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Chemistry. — In the absence of Dr. J. M. VAN BEMMELEN, Prof. H. KAMERLINGH ONNES presents a paper from Dr. F. A. H. SCHREINEMAKERS entitled: "*Notes on equilibria in ternary Systems.*"

(Read March 30, 1901).

The experimental difficulties encountered in the determination of the composition of conjugate liquid phases are sometimes so great that, however desirable a knowledge of these compositions may be, the investigation of them has to be abandoned. Such cases occur for instance:

1. When the two liquids, which are in equilibrium, form an emulsion which does not separate into two phases, or does so only after an extremely long time.

2. When analytical chemistry does not provide us with the means of quantitatively determining the components.

Nothwithstanding this we may in such cases gain our object, if only approximately, and by indirect means, as I will demonstrate in what follows.

Let us take as an example the system: Water, Phenol and Acetone. A short communication on this system is to be found in the proceedings of the Academy 1899—1900 and a more full account in Zeitschr. f. Phys. Chem. 33.78. The results communicated in those papers concern the forms and positions of the connodal curves at different temperatures. To obtain these, the following course was adopted. Varying quantities of phenol were introduced into a mixture of water and acetone of known composition, obtained by direct weighing of the components, and the temperature was determined at which the two liquid phases formed passed into a single one. In this manner mixtures of water and acetone containing 1,83, 4,24, 7,94, 12,2, 15,6, 24,6, 31,8 40,3, 50,2, 59,9 and 64,9 percent of acetone were tested.

From these determinations we may easily obtain the connodal curves for different temperatures by interpolation and this method should always be applied when it is only possible to weigh the components. The difficulties mentioned in 1 and 2 are thus without influence. Table I contains the compositions of the solutions of the connodal curve at 56°.5 obtained in this way.

TABLE I.

Compositions of the solutions of the connodal line at 56°5.

pCt W.	85,5	89.0	89.1	86.5	82.5	79.1	67.9	59.3	48.1	36.9	26	22.7
pCt Ac.	0	1.7	3,9	7.5	11.5	14.6	22.2	27.7	32.5	37.1	34	22.8
pCt Ph.	14.5	9.3	7.0	6.0	6.0	6.3	9.9	13.0	19.4	26.0	40	54.5

pCt W.	23.9	25.9	27.9	30.8	32.0	34,5	36.9	38.8	40
pCt Ac.	16.1	12.1	9.1	5.7	4.5	3.0	1.6	0.7	0
pCt Ph.	60.0	62.0	63.0	63.5	63.5	62 5	61.5	60.5	60

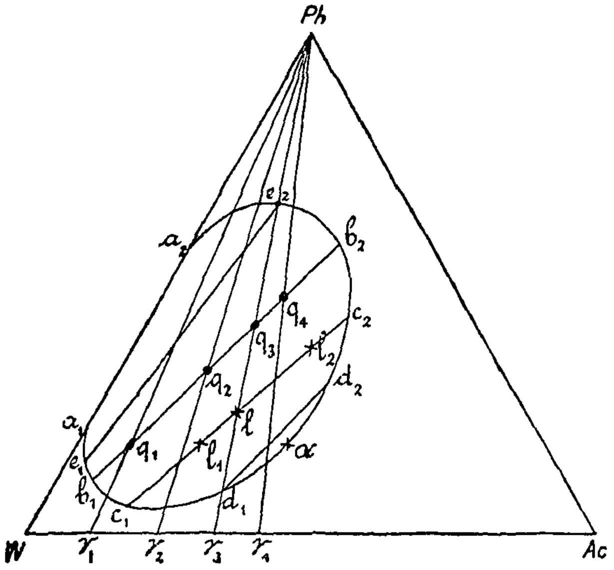

Fig. 1.

By means of table I the connodal curve for 56°5 may now be drawn; in Fig. 1 it is indicated by the curve a_1 α a_2. It is, of course, known that the liquid phase a_1 may be in equilibrium with a_2 because both are only binary liquids, but how matters are situated as regards the ternary phases is quite unknown, as is also the position of the foldpoint α. It is known, for instance, that at the given temperature a liquid phase b_2 may be in equilibrium with another, but with *which* other is *not* known; it is also known for instance that a liquid exists which may be in equilibrium with another one; with which other, however, is as yet unknown.

