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Molecular Microwave Spectra Tables

Paul Kisliuk and Charles H. Townes

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Molecular Microwave Spectra Tables

Paul Kisliuk and Charles H. Townes[1]

This group of tables gives the frequencies, assignment of quantum numbers, and intensities of about 1,800 microwave absorption lines. The best available values of other pertinent molecular data, such as rotational constants, dipole moments, quadrupole coupling constants, and rotation-vibration interaction constants are also included. The frequencies are listed once for each molecule, and again in consecutive ascending order of frequency. References are given for all data included. For easy calculation of quadrupole hyperfine structure, Casimir's function is tabulated up to $J=10$, and $I=9/2$. Explanations of the tables and a short discussion of microwave spectra and important formulas are given in the introduction.

1. Introduction

These tables of microwave spectra are a modernization and revision of those published in the Journal of Research of the National Bureau of Standards [1].[2] They are up to date as of November 15, 1950, so far as published material is concerned, and include a considerable amount of otherwise unpublished information. However, since many of the published results have been reported rather briefly, it is clear that for certain molecules more detailed information is available in the experimental laboratories than is included here.

Only molecular lines of frequency greater than 1,000 megacycles have been listed. This excludes nuclear resonances found by molecular beam techniques rather than the usual microwave absorption measurements, as well as the lines of atomic hydrogen and cesium that fall in the microwave region. Microwave absorption in paramagnetic gases due to transitions between Zeeman components has also been observed, but is not included here.

The considerable activity in microwave spectroscopy makes obsolescence of the present tables inevitable, and it is expected that they will be revised and republished from time to time. Suggestions or additions for future editions of these tables will be gladly received, by either the authors or the Microwave Standards Section, National Bureau of Standards, Washington, D. C. It is especially hoped that information obtained on microwave spectral lines that is not otherwise published will be received so that it may be included in the tables, and thus made available.

2. Description of Tables

The primary information is presented in an alphabetic listing of the molecules, which is subdivided according to the major quantum numbers involved in the transition. Hyperfine components and unidentified transitions are presented in order of frequency. With the listing of each molecule, all available molecular constants are given that are needed in interpreting the spectra. These include rotational constants, dipole moments, quadrupole coupling constants, and rotation-vibration interaction constants. In addition to the observed frequency and the transition assigned to each line, there is included a calculated value for the intensity, and references to the latest sources of data from each laboratory that has measured the line. The most precise reported values of the frequencies were used, or the average, if there seemed no reason for preference. Frequencies listed to the nearest megacycle were generally measured with a cavity wavemeter and are subject to an error of 10 or more megacycles, whereas those given to a fraction of a megacycle are generally known to an accuracy of about 0.1 megacycle. In addition to the absorption lines actually observed and listed, a large number of lines may be readily and accurately predicted with the help of molecular constants given in the tables.

Another listing of all the lines in order of frequency, with sufficient information to locate the lines in table I, is included together with a classification of the lines as strong, medium, or weak. The authors have arbitrarily taken lines of maximum absorption coefficient less than $5\times10^{-7}\mathrm{cm}^{-1}$ as weak, those from 5×10^{-7} to $10^{-5}\mathrm{cm}^{-1}$ as medium and those greater than $10^{-5}\mathrm{cm}^{-1}$ as strong.

The general characteristics of the microwave spectra of most molecules may be explained on

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[1] Consultant, National Bureau of Standards, Washington 25, D. C.

[2] Figures in brackets indicate the literature references given on page VI.

the basis of a nearly rigid rotator model. Molecules are conveniently divided into three classes: linear molecules, symmetric tops, and asymmetric tops. For linear molecules the frequency of pure rotational lines is given to a good approximation by [2]:

$$\nu_{J\rightarrow J+1}=2(J+1)B_v-4D_J\{(J+1)^3-(J+1)l^2\}\ \text{sec}^{-1}$$

while for symmetric top molecules, where the selection rule $\Delta K=0$ applies;

$$\nu_{J\rightarrow J+1}=2(J+1)B_v-4D_J(J+1)^3 -2D_{JK}(J+1)K^2\ \text{sec}^{-1}.$$

In both cases:

$$B_v=\frac{h}{8\pi^2}\left\langle\frac{1}{I_b}\right\rangle_{av}\cong B_e-\sum_i \alpha_i\left(v_i+\frac{d_i}{2}\right)$$

where

J= the total rotational momentum quantum number

l, K= the rotational momenta quantum numbers along the figure axis for linear and symmetric top molecules respectively (zero for the ground vibrational state in linear molecules)

D_{JK}, D_J= the centrifugal distortion coefficients in sec^{-1}

B_v= the average rotational constant of the molecule in sec^{-1}

B_e= the rotational constant in sec^{-1} if the nuclei were in the equilibrium position

α_i= a coefficient giving the change in rotational constant per quantum of excitation of the ith vibrational state, and v_i and d_i are the corresponding quantum number and degree of degeneracy.

In addition, there is a splitting term for the degenerate vibrational states given by $2(J+1)q$ megacycles, where q is a constant for a particular molecule. To a somewhat rougher approximation, the frequencies for both linear molecules and symmetric tops is given by the rigid rotor approximation: $\nu=2B(J+1)$. The case of the asymmetric top is complex; it is discussed in [3 and 4], and earlier papers quoted therein.

In the event that one or more of the nuclei has a quadrupole moment different from zero, the resulting coupling to the molecular electric field splits the energy levels into a hyperfine structure which depends on the various possible orientations of the nuclear spin. The interaction between nuclear magnetic moments and molecular magnetic fields is usually very much smaller, and has thus far been observed only as a small correction in rare cases. The quadrupole interaction for the case of a single nucleus in a linear or symmetric top molecule is given in [5 and 6]. The energies are given by:

$$E_Q=(eqQ)\left\{\frac{3K^2}{J(J+1)}-1\right\}\left[\frac{3/4\,C(C+1)-I(I+1)J(J+1)}{2(2J+3)(2J-1)I(2I-1)}\right],$$

where

$C=F(F+1)-I(I+1)-J(J+1)$

$F=J+I,\ J+I-1\ \ldots\ldots\ |J-I|$

eqQ= quadrupole coupling constant as defined in reference [7]

K= projection of J on molecular symmetry axis (zero for linear molecules in the ground vibrational state).

A tabulation of the function in square brackets for $J=1$ to 10 is given in table III. The somewhat more complex situation when two nuclei have quadrupole coupling is discussed in [7].

Nuclear quadrupole effects in a symmetric molecule may be described by a single coupling constant (eqQ), where e is the protonic charge, Q the nuclear quadrupole moment, and $q=\partial^2V/\partial a^2$ is the second derivative along the molecular axis of the potential at the nucleus due to all charges outside the nucleus. In an asymmetric rotor, two nuclear quadrupole coupling constants must be given, [8]

$$\left(eQ\frac{\partial^2 V}{\partial a^2}\right),\ \left(eQ\frac{\partial^2 V}{\partial b^2}\right),\ \text{where}\ \frac{\partial^2 V}{\partial a^2}\ \text{and}\ \frac{\partial^2 V}{\partial b^2}$$

are the second derivatives of the same potential along the smallest and intermediate principal axes of inertia respectively.

The absorption of a spectral line at its maximum may be written with certain approximations [9]:

$$\gamma_{\text{max.}}=\frac{8\pi^2Nf|\mu_{ij}|^2\nu^2}{3ckT\Delta\nu}.$$

Since for a given transition $\Delta\nu/P\cong\text{constant}\times\Delta\nu/N$ over a wide range of pressures [9] from about 10^{-2} mm Hg to several centimeters, $\gamma_{\text{max.}}$ for the corresponding absorption line is independent of pressure over this range.

In this formula:

N= the number of molecules per cubic centimeter

f= the fraction of the molecules in the lower state of the transition

ν= the frequency of the line

c= the velocity of light

k= Boltzmann's constant

T= the absolute temperature

$\Delta\nu$= the half width of the line at half maximum

μ_{ij}= the electric dipole matrix element.

This formula is based on simplifying assumptions regarding molecular collisions which are not completely justified, especially in regard to the temperature dependence [10]. It will nevertheless be used herein, as a more sophisticated approach depends on particular molecular characteristics, and would be prohibitively time-consuming [11].

The vibration frequencies and the classical approximation for the sum of rotational states necessary to calculate f, as well as expressions for the dipole matrix elements for the various types of molecules may be found in Herzberg [2], who also discusses more accurate formulas for the energy levels. The corresponding information for asymmetric molecules is tabulated in the papers of King, Hainer and Cross [3, 4]. Since the hyperfine splitting is small compared to the line frequency, a total absorption coefficient may be calculated by ignoring the nuclear interaction, the result being then divided among the hyperfine components. Relative intensities of the hyperfine components can be obtained from tables of relative intensities of the analogous fine structure components [12].

Thus the only quantity not as yet evaluated on the right-hand side of the formula above is $\Delta\nu$, the *half-width* (not the total width) of the line at half maximum intensity. Although $\Delta\nu$ surely depends on the dipole moment, and the temperature [10], among other things, no convenient theoretical evaluation is possible at present. It has in a few cases been measured experimentally, however, and in these cases the formula for the intensity given above has been satisfactorily confirmed [13]. At low pressure $\Delta\nu/P$ is constant for a given transition, and for the cases where $\Delta\nu$ has not been measured, we have assumed the reasonable value of $\Delta\nu=25$ Mc for 1 mm of mercury. It is this approximation or, in some cases, insufficiently accurate knowledge of the molecular dipole moment that limits the accuracy of most of the intensities listed in these tables, rather than the basic assumptions of the theory or the use of the classical sum of states. Errors as large as a factor of two or more would not be at all surprising in the cases where the half-widths have not been measured, but we consider that intensities with errors of even this magnitude may be useful, and may be easily corrected when more accurate half-widths become available. The relative intensities for the various isotopes, hyperfine components, and excited states of a single molecule are considerably more reliable.

After substituting the accepted values for the universal constants, and putting the Boltzmann factor for the rotational energy equal to unity, the intensities of pure rotational spectra become for a temperature of 300° K and $\Delta\nu=25$ Mc:

For linear molecules

$$\gamma_{\max.}=2.19\times10^{-18}\mu^2\nu^3\,\mathrm{cm}^{-1}.$$

For symmetric top molecules

$$\gamma_{\max.}=4.94\times10^{-22}\sqrt{A}\,\mu^2\nu^3\left\{1-\frac{K^2}{(J+1)^2}\right\}\mathrm{cm}^{-1},$$

where

μ = in Debye units (10^{-18} esu/cm)
ν = the frequency in megacycles
A = the rotational constant about the figure axis in megacycles $=10^{-6}h/8\pi^2I_a$
J = the quantum number of total rotational momentum
K = the quantum number of the component of the rotational momentum along the figure axis.

This formula holds for one particular value of K. In case K is not zero, transitions corresponding to $+K$ and $-K$ are always superimposed, thus doubling the intensity. In addition, if there is no hyperfine structure and negligible centrifugal distortion, transitions due to all possible values of K may be superimposed in one observed line.

In some molecules, nuclear spin and molecular symmetry considerations influence intensities [2, 14]. The most important case involves three identical nuclei of spin one-half off the molecular axis as in CH_3Cl or AsF_3. In such molecules, the intensity of each line involving a value of K that is a multiple of three (including zero) is enhanced with respect to other lines by a factor of two, and the sum of states must be multiplied by 4/3 to take into account the additional states.

The intensities when calculated as above must be multiplied by one or more factors to take into account the following effects:

1. Spin-symmetry effects altering the statistical weight of the states involved.
2. Depletion due to less than 100-percent abundance of the isotopes giving rise to the absorption.
3. Depletion due to molecules being in vibrational states other than the one giving rise to the absorption.
4. Splitting of the line into hyperfine components.
5. True line width in general differing from the value assumed in the formulas above, and giving a correction factor $25/\Delta\nu$.
6. In rare cases the Boltzmann factor for the rotational energy may have to be taken into account.

Corrections 1, 2, 3, 4, and 6, have been applied throughout the tables except when otherwise noted for particular molecules. Correction 5 has been applied wherever the true value $\Delta\nu$ is known and listed. Many of the molecules containing rare isotopes (D, N^{15}, etc.) were observed in enriched samples and therefore with intensities considerably greater than those listed below, which are based on the natural isotopic abundances.

The tables throughout give rotational constants B and A, quadrupole couplings (eqQ), l-type doubling constants q, α, D_{JK}, and D_J expressed in megacycles per second unless otherwise noted. The electric dipole moment, μ, is always in Debye units, and is taken from "Tables of electric dipole moments" [15], unless otherwise stated.

The cases of NH_3, O_2, CH_3OH, and possibly some of the spectra not yet analyzed are in one way or another exceptions to the cursory treatment above, and are, where possible, discussed individually.

Symbols

A = largest rotational constant for asymmetric molecules, or unique rotational constant for symmetric top molecules, in megacycles

α_i = change in rotational constant per quantum of excitation of the ith vibrational state, in megacycles

B = intermediate rotational constant for asymmetric top molecules or non-unique rotational constant for symmetric top molecules, in megacycles

$B_e = B$ if nuclei were stationary in their equilibrium positions

B_0 = average B for ground vibrational state, in megacycles

C = smallest rotational constant for asymmetric top molecules, in megacycles

D_{JK}, D_J = centrifugal distortion coefficients in megacycles

$\Delta\nu$ = half width (not total width) of line in megacycles at half maximum (line width parameter) with gas pressure 1 mm of mercury

(eqQ) = quadrupole coupling constant, in megacycles. This constant is a measure of the change in energy with nuclear orientation in a molecule, and is defined on page IV, and discussed further in reference [8].

F = angular momentum quantum number representing the vector sum of the rotational angular momentum and the spin(s) of all nuclei whose quadrupole coupling(s) contribute to the observed hyperfine splitting of line frequencies

$F_f = F$ of the final or higher energy state

$F_i = F$ of the initial or lower energy state

F_l = angular momentum quantum number representing the vector sum of the rotational angular momentum and the spin of the nucleus with the larger quadrupole coupling in cases where two nuclei have quadrupole coupling which contribute to observed hyperfine splitting of line frequencies

$F_{lf} = F_l$ for final or higher energy state

$F_{li} = F_l$ for initial or lower energy state

γ = maximum absorption coefficient in cm^{-1}, or "intensity"

I = nuclear spin quantum number

Int. = designation of references listed in the introduction

J = total rotational angular momentum quantum number

K = projection of J on molecular symmetry axis

l = angular momentum about axis of linear molecules due to degenerate perpendicular vibrations

m = medium intensity ($5\times10^{-7}\rightarrow10^{-5}cm^{-1}$)

μ = dipole moment in Debye Units (10^{-18} esu)

q = l-type doubling constant in megacycles

s = strong intensity ($>10^{-5}$ cm^{-1})

v_i = quantum number of the ith normal vibration

w = weak intensity ($<5\times10^{-7}$ cm^{-1})

References

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[3] G. W. King, R. M. Hainer, and P. C. Cross, J. Chem. Phys. **11**, 27 (1943).

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[13] C. H. Townes, A. N. Holden, and F. R. Merritt, Phys. Rev. **74**, 1113 (1948).

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[15] L. G. Wesson, Tables of electric dipole moments (Massachusetts Institute of Technology Laboratory for Insulation Research, Cambridge, Mass., 1947).

Table I. Molecules Listed Alphabetically by Chemical Symbol

The conventions for alphabetization are as follows:

1. Empirical formulas are the basis for alphabetization.

2. Chemical symbols are in alphabetical order except that within a molecular formula:

   a. C for carbon precedes all other symbols.

   b. In C compounds, H precedes all other symbols except C.

   c. D (for deuterium) is regarded for purposes of listing as H^2.

3. After the formulas are written as described above, they are listed in strictly alphabetical order with the rule that all molecules with A_nXYZ. . . . precede all those with $A_{n+1}X'Y'Z'$ . . ., etc.

4. In the two cases where more than one molecule with the same empirical formula occurs, the one with the customary formula which falls first alphabetically precedes the other.

This provides an unambiguous system for the molecules thus far investigated which, we believe, does not conflict with existing conventions.

$AsCl_3$ Arsenic trichloride

μ = 1.97

	$AsCl_3^{35}$	$AsCl_3^{37}$			Ref.
B_0	2147.25	2044.7			1

References

[1] P. Kisliuk and C. H. Townes, Journal of Chemical Physics **18**, 1109 (1950)

$AsCl_3$

Molecule	Rotational Transition J	Vibrational State	Frequency Mc	Intensity cm^{-1}	Ref.
$AsCl^{35}_3$	4 → 5	ground excited	21472 21426	$2.0x10^{-7}$	1
	5 → 6	ground excited excited	25767 25724 25675	$4.2x10^{-7}$	
$AsCl^{35}_2Cl^{37}$	5 → 6	ground	25308 25354 25381 25393 25411		
$AsC^{35}Cl^{37}_2$	5 → 6	ground excited	24932 24973		
$AsCl^{37}_3$	5 → 6	ground	24536	$1.3x10^{-8}$	

AsF_3 Arsenic trifluoride

μ = 2.815 (ref. 2)

The value of A was calculated from estimates of internuclear distances given in 1.

	AsF_3				Ref.
B	5879.3				1
A	3900				
$(eqQ)_{As}$	-235				
α_2	-4.9				3

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[2] R. G. Shulman, B. P. Dailey and C. H. Townes, Physical Review **78**, 145 (1950).

[3] P. Kisliuk, private communication.

AsF_3—Continued

Molecule	Rotational Transition		Vibrational State	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K						
AsF_3	1 → 2	0	ground	1/2	3/2	23458.6	1.95×10^{-7}	1
				5/2	5/2	23463.0	2.1×10^{-7}	
				1/2	1/2	23517.0	1.95×10^{-7}	
				5/2	7.2	23522.4	1.4×10^{-6}	
				3/2	5/2			
				3/2	3/2	23564.6	2.5×10^{-7}	
				3/2	1/2	23622.8	3.9×10^{-8}	3
		1	ground	3/2	5/2	23472.6	3.7×10^{-7}	1
				3/2	3/2	23494.2	1.9×10^{-7}	
				5/2	5/2	23501.6	1.6×10^{-7}	
				5/2	7/2	23532.1	7.0×10^{-7}	
				1/2	3/2	23546.4	1.5×10^{-7}	3
				1/2	1/2	23575.3	1.5×10^{-7}	1
		0	$v_2 = 1$	5/2	5/2	23482.	4.1×10^{-8}	3
				5/2	7/2	23543	2.8×10^{-7}	1, 3
				3/2	5/2			
				3/2	3/2	23584	4.9×10^{-8}	3
		1	$v_2 = 1$	3/2	3/2	23513	3.6×10^{-8}	1, 3
				5/2	7/2	23553	1.4×10^{-7}	
				1/2	1/2	23595	2.8×10^{-8}	3

AsH_3 Arsenic trihydride

$\mu = 0.22$
(ref. 1)

References

[1] C. C. Loomis, MITRLE Progress Report, July 15, 1950.

B_2BrH_5 (B_2H_5Br) Bromodiborane

$\mu =$

	$B^{10}B^{11}H_5Br^{79}$	$B^{10}B^{11}H_5Br^{81}$	$B^{11}B^{10}H_5Br^{79}$	$B^{11}B^{10}H_5Br^{81}$	$B^{11}B^{11}H_5Br^{79}$	$B^{11}B^{11}H_5Br^{81}$	Ref.
B	3523.72		3398.62	3379.95	3369.65	3350.75	1
C	3278.42		3176.05	3159.85	3141.48	3124.95	
B+C		6766.4				6766.4	
$(eqQ)_{Br}$	293	244	293	244	293	244	

References

[1] C. D. Cornwell, Journal of Chemical Physics **18**, 1118 (1950).

BrCl Bromine monochloride μ = 0.57

	$Br^{79}Cl^{35}$	$Br^{81}Cl^{35}$	$Br^{79}Cl^{37}$	$Br^{81}Cl^{37}$	Ref.
B_e	4570.92	4536.14	4499.84	4365.01	1
α	23.22	22.95	21.94	21.67	
$(eqQ)_{Br}$	876.8	732.9	876.8	732.9	
$(eqQ)_{Cl}$	-103.6		-81.1		

References

[1] D. F. Smith, M. Tidwell, and D. V. P. Williams, Physical Review **79**, 1007 (1950).

BrCl

Molecule	Rotational Transition J	Vibrational State	F_{1i}	F_i	F_{1f}	F_f	Frequency Mc	Intensity* cm^{-1}	Ref.
$Br^{79}Cl^{35}$	0 → 1	ground	3/2	3	1/2	2	8899.50	$1.4x10^{-8}$	1
			3/2	2	5/2	3	9063.77	$2.2x10^{-8}$	
			3/2	1	5/2	2	9074.91	$1.2x10^{-8}$	
			3/2	3	5/2	4	9080.73	$3.5x10^{-8}$	
			3/2	0	5/2	1	9088.61	$5.8x10^{-9}$	
			3/2	3	3/2	3	9291.61	$2.2x10^{-8}$	
			3/2	2	3/2	2	9307.96	$7.8x10^{-9}$	
		v = 1	3/2	3	5/2	4	9034.14	$2.9x10^{-9}$	
$Br^{81}Cl^{35}$	0 → 1	ground	3/2	3	1/2	2	8865.66	$1.3x10^{-8}$	
			3/2	2	5/2	3	9001.44	$2.1x10^{-8}$	
			3/2	1	5/2	2	9012.97	$1.2x10^{-8}$	
			3/2	3	5/2	4	9018.40	$3.4x10^{-8}$	
			3/2	0	5/2	1	9026.17	$5.8x10^{-9}$	
			3/2	3	3/2	3	9193.26	$2.1x10^{-8}$	
			3/2	2	3/2	2	9209.57	$7.7x10^{-9}$	
		v = 1	3/2	3	5/2	4	8972.41	$2.8x10^{-9}$	
$Br^{79}Cl^{37}$	0 → 1	ground	3/2	3	1/2	2	8559.58	$3.9x10^{-9}$	
			3/2	2	5/2	3	8725.49	$6.5x10^{-9}$	
			3/2	1	5/2	2	8733.84	$3.5x10^{-9}$	
			3/2	3	5/2	4	8738.47	$1.0x10^{-8}$	
			3/2	0	5/2	1	8745.17	$1.7x10^{-9}$	
			3/2	3	3/2	3	8951.38	$6.5x10^{-9}$	
			3/2	2	3/2	2	8964.19	$2.2x10^{-9}$	
$Br^{81}Cl^{37}$	0 → 1	ground	3/2	3	1/2	2	8525.53	$3.8x10^{-9}$	
			3/2	2	5/2	3	8663.40	$6.0x10^{-9}$	
			3/2	1	5/2	2	8671.87	$3.4x10^{-9}$	
			3/2	3	5/2	4	8676.37	$9.8x10^{-9}$	
			3/2	0	5/2	1	8683.06	$1.7x10^{-9}$	
			3/2	3	3/2	3	8852.93	$6.0x10^{-9}$	

*Calculated intensities assume pure BrCl rather than the actual equilibrium concentration in Br_2 and Cl_2.

BrF Bromine monofluoride $\mu = 1.29$

Intensities were calculated assuming 90% of the molecules to be in the ground vibrational state, and 9% in the first vibrational state.

	$Br^{79}F$	$Br^{81}F$			Ref.
B_0	10706.9	10655.7			1
α	156.3	155.8			
$(eqQ)_{Br}$	1089.0	909.2			

References

[1] D. F. Smith, M. Tidwell and D. V. P. Williams, Physical Review **77**, 420 (1950).

BrF

Molecule	Rotational Transition J	Vibrational State	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$Br^{79}F$	0→1	ground	3/2	1/2	20985.5	2.6×10^{-6}	1
			3/2	5/2	21202.6	7.9×10^{-6}	
			3/2	3/2	21475.4	5.3×10^{-6}	
		v = 1	3/2	1/2	20828.9	2.6×10^{-7}	
			3/2	5/2	21045.6	7.9×10^{-7}	
			3/2	3/2	21319.4	5.3×10^{-7}	
$Br^{81}F$	0→1	ground	3/2	1/2	20928.4	2.6×10^{-6}	
			3/2	5/2	21110.4	7.7×10^{-6}	
			3/2	3/2	21337.5	5.2×10^{-6}	
		v = 1	3/2	1/2	20772.3	2.6×10^{-7}	
			3/2	5/2	20954.6	7.7×10^{-7}	
			3/2	3/2	21181.7	5.2×10^{-7}	

BrF_3Si (SiF_3Br) Silane, bromotrifluoro- $\mu =$

	$Si^{28}F_3Br^{79}$	SiF_3Br^{81}			Ref.
Bo	1550	1534			1

References

[1] L. J. Sheridan and W. Gordy, Physical Review **77**, 719 (1950).

$BrGeH_3$ (GeH_3Br) Germane, bromo- μ =

	$Ge^{70}H_3Br^{79}$	$Ge^{70}H_3Br^{81}$	$Ge^{72}H_3Br^{79}$	$Ge^{72}H_3Br^{81}$	$Ge^{74}H_3Br^{79}$	Ref.
B_0	2438.57	2410.17	2406.42	2378.01	2375.88	1
$(eqQ)_{Br}$	380	321	380	321	380	

	$Ge^{74}H_3Br^{81}$	$Ge^{76}H_3Br^{79}$	$Ge^{76}H_3Br^{81}$			Ref.
B_0	2347.46	2346.84	2318.37			1
$(eqQ)_{Br}$	321	380	321			

References

[1] A.H. Sharbaugh, B. S. Pritchard, V. G. Thomas, J. M. Mays and B. P. Dailey, Physical Review 79,189 (1950).

BrH_3Si (SiH_3Br) Silane, bromo- μ = 1.31 (ref. 2)

	$Si^{28}H_3Br^{79}$	$Si^{28}H_3Br^{81}$	$Si^{29}H_3Br^{79}$	$Si^{29}H_3Br^{81}$	$Si^{30}H_3Br^{79}$	Ref.
B_0	4321.72	4292.64	4232.96	4203.70	4149.39	1
$(eqQ)_{Br^{79}}$	336	278	336	278	336	

	$Si^{30}H_3Br^{81}$	$Si^{28}H_3Br^{79}$	$Si^{28}H_3Br^{81}$			Ref.
B_0	4120.09	4321.82	4292.61			1
$(eqQ)_{Br}$	278	336	278			

References

[1] A. H. Sharbaugh, J. K. Bragg, T. C. Madison and V. G. Thomas, Physical Review 76,1419 (1949).

[2] A. H. Sharbaugh, B. S. Pritchard, V. G. Thomas, J. M. Mays and B. P. Dailey, Physical Review 79,189 (1950).

Br_3P (PBr_3) Phosphorus tribromide μ = .61

	$PBr_3{}^{79}$	$PBr_3{}^{81}$			Ref.
B_0	996.4	974.4			1

References

[1] Q. Williams and W. Gordy, Physical Review **79**, 225 (1950).

$CBrF_3$ (CF_3Br) Methane, bromotrifluoro- μ =

This molecule has recently been investigated by two groups of investigators; one of which observed about 40 lines of the J = 4→ 5 and 5→ 6 transition. The other[2] reports observing the J = 8→9, 10→11 transitions.

	$C^{12}F_3Br^{79}$	$C^{12}F_3Br^{81}$			Ref.
B_0	2098.12 (J=4→5) 2098.12 (J=5→6)	2078.55 (J=4→5) 2078.57 (J=5→6)			1
$(eqQ)_{Br}$	618.4 (J=4→5) 624.5 (J=5→6)	517.3 (J=4→5) 514.7 (J=5→6)			

References

[1] A. H. Sharbaugh, B. S. Pritchard and T. C. Madison, Physical Review **77**, 302 (1950).
[2] J. Sheridan and W. Gordy, Physical Review **77**, 292 (1950).

CBrN (BrCN) Cyanogen bromide $\mu = 2.94$

The half-width, $\Delta\nu = 21^2$, has been used in calculating the intensity.

	$Br^{79}C^{12}N^{14}$	$Br^{79}C^{13}N^{14}$	$Br^{81}C^{12}N^{14}$	$Br^{81}C^{13}N^{14}$	Ref.
B_0	4120.190	4073.355	4096.760	4049.606	1,2
$(eqQ)_{Br}$	686.2	686.2	573.2	573.2	
$(eqQ)_N$	-3.83				
α_1	11.36		11.23		
α_2	-11.49		-11.49		
q	3.912		3.845		
D_J	$9.1x10^{-4}$		$8.1x10^{-4}$		5

References

[1] A. G. Smith, H. Ring, W. V. Smith, and W. Gordy, Physical Review **74**, 370 (1948).
[2] C. H. Townes, A. N. Holden, and F. R. Merritt, Physical Review **74**, 1113, (1948).
[3] A. G. Smith, W. Gordy, J. W. Simmons, and W. V. Smith, Physical Review **75**, 260 (1949).
[4] J. A. Klein, W. Low, and C. H. Townes, private communication.
[5] J. W. Simmons & W. E. Anderson, Duke Quarterly Progress Report, May-Aug. 1950.

CBrN

Molecule	Rotational Transition J	Vibrational State	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$Br^{79}C^{12}N^{14}$	2 → 3	ground	3/2	3/2	24583.00	$4.3x10^{-6}$	2
			5/2	5/2	24633.71	$5.6x10^{-6}$	
			5/2 7/2	7/2 9/2	24713.05	$6.5x10^{-5}$	
			1/2 3/2	3/2 5/2	24755.22	$2.9x10^{-5}$	
			7/2	7/2	24884.57	$4.3x10^{-6}$	
	2 → 3	$v_1=1$	5/2 7/2	7/2 9/2	24645.82*	$4.0x10^{-6}$	
			1/2 3/2	3/2 5/2	24687.11	$1.8x10^{-6}$	
	2 → 3	$v_2=1, l_1$	1/2 7/2	3/2 9/2	24760.76	$7.5x10^{-6}$	2
		$v_2=1, l_2$	1/2 7/2	3/2 9/2	24784.02	$7.5x10^{-6}$	
		$v_2=1, l_1$	3/2 5/2	5/2 7/2	24803.00	$6.9x10^{-6}$	
		$v_2=1, l_2$	3/2 5/2	5/2 7/2	24826.70	$6.9x10^{-6}$	
	2 → 3	$v_2\ 1, l_1$	7/2	7/2	24890.0	$7.3x10^{-7}$	4
		$v_2\ 1, l_2$	7/2	7/2	25006.0	$7.3x10^{-7}$	
		$v_2=2, l=2$	3/2 3/2	3/2 5/2	24860.6	$6.5x10^{-7}$	
			5/2 5/2 5/2	3/2 5/2 7/2	24981.5	$9.8x10^{-7}$	

*These two lines were not resolved.

CBrN--Continued

Molecule	Rotational Transition	Vibrational State	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J						
$Br^{79}C^{12}N^{14}$ (Continued)	3→4	ground	5/2	5/2	32804.56	5.8x10^{-6}	1
			7/2 9/2	9/2 11/2	32956.68	1.5x10^{-4}	
			3/2 5/2	5/2 7/2	32976.40	8.6x10^{-5}	
	8→9	ground	19/2 17/2	21/2 19/2	74162.76	1.6x10^{-3}	5
			15/2 13/2	17/2 15/2	74159.48	1.3x10^{-3}	
	9→10	ground			82405	4.0x10^{-3}	3
$Br^{79}C^{13}N^{14}$	3→4	ground	7/2 9/2	9/2 11/2	32581.73	1.7x10^{-6}	1
			3/2 5/2	5/2 7/2	32601.46	9.2x10^{-7}	
$Br^{81}C^{12}N^{14}$	2→3	ground	3/2	3/2	24465.33	4.2x10^{-6}	2
			5/2	5/2	24507.38	5.4x10^{-6}	
			5/2 7/2	7/2 9/2	24573.86	6.3x10^{-5}	
			1/2 3/2	3/2 5/2	24608.92	2.7x10^{-5}	
			7/2	7/2	24717.19	4.2x10^{-6}	
		$v_1=1$	5/2 7/2	7/2 9/2	24506.75	3.9x10^{-6}	
			1/2 3/2	3/2 5/2	24541.18	1.7x10^{-6}	
		$v_2=1, l_1$	1/2 7/2	3/2 9/2	24622.93	7.7x10^{-6}	
		$v_2=1, l_2$	1/2 7/2	3/2 9/2	24645.82*	7.7x10^{-6}	
		$v_2=1, l_1$	3/2 5/2	5/2 7/2	24658.89	6.8x10^{-6}	
		$v_2=1, l_2$	3/2 5/2	5/2 7/2	24682.13	6.8x10^{-5}	
	3→4	ground	5/2	5/2	32643.13	5.6x10^{-6}	1
			7/2	7/2	32720.28	7.4x10^{-6}	
			7/2 9/2	9/2 11/2	32770.13	1.4x10^{-4}	
			3/2 5/2	5/2 7/2	32786.65	8.2x10^{-5}	
			9/2	9/2	32913.24	5.7x10^{-6}	
	8→9	ground	19/2 17/2	21/2 19/2	73741.20	1.5x10^{-3}	5
			15/2 13/2	17/2 15/2	73738.42	1.3x10^{-3}	
	9→10	ground			81936	3.8x10^{-3}	3
$Br^{81}C^{13}N^{14}$	3→4	ground	7/2 9/2	9/2 11/2	32392.59	1.5x10^{-6}	1
			3/2 5/2	5/2 7/2	32409.06	9.2x10^{-7}	

$CClF_3$ (CF_3Cl) Methane, chlorotrifluoro- μ =

	CF_3Cl^{35}	CF_3Cl^{37}			Ref.
B_0	3335.56	3251.51			1
$(eqQ)_{Cl}$	78.05	61.44			

References

[1]D. K. Coles and R. H. Hughes, Physical Review **76**, 858 (1949)
[2]D. K. Coles and R. H. Hughes, private communication.

