365. *Physical Properties and Chemical Constitution. Part XIX. Five-membered and Six-membered Carbon Rings.*

By Arthur I. Vogel.

New experimental data are provided for the calculation of the refractivities at 20° and the parachors of a number of *cyclo*pentane and *cyclo*hexane derivatives. These and those described in Part III (*J.*, 1938, 1338) have been employed in the computation of the constants for the 5-membered and 6-membered carbon rings respectively. The mean values, excluding ketones and halides, are as follows :

	P.	R_C.	R_D.	R_F.	$R_{G'}$.	$Mn_D^{20°}$.
5-Membered carbon ring	4·6	−0·19	−0·19	−0·19	−0·22	−4·56
6-Membered carbon ring	1·4	−0·15	−0·15	−0·16	−0·17	−3·53

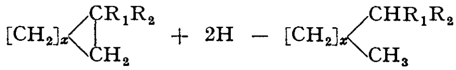
The view seems generally accepted (see, *e.g.*, Eisenlohr, " Spektrochemie organischer Verbindungen : Molekularrefraktion und -dispersion ", Ferdinand Enke, 1912, 86) that the contributions of the 5- and 6-membered carbon rings to the molecular refraction are zero. Ruzicka and Boekenoogen (*Helv. Chim. Acta*, 1931, **14**, 1323; compare Ruzicka *et al.*, *ibid.*, 1930, **13**, 1158) find the ring increments for 5-, 7-, 8-, and 15-rings to be + 0·04, − 0·10, − 0·47, and − 0·62 respectively, that for the 6-ring being assumed to be zero. They use Eisenlohr's value for CH_2 for the D line of 4·62; the correct value is, however, 4·647 (Part IX, *J.*, 1946, 133). Sugden (*J.*, 1924, **125**, 1180) assigns values of 8·5 and 6·1 (compare Sugden and Wilkins, *J.*, 1927, 142) to the 5- and 6-membered rings respectively; the data from which these constants were calculated were not stated, but a value for CH_2 of 39·0 was employed. A comparison of the physical properties of the following isomeric compounds suggests that the contributions of

	P.	R_C.	R_D.	R_F.	$R_{G'}$.	$Mn_D^{20°}$.
Methyl*cyclo*pentane (I)	243·8	27·63	27·77	28·07	28·24	118·67
Methyl*cyclo*pentane (II)	—	27·79	27·90	28·12	28·46	118·54
Methyl*cyclo*pentane (III)	243·9	27·69	27·82	28·12	28·36	118·57
*cyclo*Hexane...........................	241·8	27·63	27·75	28·05	28·27	120·06
Methyl*cyclo*hexane....................	280·9	32·36	32·53	32·87	33·12	139·82
*cyclo*Heptane	278·9	32·01	32·18	32·53	32·76	141·73
1-Methyl-Δ^2-*cyclo*pentene	232·9	27·10	27·25	27·51	27·86	117·03
*cyclo*Hexene...........................	230·4	29·96	27·11	27·47	27·74	118·82
1-Methyl-Δ^1-*cyclo*hexene	269·4	31·66	31·84	32·26	32·57	139·51
*cyclo*Heptene	268·2	31·58	31·75	32·17	32·49	140·16
3-Methyl*cyclo*pentanol	255·0	29·22	29·37	29·66	29·89	144·97
*cyclo*Hexanol (supercooled)	253·3	29·04	29·16	29·48	29·71	146·83

the rings to the molecular refractivity, although small, are not zero. The data are extracted from Part III (*J.*, 1938, 1323); under methyl*cyclo*pentane, I was prepared from 3-methyl*cyclo*pentanone, II from 1-methyl*cyclo*pentan-1-ol (Eisenlohr, " Fortschritte der Chemie, Physik und physikalischen Chemie ", 1925, Band 18, Heft 9, p. 23), and III by heating *cyclo*hexane with aluminium chloride (Wibaut *et al.*, *Rec. Trav. chim.*, 1939, **58**, 365). The results for the methylene hydrocarbons (Part III, *loc. cit.*) have been omitted since the compounds were by-products in thermal decomposition reactions and consequently their absolute purity is doubtful.