If we now wish to analyse the conjugated liquid phases which occur in this system we meet with the difficulties stated in I; with certain concentrations of phenol and acetone the two layers only formed emulsions which did not separate even after waiting for hours; as we shall see, however, the top layer was present chiefly on the surface and the other at the bottom of the emulsion. In order to learn the composition of the two layers which were in equilibrium with each other, I proceeded in the following manner.

Into a small bottle, I weighed known quantities of water, acetone and phenol so that the composition of the total liquid was accurately known. Let l in fig. 1 be the point showing the composition of this mixture and c_1 and c_2 the two liquid phases into which the mixture separates at 56°5. In order to obtain equilibrium, the two layers were thoroughly shaken which caused an emulsion to form. After this had been at rest for some time a portion was removed by means of a pipette from both the top and the bottom and submitted to analysis.

The composition of the one part is indicated in the figure by l_1, that of the other by l_2 and it is natural that the three points l, l_1 and l_2 must be situated on a straight line which is to be used as a check on the analysis. If the straight line $l_1\, l\, l_2$ is now drawn and its points of intersection with the connodal curve c_1 and c_2 determined, these will then indicate the composition of the two liquid phases which are in equilibrium with each other and which constitute the emulsion. In this manner, I have determined the position of different chords of the connodal curve and therefore, also the compositions of the liquid phases which are in equilibrium at 56°5. From the determinations communicated in table 2, to which have also been added the determinations of some clear solutions, it appears that the chords have the positions approximately indicated in fig. 1. For instance b_2 lies further from the side *W.—Ph* than b_1, c_2 further than c_1 or in other words, if we call the solution of branch $a_1\,\alpha$ the aqueous and that of $a_2\,\alpha$ the phenolic layer, acetone dissolves more readily in the phenolic than in the aqueous layer.

TABLE II.

Composition of the conjugated solutions at 56°5.

Branch $a_1\,\alpha$.			Branch $a_2\,\alpha$.		
pCt. W.	pCt. Ac.	pCt. Ph.	pCt. W.	pCt. Ac.	pCt. Ph.
88.5	0	14.5	40	0	60
88.8	1.2	10.0	29.3	7.3	63.4
89.1	3.9	7.0	230	17.1	59.4
88.62	5.28	6.1	22.5	22.8	54.7
86.7	7.3	6.0	22.5	28.0	49.5
85.5	8.5	6.0	22.9	28.8	48.3
76.0	16 9	7.1	28.6	36.1	35.3
75.1	17.5	7.4	28.8	36.3	34.9
69.5	21.5	9.0	34.0	37.5	28.5

From the foregoing it is plain how the difficulties mentioned in 1 may be got over if we can only determine quantitatively the three components or two of them. If this is also impossible, there is still at our disposal another method for determining the situation of the chords, namely determinations of vapour tensions.

Let us take, for instance, a mixture represented in figure 1 by q_1; at 56°5 this mixture will separate into the two liquid phases b_1 and b_2 possessing a certain vapour pressure. If we take a mixture q_2 this will also separate into two layers b_1 and b_2 although the relative quantities of these phases will, of course, be different. The vapour tension however, will be *the same*. This is, of course, also the case if we take mixtures like q_3 and q_4 and generally for all mixtures represented by points on the chord $b_1\ b_2$.

All mixtures represented by points on the chord $b_1\,b_2$ have therefore, the same vapour tension. Inversely the position of the chord may be determined when the compositions of different mixtures having the same vapour tensions at the same temperature are known.

In the system: water-acetone-phenol I have made many determinations of vapour tension which I hope to communicate more fully, later on; I will now mention only a few of the determinations and show how the position of the chords may be determined from them. The vapour tension of each of the mixtures investigated has been determined at 10 to 15 different temperatures; in what follows I only mention the vapour tensions at 56°5 which have been obtained from these determinations by interpolation.

