LXXIII.—*Researches on the Relation between the Molecular Structure of Carbon Compounds and their Absorption Spectra.* (Part VII.)

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Introduction.

In a paper published in the *Journal of the Chemical Society*, **39**, 153, 1882, I have given an explanation of the cause of the absorption-bands occurring in the spectra transmitted by various carbon compounds and tertiary bases; and I have also calculated the approximate mean rate of vibration of the molecules of these substances from observations on their absorption spectra. It was shown that such substances as we designate closed-chain compounds are characterised by two kinds of absorption—a general and a selective absorption—the latter not independent but a result of the former. The general absorption was considered to be due to the fundamental vibrations of the molecule, the selective absorption being caused by vibrations within the molecule corresponding to the overtones of a simple musical instrument such as a stretched string or a bell. Intimately connected with the rate of these vibrations and the chemical constitution of the molecule, is the intensity of the absorption; this was attributed to the amplitude of the vibrations.

No measurements of the wave-length of the lines occurring in ultra-violet spectra had at that time been made in sufficient number and with the accuracy necessary to afford a means of measuring these bands in a satisfactory manner; but since then many lines have been measured in the spark spectra of various elements by my assistant Mr. Adeney and myself, and consequently I have been enabled to place definite measurements of these bands on record. The method of working is that described in the *Proc. Roy. Soc.*, **33**, 1 (Abstract).

The wave-lengths in tenth-metres have been converted into reciprocal numbers which have the advantage of representing oscillation-frequencies per unit of time; for inasmuch as we assume that only those rays are absorbed by a substance which synchronise with the vibrations of the molecule, there is a very obvious connection between the molecular vibrations and the oscillation-frequencies of the absorbed rays. The quantity of substance taken in each case is a molecular weight in milligrams; this is dissolved in a diastinct medium and made up to a constant volume, definite thicknesses of the solution being examined. That is to say, a milligram-molecule is contained in, or, more correctly, an equal number of molecules are

diffused through unit of space. The oscillation-frequencies being taken as abscissæ and the thicknesses of liquid as ordinates, absorption curves are plotted which record the rate and amplitude of the molecular vibrations. The area enclosed by the curve is a description of the specific absorptive power of a substance, and it follows that as all the properties of a molecule are dependent upon its mode of vibration, each substance has its own peculiar curve by which it may be identified.

From the usual point of view of the chemist, it might be considered as open to discussion whether molecules identical in composition and of similar constitution would or would not yield different absorption-curves, for if the bands caused by selective absorption are the result of motions within the molecule, these are motions of the atoms of which it is composed, and, consequently, the distinctive properties of the atoms which are common to each molecule should be made manifest by distinctive series of vibrations indicated by similar curves.

To this we have an answer in the fact that it has already been proved (*Phil. Trans.*, **170**, 257, 1879) that the curves of some few isomeric bodies are widely different, and in no case can any so-called atomic motions be traced, or, as I have elsewhere stated, it is not possible to associate any of the absorption-bands of the aromatic hydrocarbons with any particular carbon-atoms; indeed it was shown that vibrations of the molecule, as a whole, determine the rate of the vibrations taking place within the molecule. Here then we have evidence of the constitution of matter which is inconsistent with the individual existence of atoms within the molecule; and it appears from this consideration alone that our chemical formulæ do not in any way express the constitution of the molecules of the substances they are intended to represent, but only give us a concise and useful statement of the origin of the substance and the chemical reactions which it is probably capable of undergoing, or to which it has been subjected; all such statements being referred to mass.

Each molecule appears to be a distinct individual resolvable into other individuals, it is true, but not composed of them in the manner represented by symbols.

It is considered desirable thus to preface this paper in order that the object to be studied may be kept clearly in view.

The substances which have been investigated, and the spectra of which are described in these pages are the following:—

1. Aromatic hydrocarbons, benzene and naphthalene.
2. Aromatic tertiary bases and their salts, pyridine, dipyridine, picoline, quinoline, and their hydrochlorides.
3. Addition-products of tertiary bases and salts, piperidine, tetrahydroquinoline and its hydrochloride.

4. Primary and secondary aromatic bases or amido-derivatives and salts thereof, ortho- and para-toluidine and their hydrochlorides.
5. Isomeric bodies, the three isoxylenes.

The Preparation of Solutions and Method of Examination.

In dealing with a variety of nearly related substances from which similar solutions have to be prepared, it is necessary that the least soluble shall, as far as possible, serve as a standard for the preparation of the other solutions. It was found most convenient to take a molecular weight in milligrams and dissolve it in 20 c.c. of absolute alcohol or any other menstruum better suited to the particular substance. In this way, molecular weights were distributed through—that is to say, made to occupy equal volumes. The solutions when prepared were placed in a series of cells varying in thickness from 25 mm. to 1 mm.; if with a thickness of 1 mm. absorption-bands were still visible, the liquid was diluted to five times its original volume and another series of photographs taken ranging from 5 mm. downwards. An example or two will illustrate the method of making and examining the solutions.

The solution of benzene was made by dissolving 0.078 gram in 20 c.c. of alcohol; it was examined in layers 25 mm. in thickness which were reduced gradually to 1 mm.; but below this it was necessary to dilute the liquid, and, therefore, 5 c.c. were made up to 25 c.c.; this is in the proportion of 1 milligram-molecule in 100 c.c. The proportional thickness of 1 mm. of the weaker solution is $25 \times 5 = \frac{1}{125}$ of the whole or of the original solution. In the case of paratoluidine we have a solution containing 0.107 gram dissolved in 20 c.c. of alcohol; examined first in layers of 5 mm. thickness reduced to 1 mm., the solution is then diluted to five times its original volume for a first, a second, and a third time, so that the proportional thicknesses are represented by $5^{-4} = 625$ mm. diminishing to 1 mm.

In the case of the bases and their hydrochlorides, the method of examination consisted in photographing the spectra transmitted by the base contained in one series of cells and the molecule of hydrochloric acid contained in another, the rays from the spark passing through both simultaneously. The contents of the two series of cells being then mixed and returned to their original vessels, a second series of photographs was taken. As the hydrochloric acid proved perfectly diactinic the first spectra represent the absorption caused by the base alone, the second that caused by the salt. The difference in the mode of vibration of the base, the acid, and the salt is very striking; the amplitude of the vibrations within the molecule of the

salt being much less, as one would imagine, than in that of the base. When a series of photographs had been secured which gave sufficient information from which a curve could be drawn indicating both the general and the selective absorption, the oscillation-frequencies of the absorbed rays were taken as abscissæ and the proportional thicknesses in millimetres of the weakest solution as ordinates. The curves are made continuous, and a careful description of the spectra obtained by transmitting rays through varying thicknesses of the solutions is intended to supplement the curves and serve the purpose of the shaded diagrams hitherto employed. The scale upon which these curves have been drawn is as small a one as possible, but owing to the extraordinary persistence of the bands of absorption occurring in the spectra of certain substances—such as, for instance, the paratoluidine and its hydrochloride—the diagrams are occasionally of such an unmanageable length, as much as 7 feet, that it has been found necessary to break the curves, and to reduce the scale upon which they have been drawn; unfortunately under such circumstances it is difficult to institute strict comparisons between all the substances examined.

The same difficulty in representing the spectra on a uniform scale was experienced when solutions containing equal quantities of substance were employed; this may be seen by referring to this Journal, 39, 153, and comparing the diagram of benzene with that of anthracene. It is possible that in these latter investigations bands of little intensity may have escaped observation, because the method of examination necessary in order to obtain accurate measurements does not admit of the recognition of very feeble bands or such as only occur through a small range; that is to say, which correspond to vibrations of small amplitude. The photographs taken on former occasions which were referred to the spectrum of cadmium, were taken with a wide slit and lenses of long focus; these were executed with a narrow slit and lenses of shorter focus. The latter method was convenient for ascertaining the exact position of the absorption-bands, but it has resulted in the inadequate representation of some feeble bands of absorption and their omission from the curves. The reason of this will be evident when we consider that line spectra consist of *maxima* and *minima* of intensity of chemical action with the most rapid transitions from one to the other when the lines are very clearly defined; but when the slit is open the width of the spark itself and its irregular motion cause the chemical action to be more equally diffused. When *maxima* of chemical action occur in a region of the spectrum where there is only a faint absorption, the effect of absorption is overpowered.

Probably this defect in working with spark spectra could be over-

come by the use of an arc light, but, unfortunately, I have not had such a means of research at my disposal.

The Substances Examined.

Benzene.—The observations made on benzene were numerous, but no difference was observed in the photographs obtained from different specimens; as a matter of fact, however, that preparation which afforded measurements from which the curve was drawn, was fractionated from a supply of crystallisable benzene free from thiophene, supplied by Mr. Kahlbaum's agents. It was analysed and found to give numbers agreeing with theory.

Naphthalene.—Three specimens of naphthalene have been examined at different times, two of these were carefully purified in my laboratory, and their purity ascertained by analysis. These afforded spectra identical in every particular.

Pyridine.—This specimen was fractionally distilled from a preparation obtained from Mr. Kahlbaum; its boiling point lay between 115° and 117°. It was converted into a platinum salt, and two analyses were made, which yielded the same numbers, namely, 17·68 per cent. of nitrogen.

	Found.	Calculated.
Platinum in $(C_5H_5N, HCl)_2PtCl_4$..	34·52	34·60
Nitrogen in „ ..	4·89	4·90
Nitrogen in C_5H_5N	17·68	17·72

Picoline.—For this specimen, I am indebted to Professor Ramsay, of Bristol. It was considered to be a pure preparation.