$CClF_3$

Molecule	Rotational transition		Vibrational State	F_i	F_f	Frequency Mc	Ref.
	J	K					
$C^{12}F_3Cl^{35}$	2 → 3	1	ground	5/2 3/2	7/2 5/2	20010.84	2
				7/2 1/2	9/2 3/2	20015.77	
		2	ground	5/2 5/2	7/2 5/2	19999.66	
				3/2 3/2	5/2 3/2	20013.68	
				7/2 7/2	9/2 7/2	20019.17	
	3 → 4	1	ground	5/2	7/2	26682.81	
				7/2	9/2	26683.78	
				3/2	5/2	26684.69	
				9/2	11/2	26685.73	
		2	ground	7/2	9/2	26679.62	
				5/2	7/2	26682.30	
				9/2	11/2	26687.38	
				3/2	5/2	26690.14*	
		3	ground	7/2	7/2	26670.19	
				7/2	9/2	26672.59	
				5/2	5/2	26674.77	
				5/2	7/2	26681.52	
				9/2	11/2	26690.14*	
				9/2	9/2	26697.04	
				3/2	5/2	26699.14	
		un-assigned	ground	unassigned		26669.78	
		2	excited degenerate vibration	7/2	9/2	26631.58	
				5/2	7/2	26634.31	
				9/2	11/2	26639.40	
				3/2	5/2	26642.22	

*The lines of identical frequency are unresolved.

$CClF_3$--Continued

Molecule	Rotational Transition		Vibrational State	F_i	F_f	Frequency Mc	Ref.
	J	K					
$C^{12}F_3Cl^{37}$	3 → 4	2	ground	7/2	9/2	26008.55	2
				5/2	7/2	26010.73	
				9/2	11/2	26014.69	
				3/2	5/2	26016.84*	
		3	ground	7/2	7/2	26001.20	
				7/2	9/2	26003.04	
				5/2	7/2	26010.09	
				9/2	11/2	26016.84*	
				9/2	9/2	26022.20	
				3/2	5/2	26023.94	
		un-assigned	ground	unassigned		26000.77	

*The lines of identical frequency are unresolved.

CClN (ClCN) Cyanogen chloride

$\mu = 2.802$
(ref. 4)

The halfwidth $\nu\Delta = 25^2$ has been used in calculating the intensity.

	$Cl^{35}C^{12}N^{14}$	$Cl^{37}C^{12}N^{14}$	$Cl^{35}C^{13}N^{14}$	$Cl^{37}C^{13}N^{14}$	$Cl^{36}C^{12}N^{14}$	Ref.
B_0	5970.821	5847.252	5939.795	5814.710	5907.31	1, 2 3, 5
$(eqQ)_{Cl}$	-83.4	-65.3	-83.4	-65.3	-42.2	
$(eqQ)_N$	-3.63					2
q	7.5					

References

[1] A. G. Smith, H. Ring, W. V. Smith and W. Gordy, Physical Review **74**, 370 (1948).
[2] C. H. Townes, A. N. Holden and F. R. Merritt, Physical Review **74**, 1113 (1948).
[3] C. H. Townes and L. C. Aamodt, Physical Review **76**, 691 (1949).
[4] R. G. Shulman, B. P. Dailey and C. H. Townes, Physical Review **78**, 145 (1950).

Molecule	Rotational Transition J	Vibrational State	F_{1i}	F_1	F_{1f}	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$Cl^{35}C^{12}N^{14}$	1 → 2	ground	1/2		3/2		23862.57	$9.3x10^{-6}$	2
			5/2	3/2	5/2	5/2	23863.5	$3.6x10^{-7}$	
			5/2	7/2	5/2	5/2	23863.8	$3.6x10^{-7}$	
			5/2	3/2	5/2	3/2	23864.0	$1.9x10^{-6}$	
			5/2	7/2	5/2	7/2	23864.2	$4.1x10^{-6}$	
			5/2	5/2	5/2	5/2	23864.5	$2.6x10^{-6}$	
			5/2	5/2	5/2	7/2	23864.9	$3.6x10^{-7}$	
			5/2	5/2	3/2	3/2	23865.1	$3.5x10^{-7}$	
			5/2	5/2	3/2	1/2			
			5/2	3/2	3/2	3/2	23878.6	$5.5x10^{-7}$	
			5/2	3/2	3/2	5/2			
			5/2	7/2	3/2	5/2	23878.9	$5.0x10^{-7}$	
			5/2	5/2	3/2	3/2	23879.7	$6.2x10^{-8}$	
			5/2	5/2	3/2	5/2			
			1/2		1/2		23883.30	$9.2x10^{-6}$	
			5/2	7/2	7/2	7/2	23884.2	$7.7x10^{-6}$	
			3/2	3/2	5/2	5/2			
			3/2	3/2	5/2	3/2	23884.8	$1.2x10^{-6}$	
			3/2	5/2	5/2	5/2	23884.9	$1.5x10^{-5}$	
			5/2	5/2	7/2	7/2			
			5/2	7/2	7/2	9/2	23885.16	$2.9x10^{-5}$	
			5/2	3/2	7/2	5/2			
			3/2	5/2	5/2	7/2	23885.3	$1.1x10^{-5}$	
			3/2	1/2	5/2	3/2	23886.0	$4.0x10^{-6}$	
			5/2	5/2	7/2	5/2	23886.2	$1.2x10^{-6}$	
			3/2	3/2	3/2	1/2			
			3/2	3/2	3/2	3/2	23899.59	$3.9x10^{-6}$	
			3/2	3/2	3/2	5/2			
			3/2	5/2	3/2	3/2	23900.20	$9.6x10^{-6}$	
			3/2	5/2	3/2	5/2			
			3/2	1/2	3/2	1/2	23900.7	$2.1x10^{-6}$	
			3/2	1/2	3/2	3/2			
			3/2		1/2		23920.91	$1.9x10^{-6}$	
			F_i		F_f	l			
	1 → 2	$v_2=1$	3/2		5/2	l_1	23917.9	$4.5x10^{-6}$	2
			3/2		3/2	l_1	23925.5	$1.8x10^{-6}$	
			5/2		5/2	l_1	23928.7	$1.4x10^{-6}$	
			5/2		7/2	l_1	23938.6	$8.2x10^{-6}$	
			1/2		3/2	l_1	23944.4	$1.7x10^{-6}$	
			3/2		5/2	l_2	23948.2	$4.5x10^{-6}$	
			1/2		1/2	l_1	23954.5	$3.5x10^{-6}$	
			3/2		3/2	l_2			
			5/2		5/2	l_2	23958.4	$1.8x10^{-6}$	
			5/2		7/2	l_2	23968.6	$8.2x10^{-6}$	
			1/2		3/2	l_2	23974.4	$1.7x10^{-6}$	
			1/2		1/2	l_2	23984.6	$1.7x10^{-6}$	
	2 → 3	ground		7/2		7/2	35805.09	$1,4x10^{-5}$	1
				1/2		3/2	35820.65	$1.0x10^{-4}$	
				3/2		5/2			
				5/2		7/2	35825.95	$2.3x10^{-4}$	
				7/2		9/2			
				5/2		5/2	35835.74	$2.0x10^{-5}$	

Molecule	Rotational Transition J	Vibrational State	F_{1i}	F_1	F_{1f}	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$Cl^{35}C^{13}N^{14}$	1 → 2	ground	5/2	7/2	7/2	9/2	23760.98	3.0×10^{-7}	2
	2 → 3	ground		7/2		7/2	35618.81	1.5×10^{-7}	1
				1/2		3/2	35634.85	1.1×10^{-6}	
				3/2		5/2			
				5/2		7/2	35639.78	2.4×10^{-6}	
				7/2		9/2			
				5/2		5/2	35649.56	2.1×10^{-7}	
$Cl^{37}C^{12}N^{14}$	1 → 2	ground	1/2	3/2	3/2	5/2	23372.72	1.5×10^{-6}	2
			1/2		1/2		23389.00	3.0×10^{-6}	
			3/2	3/2	5/2	5/2	23389.61	2.1×10^{-6}	
			5/2	7/2	7/2	9/2	23390.53	9.4×10^{-6}	
			5/2	3/2	7/2	5/2			
			3/2	5/2	3/2	5/2	23402.47	1.3×10^{-6}	
	2 → 3	ground	7/2		7/2		35067.99	4.4×10^{-6}	1
			1/2		3/2		35080.39	3.1×10^{-5}	
			3/2		5/2				
			5/2		7/2		35084.15	7.2×10^{-5}	
			7/2		9/2				
			5/2		5/2		35091.97	6.2×10^{-6}	
$Cl^{37}C^{13}N^{14}$	1 → 2	ground	5/2	7/2	7/2	9/2	23260.3	1.0×10^{-7}	2
	2 → 3	ground	7/2		9/2		34889.05	4.5×10^{-7}	1
$Cl^{36}C^{12}N^{14}$	1 → 2			1		2	23625.60	2.6×10^{-5}*	3
				3		3			
				2		2	23629.84	1.3×10^{-4}*	
				3		2			
				3		3			
				3		4			
				1		1			
				1		0			
				2		3			
				2		1	23634.68	4.7×10^{-6}*	

*Assuming 100% Cl^{36}.

CF_3I Methane, trifluoroiodo- μ =

	CF_3I				Ref.
B_0	1523				1

References

[1] J. Sheridan and W. Gordy, Physical Review **77**, 292 (1950).

$CHBr_3$ Methane, tribromo- $\mu = .99$

	$CHBr_3^{79}$	$CHBr_3^{81}$			Ref.
B_0	1238	1227			1

References

[1] Q. Williams and W. Gordy, Physical Review **79**, 225 (1950).

$CHClF_2$ Methane, chlorodifluoro- $\mu = 1.29$

The spectrum of this asymmetric top molecule has not been analyzed. The assignment of weak, medium or strong is that of the reference and does not correspond necessarily to the convention adopted in this table.

References

[1] B. P. Dailey, private communication.

Frequency Mc	Intensity	Ref.
22217	w	1
22247	w	
22305	m	
22353	w	
22386	w	
22410	s	
22436	w	
22462	w	
22481	m	
22545	w	
22553	w	
23308	s	
23644	w	
23680	w	
23733	s	
23803	w	
23826	w	
23845	s	

$CHCl_3$ Methane, trichloro- $\mu = 1.2$

The line listed below consists of several components which are, however, not resolved at higher pressures. The $J = 2 \rightarrow 3$ and $5 \rightarrow 6$ transitions were also observed[1]. The deuterated molecule was observed with an isotopically enriched sample.

	$CHCl_3{}^{35}$	$CDCl_3{}^{35}$			Ref.
Bo	3302.0	3250.2			1, 2

References

[1] W.V. Smith and R. R. Unterberger, Journal of Chemical Physics **17**, 1348 (1949).
[2] R. R. Unterberger, R. Trambarulo, and W. V. Smith, Journal of Chemical Physics, 18, 565 (1950).

$CHCl_3$

Molecule	Rotational Transition	Frequency Mc	Intensity cm^{-1}	Ref.
	J			
$C^{12}HCl^{35}{}_3$	$3 \rightarrow 4$	26417	2.9×10^{-7}	1,2
	$6 \rightarrow 7$	46227.2	1.6×10^{-6}	
$C^{12}DCl^{35}{}_3$	$6 \rightarrow 7$	45502.4	3.0×10^{-10}	

CHF_3 (HCF_3) Methane, trifluoro- $\mu = 1.59$

In the absence of other information, A was calculated using the C-F distance estimated by the authors, assuming tetrahedral angles. It was also assumed that 0.9 of the molecules were in the ground vibrational state for calculation of the intensity of the half width $\Delta \nu = 18$, has been used in calculating the intensity.

	CHF_3				Ref.
B_0	10348.74				1
A	5600				

References

[1] O. R. Gilliam, H. D. Edwards and W. Gordy, Physical Review **75**, 1014 (1949).

CHF_3

Molecule	Rotational Transition		Frequency Mc	Intensity cm^{-1}		Ref.
	J	K				
$HC^{12}F_3$	$1 \rightarrow 2$	0,1,2	41394.95	2.2×10^{-5}		1

CHN (HCN) (HCN) Hydrocyanic acid

$\mu = 2.957$
(ref. 1,3)

The transitions reported in (3) are of a unusual type, being between the levels of a single l-type doublet. The half width $\Delta\nu=25$[1] has been used in calculating the intensity.

	$HC^{12}N$	$HC^{13}N$	$DC^{12}N$	$DC^{13}N$		Ref.
Bo	44300.83	43154.83	36207.395	35587.565		2
$(eqQ)_N$	-4.58					
q	223.549					3

References

[1] A.G. Smith, W. Gordy, J. W. Simmons and W. V. Smith, Physical Review **75**, 260 (1949).
[2] J.W. Simmons, R. S. Anderson and W. Gordy, Physical Review **77**, 77 (1950).
[3] R.G. Sulman and C. H. Townes, Physical Review **77**, 421 (1950), and **78**, 347 (1950).

Molecule	Rotational Transition J	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$HC^{12}N^{14}$	6			9460	1.3x10^{-6}	2,3
	8			16147.67	2.9x10^{-6}	
	10			24689.96	5.5x10^{-6}	
	11			29650	7.2x10^{-6}	
	12			35043.24	9.3x10^{-6}	
	0 → 1	1	1	88600.11	4.0x10^{-3}	
		1	2	88601.49	6.7x10^{-3}	
		1	0	88603.56	1.35x10^{-3}	
$HC^{13}N^{14}$	0 → 1	1	1	86308.12	4.1x10^{-5}	
		1	2	86309.49	6.7x10^{-5}	
		1	0	86311.54	1.4x10^{-5}	
$DC^{12}N^{14}$	0 → 1	1	1	72413.25	4.2x10^{-7}	2
		1	2	72414.62	7.4x10^{-7}	
		1	0	72416.68	1.5x10^{-7}	
$DC^{13}N^{14}$	0 → 1	1	1	71173.58	2.3x10^{-9}	2
		1	2	71174.96	7.6x10^{-9}	
		1	0	71177.02	1.5x10^{-9}	

CHNO (HNCO) Isocyanic acid $\mu =$

	$HN^{14}C^{12}O^{16}$	$HN^{15}C^{12}O^{16}$	$DN^{14}C^{12}O^{16}$		Ref.
$\frac{1}{2}$ (B+C)	10991.5	10662.3	10197.9		1

References

[1] L. H. Jones, J. N. Shoolery, R. G, Shulman and D. M. Yost, Journal of Chemical Physics **18**, 990 (1950).

CHNO

Molecule	Rotational Transition	Frequency Mc	Ref.
	J		
$HN^{14}C^{12}O^{16}$	0 → 1	21981.7	1
$HN^{15}C^{12}O^{16}$	0 → 1	21323.5	
$DN^{14}C^{12}O^{16}$	0 → 1	20394.7	

CHNS (HNCS) Isothiocyanic acid $\mu = 1.72$

	$HN^{14}C^{12}S^{32}$	$DN^{14}C^{12}S^{32}$	$HN^{14}C^{13}S^{32}$	$DN^{14}C^{13}S^{32}$	$HN^{14}C^{12}S^{34}$	Ref.
1/2(B+C)	5866.0	5474.3	5847.3	5459.8	5728.8	1

References

[1] C. I. Beard and B. P. Dailey, Journal of Chemical Physics **15**, 762 (1947).
[2] C. I. Beard and B. P. Dailey, MITRLE Technical Report #79, (1948)

CHNS

Molecule	Rotational Transition	Frequency Mc			Ref.
	J				
$HN^{14}C^{12}S^{32}$	1→2	23464			1
$DN^{14}C^{12}S^{32}$	1→2	21897			
$HN^{14}C^{13}S^{32}$	1→2	23389			
$DN^{14}C^{13}S^{32}$	1→2	21839			
$HN^{14}C^{12}S^{34}$	1→2	22915			

CH_2Br_2 Methane, dibromo- $\mu = 1.5$

The intensities are listed as reported experimentally and do not necessarily correspond to the convention adopted herein. The isotopic species are not identified.

References

[1] T. E. Turner, Thesis, McGill University (1948).
[2] W. J. Pietenpol, and J. D. Rogers, Physical Review **76** , 690 (1949).

CH_2Br_2

Molecule	Frequency Mc	Intensity	Ref.
CH_2Br_2	24908	m	2
	24943	w	
	24972	w	
	24982	m	
	25002	w	
	25013	m	
	25042	s	1,2
	25072	s	2
	25090	m	
	25128	s	
	25147	w	
	25152	w	
	25160	w	
	25170	m	
	25203	m	
	25223	m	

CH_2Cl_2 Ethane, dichloro- $\mu = 1.6$

The relative intensities are those of reference (1), and do not necessarily correspond to the convention adopted herein. The frequencies are a plausible compromise between those of References (1) and (2). The isotopic species are not identified.

References

[1] T. E. Turner, Thesis, McGill University (1948).
[2] B. P. Dailey, private communication.

CH_2Cl_2--Continued

Molecule	Frequency Mc	Observed Relative Intensity	Ref.
CH_2Cl_2	23476		2
	24440	4	1
	24471	7	
	24577	4	1, 2
	24627	4	1
	24631	4	
	24636	4	1, 2
	24842	2	
	24916	2	1
	24967	2	
	24970	4	
	24976	6	
	24996		2
	25018	2	1
	25038	6	
	25046	6	
	25047	2	
	25053	2	1, 2
	25073	7	
	25099	2	
	25123	8	
	25221		2
	25269	7	1,2
	25280	6	1
	25710	7	
	25745	2	
	25748	6	
	25751	2	
	25848	10	
	26007	7	
	26295	9	

CH_2O (H_2CO) Methanal

2.17
(ref.1)

Centrifugal stretching in this molecule has been investigated in considerable detail. For this asymmetric rotor the notation for the rotational transitions is that of reference Ind. 5 and K 0.9612[1] is a measure of the asymmetry.

References

[1] J. K. Bragg and A. H. Sharbaugh, Physical Review **75**, 1774 (1949).

[2] R. B. Lawrance, M. I. T. Progress Reports, July 1949, and Jan. 1950, Physical Review **78**, 347 (1950), and private communication.

CH_2O--Continued

Molecule	Rotational Transition	Frequency Mc	Intensity cm^{-1}		Ref.
$C^{12}H_2O$	$22_{4,19} \rightarrow 22_{4,18}$	7362.60	$5.1\text{x}10^{-7}$		2
	$14_{3,12} \rightarrow 14_{3,11}$	7892.03	$1.0\text{x}10^{-6}$		
	$7_{2,6} \rightarrow 7_{2,5}$	8884.87	$1.0\text{x}10^{-6}$		
	$23_{4,20} \rightarrow 23_{4,19}$	10336.51	$7\text{x}10^{-8}$		
	$15_{3,13} \rightarrow 15_{3,12}$	11753.13	$1.5\text{x}10^{-6}$		
	$24_{4,21} \rightarrow 24_{4,20}$	14361.54	$1.0\text{x}10^{-7}$		
	$2_{1,2} \rightarrow 2_{1,1}$	14488.65	$9\text{x}10^{-6}$		
	$8_{2,7} \rightarrow 8_{2,6}$	14726.74	$2\text{x}10^{-6}$		
	$16_{3,14} \rightarrow 16_{3,13}$	17027.60	$2.5\text{x}10^{-6}$		
	$25_{4,22} \rightarrow 25_{4,21}$	19595.23	$1.5\text{x}10^{-7}$		1, 2
	$9_{2,8} \rightarrow 9_{2,7}$	22965.71	$5\text{x}10^{-6}$		
	$17_{3,15} \rightarrow 17_{3,14}$	24068.31	$5\text{x}10^{-6}$		
	$26_{4,23} \rightarrow 26_{4,22}$	26358.82	$2\text{x}10^{-7}$		
	$3_{1,3} \rightarrow 3_{1,2}$	28974.85	$2.5\text{x}10^{-5}$		2
	$4_{1,4} \rightarrow 4_{1,3}$	48284.60	$5\text{x}10^{-5}$		
	$5_{1,5} \rightarrow 5_{1,4}$	72409.35	$8.5\text{x}10^{-5}$		
	$0_{0,0} \rightarrow 1_{0,1}$	72838.14	$9.8\text{x}10^{-5}$		
$C^{13}H_2O$	$2_{1,2} \rightarrow 2_{1,1}$	13778.86	$9.\text{x}10^{-8}$		2
	$16_{3,14} \rightarrow 16_{3,13}$	14592.44	$2.5\text{x}10^{-8}$		
	$17_{3,15} \rightarrow 17_{3,14}$	20649.30	$5.\text{x}10^{-8}$		
	$9_{2,8} \rightarrow 9_{2,7}$	20736.40	$5.\text{x}10^{-8}$		1, 2
	$3_{1,3} \rightarrow 3_{1,2}$	27555.73	$2.5\text{x}10^{-7}$		2
	$18_{3,16} \rightarrow 18_{3,15}$	28582.40	$7\text{x}10^{-8}$		

CH_2O_2 ($HCOOH$) Methanoic acid $\mu = 1.7$

References

[1] W. J. Pietenpol, J. D. Rogers and D. Williams, Physical Review **78**, 480 (1950).

Molecule	Frequency Mc	Ref.
CH_2O_2	22370 22470 23200 24566 27810 31000	1

CH_3BO (BH_3CO) Borine carbonyl

μ ground = 1.795
μ(exc. state) = 1.770
(ref. 2,3)

The J=2 → 3 transition has also been observed[4] but the frequencies were not reported.

	$B^{10}H_3CO$	$B^{10}H_3CO$ $v_1=1$	$B^{10}H_3CO$ $v_2=1$	$B^{11}H_3CO$	$B^{10}D_3CO$	$B^{11}D_3CO$	Ref.
B_0	8980.1	9002.66	8985.80	8657.22	7530.34	7336.56	2,3,4
$(eqQ)_B$	3.4			1.55	3.4	1.55	3,4
D_{JK}	0.39			0.36	0.29	0.24	4

References

[1] W. Gordy, H. Ring, and A. B. Burg, Physical Review **74**, 1191 (1948)
[2] W. W. P. Strandberg, C. S. Pearsall and M. T. Weiss, Journal of Chemical Physics **71**, 429 (1949)
[3] M. T. Weiss, R. B. Lawrance and C. C. Loomis, Physical Review **78**, 202 (1950) and private communication.
[4] W. Gordy and H. Ring, and A. B. Burg, Physical Review **78**, 512 (1950)

CH_3BO--Continued

Molecule	Rotational Transition		F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K					
$B^{10}H_3CO$	0→ 1		3	2	17959.67	$2.5x10^{-7}$	2, 3
			3	4	17959.91	$3.5x10^{-7}$	
			3	3	17960.60	$4.5x10^{-7}$	
	1→ 2	0	3	2	35919.08	$4.0x10^{-7}$	4
			3	3	35919.60	$5.8x10^{-6}$	
			2	1			
			3	4			
			4	5			
			2	2	35919.95	$7.9x10^{-7}$	
			4	3	35920.22	$9.5x10^{-7}$	
			4	4			
			2	3	35920.40	$4.8x10^{-7}$	
		1	2	1	35917.66	$5.4x10^{-7}$	
			2	2	35917.96	$2.3x10^{-6}$	
			4	5			
			4	3	35918.29	$1.0x10^{-6}$	
			4	4			
			3	2			
			3	3	35918.55	$1.8x10^{-6}$	
			3	4			
$B^{11}H_3CO$	1→ 2	0	3/2	1/2	34628.16	$5.6x10^{-7}$	
			3/2	3/2	34628.58	$3.5x10^{-6}$	
			5/2	3/2	34628.85	$2.3x10^{-5}$	
			1/2	1/2			
			3/2	5/2			
			5/2	7/2			
			1/2	3/2	34629.27	$5.7x10^{-6}$	
			5/2	5/2			
		1	1/2	1/2	34627.16	$2.1x10^{-6}$	
			3/2	1/2	34627.42	$1.3x10^{-5}$	
			5/2	3/2			
			5/2	7/2			
			1/2	3/2			
			3/2	3/2	34627.64	$4.9x10^{-6}$	
			5/2	5/2			
			3/2	5/2	34627.81	$5.2x10^{-6}$	
$B^{10}D_3CO$	1→ 2	0	3	2	30120.86*	$1.9x10^{-18}$	
			3	3	30121.21	$2.7x10^{-17}$	
			2	1			
			3	4			
			4	5			
			2	2	30121.56	$3.7x10^{-18}$	
			4	3	30121.56	$2.3x10^{-18}$	
			4	4			
			2	3			
		1	2	1	30119.91	$2.5x10^{-18}$	
			4	5	30120.21	$1.1x10^{-17}$	
			2	2			
			4	3	30120.56	$4.7x10^{-18}$	
			4	4			
			3	2			
			3	4	30120.86*	$8.5x10^{-18}$	
			3	3			

*These two lines were not resolved.

Molecule	Rotational Transition		F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K					
$B^{11}D_3CO$	1 → 2	0	3/2	3/2	29345.93	$1.7x10^{-17}$	4
			5/2 1/2 3/2 5/2	3/2 1/2 5/2 7/2	29346.24	$1.1x10^{-16}$	
			1/2 5/2	3/2 5/2	29346.65	$2.8x10^{-17}$	
		1	1/2	1/2	29345.03	$1.0x10^{-17}$	
			3/2 5/2 5/2 1/2	1/2 3/2 7/2 3/2	29345.28	$6.3x10^{-17}$	
			3/2 5/2	3/2 5/2	29345.52	$2.4x10^{-17}$	
			3/2	5/2	29345.68	$2.5x10^{-17}$	

CH_3Br Methane, bromo-

$\mu = 1.797$
(ref. 3)

	$C^{12}H_3Br^{79}$	$C^{12}H_3Br^{81}$	$C^{13}H_3Br^{79}$	$C^{13}H_3Br^{81}$	Ref.
B_o	9568.19	9531.845	9119.51	9082.86	1, 2 4, 5
$(eqQ)_{Br}$	577.3	482.4	577.3	482.4	1, 2
D_J	0.0111	0.0107			5
D_{JK}	0.1294	0.1290			

References

[1] W. Gordy, J. W. Simmons and A. G. Smith, Physical Review **74**, 243 (1948).
[2] A. H. Sharbaugh and J. Mattern, Physical Review **75**, 1102 (1949).
[3] R. G. Shulman, B. P. Dailey and C. H. Townes, Physical Review **78**, 145 (1950).
[4] J. W. Simmons and W. O. Swan, Physical Review **80**, 289 (1950).
[5] J. W. Simmons and W. E. Anderson, Duke Progress Report May-Aug., (1950).

CH$_3$Br--Continued

Molecule	Rotational Transition		F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K					
$C^{12}H_3Br^{79}$	0 → 1	0	3/2	1/2	18992.36	4.8×10^{-7}	2
			3/2	3/2	19252.13	9.7×10^{-7}	
			3/2	5/2	19107.97	1.5×10^{-6}	
	1 → 2	0	3/2	3/2	38157.30	2.5×10^{-6}	1
			3/2 5/2	5/2 7/2	38260.10	1.4×10^{-5}	
			1/2	1/2	38272.40	1.9×10^{-6}	
			5/2	5/2	38404.49	2.1×10^{-6}	
			1/2	3/2	38417.09	1.9×10^{-6}	
		1	1/2	1/2	38128.40	1.4×10^{-6}	
			1/2	3/2	38200.52	1.4×10^{-6}	
			5/2	7/2	38237.14	7.0×10^{-6}	
			5/2	5/2	38309.45	1.6×10^{-6}	
			3/2	3/2	38330.25	1.9×10^{-6}	
			3/2	5/2	38381.70	3.5×10^{-6}	
	3 → 4	3	3/2	5/2	76425.18	2.4×10^{-5}	5
			9/2	11/2	76491.36	5.6×10^{-5}	
		2	3/2	5/2	76496.60	2.0×10^{-5}	
			9/2	11/2	76517.36	4.7×10^{-5}	
		1	9/2	11/2	76532.88	5.9×10^{-5}	
		0	9/2 7/2	11/2 9/2	76538.02	1.1×10^{-4}	
		1	3/2	5/2	76540.20	2.5×10^{-5}	
			7/2	9/2	76547.24	4.5×10^{-5}	
		0 1 2 3	5/2 3/2 5/2 5/2 5/2	7/2 5/2 7/2 7/2 7/2	76554.82	1.6×10^{-4}	
		2	7/2	9/2	76575.22	3.6×10^{-5}	
		3	7/2	9/2	76621.78	4.2×10^{-5}	

CH_3Br--Continued

Molecule	Rotational Transition		F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K					
$C^{12}H_3Br^{79}$ Continued	4→5	4	11/2	13/2	95615.73	4.2x10^{-5}	5
		3	5/2	7/2	95619.24	7.9x10^{-5}	
			11/2	13/2	95640.87	1.5x10^{-4}	
		2	5/2	7/2	95654.73	5.2x10^{-5}	
			11/2	13/2	95659.20	9.9x10^{-5}	
		1	11/2	13/2	95669.97	1.1x10^{-4}	
		0	11/2	13/2	95673.51	2.2x10^{-4}	
			9/2	11/2			
		1	5/2	7/2	95676.39	5.9x10^{-5}	
			9/2	11/2	95677.20	9.2x10^{-5}	
		0	7/2	9/2	95683.62	3.3x10^{-4}	
			5/2	7/2			
		1	7/2	9/2			
		2	7/2	9/2			
		3	7/2	9/2			
		2	9/2	11/2	95688.27	8.0x10^{-5}	
		3	9/2	11/2	95706.12	1.2x10^{-4}	
$C^{12}H_3Br^{81}$	0→1	0	3/2	1/2	18943.77	4.7x10^{-7}	2
			3/2	3/2	19160.82	9.5x10^{-7}	
			3/2	5/2	19040.32	1.4x10^{-6}	
	1→2	0	3/2	3/2	38030.77	2.4x10^{-6}	1
			3/2	5/2	38116.65	1.4x10^{-5}	
			5/2	7/2			
			1/2	1/2	38126.97	1.9x10^{-6}	
			5/2	5/2	38237.14	2.1x10^{-6}	
			1/2	3/2	38247.77	1.9x10^{-6}	
		1	1/2	1/2	38006.47	1.4x10^{-6}	
			1/2	3/2	38066.72	1.4x10^{-6}	
			5/2	7/2	38097.45	6.7x10^{-6}	
			5/2	5/2	38157.70	1.5x10^{-6}	
			3/2	3/2	38175.08	1.8x10^{-6}	
			3/2	5/2	38218.21	3.5x10^{-6}	

Molecule	Rotational Transition		F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K					
$C^{12}H_3Br^{81}$	$3 \rightarrow 4$	3	3/2	5/2	76152.28	2.2×10^{-5}	5
			9/2	11/2	76207.66	5.4×10^{-5}	
		2	3/2	5/2	76213.16	2.0×10^{-5}	
			9/2	11/2	76230.18	4.6×10^{-5}	
		1	9/2	11/2	76243.66	5.8×10^{-5}	
		0	9/2	11/2	76248.32	1.1×10^{-4}	
			7/2	9/2			
		1	3/2	5/2	76249.94	2.5×10^{-5}	
			7/2	9/2	76255.68	4.4×10^{-5}	
		0	5/2	7/2	76261.96	1.5×10^{-4}	
			3/2	5/2			
		1	5/2	7/2			
		2	5/2	7/2			
			7/2	9/2	76278.16	3.5×10^{-5}	
	$4 \rightarrow 5$	4	11/2	13/2	95259.24	4.1×10^{-5}	
		3	5/2	7/2	95263.47	7.7×10^{-5}	
			11/2	13/2	95281.53	1.5×10^{-4}	
		2	5/2	7/2	95293.89	5.1×10^{-5}	
			11/2	13/2	95297.55	9.7×10^{-5}	
		1	11/2	13/2	95307.48	1.1×10^{-4}	
		0	11/2	13/2	95310.78	2.0×10^{-4}	
			9/2	11/2			
		0	7/2	9/2	95319.12	2.1×10^{-4}	
			5/2	7/2			
		1	7/2	9/2			
		2	9/2	11/2	95322.15	7.8×10^{-5}	
		3	9/2	11/2	95336.01	1.2×10^{-4}	

CH_3BrHg (CH_3HgBr) Methylmercury bromide μ =

	CH_3HgBr^{79}	CH_3HgBr^{81}			Ref.
B_0	1140	1122			1

References

[1] W. Gordy and J. Sheridan, Physical Review, **79**, 224 (1950), and private communication.

CH_3Cl Methane, chloro- $\mu = 1.869$ (ref. 6,2)

	$C^{12}H_3Cl^{35}$	$C^{12}H_3Cl^{37}$	$C^{13}H_3Cl^{35}$	$C^{13}H_3Cl^{37}$	$C^{12}D_3Cl^{35}$	$C^{12}D_3Cl^{37}$	Ref.
B_0	13292.95	13088.24	12796.2	12590.0	10844	10662.5	1, 4 5, 7
A	150,000 approximately						
$(eqQ)_{Cl}$	-75.33	-58.5	-75.33	-58.5	-75.33	-58.5	1, 2
D_J	0.0264	0.0270					7
D_{JK}	0.189	0.184					

References

[1] W. Gordy, J. W. Simmons and A. G. Smith, Physical Review **74**, 243 (1948).