The problem was systematically investigated with the aid of the experimental data given in

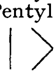
Part III (*loc. cit.*) and the new results are recorded in the experimental section. The ring contributions were computed from the relationship :



The constants for 2H were taken from Part IX (*loc. cit.*), and those for the other reference compounds from earlier papers of this series : for *cyclo*pentane the constants are obtained directly by subtracting $5 \times CH_2$. All the results for the *cyclo*pentane ring are collected in Table I.

TABLE I.

Values for the five-carbon ring from cyclo*pentane compounds.*

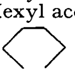
	P.	R_C.	R_D.	R_F.	$R_{G'}$.	$Mn_D^{20°}$.
*cyclo*Pentane	4·9	−0·15	−0·15	−0·14	−0·17	−4·30
Methyl*cyclo*pentane	4·3	−0·11	−0·10	−0·09	−0·15	−4·94
*cyclo*Pentene	4·5	−0·38	−0·37	−0·39	−0·43	−4·89
1-Methyl-Δ^2-*cyclo*pentene	3·7	−0·13	−0·13	−0·14	−0·14	−5·22
*cyclo*Pentanol	5·0	−0·21	−0·21	−0·22	−0·22	−4·25
*cyclo*Pentyl methyl ether	4·0	−0·16	−0·17	−0·18	−0·21	−4·59
*cyclo*Pentyl ethyl ether	4·1	−0·20	−0·19	−0·19	−0·23	−4·53
*cyclo*Pentyl formate	5·2	−0·22	−0·22	−0·22	−0·25	−4·25
*cyclo*Pentyl acetate	5·9	−0·13	−0·14	−0·14	−0·16	−4·16
Mean 	4·6	−0·19	−0·19	−0·19	−0·22	−4·56
*cyclo*Pentanone	7·5	0·11	0·12	0·12	0·10	−4·01
3-Methyl*cyclo*pentanone	5·7	0·10	0·07	0·11	—	−4·73
*cyclo*Pentyl chloride	5·2	−0·06	−0·04	−0·02	−0·03	−3·85
*cyclo*Pentyl bromide	6·3	0·07	0·06	0·08	0·05	−1·56
*cyclo*Pentyl iodide	7·9	0·19	0·21	0·24	0·23	1·99

In the calculation of the mean values, the results for the cyclic ketones and cyclic halides have been omitted. No definite explanation can be offered of the apparently anomalous refractivities of these compounds; whether these are in fact real and are characteristic of the compounds or whether the differences are due to experimental error is an open question. The latter explanation is the more probable, since the preparation of perfectly pure cyclic halides is extremely difficult; this would suggest that ketones prepared by the decomposition of the pure semicarbazones with aqueous oxalic acid are not as pure as is generally supposed.

The results for the *cyclo*hexane compounds are summarised in Table II : the constants for the ketones and halides are not included in the calculation of the mean values; the two sets of figures for 3-methyl*cyclo*hexanone were obtained by the use of the two alternative reference compounds, methyl *n*-amyl ketone and di-*n*-propyl ketone, respectively (Part V, *J.*, 1940, 171).

TABLE II.

