\eta_{obs.}$	$\eta_{calc.}$
0.0000	0.002950	—	0.002700	—	0.002480	—
0.0613	0.003599	0.003596	0.003279	0.003273	0.002990	0.002980
0.1302	0.004409	0.004414	0.003991	0.003987	0.003599	0.003604
0.1912	0.005212	0.005233	0.004700	0.004698	0.004219	0.004216
0.2695	0.00670	0.00656	0.005899	0.005756	0.005299	0.005133
0.3324	0.00808	0.00805	0.00711	0.00698	0.006281	0.006177
0.4179	0.01058	0.01065	0.00904	0.00908	0.00794	0.00794
0.4832	0.01319	0.01321	0.01101	0.01105	0.00950	0.00956
0.5581	0.01658	0.01682	0.01362	0.01384	0.01149	0.01175
0.6401	0.02179	0.02188	0.01742	0.01759	0.01425	0.01459
0.7213	0.02747	0.02838	0.02232	0.02219	0.01786	0.01768
0.8187	0.03922	0.03886	0.02874	0.02911	0.02247	0.02246
0.8880	0.04902	0.04873	0.03460	0.03516	0.02618	0.02615
1.0000	0.07092	—	0.04739	—	0.03279	—

	29.8°C.	40.1°C.	49.8°C.
	$K=0.147$ ($z_m=0.0$–0.20); $K=0.105+0.175\,z_m$ ($z_m=0.20$–1.0).	$K=0.198$ ($z_m=0.0$–0.20); $K=0.140+0.220\,z_m$ ($z_m=0.20$–1.0).	$K=0.257$ ($z_m=0.0$–0.20); $K=0.177+0.308\,z_m$ ($z_m=0.20$–1.0).

Another example of this case in which K sometimes occurs to be composed of two or more sets of linear functions of z_m suggests the molecular dissociation of one component in two or more stages. For a good example the mixture of phenol (2) with acetone (1) measured by Bramley will be adopted here. Fig. 2 shows the K's plotted against the composition, in which we make distinct classifications of the points in three sets of straight lines at 10° and 20°C., and in two sets at 30° and higher temperatures. In Table 2 $\eta_{calc.}$ are obtained by assuming these sets of linear relationship of K with composition. As judged from the numerical values of the cutting points of the elongations of these sets of lines at each temperature at phenol-pure axis, the degradation of phenol-associated molecules is well explained if we assume that the phenol in its pure state consists mainly of trimol at low temperatures and of dimol at high temperatures; that is, of the three sets at low temperatures the first phenol-rich set indicates the coexistence of trimol and dimol, the second the coexistence of dimol and monomol, and the third the existence of monomol only, whereas at higher temperatures the first set at phenol-rich solutions shows the coexistence of dimol and monomol, and the second the existence of monomol only, all in equilibrium with acetone molecules. The above elucidation, though it indicates no appreciable presence of a molecular compound, yet the presence of dynamic equilibrium of dimol and monomol whose relative amounts to each other are nearly independent of temperature, is affirmative to the melting-point diagram observed by Schmidlin and Lang⁽³⁾ which records a greatly dissociated molecular compound $(CH_3)_2CO \cdot 2C_6H_5OH$ melting at 15°C.

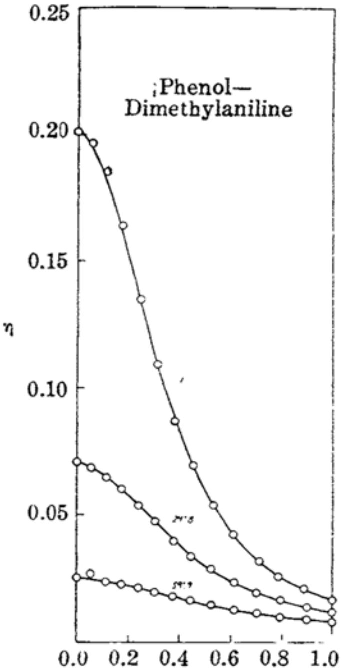

Fig. 1.

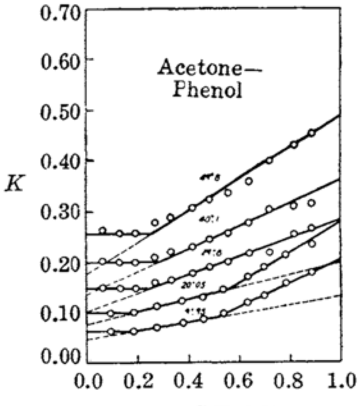

Fig. 2.

ν_1 and ν_2 signify the molecular numbers of components 1 and 2 in the molecular compound in accord with formula (4):

$$\eta = \frac{\eta_1}{1+K\dfrac{z_m}{1-z_m}} + \frac{\eta_2}{1+\dfrac{1}{K}\dfrac{1-z_m}{z_m}} + C_0(\eta_1^{\nu_1}\eta_2^{\nu_2})^{\frac{m}{\nu_1+\nu_2}}(1-z_m)^{\nu_1} z_m^{\nu_2} \qquad (4),$$

where C_0 and m are constants independent of the temperature and concentration. This case in which a compound occurs is denoted by the symbol c ($\nu_1 : \nu_2$).

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(3) J. Schmidlin and R. Lang, *Ber.*, **43** (1910), 2812.

An interesting system for case (4) is the water—pyridine mixture. The solvation viscosity $\delta = \eta - \eta_0$ of this mixture at 0° and 25°C. appears to consist of two terms up to 30 mol % pyridine, i.e. it is not simply proportional to $(1-z_m)^3 z_m$ or $(1-z_m)^2 z_m$, but it corresponds to the sum of some or other

Table 3. Water—Pyridine, (Hartley, Thomas, and Applebey).

0°C.

z_m	η	η_0	δ	$\delta_{\text{calc.}}$		$\eta_{\text{calc.}}$
0.0000	0.01778	—				—
0.0236	0.02448	0.01765	0.00683	0.00672	$0.104(1-z_m)^3 z_m + 0.197(1-z_m)^2 z_m$	0.02437
0.0564	0.03218	0.01747	1471	1482		0.03229
0.0872	0.03840	0.01730	2110	2122		0.03852
0.1306	0.04548	0.01707	2841	2825		0.04532
0.1847	0.05147	0.01679	3468	3461		0.05140
0.2483	0.05521	0.01646	3875	3860		0.05506
0.2713	0.05562	0.01635	3927	3929		0.05564
0.2985	0.05560	0.01621	3939	3965		0.05586
0.3462	0.05416	0.01598	3818	3806	$0.370(1-z_m)^3 z_m + 0.01(1-z_m) z_m$	0.05404
0.4159	0.04905	0.01564	3341	3309		0.04873
0.4780	0.04262	0.01535	2727	2766		0.04301
0.5789	0.03298	0.01489	1809	1844		0.03333
0.6746	0.02398	0.01446	952	1080		0.02526
0.8159	0.01729	0.01385	344	338		0.01723
0.9117	0.01463	0.01346	117	103		0.01449
1.0000	0.01321	—				—

$K = 1.19.$

25°C.

z_m	η	η_0	δ	$\delta_{\text{calc.}}$		$\eta_{\text{calc.}}$
0.0000	0.00890	—				—
0.0240	0.01116	0.00890	0.00226	0.00222	$0.0232(1-z_m)^3 z_m + 0.0743(1-z_m)^2 z_m$	0.01112
0.0515	0.01336	0.00890	446	446		0.01336
0.0890	0.01598	0.00890	708	705		0.01595
0.1312	0.01833	0.00889	944	936		0.01825
0.1840	0.02032	0.00889	1143	1142		0.02031
0.2522	0.02187	0.00889	1298	1293		0.02182
0.3127	0.02225	0.00888	1337	1334		0.02222
0.3450	0.02186	0.00888	1298	1318	$0.118(1-z_m)^3 z_m + 0.0077(1-z_m) z_m$	0.02206
0.4780	0.01894	0.00887	1007	994		0.01881
0.6730	0.01350	0.00887	463	447		0.01334
0.8126	0.01064	0.00886	178	180		0.01066
0.8864	0.00979	0.00886	93	92		0.00978
0.9186	0.00942	0.00885	57	64		0.00949
0.9576	0.00917	0.00885	32	32		0.00917
1.0000	0.00885	—				—

$K = 1.19.$

multiples of these concentration factors, which phenomenon undoubtedly shows the coexistence of $C_5H_5N{\cdot}3H_2O$ and $C_5H_5N{\cdot}2H_2O$ in solution for the concentration range. For higher concentrations up to more than 90 mol % pyridine a set of hydrates $C_5H_5N{\cdot}3H_2O$ and $C_5H_5N{\cdot}H_2O$ exists, of which the former greatly predominates, but the dihydrate disappears.

