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DESCRIPTION AND VIBRATIONAL ANALYSIS
OF THE MOLECULAR SPECTRUM OF POLONIUM

G. W. Charles
D. J. Hunt
G. Pish
D. L. Timma

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**STABLE ISOTOPES DIVISION
DESCRIPTION AND VIBRATIONAL ANALYSIS
OF THE MOLECULAR SPECTRUM OF POLONIUM**

G. W. Charles

D. J. Hunt, G. Pish, and D. L. Timma
(Previously at Mound Laboratory)

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DESCRIPTION AND VIBRATIONAL ANALYSIS OF THE MOLECULAR SPECTRUM OF POLONIUM¹

G. W. Charles

D. J. Hunt

G. Pish

D. L. Timma

ABSTRACT

Spectrograms of the molecular spectrum of polonium excited in an electrodeless discharge have been measured. Approximately 500 red-shaded band heads were found with mixtures of Po²⁰⁸ and Po²⁰⁹ and approximately 450 heads with Po²¹⁰. Nearly 350 bands have been classified in each spectrum into a system represented by the equation (for Po²¹⁰)

$$\sigma = 25,149.3 + 108.53 \left(v' + \frac{1}{2} \right) - 0.4417 \left(v' + \frac{1}{2} \right)^2 - 155.715 \left(v'' + \frac{1}{2} \right) + 0.3353 \left(v'' + \frac{1}{2} \right)^2 + 0.0003226 \left(v'' + \frac{1}{2} \right)^3 .$$

The values of the constants in this equation and the close agreement between calculated and observed isotope shifts prove that the emitter is diatomic polonium. Extrapolation of the observed energy levels to convergence yields an estimate of 1.895 volts for the dissociation energy of the lower state of Po²¹⁰-Po²¹⁰, based on the assumption that the dissociation products are two normal polonium atoms.

A historical survey of Group VI diatomic molecular spectra and a critical evaluation of the status of knowledge of these spectra are included.

HISTORY

The spectra of the diatomic molecules of Group VI of the periodic table have been the subjects of numerous investigations. In the case of each molecule there is a principal system of bands, and there are several subordinate systems. In the investigation reported here, an extensive and easily excited band system has been observed which is ascribed to the diatomic molecule of polonium, the spectrum of which has not been previously reported in the literature.

Oxygen

The principal system of the oxygen molecule is the well-known Schumann-Runge system, which is responsible for the ultraviolet transmission limit of air. Part of this system was discovered in absorption near 1850 Å by Schumann (1) in his pioneer work in the vacuum ultraviolet. Runge (2) discovered another part of the system between 2200 and 4900 Å in emission from a d-c high-voltage

arc in a cylinder through which oxygen was flowing. Later, Hopfield and Leifson (3) verified Schumann's results, observing 16 bands in absorption and giving the first rough wavelength measurements. Improved measurements of these absorption bands were later reported by Leifson (4).

The recognition that the bands observed by Schumann and those observed by Runge are parts of the same system is due to Mulliken (5). Füchtbauer and Holm (6), and more recently Herzog and Wieland (7), observed the absorption spectrum at high temperatures and pressures and extended the system. Extensions in emission were made by Feast (8). An early rotational analysis was made by Lochte-Holtgreven and Dieke (9), who arranged all the observed lines into 19 bands and showed that the electronic transition is $^3\Sigma_u^- - ^3\Sigma_g^-$. Feast (10) extended the system by making rotational analyses of several bands. Other rotational analyses were carried out by Curry and Herzberg (11), by Knauss and Ballard (12), and by Ossenbrüggen (13). Additional extensions were made by Herman and Weniger (14), by Garton and Feast (15),

¹This work was initiated at Mound Laboratory and was concluded at ORNL.

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and by Brix and Herzberg (16). Herman and Weniger (14) extended the vibrational analysis by observations in emission, while Garton and Feast (15) made rotational analyses of bands observed in absorption at high temperatures. Brix and Herzberg (16) made rotational analyses of absorption bands almost up to the convergence limit of the ${}^3\Sigma_u^-$ state. The origins of the Schumann-Runge system may be represented by the equation

$$(1) \quad \sigma = 49,802.1 + 700.36 \left(v' + \frac{1}{2} \right) - 8.0023 \left(v' + \frac{1}{2} \right)^2 - 0.3753 \left(v' + \frac{1}{2} \right)^3 - 1580.361 \left(v'' + \frac{1}{2} \right) + 12.0730 \left(v'' + \frac{1}{2} \right)^2 - 0.0546 \left(v'' + \frac{1}{2} \right)^3 + 0.00143 \left(v'' + \frac{1}{2} \right)^4,$$

where v' is the vibrational quantum number of a level in the upper electronic state and v'' is that of a level in the lower state.

A forbidden system of the oxygen spectrum was discovered in absorption in the near ultraviolet region by Herzberg (17). Recently, Herzberg (18) gave a rotational analysis of this system, showing it to be the transition ${}^3\Sigma_u^+ - {}^3\Sigma_g^-$, and Broida and Gaydon (19) observed it in emission in the afterglow of a discharge in oxygen.

Two other forbidden systems between electronic levels of the fundamental configuration of O-O have been observed in absorption in the earth's atmosphere. One of these systems, in the red region, belongs to the transition ${}^1\Sigma_g^+ - {}^3\Sigma_g^-$. A rotational analysis of it has been given by Babcock and Herzberg (20). Later it was observed in emission by Herman and Herman (21), by Herman and Weniger (22), by Herman *et al.* (23), and by Shimazu (24). The other forbidden system lies in the infrared and is due to the transition ${}^1\Delta_g - {}^3\Sigma_g^-$. A rotational analysis has been given by Herzberg and Herzberg (25). The transition between the upper state ${}^3\Sigma_u^+$ of the Herzberg bands and the upper state ${}^1\Sigma_g^+$ of the red atmospheric absorption bands has been observed by Broida and Gaydon (19) in emission. Two other absorption systems have been observed by Herzberg (26) and were ascribed to ${}^1\Sigma_u^- - {}^3\Sigma_g^-$ and to ${}^3\Delta_u - {}^3\Sigma_g^-$ on the basis of rotational analyses.

Sulfur

Many investigations have also been made of the spectrum of S-S. One of the first was made by Rosen (27), who observed heads of the principal

system between 3700 and 2650 Å in absorption and in fluorescence and who set up a vibrational array. The analysis was extended by Curtis and Tolansky (28), who observed bands between 4800 and 6600 Å excited in emission in a high-frequency discharge. Fowler and Vaidya (29) observed bands between 2593 and 6166 Å in emission from a carbon disulfide flame and further extended the

analysis. Other absorption studies were made by Rosen (30) and by Rosen and Neven (31), the latter employing temperatures up to 1100°C and pressures up to 550 mm Hg. Rotational analyses of this system have been given by Naudé and Christy (32), by Olsson (33), by Naudé (34), and by Ikenoue (35). Christy and Naudé (32) concluded that the transition is ${}^3\Sigma_u^- - {}^3\Sigma_g^-$ as in the Schumann-Runge system. Olsson (33) reached the same conclusion on the basis of a rotational study of seven bands in absorption. More recent studies by Naudé (34) and by Ikenoue (35) verified this conclusion and extended the knowledge of the system. The origins of the principal system of S-S have been represented by the equation

$$(2) \quad \sigma = 31,835 + 434.0 \left(v' + \frac{1}{2} \right) - 2.75 \left(v' + \frac{1}{2} \right)^2 - 725.68 \left(v'' + \frac{1}{2} \right) + 2.852 \left(v'' + \frac{1}{2} \right)^2.$$

Other systems have been observed in sulfur, one of which is the so-called "A" system found by Curtis and Tolansky (28). The weak heads of this system appear among those of the principal system between 4800 and 6600 Å. This system was further studied by Christy and Naudé (36). A rotational analysis of seven bands of this system by Olsson (37) indicates that the transition is ${}^1\Sigma_u^+ - {}^1\Sigma_g^+$, although this conclusion has not been

universally accepted. Two strong absorption systems were discovered between 1870 and 1650 Å by Wieland, Wehrli, and Miescher (38) and further investigated by Maeder (39). One of them is attributed to the transition ${}^3\Pi_u^- - {}^3\Sigma_g^-$. Other systems observed in emission in the near ultraviolet region were reported by Rosen and Désirant (40). A brief survey of the term scheme of S-S was given by Olsson (41).

Selenium

Considerable confusion exists in the interpretation of the molecular spectrum of Se-Se. Numerous systems have been proposed by various workers, while some workers have combined most of these into the principal system. The nature of the transition has not been unambiguously determined, although indications are that it is different from that of O-O and of S-S. This confusion has resulted partly from isotopic mixtures and partly from measurements of insufficient accuracy.

The first significant investigation of the spectrum was that of Rosen (27), who observed bands in absorption and fluorescence between 4900 and 3250 Å and set up the first vibrational array. Later, Nevin (42) reported the arrangement of the emission bands of Se-Se into three systems, one of which was identical with that of Rosen. Two weak systems were reported in absorption between 3150 and 2100 Å by Moraczewska (43). Those bands between 3150 and 2750 Å were later ascribed to SeO₂ by Asundi and Parti (44), since they observed the bands only when their discharge tube had a leak. In 1935, Nevin (45) reported absorption measurements, including isotope effect, between 4100 and 3230 Å. Rotational analyses made by Olsson (46,47) and by Davis (48) indicate that the transition is ${}^1\Sigma_u^+ - {}^1\Sigma_g^+$. This conclusion seems inconsistent with the observation of Bhatnagar, Lessheim, and Khanna (49) that selenium vapor is paramagnetic. The origins of the principal system of Se⁸⁰-Se⁸⁰ may be represented by the equation

$$(3) \quad \sigma = 26,035 + 271.1 \left(v' + \frac{1}{2} \right) - 2.19 \left(v' + \frac{1}{2} \right)^2 - 391.9 \left(v'' + \frac{1}{2} \right) + 1.04 \left(v'' + \frac{1}{2} \right)^2 - 0.002 \left(v'' + \frac{1}{2} \right)^3$$

Other systems were reported by Rosen and Désirant (50) between 3410 and 2980 Å in emission and by Rosen and Monfort (51,52) between 5980 and 6660 Å in emission. The first of these contains some of the bands reported by Moraczewska (43). The constants are quite similar to those of the principal system, suggesting that the bands may be part of the principal system. All the bands except those reported by Moraczewska (43) between 2100 and 2300 Å and those by Rosen and Monfort (51,52) were put in the principal system by Asundi and Parti (44), although their measurements are not good enough to make the assignments unambiguous. The bands of Rosen and Désirant (50) were also ascribed to SeO₂ by Asundi and Parti (44). The enlarged principal system postulated by Asundi and Parti (44) has many irregularities, presumably because of perturbations. Recently, Leelavathi and Rao (53) reported a new system in the range 5900 to 6500 Å observed in a high-frequency discharge. The constants of this system are nearly identical with those of the Rosen-Monfort (51,52) system, which was somewhat extended by these investigators.

Two absorption systems in the range 1780 to 1940 Å were reported by Shin-Piaw (54). One has lower state constants agreeing with those of the principal system and is analogous to the system of Wieland, Wehrli, and Miescher (38) in S-S. The other was tentatively assigned to a polyatomic selenium molecule. Rosen (55) discussed the spectrum of selenium at some length in a review article.

Tellurium

The knowledge of the spectrum of tellurium is less complete than that of the spectra discussed above. The first significant investigation was that of Rosen (27), who observed bands between 5665 and 3830 Å in absorption and fluorescence and performed a vibrational analysis. Olsson (56) presented a revised scheme based on vibrational isotope studies embracing bands from 3930 to 4890 Å observed in emission. Désirant and Minne (57) studied the so-called "fluctuation" bands between 5260 and 6360 Å, arranging them into two systems. Recently, Prasad and Rao (58)

showed that these bands fit into the principal system and gave the equation

$$(4) \quad \sigma = 22,709 + 163.0 \left(v' + \frac{1}{2} \right) - 0.96 \left(v' + \frac{1}{2} \right)^2 - 251.0 \left(v'' + \frac{1}{2} \right) + 0.56 \left(v'' + \frac{1}{2} \right)^2$$

to represent the heads of this system. Ultraviolet absorption bands were observed between 1975 and 2495 Å by Shin-Piaw (54) and were partly analyzed into one system. Migeotte (59) discussed and revised the assignments of Shin-Piaw, arranging the bands into four systems. No rotational analysis of the Te-Te bands has appeared, probably due partly to the small spacing of the lines and partly to the confusion resulting from the many isotopes of tellurium.

Polonium

Nothing has been reported in the literature on the molecular spectrum of polonium. A band structure was observed early in the study at Mound Laboratory of the spectrum of polonium excited by radiofrequency oscillations. The first such observation was made with a 730-mc source of Po^{210} in a quartz tube heated to approximately 475°C. The band spectrum was well developed in a 30-min exposure. When a problem of assaying mixtures of Po^{208} and Po^{209} arose, the problem of the molecular spectrum was re-examined. A systematic study was made at Mound Laboratory of the discharge conditions under which bands are obtained. As a result of these studies, numerous spectrograms became available with well-developed band systems of Po^{210} on the one hand and of mixtures of Po^{208} and Po^{209} on the other hand. Measurements made on such spectrograms at ORNL are the basis of this report.

EXPERIMENTAL PROCEDURE

The spectrograms upon which this report is based were made by Hunt, Pish, and Timma on the Baird 3-m grating spectrograph at Mound Laboratory. In all cases radiofrequency oscillations were used to excite the spectra. Excellent results were obtained at both 11 and 30 Mc/sec with a Signal Corps radio transmitter Model DC610

operated as described in a previous report.² Sample size varied from 20 to 800 mc. Samples were prepared as previously described² and were purified by fractional volatilization. In most cases polonium alone was used, although one source was used which contained helium at a pressure of a few tenths of a millimeter as a carrier gas for the discharge. Better results were obtained with polonium alone in the source. A few observations were made at room temperature, but most observations were made with the discharge tube heated by an electric furnace as previously described. The temperatures at which the band spectrum was best developed were about 400 to 500°C, and most of the observations were made in this range. Exposures varied from 5 min to 5 hr and were made on Eastman plates of types 1-L and SA1. The development of the spectrum seemed to depend on the condition in the discharge, a better spectrum being observed in 15 min under some conditions than in 5 hr under other conditions. It was observed that the band spectrum came out strongly when the discharge was a deep-blue color but that the line spectrum predominated when the color was purple. Figure 1 shows a reproduction of a part of the spectrum of Po^{210} .

Preliminary measurements were made by the senior author at Mound Laboratory with a Bausch and Lomb spectrum-measuring magnifier and were used as the basis for also making a preliminary analysis at Mound Laboratory. The data and analysis presented in this report are based on improved measurements made at the Oak Ridge National Laboratory on plates loaned by Mound Laboratory.³ The improved measurements were made on a Gaertner comparator, with which positions can be estimated to 0.001 mm. Wavelengths of lines of polonium and of impurities, notably mercury, helium, cadmium, lead, bismuth, and zinc, were used to correct the calculated wavelengths. It is estimated that the wavelengths are accurate to less than 0.1 Å, corresponding to less than 0.4 cm^{-1} at the upper end of the wavelength range and to less than 0.8 cm^{-1} at the short wavelength end of the range.

²G. W. Charles, D. J. Hunt, G. Pish, and D. L. Timma, *Preliminary Description and Analysis of the Spectrum of Polonium*, MLM-941 (Jan. 28, 1954).

³The courtesy of Mound Laboratory in making these plates available for remeasurement at ORNL is gratefully acknowledged.

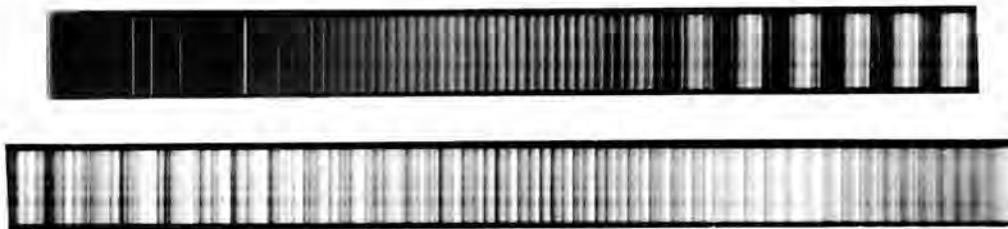


Fig. 1. A Portion of the Molecular Spectrum of Polonium.

