CLXXXII.—*The Relation Between Residual Affinity and Chemical Constitution. Part IV. Some Open-Chain Compounds.*

By HANS THACHER CLARKE (1851 Exhibition Scholar).

IN 1891 Bischoff, to account for certain problems of steric hindrance, put forward his "Dynamic Hypothesis" (*Ber.*, **24**, 1087), in which he embodied the idea that atoms situated in the 1:5- or 1:6-positions—or, as he termed them, *critical positions*—in carbon chains lie near to each other in space, thereby surmising that carbon chains tend to assume a cyclic form. In accordance with this theory, it would appear not unlikely that atoms endowed with residual affinity might, when situated in the critical positions, exert a more marked mutual influence than when in any other position.

This hypothesis, adumbrated by Bredig (*Zeitsch. physikal. Chem.*, 1894, **13**, 310) as a result of a study of the dissociation constants of salts of aliphatic diamines, $\text{NH}_2\cdot[\text{CH}_2]_n\cdot\text{NH}_2$, has been brought forward by Hilditch (T., 1909, **95**, 1578; *Zeitsch. physikal. Chem.*, 1911, **77**, 482) to account for the anomalous rotatory power of some optically active esters and salts of certain dicarboxylic acids; and an attempt to obtain viscometric evidence bearing on the same point has recently been described by Dunstan, Hilditch, and Thole (this vol., p. 133). This hypothesis is thus based exclusively on physical phenomena.

In an attempt to study the question from a strictly chemical point of view, the author has examined the reactive capacity of two series of compounds in which the necessary conditions are present, namely, $\text{NMe}_2\cdot[\text{CH}_2]_n\cdot\text{NMe}_2$, where two unsaturated atoms of the same element, and $\text{MeO}\cdot[\text{CH}_2]_n\cdot\text{NMe}_2$, where two unsaturated atoms of different elements are separated from each other by varying numbers of methylene groups. To serve as standards of reference, by means of which it was hoped to eliminate possible differences ascribable to change in molecular weight and steric influences, the two series, $\text{CHMe}_2\cdot[\text{CH}_2]_n\cdot\text{NMe}_2$ (comparable with $\text{NMe}_2\cdot[\text{CH}_2]_n\cdot\text{NMe}_2$) and $\text{Et}\cdot[\text{CH}_2]_n\cdot\text{NMe}_2$ (comparable with $\text{MeO}\cdot[\text{CH}_2]_n\cdot\text{NMe}_2$), have been examined under precisely the same conditions.

The method of determining the reactive capacity was essentially the same as in the previous work (T., 1910, **97**, 416; 1911, **99**, 1927; 1912, **101**, 1788); for the sake of convenience, the reactions were carried out at 0° , the solutions (1/4-molar) being standardised

at this temperature. In every case—with the diamines as well as with the monoamines—values agreeing well with the bimolecular formula were obtained; from this it must be concluded that in the ditertiary amines only one of the nitrogen atoms takes part in the reaction at the outset:

The results are therefore strictly comparable.

The refractive and dispersive power of the two crucial series of substances were also determined, but, as in the case of the cyclic compounds above quoted, no decisive regularity of anomaly was found, approximately normal values being observed in all the cases.

The numerical values obtained are set forth in the following tables:

TABLE I.

Reaction-velocity Constants, $10^3 \cdot K$.

<i>n</i> .	$\text{Et} \cdot [\text{CH}_2]_n \cdot \text{NMe}_2$.	$\text{Pr}^i \cdot [\text{CH}_2]_n \cdot \text{NMe}_2$.	$\text{NMe}_2 \cdot [\text{CH}_2]_n \cdot \text{NMe}_2$.	$\text{MeO} \cdot [\text{CH}_2]_n \cdot \text{NMe}_2$.
2	11.4	9.7	9.5	6.7
3	10.7	9.9	16.8	9.3
4	10.3	10.6	24.9	10.6
5	11.2	10.6	20.8	10.5
6	10.9	—	24.5	11.5
7	—	—	27.5	—

TABLE II.

Optical Constants, M and $M_\gamma - M_\alpha$.

<i>n</i> .	$\text{NMe}_2 \cdot [\text{CH}_2]_n \cdot \text{NMe}_2$.		$\text{MeO} \cdot [\text{CH}_2]_n \cdot \text{NMe}_2$.	
	M_α .	$M_\gamma - M_\alpha$.	M_α .	$M_\gamma - M_\alpha$.
2	37.39	1.185	30.71	0.974
3	42.12	1.279	35.86	0.766
4	46.40	1.382	39.87	1.186
5	51.07	1.407	44.63	1.215
6	55.84	1.618	49.32	1.685
7	60.03	1.720	—	—

From table I it will be seen that the reactive power of the normal ($\text{Et} \cdot [\text{CH}_2]_n \cdot \text{NMe}_2$) series remains fairly constant, barely altering with increase of length of chain; in the *iso*-series ($\text{Pr}^i \cdot [\text{CH}_2]_n \cdot \text{NMe}_2$) the values increase very slightly indeed, approaching the same value as shown by the normal compounds. It may therefore be concluded that no allowances for influences due to steric considerations and alterations in molecular weight need be made in the two principal series.