Quinoline.—Two specimens of quinoline have been examined, one of which was described in this Journal, **41**, 47; its boiling point (235—240°) and the particulars of its analysis are there stated. The second specimen was prepared synthetically in my laboratory, after Skraup's process (this Journal, **40**, 919). The proportions of the materials used were nitrobenzene 1·4 parts, aniline 2·1 parts, glycerine of 1·26 sp. gr. 6 parts, and sulphuric acid 5 parts. The mixture gave no very energetic reaction at first, but after heating for several hours to 130°, and not higher than 140°, the contents of the vessel entered into most violent ebullition. Nearly the whole of the base produced by this method boiled at 235° (uncorr.). The absorption curve which it yielded was identical with that obtained from the carefully purified specimen obtained from Mr. Kahlbaum, which was previously used. According to Hoogewerff and van Dorp (this Journal, **44**, 89), the identity of quinoline from cinchonine, with the base from coal-tar has been established. The former is said to boil at 238·25° to 239·25°, and the latter at 239·25° to 240·25°. De

Coninck (this Journal, **44**, 88), gives the boiling point of quinoline from cinchonine as 236—237° at a pressure of 775 mm., that obtained by synthesis, according to Skraup and Koenigs, boils at 228°, while according to Baeyer and others, it is 232°. Certainly the number given as the boiling point of my specimen is nearer to this last.

Piperidine (Kahlbaum).—A fraction boiling from 104—105° was converted into a platinum salt, and two analyses were made by Mr. W. P. Sharpley, Associate of the Royal College of Science. The following figures show the result:—

	Found.	Calculated.
Platinum in $(C_5H_{11}N, HCl)_2PtCl_4$..	33.49	33.89 per cent.
Nitrogen in " ..	4.75	4.80 "
Nitrogen in $C_5H_{11}N$	16.36	16.47 "

Tetrahydroquinoline.—The base was prepared by myself from a specimen of the hydrochloride obtained from Mr. Kahlbaum. Its boiling point was between 240° and 250°. The hydrochloride yielded the following numbers:—

	Found.	Calculated.
Platinum in $(C_9H_{11}N, HCl)_2PtCl_4$..	29.00	28.28 per cent.
Nitrogen in " ..	4.026	4.129 "

As the purity of this specimen could not be satisfactorily ascertained by analysis, various fractional distillates were examined with the spectroscope, and as they were found to yield the same spectra, it was considered that there was no impurity present in quantity sufficient to affect the spectrum.

Orthotoluidine (Kahlbaum).—This specimen was fractionated, and found to boil almost entirely at 197—197.5°.

Paratoluidine (Kahlbaum).—This substance, which was prepared from a quantity of the base obtained five years since, consisted of very fine colourless crystals in a state of very great purity. It had been carefully preserved as a typical specimen.

The three Xylenes (Kahlbaum).

Orthoxylene, b. p. 145°	} At barometric pressure of 29.883 inches.
Metaxylene, b. p. 139—141°	
Paraxylene, b. p. 139°	

In that portion of my work dealing with the chemical constitution of the alkaloids ("Absorption Spectra of the Alkaloids," Part I, *Proc. Roy. Soc.*, **38**, 1, Abstract) the absorption spectrum of piperidine was predicted to be quite different from that of pyridine. Whilst the latter gives a strong absorption-band, the former was judged to be capable of absorbing only the more refrangible of the ultra-violet rays without selection of any particular series of vibrations. This

prediction has proved to be quite correct. It was deduced from two of the laws contained in a former series of papers published in 1882 (this Journal, **39**, 153, and **41**, 45).

No molecular arrangement of carbon-atoms causes selective absorption, unless each carbon is united to the other three carbon-atoms as in the case of benzene.

The simple union of carbon with nitrogen does not cause selective absorption of the ultra-violet rays.

A third deduction here follows, which is a consequence of the observations contained in the latter paper, and is justified by these more recent investigations.

When an atom of nitrogen is substituted for an atom of carbon in the benzene or naphthalene nucleus, the property of selective absorption is still retained.

Piperidine is an addition product of pyridine, a hexahydropyridine in which the carbons and the nitrogen are less compactly united than in benzene and pyridine, and so far resembling in structure benzene hexachloride; it was easy to conclude that as this last body, and others similarly constituted, are endowed with no power of selective absorption, so hexahydropyridine, for a similar reason, would yield a similar spectrum. In forecasting the nature of the spectra transmitted by the addition products of quinoline, such as, for instance, tetrahydroquinoline and its salts, one could not confidently rely on these facts as being sufficient, for although, reading by the light of the information applied to the case of pyridine and piperidine, the substance might reasonably be expected to yield a spectrum with a band or bands of absorption, because five of the atoms of carbon, and the one atom of nitrogen, are condensed to the same degree as in pyridine, yet in addition there are four other carbon-atoms in the molecule less compactly united by reason of the added atoms of hydrogen with which they are combined. These might or might not affect the absorption spectrum. Here it may be as well to state that "the arrangement of atoms in the molecule," an expression which I have used, and shall probably still find it convenient to employ, because it connects these observations with the ordinary symbolic representations of the constitution of chemical compounds, does not refer to any assumed position of the atoms in space, but to the degree of condensation to which the matter composing the molecules has been subjected. That condition, which we may term compactness of structure, usually denoted in the case of carbon compounds by double and treble linking of the carbon-atoms, is more truly expressed by the word "condensation." In the act of combination, the greater the degree of condensation the greater is the quantity of potential converted into actual energy. The greater the amount of actual

energy resulting from the union of the atoms in a molecule, the greater is the specific actinic absorption and the molecular refractive energy, and the less in amount is its heat of combustion assumed to be. It has already been mentioned that the actinic absorption exerted by a molecule may be increased in two directions, first, in that direction which is represented longitudinally on the diagrams, which signifies that the liquid will bear great dilution without its absorptive power being destroyed, although the rays absorbed may be of small wave-length. This indicates that the molecular vibrations are of great amplitude. Secondly, the extent of the absorption may be increased in the direction of the less refrangible rays, which may be explained by the rate of vibration of the molecule being diminished. It is to be observed that the latter generally includes the former, as, for instance, in the case of benzenoid derivatives, especially when the molecule results from the union of two or more benzene nuclei, and more particularly by that mode of condensation which may be described as the fusion of the benzene-rings, as in the case of naphthalene and phenanthrene.

Isomeric Bodies.—Many previous experiments have been directed towards ascertaining by the spectroscope the orientation of isomeric bodies of the aromatic series.

In the paper by Professor Huntington and myself, diagrams show the differences between the three hydroxybenzoic acids and two nitranilines, but as these are oxygenated derivatives possessing far greater absorptive powers than benzene itself, it has been considered desirable to commence an investigation of isomeric hydrocarbons differing as little as possible from benzene, and on this account the three xylenes have been chosen as examples. Free from the complications which the introduction of oxygen into the molecules may occasion in the absorption curves, one may fairly estimate the difference in molecular absorption which is due to nothing more than the so-called relative positions of the compound radicles.

It will be observed that the area enclosed by the curve of meta-xylene appears to be the least, that of the orthoxylene stands next, whilst that of paraxylene is the greatest. Further researches on isomeric bodies are in progress.

Bases and their Hydrochlorides.—It must be remembered that the hydrochloric acid used in each case was perfectly diactinic, but the salt formed, it will be noticed, yields a curve which is distinct from that of the base. Generally speaking, the salts are more diactinic than the bases.

The following deductions may be drawn from this investigation :—

When the condensation of the carbon and nitrogen in the molecule of a benzenoid compound or tertiary base is modified by the addition thereto

of an atom of hydrogen to each atom of carbon and nitrogen, the power of selective absorption is destroyed.

When the condensation of the carbon-atoms in quinoline is modified by the combination therewith of four atoms of hydrogen, the intensity of the selective absorption is reduced, but is not destroyed.

Molecules of compounds, that is to say, molecules composed of dissimilar atoms, vibrate as wholes or units, and the fundamental vibrations give rise to secondary vibrations which stand in no visible relation to the chemical constituents of the molecule, whether these be atoms or smaller molecules.

Hence it appears that a molecule is a distinct and individual particle, which cannot be represented by our usual chemical formulæ, since these only symbolise certain chemical reactions, and fail to express any relation between physical and chemical properties.

The very beautiful researches of Abney and Festing on the absorption spectra of carbon compounds in the infra-red region render one desirous of ascertaining the relation that such spectra bear to those in the ultra-violet.

I have to thank my assistant, Mr. W. R. Barnett, for the care he has taken in measuring the spectra and drawing the curves which illustrate this paper.

Description and Measurements of Spectra.

BENZENE. 0.078 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid	25 mm.		20 mm.		15 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3151	3171	3151	3171	3151	3171
" fairly strong to	3359	2976	3359	2976	3647	2740
" weak to	3647	2740	3647	2740	3803	2629
" faint to	3768	2653	3803	2629	—	—
(1) Absorption band from	3768 to 4331	2653 to 2310	3803 to 3861	2629 to 2589	3803 to 3861	2629 to 2589
Rays transmitted, discontinuous to	—	—	—	—	3890	2568
Rays feebly transmitted at	4331	2310	3890	2568	—	—
(2) Absorption band from	—	—	3890 to 4331	2568 to 2310	3890 to 4141	2568 to 2415
Rays weak and discontinuous to	—	—	—	—	4427	2259
Rays transmitted at	—	—	4253	2352	—	—
" discontinuous and faint to	—	—	4426	2259	—	—
Thickness of layer of liquid	10 mm. The same as with 15 mm., but a rather stronger spectrum.					

