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**QUANTUM MECHANICAL STUDY OF
MOLECULES TRANSITION PROBABILITIES,
EINSTEIN A COEFFICIENTS AND
OSCILLATOR STRENGTHS OF SOME
BAND SYSTEMS OF DIATOMIC MOLECULES**

by D. C. Jain and R. C. Sabni

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SUMMARY

The Franck-Condon factors and r -centroids based on the Rydberg-Klein-Rees potential energy curves, have been presented for some band systems of the CO^+ , N_2 , N_2^+ and RbH molecules. The variation of the electronic transition moment with the internuclear distance, $R_e(r)$, has been determined by the r -centroid procedure for the band systems for which the experimental data on the relative intensity distribution is available. The absolute band strengths, Einstein A coefficients and oscillator strengths have been obtained for some band systems by employing the expression for the electric dipole transition moment, $R_e(r)$, and the lifetimes of the excited states. The influence of the vibration-rotation interaction on the transition probabilities of the band system of the RbH molecule has been studied and it has been found that for this and certain other similar band systems, the vibration-rotation interaction must be included in the theoretical interpretation of the results. The importance and possible applications of these results have been described. The Rydberg-Klein-Rees curves of the various molecules which form the basis of any such study will be presented in a forthcoming report.

INTRODUCTION

The study of the transition probabilities in the atomic and molecular systems has gained considerable momentum due to its applications to the problems connected with the re-entry of the missiles and the artificial satellites, and certain other phenomenon that occur in the atmospheres of the earth and the

various astronomical bodies. Moreover, such a study is of importance in understanding the processes that take place in flames and discharges, and in the shock tubes and other plasma devices employed in the researches on the controlled thermonuclear reactions. The present investigation is also important from the viewpoint of fundamental theory. The potential energy curves of a large number of electronic states of molecules are being computed ab initio by employing quantum mechanical techniques (refs. 1 to 5). Such calculations are essential for studying the interactions between atoms and molecules. The Rydberg-Klein-Rees (RKR) potential energy curves calculated by using the experimental data, which have been obtained during the course of present investigation, are used for comparison with the ab initio potential energy curves and serve as guide lines for improving and extending the theoretical work. Further, the electric dipole transition moments, $R_e(r)$, and the oscillator strengths given in this report would be useful for comparison with the theoretical results.

In the following sections we present a brief review of the theory and the results for some band systems of N_2 , N_2^+ , CO^+ and RbH molecules.

*

THEORY

The exact Hamiltonian operator for a molecule may be written as (ref. 6)

$$H = - \sum_{\alpha} \frac{\hbar^2}{2M_{\alpha}} \nabla_{\alpha}^2 - \sum_i \frac{\hbar^2}{2m} \nabla_i^2 + V_{nn} + V_{ne} + V_{ee}, \quad (1)$$

where the first two terms represent the kinetic energies of the nuclei and the electrons, respectively, and, V_{nn} , V_{ne} and V_{ee} are the contributions to the potential energy arising from nuclear, nuclear electronic and electronic

* Symbols are given in Appendix

interactions respectively. If for a moment the nuclei are considered as fixed, the Hamiltonian for the electrons can be written as

$$H_e = - \sum_i \frac{\hbar^2}{2m} \nabla_i^2 + V_{ne} + V_{ee} . \quad (2)$$

Further, if

$$H_n = - \sum_\alpha \frac{\hbar^2}{2M_\alpha} \nabla_\alpha^2 + V_{nn} , \quad (3)$$

then

$$H = H_n + H_e . \quad (4)$$

The electronic wave functions χ_e are defined by

$$H_e \chi_e = E_e \chi_e , \quad (5)$$

where E_e is the electronic energy. Now the total wave function of the molecule is of the form

$$\chi = \chi_e \chi_n , \quad (6)$$

where χ_n is the function of nuclear coordinates only. Thus under the Born-Oppenheimer approximation, we obtain

$$- \sum_\alpha \frac{\hbar^2}{2M_\alpha} \nabla_\alpha^2 \chi_n + (E_e + V_{nn} - E) \chi_n = 0 . \quad (7)$$

Equation (7) indicates that the effective potential for nuclear motion is equal to $(E_e + V_{nn})$ i.e. the sum of the electronic energy and the Coulomb potential of the nuclei acts as the potential energy under whose influence the nuclei carry out their motion. The most straightforward way of determining the potential energy curve consists in solving equation (5) and an extensive effort

is being made in this direction in our group and elsewhere in other laboratories. These ab initio calculations carried out by our group have yielded quite accurate results for the equilibrium internuclear separation r_e and other molecular constants. Some of these could even be predicted with sufficient accuracy for an unknown molecule like NF.

There is, however, another approach that is made for calculating the potential energy curves of diatomic molecules, viz., the Rydberg-Klein-Rees (RKR) method. In this, the potential energy curve is calculated by using the experimental data on the vibrational and rotational energy levels. Although this method has the limitation that the potential energy curve can be obtained only up to the highest energy level for which the experimental data is available, it has been found to yield quite accurate and realistic potential energy curves. A detailed account of this method along with the RKR potential energy curves of a number of molecules will be given in a subsequent report.

Inserting

$$U(r) = E_e + V_{nn} \quad (8)$$

in equation (7), we get

$$\sum_{\alpha} \frac{\hbar^2}{2M_{\alpha}} \nabla_{\alpha}^2 \chi_n + [E - U(r)] \chi_n = 0. \quad (9)$$

After some mathematical manipulation and separation of χ_n into χ_v and χ_r , the vibrational and rotational components, respectively, we obtain the well-known radial Schrödinger equation

$$\frac{d^2 \chi_v}{dr^2} + \left[\frac{2\mu}{\hbar^2} (E - U(r)) - \frac{J(J+1)}{r^2} \right] \chi_v = 0. \quad (10)$$

For the rotationless state ($J = 0$) this reduces to

$$\frac{d^2 \chi_v}{dr^2} + \frac{2\mu}{\hbar^2} [E - U(r)] \chi_v = 0. \quad (11)$$

The intensity in emission $I_{v',v''}$ of a transition from the v' vibrational level of an excited electronic state to the v'' vibrational level of a lower electronic state is given by

$$I_{v',v''} = N_{v'} A_{v',v''} h c \nu_{v',v''}, \quad (12)$$

where $N_{v'}$ is the number density of molecules in the energy level v' , $A_{v',v''}$ is the Einstein A coefficient for spontaneous transition ($v' \rightarrow v''$), h is the Planck's constant, c the velocity of light and $\nu_{v',v''}$ is the frequency of the transition in cm^{-1} . The Einstein A coefficient is given by

$$A_{v',v''} = \left(\frac{64\pi^4}{3h} \right) \left(\frac{1}{d_u} \right) \nu_{v',v''}^3 \left[\int \chi_{v'} R_e(r) \chi_{v''} dr \right]^2. \quad (13)$$

Here d_u is the degeneracy of the upper electronic state, $\chi_{v'}$ and $\chi_{v''}$ are the vibrational wave functions that are solutions of equation (11) with the appropriate potentials for the two electronic states, and $R_e(r)$ is the electric dipole transition moment defined by

$$R_e(r) = \int \chi_e^{n*} \left| \sum_i e \vec{r}_i \right| \chi_e^m d\tau. \quad (14)$$

Here χ_e^n and χ_e^m are the electronic wave functions of the upper and lower electronic states, respectively. These are solutions of equation (5).

It is rather difficult to evaluate $R_e(r)$ by using equation (14). Therefore, Fraser (ref. 7) has suggested the following procedure for the determination of $R_e(r)$ from the observed relative band intensities. By substituting for $A_{v',v''}$ from equation (13), equation (12) assumes the form

$$I_{v',v''} = D N_{v'} \frac{4}{v_{v',v''}} \left[\int \chi_{v'} R_e(r) \chi_{v''} dr \right]^2, \quad (15)$$

where all the constants have been absorbed in D. Now it has been found that

$$\int \chi_{v'} R_e(r) \chi_{v''} dr \approx R_e(\bar{r}_{v',v''}) \int \chi_{v'} \chi_{v''} dr,$$

where $R_e(\bar{r}_{v',v''})$ is some function of the r-centroid,

$$\bar{r}_{v',v''} = \frac{\int \chi_{v'} r \chi_{v''} dr}{\int \chi_{v'} \chi_{v''} dr}. \quad (16)$$

Thus equation (15) reduces to

$$I_{v',v''} = D N_{v'} \frac{4}{v_{v',v''}} R_e^2(\bar{r}_{v',v''}) q_{v',v''}. \quad (17)$$

In this $q_{v',v''}$ is the Franck-Condon factor, defined by

$$q_{v',v''} = \left[\int \chi_{v'} \chi_{v''} dr \right]^2. \quad (18)$$

Equation (17) indicates that if the values of $\left[I_{v',v''} / v_{v',v''} q_{v',v''} \right]^{1/2}$ are plotted against $\bar{r}_{v',v''}$, the points corresponding to the various bands of a v'' progression ($v' = \text{constant}$) would fall on a curve depicting the behavior of $R_e(\bar{r}_{v',v''})$; and, one would get a family of curves for the whole band system, the curves being shifted along the ordinate from one another due to the variations in $N_{v'}$. These curves can be rescaled suitably and a least square calculation can be performed to determine $R_e(r)$. Once this is done, the 'smoothed' relative band strengths, $p_{v',v''}$, and the relative intensities at infinite temperature,

$I_{v,v''}^{\infty}$, defined by

$$P_{v,v''} = \left[\int \chi_v R_e(r) \chi_{v''} dr \right]^2, \quad (19)$$

$$I_{v,v''}^{\infty} = P_{v,v''} \nu_{v,v''}^4, \quad (20)$$

can be calculated.

These results can be placed on an absolute scale in the following manner.

The lifetime τ_v of the v' level is given by

$$\frac{1}{\tau_v} = \sum_{v''} A_{v,v''} = F \sum_{v''} P_{v,v''} \nu_{v,v''}^3, \quad (21)$$

where all the constants have been absorbed in F . Equation (21) indicates that the values of the product $\tau_v \times \left(\sum_{v''} P_{v,v''} \nu_{v,v''}^3 \right)$ should be a constant ($1/F$) for

all the vibrational levels of the upper electronic state. Having determined F by this procedure, the Einstein A coefficients, $A_{v,v''}$, the band oscillator strengths, $f_{v,v''}$, and the absolute band strengths $p_{v,v''}^a$, can easily be obtained from the following relations (ref. 8)

$$A_{v,v''} = F P_{v,v''} \nu_{v,v''}^3, \quad (22)$$

$$f_{v,v''} = 1.5 \times 10^{-8} A_{v,v''} / \nu_{v,v''}^2, \quad (23)$$

and

$$p_{v,v''}^a = d_u f_{v,v''} / (0.03039 \nu_{v,v''}) . \quad (24)$$

In the above treatment the effect of the vibration-rotation interaction has been neglected. However, as is seen from equation (10), the term $\left[- \frac{J(J+1)}{r^2} \right]$

affects the potential under the influence of which the molecular vibrations take place and consequently the vibrational wave functions are modified. In the case of certain band systems, such changes in the wave functions of the two sets of vibrational energy levels of the electronic states involved almost cancel each other in the formation of the overlap integrals and so the Franck-Condon factors are not affected significantly (ref. 9). This is not the case with the band systems involving widely different electronic states and of molecules of low reduced mass (ref. 10). Thus in the case of hydrides the Franck-Condon factors are expected to depend markedly on the rotational quantum number. This has been checked for the band system of the RbH molecule. The vibrational wave functions corrected for the influence of vibration-rotation interaction have been computed by a modification of the method suggested by Jain and Sah (ref. 11).

Computational Procedure and Results

The Rydberg-Klein-Rees potential energy curves of the $X^1\Sigma_g^+$, $A^3\Sigma_u^+$, $B^3\Pi_g$, $C^3\Pi_u$ and $a^1\Pi_g$ states of N_2 , the $X^2\Sigma_g^+$, $B^2\Sigma_u^+$ and $C^2\Sigma_u^+$ states of N_2^+ , the $X^2\Sigma$, $A^2\Pi_1$ and $B^2\Sigma^+$ states of CO^+ , and the $X^1\Sigma^+$ and $A^1\Sigma^+$ states of RbH have been calculated by using the experimental data adopted from the sources listed in Table 1.

