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Wavelengths and Intensities in the First Spectrum of Bromine, 2000 to 13000 A

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The first spectrum of bromine, Br I, has been newly investigated using electrodeless discharge tubes as light sources. The observations have led to a list of wavelengths and estimated intensities of 1056 lines emitted by neutral atoms in the region from 12965 A in the infrared to 3325 A in the ultraviolet. Most of the wavelengths are given to 0.01 A and the intensities are estimated on a relative scale between 1 and 75,000. Lines of Br I were not found in the ultraviolet between 3325 and 1700 A.

1. Introduction

Electrodeless discharge tubes containing an iodide or bromide of an element are now widely used as light sources in the study of spectra. In particular, such lamps containing halides are frequently used in this and other laboratories in the study of the spectra of the rare-earth group of elements. An increasing need has therefore been felt for accurate line lists of the spectra emitted by iodine and bromine, in order that wavelengths emitted by these atoms can be successfully deleted from the line list of whatever other element is under investigation. For this reason, and because the halogen spectra present many problems interesting in their own right, this laboratory undertook a program of extending and improving the descriptions and analyses of the arc and first spark spectra of both iodine and bromine. Results of the research on the first spectrum of iodine have already appeared [1] and the results for the first spark spectrum are now in press [2]. The spectrum of singly ionized bromine, Br II, has been observed in the vacuum ultraviolet region as well as in much the visible region, and work on this spectrum is continuing.

The most comprehensive list of Br I wavelengths hitherto available is that contained in the excellent paper on the structure of the arc spectrum of bromine published thirty years ago by C. C. Kiess and T. L. deBruin [3]. Improvements in apparatus and experimental procedures have now permitted a considerable augmentation of this earlier work. Specifically, we have been able to increase the number of lines observed in the spectra region described here to 1056 compared with the 330 lines reported by Kiess and deBruin. It must be mentioned that extensive observations have been completed also in the vacuum ultraviolet and the far infrared regions of the spectrum. These data, together with some Zeeman-effect observations, have already resulted in a well advanced analysis of the first spectrum of bromine and in some revisions of its term structure as reported by Kiess and deBruin. Since this work on the analysis, however, must be temporarily interrupted, it seemed advisable to report separately at this time the complete description of the spectrum in the range from 12965 A to 3325 A, especially in view of its probable usefulness to workers in other laboratories who are using bromides for excitation in electrodeless discharge tubes. The other data, together with the completed analysis of the first spectrum of bromine will be reported at a later time.

2. Experimental Procedure

The wavelengths of Br I presented here are derived from two essentially independent sets of observations made at two different times at the Bureau. The first series of observations was made several years ago using as light source an electrodeless discharge tube of the type described by Corliss, Westfall, and Bozman [4]. The vicious attacking of hot metal internal electrodes by the chemically very active bromine, which plagued many early observers of this spectrum, was thus avoided.

The electrodeless tube contained $BeBr_2$, produced by evacuating of air a lamp blank containing Be filings and then heating the filings after bromine vapor had been admitted into the blank. To obtain the spectrograms, these lamps were excited in a field of 2,450 Mc/s provided by a microwave oscillator. Spectrograms were made in the first and, where possible, the second orders of 7,500, 15,000, and 30,000 lines per inch concave gratings mounted in parallel light (Wadsworth mounting) at first order reciprocal dispersions of 10, 5, and 2.4 A/mm respectively. Eastman Kodak spectroscopic plates of types 103a–O, 103a–F, I–N, I–Q, and I–Z were used in the appropriate regions.

