SOME OPTICAL PROPERTIES OF IODINE.

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IODINE is an interesting example of apparently several allotropic states. At low temperatures iodine vapor¹ gives a banded absorption spectrum from red to violet. As the temperature increases, absorption in the blue and violet increases, and finally becomes continuous. At still higher temperatures blue and violet are again transmitted and bands appear.

The relation of the spectra of chlorine and bromine gases² to that of iodine has also been extensively investigated. It has been found that for the halogen group the absorption lines shift toward the red with increasing atomic weight.

According to Gänge³ iodine is the only element which distinguishes itself by peculiar properties towards two groups of solvents. The first group, to which belong water, the alcohols, ethers, etc., with increasing concentration, dissolves iodine with a yellow to a dark brown color. In this group the solutions appear in colors which resemble closely those of solid and liquid iodine by transmitted light. The second group, to which belong carbon bisulphide, chloroform, benzol, etc., dissolves iodine with a violet color, which resembles more nearly that of the vapor, and gives the same spectrum. Hence, the molecular arrangement in the first group of solutions is assumed similar to that of solid and liquid iodine, and in the second group similar to that of the vapor.

The second group is also assumed to have a simpler structure. To test this the CS₂ solution was cooled in a mixture of solid carbon dioxide and ether. It became brown.⁴ In solutions of

¹ Konen, Wied. Ann., 65, p. 258 (1898), gives a very complete bibliography of work done on iodine vapor—both emission and absorption spectra. See also Kayser, Spectralanalyse, p. 284.

² E. Laird, Astrophys. Jour., Sept., 1901, for bibliography.

³ Gänge, Lehrbuch der angewand. Optik in der Chemie, p. 225.

⁴ E. Wiedemann, Sitzber. Phys. Soc. Erlangen, 1887.

iodine in carbon bisulphide above the critical temperature, where the state approximates that of a gas, but the density that of a liquid, Wood¹ found that a continuous or banded spectrum appeared according to the amount of the solvent. These bands seemed to appear only in the presence of an excess of free iodine and each aggregation apparently caused a change of spectrum.

Of a different nature is Tyndall's ingenious work on the diathermancy of iodine in carbon bisulphide. He discovered this property for the infra-red rays² in 1865, and "to make radiant heat an explorer of molecular conditions," he used the carbon bisulphide solutions to filter the obscure from the luminous rays.³

It is the purpose of the present paper to describe some experiments upon the optical properties of this interesting element. The work divides itself into four parts, viz.:

1. The study of the absorption spectrum of iodine in solution.
2. The study of the absorption spectrum of solid and liquid iodine. Comparison of the thickness of iodine as a film, and in solution.
3. Pleochroism of iodine.
4. Anomalous dispersion in solid and liquid iodine.

I. THE ABSORPTION SPECTRUM OF IODINE IN SOLUTION.

So far as the writer is aware no recent or systematic investigations of the optical properties of iodine dissolved in carbon bisulphide have been made, although iodine solutions have been used in the determination of the radiant efficiency of various sources of light for nearly half a century.

Desain and Aymonet,⁴ using a quartz prism and thermopile, report a "cold" band in the infra-red at an angle of $1^{\circ} 30'$ from the extreme red.

In 1883, H. Becquerel⁵ found that a concentrated solution, 2.5 cm. in thickness, absorbed all the rays up to the A line and allowed the less refrangible to pass.

¹ Wood, *Phil. Mag.*, 41, 1896.

² Tyndall, *Poggendorf's Ann.*, Bd. 124 (1865).

³ Tyndall, *Contributions to Molecular Physics*.

⁴ Desain and Aymonet, *Compt. Rend.*, 81, p. 423 (1875).

⁵ H. Becquerel, *Ann. Chem. et Phys.* (5), 30 (1883).

In the following paragraphs it is proposed to describe measurements of the absorption spectrum of iodine solutions, which were made for the purpose of obtaining more definite information concerning these and other points.