A clear idea of the relative reactivities can be formed by exam-

ination of the graphic representation (Fig. 1). In the monoamines, progression along the normal homologous series from dimethyl-*n*-butylamine to dimethyl-*n*-octylamine has negligible effect on reactive capacity. This is in harmony with the recent work of Segaller (this vol., p. 1154) on alkyl iodides. The same is observed in the *iso*-compounds; the members of this series are, on the average, slightly less reactive than the corresponding normal compounds.

In the series of ditertiary diamines, $(\text{NMe}_2 \cdot [\text{CH}_2]_n \cdot \text{NMe}_2)$, the only member displaying reactivity approximating to those of the

FIG. 1.

standards of reference is the first, which contains two methylene groups. The succeeding members tend to increase in reactivity with increasing numbers of methylene groups in the chain. The same, in a less degree, is the case in the series of methoxylated tertiary amines, $\text{MeO} \cdot [\text{CH}_2]_n \cdot \text{NMe}_2$, which are considerably less reactive than the monoamines in the first members, but become more reactive on ascending the series.

Now if it be assumed that the reactivities of members of both of these series should increase regularly with increasing length of chain, then the points representing these hypothetical reaction-velocity constants would lie near to the straight dotted lines shown

in Fig. 2, as do, in fact, those of the derivatives of pentane and hexane.

Notable exaltation of reactive capacity is exhibited by tetramethyltrimethylenediamine and tetramethyltetramethylenediamine, also by methyl γ -dimethylaminopropyl ether and methyl δ -dimethylaminobutyl ether, all of which are compounds in which the "unsaturated" atoms are relatively in the 1:5- and 1:6-positions respectively. The disposal of such atoms in the critical positions is thus seen, in both cases, to coincide with exalted reactive power.

No reason is at once apparent why the reactivities of the members

FIG. 2.

of both of these series should tend to increase with increasing length of chain, in contrast to those of the simpler normal and *iso*-tertiary amines.

EXPERIMENTAL.

Reaction-velocity Measurements.

The standard conditions, under which all the substances examined were treated in the reactivity determinations, were as follows: Equal volumes of quarter-molar absolute-alcoholic solutions of the base and of ethyl bromoacetate respectively were prepared at 0° , and mixed and maintained at that temperature. Successive portions were withdrawn at intervals, and the amount of ionisable bromine present was immediately determined by titration with $N/20$ -silver nitrate (Volhard's method). The resulting figures—with

AFFINITY AND CHEMICAL CONSTITUTION. PART IV. 1693

the diamines as well as with the monoamines—were found to correspond with those of a bimolecular reaction:

$$K = \frac{1}{C_0 t} \cdot \frac{x}{a - x},$$

where C_0 represents the initial concentration of the reacting substances (1/8-molar), t the number of minutes elapsed when the determination is made, x the percentage of bromine which has been converted from non-ionisable to ionisable form, and a the initial percentage of the bromine existing in non-ionisable form (100). For the sake of convenience, the resulting velocity-constant (K) is multiplied by one thousand.

Dimethylbutylamine.

t	10	20	32	45	60	75	80	88	95	105
x	1.6	2.8	4.4	6.0	8.0	9.2	9.6	10.8	12.0	13.2
$10^3 K$...	13.0	11.5	11.5	11.4	11.6	10.8	10.6	11.0	11.5	11.6

Mean value of $10^3 K = 11.4$.

Dimethylamine.

t	27	39	51	61	73	84	96	107	119	131
x	3.6	4.8	6.4	7.6	8.8	10.0	11.2	12.8	13.6	14.8
$10^3 K$...	11.1	10.4	10.7	10.8	10.6	10.6	10.5	11.0	10.6	10.6

Mean value of $10^3 K = 10.7$.

Dimethylhexylamine.

t	21	32	43	54	66	76	88	100	112	124
x	2.4	4.0	5.6	6.4	8.0	8.8	10.8	11.6	12.4	13.2
$10^3 K$...	9.4	10.4	11.0	10.1	10.5	10.2	11.0	10.5	10.1	9.8

Mean value of $10^3 K = 10.3$.

Dimethylheptylamine.

t	20	34	50	65	80	95	110	125	140	155
x	2.8	4.8	6.8	8.4	9.6	11.6	13.2	14.4	16.0	17.6
$10^3 K$...	11.5	11.9	11.7	11.3	10.6	11.0	11.1	10.6	10.9	11.0

Mean value of $10^3 K = 11.2$.

Dimethyloctylamine.

t	15	30	46	60	75	90	105	120	136	150
x	2.0	4.0	6.0	7.6	9.6	10.8	12.0	14.0	15.2	17.2
$10^3 K$	10.9	11.1	11.1	11.0	11.3	10.8	10.4	10.9	10.6	11.1

Mean value of $10^3 K = 10.9$.

Dimethylisoamylamine.

t	15	30	45	60	75	90	105	120	135
x	1.8	3.6	5.2	6.8	8.4	10.0	11.2	12.4	14.0
$10^3 K$	9.8	10.0	9.8	9.7	9.8	9.9	9.6	9.4	9.7

Mean value of $10^3 K = 9.7$.

