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Technical Note 173

TABLES TO FACILITATE THE DETERMINATION OF THE FERRIMAGNETIC RESONANCE LINEWIDTH OF NON-METALLIC MAGNETIC MATERIALS

CONSTANCE C. PRESTON AND WILLIAM E. CASE

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Tables to Facilitate the Determination of the Ferrimagnetic Resonance Linewidth of Non-Metallic Magnetic Materials

Constance C. Preston and William E. Case

A common test procedure for measuring ferrimagnetic resonance linewidth, ΔH, and gyromagnetic ratio, γ, of microwave ferrites is based upon a perturbation analysis of the complex frequency shift obtained when a small sample is placed in a resonant cavity and an applied dc magnetic field. However, this method necessitates the plotting of a ferrimagnetic resonance loss curve. To find ΔH it is possible to derive an equation using lumped circuit theory which reduces the number of needed measurements to four attenuator readings.

This paper provides a table which gives values of attenuation according to the following formula which facilitates the determination of linewidth:

$$A = 20 \log 2 - 20 \log \left(10^{\frac{A_o - A_r}{20}} + 1\right) \text{ for } A_o - A_r = 0.41(0.01)\,32.40.$$

INTRODUCTION

Microwave devices such as isolators, phase shifters, and circulators utilize ferrite materials which exhibit ferrimagnetic resonance phenomena at microwave frequencies. Two important properties of ferrites at these frequencies are the effective gyromagnetic ratio, γ, and the ferrimagnetic resonance linewidth, ΔH.

Both of these properties of a ferrite material can be determined by inserting a small sample in a cavity and measuring the transmission loss of the system. It is assumed that the sample is sufficiently small for the perturbation theory[1] to be applicable. Measurements may be made by holding the input power to the cavity constant, varying the applied dc field, measuring the complex resonant frequency with and without the sample, and plotting the imaginary susceptibility curve. Linewidth is defined as the separation of the two dc field values at which the power absorbed by the ferrite sample is one half the maximum absorption.

[1]See reference 1 on page 6.

The above method requires a number of measurements to complete the curve. By using the accepted expressions for the relationship between the Q and transmission loss of a loaded and unloaded resonant cavity[2], it is possible to derive a formula (see Appendix I) whereby the linewidth can be determined by making only four measurements. The Non-Metallic Magnetic Materials Subcommittee VII of ASTM, Committee C21, has proposed specifications for this method in which spherical-shaped ferrite samples are measured in a rectangular TE_{102} resonant cavity.

METHOD

A block diagram of the experimental setup used for this method is shown in Figure 1. A constant input power to the precision calibrated attenuator as monitored by the power detector is assumed. The frequency is adjusted to give cavity resonance for the empty cavity, and the precision attenuator is set to A_o to give a convenient output reference level as indicated on the output detector. The sample is then inserted, the dc magnetic field adjusted for maximum absorption in the sample, the frequency adjusted for cavity resonance, and the precision attenuator set to obtain the same output reference signal. The new attenuator reading is defined as A_r, and the dc field reading is defined as H_r.

The attenuator reading corresponding to the half-power points on the ferrimagnetic resonance loss curve of the sample is calculated from the following formula as derived on page 12 of the Appendix:

$$A_{\frac{1}{2}} = A_o + 20 \log 2 - 20 \log \left(10^{\frac{A_o - A_r}{20}} + 1\right).$$

The attenuator is now set at the calculated $A_{\frac{1}{2}}$ value. The dc magnetic field necessary to return the output power to its previous level on one side of resonance is then read and recorded. The dc field is then similarly adjusted and recorded for the other side of resonance. The difference between these two dc field measurements is the linewidth, ΔH. For all measurements, the frequency must be adjusted to cavity resonance.