Values for the six-carbon ring from cyclo*hexane compounds.*

	P.	R_C.	R_D.	R_F.	$R_{G'}$.	$Mn_D^{20°}$.
*cyclo*Hexane	1·8	−0·12	−0·11	−0·12	−0·12	−3·72
Methyl*cyclo*hexane	1·3	−0·03	−0·01	−0·01	−0·04	−4·34
Di*cyclo*hexyl	0·8	−0·18	−0·19	−0·19	−0·20	−3·20
*cyclo*Hexene	1·5	−0·27	−0·27	−0·28	−0·30	−3·43
*cyclo*Hexanol *	—	−0·16	−0·17	−0·16	−0·17	−3·19
*cyclo*Hexyl methyl ether	1·5	−0·18	−0·18	−0·18	−0·20	−3·66
*cyclo*Hexyl ethyl ether	0·5	−0·13	−0·16	−0·18	−0·15	−3·54
*cyclo*Hexyl formate	1·3	−0·22	−0·22	−0·21	−0·25	−3·34
*cyclo*Hexyl acetate	2·7	−0·07	−0·08	−0·07	−0·08	−3·34
Mean 	1·4	−0·15	−0·15	−0·16	−0·17	−3·53
*cyclo*Hexanone	6·1	−0·10	−0·11	−0·10	−0·12	−3·13
2-Methyl*cyclo*hexanone	4·7	0·08	0·08	0·09	0·07	−3·85
3-Methyl*cyclo*hexanone	2·6	−0·08	−0·07	−0·06	−0·08	−3·79
	6·6	0·19	0·21	0·22	0·21	−3·60
4-Methyl*cyclo*hexanone	5·4	0·22	0·22	0·23	0·23	−3·88
*cyclo*Hexyl chloride	5·8	0·31	0·31	0·31	0·29	−2·95
*cyclo*Hexyl bromide	2·7	0·06	0·07	0·08	0·06	−0·28
*cyclo*Hexyl iodide	2·7	0·22	0·24	0·29	0·30	3·46

* The experimental data for *cyclo*hexanol (Part III, *J.*, 1938, 1331) require revision as follows: M 100·16; $Mn_D^{20°}$ 146·83; $d_{4°}^{20°}$ 0·9515 (supercooled), $d_{4°}^{25°}$ 0·9475, $d_{4°}^{61·8°}$ 0·9178, $d_{4°}^{85·3°}$ 0·8975.

The data for *cyclo*heptane and *cyclo*heptene (Part III, *loc. cit.*) provide the following preliminary values for the constants of the seven-carbon ring :

	P.	R_C.	R_D.	R_F.	$R_{G'}$.	$Mn_D^{20°}$.
*cyclo*Heptane	−1·3	−0·36	−0·35	−0·34	−0·39	−2·40
*cyclo*Heptene	−0·4	−0·29	−0·30	−0·28	−0·30	−3·02

EXPERIMENTAL.

cyclo*Pentyl ethyl ether*. 15·5 G. of sodium were "molecularised" under xylene, the xylene replaced by 150 ml. of anhydrous ether, and a solution of 57 g. of *cyclo*pentanol (b. p. 141—142°/769 mm.) in 75 ml. of dry ether added with stirring during 3 hours, and the whole allowed to stand for 12 hours. 103 G. of pure ethyl iodide were added during 2 hours to the resulting solid sodio-compound : the ether boiled gently. After standing overnight, the ether was removed on a water-bath, and the residue distilled from an air-bath; the crude ether was collected at 120—130° (45 g.). Repeated distillation from sodium to constant physical properties yielded 26 g. of pure *cyclo*pentyl ethyl ether, b. p. 122·5°/763 mm.

cyclo*Pentyl methyl ether*. This was prepared similarly, 97 g. of methyl iodide being used. The yield of the pure cyclo*pentyl methyl ether*, b. p. 105°/763 mm., was 21 g. (Found : C, 72·0; H, 12·1. $C_6H_{12}O$ requires C, 72·2; H, 11·9%).

cyclo*Hexyl methyl ether*. The yield of this ether, b. p. 133·5°/762 mm., from 15·5 g. of "molecular" sodium in 100 ml. of dry ether, 66 g. of pure *cyclo*hexanol in 200 ml. of dry ether, and 97 g. of methyl iodide was 20 g.

cyclo*Hexyl ethyl ether*. This was prepared as for the methyl ether but from 108 g. of ethyl iodide; b. p. 148·5—149·5°/763 mm., yield, 27 g.