Dimethylisohexylamine.

t	22	50	71	90	110	125	143	155	170	190
x	3.2	6.0	8.4	10.4	12.4	13.6	14.8	16.0	17.2	18.8
10^3K	10.5	9.5	10.3	9.9	9.9	10.1	9.7	9.8	9.8	9.8

Mean value of $10^3K = 9.9$.*Dimethylisooheptylamine.*

t	24	45	67	90	105	120	137	151	165	190
x	3.2	6.0	8.4	10.4	12.4	13.6	14.8	16.8	17.6	19.6
10^3K	11.0	11.3	11.0	10.3	10.8	10.5	10.2	10.7	10.4	10.3

Mean value of $10^3K = 10.6$.*Dimethylisooctylamine.*

t	26	45	65	90	105	120	135	150	165	190
x	3.2	5.6	8.4	10.8	12.0	13.6	15.2	16.8	18.0	20.0
10^3K ...	10.2	10.5	11.3	10.8	10.4	10.5	10.6	10.8	10.6	10.5

Mean value of $10^3K = 10.6$.*Tetramethylethylenediamine.*

t	20	40	60	80	100	120	140	160	180	200
x	2.4	4.4	6.4	8.8	10.8	12.8	14.4	16.0	17.6	18.8
10^3K ...	9.8	9.2	9.1	9.7	9.7	9.8	9.6	9.5	9.5	9.3

Mean value of $10^3K = 9.5$.*Tetramethyltrimethylenediamine.*

t	15	30	45	60	105	120	140	160	180
x	3.0	6.0	8.4	11.6	17.6	20.0	22.8	25.2	27.6
10^3K ...	16.5	17.0	16.3	17.5	16.3	16.7	16.9	16.9	17.0

Mean value of $10^3K = 16.8$.*Tetramethyltetramethylenediamine.*

.....	20	35	45	55	65	75	85	95	105	120
x	6.0	10.0	12.0	14.8	16.8	18.8	20.8	22.8	24.4	27.2
10^3K ...	25.5	25.4	24.3	25.3	24.9	24.7	24.7	24.9	24.3	24.9

Mean value of $10^3K = 24.9$.*Tetramethylpentamethylenediamine.*

.....	15	35	50	60	70	80	90	100	110	120
x	3.8	8.4	11.2	13.2	15.6	17.2	18.8	20.8	22.4	24.0
10^3K ...	21.1	21.0	20.2	20.3	21.1	20.8	20.6	21.0	21.0	21.0

Mean value of $10^3K = 20.8$.*Tetramethylhexamethylenediamine.*

.....	15	30	40	50	60	67	75	84	95	110
x	4.4	8.4	10.8	13.2	15.6	17.2	18.8	20.4	22.8	25.2
10^3K ...	24.5	24.5	24.2	24.3	24.6	24.8	24.7	24.4	24.9	24.5

Mean value of $10^3K = 24.5$.

AFFINITY AND CHEMICAL CONSTITUTION. PART IV. 1695

Tetramethylheptamethylenediamine.

<i>t</i>	16	27	36	45	60	75	89	105	122	135
<i>x</i>	5.2	8.4	11.2	13.6	17.2	20.0	23.2	26.8	29.2	32.0
10^3K ...	27.4	27.2	28.1	28.0	27.7	26.7	27.2	27.9	27.1	27.9

Mean value of 10^3K = 27.5.*Methyl β -Dimethylaminoethyl Ether.*

<i>t</i>	20	40	60	80	95	110	125	140	155	170
<i>x</i>	1.6	3.2	4.8	6.4	7.6	8.4	9.2	10.4	11.6	12.8
10^3K ...	6.5	6.6	6.7	6.8	6.9	6.7	6.5	6.6	6.8	6.9

Mean value of 10^3K = 6.7.*Methyl γ -Dimethylaminopropyl Ether.*

<i>t</i>	15	35	55	75	95	115	135	155	180	200
<i>x</i>	1.6	4.0	6.0	8.0	10.0	12.0	13.8	15.6	17.2	19.3
10^3K ...	8.7	9.5	9.3	9.3	9.4	9.5	9.5	9.5	9.2	9.6

Mean value of 10^3K = 9.3.*Methyl δ -Dimethylaminobutyl Ether.*

<i>t</i>	24	43	58	73	86	105	120	135	150	170
<i>x</i>	3.2	5.6	7.2	8.8	10.0	12.0	13.6	15.2	16.4	18.0
10^3K ...	11.0	11.0	10.7	10.6	10.3	10.4	10.7	10.6	10.5	10.3

Mean value of 10^3K = 10.6.*Methyl ϵ -Dimethylaminoamyl Ether.*

<i>t</i>	15	26	37	48	60	71	82	95	106	120
<i>x</i>	2.0	3.2	4.8	6.0	7.2	8.4	9.6	11.2	12.4	13.6
10^3K ...	11.0	10.2	10.9	10.0	10.4	10.3	10.4	10.6	10.8	10.5