[2] R. Karplus and A. H. Sharbaugh, Physical Review **75**, 889 (1949).

[3] G. Matlock, G. Glockler, D. R. Bianco and A. Roberts, Journal of Chemical Physics **18**, 332 (1950).

[4] J. W. Simmons, Physical Review **76**, 686 (1949).

[5] B. P. Dailey, C. H. Townes, J. M. Mays and Physical Review **76**, 136 (1949) and private communication.

[6] R. G. Shulman, B. P. Dailey and C. H. Townes, Physical Review **78**, 145 (1950).

[7] J. W. Simmons and W. E. Anderson, Duke Progress Report, May - August, 1950.

[8] S. L. Miller, L. C. Aamodt, B. P. Dailey, J. Kraitchman, and C. H. Townes C. R. L. Quarterly Report September 30, 1950.

CH_3Cl

Molecule	Rotational Transition		F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K					
$C^{12}H_3Cl^{35}$	0→1		3/2	3/2	26570.77	$4.4x10^{-6}$	1
			3/2	5/2	26589.49	$6.6x10^{-6}$	
			3/2	1/2	26604.57	$2.2x10^{-6}$	
	2→3	0	7/2	7/2	79736.96	$7.2x10^{-5}$	7
			3/2	5/2	79751.02*	$2.2x10^{-4}$	
			1/2	3/2			
			7/2	9/2	79755.68*	$4.4x10^{-4}$	
			5/2	7/2			
			5/2	5/2	79764.56	$1.9x10^{-5}$	
			3/2	3/2	79769.94	$1.4x10^{-5}$	
		1	7/2	9/2	79755.68*	**	
			5/2	7/2	79751.02*	**	
			3/2	5/2			
			1/2	3/2	79755.68*	**	
		2	7/2	9/2	79755.68*	**	
			5/2	7/2	79736.96*	**	
			1/2	3/2	79768.98	$1.9x10^{-5}$	
			7/2	7/2	79755.68*	**	
			5/2	5/2	79736.96*	**	

*These lines, when of identical observed frequency, were not resolved.

**Intensity is included in line of identical frequency above.

CH_3CL--Continued

Molecule	Rotational Transition J	K	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$C^{12}H_3Cl^{37}$	$0\rightarrow 1$		3/2	3/2	26164.57	$1.4x10^{-6}$	1
			3/2	5/2	26179.30	$2.1x10^{-6}$	
			3/2	1/2	26191.13	$7.1x10^{-7}$	
	$2\rightarrow 3$	0	7/2	7/2	78512.80	$4.6x10^{-6}$	7
			1/2 3/2	3/2 5/2	78523.32*	$7.0x10^{-5}$	
			5/2 7/2	7/2 9/2	78527.10*	$1.1x10^{-4}$	
		1	3/2 5/2	5/2 7/2	78523.32*	**	
			1/2 7/2	3/2 9/2	78527.10*	**	
		2	5/2 5/2	5/2 7/2	78511.68	$1.9x10^{-6}$	
			3/2 3/2	3/2 5/2	78522.00	$1.3x10^{-6}$	
			7/2 7/2	7/2 9/2	78526.14	$2.5x10^{-6}$	
$C^{13}H_3Cl^{35}$	$0\rightarrow 1$		3/2	3/2	25577.40	$4.5x10^{-8}$	5, 3
			3/2	5/2	25596.19	$6.7x10^{-8}$	
			3/2	1/2	25611.09	$2.2x10^{-8}$	
$C^{13}H_3Cl^{37}$	$0\rightarrow 1$		3/2	3/2	25167.68	$1.4x10^{-9}$	
			3/2	5/2	25182.50	$2.1x10^{-9}$	
			3/2	1/2	25194.20	$6.9x10^{-10}$	
$C^{12}H_2DCl^{35}$	$0_{0,0}\rightarrow 1_{0,1}$		3/2	3/2	24641.70	$6.0x10^{-10}$	3
			3/2	5/2	24660.33	$9.0x10^{-10}$	
			3/2	1/2	24675.25	$3.0x10^{-10}$	
$C^{12}H_2DCl^{37}$	$0_{0,0}\rightarrow 1_{0,1}$		3/2	3/2	24252.00	$1.8x10^{-10}$	3
			3/2	5/2	24266.68	$3.8x10^{-10}$	
			3/2	1/2	24278.33	$9.2x10^{-11}$	
$C^{12}HD_2Cl^{35}$	$0_{0,0}\rightarrow 1_{0,1}$		3/2	3/2	23035.00	$1.0x10^{-13}$	
			3/2	5/2	23053.62	$1.5x10^{-13}$	
			3/2	1/2	23068.51	$5.2x10^{-14}$	
	$1_{11}\rightarrow 2_{12}$ $1_{0,1}\rightarrow 2_{0,2}$ $1_{1,0}\rightarrow 2_{1,1}$				45789. 46099.4 46407.		8
$C^{12}HD_2Cl^{37}$	$0_{0,0}\rightarrow 1_{0,1}$		3/2	3/2	22659.29	$3.1x10^{-14}$	3
			3/2	5/2	22673.80	$4.8x10^{-14}$	
			3/2	1/2	22685.60	$1.6x10^{-14}$	

*These lines, when of identical observed frequency, were not resolved.
**Intensity is included in line of identical frequency above.

CH_3ClHg (CH_3HgCl) Methylmercury chloride μ =

	CH_3HgCl^{35}				Ref.
B_0	2076				1

References

[1] W. Gordy and J. Sheridan, Physical Review **79**, 224, (1950), and private communication.

CH_3F Methane, fluoro- μ = 1.81

The half width, $\Delta\nu=20^2$, has been used in calculating the intensities.

	$C^{12}H_3F$	$C^{13}H_3F$			Ref.
B_0	25,535.85	24,862.37			1, 2
A	150,000				
D_{JK}	0.45				3

References

[1] W. Gordy, J. W. Simmons and A. G. Smith, Physical Review **74**, 243, (1948).
[2] O. R. Gilliam, H. D. Edwards and W. Gordy, Physical Review **75**, 1014, (1949).
[3] O. R. Gilliam, C. M. Johnson and W. Gordy, Physical Review **78**, 140, (1950).

CH_3F

Molecule	Rotational Transition		Frequency Mc	Intensity cm^{-1}		Ref.
	J	K				
$C^{12}H_3F$	$0 \rightarrow 1$	0	51071.69	1.4×10^{-4}		1, 2
	$1 \rightarrow 2$		102000.	2.0×10^{-3}		3
$C^{13}H_3F$	$0 \rightarrow 1$	0	49724.73	1.5×10^{-6}		2

CH_3F_3Si (CH_3SiF_3) Silane, trifluoromethyl μ =

	$Si^{28}F_3CH_3$	$Si^{28}F_3CH_3$			Ref.
B_0	3715.62				1

References

[1] J. Sheridan and W. Gordy, Physical Review **77**, 719 (1950).
[2] H. Minden, J. M. Mays and B. P. Dailey, Physical Review **78**, 347, (1950).

CH_3F_3Si

Molecule	Rotational Transition J	Vibrational State	Frequency Mc		Ref.
$Si^{28}F_3CH_3$	2 → 3	ground	22295		2
	3 → 4	ground	29724.91		1, 2
		excited	29707.24		1
	5 → 6	ground	also observed		

CH_3HgI Methylmercury iodide μ =

The $J = 27 \rightarrow 28$ and $28 \rightarrow 29$ transitions were observed[1], but frequencies were not given.

	CH_3HgI				Ref.
B_0	788.0				

References

[1] W. Gordy and J. Sheridan, Physical Review **79**, 224, (1950), and Duke Progress Report Aug.-Nov. 1949.

CH_3I Methane, iodo- μ = 1.647 (ref. 4)

Many lines of the J = 2→3 transition of CH_3I^{129} in the region 44,700 - 45,200 megacycles were observed[2], and also the J = 1→ 2 transition of CD_3I^{127}[3].

	$C^{12}H_3I^{127}$	$C^{13}H_3I^{127}$	CD_3I^{127}	CH_3I^{129}	Ref.
B_0	7501.310	7119.040	6040.5		1, 3 5
A	150,000	150,000	150,000		
$(eqQ)_I$	-1934			-1422	1, 2
D_J	7.95×10^{-3}				5
D_{JK}	9.94×10^{-2}				

References

[1] W. Gordy, J. W. Simmons and A. G. Smith, Physical Review **74**, 243 (1948).
[2] R. Livingston, O. R. Gilliam and W. Gordy, Physical Review **76**, 149 (1949).
[3] J. W. Simmons, Physical Review **76**, 686 (1949).
[4] R. G. Shulman, B. P. Dailey and C. H. Townes, Physical Review **78**, 145 (1950).
[5] J. W. Simmons and W. E. Anderson, Duke Quarterly Progress Report, May - August 1950.
*These two lines were unresolved, and the intensity given is their sum.

CH_3I

Molecule	Rotational Transition		F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K					
$C^{12}H_3I^{127}$	1→2	0	3/2	5/2	29598.95	9.2×10^{-7}	1
			7/2	7/2	26697.95	1.4×10^{-6}	
			7/2	5/2	29773.95	2.3×10^{-7}	
			3/2	3/2	29872.52	1.4×10^{-6}	
			7/2	9/2	30046.99	5.0×10^{-6}	
			5/2	7/2	30079.72	2.6×10^{-6}	
			3/2	1/2	30121.32	1.0×10^{-6}	
			5/2	5/2	30179.71	2.6×10^{-6}	
			5/2	3/2	30453.46	6.3×10^{-7}	
		1	5/2	7/2	29735.71	2.5×10^{-6}	
			5/2	5/2	29782.71	1.8×10^{-6}	
			5/2	3/2	29923.50	4.5×10^{-7}	
			7/2	7/2	29939.87	1.4×10^{-6}	
			7/2	5/2	29986.84	2.4×10^{-7}	

CH_3I--Continued

Molecule	Rotational Transition		F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K					
$C^{12}H_3I^{127}$ (Continued)	1→2	1	3/2	5/2	30075.08	$9.5x10^{-7}$	1
			7/2	9/2	30123.64	$5.1x10^{-6}$	
			3/2	3/2	30215.95	$1.4x10^{-6}$	
	4→5	0	13/2	15/2	75019.28	$6.0x10^{-5}$	5
			11/2	13/2	75027.58	$4.9x10^{-5}$	
			9/2	11/2	75004.28	$3.9x10^{-5}$	
			7/2	9/2	74977.62*	$5.4x10^{-5}$	
			5/2	7/2	74967.66	$2.4x10^{-5}$	
			3/2	5/2	74986.14	$1.9x10^{-5}$	
		1	7/2	9/2	74976.22	$3.0x10^{-5}$	
			5/2	7/2	74977.62*	$5.4x10^{-5}$	
			9/2	11/2	74993.28	$3.7x10^{-5}$	
			11/2	13/2	75016.20	$4.7x10^{-5}$	
			13/2	15/2	75026.20	$5.8x10^{-5}$	
		2	9/2	11/2	74960.76	$3.3x10^{-5}$	
			7/2	9/2	74971.76	$2.6x10^{-5}$	
			11/2	13/2	74982.18	$4.1x10^{-5}$	
			5/2	7/2	75007.62	$2.0x10^{-5}$	
			13/2	15/2	75046.48	$5.1x10^{-5}$	
		3	11/2	13/2	74926.04	$6.3x10^{-5}$	
			7/2	9/2	74964.36	$4.0x10^{-5}$	
			13/2	15/2	75081.02	$7.7x10^{-5}$	
		4	9/2	11/2	74829.54	$1.4x10^{-5}$	
			11/2	13/2	74849.92	$1.8x10^{-5}$	
$C^{13}H_3I^{127}$	1→2	0	3/2	5/2	28069.99	$1.0x10^{-8}$	1
			7/2	7/2	28145.01	$1.5x10^{-8}$	
			3/2	3/2	28343.64	$1.5x10^{-8}$	
			7/2	9/2	28518.14	$5.5x10^{-8}$	
			5/2	7/2	28550.86	$2.9x10^{-8}$	
			5/2	5/2	28650.91	$2.9x10^{-8}$	
			5/2	7/2	28206.90	$2.8x10^{-8}$	
			5/2	5/2	28253.84	$2.0x10^{-8}$	
			7/2	7/2	28411.19	$1.5x10^{-8}$	
			7/2	9/2	28594.74	$5.6x10^{-8}$	
			3/2	3/2	28687.21	$1.5x10^{-8}$	

CH_3NO_2 Methane, nitro- $\mu = 3.1$

References

[1] B. P. Dailey and E. B. Wilson jr., Physical Review **72**, 522 (1947) and private communication.
[2] B. Bak, E. S. Knudsen and E. Madsen, Physical Review **75**, 1622 (1949).
*These three lines were only very roughly measured and are not included in the frequency listing.

CH_3NO_2

Molecule	Frequency Mc	Observed Relative Intensity			Ref.
CH_3NO_2	20385	75			1
	21970*				2
	22580*				
	22620*				
	23021				
	23250	115			1
	23330				2
	23467				1
	23483				
	23706				
	24017				
	24428				
	24448				
	24599				
	25394	118			1, 2
	25412	60			1

CH_4O (CH_3OH) Methanol $\mu = 1.66$

Of the large number of lines reported, only some of the J=0 → 1 lines, and a series involving a hindred rotational transition have been positively identified. Many lines of this series have been observed and their J-values determined[6,8]. These lines are designated in the list below only by J, since for them ΔJ=0. Intensities indicated for some lines are observed values[7,8], and the designations w, m, etc. do not necessarily agree with the conventions of this table.

References

[1] W. D. Hershberger and J. Turkevitch, Physical Review **71**, 554, (1947), and private communication.
[2] B. P. Dailey and E. B. Wilson, jr., Physical Review **72**, 522, (1947).
[3] D. K. Coles, Physical Review **74**, 1194 (1948).
[4] C. H. Millar, Thesis, McGill University (1947).
[5] B. Bak, E. S. Knudsen, and E. Madsen, Physical Review **75**, 1622, (1949).
[6] D. K. Coles, W. E. Good, and R. H. Hughes, Physical Review **77**, 741, (1950).
[7] H. D. Edwards, O. R. Gilliam and W. Gordy, Duke Progress Report, August-November, 1949, and earlier private communication.
[8] R. H. Hughes, W. E. Good, and D. K. Coles, private communication.

CH$_4$O--Continued

Molecule	Rotational Assignment	Frequency Mc	Intensity		Ref.
	J				
$C^{12}H_3O^{16}H$	30	16941.6	w		6, 8
	29	19390.18	w		8
		20346.83	m		
		20908.87	m		1,2,8
		20970.65	m		
		21550.31	m		
	28	21708.68	w		8
		23121.20	m		1, 2 4, 8
		23444.82	m		1,2,4 8,5
	27	23854.25	w		
		24901.			5
	3	24928.70	m		2, 3 4, 8
	4	24933.47	m		3, 8
	2	24934.38	m		1, 3, 8
	5	24959.08	m		1,2,3 4,8
		24997.			5
	6	25018.14	m		1,2,3 4,8
		25056.32			4, 8
	7	25124.88	m		1,2,3, 4,8,5
		25151.			5
	8	25294.41	m		1,2,3 4,8
		25312.			5
		25332.			
		25349.			
	9	25541.43	m		1,2,3 4,8
	26	25787.12	w		2,4 8
	10	25878.18	m		2,3, 4,8
	11	26313.11	m		2,4, 8
		26562.			2
	12	26847.27	m		8

CH_4O--Continued

Molecule	Rotational Assignment J	Frequency Mc	Intensity		Ref.
$C^{12}H_3O^{16}H$ (Continued)	12	27283.29	m		8
	25	27470.99	m		
	13	27472.54	m		
		27817.50	m		
		27820.87	m		
	14	28169.31	m		
		28316.03	m		
	24	28874.45	w		
	15	28905.70	m		
		29113.76	w		
	16	29636.91	m		
		29889.33	w		
	23	29973.06	w		
	17	30308.	m		
		30429.88	w		
	22	30752.26	m		
	18	30858.40	m		
	21	31209.75	m		
	19	31226.70	m		
	20	31358.31	m		6,8
		33691.72	s		8
		33693.69	w		
		34001.40	w		
		34003.61	s		
		36169.24	s		7,8
		36240.	m		7
		37690.	s		
		38290.	m		
		38335.	w		
		38445.	m		
		42280.	w		
		44100.	s		
		46610.	w		
		47840.			
		48010.			
		48192.	w		
		48248.	w		
		48260.	w		
		48371.9	s		
		48376.4	s		
		48406.	w(double)		
		48707.7	m		
		49032.	w(double)		
		49750.	w		
	$0_{0,0} \rightarrow 1_{0,1}$	49867.2	s		

CH_4O--Continued

Molecule	Rotational Assignment	Frequency Mc	Intensity		Ref.
	J				
$C^{13}H_3O^{16}H$	31	17870.5	w		6,8
	30	20329.32	w		8
	29	22672.90	w		
	28	24860.62	w		
	27	26855.01	w		
		26979.03	m		
		26980.40	w		
	3	27047.19	m		
	4	27050.45	m		
	2	27052.97	m		6,8
	5	27072.17	m		8
		27104.80	w		
		27105.93	m		
	6	27122.76	m		
	7	27215.60	m		
	8	27364.12	m		
	9	27581.65	m		
	10	27880.04	m		
	11	28267.71	m		
	26	28621.04	w		
	12	28747.67	m		
		28869.59	w		
	13	29315.20	m		
	14	29955.72	m		
	25	30127.80	w		
	15	30643.69	m		
	16	31342.31	m		
	24	31350.19	w		
	17	32004.43	m		
	23	32271.10	w		
	18	32575.53	m		
	22	32883.47	m		
	19	32998.94	m		
	21	33192.97	m		
	20	33220.05	m		6,8
		47080.	w(double)		7
		47204.7	w		
		47209.2	w		
		47760.	m		
		47899.3	m		
		47950.1	m		
	$0_{0,0}\rightarrow 1_{0,1}$	48529.6	s		
		49070.8	m		

CH_4O--Continued

Molecule	Rotational Assignment	Frequency Mc	Intensity		Ref.
	J				
$C^{12}H_3O^{18}H$	2	33918.97	m		8
	3	33925.49	m		
	4	33943.63	m		
	5	33981.35	m		
	6	34048.42	m		
	7	34155.63	m		
	8	34314.64	m		
	9	34536.74	m		
	26	34761.75	w		
	10	34831.64	m		
	11	35206.11	m		
	12	35611.78	m		
	13	36193.55	m		
	25	36312.57	w		
	14	36787.33	m		
	15	37418.97	m		
	24	37579.85	w		
	16	38053.87	m		
	23	38547.73	w		
	17	38647.87	m		
	18	39149.41	m		
	22	39210.48	m		
	19	39505.01	m		
	21	39574.97	m		
	20	39661.80	m		
$C^{12}H_3O^{16}D$		47052.			7
		47266.			
		47346.			
	$0_{0,0}\rightarrow 1_{0,1}$	47359.7	s		

CH_4O--Continued

Molecule	Rotational Assignment	Frequency Mc	Intensity		Ref.
	J				
$C^{12}D_3O^{16}D$		30505.	m		7
		30600.	m(double)		
		31140.	w		
		32190.	m		
		32325.	w		
		32790.	m		
		33340.	w		
		33965.	w		
		34410.	m		
		35090.	w		
		35100.	w		
		35165.	w		
		35215.	m		
		35335.	s		
		35440.	m(double)		
		35748.2	m		
		35805.7	w		
		35810.8	w		
		36080.0	w		
		36332.7	m		
		36422.9	w		
		36483.9	m		
		36655.	w		
		36946.4	w		
		36987.	w(double)		
		37030.	m(double)		
		37229.8	s		
		37322.8	s		
		37325.	w		
		37425.	w(double)		
		37462.6	w		
		37900.	m		
		38052.6	w		
		38132.8	w		
		38530.	w		
		38967.0	s		
		39048.	w		
		39065.	w(double)		
		40083.	m		
		40240.	m		
		40640.	w		
		40940.	w		
		41230.	m		
		41540.	w		
		41688.	s		
		41750.	w		
		42000.	w(double)		
		42020.	w		
		42150.	w		
		42285.	m		
		42700.	w		
		43345.	s		
		43525.	m		
		43545.	s		
		43630.	w		
		43995.	w		

CH_5N (CH_3NH_2) Methylamine $\mu = 1.2$

	CH_3NH_2			Ref.
$\frac{1}{2}(B+C)$	22662.12			2

References

[1] W. D. Hershberger and J. Turkevitch, Physical Review **71**, 554 (1947), and private communication.

[2] H. D. Edwards, O. R. Gilliam and W. Gordy, private communication, and Duke Progress Report July 13, 1948.

CH_5N

Molecule	Rotational Transition	Frequency Mc			Ref.
	J				
CH_3NH_2		21712			1
		21935			
		22258			
		22535			
		22590			
		22595			
		22612			
		22732			
		22740			
		22977			
		23115			
		23205			
		23295			
		23300			
		23305			
		23335			
		23404			
		23425			
		23430			
		23446			
		23510			
		23680			
		24015			
		24078			
		24320			
		24528			
		24890			
		24896			
		25000			
		25065			
		25200			
		25470			
	0 → 1	45324.24			2
		45324.94			

CIN (ICN) Cyanogen iodide $\mu = 3.71$

The half width, $\Delta\nu=20^2$ has been used in calculating the intensity.

	$IC^{12}N$	$IC^{13}N$			Ref.
B_0	3225.527	3177.035			2,1
$(eqQ)_N$	-3.80	-3.80			2,1
$(eqQ)_I$	-2420	-2420			
α_1	9.33				
α_2	-9.50				
q	2.69				
D_J	$8.8x10^{-4}$				7

References

[1]A. G. Smith, H. Ring, W. V. Smith and W. Gordy, Physical Review **74**, 370 (1948).
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[4]J. Klein, W. Low and C. H. Townes, private communication.
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[7]J. W. Simmons and W. E. Anderson, Duke Progress Report, May - August, (1950).

CIN

Molecule	Rotational Transition J	Vibrational State	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$IC^{12}N^{14}$	3→4	ground	11/2	11/2	25393.87	$7.1x10^{-6}$	2
			3/2	5/2	25711.50	$2.0x10^{-5}$	
			5/2	7/2	25728.77	$2.9x10^{-5}$	
			1/2	3/2	25752.65	$1.4x10^{-5}$	
			7/2	9/2	25783.50	$4.2x10^{-5}$	
			9/2	9/2	25789.85	$1.1x10^{-5}$	
			11/2	13/2	25823.08	$7.5x10^{-5}$	
			9/2	11/2	25837.64	$5.7x10^{-5}$	
			7/2	7/2	25954.36	$1.2x10^{-5}$	
			3/2	3/2	25969.58	$6.9x10^{-6}$	
			5/2	5/2	25991.92	$1.0x10^{-5}$	
		$v_1= 1$	11/2	13/2	25748.18	$7.0x10^{-6}$	
			9/2	11/2	25763.23	$5.3x10^{-6}$	
		$v_2=1,l_1$	5/2	7/2	25802.92	$3.8x10^{-6}$	

CIN--Continued

Molecule	Rotational Transition J	Vibrational State	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$IC^{12}N^{14}$ (Continued)	J = 3→ 4	$v_2 = 1, l_1$	3/2	5/2	25815.34	3.8x10^{-6}	2
		l_1	7/2	9/2	25829.31	7.8x10^{-6}	
		l_2	7/2	9/2	25850.78	7.8x10^{-6}	
		l_1	9/2	11/2	25872.24	1.1x10^{-5}	
		l_2	9/2	11/2	25893.73	1.1x10^{-5}	
		l_1	11/2	13/2	25906.28	1.4x10^{-5}	
		l_2	11/2	13/2	25927.66	1.4x10^{-5}	
		$v_2 = 2, l$ 2	11/2	13/2	26046.32	3.5x10^{-6}	4
		l 0	11/2	13/2	25979.72	1.7x10^{-6}	6
	J = 4→5	ground	13/2	13/2	31848.77	8.5x10^{-6}	1
			11/2	11/2	32200.58	1.5x10^{-5}	
			5/2	7/2	32203.57	5.7x10^{-5}	
			7/2	9/2	32215.56	7.3x10^{-5}	
			3/2	5/2	32226.85	4.4x10^{-5}	
			9/2	11/2	32248.52	9.3x10^{-5}	
			13/2	15/2	32268.33	1.5x10^{-4}	
			11/2	13/2	32278.55	1.2x10^{-4}	
			9/2	9/2	32386.29	1.8x10^{-5}	
	J = 10→ 11	ground	17/2	19/2	70949.66	1.2x10^{-3}	7
			21/2	23/2	70959.14	1.1x10^{-3}	
			25/2	27/2	70961.30	9.9x10^{-4}	
			23/2	25/2	70963.90	8.2x10^{-4}	
	J = 11→ 12	ground			77413.	7.7x10^{-3}	3
	J = 12→ 13	ground			83864.	9.7x10^{-3}	3
	J = 19→ 20				129000.	2.2x10^{-2}	5
$IC^{13}N^{14}$	J = 4→ 5	ground	5/2	7/2	31718.28	5.5x10^{-7}	1
			7/2	9/2	31730.50	7.2x10^{-7}	
			3/2	5/2	31741.50	4.3x10^{-7}	
			9/2	11/2	31763.34	9.1x10^{-7}	
			13/2	15/2	31783.31	1.4x10^{-6}	
			11/2	13/2	31793.46	1.1x10^{-6}	

CO Carbon monoxide

$\mu = .12$

	$C^{12}O^{16}$	$C^{13}O^{16}$			Ref.
B_0	57,635.68	55,100.90			1
α_e	524.16	488.395			

References

[1] O. R. Gilliam, C. M. Johnson and W. Gordy, Physical Review **78**, 140, (1950)

CO

Molecule	Rotational Transition	Frequency Mc	Intensity		Ref.
$C^{12}O^{16}$	$0 \rightarrow 1$	115270.56	$4.8\text{x}10^{-5}$		1
$C^{13}O^{16}$	$0 \rightarrow 1$	110201.1	$4.6\text{x}10^{-7}$		

COS (OCS) Carbonyl sulfide

$\mu = 0.709$
(ref. 1, 2,14)
$\mu_{(v_2=1)} = 0.700$
(ref. 6, 14)

Examination of a number of excited states of OCS shows that the single formulae given for the effect of excited states in the introduction is not strictly correct. Interactions of the "Fermi resonance" type between different vibrational states change frequencies of some of the excited states by a few megacycles (12). The values of α given below are simply those values which allow accurate prediction of the lowest excited state frequencies from the usual formulae. The ℓ-type doubling has been observed for the first excited state of the bending mode ($v_2 = 1$), for which the value of q is quoted. It has also been measured in a higher excitation, ($v_2 = 3$) for which the ℓ-type doubling constant is 2q. Intensities for molecules containing radioactive isotopes (C^{14} and S^{35}) are based on an assumed 100% abundance for the radioactive isotope. In this case the dipole monent has been measured for the $v_2 = 1$ excited vibrational state and has been found to differ slightly from that of the ground state. The half width, $\Delta\nu = 6^3$, has been used for calculating the intensity.

COS (OCS) Carbonyl sulfide

	$O^{16}C^{12}S^{32}$	$O^{16}C^{12}S^{33}$	$O^{16}C^{12}S^{34}$	$O^{16}C^{12}S^{35}$	$O^{16}C^{12}S^{36}$	$O^{16}C^{13}S^{32}$	Ref.
B_0	6081.453	6004.918	5932.843	5865.2	5799.67	6061.939	1,3,5 8,10
$(eqQ)_{S^{33}}$		-28.5					5
$(eqQ)_{S^{35}}$			20				10
α_1	18.12		17.68			17.94	3,11
α_2	-10.56		-10.37			-10.10	3,4
α_3	55.1						
q	6.393		6.07			6.45	

	$O^{16}C^{13}S^{34}$	$O^{16}C^{14}S^{32}$	$O^{17}C^{12}S^{32}$	$O^{18}C^{12}S^{32}$	$O^{18}C^{12}S^{34}$	$O^{18}C^{13}S^{32}$	Ref.
B_0	5911.730	6043.25	5883.67	5704.83	5559.90	5690.95	3,4 8,11
α_1				16.19			11
α_2		-9.4		-10.16			3,4 11
q		6.7		5.62			

References

[1] T. W. Dakin, W. E. Good and D. K. Coles, Physical Review **71**, 640 (1947).
[2] T. W. Dakin, W. E. Good and D. K. Coles, Physical Review **70**, 560 (1946).
[3] C. H. Townes, A. N. Holden and F. R. Merritt, Physical Review **74**, 1113 (1948).
[4] A. Roberts, Physical Review **73**, 1405 (1948).
[5] C. H. Townes and S. Geschwind, Physical Review **74**, 626 (1948).
[6] M. W. P. Strandberg, T. Wentink Jr, and R. L. Kyhl, Physical Review **75**, 270 (1949).
[7] M. W. P. Strandberg et al, MITRLE Quarterly Progress Report, 10/15/1948.
[8] W. Low and C. H. Townes, Physical Review **75**, 529 (1949).
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[11] D. R. Bianco and A. Roberts, private communication.
[12] W. Low, Thesis, Columbia University (1950).
[13] S. Geschwind and R. Gunther-Mohr, to be published.
[14] R. G. Shulman and C. H. Townes, Physical Review **77**,500 (1950).

COS--Continued

Molecule	Rotational Transition J	Vibrational State	Frequency Mc	Intensity cm^{-1}	Ref.
$O^{16}C^{12}S^{32}$	$1 \rightarrow 2$	ground	24325.921	$5.5x10^{-5}$	1, 3, 13
		$v_1 = 1$	24253.51	$8.7c10^{-7}$	11
		$v_1 = 2$	24179.62	$1.3x10^{-8}$	11
		$v_2 = 1,\ l_1$	24355.50	$4.4x10^{-6}$	3
		$v_2 = 1,\ l_2$	24381.07	$4.4x10^{-6}$	
		$v_2 = 2$	24401.	$1.3x10^{-6}$	9
		$v_2 = 3,\ l_1$	24411.	$2.8x10^{-8}$	
		$v_2 = 3,\ l_2$	24459.	$2.8x10^{-8}$	
		$v_1 = 1,\ v_2 = 1,\ l_1$	24289.97	$6.2x10^{-8}$	12
		$v_1 = 1,\ v_2 = 1,\ l_2$	24316.76	$6.2x10^{-8}$	
	$2 \rightarrow 3$	ground	36488.82	$1.9x10^{-4}$	6
		$v_2 = 1,\ l_1$	36532.47	$1.3x10^{-5}$	12
		$v_2 = 1,\ l_2$	36570.83	$1.3x10^{-5}$	
		$v_2 = 2,\ l\ \ 0$	36600.81	$1.1x10^{-6}$	
		$v_2 = 2,\ l\ \ 2$	36615.26	$2.2x10^{-6}$	
	$3 \rightarrow 4$	ground	48651.64	$4.4x10^{-4}$	2
	$4 \rightarrow 5$	ground	60814.08	$8.7x10^{-4}$	

Molecule	Rotational Transition J	Vibrational State	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$O^{16}C^{12}S^{33}$	$1 \rightarrow 2$	ground	1/2 5/2	3/2 5/2	24013.04	$7.2x10^{-8}$	5
			1/2 3/2 5/2	1/2 5/2 7/2	24020.21	$2.9x10^{-7}$	
			3/2	3/2	24025.39	$4.5x10^{-8}$	
			3/2	1/2	24032.75	$7.2x10^{-9}$	
$O^{16}C^{12}S^{34}$	$1 \rightarrow 2$	ground			23731.299	$2.2x10^{-6}$	1,13
		$v_1 = 1$			23660.62	$4.1x10^{-8}$	8,11
		$v_2 = 1,\ l_1$			23760.67	$1.4x10^{-7}$	5
		$v_2 = 1,\ l_2$			23784.95	$1.4x10^{-7}$	
	$3 \rightarrow 4$	ground			47462.40	$1.9x10^{-5}$	2

COS--Continued

Molecule	Rotational Transition	Vibrational State	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J						
$O^{16}C^{12}S^{35}$	1 → 2	ground	3/2	3/2	23457.2	9.1×10^{-6}	10
			1/2	1/2			
			5/2	7/2	23461.	3.7×10^{-5}	
			3/2	5/2			
			1/2	3/2	23466.	5.8×10^{-6}	
			5/2	5/2			
$O^{16}C^{12}S^{36}$	1 → 2	ground			23198.66	8×10^{-9}	8
$O^{16}C^{13}S^{32}$	1 → 2	ground			24247.69	5.9×10^{-7}	3
		$v_2=1,\ l_1$			24274.84	6.6×10^{-8}	6,11
		$v_2=1,\ l_2$			24300.58	6.6×10^{-8}	
		$v_1=1$			24176.07	7.2×10^{-9}	11

Molecule	Rotational Transition	Vibrational State	Frequency Mc	Intensity cm^{-1}	Ref.
	J				
$O^{16}C^{13}S^{34}$	1 → 2	ground	23646.92	2.8×10^{-8}	3
$O^{16}C^{14}S^{32}$	1 → 2	ground	24173.0	5.7×10^{-5}	6
		$v_2=1,\ l_1$	24197.	6.4×10^{-6}	
		$v_2=1,\ l_2$	24224.	6.4×10^{-6}	
$O^{17}C^{12}S^{32}$	1 → 2	ground	23534.67	2.2×10^{-8}	8
$O^{18}C^{12}S^{32}$	1 → 2	ground	22819.30	9.6×10^{-8}	3
		$v_1=1$	22754.6	1.3×10^{-9}	11
		$v_2=1,\ l_2$	22871.30	6.4×10^{-9}	
		$v_2=1,\ l_1$	22848.83	6.4×10^{-9}	
$O^{18}C^{13}S^{32}$	1 → 2	ground	22763.8	1.1×10^{-9}	
$O^{18}C^{12}S^{34}$	1 → 2	ground	22239.6	4.2×10^{-9}	

COSe (OCSe) Carbonyl selenide

$\mu = 0.754$
$\mu(v_1 = 1) = 0.728$
$\mu(v_2 = 1) = 0.730$
(ref. 1)

As in OCS "Fermi Resonance" interactions in this molecule shift the frequencies of some of the excited states by a few megacycles so that they are not accurately predicted by the α's given below.[3] In this case the dipole moment has been measured for several excited vibrational states and has been found to differ slightly from the ground state.