Calculating $A_{\frac{1}{2}}$ each time a measurement is made is time-consuming and prone to error. Time delay between maximum loss and half-power measurements can introduce error due to equipment drift. Faster and more accurate data can be taken using the following

[2]See reference 2 on page 6.

table which gives values of A for $A_o - A_r$ from .41 to 32.40 decibels where A is defined as:

$$A = 20 \log 2 - 20 \log \left(10^{\frac{A_o - A_r}{20}} + 1\right),$$

and thus,

$$A_{\frac{1}{2}} = A_o + A .$$

The above technique is essentially an rf substitution method. However, an IF substitution method as shown in Figure 2 may be used for greater accuracy if a 30 Mc/s high precision piston attenuator is available because, generally, a lower frequency IF piston attenuator can be made more accurate than an rf attenuator. The IF system has the advantage of greater accuracy, greater sensitivity, and that the same IF attenuator can be used for different rf frequencies. Disadvantages of the system are that more equipment, more complicated tuning, and separate local oscillators are required for each frequency. The piston attenuator is inserted between the cavity and the output detector. The procedure is the same as for the rf substitution method except that the input power to the cavity is held constant, and the power level to the IF detector is maintained constant by adjusting the piston attenuator.

The effective gyromagnetic ratio, γ, is determined from the sphere measurement data by the formula,

$$\gamma = \frac{2\pi f_r}{H_r} ,$$

where f_r is the microwave frequency required for cavity resonance at maximum sample absorption, and H_r is the corresponding dc field. The gyromagnetic ratio is sometimes expressed in terms of the apparent g factor in which case the above expression becomes

$$g = \frac{f_r}{1.3995 H_r} \cong \frac{f_r}{1.4 H_r} ,$$

if f_r is in Mc and H_r is in oersteds.