Mean value of 10^3K = 10.5.*Methyl ζ -Dimethylaminohexyl Ether.*

<i>t</i>	19	41	63	80	105	136	156	177	202	229
<i>x</i>	2.8	5.6	8.4	10.0	12.8	16.4	18.0	20.4	22.8	24.4
10^3K ...	12.1	11.6	11.7	11.1	11.2	11.5	11.2	11.6	11.7	11.3

Mean value of 10^3K = 11.5.*Preparation of Compounds.*

The dimethylamino-compounds above enumerated were prepared by two general methods: first, by the interaction of the corresponding halogen compound and dimethylamine; secondly, by methylation of the corresponding primary amines. This second general method may be subdivided into two separate methods: (a) methylation by heating the hydrochloride of the primary amine with formaldehyde; (b) complete methylation to the quaternary ammonium iodide by means of methyl iodide in presence of alkali,

conversion of this into the sulphide, and decomposition of the sulphide by heat.

The first of these subsidiary methods has been described by Plöchl (*Ber.*, 1888, **21**, 2117), Koeppen (*Ber.*, 1905, **38**, 882), and others for the methylation of ammonia and simple monoamines. The advantage of this method lies in the fact that the end-product consists of the hydrochloride of the pure tertiary amine, unmixed with primary, secondary, or quaternary ammonium salts. The author has found it to work fairly satisfactorily for the methylation of primary monoamines, although in every case some decomposition—resulting in the formation of trimethylamine—took place. Eschweiler, in 1893, took out a patent (D.R.-P. 80520) claiming the methylation by this method of diamines, apparently basing his claim on the formation of dimethylpiperazine from piperazine, but the present author was unable to obtain satisfactory results in attempting to apply the process to the methylation of tetra-, hexa-, and hepta-methylenediamines; in every case the principal products were trimethylamine, non-volatile bases of apparently high molecular weight, and incompletely methylated substances.

In the second subsidiary method the procedure consisted in converting the quaternary trimethylammonium haloid, $R \cdot NMe_3Cl$, into the hydroxide by shaking its aqueous solution with excess of freshly-precipitated silver oxide, and thereupon saturating this solution, after filtering, with hydrogen sulphide and distilling it under atmospheric or diminished pressure. At a temperature between 200° and 230° the quaternary ammonium sulphide decomposes according to the equation $(R \cdot NMe_3)_2S = 2R \cdot NMe_2 + Me_2S$.

So far as the author is aware, this method, which furnishes excellent yields, has hitherto never been employed. The advantage in decomposing the sulphide in preference to the chloride is exemplified by the case of tetramethyltetramethylenediamine; Willstätter and Heubner (*Ber.*, 1907, **40**, 3869) endeavoured to prepare this base by distillation of the quaternary chloride,

but obtained only trimethylamine and methylpyrrolidine.

Decomposition of the corresponding sulphide, however, led to an excellent yield of the required ditertiary diamine.

In the following account all temperatures, unless otherwise stated, are uncorrected.

Dimethylbutylamine, $Et \cdot [CH_2]_2 \cdot NMe_2$.—From *n*-butyl iodide (1 mol.) and alcoholic dimethylamine (2 mols.), heated in a sealed

tube on the water-bath for four hours. The contents of the tube were distilled with dilute aqueous alkali, the distillate neutralised with hydrochloric acid and evaporated to dryness, the residue distilled with concentrated alkali, and the free base separated from the distillate by saturation with solid potassium hydroxide. After drying by boiling with solid potassium hydroxide and subsequently with sodium, the product boiled constantly at $95^{\circ}/761$ mm. It forms a colourless liquid of strongly basic properties and powerful odour, and is miscible with water in all proportions:

0.1242 gave 0.3232 CO_2 and 0.1692 H_2O . $\text{C}=71.0$; $\text{H}=15.1$.

$\text{C}_6\text{H}_{15}\text{N}$ requires $\text{C}=71.3$; $\text{H}=14.8$ per cent.

The *picrate* melted at 96° .

Dimethylamine, $\text{Et} \cdot [\text{CH}_2]_3 \cdot \text{NMe}_2$.—The pure hydrochloride of *n*-amylamine (prepared by reduction of synthetic *n*-valeronitrile) was heated with an excess (about six times the weight) of formalin (40 per cent. aqueous formaldehyde) in a sealed tube for five hours at 125° . The contents of the tube were evaporated to dryness after adding a few drops of dilute hydrochloric acid, and the residue distilled with concentrated alkali. The presence of a small quantity of a gaseous base—in all probability trimethylamine—was observed. The product was worked up as described above for dimethylaminobutane. It is a colourless liquid of strongly basic properties, boiling at $122\text{--}123^{\circ}/755$ mm. It is soluble in water, but not miscible in all proportions:

0.1237 gave 0.3303 CO_2 and 0.1664 H_2O . $\text{C}=72.8$; $\text{H}=15.0$.

$\text{C}_7\text{H}_{17}\text{N}$ requires $\text{C}=73.0$; $\text{H}=14.8$ per cent.

The *picrate* melted at 101° .