	$O^{16}C^{12}Se^{82}$	$O^{16}C^{12}Se^{80}$	$O^{16}C^{12}Se^{78}$	$O^{16}C^{12}Se^{77}$	$O^{16}C^{12}Se^{76}$	$O^{16}C^{12}Se^{74}$	Ref.
B_0	3994.009	4017.677	4042.460	4055.300	4068.465	4095.793	1
α_1	13.12	13.27	13.40	13.48			
α_2	-6.86	-6.92	-6.96	-6.98	-7.00		
q	3.12	3.15	3.19	3.21	3.24		
D_J	8.75×10^{-4}	7.55×10^{-4}	8.30×10^{-4}				

	$O^{16}C^{13}Se^{80}$	$O^{16}C^{13}Se^{78}$			Ref.
B_0	3980.045	4005.112			1

References

[1] M. W. P. Strandberg, T. Wentink, Jr. and A. G. Hill, Physical Review **75**, 827 (1949).
[2] S. Geschwind, H. Minden and C. H. Townes, Physical Review **78**, 174 (1950).
[3] W. Low, Thesis, Columbia University (1950).

COSe

Molecule	Rotational Transition J	Vibrational State	Frequency Mc	Intensity cm^{-1}	Ref.
$O^{16}C^{12}Se^{74}$	$2 \rightarrow 3$	ground	24574.76	1.3×10^{-7}	1,2
$O^{16}C^{12}Se^{76}$	$2 \rightarrow 3$	ground	24410.48	1.4×10^{-6}	
		$v_2 = 1, l_1$	24442.98	1.8×10^{-7}	1
		$v_2 = 1, l_2$	24462.42	1.8×10^{-7}	
$O^{16}C^{12}Se^{77}$	$2 \rightarrow 3$	ground	24331.38	1.2×10^{-6}	1,2
		$v_1 = 1$	24250.84	5.5×10^{-8}	1
		$v_2 = 1, l_1$	24363.97	1.6×10^{-7}	

COSe--Continued

Molecule	Rotational Transition	Vibrational State	Frequency Mc	Intensity cm^{-1}	Ref.
$O^{16}C^{12}Se^{77}$ (Continued)	$2 \rightarrow 3$	$v_2 = 1, l_2$	24383.21	$1.6x10^{-7}$	1
$O^{16}C^{12}Se^{78}$	$2 \rightarrow 3$	ground	24254.43	$3.4x10^{-6}$	1, 2
		$v_1 = 1$	24174.30	$1.6x10^{-8}$	1
		$v_2 = 1, l_1$ $v_2 = 1, l_2$	24286.82 24305.95	$4.5x10^{-7}$ $4.5x10^{-7}$	
	$5 \rightarrow 6$		48508.88	$2.8x10^{-5}$	
	$6 \rightarrow 7$		56593.16	$4.4x10^{-5}$	
$O^{16}C^{12}Se^{80}$	$2 \rightarrow 3$	ground	24105.85	$6.8x10^{-6}$	1, 2
		$v_1 = 1$	24026.39	$3.1x10^{-7}$	1
		$v_2 = 1, l_1$ $v_2 = 1, l_2$	24138.05 24156.93	$9.0x10^{-7}$ $9.0x10^{-7}$	
		$v_2 = 2, l = 0$ $v_2 = 2, l = 2$	24184.09 24188.31	$8.1x10^{-8}$ $1.6x10^{-7}$	3
	$5 \rightarrow 6$		48211.46	$5.6x10^{-5}$	1
	$6 \rightarrow 7$		56246.47	$8.8x10^{-5}$	
$O^{16}C^{12}Se^{82}$	$2 \rightarrow 3$	ground	23964.33	$1.3x10^{-6}$	1, 2
		$v_1 = 1$	23885.76	$6.0x10^{-8}$	1
		$v_2 = 1, l_1$ $v_2 = 1, l_2$	23996.26 24014.97	$1.7x10^{-7}$ $1.7x10^{-7}$	
	$6 \rightarrow 7$		55916.19	$1.1x10^{-5}$	
$O^{16}C^{13}Se^{78}$	$2 \rightarrow 3$	ground	24030.58	$3.7x10^{-8}$	
$O^{16}C^{13}Se^{80}$	$2 \rightarrow 3$	ground	23880.18	$7.5x10^{-8}$	

CSSe (SCSe) Carbon sulfoselenide

References

[1] B. Bak, R. Sloan and D. Williams, Physical Review **80**, 101 (1950).

CSSe μ =

Molecule	Rotational Transition J	Vibrational State		Frequency		Ref.
$S^{32}C^{12}Se^{82}$	5 → 6	ground		24021		1
		$v_2 = 1$	l_1 l_2	24048 24075		
$S^{32}C^{12}Se^{80}$	5 → 6	ground		24203		
		$v_2 = 1$	l_1 l_2	24214 24230		
$S^{32}C^{12}Se^{78}$	5 → 6	ground		24376		
		$v_2 = 1$	l_1 l_2	24386 24406		
$S^{32}C^{12}Se^{76}$	5 → 6	ground		24602		
		$v_2 = 1$	l_1 l_2	24614 24627		
$S^{32}C^{12}Se^{77}$	5 → 6	ground		24508		
		$v_2 = 1$	l_1 l_2	24521 24527		

C_2F_3N (CF_3CN) Acetonitrile, trifluoro-

	CF_3CN				Ref.
B_0	2947				1

References

[1] J. Sheridan and W. Gordy, Physical Review **77**, 292 (1950).

C_2HCl (HCCCl) Ethyne, chloro-

μ = .44
(Ref. 1)

Some lines due to excited vibrational states were observed on the high frequency side of those listed below[2]. It has been assumed in calculating the intensity that 70 % of the molecules are in the ground vibrational state. The deuterated molecules were actually observed with isotopically enriched samples.

	$HCCCl^{35}$	$HCCCl^{37}$	$DCCCl^{35}$	$DCCCl^{37}$	Ref.
B_0	5684.24	5572.38	5187.01	5084.24	1
$(eqQ)_{Cl}$	-79.67	-62.75	-79.66	-63.12	

References

[1] A. A. Westenberg, J. H. Goldstein and E. B. Wilson, Jr., Journal of Chemical Physics **17**, 1319 (1949).

[2] A. A. Westenberg and E. B. Wilson, Jr., private communication.

C_2HCl

Molecule	Rotational Transition J	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$HCCCl^{35}$	1 → 2	1/2	3/2	22717.07	2.1×10^{-7}	1
		5/2	5/2	22718.80	2.3×10^{-7}	
		5/2	3/2	22732.90	2.5×10^{-8}	
		1/2	1/2	22737.00	2.1×10^{-7}	
		5/2 3/2	7/2 5/2	22738.68	1.6×10^{-6}	
		3/2	3/2	22752.95	2.7×10^{-7}	
		3/2	1/2	22772.82	4.1×10^{-8}	
$HCCCl^{37}$	1 → 2	1/2	3/2	22273,90	6.8×10^{-8}	
		5/2	5/2	22275.10	7.3×10^{-8}	
		1/2	1/2	22289.55	6.8×10^{-8}	
		5/2 3/2	7/2 5/2	22290.85	5.0×10^{-7}	
		3/2	3/2	22302.10	8.7×10^{-8}	
$DCCCl^{35}$	1 → 2	1/2	3/2	20728.03	3.1×10^{-10}	1
		5/2	5/2	20729.79	3.8×10^{-10}	
		5/2	3/2	20744.00	7.0×10^{-11}	
		1/2	1/2	20748.02	3.1×10^{-10}	
		5/2 3/2	7/2 5/2	20749.76	2.4×10^{-10}	
		3/2	3/2	20763.96	4.2×10^{-10}	
		3/2	1/2	20783.80	4.5×10^{-11}	
$DCCCl^{37}$	1 → 2	1/2	3/2	20321.12	1.0×10^{-10}	
		5/2	5/2	20322.50	1.1×10^{-10}	
		1/2	1/2	20336.84	1.0×10^{-10}	
		5/2 3/2	7/2 5/2	20338.29	7.6×10^{-10}	
		3/2	3/2	20349.48	1.3×10^{-10}	

C_2H_2ClF (CH_2CFCl) Ethylene, 1, 1-chlorofluoro- μ =

Since C_2H_2ClF is an asymmetric rotor, two nuclear quadrupole coupling constants must be given as mentioned in the introduction. The notation for the rotational transitions is that of reference Int. 5.

	CH_2CFCl^{35}	CH_2CFCl^{37}			Ref.
B	5102.17	4955.00			1
A	10681.62	10681.33			
C	3448.38	3380.49			
$eQ\left(\frac{\partial^2 V}{\partial a^2}\right)_{Cl}$	-73.3				
$eQ\left(\frac{\partial^2 V}{\partial b^2}\right)_{Cl}$	39.8				

References

[1] J. K. Bragg, T. C. Madison and A. H. Sharbaugh, Physical Review 77, 148 (1950) and erratum, Physical Review 77, 571 (1950).

[2] J. K. Bragg, Physical Review 74, 533 (1948).

C_2H_2ClF

Molecule	Rotational Transition	Frequency Mc			Ref.
CH_2CFCl^{35}	$2_{1,2}$ $3_{0,3}$	20214.29			1
	$6_{1,5}$ $6_{2,4}$	20391.51			
	$1_{0,1}$ $2_{1,2}$	21026.70			
	$2_{1,2}$ $2_{2,1}$	21699.70			
	$6_{4,3}$ $7_{3,4}$	22419.13			
	$7_{2,5}$ $7_{3,4}$	23896.29			
	$3_{1,3}$ $3_{2,2}$	24362.48			
	$5_{0,5}$ $5_{1,4}$	24601.24			
	$6_{2,4}$ $6_{3,3}$	24895.46			
	$7_{1,6}$ $7_{2,5}$	25656.30			
CH_2CFCl^{37}	$1_{0,1}$ $2_{1,2}$	20822.8			
	$2_{1,2}$ $2_{2,1}$	21902.50			
	$8_{5,4}$ $9_{4,5}$	22852.40			
	$3_{1,3}$ $3_{2,2}$	24427.38			

$C_2H_2F_2$ (CH_2CF_2) 1, 1-difluoroethylene μ = 1.366

The notation for the rotational transitions of this asymmetric rotor is that of reference Int. 5.

	$C^{12}H_2C^{12}F_2$				Ref.
B_0	10427.5				1
A_0	11002				
C_0	5345.1				

References

[1] A. Roberts and W. G. Edgell, Journal of Chemical Physics **17**, 742 (1949), and private communication.

Molecule	Rotational Transition	Frequency Mc	Observed Intensity		Ref.
$C^{12}H_2C^{12}F_2$		21482	m		1
		21549	w		
		21573	w		
		21689	m		
	$8_{6,3}-8_{6,2}$	21734	m		
		22236	m		
		22281	s		
		22383	m		
		22391	m		
		22660	w		
		22752	s		
		23181	m		
		23206	w		
		23214	m		
		23220	m		
		23234	w		
		23323	m		
		23361	m		
	$7_{5,3}-7_{5,2}$	23433	s		
		23649	m		
		23770	m		
		23812	m		
		23986	m		
		24021	m		
		24150	w		
		24294	m		
		24323	s		
		24352	m		
		24357	w		

$C_2H_2F_2$--Continued

Molecule	Rotational Transition	Frequency Mc	Observed Intensity		Ref.
$C^{12}H_2C^{12}F_2$ (Continued)		24450	s		
		24545	m		
		24579	w		
		24602	w		
		24639	m		
		24734	m		
	$6_{4,3}-6_{4,2}$	24770	s		
		24806	w		
		24808	w		
	$6_{4,2}-6_{4,1}$	25248**	m		
		25350	s		
		25450	m		
		25516	s		
	$5_{3,3}-5_{3,2}$	25729	s		
		25741	m		
		26118	s		
		26163	m		
	$4_{2,3}-4_{2,2}$	26329	s		
		26337	m		
	$1_{1,1}-2_{1,2}$	26410	w		
	$1_{1,1}-2_{1,2}$	26466	m		
		26634	s		
	$3_{1,3}-3_{1,2}$	26649	m		
		26723	w		
		26832	m		
		26865	s		
	$3-3_0$	26880	m		
	$1_{0,1}-2_{0,2}$	26992	s		
	$4_{1,3}-4_{1,2}$	27014	s		
		27112	m		
		27216	m		
	$5_{2,3}-5_{2,4}$	27297	s		
		27412	m		
		27681	s		

**All identified lines except this one are due to the ground vibrational state.

$C_2H_2F_2$--Continued

Molecule	Rotational Transition	Frequency Mc	Observed Intensity		Ref.
$C^{12}H_2C^{12}F_2$ (Continued)	$6_{3,3}-6_{5,2}$	27818	s		1
		27972	s		
		28174	s		
		28314	w		
		28339	m		
		28412	s		
		28439	m		
		28458	m		
		28551	w		
		28575	w		
		28615	w		
	$7_{4,3}-7_{6,2}$	28689	w		
		28852			
		28858			
		28954	s		
	$1_{1,0}-2_{1,1}$	36632	m		

C_2H_2O (H_2C_2O) Ketene $\mu=1.45$

	$C_2{}^{12}H_2O$	$C_2{}^{12}HDO$	$C_2{}^{12}D_2O$		Ref.
B	10293.28				2
A	280000				
C	9915.87				
D_J	0.0015				
D_{JK}	0. 478				

References

[1] B. Bak, E. S. Knudsen, E. Madsen and J. Rastrup-Anderson, Physical Review **79**, 190 (1950).
[2] H. R. Johnson MITRLE Progress Report, July 15, 1950.

C_2H_2O--Continued

Molecule	Rotational Transition	Vibrational State	Frequency Mc	Intensity cm^{-1}	Ref.
$C_2{}^{12}H_2O$	0→1	ground	20209.76	3.14×10^{-6}	1, 2
		excited	20220.64	9.42×10^{-7}	2
		excited	20232.33	5.65×10^{-7}	
		excited	20267.17	1.29×10^{-6}	1, 2
	1→2		40417.90	2.51×10^{-5}	2
			40038.80	5.29×10^{-5}	
			40793.62	5.50×10^{-5}	
	2→3		60625.68	8.47×10^{-5}	
			60057.92	2.12×10^{-4}	
			60190.24	2.20×10^{-4}	
			60615.88	3.43×10^{-5}	
			60617.30	3.93×10^{-5}	
$C_2{}^{12}HDO$	0→1	ground	18825	5.0×10^{-10}*	1
		excited	18892		
$C_2{}^{12}D_2O$	0→1	ground	17690	8.6×10^{-14}*	1

*Intensities are estimated from those of $C_2{}^{12}H_2O$ above.

C_2H_3Br Ethene, bromo- $\mu = 1.41$

	$C_2H_3Br^{79}$	$C_2H_3Br^{81}$			Ref.
B	4162.3	4138.0			1
C	3863.0	3841.9			
$(eqQ)_{Br}$	479	399			

References

[1] C. D. Cornwell, Journal of Chemical Physics **18**, 1118 (1950.

C_2H_3Cl **Ethyene, chloro-** $\mu = 1.44$

Since C_2H_3Cl is an asymmetric rotor, two nuclear quadrupole coupling constants must be given as mentioned in the introduction. The notation for the rotational transitions is that of reference Int. 5.

	$C_2H_3Cl^{35}$	$C_2H_3Cl^{37}$			Ref.
B_0	6030.5	5903.7			1
A_0	56100	56070.			
C_0	5445.2	5341.3			
$eQ\left(\frac{\partial^2 V}{\partial a^2}\right)_{Cl}$	-57.4				
$eQ\left(\frac{\partial^2 V}{\partial b^2}\right)_{Cl}$	26.2				

References

[1] J. H. Goldstein and J. K. Bragg, Physical Review **75**, 1453 (1949).

C_2H_3Cl

Molecule	Rotational Transition	Frequency Mc			Ref.
$C_2{}^{12}H_3Cl^{35}$	$1_{11} \rightarrow 2_{12}$ $1_{01} \rightarrow 2_{02}$ $1_{10} \rightarrow 2_{11}$	22369.6 22946.9 23538.9			1
$C_2{}^{12}H_3Cl^{37}$	$1_{11} \rightarrow 2_{12}$ $1_{01} \rightarrow 2_{02}$ $1_{10} \rightarrow 2_{11}$	21930.2 22485.9 23055.0			

$C_2H_3F_3$ (CF_3CH_3) **Ethane, 1, 1, 1-trifluoro-** $\mu = 2.321$ (ref. 3)

Since the vibrational frequencies of this molecule are not available, it is impossible to calculate its intensity. However, observed intensities are given[2]. The weaker lines are probably due to an excited vibrational state.

	CF_3CH_3				Ref.
B_0	5185				1

$C_2H_3F_3$--Continued

References

[1] W. F. Edgell and A. Roberts, Journal of Chemical Physics **16**, 1002 (1948).
[2] R. G. Shulman and H. Minden, private communication.
[3] R. G. Shulman, B. P. Dailey and C. H. Townes, Physical Review **78**, 145 (1950).

$C_2H_3F_2$

Molecule	Rotational Transition		Vibrational State	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K				
CF_3CH_3	1 → 2	0, 1	ground	20742.32	$5.0x10^{-7}$	2
			excited	20710.6 20679.9	$2x10^{-7}$ $1x10^{-7}$	1, 2
	2 → 3		ground	31114.4	$2.4x10^{-6}$	2
			excited	31066.8 31020.7	$9.4x10^{-7}$ $3.8x10^{-7}$	

C_2H_3N (CH_3CN) Ethanenitrile

$\mu = 3.97$
(ref. 3)

	$C^{12}H_3C^{12}N^{14}$	$C^{12}H_3C^{12}N^{15}$	$C^{12}H_3C^{13}N^{14}$	$C^{12}D_3C^{12}N^{14}$	$C^{12}D_3C^{13}N^{14}$	$C^{13}H_3C^{12}N^{14}$	Ref.
B_0	9198.8	8921.81	9194.2	7857.93	7848.51	8933.15	2, 3 5
A	150,000 (approximately)						
$(eqQ)_N$	-4.35		-4.35				1, 2 3, 5
α_4	46.3						3
α_7	5.2						
α_8	-22.5						
q_7	4.5						
q_8	17.7						
D_{JK}	0.17			0.11	0.11		5

References

*The lines of identical frequency are not resolved, and the intensity given is their sum.
[1] H. Ring, H. D. Edwards, M. Kessler and W. Gordy, Physical Review **72**, 1262 (1947).
[2] H. H. Nielsen, Physical Review **75**, 1961 (1949).
[3] D. K. Coles, W. E. Good and R. H. Hughes, Physical Review **79**, 224 (1950).
[4] D. F. Smith, M. Tidwell and D. V. P. Williams, Physical Review **77**, 420 (1950).
[5] M. Kessler, H. Ring, R. Trambamlo and W. Gordy, Physical Review **79**, 54 (1950).

C_2H_3N--Continued

Molecule	Rotational Transition		Vibrational State	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K						
$C^{12}H_3C^{12}N^{14}$	0→1		ground	1	1	18396.3	$6.2x10^{-6}$	1
				1	2	18397.7	$1.1x10^{-5}$	
				1	0	18399.8	$2.0x10^{-6}$	
	1→2	0	ground	0	1	36794.26	$2.6x10^{-5}$*	5
				1 2	2 3	36795.38	$1.1x10^{-4}$	
				1	1	36797.52	$1.2x10^{-5}$	
		1	ground	1	2	36793.64	$2.8x10^{-5}$	
				2	2	36794.26	$2.6x10^{-5}$*	
				2	3	36794.88	$5.1x10^{-5}$	
				0	1	36796.27	$1.2x10^{-5}$	
			$v_8 = 1$			36870.94 36903.40 36942.15		5
$C^{12}H_3C^{13}N^{14}$	1→2	0	ground	2 1	3 2	36777.18	$2.2x10^{-6}$	5
$C^{12}D_3C^{12}N^{14}$	2→3	0	ground	1 2 3	2 3 4	47147.60	$2.3x10^{-15}$	
				3	3	47146.00*	$9.3x10^{-17}$	
		1	ground	3 1	4 2	47147.00	$1.4x10^{-15}$	
				2	3	47146.68	$6.5x10^{-16}$	
				3	3	47146.00*	$8.3x10^{-17}$	
	2→3	2	ground	1	2	47146.00*	$2.7x10^{-16}$	
				3 3 3	4 3 2	45145.20	$6.4x10^{-16}$	
				2 2	3 2	47143.85	$4.6x10^{-16}$	
$C^{12}D_3C^{13}N^{14}$	2→3	0	ground	3 2 1	4 3 2	47091.05	$2.6x10^{-17}$	
				3	3	47089.43*	$1.04x10^{-18}$	
		1	ground	3 1	4 2	47090.41	$1.5x10^{-17}$	
				3	3	47089.43*	$9.3x10^{-19}$	
		2	ground	1	2	47089.43*	$3.1x10^{-18}$	
				3 3 3	4 3 2	47088.69	$7.2x10^{-18}$	
				2 2	3 2	47087.39	$5.15x10^{-18}$	

C_2H_3N (CH_3NC) Methyl isocyanide $\mu =$

	$C^{12}H_3NC^{12}$	$C^{12}H_3NC^{13}$			Ref.
B_0	10052.90	9695.91			4
A	150,000 (approximately)				
$(eqQ)_N$	$<\lvert 0.5 \rvert$				

References

[1] H. Ring, H. D. Edwards, M. Kessler and W. Gordy, Physical Review **72**, 1262 (1947).
[2] H. H. Nielsen, Physical Review **75**, 1961 (1949).
[3] D. F. Smith, M. Tidwell and D. V. P. Williams, Physical Review **77**, 420 (1950).
[4] M. Kessler, H. Ring, R. Trambarulo, W. Gordy, Physical Review **79**, 54 (1950).

C_2H_3N

Molecule	Rotational Transition		Vibrational State	Frequency Mc		Ref.
	J	K				
$C^{12}H_3N^{14}C^{12}$	0 → 1	0	ground	20160		1
	1 → 2	1		40210.27		4
		0		40211.16		
	1 → 2		$v_8 = 1$	40313.37 40364.07 40366.55 40424.49		2,4
$C^{12}H_3N^{14}C^{13}$	1 → 2	1		38782.21		
		0		38783.21		
$C^{13}H_3N^{14}C^{12}$						3
$C^{12}D_3NC^{12}$*	1 → 2	0		34327.82		4
		1		34327.23		
	2 → 3	0		51490.90		
		1		51490.05		
		2		51487.51		
CD_3NC^{13}	2 → 3	0		49671.19		
		1		49670.43		
		2		49668.07		

*This isotopic combination was also observed by (3).

C_2H_3NS (CH_3NCS) **Methyl isothiocyanate** $\mu = 3.18$

All of the transitions of this slightly asymmetric rotor are approximately degenerate, except those for which $k=1$. Excited vibrational states are labeled D, E and J in conformity with reference 1. The notation for the rotational transitions is that of reference **Int. 5.**

	CH_3NCS^{32}	CH_3NCS^{34}			Ref.
1/2(B+C)	2526.2	2461.7			1

References

[1] C. I. Beard and B. P. Dailey, MITRLE Tech. Report #79, (1948).
*These are lines of the degenerate vibrational states.

C_2H_3NS

Molecule	Rotational Transition J	Vibrational State	Frequency Mc	Observed Relative Intensity	Ref.
$C^{12}H_3N^{14}C^{12}S^{32}$	$3 \rightarrow 4$		20020	1	1
	$3_{1,3} \rightarrow 4_{1,4}$	ground	20140	10	
		*	20216	100	
			20230	1	
		*E	20241	7	
		*D	20350	20	
			20413	1	
		*J	20443	40	
	$4 \rightarrow 5$		24824	1	
			24971	1	
			25077	1	
			25100	1	
			25161	1	
	$4_{1,4} \rightarrow 5_{1,5}$	ground	25195	10	
		*	25269	100	
		*E	25306	7	
	$4_{1,3} \rightarrow 5_{1,4}$	ground	25333	10	
			25390	1	
			25409	1	
		*D	25442	25	
		*J	25550	40	
	$4_{1,3} \rightarrow 5_{1,4}$	ground J	25653	1	
$C^{13}H_3N^{14}C^{12}S^{32}$	$4 \rightarrow 5$	*	24143	1	
$C^{12}H_3N^{14}C^{13}S^{32}$	$4 \rightarrow 5$	*	25002	1	
$C^{12}H_3N^{14}C^{12}S^{33}$	$4 \rightarrow 5$	*	24930	1	
$C^{12}H_3N^{14}C^{12}S^{34}$	$3 \rightarrow 4$	*	19700	5	
		*J	19929	1	
	$4 \rightarrow 5$	*	24609	5	
		*J	24910	2	
	$5 \rightarrow 6$	*	29700		

C_2H_3NS (CH_3SCN) Methyl thiocyanate $\mu = 3.16$

Only the strongest lines of this slightly asymmetric molecule have been measured.

	$C^{12}H_3S^{32}C^{12}N^{14}$				Ref.
1/2(B + C)	2837.				1

References

[1] L. C. I. Beard and B. P. Dailey, MITRLE Tech. Report **79**, (1948).

Molecule	Rotational Transition	Frequency Mc			Ref.
$C^{12}H_3S^{32}C^{12}N^{14}$	3 → 4	22680			1
	4 → 5	28380			

C_2H_4O Ethane, 1, 2-epoxy- $\mu = 1.88$

This asymmetric top has been investigated in two laboratories. Frequencies given are those of reference (2) and (3) which appear to be the more precise. The notation for the rotational transitions is that of reference Int. 5.

	C_2H_4O	C_2D_4O			Ref.
B_0	22121	15457			2, 3
A_0	25483	20399			
C_0	14097	11544			

References

[1] R. G. Shulman, B. P. Dailey and C. H. Townes, Physical Review **74**, 846 (1948).
[2] G. L. Cunningham, W. I. LeVan and W. D. Gwinn, Physical Review **74**, 1537 (1948).
[3] G. L. Cunningham, A. W. Boyd, W. D. Gwinn and W. I. LeVan, Journal of Chemical Physics **17**, 211 (1949).

C_2H_4O--Continued

Molecule	Rotational Transition		Frequency Mc	Intensity cm^{-1}	Ref.
$C_2{}^{12}H_4O^{16}$	$3_{2,1}$	$3_{3,0}$	23134	$3.9x10^{-6}$	2, 1
	$3_{1,2}$	$3_{2,1}$	23610	$4.1x10^{-6}$	
	$4_{2,2}$	$4_{3,1}$	24834.3	$1.2x10^{-5}$	
	$2_{0,2}$	$2_{1,1}$	24924.4	$3.9x10^{-6}$	
	$5_{3,2}$	$5_{4,1}$	29688	$1.2x10^{-5}$	2
	$4_{3,1}$	$4_{4,1}$	34150	$1.3x10^{-5}$	3
	$2_{1,2}$	$2_{2,1}$	34158	$3.0x10^{-6}$	
	$6_{3,3}$	$6_{4,2}$	35791	$3.4x10^{-5}$	2
	$7_{4,3}$	$7_{5,2}$	37329	$2.5x10^{-5}$	
	$5_{2,3}$	$5_{3,2}$	37781	$1.7x10^{-5}$	
	$6_{4,2}$	$6_{5,1}$	38702	$3.4x10^{-5}$	
	$0_{0,0}$	$1_{1,1}$	39582	$8.3x10^{-6}$	
	$3_{2,2}$	$3_{3,1}$	39677	$1.2x10^{-5}$	
	$4_{1,3}$	$4_{2,2}$	41581	$1.9x10^{-5}$	3
	$8_{5,3}$	$8_{6,2}$	43398	$6.6x10^{-5}$	
$C_2{}^{12}D_4O^{16}$	$4_{1,3}$	$4_{2,2}$	21664	$7.4x10^{-21}$	3
	$3_{0,3}$	$3_{2,1}$	24055	$3.4x10^{-21}$	
	$5_{1,3}$	$5_{3,2}$	24668	$1.1x10^{-20}$	
	$2_{1,2}$	$2_{2,1}$	26565	$2.4x10^{-21}$	
	$6_{2,4}$	$6_{3,3}$	28495	$1.8x10^{-20}$	
	$3_{1,2}$	$3_{2,1}$	29080	$5.0x10^{-21}$	
	$0_{0,0}$	$1_{1,1}$	31943	$5.1x10^{-21}$	
	$3_{1,3}$	$3_{2,2}$	33285	$6.4x10^{-21}$	
	$8_{3,5}$	$8_{4,4}$	35068	$3.7x10^{-20}$	
	$3_{2,2}$	$3_{3,1}$	35341	$7.4x10^{-21}$	
	$5_{3,2}$	$5_{4,1}$	39592	$1.8x10^{-20}$	

C_2H_6O (C_2H_5OH) Ethanol $\mu = 1.7$

References

[1] B. Bak, E. S. Knudsen and E. Madsen, Physical Review **75**, 1622 (1949).

C_2H_6O

Molecule	Frequency Mc	Ref.
C_2H_5OH	22820 23081 23148 23555 23605 24295 24369 24385 25069	1

C_3HF_3 (CF_3CCH) Acetylene, trifluoromethyl-

	C_3HF_3				Ref.
B	2877.945				1
D_J	0.22 Kc				
D_{JK}	6.5 Kc				

References

[1] W. E. Anderson, J. Sheridan and W. Gordy, Duke Progress Report, May - August 1950.

C_3HN (HCCCN) Acetylene, cyano- $\mu = 3.6$

It is assumed in calculating the intensity that 70 % of the molecules are in the ground vibrational state. A few lines due to excited vibrational states were observed on the high frequency side of the spectrum.[1]

	HCCN	HCCCN^{15}	HCCC^{13}N	HCC^{13}CN	HC^{13}CCN	Ref.
B_0	4549.07	4416.91	4530.23	4529.84	4408.45	1
$(eqQ)_N$	-4.2		-4.2			

	DCCCN	DCCCN^{15}	DCCC^{13}N	DCC^{13}CN	DC^{13}CCN	Ref.
B_0	4221.60	4100.41	4202.54	4207.59	4107.21	1
$(eqQ)_N$	-4.2		-4.2			

References

[1] A. A. Westenberg and E. B. Wilson, jr., private communication.

C_3HN--Continued

Molecule	Rotational Transition	Frequency Mc	Intensity cm^{-1}	Ref.
	J			
HCCCN	1 → 2	18196.6	1.2x10^{-4}	1
	2 → 3	27294.47	3.8x10^{-4}	
HCCCN^{15}	2 → 3	26501.46	1.3x10^{-6}	
HCCC^{13}N	2 → 3	27181.45	4.2x10^{-6}	
HCC^{13}CN	2 → 3	27179.10	4.2x10^{-6}	
HC^{13}CCN	2 → 3	26450.73	3.8x10^{-6}	
DCCCN	2 → 3	25329.62	6.0x10^{-8}	
DCCCN^{15}	2 → 3	24602.45	2.2x10^{-10}	
DCCC^{13}N	2 → 3	25215.30	6.6x10^{-10}	
DCC^{13}CN	2 → 3	25245.58	6.6x10^{-10}	
DC^{13}CCN	2 → 3	24643.29	6.2x10^{-10}	

C_3H_3Br (CH_3CCBr) Propyne, 1-bromo- μ =

	CH_3CCBr^{79}	CH_3CCBr^{81}		Ref.
B_0	1562	1549		1

References

[1] J. Sheridan and W. Gordy, Physical Review **79**, 224 (1950).

C_3H_4 (CH_3CCH) Propyne μ = 0.75

	CH_3CCH	$CH_3CC^{13}H$	$CH_3C^{13}CH$	$C^{13}H_3CCH$	CH_3CCD	CD_3CCD	Ref.
B_0	8545.84	8290.24	8542.28	8313.23	7788.14	6734.31	1
D_{JK}	0.16_1	0.1_3	0.1_6	0.1_6	0.1_4	0.0_9	
D_J	$.00_5$						

References

[1] R. Trambarulo and W. Gordy, Duke Progress Report, May - August, 1950.