BENZENE—continued. 0.078 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.		5 mm.		4 mm.		3 mm.	
Description of spectrum.		Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to		3151	3171	3151	3171	3151	3171
" fairly strong to		3647	2740	3647	2740	3647	2740
" weak to		3826	2613	3826	2613	3826	2613
(1) Absorption band from		3826 to 3855	2613 to 2593	3826 to 3855	2613 to 2593	3826 to 3844	2613 to 2601
Rays transmitted at		3855	2593	3855	2593	3844	2601
Continuous, weak to		3890	2568	—	—	3919	2549
" faint to		—	—	3890	2568	—	—
(2) Absorption band from		3890 to 3959	2568 to 2525	3890 to 3959	2568 to 2525	3919 to 3948	2549 to 2532
Rays transmitted at		3959	2525	3959	2525	3948	2532
Continuous, faint to		4016	2490	4016	2490	4028	2482
(3) Absorption band from		4016 to 4038	2490 to 2476	4016 to 4038	2490 to 2476	4028 to 4038	2482 to 2470
Rays transmitted at		4038	2476	4038	2476	4038	2470
Continuous, faint to		4098	2440	4098	2440	4098	2440
(4) Absorption band from		4098 to 4125	2440 to 2424	4098 to 4125	2440 to 2424	4098 to 4120	2440 to 2427
Rays transmitted at		4125	2424	4125	2424	4120	2427
Continuous, faint to		4566	2190	4566	2190	4566	2190

BENZENE—continued. 0·078 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.	2 mm.		1 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to " fairly strong to " weak to.....	3151 3647 3826	3171 2740 2613	3151 3647 3826	3171 2740 2613
(1) Absorption band from Rays transmitted at Continuous, weak to	3826 to 3844 3844 3919	2613 to 2601 2601 2549	3826 to 3844 3844 3919	2613 to 2601 2601 2549
(2) Absorption band from Rays transmitted at Continuous, faint to	3919 to 3948 3948 4028	2549 to 2532 2532 2482	3919 to 3948 3948 4028	2549 to 2532 2532 2482
(3) Absorption band from Rays transmitted at Continuous, faint to	4028 to 4038 4038 4098	2482 to 2470 2470 2440	4028 to 4038 4038 4098	2482 to 2470 2470 2440
(4) Absorption band from Rays transmitted at Continuous, faint to	4098 to 4120 4120 4566	2440 to 2427 2427 2190	4098 to 4120 4120 4566	2440 to 2427 2427 2190

With 1 mm. of liquid the last two bands have become rather diffuse, and definite measurements are difficult. Although the absorption is quite visible, still some rays are transmitted faintly between the measurements given.

The former solution diluted to five times its original volume, or 20 c.c. made up to 100 c.c. = 0·078 gram in 100 c.c.

Description of Spectrum.

- 5 mm. Exactly the same as with 1 mm. of the original solution.
 4 mm. The same; the first two bands are visible, but do not admit of exact measurement, the others have disappeared.
 3 mm. The first two bands are still visible.
 2 mm. The whole spectrum is continuous.

NAPHTHALENE. 0.128 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to faint to.....	3151 3187	3171 3140	3151 3194	3171 3130	3151 —	3171 —
" weak to.....	—	—	—	—	—	—
(1) Absorption band from.....	—	—	—	—	3194	3130
Rays transmitted, continuous, but very feeble to.....	—	—	—	—	3194 to 3228	3130 to 3097.5
(2) Absorption band from.....	—	—	—	—	3249	3078
Rays transmitted feebly at.....	—	—	—	—	3249 to 3297 3297	3078 to 3033 3033
Thickness of layer of liquid.....	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Continuous, strong to faint to.....	3151 3194	3171 3130	3194 —	3130 —		
" weak to.....	—	—	3207	3117		
(1) Absorption band from.....	3194 to 3228 3249	3130 to 3097.5 3078	3207 to 3228	3117 to 3097.5		
(2) Absorption band from.....	3249 to 3297 3297	3078 to 3033 3033	—	—		
Rays transmitted at.....	3324	3008	—	—		
Also very faint line at.....	—	—	—	—		
Weak continuous spectrum to.....	—	—	3359 3297	2976.5 3033		
Two strong lines at.....	—	—	3324	3008		
" "	—	—	—	—		

NAPHTHALENE—continued. 0.128 gram dissolved in 100 c.c.

Thickness of layer of liquid	5 mm.		4 mm.		3 mm.	
Description of spectrum.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3194	3130	3194	3130	3194	3130
" weak to	3207	3117	3207	3117	3207	3117
(1) Absorption band from	3207 to 3228	3117 to 3097.5	3207 to 3228	3117 to 3097.5	3207 to 3223	3117 to 3097.5
Continuous, weak to	3263	3065	3359	2976.5	3359	2976.5
Two strong lines at	3297	3033	—	—	—	—
" "	3324	3008	—	—	—	—
(3) Absorption band from	3359 to 3379	2976.5 to 2959.5	3359 to 3379	2976.5 to 2959.5	3359 to 3379	2976.5 to 2959.5
Rays transmitted at	—	—	3379	2959.5	3379	2959.5
Continuous, feeble spectrum to	3399	2942	3399	2942	3399	2942
Thickness of layer of liquid	2 mm.		1 mm.			
Continuous, strong to	3194	3130	3194	3130		
" fairly strong to	—	—	3359	2976.5		
" weak to	3207	3117	3439	2906.5		
" feeble to	3228	3097.5	—	—		
[The absorption here is still plainly perceptible, although the rays are transmitted.]						
Continuous, weak spectrum to	3359	2976.5	—	—		
(3) Absorption band from	3359 to 3379	2976.5 to 2959.5	—	—		
Rays transmitted at	3379	2959.5	—	—		
Continuous to	3439	2906.5	—	—		
(4) Absorption band from	3439 to 4259	2906.5 to 2349	3439 to 4125	2906.5 to 2424.3		
One very faint line transmitted at	4259	2349	—	—		
Rays decreasing in strength to	—	—	4331	2310		

NAPHTHALENE—continued. 0.128 gram dissolved in 500 c.c.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3194	3130	3359	2976.5	3359	2976.5
" fairly strong to	3359	2976.5	—	—	—	—
" weak to.....	3439	2906.5	3439	2906.5	3439	2906.5
" feebly to	—	—	—	—	3561	2807
" very feebly to	—	—	3531	2831.5	—	—
Two feeble lines at	—	—	—	—	3647	2740
" "	—	—	—	—	3701	2701
(+) Absorption band from	3439 to 4016	2906.5 to 2490.5	3531 to 3890	2831.5 to 2568	3701 to 3861	2701 to 2589
Rays transmitted very feebly at	4016	2490.5	3890	2568	—	—
And also at	4038	2476	—	—	—	—
Extending weakly and not continuously to..	4331	2310	4331	2310	—	—
Rays transmitted at	—	—	—	—	3861	2589
" faint, not continuous to	—	—	—	—	4016	2490
" feeble continuous to	—	—	—	—	4374.4	2286
Thickness of layer of liquid.....	2 mm.		1 mm.			
Continuous, strong to.....	3359	2976.5	3359	2976.5	—	—
" fairly strong to.....	3439	2906.5	3439	2906.5	—	—
" weak to.....	3480	2875	3480	2875	—	—
" faint to.....	—	—	3861	2589	—	—
Weak, not continuous	3701	2701	—	—	—	—
(+) Absorption band from	3701 to 3861	2701 to 2589	—	—	—	—
Rays transmitted at	3861	2589	—	—	—	—
Faint continuous spectrum to	4374.4	2286	4426.7	2259	—	—

NAPHTHALENE—continued. 0.128 gram in 2500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	
Continuous, strong to	3359	2976·5	3359	2976·5	2863
" fairly strong to	3439	2906·5	3439	2906·5	2740
" weak to	3480	2875	3480	2875	2259
" faint to	3611	2768	3890	2568	—
Feebly continuous to	3861	2589	—	—	—
Faint	4426·7	2259	—	—	—
Continuous, weak to	—	—	4426·7	2259	—
Thickness of layer of liquid.....	2 mm.		1 mm.		
.. ..	Same as	the last.	—	—	—
Same as last with trace of a line at	—	—	4464·2	2240	—

NAPHTHALENE—continued. 0.128 gram in 12,500 c.c.

Thickness of layer of liquid.....		5 mm.		4 mm.		3 mm.	
Description of spectrum.		Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to		3493	2803	3493	2863		
" fairly strong to		3647	2740	3890	2568		
" weak to.....		4426.7	2259	4426.7	2259		
Trace of a line at		4464.2	2240	—	—		
Feebly continuous to		—	—	4464.2	2240		
Two faint lines at		—	—	—	—		
Same as last; a little stronger							
Thickness of layer of liquid.....		2 mm.		1 mm.			
Continuous, strong to				3493	2863		
" fairly strong to				3890	2568		
" weak to.....				4426.7	2259		
Feebly continuous to				4474.2	2235		
Two faint lines at				4566.2	2190		
" "				4660	2145.9		

ORTHO-XYLENE (Kahlbaum). 0.106 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.....	25 mm.		20 mm.		15 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to.....	3580	2793	3580	2793	3611	2768
" faint to.....	3611	2768	—	—	—	—
" weak to.....	—	—	3611	2768	—	—
Absorption band from.....	—	—	—	—	3611 to 4331	2768 to 2310
Rays transmitted feebly at.....	—	—	—	—	4331	2310
Thickness of layer of liquid.....	10 mm.		5 mm.		4 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to.....	3611	2768	3647	2740	3647	2740
" feebly to.....	3647	2740	—	—	—	—
Absorption band from.....	3647 to 4331	2740 to 2310	3647 to 4331	2740 to 2310	3647 to 4331	2740 to 2310
Rays transmitted weakly at.....	4253	2352	4125	2424.3	—	—
Extend to.....	4378.2	2284	—	—	—	—
Continuously to.....	—	—	4426.7	2259	—	—
Rays transmitted at (just a trace).....	—	—	—	—	4033	2479.5
Faint continuous from.....	—	—	—	—	4125	2424.3
To.....	—	—	—	—	4426.7	2259

ORTHO-XYLENE—*continued*. 0.106 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.	3 mm.		2 mm.		1 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to	3647	2740	3647	2740	3647	2740
" weak to	—	—	—	—	3677	2718
" very weak to	—	—	—	—	4426.7	2259
Absorption band from	3647 to 4331	2740 to 2310	3647 to 4331	2740 to 2310	—	—
Rays transmitted faintly at	4016	2490.5	—	—	—	—
Faintly, but not continuously to	4093	2444	—	—	—	—
Faint continuous spectrum to	4426.7	2259	—	—	—	—
Line faintly transmitted at	—	—	3707	2696.5	—	—
Rays transmitted at	—	—	4016	2490.5	—	—
Feebly continuous to	—	—	4426.7	2259	—	—

ORTHO-XYLENE—*continued*. 0.106 gram dissolved in 100 c.c. of alcohol.