Dimethylhexylamine, $\text{Et} \cdot [\text{CH}_2]_4 \cdot \text{NMe}_2$.—The pure hydrochloride of *n*-hexylamine, prepared according to the directions of Frentzel (*Ber.*, 1883, **16**, 744) from the amide of *n*-heptic acid, was treated as above. The product, a colourless liquid of similar properties, but less powerfully ammoniacal odour to the foregoing, boiled at $146\text{--}147^{\circ}/766$ mm. Another sample, prepared by methylating the hexylamine with methyl iodide and alkali, converting the quaternary ammonium iodide into the sulphide, and decomposing by heat (compare tetramethyltetramethylenediamine, below), possessed identical properties:

0.1276 gave 0.3470 CO_2 and 0.1740 H_2O . $\text{C}=74.2$; $\text{H}=15.1$.

$\text{C}_8\text{H}_{19}\text{N}$ requires $\text{C}=74.4$; $\text{H}=14.7$ per cent.

The *picrate* melted at 100° .

Dimethylheptylamine, $\text{Et} \cdot [\text{CH}_2]_5 \cdot \text{NMe}_2$.—Prepared from *n*-heptyl bromide (1 mol.) and alcoholic dimethylamine (2 mols.), heated in a sealed tube on the water-bath for ten hours. It is a colourless

liquid, resembling the foregoing in general properties. It boils at $170^{\circ}/766$ mm. (corr.):

0.1297 gave 0.3579 CO_2 and 0.1721 H_2O . $\text{C}=75.3$; $\text{H}=14.8$.

$\text{C}_9\text{H}_{21}\text{N}$ requires $\text{C}=75.5$; $\text{H}=14.7$ per cent.

The *picrate* melted at 75° .

Dimethyloctylamine,* $\text{Et}\cdot[\text{CH}_2]_6\cdot\text{NMe}_2$.—Prepared from *n*-octyl iodide (1 mol.) and alcoholic dimethylamine (2 mols.), heated in a sealed tube on the water-bath for six hours. It is a colourless liquid, possessing a faint odour, almost insoluble in water. It boils at $191^{\circ}/760$ mm.:

0.1292 gave 0.3615 CO_2 and 0.1734 H_2O . $\text{C}=76.3$; $\text{H}=14.9$.

$\text{C}_{10}\text{H}_{23}\text{N}$ requires $\text{C}=76.4$; $\text{H}=14.7$ per cent.

The *picrate* melted at 72° .

Series $\text{CHMe}_2\cdot[\text{CH}_2]_n\cdot\text{NMe}_2$.

Dimethylisoamylamine, $\text{Pr}^{\beta}\cdot[\text{CH}_2]_2\cdot\text{NMe}_2$.—From *isoamyl* iodide (1 mol.) and alcoholic dimethylamine (2 mols.). It boiled at 113 — $114^{\circ}/770$ mm., agreeing with the observation of Collie and Schryver (T., 1890, 57, 774).

The *picrate* melted at 132° .

Dimethylisohexylamine, $\text{Pr}^{\beta}\cdot[\text{CH}_2]_3\cdot\text{NMe}_2$.—Prepared by reduction with sodium and alcohol of *isoamyl* cyanide, and methylating the resulting *isohexylamine* by means of formaldehyde (see above). The tertiary base is a colourless liquid, which is not miscible in all proportions with water, and boils at 139 — $140^{\circ}/766$ mm.:

0.1319 gave 0.3583 CO_2 and 0.1777 H_2O . $\text{C}=74.1$; $\text{H}=15.0$.

$\text{C}_8\text{H}_{19}\text{N}$ requires $\text{C}=74.4$; $\text{H}=14.7$ per cent.

The *picrate* melted at 132° .

Dimethylisohexylamine, $\text{Pr}^{\beta}\cdot[\text{CH}_2]_4\cdot\text{NMe}_2$.—*isoAmyl*acetic acid was converted into the amide by Aschan's method (Ber., 1898, 31, 2344), and this was converted into the nitrile, boiling at 178 — 180° , by distillation under diminished pressure with twice its weight of phosphoric oxide. The nitrile was reduced by means of sodium and alcohol, yielding *isohexylamine*, boiling at 146 — 147° , which was methylated by the formaldehyde method. The tertiary base was isolated as a colourless liquid, sparingly soluble in water, boiling at $162^{\circ}/765$ mm.:

0.1096 gave 0.3026 CO_2 and 0.1462 H_2O . $\text{C}=75.3$; $\text{H}=14.8$.

$\text{C}_9\text{H}_{21}\text{N}$ requires $\text{C}=75.5$, $\text{H}=14.7$ per cent.

* The dihydrodimethylconiine, boiling at 184 — 186° , described by Mugdan (Annalen, 1897, 298, 144) and shown by him to consist of a mixture of two bases, is erroneously quoted in Richter's *Lexikon der Kohlenstoff Verbindungen* (1911, 3rd Edition, II., 1528) as dimethyloctylamine.

The *picrate* melted at 86° .