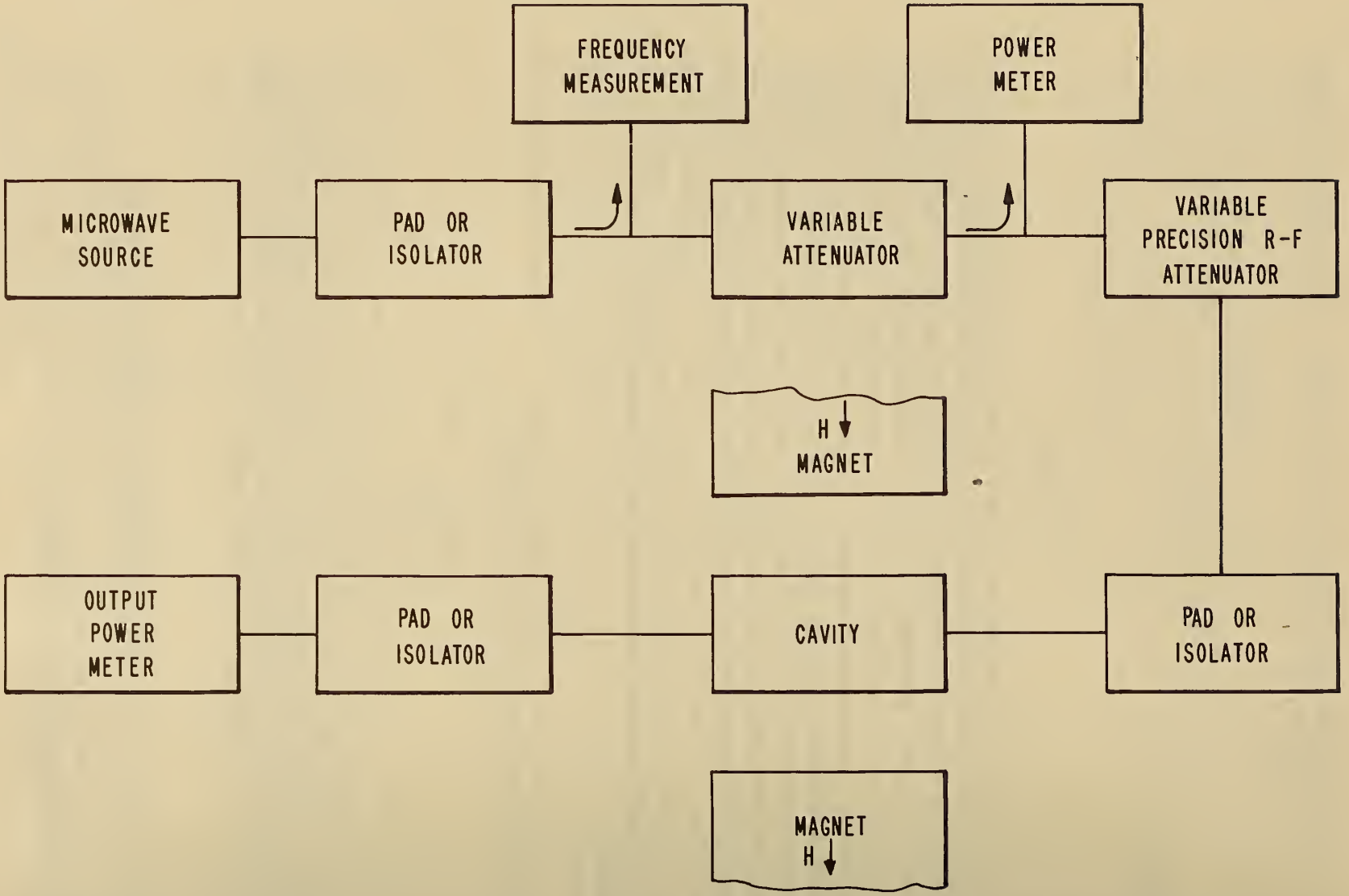

FIGURE 1. SCHEMATIC DIAGRAM OF EQUIPMENT REQUIRED FOR MEASUREMENT OF FERRIMAGNETIC RESONANCE LINEWIDTH AND GYROMAGNETIC RATIO USING THE R-F SUBSTITUTION METHOD

