Investigation of the Magnetic Susceptibility and other Physical properties of Binary Mixtures of Organic liquids.

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An Investigation of Certain Physical Properties of Binary Mixtures of some Organic Liquids.

The density, refractive index, magnetic susceptibility and viscosity of Aniline, three other substituted anilines and benzene, and of nine sets of binary mixtures made up from pairs of the five pure liquids have been measured at a temperature of 25°C, benzene being a component of all mixtures, and property composition curves have been constructed in each case. The results show that none of the mixtures is ideal. Deviations from the curve constructed from values calculated from the simple mixture law are shewn graphically for every property for each mixture examined, with the exception of magnetic susceptibility where the deviation was too irregular.

It is noticed that the property viscosity gives deviation values which are distinctly greater than those of denisty and refractive index.

The property magnetic susceptibility in the cases of Benzene-Aniline and Benzene Diethylaniline seems to give deviations which resemble those of the property viscosity for these mixtures. In the case of Benzene and Monoethylanine the trend of the deviations does not seem marked enough to enable one to draw any conculsions from it. In the case of Benzene and Methylaniline, on the other hand, there is practically no deviation from the calculated values.

Of the anilines used, the diethylaniline with Benzene gave the greatest deviation values for density and refractivity, but this mixture gave the lowest viscosity deviation value. The position of maximum deviation is similar in density and refractivity composition curves.

The specific heat and heat of mixing curves were

only completed for one set of mixtures as it proved a great difficulty to eliminate experimental error and the results were rather uncertain. In the case of heat of mixing the maximum seems to be nearer the benzene end of the series than the aniline end.

The results indicate that co-ordination occurs at least to some extent between benzene and the anilines considered, on mixing, but that no definite compounds appear to have been formed.

C O N T E N T S.

OBJECT OF THE INVESTIGATION.

The work described in this thesis consists of an examination of various Physical properties of complete series of binary mixtures of aromatic liquids.

The investigation was undertaken with a dual object in view:-

(1) To ascertain the nature of the physical or chemical changes occuring in the liquids on mixing, etc.

(2) To gain an insight into the relative suitability of the various physical properties for showing the chemical changes which may have occured.

The binary mixtures named below have been examined:-

(1) Benzene and Aniline

(2) Benzene and Ethylaniline

(3) Benzene and Diethylaniline

(4) Benzene and Methylaniline

In the case of Benzene and Aniline the following six physical properties have been investigated:-

(1) Specific Gravity

(2) Refractive Index

(3) Viscosity

(4) Specific Heat

(5) Heat of Mixing

(6) Magnetic Susceptibility.

In the case of the other three mixtures only the

following four properties were investigated:-

1(0 Specific Gravity

(2) Refractive Index

(3) Viscosity

(4) Magnetic Susceptibility.

Purification of Materials.

Before any mixtures could be prepared and examined, it was necessary (since small amounts of impurity may seriously change the values of the physical property), to purify very carefully the liquids from which the mistures were to be made.

Each liquid was purchased in a state as pure as possible and was submitted to careful fractional distillation. The middle portion only of each fractionation was retained. Constant density, together with constant boiling point was taken as the criterion of purity.

Preparation of a set of Mixtures for Investigation.

A set of nine mixtures of two liquids A and B were made up as follows:- so that their composition was accurately known and was approximately.

I.	10% A	90% B
II.	20% A	80% B
III.	30% A	70% B
IV.	40% A	60% B
V.	50% A	50% B
VI	60% A	40% B
VII.	70% A	30% B
VIII	80% A	20% B
IX	90% A	10% B

Nine glass bottles fitted with well fitting corks were

cleaned out with chromic acid and then steamed out to remove soluble impurities before use. They were inverted over a jet of steam, and left for one hour; then they were removed and dried. Each bottle was weighed empty, and the calculated volumes of liquid A were run into each bottle in turn from a burette. Each bottle was again weighed, so that the weight of liquid A in every bottle was accurately known. The calculated volumes of liquid B were then run in, and the bottles were again weighed. The weights of liquids A and B being accurately known, the composition in moles % of every mixture was calculated from the formula

$$\frac{\frac{Wa}{Ma}}{\frac{Wa}{Ma} + \frac{Wb}{Mb}} = \text{moles \% of A}$$

where

Wa = weight of liquid A

Wb = weight of liquid B

Ma = molecular weight of liquid A

Mb = molecular weight of liquid B

or

$$\frac{\frac{Wb}{Mb}}{\frac{Wa}{Ma} + \frac{Wb}{Mb}} = \text{moles \% B}$$

which was used as a check for

moles % A + moles % B = 100

The physical properties of each series of binary

mixtures have been examined, together with the physical properties of the pure liquids from which the mixtures were made.

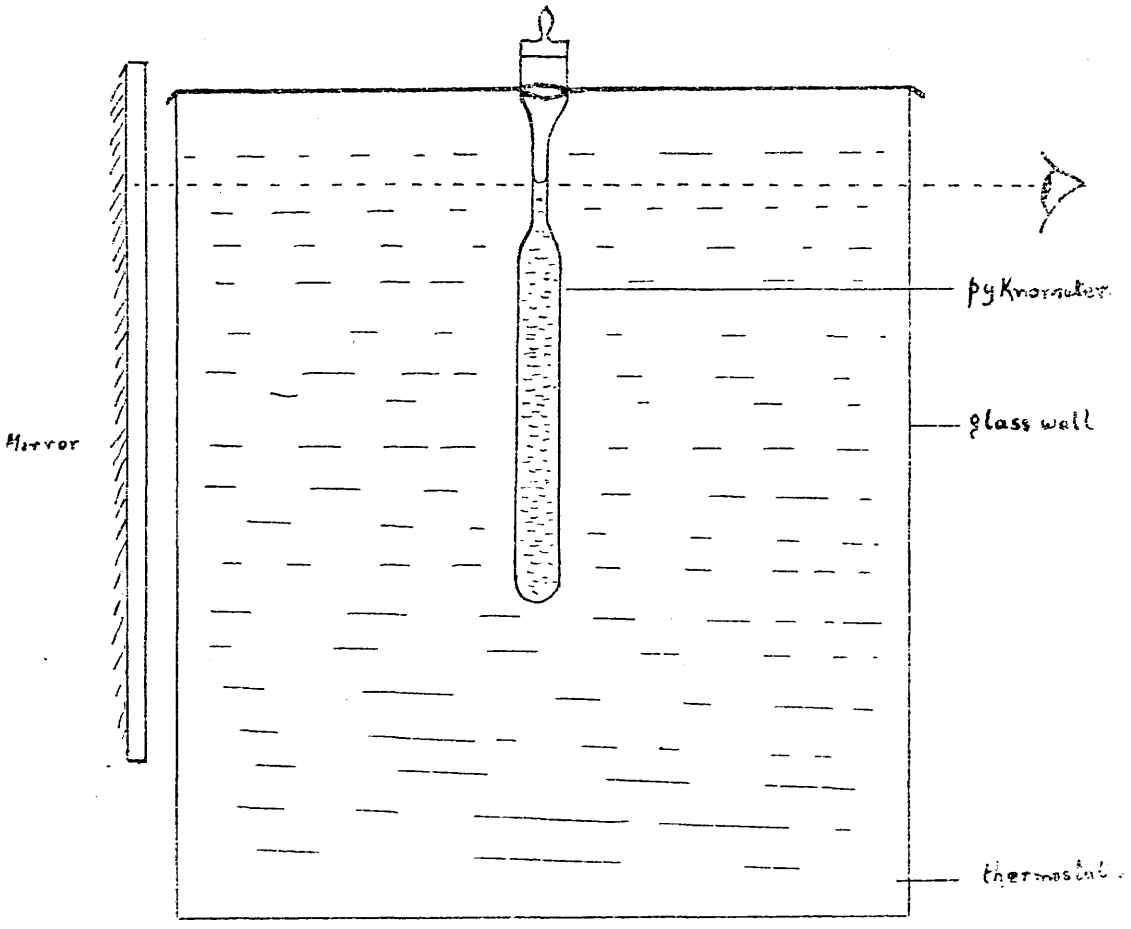


Fig. I.

Methods of measurement of the different physical properties.

(1) Specific Gravity.

Specific gravities were measured with a 2 c.c. pyknometer shaped as in figure I.

The pyknometer was cleaned, dried and weighed. It was filled with boiled distilled water and put in a thermostat at 25°C. When the pyknometer and its contents had taken on the temperature of the bath the level of the liquid was adjusted, the pyknometer removed, dried and weighed. This was repeated with the liquid of which the specific gravity was required. The specific gravity was calculated from the above data as follows:-

$$D_4^t = \{ W_s^t \times D_w^t \} / W_w^t.$$

where:-

D_4^t = Specific gravity of liquid at 25°C.

W_s^t = Weight of liquid filling pyknometer at 25°C.

W_w^t = Weight of water filling pyknometer at 25°C.

D_w^t = Density of water at 25°C.

(2) Refractive Index.

Refractive index was measured with a Pulfrich refractometer, used with a device for maintaining the prism and the liquid under observation at constant temperature. Water at constant temperature was continuously flowing through a metal heater, which was immersed in the liquid in the cell, and round the prism of the instrument. The temperature was read from a thermometer placed in the heater. As in the cases of the other properties, observations were made at 25°C., and refractive indices for the sodium D. line, which was obtained by using an ordinary sodium flame. The angles of refraction could be read to 1' of arc, and the refractive indices were calculated from them by means of tables, belonging to the instrument.

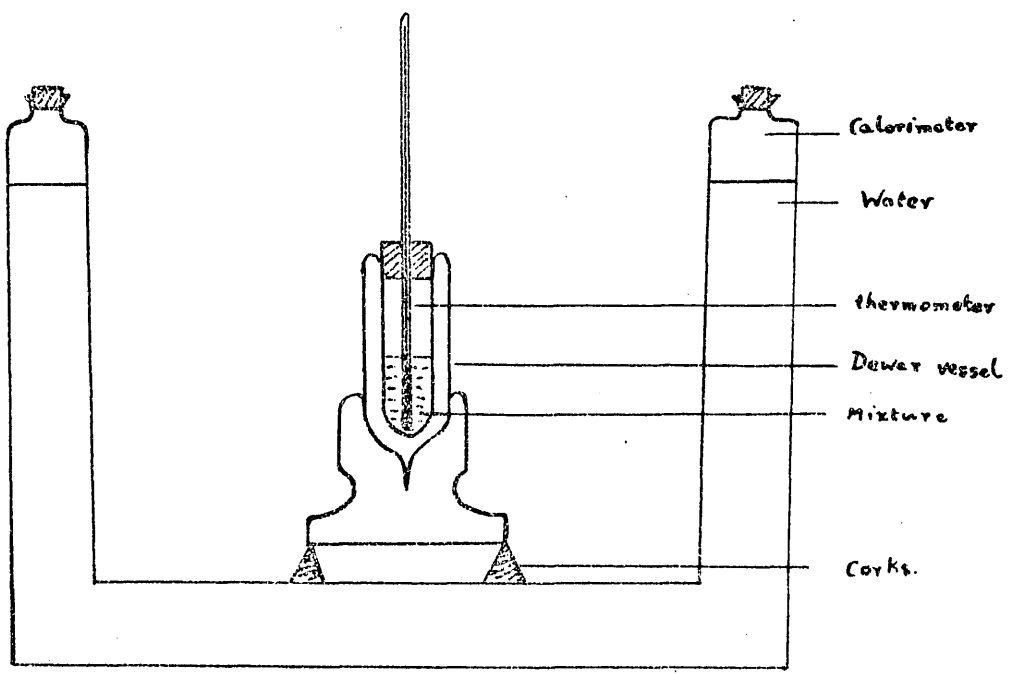

Calorimeter
Water
thermometer
Dewar vessel
Mixture
Corks.

Fig II

(3) Heat of Mixing.

Measurement of temperature changes on mixing the two liquids under investigation in varying proportions, was made in a corked Dewar vessel designed to hinder loss of heat by radiation, shewn in section in figure III. It was found that the usual type of calorimeter made of copper or glass gave very inaccurate results due to loss of heat by radiation.

Temperatures were measured to a hundredth of a degree, on a thermometer graduated in tenths of a degree and an experiment was carried out previously to determine the water equivalent of the glass calorimeter, and thermometer. The same volume of liquid was always used, so that the surface of the glass in contact with the liquid was always the same, and results were obtained which agreed within the limits of experimental error. Temperatures were measured at minute or half minute intervals, and on plotting temperature as ordinate against time as abscissac, lines were obtained which, on producing to meet the ordinate drawn at the time of mixing, gave the temperature at the time of mixing.

The formula

$$H = (t_m - t)\ S_m \left[(m_c + m_t) + W\right]\ (m_c + m_t)$$

was used to calculate the heat of mixing from the date.

where

H = heat of mixing in calories per gram

t_m = final temperature

t = initial temperature

S_m = specific heat of mixture

m_c = weight of one substance

m_t = weight of the other substance

W = water equivalent of the calorimeter and thermometer.

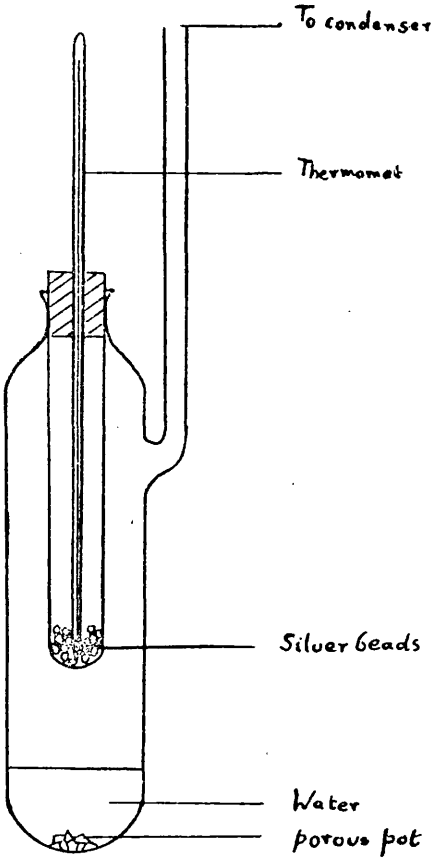


Fig. FII

(4) Specific Heat.

The specific heat of each pure substance and each mixture in the dewar vessel left from the heat of mixing determination, were measured by the method of mixtures. Pure silver of specific heat 0·566, was heated to the temperature of boiling water and was then poured into the mixture in the dewar vessel. Time readings of the temperature of the liquid in the vessel were taken before and after mixing, and the initial and final temperatures were read off from a graph similar to that drawn for the heat of mixing. The silver was shielded from loss of heat during transference to the dewar vessel by the following device. A double walled glass vessel shewn in figure V was used. The pure silver was placed in the inner vessel A and a thermometer T was placed with its bulb well immersed in the silver. The outer vessel contained the liquid, the vapour of which surrounded the vessel containing the silver. This liquid was heated to boiling over a small flame. The temperature of the silver gradually rose, and when the thermometer reading was steady, the temperature was read and the thermometer removed. The silver was then poured quickly into the calorimeter by inverting the heater as shewn in figure VI. The position of the limb L prevented the spilling of the heating liquid, and the whole arrangement ensures that the

silver is surrounded by the vapour and liquid at the constant temperature read on the thermometer until the moment of addition of the liquid in the calorimeter.

The specific heat was calculated by means of the formula:-

$$S_m = \frac{1}{W_m} \left[\frac{W_s \; S_s \; (t_3 - t_2) \; - W}{(t_2 - t_1)} \right]$$

where

S_m = specific heat of mixture
W_m = weight of mixture
W_s = weight of silver
S_s = Specific heat of silver
W = Water equivalent of calorimeter and thermometer
t_1 = initial temperature
t_2 = final temperature
t_3 = temperature of silver.