Dimethylisooctylamine, $\text{PrB} \cdot [\text{CH}_2]_5 \cdot \text{NMe}_2$.—*iso*Hexylamine, prepared by reduction of *iso*amyl cyanide, was converted by the Schotten-Baumann method into the *benzoyl* derivative, a colourless, odourless liquid, insoluble in water, boiling at $198^{\circ}/13$ mm. This was distilled with an equimolecular quantity of phosphorus pentachloride, the distillate was treated firstly with water, to remove the phosphoryl chloride, and then with concentrated sulphuric acid, to remove the benzonitrile. After washing with dilute alkali and with water, the portion insoluble in sulphuric acid was dried and distilled. The resulting α -chloro*isohexane* (*isohexyl chloride*), which boiled in its entirety at $125\text{--}126^{\circ}/761$ mm., was shaken with a concentrated alcoholic solution of slightly more than the necessary quantity of ethyl sodiomalonate in a sealed tube in steam for four hours. From the resulting ester *isoeptanecarboxylic acid*, boiling at about 230° , was obtained in the usual manner. This was converted by Aschan's method into the amide, which was dehydrated by distillation under diminished pressure with phosphoric oxide, yielding *isoeptonitrile*, boiling at 194° . This was reduced by sodium and alcohol, yielding *isooctylamine*, boiling at $167\text{--}168^{\circ}$, which was methylated by the formaldehyde method, yielding *dimethylisooctylamine*, a colourless liquid, sparingly soluble in water, boiling at $183\text{--}184^{\circ}/767$ mm.:

0.1086 gave 0.3028 CO_2 and 0.1458 H_2O . $\text{C} = 76.0$; $\text{H} = 14.9$.

$\text{C}_{10}\text{H}_{23}\text{N}$ requires $\text{C} = 76.4$; $\text{H} = 14.7$ per cent.

In this way about 4 grams of the required tertiary base were obtained in a pure state from 20 grams of *iso*amyl cyanide; the chief losses of material occurred during the conversion of the benzoylamino-compound into the corresponding chloride, and in the interaction of this with ethyl sodiomalonate. Otherwise, good yields were obtained at all the stages.

The *picrate* melted at 69° .

Series $\text{NMe}_2 \cdot [\text{CH}_2]_n \cdot \text{NMe}_2$.

Tetramethylethylenediamine, $\text{NMe}_2 \cdot [\text{CH}_2]_2 \cdot \text{NMe}_2$.—See Clarke (T., 1912, 101, 1807).

Tetramethyltrimethylenediamine, $\text{NMe}_2 \cdot [\text{CH}_2]_3 \cdot \text{NMe}_2$.—Prepared by heating trimethylene bromide (1 mol.) with alcoholic dimethylamine (4 mols.) in a sealed tube on the water-bath for sixteen hours. The base, after drying by boiling first with solid potassium hydroxide and then with metallic sodium, boiled constantly at $144^{\circ}/760$ mm. Knorr and Roth (*Ber.*, 1906, 39, 1428) give the

boiling point as 143—147°/755 mm. The following constants were determined:

$$D_4^{18.7^\circ} 0.7837, n_d^{18.7^\circ} 1.4215, n_y^{18.7^\circ} 1.4362.$$

The picrate melted with slight decomposition at 207° (K. and R. give 205°); the platinichloride melted and decomposed at 249° (K. and R. give 246—247°).

Tetramethyltetramethylenediamine, $\text{NMe}_2 \cdot [\text{CH}_2]_4 \cdot \text{NMe}_2$.

Tetramethylenediamine (the author desires to express his gratitude to Dr. N. Hess for the gift of a quantity of the hydrochloride of this costly base) was completely methylated by means of methyl iodide and alcoholic potassium hydroxide, according to the directions of Willstätter and Heubner (*Ber.*, 1907, **40**, 3869), and the quaternary iodide converted by means of silver chloride into the chloride, which was isolated in a pure condition. This was shaken, in dilute aqueous solution, with an excess of freshly precipitated silver oxide, the mixture filtered, and the filtrate saturated with hydrogen sulphide. This solution of the quaternary ammonium hydrosulphide was then distilled. Hydrogen sulphide was at first evolved, leaving the sulphide of the quaternary base in solution. On continuing to distil, all the water passed over without any basic co-distillate. On continuing to heat the syrupy residue, decomposition set in at about 220°, and tetramethyltetramethylenediamine and methyl sulphide passed over. It was found convenient to distil in a slow current of purified coal-gas, which was allowed to burn as it issued from the apparatus; in this way the uncondensed methyl sulphide was at once destroyed. The distillate was acidified with dilute hydrochloric acid, boiled until odourless, and the base worked up in the usual way. Its properties agreed well with those described by Willstätter and Heubner (*loc. cit.*) for the naturally-occurring substance:

	Base; b. p.	Picrate; m. p.	Platinichloride; m. p.
Natural (W. & H.)	169° (corr.)	198° (corr.)	234° (decomp.)
Synthetic	168°/762 (uncorr.)	197° (uncorr.)	238—239° (decomp.)

The following constants were determined:

$$D_4^{18.9^\circ} 0.8041, n_d^{18.9^\circ} 1.4316, n_y^{18.9^\circ} 1.4463.$$

An attempt to methylate tetramethylenediamine by heating the hydrochloride with excess of formaldehyde for five hours at 125° led to the formation of much trimethylamine, much basic oil which was not volatile with steam, and a small quantity of a liquid boiling at 162°, which on treatment with benzoyl chloride and alkali yielded an oil insoluble in water. This method was thus of no service.