1. Measurements in the Visible Spectrum.

In the study of the visible spectrum a "horizontal slit" spectrophotometer¹ was used. A series of thirteen solutions containing from 3.3 to 0.017 milligrams of iodine per cubic centimeter of carbon bisulphide was prepared, by dilution. Although not very economical, this method reduced the errors in the concentrations. The cell containing these solutions had thin walls of lantern slide glass. The thickness of the liquid layer was 1.5 centimeters.

Measurements of the transmitting power of these solutions were made for 19 different regions of the spectrum between 0.74μ and 0.46μ . The effect of the cell walls and of the solvent were eliminated by observations upon the cell filled with clear carbon bisulphide. The absorption of iodine in the visible spectrum was found to consist of a single broad band with its maximum at wave-length $\lambda = 0.5\mu$, the transmission curve being steeper on the side towards the violet.

Fig. 1. Iodine in CS_2 .

The gradual development of this absorption band is best indicated in Fig. 1, which shows the transmitting power throughout the visible spectrum of several solutions 1 cm. in thickness. The data for these curves were obtained by substituting the values given in Table I. in the formula $\frac{n}{m} \log \frac{I_0}{I_m} = \log \frac{I_0}{I_n}$, where n and m are the relative thicknesses, I_0 is the intensity of the incident and I_m is the

¹ E. L. Nichols, PHYSICAL REVIEW, Vol. II., p. 140.

transmitted light, and are given in Table II. For the weakest solution, 0.017 mg. per c.c., the transmission in the maximum of the band is about 64 per cent., which corresponds to a transmission of nearly 80 per cent. for a layer one centimeter thick. As the concentration increases the absorption band widens and becomes more dense, so that a solution of only 0.25 mg. per c.c. transmits only about 2 per cent. in the center of the band. All stronger solutions are opaque in this region, and as the concentrations increase this opacity extends, until finally the whole of the visible spectrum is absorbed. The strongest solution upon which it was found possible to make spectrophotometric measurements even in the red, contained 3.3 mg. per c.c.

TABLE I.

Transmission of Iodine in Carbon Bisulphide. Thickness of Cell = 1.5 cm.

Wave-lengths.	Transmission, $I_e \div I_0$.													Clear CS ₂ .
Conc. mg. per c.c.	3.3	2.9	2.0	1.6	1.3	1.0	0.7	0.5	.25	.13	.07	.035	.0175	
Normal Solutions.	$M = .012$	.0117	.0079	.0063	.0051	.0039	.0028	.00197	.00088	.00051	.00028	.00014	.00007	
.406 μ					.22	.43		.76	.86	.90	.91	.98	1.00	
.424					.07	.08		.17	.42	.61	.70	.86	.93	.98
.442					00	00		00	.20	.27	.45	.64	.83	
.46					0	0		0	.08	.19	.32	.47	.77	.96
.48					0	0		0	.04	.12	.24	.37	.70	.94
.50					0	0		0	.01	.10	.17	.30	.65	.90
.517					0	0		0	.02	.11	.16	.30	.63	.87
.534					0	0	0	0	.03	.12	.18	.34	.64	.83
.554					0	0	0	00	.06	.19	.26	.42	.68	.84
.57					0	00	00	.02	.12	.20	.36	.56	.74	.84
.59					00	.03	.03	.14	.20	.36	.53	.66	.80	.85
.61		0	00	00	.03	.11	.16	.24	.38	.51	.66	.80	.86	
.63	0	.01	.05	.08	.10	.19	.27	.35	.47	.64	.76	.84	.91	.88
.645	.01	.03	.08	.14	.20	.30	.40	.47	.60	.71	.81	.88	.94	.92
.665	.02	.06	.11	.18	.28	.38	.47	.54	.66	.74	.85	.93	.99	
.68	.04	.11	.15	.23	.33	.45	.53	.64	.72	.79	.89	.96	1.00	.95
.70	.04	.13	.18	.25	.37	.49	.55	.70	.78	.86	.93	.98	1.00	
.72	.06	.15	.22	.28	.41	.52	.62	.77	.81	.89	.95	.99	1.00	.99
.74	.09	.19	.25	.32	.45	.55	.66	.80	.87	.93	.97	1.00	1.00	

The percentages of light transmitted by the iodine in carbon bisulphide are given in Table I. From these values Table II. was obtained, which gives the transmission for solutions 1 cm. in thick-

ness. In these and the three following tables the concentrations are given in milligrams per cubic centimeter, and also as normal solutions.