Thickness of layer of liquid.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to	3647	2740	3677	2718	3707	2696.5
" weak to	4426.7	2259	—	—	—	—
" faint to	—	—	4464.2	2240	4464.2	2240
c	2 mm.		1 mm.			
Continuous, strong to	3080	3245.5	3080	3245.5	—	—
" fairly strong to	3707	2696.5	3707	2696.5	—	—
" faint to	4478	2233	4478	2233	—	—

33

c

32

ORTHO-XYLENE—*continued*. 0.106 gram dissolved in 500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm. and 3 mm.		Wave-lengths.
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	
Description of spectrum.	Continuous, strong to	3080	3245.5	3080	—
	" fairly strong to	3707	2696.5	3707	—
	" faint to	4478	2233	4478	—
	And to	—	—	4547.5	—
				2199	—
Thickness of layer of liquid.....	2 mm. and 1 mm.				
Continuous, strong to	3080	3245.5			
	3707	2699.5			
	4426.7	2259			
	4566.2	2190			

METAXYLENE (Kahlbaum). 0.106 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.....	25 mm.		20 mm.		15 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	Same as last.		3080	3245.5
" fairly strong to	3580	2793			3580	2793
" weak to	—	—			3611	2768

METAXYLENE—continued. 0.106 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid	10 mm.		5 mm.		4 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to	3580	2793	3611	2768	3647	2740
" weak to	3611	2768	—	—	—	—
" faint to	—	—	3647	2740	—	—
Absorption band from	3611 to 4331	2768 to 2310	3647 to 4331	2740 to 2310	3647 to 4331	2740 to 2310
Rays transmitted weakly at	—	—	4125	2424.3	4125	2424.3
Extension of spectrum to	—	—	4331	2310	4378.2	2284
Thickness of layer of liquid	3 mm.		2 mm.		1 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to	3647	2740	3647	2740	3647	2740
" very feebly continuous to	—	—	—	—	3890	2568
Absorption band from	3647 to 4331	2740 to 2310	3647 to 4331	2740 to 2310	—	—
Rays transmitted at	3701	2701	3701	2701	—	—
Continuous spectrum from	4125	2424.3	—	—	—	—
Extending faintly to	4378.2	2284	—	—	—	—
Also transmitted at	—	—	3890	2568	—	—
Faint not continuous to	—	—	4125	2424.3	—	—
Faint continuous to	—	—	4378.2	2284	—	—
Feebly continuous to	—	—	—	—	4426.7	2259

METAXYLENE—*continued*. 0.106 gram dissolved in 100 c.c. of alcohol.

Thickness of layer of liquid.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Description of spectrum.						
Continuous, strong to.	3080	3245·5	3080	3245·5	The same as at 4 mm.	
" fairly strong to.	3647	2740	3647	2740		
Very feebly continuous to.	3890	2568	—	—		
Feebly continuous to.	4426·7	2259	4426·7	2259		
Thickness of layer of liquid.	2 mm.		1 mm.			
Continuous, strong to.	3080	3245·5	3080	3245·5	—	—
" fairly strong to.	3647	2740	3647	2740	—	—
" faint to.	4426·7	2259	—	—	—	—
" weak to.	—	—	4464·2	2240	—	—

METAXYLENE. 0.106 gram dissolved in 500 c.c.

Thickness of layer of liquid.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.	3080	3245.5	The same as at 5 mm.		The same as at 4 mm.	
" fairly strong to.	3647	2740				
" weak to.	4464.2	2240				

METAXYLENE—*continued*. 0.106 gram dissolved in 100 c.c. of alcohol.

Thickness of layer of liquid	2 mm.		1 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5
" fairly strong to	3647	2740	3647	2740
" weak to	4478	2233	4566.2	2190
Very feebly continuous to	4566.2	2190	—	—

PARAXYLENE (Kahlbaum). 0.106 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid	25 mm.		20 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5
" fairly strong to	3537	2826.5	3537	2826.5
" faint to	—	—	—	—

3245.5
2826.5
2793

3080
3537
3580

15 mm.

20 mm.

25 mm.

30 mm.

35 mm.

40 mm.

45 mm.

50 mm.

55 mm.

60 mm.

65 mm.

70 mm.

75 mm.

80 mm.

85 mm.

90 mm.

95 mm.

100 mm.

105 mm.

110 mm.

115 mm.

120 mm.

125 mm.

130 mm.

135 mm.

140 mm.

145 mm.

150 mm.

155 mm.

160 mm.

165 mm.

170 mm.

175 mm.

180 mm.

185 mm.

190 mm.

195 mm.

200 mm.

205 mm.

210 mm.

215 mm.

220 mm.

225 mm.

230 mm.

235 mm.

240 mm.

245 mm.

250 mm.

255 mm.

260 mm.

265 mm.

270 mm.

275 mm.

280 mm.

285 mm.

290 mm.

295 mm.

300 mm.

305 mm.

310 mm.

315 mm.

320 mm.

325 mm.

330 mm.

335 mm.

340 mm.

345 mm.

350 mm.

355 mm.

360 mm.

365 mm.

370 mm.

375 mm.

380 mm.

385 mm.

390 mm.

395 mm.

400 mm.

405 mm.

410 mm.

415 mm.

420 mm.

425 mm.

430 mm.

435 mm.

440 mm.

445 mm.

450 mm.

455 mm.

460 mm.

465 mm.

470 mm.

475 mm.

480 mm.

485 mm.

490 mm.

495 mm.

500 mm.

505 mm.

510 mm.

515 mm.

520 mm.

525 mm.

530 mm.

535 mm.

540 mm.

545 mm.

550 mm.

555 mm.

560 mm.

565 mm.

570 mm.

575 mm.

580 mm.

585 mm.

590 mm.

595 mm.

600 mm.

605 mm.

610 mm.

615 mm.

620 mm.

625 mm.

630 mm.

635 mm.

640 mm.

645 mm.

650 mm.

655 mm.

660 mm.

665 mm.

670 mm.

675 mm.

680 mm.

685 mm.

690 mm.

695 mm.

700 mm.

705 mm.

710 mm.

715 mm.

720 mm.

725 mm.

730 mm.

735 mm.

740 mm.

745 mm.

750 mm.

755 mm.

760 mm.

765 mm.

770 mm.

775 mm.

780 mm.

785 mm.

790 mm.

795 mm.

800 mm.

805 mm.

810 mm.

815 mm.

820 mm.

825 mm.

830 mm.

835 mm.

840 mm.

845 mm.

850 mm.

855 mm.

860 mm.

865 mm.

870 mm.

875 mm.

880 mm.

885 mm.

890 mm.

895 mm.

900 mm.

905 mm.

910 mm.

915 mm.

920 mm.

925 mm.

930 mm.

935 mm.

940 mm.

945 mm.

950 mm.

955 mm.

960 mm.

965 mm.

970 mm.

975 mm.

980 mm.

985 mm.

990 mm.

995 mm.

1000 mm.

1005 mm.

1010 mm.

1015 mm.

1020 mm.

1025 mm.

1030 mm.

1035 mm.

1040 mm.

1045 mm.

1050 mm.

1055 mm.

1060 mm.

1065 mm.

1070 mm.

1075 mm.

1080 mm.

1085 mm.

1090 mm.

1095 mm.

1100 mm.

1105 mm.

1110 mm.

1115 mm.

1120 mm.

1125 mm.

1130 mm.

1135 mm.

1140 mm.

1145 mm.

1150 mm.

1155 mm.

1160 mm.

1165 mm.

1170 mm.

1175 mm.

1180 mm.

1185 mm.

1190 mm.

1195 mm.

1200 mm.

1205 mm.

1210 mm.

1215 mm.

1220 mm.

1225 mm.

1230 mm.

1235 mm.

1240 mm.

1245 mm.

1250 mm.

1255 mm.

1260 mm.

1265 mm.

1270 mm.

1275 mm.

1280 mm.

1285 mm.

1290 mm.

1295 mm.

1300 mm.

1305 mm.

1310 mm.

1315 mm.

1320 mm.

1325 mm.

PARAXYLENE—continued. 0.106 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid	10 mm.		5 mm.		4 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to	3537	2826.5	3537	2826.5	3580	2793
" faint to	3580	2793	—	—	—	—
" weak to	—	—	3580	2793	—	—
" feebly to	—	—	—	—	3611	3768
(1) Absorption band from	3580 to 4331	2793 to 2310	3580 to 4331	2793 to 2310	3611 to 4331	2768 to 2310
Rays transmitted feebly at	4253	2352	—	—	—	—
Spectrum extends to	4331	2310	—	—	—	—
Rays transmitted at	—	—	4125	2424.3	—	—
Faint and not continuous to	—	—	4253	2352	—	—
Feebly continuous to	—	—	4331	2310	—	—
Rays transmitted weak at	—	—	—	—	4125	2424.3
And at	—	—	—	—	4253	2352
Faint spectrum at	—	—	—	—	4347	2302.3
Trace of a line at	—	—	—	—	4378.2	2284
Thickness of layer of liquid	3 mm.		2 mm.		1 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to	3580	2793	3580	2793	3611	2768
" weak to	3611	2768	3611	2768	—	—
(1) Absorption band from	3611 to 4331	2768 to 2310	3611 to 4331	2768 to 2310	3611 to 3701	2768 to 2701
Rays transmitted weakly at	4016	2490	4016	2490	—	—
Faint spectrum not continuous to	4136	2418	4136	2418	—	—
Single ray transmitted weakly at	—	—	—	—	3701	2701
(2) Absorption band from	—	—	—	—	3701 to 3890	2701 to 2568
Weak not continuous to	—	—	—	—	4016	2490.5
Faint continuous spectrum to	4378.2	2284	4378.2	2284	4378.2	2284

PARAXYLENE—continued. 0.106 gram dissolved in 100 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to	3611	2768	3611	2768	3611	2768
" weak to	—	—	3635	2749	3635	2749
(1) Absorption band from	3611 to 3701	2768 to 2701	3635 to 3659	2749 to 2731	3635 to 3659	2749 to 2731
Single ray transmitted weakly at	3701	2701	—	—	—	—
A fairly strong line appears in the centre of this band at	—	—	3647	2740	—	—
Feebly continuous to	—	—	3701	2701	—	—
(2) Absorption band from	3701 to 3890	2701 to 2568	3701 to 3774	2701 to 2649.5	3701 to 3768	2701 to 2653
Rays transmitted faintly at	3797	2633.5	—	—	—	—
Weak discontinuous spectrum to	4016	2490.5	3890	2568	3890	2568
Faint continuous spectrum to	4378.2	2284	4378.2	2284	4426.7	2259
Fairly strong line at	—	—	—	—	3647	2740
Faint line at	—	—	4426.7	2259	—	—

PARAXYLENE—*continued*. 0.106 gram dissolved in 100 c.c. alcohol.