Tetramethylpentamethylenediamine, $\text{NMe}_2 \cdot [\text{CH}_2]_5 \cdot \text{NMe}_2$.

$\alpha\epsilon$ -Dichloropentane (1 mol.) and alcoholic trimethylamine (2 mols.) were heated in a sealed tube on the water-bath for nineteen hours. The contents of the tube were evaporated to dryness, leaving a hygroscopic, crystalline residue resembling the dichloride of hexamethyltetramethylenediamine. This was converted into the sulphide, and decomposed as described for the foregoing. The ditertiary base is a colourless, strongly basic liquid, miscible in all proportions with water, boiling at $190\text{--}191^\circ/766$ mm.:

0.1636 gave 0.4077 CO_2 and 0.2077 H_2O . $\text{C}=68.0$; $\text{H}=14.1$.

$\text{C}_9\text{H}_{22}\text{N}_2$ requires $\text{C}=68.4$; $\text{H}=13.9$ per cent.

$D_4^{19.3^\circ}$ 0.8033, $n_D^{19.3^\circ}$ 1.4327, $n_D^{19.3^\circ}$ 1.4475.

The *picrate* is precipitated from alcoholic solution as an oil, which rapidly becomes crystalline. It melted at 149° .

The *platinichloride* melted and decomposed at 250° .

This method of preparation was adopted because it had previously been shown (T., 1911, **99**, 1432) that only small quantities of the ditertiary compound were obtained by allowing $\alpha\epsilon$ -dichloropentane to react with piperidine, and it was to be expected that the same would occur with dimethylamine.

Tetramethylhexamethylenediamine, $\text{NMe}_2 \cdot [\text{CH}_2]_6 \cdot \text{NMe}_2$.

Hexamethylenediamine, prepared by v. Braun and Müller's method (*Ber.*, 1905, **38**, 2206), was methylated, and the quaternary ammonium sulphide prepared and decomposed exactly in the manner described for tetramethyltetramethylenediamine. A good yield was obtained of the ditertiary base, a colourless, strongly basic liquid, miscible in all proportions with water, and boiling at $209\text{--}210^\circ/765$ mm.:

0.1050 gave 0.2681 CO_2 and 0.1340 H_2O . $\text{C}=69.6$; $\text{H}=14.2$.

$\text{C}_{10}\text{H}_{24}\text{N}_2$ requires $\text{C}=69.8$; $\text{H}=14.0$ per cent.

$D_4^{14.5^\circ}$ 0.8064, $n_D^{14.5^\circ}$ 1.4366, $n_D^{14.5^\circ}$ 1.4512.

The *picrate* melted at 160° .

Tetramethylheptamethylenediamine, $\text{NMe}_2 \cdot [\text{CH}_2]_7 \cdot \text{NMe}_2$.

Heptamethylenediamine, prepared by v. Braun and Müller's method (*Ber.*, 1905, **38**, 2206) was treated exactly as the foregoing, with the only difference that the decomposition of the sulphide was carried out under diminished pressure (10—15 mm.). In this way a good yield was obtained of the required base, a colourless liquid, miscible in all proportions with water, boiling at $224\text{--}227^\circ$.

On redistillation, almost the entire quantity passed over at 228—230°/760 mm. (corr.):

0·1126 gave 0·2921 CO₂ and 0·1447 H₂O. C=70·8; H=14·3.

C₁₁H₂₆N₂ requires C=71·0; H=14·0 per cent.

D₄^{13·4°} 0·8177, n_D^{13·4°} 1·4407, n_D^{13·4°} 1·4553.

The *picrate* melted at 120°.

Series MeO·[CH₂]_n·NMe₂.

Methyl β-Dimethylaminoethyl Ether, MeO·[CH₂]₂·NMe₂.—See Clarke (T., 1912, **101**, 1808).

Methyl γ-Dimethylaminopropyl Ether, MeO·[CH₂]₃·NMe₂.

Methyl γ-iodopropyl ether (1 mol.), prepared by Karvonen's method (*Acad. Sci. Fennicae*, A., 1912, **3**, 1; A., 1913, **104**, i, 2), was heated with alcoholic dimethylamine (2 mols.) for four hours in a sealed tube on the water-bath. The required base, worked up in the usual manner, was obtained as a colourless, strongly basic liquid, miscible in all proportions with water, boiling at 129—130°/765 mm.:

0·1063 gave 0·2397 CO₂ and 0·1251 H₂O. C=61·4; H=13·4.

C₆H₁₅ON requires C=61·5; H=12·8 per cent.

D₄^{19·7°} 0·8123, n_D^{19·7°} 1·4091, n_D^{19·7°} 1·4224.

The *picrate* melted at 203—204°.

Methyl δ-Dimethylaminobutyl Ether, MeO·[CH₂]₄·NMe₂.