TABLE II.

Transmission of Iodine in Carbon Bisulphide. For a layer 1 cm. in thickness. Computed from Table I.

Wave-lengths. Conc. mg. per c.c.	Transmission, $I_e \div I_0$.						Extinction Coefficients.					
	2.9	1.	0.25	0.07	.035	.017	2.9	1.	0.25	0.07	0.035	0.017
Normal Solutions.	.0117	.0039	.00098	.00028	.00014	.00007	.0117	.0039	.00098	.00028	.00014	.00007
.406 μ		.58	.91	.94	1.00			.545	.0924	.060		
.424		.09		.79	.86	1.00		2.410		.235	.151	.00
.442		00	.34	.60	.74	.90		00	1.080	.510	.369	.105
.46		0	.12	.46	.59	.85			2.12	.779	.528	.165
.48		0	.05	.37	.50	.77			3.020	0.996	.697	.263
.50		0	.02	.28	.43	.69			3.900	1.271	.845	.372
.517		0	.03	.27	.42	.67			3.471	1.312	.868	.402
.534		0	.04	.31	.46	.69			3.230	1.171	.779	.372
.554		0	.08	.38	.53				2.530	.972	.635	
.57		00		.48		.77		00		.732		.263
.59		.04	.32	.62	.72	.84		3.230	1.142	.478	.328	.174
.61		.20		.72				1.610		.328		
.63		.31	.58	.79	.84	.92		1.171	.545	.235	.174	.084
.645	.04			.82	.88		3.230			.197	.128	
.665		.49	.72			1.00		.715	.328			
.68	.20			.89	1.00		1.010			.116		
.70	.25	.59	.82				1.388	.528	.193			
.72	.27	.64	.86	.96			1.312	.445	.151	.041		

The absorption of solutions of iodine in alcohol differs very markedly from that of iodine in carbon bisulphide. The solutions are far more transparent in the red and yellow, hence greater concentrations could be used. Measurements with the spectrophotometer show for all concentrations a rapidly increasing opacity toward the violet. This is best shown in Fig. 2 (obtained by computation like Fig. 1), where it will be noticed that a solution of 0.05 mg. per c.c. instead of being nearly transparent at $\lambda = .4 \mu$, transmits only about 20 per cent. of the incident light. In the red, on the other hand, the opacity of the alcohol solutions is relatively much less than that of a corresponding solution in carbon bisulphide. For example, a solution containing 3.2 mg. per c.c. transmits

60 per cent. at $\lambda = .72 \mu$, whereas the corresponding solution in CS_2 allows scarcely 6 per cent. of the incident light to pass through

Fig. 2. Iodine in Alcohol.

at that wave-length. The dilute alcohol solutions are dichroic, so that we have an increase in the amount of light transmitted in the region where the CS_2 solutions showed a maximum absorption. From the steepness of the transmission curves, Fig. 2, for the weaker solutions, which begin to trend sharply downward at about $\lambda = .50 \mu$, one would infer the existence of an absorption band located in the ultra-violet.

The very different absorption of iodine in these two solvents is further exhibited in the isochromatic curves in Figs. 3 and 4, which show the increasing opacity of the various wave-lengths as the concentration increases. From the isochromatic curves, for solutions 1 cm. in thickness, where concentrations are plotted as abscissæ and transmission as ordinates, the transmission of normal solutions, $M = .01, .001$ and $.0001$, were obtained and are given in Table IIa.