The technique suggested by Weissman, Vanderslice and Battino (ref. 12) has been adopted for evaluating the integrals necessary for obtaining the values of the quantities 'f' and 'g' for the various vibrational levels in the RKR calculations. The experimental data on the vibrational energy levels $G(v)$ and the rotational constant B_v have been fitted into polynomials in $(v + 1/2)$, of suitable degrees so as to achieve a very accurate fit in each case. Whenever a precise fit could not be achieved by using a single polynomial over the entire range, the data has been considered in two regions. The turning points, $r_{\min}$ and $r_{\max}$, have

been calculated for $(v + 1/2) = 0.125, 0.25, 0.375, 0.75, 1.0$ and 1.25 also, so that a smooth interpolation of the RKR curves could be achieved. In most cases the results are in good agreement with the results published by other workers. The accuracy of these RKR curves has been checked by interpolating them at small intervals of the internuclear separation r , and evaluating the integrals.

$$I = \left(\frac{8\mu c}{h} \right)^{1/2} \int_{r_{\min}}^{r_{\max}} [G(v) - U(r)]^{1/2} dr = (v + 1/2) \quad (25)$$

In all cases excepting the $B \Sigma_u^+$ state of N_2^+ the two sides of equation (25) have been found to agree closely. This indicates that the RKR curves obtained by us satisfy the quantization condition quite accurately. Another sensitive check on the accuracy of the RKR curves consists in deriving the rotational constant B_v by using the vibrational wave functions χ_v by the relation

$$B_v = \left(\frac{h}{8\pi^2 \mu c} \right) \int_0^\infty \left(\frac{\chi_v(r)}{r} \right)^2 dr. \quad (26)$$

These derived values of B_v have also been found to be in good agreement with the observed values of B_v . The results for such checks will be presented in greater details in the forthcoming report on the RKR curves. However, it should be mentioned that the RKR curves of the ground states of N_2 and CO obtained by us have been found to satisfy the quantization rule and to reproduce the values of B_v to a greater degree of accuracy than those obtained by Benesch, Vanderslice, Tilford and Wilkinson (ref. 13), and by Krupenie and Weissman (ref. 14), respectively, which have been employed by Benesch et. al. (ref. 9) and by Young and Eachus (ref. 15) in their calculations.

The vibrational wave functions appropriate to the RKR curves have been

obtained by the method of numerical integration due to Numerov (ref. 16). The experimental values of energy levels have been used. The scheme of iteration for obtaining the vibrational levels suggested by Cooley (ref. 17) has also been tried in a number of cases and it has been found that the vibrational energy levels, the wave functions and the Franck-Condon factors are not affected significantly by iteration. The final results that have been presented are those obtained without iteration. The Franck-Condon factors and r-centroids for the band systems of N_2 , N_2^+ and CO^+ have been presented in Tables 2 to 11.

The calculations of the Franck-Condon factors and r-centroids for the band system of RbH have been performed by the method suggested by Jain and Sah (ref. 11). In this case the vibrational wave functions have been computed by the Wentzel-Kramers-Brillouin (WKB) method. These have been obtained for the various combinations of the vibrational and rotational quantum numbers. The Franck-Condon factors and r-centroid for the band system have been tabulated in Tables 12 and 13.

The variation of the electronic transition moment with the internuclear distance, $R_e(r)$, has been determined for the first positive, the second positive and the Vegard-Kaplan band systems of N_2 , the first negative system of N_2^+ , and the comet-tail system of CO^+ . The expressions for $R_e(r)$ obtained are given below along with the sources from which the experimental data on relative intensities have been adopted:

First positive system of N_2 :

$$R_e(r) = \underset{0}{\text{constant}} \times (1 - 1.2550 \underset{0}{r} + 0.4063 \underset{0}{r}^2),$$

$$1.16 \text{ \AA} < r < 1.61 \text{ \AA}.$$

Experimental data from R. G. Turner and R. W. Nicholls, Can. J. Phys., vol. 32, 1954, pp. 468, 475.

Second positive system of N_2 :

$$R_e(r) = \text{constant} \times (-1 + 1.9669 r - 0.8636 r^2),$$
$$1.03 \text{ \AA} < r < 1.30 \text{ \AA}.$$

Experimental data from D. C. Tyte, Proc. Phys. Soc. (London), vol. 80, 1962, pp. 1347, 1354.

Vegard-Kaplan system of N_2 :

$$R_e(r) = \text{constant} \times (-1 + 0.8371 r),$$
$$1.24 \text{ \AA} < r < 1.36 \text{ \AA}.$$

Experimental data from N. P. Carleton and C. Papaliolios, J. Quant. Spectry. and Radiative Transfer, vol. 2, 1962, pp. 241.

First negative system of N_2^+ :

$$R_e(r) = \text{constant} \times (1 - 18.794 r + 12.216 r^2),$$
$$0.978 \text{ \AA} < r < 1.215 \text{ \AA}.$$

Experimental data from L. Wallace and R. W. Nicholls, J. Atmos. Terr. Phys., vol. 7, 1955, pp. 101; ibid vol. 24, 1962, pp. 749.

Comet-tail system of CO^+ :

$$R_e(r) = \text{constant} \times (-1 + 1.7380 r - 0.7454 r^2)$$
$$1.07 \text{ \AA} < r < 1.20 \text{ \AA}.$$

Experimental data from D. Robinson and R. W. Nicholls, Proc. Phys. Soc. (London) vol. A75, 1960, pp. 817.

These expressions have been employed for calculating the 'smoothed' relative band strengths and relative intensities at infinite temperature, $I_{v',v}^\infty$, entered in Tables 14 to 17. Equations (19) and (20) have been adopted for these calculations.

The expressions for $R_e(r)$ of the first negative system of N_2^+ and the comet-tail system of CO^+ have been used together with the lifetimes of the vibrational

energy levels of the corresponding excited states reported by Jeunehomme (ref. 18) and by Bennett and Dalby (ref. 19), for calculating the Einstein A coefficients, the band oscillator strengths and the absolute band strengths, entered in Tables 18 and 19.

Discussion of Results

In view of the accuracy of the RKR potential energy curves, the Franck-Condon factors and r-centroids presented in Tables 2 to 12 are expected to have a high degree of accuracy. This is borne out by the fact that the Franck-Condon factors presented here for the transitions for which the potential energy curves can be adequately represented by the Morse potential energy function, are in good agreement with those obtained by employing the exact Morse wave functions as has been observed by Jain and Sahni (ref. 20). Moreover, it has been found that in the determination of $R_e(r)$, the plots of $(I_{v',v''}/v_{v',v''}^4 q_{v',v''})^{1/2}$ against $\bar{r}_{v',v''}$ obtained by using these results exhibit somewhat lesser amount of scatter than that obtained by other workers as is evident from a careful study of the curves published by Zare, Larsson and Berg (ref. 21) and by Jain and Sahni (ref. 22). Thus a more accurate interpretation of the experimental results can be achieved by using these Franck-Condon factors and r-centroids.

One more observation which indicates the necessity of employing the more realistic RKR Franck-Condon factors in the interpretation of the experimental data on relative intensities, is the following. Nicholls (ref. 23), in his investigation of the intensities in comet-tail band system has employed the Morse Franck-Condon factors for calculating the product $\tau_{v'} \times \left(\sum_{v''} I_{v',v''} \lambda_{v',v''} \right)$ which is expected to be constant for various v' values. We have found that the constancy of this product is markedly improved when the RKR Franck-Condon factors are employed in the investigation. It is evident from Table 12 that the Franck-Condon

factors for the band system of RbH are markedly dependent on the vibration-rotation interaction.

It should be pointed out that the radial Schrödinger equation, (equation (11)), can be solved numerically for both the eigenvalues and the vibrational wave functions. Benesch et. al. (ref. 9) have remarked that "it has been considered at best wasteful and at worst detrimental to perform combined computations of eigenvalues and wave functions." As has been mentioned above, we have performed iterations for obtaining eigenvalues also along with the wave functions without encountering the failure of the iteration scheme but we find that there is inappreciable effect of such iterations on the Franck-Condon factors. Thus we have used the experimental values of energy levels in the final calculations reported here.

So far the various workers in this field have been using the following relation for calculating the 'smoothed' band strengths:

$$p_{v',v''} = R_e^2 (\bar{r}_{v',v''}) q_{v',v''} . \quad (27)$$

However, we have employed the exact relation [equation (19)], for determining $p_{v',v''}$ entered in Tables 14 to 17. Thus we have obtained the more accurate values of $p_{v',v''}$ for the expressions for $R_e(r)$ listed above. We find that the values of $p_{v',v''}$ calculated by equation (27) are in fairly good agreement with those obtained by the exact calculation [equation (19)]. This gives us some confidence in the applicability of the r-centroid procedure that has been employed for determining the expressions for $R_e(r)$.

Conclusion

The results for the Franck-Condon factors, r-centroids, band strengths, oscillator strengths, Einstein A coefficients, etc. obtained by this investigation would be found very valuable in the following investigations:

1. Interpretation of intensity measurements and determination of $R_e(r)$

for the band systems for which accurate data on relative intensities is not available at present,

2. calculations of the f numbers based on absolute absorption measurements, and
3. construction of emission intensity profiles.

A fairly large amount of work has been performed on the spectral absorption coefficients in electronic transitions in diatomic molecules (ref. 24), on the relation between the electronic oscillator strengths and the wave length for diatomic molecules (ref. 25), on the excitation rates in auroral nitrogen bands (ref. 26), etc. More recently Mentall and Nicholls (ref. 27) have used the band strengths of certain band systems in the spectroscopic determination of vibrational-rotational temperature of laser-produced flames. Most of these investigations have been made by employing the Franck-Condon factors, etc. based on the Morse potential energy curves. Much more reliable results would be obtained by employing the more realistic Franck-Condon factors, etc. to such problems.

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TABLE 1
SOURCES OF EXPERIMENTAL DATA

Molecule	States	Reference
N_2	$x \ ^1\Sigma_g^+$, $A \ ^3\Sigma_u^+$, $B \ ^3\Pi_g$, $C \ ^3\Pi_u$, $a \ ^1\Pi_g$	Wallace ^a , Lofthus ^b
N_2^+	$X \ ^2\Sigma_g^+$, $B \ ^2\Sigma_u^+$, $C \ ^2\Sigma_u^+$	Gilmore ^c
CO^+	$x \ ^2\Sigma^+$, $A \ ^2\Pi_1$, $B \ ^2\Sigma^+$	Krupenie ^d
RbH	$X \ ^1\Sigma^+$, $A \ ^1\Sigma^+$	Gaydon and Pearse ^e

- a. Wallace, L.: Band-Head Wavelengths of C_2 , CH , CN , CO , NH , NO , O_2 , OH , and their Ions. *Astrophys. J., Supplement Series*, vol. 7, 1962, pp. 165-290.
- b. Lofthus, A.: The Molecular Spectrum of Nitrogen. *Spectroscopic Report No. 2*, Department of Physics, University of Oslo, 1960.
- c. Gilmore, F. R.: Potential Energy Curves for N_2 , NO , O_2 and Corresponding Ions. *J. Quant. Spectry. and Radiative Transfer*. vol. 5, 1965, pp. 369-389; and private communication.
- d. Krupenie, P. H.: The Band Spectrum of Carbon Monoxide. *National Bureau of Standards Monograph*, NSRDS - NBS 5, 1966.
- e. Gaydon, A. G., and Pearse, R. W. B.: The Spectrum of Rubidium Hydride, RbH . *Proc. Roy. Soc. (London)*, Series A, vol. 173, 1939, pp. 28-37.

TABLE 2

FRANCK-CONDON FACTORS AND r-CENTROIDS FOR THE FIRST POSITIVE ($B^3\Pi_g - A^3\Sigma_u^+$) BAND SYSTEM OF N_2

v'	v''	0	1	2	3	4	5	6	7	8	9
0		0.401-0 1.2533	0.330-0 1.2159	0.166-0 1.1826	0.670-1 1.1524	0.240-1 1.1250	0.802-2 1.0999	0.259-2 1.0768	0.823-3 1.0555	0.260-3 1.0358	0.831-4 1.0177
1		0.399-0 1.2978	0.291-2 1.3076	0.159-0 1.2272	0.196-0 1.1919	0.130-0 1.1611	0.655-1 1.1334	0.284-1 1.1081	0.113-1 1.0850	0.429-2 1.0638	0.158-2 1.0442
2		0.161-0 1.3473	0.275-0 1.3086	0.689-1 1.2572	0.221-1 1.2483	0.125-0 1.2026	0.143-0 1.1704	0.101-0 1.1422	0.562-1 1.1167	0.273-1 1.0935	0.122-1 1.0722
3		0.339-1 1.4034	0.277-0 1.3566	0.959-1 1.3232	0.152-0 1.2708	0.516-2 1.1981	0.424-1 1.2174	0.108-0 1.1807	0.111-0 1.1514	0.800-1 1.1256	0.474-1 1.1023
4		0.404-2 1.4683	0.968-1 1.4121	0.297-0 1.3665	0.751-2 1.3671	0.151-0 1.2826	0.513-1 1.2352	0.220-2 1.2738	0.549-1 1.1932	0.938-1 1.1615	0.898-1 1.1350
5		0.272-3 1.5465	0.162-1 1.4771	0.169-0 1.4213	0.243-0 1.3774	0.105-1 1.2881	0.956-1 1.2959	0.949-1 1.2491	0.877-2 1.1917	0.140-1 1.2141	0.595-1 1.1730
6		0.979-5 1.6470	0.141-2 1.5558	0.388-1 1.4860	0.230-0 1.4308	0.156-0 1.3901	0.583-1 1.3216	0.355-1 1.3149	0.105-0 1.2614	0.394-1 1.2180	0.274-6
7		0.156-6 1.8031	0.620-4 1.6576	0.428-2 1.5648	0.716-1 1.4952	0.265-0 1.4408	0.743-1 1.4069	0.106-0 1.3369	0.307-2 1.3803	0.816-1 1.2744	0.677-1 1.2324
8		0.432-9	0.120-5 1.8052	0.224-3 1.6683	0.983-2 1.5741	0.112-0 1.5048	0.271-0 1.4513	0.199-1 1.4382	0.129-0 1.3499	0.474-2 1.2489	0.447-1 1.2903
9		0.592-11	0.772-8	0.481-5 1.8261	0.610-3 1.6781	0.189-1 1.5837	0.155-0 1.5146	0.249-0 1.4627	0.183-3 1.8680	0.120-8 1.3630	0.292-1 1.2976
10		0.202-12	0.285-9	0.373-7	0.144-4 1.8451	0.138-2 1.6879	0.322-1 1.5937	0.198-0 1.5248	0.206-0 1.4752	0.103-1 1.3526	0.900-1 1.3775
11		0.893-15	0.264-9	0.161-9	0.781-7	0.364-4 1.8597	0.275-2 1.6979	0.501-1 1.6038	0.233-0 1.5354	0.151-0 1.4893	0.389-1 1.3940
12		0.169-11	0.163-9	0.175-8	0.189-8	0.189-6	0.835-4 1.8658	0.497-2 1.7084	0.725-1 1.6143	0.259-0 1.5464	0.966-1 1.5064