Let us first consider the side *W-Ph* of fig. 1, that is mixtures which contain only water and phenol.

TABLE 3.

Vapour tensions at 56°5.

0% *Ac.*

% Ph.	0	2 0	5.58	7.42	10.88	14 5	60.0	69.2	76.7	80.34	88.06
P in m.M.	125	125	127	127	127	126	126	124	122	118	102

7.94% *Ac.*

% Ph.	0	1.22	2.41	5.93	10 02	15 19	19.81	29.93	40.48	49.28	62.67	70.15	74 25	80.76
P in m.M.	278	271	262	236	216	193	180	158	147	140	135	130	126	119

15.6% *Ac.*

% Ph.	0	1.39	3.03	6.14	9.63	14.30	19.81	29.74	38.81	49.60	60.13	66.98	74.88	83.00
P in m.M.	387	369	350	318	292	262	232	193	171	155	144	137	130	115

22.52% *Ac.*

% Ph.	0	3.08	8.38	13.95	20.01	24.38	29.72	35.95	41.69	49.51	59.49	69.29	79.68.
P in m.M.	446	408	359	318	277	253	226	205	186	167	155	140	122.

31.82% *Ac.*

% Ph.	0	4,10	7.68	13.36	20.13	24.77	29.99	34.13	39.29	40.93	45.57	51.48	57.64	62.96	71.06	79.77
P in mM.	524	468	428	379	335	302	274	251,5	224	218	202	186	170	160	141	123.

The vapour tensions are given in table 3 under 0 pCt. of acetone. It will be seen that as the quantity of phenol increases, the pressure first rises from 125—127 m.m., falling again to 126 m.m. when the liquid contains 14.5 per cent of phenol. If more phenol is added, two liquid phases appear and the pressure remains 126 m.m. until the mixture contains 60 per cent of phenol; if still more phenol is added, there only remains one liquid phase and the vapour tension decreases continuously. This is represented in the usual way in fig. 2. The amount of phenol is given on the horizontal and the pressure on the vertical axis. A line is thus obtained which is indicated diagrammatically by the one marked 0 pCt. of acetone. At the left hand side A consist of a part with a maximum, in the centre, where both liquid phases occur, of a horizontal part and for the remainder of a slanting line. Passing now, in fig. 1, along the side *W—Ph* from *W* to *Ph*, the pressure at first increases, reaches a maximum and then decreases until a_1 in reached; from a_1 to a_2 the pressure remains constant and from a_2 to *Ph* it again decreases; the pressure therefore remains constant in the region in which two liquid phases are present.