cyclo*Hexyl acetate*. Attempts to prepare this ester by refluxing a mixture of 50 g. of *cyclo*hexanol, 90 g. of glacial acetic acid, and 4 g. of concentrated sulphuric acid gave a product of b. p. 160—195°. The fractionation of B.D.H. "pure" *cyclo*hexyl acetate yielded a middle fraction, b. p. 161°/770 mm., $d_{4°}^{20°}$ 0·9609, $n_D^{20°}$ 1·4435, whence R_D 39·27; this was evidently impure and contained free *cyclo*hexanol. The pure ester was readily prepared by making use of the experimental fact that hydrogen chloride dissolves in *cyclo*hexanol without the formation of any appreciable quantity of *cyclo*hexyl chloride. 75 G. of pure *cyclo*hexanol were treated with dry hydrogen chloride until 1·5 g. were absorbed, 135 g. of A.R. glacial acetic acid were added, and the mixture was refluxed for 14 hours. The product was poured into excess of water, the ester layer separated and washed successively with water, saturated sodium hydrogen carbonate solution, and water, dried ($MgSO_4$), and fractionated. The yield of *cyclo*hexyl acetate, b. p. 172°/752 mm., was 57 g.

cyclo*Hexyl formate*. When a mixture of 50 g. of pure *cyclo*hexanol and 70 g. of A.R. 98/100% formic acid was refluxed for 6 hours, the product, isolated in the usual way, had b. p. 160—170°. Fractionation of B.D.H. "pure" *cyclo*hexyl formate gave a large middle fraction of b. p. 172·5°/772 mm., $d_{4°}^{20°}$ 0·9872, $n_D^{20°}$ 1·4437, whence R_D 34·47. The pure ester was prepared by refluxing a mixture of 75 g. of pure *cyclo*hexanol containing 1·5 g. of dissolved hydrogen chloride and 103 g. of A.R. 98/100% formic acid for 14 hours, pouring the mixture into excess of concentrated calcium chloride solution (to facilitate separation of the crude ester), and working up as for *cyclo*hexyl acetate. After about 6 g. of *cyclo*hexene had passed over, pure *cyclo*hexyl formate distilled at 159·5—160°/757 mm.; yield, 57 g.

cyclo*Pentyl formate*. This was prepared by refluxing a mixture of 43 g. of distilled *cyclo*pentanol containing 1 g. of dissolved hydrogen chloride and 69 g. of pure A.R. formic acid for 14 hours; after working up as detailed for *cyclo*hexyl formate and fractionating through a Widmer column 26 g. of the pure ester, b. p. 138°/762 mm., were obtained.

cyclo*Pentyl acetate*. This was prepared as for *cyclo*pentyl formate, 90 g. of A.R. glacial acetic acid being used instead of formic acid; the yield of ester, b. p. 152·5—153°/760 mm., was 27 g.

cyclo*Hexyl chloride*. A mixture of 150 g. of pure *cyclo*hexanol, 375 ml. of concentrated hydrochloric acid, and 150 g. of anhydrous calcium chloride was refluxed for 16 hours with frequent shaking. The crude chloride layer was separated, washed successively with water, saturated sodium hydrogen carbonate solution, and water, and dried for 24 hours over excess of calcium chloride. The crude dry product was fractionated through a Widmer column : after a low b. p. fraction (*ca.* 6 g.; mainly *cyclo*hexene) had passed over, 102 g. of *cyclo*hexyl chloride were collected at 141—142°/755 mm.

cyclo*Pentyl chloride*. In a 500-ml. three-necked flask, equipped with a mechanical stirrer and reflux condenser, were placed 43 g. of *cyclo*pentanol (b. p. 140·5—141·5°/769 mm.), 125 ml. of concentrated hydrochloric acid, and 50 g. of anhydrous calcium chloride. The mixture was heated, with stirring, at 100° for 1 hour and the product was isolated as for the *cyclo*hexyl compound. The yield of *cyclo*pentyl chloride, b. p. 114—115°/777 mm., was 30 g.

cyclo*Hexyl bromide*. A mixture of 50 g. of pure *cyclo*hexanol and 260 g. of A.R. 47% hydrobromic acid was slowly distilled during 6 hours from a 500-ml. distilling flask. The distillate was diluted with a little water, and the lower layer separated and washed successively with concentrated hydrochloric acid (to remove unchanged alcohol), water, saturated sodium hydrogen carbonate solution, and water, and dried ($CaCl_2$). The resulting crude bromide (69 g.) was fractionated and the pure *cyclo*hexyl bromide collected at 164°/766 mm.