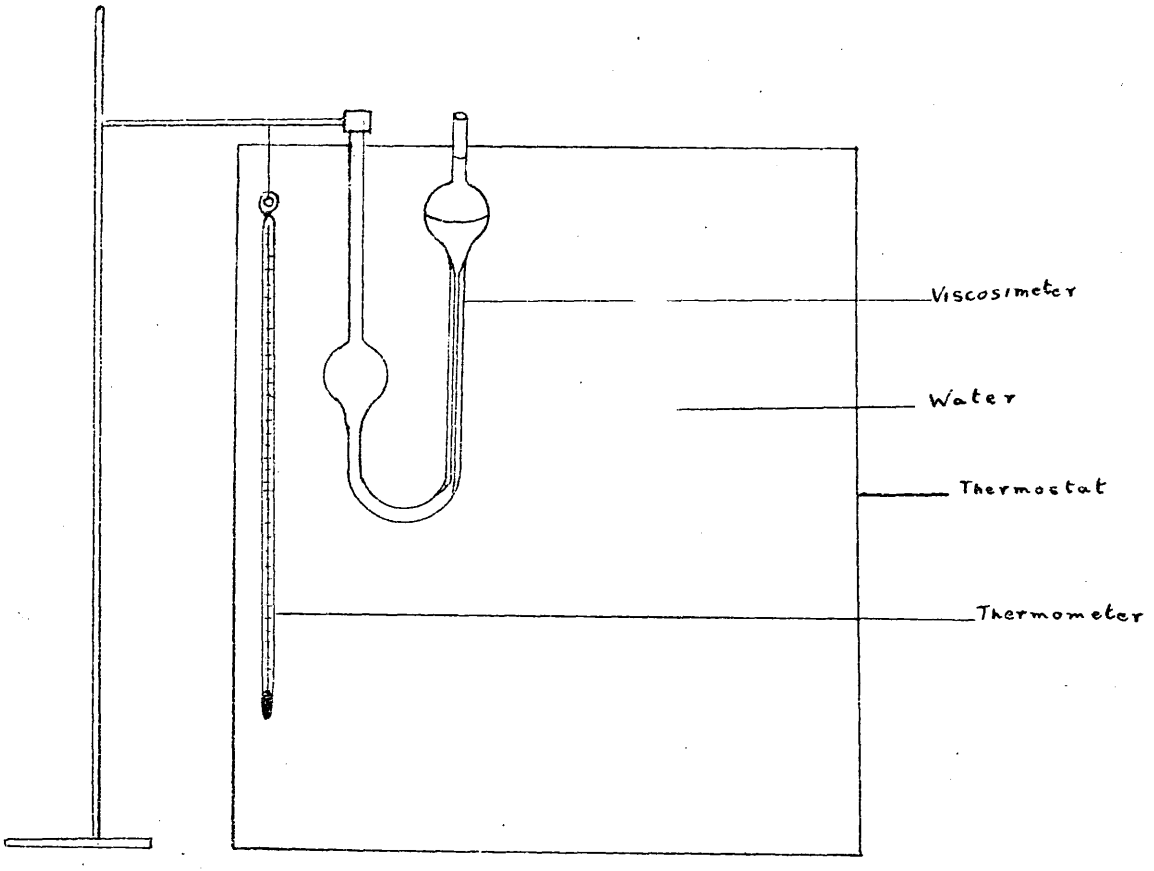


FIG. IV

(5) Viscosity.

The viscosity of the pure liquids and of each mixture was determined at 25°C using an Ostwald viscisimeter constructed according to the specification 118/1923 of the British Engineering Standards Association. The instrument chosen was of such a size that the minimum time of flow of the liquid was not less than 60 secs., this being within the limit of the value required by Reynold's criterion for non-turbulent flow as deduced from the dimensions of the viscosimeter,

Namely $$V < \frac{1000\eta}{rd}$$

where

V = velocity in cm/ sec

η = viscosity of liquid

d = density of liquid

r = radius of tube

The viscosimeter was first cleaned and dried and then a quantity of freshly boiled distilled water at 25°C was introduced by means of a pipette. This was fashioned with a drawn-out end, to facilitate insertion into the viscosimeter, and with a narrow neck to enable an exact volume of liquid to be introduced.

The viscosimeter was hung in a Rernostat of water

at 25°C. for about 10 minutes after which period the time taken for the liquid to flow through the viscosimeter was noted by means of a stop watch reading correctly to 1/5th of a second. A large number of readings were made with water as it was used as the basis of all the calculations. Each liquid was dealt with in a similar way and the mean of three sets of readings taken.

Having obtained in this way the time of flow of equal volumes of water and liquids and knowing the densities of these liquids, and assuming the viscosity of water at 25°C. to be $8{\cdot}95 \times 10^{-3}$ the viscosity of the liquids were calculated from the following formula:-

$$N = \frac{d_l t_l}{d_w t_w} \times 8{\cdot}91 \times 10^{-3}$$

where

d_l = density of liquid (d_{25}^{25})

d_w = density of water at 25°C.

t_l = time of flow of liquid in secs.

t_w = time of flow of water in secs.

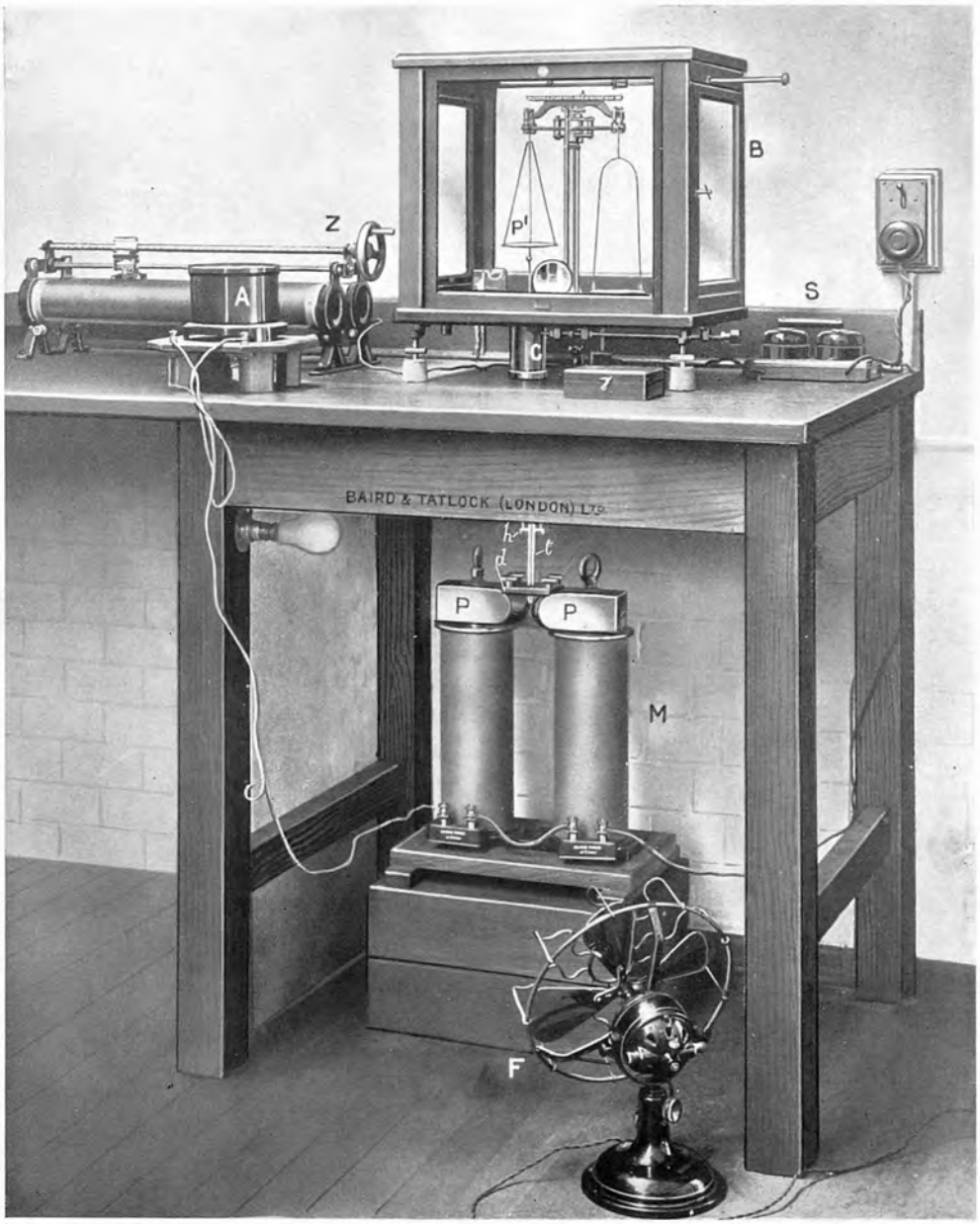
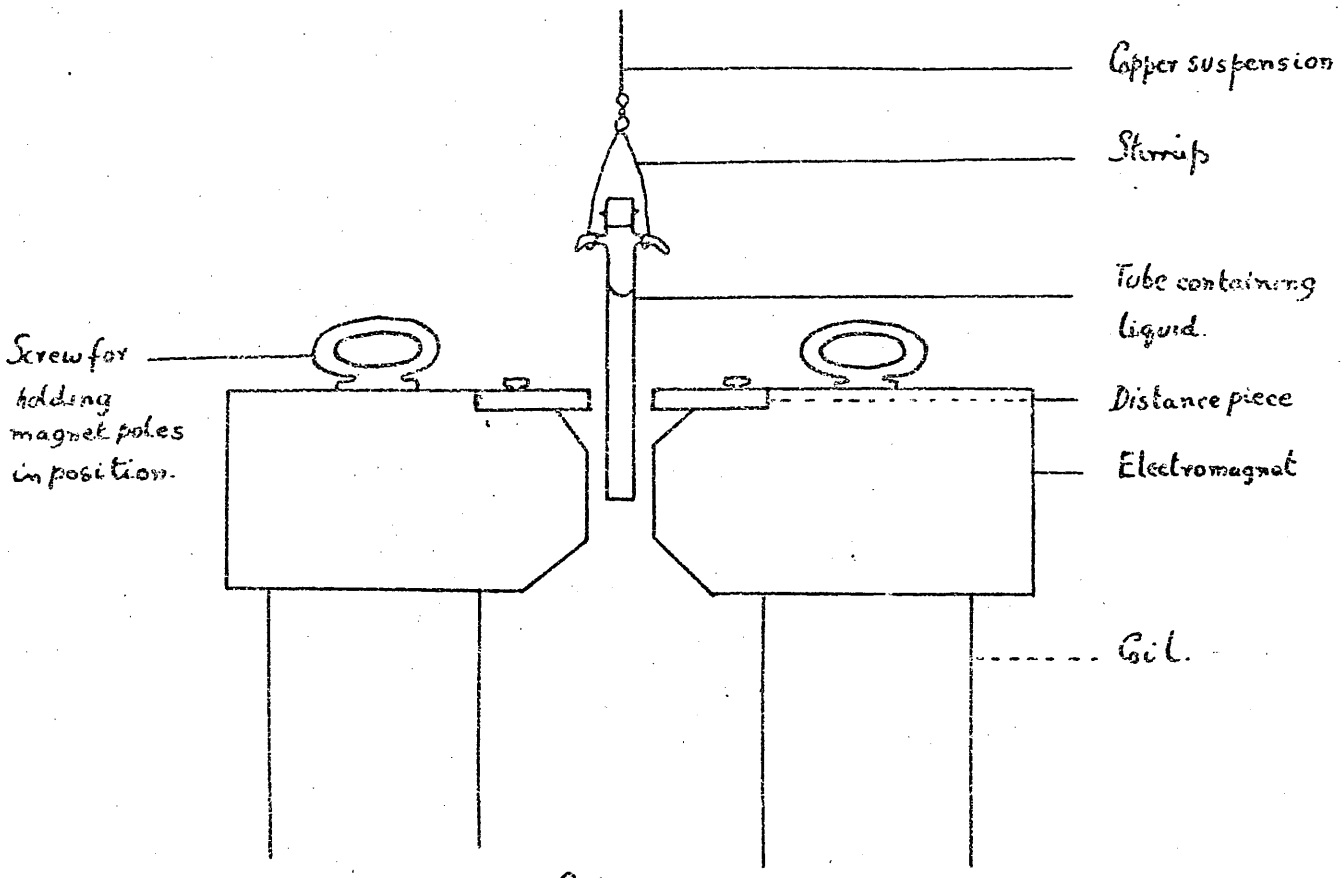
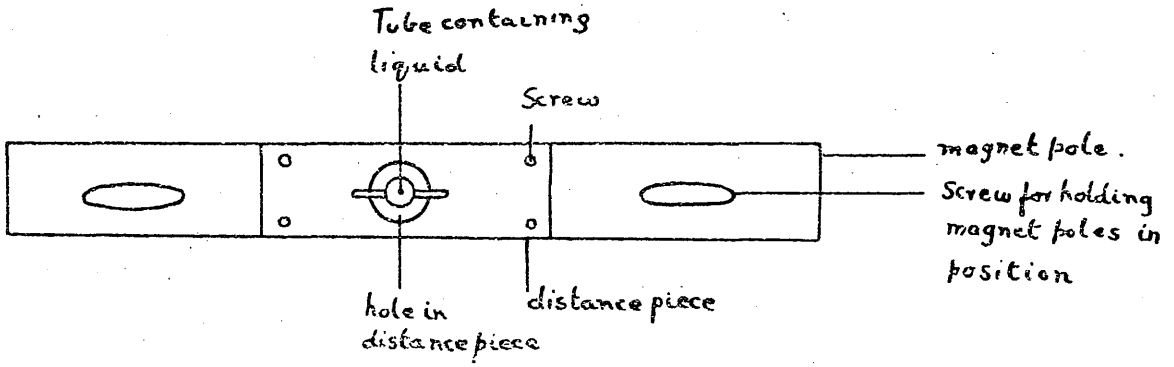


Fig. Va.



Side view.



View from top.

Fig. V b

(6) Magnetic Susceptibility.

For the measurement of the Magnetic Susceptibility of the liquids under consideration the Guoy method was used, and the apparatus shewn in Fig. (5a). A column of liquid of constant length was suspended in a homogeneous field between the poles P of an electro magnet M, so that one end of the column was in the maximum field and the other end in a region of no magnetic field, and the pull exerted on the liquid was determined by weighing.

The balance B used for the purpose was of the Bunge type, modified so that the lever D was worked from the right hand side, while the fine copper wire E carrying the vessel and liquid to be weighed passed up through a hole in the bench to the beam of the balance. The vessel (t) was of glass, shaped with arms as shewn in Fig (5b) and was hung between the poles of the magnet by means of a copper stirrup (h). This was attached to the suspension in such a way that the position of the glass tube could be readjusted so that the inside meniscus of the bottom of the tube was level with a mark on the centre of the pole piece of the magnet. The distance between the pole pieces was maintained by a brass distance piece (d) with a circular hole through which the tube containing the liquid hung. The metal plate was kept in its position on the pole pieces by means of screws.

A current of 3 amps passing through magnet coils of

20,000 turns produced a field of about 5,400 Gauss. The current was controlled by a resistance Z connected with a two-pole switch (s) and was registered on an ammeter A. The field was explored in preliminary experiments and was found to be uniform for at least 2 mm, on either side of the mark, and was negligable at a region of 6·5 cms. above. The pull on a known volume of liquid was determined in the following way. The tube was weighed in and out of the magnetic field, the liquid was measured out and added by means of a pipette and the apparatus was again weighed in and out of the field.

To obtain reliable results the following precautions were taken. Weighings were made by the oscillation method, using standardised weights, and allowing only small amplitudes. In this way swinging of the tube out of a uniform field was prevented. The magnet and apparatus below the bench was boarded in, and the suspension up to the base of the balance was surrounded by a copper tube C, to shield from draughts and sudden changes of temperature. The magnet was left on for as short a time as possible to avoid overheating, and cooled by means of an electric fan F, after each time of using. The temperature of the air between the poles was noted before and after each reading by means of a thermometer placed between the poles.

The magnetic susceptibility was calculated from the following formula:-

$$10^6 \chi = \frac{0{\cdot}03\, l A + \alpha F}{W.}$$

where X = magnetic susceptibility

$.03 \times 10^{-6}$ = volume susceptibility of air

W = weight of substance in gms

F = pull of substance in mgms

A = area of cross section of tube

l = length of liquid column

α = constant for apparatus

$$= \frac{2l \times 981 \times 10^6}{H_1^2 \times 100}$$ C.G.S units

H_1 = field at bottom of cylinder depending on the distance between the pole pieces.

Preliminary experiments gave α = ·531

(mean of 16 determinations)

RESULTS.