Thickness of layer of liquid	2 mm.		1 mm.		Wave-lengths.
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	
Continuous, strong to	3080	3245.5	3080	3245.5	—
" fairly strong to	3611	2768	3611	2768	—
" weak to	3635	2749	3635	2749	—
" feebly to	—	—	4426.7	2259	—
(1) Absorption band from	3635 to 3659	2749 to 2731	—	—	—
Strong line at	3647	2740	—	—	—
Faint continuous to	3701	2701	—	—	—
(2) Absorption band from	3701 to 3768	2701 to 2653	—	—	—
Very feebly continuous to	3890	2568	—	—	—
Faint continuous to	4426.7	2259	—	—	—

PARAXYLENE—*continued*. 0.106 gram dissolved in 500 c.c. alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	3808 3611 3635 4426.7	3245.5 2768 2749 2259	The same as 5 mm., but stronger.		The same as 5 mm., but stronger.	
Continuous, strong to						
" fairly strong to						
" weak to						
" faint to						
Thickness of layer of liquid.....						
	2 mm.		1 mm.			
Continuous, strong to	3808	3245	The same as 2 mm., with a faint line at 4566.2		—	
" fairly strong to	8647	2740			—	
" weak to	4426.7	2259			—	
Faint line at	4464.2	2240			—	

Pyridine (Kahlbaum). 0.079 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.	5 mm., 4 mm., and 3 mm.	
Description of spectrum.	Oscillation frequencies.	Wave-lengths.
Weak continuous to	2259	4414
Strong "	2615	3825
Fairly strong continuous to.....	3493	2863
Weak continuous to	3586	2788
Feebly "	3611	2768
Thickness of layer of liquid	2 mm. and 1 mm.	
Weak continuous to	2259	4414
Strong "	2615	3825
Fairly strong continuous to.....	3493	2863
Weak continuous to	3647	2740

PYRIDINE—continued. 0.079 gram dissolved in 100 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Description of spectrum.	Weak continuous to	4414	2259	4414	2259	4414
	Strong "	3245.5	3080	2740	3647	2740
	Fairly strong continuous to	2740	3647	—	—	—
	Very feebly "	2696.5	—	—	—	—
	Faint continuous to	—	3707	2696.5	—	—
	Weak continuous to	—	—	—	3707	2696.5
	Absorption band from	2696.5 to 2259	3707 to 4426.7	2696.5 to 2259	3707 to 4426.7	2696.5 to 2259
	Rays transmitted very feebly at	2259	—	—	—	—
	Rays transmitted feebly from	—	4331	2310	—	—
	To	—	4547.5	2199	—	—
	Rays transmitted at	—	—	—	4316	2318
	Spectrum extends, but is not continuous to	—	—	—	4566.2	2190
Thickness of layer of liquid	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Description of spectrum.	Weak continuous to	4414	2259	4414		
	Strong "	2740	3647	2740		
	Weak "	2696.5	3707	2696.5		
	Rays transmitted weak to	—	3832	2609		
	Absorption band from	2696.5 to 2259	3707 to 4253	2696.5 to 2352		
	Rays transmitted at	2318	4125	2424.3		
	Not continuous to	2148	—	—		
	Faint, not continuous to	—	4301	2326		
	Faint continuous to	—	4426.7	2259		
	Spectrum extends, but is not continuous to	—	4660	2148		

PYRIDINE—*continued*. 0.079 gram dissolved in 500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3647	2740	3647	2740	3647	2740
" fairly strong to.....	3707	2696.5	3707	2696.5	3707	2696.5
" weak to.....	3768	2653	3768	2653	3768	2653
" feeble to	—	—	3832	2609	3832	2609
Rays transmitted weakly to.....	3832	2609	—	—	—	—
Weak and not continuous to	—	—	—	—	3936	2538.5
Absorption band from	3768 to 4253	2653 to 2352	3768 to 4125	2653 to 2424.3	3768 to 4125	2653 to 2424.3
Rays transmitted at	4125	2424.3	4033	2479.5	4016	2490.5
Faint but not continuous spectrum at	4301	2326	4301	2326	4125	2326
" continuous to	4426.7	2259	4426.7	2259	—	—
Very feebly continuous to	—	—	4566.2	2190	4566.2	2190
Spectrum extends but is not continuous to.....	4660	2148	4660	2148	4660	2148
Thickness of layer of liquid.....	2 mm. and 1 mm.					
Continuous, strong to	3617	2740	—	—	—	—
" fairly strong to.....	3707	2696.5	—	—	—	—
" weak to.....	3768	2653	—	—	—	—
" faint to.....	3890	2568	—	—	—	—
Very feebly continuous to	4301	2326	—	—	—	—
Weak continuous to	4426.7	2259	—	—	—	—
Very feebly continuous to	4566.2	2190	—	—	—	—
Spectrum not continuous, extends to.....	4660	2148	—	—	—	—

PYRIDINE. 0·079 gram dissolved in 20 c.c. + HCl. 0·0365 gram in 20 c.c., or 0·1155 gram of the salt in 40 c.c.
Double thickness of cells taken.

Description of spectrum.	10 mm.		8 mm.		6 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245·5			3080	3245·5
" fairly strong to	3531	2826·5			3531	2826·5
" weak to	3580	2793	The same as with 10 mm.		3611	2768
Faint to	3611	2768			—	—
Very feebly continuous to	—	—			3647	2740
Thickness of layer of liquid.	4 mm.		2 mm.			
Continuous, strong to	3080	3245·5	3080	3245·5	—	—
" fairly strong to	3531	2826·5	3647	2740	—	—
" weak to	3647	2740	—	—	—	—
Absorption band from	3647 to 4426·7	2740 to 2259	3647 to 4426·7	2740 to 2259	—	—
Rays transmitted at one faint line	4426·7	2259	—	—	—	—
Rays transmitted weakly at	—	—	4331	2310	—	—
And extending, weak and not continuous to	—	—	4426·7	2259	—	—

PYRIDINE and HCl—*continued*. 0·1155 gram in 200 c.c., or equal to 0·1155 in 40 c.c. Diluted 2 c.c. to 10 c.c.

Thickness of layer of liquid.....	10 mm.		8 mm.		6 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245·5	3080	3244·5	3080	3245·5
„ fairly strong to	3647	2740	3647	2740	3647	2740
Line at (just visible)	—	—	3701	2701	—	—
Very feebly continuous to	—	—	—	—	3701	2701
Absorption band from	3647 to 4426·7	2740 to 2259	3701 to 4331	2701 to 2310	3701 to 4316	2701 to 2318
Rays transmitted at	4331	2310	—	—	—	—
Extend weak, not continuous to	4426·7	2259	4426·7	2259	4426·7	2259
Thickness of layer of liquid	4 mm.		2 mm.			
Continuous, strong to	3080	3245·5	3080	3245·5	—	—
„ fairly strong to	3647	2740	3647	2740	—	—
„ faint to	3701	2701	3701	2701	—	—
Very feebly continuous to	—	—	3762	2658	—	—
Absorption band from	3701 to 4253	2701 to 2352	3762 to 4125	2658 to 2424·3	—	—
Rays transmitted weak, but not continuous to ..	4566·2	2190	4253	2352	—	—
Faint continuous to	—	—	4456·3	2244	—	—
„ not continuous to	—	—	4660	2145·9	—	—

Pyridine and HCl—continued. 0.1155 gram dissolved in 1000 c.c.

Thickness of layer of liquid.....	10 mm.		8 mm.		6 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to.....	3647	2740	3647	2740	3647	2740
" weak to.....	3701	2701	3701	2701	3701	2701
Very feebly continuous to.....	3762	2658	—	—	—	—
Feebly continuous to.....	—	—	3762	2658	3762	2658
Absorption band from.....	3762 to 4125	2658 to 2424.3	3762 to 4125	2658 to 2424.3	3762 to 4028	2658 to 2482.5
Rays transmitted weak not continuous to.....	4253	2352	4253	2352	4253	2352
Weak continuous spectrum to.....	4456.3	2244	4426.7	2259	4426.7	2259
Not continuous to.....	4660	2145.9	4660	2145.9	4660	2145.9
Thickness of layer of liquid.....						
	4 mm.		2 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3080	3245.5	3080	3245.5	—	—
" fairly strong to.....	3647	2740	3647	2740	—	—
" weak to.....	3762	2658	3890	2568	—	—
" faint to.....	—	—	4253	2352	—	—
" weak to.....	—	—	4426.7	2259	—	—
" faint to.....	—	—	4566.2	2190	—	—
" feeble to.....	3890	2568	—	—	—	—
Very feebly continuous to.....	4136	2418	—	—	—	—
Faint continuous to.....	4253	2352	—	—	—	—
Weak ".....	4426.7	2259	—	—	—	—
Faint ".....	4460.3	2242	—	—	—	—
" not continuous to.....	4660	2145.9	—	—	—	—
Feebly continuous to.....	—	—	4660	3145.9	—	—

DIPYRIDINE (Dr. Ramsay). 0.158 gram dissolved in 1000 c.c. alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" weak to.....	3392	2948	3392	2948	3392	2948
" faint to.....	3493	2863	3493	2863	3493	2863
Faint to.....	3580	2793	3580	2793	—	—
Lines fairly strong, but not continuous to.....	—	—	—	—	3580	2793
Fairly strong line at.....	—	—	—	—	3647	2740
Thickness of layer of liquid	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Continuous, strong to	3080	3245.5	3080	3245.5		
" weak to.....	3392	2948	3392	2948		
" faint to.....	3556	2812	3556	2812		
Spectrum extends to.....	3890	2568	—	—		
The lines are fairly strong, but not continuous to	—	—	3890	2568		
Absorption band from	—	—	3890 to 4331	2568 to 2310		
Rays transmitted from.....	—	—	4331	2310		
To	—	—	4426.7	2259		

DIPYRIDINE—*continued*. 0.158 gram dissolved in 5000 c.c. alcohol.