cyclo*Pentyl bromide*. This was prepared from 43 g. of pure *cyclo*pentanol and 260 g. of constant b. p. hydrobromic acid. The crude, dry bromide (60 g.) upon fractionation afforded pure *cyclo*pentyl bromide, b. p. 136·5°/763 mm.

cyclo*Hexyl iodide*. Vogel's procedure (B.P. 565,452, 1944) was adopted. The flask was charged with 81 g. of pure *cyclo*hexanol and 10·2 g. of purified red phosphorus, and the special apparatus with 100 g. of iodine. The *cyclo*hexanol was kept at the b. p. until a few ml. of the solution of iodine in the alcohol had collected; the latter was slowly added to the *cyclo*hexanol–phosphorus mixture. Heat was liberated in the subsequent formation of *cyclo*hexyl iodide and only a minute flame was necessary beneath the flask to maintain the reaction. After all the iodine had been introduced into the flask, most of the iodide was distilled into the special apparatus. About 70 ml. of water were then added to the contents of the flask, and the distillation continued to remove the remaining iodide. The yield of crude *cyclo*hexyl iodide, after washing successively with water, concentrated hydrochloric acid, water, saturated sodium hydrogen carbonate solution, and water, and drying ($CaCl_2$), was 145 g. Upon distillation under reduced pressure, the *cyclo*hexyl iodide passed over at 81—83°/20 mm.: a middle fraction, b. p. 81·5°/20 mm., was used for the physical measurements. The pale colour was readily removed by shaking with pure silver powder.

cyclo*Pentyl iodide*. A mixture of 43 g. of pure *cyclo*pentanol and 340 g. of constant b. p. hydriodic acid was slowly distilled during 6 hours from a 500-ml. distilling flask. The crude iodide layer (89 g.) was separated, washed with a little sodium hydrogen sulphite solution to remove the dark colour, and then washed and dried as for the preceding iodide. Distillation of the dry product (83 g.) gave colourless *cyclo*pentyl iodide, b. p. 58°/22 mm.

*Di*cyclo*hexyl*. The Eastman Kodak product was shaken mechanically with half its volume of concentrated sulphuric acid, but the latter did not darken. The acid was separated and the hydrocarbon was washed repeatedly with water, dried ($CaCl_2$), and heated for 5 hours with excess of sodium at 110°. After filtration, the hydrocarbon was distilled. It boiled constantly at 233°/750 mm. and had m. p. 4°.

438. cyclo*Pentyl methyl ether*. B. p. 105°/763 mm.; M 100·16; n_{C} 1·41828, n_{D} 1·42036, n_{F} 1·42543, $n_{G'}$ 1·42916; R_{C} 29·29, R_{D} 29·42, R_{F} 29·72, $R_{G'}$ 29·95; $Mn_{D}^{20°}$ 142·27. Densities determined: $d_{4°}^{20°}$ 0·8624, $d_{4°}^{41·0°}$ 0·8430, $d_{4°}^{61·5°}$ 0·8240, $d_{4°}^{87·8°}$ 0·7972. Apparatus *A*.

(These headings apply to all subsequent tables in this paper.)

t.	H.	$d_{4°}^{t°}$.	γ.	P.	t.	H.	$d_{4°}^{t°}$.	γ.	P.
16·9°	16·51	0·8653	26·75	263·2	41·5°	15·23	0·8425	24·03	263·2
19·1	16·43	0·8632	26·56	263·4	60·1	14·15	0·8253	21·86	262·7
24·4	16·13	0·8583	25·92	263·3				Mean	263·2

439. cyclo*Pentyl ethyl ether*. B. p. 122·5°/766 mm.; M 114·18; n_{C} 1·42102, n_{D} 1·42316, n_{F} 1·42831, $n_{G'}$ 1·43207; R_{C} 33·95, R_{D} 34·11, R_{F} 34·47, $R_{G'}$ 34·73; $Mn_{D}^{20°}$ 162·50. Densities determined: $d_{4°}^{20°}$ 0·8528, $d_{4°}^{41·0°}$ 0·8334, $d_{4°}^{60·6°}$ 0·8146, $d_{4°}^{86·3°}$ 0·7899. Apparatus *D*.