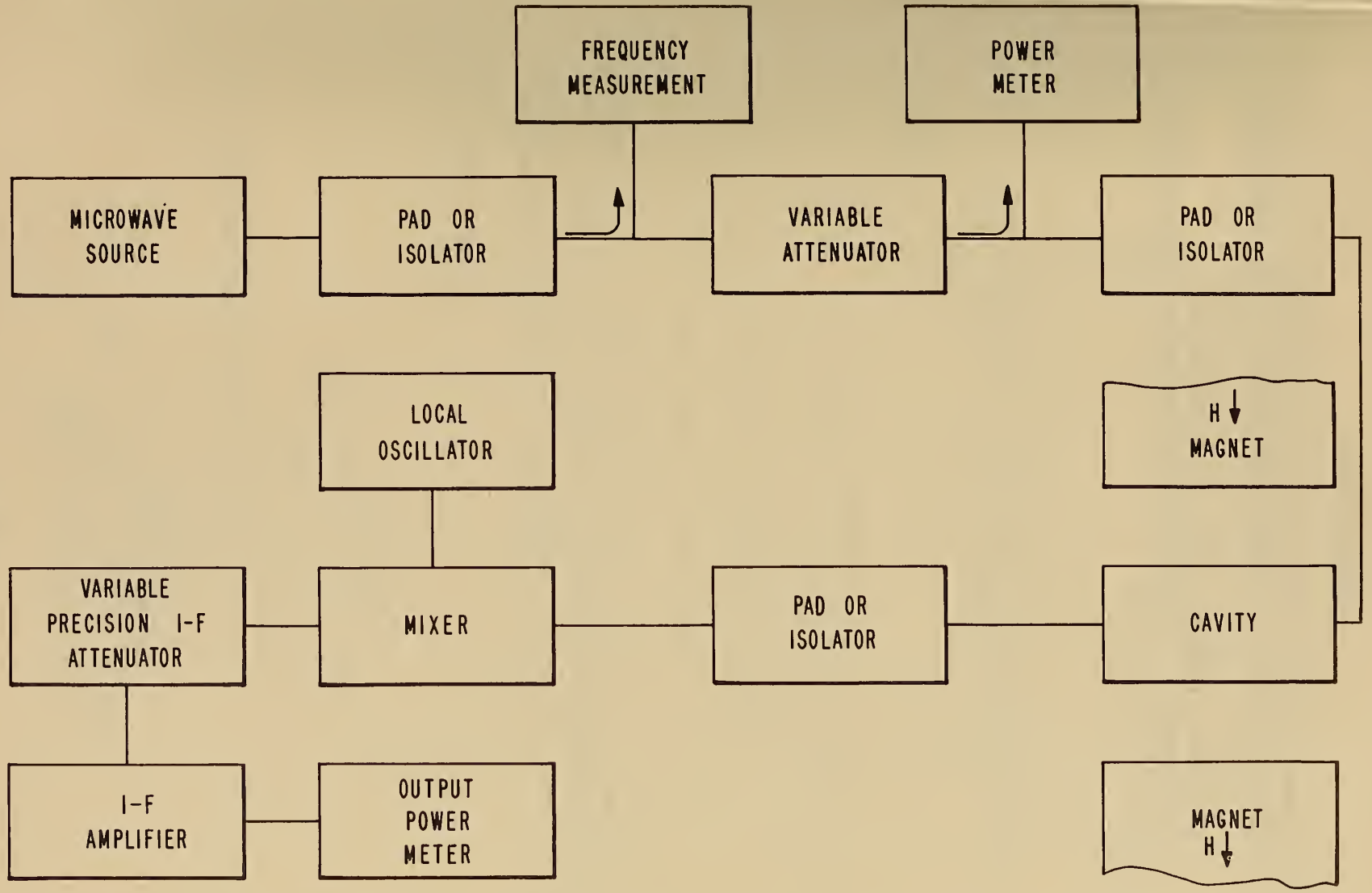

FIGURE 2. SCHEMATIC DIAGRAM OF EQUIPMENT REQUIRED FOR MEASUREMENT OF FERRIMAGNETIC RESONANCE LINEWIDTH AND GYROMAGNETIC RATIO USING THE I-F SUBSTITUTION METHOD

REFERENCES

1. R. F. Soohoo, "Theory and Application of Ferrites," p. 260-263, (Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1960).

2. C. G. Montgomery (ed.), "Techniques of Microwave Measurements," p. 289-291, (McGraw-Hill Book Company, Inc., New York, 1947).

APPENDIX

The equivalent circuit for a transmission microwave cavity is commonly shown as in Figure 3 (see reference 2).

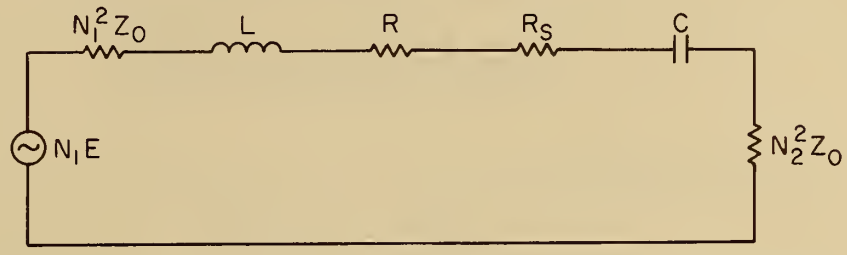

FIG. 3 EQUIVALENT CIRCUIT FOR TRANSMISSION LINE CAVITY COUPLED TO MATCHED GENERATOR AND LOAD

where

R = resistance representing loss of empty cavity

R_s = resistance representing loss due to sample

$N_1^2 Z_o$ = resistance of matched generator

$N_2^2 Z_o$ = resistance of matched load

Assume that the output power is kept constant by varying the input power (input voltage $N_1 E$) by means of a matched precision adjustable attenuator. We now write the power $[P_{load} = N_2^2 Z_o |I|^2]$ delivered to the load for the following three conditions:

(1) Empty cavity $E = E_1$; $R_s = 0$

$$P_a = \frac{N_1^2 N_2^2 E_1^2 Z_o}{[(N_1^2 + N_2^2)Z_o + R]^2} .$$

(2) Sample at maximum loss $E = E_2$

$$P_b = \frac{N_1^2 N_2^2 E_2^2 Z_o}{[(N_1^2 + N_2^2)Z_o + R + R_s]^2} .$$

(3) Sample at $\frac{1}{2}$ maximum loss $E = E_3$

$$P_c = \frac{N_1^2 N_2^2 E_3^2 Z_o}{\left[(N_1^2 + N_2^2)Z_o + R + \frac{R_s}{2}\right]^2} .$$