Benzene and Aniline.

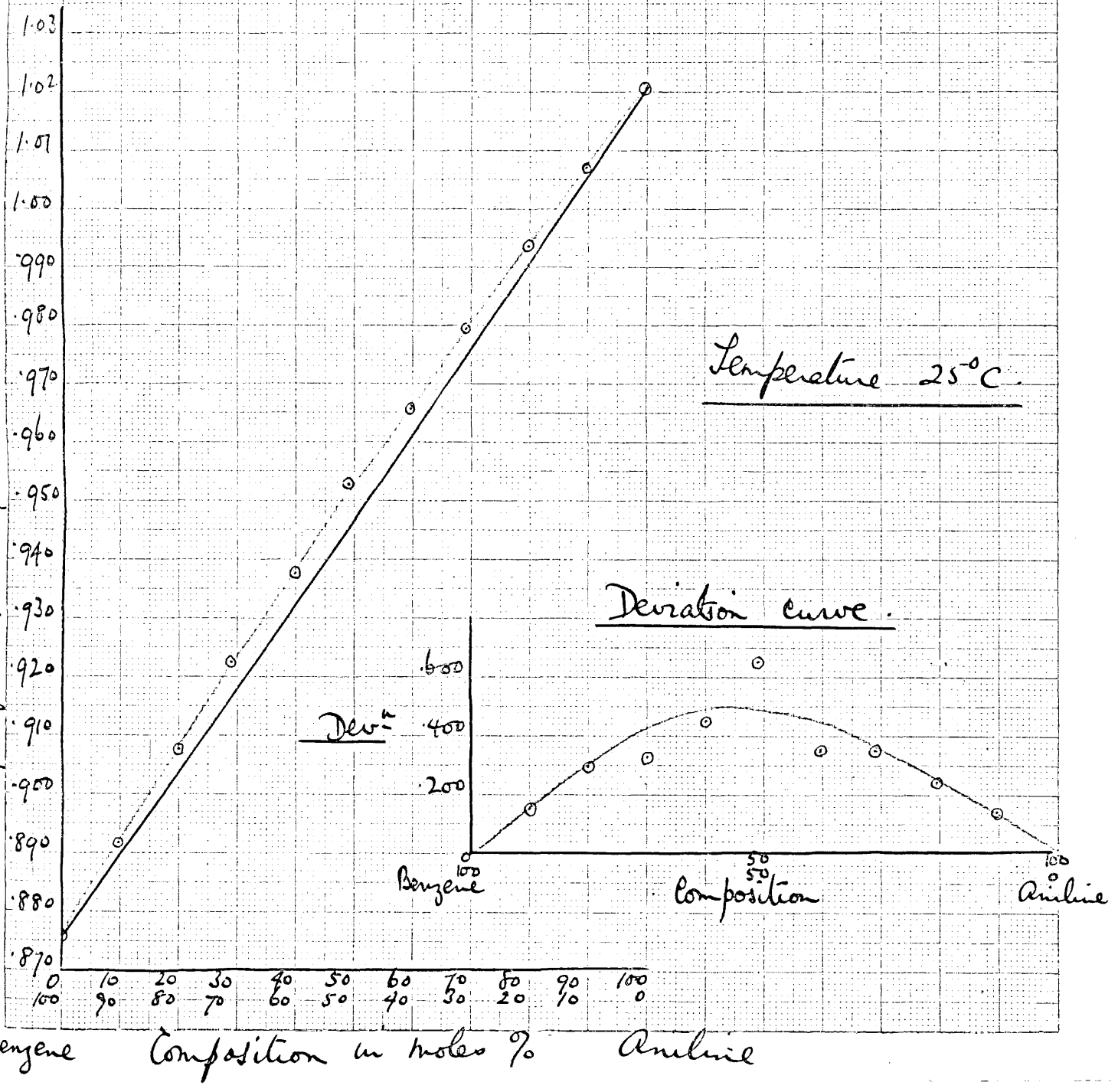
Benzene and Aniline.

Composition of the Mixtures.

Mixture	Weight of Benzene in grams.	Weight of Aniline in grams.	Comp. Benzene	in Moles % Aniline
A	35.0928	4.7212	90.03	9.97
B	31.1552	9.2506	80.00	20.00
C	27.2856	13.8604	70.11	29.89
D	23.4296	18.5916	60.04	39.96
E	19.4280	22.1870	51.09	48.91
F	15.5178	27.4378	40.28	59.72
G	11.9274	31.8406	30.87	69.13
H	7.8332	36.7498	20.26	79.74
I	3.9464	40.9988	10.29	89.71

Benzene and Aniline

Specific gravity and composition



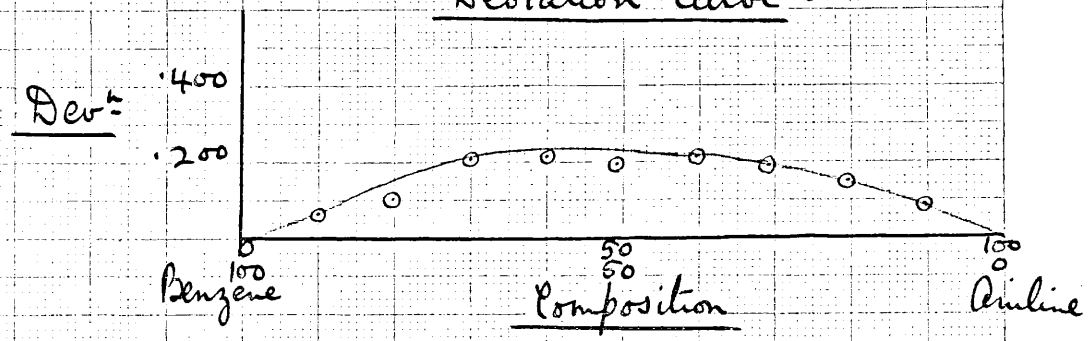
Specific Gravity.

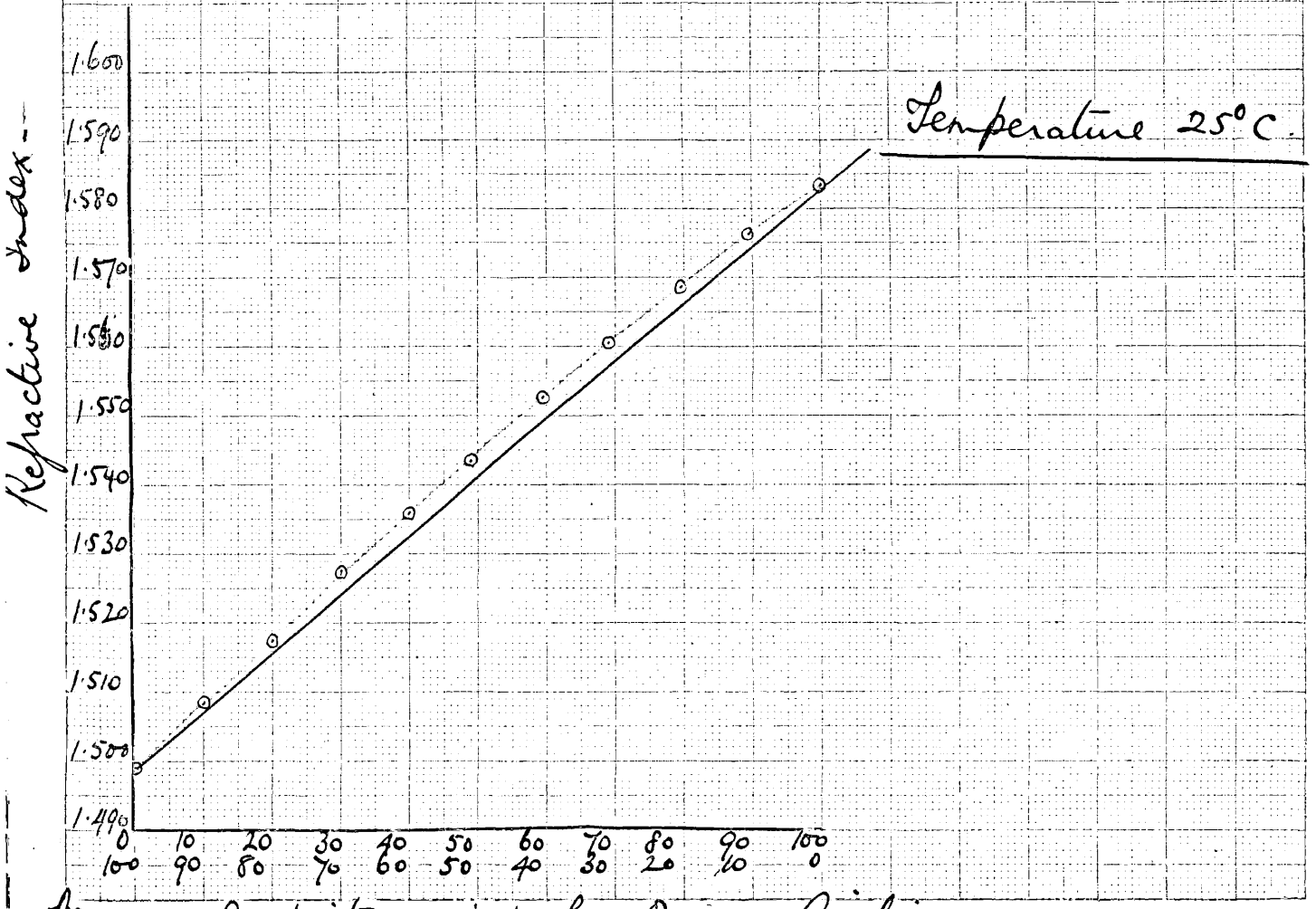
Mixture Aniline and Benzene.

Substance	Wt. of mixture in gms.	$^{25}d_{25}$ (expt)	$^{25}d_{25}$ (calcd)	% gm. mol. deviation from calcd.
Benzene	1.74256	.87615	—	
A	1.77409	.89190	.89055	+ .151
B	1.80557	.90770	.90504	+ .294
C	1.83455	.92230	.91931	+ .325
D	1.86554	.93787	.93386	+ .429
E	1.89960	.95300	.94678	+ .657
F	1.92110	.96580	.96240	+ .353
G	1.94823	.97944	.97599	+ .353
H	1.97841	.99362	.99123	+ .241
I	2.00330	1.0o713	1.00572	+ .140
Aniline	2.03028	1.02060	-	

Refractive Index.

Benzene and Aniline.





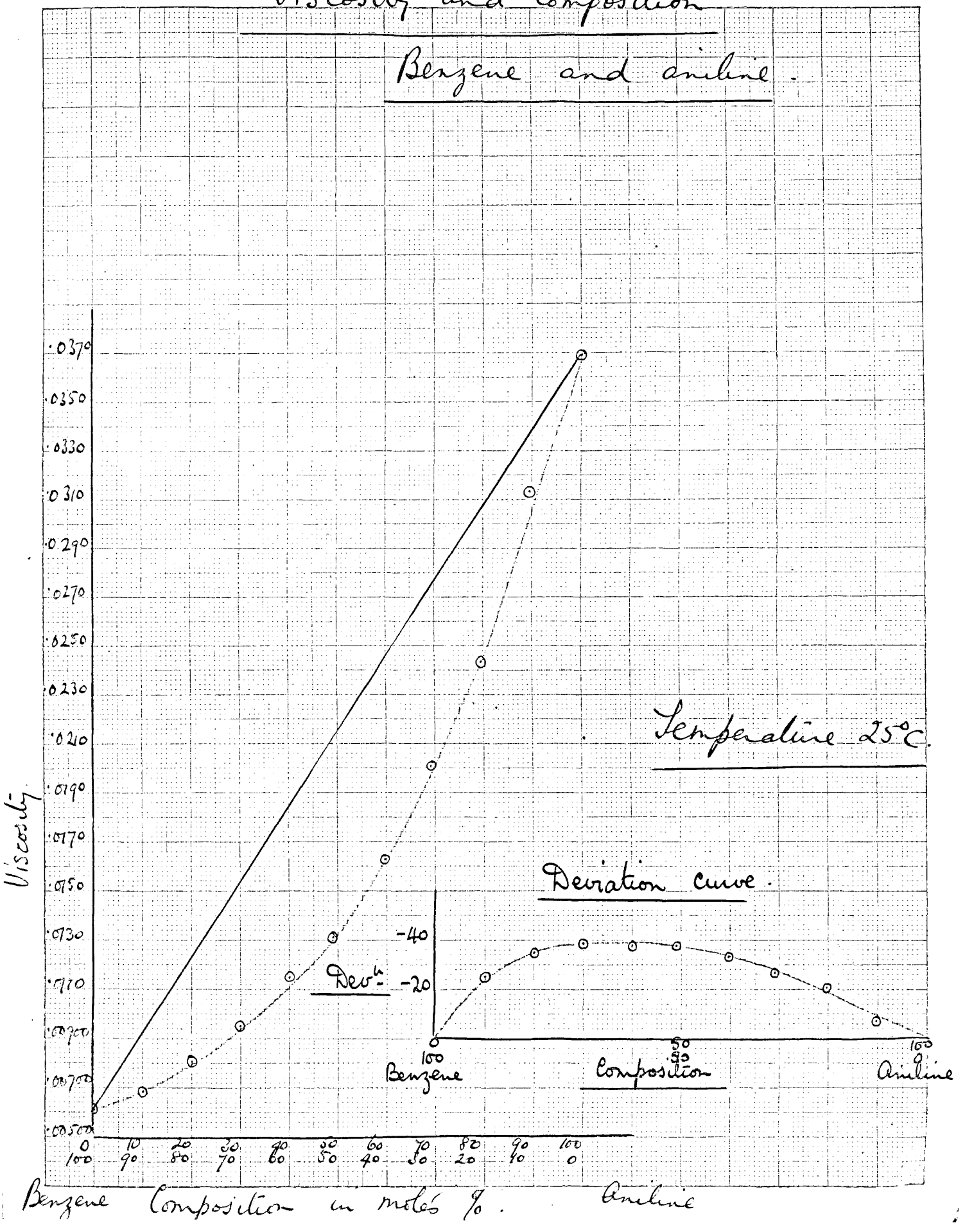
Refractive Index.

Mixture. Benzene and Aniline.

Substance	Angle of Deviation	$N_{d_{25}}$ (expt)	$N_{d_{25}}$ (calcd.)	% gm. mol. deviation from calcd.
Benzene	37° 40'	1.499025	-	-
A	36° 00'	1.508440	1.507432	.067
B	34° 19'	1.517444	1.515903	.101
C	32° 25'	1.527445	1.524247	.209
D	30° 44'	1.536003	1.532745	.212
E	29° 14'	1.543361	1.540791	.199
F	27° 15'	1.552686	1.549420	.218
G	25° 32'	1.560341	1.557363	.191
H	23° 33'	1.568699	1.566315	.152
I	21° 38'	1.576241	1.574790	.092
Aniline	19° 40'	1.583415	-	-

Viscosity and Composition

Benzene and aniline.