C_3H_4

Molecule	Rotational Transition		Vibrational State	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K				
$C^{12}H_3C^{12}C^{12}H$	1 2	0	ground	34183.37	3.6×10^{-6}	1
		1	ground	34182.71	2.7×10^{-6}	
			$v_{10} = 1$	34246.30		
				34277.05		
			$v_{10} = 1$	34278.98		
				34313.21		
	2 3	0	ground	51274.75	1.2×10^{-5}	
		1		51273.76	1.1×10^{-5}	
		2		51270.86	6.8×10^{-6}	
			$v_9 = 1$	51280.45		
				51296.33		
				51304.05		
				51305.93		
				51307.47		
				51334.81		

C_3H_4--Continued

Molecule	Rotational Transition		Vibrational State	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K				
$C^{12}H_3C^{12}C^{12}H$ (Continued)	2→3		$v_{10}=1$	51369.12 51410.51 51415.35 51418.23 51418.75 51469.85		1
$C^{12}H_3C^{13}C^{12}H$	1→2	0	ground	34169.13	$3.9x10^{-8}$	
		1		34168.47	$2.9x10^{-8}$	
$C^{13}H_3C^{12}C^{12}H$	1→2	0	ground	33252.88	$3.6x10^{-8}$	
		1		33252.22	$2.8x10^{-8}$	
$C^{12}H_3CC^{13}H$	1→2	0	ground	33160.94	$3.6x10^{-8}$	
		1		33160.35	$2.7x10^{-8}$	
$C^{12}H_3C^{12}C^{12}D$	1→2	0	ground	31152.56	$5.4x10^{-10}$	
		1		31152.00	$4.0x10^{-10}$	
$C^{12}D_3C^{12}C^{12}D$	1→2	0	ground	26937.24	$1.4x10^{-17}$	
		1		26936.87	$1.0x10^{-17}$	

C_3H_6O $(CH_3)_2CO$ 2-propanone $\mu = 2.8$

References

[1] B. Bak, E. S. Knudsen and E. Madsen, Physical Review **75**, 1622 (1949).
[2] C. C. Loomis, MITRLE Progress Report, July 1949.
*These three lines were only very roughly measured, and are not included in frequency listing.

C_3H_6O

Molecule	Frequency Mc	Ref.
$(CH_3)_2CO$	22410* 22500* 22560* 22940 23339 23603 23661 23749 23778	1

Molecule	Frequency Mc	Ref.
$(CH_3)_2CO$ -- Continued	23793 23827 23839 23934 24102 24646 24691 24758	1

Many additional lines in region 27,000-29,000 were found (2).

C_4H_9Br $(CH_3)_3CBr$ Propane, 2-bromo-2methyl- $\mu = 2.21$

	$(CH_3)_3CBr^{79}$	$(CH_3)_3CBr^{81}$			Ref.
$B_0 =$	2044.	2028			1

References

[1] J. Q. Williams and W. Gordy, Journal of Chemical Physics 18, 994 (1950).

C_4H_9Br

Molecule	Rotational Transition	Frequency Mc			Ref.
$(C^{12}H_3)_3C^{12}Br^{79}$	$6 \to 7$	28610			1
	$7 \to 8$	32690			
	$8 \to 9$	36790			
	$9 \to 10$	40885			
$(C^{12}H_3)_3C^{12}Br^{81}$*	$6 \to 7$				
	$7 \to 8$				
	$8 \to 9$				
	$9 \to 10$				

*Misprint in reference (1).

C_4H_9Cl $(CH_3)_3CCl$ Propane, 2-chloro-2methyl- $\mu = 2.15$

	$(CH_3)_3CCl^{35}$	$(CH_3)_3CCl^{37}$			Ref.
B_0	3016.	2954.			1

References

[1] J. Q. Williams and W. Gordy, Journal of Chemical Physics 18, 994 (1950).

C_4H_9Cl--Continued

Molecule	Rotational Transition J	Frequency Mc			Ref.
$(C^{12}H_3)_3C^{12}Cl^{35}$	4 → 5	30150			1
	5 → 6	36210			
	6 → 7	42200			
$(C^{12}H_3)_3C^{12}Cl^{37}$	4 → 5	29530			1
	5 → 6	35460			
	6 → 7	41330			

C_4H_9I $(CH_3)_3CI$ Propane, 2-iodo-2methyl- $\mu = 2.13$

	$(C^{12}H_3)_3C^{12}I^{127}$				Ref.
B_0	1562				1

References

[1] J. Q. Williams and W. Gordy, Journal of Chemical Physics **18**, 994 (1950).

C_4H_9I

Molecule	Rotational Transition J	Frequency Mc			Ref.
$(C^{12}H_3)_3C^{12}I^{127}$	8 → 9 9 → 10 10 → 11 11 → 12 12 → 13	28085 31185 34310 37490 40570			1

$C_4H_{10}O$ $(C_2H_5)_2O$ Ethane, ethoxy-

References

[1] D. R. Lide and D. K. Coles, private communication.
*Observed at 195° K.

$C_4H_{10}O$

Molecule	Frequency Mc	Observed Relative Intensity*	Ref.
$C_4H_{10}O$	19230	1	1
	19440	5	
	19590	5	
	20260	1	
	20320	1	
	20510	1	
	20570	1	
	20720	1	
	20740	5	
	20880	5	
	20950	5	
	20965	5	
	21000	10	
	21175	1	
	21230	5	
$C_4H_{10}O$ -- Continued	21310	1	1
	21340	5	
	21450	1	
	21560	5	
	21780	1	
	21850	0	
	21890	1	
	22015	10	
	22215	1	
	22490	0	
	22900	1	
	23080	1	
	23250	5	

C_6H_5Br Benzene, bromo- $\mu = 1.6$

References

[1] B. Bak, E. S. Knudsen and E. Madsen, Physical Review **75**, 1622 (1949).
*Very roughly measured, not in frequency listing.

C_6H_5Br

Molecule	Frequency Mc				Ref.
C_6H_5Br	23690				1
	23742				
	22050*				

ClF (FCl) Chlorine monofluoride $\mu = 0.881$

Intensities were calculated on the assumption that 94 % of the molecules were in the ground vibrational state, and 6 % in the first vibrational state.

	FCl^{35}	FCl^{37}			Ref.
B_0	15483.69	15189.22			1
$(eqQ)_{Cl}$	-145.99	-114.92			
α	130.666	126.957			

References

[1] D. A. Gilbert, A. Roberts and P. A. Griswold, Physical Review **76**, 1723 (1949).

ClF--Continued

Molecule	Rotational Transition J	Vibrational State	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
FCl^{35}	0→1	ground	3/2	3/2	30807.41	$1.1x10^{-5}$	1
			3/2	5/2	30843.95	$1.7x10^{-5}$	
			3/2	1/2	30873.00	$5.6x10^{-6}$	
		v=1	3/2	3/2	30545.99	$6.7x10^{-7}$	
			3/2	5/2	30582.61	$1.0x10^{-6}$	
			3/2	1/2	30611.76	$3.3x10^{-7}$	
FCl^{37}	0→1	ground	3/2	3/2	30228.36	$3.85x10^{-6}$	
			3/2	5/2	30257.16	$5.8x10^{-6}$	
			3/2	1/2	30280.11	$1.9x10^{-6}$	
		v=1	3/2	3/2	29974.47	$2.3x10^{-7}$	
			3/2	5/2	30003.22	$3.5x10^{-7}$	
			3/2	1/2	30026.19	$1.2x10^{-7}$	

ClF_3Ge (GeF_3Cl) Germane, chlorotrifluoro- μ =

	$Ge^{74}F_3Cl^{35}$	$Ge^{74}F_3Cl^{37}$			Ref.
B_0	2166.49	2137.8			1

References

[1] W. Anderson, J. Sheridan and W. Gordy, Duke Progress Report, May-August, (1950).

ClF_3Si (SiF_3Cl) Silane, chlorotrifluoro- μ =

The J = 6→7, 7→8, 8→9 transitions of $Si^{28}F_3Cl^{35}$ and the J = 7→8 transition of $Si^{28}F_3Cl^{37}$ were observed[1].

	$Si^{28}F_3Cl^{35}$	$Si^{28}F_3Cl^{37}$			Ref.
B_0	2478	2414			1

References

[1] J. Sheridan and W. Gordy, Physical Review **77**, 719 (1950).

$ClGeH_3$ (GeH_3Cl) Germane, chloro- $\mu = 1.88$

The following values were determined from the J = 0 → 1 transition.

	$Ge^{70}H_3Cl^{35}$	$Ge^{74}H_3Cl^{35}$	$Ge^{74}H_3Cl^{37}$	$Ge^{76}H_3Cl^{35}$	Ref.
B_0	4401.71	4333.91	4177.90	4146.5	1,2
$(eqQ)_{Ge^{73}}$	-95				
$(eqQ)_{Cl}$	-46		-36	-46	

References

[1] C. H. Townes, J. M. Mays and B. P. Dailey, Physical Review **76**, 700 (1949), and 137 (1949).

[2] J. M. Mays, Thesis, Columbia University, (1950).

**Lines of Ge^{72} and Ge^{73} were also found.

ClH_3Si (SiH_3Cl) Silane, chloro- $\mu = 1.303$ (Ref. 2)

Intensities were calculated assuming that 90% of the molecules are in ground vibrational state.

	$Si^{28}H_3Cl^{35}$	$Si^{28}H_3Cl^{37}$	$Si^{30}H_3Cl^{35}$		Ref.
B_0	6673.81	6512.40	6485.8		1,3
$(eqQ)_{Cl}$	-40.0	-30.8	-40.0		

References

[1] C. H. Townes, J. M. Mays and B. P. Dailey, Physical Review **76**, 700 (1949), and **76**, 137 (1949).

[2] J. M. Mays, Thesis, Columbia University (1950).

[3] A. H. Sharbaugh, private communication.

ClH_3Si--Continued

Molecule	Rotational Transition J	Rotational Transition K	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$Si^{28}H_3Cl^{35}$	1→2	0	1/2	3/2	26685.25	$3.4x10^{-7}$	3
			5/2	5/2	26686.15	$3.7x10^{-7}$	
			1/2	1/2	26695.00	$3.4x10^{-7}$	
			3/2 5/2	5/2 7/2	26696.10	$2.5x10^{-6}$	
			3/2	3/2	26703.34	$4.5x10^{-7}$	
			3/2	1/2	26713.07	$7.0x10^{-8}$	
		1	3/2	5/2	26687.34	$6.6x10^{-7}$	
			3/2	3/2	26690.92	$3.4x10^{-7}$	
			5/2	5/2	26692.66	$2.8x10^{-7}$	
			5/2	7/2	26697.45	$1.3x10^{-6}$	
			1/2	3/2	26700.48	$2.6x10^{-7}$	
			1/2	1/2	26705.02	$2.6x10^{-7}$	
$Si^{28}H_3Cl^{37}$	1→2	0	1/2 5/2	3/2 5/2	26042.41	$2.2x10^{-7}$	
			3/2 5/2	5/2 7/2	26050.26	$7.9x10^{-7}$	
			3/2	3/2	26055.86	$1.4x10^{-7}$	
			3/2	1/2	26063.52	$2.2x10^{-8}$	
	1→2	1	3/2	5/2	26043.29	$2.0x10^{-7}$	
			3/2	3/2	26046.30	$1.0x10^{-7}$	
			5/2	5/2	26047.97	$8.7x10^{-8}$	
			5/2	7/2	26051.09	$3.9x10^{-7}$	
			1/2	3/2	26053.35	$8.1x10^{-8}$	
			1/2	1/2	26057.10	$8.1x10^{-8}$	

ClI (ICl) Iodine monchloride μ = 0.65

The half widths, (Δ ν =3.15 for J = 0→1 and 5.5 for J=3→4) dipole moment and intensities are discussed in reference 2.

	ICl^{35}	ICl^{37}			Ref.
B_e	3422.300				2
$(eqQ)_{Cl^{35}}$	-82.5				
$(eqQ)_I$	-2930.0				
α	16.060				

The half widths, (3.15 and 5.5) dipole moment and intensities are discussed in reference

References

μ =

[1] R. T. Weidner, Physical Review **72**, 1268 (1947), and **73**, 254 (1948).

[2] C. H. Townes, A. N. Holden and F. R. Merritt, Physical Review **73**, 1334 (1948).

ClI--Continued

Molecule	Rotational Transition	Vibrational State	F_{1i}	F_i	F_{1f}	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
ICl^{35}	0 → 1	ground	5/2		1/2		6980	1.1x10^{-6}	1
	3 → 4	ground	3/2	2	5/2	3	27194.75	9.1x10^{-7}	2
			3/2	1	5/2	2	27202.64	5.0x10^{-7}	
			3/2	3	5/2	4	27204.99	1.5x10^{-6}	
			5/2	3	7/2	4	27217.51	1.4x10^{-6}	
			5/2	2	7/2	3	27221.02	1.0x10^{-6}	
			5/2	4	7/2	5	27225.32	2.0x10^{-6}	
			5/2	1	7/2	2	27228.34	7.3x10^{-7}	
			1/2	1	3/2	2	27242.59	3.9x10^{-7}	
			1/2	2	3/2	3	27254.90	1.1x10^{-6}	
			7/2 9/2		9/2		27283.66		
			7/2 9/2		9/2		27286.25		
			7/2 9/2		9/2		27292.63		
			7/2 9/2		9/2		27295.05		
			7/2 9/2	5	11/2	6	27333.85	2.8x10^{-6}	
			11/2 11/2	5 6	13/2 13/2	6 7	27336.68	6.8x10^{-6}	
			11/2 11/2	4 7	13/2 13/2	5 8	27337.38	6.8x10^{-6}	
			9/2	3	11/2	4	27346.31	1.9x10^{-6}	
			9/2	4	11/2	5	27554.71	2.3x10^{-6}	
			9/2	6	11/2	7	27356.58	3.4x10^{-6}	
			9/2	5	11/2	6	27357.73	2.8x10^{-6}	
		v = 1	11/2		13/2		27208.54	2.2x10^{-6}	
ICl^{37}	0 → 1	ground	5/2		7/2		6684.	3.1x10^{-7}	1
	3 → 4	ground	11/2		13/2		26181.6	4.4x10^{-6}	2

ClNO (NOCl) Nitrosyl chloride $\mu = 1.83$

The intensities were calculated on the basis of the symmetric top formula. The notation for the rotational transitions of this asymmetric rotor is that of reference Int. 5.

	$NOCl^{35}$	$NOCl^{37}$			Ref.
B_0	5696.0	5665.8			1
A_0	159289	170168			
C_0	5499.4	5483.2			
$(eqQ)_{Cl}$	-62	-48			
$(eqQ)_N$	-5.45				

References

[1] W. J. Pietenpol, J. D. Rogers and D. Williams, Physical Review **77**, 741 (1949), and private communication.

[2] W. J. Pietenpol, J. D. Rogers, and D. Williams, Physical Review **78**, 480 (1950).

ClNO

Molecule	J i	J f	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$NOCl^{35}$	$1_{1,1}$	$2_{1,2}$	3/2	5/2	21857	4.9×10^{-7}	1
			3/2	3/2	21861	2.5×10^{-7}	
			5/2	5/2	21865	2.1×10^{-7}	
			5/2	7/2	21869	9.0×10^{-7}	
			1/2	3/2	21874	2.0×10^{-7}	
			1/2	1/2	21879	2.0×10^{-7}	
	$1_{0,1}$	$2_{0,2}$	1/2 5/2	3/2 5/2	22215	5.4×10^{-7}	
			5/2 3/2	7/2 5/2	22227	1.9×10^{-6}	
			3/2	3/2	22236	3.3×10^{-7}	
	$1_{0,1}$	2_{11}	3/2	5/2	22580	4.8×10^{-7}	
			3/2 5/2	3/2 5/2	22586	4.5×10^{-7}	
			5/2 1/2	7/2 3/2	22593	1.1×10^{-6}	
			1/2	1/2	22600	1.9×10^{-7}	
	J = 2 → 3						2

ClNO--Continued

Molecule	J i	J f	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
$NOCl^{37}$	$1_{1,1}$	$2_{1,2}$	3/2	5/2	21363	$1.6x10^{-7}$	1
			3/2	3/2	21365	$8.2x10^{-8}$	
			5/2	5/2	21367	$6.8x10^{-8}$	
			5/2	7/2	21372	$3.0x10^{-7}$	
	$1_{0,1}$	$2_{0,2}$	1/2	3/2	21704	$1.7x10^{-7}$	
			5/2	5/2			
			5/2	7/2	21713	$6.1x10^{-7}$	
			3/2	5/2			
			3/2	3/2	21720	$1.1x10^{-7}$	
	$1_{1,0}$	$2_{1,1}$	3/2	5/2	22052	$1.6x10^{-7}$	
			3/2	3/2	22056	$1.5x10^{-7}$	
			5/2	5/2			
			5/2	7/2	22062	$3.1x10^{-7}$	
			1/2	3/2	22068	$6.4x10^{-8}$	
	J= 2→3						2

Cl_3OP ($POCl_3$) Phosphorous oxytrichloride

$\mu = 2.4$

	$POCl_3{}^{35}$	$POCl_3{}^{37}$			Ref.
B_0	2015.2	1932.			1

References

[1] Q. Williams, J. Sheridan and W. Gordy, Duke Progress Report, May - August, 1950.

Cl_3P (PCl_3) Phosphorous trichloride

$\mu = 0.80$

The notation for the rotational transitions of this asymmetric rotor is that of reference Int. 5.

	$PCl^{35}{}_3$	$PCl^{37}{}_3$			Ref.
B_0	2617.1	2487.5			1

References

[1]P. Kisliuk and C. H. Townes, Journal of Chemical Physics **18**, 1109 (1950).

Cl_3P--Continued

Molecule	Rotational Transition J	J i	J f	Frequency Mc	Intensity cm^{-1}	Ref.
PCl_3^{35}	4→5			26171 26190* 26152*	$9.8x10^{-8}$	1
$PCl_2^{35}Cl^{37}$	4→5	$4_{3,1}$	$5_{4,1}$	25552		
		$4_{2,2}$	$5_{3,2}$	25649		
		$4_{1,3}$	$5_{2,3}$	25716		
		$4_{1,4}$	$5_{2,4}$			
		$4_{0,4}$	$5_{1,4}$	25725		
		$4_{2,3}$	$5_{3,3}$			
		$4_{3,2}$	$5_{4,2}$	25748		
		$4_{4,1}$	$5_{5,1}$	25971		
$PCl_2^{37}Cl^{35}$	4→5			25306		
PCl_3^{37}	4→5			24875	$2.8x10^{-9}$	

*Excited vibrational States.

Cl_3PS ($PSCl_3$) **Phosphorous thiotrichloride** $\mu =$

	$PS^{32}Cl_3^{35}$				Ref.
B_0	1402.7				1

References

[1]Q. Williams, J. Sheridan and W. Gordy, Duke Progress Report, May to August, (1950).

Cl_3Sb ($SbCl_3$) Antimony trichloride $\mu = 3.9$

	$Sb^{121}Cl_3^{35}$	$Sb^{123}Cl_3^{35}$			Ref.
B_0	1754	1750.5			

References

[1] P. Kisliuk, C. R. L. Quarterly Report, September 30, 1950, and private communication.

Cl_3Sb

Molecule	Rotational Transition	Frequency Mc			Ref.
$Sb^{121}Cl_3^{35}$	6 → 7	24554			1
$Sb^{123}Cl_3^{35}$	6 → 7 7 → 8*	24510			

*This transition has also been observed.

FH_3Si (SiH_3F) Silane, fluoro- $\mu = 1.268$

Intensities were calculated assuming 90% of the molecules to be in the ground vibrational state.

	$Si^{28}H_3F$	$Si^{29}H_3F$	$Si^{30}H_3F$		Ref.
B_0	14327.9	14196.7	14072.6		1

References

[1] A. H. Sharbaugh, V. G. Thomas and B. S. Pritchard, Physical Review **78**, 64 (1950).

FH_3Si

Molecule	Rotational Transition J	Frequency Mc	Intensity		Ref.
$Si^{28}H_3F$	0 → 1	28655.80	6.8×10^{-6}		1
$Si^{29}H_3F$	0 → 1	28393.4	4.7×10^{-7}		
$Si^{30}H_3F$	0 → 1	28145.2	3.0×10^{-7}		

F_3HSi (SiF_3H) Silane, trifluoro- $\mu =$

	$Si^{28}F_3H$				Ref.
B_0	7207.98				1

References

[1] J. Sheridan and W. Gordy, Physical Review **77**, 719 (1950).

F_3HSi

Molecule	Rotational Transition J	Frequency Mc			Ref.
$Si^{28}F_3H$	1 → 2	28831.90			1
	2 → 3*				
$Si^{29}F_3H$	2 → 3*				

*These transitions were also observed.

F_3N (NF_3) Nitrogen trifluoride $\mu = 0.21$

	$N^{14}F_3$	$N^{15}F_3$			Ref.
B_0	10680.96	10629.35			1
$(eqQ)_{N^{14}}$	-7.07				
D_{JK}	-0.025				

References

[1] J. Sheridan and W. Gordy, Physical Review **79**, 513 (1950).

F_3N--Continued

Molecule	Rotational Transitions		F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J	K					
$N^{14}F_3$	1 → 2	0	2	2	42721.73	$1.2\text{x}10^{-8}$	1
			0	1	42722.16*	$4.4\text{x}10^{-8}$	
			1	2			
					42723.94	$1.05\text{x}10^{-7}$	
			2	3			
			1	1	42727.39	$1.2\text{x}10^{-8}$	
		1	1	2	42722.16*	*	
			2	2	42723.28	$9.2\text{x}10^{-9}$	
			2	3	42724.36	$5.1\text{z}10^{-8}$	
			0	1	42726.60	$1.2\text{x}10^{-8}$	
$N^{15}F_3$**	1 → 2	0,1			42517.38	$8.3\text{x}10^{-10}$	

*These two lines were not resolved, and the intensity is the sum of the two.
**Observed with an enriched sample.

F_3OP (OPF_3) Phosphorous oxytrifluoride

$\mu = 1.735$
(ref. 1)

	F_3OP				Ref.
B_0	4594				1, 2

References

[1] S. J. Senatore, Physical Review **78**, 293 (1950).
[2] W. Gordy, J. Sheridan and Q. Williams, Duke Quarterly Progress Report, May - August, 1950.

F_3OP

Molecule	Rotational Transition	Frequency Mc			Ref.
OPF_3	0 → 1	9186.99			1

F_3P (PF_3) Phosphorous trifluoride

μ =
(Ref. 2)

Intensities were calculated assuming 80% of the molecules in the ground vibrational state and the half width, Δν, equal to 16.

	PF_3				Ref.
B_0	7819.90				1

References

[1] O. R. Gilliam, H. D. Edwards and W. Gordy, Physical Review **75**, 1014 (1949).
[2] R. G. Shulman, B. P. Dailey and C. H. Townes, Physical Review **78**, 145 (1950).

F_3P

Molecule	Rotational Transition		Frequency Mc	Intensity cm^{-1}		Ref.
	J	K				
PF_3	1→2	0,1	31279.60	2.3x10^{-6}		1
	2→3	0,1	46918.82	6.7x10^{-6}		
		2	46919.02	1.5x10^{-6}		
	2→3		46940** 47010** 47033** 47040**			

**Excited vibrational states.

F_3PS (SPF_3) Phosphorous thiotrifluoride

μ=

	$S^{32}PF_3$	$S^{34}PF_3$			Ref.
B_0	2657.637	2579.766			2
D_{JK}	1.8 Kc.				

References

[1] A. Roberts, private communication.
[2] W. Gordy, J. Sheridan and Q. Williams, Duke Progress Report, May - August, 1950.

F_3PS--Continued

Molecule	Rotational Transition J	Frequency Mc			Ref.
$S^{32}PF_3$	3→4	21262			1
	4→5	21283*			
	4→5	26574 26553*			

*Excited vibrational states.

HN_3 Hydrazoic acid

$\mu = 0.847$
(ref. 1)

References

[1] E. Amble and B. P. Dailey, Journal of Chemical Physics **18**, 1422 (1950).

HN_3

Molecule	Rotational Transition J	Frequency Mc			Ref.
$HN_3{}^{14}$	0→1	23815.7			1
$HN_2{}^{14}N^{15}$	0→1	23048.2			
$HN^{14}N^{15}N^{14}$	0→1	23814			
$DN_3{}^{14}$	0→1	22316.1			

H_2O Water

$\mu = 1.94$
(ref. 3)

The H_2O line has been investigated at higher pressures by several workers not quoted herein. For this asymmetric rotor the notation for the rotational transitions is that of reference Int. 5, and $\kappa = -0.696$[6] is a measure of the asymmetry.

References

[1] C. H. Townes and F. R. Merritt, Physical Review **70**, 558 (1946).
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[4] M. W. P. Strandberg, T. Wentink jr., R. E. Hillger, G. H. Wannier and M. L. Deutsch, Physical Review **73**, 188 (1948).
[5] M. W. P. Strandberg, MITRLE Report #85 (1948).
[6] M. W. P. Strandberg, Journal of Chemical Physics **17**, 901 (1949).

H_2O--Continued

Molecule	Rotational Transition	Frequency Mc	Intensity cm^{-1}		Ref.
H_2O^{16}	$5_{2,3},\rightarrow 6_{1,6}$	22235.22	9.6×10^{-6}		1, 2,3
HDO^{16}	$2_{1,2},\rightarrow 2_{0,2}$	10278.99	8.6×10^{-9}		5
	$4_{1,4},\rightarrow 3_{1,2}$	20460.40	1.3×10^{-8}		
	$5_{3,3},\rightarrow 5_{3,2}$	22307.67	1.0×10^{-8}		2,4
	$3_{2,2},\rightarrow 3_{2,1}$	50236.90	1.1×10^{-7}		5

H_2S Hydrogen sulfide

$\mu = 1.02$
(ref. 1)

Reference (1) also includes certain centrifugal distortion coefficients. The notation for the rotational transitions of this asymmetric rotor is that of reference Int. 5.

References

[1]R. E. Hillger, MITRLE Progress Report, October 15, 1949, July 15, 1950.

H_2S

Molecule	Rotational Transition	Frequency Mc	Intensity*		Ref.
HDS^{32}	$1_{1,1} - 1_{1,0}$	51073.27	2.9×10^{-4}		1
	$2_{2,1} - 2_{2,0}$	11283.83	2.3×10^{-5}		
	$3_{2,2} - 3_{2,1}$	53200.93	3.0×10^{-4}		
	$4_{3,2} - 4_{3,1}$	10861.07	1.3×10^{-5}		
	$5_{3,3} - 5_{3,2}$	40929.20	1.1×10^{-5}		
	$6_{4,3} - 6_{4,2}$	7936.74	3.2×10^{-6}		
	$7_{4,4} - 7_{4,3}$	27566.31	2.1×10^{-5}		
	$8_{4,5} - 8_{4,4}$	75551.73	7.6×10^{-5}		
	$9_{5,5} - 9_{5,4}$	17212.61	2.2×10^{-6}		
	$10_{5,6} - 10_{5,5}$	47905.36	8.0×10^{-6}		
	$11_{6,6} - 11_{6,5}$	10235.81	1.5×10^{-7}		
	$12_{6,7} - 12_{6,6}$	28842.84	4.8×10^{-7}		
HDS^{34}	$1_{1,1} - 1_{1,0}$	50912.27	1.3×10^{-5}		
	$2_{2,1} - 2_{2,0}$	11235.45	1.0×10^{-6}		
	$3_{2,2} - 3_{2,1}$	52979.67	1.4×10^{-5}		
	$4_{3,2} - 4_{3,1}$	10802.36	5.9×10^{-7}		
	$7_{4,4} - 7_{4,3}$	27392.00	1.1×10^{-6}		
HDS^{33}	$2_{2,1} - 2_{2,0}$	11258.21**	9.1×10^{-8}		1

*Calculated in Ref. 1 for T = 195° K.
**Most intense line of a group.

H_3N (NH_3) Ammonia

The ammonia spectrum is the first known, and one of the most widely studied microwave spectra[1,2,3,4]. It is unusual in being produced by inversion or vibration, rather than rotation of the molecule, and is of considerably greater intensity than other microwave spectra of the same frequency. The dependence of the inversion frequency on the rotational quantum numbers J and K of the molecule, produces a "fine" structure. One of the most recent and best fitting formulas for the fine structure of $N^{14}H_3$ is[5]

$$\begin{aligned}\nu = 23{,}785.8 &- 151.450J(J+1)+211.342K^2+0.503027\,(J+1)^2\\ &-1.38538J(J+1)K^2+0.949155K^4\\ &-0.001259997J^3(J+1)^3+0.005182367\,J^2(J+1)^2K^2\\ &-0.007088534J(J+1)K^4+0.003210437K^6\end{aligned}$$

There is a systematic deviation from such formulas when $K=3$[6] due to higher order terms in the molecular Hamiltonian which can perturb these levels because of their three-fold symmetry[7]. Most of the lines listed for the deutero ammonias probably involve inversion, but have not yet been identified in detail.

Each of the $N^{14}H_3$ lines may be expected to show hyperfine structure due to the quadrupole coupling of the N^{14} nucleus[8,9,10,11,12]. Additional small frequency shifts of this hyperfine structure have been detected[12] and explained as resulting from the magnetic coupling of the N^{14} nucleus[13].

The symmetric pattern, due to quadrupole coupling, of two weak lines (not listed in this table), on each side of the stronger lines listed, have been studied up to $J=9$[12]. The frequency differences between these satellites and the strong components are given by:

$$\delta\nu = \pm\ 3/4eqQ\Big[1-\frac{3K^2}{J(J+1)}\Big)\ \frac{J+1}{2J+3} - (J+1)\Big\{\frac{0.0011K^2}{J(J+1)} + 0.0057\Big\}\Big]$$

$$\delta\nu' = \pm\ 3/4eqQ\Big[1-\frac{3K^2}{J(J+1)}\Big)\ \frac{J}{2J-1} + J\Big\{\frac{0.0011K^2}{J(J+1)} + 0.0057\Big\}\Big]$$

The sign of eqQ cannot be definitely measured experimentally, but is very probably negative, and is assumed to be negative in the expressions above for $\delta\nu$ and $\delta\nu'$. The intensities for the weak hyperfine components relative to the strong components decrease approximately as $1/J^2$, the rather involved exact expressions being given by White[14], and tabulated for low values of J.

Intensities listed in the table are for the entire fine structure lines without resolution of the hyperfine components, assuming for each line a half-width ($\Delta\nu$) of 25 Mc, that measured for the (3,3) line[4]*. The intensities as a function of J and K are then given approximately by

$$\gamma_{max} = 6.5 \times 10^{-11}\ \frac{V^2}{T}\ \frac{K^2(2J+1)}{J(J+1)}\ \exp\Big\{\frac{-14.3}{T}\ \Big[J(J+1)-0.366K^2\Big]\Big\}$$

Bleaney and Penrose[15] find actually that for a number of NH_3 lines $\Delta\nu$ depends on J and K according to the formula

$$\left(\frac{K^2}{J(J+1)}\right)^{1/3}$$

as was partly justified in their paper, and later discussed theoretically by Margenau[16] and by Anderson[22]. Therefore, more accurate intensities may be obtained from those in the table by multiplying by

$$\left(\frac{3J(J+1)}{4K^2}\right)^{1/3}$$

---

*Note that in reference 4 the value of $\Delta\nu$ in fig. 3 ($\Delta\nu = 29.4\ P_{mm}$) is correct, and the value of ($\tau = \frac{1}{2\pi\Delta\nu}$) on page 667 is incorrect.

The lines of ammonia have been used extensively to test the theories of pressure broadening and power broadening, and to compare the apparent molecular diameters with those from the kinetic theory of gasses[2,4,17,18,19]. Smith and Howard[23,24] have investigated foreign gas broadening, and the temperature dependence of $\Delta\nu$. The apparent frequencies and values of $\Delta\nu$ at atmospheric and higher pressures differ widely from those given here[15,20,21] and have stimulated theoretical investigation of this problem[22,29].

The Stark[25,26] and Zeeman effects[25,27,28] of these lines has also been investigated.

---

[1] C. E. Cleeton and N. H. Williams, Physical Review **46**, 235 (1934).

[2] B. Bleaney and R. P. Penrose, Nature **157**, 339 (1946).

[3] W. E. Good, Physical Review **69**, 539 (1946).

[4] C. H. Townes, Physical Review **70**, 665 (1946).

[5] A. H. Sharbaugh, T. C. Madison and J. K. Bragg, Physical Review **76**, 1529 (1949).

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[16] H. Margenau, Physical Review **76**, 121 (1949).

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[21] D. F. Smith, Physical Review **74**, 506 (1948).

[22] P. W. Anderson, Physical Review **76**, 647 (1949), and **80**, 511 (1950).

[23] W. V. Smith and R. Howard **79**, 132 (1950).

[24] R. Howard and W. V. Smith, Physical Review **79**, 128 (1950).

[25] D. K. Coles and W. E. Good, Physical Review **70**, 979 (1946).

[26] J. M. Jauch, Physical Review **72**, 715 (1947).

[27] C. K. Jen, Physical Review **74**, 1396 (1948).

[28] C. K. Jen, Physical Review **76**, 1494 (1949).