RESULTS

The wavelengths of the more than 450 red-degraded band heads are given in Table 1, showing intensities as visual estimates on a scale of 10, wavelengths (λ), and frequencies (σ). The entries on the same line are heads of the three isotopic species $\text{Po}^{210}\text{-Po}^{210}$, $\text{Po}^{208}\text{-Po}^{208}$, and $\text{Po}^{208}\text{-Po}^{209}$ belonging to the same transition. The correlation between the intensities of entries in the first and second groups in Table 1 is striking, and the regularity of the variation of the frequency intervals between them suggests that either all the observed bands belong to one system or that the constants of the different systems are not much different from one another.

ANALYSIS

The first step in the analysis was the rough prediction, by extrapolation, of constants to be expected for the principal system of diatomic polonium. This step followed from the expectation that the principal system should be quite prominent in the spectrum. The parameters used are shown in Table 2. There are several empirical equations relating the vibrational frequency ω_e to other parameters, such as n , the principal quantum number of the valence electrons in the molecule, or μ , the reduced mass, defined as $m_1 m_2 / (m_1 + m_2)$, or Z , the atomic number of the atoms, or V , the ionization potential of the atoms. The equation

$$(5) \quad \log \omega_e + l \log \mu = m$$

has been given by Matuyama (60); l and m are constants for molecules of the same group. When this equation is applied to Group VI, $l = 0.8867$ and $m = 4.192$. This leads to an estimate of

$\omega_e'' = 161.1 \text{ cm}^{-1}$ for $\text{Po}^{210}\text{-Po}^{210}$ ($\mu = 105 \times 1.649$). Clark (61) has used an expression modified from that of Matuyama:

$$(6) \quad \log \omega_e + n \log (2Z) = p,$$

n and p being constants and Z the atomic number. For Group VI, $n = 0.9831$ and $p = 4.382$. For Po-Po , $2Z = 168$, so that ω_e'' comes out to 156.3 cm^{-1} . Another equation used by Clark (62) is

$$(7) \quad c^3 - 3.9c^2b + 3cb^2 + b^3 = 0,$$

where b and c represent ground-state vibrational frequencies of molecules in the same group. If c in this equation is taken as ω_e'' for Se-Se (391.9 cm^{-1}), two physically reasonable values are obtained for b , one of which is very close to ω_e'' for Te-Te, while the other is 148.9 cm^{-1} . On the other hand, if c is taken as ω_e'' for Te-Te (251.0 cm^{-1}), a value of 157.7 cm^{-1} is obtained for b .

Still another relationship, which was proposed by Majumdar and Varshni (63), is

$$(8) \quad \log \omega_e = g - b \log n^2 V,$$

where V is the ionization potential of the atoms in the molecule, n is the principal quantum number of the valence electrons, and g and b are constants. Correction of a numerical error in the paper of Majumdar and Varshni results in a value of 179.1 cm^{-1} for ω_e'' of $\text{Po}^{210}\text{-Po}^{210}$. A re-determination of the constants g and b to give the best fit for S-S, Se-Se, and Te-Te yields $\omega_e'' = 175.2 \text{ cm}^{-1}$ for $\text{Po}^{210}\text{-Po}^{210}$. Table 3 summarizes the predictions of ω_e'' for $\text{Po}^{210}\text{-Po}^{210}$. The experimental value derived from the analysis presented here is added at the bottom of the table for comparison.

TABLE 1. OBSERVED BAND HEADS OF POLONIUM

$Po^{210}-Po^{210}$			$Po^{208}-Po^{208}$			$Po^{208}-Po^{209}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
0	5131.40	19,482.4						
1	5109.50	19,565.9						
0	5095.30	19,620.5						
1	5072.03	19,710.5						
0	5052.53	19,786.6						
1	5045.50	19,814.1						
0	5030.32	19,873.9						
1	5023.14	19,902.3						
1	5016.23	19,929.7						
1	5009.38	19,957.0						
0	5002.25	19,985.4	0	5007.35	19,965.1			
			1	5006.39	19,968.9			
0	4994.04	20,018.3	1	4999.27	19,997.4	0	4997.96	20,002.6
1	4989.02	20,038.4	0	4993.73	20,019.5			
1	4987.17	20,045.9	0	4991.90	20,026.9			
1	4980.17	20,074.1	0	4984.93	20,054.9			
1	4972.97	20,103.1	1	4977.93	20,083.1			
1	4966.14	20,130.8	1	4971.04	20,110.9	0	4969.99	20,115.2
1	4959.06	20,159.5	1	4963.99	20,139.5			
1	4952.15	20,187.6	0	4957.13	20,167.4			
2	4950.92	20,192.6	2	4955.66	20,173.3	0	4954.51	20,178.0
1	4945.54	20,214.6						
2	4943.67	20,222.3	1	4948.40	20,202.9			
			0	4942.61	20,226.6			
2	4936.65	20,251.0	1	4941.46	20,231.3	0	4940.34	20,235.9
0	4930.28	20,277.2						
2	4929.65	20,279.8	2	4934.36	20,260.4			
			0	4928.92	20,282.8			
3	4922.64	20,308.7	2	4927.38	20,289.1	0	4926.41	20,293.1
2	4915.73	20,337.2	1	4920.51	20,317.4			
1	4914.57	20,342.0	2	4919.29	20,322.5			
			1	4914.46	20,342.5			
1	4908.98	20,365.2	1	4913.53	20,346.3			
3	4907.48	20,371.4	2	4912.10	20,352.2	0	4911.02	20,356.7
0	4901.95	20,394.4	0	4906.72	20,374.5			
			0	4903.62	20,387.4			
0	4894.46	20,425.6						
3	4893.24	20,430.7	2	4897.84	20,411.5	0	4896.76	20,416.0
3	4886.23	20,460.0	2	4890.98	20,440.1			
3	4879.23	20,489.3	2	4883.79	20,470.2			
			2	4882.77	20,474.5			
2	4872.41	20,518.0						
			0	4874.51	20,509.2			
2	4871.17	20,523.2						
2	4865.31	20,548.0	1	4869.94	20,528.4			

TABLE 1 (continued)

$P_{O210}-P_{O210}$			$P_{O208}-P_{O208}$			$P_{O208}-P_{O209}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
3	4863.98	20,553.6	2	4868.37	20,535.0			
3	4858.60	20,576.3	1	4862.98	20,557.8			
4	4856.88	20,583.6	3	4861.32	20,564.8	0	4860.18	20,569.6
0	4853.93	20,596.1	0	4858.39	20,577.2			
2	4850.75	20,609.6	0	4855.20	20,590.7			
3	4849.84	20,613.5	5	4854.26	20,594.7	0	4853.22	20,599.1
3	4842.90	20,643.0	3	4847.30	20,624.3	0	4846.34	20,628.4
0	4838.49	20,661.9						
4	4835.93	20,672.8	3	4840.33	20,654.0			
3	4834.97	20,676.9	3	4839.22	20,658.7	0	4838.18	20,663.2
3	4829.10	20,702.0	3	4833.37	20,683.7			
5	4827.73	20,707.9	4	4832.00	20,689.6	0	4830.93	20,694.2
0	4822.07	20,732.2						
4	4820.59	20,738.6	3	4824.88	20,720.1	0	4823.81	20,724.7
0	4818.29	20,748.5	0	4822.19	20,731.7			
3	4815.04	20,762.5	2	4819.02	20,745.3			
4	4813.57	20,768.8	3	4817.74	20,750.8	0	4816.72	20,755.2
0	4810.07	20,783.9	0	4814.39	20,765.3			
2	4807.28	20,796.0						
5	4806.49	20,799.4	5	4810.66	20,781.4	0	4809.58	20,786.0
5	4799.59	20,829.3	5	4803.69	20,811.5	1	4802.77	20,815.5
2	4792.65	20,859.5	1	4796.67	20,842.0			
3	4791.48	20,864.6	3	4795.65	20,846.4	0	4794.71	20,850.5
1	4785.70	20,889.8	1	4789.75	20,872.1			
3	4784.41	20,895.4	4	4788.44	20,877.8	0	4787.45	20,882.1
0	4778.93	20,919.4	0	4783.02	20,901.5			
5	4777.28	20,926.6	6	4781.30	20,909.0		4780.37	20,913.1
1	4774.65	20,938.1	0	4778.54	20,921.1			
2	4771.30	20,952.8	2	4775.25	20,935.5			
6	4770.24	20,957.5	7	4774.24	20,939.9	1	4773.16	20,944.6
1	4766.74	20,972.9						
3	4763.90	20,985.4						
4	4763.22	20,988.4	6	4767.15	20,971.0			
0	4758.80	21,007.8						
5	4756.23	21,019.2	4	4760.18	21,001.8			
2	4755.45	21,022.6	2	4759.32	21,005.6	0	4758.40	21,009.6
1	4749.33	21,049.7	0	4753.29	21,032.2			
6	4748.17	21,054.9	6	4752.13	21,037.3	1	4751.13	21,041.8
1	4742.17	21,081.5						
7	4741.02	21,086.6	7	4744.91	21,069.3	1	4743.96	21,073.6
0	4738.97	21,095.7						
2	4735.56	21,110.9	3	4739.40	21,093.8			
7	4733.93	21,118.2	7	4737.79	21,101.0	1	4736.86	21,105.1
1	4730.95	21,131.5	0	4734.58	21,115.3			
2	4727.90	21,145.1	2	4731.63	21,128.5			

TABLE 1 (continued)

$P_{O^{210}}P_{O^{210}}$			$P_{O^{208}}P_{O^{208}}$			$P_{O^{208}}P_{O^{209}}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
7	4726.97	21,149.3	7	4730.78	21,132.3	1	4729.75	21,136.9
1	4723.02	21,167.0	0	4726.83	21,149.9			
7	4719.98	21,180.6	4	4723.82	21,163.4			
0	4719.34	21,183.5	2	4723.07	21,166.8			
3	4712.94	21,212.3	3	4716.63	21,195.7			
3	4712.10	21,216.0	5	4715.83	21,199.2	1	4714.88	21,203.5
2	4706.03	21,243.4						
7	4704.91	21,248.5	7	4708.58	21,231.9	1	4707.70	21,235.9
7	4697.76	21,280.8	7	4701.45	21,264.1	1	4700.57	21,268.1
0	4695.28	21,292.0	1	4698.77	21,276.2			
3	4691.98	21,307.0	3	4695.62	21,290.5			
5	4690.70	21,312.8	6	4694.38	21,296.1	1	4693.41	21,300.5
1	4687.39	21,327.9	0	4691.03	21,311.3			
2	4684.57	21,340.7	1	4688.11	21,324.6			
3	4683.64	21,345.0	3	4687.34	21,328.1	0	4686.47	21,332.1
1	4679.45	21,364.1	0	4683.00	21,347.9			
3	4676.87	21,375.9	4	4680.41	21,359.7			
3	4676.08	21,379.5	4	4679.63	21,363.3	0	4678.77	21,367.2
1	4669.56	21,409.3						
7	4668.87	21,412.5	7	4672.38	21,396.4	1	4671.53	21,400.3
6	4661.70	21,445.4	7	4665.22	21,429.2	1	4664.34	21,433.3
0	4659.72	21,454.5						
3	4656.39	21,469.9	2	4659.84	21,454.0			
6	4654.62	21,478.0	6	4658.09	21,462.0	0	4657.23	21,466.0
0	4653.40	21,483.7						
1	4651.93	21,490.5	1	4655.10	21,475.8			
2	4648.93	21,504.3	3	4652.05	21,489.9			
5	4647.66	21,510.2	6	4650.93	21,495.1		4650.07	21,499.1
1	4643.98	21,527.2	2	4647.22	21,512.2			
2	4641.40	21,539.2	3	4644.53	21,524.7			
1	4640.71	21,542.4						
6	4640.30	21,544.3	6	4643.49	21,529.5			
			0	4642.55	21,533.9			
2	4633.79	21,574.6	3	4636.92	21,560.0			
3	4633.09	21,577.8	4	4636.23	21,563.2	0	4635.37	21,567.2
6	4625.83	21,611.7	6	4629.02	21,596.8	0	4628.25	21,600.4
0	4621.08	21,633.9						
5	4618.77	21,644.7	5	4621.88	21,630.2	0	4621.13	21,633.7
1	4616.43	21,655.7	0	4619.47	21,641.5			
3	4613.21	21,670.8	3	4616.22	21,656.7			
4	4611.63	21,678.3	4	4614.85	21,663.1	0	4613.98	21,667.2
1	4608.62	21,692.4						
3	4605.70	21,706.2	4	4608.77	21,691.7			
6	4604.62	21,711.3	6	4607.77	21,696.4			
1	4600.89	21,728.9	1	4603.65	21,715.8			

TABLE 1 (continued)

$P_{O^{210}}-P_{O^{210}}$			$P_{O^{208}}-P_{O^{208}}$			$P_{O^{208}}-P_{O^{209}}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
3	4598.19	21,741.6	3	4601.19	21,727.4			
4	4597.31	21,745.8	5	4600.29	21,731.7	1	4599.47	21,735.6
6	4590.02	21,780.3	7	4593.09	21,765.8	1	4592.23	21,769.8
5	4582.84	21,814.4	5	4585.95	21,799.6	0	4585.17	21,803.4
0	4580.77	21,824.3						
2	4577.55	21,839.6	3	4580.65	21,824.9			
4	4575.77	21,848.1	4	4578.90	21,833.2			
0	4574.42	21,854.6						
1	4573.13	21,860.8	1	4576.05	21,846.8			
3	4570.13	21,875.1	3	4573.10	21,860.9	0	4572.44	21,864.1
4	4568.84	21,881.3	4	4571.76	21,867.3	0	4571.05	21,870.7
1	4565.41	21,897.7						
3	4562.66	21,910.9	3	4565.53	21,897.1			
5	4561.58	21,916.1	6	4564.59	21,901.7			
			1	4563.64	21,906.2			
0	4557.61	21,935.2						
1	4555.18	21,946.9	1	4558.00	21,933.3			
4	4554.40	21,950.7	6	4557.23	21,937.0	0	4556.39	21,941.1
5	4547.12	21,985.8	5	4550.06	21,971.6	0	4549.34	21,975.1
0	4542.43	22,008.5	0	4545.21	21,995.0			
5	4540.13	22,019.7				0	4542.29	22,009.2
2	4537.98	22,030.1	2	4540.47	22,018.0			
3	4534.56	22,046.7	4	4537.42	22,032.8			
4	4533.20	22,053.3	3	4535.96	22,039.9	0	4535.19	22,043.6
2	4530.16	22,068.1	2	4532.76	22,055.4			
3	4527.32	22,082.0	4	4529.87	22,069.5	0	4529.23	22,072.6
6	4526.04	22,088.2	7	4528.68	22,075.3	0	4527.99	22,078.7
0	4523.99	22,098.2						
2	4522.53	22,105.3	2	4525.10	22,092.8			
3	4519.86	22,118.4	3	4522.45	22,105.7			
6	4518.88	22,123.2	6	4521.46	22,110.6	0	4520.70	22,114.3
6	4511.63	22,158.7	6	4514.26	22,145.8			
4	4504.47	22,194.0	4	4507.20	22,180.5	0	4506.47	22,184.1
0	4502.78	22,202.3	1	4505.25	22,190.1			
3	4499.30	22,219.5		4502.05	22,205.9			
4	4497.67	22,227.5	3	4500.30	22,214.5	0	4499.71	22,217.4
1	4494.90	22,241.2	1	4497.41	22,228.8			
			1	4494.57	22,242.9			
4	4490.75	22,261.8						
1	4489.17	22,269.6						
2	4487.46	22,278.1	4	4489.72	22,266.9			
1	4484.73	22,291.7	2	4487.06	22,280.1			
7	4483.54	22,297.6	6	4485.85	22,286.1	0	4485.18	22,289.4
6	4476.38	22,333.2	6	4478.71	22,321.6	0	4478.12	22,324.6
3	4469.02	22,370.0	4	4471.58	22,357.2	0	4470.95	22,360.4