Fig. 3. Iodine in CS_2 .

In Table IV. the transmission of alcohol solutions 1 cm. in thickness is given. These values were obtained from Table III. by com-

putation, in the same manner as for the carbon bisulphide solutions,

Fig. 4. Solution in Alcohol.

TABLE IIa.

Transmission of Normal Solutions. Cell 1 cm. in Thickness.

Transmission of Carbon Bisulphide Sols. Normal Solutions ($M=1$).				Transmission of Alcohol Sols. Normal Solutions ($M=1$).		
Wave-lengths in μ .	$M=.01$.	$M=.001$.	$M=.0001$.	Wave-lengths in μ .	$M=.001$.	$M=.0001$.
.50		2	42	.46	24	60
.56		13	64	.50	50	73
.59		30	72	.534	60	80
.60	0	38	77	.57	67	84
.64	7	60	87	.61	78	89
.66	18	69	93	.645	89	97
.68	24	75	96	.665	92	99
.70	29	82	99	.68	96	100
.72	32	85	100			

From the equation

$$I_e = I_0 e^{-kl}$$

the extinction coefficient,¹ k , was computed for a thickness, d , ($= 1$ cm.), using the percentages of light transmitted given in

¹ Ångström, Wied. Ann., 36, p. 715 (1889).

TABLE III.

Transmission of Iodine in Ethyl Alcohol. Cell 1.5 cm. in Thickness.

Wave-lengths.	Transmission, $I_e \div I_0$.									
Concentra-tions.	Clear Sol.	6 mg.	c.c. 4.5	3.2	1.6	1.0	0.5	0.25	0.13	0.5
Normal Solutions, $M = 1$.		$M = .024$	$M = .018$	$M = .013$	$M = .0063$	$M = .0039$	.00197	.00098	.00051	.0002
.406 μ	.94								.09	.15
.424								.00	.16	.24
.442								.09	.26	.36
.460								.13	.35	.47
.48	.94						.04	.26	.43	.54
.50							.13	.39	.52	.63
.517	.96					.00	.18	.45	.59	.67
.534						.04	.24	.51	.62	.70
.554	.96					.09	.29	.56	.66	.74
.57					.00	.12	.38	.59	.68	.79
.59	.97				.07	.18	.44	.66	.73	.83
.61	.98			.00	.14	.28	.50	.71	.78	.87
.63	.99	.02	.06	.08	.24	.47	.61	.76	.83	.91
.645		.05	.09	.13	.35	.54	.71	.85	.91	.96
.665	.99	.10	.14	.22	.47	.68	.83	.92	.96	.99
.68		.16	.24	.37	.64	.78	.89	.95	.97	.99
.70	1.00	.22	.35	.53	.72	.84	.92	.97	.99	1.00
.72		.28	.44	.61	.78	.87	.94	.97	1.00	

Tables II. and IV. The corresponding extinction coefficients are given in the same tables.

This work was performed at room temperature, — about 20° C. — on old and new solutions. The principal errors in such work are those introduced in handling the solutions, which evaporate readily, and those due to inaccuracies in the spectrophotometric comparisons, which depend in part upon the physical condition of the observer.

Observations in the Infra-red.

The Radiometer.—This instrument was built according to the design used by Nichols ¹ and only the modifications to suit the work in hand need be described. The vanes were of mica blackened by burning camphor gum. To cause the lamp-black to adhere to the mica, a very thin coating of beeswax was first applied by means of a hot wire. When the vanes were held above the burning gum the

¹ E. F. Nichols, PHYSICAL REVIEW, Vol. 11, p. 891 (1897).

TABLE IV.