[29] H. Margenau, Physical Review **76**, 585 (1949).

H_3N (NH_3) Ammonia

μ = 1.45 (ref. 1)

	$N^{14}H_3$		$N^{15}H_3$		Ref.
B_0	298000				1
A_0	189000		189000		
$(eqQ)_N$	-4.10		0		6

References

[1] C. H. Townes, Physical Review **70**, 665 (1946).
[2] B. Bleaney and R. P. Penrose, Proceedings of the Royal Society A189, 358 (1947).
[3] W. E. Good and D. K. Coles, Physical Review **71**, 383 (1947).
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[7] C. H. Townes and W. Low, private communication.
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H_3N

Molecule	Rotational State		Frequency Mc	Intensity cm^{-1}		Ref.
	J	K				
$N^{14}H_3$	9	5	16798.3	6.2x10^{-6}		8
	7	1	16841.3	1.0x10^{-6}		
	7	2	17291.6	4.6x10^{-6}		
	8	4	17378.1	9.6x10^{-7}		
	7	3	18017.6	2.5x10^{-6}		
	12	9	18127.2	4.1x10^{-6}		
	11	8	18162.6	4.1x10^{-6}		
	13	10	18178.0	9.4x10^{-7}		
	10	7	18285.6	7.8x10^{-6}		
	14	11	18313.9	4.1x10^{-7}		
	6	1	18391.6	2.0x10^{-6}		
	9	6	18499.5	2.7x10^{-5}		
	15	12	18535.1	3.3x10^{-7}		
	8	5	18808.7	2.1x10^{-5}		
	16	13	18842.9	6.2x10^{-8}		
	6	2	18884.9	1.3x10^{-5}		
	7	4	19218.52	2.9x10^{-5}		4
	6	3	19757.56	6.8x10^{-5}		2,3,4
	5	1	19838.4	6.9x10^{-6}		8
	5	2	20371.48	3.1x10^{-5}		2,3,4
	8	6	20719.20	8.8x10^{-5}		
	9	7	20735.46	2.9x10^{-5}		
	7	5	20804.80	6.2x10^{-5}		
	10	8	20852.51	1.7x10^{-5}		
	6	4	20994.62	7.8x10^{-5}		
	11	9	21070.73	1.9x10^{-5}		
	4	1	21134.37	1.6x10^{-5}		

H_3N--Continued

Molecule	Rotational State		Frequency Mc	Intensity cm^{-1}		Ref.
	J	K				
$N^{14}H_3$ (Continued)	5	3	21285.30	1.7×10^{-4}		2,3,4
	12	10	21391.55	4.9×10^{-6}		4
	4	2	21703.34	6.9×10^{-5}		2,3,4
	14	11	21818.1	5.8×10^{-7}		8
	3	1	22234.51	3.3×10^{-5}		2,3,4
	14	12	22355	2.1×10^{-6}		7
	5	4	22653.00	1.9×10^{-4}		2,3,4
	4	3	22688.24	3.7×10^{-4}		2,3, 4,5
	6	5	22732.45	1.6×10^{-4}		2,3,4
	16	14	23777.4	1.8×10^{-7}		8
	3	2	22834.10	1.5×10^{-4}		1,2, 3,4
	7	6	22924.91	2.7×10^{-4}		
	15	13	23004	4.7×10^{-7}		7
	2	1	23098.78	6.7×10^{-5}		1,2, 3,4
	8	7	23232.20	9.5×10^{-5}		
	9	8	23657.46	6.3×10^{-5}		
	1	1	23694.48	1.6×10^{-4}		
	2	2	23722.61	3.0×10^{-4}		
	3	3	23870.11	7.9×10^{-4}		
	4	4	24139.39	4.3×10^{-4}		
	10	9	24205.25	7.8×10^{-5}		
	5	5	24532.94	4.1×10^{-4}		
	17	15	24680.1	1.1×10^{-7}		8
	11	10	24881.90	2.2×10^{-5}		1,3
	6	6	25056.04	7.1×10^{-4}		1,2, 3,4
	12	11	25695.23	1.3×10^{-5}		3
	7	7	25715.14	2.8×10^{-4}		2,3,4
	8	8	26518.91	2.1×10^{-4}		6
	13	12	26655.00	1.3×10^{-5}		6
	9	9	27478.00	2.9×10^{-4}		
	14	13	27772.52	3.0×10^{-6}		
	10	10	28604.73	9.5×10^{-5}		
	15	14	29061.14	1.4×10^{-6}		
	11	11	29914.66	5.8×10^{-5}		
	12	12	31424.97	6.6×10^{-5}		
	13	13	33156.95.	1.8×10^{-5}		
	14	14	35134.44	9.2×10^{-6}		
	15	15	37385.18	8.9×10^{-6}		
	16	16	39941.54	2.0×10^{-6}		

H_3N--Continued

Molecule	Rotational State		Frequency Mc	Intensity cm^{-1}		Ref.
	J	K				
$N^{15}H_3$	7	3	17097.2	$1.8x10^{-7}$		8
	9	6	17548.4	$1.9x10^{-7}$		
	8	5	17855.3	$7.1x10^{-7}$		
	6	2	17943.4	$4.4x10^{-8}$		
	7	4	18258.8	$1.0x10^{-7}$		
	6	3	18788.2	$4.7x10^{-7}$		
	5	2	19387.5	$1.1x10^{-7}$		
	8	6	19702.1	$6.0x10^{-7}$		
	9	7	19708.2	$9.8x10^{-8}$		
	7	5	19793.4	$2.1x10^{-7}$		
	10	8	19810.8	$5.9x10^{-8}$		
	6	4	19984.6	$2.7x10^{-7}$		
	11	9	20009.9	$1.3x10^{-7}$		
	4	1	20131.6	$5.0x10^{-8}$		
	5	3	20272.04	$6.4x10^{-7}$		3,8
	4	2	20682.87	$2.6x10^{-7}$		
	3	1	21202.30	$1.3x10^{-7}$		3
	5	4	21597.86	$7.2x10^{-7}$		
	4	3	21637.91	$1.4x10^{-6}$		
	6	5	21667.93	$6.0x10^{-7}$		
	3	2	21783.98	$5.6x10^{-7}$		
	7	6	21846.41	$9.9x10^{-7}$		
	2	1	22044.28	$2.6x10^{-7}$		
	8	7	22134.89	$3.5x10^{-7}$		
	9	8	22536.26	$2.3x10^{-7}$		
	1	1	22624.96	$6.0x10^{-7}$		
	2	2	22649.85	$1.2x10^{-6}$		
	3	3	22789.41	$3.0x10^{-6}$		
	4	4	23046.10	$1.6x10^{-6}$		
	10	9	23054.97	$3.0x10^{-7}$		
	5	5	23421.99	$1.5x10^{-6}$		
	6	6	23922.32	$2.6x10^{-6}$		
	7	7	24553.42	$1.1x10^{-6}$		
	8	8	25323.51	$8.0x10^{-7}$		
	9	9	26243.0	$2.0x10^{-7}$		8

(ND_3, ND_2H, NDH_2)

Deutero Ammonias

In the following list of absorption lines reported[10] from a mixture of the deutero-ammonias the isotopic assignment is shown for each line which has been identified positively. Intensities listed are the observed relative intensities for a particular mixture of the enriched deutero ammonias. The superscripts 0, 1, 2, indicate lines positively identified as belonging to ND_3, ND_2H, and NDH_2, respectively.

H_3N Deutero Ammonia

Frequency Mc	Intensity	Frequency Mc	Intensity	Frequency Mc	Intensity
2093.6^{0}	w	5030.	w	9521.0	m
2186.4^{0}	w	5122.	w	9635.5	
2290.5^{0}	w	5123.5	w	9829.0	
2361.		5192.	w	9967.	
$2403.^{0}$	w	$5199.^{1}$	m	10091.	
2408.		5213.	w	10660.	w
2431.6		5230.	w	10844.	s
2480.		5236.	w	11400.	m
$2533.^{0}$	w	5364.	m	11975.	m
2599.		5368.	m	11983.	m
2614	w	5392.	m	12147.	m
2652	w	5415.	m	12150.	s
2668.		5495.	m	12392.	m
2699		5507.5^{1}	w	12444.	w
2746.		5549.	w	12620.	w
2786.		5574.	w	12778.	s
2800	w	5581.7^{1}	m	13065.	m
2900.	w	5631.9^{1}	w	13119.	m
2939.	w	$5635.^{1}$	m	13175.	w
2978.	w	5689.	w	13210.	s
3010.	w	5726.	w	13316.	m
3187.	w	5785.85^{1}	m	13488.	m
$3470.^{1}$	w	5786.5^{1}	m	13626.	m
$3865.^{1}$	m	$5964.^{1}$	m	13657.	m
$4086.^{1}$	w	6105.0^{1}	m	13923.	m
4161.	w	$6164.^{1}$	m	14067.	m
4199.	w	6389.5^{1}	w	14102.	m
4216.	w	6463.0	m	14566.	m
4219.	w	6597.5	w	15004.	w
4241.	w	6641.0^{1}	w	15132.	m
4281.5	w	6922.1^{1}	w	15524.	w
4407.5	m	6974.5	w	15634.	w
4410.0	w	7104.	w	15772.	m
4511.	w	$7238.^{1}$	w	15935.	w
4720.5	w	7387.5^{1}	w	16320.	m
4850.	w	7562.1^{2}	m	16455.	m
4859.	m	7802.5	m	16493.	m
4907.	w	8278.		16497.	w
4915.	w	8283.1	m		
4938.	w	8777.5	w		
4948.	m	8902.5	w		
4956.	w	8922.2			
5025.	w	9013.5	m		

H_3N Deutero Ammonia

Molecule	Vibrational State	Frequency			Ref.
ND_3	$v_2 = 1$	117000			9

H_3P (PH_3) Phosphine

$\mu = 0.55$
(ref. 1)

References

[1] C. C. Loomis, MITRLE Progress Report, July 15, 1950.

H_3Sb (SbH_3) Antimony trihydride

$\mu = 0.116$
(ref. 1)

References

[1] C. C. Loomis, MITRLE Progress Report, July 15, 1950.

NO_2 Nitrogen dioxide

$\mu = .4$

Six lines ($6_{0,6} \rightarrow 5_{1,5}$) have been observed within 85 Mc. at 26,600 Mc.

References

[1] K. B. McAfee Jr., Physical Review **78**, 340 (1950).

N_2O Nitrous oxide

$\mu = 0.166$
(ref. 2,3)

The half width, $\Delta\nu = 6.70^2$, has been used in calculating the intensity.

	$N_2{}^{14}O^{16}$	$N_2{}^{14}O^{18}$	$N^{14}N^{15}O^{16}$	$N^{14}N^{15}O^{18}$	$N^{15}N^{14}O^{16}$	$N^{15}N^{14}O^{18}$	Ref.
B_0	12561.64	11859.11	12560.78	11855.82	12137.31	11449.66	1,2 4
$(eqQ)_{N^{14}}$	-0.27_{central} -1.03_{end}		-1.03		-0.27		

Nitrous oxide--Continued

References

[1] D. K. Coles, E. S. Elyash and J. G. Gorman, Physical Review **72**, 973 (1947), and private communication.
[2] D. K. Coles and R. H. Hughes, Physical Review **76**, 178 (1949).
[3] R. G. Shulman, B. P. Dailey and C. H. Townes, Physical Review **78**, 145 (1950).
[4] D. K. Coles, W. E. Good and D. R. Lide, private communication.

N_2O

Molecule	Rotational Transition	F_i	F_f	Frequency Mc	Intensity cm^{-1}	Ref.
	J					
$N^{14}N^{14}O^{16}$	0 →1	1	1	25123.03	2.8×10^{-7}	1
		1	2	25123.28	4.7×10^{-7}	
		1	0	25123.64	9.3×10^{-8}	
$N^{15}N^{14}O^{16}$	0 →1	1	1	24274.53	9.6×10^{-10}	
		1	2	24274.61	1.6×10^{-9}	
		1	0	24274.73	3.2×10^{-10}	
$N^{14}N^{15}O^{16}$	0 →1			25121.55	3.2×10^{-9}	2
$N^{15}N^{15}O^{16}$	0 →1			24274.78	1.1×10^{-11}	

Molecule	Rotational Transition	Frequency Mc	Intensity cm^{-1}		Ref.
	J				
$N_2{}^{14}O^{18}$	0 →1	23718.21	1.4×10^{-9}		4
$N^{14}N^{15}O^{18}$	0 →1	23711.64	5.4×10^{-12}		
$N_2{}^{15}O^{18}$	0 →1	22896.07	1.9×10^{-14}		
$N^{15}N^{14}O^{18}$	0 →1	22899.32	5.0×10^{-12}		

O_2 Oxygen $\mu=0$

This spectrum is of a different nature from the other molecular spectra recorded herein, being due to a magnetic coupling to the microware field, rather than an electric dipole coupling. The theory of the transition has been discussed by Van Vleck[1]. The transitions were first observed at higher pressures[2,3,4], but only the resolved lines are recorded here. The Half-widths, $\Delta\nu$, from 0.8 to 2.1 are given in references (2) and (5).

References

[1] J. H. Van Vleck, Physical Review **71**, 413 (1947).
[2] R. Beringer, Physical Review **70**, 53 (1946).
[3] H. R. L. Lamont, Physical Review **74**, 353 (1948).
[4] M. W. P. Strandberg, C. Y. Meng, and J. G. Ingersoll, Physical Review **75**, 1524 (1949).
[5] J. H. Burkhalter, R. S. Anderson, W. V. Smith and W. Gordy, Physical Review **79**, 651 (1950).

O_2--Continued

Molecule	Rotational Transition			Frequency Mc	Intensity* cm^{-1}		Ref.
	J_i	J_f	K				
O_2^{16}	25	24	25	53592.2	1.5x10^{-6}		
	23	22	23	54130.0	2.8x10^{-6}		
	21	20	21	54672.5	4.8x10^{-6}		
	19	18	19	55220.8	7.9x10^{-6}		
	17	16	17	55784.1	1.2x10^{-5}		
	1	2	1	56265.1	7.1x10^{-6}		
	15	14	15	56362.8	1.7x10^{-5}		
	13	12	13	56968.7	2.3x10^{-5}		
	11	10	11	57612.0	2.8x10^{-5}		
	9	8	9	58324.0	3.1x10^{-5}		
	3	4	3	58446.2	1.9x10^{-5}		
	7	6	7	59163.4	3.2x10^{-5}		
	5	6	5	59610	2.9x10^{-5}		
	5	4	5	60306.4	2.9x10^{-5}		
	7	8	7	60436.	3.4x10^{-5}		
	9	10	9	61120	3.5x10^{-5}		
	11	12	11	61800.2	3.2x10^{-5}		
	13	14	13	62411.7	2.7x10^{-5}		
	3	2	3	62486.1	2.2x10^{-5}		
	15	16	15	62970	2.1x10^{-5}		
	17	18	17	63568.3	1.6x10^{-5}		
	19	20	19	64127.6	1.1x10^{-5}		
	21	22	21	64678.9	6.8x10^{-6}		
	23	24	23	65220	4.0x10^{-6}		
	25	26	25	65770	2.3x10^{-6}		

*Intensities calculated by L. C. Aamodt using $\Delta\nu$=1.2 Mc. at 1 mm.

O_2S (SO_2) Sulfur dioxide $\mu = 1.7$

The notation for the rotational transitions of this asymmetric rotor is that of reference Int. 5.

	$S^{32}O_2^{16}$				Ref.
B_0	10336				1
A_0	60880				
C_0	8817				

References

[1] B. P. Dailey, S. Golden and E. B. Wilson jr., Physical Review 72, 871 (1947).

[2] M. H. Sirvetz, private communication.

O_2S--Continued

Molecule	Rotational Transition	Frequency Mc	Intensity		Ref.
$S^{32}O_2{}^{16}$		20335.41	s		1,2
	$13_{2,12} - 12_{3,9}$	20420			1
		20460.05	w		1,2
		22220.32	w		1,2
		22482.51	s		
		22733.83	w		
		22904.95	w		
		22928.45	w		
		23034.80	s		
	$6_{1,5} - 5_{2,4}$	23414.25	s		
		23733.03	w		
	$9_{1,9} - 8_{2,6}$	24039.50	s		
		24083.39	s		
		24319.67	w		
		25049.13	s		1,2
		25170.97	w		
	$7_{2,6} - 8_{1,7}$	25392.81	s		
		26777.20	s		2
		28858.11	s		
		29321.46	s		1,2
	$3_{1,3} - 4_{0,4}$	29460			1

Table II. Lines Listed in Order of Frequency

In this table, the chemical symbols C, N, S, etc., stand for the most abundant isotope (C^{12}, N^{14}, S^{32}, . . .), all rarer isotopes being specifically noted in each instance. The intensities are those calculated as described in the introduction, except those in parentheses ( ), which are observed intensities estimated by the various authors, and do not necessarily follow the convention adopted herein as to weak, medium, and strong. Intensities marked with an asterisk (*) are due to radioactive isotopes (normally with zero abundance), calculated as if the isotope in question were 100 percent abundant.

Table II. Lines Listed in Order of Frequency

Frequency Mc	Molecule	Intensity
2093.6	ND_3	(w)
2186.4	ND_3	(w)
2290.5	ND_3	(w)
2361	deutero ammonia	
2403	ND_3	(w)
2408	deutero ammonia	
2431.6	deutero ammonia	
2480.9	deutero ammonia	
2533	ND_3	(w)
2599	deutero ammonia	(w)
2614	deutero ammonia	(w)
2652	deutero ammonia	(w)
2668	deutero ammonia	
2699	deutero ammonia	
2746	deutero ammonia	
2786	deutero ammonia	
2800	deutero ammonia	(w)
2900	deutero ammonia	(w)
2939	deutero ammonia	(w)
2978	deutero ammonia	(w)
3010	deutero ammonia	(w)
3187	deutero ammonia	(w)
3470	ND_2H	(w)
3865	ND_2H	(m)
4086	ND_2H	(w)
4161	deutero ammonia	(w)
4199	deutero ammonia	(w)
4216	deutero ammonia	(w)
4219	deutero ammonia	(w)
4241	deutero ammonia	(w)
4281.5	deutero ammonia	(w)
4407.5	deutero ammonia	(m)
4410.0	deutero ammonia	(w)
4511	deutero ammonia	(w)
4720.5	deutero ammonia	(w)
4850	deutero ammonia	(w)
4859	deutero ammonia	(m)
4907	deutero ammonia	(w)
4915	deutero ammonia	(w)
4938	deutero ammonia	(w)
4948	deutero ammonia	(m)
4956	deutero ammonia	(w)
5025	deutero ammonia	(w)
5030	deutero ammonia	(w)
5122	deutero ammonia	(w)
5123.5	deutero ammonia	(w)
5192	deutero ammonia	(w)
5199	ND_2H	(m)
5213	deutero ammonia	(w)
5230	deutero ammonia	(w)
5236	deutero ammonia	(w)
5364	deutero ammonia	(m)
5368	deutero ammonia	(w)
5392	deutero ammonia	(m)
5415	deutero ammonia	(m)
5495	deutero ammonia	(m)
5507.5	ND_2H	(w)
5549	deutero ammonia	(w)
5574	deutero ammonia	(w)
5581.7	ND_2H	(m)
5631.9	ND_2H	(w)
5635	ND_2H	(m)
5689	deutero ammonia	(w)
5726	deutero ammonia	(w)
5785.85	ND_2H	(m)
5786.5	ND_2H	(m)
5964	ND_2H	(m)
6105.0	ND_2H	(m)
6164	ND_2H	(m)
6389.5	ND_2H	(w)
6463.0	deutero ammonia	(m)
6597.5	deutero ammonia	(w)
6641.0	ND_2H	(w)
6684	ICl^{37}	w
6922.1	ND_2H	(w)
6974.5	deutero ammonia	(w)
6980	ICl^{35}	m
7104	deutero ammonia	(w)

Table II. Lines Listed in Order of Frequency—Continued

Frequency Mc	Molecule	Intensity
7238	ND_2H	(w)
7362.60	CH_2O	m
7387.5	ND_2H	(w)
7562.1	NDH_2	(m)
7802.5	deutero ammonia	(m)
7892.03	CH_2O	m
7936.74	HDS	w
8278	deutero ammonia	
8283.1	deutero ammonia	(m)
8525.53	$Br^{81}Cl^{37}$	w
8559.58	$Br^{79}Cl^{37}$	w
8663.40	$Br^{81}Cl^{37}$	w
8671.87	$Br^{81}Cl^{37}$	w
8676.37	$Br^{81}Cl^{37}$	w
8683.06	$Br^{81}Cl^{37}$	w
8725.49	$Br^{79}Cl^{37}$	w
8733.84	$Br^{79}Cl^{37}$	w
8738.47	$Br^{79}Cl^{37}$	w
8745.17	$Br^{79}Cl^{37}$	w
8777.5	deutero ammonia	(w)
8852.93	$Br^{81}Cl^{37}$	w
8865.66	$Br^{81}Cl^{35}$	w
8884.87	CH_2O	m
8899.50	$Br^{79}Cl^{35}$	w
8902.5	deutero ammonia	(w)
8922.2	deutero ammonia	
8951.38	$Br^{79}Cl^{37}$	w
8964.19	$Br^{79}Cl^{37}$	w
8972.41	$Br^{81}Cl^{35}$	w
9001.44	$Br^{81}Cl^{35}$	w
9012.97	$Br^{81}Cl^{35}$	w
9013.5	deutero ammonia	(m)
9018.40	$Br^{81}Cl^{35}$	w
9026.17	$Br^{81}Cl^{35}$	w
9034.14	$Br^{79}Cl^{35}$	w
9063.77	$Br^{79}Cl^{35}$	w
9074.91	$Br^{79}Cl^{35}$	w
9080.73	$Br^{79}Cl^{35}$	w
9088.61	$Br^{79}Cl^{35}$	w
9186.99	F_3OP	
9193.26	$Br^{81}Cl^{35}$	w
9209.57	$Br^{81}Cl^{35}$	w
9291.61	$Br^{79}Cl^{35}$	w
9307.96	$Br^{79}Cl^{35}$	w
9460	CHN	m
9521.0	deutero ammonia	(m)
9635.5	deutero ammonia	
9829.0	deutero ammonia	
9967	deutero ammonia	
10091.	deutero ammonia	
10235.81	HDS	w
10278.99	HDO	w
10366.51	CH_2O	w
10660	deutero ammonia	(w)
10802.36	HDS^{34}	w
10844	deutero ammonia	(s)
10861.07	HDS	w
11235.45	HDS^{34}	w
11258.21	HDS^{33}	w
11283.83	HDS	w
11400	deutero ammonia	(m)
11753.13	CH_2O	m
11975	deutero ammonia	(m)
11983	deutero ammonia	(m)
12147	deutero ammonia	(m)
12150	deutero ammonia	(s)
12392	deutero ammonia	(m)
12444	deutero ammonia	(m)
12620	deutero ammonia	(w)
12778	deutero ammonia	(s)
13065	deutero ammonia	(m)
13119	deutero ammonia	(m)
13175	deutero ammonia	(w)
13210	deutero ammonia	(s)
13316	deutero ammonia	(m)
13488	deutero ammonia	(m)
13626	deutero ammonia	(m)
13657	deutero ammonia	(m)

Table II. Lines Listed in Order of Frequency—Continued

Frequency Mc	Molecule	Intensity
13778.86	$C^{13}H_2O$	w
13923	deutero ammonia	(m)
14067	deutero ammonia	(m)
14102	deutero ammonia	(m)
14361.54	CH_2O	w
14488.65	CH_2O	m
14566	deutero ammonia	(m)
14592.44	$C^{13}H_2O$	w
14726.74	CH_2O	m
15004	deutero ammonia	(w)
15132	deutero ammonia	(m)
15524	deutero ammonia	(w)
15634	deutero ammonia	(w)
15772	deutero ammonia	(m)
15935	deutero ammonia	(w)
16147.67	CHN	m
16320	deutero ammonia	(m)
16455	deutero ammonia	(m)
16493	deutero ammonia	(m)
16497	deutero ammonia	(w)
16798.3	H_3N	m
16841.3	H_3N	m
16941.6	CH_4O	
17027.60	CH_2O	m
17097.2	H_3N^{15}	w
17212.61	HDS	w
17291.6	H_3N	m
17378.1	H_3N	m
17548.4	H_3N^{15}	w
17690	C_2D_2O	w
17855.3	H_3N^{15}	m
17870.5	$C^{13}H_4O$	
17943.4	H_3N^{15}	w
17959.67	$CH_3B^{10}O$	w
17959.91	$CH_3N^{10}O$	w
17960.60	$CH_3B^{10}O$	w
18017.6	H_3N	m
18127.2	H_3N	m
18162.6	H_3N	m
18178.0	H_3N	m
18196.6	C_3HN	s
18258.8	H_3N^{15}	w
18285.6	H_3N	m
18313.9	H_3N	w
18391.6	H_3N	m
18396.3	C_2H_3N	m
18397.7	C_2H_3N	s
18399.8	C_2H_3N	m
18499.5	H_3N	s
18535.1	H_3N	w
18788.2	H_3N^{15}	w
18808.7	H_3N	s
18825	C_2HDO	
18842.9	H_3N	w
18884.9	H_3N	s
18892	C_2HDO	
18943.77	CH_3Br^{81}	w
18992.36	CH_3Br^{79}	m
19040.32	CH_3Br^{81}	m
19107.97	CH_3Br^{79}	m
19160.82	CH_3Br^{81}	m
19218.52	H_3N	s
19230	$C_4H_{10}O$	
19252.13	CH_3Br^{79}	m
19387.5	H_3N^{15}	w
19390.18	CH_4O	
19440	$C_4H_{10}O$	
19590	$C_4H_{10}O$	
19595.23	CH_2O	w
19700	$C_2H_3NS^{34}$	
19702.1	H_3N^{15}	m
19708.2	H_3N^{15}	w
19757.56	H_3N	s
19793.4	H_3N^{15}	w
19810.8	H_3N^{15}	w
19838.4	H_3N	m
19929	$C_2H_3NS^{34}$	
19984.6	H_3N^{15}	w

Table II. Lines Listed in Order of Frequency—Continued

Frequency Mc	Molecule	Intensity
19999.66	$CCl^{35}F_3$	
20009.9	H_3N^{15}	w
20010.84	$CCl^{35}F_3$	
20013.68	$CCl^{35}F_3$	
20015.77	$CCl^{35}F_3$	
20019.17	$CCl^{35}F_3$	
20020	C_2H_3NS	
20131.6	H_3N^{15}	w
20140	C_2H_3NS	
20160	C_2H_3N	
20209.76	C_2H_2O	
20214.29	$C_2H_2Cl^{35}F$	
20216	C_2H_3NS	
20220.64	C_2H_2O	
20230	C_2H_3NS	
20232.33	C_2H_2O	
20241	C_2H_3NS	
20260	$C_4H_{10}O$	
20267.17	C_2H_2O	
20272.04	H_3N^{15}	m
20320	$C_4H_{10}O$	
20321.12	C_2DCl^{37}	w
20322.50	C_2DCl^{37}	w
20329.32	$C^{13}H_4O$	(w)
20335.41	O_2S	(s)
20336.84	C_2DCl^{37}	w
20338.29	C_2DCl^{37}	w
20346.83	CH_4O	
20349.48	C_2DCl^{37}	w
20350	C_2H_3NS	
20371.48	H_3N	s
20385	CH_3NO_2	
20391.51	$C_2H_2Cl^{35}F$	
20394.7	CDNO	
20413	C_2H_3NS	
20420	O_2S	
20443	C_2H_3NS	
20460.05	O_2S	(w)
20460.40	HDO	w
20510	$C_4H_{10}O$	
20570	$C_4H_{10}O$	
20649.30	$C^{13}H_2O$	w
20679.9	$C_2H_3F_3$	w
20682.87	H_3N^{15}	w
20710.6	$C_2H_3F_3$	w
20719.20	H_3N	s
20720	$C_4H_{10}O$	
20728.03	C_2DCl^{35}	w
20729.79	C_2DCl^{35}	w
20735.46	H_3N	s
20736.40	$C^{13}H_2O$	w
20740	$C_4H_{10}O$	
20742.32	$C_2H_3F_3$	w
20744.00	C_2DCl^{35}	w
20748.02	C_2DCl^{35}	w
20749.76	C_2DCl^{35}	w
20763.96	C_2DCl^{35}	w
20772.3	$Br^{81}F$	w
20783.80	C_2DCl^{35}	w
20804.80	H_3N	s
20822.8	$C_2H_2Cl^{37}F$	
20828.9	$Br^{79}F$	w
20852.51	H_3N	s
20880	$C_4H_{10}O$	
20908.87	CH_4O	
20928.4	$Br^{81}F$	m
20950	$C_4H_{10}O$	
20954.6	$Br^{81}F$	m
20965	$C_4H_{10}O$	
20970.65	CH_4O	
20985.5	$Br^{79}F$	m
20994.62	H_3N	s
21000	$C_4H_{10}O$	
21026.70	$C_2H_2Cl^{35}F$	
21045.6	$Br^{79}F$	m
21070.73	H_3N	s
21110.4	$Br^{81}F$	m
21134.37	H_3N	s

Table II. Lines Listed in Order of Frequency—Continued

Frequency Mc	Molecule	Intensity
21175	$C_4H_{10}O$	
21181.7	$Br^{81}F$	m
21202.30	H_3N^{15}	w
21202.6	$Br^{79}F$	m
21230	$C_4H_{10}O$	
21262	F_3PS	
21283	F_3PS	
21285.30	H_3N	s
21310	$C_4H_{10}O$	
21319.4	$Br^{79}F$	m
21323.5	$CHN^{15}O$	
21337.5	$Br^{81}F$	m
21340	$C_4H_{10}O$	
21363	$Cl^{37}NO$	w
21365	$Cl^{37}NO$	w
21367	$Cl^{37}NO$	w
21372	$Cl^{37}NO$	w
21391.55	H_3N	m
21426	$AsCl_3{}^{35}$	w
21450	$C_4H_{10}O$	
21472	$AsCl_3{}^{35}$	w
21475.4	$Br^{79}F$	m
21482	$C_2H_2F_2$	(m)
21549	$C_2H_2F_2$	(w)
21550.31	CH_4O	
21560	$C_4H_{10}O$	
21573	$C_2H_2F_2$	(w)
21597.86	H_3N^{15}	m
21637.91	H_3N^{15}	m
21664	C_2D_4O	w
21667.93	H_3N^{15}	m
21669	$C_2H_2F_2$	(m)
21669.70	$C_2H_2Cl^{35}F$	
21703.34	H_3N	s
21704	$Cl^{37}NO$	w
21708.68	CH_4O	
21712	CH_5N	
21713	$Cl^{37}NO$	m
21720	$Cl^{37}NO$	w
21734	$C_2H_2F_2$	(m)
21780	$C_4H_{10}O$	
21783.98	H_3N^{15}	m
21818.1	H_3N	m
21839	$C^{13}DNS$	w
21846.41	$N^{15}H_3$	m
21850	$C_4H_{10}O$	
21857	$Cl^{35}NO$	w
21861	$Cl^{35}NO$	w
21865	$Cl^{35}NO$	w
21869	$Cl^{35}NO$	m
21874	$Cl^{35}NO$	w
21879	$Cl^{35}NO$	w
21890	$C_4H_{10}O$	
21897	$CDNS$	
21902.50	$C_2H_2Cl^{37}F$	
21930.2	$C_2H_3Cl^{37}$	
21935	CH_5N	
21981.7	$CHNO$	
22015	$C_4H_{10}O$	
22044.28	H_3N^{15}	w
22052	$Cl^{37}NO$	w
22056	$Cl^{37}NO$	w
22062	$Cl^{37}NO$	w
22068	$Cl^{37}NO$	w
22134.89	H_3N^{15}	w
22215	$Cl^{35}NO$	m
22215	$C_4H_{10}O$	
22217	$CHClF_2$	(w)
22220.32	O_2S	(w)
22227	$Cl^{35}NO$	m
22234.51	H_3N	s
22236	$Cl^{35}NO$	w
22235.22	H_2O	m
22236	$C_2H_2F_2$	(m)
22239.6	$CO^{18}S^{34}$	w
22247	$CHClF_2$	(w)
22258	CH_5N	
22273.90	C_2HCl^{37}	w
22275.10	C_2HCl^{37}	w
22281	$C_2H_2F_2$	