Baud⁽⁴⁾ has determined the freezing points of the system but found no decisive hydrates owing to the existence of hidden maxima. He also points out that the volume contraction maximum occurs at 30 mol % pyridine corresponding to $C_5H_5N{\cdot}2.3H_2O$, whereas Pariselle⁽⁵⁾ has observed that the density maxima at 17° and 25°C. correspond to $C_5H_5N{\cdot}3H_2O$ and $C_5H_5N{\cdot}3.3H_2O$ respectively. However, if we consider the volume contraction per gram at 0°, 25°, and 50°C. from the density measurements done by Faust,⁽⁶⁾ the points of maximum at these temperatures nearly lie at the same composition probably corresponding to $C_5H_5N{\cdot}2.3H_2O$. These results may be fairly understood from the present study that the two hydrates $C_5H_5N{\cdot}3H_2O$ and $C_5H_5N{\cdot}2H_2O$ coexist in solution, and the former is more stable than the latter as clearly recognized from the concentration ranges of their existence (see Table 3) and also from the amounts of m, the stability coefficient, of these compounds, m of the former being estimated to be 2.4 up to 30 mol % and 1.8 up to more than 90 mol % or in the mean 2.1, while m of the latter to be 1.6 between 0 and 30 mol %.

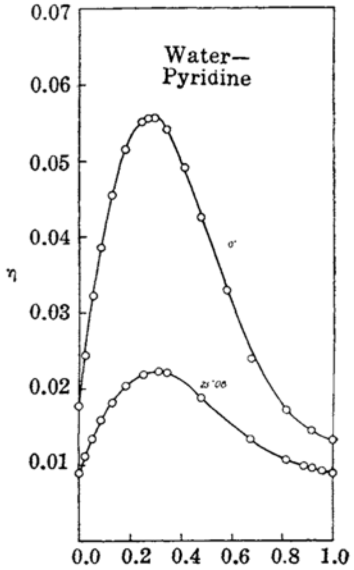

Fig. 3.

Fig. 3 shows how the theoretical and observed viscosities compare graphically.

It rarely happens that anomalous change occurs in association and thence follows a further chemical change to form a molecular compound. For such a case, the formula in combination of formula (2) with the second term of formula (4) may suffice to express the nature of the viscosity—composition curve. Mixtures as that of formamide with i-butyl alcohol or with i-amyl

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(4) E. Baud, *Bull. soc. chim.*, [4], **5** (1909), 1022.

(5) Pariselle, *Compt. rend.*, **172** (1921), 673.

(6) O. Faust, *Z. physik. Chem.*, **79** (1912), 104.

alcohol where both a maximum and a minimum display themselves at low temperatures belong to this case:

$$\eta = \frac{\eta_1}{1+K'\frac{z_m}{1-z_m}} + \frac{\eta_2}{1+K''\frac{1-z_m}{z_m}} + C_0(\eta_1^{\nu_1}\eta_2^{\nu_2})^{\frac{m}{\nu_1+\nu_2}}(1-z_m)^{\nu_1} z_m^{\nu_2} \qquad (5).$$

The calculation by this formula which appears to be difficult will become easy, if we remember that K' or K'' is often nearly equivalent to K or its reciprocal as in the mixtures of higher alcohols with benzene, together with the presupposition for the values ν_1 and ν_2 from the position of a maximum point in the actual curve. For example, the mixture of *i*-amyl alcohol (1) and formamide (2) as determined by Drucker and Kassel will be considered in the following. Since K of formamide is 0.34 and that of *i*-amyl alcohol is nearly 0.30 as supposed from K (0.29) of γ-amyl alcohol, the probable value for K in this mixture may be nearly 1.17 at an extremity. From the maximum points of the viscosity curves at 0° and 76.5°C., the case for which $\nu_1 = 1$ and $\nu_2 = 2$ is highly probable. After a few trials we have the following equations which are good enough to represent the nature of the curves:

$$\eta = \frac{0.0883}{1+1.77\frac{z_m}{1-z_m}} + \frac{0.0755}{1+1.1\frac{1-z_m}{z_m}} + 0.287(1-z_m)z_m^2 \quad \text{at} \quad 0°\text{C.},$$

$$\eta = \frac{0.00951}{1+1.1\frac{z_m}{1-z_m}} + \frac{0.01255}{1+1.1\frac{1-z_m}{z_m}} + 0.0128(1-z_m)z_m^2 \quad \text{at} \quad 76.5°\text{C.}$$

The calculated viscosities show no functional divergence from the observed viscosities as seen from Table 4 and also Fig. 4 in which the curves are drawn with the calculated values.

Peculiar systems for which the viscosity maxima often display themselves as hundreds times greater than the component viscosities are also understood as special cases of formula (4).

Acetic acid—stannic chloride and ethyl formate—stannic chloride are good examples of such cases. For the former pair a molecular compound $SnCl_4 \cdot 3CH_3COOH$ is pointed out by Stranathan and Strong with the viscosity courves the maximum points of which exactly correspond to this molecular ratio, probably independent of temperature. For the latter pair a molecular compound $SnCl_4 \cdot 2HCO_2C_2H_5$ has been confirmed by Kurnakow from the measurements of the viscosities at 30°, 40°, and 50°C. and of the fusion curve.

Table 4. *i*-Amyl alcohol—Formamide, (Drucker and Kassel).

z_m	0°C.		76.5°C.	
	$\eta_{obs.}$	$\eta_{calc.}$	$\eta_{obs.}$	$\eta_{calc.}$
0.0000	0.0883	—	0.00951	—
0.0538	0.0848	0.0848	0.00966	0.00960
0.1783	0.0836	0.0837	0.01005	0.01008
0.4571	0.0992	0.1008	0.01178	0.01183
0.6633	0.1111	0.1106	0.01311	0.01295
0.8194	0.1064	0.1053	0.01322	0.01324
0.9441	0.0858	0.0881	0.01292	0.01292
1.0000	0.0755	—	0.01255	—

Since the viscosities of both components in this type of mixtures are negligibly small as compared to the viscosity of the solution, the consideration of the true value of K is not useful for the approximate estimation of ν_1 and ν_2 in formula (4). In the following calculation, therefore, viscosity deviations are taken from formula (1) in which K is put as unity.

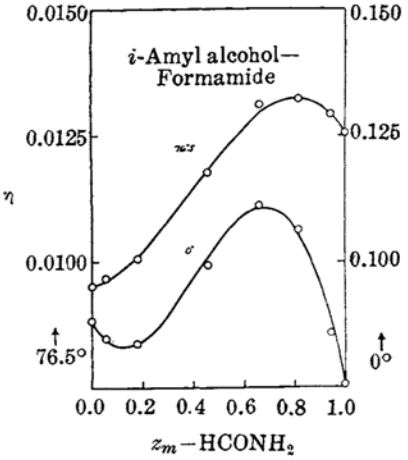

Fig. 4.

As clearly indicated in Table 5, a molecular compound $SnCl_4 \cdot 3CH_3COOH$ exists as some multiple of the simplest molecular ratio, 2-fold up to 5 mol %, 7-fold up to 17 mol %, and 14-fold for higher concentrations.

Similar phenomena are also seen from Table 6 for the mixture of ethyl formate and stannic chloride. In this mixture a molecular compound $SnCl_4 \cdot 2HCO_2C_2H_5$ exists as a great molecule of 30-fold of the simplest ratio at concentrations up to ca 36 mol % at 30°, 40°, and 50°C., but exists as a greater molecule of 60-fold at the concentration range from 32 to 36 mol % at 30°C., under which temperature an enormous crystallization of this compound begins, the melting point of it, however, being at 49°C. according to the same observer.

One more molecular compound $SnCl_4 \cdot HCO_2C_2H_5$ may probably exist at ca 7-fold of the simplest ratio, though the constancy of $\delta/\{(1-z_m)z_m\}^{\nu}$ is not sufficiently good.

These studies suggest that the multiple number of the simplest ratio of a molecular compound at sufficiently low temperature as crystallization begins may be in close relationship with the crystal structure or probably with the dimension of the secondary structure of a crystal as judged from the magnitude of thus estimated multiple of the supposed molecular volume of the molecular compound.(7)

Table 5. Acetic acid—Stannic chloride, 25.2°C., (Stranathan and Strong).

z_m	η	δ	$\delta/(1-z_m)^{\nu_1} z_m^{\nu_2}$		
0.0000	0.01155				
0.0244	0.02121	0.00974	19.0	mean **17.7**	$\nu_1 = 3\times2$, $\nu_2 = 1\times2$.
0.0520	0.04373	0.03234	16.4		
0.1084	0.1897	0.1785	1.13×10^7	mean $\mathbf{1.13\times10^7}$	$\nu_1 = 3\times7$, $\nu_2 = 1\times7$.
0.1719	0.963	0.952	1.13 ,,		
			(1.33×10^{14})		
0.2290	2.582	2.571	1.30×10^{14}	mean $\mathbf{1.42\times10^{14}}$	$\nu_1 = 3\times14$, $\nu_2 = 1\times14$.
0.2527	3.034	3.023	1.44 ,,		
0.2682	2.909	2.898	1.44 ,,		
0.2969	2.105	2.094	1.34 ,,		
0.3151	1.649	1.638	1.42 ,,		
0.3498	0.864	0.854	1.45 ,,		
0.3608	0.691	0.681	1.57 ,,		
0.4111	0.4234	0.4131	(4.75 ,,)		
1.0000	0.0084				

Table 6. Ethyl formate—Stannic chloride, (Kurnakow).