17·2°	12·55	0·8554	26·51	302·9	40·9°	11·57	0·8335	23·82	302·6
21·3	12·34	0·8516	25·95	302·6	61·1	10·81	0·8141	21·73	302·8
23·7	12·27	0·8493	25·74	302·8	86·7	9·78	0·7895	19·07	302·2
								Mean	302·7

440. cyclo*Pentyl formate*. B. p. 138°/762 mm.; M 114·14; n_{C} 1·42990, n_{D} 1·43209, n_{F} 1·43741, $n_{G'}$ 1·44127; R_{C} 29·40, R_{D} 29·53, R_{F} 29·43, $R_{G'}$ 30·08; $Mn_{D}^{20°}$ 163·46. Densities determined: $d_{4°}^{20°}$ 1·0026, $d_{4°}^{41·3°}$ 0·9819, $d_{4°}^{60·4°}$ 0·9624, $d_{4°}^{85·3°}$ 0·9368. Apparatus *A*.

15·8°	17·08	1·0068	32·20	270·1	60·7°	15·03	0·9621	27·08	270·6
19·3	17·02	1·0034	31·98	270·5	85·6	13·81	0·9365	24·22	270·4
41·5	15·90	0·9817	29·23	270·2				Mean	270·4

441. cyclo*Pentyl acetate*. B. p. 153°/760 mm.; M 128·17; n_{C} 1·42962, n_{D} 1·43178, n_{F} 1·43708, $n_{G'}$ 1·44094; R_{C} 33·92, R_{D} 34·07, R_{F} 34·43, $R_{G'}$ 34·70; $Mn_{D}^{20°}$ 183·51. Densities determined: $d_{4°}^{20°}$ 0·9753, $d_{4°}^{40·7°}$ 0·9540, $d_{4°}^{60·1°}$ 0·9350, $d_{4°}^{86·6°}$ 0·9086. Apparatus *D*.

20·4°	12·74	0·9749	30·67	309·4	60·9°	11·24	0·9342	25·93	309·6
41·4	11·92	0·9533	28·06	309·4	86·1	10·30	0·9091	23·12	309·2
								Mean	309·4

442. cyclo*Pentyl chloride*. B. p. 114·5—115°/777 mm.; M 104·58; n_{C} 1·44894, n_{D} 1·45127, n_{F} 1·45703, $n_{G'}$ 1·46125; R_{C} 27·83, R_{D} 27·96, R_{F} 28·27, $R_{G'}$ 28·50; $Mn_{D}^{20°}$ 151·78. Densities determined: $d_{4°}^{20}$ 1·0053, $d_{4°}^{40·1°}$ 0·9855, $d_{4°}^{61·7°}$ 0·9646, $d_{4°}^{86·1°}$ 0·9390. Apparatus *A*.

15·0°	16·40	1·0103	31·03	244·3	40·7°	15·14	0·9849	27·92	244·1
20·5	16·08	1·0048	30·25	244·1	61·3	14·12	0·9650	25·51	243·7
26·6	15·89	0·9987	29·72	244·5	87·0	12·83	0·9381	22·54	243·3
								Mean	244·0

443. cyclo*Pentyl bromide*. B. p. 136·5°/753 mm.; M 149·04; n_{C} 1·48565, n_{D} 1·48858, n_{F} 1·49590, $n_{G'}$ 1·50142; R_{C} 30·83, R_{D} 30·99, R_{F} 31·38, $R_{G'}$ 31·67; $Mn_{D}^{20°}$ 221·86. Densities determined: $d_{4°}^{20°}$ 1·3873, $d_{4°}^{40·8°}$ 1·3603, $d_{4°}^{60·8°}$ 1·3348, $d_{4°}^{88·1°}$ 1·2983. Apparatus *D*.