Table II. Lines Listed in Order of Frequency—Continued

Frequency Mc	Molecule	Intensity
22289.55	C_2HCl^{37}	w
22290.85	C_2HCl^{37}	w
22295	CH_3F_3Si	
22302.10	C_2HCl^{37}	w
22305	$CHClF_2$	(m)
22307.67	HDO	w
22316.1	DN_3	
22353	$CHClF_2$	(w)
22355	H_3N	m
22369.6	$C_2H_3Cl^{35}$	
22370	CH_2O_2	
22383	$C_2H_2F_2$	(m)
22386	$CHClF_2$	(w)
22391	$C_2H_2F_2$	(m)
22410	$CHClF_2$	(s)
22419.13	$C_2H_2Cl^{35}F$	
22436	$CHClF_2$	(w)
22462	$CHClF_2$	(w)
22470	CH_2O_2	
22481	$CHClF_2$	(m)
22482.51	O_2S	(s)
22485.9	$C_2H_3Cl^{37}$	
22490	$C_4H_{10}O$	
22535	CH_5N	
22536.26	H_3N^{15}	w
22545	$CHClF_2$	(w)
22553	$CHClF_2$	(w)
22580	$Cl^{35}NO$	w
22586	$Cl^{35}NO$	w
22590	CH_5N	
22593	$Cl^{35}NO$	m
22595	CH_5N	
22600	$Cl^{35}NO$	w
22612	CH_5N	
22624.96	H_3N^{15}	m
22649.85	H_3N^{15}	m
22653.00	H_3N	s
22659.29	CHD_2Cl^{37}	w
22660	$C_2H_2F_2$	(w)
22672.90	$C^{13}H_4O$	
22673.80	CHD_2Cl^{37}	w
22680	C_2H_3NS	
22685.60	CHD_2Cl^{37}	w
22688.24	H_3N	s
22717.07	C_2HCl^{35}	w
22718.80	C_2HCl^{35}	w
22732	CH_5N	
22732.45	H_3N	s
22732.90	C_2HCl^{35}	w
22733.83	O_2S	(w)
22737.00	C_2HCl^{35}	w
22738.68	C_2HCl^{35}	w
22740	CH_5N	
22752	$C_2H_2F_2$	(s)
22752.95	C_2HCl^{35}	w
22754.6	$CO^{18}S$	w
22763.8	$C^{13}O^{18}S$	w
22772.82	C_2HCl^{35}	w
22789.41	H_3N^{15}	m
22819.30	$CO^{18}S$	w
22820	C_2H_6O	
22834.10	H_3N	s
22848.83	$CO^{18}S$	w
22852.40	$C^2H_2Cl^{37}F$	
22871.30	$CO^{18}S$	w
22896.07	$N_2^{15}O^{18}$	w
22899.32	$N^{15}N^{14}O^{18}$	w
22900	$C_4H_{10}O$	
22904.95	O_2S	(w)
22915	$CHNS^{34}$	
22924.91	H_3N	s
22928.45	O_2S	(w)
22940	C_3H_6O	
22946.9	$C_2H_3Cl^{35}$	
22965.71	CH_2O	m
22977	CH_5N	
23004	H_3N	w
23021	CH_3NO_2	
23034.80	O_2S	(s)
23035.00	CHD_2Cl^{35}	w

Table II. Lines Listed in Order of Frequency—Continued

Frequency Mc	Molecule	Intensity
23046.10	H_3N^{15}	w
23048.2	$HN^{14}{}_2N^{15}$	
23053.62	CHD_2Cl^{35}	w
23054.97	H_3N^{15}	m
23055.0	$C_2H_3Cl^{37}$	
23068.51	CHD_2Cl^{35}	w
23080	$C_4H_{10}O$	
23081	C_2H_6O	
23096.7	$HN_2{}^{14}N^{15}$	
23098.78	H_3N	s
23115	CH_5N	
23121.20	CH_4O	
23134	C_2H_4O	m
23148	C_2H_6O	
23181	$C_2H_2F_2$	(m)
23198.66	COS^{36}	w
23200	CH_2O_2	
23205	CH_5N	
23206	$C_2H_2F_2$	(w)
23214	$C_2H_2F_2$	(m)
23220	$C_2H_2F_2$	(m)
23232.20	H_3N	s
23234	$C_2H_2F_2$	(w)
23250	$C_4H_{10}O$	
23250	CH_3NO_2	
23260.3	$C^{13}Cl^{37}N$	w
23295	CH_5N	
23300	CH_5N	
23305	CH_5N	
23308	$CHClF_2$	(s)
23323	$C_2H_2F_2$	(m)
23330	CH_3NO_2	
23335	CH_5N	
23339	C_3H_6O	
23347.53	CH_4O	
23361	$C_2H_2F_2$	(m)
23372.72	$CCl^{37}N$	m
23389.00	$CCl^{37}N$	m
23389	$C^{13}HNS$	

Frequency Mc	Molecule	Intensity
23389.61	$CCl^{37}N$	m
23390.53	$CCl^{37}N$	m
23402.47	$CCl^{37}N$	m
23404	CH_5N	
23414.25	O_2S	(s)
23421.99	H_3N^{15}	m
23425	CH_5N	
23430	CH_5N	
23433	$C_2H_2F_2$	(s)
23444.82	CH_4O	
23446	CH_5N	
23457	CH_4O	
23457.2	COS^{35}	m*
23458.6	AsF_3	w
23461	COS^{35}	s*
23463.0	AsF_3	w
23464	$CHNS$	
23466	COS^{35}	m*
23467	CH_3NO_2	
23472.6	AsF_3	w
23476	CH_2Cl_2	
23482	AsF_3	w
23483	CH_3NO_2	
23494.2	AsF_3	w
23501.6	AsF_3	w
23510	CH_5N	
23513	AsF_3	w
23517.0	AsF_3	w
23522.4	AsF_3	m
23532.1	AsF_3	m
23534.67	$CO^{17}S$	w
23538.9	$C_2H_3Cl^{35}$	
23543	AsF_3	w
23546.4	AsF_3	w
23553	AsF_3	w
23555	C_2H_6O	
23564.6	AsF_3	w
23575.3	AsF_3	w
23584	AsF_3	w

Table II. Lines Listed in Order of Frequency—Continued

Frequency Mc	Molecule	Intensity
23595	AsF_3	w
23603	C_3H_6O	
23605	C_2H_6O	
23610	C_2H_4O	m
23622.8	AsF_3	w
23625.60	$CCl^{36}N$	s*
23629.84	$CCl^{36}N$	s*
23634.68	$CCl^{36}N$	m*
23644	$CHClF_2$	(w)
23646.92	$C^{13}OS^{34}$	w
23649	$C_2H_2F_2$	(m)
23657.46	H_3N	s
23660.62	C_3H_6O	
23661	COS^{34}	w
23680	$CHClF_2$	(w)
23680	CH_5N	
23690	C_6H_5Br	
23694.48	H_3N	s
23706	CH_3NO_2	
23711.64	N_2O^{18}	w
23718.21	$N^{14}N^{15}O^{18}$	w
23722.61	H_3N	s
23731.33	COS^{34}	m
23733	$CHClF_2$	(s)
23733.03	O_2S	(w)
23742	C_6H_5Br	
23749	C_3H_6O	
23760.67	COS^{34}	w
23760.98	$C^{13}Cl^{35}N$	w
23770	$C_2H_2F_2$	(m)
23777.4	H_3N	w
23778	C_3H_6O	
23784.95	COS^{34}	w
23793	C_3H_6O	
23803	$CHClF_2$	(w)
23812	$C_2H_2F_2$	(m)
23814	$HN_2{}^{14}N^{15}$	
23815.7	HN_3	
23826	$CHClF_2$	(w)
23827	C_3H_6O	
23839	C_3H_6O	
23845	$CHClF_2$	(s)
23854.25	CH_4O	
23862.57	$CCl^{35}N$	m
23863.5	$CCl^{35}N$	w
23863.8	$CCl^{35}N$	w
23864.0	$CCl^{35}N$	m
23864.2	$CCl^{35}N$	m
23864.5	$CCl^{35}N$	m
23864.9	$CCl^{35}N$	w
23865.1	$CCl^{35}N$	w
23870.11	H_3N	s
23878.6	$CCl^{35}N$	m
23878.9	$CCl^{35}N$	w
23879.7	$CCl^{35}N$	w
23880.18	$C^{13}OSe^{80}$	w
23883.30	$CCl^{35}N$	m
23884.2	$CCl^{35}N$	m
23884.8	$CCl^{35}N$	m
23884.9	$CCl^{35}N$	s
23885.16	$CCl^{35}N$	s
23885.3	$CCl^{35}N$	s
23885.76	$COSe^{82}$	w
23886.0	$CCl^{35}N$	m
23886.2	$CCl^{35}N$	m
23896.29	$C_2H_2Cl^{35}F$	
23899.59	$CCl^{35}N$	m
23900.20	$CCl^{35}N$	m
23900.7	$CCl^{35}N$	m
23917.9	$CCl^{35}N$	m
23920.91	$CCl^{35}N$	m
23922.32	H_3N^{15}	m
23925.5	$CCl^{35}N$	m
23928.7	$CCl^{35}N$	m
23934	C_3H_6O	
23938.6	$CCl^{35}N$	m
23944.4	$CCl^{35}N$	m
23948.2	$CCl^{35}N$	m

Table II. Lines Listed in Order of Frequency—Continued

Frequency Mc	Molecule	Intensity
23954.5	$CCl^{35}N$	m
23958.4	$CCl^{35}N$	m
23964.33	$COSe^{82}$	m
23968.6	$CCl^{35}N$	m
23974.4	$CCl^{35}N$	m
23984.6	$CCl^{35}N$	m
23986	$C_2H_2F_2$	(m)
23996.26	$COSe^{82}$	w
24013.04	COS^{33}	w
24014.97	$COSe^{82}$	w
24015	CH_5N	
24017	CH_3NO_2	
24020.21	COS^{33}	w
24021	$C_2H_2F_2$	(m)
24021	$CSSe^{82}$	
24025.39	COS^{33}	w
24026.39	$COSe^{80}$	w
24030.58	$C^{13}OSe^{78}$	w
24032.75	COS^{33}	w
24039.50	O_2S	(s)
24048	$CSSe^{82}$	
24055	CD_4O	w
24068.31	CH_2O	m
24075	$CSSe^{82}$	
24078	CH_5N	
24083.39	O_2S	(s)
24102	C_3H_6O	
24105.85	$COSe^{80}$	m
24138.05	$COSe^{80}$	m
24139.39	H_3N	s
24143	$C^{12}C^{13}H_3NS$	
24150	$C_2H_2F_2$	(w)
24156.93	$COSe^{80}$	m
24173.0	$C^{14}OS$	s*
24174.30	$COSe^{78}$	w
24176.07	$C^{13}OS$	w
24179.62	COS	w
24184.09	$COSe^{80}$	w
24188.31	$COSe^{80}$	w
24197	$C^{14}OS$	m*
24203	$CSSe^{80}$	
24205.25	H_3N	s
24214	$CSSe^{80}$	
24224	$C^{14}OS$	m*
24230	$CSSe^{80}$	
24247.69	$C^{13}OS$	m
24250.84	$COSe^{77}$	w
24252.00	CH_2DCl^{37}	w
24253.51	COS	m
24254.43	$COSe^{78}$	m
24266.68	CH_2DCl^{37}	w
24274.53	$N^{14}N^{15}O$	w
24274.61	$N^{14}N^{15}O$	w
24274.73	$N^{14}N^{15}O$	w
24274.78	$N_2{}^{15}O$	w
24274.84	$C^{13}OS$	w
24278.33	CH_2DCl^{37}	w
24286.82	$COSe^{78}$	w
24289.97	COS	w
24294	$C_2H_2F_2$	(m)
24295	C_2H_6O	
24300.58	$C^{13}OS$	w
24305.95	$COSe^{78}$	w
24316.76	COS	w
24319.67	O_2S	(w)
24320	CH_5N	
24323	$C_2H_2F_2$	(s)
24325.92	COS	s
24331.38	$COSe^{77}$	m
24352	$C_2H_2F_2$	(m)
24355.50	COS	m
24357	$C_2H_2F_2$	(w)
24362.48	$C_2H_2Cl^{35}F$	
24363.97	$COSe^{77}$	w
24369	C_2H_6O	
24376	$CSSe^{78}$	
24381.07	COS	m

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
24383.21	$COSe^{77}$	w
24385	C_2H_6O	
24386	$CSSe^{78}$	
24401	COS	m
24406	$CSSe^{78}$	
24410.48	$COSe^{76}$	m
24411	COS	w
24427.38	$C_2H_2Cl^{37}F$	
24428	CH_3NO_2	
24440	CH_2Cl_2	
2442.98	$COSe^{76}$	w
24448	CH_3NO_2	
24450	$C_2H_2F_2$	(s)
24459	COS	w
24462.42	$COSe^{76}$	w
24465.33	$CBr^{81}N$	m
24471	CH_2Cl_2	
24506.75	$CBr^{81}N$	m
24507.38	$CBr^{81}N$	m
24508	$CSSe^{77}$	
24510	$Cl_3{}^{35}Sb^{123}$	
24521	$CSSe^{77}$	
24527	$CSSe^{77}$	
24528	CH_5N	
24532.94	H_3N	s
24536	$AsCl_3{}^{37}$	w
24541.18	$CBr^{81}N$	m
24545	$C_2H_2F_2$	(m)
24553.42	H_3N^{15}	m
24554	$Cl_3{}^{35}Sb^{121}$	
24566	CH_2O_2	
24573.86	$CBr^{81}N$	s
24574.76	$COSe^{74}$	w
24577	CH_2Cl_2	
24579	$C_2H_2F_2$	(w)
24583.00	$CBr^{79}N$	m
24599	CH_3NO_2	
24601.24	$C_2H_2Cl^{35}F$	
24602	$CSSe^{76}$	

Frequency Mc	Molecule	Intensity
24602	$C_2H_2F_2$	(w)
24602.45	C_3DN^{15}	w
24608.92	$CBr^{81}N$	s
24609	$C_2H_3NS^{34}$	
24614	$CSSe^{76}$	
24622.93	$CBr^{81}N$	m
24627	$CSSe^{76}$	
24627	CH_2Cl_2	
24631	CH_2Cl_2	
24633.71	$CBr^{79}N$	m
24636	CH_2Cl_2	
24639	$C_2H_2F_2$	(m)
24641.70	CH_2DCl^{35}	w
24643.29	$C_2{}^{12}C^{13}DN$	w
24645.82	$CBr^{81}N$ $CBr^{79}N$	m
24646	C_3H_6O	
24658.89	$CBr^{81}N$	m
24660.33	CH_2DCl^{35}	w
24668	C_2D_4O	w
24675.25	CH_2DCl^{35}	w
24680.1	H_3N	w
24682.13	$CBr^{81}N$	m
24687.11	$CBr^{79}N$	m
24689.96	CHN	m
24691	C_3H_6O	
24713.05	$CBr^{79}N$	s
24717.19	$CBr^{81}N$	m
24734	$C_2H_2F_2$	(m)
24755.22	$CBr^{79}N$	s
24758	C_3H_6O	
24760.76	$CBr^{79}N$	m
24770	$C_2H_2F_2$	(s)
24784.02	$CBr^{79}N$	m
24803.00	$CBr^{79}N$	m
24806	$C_2H_2F_2$	(w)
24808	$C_2H_2F_2$	(w)
24824	C_2H_3NS	
24826.70	$CBr^{79}N$	m

Table II. Lines Listed in Order of Frequency—Continued

Frequency Mc	Molecule	Intensity
24834.3	C_2H_4O	s
24842	CH_2Cl_2	
24860.6	$CBr^{79}N$	m
24860.72	$C^{13}H_4O$	
24875	$PCl_3{}^{37}$	w
24881.90	H_3N	s
24884.57	$CBr^{79}N$	m
24890.0	$CBr^{79}N$	m
24890	CH_5N	
24895.46	$C_2H_2Cl^{35}F$	
24896	CH_5N	
24901	$CH_4{}^0$	
24908	CH_2Br_2	(m)
24910	$C_2H_3NS^{34}$	
24916	CH_2Cl_2	
24924.4	C_2H_4O	m
24928.70	CH_4O	
24930	$C_2H_3NS^{33}$	
24931.5	$AsCl^{35}Cl_2{}^{37}$	w
24933.47	CH_4O	
24934.38	CH_4O	
24943	CH_2Br_2	(w)
24959.08	CH_4O	
24967	CH_2Cl_2	
24970	CH_2Cl_2	
24971	C_2H_3NS	
24972	CH_2Br_2	(w)
24973	$AsCl^{35}Cl_2{}^{37}$	w
24976	CH_2Cl_2	
24981.5	$CBr^{79}N$	m
24982	CH_2Br_2	(m)
24996	CH_2Cl_2	
24997	CH_4O	
25000	CH_5N	
25002	$C^{12}C^{13}H_3NS$	
25002	CH_2Br_2	(w)
25006.0	$CBr^{79}N$	m
25013	CH_2Br_2	(m)
25018	CH_2Cl_2	
25018.14	CH_4O	
25038	CH_2Cl_2	
25042	CH_2Br_2	(s)
25046	CH_2Cl_2	
25047	CH_2Cl_2	
25049.13	O_2S	(s)
25053	CH_2Cl_2	
25056.04	H_3N	s
25056.31	CH_4O	
25065	CH_5N	
25069	C_2H_6O	
25072	CH_2Br_2	(s)
25073	CH_2Cl_2	
25077	C_2H_3NS	
25090	CH_2Br_2	(m)
25099	CH_2Cl_2	
25100	C_2H_3NS	
25110	CH_4O	
25121.55	$N^{14}N^{15}O$	w
25123	CH_2Cl_2	
25123.03	$N_2{}^{14}O$	m
25123.28	$N_2{}^{14}O$	m
25123.64	$N_2{}^{14}O$	w
25124.88	CH_4O	
25128	CH_2Br_2	(s)
25147	CH_2Br_2	w
25151	CH_4O	
25152	CH_2Br_2	(w)
25160	CH_2Br_2	(w)
25161	C_2H_3NS	
25167.68	$C^{13}H_3Cl^{37}$	w
25170	CH_2Br_2	(m)
25170.97	O_2S	(w)
25182.50	$C^{13}H_3Cl^{37}$	w
25194.20	$C^{13}H_3Cl^{37}$	w
25195	C_2H_3NS	
25200	CH_5N	
25203	CH_2Br_2	
25215.30	$C_2{}^{12}C^{13}DN$	w
25221	CH_2Cl_2	

Table II. Lines Listed in Order of Frequency—Continued

Frequency Mc	Molecule	Intensity
25223	CH_2Br_2	(m)
25245.58	$C_2{}^{12}C^{13}DN$	w
25248	$C_2H_2F_2$	(m)
25269	C_2H_3NS	
25269	CH_2Cl_2	
25280	CH_2Cl_2	
25294.41	CH_4O	
25306	C_2H_3NS	
25306	$PCl^{35}Cl_2{}^{37}$	w
25308	$AsCl_2{}^{35}Cl^{37}$	w
25312	CH_4O	
25323.51	H_3N^{15}	m
25329.62	C_3DN	w
25332	CH_4O	
25333	C_2H_3NS	
25349	CH_4O	
25350	$C_2H_2F_2$	(s)
25354	$AsCl_2{}^{35}Cl^{37}$	w
25381	$AsCl_2{}^{35}Cl^{37}$	w
25381	CH_4O	
25390	C_2H_3NS	
25392.81	O_2S	(s)
25393	$AsCl_2{}^{35}Cl^{37}$	w
25393.87	CIN	m
25394	CH_3NO_2	
25409	C_2H_3NS	
25411	$AsCl_2{}^{35}Cl^{37}$	w
25412	CH_3NO_2	
25442	C_2H_3NS	
25450	$C_2H_2F_2$	(m)
25470	CH_5N	
25516	$C_2H_2F_2$	(s)
25541.43	CH_4O	
25550	C_2H_3NS	
25552	$PCl_2{}^{35}Cl^{37}$	w
25577.40	$C^{13}H_3Cl^{35}$	w
25596.19	$C^{13}H_3Cl^{35}$	w
25611.09	$C^{13}H_3Cl^{35}$	w
25649	$PCl_2{}^{35}Cl^{37}$	w
25653	C_2H_3NS	
25656.30	$C_2H_2Cl^{35}F$	
25675	$AsCl_3{}^{35}$	w
25695.23	H_3N	s
25710	CH_2Cl_2	
25711.50	CIN	s
25715.14	H_3N	s
25716	$PCl_2{}^{35}Cl^{37}$	w
25724	$AsCl_3{}^{35}$	w
25725	$PCl_2{}^{35}Cl^{37}$	w
25728.77	CIN	s
25729	$C_2H_2F_2$	(s)
25741	$C_2H_2F_2$	(m)
25745	CH_2Cl_2	
25748	$PCl_2{}^{35}Cl^{37}$	w
25748	CH_2Cl_2	
25748.18	CIN	m
25751	CH_2Cl_2	
25752.65	CIN	s
25763.23	CIN	m
25767	$AsCl_3{}^{35}$	w
25783.50	CIN	s
25787.12	CH_4O	
25789.85	CIN	s
25802.92	CIN	m
25815.34	CIN	m
25823.08	CIN	s
25829.31	CIN	m
25837.64	CIN	s
25848	CH_2Cl_2	
25850.78	CIN	m
25872.24	CIN	s
25878.18	CH_4O	
25893.73	CIN	s
25906.28	CIN	s
25927.66	CIN	s
25954.36	CIN	s
25969.58	CIN	m
25971	$PCl_2{}^{35}Cl^{37}$	w

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
25991.92	CIN	s
26000.77	$CCl^{37}F_3$	
26001.20	$CCl^{37}F_3$	
26003.04	$CCl^{37}F_3$	
26007	CH_2Cl_2	
26008.55	$CCl^{37}F_3$	
26010.09	$CCl^{37}F_3$	
26010.73	$CCl^{37}F_3$	
26014.69	$CCl^{37}F_3$	
26016.84	$CCl^{37}F_3$	
26022.20	$CCl^{37}F_3$	
26023.93	$CCl^{37}F_3$	
26042.41	$H_3Cl^{37}Si^{28}$	w
26043.29	$H_3Cl^{37}Si^{28}$	w
26046.30	$H_3Cl^{37}Si^{28}$	w
26046.32	CIN	m
26047.97	$H_3Cl^{37}Si^{28}$	w
26050.26	$H_3Cl^{37}Si^{28}$	m
26051.09	$H_3Cl^{37}Si^{28}$	w
26053.35	$H_3Cl^{37}Si^{28}$	w
26055.86	$H_3Cl^{37}Si^{28}$	w
26057.10	$H_3Cl^{37}Si^{28}$	w
26063.52	$H_3Cl^{35}Si^{28}$	w
26118	$C_2H_2F_2$	(s)
26120	CH_4O	
26152	$PCl_3{}^{35}$	w
26163	$C_2H_2F_2$	(m)
26164.57	CH_3Cl^{37}	m
26171	$PCl_3{}^{35}$	w
26179.30	CH_3Cl^{37}	m
26181.6	ICl^{37}	m
26190	$PCl_3{}^{35}$	w
26191.13	CH_3Cl^{37}	m
26243.0	H_3N^{15}	w
26295	CH_2Cl_2	
26313.11	CH_4O	
26328	$C_2H_2F_2$	(s)
26337	$C_2H_2F_2$	(m)
26358.82	CH_2O	w
26410	$C_2H_2F_2$	(w)
26417	$CHCl_3{}^{35}$	w
26450.73	$C_2{}^{12}C^{13}HN$	m
26466	$C_2H_2F_2$	(m)
26501.46	C_3HN^{15}	m
26518.91	H_3N	s
26553	F_3PS	
26562	CH_4O	
26565	C_2D_4O	w
26570.77	CH_3Cl^{35}	m
26574	F_3PS	
26589.49	CH_3Cl^{35}	m
26600	NO_2	
26604.57	CH_3Cl^{35}	m
26631.58	$CCl^{35}F_3$	
26634	$C_2H_2F_2$	(s)
26634.31	$CCl^{35}F_3$	
26639.40	$CCl^{35}F_3$	
26642.22	$CCl^{35}F_3$	
26649	$C_2H_2F_2$	(m)
26655.00	H_3N	s
26669.78	$CCl^{35}F_3$	
26670.19	$CCl^{35}F_3$	
26672.59	$CCl^{35}F_3$	
26674.77	$CCl^{35}F_3$	
26679.62	$CCl^{35}F_3$	
26681.52	$CCl^{35}F_3$	
26682.30	$CCl^{35}F_3$	
26683.78	$CCl^{35}F_3$	
26684.69	$CCl^{35}F_3$	
26685.25	$H_3Cl^{35}Si^{28}$	w
26685.73	$CCl^{35}F_3$	
26686.15	$H_3Cl^{35}Si^{28}$	w
26687.34	$H_3Cl^{35}Si^{28}$	w
26687.38	$CCl^{35}F_3$	
26690.14	$CCl^{35}F_3$	
26690.92	$H_3Cl^{35}Si^{28}$	w
26692.66	$H_3Cl^{35}Si^{28}$	w

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
26695.00	$H_3Cl^{35}Si^{28}$	w
26696.10	$H_3Cl^{35}Si^{28}$	m
26697.04	$CCl^{35}F_3$	
26697.45	$H_3Cl^{35}Si^{28}$	m
26699.14	$CCl^{35}F_3$	
26700.48	$H_3Cl^{35}Si^{28}$	w
26703.34	$H_3Cl^{35}Si^{28}$	w
26705.02	$H_3Cl^{35}Si^{28}$	w
26713.07	$H_3Cl^{35}Si^{28}$	w
26723	$C_2H_2F_2$	(w)
26777.20	O_2S	(s)
26832	$C_2H_2F_2$	(m)
26847.27	CH_4O	
26855.01	$C^{13}H_4O$	w
26865	$C_2H_2F_2$	(s)
26880	$C_2H_2F_2$	(m)
26936.87	C_3D_4	w
26937.24	C_3D_4	w
26979.03	$C^{13}H_4O$	
26980.40	$C^{13}H_4O$	
26992	$C_2H_2F_2$	(s)
27014	$C_2H_2F_2$	(s)
27047.19	$C^{13}H_4O$	
27050.45	$C^{13}H_4O$	
27052.97	$C^{13}H_4O$	
27072.17	$C^{13}H_4O$	
27104.80	$C^{13}H_4O$	
27105.93	$C^{13}H_4O$	
27112	$C_2H_2F_2$	(m)
27122.76	$C^{13}H_4O$	
27179.10	$C_2{}^{12}C^{13}HN$	m
27181.45	$C_2{}^{12}C^{13}HN$	m
27194.75	ICl^{35}	m
27202.64	ICl^{35}	w
27204.99	ICl^{35}	m
27208.54	ICl^{35}	m
27215.60	$C^{13}H_4O$	
27216	$C_2H_2F_2$	(m)
27217.51	ICl^{35}	m
27221.02	ICl^{35}	m
27225.32	ICl^{35}	m
27228.34	ICl^{35}	m
27242.59	ICl^{35}	w
27254.90	ICl^{35}	m
27283.29	CH_4O	
27283.66	ICl^{35}	
27286.25	ICl^{35}	
27292.63	ICl^{35}	
27294.47	C_3HN	s
27295.05	ICl^{35}	
27297	$C_2H_2F_2$	(s)
27333.85	ICl^{35}	m
27336.68	ICl^{35}	m
27337.38	ICl^{35}	m
27346.31	ICl^{35}	m
27354.71	ICl^{35}	m
27356.58	ICl^{35}	m
27357.73	ICl^{35}	m
27364.12	$C^{13}H_4O$	
27392.00	HDS^{34}	
27412	$C_2H_2F_2$	(m)
27470.99	CH_4O	
27472.54	CH_4O	
27478.00	H_3N	s
27555.73	$C^{13}H_2O$	w
27566.31	HDS	
27581.65	$C^{13}H_4O$	w
27681	$C_2H_2F_2$	(s)
27772.52	H_3N	m
27810	CH_2O_2	
27817.50	CH_4O	
27818	$C_2H_2F_2$	(s)
27820.87	CH_4O	
27880.04	$C^{13}H_4O$	
27972	$C_2H_2F_2$	(s)
28069.99	$C^{13}H_3I$	w
28085	C_4H_9I	
28145.01	$C^{13}H_3I$	w

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
28145.2	H_3FSi^{30}	w
28169.31	CH_4O	
28174	$C_2H_2F_2$	(s)
28206.90	$C^{13}H_3I$	w
28253.84	$C^{13}H_3I$	w
28267.71	$C^{13}H_4O$	w
28314	$C_2H_2F_2$	(w)
28316.03	CH_4O	
28339	$C_2H_2F_2$	(m)
28343.64	$C^{13}H_3I$	w
28380	C_2H_3NS	
28393.4	H_3FSi^{29}	w
28411.19	$C^{13}H_3I$	w
28412	$C_2H_2F_2$	(s)
28439	$C_2H_2F_2$	(m)
28458	$C_2H_2F_2$	(m)
28495	C_2D_4O	w
28518.14	$C^{13}H_3I$	w
28550.86	$C^{13}H_3I$	w
28551	$C_2H_2F_2$	(w)
28575	$C_2H_2F_2$	(w)
28582.40	$C^{13}H_2O$	w
28594.74	$C^{13}H_3I$	w
28604.73	H_3N	s
28610	$C_4H_9Br^{79}$	
28615	$C_2H_2F_2$	(w)
28621.04	$C^{13}H_4O$	w
28650.91	$C^{13}H_3I$	w
28655.80	H_3FSi^{28}	m
28687.21	$C^{13}H_3I$	w
28689	$C_2H_2F_2$	(w)
28747.67	$C^{13}H_4O$	w
28831.90	HF_3Si^{28}	
28842.84	HDS	
28852	$C_2H_2F_2$	
28858	$C_2H_2F_2$	
28858.11	O_2S	(s)
28869.59	$C^{13}H_4O$	w
28874.45	CH_4O	
28905.70	CH_4O	
28954	$C_2H_2F_2$	(s)
28974.85	CH_2O	s
29061.14	H_3N	m
29080	C_2D_4O	w
29113.76	CH_4O	
29315.20	$C^{13}H_4O$	
29321.46	O_2S	(s)
29345.03	$CD_3B^{11}O$	w
29345.28	$CD_3B^{11}O$	w
29345.52	$CD_3B^{11}O$	w
29345.68	$CD_3B^{11}O$	w
29345.93	$CD_3B^{11}O$	w
29346.24	$CD_3B^{11}O$	w
29346.65	$CD_3B^{11}O$	w
29460	O_2S	
29530	$C_4H_9Cl^{37}$	
29598.95	CH_3I	m
29636.91	CH_4O	
29650	CHN	m
29688	C_2H_4O	s
29697.95	CH_3I	m
29700	$C_2H_3NS^{34}$	
29707.24	CH_3F_3Si	
29724.91	CH_3F_3Si	
29735.71	CH_3I	m
29773.95	CH_3I	w
29782.71	CH_3I	m
29872.52	CH_3I	m
29889.33	CH_4O	
29914.66	H_3N	s
29923.50	CH_3I	m
29939.87	CH_3I	m
29955.72	$C^{13}H_4O$	
29973.06	CH_4O	
29974.47	$Cl^{37}F$	w
29986.84	CH_3I	w
30003.22	$Cl^{37}F$	w
30026.19	$Cl^{37}F$	w

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
30046.99	CH_3I	m
30075.08	CH_3I	m
30079.72	CH_3I	m
30119.91	$CD_3B^{10}O$	w
30120.21	$CD_3B^{10}O$	w
30120.56	$CD_3B^{10}O$	w
30120.86	$CD_3B^{10}O$	w
30121.21	$CD_3B^{10}O$	w
30121.32	CH_3I	m
30121.56	$CH_3B^{10}O$	w
30121.86	$CH_3B^{10}O$	w
30123.64	CH_3I	m
30127.80	$C^{13}H_4O$	w
30150	$C_4H_9Cl^{35}$	
30179.71	CH_3I	m
30215.95	CH_3I	m
30288.36	$Cl^{37}F$	m
30257.16	$Cl^{37}F$	m
30280.11	$Cl^{37}F$	m
30308.00	CH_4O	
30429.88	CH_4O	
30453.46	CH_3I	m
30505	CD_4O	w
30545.99	$Cl^{35}F$	m
30582.61	$Cl^{35}F$	m
30600	CD_4O	w
30611.76	$Cl^{35}F$	w
30643.69	$C^{13}H_4O$	
30752.26	CH_4O	
30807.41	$Cl^{35}F$	s
30843.95	$Cl^{35}F$	s
30858.40	CH_4O	
30873.00	$Cl^{35}F$	m
31000	CH_2O_2	
31020.7	$C_2H_2F_3$	m
31066.8	$C_2H_2F_3$	m
31114.4	$C_2H_2F_3$	m
31140	CD_4O	w
31152.00	C_3H_3D	w
31152.56	C_3H_3D	w
31185	C_4H_9I	
31209.75	CH_4O	
31226.70	CH_4O	
31279.60	F_3P	m
31342.31	$C^{13}H_4O$	
31350.19	$C^{13}H_4O$	
31358.31	CH_4O	
31424.97	H_3N	s
31718.28	$C^{13}IN$	m
31730.50	$C^{13}IN$	m
31741.50	$C^{13}IN$	w
31763.34	$C^{13}IN$	m
31783.31	$C^{13}IN$	m
31793.46	$C^{13}IN$	m
31848.77	CIN	m
31943	C_2D_4O	w
32004.43	$C^{13}H_4O$	w
32190	CD_4O	w
32200.58	CIN	s
32203.57	CIN	s
32215.56	CIN	s
32226.85	CIN	s
32248.52	CIN	s
32286.33	CIN	s
32271.10	$C^{13}H_4O$	w
32278.55	CIN	s
32325	CD_4O	w
32386.29	CIN	s
32392.59	$C^{13}Br^{81}N$	m
32409.06	$C^{13}Br^{81}N$	m
32575.53	$C^{13}H_4O$	w
32581.73	$C^{13}Br^{79}N$	m
32601.46	$C^{13}Br^{79}N$	m
32643.13	$CBr^{81}N$	m
32690	$C_4H_9Br^{79}$	
32720.28	$CBr^{81}N$	m
32770.13	$CBr^{81}N$	s
32786.65	$CBr^{81}N$	s