30°C.

z_m	η	δ	$\delta/(1-z_m)^{\nu_1} z_m^{\nu_2}$		
0.00	0.00375				
0.25	0.08788	0.08305	2.99×10^{24}	mean $\mathbf{2.96\times10^{24}}$	$\nu_1 = 2\times30$, $\nu_2 = 1\times30$.
0.30	0.31158	0.30654	2.93 ,,		
0.32	0.52286	0.51773	3.22×10^{49}	$\mathbf{3.28\times10^{49}}$	$\nu_1 = 2\times60$, $\nu_2 = 1\times60$.
0.335	0.57832	0.57313	3.33 ,,		
0.36	0.44142	0.43612	3.29 ,,		
0.50	0.06871	0.06281	1.03×10^3	$\mathbf{1.03\times10^3}$	$\nu_1 = 1\times 7$, $\nu_2 = 1\times 7$.
0.75	0.01526	0.00828	1.02 ,,		
1.00	0.00806				

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(7) This Bulletin, **10** (1935), 248.

Table 6. (*Concluded*)

40°C.

z_m	η	δ	$\delta/(1-z_m)^{\nu_1} z_m^{\nu_2}$		
0.00	0.00342				
0.25	0.06384	0.05946	2.14×10^{24}	mean 2.05×10^{24}	$\nu_1=2\times30$, $\nu_2=1\times30$.
0.30	0.19034	0.18577	1.78 ,,		
0.32	0.27615	0.27150	2.14 ,,		
0.335	0.29541	0.29071	2.22 ,,		
0.36	0.23514	0.23034	2.00 ,,		
0.50	0.04952	0.04419	7.2×10^2	7.7×10^2	$\nu_1=1\times7$, $\nu_2=1\times7$.
0.75	0.01292	0.00663	8.1 ,,		
1.00	0.00725				

50°C.

z_m.	η	δ	$\delta/(1-z_m)^{\nu_1} z_m^{\nu_2}$		
0.00	0.00311				
0.25	0.04904	0.04504	1.62×10^{24}	mean 1.29×10^{24}	$\nu_1=2\times30$, $\nu_2=1\times30$.
0.30	0.12463	0.12045	1.15 ,,		
0.32	0.16102	0.15667	1.24 ,,		
0.335	0.16758	0.16327	1.24 ,,		
0.36	0.14237	0.13798	1.20 ,,		
0.50	0.03753	0.03264	5.3×10^2	5.9×10^2	$\nu_1=1\times7$, $\nu_2=1\times7$.
0.75	0.01115	0.00536	6.5 ,,		
1.00	0.00668				

General Conclusions. The validity of the above formulas is acknowledged from a great deal of calculations already made (see Table 8). It may fairly be said that formula (1) deserves to be an ideal mixture law which has long been aimed at. The consideration of the viscosity deviation from the ideal mixture law in case where viscosity exhibits a maximum, which idea was introduced by Findlay⁽⁸⁾ and by Denision⁽⁹⁾ but failed owing to the lack of the true law of ideal mixtures, proves to be true in our case not only in determining the composition of a molecular compound but also in estimating its stability in solution.

The second term of formula (4) or (5) contains two factors, one being concentration function $(1-z_m)^{\nu_1} z_m^{\nu_2}$, the other main corresponding to the viscosity of a molecular compound. One may readily understand that the former is at once deduced from the law of probability by considering the

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(8) A. Findlay, *Z. physik. Chem.*, **69** (1909), 203.

(9) R. B. Denison, *Trans. Faraday Soc.*, **8** (1912), 20.

number of encounter between reacting molecules, but one may throw doubt on the form of the latter in which C_0 is independent of concentration and temperature ; that is, formula (4) or (5) the second term of which appears to superpose on the first term with respect to composition cannot be elucidative by the classical treatment of chemical equilibrium. If the viscosity of liquids is defined by $\frac{cm\nu}{\sigma}$ as Andrade⁽¹⁰⁾ proposes where m is a mass of a molecule, σ the distance between the centres of molecules, ν the vibration frequency, and c a constant, the number of molecular encounter or collision is proportional to $\frac{\nu}{\sigma}$ which is of the order of some 10^{20} per second. Although the collision probability between ν_1 molecules of kind 1 and ν_2 molecules of kind 2 to form a molecular compound is much less than this amount, the time of such encounter may be beyond comparison with the time ordinarily required for viscosity measurements, so long as a molecular compound is only statistically recognized as such the component molecules of which are freely interchangable with the same kinds of molecules outside of its reaction sphere. Hence the fact that the viscosity of chemically reactive mixtures strictly obeys formula (4) or (5) leads to the conception that a molecular compound is not a fast-combined molecule but a molecular grouping in a statistical meaning.

Formula (4) when applied to the viscosity which exhibits a very marked maximum at low temperature may afford a clue to the study on the mechanism of crystal formation.

Formula (1) is also valid for ideal solutions of solids in liquids.

For a strong electrolyte solution (i) where there occurs no solvation or hydration, the viscosity difference (η^{**}) between the observed specific viscosity (η^{*}) and the viscosity caused by the inter-ionic forces according to the Falkenhagen—Vernon theory⁽¹¹⁾ obeys formula (1) as expressed in specific quantity :

$$\left.\begin{aligned} &\eta^{**} = 1+\frac{(H-1)Kz_m}{1-z_m+Kz_m} \\ \text{or}\quad &\eta^{*} = 1+A\sqrt{\frac{1000sz_m}{M_1+(M_2-M_1)z_m}}+\frac{(H-1)Kz_m}{1-z_m+Kz_m} \\ \text{or}\quad &\eta^{*} = 1+A\sqrt{c}+\frac{(H-1)KM_1c}{1000s+(KM_1-M_2)c} \end{aligned}\right\} \qquad (6),$$

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(10) E. N. Da C. Andrade, *Nature*, **128** (1931), 835 ; *Phil. Mag.*, **17** (1934), 497.

(11) H. Falkenhagen and E. L. Vernon, *Phil. Mag.*, **14** (1932), 537.

in which H is the specific solutional viscosity of the solute, the viscosity of solvent being taken as unity, s the density of the solution at concentration c (g. mol/litre soln.), M_1 and M_2 the formal molecular weights of the solvent and the solute, and A the Falkenhagen–Vernon constant.

For a strong electrolyte solution (ii) where there forms a solvated or hydrated compound, formula (2) for which the Falkenhagen–Vernon effect is taken into account holds true for concentrations up to saturation:

$$\eta^{**} = 1 + \frac{(H-1)Kz_m}{1-z_m+Kz_m} + C^*(1-z_m)^{\nu_1} z_m^{\nu_2} \tag{7}$$

where C^* is a constant independent of concentration.

The solutional viscosity of a solid in a liquid in accord with formulas (1), (6), and (7) is the viscosity probably due to the block of a secondary structure in accordance with the secondary structure theory on crystals when the substance is an organic non-electrolyte or is the viscosity due to the ionic pair when the substance is an ionic crystal.

At very dilute solutions where the solvation or hydration, though it happens, is not appreciable and the Falkenhagen–Dole–Vernon equation holds, formula (6) or (7) becomes

$$\eta^* = 1+A\sqrt{c} + \frac{(H-1)KM_1}{1000s_1}c \tag{8},$$

whence it readily follows that the theoretically as yet unknown factor B of the Falkenhagen–Dole–Vernon equation is defined by

$$B = \frac{(H-1)KM_1}{1000s_1}.$$

Quite recently Sulston has made careful measurements on the temperature variation of B for aqueous solutions of KCl and K_2SO_4. As we have had for KCl $H_{18}=0.9471$, $H_{25}=0.9765$, and $K = 40.39$ and this K may be regarded to keep constancy for higher temperatures, we can estimate the

Table 7. The Solutional Viscosity of KCl.

t°C.	B	η	$\eta_{calc.}$
18	−0.0330	0.01003	0.01003
25	−0.0140	0.00874	0.00874
35	+0.0090	0.00731	0.00731
55	+0.0400	0.00540	0.00539
65	+0.0506	0.00472	0.00471
70	+0.0545	0.00442	0.00442
75	+0.0561	0.00415	0.00416
80	+0.0613	0.00392	0.00392
85	+0.0654	0.00371	0.00370

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(12) W. J. Sulston, *Proc. Phys. Soc.*, **47** (1935), 657.

Table 8. I. Mixture.