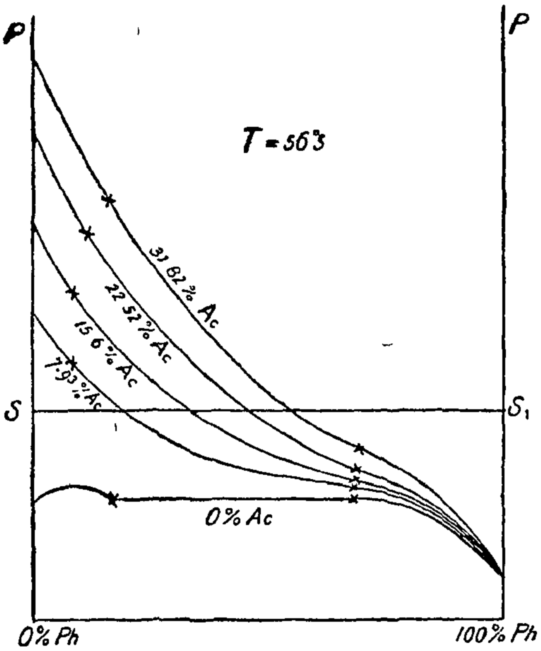

Fig. 2

It is different, however, if we move along a line through the triangle, for instance from r_3 to *Ph*, along the line $r_3\,Ph$; from r_3 to d_1 we then move in the homogenous field; from d_1 to e_2 we traverse the heterogenous and from e_2 to *Ph* we find ourselves again in the homogenous field. It is, of course, plain that if we move over the parts $r_3\ d_1$ and $e_2\ Ph$ the pressure will be continually altering, as was the case with the parts Wa_1 and $a_2\ Ph$; on the part $d_1\ e_2$, the behaviour is, however, different from that on $a_1\ a_2$. On the part $a_1\ a_2$ the vapour tension remains unchanged; on $d_1\ e_2$ it changes continuously. This will be easily unterstood if we reflect that the pressure at d_1 is the same as the pressure of the two conjugated phases $d_1 + d_2$; at l the vapour pressure is that of the system $c_1 + c_2$; in q_3 the vapour pressure corresponds to that of the system $b_1 + b_2$; in e_2 the vapour pressure is the same as that of the system $e_1 + e_2$. We therefore see that if we move from d_1 to e_2 the vapour pressure must be changing continually just as it alters along the connodal line from d_1 to e_1 or from d_2 to e_2. From the determinations it follows that the vapour pressure increases along the connodal line from a_1 and a_2 in the direction of the foldpoint α.

If, therefore, we move from d_1 to e_2 we must notice a continual decrease of the vapour pressure.

All the solutions situated on the line r_3 *Ph* have the peculiarity that the relation between water and acetone is the same in all of them. The vapour tensions of the solutions on this line may therefore be represented as though we had a binary mixture of the components of which one is phenol and the other a mixture of water and acetone in constant proportion. We, therefore, put down in figure 2 the amount of phenol on the horizontal and the pressure on the vertical axis. Let us take as example the solutions in which the relation between water and acetone is 84.4 : 15.6 or in other words those which contain 15.6 percent of acetone if we disregard the presence of the phenol. These determinations are given in table 3 marked 15.6 percent acetone. Under *P* the vapour pressure in m.m. is given and under pCt. *Ph* the total amount of phenol in the liquids. The first determination, therefore, gives the vapour tension of a mixture which contains no phenol, that is of a mixture of water and acetone containing 15.6 percent of acetone. As may be plainly seen from this series, the vapour pressure decreases continually with increasing quantities of phenol.

In fig. 2 this series is indicated by the curve marked 15,6; the curve is not continued to its endpoint, 100 percent of phenol, but only to 83 percent. It must, of course, end at the same point as the line indicating the vapour tension of water and phenol only.

In table 3 some other determinations are given under 7.94, 22.52 and 31.82 percent acetone, the significance of which will be sufficiently apparent after the foregoing explanation. The corresponding vapour pressure curves in fig. 2 are marked by the same figures. Each of these curves consists of three parts, namely the two portions at the sides which relate to the homogenous liquids and the portion in the middle (between the two crosses) which relates to the mixtures which separate into two liquid phases on the connodal curve. In the two points where these three meet, they exhibit a discontinuity.

From fig. 2 the situation of the chords of the connodal curve at 56°.5 may be obtained.

Let us draw an horizontal line ss_1 which intersects some of the vapour tension curves; each point of intersection indicates a solution or a complex; all the solutions and complexes situated on this line have the same vapour tension. Let us confine ourselves to the complexes only or to those parts of the vapour tension curves, which are indicated in figure 1 by points within the connodal curve and therefore belong to the heterogenous field. Let us draw the line

ss_1 in such a way that it indicates for instance a vapour tension of 180 m m. We then have 4 complexes, indicated on the curves by 7.94, 15.6, 22.52 and 31.82 percent acetone, which at 56°.5 have a vapour pressure of 180 m.m. and must therefore in fig. 1 be situated on the same chord as for instance the points q_1, q_2, q_3 and q_4.

The composition of these complexes may be ascertained from fig. 2; from the figure we may obtain the amount of phenol in the complex, whilst the relation between the other two components, that is between water and acetone, is known. Thus it is found, for instance, that the point of intersection of the line ss_1 with the vapour tension curve of 15.6 percent acetone indicates an amount of phenol of 34.6 percent. The complex, therefore, contains $100 - 34.6 = 65.4$ percent of water and acetone of which $\frac{15.6}{100} \times 65.4$ percent is acetone and $\frac{84.4}{100} \times 65.4$ percent is water. We, therefore, find that this complex consists of 55.2 percent of water, 10.2 percent of acetone and 34.6 percent of phenol. In the same manner, the composition of the complexes, indicated by the other parts of intersection may be calculated.