TABLE 3

FRANCK-CONDON FACTORS AND r-CENTROIDS FOR THE SECOND POSITIVE ($C^3\Pi_u - B^3\Pi_g$) BAND SYSTEM OF N_2

v''	0	1	2	3	4	5	6	7	8	9	10	11	12
v'													
0	0.457-0 1.1843	0.328-0 1.1466	0.144-0 1.1133	0.449-1 1.0821	0.152-1 1.0532	0.434-2 1.0270	0.120-2 1.0037	0.329-3 0.9827	0.892-4 0.9624	0.236-4 0.9407	0.604-5 0.9156	0.148-5 0.8866	0.349-6 0.8555
1	0.387-0 1.2285	0.227-1 1.2083	0.206-0 1.1548	0.200-0 1.1211	0.111-0 1.0903	0.469-1 1.0614	0.171-1 1.0346	0.573-2 1.0102	0.183-2 0.9880	0.569-3 0.9677	0.173-3 0.9483	0.509-4 0.9279	0.140-4 0.9021
2	0.134-0 1.2778	0.339-0 1.2394	0.241-1 1.1684	0.633-1 1.1648	0.161-0 1.1286	0.140-0 1.0978	0.797-1 1.0690	0.364-1 1.0421	0.145-1 1.0172	0.537-2 0.9944	0.188-2 0.9733	0.632-3 0.9528	0.203-3 0.9313
3	0.209-1 1.3396	0.254-0 1.2892	0.210-0 1.2549	0.896-1 1.1835	0.492-2 1.1914	0.927-1 1.1358	0.130-0 1.1045	0.989-1 1.0759	0.554-1 1.0489	0.260-1 1.0237	0.110-1 1.0005	0.428-2 0.9786	0.158-2 0.9574
4	0.919-3 1.4615	0.539-1 1.3568	0.328-0 1.3025	0.117-0 1.2791	0.118-0 1.1875	0.340-2 1.1313	0.407-1 1.1429	0.101-0 1.1102	0.101-0 1.0817	0.682-1 1.0549	0.371-1 1.0295	0.176-1 1.0058	0.759-2 0.9836

TABLE 4

FRANCK-CONDON FACTORS AND r -CENTROIDS FOR THE VEGARD-KAPLAN ($A^3\Sigma_u^+ - X^1\Sigma_g^+$) BAND SYSTEM OF N_2

v'	v''	0	1	2	3	4	5	6	7	8	9	10
18	0	0.980-3 1.1849	0.809-2 1.2018	0.321-1 1.2192	0.799-1 1.2371	0.140-0 1.2555	0.185-0 1.2744	0.191-0 1.2940	0.157-0 1.3142	0.105-0 1.3352	0.577-1 1.3569	0.264-1 1.3794
	1	0.521-2 1.1745	0.319-1 1.1910	0.871-1 1.2078	0.131-0 1.2250	0.110-0 1.2425	0.399-1 1.2597	0.105-4 1.1164	0.373-1 1.3034	0.110-0 1.3223	0.150-0 1.3429	0.134-0 1.3644
	2	0.148-1 1.1645	0.657-1 1.1805	0.114-0 1.1968	0.827-1 1.2132	0.111-1 1.2275	0.152-1 1.2535	0.781-1 1.2693	0.814-1 1.2871	0.214-1 1.3041	0.396-2 1.3386	0.627-1 1.3517
	3	0.301-1 1.1550	0.928-1 1.1705	0.903-1 1.1861	0.149-1 1.2002	0.155-1 1.2240	0.723-1 1.2388	0.451-1 1.2549	0.105-4 1.0864	0.434-1 1.2969	0.812-1 1.3146	0.361-1 1.3327
	4	0.488-1 1.1458	0.998-1 1.1609	0.417-1 1.1755	0.295-2 1.2011	0.593-1 1.2108	0.411-1 1.2259	0.436-3 1.2727	0.496-1 1.2649	0.530-1 1.2812	0.213-2 1.2872	0.314-1 1.3250
	5	0.674-1 1.1369	0.852-1 1.1516	0.650-2 1.1629	0.329-1 1.1853	0.530-1 1.1995	0.864-3 1.1993	0.386-1 1.2361	0.445-1 1.2509	0.601-4 1.1866	0.417-1 1.2914	0.506-1 1.3077
	6	0.824-1 1.1285	0.577-1 1.1425	0.155-2 1.1683	0.550-1 1.1748	0.161-0 1.1875	0.171-1 1.2104	0.482-1 1.2235	0.171-2 1.2270	0.340-1 1.2614	0.400-1 1.2762	0.228-4 1.4478
	7	0.916-1 1.1203	0.293-1 1.1336	0.182-1 1.1524	0.473-1 1.1650	0.399-4 1.2549	0.436-1 1.1983	0.141-1 1.2103	0.167-1 1.2349	0.419-1 1.2478	0.304-3 1.2279	0.374-1 1.2869
	8	0.944-1 1.1125	0.912-2 1.1243	0.382-1 1.1429	0.231-1 1.1552	0.141-1 1.1759	0.375-1 1.1876	0.612-3 1.2266	0.407-1 1.2218	0.723-2 1.2317	0.230-1 1.2590	0.332-1 1.2722
	9	0.916-1 1.1050	0.450-3 1.1067	0.484-1 1.1344	0.401-2 1.1430	0.339-1 1.1653	0.130-1 1.1763	0.192-1 1.1984	0.268-1 1.2101	0.460-2 1.2372	0.380-1 1.2455	0.102-2 1.2418

TABLE 4 (Continued)

	v'											
	v''	11	12	13	14	15	16	17	18	19	20	21
6	0	0.102-1 1.4027	0.329-2 1.4271	0.891-3 1.4528	0.201-3 1.4803	0.379-4 1.5093	0.599-5 1.5398	0.788-6 1.5713	0.837-7 1.6048	0.529-8 1.6843	0.132-9 1.9693	0.101-9 1.4897
	1	0.886-1 1.3869	0.455-1 1.4102	0.187-1 1.4346	0.621-2 1.4604	0.168-2 1.4878	0.373-3 1.5164	0.681-4 1.5463	0.991-5 1.5808	0.108-5 1.6262	0.939-7 1.6685	0.860-8 1.6670
	2	0.127-0 1.3724	0.136-0 1.3946	0.991-1 1.4179	0.533-1 1.4423	0.221-1 1.4680	0.721-2 1.4954	0.188-2 1.5244	0.393-3 1.5550	0.653-4 1.5882	0.831-5 1.6279	0.784-6 1.6793
	3	0.142-3 1.4186	0.462-1 1.3819	0.116-0 1.4029	0.134-0 1.4259	0.990-1 1.4502	0.525-1 1.4759	0.210-1 1.5032	0.648-2 1.5322	0.155-2 1.5636	0.291-3 1.5979	0.431-4 1.6344
	4	0.763-1 1.3426	0.374-1 1.3611	0.726-4 1.4846	0.465-1 1.4127	0.116-0 1.4345	0.131-0 1.4584	0.924-1 1.4840	0.461-1 1.5112	0.170-1 1.5404	0.476-2 1.5718	0.102-2 1.6060
	5	0.192-2 1.3119	0.322-1 1.3532	0.733-1 1.3712	0.304-1 1.3897	0.137-2 1.4427	0.580-1 1.4442	0.124-0 1.4672	0.125-0 1.4925	0.803-1 1.5196	0.362-1 1.5487	0.120-1 1.5800
	6	0.433-1 1.3181	0.435-1 1.3345	0.154-3 1.2884	0.409-1 1.3816	0.692-1 1.4004	0.181-1 1.4178	0.796-2 1.4609	0.783-1 1.4768	0.131-0 1.5013	0.114-0 1.5282	0.642-1 1.5573
	7	0.310-1 1.3015	0.186-2 1.3419	0.492-1 1.3450	0.315-1 1.3614	0.170-2 1.4091	0.545-1 1.4107	0.591-1 1.4303	0.528-2 1.4410	0.248-1 1.4893	0.103-0 1.5108	0.133-0 1.5372
	8	0.832-3 1.3182	0.429-1 1.3125	0.183-1 1.3263	0.960-2 1.3596	0.532-1 1.3725	0.157-1 1.3872	0.121-1 1.4255	0.666-1 1.4408	0.403-1 1.4604	0.103-3 1.6213	0.540-1 1.5217
	9	0.322-1 1.2833	0.203-1 1.2962	0.781-2 1.3275	0.444-1 1.3386	0.532-2 1.3473	0.250-1 1.3845	0.483-1 1.4004	0.239-2 1.4015	0.330-1 1.4528	0.679-1 1.4717	0.166-1 1.4889

TABLE 5
FRANCK-CONDON FACTORS AND r-CENTROIDS OF THE LYMAN-BIRGE-HOPFIELD SYSTEM OF N₂

v'	v''	0	1	2	3	4	5	6	7	8	9	10
0	4.336-2 1.1576	1.515-1 1.1805	2.496-1 1.2041	2.503-1 1.2286	1.723-1 1.2542	8.681-2 1.2808	3.308-2 1.3084	9.674-3 1.3376	2.183-3 1.3690	3.860-4 1.4027	5.561-5 1.4355	
1	1.163-1 1.1413	1.920-1 1.1631	8.051-2 1.1847	5.109-4 1.2423	8.987-2 1.2372	1.879-1 1.2618	1.753-1 1.2881	1.013-1 1.3158	4.058-2 1.3449	1.190-2 1.3758	2.635-3 1.4086	
2	1.713-1 1.1257	9.629-2 1.1462	3.250-3 1.1810	1.080-1 1.1938	8.515-2 1.2155	5.497-4 1.2042	6.857-2 1.2709	1.680-1 1.2959	1.606-1 1.3233	9.075-2 1.3522	3.464-2 1.3829	
3	1.835-1 1.1108	1.213-2 1.1278	7.521-2 1.1552	6.882-2 1.1749	4.002-3 1.2123	9.665-2 1.2247	6.395-2 1.2464	5.133-4 1.3200	8.460-2 1.3046	1.667-1 1.3310	1.404-1 1.3597	
4	1.603-1 1.0965	6.293-3 1.1231	9.640-2 1.1385	5.239-4 1.1313	7.806-2 1.1842	3.610-2 1.2030	1.871-2 1.2370	9.805-2 1.2558	3.285-2 1.2769	1.236-2 1.3187	1.160-1 1.3394	
5	1.213-1 1.0828	4.674-2 1.1050	4.685-2 1.1224	3.414-2 1.1482	5.611-2 1.1658	9.123-3 1.1983	7.895-2 1.2132	6.501-3 1.2253	5.088-2 1.2658	8.399-2 1.2874	5.400-3 1.3004	
6	8.277-2 1.0696	8.521-2 1.0907	4.712-3 1.1029	7.296-2 1.1315	2.598-3 1.1391	6.411-2 1.1753	1.363-2 1.1902	4.290-2 1.2234	5.281-2 1.2420	3.462-3 1.2888	8.259-2 1.2968	
7	5.221-2 1.0568	9.978-2 1.0774	5.536-3 1.1035	5.661-2 1.1162	1.754-2 1.1424	4.623-2 1.1576	1.390-2 1.1876	5.624-2 1.2026	1.842-3 1.2512	6.914-2 1.2520	1.223-2 1.2668	
8	3.104-2 1.0446	9.249-2 1.0647	3.311-2 1.0863	1.834-2 1.1006	5.363-2 1.1253	3.855-3 1.1339	5.297-2 1.1672	3.828-3 1.1744	5.227-2 1.2126	1.488-2 1.2268	3.572-2 1.2629	
9	1.763-2 1.0328	7.388-2 1.0524	6.041-2 1.0729	1.454-4 1.0478	5.474-2 1.1106	9.680-3 1.1378	3.879-2 1.1502	1.735-2 1.1788	3.680-2 1.1927	1.425-2 1.2257	4.883-2 1.2397	
10	9.679-3 1.0216	5.326-2 1.0407	7.334-2 1.0605	9.595-3 1.0839	2.776-2 1.0962	3.958-2 1.1200	4.536-3 1.1286	4.794-2 1.1600	4.775-4 1.1397	5.012-2 1.2031	8.519-4 1.1886	
11	5.182-3 1.0108	3.565-2 1.0294	7.144-2 1.0487	3.172-2 1.0693	4.475-3 1.0789	4.908-2 1.1057	5.416-3 1.1342	3.331-2 1.1438	1.919-2 1.1713	2.290-2 1.1836	2.560-2 1.2144	
12	2.723-3 1.0006	2.259-2 1.0186	6.044-2 1.0374	5.072-2 1.0571	1.184-3 1.0892	3.262-2 1.0921	2.933-2 1.1153	5.043-3 1.1239	4.217-2 1.1538	3.366-5 1.3268	4.291-2 1.1947	
13	1.409-3 0.9907	1.372-2 1.0082	4.631-2 1.0266	5.927-2 1.0456	1.402-2 1.0671	1.061-2 1.0778	4.254-2 1.1015	2.860-3 1.1321	2.935-2 1.1383	1.956-2 1.1649	1.401-2 1.1752	
14	7.215-4 0.9813	8.072-3 0.9982	3.302-2 1.0161	5.773-2 1.0348	3.139-2 1.0545	2.118-4 1.0368	3.433-2 1.0885	2.148-2 1.1115	5.635-3 1.1201	3.728-2 1.1484	5.446-4 1.2041	
15	3.663-4 0.9720	4.639-3 0.9886	2.233-2 1.0061	4.985-2 1.0243	4.435-2 1.0433	4.421-3 1.0674	1.621-2 1.0755	3.594-2 1.0980	1.235-3 1.1332	2.665-2 1.1337	1.880-2 1.1594	