Component 1	Component 2	t°C.	K	Remarks	Observer
Benzene	Toluene	25	1.23	n	Linebarger
	Diphenyl	25	0.30	n	Kendall and Monroe
	Naphthalene	25	0.49	n	,,
	Chloroform	25	(1.81)	n	Linebarger
	Carbon tetrachloride	0	1.08	n	Thorpe and Rodger
	,,	10	0.99	n	
	,,	20	0.96	n	
	,,	30	0.94		
	,,	40	0.88	n	
	,,	50	0.83	n	
	,,	60	0.79	n	
	,,	70	0.81	n	
	Ethylene dichloride	0	K'1.13, K''1.30	a	Faust
	,,	19.4	K'1.00, K''1.37	a	
	,,	50	K'0.72, K''1.66	a	
	Bromobenzene	18.2	1.06	n	Yajnik and coworkers
	,,	30	1.10	n	
	,,	40	1.07	n	
	Nitrobenzene	25	0.49	n	Linebarger
	m-Nitrotoluene	15	0.40	n	Dessart
	,,	30	0.44	n	
	Methyl alcohol	25	K'0.62, K''1.60	a	Fischler
	Ethyl alcohol	25	K'1.75, K''1.45	a	Dunstan
	n-Propyl alcohol	25	K'1.70, K''2.25	a	,,
	i-Amyl alcohol	30	K'1.71, K''3.36	a	Bhide and Watson
	Phenol	20	0.087–0.23	v	Bramley
	,,	25	0.12 – 0.32	v	Swearingen
	m-Cresol	60	0.27	n	Piatti
	Guaiacol	30	0.17 – 0.29	v	Puschin and Pinter
	Ether	25	2.28	n	Linebarger
	,,	10	2.35	n	I. C. T.
	,,	20	2.20	n	
	,,	30	2.07	n	
	Anisol	0	0.83	n	Piatti
	,,	10	0.80	n	
	,,	20	0.84	n	
	,,	30	0.84	n	
	,,	40	0.89	n	

I. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	Remarks	Observer
Benzene	Anisol	50	0.94	n	
	,,	60	0.97	n	
	Acetone	10	1.87	n	I. C. T.
	,,	20	1.79	n	
	,,	30	1.66	n	
	,,	25	1.70	n	Fischler
	Acetophenone	16	0.65	n	I. C. T.
	Acetic acid	25	K'0.71, K''3.11	a	Dunstan
	Ethyl acetate	25	2.01	n	,,
	Ethyl benzoate	25	0.69	n	Kendall and Monroe
	Benzyl benzoate	25	0.31–0.50	v	,,
	,,	5	0.20–0.38	v	Bingham and Sarver
	,,	15	0.25–0.47	v	
	,,	25	0.31–0.53	v	
	,,	40	0.37–0.61	v	
	,,	60	0.48–0.74	v	
	m-Toluidine	15	0.18	n	Dessart
	,,	30	0.24	n	
	Pyridine	25	(0.76)	c(1:2)	Dunstan, Thole and Hunt
	Quinoline	25	0.46	n	I. C. T.
	Carbon bisulphide	25	0.91	n	Linebarger
	Sulphur chloride	15.5	0.78	n	De Carli
	,,	20	0.78	n	
	Stannic chloride	25	K'0.86, K''2.08	a	Kurnakow
	,,	70	K'0.95, K''1.68	a	

II. Mixture.

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
n-Hexane	n-Decane	25	0.74		n	Bingham, White, Thomas and Cadwell
	,,	35	0.79		n	
	,,	50	0.84		n	
	,,	65	0.87		n	
	Nitrobenzene	8	0.33 } mean 0.33	1.48 } mean 1.52	n	Tab. internat., 1927–1928
	,,	15	0.33		n	
	,,	15	0.31 } mean 0.31	1.58	n	I. C. T.
	,,	20	0.30		n	
	,,	25	0.31		n	
	m-Nitrotoluene	15	0.28 } mean 0.29	1.41	n	Dessart
	,,	30	0.29		n	
	m-Toluidine	22	0.19 } mean 0.20	1.60	n	,,
	,,	32	0.20		n	
Cyclohexane	m-Nitrotoluene	15	0.36 } mean 0.41	1.00 } mean 0.99	n	,,
	,,	30	0.46		n	
	m-Toluidine	15	0.33 } mean 0.33	0.97	n	,,
	,,	30	0.32		n	
Methyl cyclohexane	m-Nitrotoluene	15	0.30 } mean 0.36	1.14 } mean 1.14	n	,,
	,,	30	0.41		n	
	m-Toluidine	15	0.26 } mean 0.28	1.14	n	,,
	,,	30	0.29		n	
n-Decane	n-Hexane	25	1.35	1.13	n	Bingham, White, Thomas and Cadwell
	,,	35	1.27	1.20	n	
	,,	50	1.19	1.28	n	
	,,	65	1.15	1.32	n	
Toluene	Benzene	25	0.81	1.23	n	Linebarger
	Diphenyl	25	0.24	1.25	n	Kendall and Monroe
	Naphthalene	25	0.38	1.26	n	,,
	Chlorobenzene	20	1.02 } mean 1.02	1.25	n	Yajnik and coworkers
	,,	35	1.03		n	
	,,	50	1.02		n	

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Toluene	Bromobenzene	20	0.86 mean 0.86	1.24 mean 1.24	n	Yajnik and coworkers
	,,	35	0.85		n	
	m-Nitrotoluene	15	0.32 mean 0.34	1.21	n	Dessart
	,,	30	0.36		n	
	Guaiacol	30	0.18–0.24	1.67–1.25	v	Puschin and Pinter
	Benzaldehyde	17	0.57	1.23	n	Schaaf
	Ethyl acetate	25	(1.63)	1.25	n	Linebarger
	Ethyl benzoate	25	0.59 mean 0.60	1.22	n	,,
	,,	25	0.60		n	Kendall and Monroe
	Benzyl benzoate	25	0.25–0.39	1.92–1.23	v	,,
	m-Toluidine	15	0.15	(2.13?)	n	Dessart
	,,	30	0.21	(1.52?)	n	
Diphenyl	Benzene	25	3.33	0.30 mean 0.30	n	Kendall and Monroe
	Toluene	25	4.10	0.30	n	,,
Stilbene	Dibenzyl	125	0.95		n	Beck
	Azobenzene	125	0.86		n	,,
	Benzal aniline	125	0.90		n	,,
Dibenzyl	Stilbene	125	1.05		n	,,
	Azobenzene	75	0.97		n	,,
Naphthalene	Benzene	25	2.04	0.49 mean 0.48	n	Kendall and Monroe
	Toluene	25	2.63	0.47	n	,,
Tetralin	Methyl alcohol	25	(3.03)	0.21 mean 0.22	c(1:1)	Herz and Schuftan
	Ethyl alcohol	25	(2.22)	0.22	c(1:1)	,,
	n-Butyl alcohol	25	K'1.72, K''1.30	0.21, 0.45	a	,,
Dekalin	n-Butyl alcohol	25	K'1.63, K''1.10	0.22, 0.40	a	,,

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Methylene chloride	Acetone	0	0.56	3.38	n	Sachanov and Rjachowsky
Chloroform	Benzene	25	(0.55)	1.82	n	Linebarger
	Carbon tetrachloride	25	0.52	1.79	n	,,
	Ether	0	(1.13)			Thorpe and,Rodger
	,,	10		2.02	c(2:1)	
	,,	20		mean 1.87	$m = 2.62$	
	,,	30			$C_0 = 6.08 \times 10^3$	
	Phenetol	0	(0.56)	1.84	c(2:1)	Sachanov and Rjachowsky
	Acetone	0	(0.95)		c(2:1)	Tsakalotos
	,,	20		1.88	$m = 2.32$	
	,,	40			$C_0 = 1.52 \times 10^2$	
Carbon tetrachloride	Benzene	0	0.96	**1.08**	n	Thorpe and Rodger
	,,	10	1.01	**0.99**	n	
	,,	20	1.04	**0.96**	n	
	,,	30	1.06	**0.94**	n	
	,,	40	1.14	**0.88**	n	
	,,	50	1.21	**0.83**	n	
	,,	60	1.27	**0.79**	n	
	,,	70	1.24	**0.81**	n	
	Chloroform	25	1.94	0.96	n	Linebarger
	Tetrachloroethylene	25	$K'1.44$, $K''0.94$		a	Herz and Rathmann
	Tetrachloroethane	25	$K'1.05$, $K''1.44$	1.10, 1.68	a	,,
	Acetone	0	1.75	1.08	n	Sachanov and Rjachowsky
	Acetophenone	25	0.74	0.91	n	,,
Ethylene dichloride	Benzene	0	$K'1.30$, $K''1.13$	0.77, 0.89	a	Faust
	,,	19.4	$K'1.37$, $K''1.00$	0.73, 1.00	a	
	,,	50	$K'1.66$, $K''0.72$	0.60, 1.39	a	
Trichloroethylene	Pentachloroethane	25	0.41	1.71	n	Herz and Rathmann