The line list thus obtained was regarded as fairly complete until the fall of 1959 when W. F. Meggers pointed out that some bromine lines of intensity one in our list appeared much more strongly than that on some plates he was measuring which had been exposed to a lamp containing YbBr. It was then decided to prepare some new lamps and to obtain at least one more set of observations in the entire range of wavelengths. In fact, however, except for the

region extending from 4264 to 5721 A and except for the fainter new lines, at least two new measurements were made on each line. The lamps used in this second series of observations were also of the electrodeless type. They contained, however, not a salt, but bromine vapor at a few millimeters pressure. The bromine used was of ACS purity. To avoid the presence of objectionable water vapor in the lamps, which also had often been a source of annoyance in the early observations of the spectrum, the bromine was thoroughly dried. This drying was accomplished on a vacuum system by means of a U-tube terminated at both ends by stopcocks and leading on one side to a reservoir into which bromine had been admitted and on the other side to another reservoir, the lamp blank, and finally the pumps. The U-tube was filled in a dry-box with P_2O_5. The bromine vapor made several passes through the drying agent before it was finally collected in the lamp blank. By setting up the microwave oscillator at the vacuum system, the pressure of bromine vapor was adjusted until the most complete arc spectrum was obtained, as judged by observing the discharge visually through a small spectroscope. The pressure was of the order of several millimeters of mercury and the discharge exhibited a reddish color. At much below this optimum pressure the discharge changed to a white color, and there appeared a continuous emission spectrum interrupted only by the strongest Br I lines and apparently arising from the Br_2 molecule. In the other direction, as the pressure was increased above the optimum pressure, the spectrum remained pure, but the length of the discharge became shorter and eventually the lamp ceased to operate. This same behavior at lower pressures could be observed after the lamp was sealed off the vacuum system, of course, by immersing the side limb with which the lamp had been provided into a coolant. The white discharge appeared and the molecular background became objectionable at temperatures of the order of −60 °C, which corresponds to a bromine vapor pressure of slightly less than 1 mm of mercury.

Despite this procedure, the molecular background appeared throughout the visible region of the spectrum on plates bearing long exposures. It is thus possible that some of the fainter lines in the appended table of wavelengths, especially in the region from 5000 A to 7000 A, actually are characteristic of molecular, rather than atomic bromine. Further, bromine exhibits continuous emission which begins strongly at about 3800 A and extends to shorter wavelengths although on one set of plates of emulsion type EK I–F exposed for 5 hours this continuous emission already began faintly at about 4400 A. Above that wavelength, discrete molecular lines appear on these plates.

Within this region of continuous emission, atomic emission lines could still be observed and measured. It was discovered, however, that it was more satisfactory in the region below 4000 A to reduce the pressure in the lamp by immersing the side limb in a mixture of solid carbon dioxide and alcohol at about −70 °C. This procedure had the result that the continuous emission spectrum disappeared and was replaced by a weaker background of discrete molecular lines upon which the atomic emission lines, now enhanced, could more easily be identified and measured.

All of the spectrograms bore exposures to an electrodeless lamp containing thorium or iron, or to the iron arc, to serve as standards in the determination of bromine wavelengths. In the first series of observations, the plates were reduced by linear interpolation with a correction curve, whereas in the second series, the micrometer readings of the bromine lines and of the standard lines on each plate were punched on cards so that the computation of bromine wavelengths could be accomplished by an IBM–704, which adjusted all wavelengths by least squares to fit a fourth degree equation.

3. Results

In the table are listed the wavelengths of the lines of Br I, together with their character and estimated intensities. It includes all the lines observable by photography in air, since there are no lines of Br I between 1700 A and 3300 A. The given wavelengths of most lines are weighted means of from two to eight different measurements. The character of a line is indicated by inserting the following symbols after the intensity of the line:

bl	blend
c	partially resolved hyperfine structure
d	double line
h	hazy, diffuse
H	very hazy, very diffuse
w	widened line, probably owing to unresolved hfs
W	very wide line

The intensities are visual estimates on an approximately linear scale where the faintest line is assigned an intensity 1. It must be emphasized that these relative intensities are valid only over small wavelength ranges, and no attempt has been made to adjust the values in accordance with the varying sensitivity of the photographic emulsions. In the case of lines which are separated by just a few angstrom units and which thus all appeared at once in the field of view of the microscope of the comparator used to measure the spectrograms, finer variations of intensities have been indicated, which, however, are meaningless over a wider range. For example, a group of four lines in the field, all of which appear with an intensity of about 200 when compared with other lines on the same plate, might be assigned intensities 180, 195, 205, and 200, to give an approximate index of their own relative intensities.