TABLE 5 (continued)

v'	v''	11	12	13	14	15	16	17	18	19	20	21
0	6.698-6 1.4650	5.543-7 1.5159	1.837-8 1.6911	1.618-9 1.5731	1.363-9 1.3172	1.273-10 1.1000	2.687-10 1.2377	3.340-10 1.2098	7.948-12 1.3150	3.144-10 1.2312	8.810-11 1.2154	
1	4.519-4 1.4426	5.999-5 1.4786	5.796-6 1.5246	3.7795-7 1.5884	2.312-8 1.6069	1.550-9 1.5808	1.896-12 1.678-13	5.421-12 1.207-9	2.747-11 1.3155	2.823-12 1.0461	1.2805 1.3570	
2	9.530-3 1.4155	1.954-3 1.4497	2.999-4 1.4865	3.287-5 1.5324	2.486-6 1.5926	1.770-7 1.6132	1.776-8 1.5514	1.942-14 1.207-9	1.207-9 1.3155	4.397-11 1.0461	3.514-10 1.3570	
3	7.106-2 1.3902	2.430-2 1.4227	5.934-3 1.4573	1.056-3 1.4945	1.357-4 1.5374	1.224-5 1.5898	8.164-7 1.6399	4.308-8 1.6765	8.453-10 1.8499	1.856-10 1.2712	1.219-10 1.4271	
4	1.637-1 1.3675	1.134-1 1.3977	4.880-2 1.4302	1.426-2 1.4649	2.954-3 1.5023	4.355-4 1.5446	4.535-5 1.5937	3.321-6 1.6451	1.333-7 1.7421	4.248-10 1.7421	1.735-10 1.4903	
5	4.643-2 1.3495	1.466-1 1.3746	1.477-1 1.4055	8.155-2 1.4378	2.883-2 1.4726	6.958-3 1.5102	1.171-3 1.5523	1.363-4 1.6015	1.083-5 1.6559	4.935-7 1.7415	4.555-9 1.7415	
6	4.656-2 1.3190	3.800-3 1.3731	9.719-2 1.3845	1.596-1 1.4136	1.167-1 1.4456	5.046-2 1.4804	1.428-2 1.5182	2.737-3 1.5603	3.536-4 1.6099	3.017-5 1.6683	1.639-6 1.7416	
7	3.785-2 1.3077	8.232-2 1.3290	7.830-3 1.3438	4.110-2 1.3954	1.429-1 1.4221	1.455-1 1.4537	7.821-2 1.4884	2.608-2 1.5263	5.701-3 1.5686	8.215-4 1.6184	7.778-5 1.6766	
8	5.041-2 1.2810	2.756-3 1.3348	7.812-2 1.3387	4.283-2 1.3610	5.344-3 1.4182	1.029-1 1.4314	1.589-1 1.4622	1.087-1 1.4967	4.307-2 1.5346	1.079-2 1.5770	1.748-3 1.6266	
9	2.743-3 1.2887	6.481-2 1.2913	8.440-3 1.3032	4.212-2 1.3495	7.539-2 1.3716	3.216-3 1.3742	5.464-2 1.4423	1.517-1 1.4710	1.367-1 1.5052	6.506-2 1.5431	1.879-2 1.5856	
10	5.146-2 1.2501	8.258-3 1.2604	4.122-2 1.3023	3.986-2 1.3202	7.879-3 1.3683	8.061-2 1.3815	2.830-2 1.4025	1.606-2 1.4587	1.246-1 1.4805	1.560-1 1.5140	9.084-2 1.5518	
11	2.369-2 1.2275	2.259-2 1.2623	3.719-2 1.2768	9.059-3 1.3194	6.103-2 1.3312	1.534-3 1.3193	5.697-2 1.3922	6.068-2 1.4148	1.512-4 1.6268	8.468-2 1.4909	1.618-1 1.5231	
12	1.465-3 1.2449	4.498-2 1.2391	7.813-4 1.3078	5.144-2 1.2879	1.029-3 1.2687	5.235-2 1.3419	2.241-2 1.3580	2.318-2 1.4060	7.952-2 1.4254	9.284-3 1.4370	4.365-2 1.5037	
13	3.134-2 1.2056	7.892-3 1.2136	3.657-2 1.2501	9.040-3 1.2590	3.613-2 1.2993	2.018-2 1.3126	2.433-2 1.3549	4.900-2 1.3710	1.898-3 1.4472	7.463-2 1.4361	3.493-2 1.4571	
14	3.493-2 1.1875	6.758-3 1.2218	3.072-2 1.2291	1.147-2 1.2648	3.250-2 1.2749	1.010-2 1.3156	4.313-2 1.3256	2.584-3 1.3870	5.897-2 1.3823	4.466-3 1.3827	5.027-2 1.4480	
15	8.807-3 1.1678	3.246-2 1.1983	1.311-3 1.1892	3.823-2 1.2404	4.578-5 1.0788	4.217-2 1.2864	1.423-4 1.1894	4.679-2 1.3370	3.572-3 1.3342	4.577-2 1.3940	2.533-2 1.4093	

TABLE 6

FRANCK-CONDON FACTORS AND r-CENTROIDS OF THE TANAKA SYSTEM OF N_2

v'	v''	0	1	2	3	4	5	6	7	8	9	10
0		5.501-1 1.1262	3.427-1 1.1723	9.195-2 1.2216	1.368-2 1.2740	1.302-3 1.3286	9.381-5 1.3771	6.536-6 1.4009	4.400-7 1.4185	1.936-8 1.4923	2.006-10	2.122-9 1.3055
1		3.049-1 1.0867	8.215-2 1.1377	3.607-1 1.1799	1.976-1 1.2286	4.705-2 1.2798	6.625-3 1.3312	6.843-4 1.3749	6.207-5 1.4027	4.433-6 1.4525	4.393-7 1.4664	2.031-7 1.3440
2		1.048-1 1.0507	2.689-1 1.0957	2.331-3 1.1015	2.344-1 1.1882	2.672-1 1.2357	9.888-2 1.2857	1.988-2 1.3349	2.843-3 1.3767	3.700-4 1.4006	4.537-5 1.4261	5.394-6 1.4571
3		2.922-2 1.0180	1.827-1 1.0598	1.301-1 1.1070	7.275-2 1.1426	9.099-2 1.1979	2.743-1 1.2432	1.613-1 1.2918	4.680-2 1.3386	9.436-3 1.3780	1.736-3 1.4011	3.143-4 1.4191
4		7.511-3 0.9889	7.910-2 1.0282	1.844-1 1.0707	2.394-2 1.1261	1.485-1 1.1561	6.686-3 1.2127	2.070-1 1.2510	2.133-1 1.2981	9.319-2 1.3422	2.710-2 1.3793	6.787-3 1.4041
v'	v''	11	12	13	14	15	16	17	18	19	20	21
0		2.041-9 1.2132	1.467-9 1.1670	4.496-10 1.2032	1.882-9 1.1674	1.019-10 1.1165	8.816-10 1.1676	1.123-9 1.1552	1.104-11 1.1138	7.570-10 1.1565	9.543-10 1.1523	5.124-11 1.1418
1		1.975-8 1.4080	1.147-8 1.1386	1.699-10 1.4575	6.187-9 1.1924	7.669-10 1.0819	1.291-9 1.2213	1.864-9 1.1652	9.892-12	8.502-10 1.2251	4.970-10 1.1705	3.463-11 1.4140
2		9.827-7 1.4346	1.703-7 1.4259	2.103-10	1.388-8 1.2284	7.168-10 1.2040	1.057-8 1.2766	7.077-10 1.1454	4.861-9 1.2877	1.507-9 1.2458	1.955-9 1.2729	3.063-9 1.2523
3		5.022-5 1.4458	6.066-6 1.4851	4.789-7 1.5735	1.125-7 1.4596	2.753-8 1.3935	6.558-9 1.0999	2.648-10 1.0935	1.363-8 1.2669	4.128-10 1.2746	1.038-8 1.2598	4.940-9 1.2604
4		1.584-3 1.4242	3.192-4 1.4498	4.955-5 1.4832	4.888-6 1.5578	7.293-7 1.5524	4.056-7 1.4247	3.461-8 1.5477	2.031-8 1.1991	1.280-10	1.718-8 1.3033	2.414-10

TABLE 7
FRANCK-CONDON FACTORS AND r-CENTROIDS FOR THE FIRST NEGATIVE
BAND SYSTEM OF N₂

v'	v''	0	1	2	3	4	5	6	7	8
0		6.481-1*	2.619-1	7.045-2	1.565-2	3.161-3	6.106-4	1.151-4	2.084-5	
		1.1004	1.0529	1.0138	0.9782	0.9458	0.9166	0.8896	0.8611	
1		3.010-1	2.149-1	2.889-1	1.364-1	4.369-2	1.150-2	2.709-3	5.980-4	1.270-4
		1.1522	1.1121	1.0583	1.0192	0.9837	0.9510	0.9205	0.8920	0.8653
2		4.897-2	4.041-1	4.542-2	2.250-1	1.699-1	7.354-2	2.427-2	6.830-3	1.746-3
		1.2152	1.1605	1.1382	1.0636	1.0243	0.9887	0.9560	0.9252	0.8962
3		2.733-3	1.118-1	4.123-1	1.628-3	1.467-1	1.720-1	9.661-2	3.870-2	1.274-2
		1.3111	1.2251	1.1701	1.3312	1.0684	1.0291	0.9932	0.9605	0.9296
4			7.402-3	1.711-1	3.876-1	4.751-3	8.446-2	1.550-1	1.093-1	5.186-2
			1.3335	1.2360	1.1816	0.9478	1.0718	1.0336	0.9970	0.9644
5				1.169-2	2.201-1	3.639-1	1.630-2	4.373-2	1.305-1	1.120-1
				1.3630	1.2483	1.1953	0.9994	1.0707	1.0382	1.0000
6			3.016-5	5.710-5	1.301-2	2.555-1	3.569-1	2.126-2	2.019-2	1.069-1
					1.4072	1.2624	1.2111	0.9793	1.0561	1.0435
7				1.019-4	6.122-4	9.815-3	2.746-1	3.745-1	1.671-2	7.688-3
				1.3047	1.0152	1.4886	1.2787	1.2283	0.8978	0.9952
8					1.985-4	2.535-3	3.289-3	2.691-1	4.198-1	6.311-3
					1.3854	1.1560	1.7423	1.2983	1.2458	0.5943
9					1.496-5	1.836-4	6.484-3	2.832-4	2.268-1	4.867-1
					1.0438	1.5450	1.2392		1.3238	1.2624
10						9.112-5		1.092-2	1.542-2	1.400-1
						1.2115		1.3117	1.0426	1.3639
11							2.420-4	5.502-4	1.026-2	5.938-2
							1.3279	0.9621	1.4073	1.1918
12							2.496-5	2.369-4	3.808-3	2.402-3
							1.0502	1.5088	1.1946	1.7372
13								1.582-4		8.681-3
								1.2516		1.3031
14									2.886-4	1.242-3
									1.4063	1.0790

* The sign and final digit indicate the power of 10 to which each entry should be raised.