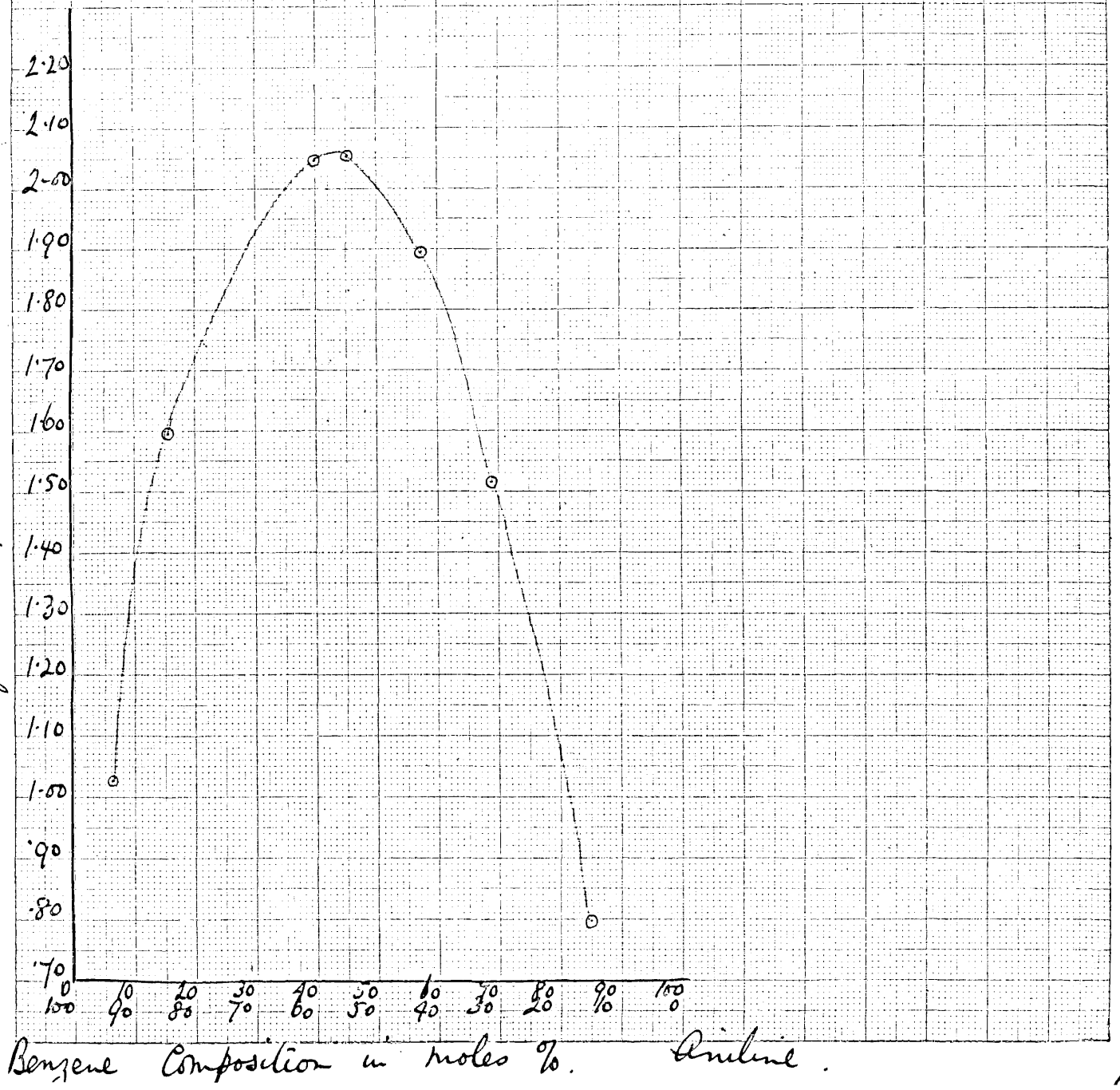
Viscosity.

Mixture. Benzene and Aniline.

Substance	Time of flow for water.	Time of flow for substance	Viscosity (N25) expt.	Viscosity (N25) calcd.	% gm.mol. deviation from calcd.
Benzene	1'25.2"	1'6"	0.006092	-	-
A	1'25.2"	1'13.4"	0.006878	.009165	-24.95
B	1'25.2"	1'24.4"	0.008033	.012257	-34.46
C	1'25.2"	1'38.1"	0.009503	.015366	-38.15
D	1'25.2"	1'55.6"	0.011442	.018410	-37.85
E	1'25.2"	2'11.6"	0.013150	.021169	-37.88
F	1'37"	3'06"	0.016270	.024502	-33.59
G	1'39"	3'46"	0.20140	.027403	-26.51
H	1'25.2"	3'50.4"	0.024351	.030674	-20.61
I	1'25.2"	4'38"	0.031354	.033747	- 7.09
Aniline	1'37"	6'39"	0.036920	-	-

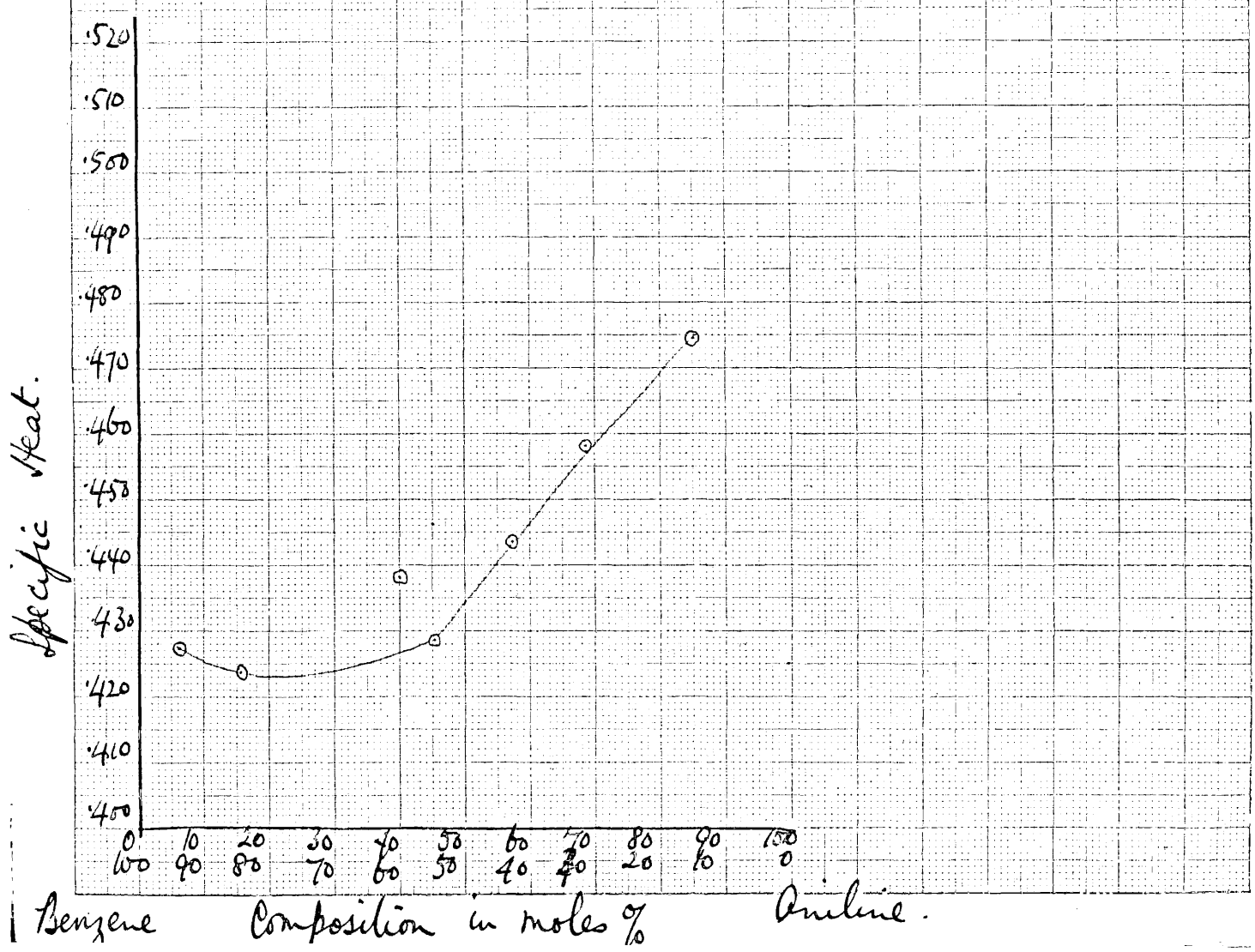
Heat of Mixing

Benzene and Aniline.



Specific Heat

Benzene and Aniline.



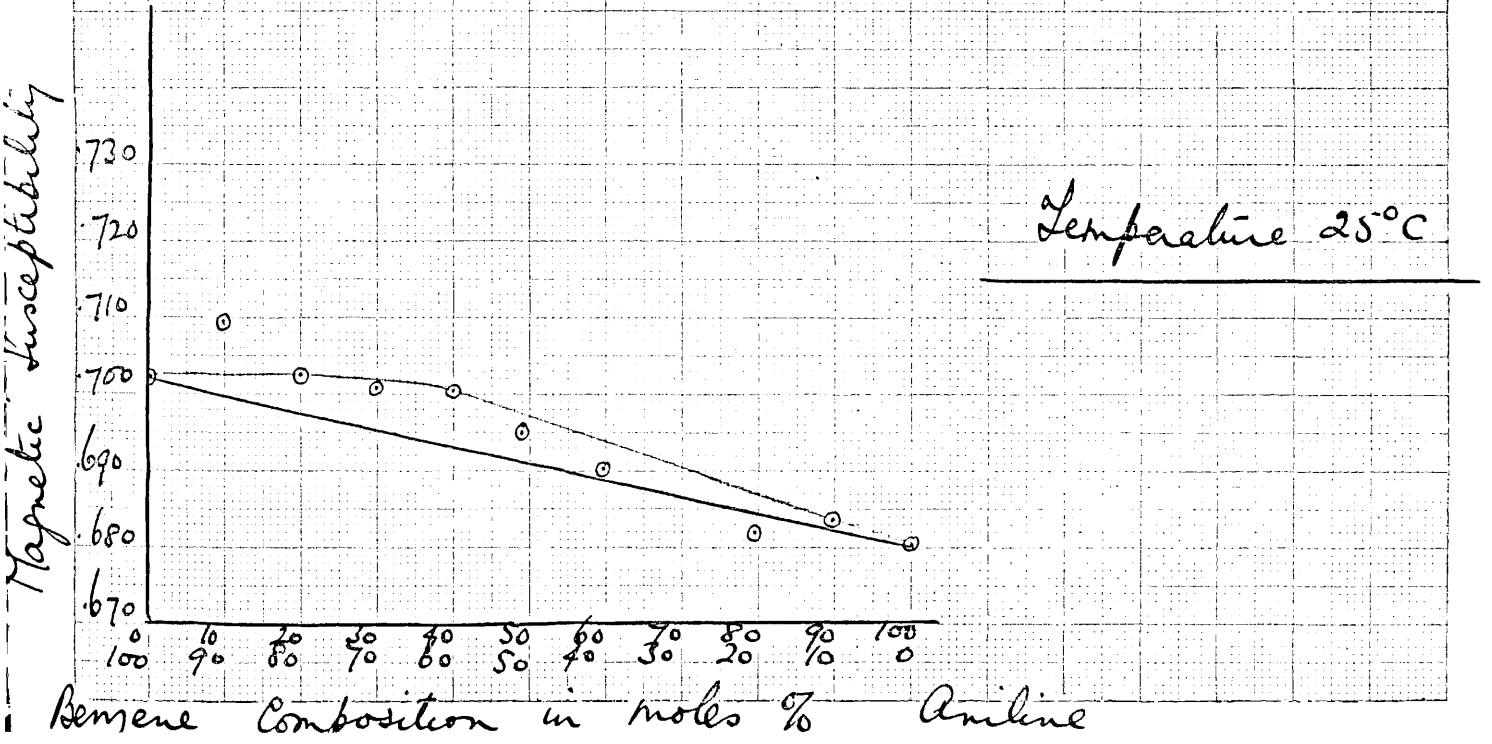
Heat of Mixing.

Mixture. Benzene and Aniline.

Substance	Wt. of Benzene.	Aniline	% gm. mol. comp of Mixture Benzene.	Aniline	$t_3 - t_2$	$t_2 - t_1$	P_m^S	$t_m - t$	Heat of Mixing
	gms	gms							
1	4.034	26.421	14.985	85.075	78.45	4.5	.4743	-1.3	.7995
2	8.314	21.853	31.2	68.8	79.2	4.7	.4582	-2.525	1.516
3	11.084	17.75	42.67	57.33	77.1	4.85	.4437	-3.2	1.895
4	14.475	14.287	54.71	45.29	79.65	5.15	.4287	-3.55	2.0514
5	15.392	12.199	60.08	39.92	80	5.25	.4381	-3.45	2.048
6	22.374	4.925	84.38	15.62	78.95	5.35	.4238	-2.75	1.5974
7	25.084	2.00	93.71	6.29	79.7	5.4	.4273	-1.75	1.025

Magnetic Susceptibility

Benzene and Aniline



Temperature 25°C

Magnetic Susceptibility.

Mixture. Benzene and Aniline.

Pull on Empty Tube = 4.0 mgms.

Temperature = 23° - 25°C.

Height of column of liquid = 7.5 cms.

Volume of liquid = 3.512 ccs.

Substance	Mean pull mgms.	wt. of substance gms.	Magnetic Susceptibility 10^6 X (expt)	calcd	% deviation from calcd.
Benzene	4.32	3.11760	.7021	-	-
A	4.39	3.13538	.7098	.6999	1.41
B	4.43	3.19838	.7025	.6977	.69
C	4.47	3.23563	.7010	.6055	.79
D	4.52	3.27542	.7006	.6933	1.05
E	4.60	3.36300	.6950	.6914	.52
F	4.65	3.42420	.6903	.6890	.19
G	---	-----	----	----	----
H. H	4.69	3.40665	.6820	.6846	-.38
I	4.73	3.51792	.6837	.6825	.17
Aniline	4.76	3.56040	.6803	----	----

Benzene and Monoethylaniline.