TABLE 1 (continued)

$P_{O^{210}}-P_{O^{210}}$			$P_{O^{208}}-P_{O^{208}}$			$P_{O^{208}}-P_{O^{209}}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
0	4467.73	22,376.5						
3	4464.33	22,393.5	4	4466.76	22,381.3			
3	4462.42	22,403.1	3	4464.88	22,390.8			
2	4459.93	22,415.6	2	4462.35	22,403.5			
4	4456.80	22,431.3	4	4459.21	22,419.2			
4	4455.31	22,438.9	4	4457.73	22,426.7	0	4457.18	22,429.4
0	4454.13	22,444.8						
3	4452.32	22,453.9	3	4454.52	22,442.8			
3	4449.42	22,468.6	3	4451.70	22,457.0	0	4451.20	22,459.6
5	4448.16	22,474.9	5	4450.41	22,463.6	0	4449.93	22,466.0
1	4446.12	22,485.2	0	4448.07	22,475.4			
1	4444.40	22,493.9	1	4446.48	22,483.4			
3	4441.11	22,510.6	2	4443.38	22,499.1			
2	4433.90	22,547.2	2	4436.17	22,535.7			
3	4429.51	22,569.5	3	4431.59	22,559.0			
4	4427.40	22,580.3	3	4429.68	22,568.7	0	4429.18	22,571.2
2	4425.10	22,592.0	2	4427.32	22,580.7			
4	4421.89	22,608.4	4	4424.12	22,597.0			
4	4420.22	22,617.0	4	4422.45	22,605.6	0	4421.78	22,609.0
2	4417.43	22,631.3	2	4419.64	22,620.0			
3	4414.53	22,646.1	2	4416.74	22,634.8			
1	4413.99	22,648.9	0	4415.95	22,638.8			
6	4413.05	22,653.7	6	4415.24	22,642.5	0	4414.67	22,645.4
1	4411.28	22,662.8	1	4413.39	22,652.0			
2	4409.74	22,670.7	3	4411.83	22,660.0			
4	4405.99	22,690.0	5	4408.10	22,679.2			
3	4394.66	22,748.5	2	4396.71	22,737.9			
5	4392.49	22,759.8	5	4394.55	22,749.1	0	4394.08	22,751.5
1	4390.57	22,769.7	2	4392.50	22,759.7			
4	4387.17	22,787.4	4	4389.19	22,776.9			
6	4385.24	22,797.4	5	4387.33	22,786.5	0	4386.73	22,789.6
3	4382.78	22,810.2	2	4384.73	22,800.0			
4	4379.39	22,827.8	3	4381.42	22,817.3			
3	4378.15	22,834.3	4	4380.18	22,823.7			
1	4376.97	22,840.5	1	4378.79	22,831.0			
2	4375.29	22,849.2	3	4377.05	22,840.0			
3	4371.14	22,870.9	2	4373.04	22,861.0			
0	4368.85	22,882.9	0	4370.69	22,873.3			
1	4366.29	22,896.3	1	4368.35	22,885.5			
3	4365.14	22,902.4	3	4366.94	22,892.9			
3	4360.03	22,929.2	2	4361.82	22,919.8			
6	4357.74	22,941.2	6	4359.63	22,931.5	0	4359.15	22,933.8
1	4356.04	22,950.2						
3	4352.62	22,968.2	4	4354.40	22,958.8			
6	4350.61	22,978.8	5	4352.42	22,969.3			

TABLE 1 (continued)

P _o 210-P _o 210			P _o 208-P _o 208			P _o 208-P _o 209		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
3	4348.17	22,991.7	3	4350.13	22,981.4			
4	4345.04	23,008.3	3	4346.75	22,999.2			
1	4343.34	23,017.3	1	4345.26	23,007.1			
0	4342.35	23,022.6	1	4344.22	23,012.7			
2	4340.65	23,031.6	2	4342.50	23,021.8			
1	4337.00	23,051.0	2	4338.75	23,041.7			
1	4334.43	23,064.6	2	4336.23	23,055.0			
1	4332.57	23,074.5	1	4334.15	23,066.1			
3	4330.49	23,085.6	4	4332.19	23,076.5			
			0	4331.58	23,079.8			
3	4325.43	23,112.6	3	4327.34	23,102.4			
6	4323.17	23,124.7	6	4324.89	23,115.5			
			2	4323.27	23,124.2			
4	4318.01	23,152.3	5	4319.69	23,143.3			
4	4315.93	23,163.5	4	4317.74	23,153.8			
3	4313.87	23,174.6	3	4315.59	23,165.3			
4	4310.75	23,191.3	5	4312.28	23,183.1			
4	4308.29	23,204.6	3	4309.98	23,195.5			
0	4306.23	23,215.7	1	4308.06	23,205.8			
2	4303.57	23,230.0						
2	4302.88	23,233.7	3	4304.54	23,224.8			
1	4300.27	23,247.8	2	4301.89	23,239.1			
1	4298.60	23,256.9	2	4300.09	23,248.8			
6	4295.99	23,271.0	7	4297.56	23,262.5	0	4297.24	23,264.2
3	4291.29	23,296.5	4	4292.80	23,288.3			
6	4288.76	23,310.2	5	4290.43	23,301.2			
0	4287.51	23,317.0	1	4289.01	23,308.9			
2	4283.84	23,337.0	5	4285.32	23,328.9			
2	4283.55	23,338.6						
3	4279.69	23,359.6	3	4281.31	23,350.8			
2	4276.51	23,377.0	3	4278.06	23,368.5			
1	4274.41	23,388.5	1	4275.86	23,380.6			
8	4269.05	23,417.9	8	4270.47	23,410.1			
1	4266.47	23,432.0	0	4268.11	23,423.0			
			2	4267.72	23,425.1			
1	4264.88	23,440.7	2	4266.18	23,433.5			
8	4261.79	23,457.7	7	4263.24	23,449.8			
4	4257.15	23,483.3	5	4258.57	23,475.5			
0	4255.77	23,490.9						
2	4253.51	23,503.4	3	4254.82	23,496.2			
2	4249.63	23,524.9	2	4251.13	23,516.6			
0	4247.47	23,536.8	1	4248.64	23,530.3			
3	4245.82	23,546.0	3	4247.16	23,538.5			
4	4242.58	23,564.0	6	4243.78	23,557.3			
0	4240.91	23,573.2						

TABLE 1 (continued)

$P_{O}^{210}-P_{O}^{210}$			$P_{O}^{208}-P_{O}^{208}$			$P_{O}^{208}-P_{O}^{209}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
5	4235.00	23,606.1	5	4236.00	23,600.6			
2	4232.67	23,619.1	3	4233.70	23,613.4			
3	4230.70	23,630.1	4	4232.02	23,622.8			
1	4227.26	23,649.3						
5	4223.13	23,672.5	5	4224.28	23,666.0			
3	4219.59	23,692.3	4	4220.72	23,686.0			
1	4213.82	23,724.8	2	4214.92	23,718.6			
1	4211.99	23,735.1						
9	4208.48	23,754.9	10	4209.54	23,748.9			
1	4201.21	23,796.0	2	4202.26	23,790.0			
2	4198.88	23,809.2	3	4199.98	23,803.0			
5	4196.93	23,820.3	5	4197.94	23,814.5			
3	4194.89	23,831.8						
3	4189.45	23,862.8	4	4190.51	23,856.7			
1	4186.93	23,877.1						
3	4185.81	23,883.5	3	4187.03	23,876.6			
7	4182.10	23,904.7	7	4183.15	23,898.7			
2	4180.35	23,914.7	3	4181.50	23,908.1			
4	4175.60	23,941.9	5	4176.44	23,937.1			
0	4167.73	23,987.1	1	4168.62	23,982.0			
2	4165.50	24,000.0	3	4166.49	23,994.3			
			0	4165.10	24,002.3			
1	4163.50	24,011.5	1	4164.20	24,007.5			
1	4160.33	24,029.8	2	4161.06	24,025.6			
9	4156.00	24,054.8	9	4156.88	24,049.7			
3	4152.49	24,075.2	4	4153.49	24,069.4			
2	4150.02	24,089.5	2	4150.66	24,085.8			
3	4147.18	24,106.0	3	4148.03	24,101.1			
3	4142.22	24,134.9	4	4142.93	24,130.7			
			1	4140.97	24,142.1			
0	4138.84	24,154.6	1	4139.73	24,149.4			
7	4137.49	24,162.4	7	4138.29	24,157.8			
3	4132.34	24,192.6	4	4133.05	24,188.4			
1	4131.09	24,199.9	2	4131.76	24,196.0			
6	4130.02	24,206.2	5	4130.89	24,201.0			
4	4126.80	24,225.0	3	4127.64	24,220.1			
			1	4124.27	24,239.9			
3	4122.89	24,248.0	2	4123.74	24,243.0			
0	4119.32	24,269.0	0	4120.15	24,264.1			
4	4116.77	24,284.1	5	4117.28	24,281.0			
3	4114.15	24,299.5	3	4114.96	24,294.7			
7	4111.80	24,313.4	7	4112.49	24,309.3			
1	4109.18	24,328.9	2	4109.79	24,325.3			
1	4107.41	24,339.4	2	4107.78	24,337.2			
1	4105.86	24,348.6	1	4106.60	24,344.2			

TABLE 1 (continued)

$P_{O^{210}}-P_{O^{210}}$			$P_{O^{208}}-P_{O^{208}}$			$P_{O^{208}}-P_{O^{209}}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
3	4104.39	24,357.3	3	4105.00	24,353.7			
3	4101.36	24,375.3	2	4102.05	24,371.2			
			0	4100.78	24,378.7			
3	4099.41	24,386.9	3	4100.02	24,383.3			
2	4098.17	24,394.3	3	4098.84	24,390.3			
4	4093.86	24,420.0	3	4094.40	24,416.7			
0	4091.28	24,435.4	0	4091.51	24,434.0			
4	4090.00	24,443.0	3	4090.68	24,438.9			
6	4086.34	24,464.9	5	4086.89	24,461.6			
3	4083.91	24,479.5	4	4084.46	24,476.2			
1	4081.48	24,494.0	2	4082.09	24,490.4			
0	4078.76	24,510.4	0	4079.39	24,506.6			
2	4074.42	24,536.5	3	4074.82	24,534.1			
2	4073.28	24,543.3	2	4073.87	24,539.8			
6	4068.65	24,571.3	7	4069.05	24,568.8			
0	4066.73	24,582.9	1	4066.97	24,581.4			
2	4065.54	24,590.1	3	4065.89	24,587.9			
5	4061.05	24,617.2	5	4061.52	24,614.4			
3	4058.91	24,630.2	2	4059.34	24,627.6			
5	4057.51	24,638.7	5	4057.85	24,636.7			
2	4056.97	24,642.0						
3	4051.17	24,677.3	2	4051.62	24,674.5			
1	4049.91	24,685.0	1	4050.28	24,682.7			
2	4048.90	24,691.1	2	4049.26	24,688.9			
7	4043.58	24,723.6	7	4043.96	24,721.3			
3	4041.91	24,733.8	3	4042.15	24,732.3			
2	4040.86	24,740.2	2	4041.17	24,738.3			
			0	4036.91	24,764.5			
4	4036.03	24,769.9	4	4036.37	24,767.8			
4	4033.01	24,788.4	5	4033.28	24,786.7			
0	4030.86	24,801.6	0	4031.11	24,800.1			
6	4026.33	24,829.5	6	4026.64	24,827.6			
3	4024.94	24,838.1	3	4025.28	24,836.0			
6	4018.75	24,876.4	5	4018.90	24,875.4			
2	4017.43	24,884.5	3	4017.61	24,883.4			
1	4016.57	24,889.9	2	4016.74	24,888.8			
0	4010.82	24,925.5	1	4010.92	24,924.9			
2	4009.37	24,934.5	2	4009.72	24,932.4			
2	4008.48	24,940.1	3	4008.66	24,939.0			
			0	4006.91	24,949.9			
			1	4004.59	24,964.3			
5	4001.69	24,982.4	6	4001.93	24,980.9			
3	4000.67	24,988.8	3	4000.90	24,987.3			
0	3998.71	25,001.0	0	3998.79	25,000.5			
0	3995.61	25,020.4	1	3995.78	25,019.3			

TABLE 1 (continued)

$P_{O210}\text{-}P_{O210}$			$P_{O208}\text{-}P_{O208}$			$P_{O208}\text{-}P_{O209}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
2	3994.16	25,029.5	2	3994.18	25,029.4			
3	3992.52	25,039.8	2	3992.73	25,038.5			
0	3989.53	25,058.5	0	3989.78	25,057.0			
7	3984.94	25,087.4	9	3984.99	25,087.1			
1	3984.33	25,091.3	2	3984.44	25,090.6			
			2	3978.62	25,127.3			
3	3977.24	25,136.0	4	3977.33	25,135.4			
2	3976.40	25,141.3	3	3976.40	25,141.3			
			0	3972.24	25,167.6			
1	3969.99	25,181.9	2	3970.11	25,181.1			
5	3968.52	25,191.2	5	3968.53	25,191.1			
0	3963.60	25,222.5	1	3963.70	25,221.8			
10	3960.61	25,241.5	10	3960.55	25,241.9			
1	3957.60	25,260.7	0	3957.64	25,260.5			
4	3953.31	25,288.1	5	3953.22	25,288.7			
2	3952.31	25,294.5	1	3952.24	25,295.0			
			2	3946.47	25,332.0			
10	3944.39	25,345.3	10	3944.38	25,345.4			
			0	3943.29	25,352.4			
3	3938.10	25,385.8	3	3938.21	25,385.1			
4	3936.65	25,395.1	5	3936.62	25,395.3			
			0	3933.40	25,416.1			
1	3931.79	25,426.5	2	3931.78	25,426.6			
8	3928.42	25,448.3	9	3928.31	25,449.1			
0	3925.85	25,465.0	0	3925.94	25,464.5			
3	3921.54	25,493.0	4	3921.48	25,493.4			
4	3920.51	25,499.7	5	3920.45	25,500.1			
0	3917.34	25,520.3	0	3917.22	25,521.1			
1	3914.76	25,537.1	0	3914.73	25,537.3			
6	3912.72	25,550.5	7	3912.52	25,551.8			
			0	3911.50	25,558.4			
4	3906.51	25,591.1	5	3906.36	25,592.1			
			2	3905.17	25,599.8			
9	3904.76	25,602.5	8	3904.53	25,604.1			
3	3900.23	25,632.3	2	3900.00	25,633.8			
			2	3897.38	25,651.0			
2	3897.02	25,653.4	1	3896.89	25,654.2			
0	3894.33	25,671.1	0	3894.15	25,672.3			
			0	3892.64	25,682.3			
			0	3891.57	25,689.3			
3	3890.13	25,698.8	5	3889.82	25,700.9			
4	3889.21	25,704.9	5	3888.86	25,707.2			
2	3885.80	25,727.5	2	3885.55	25,729.1			
			1	3883.20	25,744.7			
2	3881.22	25,757.8	2	3880.97	25,759.5			

TABLE 1 (continued)