In the foregoing, we have drawn the line ss_1 in such a manner that it indicated a vapour tension of 180 m.m.; this vapour tension may, of course, be taken differently; we then obtain other points of intersection and consequently other complexes and also other chords. In table 4 a few results of these calculations are given for 180, 220, 260 and 300 m.m.

TABLE 4.

Temperature 56°5.

Composition of the complexes with a vapour pressure of 180 m.m.

pCt. W.	pCt. Ac.	pCt. Ph.
73.8	6.4	19.8
55.2	10.2	34.6
43.4	12.6	44.0
31.6	14.8	53.6

Composition of the complexes with a vapour pressure of 220 m.m.

pCt. W.	pCt. Ac.	pCt. Ph.
83.7	7.3	9.0
65.3	12.1	22.6
53.0	15.4	31.6
40.7	18.9	40.4

Composition of the complexes with a vapour pressure of 260 m.m.

pCt. W.	pCt. Ac.	pCt. Ph.
72.2	13.3	14.5
59.7	17.3	23.0
46.1	21.5	32.4

Composition of the complexes with a vapour pressure of 300 m.M.

pCt. W.	pCt. Ac.	pCt. Ph.
77.3	14.3	8.4
64.7	18.8	16.5
51.2	23.8	25.0

Let us first take the 4 complexes which at 56°.5 have a vapour tension of 180 m.m.; if these are placed in the triangle it will be seen, that they are situated on a straight line; the same is the case with the 4 complexes with a vapour pressure of 260 m.m. and also with the three complexes whose vapour pressure amounts to 300 m.m.

We have, therefore, again found four chords; for the determination of each of these, of course, only two points were needed; the others only serve as a check to control the accuracy obtained.

It is worthy of attention that the chords derived from table 4 are, theoretically, not altogether comparable with those from table 2; the latter belong to a connodal line at 56°.5 at a constant pressure, the former, to a connodal line at 56°.5 at *its own* vapour pressure. As however, a small change in the pressure has generally a very small influence on the composition of the two liquid phases in equilibrium, the chords determined in the two ways are practically comparable. That this is the case is seen when the chords obtained from the figures given in the two tables are set out in the triangular diagram.

An *examination of figure* 2 reveals some *further peculiarities* which may be explained. From the vapour tension curve, marked 0 percent acetone, it is seen that the vapour tension of water is increased by the addition of small quantities of phenol. I have already shown in a former article that this is in accordance with the formula of VAN DER WAALS which applies in this case. But if we add phenol to a water-acetone mixture it is different, for, if we take mixtures of water and acetone containing 7.93, 15.6, 22.52 or 31.82 percent of acetone, we notice from the corresponding vapour tension curves in fig 2 that the vapour pressure falls. The question is now whether the addition of a new substance to a binary mixture has the same influence as the addition of the same to a simple liquid. As I will show this is by no means the case.

We take for example a liquid of the composition

$$1\,Mol\,A \quad x_1\,Mol\,B \quad y_1\,Mol\,C.$$

which is in equilibrium with a vapour of the composition

$$1\,Mol\,A \quad x\,Mol\,B \quad y\,Mol\,C.$$

Let us call the thermodynamic potential, the entropy and the volume of this liquid ζ_1, η_1 and V_1 and that of the vapour phase ζ, η and V.