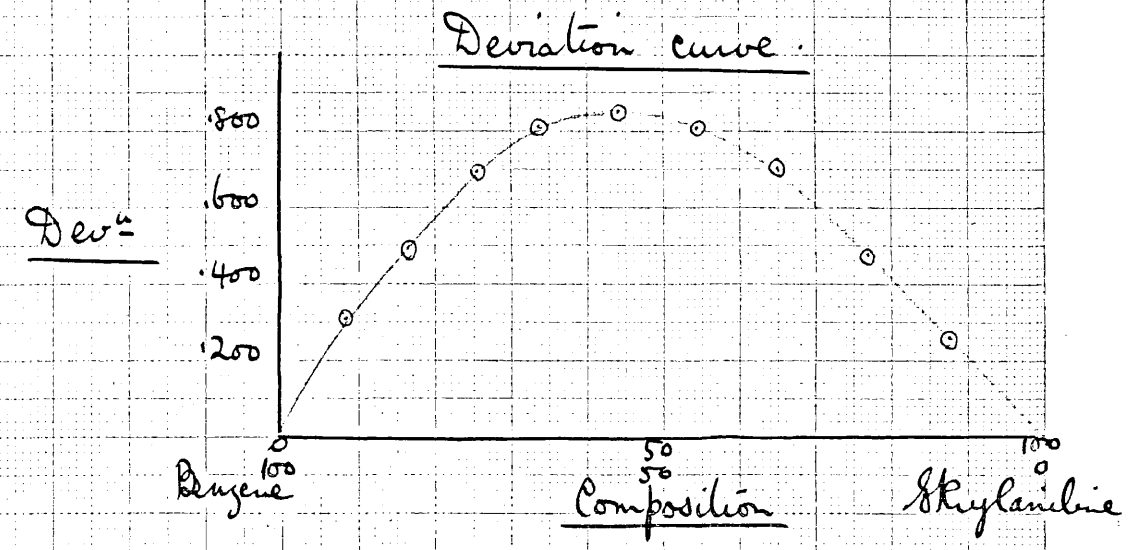
Benzene and Monoethylaniline

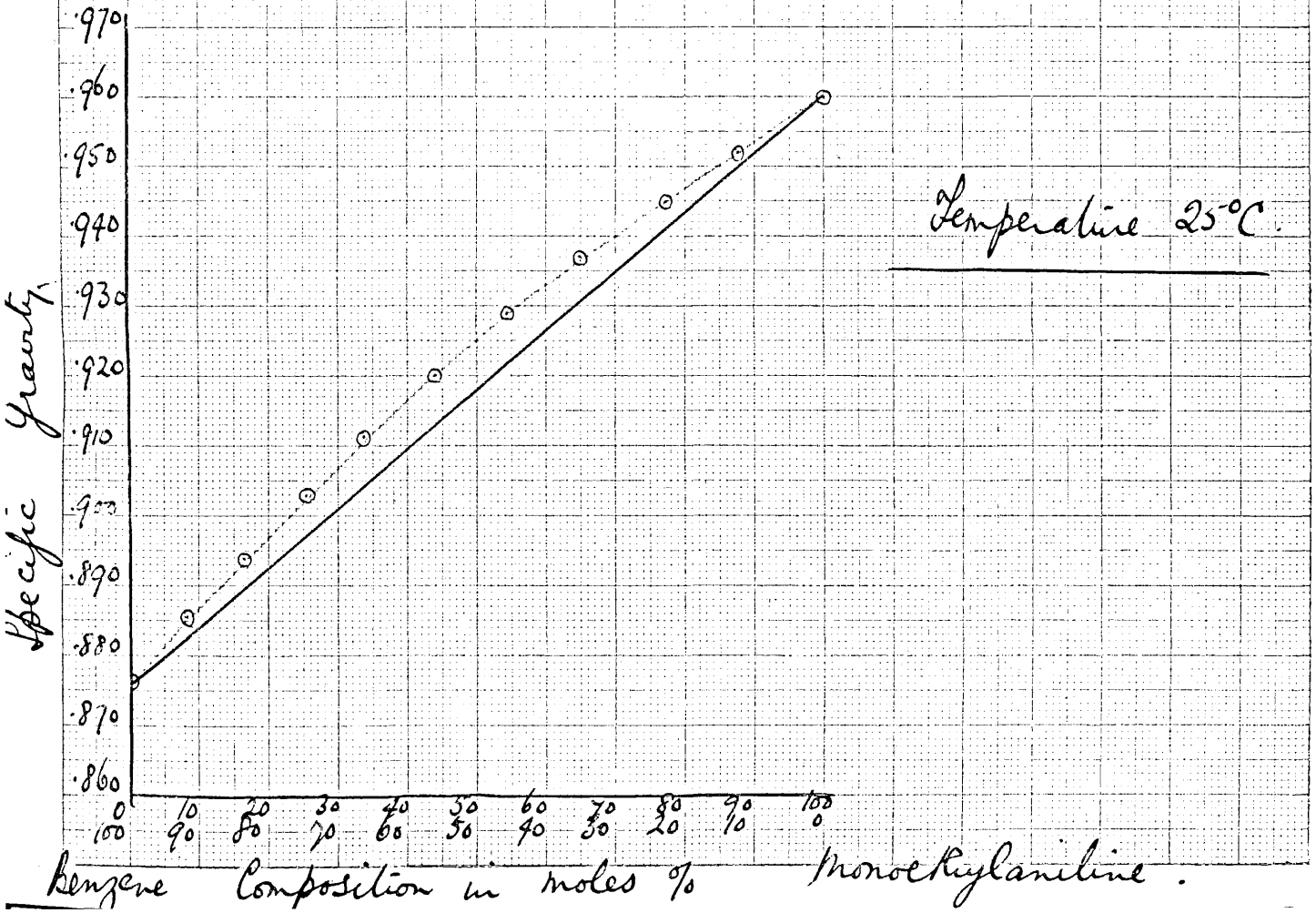
Composition of the Mixtures.

Mixture	Weight of Benzene in gms.	Weight of Ethyl-aniline in gms.	Comp. in Mols. % Benzene	Ethylaniline
A	3.9593 gms	43.2572 gms.	12.43	87.57
B	7.3688 "	38.4906 "	22.01.	7709
C	11.6682 "	33.6840 "	34.95	65.05
D	15.6184 "	28.9152 "	45.61	54.39
E	19.6870 "	23.9468 "	56.o4	43.96
F	24.4574 "	19.2994 "	66.20	33.80
G	27.4904 "	14.4846 "	74.60	25.40
H	31.4426 "	9.5638 "	83.60	16.40
I	35.2826 "	4.9608 "	91.70	8.30

Specific gravity

Benzene and monoethylaniline.





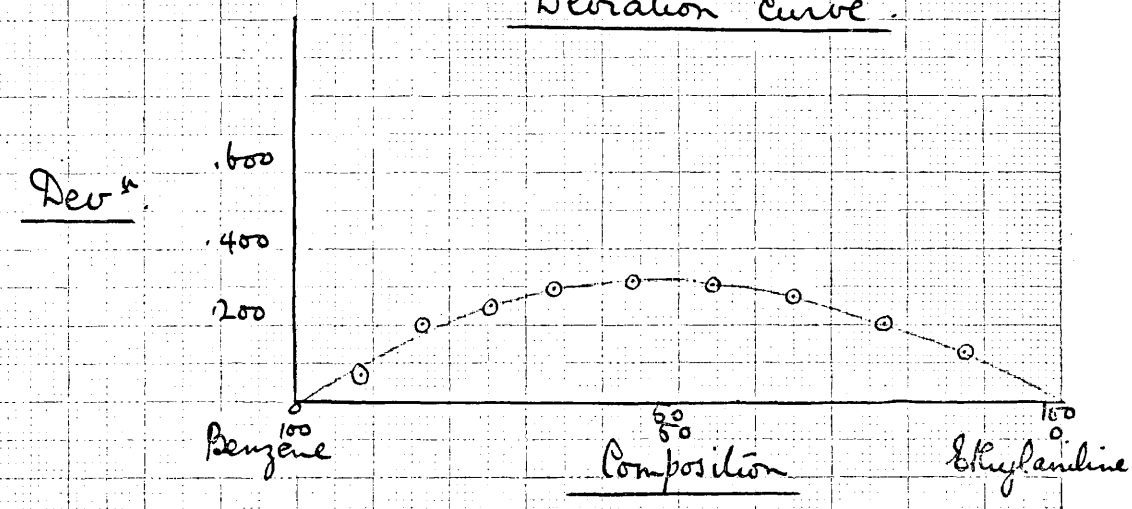
Specific Gravity.

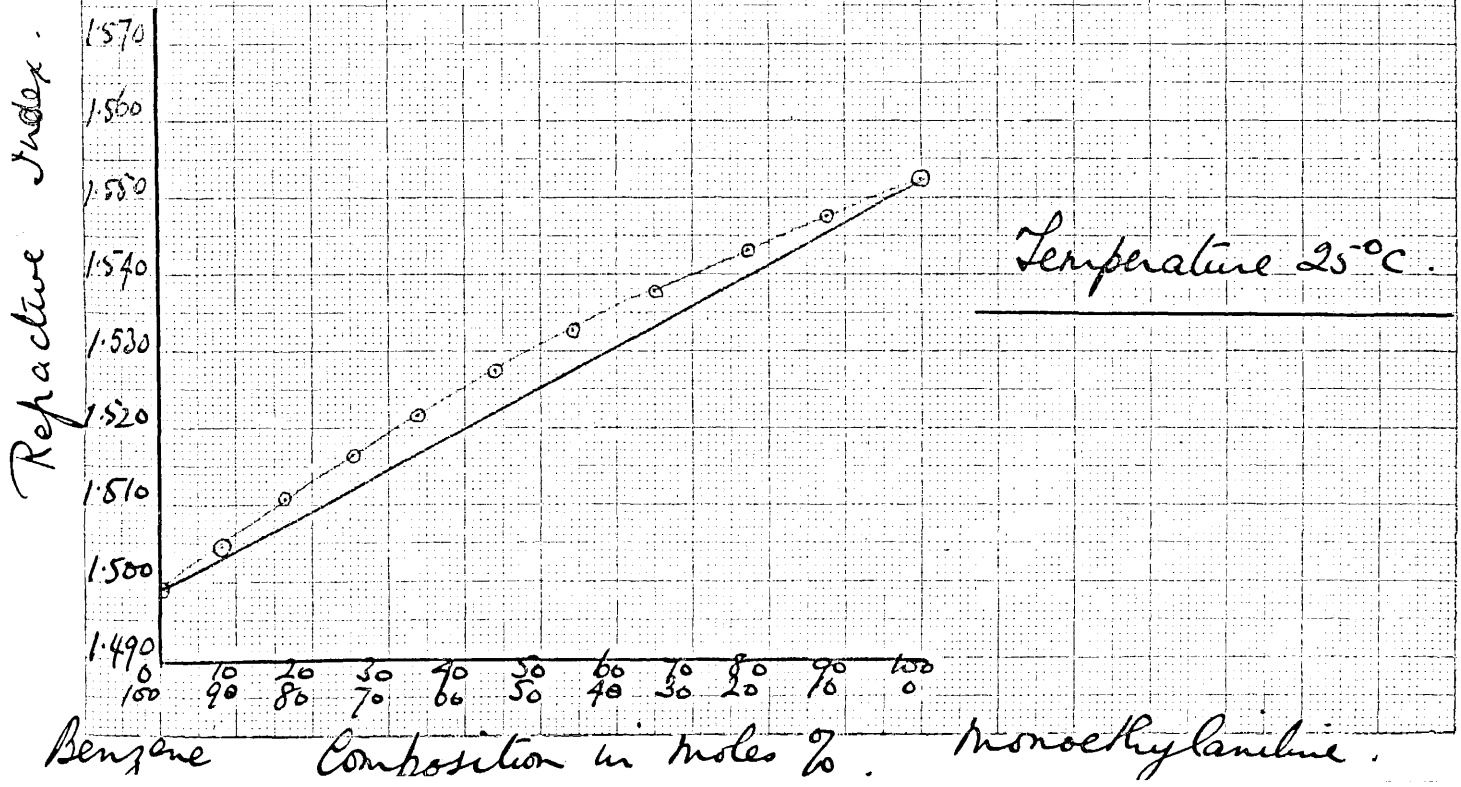
Mixture. Benzene and Monoethylaniline

Substance	Wt. of Mixture gms.	$^{25}d_{25}$ expt	$^{25}d_{25}$ calcd	%gm. mol. deviation from calcd.
Benzene	1.74256	.87615	-	-
I	1.76206	.88585	.88310	+.311
H	1.77886	.89429	.88989	+.494
G	1.79746	.90365	.89743	+.693
F	1.81376	.91184	.90447	+.814
E	1.83146	.92074	.91299	+.848
D	1.84826	.92919	.92173	+.809
C	1.86416	.93718	.93066	+.700
B	1.88016	.94522	.94075	+.475
A	1.89386	.95211	.94963	+.261
Ethylaniline	1.90948	.95996	-	-

Refractive Index.

Benzene and Monoethylaniline.

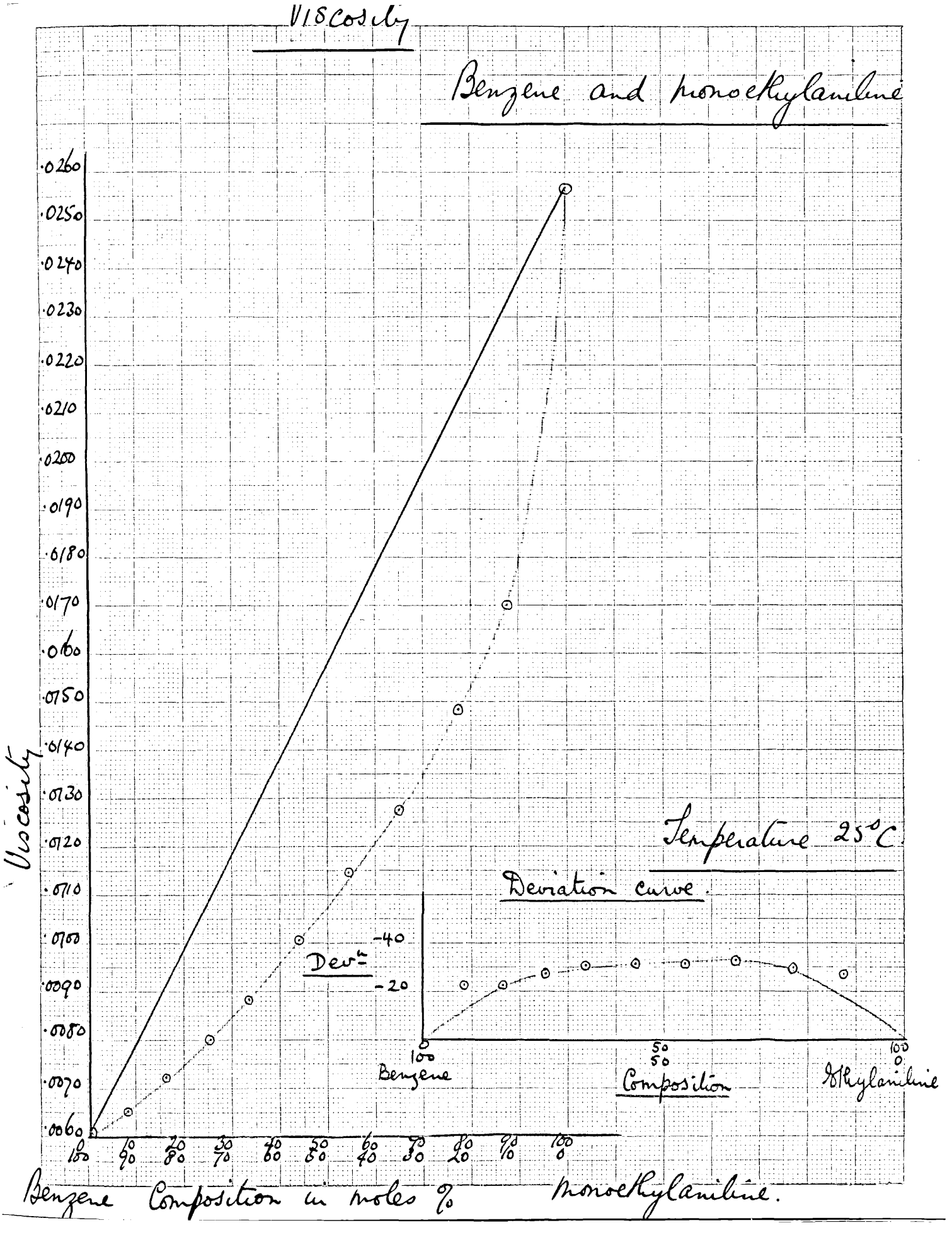




Refractive Index.

Mixture. Benzene and Monoethylaniline

Substance	Angle of deviation	$n_{D_{25}}$ (expt)	$n_{D_{25}}$ (calcd)	% gm mol. deviation from calcd.
Benzene	37° 40'	1.499025	-	-
I	36° 40'	1.504615	1.503458	.070
H	35° 32'	1.510863	1.507785	.204
G	34° 30'	1.516455	1.512592	.255
F	33° 32'	1.521609	1.517081	.298
E	32° 26'	1.527359	1.522510	.318
D	31° 23'	1.532726	1.528080	.304
C	30° 20'	1.537985	1.533775	.274
B	29° 14'	1.543361	1.540208	.204
A	28° 19'	1.547724	1.545650	.134
Monoethylaniline	27° 18	1.552449	-	-


Viscosity
Benzene and monoethylaniline
·0260
·0250
·0240
·0230
·0220
·0210
·0200
·0190
·0180
·0170
·0160
·0150
·0140
·0130
·0120
·0110
·0100
·0090
·0080
·0070
·0060
Viscosity
Temperature 25°C.
Deviation curve.
Dev^n
-40
-20
100
0
Benzene
50
50
Composition
0
100
Monoethylaniline
100 0
90 10
80 20
70 30
60 40
50 50
40 60
30 70
20 80
10 90
0 100
Benzene Composition in moles %
monoethylaniline.

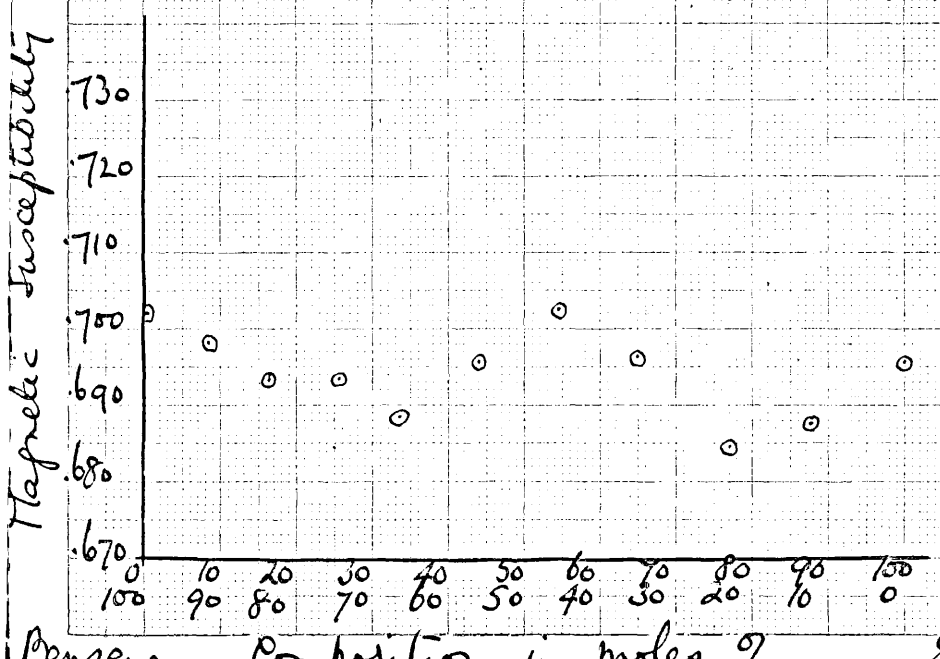
Viscosity

Mixture. Benzene and Monoethylaniline.