In conclusion, the authors thank William R. Bozman, who very kindly guided them in the preparation of data for computation by the IBM–704. Further, we wish to express our gratitude to William F. Meggers and especially C. C. Kiess, both of whom have generously provided us counsel and encouragement throughout the course of this work.

TABLE 1. *Wavelengths and intensities of* Br I

Wavelength	Intensity	Wavelength	Intensity	Wavelength	Intensity
A		*A*		*A*	
3325. 307	10 *w*	3942. 026	2 *h*	4412. 49	100
3347. 990	4	3943. 776	2	4423. 03	200
3348. 566	15	3943. 835	8	4425. 14	1500
3400. 050	40 *c*	3945. 565	4	4427. 20	40
3402. 420	20 *c*	3969. 430	1 *c*	4431. 59	1
3409. 740	20 *c*	3973. 967	5	4441. 74	10000
3418. 888	15 *w*	3991. 363	300	4446. 08	15
3425. 577	60	3992. 363	1500	4466. 21	200
3428. 605	15	3993. 177	5	4469. 98	150
3429. 809	8	3998. 492	35	4471. 67	80
3472. 200	30 *c*	3999. 070	200	4472. 61	10000
3496. 366	5	4000. 599	2 *w*	4475. 87	15
3497. 430	1	4009. 310	2 *c*	4477. 72	20000
3516. 144	40	4012. 570	75 *c*	4479. 59	15
3541. 173	100	4016. 453	1 *h*	4490. 42	1000
3556. 530	40 *c*	4018. 316	2	4513. 44	3000
3557. 461	250	4021. 772	250	4513. 82	150
3558. 616	75	4033. 762	1 *h*	4525. 59	15000
3563. 706	50	4037. 324	500	4528. 61	400
3564. 480	15 *c*	4056. 420	35 *c*	4529. 79	600
3579. 081	40	4057. 020	30	4575. 74	3000
3581. 712	15	4058. 406	75	4592. 16	200
3589. 818	100	4064. 150	4	4614. 58	2500
3599. 962	100	4075. 503	50	4640. 92	40
3606. 518	20	4076. 956	75	4641. 02	70
3608. 864	7	4083. 149	50	4643. 52	900
3644. 190	10 *c*	4094. 643	35	4693. 56	300
3646. 620	100 *c*	4106. 352	25	4703. 42	50
3658. 486	2 *h*	4113. 132	4	4706. 36	12 *h*
3659. 970	20	4114. 165	25	4720. 03	100
3735. 800	500	4124. 233	75	4722. 97	9
3745. 419	50	4143. 974	600	4727. 05	4
3751. 287	10	4157. 425	250	4752. 28	2500
3753. 351	5	4164. 158	4	4757. 19	2
3756. 032	30	4164. 270	15	4762. 04	4
3757. 265	5	4168. 115	10	4763. 84	5
3761. 746	2	4175. 786	750	4765. 18	8 *h*
3761. 847	1	4179. 322	100	4765. 63	250
3770. 880	150 *c*	4191. 935	50	4775. 20	750
3794. 030	900 *c*	4196. 468	50	4780. 31	4000
3798. 805	5 *w*	4199. 473	35	4785. 19	1600
3810. 950	1 *h*	4202. 487	450	4796. 85	5
3811. 440	30 *h*	4220. 701	5 *h*	4802. 67	250
3815. 650	1200	4220. 859	2	4803. 47	5
3828. 505	700	4231. 643	4	4804. 64	4 *h*
3829. 750	200 *c*	4240. 366	40	4806. 03	6
3844. 035	100	4242. 497	2 *h*	4806. 57	7
3847. 360	2 *h*	4248. 414	50	4807. 61	350
3850. 619	10	4250. 818	40	4809. 46	5
3850. 740	1	4250. 924	15	4812. 09	6
3851. 654	3	4260. 625	40	4812. 21	6
3854. 702	90	4261. 964	3	4814. 80	7
3896. 653	200	4334. 54	20	4817. 21	3
3899. 767	25	4342. 45	2	4818. 71	7
3905. 850	20 *c*	4358. 33	1	4834. 46	500
3909. 385	175	4365. 14	2000	4848. 39	25
3913. 560	12	4369. 22	75	4860. 04	250
3917. 810	200 *c*	4391. 60	800	4906. 49	10
3929. 196	5	4399. 73	450	4920. 98	300
3934. 090	125 *c*	4404. 57	10	4921. 80	10 *w*