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Tetrachloroethylene	Carbon tetrachloride	25	K'0.94, K''1.44	0.99, 1.35	a	Herz and Rathmann
Tetrachloroethane	Carbon tetrachloride	25	K'1.44, K''1.05	0.65, 1.01	a	,,
	Ether	0	2.22	1.12 } mean 1.16	n	Sachanov and Rjachowsky
	Phenetol	0	0.86	1.20	n	,,
	Acetone	0	1.05–1.85	1.80–1.02	v	,,
Pentachloroethane	Trichloroethylene	25	2.44		n	Herz and Rathmann
	Ether	0	1.85–3.85	1.34–0.64	v	Sachanov and Rjachowsky
	Phenetol	25	1.48	0.70	n	,,
Chlorobenzene	Toluene	20	0.98		n	Yajnik and coworkers
	,,	35	0.97 } mean 0.98	1.27	n	
	,,	50	0.98	} mean 1.27	n	
	Bromobenzene	20	0.78		n	Unkovskaja and Volova
	,,	40	0.83		n	
	,,	60	0.83 } mean 0.84	1.27	n	
	,,	12	0.85		n	Kremann, Gugle and Meingast
	,,	64	0.93		n	
	Phenol	20	0.082–0.184	2.80–1.25	v	Bramley
Bromobenzene	Benzene	18.2	0.94		n	Yajnik and coworkers
	,,	30	0.91 } mean 0.93	1.08	n	
	,,	40	0.93		n	
	Toluene	20	1.16 } mean 1.17		n	,,
	,,	35	1.18	1.06 } mean 1.07	n	
	Chlorobenzene	20	1.28		n	Unkovskaja and Volova
	,,	40	1.21		n	
	,,	60	1.21 } mean 1.19	1.07	n	
	,,	12	1.18		n	Kremann, Gugle and Meingast
	,,	64	1.08		n	
	Acetone	0	1.22–1.67	1.55–1.13	v	Sachanov and Rjachowsky

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Methyl iodide	Carbon bisulphide	0	1.89	0.50	n	Thorpe and Rodger
	,,	10	1.64	0.58	n	
	,,	20	1.64	0.58	n	
	,,	30	1.45	0.66	n	
	,,	40	1.39	0.68	n	
Ethyl iodide	Methyl alcohol	20	(0.29)	2.21 mean 2.20	n	Yajnik and coworkers
	,,	45			n	
	Phenetol	0	0.47	2.19	n	Sachanov and Rjachowsky
Nitromethane	Ethyl alcohol	—	K'1.27, K''2.23	0.39, 1.09	a	Wagner
Nitrobenzene	n-Hexane	8	3.03 mean 3.03	0.50	n	Tab. internat., 1927–1928
	,,	15	3.03		n	
	,,	15	3.23 mean 3.26		n	I. C. T.
	,,	20	3.33	0.47 mean **0.49**	n	
	,,	25	3.23		n	
	Benzene	25	2.04	0.49	n	Linebarger
	Methyl alcohol	25	1.32	0.49	n	Fischler
	n-Butyl alcohol	35	K'2.06, K''1.48	0.18, 0.53	a	Swearingen and Heck
	,,	45	K'1.66, K''1.61	0.22, 0.58	a	
	,,	55	K'1.53, K''1.52	0.24, 0.54	a	
	,,	65	K'1.53, K''1.47	0.24, 0.53	a	
	,,	75	K'1.50, K''1.41	0.24, 0.51	a	
	,,	80	K'1.31, K''1.60	0.27, 0.57	a	
	i-Butyl alcohol	—	K'1.02, K''3.16	0.22, 0.72	a	Wagner
	i-Amyl alcohol	0	K'1.97, K''2.25		a	Drucker and Kassel
		80	K'1.58, K''1.41		a	
	Sulphur chloride	3	1.61–2.89	0.48–0.27	v	De Carli
	,,	20	1.61–1.21	0.48–0.64	v	
	Stannic chloride	15	(1.35)		c(2:1) $m = 2.00$ $C_0 = 1.31\times10^2$	,,
		25	(1.70)			
	Stannic bromide	25	(1.00)		c(1:1)	,,
	,,	40	(1.00)			

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
m-Nitrotoluene	n-Hexane	15	3.57 mean 3.51	0.43	n	Dessart
	,,	30	3.45		n	
	Cyclohexane	15	2.78 mean 2.48	0.40	n	,,
	,,	30	2.17		n	
	Methyl cyclohexane	15	3.33 mean 2.89	0.39 mean 0.41	n	,,
	,,	30	2.44		n	
	Benzene	15	2.50 mean 2.39	0.42	n	,,
	,,	30	2.27		n	
	Toluene	15	3.13 mean 2.96	0.42	n	,,
	,,	30	2.78		n	
Cyanobenzene	Ethyl alcohol	—	K'0.92, K''2.00	0.53, 1.58	a	Wagner
Azobenzene	Stilbene	125	1.16		n	Beck
	Dibenzyl	75	1.03		n	,,
	Benzal aniline	75	1.03		n	,,
Water	Methyl alcohol	20	(0.96)	0.68	c(2:1) $m = 2.00$ $C_0 = 9.2\times10^2$	Traube
	,,	30				
	,,	40				
	,,	50				
	,,	60				
	Ethyl alcohol	0	(0.70)	0.70	c(3:1) $m = 2.00$ $C_0 = 1.55\times10^3$ & c(2:1) $m = 1.83$ $C_0 = 4.08\times10^2$	I. C. T.
	,,	10				
	,,	20				
	,,	30				
	,,	40				
	,,	50				
	,,	60				
	,,	70				
	n-Propyl alcohol	20	(0.60)	0.68	c(3:1) $m = 2.00$ $C_0 = 1.31\times10^3$	Dunstan and Thole
	,,	25				
	,,	30				
	Allyl alcohol	25	(0.70)		c(4:1, 3:1, 2:1)	Dunstan
	Acetone	0	(2.97)	0.64	c(5:1)	Davis, Hughes and Jones
	,,	25	(2.58)	0.67	c(4:1)	

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Water	Formic acid	15				
	,,	25				
	,,	35	(0.69)	0.68 mean 0.67	c(1:1)	I. C. T.
	,,	45				
	,,	55				
	Acetic acid	15				
	,,	20				
	,,	25				
	,,	30				
	,,	35				
	,,	40			c(1:1)	
	,,	45	(1.29)	0.67	$m = 1.68$	I. C. T.
	,,	50			$C_0 = 1.16 \times 10^2$	
	,,	55				
	,,	60				
	,,	65				
	,,	75				
	,,	85				
	,,	95				
	Lactic acid	25	0.28		n	Dunstan
	Formamide	25	0.48 mean	0.69	n	Merry and Turner
	,,	40	0.50 0.49		n	
	Pyridine	0	(1.19)	0.66	c(3:1+2:1)	Hartley, Thomas and Applebey
		25.08			c(3:1+1:1)	
Methyl alcohol	Benzene	25	K'1.60, K''0.62	0.63, 0.62	a	Fischler
	Tetralin	25	(0.33)	0.67	c(1:1)	Herz and Schuftan
	Ethyl iodide	20	(3.45)	0.64	n	Yajnik and coworkers
	,,	45			n	
	Nitrobenzene	25	0.76	0.64	n	Fischler
	Water	20				
	,,	30			c(1:2)	
	,,	40	(1.04)	0.64 mean 0.64	$m = 2.00$	Traube
	,,	50			$C_0 = 9.2 \times 10^2$	
	,,	60				

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene		Remarks	Observer
Methyl alcohol	Ethyl alcohol	25	0.78	0.63	0.91–0.47	n	Bingham, White, Thomas and Cadwell
	,,	35	0.84			n	
	,,	45	0.86			n	
	,,	55	0.91			n	
	n-Propyl alcohol	25	0.63	0.65		n	Herz and Kuhn
	Ether	25	2.33–4.55			v	Baker
	Phenetol	25	1.60	0.64		n	,,
	Acetic acid	25	(1.34)	0.64		c(1:2)	Mardles
	Formamide	25	0.50 } mean 0.53	0.64		n	Merry and Turner
	,,	40	0.55			n	
Ethyl alcohol	Benzene	25	K'1.45, K''1.75		0.69, 1.75	a	Dunstan
	Tetralin	25	(0.45)	0.49		c(1:1)	Herz and Schuftan
	Nitromethane	—	K'2.23, K''1.27			a	Wagner
	Cyanobenzene	—	K'2.00, K''0.92			a	,,
	Water	0	(1.43)	0.47		c(1:3) $m = 2.00$ $C_0 = 1.55 \times 10^3$ & c(1:2) $m = 1.83$ $C_0 = 4.08 \times 10^2$	I. C. T.
	,,	10					
	,,	20					
	,,	30					
	,,	40					
	,,	50					
	,,	60					
	,,	70					
	Methyl alcohol	25	1.28	0.51	mean 0.49	n	Bingham, White, Thomas and Cadwell
	,,	35	1.19			n	
	,,	45	1.16			n	
	,,	55	1.10			n	
	n-Propyl alcohol	25	0.88	0.47		n	Parks and Schwenck
	i-Propyl alcohol	25	0.78	0.51		n	Parks and Kelley
	Ether	25	3.30–6.60		0.65–0.32	v	Baker
	Anisol	25	K'1.81, K''1.01		0.46, 0.85	a	,,
	Phenetol	25	K'1.70, K''0.96		0.61, 0.99	a	,,
	Acetaldehyde	0	(1.7)			c(1:1, 3:1)	Leeuw
	,,	18	(1.9)				
	Acetone	25	3.7–6.9		0.47–0.25	v	Dunstan