Substance	Time of flow for Water	Time of flow for Substance	Viscosity (N 25) (expt)	Viscosity (N 25) (calcd)	% gm. mol. deviation from calcd.
Benzene	1'25.2"	1' 6"	.00609	-	-
I	1'36.8"	1'20"	.006520	.008413	-22.50
H	1'36.8"	1'27.6"	.007223	.009307	-22.40
G	1'36.8"	1'36.8"	.007990	.011072	-27.83
F	1'36.8"	1'45"	.008830	.012719	-30.57
E	1'36.8"	1'59"	.010080	.014711	-31.48
D	1'36.8"	2'14"	.011470	.016756	-31.54
C	1'36.8"	2'27.6"	.012760	.018846	-32.29
B	1'36.8"	2'50.6"	.014820	.021207	-30.11
A	1'36.8"	3'13.2"	.016960	.23262	-27.09
Monoethylaniline	1'35.8"	4'41.6"	.025700	-	-

Magnetic Susceptibility

Benzene and Ethylaniline.



Temperature 23°-25°C

Magnetic Susceptibility

Mixture. Benzene and Monoethylaniline

Pull on empty tube = 4.0 mgms

Temperature = 23°- 25°C

Height of column of liquid = 7.5 cms.

Volume of liquid = 3.512 ccs.

Substance	Mean pull mgms	Wt. of substance gms	Magnetic Susceptibility 10^6 X (expt)	(calcd)	% Deviation from calcd.
Benzene	4.32	3.11760	.7021	-	-
I	4.33	3.14258	.6981		
H	4.35	3.17768	.6934		
G	4.38	3.20185	.6935		
F	4.40	3.23891	.6888		
E	4.44	3.23680	.6958		
D	4.48	3.23588	.7026		
C	4.52	3.29546	.6964		
B	4.59	3.40769	.6843		
A	4.66	3.44451	.6878		
Monoethylaniline	4.70	3.4225	.6955		

Benzene and Diethylaniline

Benzene and Diethylaniline

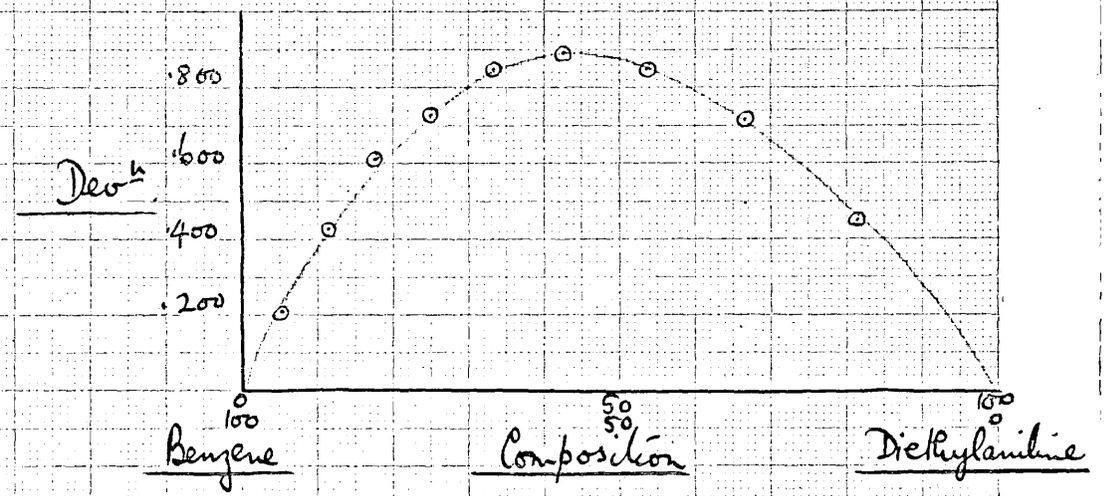
Composition of the Mixtures.

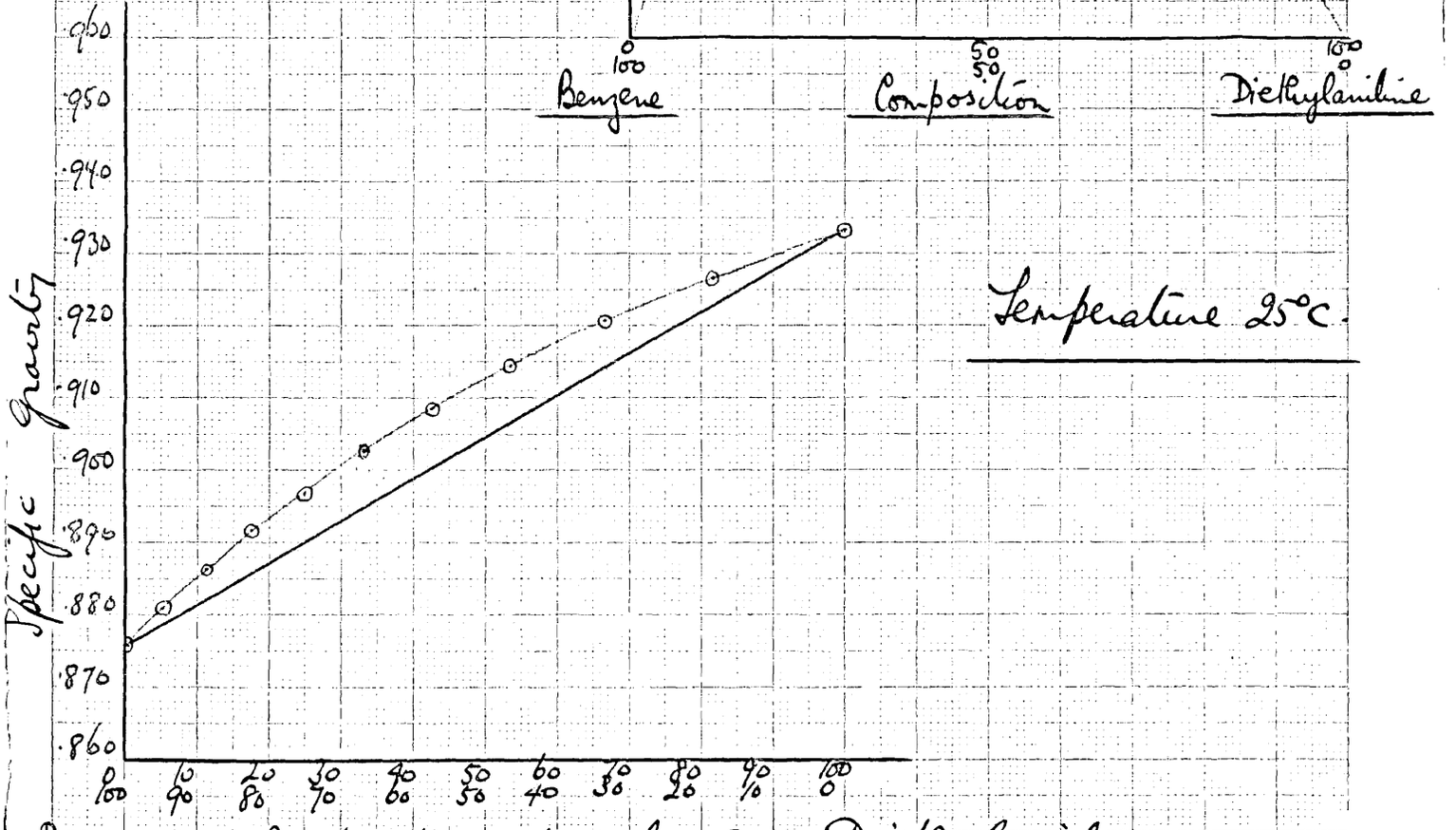
Mixture	Wt. of Benzene in gms.	Wt of Diethylaniline in gms.	Comp. in Moles % Benzene	Diethylaniline
A	39.2256	4.1439	94.75	5.25
B	34.9046	8.3970	88.80	11.20
C	30.5824	12.5554	82.30	17.70
D	26.2144	16.7382	74.95	25.05
E	21.8871	20.8037	66.78	33.22
F	17.4746	25.0059	57.17	42.83
G	13.1068	29.0335	46.31	53.69
H	8.6935	33.4833	33.17	66.83
I	4.4326	37.5706	18.4	81.6

Specific Gravity

Benzene and Diethylaniline

Deviation curve.





Temperature 25°C.

Specific Gravity

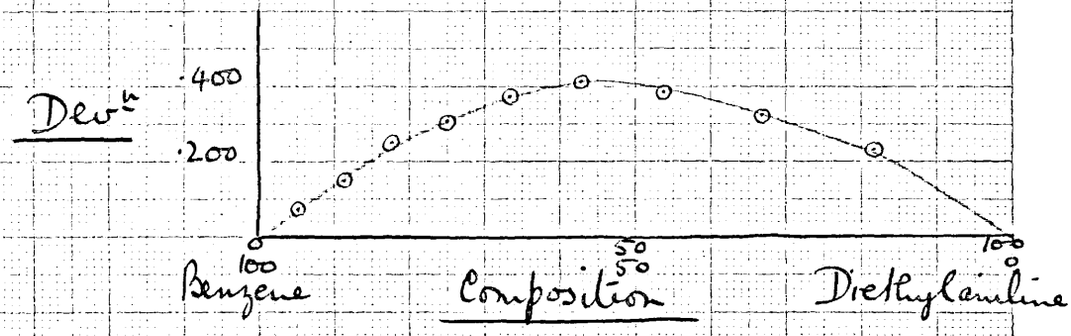
Mixture Benzene and Diethylaniline

Substance	Wt of Mixture in grms.	$25_{d_{25}}$ (expt)	$25_{d_{25}}$ (calcd)	% gm. mol. deviation from calcd.
Benzene	1.74256	.87615	-	-
A	1.7523	.88094	.87914	+ .204
B	1.7631	.88636	.88254	+ .432
C	1.7737	.89170	.88625	+ .615
D	1.7842	.89698	.89044	+ .734
E	1.7955	.90265	.89510	+ .843
F	1.8073	.90859	.90059	+ .888
G	1.8189	.91442	.90679	+ .841
H	1.8317	.92086	.91429	+ .718
I	1.8436	.92684	.92272	+ .446
Diethylaniline	1.8563	.93323	-	-

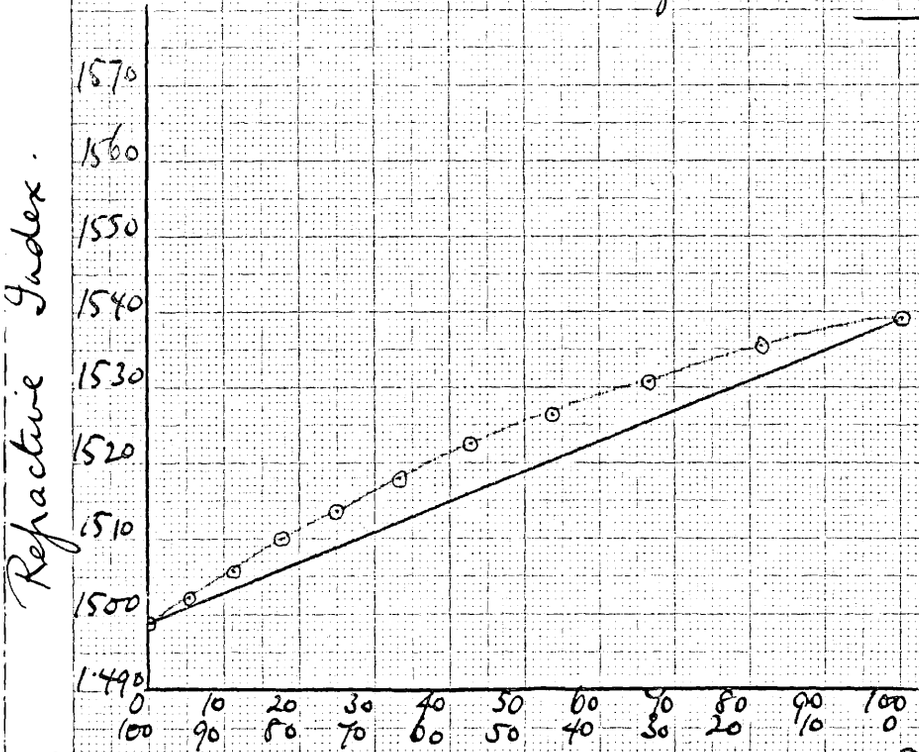
Refractive Index.

Benzene and Diethylaniline

Deviation curve.



Temperature 25°C.



Refractive Index

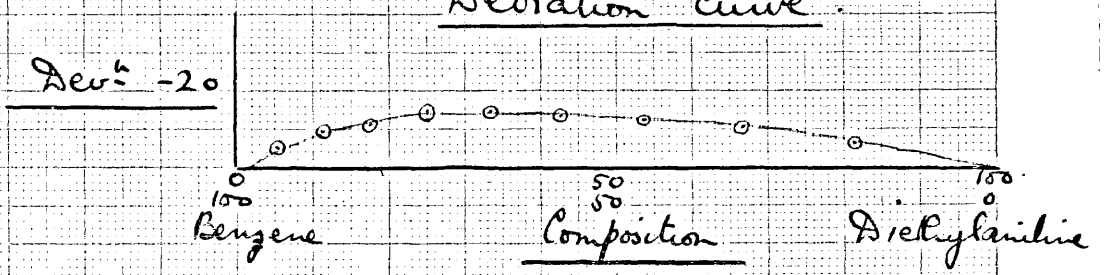
Mixture Benzene and Diethylaniline

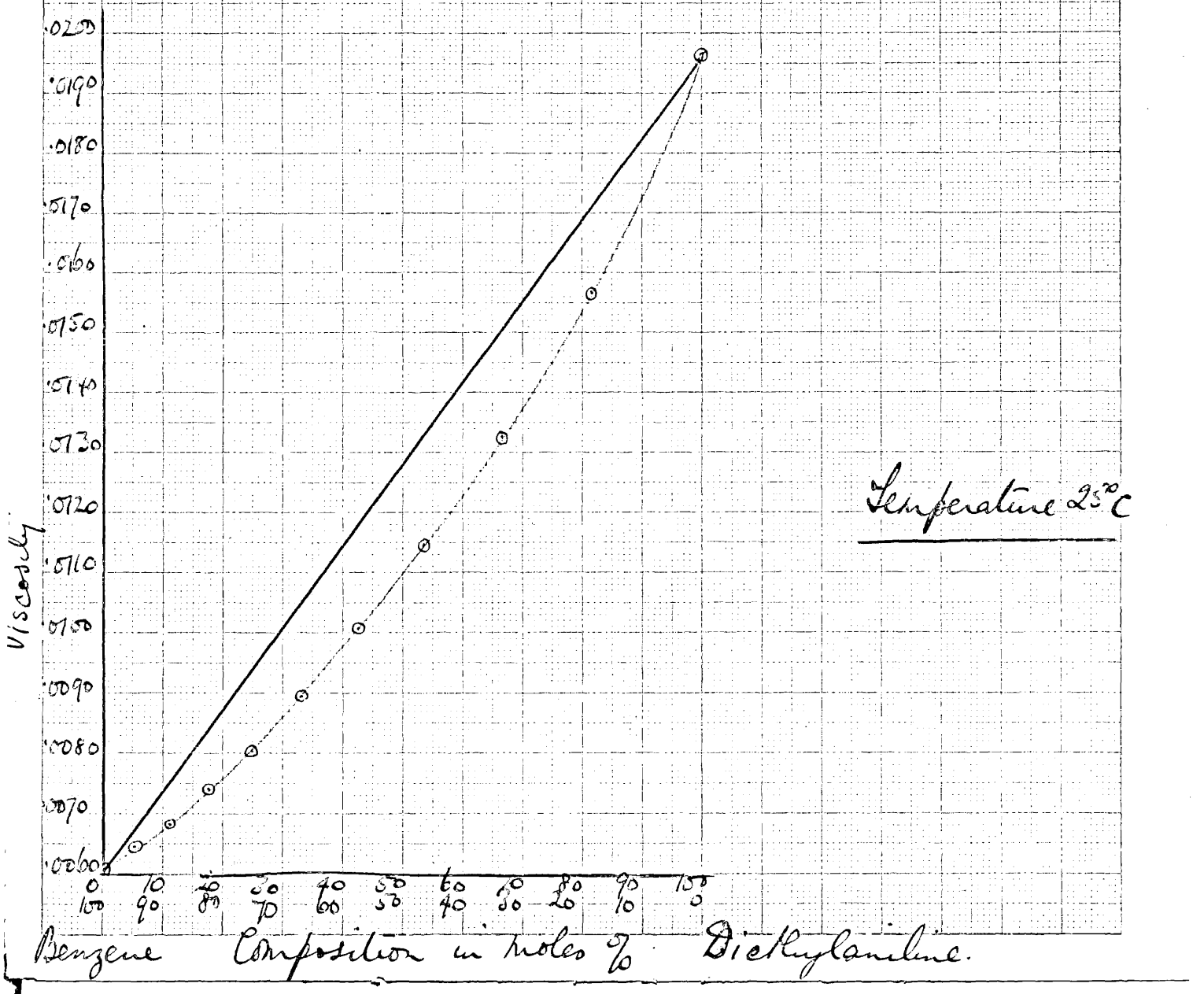
Substance	Angle of deviation	$n_{D_{25}}$ (expt)	$n_{D_{25}}$ (calcd)	% gm. mol. deviation from calcd.
Benzene	37° 40"	1.499025	-	-
A	37° 5'	1.502290	1.501134	.077
B	36° 26'	1.505907	1.503527	.158
C	35° 41'	1.510043	1.506139	.259
D	35° 0'	1.513765	1.509093	.309
E	34° 12'	1.518067	1.512376	.376
F	33° 22'	1.522489	1.516239	.412
G	32° 36'	1.526493	1.520605	.387
H	31° 44'	1.530955	1.525887	.382
I	30° 51'	1.535421	1.531828	.234
Diethylaniline	30° 5'	1.539225	-	-

Viscosity

Benzene and Diethylaniline

Deviation curve.