TABLE 1. *Wavelengths and intensities of* Br I—Continued

Wavelength	Intensity	Wavelength	Intensity	Wavelength	Intensity
A		*A*		*A*	
4954. 73	300	5529. 01	175	5898. 96	90
4979. 76	4000	5532. 22	100	5905. 45	900
4983. 25	75	5536. 37	300	5905. 66	80
5002. 72	500	5544. 72	6	5909. 31	250
5029. 37	200	5546. 90	20	5937. 85	90
5063. 74	40	5558. 13	40	5940. 48	1600
5083. 83	6 *w*	5558. 40	10	5943. 71	140
5092. 60	4	5588. 17	160	5945. 50	600
5099. 79	20	5590. 56	50	5950. 32	750
5138. 55	10	5597. 26	15	5953. 92	750
5139. 47	10 *w*	5602. 41	8 *h*	5982. 90	12
5148. 78	10	5604. 96	4	5983. 35	5
5150. 47	6 *h*	5609. 83	10 *h*	5985. 32	125
5220. 71	8	5611. 62	125	5992. 89	100
5222. 32	12	5627. 24	200	5999. 73	95
5226. 91	20	5633. 97	140	6007. 96	200
5241. 43	5	5637. 27	130	6018. 17	200
5245. 12	350	5640. 86	35	6022. 66	30
5261. 80	5	5645. 31	30	6025. 24	10 *h*
5285. 22	50	5645. 96	45	6048. 15	5
5297. 32	15	5667. 75	9	6057. 87	200
5310. 04	5 *h*	5667. 92	8	6059. 74	5
5314. 18	10	5685. 77	15 *W*	6061. 46	5
5315. 85	8	5697. 29	18	6062. 88	4
5317. 25	20	5705. 74	85	6064. 35	200
5318. 83	7	5709. 44	9	6067. 36	5
5323. 20	12	5716. 26	225	6095. 74	700
5328. 92	200	5721. 11	100	6107. 69	125
5329. 30	12	5722. 97	40 *h*	6111. 10	80
5337. 10	40	5764. 66	45	6116. 19	60
5345. 42	600	5771. 30	5	6118. 80	300
5348. 29	10	5777. 69	10	6122. 14	2400
5354. 67	120	5779. 97	4	6126. 53	30 *W*
5356. 74	12 *w*	5783. 32	500	6132. 71	800
5364. 19	300	5784. 02	30	6134. 70	75
5365. 20	5 *h*	5793. 98	100	6137. 49	150
5370. 34	300	5801. 50	40	6141. 04	100 *w*
5379. 13	15	5803. 82	30	6142. 73	100
5382. 96	120	5805. 04	30	6146. 00	25 *cw*
5384. 27	8	5809. 59	250	6148. 60	40000
5393. 58	7	5819. 56	80	6151. 10	50 *d*
5395. 50	1500 *c*	5821. 45	12	6158. 19	750
5414. 26	4	5826. 07	5	6177. 39	2000
5420. 43	13	5827. 07	10	6184. 09	200
5420. 80	18	5828. 51	150	6199. 74	50
5424. 61	8 *h*	5828. 89	7	6203. 08	900
5432. 47	60	5830. 39	400	6204. 35	90
5434. 22	7	5833. 39	900	6204. 49	90
5450. 09	550	5836. 84	150	6205. 40	120
5453. 03	90	5852. 08	1800	6208. 26	100
5455. 16	60	5861. 20	120	6216. 71	5
5455. 96	70	5864. 82	90	6225. 51	65
5463. 72	80	5867. 05	60	6235. 87	10
5466. 22	1200	5869. 47	18	6244. 39	400
5469. 76	15	5877. 15	50 *w*	6248. 24	200
5470. 90	5	5886. 87	60 *cw*	6251. 32	300
5504. 46	35 *h*	5889. 87	60	6253. 69	400
5512. 98	5 *h*	5894. 28	18	6282. 46	600
5520. 86	20	5898. 32	8	6284. 69	8
5522. 53	90	5898. 51	8 *d*	6290. 13	550