In equilibrium we have:

$$\left.\begin{array}{c} \zeta_1 - x_1 \dfrac{\partial \zeta_1}{\partial x_1} - y_1 \dfrac{\partial \zeta_1}{\partial y_1} = \zeta - x \dfrac{\partial \zeta}{\partial x} - y \dfrac{\partial \zeta}{\partial y} \\ \dfrac{\partial \zeta_1}{\partial x_1} = \dfrac{\partial \zeta}{\partial x} \qquad \dfrac{\partial \zeta_1}{\partial y_1} = \dfrac{\partial \zeta}{\partial y} \end{array}\right\} \quad . \; . \; . \quad (I)$$

Assuming that the relative quantities of the components A and B is kept constant in the liquid, x_1 is also constant. If we also keep the temperature constant the only variable quantities remaining are y_1 x y and P. From the equations (I) we obtain:

$$\left.\begin{aligned} &-(s_1 x_1 + t_1 y_1)\,dy_1 + \left(V_1 - x_1\frac{\partial V_1}{\partial x_1} - y_1\frac{\partial V_1}{\partial y_1}\right)dp = \\ &= -(rx + sy)\,dx - (sx + ty)\,dy + \left(V - x\frac{\partial V}{\partial x} - y\frac{\partial V}{\partial y}\right)dp \\ &s_1\,dy_1 + \frac{\partial V_1}{\partial x_1}\,dp = r\,dx + s\,dy + \frac{\partial V}{\partial x}\,dp \\ &t_1\,dy_1 + \frac{\partial V_1}{\partial y_1}\,dp = s\,dx + t\,dy + \frac{\partial V}{\partial y}\,dp \end{aligned}\right\} \quad . \quad \text{(II)}$$

in which

$$s_1 = \frac{\partial^2 \zeta_1}{\partial x_1\,\partial y_1} \quad t_1 = \frac{\partial^2 \zeta_1}{\partial y_1^2} \quad r = \frac{\partial^2 \zeta}{\partial x^2} \quad s = \frac{\partial^2 \zeta}{\partial x\,\partial y} \quad t = \frac{\partial^2 \zeta}{\partial y^2}$$

If we multiply the second equation by x and the third by y and add the results to the first we find:

$$[s_1(x - x_1) + t_1(y - y_1)]\,dy_1 + \left[V_1 + (x - x_1)\frac{\partial V_1}{\partial x_1} + (y - y_1)\frac{\partial V_1}{\partial y_1}\right]dp = V\,dp$$

$$\frac{dp}{dy_1} = \frac{s_1(x - x_1) + t_1(y - y_1)}{V - V_1 + (x_1 - x)\dfrac{\partial V_1}{\partial x_1} + (y_1 - y)\dfrac{\partial V_1}{\partial y_1}} \quad . \quad . \quad \text{(III)}$$

This equation shows the change in pressure which occurs when we add new substance to a liquid made up of the components A and B. Let us assume that the quantity y_1 of the new substance is exceedingly small so that y is also very small. We then find for the limit value [1]:

$$t_1 = \frac{RT}{y_1}$$

Formula III now becomes:

$$\frac{dp}{dy_1} = \frac{s_1(x - x_1) + RT\left(\dfrac{y}{y_1} - 1\right)}{V - V_1 + (x_1 - x)\dfrac{\partial V_1}{\partial x_1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (IV)$$

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[1] Zeitschr. für Phys. Chem. 25, 327.

which may, therefore, be applied when only small quantities of the new substance are added. As will be readily understood, the sign of the denominator is always positive; as to the sign of the numerator, this cannot be judged without further information. The quantity $\frac{y}{y_1}$ is the partition coefficient of the new substance between vapour and liquid. This coefficient decides whether, on adding a new substance to a simple liquid, an increase or decrease of P will take place; this, however, is by no means the case here, as there is, in addition, another term $s_1(x-x_1)$ which may be either positive or negative.

The value of $\frac{dp}{dy_1}$ from IV may also be considered as a function of x_1, that is of the composition of the binary mixture to which the new substance is added. It may, therefore, happen that if x_1 is allowed to vary within wide limits, $\frac{dp}{dy_1}$ may change sign.

We, therefore, come to the following conclusion:

„if we add a new substance to a binary mixture, either an „increase or a decrease of the vapour tension may take place according to the composition of the binary mixture."

This is in accordance with observations made on the system water, acetone and phenol. If we take water and add phenol to it the vapour pressure increases (see fig. 2). This is also the case when, instead of pure water, we use water containing but little acetone. If, however, we use mixtures containing 7.94 or more of acetone a decrease of vapour tension will be noticed as shown in fig. 2.