16·9°	9·84	1·3913	33·81	258·3	61·1°	8·62	1·3343	28·40	257·9
20·5	9·70	1·3866	33·22	258·0	86·5	7·97	1·3004	25·60	257·8
40·5	9·17	1·3608	30·82	258·1				Mean	258·0

444. cyclo*Pentyl iodide*. B. p. 58°/22 mm.; M 196·04; n_{C} 1·54268, n_{D} 1·54705, n_{F} 1·55817, $n_{G'}$ 1·56700; R_{C} 36·13, R_{D} 36·38, R_{F} 36·99, $R_{G'}$ 37·47; $Mn_{D}^{20°}$ 303·29. Densities determined: $d_{4°}^{20°}$ 1·7092, $d_{4°}^{40·6°}$ 1·6794, $d_{4°}^{60·5°}$ 1·6498, $d_{4°}^{86·9°}$ 1·6117. Apparatus *D*.

14·9°	8·68	1·7166	36·80	281·3	61·1°	7·74	1·6489	31·52	281·7
20·0	8·58	1·7092	36·21	281·4	85·6	7·23	1·6097	28·74	282·0
42·0	8·12	1·6771	33·63	281·5				Mean	281·6

445. *Dicyclohexyl*. B. p. 233°/750 mm., m. p. 4°; M 166·30; n_C 1·47696, n_D 1·47954, n_F 1·48538, $n_{G'}$ 1·48993; R_C 52·99, R_D 53·22, R_F 53·78, $R_{G'}$ 54·21; $Mn_D^{20°}$ 246·04. Densities determined: $d_{4°}^{20°}$ 0·8868, $d_{4°}^{40·1°}$ 0·8727, $d_{4°}^{60·7°}$ 0·8585, $d_{4°}^{85·0°}$ 0·8420. Apparatus *E*.

t.	*H*.	$d_{4°}^{t°}$.	γ.	*P*.	*t*.	*H*.	$d_{4°}^{t°}$.	γ.	*P*.
15·9°	16·04	0·8897	33·24	448·8	60·4°	14·46	0·8587	28·92	449·1
20·5	15·83	0·8864	32·68	448·6	86·7	13·50	0·8408	26·44	448·5
41·2	15·05	0·8720	30·56	448·4					Mean 448·7

446. cyclo*Hexyl methyl ether*. B. p. 133·5°/763 mm.; M 114·18; n_C 1·43248, n_D 1·43470, n_F 1·44004, $n_{G'}$ 1·44398; R_C 33·87, R_D 34·02, R_F 34·38, $R_{G'}$ 34·65; $Mn_D^{20°}$ 163·81. Densities determined: $d_{4°}^{20°}$ 0·8752, $d_{4°}^{40·5°}$ 0·8574, $d_{4°}^{61·9°}$ 0·8395, $d_{4°}^{86·7°}$ 0·8168. Apparatus *D*.

14·7°	13·26	0·8798	28·81	300·7	41·3°	12·19	0·8567	25·79	300·4
17·9	13·14	0·8770	28·46	300·7	60·8	11·42	0·8404	23·70	299·8
27·4	12·77	0·8688	27·40	300·7	86·0	10·41	0·8162	20·98	299·4
									Mean 300·3

447. cyclo*Hexyl ethyl ether*. B. p. 148·5—149·5°/763 mm.; M 128·21; n_C 1·43284, n_D 1·43505, n_F 1·44042, $n_{G'}$ 1·44506; R_C 38·55, R_D 38·73, R_F 39·14, $R_{G'}$ 39·50; $Mn_D^{20°}$ 183·99. Densities determined: $d_{4°}^{20°}$ 0·8640, $d_{4°}^{41·6°}$ 0·8466, $d_{4°}^{60·1°}$ 0·8295, $d_{4°}^{85·3°}$ 0·8074. Apparatus *A*.

17·3°	16·92	0·8663	27·45	338·7	40·6°	15·91	0·8475	25·25	339·1
20·7	16·85	0·8634	27·24	339·2	60·9	14·84	0·8288	23·03	338·9
27·6	16·55	0·8585	26·60	339·2	85·4	13·63	0·8073	20·60	338·4
									Mean 338·9

448. cyclo*Hexyl formate*. B. p. 160°/757 mm.; M 128·17; n_C 1·44073, n_D 1·44305, n_F 1·44857, $n_{G'}$ 1·45263; R_C 34·03, R_D 34·19, R_F 34·56, $R_{G'}$ 34·82; $Mn_D^{20°}$ 184·96. Densities determined: $d_{4°}^{20°}$ 0·9941, $d_{4°}^{41·3°}$ 0·9735, $d_{4°}^{61·1°}$ 0·9552, $d_{4°}^{87·1°}$ 0·9317. Apparatus *A*.