*Transmission of Iodine in Ethyl Alcohol for a Layer 1 cm. in Thickness.
Computed from Table III.*

Wave-lengths.	Transmission, $I_e \div I_0$.					Extinction Coefficients.				
Concent'ns, mg. per c.c.	1.6	1.0	0.5	0.25	0.05	1.6	1.0	0.5	0.25	0.05
Normal Solutions.	$M = .0063$	.0039	.00197	.00098	.0002	.0063	.0039	.00197	.00098	.0002
.424 μ					.38					.972
.460				.25	.58				1.389	.545
.50			.24	.52	.71			1.430	.655	.343
.517			.32					1.150		
.534			.38	.62	.77			.972	.478	.263
.554		.09			.82		2.410			.198
.57		.23	.50	.69			1.470	.697	.372	
.59	.08	.32			.87	2.530	1.150	.500		1.39
.61	.27		.61	.78		1.312		.496	.249	
.63	.38	.60			.93	.972	.510			.072
.645	.50		.80	.90	.97	.697		.226	.106	.034
.665	.60	.77	.88			.510	.263	.128		
.68	.74	.85	.92	.96	1.00	.369	.165	.0835	.041	00
.70	.80			.98		.226			.020	
.72	.85	.92	.96			.165	.0835	.041		

wax softened, and the soot deposited in an even layer. The inner window was of mica while the outer one was of plate glass.

The quartz fiber suspension was purposely chosen of medium weight to avoid the effects of temperature changes and earth tremors. There seems to be no criterion for selecting a fiber. Experience shows that a fiber about 8 cm. long, which will float freely in still air without bending over, is a good one to begin with. Such a fiber is quite invisible when held in the light on a cloudy day. The one used in this work was of such a nature, and observations could be made at any time of the day without being affected by outside disturbances. The drift of the zero reading was small, never greater than 1.5 mm. during one reading. Electrification of the vanes in exhausting was the only source of annoyance. This electrification was found greatest, *i. e.*, the vanes were attracted to the mica window the longest, for newly blackened vanes. The vanes no doubt become electrified in handling. The most effective treatment was to wipe off the mica window with alcohol or, better still, with

water, just before exhausting. This trouble was avoided to some extent by exhausting slowly, and during the latter part of the work, by covering the mica window with tinfoil. The spectrometer slits were .4 mm. wide and the maximum deflection, as read on a scale at a distance of 1.5 m., was $40 \pm$ cm. The pressure, measured by a McLeod gauge, was about .08 mm. and the period was such that the maximum deflection was reached in 16 seconds.

The Spectrometer. — A mirror spectrometer was used. The mirrors were of 14 centimeters focal length, 6 cm. aperture, and were in good condition. The arrangement of the apparatus is shown in Fig. 5, in which F_1 is the collimator slit; C is the cell containing

Fig. 5.

the solution; S , a double screen which could be interposed or removed by the observer at the reading telescope; P , the carbon bisulphide prism; and R , the radiometer. To a bracket, rigidly attached to the collimator tube, a cylindrical flame acetylene burner was mounted, with its center directly behind

the collimator slit. In order to avoid the inconvenience of shifting the radiometer in exploring the spectrum, the arm carrying the mirror and the slit, F_2 , which is placed at the vertical focus of the refracted ray, was clamped rigidly and placed in line with the radiometer. This makes the radiometer and spectrometer each a system by itself, and the shifting of either will simply vary the total amount of energy falling upon the vanes.

The spectrometer and radiometer were rigidly fixed upon a heavy slate slab. A bit of white paper on the rear wall of the radiometer indicated whether all the incident light fell upon the mica vane. The sensitiveness of the radiometer was varied by means of the leveling-screw opposite the window, and also by means of the exhaust pump.

In this work ratios are dealt with, and the only errors due to shifting would occur during two successive readings. The consistent

results of successive settings leads to the conclusion that no such shifting occurred. This is best graphically illustrated in Fig. 6, which shows the constancy of the point of maximum deflection. The data for these curves are selected at random from the notebook. They extend over several months, and originally were not taken to illustrate this point.