TABLE 1. *Wavelengths and intensities of* Br I—Continued

Wavelength	Intensity	Wavelength	Intensity	Wavelength	Intensity
A		*A*		*A*	
6296. 71	700	6646. 59	120	6927. 34	8
6301. 36	275	6653. 82	15	6929. 78	400
6315. 12	5	6666. 93	150	6936. 76	20
6331. 99	300	6672. 15	600	6962. 99	10
6335. 48	1500	6676. 54	15	6971. 96	250
6336. 48	500 *cw*	6676. 72	8	6992. 25	5
6337. 85	60	6682. 28	20000	6992. 83	5
6343. 79	35 *w*	6684. 22	100 *cw*	6993. 31	20
6345. 30	500	6687. 33	90	7005. 19	10000
6349. 82	500	6688. 08	90	7011. 53	50
6350. 73	60000	6690. 35	120 *cw*	7015. 15	75
6371. 60	200 *w*	6692. 13	10000	7024. 70	20
6392. 57	35 *W*	6694. 62	10	7026. 53	2
6394. 67	7	6700. 71	60 *h*	7031. 36	15
6398. 03	30	6702. 07	110	7054. 88	50
6399. 99	10 *W*	6706. 79	60	7058. 38	200
6405. 65	15 *cw*	6712. 12	30	7061. 71	1
6410. 32	2500	6713. 06	125	7066. 33	4
6418. 28	45	6714. 86	90	7076. 71	5
6418. 97	35 *cw*	6719. 97	8	7082. 34	2
6426. 30	500	6720. 68	75 *h*	7082. 63	3
6435. 81	15	6723. 65	400	7091. 12	4
6436. 60	10	6728. 28	8000	7101. 80	5 *h*
6438. 02	600	6738. 61	100	7111. 62	200 *cw*
6458. 92	25 *h*	6739. 66	8	7113. 22	50
6462. 32	500	6740. 83	5	7113. 60	100
6470. 41	200	6752. 67	6	7117. 59	15
6475. 23	100 *h*	6760. 06	2000	7120. 78	10
6483. 56	1800	6761. 92	25	7120. 87	10 *c*
6483. 96	35	6765. 12	8	7133. 95	5
6488. 62	800	6771. 95	175	7138. 05	2
6493. 80	20 *h*	6774. 63	30 *h*	7138. 19	4
6501. 50	4	6778. 57	60	7142. 25	500 *c*
6514. 32	12	6779. 48	2000	7145. 56	2
6514. 62	1000	6785. 23	10	7147. 06	4
6531. 39	70 *bl* *with* Cl	6785. 74	900	7149. 08	15
6532. 29	600	6786. 74	2200	7150. 00	8
6541. 30	600	6787. 34	175	7150. 30	75
6544. 57	20000	6787. 77	8	7153. 13	5 *h*
6548. 09	1500	6790. 04	6500	7160. 74	15
6551. 57	12	6791. 48	1600 *c*	7162. 10	750
6559. 80	50000 *cw*	6801. 35	60	7172. 22	25
6571. 31	1000	6816. 72	50	7175. 74	5 *H*
6574. 29	15	6820. 39	800 *c*	7177. 89	5 *h*
6576. 24	10 *W*	6826. 02	400	7184. 30	300
6579. 14	1800	6840. 62	175	7194. 40	15 *cw*
6579. 36	300	6844. 82	5	7214. 95	5 *c*
6582. 17	20000	6845. 24	40	7217. 78	20
6584. 14	600	6845. 30	40	7222. 31	50
6589. 62	10 *w*	6846. 27	150	7232. 45	100
6604. 80	15	6858. 22	45	7236. 86	7
6613. 05	4	6859. 43	20	7247. 29	5 *h*
6620. 47	1500	6861. 15	1800	7255. 47	10 *cw*
6621. 44	8	6875. 22	20 *w*	7255. 63	15 *W*
6624. 26	20	6887. 99	12 *h*	7257. 40	4
6631. 62	50000 *cw*	6888. 73	80 *h*	7257. 82	10
6635. 10	60	6895. 65	1 *w*	7260. 45	2000
6636. 62	150	6904. 95	400	7261. 46	20
6639. 57	40	6922. 86	30	7262. 40	25
6645. 17	40	6923. 04	1	7265. 16	5