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Ethyl alcohol	Formamide	25	0.70 mean	0.48	n	Merry and Turner
	,,	40	0.71 0.71		n	
	Quinoline	25	0.89	0.51	n	I. C. T.
	Carbon bisulphide	25	2.00	0.48	n	Dunstan
	Mercaptan	25	2.70		n	,,
	Allyl thiocyanide	—	K′1.82, K''1.22		a	Wagner
n-Propyl alcohol	Benzene	25	K'2.25, K''1.70	0.44, 1.70	a	Dunstan
	Water	20			c(1:3)	Dunstan and Thole
	,,	25	(1.67)	0.40	$m = 2.00$	
	,,	30			$C_0 = 1.31 \times 10^3$	
	Methyl alcohol	25	1.59	0.41 mean	n	Herz and Kuhn
	Ethyl alcohol	25	1.14	0.43 **0.41**	n	Parks and Schwenck
	n-Butyl alcohol	25	0.89	0.40	n	Trew and Watkins
	Ether	25	3.88–7.75	0.55–0.27	v	Baker
	Formamide	25	K'2.30, K''0.80	0.15, 0.27	a, c(1:2)	English and Turner
i-Propyl alcohol	Ethyl alcohol	25	1.28	0.38 mean	n	Parks and Kelley
	n-Butyl alcohol	25	0.85	0.42 **0.40**	n	Trew and Watkins
	Acetone	25	K'4.76, K''0.85	0.37, 1.47	a	Parks and Chaffee
n-Butyl alcohol	Tetralin	25	K'1.30, K''1.72	0.17, 0.38	a	Herz and Schuftan
	Dekalin	25	K'1.10, K''1.63		a	,,
	Nitrobenzene	35	K'1.48, K''2.06	0.33, 1.01	a	Swearingen and Heck
	,,	45	K'1.61, K''1.66	0.30, 0.81	a	
	,,	55	K'1.52, K''1.53	0.32, 0.75	a	
	,,	65	K'1.47, K''1.53	0.33, 0.75	a	
	,,	75	K'1.41, K''1.50	0.35, 0.74	a	
	,,	80	K'1.60, K''1.31	0.31, 0.64	a	
	n-Propyl alcohol	25	1.12	0 37 mean	n	Trew and Watkins
	i-Propyl alcohol	25	1.17	0.35 **0.36**	n	,,
	i-Butyl alcohol	25	0.63		n	,,
	i-γ-methyl butyl alcohol	25	0.89		n	,,
i-Butyl alcohol	Nitrobenzene	—	K'3.16, K''1.02	0.16, 0.50	a	Wagner

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
i-Butyl alcohol	*n*-Butyl alcohol	25	1.59	0.23	n	Trew and Watkins
	Formamide	25	$K'1.99$, $K''0.90$	0.17, 0.44	a, c(1:2)	English and Turner
i-Amyl alcohol	Benzene	30	$K'3.36$, $K''1.71$	0.30, 1.71	a	Bhide and Watson
	Nitrobenzene	0	$K'2.25$, $K''1.97$	0.22, 0.96	a	Drucker and Kassel
	,,	80	$K'1.41$, $K''1.58$	0.35, 0.78	a	
	Formamide	0	$K'1.77$, $K''1.10$	0.19, 0.37	a, c(1:2)	,,
	,,	76.5	$K'1.10$, $K''1.10$	0.31, 0.37		
	,,	25	$K'1.60$, $K''1.10$	0.21, 0.37		English and Turner
i-γ-Methyl butyl alcohol	*n*-Butyl alcohol	25	1.25	0.29	n	Trew and Watkins
Allyl alcohol	Water	25	(1.43)	0.48	c(1:4, 1:3, 1:2)	Dunstan
Phenol	Benzene	20	4.35-11	0.23-0.09	v	Bramley
	,,	25	3.13-8.3	0.32-0.12	v	Swearingen
	Chlorobenzene	20	5.44-12	0.23-0.11	v	Bramley
	o-Cresol	25	0.69		n	Kendall and Beaver
	m-Cresol	25	0.52		n	,,
	p-Cresol	25	0.58		n	,,
	Acetone	9.95	$0.063(z_m = 0.00\text{–}0.20)$ $0.0485+0.0792z_m(z_m = 0.20\text{–}0.55)$ $-0.026+0.228z_m(z_m = 0.55\text{–}1.00)$		v	Bramley
	,,	20.05	$0.10(z_m = 0.00\text{–}0.20)$ $0.077+0.12z_m(z_m = 0.20\text{–}0.55)$ $-0.033+0.316z_m(z_m = 0.55\text{–}1.00)$		v	
	,,	29.8	$0.147(z_m = 0.00\text{–}0.20)$ $0.105+0.175z_m(z_m = 0.20\text{–}1.00)$		v	
	,,	40.1	$0.198(z_m = 0.00\text{–}0.20)$ $0.140+0.22z_m(z_m = 0.20\text{–}1.00)$		v	
	,,	49.8	$0.257(z_m = 0.00\text{–}0.20)$ $0.177+0.308z_m(z_m = 0.20\text{–}1.00)$		v	
	Dimethyl aniline	10	0.25-6.30		v	
	,,	20	0.50-4.53		v	
	,,	29.8	0.50-3.86		v	

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Phenol	Dimethyl aniline	40.2	0.60–3.10		v	Bramly
	,,	59.9	0.50–2.43		v	
	,,	80	0.50–2.10		v	
	,,	126	0.50–1.75		v	
	,,	177	1.40		n	
	Diphenyl amine	30	0.52–0.93		v	,,
	,,	40	0.55–0.95		v	
	,,	81	0.75		n	
	Diphenyl methyl amine	9.8	K'1.65, K''1.15		a	,,
	,,	20.1	K'1.44, K''1.19		a	
	,,	30	K'1.79, K''0.81		a	
	,,	40	K'1.56, K''0.92		a	
	,,	60	K'1.08, K''1.16		a	
	,,	80	K'0.91, K''1.20		a	
o-Cresol	Phenol	25	1.45		n	Kendall and Beaver
	m-Cresol	25	0.67		n	,,
	p-Cresol	25	0.68		n	,,
m-Cresol	Benzene	60	3.70	0.27	n	Piatti
	Phenol	25	1.92		n	Kendall and Beaver
	o-Cresol	25	1.49		n	,,
	p-Cresol	25	0.31–0.87		v	,,
p-Cresol	Phenol	25	1.72		n	,,
	o-Cresol	25	1.47		n	,,
	m-Cresol	25	1.16–3.23		v	,,
Guaiacol	Benzene	30	3.45–5.88	0.29–0.17	v	Puschin and Pinter
	Toluene	30	4.17–5.56	0.30–0.22	v	,,
	Acetone	30	2.00–5.56	0.85–0.31	v	,,
	Methyl aniline	30	1.41		n	,,
	Dimethyl aniline	30	2.50		n	,,

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
o-Nitrophenol	Aniline	30	$K'1.10$, $K''1.83$	0.36, 0.73	a	Bramley
	,,	40	$K'0.96$, $K''1.76$	0.44, 0.74	a	
	,,	60	$K'0.91$, $K''1.69$	0.53, 0.85	a	
	,,	80	$K'0.93$, $K''1.55$	0.59, 0.85	a	
	Pyridine	30	(1.82)	0.43	c(2:1) $m = 2.00$ $C_0 = 7.02 \times 10$	,,
	,,	40	(1.54)	0.51		
	,,	60	(1.35)	0.59		
	,,	80	(1.19)	0.66		
Ether	Benzene	25	0.44	2.28	n	Linebarger
	,,	10	0.43	2.35	n	I. C. T.
	,,	20	0.45	2.20	n	
	,,	30	0.48	2.07	n	
	Chloroform	0	(0.89)	2.10	c(1:2) $m = 2\ 62$ $C_0 = 6.08 \times 10^3$	Thorpe and Rodger
	,,	10				
	,,	20				
	,,	30				
	Tetrachloroethane	0	0.45	2.58	n	Sachanov and Rjachowsky
	Pentachloroethane	0	0.26–0.54	2.69-1.36	v	,,
	Methyl alcohol	25	0.22–0.43	2.91-1.49	v	Baker
	Ethyl alcohol	25	0.15–0.30	3.27–1.63	v	,,
	n-Propyl alcohol	25	0.13–0.26	3.15–1.58	v	,,
	Phenetol	25	0.48	2.15	n	Kendall and Wright
Anisol	Benzene	0	1.21	0.83	n	Piatti
	,,	10	1.25	0.80	n	
	,,	20	1.19	0.84	n	
	,,	30	1.19	0.84	n	
	,,	40	1.12	0.89	n	
	,,	50	1.06	0.94	n	
	,,	60	1.03	0.97	n	
	Ethyl alcohol	25	$K'1.01$, $K''1.81$	0.49, 0.89	a	Baker