Methyl γ-iodopropyl ether (10 grams) and finely-powdered potassium cyanide (5 grams), with about 10 c.c. of dry methyl alcohol, were shaken in a sealed tube in steam for four hours. The resulting nitrile (not isolated) was reduced in alcoholic solution by means of sodium, and the resulting base (not isolated) was methylated with methyl iodide and alkali, and the quaternary ammonium sulphide prepared and decomposed in the usual manner. The tertiary base is a colourless, strongly basic liquid, miscible in all proportions with water, boiling at 150°/766 mm.:

0·1394 gave 0·3223 CO₂ and 0·1596 H₂O. C=64·0; H=12·7.

C₇H₁₇ON requires C=64·1; H=13·0 per cent.

D₄^{19·9°} 0·8228, n_D^{19·9°} 1·4150, n_D^{19·9°} 1·4280.

The *picrate* melted at 108—109°.

Methyl ε-Dimethylaminoamyl Ether, $\text{MeO} \cdot [\text{CH}_2]_5 \cdot \text{NMe}_2$.

αε-Dibromopentane * (100 grams) was dissolved in twice to three times its volume of absolute methyl alcohol, and the mixture gently warmed on the water-bath under reflux. A solution of 10.0 grams of sodium in dry methyl alcohol, to which had been added 0.1—0.2 gram of potassium iodide, was slowly added in small portions, and the heating continued, more vigorously towards the end, until the alkaline reaction had disappeared. The bulk of the methyl alcohol was then distilled off on the water-bath, and the residue treated with just enough water to dissolve all the sodium bromide. The oil floating on the aqueous solution was separated, washed with concentrated calcium chloride solution, dried with calcium chloride, and distilled. The main portion boiled between 180° and 190°; this was repeatedly fractionally distilled, and the fraction boiling between 183° and 187° collected. The total yield amounted to only about 40 grams of the crude product, and about 20 grams of the fraction boiling at 183—187°, which consisted chiefly of *methyl ε-bromoamyl ether*, probably contaminated with a small quantity of *αε*-dimethoxypentane, which, however, would not interfere with the reactions which the bromo-ether was intended to undergo:

0.1669 gave 0.1644 AgBr. Br=41.9.

$\text{C}_6\text{H}_{13}\text{OBr}$ requires Br=44.2 per cent.

Methyl ε-bromoamyl ether (1 mol.) was heated with alcoholic dimethylamine (2 mols.) for six hours in a sealed tube on the water-bath, and the resulting *methyl ε-dimethylaminoamyl ether* worked up in the usual manner. It is a colourless liquid, miscible in all proportions with water, boiling at 171—172°/755 mm.:

0.1038 gave 0.2514 CO_2 and 0.1254 H_2O . C=66.1; H=13.4.

$\text{C}_8\text{H}_{19}\text{ON}$ requires C=66.2; H=13.1 per cent.

$D_4^{19.0^\circ}$ 0.8221, $n_D^{19.0^\circ}$ 1.4199, $n_D^{10.0^\circ}$ 1.4330.

The *picrate* melted at 89°.

Methyl ζ-Dimethylaminohexyl Ether, $\text{MeO} \cdot [\text{CH}_2]_6 \cdot \text{NMe}_2$.

A mixture of *methyl ε-bromoamyl ether* (20 grams) and finely powdered potassium cyanide (20 grams) in about 30 c.c. of pure methyl alcohol, was shaken in a sealed tube in steam for four hours. The potassium bromide and some unchanged potassium cyanide were removed, and the bulk of the methyl alcohol distilled off on

* The dibromopentane can readily be freed from benzonitrile (compare v. Braun and Steindorff, *Ber.*, 1905, **38**, 2339) by mixing with twice its volume of light petroleum and shaking this mixture repeatedly with concentrated sulphuric acid (compare Clarke, *T.*, 1912, **101**, 1805).

the water-bath. The residue was then treated with water, the oil extracted with ether, and the ethereal solution dried. On fractionally distilling, *ε-methoxyhexonitrile* was obtained as a colourless oil, boiling at 213—215°. This was reduced by means of sodium and alcohol, yielding *methyl ζ-aminoheptyl ether*, a colourless, strongly basic liquid, of faint odour, miscible in all proportions with water, boiling at 186°. This base was methylated by means of methyl iodide and potassium hydroxide in methyl-alcoholic solution. On completion of the reaction the alcohol was removed in a current of steam, and the residual aqueous solution saturated with solid potassium hydroxide, whereby the quaternary iodide was salted out, and formed an oily layer floating on the strongly alkaline solution. This was separated, freed from small quantities of potassium salts by dissolving in chloroform and filtering, and finally converted into the sulphide and decomposed in the ordinary way. *Methyl ζ-dimethylaminoheptyl ether* was thus obtained as a colourless, strongly basic liquid, of faint odour, boiling at 192—193°/765 mm. It is moderately soluble in water, although not in all proportions:

0.1339 gave 0.3334 CO₂ and 0.1627 H₂O. C=67.9; H=13.5.

C₉H₂₁ON requires C=68.0; H=13.2 per cent.

D₄^{10.9°} 0.8300, *n*_D^{10.9°} 1.4284, *n*_D^{10.90°} 1.4419.

The *picrate* melted at 68°.

I. CHEMISCHES INSTITUT,
UNIVERSITY OF BERLIN.

THE SIR DONALD CURRIE LABORATORIES,
QUEEN'S UNIVERSITY, BELFAST.