TABLE 1. *Wavelengths and intensities of* Br I—Continued

Wavelength	Intensity	Wavelength	Intensity	Wavelength	Intensity
A		*A*		*A*	
7272. 58	3 *w*	7711. 68	5	8111. 55	50
7284. 41	5	7713. 28	200	8113. 02	20 *h*
7288. 40	150	7713. 53	45	8131. 52	30000
7291. 92	1	7715. 30	500 *cw*	8137. 88	150
7305. 03	75	7721. 45	300	8142. 79	40 *h*
7310. 45	4	7726. 16	125 *cw*	8152. 65	1000 *c*
7311. 48	100 *d*	7733. 61	900	8153. 75	10000
7319. 44	50 *cw*	7734. 60	25	8153. 98	25000
7323. 35	10	7742. 00	1	8166. 30	175
7329. 20	10 *hw*	7795. 00	15	8170. 19	200 *d*
7333. 72	50 *c*	7803. 02	30000	8172. 07	200
7344. 53	100	7807. 66	125 *cw*	8173. 70	20
7348. 51	10000	7821. 09	30	8175. 57	25
7378. 41	20 *d*	7827. 23	1200	8179. 62	40
7383. 69	5	7835. 09	30	8179. 98	100
7385. 54	4 *h*	7841. 87	30	8183. 49	450
7420. 69	2	7843. 58	600	8189. 91	1 *hw*
7425. 85	750	7844. 04	150 *d*	8190. 05	1 *hw*
7452. 11	60	7869. 52	10	8190. 25	40
7453. 41	70	7881. 52	4000 *c*	8197. 71	175 *h*
7458. 22	50 *h*	7889. 85	600	8210. 48	3 *h*
7461. 84	70	7903. 66	50	8215. 11	200
7464. 67	8	7905. 69	50	8237. 94	500
7495. 46	15 *hw*	7925. 81	2500	8246. 86	5000
7497. 79	5	7929. 68	250	8247. 97	30
7512. 96	40000	7932. 97	30 *W*	8252. 38	30
7532. 76	50	7938. 68	30000 *c*	8253. 87	35
7535. 78	400	7940. 04	60	8258. 32	300
7551. 49	500 *cw*	7947. 94	3000	8264. 96	15000
7559. 97	70	7950. 18	3000	8272. 45	75000 *c*
7569. 07	500	7961. 33	350	8280. 23	100
7570. 85	550	7966. 94	900 *c*	8280. 75	100 *w*
7575. 22	15 *w*	7978. 44	8000 *bl*	8291. 05	900
7582. 55	10 *h*	7978. 57	10000 *bl*	8293. 56	100
7582. 98	100 *h*	7987. 12	30	8304. 59	10
7586. 59	25	7989. 94	30000	8308. 48	20
7591. 59	1600	7997. 01	80	8313. 09	10
7594. 50	25	7998. 74	175	8334. 70	20000
7595. 06	1800	8004. 35	25	8343. 69	10000
7598. 00	4	8008. 87	30 *h*	8357. 53	10
7604. 02	70	8009. 36	75	8359. 05	5
7606. 26	120	8010. 00	800 *cw*	8361. 71	300
7607. 37	400 *cw*	8014. 72	500 *cw*	8362. 38	100 *h*
7616. 39	2000	8021. 70	500 *cw*	8367. 19	15
7617. 90	20 *cw*	8022. 51	800	8369. 00	20
7632. 85	50	8023. 13	20	8372. 77	150
7641. 62	600	8023. 91	900	8378. 63	100 *w*
7647. 67	40	8026. 45	5000 *c*	8384. 02	1200
7652. 82	150 *cw*	8028. 21	18	8387. 97	100
7663. 51	100 *cw*	8028. 79	400	8389. 73	300
7680. 71	10 *hw*	8029. 66	500 *cw*	8392. 76	75
7681. 74	20	8030. 91	250 *h*	8397. 61	50
7685. 08	50	8033. 40	40	8402. 07	20
7698. 71	35	8034. 94	250 *cw*	8408. 67	250
7699. 56	80	8037. 32	40	8410. 79	10 *w*
7704. 32	60 *h*	8037. 63	60	8411. 61	5 *w*
7706. 68	15 *hw*	8050. 40	15	8421. 88	4
7708. 38	8	8066. 36	200	8428. 76	75
7709. 34	15 *h*	8072. 87	300	8430. 50	50
7709. 54	15 *h*	8101. 20	150	8432. 49	10