Temperature 25°C

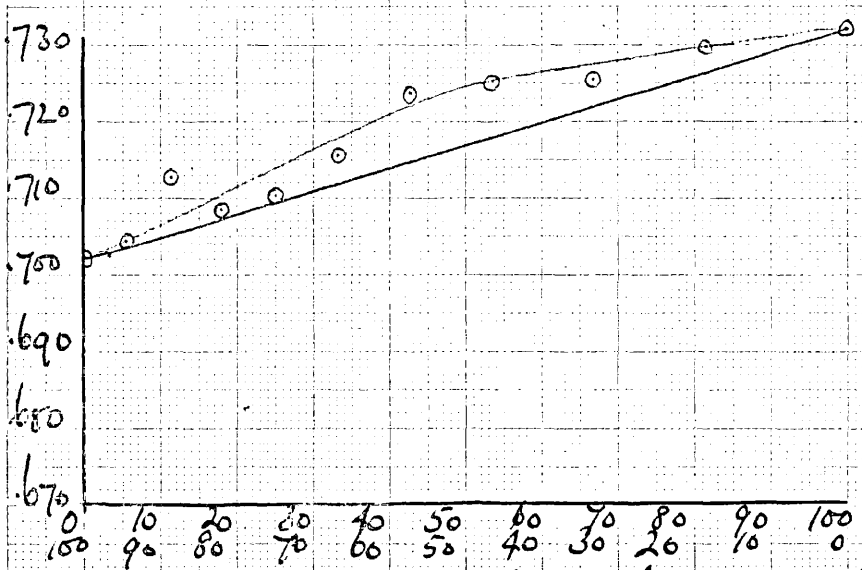
Viscosity

Mixture Benzene and Diethylaniline

Substance	Time of flow for water	Time of flow for substance	Viscosity N25 (expt)	Viscosity n25 (calcd)	% gm. mol. deviation from calcd.
Benzene	1'25.2"	1' 6"	.006092	-	-
A	1'36.8"	1'18.6"	.006441	.006778	-4.97
B	1'36.8"	1'23.6"	.006812	.007556	-9.84
C	1'36.8"	1'30.2"	.007407	.008406	-11.88
D	1'36.8"	1'38.4"	.008033	.009367	-14.24
E	1'36.8"	1'47.8"	.008956	.010436	-14.18
F	1'36.8"	2'0.4"	.010072	.011693	-13.86
G	1'36.8"	2'16.4"	.011480	.013113	-12.45
H	1'37"	2'38.0"	.013273	.014831	-10.50
I	1'37"	3'5.6"	.015690	.016758	-6.37
Diethylaniline	1'36.8"	3'43.2"	.019170	-	-

Magnetic Susceptibility

Benzene and Diethylaniline



Temperature 23° - 25°C.

Magnetic Susceptibility

Mixture Benzene and Diethylaniline

Pull on empty tube 2.0

Temperature 23° - 25°C.

Height of column of liquid 7.5 cms

Volume of liquid 3.512 ccs

Substance	Mean pull mgms	Wt. of substance gms.	Magnetic Susceptibility 10^6 X (expt)	(calcd)	% deviation from calcd.
Benzene	4.32	3.11760	.7021	-	-
A	4.34	3.12324	.7041	.7036	.07
B	4.40	3.12975	.7128	.7054	1.05
C	4.42	3.16379	.7085	.7073	.18
D	4.45	3.17876	.7102	.7095	.09
E	4.50	3.19262	.7154	.7120	.42
F	4.57	3.20653	.7239	.7149	1.26
G	4.59	3.21602	.7251	.7181	.97
H	4.62	3.23636	.7254	.7221	.45
I	4.66	3.24579	.7299	.7265	.47
Diethylaniline	4.70	3.26492	.7321	-	-

Benzene and Methylaniline.

Benzene and Methylaniline

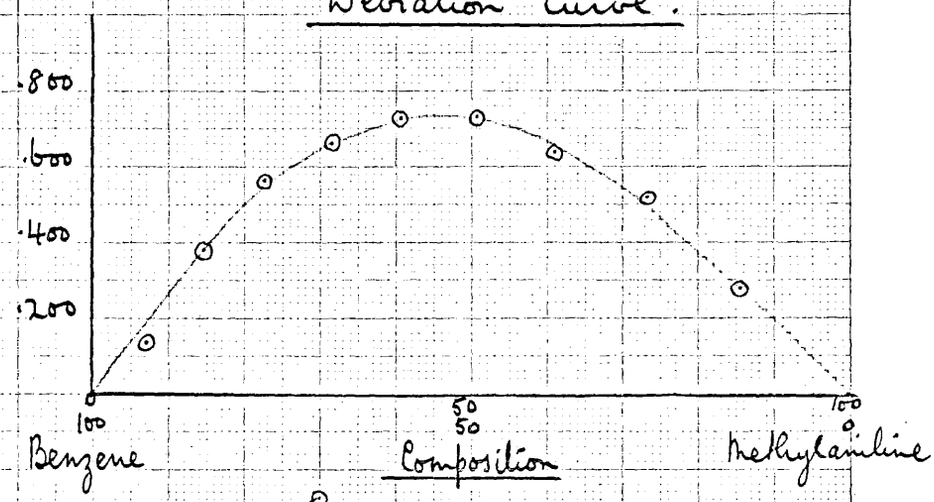
Composition of the Mixtures.

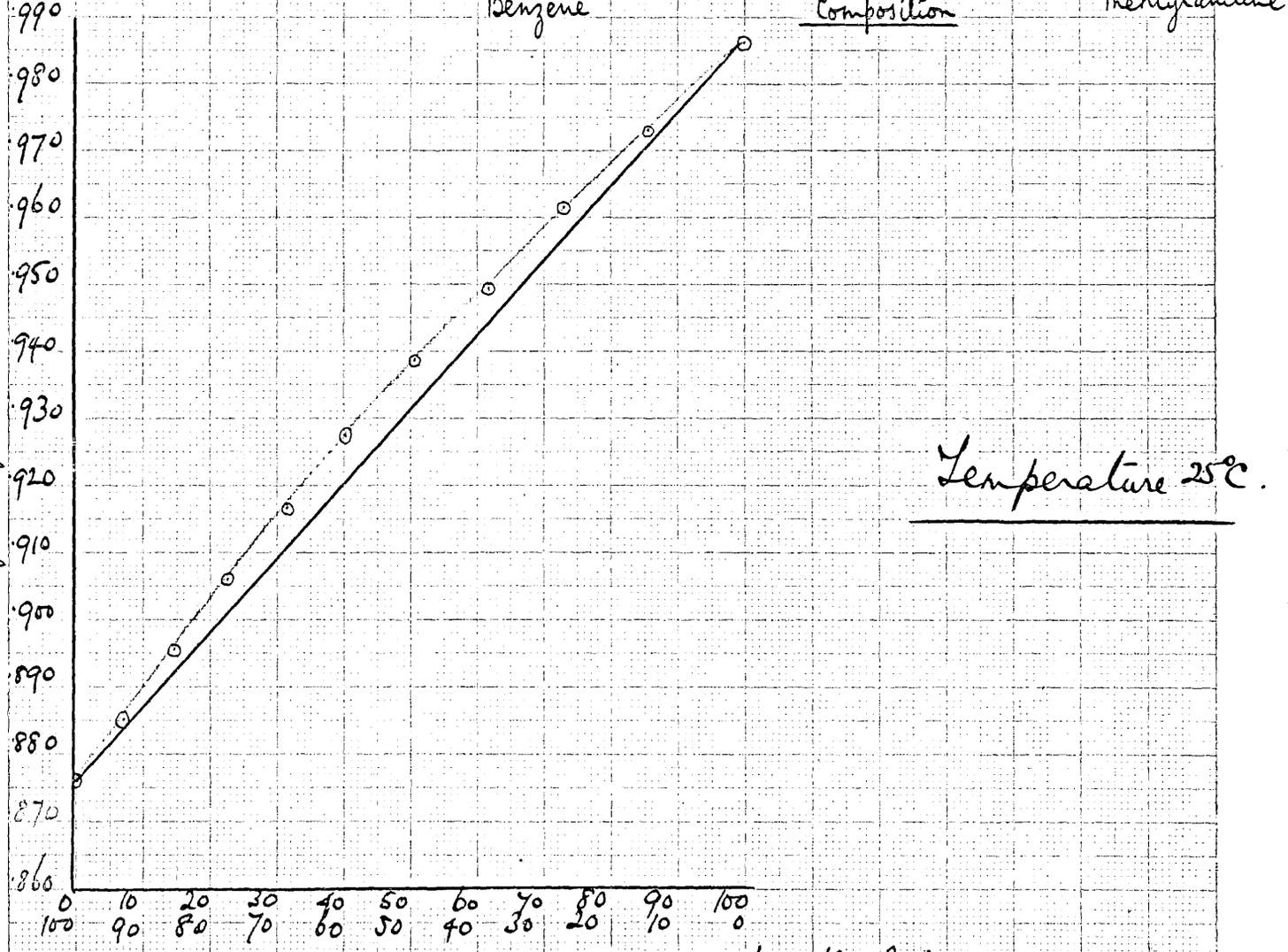
Mixture	Wt. of Benzene in gms.	Wt. of Methylaniline in gms	Comp. in moles % Benzene	Methylaniline
A	5.3298	43.8858	14.28	85.72
B	10.4918	39.1638	26.87	73.13
C	15.8108	34.0548	38.93	61.07
D	20.9677	29.6491	49.23	50.77
E	26.2830	24.4818	59.63	40.37
F	31.3632	19.6422	68.64	31.36
G	36.6540	14.6970	77.4	22.6
H	41.9646	9.8046	85.43	14.57
I	47.2575	4.9284	92.95	7.05

Specific Gravity

Benzene and Methylaniline

Deviation Curve.





Temperature 25°C.

Specific Gravity

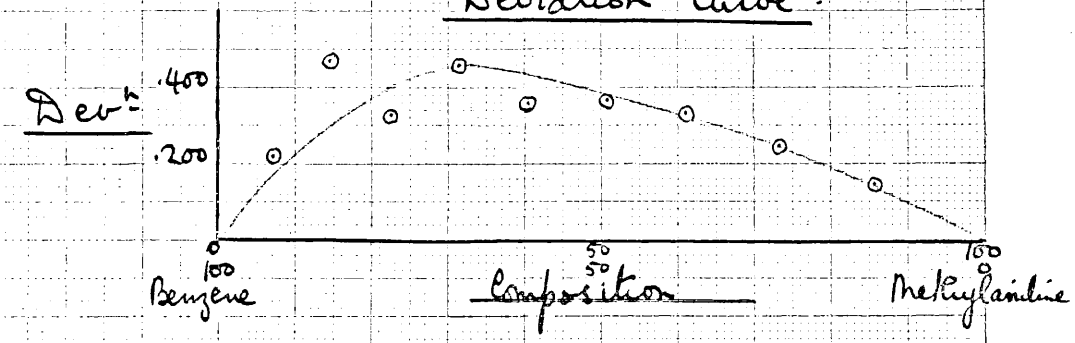
Mixture Benzene and Methylaniline

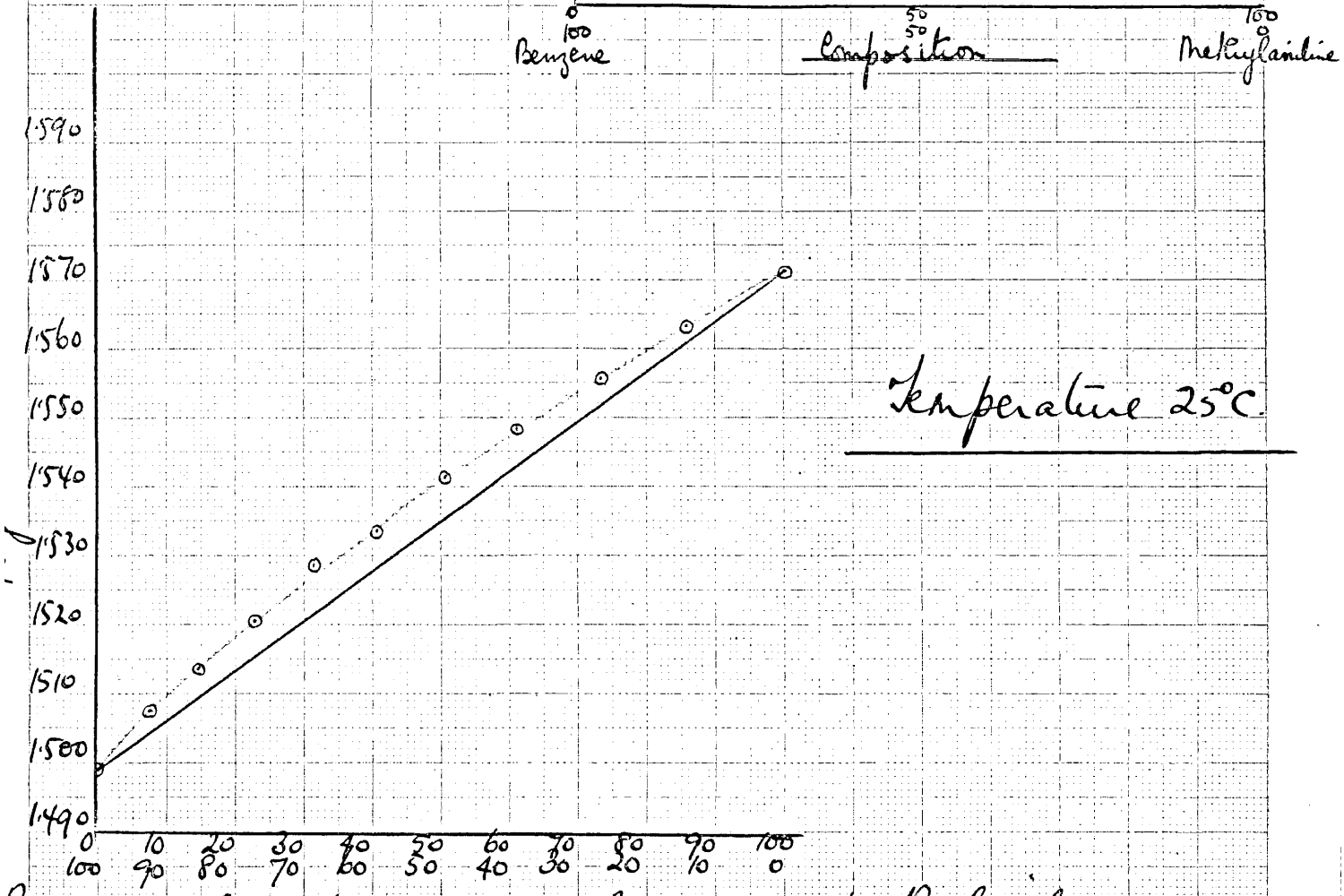
Substance	Wt. of Mixture in gms.	$^{25}d_{25}$ (expt)	$^{25}d_{25}$ (calcd)	% gm. mol. deviation from calcd.
Benzene	1.74256	.87615	-	-
I	1.7605	.88507	.88389	+.141
H	1.7815	.89562	.89215	+.388
G	1.8023	.9068	.90097	+.567
F	1.8233	.91664	.91060	+.663
E	1.8445	.92729	.92050	+.737
D	1.8673	.93876	.93193	+.732
C	1.8883	.94932	.94324	+.644
B	1.9125	.96148	.95649	+.521
A	1.9355	.97304	.97031	+.281
Methylaniline	1.9613	.98602	-	-

Refractive Index.