TABLE 7 (continued)

v'	v''	9	10	11	12	13	14	15	16	17
0										
1	2.580-4									
	0.8385									
2	4.186-4	9.377-5	1.849-5							
	0.8690	0.8407	0.8007							
3	3.713-3	9.918-4	2.429-4	5.254-5						
	0.9005	0.8725	0.8422	0.8017						
4	1.959-2	6.426-3	1.899-3	5.081-4	1.215-4	2.558-5				
	0.9335	0.9046	0.8762	0.8448	0.8056	0.7541				
5	6.161-2	2.628-2	9.600-3	3.116-3	9.087-4	2.402-4	5.845-5	1.297-5		
	0.9678	0.9369	0.9084	0.8799	0.8480	0.8109	0.7701	0.7235		
6	1.074-1	6.730-2	3.193-2	1.284-2	4.533-3	1.438-3	4.208-4	1.170-4	3.042-5	
	1.0015	0.9705	0.9396	0.9117	0.8830	0.8511	0.8174	0.7859	0.7507	
7	8.845-2	9.796-2	6.901-2	3.581-2	1.566-2	5.961-3	2.052-3	6.668-4	2.083-4	
	1.0519	1.0003	0.9728	0.9416	0.9146	0.8850	0.8540	0.8256	0.8008	
8	1.665-3	7.724-2	8.547-2	6.774-2	3.752-2	1.765-2	7.182-3	2.691-3	9.610-4	
	0.7009	1.0673	0.9937	0.9760	0.9421	0.9162	0.8858	0.8580	0.8343	
9	2.320-5	4.965-5	7.511-2	7.073-2	6.484-2	3.676-2	1.853-2	8.012-3	3.252-3	
			1.0958	0.9756	0.9825	0.9388	0.9172	0.8864	0.8629	
10	5.473-1	1.445-2	4.231-3	8.546-2	5.371-2	6.198-2	3.336-2	1.846-2	8.300-3	
	1.2764	1.8466	1.9024	1.1417	0.9320	0.9970	0.9270	0.9213	0.8855	
11	4.027-2	5.403-1	5.898-2	1.872-2	1.144-1	3.388-2	6.218-2	2.803-2	1.808-2	
	1.4660	1.2859	1.5924	1.7112	1.2004	0.8193	0.0289	0.8983	0.9334	
12	1.124-1	1.293-3	4.184-1	1.138-1	4.415-2	1.675-1	1.386-2	6.928-2	2.072-2	
	1.2618		1.2871	1.5153	1.6673	1.2578		1.0869	0.8263	
13	3.481-3	1.174-1	8.231-2	2.129-1	1.334-1	6.797-2	2.419-1	9.413-4	8.766-2	
	0.8343	1.3168	1.1953	1.2688	1.4790	1.6707	1.3045		1.1682	
14	7.401-3	3.746-2	5.286-2	2.266-1	4.358-2	9.208-2	6.501-2	3.117-1	4.145-3	
	1.4343	1.1767	1.3974	1.2595	1.1640	1.4470	1.7208	1.3356		

TABLE 8

FRANCK-CONDON FACTORS AND r-CENTROIDS FOR THE SECOND NEGATIVE
BAND SYSTEM OF N_2^+

v', v''	0	1	2	3	4	5	6	7	8
0	1.319-2*	7.599-2	1.917-1	2.755-1	2.460-1	1.388-1	4.794-2	9.087-3	6.776-4
	1.1952	1.2131	1.2323	1.2533	1.2767	1.3039	1.3378	1.3856	1.4784
1	4.876-2	1.568-1	1.569-1	2.711-2	3.217-2	1.889-1	2.311-1	1.242-1	3.073-2
	1.1783	1.1945	1.2105	1.2204	1.2681	1.2831	1.3088	1.3424	1.3913
2	9.637-2	1.530-1	2.594-2	3.898-2	1.179-1	1.794-2	5.811-2	2.265-1	1.961-1
	1.1629	1.1775	1.1883	1.2184	1.2304	1.2290	1.2983	1.3154	1.3476
3	1.354-1	8.326-2	8.036-3	9.677-2	1.255-2	5.608-2	8.184-2	1.708-3	1.667-1
	1.1485	1.1615	1.1887	1.1954	1.1989	1.2377	1.2457	1.4347	1.3254
4	1.519-1	1.911-2	6.120-2	4.203-2	2.457-2	6.885-2	2.084-3	9.034-2	1.282-2
	1.1351	1.1450	1.1660	1.1762	1.2029	1.2105	1.2842	1.2521	1.2166
5	1.449-1	1.875-4	8.147-2	1.501-4	6.885-2	2.997-3	6.262-2	1.377-2	5.433-2
	1.1224	1.1802	1.1504	1.0933	1.1811	1.1716	1.2158	1.2118	1.2594
6	1.224-1	1.892-2	5.272-2	2.323-2	3.893-2	2.349-2	3.753-2	2.144-2	4.511-2
	1.1105	1.1278	1.1360	1.1559	1.1634	1.1874	1.1926	1.2243	1.2245
7	9.412-2	4.888-2	1.543-2	5.514-2	2.260-3	5.420-2	2.416-5	5.371-2	3.228-4
	1.0992	1.1143	1.1208	1.1400	1.1358	1.1678		1.1976	1.3223
8	6.734-2	7.023-2	8.373-5	5.444-2	9.635-3	3.300-2	2.429-2	1.762-2	3.606-2
	1.0886	1.1026		1.1264	1.1475	1.1514	1.1730	1.1759	1.2025
9	4.558-2	7.664-2	8.062-3	3.021-2	3.576-2	3.771-3	4.461-2	1.024-3	3.863-2
	1.0785	1.0919	1.1108	1.1131	1.1307	1.1293	1.1556	1.2009	1.1819
10	2.967-2	7.112-2	2.596-2	7.747-3	4.597-2	3.896-3	2.801-2	2.405-2	7.018-3
	1.0692	1.0819	1.0970	1.0977	1.1178	1.1422	1.1405	1.1604	1.1596

Legend: $q_{v',v''}$; $\bar{r}_{v',v''}$ (Å)

* The sign and final digit indicate the power of 10 to which each entry should be raised.

TABLE 8 (continued)

v'	v''	9	10	11	12	13	14	15	16	17
0										
1	2.583-3			2.585-5						
	1.4903			1.3198						
2	6.289-2	5.801-3			8.370-5					
	1.3970	1.5031			1.3512					
3	2.460-1	1.013-1	1.010-2	2.943-5	2.009-4					
	1.3538	1.4032	1.5163		1.3809					
4	9.818-2	2.713-1	1.423-1	1.500-2	1.479-4	3.886-4			1.285-5	
	1.3419	1.3613	1.4098	1.5307		1.4109			1.4075	
5	4.473-2	4.568-2	2.766-1	1.830-1	2.004-2	4.581-4	6.390-4	1.240-5	2.265-5	
	1.2471	1.3726	1.3702	1.4171	1.5461		1.4420			
6	1.715-2	6.712-2	1.474-2	2.685-1	2.223-1	2.482-2	1.082-3	9.212-4	5.129-5	
	1.2746	1.2566	1.4451	1.3808	1.4248	1.5628	1.0208	1.4752		
7	5.758-2	6.717-4	7.147-2	1.742-3	2.526-1	2.597-1	2.902-2	2.136-3	1.178-3	
	1.2300	1.3930	1.2620	1.7664	1.3934	1.4332	1.5810	1.1022	1.5127	
8	8.660-3	4.662-2	4.179-3	6.159-2	5.730-4	2.328-1	2.949-1	3.275-2	3.702-3	
	1.1951	1.2351	1.1926	1.2666		1.4084	1.4421	1.6000	1.1594	
9	1.071-2	2.775-2	2.537-2	1.768-2	4.454-2	5.736-3	2.113-1	3.288-1	3.606-2	
	1.2119	1.2073	1.2422	1.2249	1.2715	1.0024	1.4260	1.4514	1.6197	
10	3.819-2	2.609-5	3.925-2	7.584-3	3.137-2	2.679-2	1.333-2	1.885-1	3.613-1	
	1.1862	1.4975	1.2128	1.2578	1.2348	1.2785	1.0948	1.4468	1.4614	

TABLE 9
FRANCK-CONDON FACTORS AND r-CENTROIDS FOR THE COMET-TAIL ($A^2\Pi_1 - X^2\Sigma^+$) BAND SYSTEM OF CO⁺

		v''	0	1	2	3	4	5	6	7	8	9	10	11	12	13
		v'														
27	0	0.423-1 1.1780	0.152-0 1.2022	0.250-0 1.2271	0.252-0 1.2531	0.173-0 1.2802	0.861-1 1.3085	0.320-1 1.3384	0.904-2 1.3700	0.196-2 1.4036	0.329-3 1.4397	0.422-4 1.4794	0.403-5 1.5247	0.285-6 1.5764	0.165-7 1.6183	
	1	0.113-0 1.1611	0.193-0 1.1840	0.812-1 1.2068	0.528-3 1.2686	0.919-1 1.2627	0.191-0 1.2887	0.176-0 1.3167	0.997-1 1.3464	0.387-1 1.3779	0.108-1 1.4116	0.222-2 1.4480	0.339-3 1.4878	0.386-4 1.5308	0.327-5 1.5770	
	2	0.167-0 1.1450	0.987-1 1.1664	0.282-2 1.2046	0.108-0 1.2168	0.856-1 1.2396	0.410-3 1.2184	0.722-1 1.2987	0.173-0 1.3253	0.162-0 1.3546	0.882-1 1.3860	0.319-1 1.4197	0.808-2 1.4562	0.147-2 1.4961	0.193-3 1.5399	
	3	0.180-0 1.1297	0.141-1 1.1471	0.728-1 1.1764	0.704-1 1.1969	0.367-2 1.2379	0.972-1 1.2497	0.633-1 1.2724	0.919-3 1.3427	0.913-1 1.3351	0.173-0 1.3633	0.140-0 1.3944	0.667-1 1.4280	0.210-1 1.4644	0.454-2 1.5042	
	4	0.159-0 1.1150	0.455-2 1.1453	0.962-1 1.1590	0.979-3 1.1572	0.768-1 1.2071	0.371-1 1.2267	0.189-1 1.2632	0.989-1 1.2828	0.308-1 1.3044	0.158-1 1.3506	0.127-0 1.3728	0.169-0 1.4032	0.109-0 1.4365	0.430-1 1.4728	
	5	0.122-0 1.1010	0.415-1 1.1248	0.498-1 1.1424	0.307-1 1.1701	0.581-1 1.1879	0.799-2 1.2235	0.792-1 1.2379	0.648-2 1.2498	0.527-1 1.2939	0.831-1 1.3164	0.341-2 1.3221	0.569-1 1.3840	0.159-0 1.4124	0.147-0 1.4453	
	6	0.850-1 1.0877	0.790-1 1.1099	0.664-2 1.1229	0.704-1 1.1525	0.390-2 1.1614	0.622-1 1.1983	0.150-1 1.2136	0.420-1 1.2491	0.528-1 1.2683	0.419-2 1.3183	0.854-1 1.3269	0.418-1 1.3494	0.810-2 1.4055	0.115-0 1.4223	
	7	0.549-1 1.0748	0.954-1 1.0962	0.339-2 1.1265	0.585-1 1.1366	0.141-1 1.1653	0.485-1 1.1798	0.118-1 1.2128	0.572-1 1.2271	0.158-2 1.2825	0.694-1 1.2793	0.109-1 1.2929	0.426-1 1.3389	0.807-1 1.3611	0.356-2 1.3636	
	8	0.335-1 1.0626	0.907-1 1.0832	0.275-1 1.1063	0.220-1 1.1207	0.495-1 1.1468	0.579-2 1.1565	0.529-1 1.1904	0.511-2 1.1987	0.509-1 1.2380	0.154-1 1.2522	0.365-1 1.2913	0.486-1 1.3096	0.488-2 1.3643	0.833-1 1.3720	
	9	0.196-1 1.0507	0.746-1 1.0708	0.541-1 1.0923	0.955-3 1.0919	0.550-1 1.1315	0.659-2 1.1623	0.413-1 1.1726	0.144-1 1.2039	0.387-1 1.2172	0.128-1 1.2530	0.490-1 1.2663	0.325-2 1.3187	0.655-1 1.3211	0.538-2 1.3266	
	10	0.111-1 1.0394	0.554-1 1.0590	0.688-1 1.0795	0.594-2 1.1058	0.316-1 1.1167	0.346-1 1.1419	0.699-2 1.1513	0.458-1 1.1834	0.122-2 1.1759	0.491-1 1.2284	0.119-2 1.2162	0.513-1 1.2778	0.711-2 1.2856	0.449-1 1.3331	
	11	0.611-2 1.0285	0.382-1 1.0477	0.697-1 1.0676	0.253-1 1.0894	0.744-2 1.1004	0.477-1 1.1270	0.284-2 1.1620	0.360-1 1.1664	0.155-1 1.1965	0.254-1 1.2081	0.234-1 1.2410	0.243-1 1.2537	0.231-1 1.2912	0.351-1 1.3052	