TABLE 1. *Wavelengths and intensities of* Br I—Continued

Wavelength	Intensity	Wavelength	Intensity	Wavelength	Intensity
A		*A*		*A*	
8434. 83	150	8839. 98	20	9314. 85	30
8435. 33	75	8842. 84	125	9320. 86	15000
8441. 25	100	8861. 69	85	9325. 32	20
8446. 55	40000	8869. 64	300	9352. 55	175
8454. 25	75	8870. 45	200	9354. 56	15
8463. 32	4	8877. 89	90	9369. 96	100
8470. 62	100	8878. 41	90	9379. 22	30
8471. 51	500	8882. 86	30	9399. 57	5
8477. 45	4000	8883. 46	15	9400. 18	90
8484. 40	30	8886. 35	40	9409. 56	20
8491. 52	4	8888. 98	4000	9438. 22	80
8503. 78	400	8890. 27	50	9460. 14	500 *d*
8513. 38	1500	8895. 21	20	9470. 67	20 *h*
8515. 68	100	8895. 88	150	9475. 08	80
8529. 38	8 *h*	8897. 62	30000	9476. 32	30
8557. 73	1000	8909. 72	300	9477. 48	60
8560. 57	300	8932. 40	6000	9488. 66	120
8565. 28	200	8933. 29	25	9495. 30	50
8566. 28	1000	8936. 96	15	9498. 32	20
8578. 84	400	8944. 84	50	9503. 78	6 *w*
8580. 00	20	8945. 19	15	9504. 53	3
8592. 32	250	8949. 38	1800	9507. 03	75
8595. 49	50	8955. 44	30	9517. 27	100
8595. 66	50	8964. 00	9000	9543. 04	40
8603. 69	100	8972. 82	350	9552. 65	175
8604. 06	20 *hw*	8979. 59	200	9560. 58	6
8606. 68	20	8984. 56	100	9570. 32	2
8608. 97	30 *hw*	8995. 22	50	9588. 60	300
8610. 48	100	9005. 21	50 *h*	9590. 33	20
8611. 83	250	9012. 23	20	9598. 78	60
8612. 48	75	9029. 94	300	9603. 62	35
8625. 39	750 *c*	9045. 08	40	9604. 30	6
8628. 84	200	9066. 26	400	9621. 02	35 *h*
8638. 66	20000	9078. 64	700	9623. 33	15
8655. 10	100	9079. 29	125	9625. 17	8
8658. 84	10	9084. 29	25	9627. 54	4
8668. 84	300	9086. 81	100	9631. 29	60
8698. 53	4000	9107. 39	10	9635. 05	20
8708. 68	75	9123. 17	50	9662. 00	40
8708. 95	100	9129. 31	70	9662. 99	20
8725. 33	500	9147. 05	75 *h*	9710. 64	12
8726. 75	100 *c*	9151. 49	4	9717. 44	40
8741. 63	50	9166. 06	30000	9719. 18	600
8742. 98	75	9173. 62	15000	9725. 39	40
8749. 09	10	9178. 16	20000	9731. 73	350
8757. 22	10	9183. 14	30	9732. 86	50
8760. 46	700	9193. 46	20	9740. 38	15
8764. 19	500	9197. 16	50	9745. 83	100
8775. 70	250	9201. 22	80 *w*	9751. 41	90
8779. 16	50	9201. 78	80	9793. 43	6000
8793. 47	10000 *c*	9202. 48	80	9810. 63	60
8801. 03	150	9220. 55	200	9817. 98	60 *bl*
8803. 40	100	9221. 20	35	9818. 15	70 *bl*
8804. 77	20	9226. 57	15	9828. 34	15
8807. 57	100 *c*	9229. 11	5	9844. 13	7
8808. 85	500	9254. 06	70	9864. 92	2
8810. 57	10	9254. 39	30	9896. 37	10000
8819. 96	15000	9265. 42	40000	9944. 04	400 *c*
8825. 22	25000	9282. 78	100	9945. 19	1
8833. 32	175	9288. 56	200	9962. 04	35 *c*