$P_{O210-P_{O210}}$			$P_{O208-P_{O208}}$			$P_{O208-P_{O209}}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
0	3880.22	25,764.5	1	3879.93	25,766.4			
5	3875.11	25,798.4	6	3874.88	25,800.0			
6	3873.89	25,806.6	7	3873.53	25,809.0			
1	3871.80	25,820.5	1	3871.14	25,824.9			
2	3869.03	25,839.0	3	3868.44	25,842.9			
2	3867.36	25,850.1						
4	3865.88	25,860.0	5	3865.38	25,863.4			
0	3861.56	25,889.0						
			0	3860.10	25,898.7			
6	3858.82	25,907.3	7	3858.37	25,910.4			
2	3854.43	25,936.8	3	3854.05	25,939.4			
0	3852.43	25,950.3	1	3851.78	25,954.7			
5	3850.71	25,961.9	6	3850.23	25,965.1			
			0	3848.45	25,977.1			
2	3844.44	26,004.2						
5	3844.02	26,007.1	6	3843.50	26,010.6			
1	3840.48	26,031.0						
2	3837.89	26,048.6	2	3837.18	26,053.4			
5	3835.79	26,062.9	4	3835.33	26,066.0			
			0	3834.48	26,071.8			
0	3835.40	26,065.5						
1	3829.29	26,107.1	1	3828.86	26,110.1			
3	3823.44	26,147.1	4	3822.78	26,151.6			
8	3821.32	26,161.6	8	3820.60	26,166.5			
			0	3812.41	26,222.7			
2	3809.41	26,243.4	3	3808.98	26,246.3			
5	3806.87	26,260.9	6	3806.19	26,265.6			
0	3804.25	26,279.0	1	3803.43	26,284.6			
1	3795.58	26,339.0	1	3795.02	26,342.9			
7	3792.58	26,359.8	7	3791.87	26,364.8			
1	3790.61	26,373.5	1	3790.24	26,376.1			
			0	3781.42	26,437.6			
6	3778.67	26,456.9	6	3777.95	26,461.9			
1	3777.37	26,466.0	1	3776.62	26,471.2			
			1	3772.65	26,499.1			
6	3765.09	26,552.3	5	3764.21	26,558.5			
3	3760.44	26,585.1	3	3759.61	26,591.0			
6	3751.46	26,648.7	6	3750.68	26,654.3			
			0	3747.11	26,679.7			
2	3747.03	26,680.3	3	3745.99	26,687.7			
5	3738.25	26,742.9	5	3737.38	26,749.1			
1	3735.56	26,762.2	0	3734.58	26,769.2			
3	3734.04	26,773.1	4	3732.93	26,781.0			
1	3732.65	26,783.0	2	3731.76	26,789.4			
1	3730.09	26,801.4	0	3729.12	26,808.4			

TABLE 1 (continued)

$P_{O210}-P_{O210}$			$P_{O208}-P_{O208}$			$P_{O208}-P_{O209}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
6	3725.34	26,835.6	6	3724.25	26,843.4			
1	3723.46	26,849.1	1	3722.26	26,857.8			
5	3721.29	26,864.8	6	3720.24	26,872.4			
0	3718.31	26,886.3						
			0	3716.64	26,898.4			
6	3712.44	26,928.8	5	3711.44	26,936.1			
6	3708.69	26,956.1	6	3707.69	26,963.3			
0	3707.13	26,967.4						
2	3705.34	26,980.4	2	3704.25	26,988.4			
4	3699.81	27,020.8	3	3698.75	27,028.5			
4	3696.35	27,046.0	4	3695.29	27,053.8			
3	3693.05	27,070.2	2	3692.16	27,076.7			
3	3687.52	27,110.8	3	3686.35	27,119.4			
5	3684.23	27,135.0	5	3683.11	27,143.3			
1	3681.85	27,152.6						
3	3681.38	27,156.0	3	3680.25	27,164.4			
0	3678.85	27,174.7	0	3677.85	27,182.1			
3	3675.36	27,200.5	2	3674.07	27,210.1			
5	3672.27	27,223.4	5	3671.10	27,232.1			
3	3669.63	27,243.0	3	3668.56	27,250.9			
1	3667.62	27,257.9	0	3666.28	27,267.9			
2	3663.24	27,290.5	2	3661.93	27,300.3			
3	3660.62	27,310.0	3	3659.35	27,319.5			
2	3658.37	27,326.8	3	3656.94	27,337.5			
1	3656.52	27,340.6	1	3654.96	27,352.3			
0 ?	3651.62	27,377.3						
2	3648.97	27,397.2	2	3647.76	27,406.3			
3	3646.98	27,412.2	3	3645.63	27,422.3			
2	3645.07	27,426.5						
			1	3644.09	27,433.9			
0	3639.92	27,465.3						
1	3637.69	27,482.2	1	3636.27	27,492.9			
2	3635.70	27,497.2	1	3634.65	27,505.2			
1	3634.33	27,507.6	1	3633.11	27,516.8			
1	3625.03	27,578.1	0	3623.66	27,588.6			
			0	3622.62	27,596.5			
1	3615.65	27,649.7						
2	3614.10	27,661.5						
1	3613.13	27,669.0	5	3611.62	27,680.5			
1	3612.35	27,674.9						
1	3604.86	27,732.8						
4	3602.38	27,751.5	5	3601.46	27,758.6			
4	3592.52	27,827.7	5	3591.27	27,837.4			
2	3583.90	27,894.6						
4	3582.76	27,903.5	5	3581.47	27,913.6			

TABLE 1 (continued)

$P_{O^{210}}-P_{O^{210}}$			$P_{O^{208}}-P_{O^{208}}$			$P_{O^{208}}-P_{O^{209}}$		
Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)	Intensity	λ (Å)	σ (cm ⁻¹)
			5	3577.16	27,947.2			
4	3572.98	27,979.9	3	3571.73	27,989.7			
3	3563.26	28,056.2	3	3562.01	28,066.0			
			2	3552.25	28,143.2			
0 ?	3546.60	28,188.0	0 ?	3545.49	28,196.8			
2	3534.94	28,281.0						
0 ?	3531.43	28,309.1	0 ?	3530.16	28,319.3			
0 ?	3529.40	28,325.4	1	3527.91	28,337.3			
0 ?	3526.30	28,350.3	1	3524.85	28,361.9			
0 ?	3521.12	28,392.0	0 ?	3519.56	28,404.5			
1 ?	3518.18	28,415.7	0	3516.82	28,426.7			
1	3510.38	28,478.8	0 ?	3509.33	28,487.4			
0 ?	3499.63	28,566.3	0 ?	3498.39	28,576.4			

TABLE 2. PARAMETERS OF ATOMS AND MOLECULES OF GROUP VI*

n	Atom	ω_e'' (cm ⁻¹)	V (volts)	μ (atomic units)	Z	ω_e' (cm ⁻¹)	Ratio, ω_e''/ω_e'
2	O ¹⁶	1580.4	13.62	8.0	8	700.4	2.26
3	S ³²	725.7	10.36	16.0	16	434.0	1.67
4	Se ⁸⁰	391.9	9.75	40.0	34	271.1	1.45
5	Te	251.0	9.01	63.8	52	163.0	1.54
6	P _O ²¹⁰		8.43	105.0	84		

*A single prime on a symbol signifies that it refers to the upper state of the principal system, and a double prime indicates that it refers to the lower state of that system.

TABLE 3. PREDICTIONS OF ω_e'' FOR $P_{O^{210}}-P_{O^{210}}$

Bibliographical Reference	Equation	ω_e'' (cm ⁻¹)	Notes
(60)	$\log \omega_e'' + l \log \mu = m$	161.1	
(61)	$\log \omega_e'' + n \log (2Z) = p$	156.3	
(62)	$c^3 - 3.9c^2b + 3cb^2 + b^3 = 0$	148.9	$c = 391.9 \text{ cm}^{-1} = \omega_e''$ for Se-Se
(62)	$c^3 - 3.9c^2b + 3cb^2 + b^3 = 0$	157.7	$c = 251.0 \text{ cm}^{-1} = \omega_e''$ for Te-Te
(63)	$\log \omega_e'' = g - b \log n^2V$	175.2	Corrected by G. W. Charles
	Experimental value	155.715	

Next an array of the frequency differences of the strongest bands at the short wavelength end of the spectrum was set up. This array is reproduced in Table 4. Differences of about 50, 100, 150, 200, 250, 300, 350, 400, and 450 cm^{-1} are seen to occur frequently. These may be regarded as combinations of two differences of about 100 and 150 cm^{-1} . According to the considerations stated above, these should be approximately the constants for the excited electronic state and for the fundamental electronic state, respectively, of the principal system of Po-Po. Furthermore, a decrease of frequency by changes in the excited state, corresponding to an approach toward lower levels of this state, should be accompanied by an increase in the difference, which is observed. The difference near 100 cm^{-1} increases from 93 cm^{-1} at 26,700 cm^{-1} to 106 cm^{-1} at 24,500 cm^{-1} . For this reason, also, the difference near 50 cm^{-1} cannot be the correct one for the upper state, since differences near this figure decrease from 56 cm^{-1} near 26,000 cm^{-1} to 46 cm^{-1} near 24,500 cm^{-1} . In the same way, the differences near 150 cm^{-1} vary in the proper manner to correspond to differences in the lower state, since a decrease of frequency here corresponds to a change toward higher vibrational levels with a corresponding decrease in differences. Here the difference varies from 156 cm^{-1} near 25,900 cm^{-1} to 152 cm^{-1} near 24,500 cm^{-1} .

A similar array set up for the strongest bands near the long wavelength end of the spectrum is reproduced in Table 5. The recurring differences in this array were considered to be combinations of differences of about 100 and 135 cm^{-1} . The difference around 135 cm^{-1} varies in the proper fashion to belong to the lower state, decreasing toward smaller frequencies. Differences near 35 cm^{-1} and near 70 cm^{-1} vary in the wrong fashion to belong to the upper state, decreasing toward smaller frequencies. The fundamental differences in the two arrays being nearly equal suggested that both sets of bands of Tables 4 and 5 are parts of a larger array. Therefore an attempt was made to fit the two together; the result is shown in Fig. 2, which is the Deslandres array for the polonium molecular spectrum.

In this array, an asterisk denotes a double assignment. The different curves distinguish what appear to be different Franck-Condon parabolas. Such multiplicity of parabolas has been observed by Herzberg (64) for P-P, by Almy and Kinzer (65) for As-As, by Jenkins and Rochester (66) for AgCl, and by Gaydon and Pearse (67) for RbH. A similar array was set up for $\text{Po}^{208}\text{-Po}^{208}$ and a less

extensive one for $\text{Po}^{208}\text{-Po}^{209}$. There is no need to reproduce these. Only one band was found that could be placed in a column at the left of the first column. Very few bands were found that would fit into a row above the top row. The numbering employed in the array followed from these observations.

The Deslandres arrays having been set up, the next step was to calculate a set of empirical energy levels which would satisfactorily reproduce the arrays. The procedure consisted in starting with the lowest vibrational level of the lower state as zero, using only the bands in the vicinity of the principal Franck-Condon parabola, and then calculating a set of energy levels by successive adjustment until the best fit with observed frequencies was obtained. The set of levels for Po^{210} is shown in Table 6, and the set for Po^{208} is shown in Table 7. With these sets of levels, the deviation between the observed and calculated frequencies of 200 heads in the principal parabola had a mean value of 0.3 cm^{-1} in each spectrum. The same mean deviation holds for the entire array of 334 bands shown in Fig. 2.

Next, an attempt was made to fit the observed energy levels for Po^{210} to the expected formula by least squares. The best fit was obtained with the equation

$$(9) \quad G' = 25,125.7 + 108.090 v' - 0.4417 v'^2$$

for the upper state and

$$(10) \quad G'' = 155.380 v'' - 0.3358 v''^2 - 0.0003226 v''^3$$

for the lower state. When rewritten so that the minimum of the potential curve (equilibrium energy) is taken as zero for the lower state, the equations become, respectively,

$$(11) \quad G' = 25,149.3 + 108.532 \left(v' + \frac{1}{2} \right) - 0.4417 \left(v' + \frac{1}{2} \right)^2$$

$$(12) \quad G'' = 155.715 \left(v'' + \frac{1}{2} \right) - 0.3353 \left(v'' + \frac{1}{2} \right)^2 - 0.0003226 \left(v'' + \frac{1}{2} \right)^3$$

TABLE 4. DIFFERENCES OF FREQUENCIES OF STRONG BANDS OF Po^{210} AT SHORT WAVELENGTH END OF SPECTRUM

Frequency (cm^{-1})	Frequency (cm^{-1})																													
	26,836	26,743	26,649	26,552	26,457	26,360	26,261	26,162	26,063	26,007	25,962	25,907	25,807	25,798	25,705	25,603	25,551	25,500	25,448	25,345	25,242	25,191	25,087	24,982	24,876	24,830	24,724	24,639	24,617	24,571
26,836																														
26,743	93																													
26,649	187	94																												
26,552	284	191	97																											
26,457	379	286	192	95																										
26,360		383	289	192	97																									
26,261		482	388	291	196	99																								
26,162			487	390	295	198	99																							
26,063				489	394	297	198	99																						
26,007					450	353	254	155	56																					
25,962					495	398	299	200	101	45																				
25,907						453	354	255	156	100	55																			
25,807							454	355	256	200	155	100																		
25,798							463	364	265	209	164	109	9																	
25,705								457	358	302	257	202	102	93																
25,603									460	404	359	304	204	195	102															
25,551										456	411	356	256	247	154	52														
25,500											462	407	307	298	205	103	51													
25,448												459	359	350	257	155	103	52												
25,345													462	453	360	258	206	155	103											
25,242														463	361	309	258	206	103											
25,191															412	360	309	257	154	51										
25,087																464	413	361	258	155	104									
24,982																	466	363	260	209	105									
24,876																		469	366	315	211	106								
24,830																			412	361	257	152	46							
24,724																				467	363	258	152	106						
24,639																					448	343	237	191	85					
24,617																					470	365	259	213	107	22				
24,571																						411	305	259	153	68	46			
24,465																							411	365	259	174	152	106		

TABLE 5. DIFFERENCES OF FREQUENCIES OF STRONG BANDS OF Po^{210} AT LONG WAVELENGTH END OF SPECTRUM

Frequency (cm^{-1})	Frequency (cm^{-1})																								
	22,333	22,298	22,159	22,123	22,088	22,020	21,986	21,916	21,814	21,780	21,711	21,645	21,612	21,544	21,510	21,478	21,445	21,413	21,313	21,281	21,249	21,181	21,149	21,118	
22,333																									
22,298	35																								
22,159	174	139																							
22,123	210	175	36																						
22,088	245	210	71	35																					
22,020	313	278	139	103	68																				
21,986	347	312	173	137	102	34																			
21,916	417	382	243	207	172	104	70																		
21,814		484	345	309	274	206	172	102																	
21,780			379	343	308	240	206	136	34																
21,711			448	412	377	309	275	205	103	69															
21,645				478	443	375	341	271	169	135	66														
21,612					476	408	374	304	202	168	99	33													
21,544						476	442	372	270	236	167	101	68												
21,510							476	406	304	270	201	135	102	34											
21,478								438	336	302	233	167	134	66	32										
21,445								471	369	335	266	200	167	99	65	33									
21,413									401	367	298	232	199	131	97	65	32								
21,313									501	467	398	332	299	231	197	165	132	100							
21,281										499	430	364	331	263	229	197	164	132	32						
21,249											462	396	363	295	261	229	196	164	64	32					
21,181												464	431	363	329	297	264	232	132	100	68				
21,149												496	463	395	361	329	296	264	164	132	100	32			
21,118													494	426	392	360	327	295	195	163	131	63	31		
21,087														457	423	391	358	326	226	194	162	94	62	31	