Thickness of layer of liquid.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Description of spectrum.	Continuous, strong to.	3080	3245.5	3080	3080	3245.5
	" fairly strong to.	—	—	3493	3493	2863
	" weak to.	3392	2948	—	—	—
	" faint to.	3647	2740	3890	3647	2740
	The lines are fairly strong but not continuous to	3890	2568	—	—	—
	Absorption band from.	3890 to 4331	2568 to 2310	—	—	—
	Rays transmitted from.	4331	2310	—	—	—
	To.	4426.7	2259	—	—	—
	Rays are transmitted <i>very feebly</i> to.	—	—	4331	—	—
	Feebly continuous to.	—	—	—	3890	2568
	Rays transmitted feebly to.	—	—	—	4331	2310
	Spectrum extends to.	—	—	4543.3	4543.3	2201
Thickness of layer of liquid.	2 mm.		1 mm.			
Continuous, strong to.	Same as last spectrum.	3080	3245.5	—	—	
		3493	2863	—	—	
		3647	2740	—	—	
		4028	2482.5	—	—	
		4190	2387	—	—	
		4660	2145.9	—	—	

PICOLINE (Dr. Ramsay). 0.094 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.	3080	3245.5	3080	3245.5	3080	3245.5
" weak to.	3397	3033	3392	2948	3556	2812
" faint to.	3392	2948	—	—	—	—
Faint to.	3537	2826.5	—	—	—	—
Weak, not continuous to.	—	—	3537	2826.5	—	—
Thickness of layer of liquid.	2 mm.		1 mm.			
Continuous, strong to.	3080	3245.5	3556	2812	—	—
" weak to.	3556	2812	3580	2793	—	—
Fairly strong line at.	3580	2793	—	—	—	—
Absorption band from.	—	—	3580 to 4331	2793 to 2310	—	—

PICOLINE—continued. 0.094 gram dissolved in 100 c.c. alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3556	2812	3580	2793	3580	2793
" weak to.....	3580	2793	—	—	—	—
Absorption band from.....	3580 to 4331	2793 to 2310	3580 to 4331	2793 to 2310	3580 to 4331	2793 to 2310
Rays transmitted at.....	—	—	4426.7	2259	4462.7	2259
Thickness of layer of liquid.....	2 mm.		1 mm.			
Continuous, strong to.....	3580	2793	3580	2793	—	—
" weak to.....	—	—	3611	2768	—	—
Absorption band from.....	3580 to 4331	2793 to 2310	3647 to 4331	2740 to 2310	—	—
Rays transmitted at.....	4426.7	2259	4426.7	2259	—	—

PICOLINE—continued. 0·094 gram dissolved in 500 c.c. alcohol.

Thickness of layer of liquid.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3580	2793	3580	2793	3580	2793
" weak to.....	3611	2768	3647	2740	3647	2740
Absorption band from	3647 to 4331	2740 to 2310	3647 to 4331	2740 to 2310	3647 to 4331	2740 to 2310
Rays transmitted from.....	4038	2476	4038	2476	3647	2740
To	4426·7	2259	4543·3	2201	3890	2568
Also from.	—	—	—	—	4038	2476
To	—	—	—	—	4543·3	2201
Thickness of layer of liquid.	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Continuous, strong to.....	3580	2793	3647	2740		
" weak to.....	3647	2740	—	—		
Absorption band from	3647 to 4331	2740 to 2310	—	—		
Rays transmitted to	3930	2542	—	—		
Also from	4016	2490·5	—	—		
To	4543·3	2201	—	—		
Feebly continuous to	—	—	4426·7	2259		
Spectrum ends at	—	—	4560	2193		

QUINOLINE. Specimen I. Prepared from Coal-tar. 0.129 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
Thickness of layer of liquid.....	2 mm.		1 mm.			
Continuous, strong to	3080	3245.5	3080	3245.5	—	—
Feebly continuous to	—	—	3115	3208	—	—

QUINOLINE. Specimen I—continued. 0.129 gram dissolved in 100 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" faint to	3151	3171	3151	3171	—	—
" weak to	—	—	—	—	—	—
" fairly strong to	—	—	—	—	3151	3171
Thickness of layer of liquid.....	2 mm.		1 mm.			
Continuous, strong to	3151	3171	3151	3171	—	—

QUINOLINE. Specimen I—continued. 0.129 gram dissolved in 500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to faint to	3151	3171	3151	3171	3151	3171
" Absorption band from	—	—	—	—	3187	3140
Rays transmitted faintly from To	3832	3171 to 2568	3151 to 3228	3171 to 3097.5	3187 to 3228	3140 to 3097.5
Rays transmitted at	4185	2609	—	—	—	—
" feebly continuous to	—	2390	—	—	—	—
(2) Absorption band from	—	—	3228	3097.5	3228	3097.5
Faint line at	—	—	3242	3085	3242	3085
(3) Absorption band from	—	—	3242 to 3297	3085 to 3033	3242 to 3290	3085 to 3039
Rays faintly transmitted from	—	—	3359	2976.5	—	—
Spectrum extends, weak but not continuous to	—	—	3297 to 3537	3033 to 2826.5	—	—
	—	—	4185	2330	—	—
	—	—	—	—	4185	2390
Thickness of layer of liquid.....						
	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to faint to	3151	3171	3151	3171	—	—
" Absorption band from	3187	3140	3187	3140	—	—
Rays transmitted at	3228	3140 to 3097.5	3187 to 3200	3140 to 3123.5	—	—
" feebly continuous to	3249	3097.5	3200	3123.5	—	—
" weak continuous to	—	3078	—	—	—	—
(2) Absorption band from	3249 to 3290	3078 to 3039	3249	3078	—	—
Very feebly continuous to	4248	2355	3249 to 3290	3078 to 3039	—	—
Faint continuous to	—	—	—	—	—	—
Feebly	—	—	3392	2948	—	—
Spectrum very feebly continuous to	—	—	4185	2390	—	—
	—	—	4248	2355	—	—

QUINOLINE. Specimen I—continued. 0.129 gram dissolved in 2500 c.c. of alcohol.

Description of spectrum.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3151	3171	3151	3171	3151	3171
" weak to.....	3647	2740	3647	2740	3890	2568
" faint to.....	4248	2355	4248	2355	4248	2355
Spectrum ends at	—	—	4296	2329	4326	2313
Thickness of layer of liquid.....	2 mm.		1 mm.			
Continuous, strong to.....	3151	3171	3647	2740	—	—
" fairly strong to	3647	2740	3890	2568	—	—
" weak to	3890	2568	4248	2355	—	—
" faint to	4326	2313	4331	2310	—	—
Two faint lines at	4371	2289	—	—	—	—
Spectrum extends to but is not continuous.....	4386.7	2264.5	4660	2148	—	—

QUINOLINE HYDROCHLORIDE. Specimen I—continued. 0.129 gram dissolved in 20 c.c. of alcohol. To the solution of Quinoline, HCl was added till the solution gave an acid reaction.

Description of spectrum.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	2803	3569	2803	3569	2803	3569
" feebly to.....	—	—	2833.5	3530	—	—
" faint to.....	—	—	—	—	2833.5	3530
Very feeble line at	—	—	—	—	2887	3464

Thickness of layer of liquid	2 mm.		1 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	2803	3569	2803	3569
" weak to	2833·5	3530	2887	3464
" feeble to	2887	3464	—	—

QUINOLINE + HCl. Specimen I—*continued*. 0·129 gram dissolved in 100 c.c. of alcohol.

Thickness of layer of liquid	5 mm.		4 mm.		3 mm.
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.
Continuous, strong to	2803	3569	2803	3569	2887
" weak to	2887	3464	2887	3464	2918
" feeble to	2918	3420	—	—	—
" faint to	—	—	2941	3403	2941
Absorption band from	—	—	—	—	2941 to 3647
					3403 to 2740

Thickness of layer of liquid	2 mm.		1 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	2887	3464	2887	3464
" weak to	2918	3420	2941	3403
" faint to	2941	3403	3008	3324
Absorption band from	2941 to 3647	3403 to 2740	3008 to 3647	3324 to 2740
Rays transmitted at	—	—	3525	2836·5
And extend, but are not continuous to	—	—	3890	2568
Line visible at	—	—	4044	2472·5

QUINOLINE + HCl. Specimen I—*continued*. 0.129 gram dissolved in 500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	2887	3464	2887	3464	2887	3464
" weak to.....	2941	3403	3008	3324	3008	3324
" faint to.....	3008	3324	—	—	3073	3253
" feeble to.....	—	—	3073	3253	—	—
Absorption band from.....	3008 to 3647	3324 to 2740	3073 to 3647	3253 to 2740	3073 to 3647	3253 to 2740
Rays transmitted at.....	3525	2836.5	3493	2863	3493	2863
" extend (not continuous) to.....	—	—	4044	2472.5	—	—
" extend (feebly continuous) to.....	—	—	—	—	4044	2472.5
Thickness of layer of liquid.....	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Continuous, strong to.....	2887	3464	3080	3245.5		
" weak to.....	3008	3324	—	—		
" faint to.....	3080	3245.5	—	—		
" feeble to.....	—	—	4130	2421		
Absorption band from.....	3080 to 3647	3245.5 to 2740	—	—		
Rays transmitted at.....	3487	2869	—	—		
" extend feebly continuous to.....	4044	2472.5	—	—		

QUINOLINE + HCl. Specimen I—*continued*. 0·129 gram dissolved in 2500 c.c. of alcohol.

Thickness of layer of liquid.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.	3080	3245·5	3080	3245·5	3080	3245·5
" feeble to.	4136	2418	—	—	—	—
" faint to.	—	—	3493	2863	3493	2863
" weak to.	—	—	4044	2472·5	4044	2472·5
" faint to.	—	—	4136	2418	4136	2418
Absorption band from	—	—	4136 to 4547·5	2418 to 2199	4136 to 4547·5	2418 to 2199
Rays transmitted at	—	—	—	—	4426·7	2259
Extend, but are not continuous to	—	—	—	—	4566·2	2190
Thickness of layer of liquid.	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.				
Continuous, strong to.	3080	3245·5				
" faint to.	3859	2976·5				
" weak to.	4044	2472·5				
" faint to.	4136	2418				
Very feeble, not continuous to.	4190	2387				
Absorption band from	4136 to 4547·5	2418 to 2199				
Rays transmitted at	4831	2310				
Extend to	4660	2148				

QUINOLINE. Specimen II. Prepared synthetically by Skrap's reaction. 0.129 gram dissolved in 20 c.c. of alcohol.