Benzene and Methylaniline

Deviation curve.





Temperature 25°C.

Refractive Index

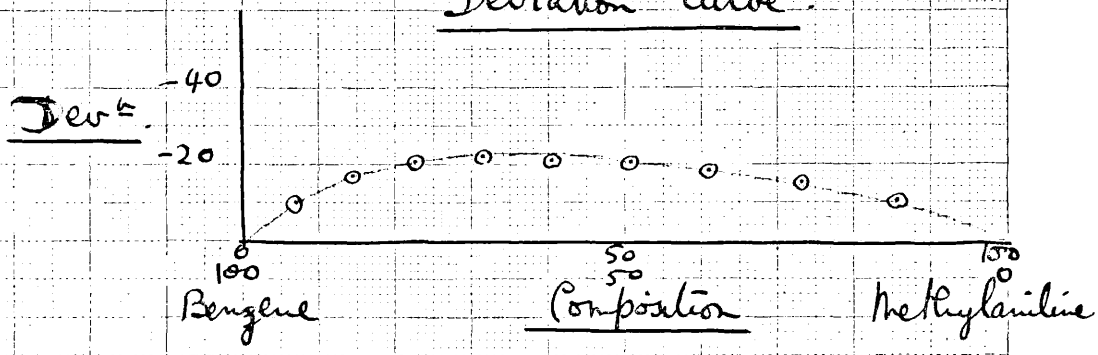
Mixture Benzene and Methylaniline

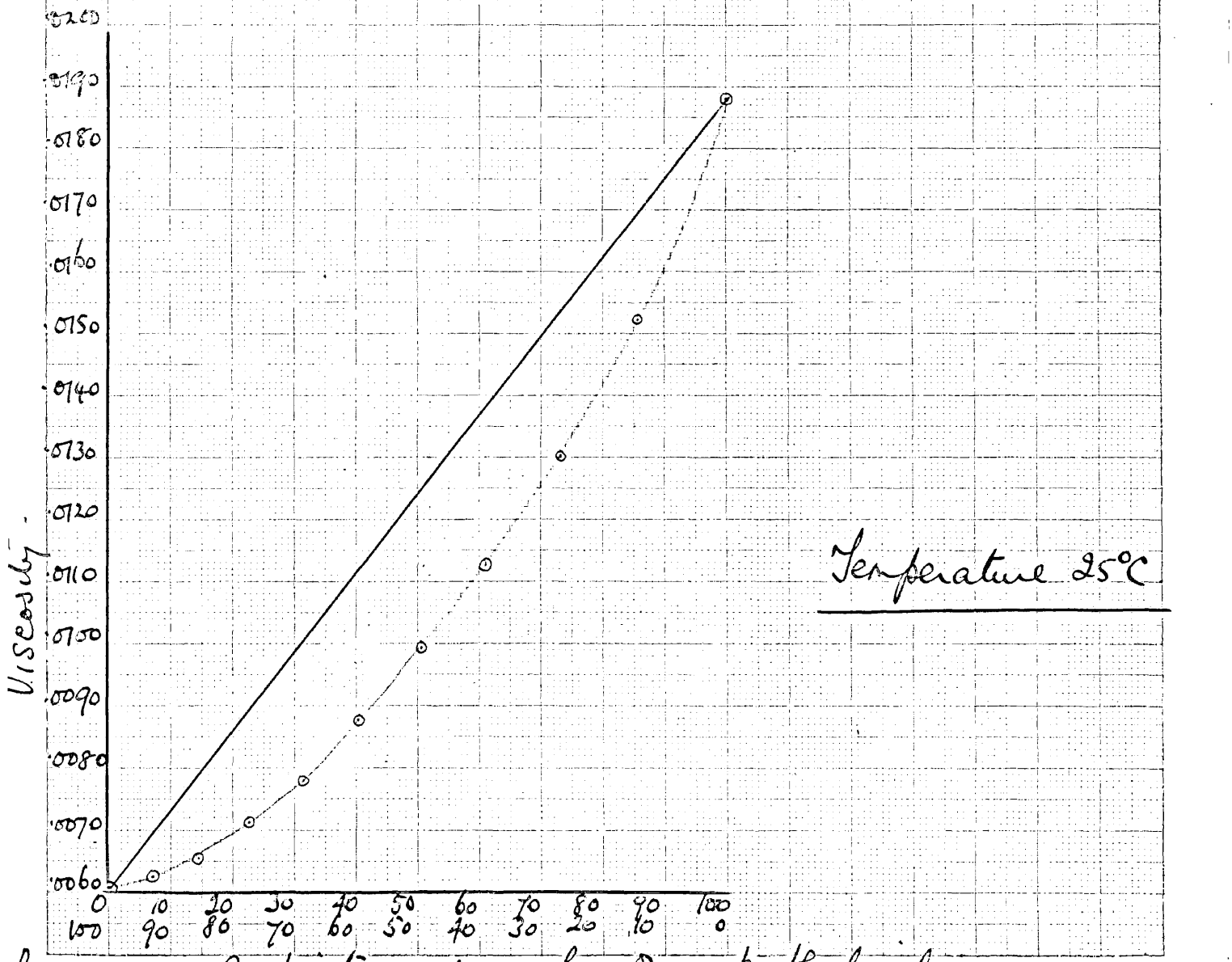
Substance	Angle of deviation	$n_{D_{25}}$ (expt)	$n_{D_{25}}$ (calcd)	%gm. mol. deviation from calcd.
Benzene	37°40'	1.499025	-	-
I	36°9.5'	1.507431	1.504114	.220
H	35°2.5'	1.513537	1.506400	.473
G	33°46.5'	1.520323	1.515340	.328
F	32°18.5'	1.528664	1.521665	.459
E	31°11.5'	1.533699	1.528168	.362
D	29°39.5'	1.541305	1.535677	.367
C	28°12.5'	1.548237	1.543114	.332
B	26°35.5'	1.555662	1.551820	.247
A	24°52.5'	1.563177	1.560910	.145
Methylaniline	22°55.5'	1.571222	-	-

Viscosity.

Benzene and Methylaniline

Deviation curve.





Temperature 25°C.

Viscosity

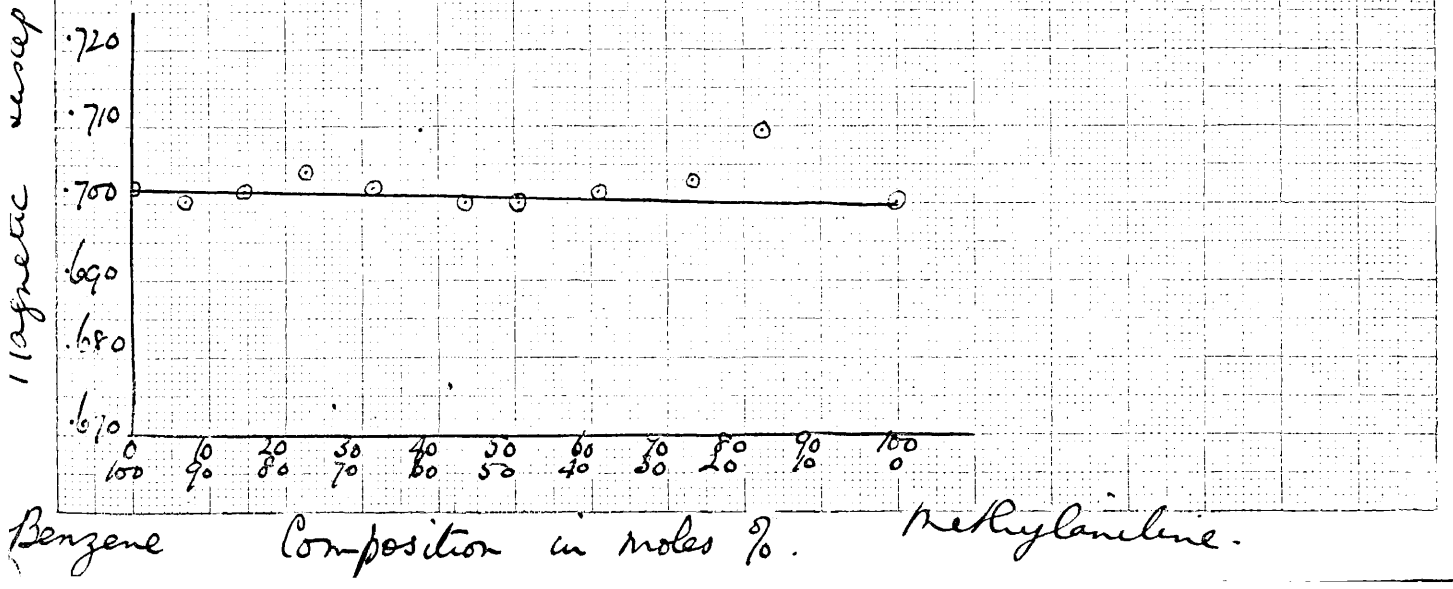
Mixture Benzene and Methylaniline

Substance	Time of flow for Water.	Time of flow for substance	Viscosity N25 (expt)	Viscosity N25 (calcd)	% gm.mol. deviation from calcd.
Benzene	1'25.2"	1' 6"	.006092	-	-
I	1'36.8"	1'13.6"	.006240	.006987	-10.63
H	1'36.8"	1'19"	.006537	.007943	-17.70
G	1'36.8"	1'25"	.007121	.008964	-20.57
F	1'36.8"	1'32.6"	.007807	.010077	-22.52
E	1'36.8"	1'49.8"	.008782	.011222	-21.56
D	1'36.8"	1'55.0"	.009934	.012544	-20.80
C	1.36.8"	2'8.8"	.011260	.013853	-18.71
B	1'36.8"	2'27.0"	.013010	.015385	-15.43
A	1'36.8"	2'49.8"	.015212	.016985	-10.44
Methylaniline	1'36.8"	3'27.2"	.018801	-	-

Magnetic Susceptibility

Benzene – Methylaniline.

Temperature 23°C.



Magnetic Susceptibility

Mixture Benzene and Methylaniline.

Pull on empty tube = 2 o mgms

Temperature = 23° - 25°C

Height of column of liquid = 7.5 cms

Volume of liquid = 3.512 ccs.

Substance	Mean pull mgms	Wt. of substance gms	Magnetic Susceptibility 10^6 X Expt.	calcd.	% deviation from calcd
Benzene	4.32	3.11760	.7021	-	
I	4.35	3.14869	.7001		
H	4.41	3.18830	.7014		
G	4.45	3.20610	.7040		
F	4.50	3.25400	.7019		
E	4.54	3.29332	.7000		
D	4.60	3.33873	.7000		
C	4.65	3.36900	.7017		
B	4.70	3.40005	.7030		
A	4.78	3.42900	.7094		
Methylaniline	4.81	3.49811	.7000		

Discussion of Results.

In taking a series of amines with Benzene it was thought that some light might be shed upon the nature of the changes taking place on mixing, and upon the electronic and magnetic relationships of the molecules.

In the following table (A) a list of results is given shewing the approximate composition of the mixtures with maximum deviation of the experimental values from the values as calculated by the additive law.

Table (B) shews the percentage deviation in each case for mixtures of this composition.

Table A.

Mixture	% gm. mol. composition of mixture with maximum deviation.				
	Density	Refractivity	Viscosity	Magnetic Susceptibility	Heat of mixing
Benzene and Aniline	about 45	60	30	40	45
Ethylaniline	44	44	65	—	
Diethylaniline	42.8	42.8	25	43	
Methylaniline	45	31.3	31.3	—	

Table B.

Mixture	Maximum % deviation of mixtures of composition given in previous table.				
Benzene and Aniline	—	+ .218	-38.15	+ 1.05	
Ethylaniline	+ .848	+ .318	-32.29	—	
Diethylaniline	+ .888	+ .412	-14.24	+ 1.26	
Methylaniline	+ .737	+ .459	-22.52	—	

Consideration of property-composition curves for each Mixture.

(1) Benzene and Aniline.

All curves indicate that association occurs to some extent between these two liquids on mixing. Density, Viscosity and Magnetic Susceptibility measurements give curves with mixtures of maximum deviation having the smaller proportion of benzene and therefore indicate some de-association of aniline.

The loss of symmetry of the curves is counteracted to some extent by the higher degree of association of the pure aniline over that of benzene.

The refractivity curve shews a maximum at about 60% benzene, suggesting de-association of this liquid, or it might be only apparent, due to the influence of the greater degree of association of aniline over that of benzene.

(2) Benzene and Ethylaniline.

Density and refractivity curves indicate the amount of association of benzene with ethylaniline to be more than with aniline. This is inferred by the increase of deviation.

In the case of viscosity the deviation decreases from aniline to ethylaniline; but here again it is indicated that association has taken place. The composition of the mixtures at maximum deviation intimates de-association of the ethylaniline by the addition of benzene.

(3) Benzene and Diethylaniline.

Density and refractivity results show another increase in association between benzene and diethylaniline over mixtures contining the two previous amines. But the viscosity curve indicates a decrease in association.

The magnetic susceptibility curve indicates an increase in association over that of benzene and aniline.

All the curves point to de-association of the diethylaniline.

(4) Benzene and Methylaniline.

Here the density curve seems to indicate a decrease in association from those of mono- and diethylaniline, aniline although it does not fall below that of aniline itself. This is opposed by the refractivity curve which shows an increase in association over all the other curves.

The visoosity curve indicates that the degree of association between benzene and methylaniline lies between mono- and diethylaniline.

The magnetic susceptibility curve does not seem to point to any association as the experimental values barely differ from the calculated ones.

Consideration of Tables (A and B) indicate that

(1) Every mixture shows atleast some departure from the additive mixture law, that is, none of the pans of liquid examined can be regarded as ideal.

(2) Deviation values for viscosity and magnetic susceptibility are much greater than those for density and refractivity.

(3) In the case of density the order of deviations in ascending magnitude is given by mixtures of benzene with aniline, methylaniline, monoethylaniline and diethylaniline respectively. For refractivity the order of deviations in ascending magnitude is given by aniline, ethylaniline, diethylaniline and methylaniline.

In the case of viscosity, the order is reversed, aniline and ethylaniline having high values followed by methylaniline, while diethylaniline has the lowest value.

(4) The position of maximum deviation is similar in practically all the curves, and lies nearer the benzene end of the series.

(5) On the whole the density and refractivity curves resemble one another, while viscosity and magnetic susceptibility curves appear distinct from these.

Conclusion.

(1) Association, to a small extent, takes place between benzene and either aniline, ethylaniline, diethylaniline or methylaniline on mixing. De-association of the amines is occasioned by the addition of benzene.

(2) It is highly probable that magnetic susceptibility measurements will yield valuable results indicating the changes which occur on mixing 2 liquids.