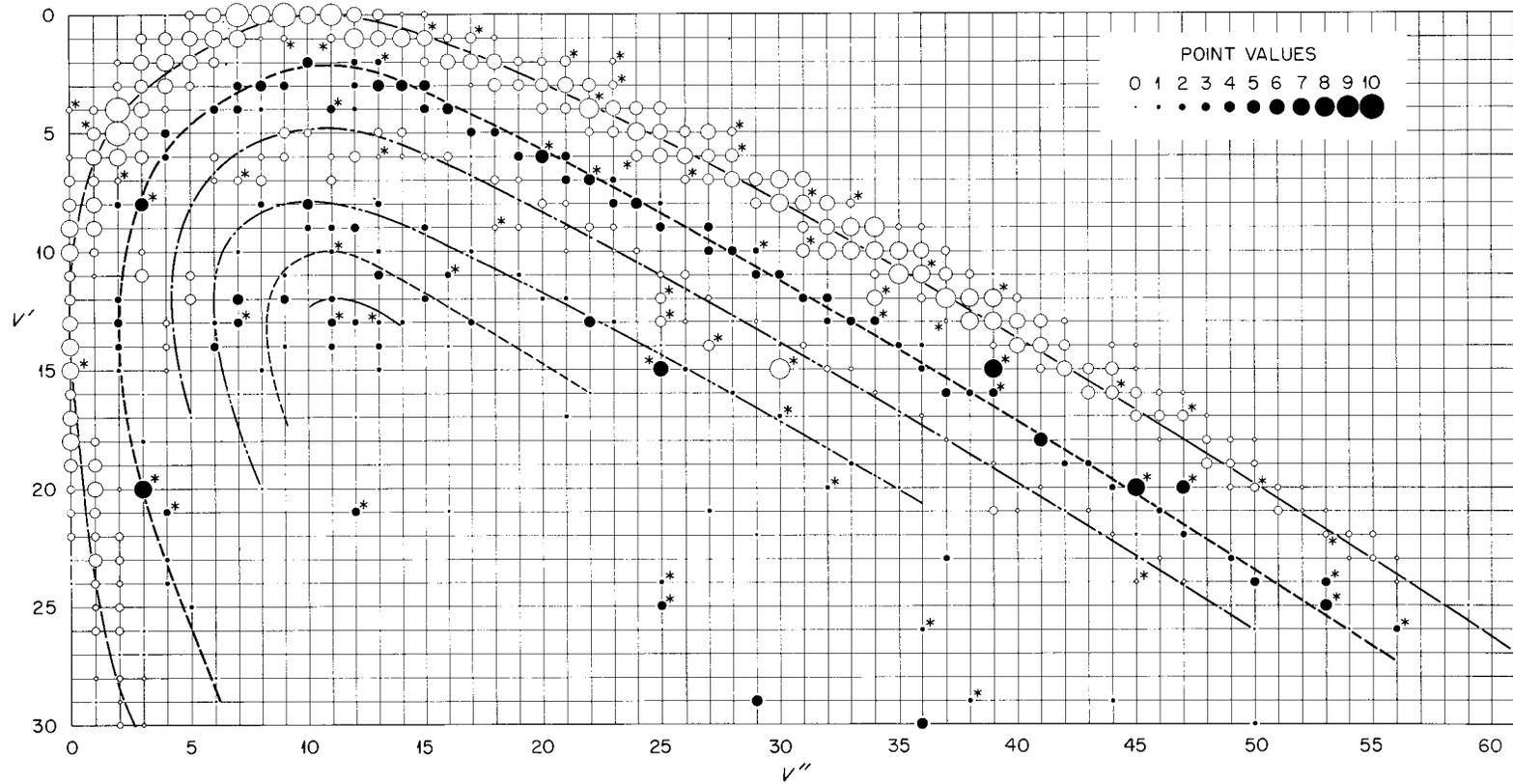


Fig. 2. Deslandres Array of the Principal System of Po-Po.

TABLE 6. EMPIRICAL ENERGY LEVELS OF Po^{210}

Lower State		Upper State		Lower State		Upper State	
ν''	Level (cm^{-1})	ν'	Level (cm^{-1})	ν''	Level (cm^{-1})	ν'	Level (cm^{-1})
0	0.0	0	25,125.7	30	4350.2	30	27,971.1
1	155.4	1	25,233.2	31	4484.5		
2	309.7	2	25,339.9	32	4617.8		
3	463.4	3	25,445.7	33	4750.0		
4	615.9	4	25,550.7	34	4882.0		
5	768.4	5	25,654.7	35	5013.0		
6	919.7	6	25,758.1	36	5143.6		
7	1070.8	7	25,860.2	37	5273.0		
8	1221.3	8	25,962.3	38	5402.3		
9	1370.6	9	26,062.7	39	5530.2		
10	1519.6	10	26,162.5	40	5657.6		
11	1668.6	11	26,261.6	41	5783.8		
12	1815.3	12	26,360.0	42	5909.4		
13	1962.5	13	26,457.0	43	6034.3		
14	2108.4	14	26,552.5	44	6158.6		
15	2254.3	15	26,648.0	45	6282.4		
16	2398.7	16	26,742.3	46	6405.1		
17	2542.8	17	26,836.1	47	6527.3		
18	2686.2	18	26,928.0	48	6648.6		
19	2829.0	19	27,020.0	49	6768.9		
20	2970.3	20	27,111.2	50	6889.1		
21	3112.2	21	27,200.4	51	7007.8		
22	3251.7	22	27,289.7	52	7125.8		
23	3392.5	23	27,378.5	53	7243.6		
24	3530.9	24	27,465.5	54	7360.1		
25	3669.3	25	27,552.8	55	7475.9		
26	3807.0	26	27,637.5	56	7591.7		
27	3943.7	27	27,721.4	59	7932.3 (?)		
28	4080.0	28	27,805.4	61	8155.3 (?)		
29	4216.0	29	27,887.8				

TABLE 7. EMPIRICAL ENERGY LEVELS OF Po^{208}

Lower State		Upper State		Lower State		Upper State	
ν''	Level (cm^{-1})	ν'	Level (cm^{-1})	ν''	Level (cm^{-1})	ν'	Level (cm^{-1})
0	0.0	0	25,125.4	28	4097.2	28	27,817.1
1	156.3	1	25,233.3	29	4233.4	29	27,899.6
2	311.2	2	25,340.4	30	4368.2	30	27,982.3
3	465.5	3	25,446.8	31	4503.2		
4	619.3	4	25,552.2	32	4637.0		
5	771.8	5	25,657.1	33	4770.0		
6	924.1	6	25,760.3	34	4902.4		
7	1075.8	7	25,863.3	35	5034.1		
8	1226.3	8	25,965.3	36	5164.8		
9	1376.6	9	26,066.1	37	5294.8		
10	1525.3	10	26,166.6	38	5424.3		
11	1675.7	11	26,266.0	39	5552.9		
12	1823.7	12	26,364.2	40	5680.5		
13	1971.4	13	26,461.8	41	5807.5		
14	2118.1	14	26,558.0	42	5933.8		
15	2263.9	15	26,654.1	43	6059.3		
16	2409.2	16	26,748.7	44	6183.7		
17	2554.0	17	26,843.6	45	6308.3		
18	2697.7	18	26,936.6	46	6431.7		
19	2841.3	19	27,028.4	47	6554.5		
20	2983.4	20	27,119.6	48	6676.2		
21	3125.6	21	27,209.7	49	6797.1		
22	3266.1	22	27,299.8	50	6917.1		
23	3406.6	23	27,388.0	51	7036.5		
24	3546.1	24	27,475.7	52	7154.6		
25	3685.2	25	27,562.4	53	7272.9		
26	3823.5	26	27,648.5	54	7390.6		
27	3961.1	27	27,733.5	55	7506.8 (?)		

Table 8 shows a comparison of the levels calculated from Eq. 11 with the experimental levels modified by the addition of 77.8 cm^{-1} to those given in Table 6. Table 9 shows a similar comparison of the levels calculated from Eq. 12 with those modified in the same way from Table 6. The agreement is very satisfactory. It should be pointed out that a cubic equation permitted no better fit for the upper state than the quadratic equation given. The reason for this is probably

TABLE 8. COMPARISON OF CALCULATED AND OBSERVED LEVELS OF THE UPPER STATE OF Po^{210}

v'	Calculated Level (cm^{-1})	Observed Level (cm^{-1})	Difference (obs - calc) (cm^{-1})
0	25,203.5	25,203.5	0.0
1	25,311.1	25,311.0	-0.1
2	25,417.9	25,417.7	-0.2
3	25,523.7	25,523.5	-0.2
4	25,628.7	25,628.5	-0.2
5	25,732.9	25,732.5	-0.4
6	25,836.1	25,835.9	-0.2
7	25,938.4	25,938.0	-0.4
8	26,039.9	26,040.1	+0.2
9	26,140.5	26,140.5	0.0
10	26,240.2	26,240.3	+0.1
11	26,339.0	26,339.4	+0.4
12	26,436.9	26,437.8	+0.9
13	26,534.0	26,534.8	+0.8
14	26,630.1	26,630.3	+0.2
15	26,725.4	26,725.8	+0.4
16	26,819.8	26,820.1	+0.3
17	26,913.3	26,913.9	+0.6
18	27,005.9	27,005.8	-0.1
19	27,097.7	27,097.8	+0.1
20	27,188.5	27,189.0	+0.5
21	27,278.5	27,278.2	-0.3
22	27,367.6	27,367.5	-0.1
23	27,455.8	27,456.3	+0.5
24	27,543.2	27,543.3	+0.1
25	27,629.6	27,630.6	+1.0
26	27,715.2	27,715.3	+0.1
27	27,799.8	27,799.2	-0.6
28	27,883.6	27,883.2	-0.4
29	27,966.5	27,965.6	-0.9
30	28,048.6	28,048.9	+0.3
			Mean 0.3

that the quadratic equation already represents the levels as well as they are known, or approximately 0.3 cm^{-1} on the average.

The interpretation of the constants in Eqs. 11 and 12 is as follows:

	cm^{-1}
T'_e	25,149.3
ω_e	108.532
$\omega'_e x'_e$	0.4417
ω''_e	155.715
$\omega''_e x''_e$	0.3353
$\omega''_e y''_e$	-0.0003226

Similar considerations led to the following equations for Po^{208} :

$$(13) \quad G' = 25,149.1 + 108.977 \left(v' + \frac{1}{2} \right) - 0.4423 \left(v' + \frac{1}{2} \right)^2$$

for the upper state and

$$(14) \quad G'' = 156.440 \left(v'' + \frac{1}{2} \right) - 0.3400 \left(v'' + \frac{1}{2} \right)^2 - 0.0002949 \left(v'' + \frac{1}{2} \right)^3$$

for the lower state. Table 10 shows a comparison of levels calculated from Eq. 13 with those obtained from Table 7 by the addition of 78.1 cm^{-1} . Table 11 shows a similar comparison between levels calculated from Eq. 14 and those modified from Table 7 in the same way. Again the agreement is excellent. The constants in Eqs. 11 through 13 and in the tabulation above are summarized in Table 12, which also contains probable errors in the constants.

Now, according to the theory of vibrational isotope effect (68) of diatomic molecules, the vibrational energy of an isotope molecule may be

TABLE 9. COMPARISON OF CALCULATED AND OBSERVED LEVELS OF THE LOWER STATE OF Po^{210}

ν''	Calculated Level (cm^{-1})	Observed Level (cm^{-1})	Difference (obs - calc) (cm^{-1})	ν''	Calculated Level (cm^{-1})	Observed Level (cm^{-1})	Difference (obs - calc) (cm^{-1})
0	77.8	77.8	0.0	30	4428.2	4428.0	-0.2
1	232.8	233.2	+0.4	31	4562.2	4562.3	+0.1
2	387.2	387.5	+0.3	32	4695.5	4695.6	+0.1
3	540.9	541.2	+0.3	33	4828.0	4827.8	-0.2
4	693.9	693.7	-0.2	34	4959.8	4959.8	0.0
5	846.2	846.2	0.0	35	5090.9	5090.8	-0.1
6	997.9	997.5	-0.4	36	5221.2	5221.4	+0.2
7	1148.9	1148.6	-0.3	37	5350.8	5350.8	0.0
8	1299.2	1299.1	-0.1	38	5479.6	5480.1	+0.5
9	1448.8	1448.4	-0.4	39	5607.7	5608.0	+0.3
10	1597.7	1597.4	-0.3	40	5735.1	5735.4	+0.3
11	1745.9	1746.4	+0.5	41	5861.6	5861.6	0.0
12	1893.4	1893.1	-0.3	42	5987.5	5987.2	-0.3
13	2040.3	2040.3	0.0	43	6112.6	6112.1	-0.5
14	2186.4	2186.2	-0.2	44	6236.9	6236.4	-0.5
15	2331.8	2332.1	+0.3	45	6360.5	6360.2	-0.3
16	2476.6	2476.5	-0.1	46	6483.3	6482.9	-0.4
17	2620.6	2620.6	0.0	47	6605.4	6605.1	-0.3
18	2763.9	2764.0	+0.1	48	6726.7	6726.4	-0.3
19	2906.6	2906.8	+0.2	49	6847.2	6846.7	-0.5
20	3048.5	3048.1	-0.4	50	6967.0	6966.9	-0.1
21	3189.7	3190.0	+0.3	51	7086.0	7085.6	-0.4
22	3330.2	3329.5	-0.7	52	7204.2	7203.6	-0.6
23	3469.9	3470.3	+0.4	53	7321.6	7321.4	-0.2
24	3609.0	3608.7	-0.3	54	7438.3	7437.9	-0.4
25	3747.4	3747.1	-0.3	55	7554.2	7553.7	-0.5
26	3885.0	3884.8	-0.2	56	7669.4	7669.5	+0.1
27	4021.9	4021.5	-0.4	59	8010.0	8010.1	+0.1
28	4158.1	4157.8	-0.3	61	8233.2	8233.1	-0.1
29	4293.5	4293.8	+0.3				Mean 0.3

written

$$(15) \quad G^i(v) = T_e + \rho\omega_e \left(v + \frac{1}{2} \right) - \rho^2\omega_e x_e \left(v + \frac{1}{2} \right)^2 + \rho^3\omega_e y_e \left(v + \frac{1}{2} \right)^3 + \dots,$$

where the constants are respectively T_e , ω_e , $\omega_e x_e$, and $\omega_e y_e$ for the reference molecule; ρ is defined by the equation $(\mu/\mu^i)^{1/2}$, where $\mu = m_1 m_2 / (m_1 + m_2)$ is the reduced mass of the molecule. Assuming the reference molecule to be $\text{Po}^{210}\text{-Po}^{210}$ and the isotope molecule to be $\text{Po}^{208}\text{-Po}^{208}$, ρ comes out to be $(105/104)^{1/2} = 1.004796$, ρ^2 is 1.009615, while ρ^3 is 1.014457. In the case where the isotope molecule is $\text{Po}^{208}\text{-Po}^{209}$, these constants are respectively 1.003594, 1.007201, and 1.010821. With the use of the values of ρ , ρ^2 , and ρ^3 for $\text{Po}^{210}\text{-Po}^{210}$ and $\text{Po}^{208}\text{-Po}^{208}$ and of the observed constants for $\text{Po}^{210}\text{-Po}^{210}$, the predicted values for $\text{Po}^{208}\text{-Po}^{208}$ given in Table 12 were obtained. The excellent agreement of the observed and predicted constants for $\text{Po}^{208}\text{-Po}^{208}$, especially in the lower state, is very strong support for the assignment of the band system to diatomic polonium and for the correctness of the numbering scheme.

Table 13 gives a complete summary of the constants of the principal systems of the Group VI homonuclear diatomic molecules. The data for $\text{O}^{16}\text{-O}^{16}$, $\text{S}^{32}\text{-S}^{32}$, $\text{Se}^{80}\text{-Se}^{80}$, and Te-Te are taken from the literature (48, 58, and 69), while those for $\text{Po}^{210}\text{-Po}^{210}$ are derived from the analysis described above.

A summary of the classified bands is given in Table 14, which shows intensities and frequencies for $\text{Po}^{210}\text{-Po}^{210}$, vibrational quantum numbers, differences between observed and calculated band

TABLE 10. COMPARISON OF CALCULATED AND OBSERVED LEVELS OF THE UPPER STATE OF Po^{208}

v'	Calculated Level (cm ⁻¹)	Observed Level (cm ⁻¹)	Difference (obs - calc) (cm ⁻¹)
0	25,203.5	25,203.5	0.0
1	25,311.6	25,311.4	-0.2
2	25,418.8	25,418.5	-0.3
3	25,525.1	25,524.9	-0.2
4	25,630.5	25,630.3	-0.2
5	25,735.1	25,735.2	+0.1
6	25,838.8	25,838.4	-0.4
7	25,941.5	25,941.4	-0.1
8	26,043.4	26,043.4	0.0
9	26,144.5	26,144.2	-0.3
10	26,244.6	26,244.7	+0.1
11	26,343.8	26,344.1	+0.3
12	26,442.2	26,442.3	+0.1
13	26,539.7	26,539.9	+0.2
14	26,636.3	26,636.1	-0.2
15	26,732.0	26,732.2	+0.2
16	26,826.8	26,826.8	0.0
17	26,920.7	26,921.7	+1.0
18	27,013.8	27,014.7	+0.9
19	27,106.0	27,106.5	+0.5
20	27,197.3	27,197.7	+0.4
21	27,287.7	27,287.8	+0.1
22	27,377.2	27,377.9	+0.7
23	27,465.8	27,466.1	+0.3
24	27,553.5	27,553.8	+0.3
25	27,640.4	27,640.5	+0.1
26	27,726.4	27,726.6	+0.2
27	27,811.5	27,811.6	+0.1
28	27,895.7	27,895.2	-0.5
29	27,979.0	27,977.7	-1.3
30	28,061.4	28,060.4	-1.0
			Mean 0.3

frequencies, and observed and calculated isotope shifts between $\text{Po}^{208}\text{-Po}^{208}$ and $\text{Po}^{210}\text{-Po}^{210}$ and between $\text{Po}^{208}\text{-Po}^{209}$ and $\text{Po}^{210}\text{-Po}^{210}$.