TABLE 10

FRANCK-CONDON FACTORS AND r-CENTROIDS FOR THE FIRST NEGATIVE ($B^2\Sigma^+ - X^2\Sigma^+$) BAND SYSTEM OF CO^+

v'	v''													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
B	0	0.538 0 1.1447	0.335-0 1.1953	0.102-0 1.2431	0.205-1 1.2876	0.310-2 1.3287	0.372-3 1.3682	0.363-4 1.4086	0.310-5 1.4415	0.213-6 1.4838	0.901-8 1.5750	0.532-9 1.5854	0.315-9 1.2917	0.572-1 0.210-10
	1	0.315-0 1.1059	0.648-1 1.1534	0.319-0 1.2049	0.212-0 1.2517	0.702-1 1.2954	0.155-1 1.3361	0.254-2 1.3746	0.325-3 1.4137	0.340-4 1.4501	0.285-5 1.4934	0.212-6 1.5201	0.113-7 1.5898	0.412-9 1.6130
	2	0.109-0 1.0671	0.273-0 1.1184	0.110-1 1.1784	0.160-0 1.2142	0.255-0 1.2607	0.138-0 1.3036	0.433-1 1.3438	0.953-2 1.3816	0.156-2 1.4204	0.205-3 1.4562	0.214-4 1.4966	0.187-5 1.5260	0.979-7 1.6203
	3	0.294-1 1.0286	0.200-0 1.0815	0.115-0 1.1303	0.105-0 1.1833	0.289-1 1.2207	0.208-0 1.2700	0.194-0 1.3121	0.875-1 1.3518	0.256-1 1.3890	0.537-2 1.4273	0.864-3 1.4632	0.108-3 1.5043	0.113-4 1.5353
	4	0.699-2 0.9905	0.867-1 1.0446	0.205-0 1.0960	0.107-1 1.1361	0.161-0 1.1940	0.367-2 1.2578	0.109-0 1.2792	0.206-0 1.3209	0.138-0 1.3603	0.543-1 1.3968	0.145-1 1.4346	0.286-2 1.4705	0.430-3 1.5107
	5	0.154-2 0.9530	0.291-1 1.0079	0.143-0 1.0608	0.131-0 1.1102	0.140-1 1.1689	0.124-0 1.2048	0.584-1 1.2542	0.235-1 1.2873	0.164-0 1.3299	0.175-0 1.3692	0.941-1 1.4051	0.322-1 1.4423	0.788-2 1.4777
	6	0.328-3 0.9160	0.850-2 0.9719	0.672-1 1.0258	0.161-0 1.0772	0.413-1 1.1231	0.762-1 1.1766	0.439-1 1.2136	0.114-0 1.2638	0.139-2 1.3153	0.876-1 1.3388	0.178-0 1.3785	0.136-0 1.4137	0.605-1 1.4505
	7	0.691-4 0.8793	0.230-2 0.9367	0.257-1 0.9912	0.109-0 1.0438	0.127-0 1.0935	0.208-3 1.0835	0.115-0 1.1883	0.565-3 1.1650	0.111-0 1.2746	0.402-1 1.3140	0.204-1 1.3459	0.138-0 1.3883	0.164-0 1.4227
	8	0.147-4 0.8433	0.599-3 0.9026	0.868-2 0.9576	0.542-1 1.0108	0.130-0 1.0620	0.595-1 1.1095	0.252-1 1.1616	0.899-1 1.1995	0.227-1 1.2565	0.567-1 1.2860	0.908-1 1.3233	0.681-3 1.3894	0.732-1 1.3986
	9	0.326-5 0.8102	0.155-3 0.8702	0.276-2 0.9253	0.229-1 0.9786	0.866-1 1.0306	0.113-0 1.0803	0.763-2 1.1239	0.754-1 1.1732	0.313-1 1.2069	0.706-1 1.2641	0.682-2 1.2985	0.101-0 1.3334	0.313-1 1.3755
	10	0.797-6 0.7854	0.414-4 0.8407	0.856-3 0.8950	0.881-2 0.9479	0.460-1 0.9999	0.106-0 1.0505	0.635-1 1.0987	0.632-2 1.1454	0.923-1 1.1855	0.113-3 1.0117	0.842-1 1.2755	0.743-2 1.3072	0.615-1 1.3432

TABLE 11

FRANCK-CONDON FACTORS AND r -CENTROIDS FOR THE BALDET-JOHNSON ($B^2\Sigma^+ - A^2\Pi_1$) BAND SYSTEM OF CO^+

	v''	0	1	2	3	4	5	6	7	8	9	10	11
v'													
62	0	0.408-0 1.2125	0.314-0 1.1724	0.163-0 1.1409	0.708-1 1.1141	0.280-1 1.0904	0.104-1 1.0688	0.376-2 1.0490	0.133-2 1.0306	0.464-3 1.0133	0.162-3 0.9970	0.564-4 0.9814	0.198-4 0.9667
	1	0.430-0 1.2566	0.808-2 1.2837	0.149-0 1.1821	0.175-0 1.1471	0.120-0 1.1193	0.647-1 1.0952	0.306-1 1.0735	0.134-1 1.0536	0.554-2 1.0352	0.222-2 1.0180	0.877-3 1.0019	0.342-3 0.9869
	2	0.145-0 1.3133	0.361-0 1.2699	0.370-1 1.1787	0.308-1 1.2020	0.113-0 1.1542	0.122-0 1.1245	0.885-1 1.0997	0.520-1 1.0779	0.270-1 1.0580	0.130-1 1.0397	0.591-2 1.0226	0.260-2 1.0065
	3	0.162-1 1.4018	0.272-0 1.3245	0.221-0 1.2883	0.101-0 1.1986	0.199-4 1.1640	0.502-1 1.1299	0.951-1 1.1042	0.924-1 1.0821	0.668-1 1.0821	0.408-1 1.0622	0.224-1 1.0439	0.115-1 1.0268
	4	0.263-3 1.6694	0.435-1 1.4164	0.353-0 1.3365	0.116-0 1.3167	0.127-0 1.2067	0.134-1 1.1433	0.132-1 1.1835	0.600-1 1.1361	0.807-1 1.1087	0.717-1 1.0862	0.511-1 1.0662	0.318-1 1.0479
	5	0.116-4	0.638-3	0.747-1 1.4319	0.400-0 1.3495	0.542-1 1.3647	0.121-0 1.2117	0.368-1 1.1639	0.494-3 1.3215	0.307-1 1.1440	0.616-1 1.1134	0.677-1 1.0903	0.561-1 1.0700
	6	0.660-6	0.790-4	0.820-3	0.104-0 1.4485	0.427-0 1.3636	0.231-1 1.4529	0.100-0 1.2145	0.548-1 1.1727	0.255-2 1.0842	0.117-1 1.1568	0.416-1 1.1185	0.579-1 1.0943
	7	0.597-7	0.192-5	0.276-3	0.627-3	0.129-0 1.4663	0.445-0 1.3787	0.931-2	0.762-1 1.2145	0.640-1 1.1787	0.109-1 1.1253	0.243-2 1.1897	0.250-1 1.1247
	8	0.274-9	0.670-6	0.217-5	0.682-3	0.190-3	0.148-0 1.4855	0.461-0 1.3947	0.396-2	0.546-1 1.2099	0.659-1 1.1838	0.200-1 1.1376	0.152-7
	9	0.308-9	0.588-8	0.272-5	0.180-6	0.133-2	0.324-4 1.5069	0.157-0 1.4113	0.480-0	0.229-2	0.373-1 1.1976	0.630-1 1.1886	0.274-1 1.1442
	10	0.343-10	0.781-8	0.581-7	0.719-5	0.535-5	0.215-2	0.105-2	0.158-0 1.5309	0.502-0 1.4284	0.231-2	0.244-1 1.1715	0.580-1 1.1942

TABLE 12

FRANCK-CONDON FACTORS FOR THE BAND SYSTEM OF RbH MOLECULE

v, v''	0		1		2		3		4		5	
J''	P	R	P	R	P	R	P	R	P	R	P	R
0												
1	1.82-5	1.76-5	2.01-4	1.95-4	1.14-3	1.11-3	4.32-3	4.22-3	1.24-2	1.21-2	2.84-2	2.80-2
6	1.66-5	1.43-5	1.85-4	1.63-4	1.06-3	9.51-4	4.05-3	3.69-3	1.18-2	1.10-2	2.73-2	2.57-2
11	1.26-5	9.74-6	1.47-4	1.17-4	8.72-4	7.15-4	3.47-3	2.92-3	1.04-2	9.00-3	2.47-2	2.19-2
16	8.45-6	6.04-6	1.05-4	7.83-5	6.55-4	5.09-4	2.74-3	2.21-3	8.61-3	7.19-3	2.13-2	1.83-2
1												
1	2.10-4	2.03-4	1.89-3	1.84-3	8.52-3	8.33-3	2.51-2	2.47-2	5.44-2	5.37-2	8.92-2	8.85-2
6	1.93-4	1.70-4	1.76-3	1.58-3	8.05-3	7.36-3	2.39-2	2.23-2	5.28-2	5.02-2	8.74-2	8.48-2
11	1.52-4	1.21-4	1.44-3	1.19-3	6.85-3	5.82-3	2.13-2	1.87-2	4.84-2	4.38-2	8.32-2	7.77-2
16	1.06-4	7.79-5	1.08-3	8.28-4	5.41-3	4.33-3	1.77-2	1.48-2	4.23-2	3.71-2	7.65-2	7.00-2
2												
1	1.12-3	1.09-3	8.16-3	7.99-3	2.89-2	2.84-2	6.37-2	6.31-2	9.52-2	9.49-2	9.31-2	9.36-2
6	1.05-3	9.35-4	7.72-3	7.03-3	2.78-2	2.58-2	6.20-2	5.89-2	9.49-2	9.27-2	9.43-2	9.58-2
11	8.55-2	6.96-4	6.59-3	5.56-3	2.46-2	2.16-2	5.78-2	5.26-2	9.19-2	8.75-2	9.69-2	9.83-2
16	6.27-4	4.74-4	5.17-3	4.12-3	2.05-2	1.72-2	5.12-2	4.51-2	8.72-2	8.14-2	9.98-2	1.00-1
3												
1	3.96-3	3.86-3	2.28-2	2.24-2	6.08-2	6.01-2	9.22-2	9.18-2	7.89-2	7.95-2	2.69-2	2.78-2
6	3.74-3	3.38-3	2.18-2	2.02-2	5.93-2	5.64-2	9.13-2	8.97-2	8.08-2	8.33-2	2.91-2	3.32-2
11	3.13-3	2.61-3	1.92-2	1.67-2	5.44-2	4.97-2	8.92-2	8.60-2	8.46-2	8.78-2	3.58-2	4.30-2
16	2.38-3	1.85-3	1.57-2	1.29-2	4.78-2	4.17-2	8.49-2	7.94-2	8.96-2	9.21-2	4.62-2	5.62-2
4												
1	1.03-2	1.01-2	4.55-2	4.51-2	8.58-2	8.56-2	7.78-2	7.84-2	2.31-2	2.39-2	1.83-3	1.56-3
6	9.87-3	9.02-3	4.43-2	4.17-2	8.57-2	8.36-2	7.92-2	8.14-2	2.50-2	2.88-2	1.32-3	4.61-4
11	8.47-3	7.22-3	4.03-2	3.61-2	8.23-2	7.82-2	8.33-2	8.58-2	3.12-2	3.84-2	1.73-4	1.94-4
16	6.70-3	5.36-3	3.46-2	2.96-2	7.69-2	7.10-2	8.71-2	8.90-2	4.13-2	5.10-2	5.42-4	3.50-3
5												
1	2.16-2	2.12-2	7.08-2	7.01-2	8.61-2	8.63-2	3.31-2	3.40-2	5.11-4	3.68-4	4.00-2	3.91-2
6	2.07-2	1.91-2	6.90-2	6.57-2	8.67-2	8.69-2	3.52-2	3.92-2	2.19-4	3.39-7	3.83-2	3.48-2
11	1.82-2	1.58-2	6.48-2	5.98-2	8.78-2	8.78-2	4.17-2	4.86-2	5.56-5	1.16-3	3.29-2	2.62-2
16	1.49-2	1.20-2	5.82-2	5.18-2	8.83-2	8.68-2	5.15-2	6.02-2	1.85-3	6.05-3	2.43-2	1.56-2