Since $P_a = P_b$ and $P_b = P_c$,

$$\frac{E_1}{E_2} = \frac{(N_1^2 + N_2^2)Z_o + R}{(N_1^2 + N_2^2)Z_o + R + R_s} = K_1 = \frac{\sqrt{P_1}}{\sqrt{P_2}}$$

$$\frac{E_2}{E_3} = \frac{(N_1^2 + N_2^2)Z_o + R + R_s}{(N_1^2 + N_2^2)Z_o + R + \frac{R_s}{2}} = K_2 = \frac{\sqrt{P_2}}{\sqrt{P_3}},$$

where P_1, P_2 and P_3 are the powers delivered by the attenuator for the three conditions.

Let

$$(N_1^2 + N_2^2)Z_o + R = B$$

$$\frac{B}{B + R_s} = K_1$$

$$B = K_1 B + K_1 R_s$$

$$B(1 - K_1) = K_1 R_s$$

$$\frac{B + R_s}{B + \frac{R_s}{2}} = K_2$$

$$B = K_2 B + \frac{K_2 R_s}{2} - R_s$$

$$B(1 - K_2) = \frac{R_s}{2}(K_2 - 2)$$

$$\frac{R_s(K_2 - 2)}{2(1 - K_2)} = \frac{K_1 R_s}{1 - K_1}$$

$$K_2 - 2 - K_1 K_2 + 2K_1 = 2K_1 - 2K_1 K_2$$

$$K_2 + K_1 K_2 = 2$$

$$K_2 = \frac{2}{1 + K_1}$$

$$\frac{\sqrt{P_2}}{\sqrt{P_3}} = \frac{2}{1 + \frac{\sqrt{P_1}}{\sqrt{P_2}}}$$

$$\frac{P_2}{P_3} = \left(\frac{2}{1 + \frac{\sqrt{P_1}}{\sqrt{P_2}}} \right)^2 .$$

Referring to Figure 4, we may develop the relationships between the various power levels and the corresponding attenuator readings.

FIG. 4 BLOCK DIAGRAM INDICATING POWER RELATIONSHIPS

where

P_i = input power delivered to precision attenuator.

P_o = output power delivered to load.

Assume P_i and P_o are held constant.

For empty cavity, let

$$A_o = 10 \log \frac{P_i}{P_1} = 10 \log P_i - 10 \log P_1 .$$

For cavity with sample at maximum loss, let

$$A_r = 10 \log \frac{P_i}{P_2} = 10 \log P_i - 10 \log P_2 .$$

For cavity with sample at $\frac{1}{2}$ maximum loss, let

$$A_{\frac{1}{2}} = 10 \log \frac{P_i}{P_3} = 10 \log P_i - 10 \log P_3$$

$$A_o - A_r = 10 \log P_2 - 10 \log P_1 = 10 \log \frac{P_2}{P_1}$$

$$A_{\frac{1}{2}} - A_r = 10 \log P_2 - 10 \log P_3 = 10 \log \frac{P_2}{P_3} .$$

From above

$$10 \log \frac{P_2}{P_1} = A_o - A_r$$

$$20 \log \frac{\sqrt{P_2}}{\sqrt{P_1}} = A_o - A_r$$

$$\log \frac{\sqrt{P_2}}{\sqrt{P_1}} = \frac{A_o - A_r}{20}$$

$$\frac{\sqrt{P_2}}{\sqrt{P_1}} = 10^{\frac{A_o - A_r}{20}}$$

$$A_{\frac{1}{2}} - A_o = A_{\frac{1}{2}} - A_r - (A_o - A_r)$$

$$A_{\frac{1}{2}} - A_o = 10 \log \frac{P_2}{P_3} - 10 \log \frac{P_2}{P_1}$$

$$A_{\frac{1}{2}} - A_o = 20 \log \frac{2}{1 + \frac{\sqrt{P_1}}{\sqrt{P_2}}} - 20 \log \frac{\sqrt{P_2}}{\sqrt{P_1}}$$

$$A_{\frac{1}{2}} - A_o = 20 \log 2 - 20 \log \left(\frac{\sqrt{P_2}}{\sqrt{P_1}} + 1 \right)$$

$$A_{\frac{1}{2}} = A_o + 20 \log 2 - 20 \log \left[10^{\frac{A_o - A_r}{20}} + 1 \right],$$

which is the working equation given in the text of this paper.