TABLE 11. COMPARISON OF CALCULATED AND OBSERVED LEVELS OF THE LOWER STATE OF Po^{208}

ν''	Calculated Level (cm^{-1})	Observed Level (cm^{-1})	Difference (obs - calc) (cm^{-1})	ν''	Calculated Level (cm^{-1})	Observed Level (cm^{-1})	Difference (obs - calc) (cm^{-1})
0	78.1	78.1	0.0	29	4311.5	4311.5	0.0
1	233.9	234.4	+0.5	30	4446.8	4446.3	-0.5
2	389.0	389.3	+0.3	31	4581.3	4581.3	0.0
3	543.4	543.6	+0.2	32	4715.1	4715.1	0.0
4	697.1	697.4	+0.3	33	4848.1	4848.1	0.0
5	850.1	849.9	-0.2	34	4980.4	4980.5	+0.1
6	1002.4	1002.2	-0.2	35	5111.9	5112.2	+0.3
7	1154.1	1153.9	-0.2	36	5242.8	5242.9	+0.1
8	1305.0	1304.4	-0.6	37	5372.8	5372.9	+0.1
9	1455.2	1454.7	-0.5	38	5502.1	5502.4	+0.3
10	1604.8	1603.4	-1.4	39	5630.7	5631.0	+0.3
11	1753.6	1753.8	+0.2	40	5758.5	5758.6	+0.1
12	1901.8	1901.8	0.0	41	5885.6	5885.6	0.0
13	2049.3	2049.5	+0.2	42	6011.9	6011.9	0.0
14	2196.0	2196.2	+0.2	43	6137.5	6137.4	-0.1
15	2342.0	2342.0	0.0	44	6262.3	6261.8	-0.5
16	2487.4	2487.3	-0.1	45	6386.4	6386.4	0.0
17	2632.0	2632.1	+0.1	46	6509.6	6509.8	+0.2
18	2775.9	2775.8	-0.1	47	6632.2	6632.6	+0.4
19	2919.1	2919.4	+0.3	48	6753.9	6754.3	+0.4
20	3061.6	3061.5	-0.1	49	6874.9	6875.2	+0.3
21	3203.4	3203.7	+0.3	50	6995.2	6995.2	0.0
22	3344.4	3344.2	-0.2	51	7114.6	7114.6	0.0
23	3484.7	3484.7	0.0	52	7233.3	7232.7	-0.6
24	3624.4	3624.2	-0.2	53	7351.2	7351.0	-0.2
25	3763.2	3763.3	+0.1	54	7468.4	7468.7	+0.3
26	3901.4	3901.6	+0.2	55	7584.7	7584.9	+0.2
27	4038.8	4039.2	+0.4				Mean 0.2
28	4175.5	4175.3	-0.2				

TABLE 12. SUMMARY OF CONSTANTS OF PRINCIPAL SYSTEM OF POLONIUM

Molecule	State	Constants (cm ⁻¹)						
		T_e	ω_e	Probable Error	$\omega_e x_e$	Probable Error	$\omega_e y_e$	Probable Error
Po ²¹⁰ -Po ²¹⁰	Lower	0.0	155.71 ₅	0.03	-0.335 ₃	0.002	-0.00032 ₃	0.00003
Po ²¹⁰ -Po ²¹⁰	Upper	25,149.3	108.53 ₂	0.04	-0.441 ₇	0.002		
Po ²⁰⁸ -Po ²⁰⁸	Lower	0.0	156.44 ₀	0.03	-0.340 ₀	0.002	-0.00029 ₅	0.00003
Po ²⁰⁸ -Po ²⁰⁸	Lower		156.46 ₂ [*]		-0.338 ₅ [*]		-0.00032 ₇ [*]	
Po ²⁰⁸ -Po ²⁰⁸	Upper	25,149.1	108.97 ₇	0.05	-0.442 ₃	0.002		
Po ²⁰⁸ -Po ²⁰⁸	Upper		109.05 ₃ [*]		-0.445 ₉ [*]			

*Predicted from the observed constants of Po²¹⁰-Po²¹⁰.

TABLE 13. CONSTANTS OF PRINCIPAL SYSTEMS OF GROUP VI DIATOMIC MOLECULES

Molecule	Constants (cm ⁻¹)						
	T'_e	ω''_e	$\omega''_e x''_e$	$\omega''_e y''_e$	ω'_e	$\omega'_e x'_e$	$\omega'_e y'_e$
O ¹⁶ -O ¹⁶	49,802.1	1580.361	12.0730	+0.0546	700.36	8.002	-0.3753
S ³² -S ³²	31,835	725.68	2.852		434.0	2.75	
Se ⁸⁰ -Se ⁸⁰	26,035	391.9	1.04	+0.002	271.1	2.19	
Te-Te	22,709	251.0	0.56		163.0	0.96	
Po ²¹⁰ -Po ²¹⁰	25,149.3	155.71 ₅	0.335 ₃	-0.00032 ₃	108.53 ₂	0.441 ₇	

TABLE 14. CLASSIFIED BANDS OF $\text{Po}^{210}\text{-Po}^{210}$

$\text{Po}^{210}\text{-Po}^{210}$					$\sigma_{208-208} - \sigma_{210-210}$		$\sigma_{208-209} - \sigma_{210-210}$	
Intensity	σ (cm^{-1})	ν'	ν''	$\Delta\sigma$ (cm^{-1})	Observed (cm^{-1})	Calculated (cm^{-1})	Observed (cm^{-1})	Calculated (cm^{-1})
0	19,482.4	26	61	+0.2				
1	19,565.9	27	61	-0.2				
0	19,620.5	25	59	0.0				
1	19,786.6	23	56	-0.2				
2	19,814.1	22	55	+0.3				
1	19,873.9	24	56	+0.1				
2	19,902.3	23	55	-0.3				
2	19,929.7	22	54	+0.1				
1	19,957.0	21	53	+0.2				
1	19,985.4	20	52	0.0	-20.3	-20.3		
1	20,018.3	23	54	-0.1	-20.9	-20.1	-15.7	-15.1
1	20,038.4	18	50	-0.5	-18.9	-20.3		
2	20,045.9	22	53	-0.2	-19.0	-20.0		
		26	56	+0.1				
1	20,074.1	21	52	-0.5	-19.2	-19.9		
2	20,103.1	20	51	-0.3	-20.0	-19.8		
2	20,130.8	19	50	-0.1	-19.9	-19.9		
2	20,159.5	18	49	+0.4	-20.0	-19.8		
1	20,187.6	17	48	+0.1	-20.2	-19.8		
3	20,192.6	21	51	0.0	-19.3	-19.4	-14.6	-14.4
1	20,214.6	16	47	-0.4				
3	20,222.3	20	50	+0.2	-19.4	-19.4		
		24	53	+0.4		-19.3		
3	20,251.0	19	49	-0.1	-19.7	-19.4	-15.1	-14.4
0	20,277.2	26	54	-0.2				
3	20,279.8	18	48	+0.4	-19.4	-19.3		
4	20,308.7	25	53	-0.5	-19.6	-18.8	-15.6	-13.9
		17	47	-0.1		-19.4		-14.4
2	20,337.2	16	46	0.0	-19.8	-19.3		
2	20,342.0	20	49	-0.3	-19.5	-18.9		
1	20,365.2	15	45	-0.4	-18.9	-19.3		
4	20,371.4	19	48	0.0	-19.2	-18.9	-14.7	-14.0
1	20,394.4	14	44	+0.5	-19.9	-19.2		
4	20,430.7	17	46	-0.3	-19.2	-18.9	-14.7	-14.0
4	20,460.0	16	45	+0.1	-19.9	-18.9		
5	20,489.3	15	44	-0.1	-19.1	-18.8		
2	20,518.0	14	43	-0.2				
1	20,523.2	18	46	+0.3				
2	20,548.0	13	42	+0.4	-19.6	-18.7		
4	20,553.6	17	45	-0.1	-18.6	-18.5		
3	20,576.3	24	50?	-0.1	-18.5	-17.9		
5	20,583.6	16	44	-0.1	-18.8	-18.4	-14.0	-13.6
		20	47	-0.3		-18.0		-13.5
2	20,609.6	23	49	0.0	-18.9	-17.7		
4	20,613.5	15	43	-0.2	-18.8	-18.3	-14.4	-13.5

TABLE 14 (continued)

Intensity	$P_{0,210}-P_{0,210}$				$\sigma_{208-208} - \sigma_{210-210}$		$\sigma_{208-209} - \sigma_{210-210}$	
	σ (cm^{-1})	v'	v''	$\Delta\sigma$ (cm^{-1})	Observed (cm^{-1})	Calculated (cm^{-1})	Observed (cm^{-1})	Calculated (cm^{-1})
4	20,643.0	14	42	-0.1	-18.7	-18.2	-14.6	-13.5
5	20,672.8	13	41	-0.4	-18.8	-18.3		
3	20,702.0	12	40	-0.4	-18.3	-18.1		
5	20,707.9	16	43	-0.1	-18.3	-17.9	-13.7	-13.2
0	20,732.2	11	39?	+0.8				
6	20,738.6	15	42	0.0	-18.5	-17.8	-13.8	-13.2
0	20,748.5	26	50	+0.1	-16.8	-17.0		
2	20,762.5	22	47	+0.1	-17.2	-17.2		
6	20,768.8	14	41	+0.1	-18.0	-17.8	-13.6	-13.2
0	20,783.9	25	49	0.0	-18.6	-16.9		
2	20,796.0	21	46?	+0.7				
6	20,799.4	13	40	0.0	-18.0	-17.7	-13.4	-13.1
7	20,829.3	12	39	-0.5	-17.8	-17.7	-13.8	-13.1
		20	45	+0.5		-17.1		-12.7
3	20,859.5	11	38	+0.2	-17.5	-17.7		
3	20,864.6	15	41	+0.4	-18.2	-17.4	-14.1	-12.9
3	20,889.8	10	37	+0.3	-17.7	-17.6		
6	20,895.4	14	40	+0.5	-17.6	-17.2	-13.3	-12.7
2	20,919.4	9	36	+0.3	-17.9	-17.6		
7	20,926.6	13	39	-0.2	-17.6	-17.3	-13.5	-12.8
1	20,938.1	24	47	-0.1	-17.0	-16.5		
2	20,952.8	20	44	+0.2	-17.3	-16.6		
7	20,957.5	12	38	-0.2	-17.6	-17.2	-12.9	-12.7
1	20,972.9	23	46	-0.5				
2	20,985.4	19	43	-0.3				
5	20,988.4	11	37	-0.2	-17.4	-17.2		
0	21,007.8	22	45	+0.5				
6	21,019.2	10	36	+0.3	-17.4	-17.2		
2	21,022.6	14	39	+0.3	-17.0	-16.8	-13.0	-12.4
2	21,049.7	9	35	0.0	-17.5	-17.0		
7	21,054.9	13	38	+0.2	-17.6	-16.8	-13.0	-12.4
1	21,081.5	30	50?	-0.5				
8	21,086.6	12	37	-0.4	-17.3	-16.7	-13.0	-12.4
0	21,095.7	23	45	-0.4				
2	21,110.9	19	42?	+0.3	-17.1	-16.1		
7	21,118.2	15	39	+0.4	-17.2	-16.4	-13.1	-12.1
		11	36	+0.2		-16.8		-12.6
1	21,131.5	22	44?	+0.4	-16.2	-15.8		
5	21,145.1	18	41?	+0.9	-16.6	-16.1		
7	21,149.3	10	35	-0.2	-17.0	-16.6	-12.4	-12.3
1	21,167.0	21	43?	+0.9	-17.1	-15.7		
8	21,180.6	9	34	-0.1	-17.2	-16.6		
1	21,183.5	24	45	+0.4	-16.7	-15.6		
		13	37	-0.5		-16.3		
3	21,212.3	16	39	+0.2	-16.6	-16.0		
		8	33	0.0		-16.6		

TABLE 14 (continued)

Intensity	$P_0^{210}\text{-}P_0^{210}$				$\sigma_{208-208} - \sigma_{210-210}$		$\sigma_{208-209} - \sigma_{210-210}$	
	σ (cm $^{-1}$)	ν'	ν''	$\Delta\sigma$ (cm $^{-1}$)	Observed (cm $^{-1}$)	Calculated (cm $^{-1}$)	Observed (cm $^{-1}$)	Calculated (cm $^{-1}$)
3	21,216.0	12	36	-0.4	-16.8	-16.3	-12.5	-12.1
8	21,248.5	11	35	-0.1	-16.6	-16.2	-12.6	-12.0
7	21,280.8	10	34	+0.3	-16.7	-16.2	-12.7	-12.0
0	21,292.0	21	42?	+1.0	-15.8	-15.2		
7	21,312.8	9	33	+0.1	-16.7	-16.1	-12.4	-11.9
1	21,327.9	20	41?	+0.5	-16.6	-15.2		
2	21,340.7	16	38	+0.7				
6	21,345.0	8	32	+0.5	-16.9	-16.1	-12.9	-11.9
6	21,375.9	7	31	+0.2	-16.2	-16.0		
3	21,379.5	11	34	-0.1	-16.2	-15.8	-12.3	-11.7
1	21,409.3	14	36	+0.4				
7	21,412.5	10	33	0.0	-16.1	-15.7	-12.2	-11.6
6	21,445.4	9	32	+0.5	-16.2	-15.6	-12.1	-11.5
0	21,454.5	20	40?	+0.9				
3	21,469.9	16	37	+0.6	-15.9	-15.0		
6	21,478.0	8	31	+0.2	-16.0	-15.6	-12.0	-11.7
		12	34	0.0		-15.3		-11.5
1	21,490.5	19	39?	+0.7	-14.7	-14.7		
2	21,504.3	15	36	-0.1	-14.4	-15.0		
7	21,510.2	7	30	+0.2	-15.1	-15.5	-11.1	-11.5
2	21,539.2	14	35?	-0.3	-14.5	-14.8		
1	21,542.4	21	40	-0.4				
7	21,544.3	10	32	-0.4	-14.8	-15.2	-10.9	-11.2
3	21,574.6	5	28	-0.1	-14.6	-15.2		
		13	34?	-0.4		-14.9		
4	21,577.8	9	31	-0.4	-14.6	-15.1	-10.6	-11.2
7	21,611.7	8	30	-0.4	-14.9	-15.3	-11.3	-11.3
5	21,644.7	7	29	+0.5	-14.5	-15.0	-11.0	-11.1
1	21,655.7	18	37	+0.7	-14.2	-14.1		
3	21,670.8	21	39?	+0.6	-14.1	-13.8		
5	21,678.3	6	28	+0.2	-15.2	-14.7	-11.1	-10.9
		10	31	+0.3		-14.7		-10.9
1	21,692.4	17	36	-0.1				
3	21,706.2	13	33?	-0.8	-14.5	-14.4		
6	21,711.3	5	27	+0.3	-14.9	-14.7		
1	21,728.9	29	44?	+0.3	-13.1	-12.9		
3	21,741.6	12	32	-0.6	-14.2	-14.3		
4	21,745.8	8	29	-0.5	-14.1	-14.6	-10.2	-10.8
6	21,780.3	7	28	+0.1	-14.5	-14.3	-11.0	-10.6
5	21,814.4	6	27	0.0	-14.8	-14.2	-11.0	-10.5
0	21,824.3	17	35?	+1.2				
2	21,839.6	13	32	+0.4	-14.7	-13.9		
4	21,848.1	5	26	+0.4	-14.9	-14.2		
1	21,860.8	16	34	+0.5	-14.0	-13.6		
3	21,875.1	12	31	-0.4	-14.2	-13.8		