Description of spectrum.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
Thickness of layer of liquid.....	2 mm.		1 mm.			
Continuous, strong to.....	3080	3245.5	3080	3245.5	—	—

QUINOLINE. Specimen II—continued. 0.129 gram dissolved in 100 c.c. of alcohol.

Description of spectrum.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3080	3245.5	3080	3245.5	3080	3245.5
" faint to.....	—	—	3115	3208	3115	3208
Thickness of layer of liquid.....	2 mm.		1 mm.			
Continuous, strong to.....	3080	3245.5	3080	3245.5	—	—
" faint to.....	3151	3171	—	—	—	—
" weak to	—	—	3151	3171	—	—

QUINOLINE. Specimen II—*continued*. 0.129 gram dissolved in 500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3151	3171	3151	3171	3151	3171
" very feeble to.....	—	—	3359	2976.5	—	—
" feeble to.....	—	—	—	—	3359	2976.5
Absorption band from.....	3151 to 3890	3171 to 2568	3359 to 3493	2976.5 to 2863	3359 to 3493	2976.5 to 2863
Rays transmitted feebly to.....	3890	2568	—	—	—	—
Rays transmitted to not continuous.....	—	—	4130	2421	—	—
" weak at.....	—	—	—	—	3493	2863
Extend to but are not continuous at.....	—	—	—	—	4130	2421
Thickness of layer of liquid.....	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Continuous, strong to.....	3151	3171	3151	3171		
" faint to.....	3359	2976.5	3647	2740		
" feeble to.....	4130	2421	4185	2390		

QUINOLINE. Specimen II—continued. 0.129 gram dissolved in 2500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3151	3171	3151	3171	3151	3171
" fairly strong to.....	—	—	—	—	3647	2740
" weak to.....	—	—	3647	2740	4028	2482.5
" faint to.....	3647	2740	3890	2568	4190	2387
Spectrum extends to.....	—	—	—	—	4243	2358
Thickness of layer of liquid.....	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Continuous, strong to.....	3151	3171	3647	2740		
" fairly strong to.....	3647	2740	3890	2568		
" weak to.....	4028	2482.5	4136	2418		
" faint to.....	4185	2390	4426.7	2259		
Spectrum extends to (weak but not continuous).	4248	2355	4660	2145.9		

PIPERIDINE (Kahlbaum). 0.085 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to.....	3647	2740	3647	2740	3647	2740
" weak to.....	3890	2568	3890	2568	3890	2568
" faint to.....	3970	2519	4016	2490.5	4016	2490.5
Weak line at.....	4038	2476	4038	2476	4044	2472.5
Spectrum extends feebly, but is not continuous to.....	—	—	4185	2390	4331	2310

Thickness of layer of liquid.....	2 mm.		1 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3080	3245.5	3647	2740
" fairly strong to.....	3647	2740	3890	2568
" weak to.....	3890	2568	4130	2421
" faint to.....	4044	2472.5	—	—
Very feebly continuous to.....	4185	2390	—	—
Spectrum extends to.....	4374.4	2286	—	—

TETRAHYDROQUINOLINE. A distillate boiling between 240° and 250° C. 0.133 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3008.5	3324	3008.5	3324	3008.5	3324

TETRAHYDROQUINOLINE—*continued*. 0.133 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.	2 mm.		1 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.	3008.5	3324	3073	3253
Fairly strong line at.	3051.5	3275.5	—	—
Weak line at.	3073	3253	—	—

TETRAHYDROQUINOLINE. A distillate boiling between 240° and 250° C. 0.133 gram dissolved in 100 c.c. of alcohol.

Thickness of layer of liquid.	5 mm.		4 mm.		3 mm.
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.
Continuous, strong to.	3073	3253	3080	3245.5	3080
Faint line at.	—	—	—	—	3151
Absorption band from.	—	—	—	—	3151 to 3647
Very faint line at.	—	—	—	—	3647

Thickness of layer of liquid.	2 mm.		1 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.	3080	3245.5	3080	3245.5
" faint to.	—	—	3151	3171
Fairly strong line at.	3151	3171	—	—
Absorption band from.	3151 to 3500	3171 to 2857.5	3151 to 3493	3171 to 2863
Rays transmitted faint, but not continuous to.	3647	2740	—	—
Rays transmitted weak, but not continuous to.	—	—	3701	2701

TETRAHYDROQUINOLINE—*continued*. A distillate boiling between 240° and 250° C. 0.133 gram dissolved in 500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3080	3245.5	3080	3245.5	3080	3245
" weak to.....	3151	3171	3151	3171	3701	2701
Very feebly continuous to.....	3647	2740	3647	2740	—	—
Absorption band from.....	—	—	3701 to 4331	2701 to 2310	3768 to 4253	2653 to 2352
Rays transmitted, faint at	—	—	4331	2310	4426.7	2259
Thickness of layer of liquid.....	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Continuous, strong to.....	3080	3245.5	3080	3245.5		
" fairly strong to.....	3151	3171	3151	3171		
" weak to.....	3890	2568	3768	2653		
" very faint to	—	—	3890	2568		
Absorption band from.....	3890 to 4125	2568 to 2424.3	—	—		
Rays transmitted weak, but not continuous to..	4321	2315.5	—	—		
Very feebly continuous to	4426.7	2259	—	—		
Faint not continuous to	—	—	4253	2352		
Weak continuous to	—	—	4426.7	2259		
Spectrum extends very faint, not continuous to.	—	—	4566.2	2190		

TETRAHYDROQUINOLINE—*continued*. A distillate boiling between 240° and 250° C. 0.133 gram dissolved in 2500 c.c. of alcohol.

Thickness of layer of liquid.	5 mm.		4 mm. and 3 mm.		Wave-lengths.
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	
Continuous, strong to	3080	3245.5	3080	3245.5	—
" fairly strong to	3151	3171	3151	3171	—
" weak to	3768	2653	3768	2653	—
" very faint to	3890	2568	—	—	—
" faint to	—	—	4253	2352	—
" weak to	—	—	4426.7	2259	—
" Rays transmitted faint, but not continuous to ..	4253	2352	—	—	—
Weak continuous to	4426.7	2259	—	—	—
Spectrum extends very faint, but not continuous to	4543.3	2201	4566.2	2190	—
Thickness of layer of liquid.	2 mm.		1 mm.		
Continuous, strong to	The same as with 3 mm., but a little stronger.		3151	3171	—
Gradually weakening to					

A portion of this substance with a different boiling point, from 235—240°, was dissolved in the same molecular proportion, *i.e.*, 0.133 gram in 20 c.c. alcohol, and diluted accordingly. It gave identically the same photographs as the portion described here, which distilled over from 240—250°.

TETRAHYDROQUINOLINE HYDROCHLORIDE (Kahlbaum). 0.1695 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.....	10 mm.		9 mm.		8 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	2615	3825	—	—	2615	3825
" weak to.....	2934	3411	—	—	3008	3324
" faint to.....	3008	3324	—	—	—	—
Faint line at.....	—	—	—	—	3073	3253
The same as with 1c mm., with a very feeble line at.....	—	—	3073	3253	—	—
Thickness of layer of liquid.....	7 mm.		6 mm.		5 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	2615	3825	2615	3825	2615	3825
" weak to.....	2934	3411	3008	3324	3008	3324
" faint to.....	3008	3324	3080	3245.5	3080	3245
Absorption band from.....	3080 to 3574	3245.5 to 2798	3080 to 3574	3245.5 to 2798	3080 to 3574	3245.5 to 2798
A single line transmitted at.....	3531	2831.5	3531	2831.5	—	—
{ With single lines transmitted at.....	—	—	—	—	3487	2869
	—	—	—	—	3531	2831.5
	—	—	—	—	3647	2740

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TETRAHYDROQUINOLINE HYDROCHLORIDE—*continued*. 0.1695 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.....	4 mm.		3 mm.		2 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	2615	3825	2615	3825	2615	3825
" fairly strong to.....	—	—	—	—	3008	3324
" weak to.....	3080	3245.5	3080	3245.5	3080	3245.5
" feeble to.....	—	—	—	—	3151	3171
Weak line at.....	—	—	3151	3171	—	—
Absorption band from	3080 to 3487	3245.5 to 2869	3151 to 3359	3171 to 2976.5	3151 to 3297	3171 to 3033
Rays transmitted at.....	3487	2869	3359	2976.5	3297	3033
To.....	3647	2740	—	—	—	—
Extend not continuous to.....	—	—	3647	2740	3647	2740
Thickness of layer of liquid.....	1 mm.					
	Oscillation frequencies.	Wave-lengths.				
Continuous, strong to.....	2615	3825				
" fairly strong to.....	3008	3324				
" weak to.....	3080	3245.5				
Feebly continuous to.....	3647	2740				
Absorption band from	3647 to 4331	2740 to 2310				

TETRAHYDROQUINOLINE HYDROCHLORIDE—*continued*. 0.1695 gram dissolved in 100 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	2615	3825	2615	3825	2615	3825
" fairly strong to	3088	3324	3088	3324	3080	3245.5
" weak to.....	3080	3245.5	3080	3245.5	3151	3171
" feeble to	3647	2740	3647	2740	3647	2740
Absorption band from	3647 to 4331	2740 to 2310	3647 to 4331	2740 to 2310	3647 to 4331	2740 to 2310
Rays transmitted at	—	—	4331	2310	—	—
And extending (not continuous) to.....	—	—	4426.7	2259	—	—
Rays transmitted but not continuous from.....	—	—	—	—	3647	2740
To	—	—	—	—	3890	2568
Rays also transmitted at	—	—	—	—	4331	2310
Extend (not continuous) to.....	—	—	—	—	4426.7	2259
Thickness of layer of liquid.....	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Continuous, strong to.....	2615	3825	2615	3825		
" fairly strong to	3080	3245.5	3080	3245.5		
" weak to.....	3187	3140	3187	3140		
" faint to.....	3647	2740	3647	2740		
Very feebly continuous to	—	—	3890	2568		
Absorption band from	3647 to 4331	2740 to 2310	3647 to 4331	2740 to 2310		
Rays weakly transmitted from	3647	2740	4038	2476		
To	3890	2568	4426.7	2259		
Rays also transmitted at	4296	2339	—	—		
And extend (not continuous) to.....	4426.7	2259	—	—		