The difference between the behaviour of a single substance and of a binary mixture is even more evident when the addition af a new substance, which does not appear in the vapour phase, is considered.

In formule IV we must then put $y=0$ and we obtain:

$$\frac{dp}{dy_1}=\frac{s_1(x-x_1)-RT}{V-V_1+(x_1-x)\frac{dV_1}{dx_1}} \quad \ldots\ldots\ldots \quad (V)$$

The numerator of this fraction may now be either positive or negative so that we come to the following conclusion:

„if we add to a binary mixture new substance not passing

„into the vapour, the vapour tension may be either increased or „decreased."

We, therefore find an important deviation from the law of decrease of vapour tension in the case of simple substances. Let us assume that the binary mixture has a maximum or minimum vapour pressure. We then must put $x = x_1$, causing the term $s_1 (x - x_1)$, to disappear from the formula; $\frac{dp}{dy}$ will consequently be negative so that we find that:

„if we add to a binary mixture with a maximum or minimum „vapour pressure a new substance, which does not pass into the „vapour, pressure is decreased."

We, therefore, come to the conclusion that the law of the decrease of vapour pressure for a simple liquid is still applicable to a binary mixture with a maximum or minimum vapour pressure, but that in general either an increase or a decrease of vapour pressure may occur with binary mixtures.

When calculating the formula II from I we have taken the pressure as variable and the temperature as constant. If we now take the pressure as constant and the temperature as variable we find in a similar manner that:

„if we add to a binary mixture a new substance which does not pass into the vapour, the boiling point may be either increased or decreased. Only binary mixtures with a maximum or minimum boiling point obey the ordinary law of increase of boiling point for simple substances."

In the equilibria of the system water, ethylalcohol and sodium carbonate investigated in our laboratory by Mr. KETNER, we also meet with an example of the deviations which binary mixtures show on adding a third substance, in contrast to simple substances.

The boiling point of water rises when sodium carbonate is added to it; if however, we take mixtures of water and alkohol, the boiling point is depressed by the addition of this salt, provided that the amount of alcohol in the mixture exceeds a certain limit. The determinations are given in table V. As will be seen these determinations have been made for alcoholic mixtures containing:

0, 1.2, 2.2, 5.0, 9.8, 21.3, 35.6, 45.4 *and* 55.0 percent *of alkohol.*

Under percentage of salt are given the quantity of added $Na_2 CO_3$ to 100 parts of the water-alcohol mixture; under ΔT the change in the boiling point, the sign + indicating the increase and — the decrease of the boiling point.

TABLE V.

Change in the boiling point of water-alcoholmixtures on addition of Na_2CO_3.

0 % Alcohol.		1.2 % Alcohol.		2.2 % Alcohol.	
% salt	ΔT	% salt	ΔT	% salt	ΔT
0.65	+ 0°.10	0.80	+ 0.05	0.44	+ 0.01
1.62	+ 0°.21	1.79	+ 0.13	0.91	+ 0.01
		2.57	+ 0.16	1.75	+ 0.03
		3.38	+ 0.20	2.52	0.00

5.0 % Alcohol .		9.8 % Alcohol		21.3 % Alcohol.	
% salt	ΔT	% salt	ΔT	% salt	ΔT
0.48	—0.04	0.67	—0.02	0.61	—0.14
1.31	—0.07	1.33	—0.12	1.04	—0.27
2.15	—0.14	2.02	—0.22	1.72	—0.46
		2.67	—0.30	2.37	—0.66
				3.23	—0.91

35.6 % Alcohol		45.4 % Alcohol		55.0 % Alcohol	
% salt	ΔT	% salt	ΔT	% salt	ΔT
0.52	—0.14	0.43	—0.08	0.16	—0.03
1.06	—0.29	0.84	—0.16	0.60	—0.15
1.62	—0.45	1.45	—0.31	1.19	—0.25
		2.09	—0.42	1.80	—0.35
		2.63	—0.52		