TABLE 14 (continued)

Intensity	P_o^{210}, P_o^{210}				$\sigma_{208-208} - \sigma_{210-210}$		$\sigma_{208-209} - \sigma_{210-210}$	
	σ (cm $^{-1}$)	ν'	ν''	$\Delta\sigma$ (cm $^{-1}$)	Observed (cm $^{-1}$)	Calculated (cm $^{-1}$)	Observed (cm $^{-1}$)	Calculated (cm $^{-1}$)
5	21,881.3	4	25	-0.1	-14.0	-14.0	-10.6	-10.4
1	21,897.7	15	33	-0.3				
3	21,910.9	11	30	-0.5	-13.8	-13.8		
4	21,916.1	7	27	-0.4	-14.4	-13.8		
0	21,935.2	14	32	+0.5				
2	21,946.9	10	29	+0.4				
		2	23	-0.5	-13.6	-13.7		
6	21,950.7	6	26	-0.4	-13.7	-13.7	-9.6	-10.1
6	21,985.8	5	25	+0.4	-14.2	-13.6	-10.7	-10.1
5	22,019.7	4	24	-0.1				
2	22,030.1	15	32?	-0.1	-12.1	-13.0		
3	22,046.7	11	29?	+1.1	-13.9	-13.3		
3	22,053.3	7	26	+0.1	-13.4	-13.3		
		3	23	+0.1		-13.4	-9.7	-9.8
2	22,068.1	14	31	+0.1	-12.7	-12.9		
3	22,082.0	10	28	-0.5	-12.5	-13.0		
6	22,088.2	6	25	-0.6	-12.9	-13.1	-9.5	-9.8
0	22,098.2	20	35	0.0				
2	22,105.3	23	37?	-0.2	-12.5	-12.0		
3	22,118.4	9	27?	-0.6	-12.7	-12.9		
7	22,123.2	5	24	-0.6	-12.6	-13.2	-8.9	-9.8
6	22,158.7	4	23	+0.5	-12.9	-13.0		
5	22,194.0	3	22	0.0	-13.5	-12.8	-9.9	-9.5
0	22,202.3	14	30	0.0	-12.2	-12.4		
4	22,227.5	2	21	-0.2	-13.0	-12.8	-10.1	-9.5
		6	24	+0.3		-12.7		-9.4
1	22,241.2	13	29	+0.2	-12.4	-12.4		
4	22,261.8	5	23	-0.4				
1	22,269.6	19	33	-0.4				
1	22,291.7	8	25?	-1.3	-11.6	-12.3		
8	22,297.6	4	22?	-1.4	-11.5	-12.4		
		15	30?	-0.2		-12.0		
6	22,333.2	3	21	-0.3	-11.6	-12.3	-8.6	-9.1
3	22,370.0	2	20	+0.4	-12.8	-12.2	-9.6	-9.0
0	22,376.5	13	28	-0.5				
3	22,393.5	9	25	+0.1	-12.2	-11.8		
3	22,403.1	5	22	+0.1	-12.3	-12.0		
2	22,415.6	12	27	-0.7	-12.1	-11.6		
4	22,431.3	8	24	-0.1	-12.1	-11.9		
4	22,438.9	4	21	+0.4	-12.2	-11.9	-9.5	-8.9
3	22,453.9	11	26	-0.7	-11.1	-11.6		
2	22,468.6	7	23	+0.9	-11.6	-11.5		
5	22,474.9	3	20	-0.5	-11.3	-11.7	-8.9	-8.7
1	22,485.2	17	30	-0.7				
		29	38?	-0.3	-9.8	-11.2		
						-10.0		

TABLE 14 (continued)

Intensity	$P_{0210}-P_{0210}$				$\sigma_{208-208}-\sigma_{210-210}$		$\sigma_{208-209}-\sigma_{210-210}$	
	σ (cm ⁻¹)	ν'	ν''	$\Delta\sigma$ (cm ⁻¹)	Observed (cm ⁻¹)	Calculated (cm ⁻¹)	Observed (cm ⁻¹)	Calculated (cm ⁻¹)
1	22,493.9	20	32?	+0.5		-10.8		
		26	36?	0.0	-10.5	-10.4		
3	22,510.6	2	19	-0.3	-11.5	-11.6		
2	22,547.2	1	18	+0.2	-11.5	-11.5		
3	22,569.5	8	23	-0.3	-10.5	-11.3		
4	22,580.3	4	20	-0.1	-11.6	-11.3	-9.1	-8.4
2	22,592.0	11	25	-0.3	-11.3	-11.0		
4	22,608.4	14	27	-0.4	-11.4	-10.7		
		7	22	-0.1		-11.1		
4	22,617.0	3	19	+0.3	-11.4	-11.1	-8.0	-8.2
2	22,631.3	10	24	-0.3	-11.3	-11.0		
3	22,646.1	6	21	+0.2	-11.3	-11.0		
1	22,648.9	13	26?	-1.1	-10.1	-10.7		
6	22,653.7	2	18	0.0	-11.2	-11.2	-8.3	-8.3
1	22,662.8	16	28	+0.5	-10.8	-10.4		
2	22,670.7	9	23	+0.5	-10.7	-10.8		
4	22,690.0	1	17	-0.4	-10.8	-10.9		
		12	25?	-0.7		-10.5		
3	22,748.5	7	21	+0.5	-10.6	-10.6		
5	22,759.8	3	18	+0.3	-10.7	-10.6	-8.3	-7.8
1	22,769.7	10	23	-0.3	-10.0	-10.4		
4	22,787.4	13	25	-0.3	-10.5	-10.1		
		6	20	-0.4		-10.4		
6	22,797.4	2	17	+0.3	-10.9	-10.5	-7.8	-7.8
3	22,810.2	9	22	-0.8	-10.2	-10.2		
4	22,827.8	30	36?	+0.3	-10.5	-8.8		
3	22,834.3	1	16	-0.2	-10.6	-10.3		
1	22,840.5	15	26	-0.5	-9.5	-9.8		
2	22,849.2	8	21?	-0.9	-9.2	-10.2		
2	22,870.9	0	15	-0.5	-9.9	-10.3		
0	22,882.9	14	25	-0.3	-9.6	-9.6		
1	22,902.4	3	17	-0.5	-9.5	-10.0		
3	22,929.2	6	19	+0.1	-9.4	-9.8		
6	22,941.2	2	16	0.0	-9.7	-9.9	-7.4	-7.3
1	22,950.2	9	21	-0.3				
3	22,968.2	5	18	-0.3	-9.4	-9.8		
6	22,978.8	1	15	-0.1	-9.5	-9.8		
		15	25	+0.1		-9.2		
3	22,991.7	8	20	-0.3	-10.3	-9.6		
1	23,017.3	0	14	0.0	-10.2	-9.6		
2	23,031.6	7	19	+0.4	-9.8	-9.4		
1	23,051.0	10	21?	+0.7	-9.3	-9.3		
1	23,064.6	13	23	+0.1	-9.6	-9.1		
0	23,074.5	22	29?	+0.8	-8.4	-8.5		
3	23,085.6	2	15	0.0	-9.1	-9.4	-5.8	-7.0
3	23,112.6	5	17?	+0.7	-10.2	-9.2		

TABLE 14 (continued)

Intensity	$P_{O_2}^{210}, P_{O_2}^{210}$				$\sigma_{208-208} - \sigma_{210-210}$		$\sigma_{208-209} - \sigma_{210-210}$	
	σ (cm $^{-1}$)	ν'	ν''	$\Delta\sigma$ (cm $^{-1}$)	Observed (cm $^{-1}$)	Calculated (cm $^{-1}$)	Observed (cm $^{-1}$)	Calculated (cm $^{-1}$)
7	23,124.7	1	14	-0.1	-9.2	-9.1		
4	23,152.3	4	16	+0.3	-9.0	-9.0		
4	23,163.5	0	13	+0.3	-9.7	-9.0		
3	23,174.6	7	18	+0.6	-9.3	-8.9		
4	23,191.3	3	15	-0.1	-8.2	-8.9		
4	23,204.6	13	22?	-0.7	-9.1	-8.5		
0	23,215.7	6	17	+0.4	-9.9	-8.7		
2	23,233.7	9	19	0.0	-8.9	-8.5		
1	23,247.8	12	21	0.0	-8.7	-8.4		
1	23,256.9	21	27?	+0.2	-8.1	-7.7		
6	23,271.0	1	13	+0.3	-8.5	-8.5	-6.8	-6.3
3	23,296.5	4	15	+0.1	-8.2	-8.5		
6	23,310.2	0	12	-0.2	-9.0	-8.4		
0	23,317.0	7	17	-0.4	-8.1	-8.3		
4	23,337.0	3	14	-0.3	-8.1	-8.2		
3	23,359.6	6	16	+0.2	-8.8	-8.1		
2	23,377.0	2	13	-0.4	-8.5	-8.1		
		9	18	+0.5	-8.5	-8.0		
1	23,388.5	12	20	-1.2	-7.9	-7.8		
8	23,417.9	1	12	0.0	-7.8	-7.9		
1	23,432.0	11	19	-0.6	-6.9	-7.7		
9	23,357.7	0	11	+0.6	-7.9	-7.8		
4	23,483.3	3	13	+0.1	-7.8	-7.6		
0	23,490.9	16	22	+0.3				
2	23,503.4	6	15	-0.4	-7.2	-7.6		
2	23,524.9	2	12	+0.3	-8.3	-7.5		
3	23,546.0	5	14	-0.3	-7.5	-7.4		
3	23,564.0	1	11	-0.6	-6.7	-7.3		
7	23,606.1	0	10	0.0	-5.5	-7.1		
1	23,619.1	10	17?	-0.6	-5.7	-7.0		
2	23,630.1	3	12	-0.3	-7.3	-7.0		
1	23,649.3	6	14	-0.4				
4	23,672.5	29	29?	+0.7	-6.5	-5.6		
3	23,692.3	5	13	+0.1	-6.3	-6.8		
1	23,724.8	17	21?	+0.9	-6.0	-6.3		
1	23,735.1	4	12	-0.3				
10	23,754.9	0	9	-0.2	-6.0	-6.5		
1	23,796.0	6	13?	+0.4	-6.0	-6.3		
		24	25	-0.2	-6.0	-5.5		
2	23,809.2	9	15?	+0.8	-6.2	-6.3		
4	23,820.3	2	10	0.0	-5.8	-6.2		
2	23,862.8	11	16	-0.1	-6.1	-6.0		
		1	9	+0.2	-6.1	-6.0		
3	23,883.5	4	11?	+1.4	-6.9	-6.0		
		25	25?	0.0	-6.9	-5.0		

TABLE 14 (continued)

Intensity	P_0^{210}, P_0^{210}				$\sigma_{208-208} - \sigma_{210-210}$		$\sigma_{208-209} - \sigma_{210-210}$	
	σ (cm ⁻¹)	ν'	ν''	$\Delta\sigma$ (cm ⁻¹)	Observed (cm ⁻¹)	Calculated (cm ⁻¹)	Observed (cm ⁻¹)	Calculated (cm ⁻¹)
8	23,904.7	0	8	+0.3	-6.0	-5.8		
2	23,914.7	13	17	+0.5	-6.6	-5.7		
4	23,941.9	6	12?	-0.9	-4.8	-5.7		
2	24,000.0	8	13	+0.2	-5.7	-5.5		
1	24,011.5	1	8	-0.4	-4.0	-5.3		
10	24,054.8	0	7	-0.1	-5.1	-5.2		
3	24,075.2	3	9	+0.1	-5.8	-5.1		
2	24,089.5	6	11?	0.0	-3.7	-5.1		
2	24,106.0	12	15?	+0.3	-4.9	-5.0		
3	24,134.9	5	10?	-0.2	-4.2	-4.9		
0	24,154.6	14	16?	+0.8	-5.2	-4.6		
7	24,162.4	1	7	0.0	-4.6	-4.7		
3	24,192.6	7	11?	+1.0	-4.2	-4.7		
1	24,199.9	10	13	-0.1	-3.9	-4.6		
6	24,206.2	0	6	+0.2	-5.2	-4.5		
4	24,225.0	3	8	+0.6	-4.9	-4.4		
3	24,248.0	9	12	+0.6	-5.0	-4.4		
0	24,269.0	2	7	-0.1	-4.9	-4.3		
4	24,284.1	5	9	0.0	-3.1	-4.3		
3	24,299.5	11	13	+0.4	-4.8	-4.2		
7	24,313.4	1	6	-0.1	-4.1	-4.0		
1	24,328.9	4	8	-0.5	-3.6	-4.0		
1	24,348.6	13	14	0.0	-4.4	-3.9		
3	24,357.3	0	5	0.0	-3.6	-3.9		
3	24,375.3	3	7	+0.4	-4.1	-3.8		
3	24,386.9	6	9	-0.6	-3.6	-3.8		
2	24,394.3	9	11	+0.2	-4.0	-3.8		
4	24,420.0	2	6	-0.2	-3.3	-3.6		
4	24,443.0	8	10?	+0.3	-4.1	-3.6		
6	24,464.9	1	5	+0.1	-3.3	-3.4		
3	24,479.5	4	7	-0.4	-3.3	-3.4		
1	24,494.0	10	11	+0.1	-3.6	-3.4		
		13	13	-0.5	-3.6	-3.3		
0	24,510.4	0	4	+0.6	-3.8	-3.2		
2	24,536.5	6	8	-0.3	-2.4	-1.8		
2	24,543.3	9	10?	+0.2	-3.5	-3.1		
6	24,571.3	2	5	-0.2	-2.5	-3.0		
0	24,582.9	5	7?	-1.0	-1.5	-3.0		
2	24,590.1	14	13?	+0.1	-2.2	-2.8		
5	24,617.2	1	4	-0.1	-2.8	-2.7		
3	24,630.2	4	6	-0.8	-2.6	-2.7		
4	24,638.7	7	8	-0.2	-2.0	-2.7		
2	24,642.0	13	12	+0.3				
3	24,677.3	3	5	0.0	-2.8	-2.5		

TABLE 14 (continued)

Intensity	$P_{0^{210}}P_{0^{210}}$				$\sigma_{208-208} - \sigma_{210-210}$		$\sigma_{208-209} - \sigma_{210-210}$	
	σ (cm ⁻¹)	ν'	ν''	$\Delta\sigma$ (cm ⁻¹)	Observed (cm ⁻¹)	Calculated (cm ⁻¹)	Observed (cm ⁻¹)	Calculated (cm ⁻¹)
1	24,685.0	15	13?	-0.5	-2.3	-2.4		
2	24,691.1	12	11	-0.3	-2.2	-2.5		
7	24,723.6	2	4	-0.4	-2.3	-2.3		
2	24,740.2	8	8?	-0.8	-1.9	-2.3		
4	24,769.9	1	3	+0.1	-2.1	-2.0		
3	24,788.4	7	7	-1.0	-1.7	-2.1		
		13	11?	0.0		-2.1		
0	24,801.6	21	16?	-0.1	-1.5	-1.6		
6	24,829.5	3	4	-0.3	-1.9	-1.8		
3	24,838.1	6	6	-0.3	-2.1	-1.8		
6	24,876.4	2	3	-0.1	-1.0	-1.6		
2	24,884.5	14	11?	+0.6	-1.1	-1.6		
1	24,889.9	11	9?	-1.1	-1.1	-1.7		
2	24,934.5	4	4	-0.3	-2.1	-1.4		
2	24,940.1	7	6	-0.4	-1.1	-1.4		
5	24,982.4	3	3	+0.1	-1.5	-1.1		
3	24,988.8	6	5?	-0.9	-1.5	-1.2		
		12	9?	-0.6		-1.2		
0	25,020.4	17	12?	-0.4	-1.1	-1.0		
2	25,029.5	2	2	-0.7	-0.1	-0.9		
3	25,039.8	5	4	-0.5	-1.3	-1.0		
0	25,058.5	19	13?	+1.0	-1.5	-0.7		
6	25,087.4	4	3	+0.1	-0.3	-0.7		
1	25,091.3	10	7	-0.4	-0.7	-0.8		
3	25,136.0	3	2	0.0	-0.6	-0.4		
2	25,141.3	6	4	-0.9		-0.5		
		30	19?	-0.8	0.0	+0.3		
1	25,181.9	14	9	0.0	-0.8	-0.3		
5	25,191.2	5	3	-0.1	-0.1	-0.3		
10	25,241.5	4	2	+0.5	+0.4	0.0		
4	25,288.1	12	7?	-1.1	+0.6	+0.1		
5	25,294.5	6	3	-0.2	+0.5	+0.2		
10	25,345.3	5	2	+0.3	+0.1	+0.4		
3	25,385.8	13	7?	-0.4	-0.7	+0.5		
		21	12?	+0.7		+0.8		
3	25,395.1	4	1	-0.2	+0.2	+0.7		
1	25,426.5	15	8?	-0.2	+0.1	+0.8		
7	25,448.3	6	2	-0.1	+0.8	+0.9		
3	25,493.0	11	5	-0.2	+0.4	+0.9		
5	25,499.7	5	1	+0.4	+0.4	+1.1		
		8	3?	+0.8		+1.0		
0	25,520.3	16	8?	-0.7	+0.8	+1.2		
1	25,537.1	13	6	-0.2	+0.2	+1.2		
2	25,550.5	7	2	0.0		+1.3		
		4	0	-0.2	+1.3	+1.5		
4	25,591.1	12	5	-0.5	+1.0	+1.4		