The prism was set for minimum deviation of the D lines by means of a telescope. By moving the collimator which carried the light, different portions of the spectrum could be brought on the radio-

Fig. 6.

meter. Changes of temperature are negligible, since it is known that for a carbon bisulphide prism a change of temperature of 5° is necessary to bring the D_1 line in the place of D_2 .¹ The temperature of the prism was observed at the beginning and at the end of each series of measurements. It was found that during a single series of observations, which took from 30 to 50 minutes, the variation was only about $0^\circ.3$ C., the maximum recorded being $0^\circ.6$ C. The temperature of the room was fairly constant at 18° C. in the morning, rising to 19° or 20° in the afternoon. The solutions stood on an open shelf in the same room and were assumed to be at the same temperature.

Calibration.—The spectrometer was calibrated by using Snow's² values for the position of the sodium lines at 0.59μ , 0.83μ and 1.4μ , and by observing the position of the emission band of CO_2 at 2.7μ . The wave-length of this band has been determined by Paschen. The position of the sodium lines was determined³ by mounting an electric arc of cored carbons, filled with pure sodium chloride, in place of the acetylene flame and noting the circle read-

¹ G. Krüss, *Kolorimetrie*, last ed., also *Berlin Chem. Ges.*, 17, p. 2732 (1884).

² Paschen, *Wied. Ann.*, 51, p. 1 (1894.)

³ Snow, *PHYSICAL REVIEW*, Vol. I., p. 28 (1894).

ing at which a deflection was produced by these lines. The position of the CO_2 band was similarly observed by using a Bunsen acetylene burner. The calibration curve plotted from the observed readings is given in Fig. 7. The computed circle readings for the

Fig. 7.

same lines—indicated on the same curve by the crosses (* *), were obtained by assuming the indices of refraction of CS_2 as determined by Rubens,¹ the prism in these computations being taken at minimum deviation for each line.

3. *Curves and Results.*—Observations were made with and without the cell of iodine solution interposed in the path of the incident light, and the ratio of the deflections gave the percentage of transmission. At first the entire spectrum to 2.7μ was explored, using a single solution. This was found impracticable far in the infra-red on account of the absorption band of CS_2 found by Paschen² at 2.7μ , the increased absorption of the glass, and the very narrow dispersion of the spectrum in this region. Between 1.8μ and 2.7μ a slight variation in the circle reading caused a great variation in transmission through the same solution.

¹ Rubens, Wied. Ann., 53 (1894).

² Paschen, Wied. Ann., p. 337 (1894).

To avoid errors in setting the collimator, from $1.8\ \mu$ to $2.7\ \mu$, a less convenient method had to be adopted. The collimator arm was set so that a given region of the spectrum fell upon the radiometer vane, and the transmission of the entire group of solutions was found without changing the setting. This method gave consistent results. The influence of the walls of the cell and the solvent were eliminated as in the case of the spectrophotometric observations already described, by determining the transmission through the cell when filled with clear carbon bisulphide.

Fig. 8.

The absorption of the cell when filled with a saturated solution of iodine in CS_2 is best illustrated by the curves in Fig. 8. The ordinates are deflections in centimeters, and the abscissæ are wavelengths. Curve I. shows the deflections in various parts of the spectrum when the radiometer vane was exposed to the uninterrupted rays of the acetylene flame, while curve II. shows the corresponding deflections after the light has passed through the cell containing the iodine solution. The ratio of the two curves beyond $.76\ \mu$ is about .77.

Table V. gives the percentage of radiation transmitted by the cell filled with clear CS_2 , and with various concentrations of iodine ranging from 2.5 milligrams per c.c. to saturation.

The data contained in this table are shown graphically in Fig. 9, from which it will be seen that the cell containing clear CS_2 is not uniform in its transmitting power for different rays, the curve being a minimum at about $1.0\ \mu$, and a maximum at $1.8\ \mu$. The

TABLE V.
Transmission of Iodine in Carbon Bisulphide.