TABLE 12 (continued)

v'	0		1		2		3		4		5	
J''	P	R	P	R	P	R	P	R	P	R	P	R
6												
1	3.75-2	3.68-2	8.67-2	8.59-2	5.81-2	5.88-2	1.89-3	2.23-3	2.78-2	2.69-2	5.40-2	5.45-2
6	3.65-2	3.42-2	8.60-2	8.43-2	6.03-2	6.34-2	2.59-3	4.13-3	2.61-2	2.28-2	5.44-2	5.50-3
11	3.27-2	2.90-2	8.33-2	7.95-2	6.53-2	6.99-2	5.27-3	9.18-3	2.09-2	1.53-2	5.55-2	5.52-2
16	2.76-2	2.32-2	7.87-2	7.27-2	7.24-2	7.72-2	1.11-2	1.85-2	1.33-2	6.80-3	5.52-2	5.15-2
7												
1	5.69-2	5.63-2	8.67-2	8.70-2	2.21-2	2.29-2	8.86-3	8.25-3	5.27-2	5.22-2	2.03-2	2.12-2
6	5.58-2	5.26-2	8.70-2	8.68-2	2.39-2	2.75-2	7.70-3	5.36-3	5.23-2	5.10-2	2.18-2	2.57-2
11	5.08-2	4.60-2	8.74-2	8.68-2	2.97-2	3.61-2	4.36-3	1.74-3	5.01-2	4.64-2	2.74-2	3.34-2
16	4.41-2	3.80-2	8.70-2	8.44-2	3.89-2	4.76-2	1.03-3	7.46-6	4.53-2	3.81-2	3.58-2	4.36-2
8												
1	7.65-2	7.60-2	6.96-2	7.02-2	1.32-3	1.52-3	3.63-2	3.58-2	3.89-2	3.94-2	4.03-5	1.33-5
6	7.49-2	7.20-2	7.05-2	7.30-2	1.86-3	3.19-3	3.48-2	3.15-2	4.05-2	4.28-2	7.70-6	2.26-4
11	6.98-2	6.44-2	7.42-2	7.76-2	4.01-3	7.65-3	3.03-2	2.40-2	4.43-2	4.76-2	4.36-4	2.39-3
16	6.21-2	5.49-2	7.88-2	8.15-2	9.19-3	1.61-2	2.21-2	1.39-2	4.93-2	5.11-2	3.23-3	8.87-3
9												
1	9.28-2	9.20-2	4.26-2	4.35-2	5.36-3	4.82-3	5.10-2	5.07-2	9.26-3	1.00-2	1.93-2	1.84-2
6	9.15-2	8.85-2	4.42-2	4.76-2	4.42-3	2.87-3	5.07-2	4.99-2	1.05-2	1.32-2	1.81-2	1.52-2
11	8.64-2	8.12-2	4.98-2	5.58-2	2.14-3	4.13-4	4.96-2	4.61-2	1.46-2	2.02-2	1.43-2	9.03-3
16	7.88-2	7.15-2	5.81-2	6.51-2	1.27-4	5.69-4	4.50-2	3.81-2	2.25-2	3.04-2	8.02-3	2.73-3
10												
1	1.03-1	1.02-1	1.72-2	1.79-2	2.50-2	2.42-2	3.95-2	4.00-2	7.37-4	5.58-4	4.00-2	3.98-2
6	1.03-1	9.92-2	1.86-2	2.18-2	2.35-2	2.02-2	4.06-2	4.28-2	4.71-4	4.78-4	4.00-2	3.88-2
11	9.75-2	9.35-2	2.39-2	3.01-2	1.85-2	1.30-2	4.37-2	4.56-2	1.22-6	6.15-4	3.88-2	3.48-2
16	9.14-2	8.40-2	3.28-2	4.03-2	1.12-2	5.84-3	4.65-2	4.82-2	1.09-3	4.67-3	3.48-2	2.85-2
11												
1	1.06-1	1.05-1	2.19-3	2.54-3	4.36-2	4.28-2	1.56-2	1.64-2	1.75-2	1.67-2	3.15-2	3.23-2
6	1.05-1	1.04-1	2.90-3	4.47-3	4.22-2	3.97-2	1.71-2	1.99-2	1.65-2	1.39-2	3.28-2	3.51-2
11	1.02-1	9.97-2	5.72-3	9.99-3	3.81-2	3.16-2	2.10-2	2.60-2	1.30-2	8.01-3	3.63-2	3.90-2
16	9.81-2	9.36-2	1.19-2	1.94-2	2.99-2	2.11-2	2.74-2	3.31-2	7.33-3	2.46-3	4.04-2	4.12-2

TABLE 13
r-CENTROIDS FOR THE BAND SYSTEM OF RbH MOLECULE

v'	v''		0		1		2		3		4		5	
	J''		P	R	P	R	P	R	P	R	P	R	P	R
0	1		2.7638	2.7645	2.8656	2.8662	2.9649	2.9653	3.0623	3.0627	3.1599	3.1602	3.2575	3.2577
	6		2.7705	2.7736	2.8724	2.8752	2.9709	2.9732	3.0685	3.0703	3.1660	3.1671	3.2637	3.2645
	11		2.7874	2.7923	2.8890	2.8932	2.9871	2.9906	3.0840	3.0871	3.1813	3.1838	3.2786	3.2806
	16		2.8138	2.8209	2.9149	2.9209	3.0125	3.0176	3.1091	3.1133	3.2054	3.2085	3.3019	3.3040
1	1		2.7330	2.7337	2.8354	2.8360	2.9358	2.9363	3.0342	3.0346	3.1307	3.1311	3.2251	3.2254
	6		2.7396	2.7428	2.8421	2.8447	2.9418	2.9438	3.0403	3.0420	3.1369	3.1384	3.2317	3.2329
	11		2.7562	2.7614	2.8582	2.8624	2.9574	2.9608	3.0555	3.0583	3.1521	3.1546	3.2465	3.2489
	16		2.7825	2.7896	2.8835	2.8896	2.9818	2.9870	3.0796	3.0839	3.1759	3.1794	3.2704	3.2731
2	1		2.7032	2.7040	2.8068	2.8074	2.9072	2.9077	3.0040	3.0044	3.0982	3.0986	3.1909	3.1912
	6		2.7099	2.7138	2.8135	2.8158	2.9133	2.9153	3.0101	3.0121	3.1044	3.1063	3.1971	3.1986
	11		2.7261	2.7313	2.8291	2.8333	2.9285	2.9321	3.0252	3.0285	3.1194	3.1227	3.2118	3.2148
	16		2.7520	2.7594	2.8541	2.8601	2.9529	2.9578	3.0493	3.0536	3.1432	3.1472	3.2358	3.2393
3	1		2.6735	2.6742	2.7776	2.7782	2.8768	2.8773	2.9720	2.9725	3.0646	3.0651	3.1541	3.1545
	6		2.6801	2.6832	2.7841	2.7867	2.8830	2.8853	2.9782	2.9802	3.0711	3.0728	3.1605	3.1623
	11		2.6961	2.7018	2.7995	2.8042	2.8982	2.9021	2.9934	2.9968	3.0861	3.0892	3.1756	3.1791
	16		2.7219	2.7295	2.8245	2.8307	2.9225	2.9279	3.0174	3.0224	3.1100	3.1146	3.2012	3.2057
4	1		2.6428	2.6438	2.7475	2.7482	2.8463	2.8465	2.9402	2.9405	3.0270	3.0284	3.1636	3.1649
	6		2.6496	2.6530	2.7540	2.7568	2.8521	2.8545	2.9458	2.9680	3.0343	3.0366	3.1716	3.1999
	11		2.6658	2.6715	2.7694	2.7742	2.8672	2.8715	2.9608	2.9649	3.0498	3.0538	3.2458	3.0545
	16		2.6916	2.6997	2.7942	2.8010	2.8915	2.8973	2.9849	2.9902	3.0755	3.0810	3.1341	3.1635
5	1		2.6118	2.6127	2.7169	2.7176	2.8146	2.8152	2.9068	2.9073	3.0589	3.0694	3.1016	3.1019
	6		2.6183	2.6218	2.7234	2.7265	2.8212	2.8240	2.9130	2.9149	3.1043	3.1053	3.1076	3.1091
	11		2.6347	2.6410	2.7387	2.7439	2.8359	2.8406	2.9277	2.9321	2.8519	2.9882	3.1215	2.1258
	16		2.6608	2.6694	2.7636	2.7708	2.8602	2.8665	2.9519	2.9578	3.0237	3.0401	3.1439	3.1493

TABLE 13 (continued)

v, v''		0		1		2		3		4		5	
J''		P	R	P	R	P	R	P	R	P	R	P	R
6	1	2.5801	2.5809	2.6865	2.6875	2.7834	2.7842	2.8601	2.8590	2.9790	2.9799	3.0644	3.0639
	6	2.5867	2.5907	2.6928	2.6957	2.7898	2.7921	2.8715	2.8759	2.9856	2.9878	3.0708	3.0726
	11	2.6032	2.6099	2.7080	2.7134	2.8046	2.8090	2.8885	2.8937	3.0001	3.0055	3.0840	3.0867
	16	2.6297	2.6388	2.7328	2.7404	2.8288	2.8355	2.9159	2.9228	3.0230	3.0330	3.1064	3.1111
7	1	2.5480	2.5490	2.6560	2.6567	2.7508	2.7520	2.8555	2.8555	2.9427	2.9439	3.0283	3.0291
	6	2.5547	2.5589	2.6620	2.6655	2.7573	2.7602	2.8602	2.8666	2.9494	2.9516	3.0339	3.0349
	11	2.5715	2.5786	2.6774	2.6828	2.7726	2.7773	2.8803	2.8922	2.9628	2.9667	3.0459	3.0497
	16	2.5982	2.6080	2.7021	2.7101	2.7970	2.8040	2.9149	2.8636	2.9845	2.9913	3.0678	3.0735
8	1	2.5157	2.5167	2.6263	2.6267	2.7134	2.7142	2.8190	2.8191	2.9099	2.9104	3.1259	3.2056
	6	2.5226	2.5269	2.6324	2.6353	2.7170	2.7233	2.8249	2.8269	2.9146	2.9170	3.1599	2.9397
	11	2.5394	2.5471	2.6466	2.6526	2.7348	2.7432	2.8398	2.8448	2.9268	2.9309	2.9648	2.9936
	16	2.5666	2.5772	2.6713	2.6799	2.7625	2.7714	2.8633	2.8713	2.9475	2.9539	3.0095	3.0248
9	1	2.4831	2.4843	2.5979	2.5989	2.6964	2.6978	2.7862	2.7871	2.8767	2.8764	2.9732	2.9739
	6	2.4902	2.4948	2.6041	2.6065	2.7057	2.7112	2.7917	2.7938	2.8789	2.8806	2.9795	2.9819
	11	2.5072	2.5156	2.6174	2.6237	2.7220	2.7353	2.8051	2.8097	2.8892	2.8927	2.9932	3.0025
	16	2.5352	2.5465	2.6419	2.6506	2.7629	2.7351	2.8272	2.8339	2.9066	2.9136	3.0249	3.0530
10	1	2.4505	2.4517	2.5756	2.5759	2.6642	2.6650	2.7549	2.7553	2.8561	2.8609	2.9385	2.9387
	6	2.4576	2.4627	2.5810	2.5824	2.6711	2.6748	2.7592	2.7611	2.8845	2.9894	2.9431	2.9443
	11	2.4752	2.4841	2.5922	2.5975	2.6842	2.6877	2.7708	2.7746	3.9779	2.8062	2.9539	2.9592
	16	2.5038	2.5154	2.6148	2.6208	2.7042	2.7188	2.7904	2.7975	2.8121	2.8480	2.9759	2.9814
11	1	2.4173	2.4188	2.5875	2.5843	2.6340	2.6350	2.7228	2.7230	2.8165	2.8179	2.9058	2.9055
	6	2.4249	2.4302	2.5868	2.5764	2.6401	2.6425	2.7257	2.7265	2.8250	2.8285	2.9088	2.9094
	11	2.4429	2.4530	2.5813	2.5821	2.6511	2.6551	2.7329	2.7368	2.8408	2.8542	2.9170	2.9204
	16	2.4726	2.4861	2.5954	2.6022	2.6691	2.6739	2.7491	2.7558	2.8793	2.9214	2.9332	2.9409

TABLE 14

'SMOOTHED' RELATIVE BAND STRENGTHS AND RELATIVE INTENSITIES AT
INFINITE TEMPERATURE FOR THE FIRST POSITIVE BANDS OF N_2

v'	v'' 0	1	2	3	4	5	6	7	8
0	3.35 6.26	3.61 3.52	2.30 1.05	1.14 0.21	0.49 0.03	0.19 0.002	0.07	0.03	0.01
1	2.42 8.71	0.02 0.03	1.61 1.81	2.55 1.41	2.09 0.49	1.27 0.10	0.65 0.01	0.30 0.001	0.13
2	0.69 4.31	1.54 6.05	0.56 1.31	0.19 0.25	1.50 0.99	2.15 0.65	1.85 0.21	1.22 0.04	0.69 0.004
3	0.01 1.02	1.11 7.44	0.48 2.07	1.12 2.90	0.06 0.09	0.46 0.36	1.51 0.57	1.91 0.30	1.64 0.09
4	0.01 0.14	0.27 2.92	1.12 7.98	0.03 0.13	1.02 2.94	0.49 0.82	0.02 0.01	0.71 0.33	1.50 0.31
5		0.03 0.55	0.45 5.09	0.85 6.47	0.07 0.34	0.59 1.86	0.82 1.56	0.11 0.12	0.16 0.09
6		0.06	0.08 1.32	0.59 6.92	0.50 4.09	0.30 1.61	0.19 0.66	0.82 1.78	0.42 0.54
7			0.01 0.19	0.14 2.46	0.65 7.98	0.22 1.86	0.49 2.84	0.01 0.04	0.59 1.42
8			0.02 0.02	0.02 0.46	0.22 3.91	0.63 8.14	0.05 0.45	0.54 3.39	0.04 0.17
9				0.04 0.06	0.04 0.93	0.30 5.53	0.55 7.45	0.002 0.02	0.46 3.12
10					0.14	0.06 1.65	0.37 7.19	0.44 6.16	0.04 0.43
11						0.01 0.31	0.10 2.71	0.44 8.72	0.31 4.54
12						0.04	0.02 0.60	0.15 4.16	0.49 10.00

Legend: $p_{v',v''}$ (arbitrary units)

$I_{v',v''}^{\infty}$ (I^{∞} for the strongest band is normalized to 10).