TABLE 14 (continued)

Intensity	$P_0^{210}-P_0^{210}$				$\sigma_{208-208} - \sigma_{210-210}$		$\sigma_{208-209} - \sigma_{210-210}$	
	σ (cm ⁻¹)	v'	v''	$\Delta\sigma$ (cm ⁻¹)	Observed (cm ⁻¹)	Calculated (cm ⁻¹)	Observed (cm ⁻¹)	Calculated (cm ⁻¹)
6	25,602.5	6	1	-0.2	+1.6	+1.6		
3	25,632.3	14	6	-0.5	+1.5	+1.7		
2	25,653.4	8	2	+0.8	+0.8	+1.7		
0	25,671.1	16	7	-0.4	+1.2	+1.8		
2	25,698.8	10	3	-0.3	+2.1	+1.9		
4	25,704.9	7	1	+0.1	+2.3	+2.0		
2	25,757.8	6	0	-0.3	+1.7	+2.4		
5	25,798.4	11	3	+0.2	+1.6	+2.3		
6	25,806.6	8	1	-0.3	+2.4	+2.4		
2	25,839.0	13	4?	-2.1	+3.9	+2.5		
4	25,860.0	7	0	-0.2	+3.4	+2.8		
0	25,889.0	20	8?	-0.9				
6	25,907.3	9	1	0.0	+3.1	+2.9		
2	25,936.8	14	4	+0.2	+2.6	+3.0		
0	25,950.3	11	2?	-1.6	+4.4	+3.0		
5	25,961.9	8	0	-0.4	+3.2	+3.2		
3	26,007.1	10	1	0.0	+3.5	+3.3		
1	26,031.1	15	4	-1.0				
2	26,048.6	12	2?	-1.7	+4.8	+3.5		
7	26,062.9	9	0	+0.2	+3.1	+3.7		
0	26,065.5	17	5?	-2.2				
1	26,107.1	11	1	+0.9	+3.0	+3.7		
3	26,147.1	13	2?	-0.2	+4.5	+3.9		
7	26,161.6	10	0	-0.9	+4.9	+4.1		
2	26,243.4	14	2	+0.6	+2.9	+4.4		
4	26,260.9	11	0	-0.7	+4.7	+4.5		
0	26,279.0	16	3?	+0.1	+5.6	+4.5		
1	26,339.0	15	2	+0.7	+3.9	+4.8		
4	26,359.8	12	0	-0.2	+5.0	+5.0		
6	26,456.9	13	0	-0.1	+5.0	+5.4		
1	26,466.0	18	3?	+1.4	+5.2	+5.4		
7	26,552.3	14	0	-0.2	+6.2	+5.9		
3	26,585.1	21	4	+0.6	+5.9	+6.0		
		28	8?	+1.0		+6.3		
7	26,648.7	15	0	-0.7		+6.3		
		20	3	+0.9	+5.6	+6.3		
2	26,680.3	17	1	-0.4	+7.4	+6.3		
4	26,742.9	16	0	+0.6	+6.2	+6.7		
1	26,762.2	23	4	-0.4				
3	26,773.1	18	1	+0.5	+7.9	+6.8		
1	26,783.0	25	5?	-1.4	+6.4	+6.9		
1	26,801.4	20	2	-0.1	+7.0	+7.0		
6	26,835.6	17	0	-0.5	+7.8	+7.1		
1	26,849.1	24	4?	-0.5	+8.7	+7.1		
5	26,864.8	19	1	+0.2	+7.6	+7.2		

TABLE 14 (continued)

Intensity	$\text{Po}^{210}\text{-Po}^{210}$				$\sigma_{208-208} - \sigma_{210-210}$		$\sigma_{208-209} - \sigma_{210-210}$	
	σ (cm^{-1})	v'	v''	$\Delta\sigma$ (cm^{-1})	Observed (cm^{-1})	Calculated (cm^{-1})	Observed (cm^{-1})	Calculated (cm^{-1})
0	26,886.3	28	6	+0.6				
7	26,928.8	18	0	-0.8	+7.3	+7.6		
6	26,956.1	20	1	+0.3	+7.2	+7.7		
0	26,967.4	29	6	-0.7				
3	26,980.4	22	2	+0.4	+8.0	+7.8		
5	27,020.8	19	0	+0.8	+7.7	+8.0		
4	27,046.0	21	1	+1.0	+7.8	+8.1		
3	27,070.2	23	2?	+1.4	+6.5	+8.2		
3	27,110.8	20	0	-0.4	+8.6	+8.5		
3	27,135.0	22	1	+0.7	+8.3	+8.5		
2	27,156.0	24	2	+0.2	+8.4	+8.5		
0	27,174.7	26	3	+0.6	+7.4	+8.7		
3	27,200.5	21	0	+0.1	+9.6	+8.9		
5	27,223.4	23	1	+0.3	+8.7	+8.9		
3	27,243.0	25	2	-0.1	+7.9	+9.0		
0	27,257.9	27	3	-0.1	+10.0	+9.2		
3	27,290.5	22	0	+0.8	+9.8	+9.3		
3	27,310.0	24	1	-0.1	+9.5	+9.2		
3	27,326.8	26	2	-1.0	+10.7	+9.4		
1	27,340.6	28	3	-1.4	+11.7	+9.6		
0	27,377.3	23	0	-1.2				
2	27,397.2	25	1	-0.2	+9.1	+9.7		
0	27,412.2	27	2	+0.5	+10.1	+9.9		
0	27,465.3	24	0	-0.2				
3	27,482.2	26	1	+0.1	+10.7	+10.1		
2	27,497.2	28	2	+1.5	+8.0	+10.3		
1	27,507.6	30	3	-0.1	+9.2	+10.3		
1	27,578.1	29	2	0.0	+10.5	+10.7		
1	27,649.7	28	1	-0.3				
2	27,661.5	30	2	+0.1				
0	27,732.4	29	1	0.0				

DISCUSSION

The dissociation energy of a diatomic molecule can be estimated from the observed energy levels by extrapolating them to convergence. Two examples of such an extrapolation are shown by Herzberg (70). Numerous others are given by Gaydon (71). Figure 3 shows a plot of successive energy level differences ($\Delta G = G_{v+1} - G_v$) against vibrational quantum number ($v + 1/2$) for the lower state of $\text{Po}^{210}\text{-Po}^{210}$, while Fig. 4 shows a similar plot for the upper state of this molecule. Linear extrapolation in each case should yield an

upper limit of the dissociation energy. This extrapolation leads to 2.10 volts for the lower state and to 3.94 volts for the upper state. The other extrapolation indicated leads to estimates of 1.75 and 3.91 volts, respectively. Analytically, the dissociation energy may be calculated by solving the equation $dG/dv = 0$ for v , then using the energy level equation $G(v)$ to determine the energy. For the lower state of $\text{Po}^{210}\text{-Po}^{210}$, this leads to $v'' = 183$, $G'' = 15,290 \text{ cm}^{-1} = 1.895$ volts. For the upper state the result is $v' = 122$, $G' = 31,800 \text{ cm}^{-1} = 3.94$ volts. The difference between these

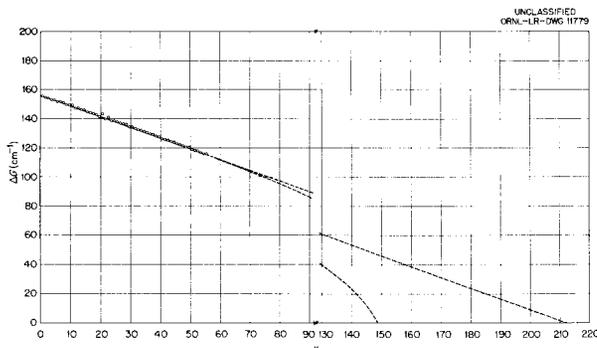


Fig. 3. Plot of ΔG vs V ; Lower State of Po^{210} .

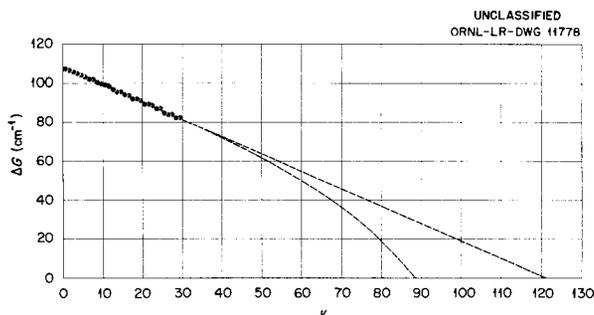


Fig. 4. Plot of ΔG vs V ; Upper State of Po^{210} .

two values is 2.04 volts, which may be compared with a difference of 2.09 volts between 3P_2 and 3P_1 of the polonium atom (72) and a difference of 2.69 volts between 3P_2 and 1D_2 of the atom. This result suggests that the upper state of the principal system of Po-Po arises from one atom in the normal state and one atom in the state 3P_1 , while the lower state arises from two normal atoms. This is consistent with the assumption that the lower state is the ground state of the molecule.

The possibility is not excluded that this system is due to $(\text{Po-Po})^+$, although the excellent fit of the predicted constants with the observed constants and the absence of any spectra of ionized diatomic molecules of Group VI except $(\text{O-O})^+$ would seem to make the possibility remote. A rotational analysis is required to definitely establish the nature of the transition and hence also the emitter.

It seems appropriate in connection with a discussion of the Po-Po spectrum to evaluate the

status of knowledge of the Group VI diatomic molecular spectra. It can be said at the outset that, except for O-O, knowledge is quite incomplete and not completely satisfactory. In O-O, the three even electronic states to be expected from the fundamental electron configuration are all known, while four of the six states to be expected from the first excited configuration are also known. In addition, there are six higher states which apparently form Rydberg series but which have not been correlated with electron configurations.

After O-O, the situation rapidly deteriorates. The principal system of S-S is well known. However, except for two systems in the ultraviolet apparently associated with the electron transition $4s-3p$, there is nothing else known about this spectrum. Knowledge of the so-called "A Bands" (28,36), which Olsson's analysis (37) indicates as possibly the transition $^1\Sigma_u^+ - ^1\Sigma_g^+$, is quite fragmentary, no constants having been found and no vibrational analysis having been made.

In Se-Se, the principal system is generally, but not universally, accepted to be $^1\Sigma_u^+ - ^1\Sigma_g^+$, but the vibrational analysis of this system leaves something to be desired. The vibrational array of Asundi and Parti (44), which embraces bands assigned to several systems by others, is unconvincing, showing deviations up to $\pm 10 \text{ cm}^{-1}$ in a spectrum where the band heads are expected to lie only about 0.3 cm^{-1} from the band origins. The rotational analysis is incomplete because of complication resulting from considerable overlapping of the bands. Again there are two systems in the ultraviolet apparently associated with the electron transition $5s-4p$. One of these is of doubtful assignment to Se-Se, while the analysis of the other has been questioned. The assumption of $^1\Sigma_g^+$ as the ground state of the molecule is difficult to reconcile with the observed paramagnetism of the vapor, which indicates a low triplet state. This may be the lower state of the Rosen-Monfort system, which is at 6300 cm^{-1} above ground. The recent announcement (53) of a system in the same region and having nearly the same constants as the Rosen-Monfort system adds to the confusion.

The spectra of Te-Te and of Po-Po are still less well known. No rotational analysis has been made for either; such an analysis will be more difficult, because of even greater overlapping, than it was for Se-Se. The vibrational analysis of

Te-Te seems capable of some further improvement. With the exception of two systems in Te-Te in the ultraviolet, apparently associated with the electron transition $6s-5p$, nothing further is known about either spectrum. Approximately 100 weak bands remain in the polonium spectrum which do not fit into the system described in this report. These presumably belong to one or more additional systems. Nothing definite can be said on this point at the present time.

There is an interesting group, however, of six bands at the short wavelength end of the spectrum, as follows:

Intensity	Frequency (cm^{-1})
1	27,674.9
4	27,751.5
4	27,827.7
4	27,903.5
4	27,979.9
3	28,056.2

There is a constant difference of 76 cm^{-1} between successive bands of this group. All attempts to find any other reasonable regularities involving these bands have met with failure, suggesting that these six bands may form a sequence. They are relatively stronger than bands of the principal system in the same region, suggesting that they may belong to a separate system.

SUMMARY

Spectrograms of the molecular spectrum of polonium excited in an electrodeless discharge have been measured. Approximately 500 red-shaded band heads have been found with mixtures of Po^{208} and Po^{209} and more than 450 heads with Po^{210} , in the wavelength range 3500 to 5100 Å. Approximately 350 bands have been classified in each spectrum as transitions between two sets of energy levels, the mean deviation between observed and calculated frequencies being about 0.3 cm^{-1} in each spectrum. Vibrational quantum numbers extend to $v'' = 61$ and to $v' = 30$. The

observed energy levels are represented with a mean deviation of 0.3 cm^{-1} by the equations

$$G(v') = 25,149.3 + 108.532 \left(v' + \frac{1}{2} \right) - 0.4417 \left(v' + \frac{1}{2} \right)^2$$

$$G(v'') = 155.715 \left(v'' + \frac{1}{2} \right) - 0.3353 \left(v'' + \frac{1}{2} \right)^2 - 0.0003226 \left(v'' + \frac{1}{2} \right)^3$$

for $\text{Po}^{210}\text{-Po}^{210}$ and by the equations

$$G(v') = 25,149.1 + 108.977 \left(v' + \frac{1}{2} \right) - 0.4423 \left(v' + \frac{1}{2} \right)^2$$

$$G(v'') = 156.440 \left(v'' + \frac{1}{2} \right) - 0.3400 \left(v'' + \frac{1}{2} \right)^2 - 0.0002949 \left(v'' + \frac{1}{2} \right)^3$$

for $\text{Po}^{208}\text{-Po}^{208}$. Observed and calculated values of the shifts between $\sigma_{208-208}$ and $\sigma_{210-210}$ and between $\sigma_{208-209}$ and $\sigma_{210-210}$ show satisfactory agreement.

Extrapolation of the energy levels to convergence by the use of the above equations yields an estimate of 1.895 volts for the dissociation energy of the lower state of $\text{Po}^{210}\text{-Po}^{210}$ and of 3.94 volts for the dissociation energy of the upper state of $\text{Po}^{210}\text{-Po}^{210}$, on the assumption that the dissociation products of the lower state are two polonium atoms in the normal state $^3P'_2$.

The present status of knowledge of the spectra of Group VI homonuclear diatomic molecules is considered to be incomplete and unsatisfactory, except for oxygen.

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