TABLE 1. *Wavelengths and intensities of* Br I—Continued

Wavelength	Intensity	Wavelength	Intensity	Wavelength	Intensity
A		*A*		*A*	
9963. 86	1	10529. 48	3 *h*	11093. 46	250
10001. 92	10	10539. 14	6	11094. 19	100
10002. 15	5 *h*	10554. 72	1	11096. 54	20
10025. 20	4 *h*	10566. 12	250	11100. 59	1
10045. 67	3 *h*	10566. 85	100	11101. 30	1
10056. 86	15	10569. 62	2	11161. 68	1 *w*
10061. 57	25 *d*	10591. 48	20 *w*	11194. 94	100
10079. 72	10	10608. 64	40	11197. 00	2
10085. 97	35	10616. 27	1	11197. 11	3
10087. 92	1	10619. 62	1	11225. 04	250
10088. 27	10	10624. 28	1	11247. 46	2
10102. 79	12	10629. 43	18	11286. 92	2
10107. 76	150 *d*	10634. 04	1	11292. 69	2
10113. 72	2	10638. 80	15	11297. 98	2
10119. 17	3	10660. 76	3	11316. 92	10 *w*
10128. 76	4	10718. 80	100	11325. 97	1
10139. 04	3000	10723. 07	15	11330. 17	3
10174. 72	12	10742. 09	1000	11350. 02	65
10175. 44	20	10742. 43	100	11367. 21	4 *w*
10183. 98	300	10747. 17	20	11367. 88	4 *w*
10184. 45	200	10753. 88	200 *cw*	11436. 18	3
10197. 58	18	10755. 86	3000	11437. 59	9
10208. 88	300	10757. 76	6	11447. 25	18
10225. 20	1	10795. 01	10 *cw*	11464. 56	35
10231. 58	8	10798. 06	25	11501. 27	1
10232. 36	15	10804. 38	3	11508. 75	30
10237. 11	75	10810. 04	300	11583. 66	10
10237. 72	6000	10815. 63	6	11597. 58	1
10243. 28	3	10840. 04	500 *d*	11631. 30	2
10248. 24	3	10869. 65	100	11636. 05	1
10265. 85	15 *h*	10871. 58	90	11640. 91	1
10293. 63	50	10891. 37	250	11666. 17	20 *d*
10299. 62	1000	10892. 74	100	11742. 82	400
10305. 96	10	10896. 75	200	11810. 27	1
10310. 50	800	10908. 58	60 *w*	11819. 31	2
10310. 72	600	10973. 40	500	11833. 03	1
10310. 91	700	10978. 52	40	11870. 75	4
10312. 87	40	10978. 93	300	11883. 89	4
10314. 01	8	10982. 25	100	11902. 60	5
10320. 06	15	10991. 07	2	11903. 57	8
10324. 93	3	10997. 78	600	11928. 09	8
10329. 99	100 *cw*	10998. 23	400	11990. 51	15
10374. 35	12 *cw*	11007. 36	10	12088. 15	2
10377. 61	1500	11010. 38	600	12285. 46	2
10390. 71	175	11012. 27	5	12303. 82	35
10392. 49	25	11013. 17	20	12349. 26	1
10415. 05	12 *w*	11024. 19	10	12354. 35	1
10457. 90	30000	11039. 75	60	12368. 85	1 *w*
10483. 31	8	11045. 69	800 *d*	12450. 44	1
10505. 02	8	11047. 15	10	12809. 50	1
10507. 87	12	11047. 57	17	12826. 01	1
10513. 64	1	11074. 04	40	12965. 11	4

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