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
32790	CD_4O	w
32804.56	$CBr^{79}N$	m
32883.47	$C^{13}H_4O$	w
32913.24	$CBr^{81}N$	m
32956.68	$CBr^{79}N$	m
32976.40	$CBr^{79}N$	s
32998.94	$C^{13}H_4O$	
33156.95	H_3N	s
33160.35	$C_2{}^{12}C^{13}H_4$	w
33160.94	$C_2{}^{12}C^{13}H_4$	w
33192.97	$C^{13}H_4O$	
33220.05	$C^{13}H_4O$	
33252.22	$C_2{}^{12}C^{13}H_4$	w
33252.88	$C_2{}^{12}C^{13}H_4$	w
33285	C_2D_4O	w
33340	CD_4O	w
33691.72	CH_4O	
33693.69	CH_4O	
33918.97	CH_4O^{18}	w
33925.49	CH_4O^{18}	w
33965	CD_4O	w
34001.40	CH_4O	
34003.61	CH_4O	
34048.42	CH_4O^{18}	w
34150	C_2H_4O	s
34155.63	CH_4O^{18}	w
34158	C_2H_4O	m
34168.47	$C_2{}^{12}C^{13}H_4$	
34169.13	$C_2{}^{12}C^{13}H_4$	
34182.71	C_3H_4	m
34183.37	C_3H_4	m
34246.30	C_3H_4	
34277.05	C_3H_4	
34278.98	C_3H_4	
34310	C_4H_9I	
34313.21	C_3H_4	
34314.64	CH_4O^{18}	w
34327.23	C_2D_3N	w
34327.82	C_2D_3N	w
34410	CD_4O	w
34536.74	CH_4O^{18}	w
34627.16	$CH_3B^{11}O$	m
34627.42	$CH_3B^{11}O$	s
34627.64	$CH_3B^{11}O$	m
34627.81	$CH_3B^{11}O$	m
34628.16	$CH_3B^{11}O$	m
34628.58	$CH_3B^{11}O$	m
34628.85	$CH_3B^{11}O$	s
34629.27	$CH_3B^{11}O$	m
34761.75	CH_4O^{18}	w
34831.64	CH_4O^{18}	w
34889.05	$C^{13}Cl^{37}N$	w
35043.24	CHN	m
35067.99	$CCl^{37}N$	m
35068	C_2D_4O	w
35080.39	$CCl^{37}N$	s
35084.15	$CCl^{37}N$	s
35090	CD_4O	w
35091.97	$CCl^{37}N$	m
35100	CD_4O	w
35134.44	H_3N	m
35165	CD_4O	w
35206.11	CH_4O^{18}	w
35215	CD_4O	w
35335	CD_4O	w
35341	C_2D_4O	w
35440	CD_4O	w
35460	$C_4H_9Cl^{37}$	
35618.81	$C^{13}Cl^{35}N$	w
35634.85	$C^{13}Cl^{35}N$	m
35639.78	$C^{13}Cl^{35}N$	m
35649.56	$C^{13}Cl^{35}N$	w
35661.78	CH_4O^{18}	w
35748.2	CD_4O	w
35791	C_2H_4O	s
35805.09	$CCl^{35}N$	s
35805.7	CD_4O	w
35810.8	CD_4O	w
35820.65	$CCl^{35}N$	s

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
35825.95	$CCl^{35}N$	s
35835.74	$CCl^{35}N$	s
35917.66	$CH_3B^{10}O$	m
35917.96	$CH_3B^{10}O$	m
35918.29	$CH_3B^{10}O$	m
35918.55	$CH_3B^{10}O$	m
35919.08	$CH_3B^{10}O$	w
35919.60	$CH_4B^{10}O$	m
35919.95	$CH_4B^{10}O$	m
35920.22	$CH_4B^{10}O$	m
35920.40	$CH_4B^{10}O$	w
36080.0	CD_4O	w
36169.24	CH_4O	(s)
36193.55	CH_4O^{18}	w
36210	$C_4H_9Cl^{35}$	
36240	CH_4O	(m)
36312.57	CH_4O^{18}	w
36332.7	CD_4O	w
36442.9	CD_4O	w
36483.9	CD_4O	w
36488.82	COS	s
36532.47	COS	s
36570.83	COS	s
36600.81	COS	m
36615.26	COS	m
36632	$C_2H_2F_2$	(m)
36655	CD_4O	w
36777.18	$C^{12}C^{13}H_3N$	
36787.33	CH_4O^{18}	w
36790	$C_4H_9Br^{79}$	
36793.64	C_2H_3N	s
36794.26	C_2H_3N	s
36794.88	C_2H_3N	s
36795.38	C_2H_3N	s
36796.27	C_2H_3N	s
36797.52	C_2H_3N	s
36870.94	C_2H_3N	
36903.40	C_2H_3N	
36942.15	C_2H_3N	
26946.4	CD_4O	w
36987	CD_4O	w
37030	CD_4O	w
37229.8	CD_4O	w
37322.8	CD_4O	w
37325	CD_4O	w
37329	C_2H_4O	s
37385.18	H_3N	m
37418.97	CH_4O^{18}	w
37425	CD_4O	w
37462.6	CD_4O	w
37490	C_4H_9I	
37579.85	CH_4O^{18}	w
37690	CH_4O	(s)
37781	C_2H_4O	s
37900	CD_4O	w
38006.47	CH_3Br^{81}	w
38030.77	CH_3Br^{81}	m
38052.6	CD_4O	w
38053.87	CH_4O^{18}	w
38066.72	CH_3Br^{81}	m
38097.45	CH_3Br^{81}	m
38116.65	CH_3Br^{81}	s
38126.97	CH_3Br^{81}	m
38128.40	CH_3Br^{79}	w
38123.8	CD_4O	w
38157.30	CH_3Br^{79}	m
38157.70	CH_3Br^{81}	m
38175.08	CH_3Br^{81}	m
38200.52	CH_3Br^{79}	m
38218.21	CH_3Br^{81}	m
38237.14	CH_3Br^{79}	m
38237.14	CH_3Br^{81}	m
38247.77	CH_3Br^{81}	m
38260.10	CH_3Br^{79}	s
38272.40	CH_3Br^{79}	m
38290	CH_4O	(m)
38309.45	CH_3Br^{79}	m

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
38330.25	CH_3Br^{79}	m
38335	CH_4O	(w)
38381.70	CH_3Br^{79}	m
38404.49	CH_3Br^{79}	m
38417.09	CH_3Br^{79}	m
38445	CH_4O	(m)
38530	CD_4O	w
38547.73	CH_4O^{18}	w
38647.87	CH_4O^{18}	w
38702	C_2H_4O	s
38782.21	$C^{12}C^{13}H_3N$	
38783.31	$C^{12}C^{13}H_3N$	
38967.0	CD_4O	w
39048	CD_4O	w
39065	CD_4O	w
39149.41	CH_4O^{18}	w
39210.48	CH_4O^{18}	w
39505.01	CH_4O^{18}	w
39574.97	CH_4O^{18}	w
39582	C_2H_4O	m
39592	C_2D_4O	w
39661.80	CH_4O^{18}	w
39677	C_2H_4O	s
39941.54	H_3N	m
40038.80	C_2H_2O	
40083	CD_4O	w
40210.27	C_2H_3N	
40211.16	C_2H_3N	
40240	CD_4O	w
40313.37	C_2H_3N	
40364.07	C_2H_3N	
40366.55	C_2H_3N	
40417.90	C_2H_2O	
40424.49	C_2H_3N	
40570	C_4H_9I	
40640	CD_4O	w
40793.62	C_2H_2O	
40885	$C_4H_9Br^{79}$	
40929.20	HDS	
40940	CD_4O	w
41230	CD_4O	w
41330	$C_4H_9Cl^{37}$	
41394.95	CHF_3	s
41540	CD_4O	w
41581	C_2H_4O	s
41688	CD_4O	w
41750	CD_4O	w
42000	CD_4O	w
42020	CD_4O	w
42150	CD_4O	w
42200	$C_4H_9Cl^{35}$	
42280	CH_4O	(w)
42285	CD_4O	w
42517.38	F_3N^{15}	
42700	CD_4O	w
42721.73	F_3N	w
42722.16	F_3N	w
42723.28	F_3N	w
42723.94	F_3N	w
42724.36	F_3N	w
42726.60	F_3N	w
42727.39	F_3N	w
42345	CD_4O	w
43398	C_2H_4O	s
42525	CD_4O	w
42545	CD_4O	w
43630	CD_4O	w
43995	CD_4O	w
44100	CH_4O	(s)
45324.24	CH_5N	
45324.94	CH_5N	
45502.4	$CDCl_3{}^{35}$	w
45789	CHD_2Cl^{35}	w
46099.4	CHD_2Cl^{35}	w
46227.2	$CHCl_3{}^{35}$	m
46407	CHD_2Cl^{35}	w
46610	CH_4O	(w)
46918.82	F_3P	m

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
46919.02	F_3P	m
46940	F_3P	
47010	F_3P	
47033	F_3P	
47040	F_3P	
47052	CH_3DO	w
47080	$C^{13}H_4O$	w
47087.39	$C^{12}C^{13}D_3N$	w
47088.69	$C^{12}C^{13}D_3N$	w
47089.43	$C^{12}C^{13}D_3N$	w
47090.41	$C^{12}C^{13}D_3N$	w
47091.05	$C^{12}C^{13}D_3N$	w
47143.85	C_2D_3N	w
47145.20	C_2D_3N	w
47146.00	C_2D_3N	w
47146.68	C_2D_3N	w
47147.00	C_2D_3N	w
47147.60	C_2D_3N	w
47204.7	$C^{13}H_4O$	
47209.2	$C^{13}H_4O$	
47266	CH_3DO	w
47346	CH_3DO	w
47359.7	CH_3DO	w
47462.40	COS^{34}	s
47760	$C^{13}H_4O$	
47840	CH_4O	
47899.3	$C^{13}H_4O$	
47905.36	HDS	
47950.1	$C^{13}H_4O$	
48010	CH_4O	
48192	CH_4O	(w)
48211.46	$COSe^{80}$	s
48248	CH_4O	(w)
48260	CH_4O	(w)
48284.60	CH_2O	s
48371.9	CH_4O	(s)
48376.4	CH_4O	(s)
48406	CH_4O	(w)
48508.88	$COSe^{78}$	s
48529.6	$C^{13}H_4O$	
48651.64	COS	s
48707.7	CH_4O	(m)
49032	CH_4O	(w)
49070.8	$C^{13}H_4O$	
49668.07	$C^{12}C^{13}D_3N$	w
46670.43	$C^{12}C^{13}D_3N$	w
49671.19	$C^{12}C^{13}D_3N$	w
49724.73	$C^{13}H_3F$	m
49750	CH_4O	(w)
49867.2	CH_4O	(s)
50236.90	HDO	w
50912.27	HDS^{34}	
51071.69	CH_3F	s
51073.27	HDS	
51270.86	C_3H_4	m
51273.76	C_3H_4	s
51274.75	C_3H_4	s
51280.45	C_3H_4	
51296.33	C_3H_4	
51304.65	C_3H_4	
51305.93	C_3H_4	
51307.47	C_3H_4	
51334.81	C_3H_4	
51369.12	C_3H_4	
51410.51	C_3H_4	
51415.35	C_3H_4	
51418.23	C_3H_4	
51418.75	C_3H_4	
51469.85	C_3H_4	
51487.51	C_2D_3N	w
51490.05	C_2D_3N	w
51490.90	C_2D_3N	w
52979.67	HDS^{34}	w
53200.93	HDS	w
53592.2	O_2	m
54130.0	O_2	m
54672.5	O_2	m
55220.8	O_2	m

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
55784.1	O_2	s
55916.19	$COSe^{82}$	s
56246.47	$COSe^{80}$	s
56265.1	O_2	m
56362.8	O_2	s
56593.16	$COSe^{78}$	s
56968.7	O_2	s
57612.0	O_2	s
58324.0	O_2	s
58446.2	O_2	s
59163.4	O_2	s
59610	O_2	s
60057.92	C_2H_2O	
60306.4	O_2	s
60436	O_2	s
60615.88	C_2H_2O	
60617.30	C_2H_2O	
60625.68	C_2H_2O	
60814.08	COS	s
61120	O_2	s
61190.24	C_2H_2O	
61800.2	O_2	s
62411.7	O_2	s
62486.1	O_2	s
62970	O_2	s
63568.3	O_2	s
64127.6	O_2	s
64678.9	O_2	m
65220	O_2	m
65770	O_2	m
70949.66	CIN	s
70959.14	CIN	s
70961.30	CIN	s
70963.90	CIN	s
71173.58	$C^{13}DN$	w
71174.96	$C^{13}DN$	w
71177.02	$C^{13}DN$	w
72409.35	CH_2O	s
72413.25	CDN	w
72414.62	CDN	m
72416.68	CDN	w
72838.14	CH_2O	s
73738.42	$CBr^{81}N$	s
73741.20	$CBr^{81}N$	s
74159.48	$CBr^{79}N$	s
74162.76	$CBr^{79}N$	s
74829.54	CH_3I	s
74849.92	CH_3I	s
74926.04	CH_3I	s
74960.76	CH_3I	s
74964.36	CH_3I	s
74967.66	CH_3I	s
74971.76	CH_3I	s
74976.22	CH_3I	s
74977.62	CH_3I	s
74982.18	CH_3I	s
74986.14	CH_3I	s
74993.28	CH_3I	s
75004.28	CH_3I	s
75007.62	CH_3I	s
75016.20	CH_3I	s
75019.28	CH_3I	s
75026.20	CH_3I	s
75027.58	CH_3I	s
75081.02	CH_3I	s
75551.73	HDS	
76152.28	CH_3Br^{81}	s
76207.66	CH_3Br^{81}	s
76213.16	CH_3Br^{81}	s
76230.18	CH_3Br^{81}	s
76243.66	CH_3Br^{81}	s
76248.32	CH_3Br^{81}	s
76249.94	CH_3Br^{81}	s
76255.68	CH_3Br^{81}	s
76261.96	CH_3Br^{81}	s
76278.16	CH_3Br^{81}	s
76425.18	CH_3Br^{79}	s
76491.36	CH_3Br^{79}	s

Table II. Lines Listed in Order of Frequencies—Continued

Frequency Mc	Molecule	Intensity
76496.60	CH_3Br^{79}	s
76517.36	CH_3Br^{79}	s
76532.88	CH_3Br^{79}	s
76538.02	CH_3Br^{79}	s
76540.20	CH_3Br^{79}	s
76547.24	CH_3Br^{79}	s
76554.82	CH_3Br^{79}	s
76575.22	CH_3Br^{79}	s
76621.78	CH_3Br^{79}	s
77413	CIN	s
78511.68	CH_3Cl^{37}	m
78512.80	CH_3Cl^{37}	m
78522.00	CH_3Cl^{37}	m
78523.32	CH_3Cl^{37}	s
78526.14	CH_3Cl^{37}	m
78527.10	CH_3Cl^{37}	s
79736.96	CH_3Cl^{35}	s
79751.02	CH_3Cl^{35}	s
79755.68	CH_3Cl^{35}	s
79764.56	CH_3Cl^{35}	s
79768.98	CH_3Cl^{35}	s
79769.94	CH_3Cl^{35}	s
81936	$CBr^{81}N$	s
82405	$CBr^{79}N$	s
83864	CIN	s
86308.12	$C^{13}HN$	s
86309.49	$C^{13}HN$	s
86311.54	$C^{13}HN$	s
88600.11	CHN	s
88601.49	CHN	s
88603.56	CHN	s
95259.24	CH_3Br^{81}	s
95263.47	CH_3Br^{81}	s
95281.53	CH_3Br^{81}	s
95293.89	CH_3Br^{81}	s
95297.55	CH_3Br^{81}	s
95307.48	CH_3Br^{81}	s
95310.78	CH_3Br^{81}	s
95319.12	CH_3Br^{81}	s
95322.15	CH_3Br^{81}	s
95336.01	CH_3Br^{81}	s
95615.73	CH_3Br^{79}	s
95619.24	CH_3Br^{79}	s
95640.87	CH_3Br^{79}	s
95654.73	CH_3Br^{79}	s
95659.20	CH_3Br^{79}	s
95669.97	CH_3Br^{79}	s
95673.54	CH_3Br^{79}	s
95676.39	CH_3Br^{79}	s
95677.20	CH_3Br^{79}	s
95683.62	CH_3Br^{79}	s
95688.27	CH_3Br^{79}	s
95706.12	CH_3Br^{79}	s
102000	CH_3F	s
110201.1	$C^{13}O$	w
115270.56	CO	s
117000	ND_3	
129000	CIN	s

Table III. Casimir's Function for $J=1\rightarrow 10$, $I=1\rightarrow 9/2$

Values of $[3/4C(C+1)-I(I+1)J(J+1)]/2I(2I-1)(2J-1)(2J+3)$,
where $C=F(F+1)-I(I+1)-J(J+1)$

Table III

Casimir's function for $J = 1 \rightarrow 10$, $I = 1 \rightarrow 9/2$.

Table III. Values of $[3/4C(C+1)-I(I+1)J(J+1)]/2I(2I-1)(2J-1)(2J+3)$, where $C=F(F+1)-I(I+1)-J(J+1)$

I		1	3/2	2	5/2	3	7/2	4	9/2
J	F								
1	11/2	---------	---------	---------	---------	---------	---------	---------	0.050000
	5	---------	---------	---------	---------	---------	---------	0.050000	---------
	9/2	---------	---------	---------	---------	---------	0.050000	---------	-0.133333
	4	---------	---------	---------	---------	0.050000	---------	-0.137500	---------
	7/2	---------	---------	---------	0.050000	---------	-0.142857	---------	0.091667
	3	---------	---------	0.050000	---------	-0.150000	---------	0.098214	---------
	5/2	---------	0.050000	---------	-0.160000	---------	0.107143	---------	---------
	2	0.050000	---------	-0.175000	---------	0.120000	---------	---------	---------
	3/2	---------	-0.200000	---------	0.140000	---------	---------	---------	---------
	1	-0.250000	---------	0.175000	---------	---------	---------	---------	---------
	1/2	---------	0.250000	---------	---------	---------	---------	---------	---------
	0	0.500000	---------	---------	---------	---------	---------	---------	---------
2	13/2	---------	---------	---------	---------	---------	---------	---------	0.071429
	6	---------	---------	---------	---------	---------	---------	0.071429	---------
	11/2	---------	---------	---------	---------	---------	0.071429	---------	-0.083333
	5	---------	---------	---------	---------	0.071429	---------	-0.089286	---------
	9/2	---------	---------	---------	0.071429	---------	-0.096939	---------	-0.083333
	4	---------	---------	0.071429	---------	-0.107142	---------	-0.082908	---------
	7/2	---------	0.071429	---------	-0.121428	---------	-0.081633	---------	0.005952
	3	0.071429	---------	-0.142857	---------	-0.078571	---------	0.014031	---------
	5/2	---------	-0.178571	---------	-0.071429	---------	0.025510	---------	0.130952
	2	-0.250000	---------	-0.053571	---------	0.042857	---------	0.140306	---------
	3/2	---------	0	---------	0.071429	---------	0.153061	---------	---------
	1	0.250000	---------	0.125000	---------	0.171429	---------	---------	---------
	1/2	---------	0.250000	---------	0.200000	---------	---------	---------	---------
	0	---------	---------	0.250000	---------	---------	---------	---------	---------
3	15/2	---------	---------	---------	---------	---------	---------	---------	0.083333
	7	---------	---------	---------	---------	---------	---------	0.083333	---------
	13/2	---------	---------	---------	---------	---------	0.083333	---------	-0.055556
	6	---------	---------	---------	---------	0.083333	---------	-0.062500	---------
	11/2	---------	---------	---------	0.083333	---------	-0.071429	---------	-0.091667
	5	---------	---------	0.083333	---------	-0.083333	---------	-0.094643	---------
	9/2	---------	0.083333	---------	-0.100000	---------	-0.097619	---------	-0.061111
	4	0.083333	---------	-0.125000	---------	-0.100000	---------	-0.055952	---------
	7/2	---------	-0.166667	---------	-0.100000	---------	-0.047619	---------	0.005556
	3	-0.250000	---------	-0.091667	---------	-0.033333	---------	0.017857	---------
	5/2	---------	-0.050000	---------	-0.006667	---------	0.035714	---------	0.083333
	2	0.200000	---------	0.050000	---------	0.063333	---------	0.098214	---------
	3/2	---------	0.200000	---------	0.110000	---------	0.119048	---------	0.152777
	1	---------	---------	0.200000	---------	0.150000	---------	0.163690	---------
	1/2	---------	---------	---------	0.200000	---------	0.178571	---------	---------
	0	---------	---------	---------	---------	0.200000	---------	---------	---------

Table III. Values of [3/4C(C+1)-I(I+1)J(J+1)]/2I(2I-1)(2J-1)(2J+3), where C=F(F+1)-I(I+1)-J(J+1)—Continued

I		1	3/2	2	5/2	3	7/2	4	9/2
J	F								
4	17/2	---------	---------	---------	---------	---------	---------	---------	0.090909
	8	---------	---------	---------	---------	---------	---------	0.090909	---------
	15/2	---------	---------	---------	---------	---------	0.090909	---------	-0.037879
	7	---------	---------	---------	---------	0.090909	---------	-0.045455	---------
	13/2	---------	---------	---------	0.090909	---------	-0.055195	---------	-0.086580
	6	---------	---------	0.090909	---------	-0.068182	---------	-0.091721	---------
	11/2	---------	0.090909	---------	-0.086364	---------	-0.097403	---------	-0.079545
	5	0.090909	---------	-0.113636	---------	-0.103246	---------	-0.077110	---------
	9/2	---------	-0.15091	---------	-0.107792	---------	-0.071892	---------	-0.037879
	4	-0.250000	---------	-0.105519	---------	-0.061039	---------	-0.026670	---------
	7/2	---------	-0.071429	---------	-0.037662	---------	-0.009276	---------	0.020563
	3	0.178571	---------	0.017857	---------	0.019481	---------	0.38729	---------
	5/2	---------	0.178571	---------	0.071429	---------	0.065399	---------	0.081169
	2	---------	---------	0.178571	---------	0.107143	---------	0.102389	---------
	3/2	---------	---------	---------	0.178571	---------	0.132653	---------	0.132576
	1	---------	---------	---------	---------	0.178571	---------	0.151786	---------
	1/2	---------	---------	---------	---------	---------	0.178571	---------	0.166667
	0	---------	---------	---------	---------	---------	---------	0.178571	---------
5	19/2	---------	---------	---------	---------	---------	---------	---------	0.096154
	9	---------	---------	---------	---------	---------	---------	0.096154	---------
	17/2	---------	---------	---------	---------	---------	0.096154	---------	-0.025641
	8	---------	---------	---------	---------	0.096154	---------	-0.033654	---------
	15/2	---------	---------	---------	0.096154	---------	-0.043956	---------	-0.080128
	7	---------	---------	0.096154	---------	-0.057692	---------	-0.086767	---------
	13/2	---------	0.096154	---------	-0.076923	---------	-0.094322	---------	-0.085470
	6	0.096154	---------	-0.105769	---------	-0.102564	---------	-0.085165	---------
	11/2	---------	-0.153846	---------	-0.110256	---------	-0.082418	---------	-0.057692
	5	-0.250000	---------	-0.112179	---------	-0.074571	---------	-0.048077	---------
	9/2	---------	-0.083333	---------	-0.053846	---------	-0.032051	---------	-0.010684
	4	0.166667	---------	0	---------	-0.003846	---------	0.008013	---------
	7/2	---------	0.166667	---------	0.050000	---------	0.036630	---------	0.043803
	3	---------	---------	0.166667	---------	0.083333	---------	0.069368	---------
	5/2	---------	---------	---------	0.166667	---------	0.107143	---------	0.096154
	2	---------	---------	---------	---------	0.166667	---------	0.125000	---------
	3/2	---------	---------	---------	---------	---------	0.166667	---------	0.138889
	1	---------	---------	---------	---------	---------	---------	0.166667	---------
	1/2	---------	---------	---------	---------	---------	---------	---------	0.166667
6	21/2	---------	---------	---------	---------	---------	---------	---------	0.100000
	10	---------	---------	---------	---------	---------	---------	0.100000	---------
	19/2	---------	---------	---------	---------	---------	0.100000	---------	-.016667
	9	---------	---------	---------	---------	0.100000	---------	--.025000	---------
	17/2	---------	---------	---------	0.100000	---------	-.035174	---------	-.074242
	8	---------	---------	0.100000	---------	-.050000	---------	-.081981	---------
	15/2	---------	0.100000	---------	-.070000	---------	-.090909	---------	-.087121
	7	0.100000	---------	-.100000	---------	-.100909	---------	-.088474	---------
	13/2	---------	-.150000	---------	-.110909	---------	-.087662	---------	-.068182
	6	-.250000	---------	-.115909	---------	-.081818	---------	-.060065	---------
	11/2	---------	-.090909	---------	-.063636	---------	-.045455	---------	-.028788
	5	.159091	---------	-.011364	---------	-.018182	---------	-.010389	---------
	9/2	---------	.159091	---------	.036364	---------	.018331	---------	.021212
	4	---------	---------	.159091	---------	.068182	---------	.048864	---------
	7/2	---------	---------	---------	.159091	---------	.090909	---------	.074485
	3	---------	---------	---------	---------	.159091	---------	.107955	---------
	5/2	---------	---------	---------	---------	---------	.159091	---------	.121212
	2	---------	---------	---------	---------	---------	---------	.159091	---------
	3/2	---------	---------	---------	---------	---------	---------	---------	.159091

Table III. Values of [3/4C(C+1)-I(I+1)J(J+1)]/2I(2I-1)(2J-1)(2J+3), where C=F(F+1)-I(I+1)-J(J+1)—Continued

I		1	3/2	2	5/2	3	7/2	4	9/2
J	F								
7	23/2	---------	---------	---------	---------	---------	---------	---------	.102941
	11	---------	---------	---------	---------	---------	---------	.102941	---------
	21/2	---------	---------	---------	---------	---------	.102941	---------	-.009804
	10	---------	---------	---------	---------	.102941	---------	-.018382	---------
	19/2	---------	---------	---------	.102941	---------	-.029412	---------	-.069193
	9	---------	---------	.102941	---------	-.044118	---------	-.077771	---------
	17/2	---------	.102941	---------	-.064705	---------	-.087750	---------	-.087104
	8	.102941	---------	-.095588	---------	-.099095	---------	-.090417	---------
	15/2	---------	-.147059	---------	-.110859	---------	-.090498	---------	-.074284
	7	-.250000	---------	-.118212	---------	-.086425	---------	-.067469	---------
	13/2	---------	-.096154	---------	-.070136	---------	-.054137	---------	-.040347
	6	.153846	---------	-.019231	---------	-.027828	---------	-.022503	---------
	11/2	---------	.153846	---------	.026923	---------	.006787	---------	.006222
	5	---------	---------	.153846	---------	.057692	---------	.034947	---------
	9/2	---------	---------	---------	.153846	---------	.079670	---------	.058069
	4	---------	---------	---------	---------	.153846	---------	.096154	---------
	7/2	---------	---------	---------	---------	---------	.153846	---------	.108974
	3	---------	---------	---------	---------	---------	---------	.153846	---------
	5/2	---------	---------	---------	---------	---------	---------	---------	.153846
8	25/2	---------	---------	---------	---------	---------	---------	---------	0.105263
	12	---------	---------	---------	---------	---------	---------	0.105263	---------
	23/2	---------	---------	---------	---------	---------	0.105263	---------	-.004386
	11	---------	---------	---------	---------	0.105263	---------	-.013158	---------
	21/2	---------	---------	---------	0.105263	---------	-.024436	---------	-.064912
	10	---------	---------	0.105263	---------	-.039474	---------	-.074154	---------
	19/2	---------	0.105263	---------	-.060526	---------	-.084962	---------	-.086404
	9	0.105263	---------	-.092105	---------	-.097368	---------	-.090132	---------
	17/2	---------	-.144737	---------	-.110526	---------	-.092105	---------	-.078070
	8	-.250000	---------	-.119737	---------	-.089474	---------	-.072368	---------
	15/2	---------	-.100000	---------	-.074737	---------	-.060150	---------	-.048246
	7	.150000	---------	-.025000	---------	-.034737	---------	-.031015	---------
	13/2	---------	.150000	---------	.020000	---------	-.001880	---------	-.004386
	6	---------	---------	.150000	---------	.050000	---------	.024906	---------
	11/2	---------	---------	---------	.150000	---------	.071429	---------	.046930
	5	---------	---------	---------	---------	.150000	---------	.087500	---------
	9/2	---------	---------	---------	---------	---------	.150000	---------	.100000
	4	---------	---------	---------	---------	---------	---------	.150000	---------
	7/2	---------	---------	---------	---------	---------	---------	---------	.150000
9	27/2	---------	---------	---------	---------	---------	---------	---------	.107143
	13	---------	---------	---------	---------	---------	---------	.107143	---------
	25/2	---------	---------	---------	---------	---------	.107143	---------	0
	12	---------	---------	---------	---------	.107143	---------	-.008929	---------
	23/2	---------	---------	---------	.107143	---------	-.020408	---------	-.061275
	11	---------	---------	.107143	---------	-.035714	---------	-.071053	---------
	21/2	---------	.107143	---------	-.057143	---------	-.082533	---------	-.085434
	10	.107143	---------	-.089286	---------	-.095798	---------	-.090036	---------
	19/2	---------	-.142857	---------	-.110084	---------	-.093037	---------	-.080532
	9	-.250000	---------	-.120798	---------	-.091597	---------	-.075780	---------
	17/2	---------	-.102941	---------	-.078151	---------	-.064526	---------	-.053922
	8	.147059	---------	-.029412	---------	-.039916	---------	-.037290	---------
	15/2	---------	.147059	---------	.014706	---------	-.008403	---------	-.012255
	7	---------	---------	.147059	---------	.044118	---------	.017332	---------
	13/2	---------	---------	---------	.147059	---------	.065126	---------	.038515
	6	---------	---------	---------	---------	.147059	---------	.080882	---------
	11/2	---------	---------	---------	---------	---------	.147059	---------	.093137
	5	---------	---------	---------	---------	---------	---------	.147059	---------
	9/2	---------	---------	---------	---------	---------	---------	---------	.147059

Table III. Values of $[3/4C(C+1)-I(I+1)J(J+1)]/2I(2I-1)(2J-1)(2J+3)$, where $C=F(F+1)-I(I+1)-J(J+J(J+1)$—Continued

I		1	3/2	2	5/2	3	7/2	4	9/2
J	F								
10	29/2	---------	---------	---------	---------	---------	---------	---------	0.108696
	14	---------	---------	---------	---------	---------	---------	0.108696	---------
	27/2	---------	---------	---------	---------	---------	0.018696	---------	-.003623
	13	---------	---------	---------	---------	0.108696	---------	-.005435	---------
	25/2	---------	---------	---------	0.108696	---------	-.017081	---------	-.058162
	12	---------	---------	0.108696	---------	-.032609	---------	-.068384	---------
	23/2	---------	0.108696	---------	-.054348	---------	-.080418	---------	-.084382
	11	0.108696	---------	-.086957	---------	-.094394	---------	-.089715	---------
	21/2	---------	-.141304	---------	-.109610	---------	-.093576	---------	-.082189
	10	-.250000	---------	-.121568	---------	-.093135	---------	-.078253	---------
	19/2	---------	-.105263	---------	-.080778	---------	-.067833	---------	-.058162
	9	.144737	---------	-.032895	---------	-.043936	---------	-.042089	---------
	17/2	---------	.144737	---------	.010526	---------	-.013485	---------	-.018307
	8	---------	---------	.144737	---------	.039474	---------	.001142	---------
	15/2	---------	---------	---------	.144737	---------	.060150	---------	.031941
	7	---------	---------	---------	---------	.144737	---------	.075658	---------
	13/2	---------	---------	---------	---------	---------	.144737	---------	.087719
	6	---------	---------	---------	---------	---------	---------	.144737	---------
	11/2	---------	---------	---------	---------	---------	---------	---------	.144737

INDEX I

MOLECULES BY CHEMICAL SYMBOL

Empirical Formula	Structural or Common Formula	Page No.
Cl_3OP	$POCl_3$	
Cl_3P	PCl_3	
Cl_3PS	$PSCl_3$	
Cl_3Sb	$SbCl_3$	
FH_3Si	SiH_3F	
F_3HSi	$SiHF_3$	
F_3N	NF_3	
F_3OP	POF_3	
	OPF_3	
F_3P	PF_3	
F_3PS	PSF_3	
	SPF_3	

Empirical Formula	Structural or Common Formula	Page No.
HN_3		
H_2O		
H_2S		
H_3N	NH_3	
H_3P	PH_3	
H_3Sb	SbH_3	
NO_2		
N_2O		
O_2		
O_2S	SO_2	

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MOLECULES BY NAME

INDEX III

The authors quoted are listed alphabetically, and the molecules in connection with which they were quoted are given together with the reference number under that molecule in table I. "H_3N Int." and "Int." refer to the brief introduction to the Ammonia molecule and to the introduction to the paper as a whole respectively, each of which have separate lists of references.

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