TETRAHYDROQUINOLINE HYDROCHLORIDE--continued. 0.1695 gram dissolved in 500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	2615	3825			2615	3825
" fairly strong to.....	3080	3245.5			3080	3245.5
" weak to.....	3187	3140			3187	3140
" faint to.....	3647	2740	The same as 5 mm.		4426.7	2259
" very feeble to.....	3890	2568			—	—
Very feeble line at.....	—	—			4543.3	2201
Absorption band from	3647 to 4331	2740 to 2310			—	—
Rays transmitted at.....	4038	2476			—	—
Extend to.....	4426.7	2259			—	—
Thickness of layer of liquid.....	2 mm.		1 mm.			
The same, but a little stronger, and weak line at	The same	as 3 mm.	4555.8	2195	—	—

ORTHOTOLUIDINE HYDROCHLORIDE. 0.107 gram of base dissolved in 20 c.c. of an alcoholic solution of hydrochloric acid.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3080	3245.5			3493	2863
" fairly strong to, but decreasing in strength	3359	2976.5	The same as 5 mm.		—	—
" feebly to.....	3647	2740			—	—
Weak continuous to.....	—	—			3701	2701
Absorption band from	—	—			3701 to 4426.7	2701 to 2259
Rays transmitted very faint at	—	—			4426.7	2259
Thickness of layer of liquid.....	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Continuous, strong to	—	—	3647	2740	—	—
" weak to	—	—	3701	2701	—	—
" feebly to	—	—	3768	2653	—	—
Continuous to	3647	2740	—	—	—	—
Weak continuous to	3701	2701	—	—	—	—
Absorption band from	3701 to 4331	2701 to 2310	—	—	—	—
Rays transmitted feebly at	4125	2424.3	—	—	—	—
Spectrum extends to.....	4331	2310	4547.5	2199	—	—
Weak discontinuous to.....	4426.7	2259	—	—	—	—
Faint line at.....	4464.2	2240	—	—	—	—

ORTHO-TOLUIDINE HYDROCHLORIDE—continued. 0.107 gram of base dissolved in 100 c.c. of an alcoholic solution of hydrochloric acid.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Description of spectrum.						
Continuous, strong to	The spectrum	the same as at	3080	3245·5		
" fairly strong to	1 mm. of	the original	3647	2740		
" weak to	solution.		3701	2701	The same as	with 4 mm.
" feeble to			3768	2653		
Faint discontinuous to			4547·5	2199		
Thickens of layer of liquid.	2 mm.		1 mm.			
Continuous spectrum strong to	3080	3245·5				
Weak to	4566·2	2190	Same as 2 mm.	but stronger.	--	--

ORTHOLOUIDINE HYDROCHLORIDE—continued. 0.107 gram of base dissolved in 500 c.c. of an alcoholic solution of hydrochloric acid.

Thickness of layer of liquid.....	5 mm.	4 mm.	3 mm.
Continuous, strong to.....	3080		
Fairly strong to.....	3647		
Weak to.....	3890	The same, but stronger.	The same, but stronger.
Feebly continuous to.....	4556·2	2190	
Thickness of layer of liquid.....	2 mm.	1 mm.	
The same, but stronger, the spectrum extending to	The same, but stronger.	4660	2146
			—

PARATOLUIDINE. 0.107 gram dissolved in 20 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" feeble to.....	—	—	3115	3208	—	—
" weak to.....	—	—	—	—	3115	3208
Feeble line at.....	—	—	3151	3171	—	—
Weak line at	—	—	—	—	3151	3171
Thickness of layer of liquid.....	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.		
Continuous, strong to.....	3080	3245.5	3080	3245.5		
" weak to.....	3115	3208	—	—		
" fairly strong to	—	—	3151	3171		
" very feeble to.....	—	—	3157	3140		
Fairly strong line at	3151	3171	—	—		

PARATOLUIDINE—*continued*. 0.107 gram dissolved in 100 c.c. of alcohol.

Thickness of layer of liquid.	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to	3151	3171	3151	3171	3151	3171
" very feeble to	3187	3140	—	—	—	—
" feeble to	—	—	3194	3130	—	—
Feebly continuous to	—	—	—	—	3194	3130
Absorption band from	3151 to 3701	3171 to 2701	3151 to 3647	3171 to 2740	3151 to 3647	3171 to 2740
Rays transmitted very faintly at.	3701	2701	—	—	—	—
Rays transmitted at	—	—	3647	2740	3647	2740
And extends very weakly and not continuously to	—	—	3803	2629.5	—	—
Rays extend to	—	—	—	—	3832	2609
Thickness of layer of liquid.	2 mm.		1 mm.			
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to	3080	3245.5	3080	3245.6	—	—
" fairly strong to	3151	3171	3187	3140	—	—
" weak to	3324	3008	3890	2568	—	—
Absorption band from	3324 to 3493	3008 to 2863	—	—	—	—
Rays transmitted at	3493	2863	—	—	—	—
" extend weakly and not continuously to...	3890	2568	—	—	—	—

PARATOLUIDINE—*continued*. 0.107 gram dissolved in 500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.		
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	
Description of spectrum.							
Continuous, strong to.....	3080	3245.5	The same as with 5 mm.	3080 3187 3930	3245 3140 2542		
Fairly strong continuous to.....	3187	3140					
Weakening progressively to.....	3930	2542					
Thickness of layer of liquid.....	2 mm.		1 mm.				
Continuous, strong to..... Fairly strong continuous to..... The spectrum diminishing in strength to..... Absorption band from Rays transmitted very faint at Traces of lines at..... Rays transmitted, weak and not continuous, to..... Rays also transmitted weak, but not continuous to.....	3080	3245.5	3080	3245.5	—	—	
	3187	3140	3187	3140	—	—	
	4033	2479.5	4033	2479.5	—	—	
	3890 to 4426.7	2568 to 2259	4033 to 4331	2479.5 to 2310	—	—	
	4426.7	2259	—	—	—	—	
	4547.5	2199	—	—	—	—	
	4566.2	2190	—	—	—	—	
	4660	2145.9	—	—	—	—	
	—	—	4136	2418	—	—	
	—	—	4660	2145.9	—	—	

PARATOLUIDINE—continued. 0.107 gram dissolved in 2500 c.c. of alcohol.

Thickness of layer of liquid.....	5 mm.		4 mm.		3 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Description of spectrum.	Continuous, strong to.....					
	" fairly strong to.....	3080	3245	3187	3140	
	" weak to.....	3187	3140	—	—	
	Spectrum diminishing in strength to.....	—	—	4426.7	2259	
	Spectrum extends faintly to.....	4083	2479.5	—	—	
	Absorption band from.....	—	—	4660	2145.9	The same as with 4 mm.
	Rays transmitted weakly at.....	4083 to 4331	2479.5 to 2310	—	—	
	" also transmitted weakly, and not con-	4186	2418	—	—	
	tinuously to.....	4660	2145.9	—	—	
	Thickness of layer of liquid.....	2 mm.		1 mm.		
The same as with 3 mm., but a little stronger.			3187	3140	—	—
Continuous, strong to.....			4660	2145.9	—	—
Weakly continuous to.....						

PARATOLUIDINE. 0.107 gram dissolved in 20 c.c. of alcohol, mixed with an alcoholic solution of hydrochloric acid, 0.0365 gram dissolved in 20 c.c., or 0.1435 gram of the salt in 40 c.c. For these mixed solutions double thicknesses of cells were taken.

Thickness of layer of liquid.....	10 mm.		8 mm.		6 mm.	
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.
Continuous, strong to.....	3080	3245.5	3080	3245.5	3080	3245.5
" fairly strong to	3647	2740	3647	2740	3647	2740
Feebly continuous to.....	—	—	—	—	3666	2727
Absorption band from	3647 to 4253	2740 to 2352	3647 to 4253	2740 to 2352	3701 to 4120	2701 to 2427.0
Rays transmitted weakly to.....	4426.7	2259	4426.7	2259	—	—
Faint not continuous to.....	—	—	—	—	4331	2310
Feebly continuous to.....	—	—	—	—	4426.7	2259
Thickness of layer of liquid.....	4 mm.		2 mm.			
Continuous, strong to.....	3080	3245.5	3080	3245.5	—	—
Diminishing in strength to	4474.2	2235	4474.2	2235	—	—
PARATOLUIDINE + HCl—continued. 0.1435 gram dissolved in 200 c.c. of alcohol (or equal to 0.1435 gram in 40 c.c. diluted 2 c.c. to 10 c.c.).						
Thickness of layer of liquid.....	10 mm.		8 mm.		6 mm.	
Continuous, strong to.....	3080	3245.5	The same as 10 mm.	as 10 mm.	The same	as 8 mm.
" diminishing in strength to	4474.2	2235				

Thickness of layer of liquid.....	4 mm.		2 mm.		Wave-lengths.
	Oscillation frequencies.	Wave-lengths.	Oscillation frequencies.	Wave-lengths.	
Description of spectrum.					
Continuous, strong to.....	3080	3245·5	3080	3245·5	—
” fairly strong to	3701	2701	3701	2701	—
” feeble to.....	4547·5	2129	4566·2	2190	—
Decreasing in strength to.....			—	—	—

Scale of Oscillation-frequencies.

Curve of Molecular Vibrations—
METAXYLENE.

Scale of Oscillation-frequencies.

Scale of Oscillation-frequencies. *Curves of Molecular Vibrations—***QUINOLINE AND QUINOLINE HYDROCHLORIDE.***The dotted line represents the hydrochloride.*

Curves of Molecular Vibrations—

TETRAHYDROQUINOLINE and TETRAHYDROQUINOLINE HYDROCHLORIDE.

The dotted line represents the hydrochloride.

Scale of Oscillation-frequencies.

ORTHOTOLUIDINE and ORTHOTOLUIDINE HYDROCHLORIDE.

The dotted line represents the hydrochloride.

Scale of Oscillation-frequencies.

Curves of Molecular Vibrations—

PARATOLUIDINE and PARATOLUIDINE HYDROCHLORIDE.

The dotted line represents the hydrochloride.