13·0°	17·62	1·0007	33·02	307·0	61·3°	15·38	0·9550	27·50	307·3
19·0	17·39	0·9950	32·40	307·3	87·1	14·25	0·9317	24·86	307·2
41·0	16·35	0·9738	29·81	307·6					Mean 307·3

449. cyclo*Hexyl acetate*. B. p. 172°/752 mm.; M 142·19; n_C 1·43950, n_D 1·44174, n_F 1·44718, $n_{G'}$ 1·45118; R_C 38·61, R_D 38·77, R_F 39·19, $R_{G'}$ 39·50; $Mn_D^{20°}$ 205·00. Densities determined: $d_{4°}^{20°}$ 0·9697, $d_{4°}^{40·6°}$ 0·9501, $d_{4°}^{62·3°}$ 0·9298, $d_{4°}^{86·6°}$ 0·9072. Apparatus *D*.

20·3°	13·08	0·9694	31·31	347·0	61·5°	11·57	0·9306	26·59	347·0
41·1	12·31	0·9496	28·87	347·1	87·1	10·66	0·9067	23·87	346·6
									Mean 346·9

450. cyclo*Hexyl chloride*. B. p. 142°/755 mm.; M 118·61; n_C 1·45993, n_D 1·46235, n_F 1·46828, $n_{G'}$ 1·47266; R_C 32·84, R_D 32·99, R_F 33·35, $R_{G'}$ 33·62; $Mn_D^{20°}$ 173·46. Densities determined: $d_{4°}^{20°}$ 0·9891, $d_{4°}^{40·6°}$ 0·9690, $d_{4°}^{61·0°}$ 0·9497, $d_{4°}^{85·5°}$ 0·9256. Apparatus *A*.

15·9°	17·34	0·9932	32·25	284·6	60·9°	15·24	0·9498	27·10	284·9
40·0	16·20	0·9696	29·41	284·9	86·0	14·16	0·9251	24·53	285·3
									Mean 284·9

451. cyclo*Hexyl bromide*. B. p. 164°/766 mm.; M 163·07; n_C 1·49226, n_D 1·49526, n_F 1·50269, $n_{G'}$ 1·50830; R_C 35·43, R_D 35·61, R_F 36·06, $R_{G'}$ 36·40; $Mn_D^{20°}$ 243·84. Densities determined: $d_{4°}^{20°}$ 1·3360, $d_{4°}^{42·5°}$ 1·3092, $d_{4°}^{61·7°}$ 1·2875, $d_{4°}^{85·7°}$ 1·2583. Apparatus *A*.

23·1°	13·45	1·3323	33·55	294·6	60·6°	12·18	1·2888	29·39	294·6
41·2	12·84	1·3107	31·51	294·8	86·3	11·27	1·2577	26·48	294·4
									Mean 294·6

452. cyclo*Hexyl iodide*. B. p. 81·5°/20 mm.; M 210·07; n_C 1·54333, n_D 1·54765, n_F 1·55856, $n_{G'}$ 1·56730; R_C 40·78, R_D 41·05, R_F 41·73, $R_{G'}$ 42·26; $Mn_D^{20°}$ 325·13. Densities determined: $d_{4°}^{20°}$ 1·6244, $d_{4°}^{41·2°}$ 1·5968, $d_{4°}^{62·2°}$ 1·5702, $d_{4°}^{86·3°}$ 1·5403. Apparatus *D*.

15·2°	9·17	1·6306	36·93	317·6	61·2°	8·19	1·5715	31·06	315·6
25·0	8·92	1·6180	35·64	317·2	86·8	7·66	1·5397	29·13	317·0
40·5	8·65	1·5977	34·13	317·8					Mean 317·1

WOOLWICH POLYTECHNIC, LONDON, S.E. 18.

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