TABLE 15

'SMOOTHED' RELATIVE BAND STRENGTHS AND RELATIVE INTENSITIES AT
INFINITE TEMPERATURE FOR THE SECOND POSITIVE BANDS OF N_2

v'	v''	0	1	2	3	4	5	6	7	8	9
0	10.28 9.92	7.61 5.79	3.33 1.98	1.12 0.52	0.33 0.11	0.09 0.02	0.02 0.004	0.005 0.001	0.001		
1	7.98 10.00	0.49 0.49	4.77 3.80	4.65 2.92	2.52 1.23	1.02 0.38	0.35 0.10	0.11 0.02	0.03 0.005	0.01 0.001	
2	2.33 3.70	6.78 8.75	0.55 0.57	1.45 1.21	3.74 2.46	3.20 1.65	1.76 0.70	0.76 0.23	0.28 0.07	0.10 0.02	
3	0.26 0.51	4.20 6.80	3.99 5.28	2.02 2.16	0.11 0.09	2.16 1.48	3.00 1.62	2.21 0.93	1.17 0.38	0.52 0.13	
4	0.002 0.005	0.58 1.15	5.08 8.33	2.03 2.73	2.65 2.90	0.08 0.07	0.94 0.67	2.33 1.31	2.27 1.01	1.47 0.51	

Legend: $p_{v',v''}$ (arbitrary units)
 $I_{v',v''}^{\infty}$ (I^{∞} for the strongest band is normalized to 10).

TABLE 16

'SMOOTHED' RELATIVE BAND STRENGTHS AND RELATIVE INTENSITIES AT
INFINITE TEMPERATURE FOR THE VEGARD-KAPLAN BANDS OF N_2

v'	v''	0	1	2	3	4	5	6	7	8	9	10
0				0.07 0.25	0.52 1.50	1.88 4.35	4.27 7.91	6.82 10.00	8.12 9.32	7.49 6.64	5.50 3.71	3.27 1.65
1	0.01 0.04	0.002 0.01	0.05 0.22	0.44 1.44	0.92 2.44	0.61 1.31			1.60 2.16	6.51 6.87	11.92 9.71	13.98 8.66

Legend: $p_{v',v''}$ (arbitrary units)
 $I_{v',v''}^{\infty}$ (I^{∞} for the strongest band is normalized to 10).

TABLE 17

'SMOOTHED RELATIVE BAND STRENGTHS AND RELATIVE INTENSITIES AT
INFINITE TEMPERATURE FOR THE COMET-TAIL BANDS OF CO⁺

v'	v''	0	1	2	3	4	5
0		1.18 1.21	3.68 2.40	4.38 1.73	2.29 0.51	0.32 0.04	0.06
1		3.21 4.40	5.27 4.75	1.88 1.07		0.57 0.11	0.11 0.01
2		4.51 8.07	2.80 3.39	0.07 0.05	2.22 1.10	1.16 0.34	
3		4.37 10.00	0.38 0.61	2.04 2.17	1.79 1.23	0.05 0.02	0.99 0.25
4		3.28 9.41	0.12 0.25	2.72 3.80	0.03 0.03	1.78 1.06	0.66 0.24
5		2.01 7.11	0.96 2.46	1.33 2.39	0.87 1.07	1.56 1.27	0.15 0.08
6		1.03 4.43	1.52 4.79	0.15 0.34	1.96 3.11	0.11 0.12	1.56 1.11
7		0.44 2.26	1.42 5.47	0.08 0.22	1.50 3.02	0.40 0.56	1.35 1.27
8		0.15 0.90	0.96 4.47	0.50 1.71	0.49 1.21	1.35 2.39	0.16 0.20
9		0.03 0.24	0.50 2.76	0.74 3.05	0.01 0.04	1.36 3.00	0.19 0.29
10		0.003 0.02	0.19 1.25	0.65 3.20	0.11 0.39	0.67 1.81	0.92 1.79
11			0.05 0.35	0.40 2.33	0.32 1.41	0.12 0.40	1.13 2.71

Legend: $P_{v',v''}$ (arbitrary units)

$I_{v',v''}^{\infty}$ (I^{∞} for the strongest band is normalized to 10).

TABLE 18

EINSTEIN A COEFFICIENTS, ABSOLUTE BAND STRENGTHS AND BAND
OSCILLATOR STRENGTHS FOR THE COMET-TAIL BANDS OF CO⁺

v''	0	1	2	3	4	5
v'						
0	4.33+4* 1.01-2 1.56-4	9.61+4 3.13-2 4.34-4	7.84+4 3.73-2 4.56-4	2.68+4 1.95-2 2.07-4	2.30+3 2.72-3 2.45-5	2.54+2 5.34-4 3.97-6
1	1.46+5 2.73-2 4.55-4	1.75+5 4.48-2 6.73-4	4.43+4 1.60-2 2.15-4	3.80+1 2.02-5 2.38-7	5.85+3 4.81-3 4.89-5	6.67+2 9.07-4 7.80-6
2	2.51+5 3.84-2 6.84-4	1.16+5 2.39-2 3.85-4	2.01+3 5.69-4 8.26-6	4.70+4 1.89-2 2.44-4	1.65+4 9.84-3 1.11-4	7.52+1 7.02-5 6.84-7
3	2.92+5 3.72-2 7.05-4	1.95+4 3.26-3 5.64-5	7.68+4 1.74-2 2.72-4	4.85+4 1.52-2 2.13-4	9.77+2 4.39-4 5.46-6	1.25+4 8.44-3 9.18-5
4	2.60+5 2.79-2 5.59-4	7.53+3 1.05-3 1.93-5	1.26+5 2.31-2 3.87-4	9.40+2 2.35-4 3.55-6	4.34+4 1.51-2 2.05-4	1.11+4 5.58-3 6.68-5
5	1.86+5 1.71-2 3.61-4	6.98+4 8.18-3 1.59-4	7.40+4 1.13-2 2.01-4	3.65+4 7.39-3 1.20-4	4.80+4 1.33-2 1.94-4	3.26+3 1.27-3 1.66-5
6	1.10+5 8.73-3 1.94-4	1.29+5 1.29-2 2.65-4	1.00+4 1.29-3 2.43-5	9.94+4 1.67-2 2.88-4	4.20+3 9.39-4 1.47-5	4.33+4 1.33-2 1.88-4
7	5.38+4 3.71-3 8.61-5	1.40+5 1.21-2 2.61-4	6.23+3 6.80-4 1.36-5	9.11+4 1.28-2 2.35-4	1.84+4 3.40-3 5.70-5	4.62+4 1.15-2 1.74-4
8	2.06+4 1.25-3 3.03-5	1.09+5 8.19-3 1.85-4	4.51+4 4.23-3 8.87-5	3.47+4 4.15-3 8.02-5	7.43+4 1.15-2 2.04-4	6.80+3 1.39-3 2.24-5
9	5.33+3 2.86-4 7.23-6	6.48+4 4.26-3 1.01-4	7.67+4 6.26-3 1.38-4	1.07+3 1.10-4 2.23-5	8.83+4 1.16-2 2.17-4	9.35+3 1.59-3 2.73-5
10	4.50+2 2.15-5 5.66-7	2.82+4 1.64-3 4.04-5	7.71+2 5.52-3 1.27-4	1.02+4 9.07-4 1.94-5	5.06+4 5.69-3 1.12-4	5.44+4 7.83-3 1.42-4
11	1.91+2 8.20-6 2.23-7	7.48+3 3.88-4 9.92-6	5.39+4 3.41-3 8.16-5	3.49+4 2.72-3 6.07-5	1.06+4 1.03-3 2.13-5	7.82+4 9.64-3 1.84-4

* The sign and final digit indicate the power of 10 to which each entry should be raised.

Legend: $A_{v',v''}$
 $p_{v',v''}^a$
 $f_{v',v''}$

TABLE 19
EINSTEIN A COEFFICIENTS, ABSOLUTE BAND STRENGTHS AND BAND
OSCILLATOR STRENGTHS FOR THE FIRST NEGATIVE BANDS OF N_2^+

v' \ v''	0	1	2	3	4	5
0	9.64+6*	3.48+6	7.75+5	1.36+5	2.06+4	2.83+3
	5.69-1	2.68-1	7.97-2	1.91-2	4.09-3	8.25-4
	2.21-2	9.53-3	2.57-3	5.56-4	1.06-4	1.88-5
1	4.87+6	3.08+6	3.87+6	1.53+6	3.92+5	7.85+4
	2.21-1	1.78-1	2.90-1	1.52-1	5.27-2	1.47-2
	9.36-3	6.97-3	1.04-2	4.97-3	1.56-3	3.89-4
2	7.57+5	6.36+6	5.74+5	3.03+6	1.94+6	6.80+5
	2.70-2	2.84-1	3.25-2	2.21-1	1.86-1	8.76-2
	1.24-3	1.21-2	1.28-3	8.00-3	6.16-3	2.62-3
3	2.81+4	1.64+6	6.24+6	3.62+3	1.98+6	2.00+6
	8.06-4	5.80-2	2.75-1	2.01-4	1.41-1	1.86-1
	3.98-5	2.67-3	1.18-2	7.99-6	5.15-3	6.20-3
4		6.23+4	2.35+6	5.55+6	1.54+5	1.14+6
		1.79-3	8.26-2	2.42-1	8.45-3	7.98-2
		8.83-5	3.82-3	1.04-2	3.37-4	2.93-3
5			7.26+4	2.78+6	4.83+6	4.31+5
			2.09-3	9.77-2	2.09-1	2.34-2
			1.03-4	4.51-3	9.02-3	9.35-4

Legend: $A_{v',v''}(\text{sec}^{-1})$; $p_{v',v''}^a (a_0^2 e^2)$; $f_{v',v''}$.

* The sign and final digit indicate the power of 10 to which each entry should be raised.

APPENDIX

SYMBOLS

r	Internuclear distance
$R_e(r)$	electronic transition moment (electric dipole transition moment)
RKR	Rydberg-Klein-Rees
H	exact Hamiltonian operator for a molecule
h	Planck's constant
$\hbar$	Planck's constant divided by 2π
M_α	mass of α^{th} atom
$\nabla_\alpha^2, \nabla_i^2$	Laplacian operators
V_{nn}	potential energy arising from nuclear interactions
V_{ne}	potential energy arising from nuclear electronic interactions
V_{ee}	potential energy arising from electronic interactions
H_e	Hamiltonian operator for electronic motion
H_n	nuclear part of Hamiltonian operator
χ_e	electronic wave function of the molecule
E_e	electronic energy
χ	total wave function of the molecule
χ_n	nuclear part of the wave function of the molecule

E	total energy of the molecule
$U(r)$	potential energy for nuclear motion
χ_v	vibrational wave function
χ_r	rotational wave function
μ	reduced mass of the molecule
J	rotational quantum number
v'	vibrational quantum number for the upper electronic state
v''	vibrational quantum number for the lower electronic state
$I_{v',v''}$	intensity in emission of a transition from the v' vibrational level to the v'' vibrational level
$N_{v'}$	number density of molecules in the energy level v'
$A_{v',v''}$	Einstein A coefficient
C	velocity of light
$\nu_{v',v''}$	frequency in cm^{-1}
d_u	degeneracy of the upper electronic state
$\bar{r}_{v',v''}$	r-centroid for the transition $v' \rightarrow v''$
$q_{v',v''}$	Franck-Condon factor for the transition $v' \rightarrow v''$
$I_{v',v''}^\infty$	relative intensity at infinite temperature
$p_{v',v''}$	relative band strength
$p_{v',v''}^a$	absolute band strength
$\tau_{v'}$	life time of the v' energy level
$f_{v',v''}$	band oscillator strength

$X \ ^1\Sigma_g^+$	ground state of N_2
$\left. \begin{array}{l} A \ ^3\Sigma_u^+, B \ ^3\Pi_g^+, \\ C \ ^3\Pi_u, a \ ^1\Pi_g \end{array} \right\}$	excited states of N_2
$X \ ^2\Sigma_g$	ground state of N_2^+
$B \ ^2\Sigma_u^+, C \ ^2\Sigma_u^+$	excited states of N_2^+
$X \ ^2\Sigma$	ground state of CO^+
$A \ ^2\Pi_1, B \ ^2\Sigma^+$	excited states of CO^+
$X \ ^1\Sigma^+$	ground state of RbH
$A \ ^1\Sigma^+$	excited state of RbH
$G(v)$	vibrational energy level of a molecule
B_v	rotational constant of a molecule
$r_{\min}, r_{\max}$	classical turning points for the vibrational motion of a molecule
$\lambda_{v',v''}$	wave length corresponding to the transition $v' \longleftrightarrow v''$

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