Wave-lengths. Concentrations.	Transmission, $I_e \div I_0$.					
	Cell + Clear CS ₂ .	2.5 mg. per c.c.	5 mg.	10 mg.	20 mg.	Saturated Solution.
.73 μ	63	2	00	00	00	00
.76	64.5	34	18	7	00	00
.78	65	43	31	18	5	00
.81	66	53	44	34	17	00
.84	65	55	50	46	35	00
.88	62	59	54	52	48	11
.92	61	—	58	54	56	32
.97	61	57	—	60	59	48
1.02	63	—	59	62	61	54
1.08	64	61	—	63	—	—
1.16	65	65	62	66	63	64.5
1.26	67	68.5	70	69	66	68
1.40	70	71.5	69	71.5	70	71
1.56	74	75	74	74	75	76
1.80	78	78.5	75	76.5	78.5	79
2.12	73	72.5	72.5	72	73.5	73.5
2.70	59	57	55	59	57.5	57.5

curves for the transmitting power of the cell when filled with the iodine solutions rise rapidly from zero in the region between 0.7 μ and 0.9 μ and join the curve for the clear CS₂ at about 1.1 μ . It ap-

Fig. 9.

pears that beyond this point the addition of iodine to the solution has no effect whatever upon the transmitting power. This effect

will be noticed again in considering the transmission through solid films of iodine, while the absorption band is of interest in the work on anomalous dispersion.

Similar measurements of the transmission of iodine in ethyl alcohol were made, but it was found impossible to carry the observations

Fig. 10.

beyond 1.4μ on account of the increasing opacity of the alcohol, the transmission of which at that wave-length was only 3 per cent.

The transmission of iodine in alcohol is shown in Fig. 10, from which it will be seen that the alcohol was by no means free from water, as is evident from the presence of the narrow absorption bands at 0.93μ and 1.08μ . This gives an excellent check of the spectrometer calibration for this region. Abney and Festing¹ have published photographs of the infra-red absorption spectrum of ethyl alcohol, which shows these bands. The observations of E. F. Nichols² also agree with the above, showing that alcohol becomes opaque at about 1.4μ . It seems probable that the presence of these bands and the rapidly increasing opacity of the alcohol for the longer wave-lengths is due to the presence of water. Puccianti³ has published descriptive curves for pure alcohol which show that the transparency extends beyond 1.4μ . Table VI. gives the

¹ Abney and Festing, Phil. Trans., Vol. 172, p. 887 (1881).

² E. F. Nichols, PHYSICAL REVIEW, Vol. 1, p. 1.

³ Puccianti, Nuovo Cimento, Vol. 2, p. 241 (1900).

measurements of iodine dissolved in alcohol, for solutions containing respectively 3, 15 and 30 milligrams per c.c. — also a saturated solution.

TABLE VI.
Transmission of Iodine in Ethyl Alcohol.

Wave-lengths.	Transmission, $I_e \div I_0$.			
Concentrations.	Cell + Clear C_2H_5OH .	15 mg. per c.c.	30 mg.	Saturated Solution.
.68 μ	76	40	21	00
.70	73	44	26	4
.73	73	56	49	14
.76	70	58	53	17
.78	71	59	57	26
.81	67	60	58	31
.84	64	61	57	30
.88	62	57	51	25
.92	54	51	49.5	25
.98	56	—	49	23
1.02	52.5	52	40	25.5
1.08	25	23	21.5	12.5
1.16	30	29.5	24	18
1.28	5	5	4	4
1.40	3	3	4	3

The question of the difference in absorption of new and old solutions, *i. e.*, "velocity reaction," is illustrated by the curves in Fig. 11 which show the transmission through a saturated solution

Fig. 11.

while new, curve I., and after standing thirty-one days, curve II. The comparison is not quite a fair one in the regions where the energy transmitted is small, *e. g.*, beyond 1.6 μ , because for the first curve a very stiff fiber was used, while for the second curve the radiometer was almost

fourteen times more sensitive. But, as a whole, they show that no chemical action occurred.

(To be concluded.)