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Phenetol	Chloroform	0	(1.79)	1.04	c(1:2)	Sachanov and Rjachowsky
	Tetrachloroethane	0	1.16	1.00	n	,,
	Pentachloroethane	25	0.68		n	,,
	Ethyl iodide	0	2.12	1.04 mean 1.03	n	,,
	Methyl alcohol	25	0.63	1.03	n	Baker
	Ethyl alcohol	25	K'0.96, K''1.70	0.51, 0.83	a	,,
	Ether	25	2.08	1.02	n	Kendall and Wright
	Diphenyl ether	25	0.54		n	,,
	Aniline	0	0.29		n	Bramley
	,,	10	0.32		n	
	,,	20	0.37		n	
	,,	30	0.39		n	
	,,	40	0.41		n	
	,,	60	0.47		n	
	,,	80	0.54		n	
Diphenyl ether	Phenetol	25	1.85	0.56	n	Kendall and Wright
Acetaldehyde	Ethyl alcohol	0	(0.59)	0.83	c(1:1, 1:3)	Leeuw
	,,	18	(0.53)	0.92		
Benzaldehyde	Toluene	17	1.75	0.71	n	Schaaf
	Sulphur chloride	3	0.89–0.53	0.89–1.47	v	De Carli
	,,	13.2	0.91	0.86	n	
	,,	20	1.16	0.67	n	
Acetone	Benzene	10	0.53	1.87	n	I. C. T.
	,,	20	0.56	1.79	n	
	,,	30	0.60	1.66	n	
	,,	25	0.59	1.70	n	Fischler
	Methylene chloride	0	1.79		n	Sachanov and Rjachowsky

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Acetone	Chloroform	0	(1.05)	1.78	c(1:2)	Tsakalotos
	,,	20			$m = 2.32$	
	,,	40			$C_0 = 1.52\times10^2$	
	Carbon tetrachloride	0	0.57	1.89	n	Sachanov and Rjachowsky
	Tetrachloroethane	0	0.54–0.95	2.15–1.22	v	,,
	Bromobenzene	0	0.60–0.82	1.78–1.30	v	,,
	Water	0	0.34	1.98	c(1:5)	Davis, Hughes and Jones
	,,	25	0.39	1.72	c(1:4)	,,
	Ethyl alcohol	25	0.14–0.27	3.50–1.81	v	Dunstan
	i-Propyl alcohol	25	K'0.85, K''4.76	0.47, 1.92	a	Parks and Chaffee
	Phenol	9.95	See Phenol-Acetone		v	Bramley
	,,	20.05			v	
	,,	29.8			v	
	,,	40.1			v	
	,,	49.8			v	
	Guaiacol	30	0.18–0.50	1.67–0.60	v	Puschin and Pinter
	Acetic acid	25	(0.49)	1.76	c(1:2, 1:4)	Kendall and Brakeley
	Carbon bisulphide	-13	K'1.27, K''1.16	0.75, 1.10	a	Faust
	,,	-10	K'1.02, K''1.31	0.93, 1.24	a	
	,,	0	K'1.42, K''0.89	0.67, 0.85	a	
Acetophenone	Benzene	16	1.54	0.65 mean **0.67**	n	I. C. T.
	Carbon tetrachloride	25	1.35	0.70	n	Sachanov and Rjachowsky
	Acetic acid	25	(1.28)	0.67	c(1:1)	Kendall and Brakeley
Formic acid	Water	15	(1.45)	0.46	c(1:1)	I. C. T.
	,,	25				
	,,	35				
	,,	45				
	,,	55				

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Formic acid	Acetic acid	15	(1.87)	0.46 mean 0.47	c(1:1)	Davis and Jones
	,,	25				
	Formamide	25	(0.71)	0.48	c(1:1)	Merry and Turner
	,,	40				
Acetic acid	Benzene	25	K'3.11, K''0.71	0.32.0.71	a	Dunstan
	Water	15	(0.78)	0.86 mean 0.86	c(1:1) $m = 1.68$ $C_0 = 1.16\times10^2$	I. C. T.
	,,	20				
	,,	25				
	,,	30				
	,,	35				
	,,	40				
	,,	45				
	,,	50				
	,,	55				
	,,	60				
	,,	65				
	,,	75				
	,,	85				
	,,	95				
	Methyl alcohol	25	(0.75)	0.87	c(2:1)	Mardles
	Acetone	25	(2.04)	0.85	c(2:1, 4:1)	Kendall and Brakeley
	Acetophenone	25	(0.78)	0.86	c(1:1)	,,
	Formic acid	15	(0.53)	0.89	c(1:1)	Davis and Jones
	,,	25				
	Trichloroacetic acid	25	0.49		n	Kendall and Brakeley
	Ethyl acetate	25	2.33	0.85	n	,,
	Ethyl benzoate	25	0.89	0.82	c(1:2)	,,
	Pyridine	35	(0.93)	0.85	c(1:1) $m = 1.44$ $C_0 = 1.4\times10$ & c(5:1) $m = 2.00$ $C_0 = 3.44\times10^3$	Swearingen and Heck
	,,	45				
	,,	55				
	,,	65				
	,,	75				
	,,	80				

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Acetic acid	Stannic chloride	25.2		Polym. $\nu_1 = 3\times2, 3\times7, 3\times14$ $\nu_2 = 1\times2, 1\times7, 1\times14$		Stranathan and Strong
n-Butyric acid	Pyridine	20	(0.60)	1.32	c(3:1)	Tsakalotos
	,,	18.2	(0.60)	1.32	c(3:1)	Yajnik and coworkers
	,,	30	(0.52)	1.52	$m = 1.60$	
	,,	40	(0.40)	1.98	$C_0 = 1.60\times10^2$	
Lactic acid	Water	25	3.57	0.19	n	Dunstan
Trichloroacetic acid	Acetic acid	25	2.04	0.42	n	Kendall and Brakeley
Formamide	Water	25	2.08 mean		n	Merry and Turner
	,,	40	2.00 2.04	0.33	n	
	Methyl alcohol	25	2.00 mean		n	,,
	,,	40	1.82 1.91	0.34	n	
	Ethyl alcohol	25	1.43 mean	mean	n	,,
	,,	40	1.41 1.42	0.35 0.34	n	
	n-Propyl alcohol	25	K'0.80, K''2.30	0.51, 0.94	a, c(2:1)	English and Turner
	i-Butyl alcohol	25	K'0.90, K''1.90	0.26, 0.78	a, c(2:1)	,,
	i-Amyl alcohol	25	K'1.10, K''1.60	0.26, 0.46	a, c(2:1)	,,
	,,	0	K'1.10, K''1.77	0.26, 0.51	a, c(2:1)	Drucker and Kassel
	,,	76.5	K'1.10, K''1.10	0.26, 0.19		
	Formic acid	25	(1.43)	0.33	c(1:1)	Merry and Turner
	,,	40				
Ethyl formate	Stannic chloride	30		Polym. $\nu_1 = 2\times30, 2\times60, 1\times7$ $\nu_2 = 1\times30, 1\times60, 1\times7$		Kurnakow
	,,	40		Polym. $\nu_1 = 2\times30, 1\times7$ $\nu_2 = 1\times30, 1\times7$		
	,,	50				

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
i-Butyl formate	Ethyl propionate	20	1.24–0.99		v	Unkovskaja and Volova
	,,	40	1.08		n	
Amyl formate	Propyl acetate	12	1.00		n	Kremann, Gugl and Meingast
	,,	64	1.08		n	
Methyl acetate	Ethyl acetate	25	0.94	2.16	n	Chadwell
Ethyl acetate	Benzene	25	0.50	2.00 } mean	n	Dunstan
	Toluene	25	(0.61)	2.03 } 2.03	n	Linebarger
	Acetic acid	25	0.42	2.05	n	Kendall and Brakeley
	Methyl acetate	25	1.06		n	Chadwell
	Benzyl benzoate	25	0.22–0.38	2.17–1.26	v	Kendall and Wright
	Aniline	0	0.13–0.19	2.31–1.58	v	I. C. T.
Propyl acetate	Amyl formate	12	1.00		n	Kremann, Gugl and Meingast
	,,	64	0.93		n	
	Ethyl propionate	20	1.47–0.96		v	Unkovskaja and Volova
	,,	40	1.02		n	
Ethyl propionate	i-Butyl formate	20	1.01–0.81		v	,,
	,,	40	0.93		n	
	Propyl acetate	20	0.68–1.04		v	,,
	,,	40	0.98		n	
Ethyl benzoate	Benzene	25	1.45	0.69	n	Kendall and Monroe
	Toluene	25	1.70 } mean	0.73	n	Linebarger
	,,	25	1.60 } 1.69		n	Kendall and Monroe
	Acetic acid	25	(1.12)	0.76	c(2:1)	Kendall and Brakeley
	Benzyl benzoate	25	0.50–0.59	0.96–0.81	v	Kendall and Wright
Benzyl benzoate	Benzene	25	2.00–3.23	0.50–0.31	v	Kendall and Monroe

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Benzyl benzoate	Benzene	5	2.63–5.00	0.38–0.20	v	Bingham and Sarver
	,,	15	2.13–4.00	0.47–0.25	v	
	,,	25	1.89–3.23	0.53–0.31	v	
	,,	40	1.64–2.70	0.61–0.37	v	
	,,	60	1.35–2.08	0.74–0.48	v	
	Toluene	25	2.56–4.00	0.49–0.31	v	Kendall and Monroe
	Ethyl acetate	25	2.63–4.55	0.77–0.45	v	Kendall and Wright
	Ethyl benzoate	25	1.70–2.00	0.43–0.37	v	,,
Aniline	o-Nitrophenol	30	K'1.83, K''1.10		a	Bramley
	,,	40	K'1.76, K''0.96		a	
	,,	60	K'1.69, K''0.91		a	
	,,	80	K'1.55, K''0.93		a	
	Phenetol	0	3.45	**0.30**	n	,,
	,,	10	3.12	**0.33**	n	
	,,	20	2.72	**0.38**	n	
	,,	30	2.54	**0.40**	n	
	,,	40	2.43		n	
	,,	60	2.11		n	
	,,	80	1.86		n	
	Ethyl acetate	0	5.26–7.69	0.39–0.26	v	I. C. T.
Methyl aniline	Guaiacol	30	0.71		n	Puschin and Pinter
Dimethyl aniline	Phenol	10	0.16–4.0		v	Bramley
	,,	20	0.22–2.0		v	
	,,	29.8	0.26–2.0		v	
	,,	40.2	0.32–1.7		v	
	,,	59.9	0.41–2.0		v	
	,,	80	0.48–2.0		v	
	,,	126	0.57–2.0		v	
	,,	177	0.71		n	
	Guaiacol	30	0.40		n	Puschin and Pinter

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Diphenyl amine	Phenol	30	1.08–1.92		v	Bramley
	,,	40	1.05–1.82		v	
	,,	81	1.33		n	
Diphenyl methyl amine	Phenol	9.8	K'1.15, K''1.65		a	,,
	,,	20.1	K'1.19, K''1.44		a	
	,,	30	K'0.81, K''1.79		a	
	,,	40	K'0.92, K''1.56		a	
	,,	60	K'1.16, K''1.08		a	
	,,	80	K'1.20, K''0.91		a	
Benzal aniline	Stilbene	125	1.11		n	Beck
	Azobenzene	75	0.97		n	,,
	Benzyl aniline	75	0.99		n	,,
Benzyl aniline	Benzal aniline	75	1.01		n	,,
m-Toluidine	n-Hexane	22	5.26 mean		n	Dessart
	,,	32	5.00 5.13	0.30	n	
	Cyclohexane	15	3.03 mean		n	,,
	,,	30	3.13 3.08	0.32 mean 0.31	n	
	Methyl cyclohexane	15	3.85 mean		n	,,
	,,	30	3.45 3.65	0.31	n	
	Benzene	15	5.56	(0.18?)	n	,,
	,,	30	4.17	(0.24?)	n	
	Toluene	15	6.67	(0.18?)	n	,,
	,,	30	4.76	(0.26?)	n	
Pyridine	Benzene	25	(1.32)	0.76	c(2:1)	Dunstan, Thole and Hunt
	Water	0	(0.84)	0.80	c(1:3+1:2)	Hartley, Thomas and Applebey
	,,	25.08			c(1:3+1:1)	
	o-Nitrophenol	30	(0.55)		c(1:2)	Bramley
	,,	40	(0.65)	mean	$m = 2.00$	
	,,	60	(0.74)	**0.79**	$C_0 = 7.02\times 10$	

II. Mixture. (*Continued*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Pyridine	o-Nitrophenol	80	(0.84)	0.80	c(1:1) $m = 1.44$ $C_0 = 1.4\times10$ & c(1:5) $m = 2.00$ $C_0 = 3.44\times10^3$	Swearingen and Heck
	Acetic acid	35	(1.08)			
	,,	45				
	,,	55				
	,,	65				
	,,	75				
	,,	80				
	Butyric acid	20	(1.67)		c(1:3)	Tsakalotos
	,,	18.2	(1.67)		c(1:3) $m = 1.60$ $C_0 = 1.6\times10^2$	Yajnik and coworkers
	,,	30	(1.92)			
	,,	40	(2.50)			
Quinoline	Benzene	25	2.17	0.46 mean	n	I. C. T.
	Ethyl alcohol	25	1.12	0.44 **0.45**	n	,,
Carbon bisulphide	Benzene	25	1.10	0.91	n	Linebarger
	Methyl iodide	0	0.53		n	Thorpe and Rodger
	,,	10	0.61		n	
	,,	20	0.61	mean **0.95**	n	
	,,	30	0.69		n	
	,,	40	0.72		n	
	Ethyl alcohol	25	0.50	0.98	n	Dunstan
	Acetone	–13	$K'1.16$, $K''1.27$		a	Faust
	,,	–10	$K'1.31$, $K''1.02$		a	
	,,	0	$K'0.89$, $K''1.42$		a	
Mercaptan	Ethyl alcohol	25	0.37	1.32	n	Dunstan
Allyl thiocyanide	Ethyl alcohol	—	$K'1.22$, $K''1.82$	0.40, 0.89	a	Wagner
Lead	Tin	400	1.15		n	Arpi
	,,	500	1.03		n	
	Bismuth	400	2.6		n	,,
	,,	500	1.6		n	

II. Mixture. (*Concluded*)

Component 1	Component 2	t°C.	K	(ka) of comp. 1 rel. to (ka) of benzene	Remarks	Observer
Tin	Lead	400	0.87		n	Arpi
	”	500	0.97		n	
Bismuth	Lead	400	0.38		n	”
	”	500	0.63		n	
Sulphur chloride	Benzene	15.5	1.28	0.78 } mean	n	De Carli
	”	20	1.28	0.78 } 0.78	n	
	Nitrobenzene	3	0.35–0.62	1.40–0.79	v	”
	”	20	0.83–0.62	0.59–0.79	v	
	Benzaldehyde	3	1.89–1.12		v	”
	”	13.2	1.10		n	
	”	20	0.86		n	
Stannic chloride	Benzene	25	K'2.08, K''0.86	0.48, 0.86	a	Kurnakow
	”	70	K'1.68, K''0.95	0.60, 0.95	a	
	Nitrobenzene	15	(0.74)	0.66	c(1:2)	De Carli
	”	25	(0.59)	0.83	$m = 2.00$ $C_0 = 1.31 \times 10^2$	
	Acetic acid	25.2		Polym. $\nu_1 = 1 \times 2,\ 1 \times 7,\ 1 \times 14$ $\nu_2 = 3 \times 2,\ 3 \times 7,\ 3 \times 14$		Stranathan and Strong
	Ethyl formate	30		Polym. $\nu_1 = 1 \times 30,\ 1 \times 60,\ 1 \times 7$ $\nu_2 = 2 \times 30,\ 2 \times 60,\ 1 \times 7$		Kurnakow
	”	40		Polym. $\nu_1 = 1 \times 30,\ 1 \times 7$ $\nu_2 = 2 \times 30,\ 1 \times 7$		
	”	50				
Stannic bromide	Nitrobenzene	25	(1.00)	0.49	c(1:1)	De Carli
	”	40				

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solutional viscosity or the viscosity of ionic pair of KCl. Column 3 in Table 7 shows thus estimated solutional viscosities, the viscosities of water at the corresponding temperatures being adopted from Internat. Crit. Tables, V.

By simple calculation, we see that these viscosity values are quite sufficiently expressed by the quadratic equation:

$$\eta_t = \frac{0.01533}{1+0.02730t+0.0001141t^2} .$$

The fact that the equation of this type has been proved by Thorpe and Rodger(13) to reproduce very closely the viscosity of numerous organic liquids without molecular complexity, and further that the magnitudes of these here obtained coefficients also are reasonably acceptable as compared with those for such liquids as ethylene chloride, carbon tetrachloride, and acid anhydrides, draws the conclusion that the solutional state of an electrolyte which is composed of its ionic pairs behave, as would be expected, like a liquid containing no molecular aggregates.

In conjunction with our study hitherto made some inquiry about the characteristic constant K along quite different lines, which we earnestly hope, may afford a clue to unvail the mysterious nature of liquids.

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