TABLES FOR DETERMINING THE HALF-POWER POINTS ON THE FERRIMAGNETIC RESONANCE CURVE

ATTENUATOR READINGS

A_o - empty cavity

A_r - sample in cavity--maximum absorption of sample

$A_{\frac{1}{2}}$ - sample in cavity-- one half maximum absorption of sample

WORKING EQUATIONS

$$A_{\frac{1}{2}} = A_o + 20 \log 2 - 20 \log \left(10^{\frac{A_o - A_r}{20}} + 1\right),$$

or

$$A_{\frac{1}{2}} = A_o + A .$$

Tables give values of A as a function of $A_o - A_r$.

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
0.41	-0.21	0.81	-0.41	1.21	-0.63	1.61	-0.84
0.42	-0.21	0.82	-0.42	1.22	-0.63	1.62	-0.85
0.43	-0.22	0.83	-0.43	1.23	-0.64	1.63	-0.85
0.44	-0.22	0.84	-0.43	1.24	-0.64	1.64	-0.86
0.45	-0.23	0.85	-0.44	1.25	-0.65	1.65	-0.86
0.46	-0.23	0.86	-0.44	1.26	-0.65	1.66	-0.87
0.47	-0.24	0.87	-0.45	1.27	-0.66	1.67	-0.88
0.48	-0.24	0.88	-0.45	1.28	-0.66	1.68	-0.88
0.49	-0.25	0.89	-0.46	1.29	-0.67	1.69	-0.89
0.50	-0.25	0.90	-0.46	1.30	-0.67	1.70	-0.89
0.51	-0.26	0.91	-0.47	1.31	-0.68	1.71	-0.90
0.52	-0.26	0.92	-0.47	1.32	-0.69	1.72	-0.90
0.53	-0.27	0.93	-0.48	1.33	-0.69	1.73	-0.91
0.54	-0.27	0.94	-0.48	1.34	-0.70	1.74	-0.91
0.55	-0.28	0.95	-0.49	1.35	-0.70	1.75	-0.92
0.56	-0.29	0.96	-0.49	1.36	-0.71	1.76	-0.93
0.57	-0.29	0.97	-0.50	1.37	-0.71	1.77	-0.93
0.58	-0.30	0.98	-0.50	1.38	-0.72	1.78	-0.94
0.59	-0.30	0.99	-0.51	1.39	-0.72	1.79	-0.94
0.60	-0.31	1.00	-0.51	1.40	-0.73	1.80	-0.95
0.61	-0.31	1.01	-0.52	1.41	-0.73	1.81	-0.95
0.62	-0.32	1.02	-0.53	1.42	-0.74	1.82	-0.96
0.63	-0.32	1.03	-0.53	1.43	-0.74	1.83	-0.96
0.64	-0.33	1.04	-0.54	1.44	-0.75	1.84	-0.97
0.65	-0.33	1.05	-0.54	1.45	-0.76	1.85	-0.97
0.66	-0.34	1.06	-0.55	1.46	-0.76	1.86	-0.98
0.67	-0.34	1.07	-0.55	1.47	-0.77	1.87	-0.99
0.68	-0.35	1.08	-0.56	1.48	-0.77	1.88	-0.99
0.69	-0.35	1.09	-0.56	1.49	-0.78	1.89	-1.00
0.70	-0.36	1.10	-0.57	1.50	-0.78	1.90	-1.00
0.71	-0.36	1.11	-0.57	1.51	-0.79	1.91	-1.01
0.72	-0.37	1.12	-0.58	1.52	-0.79	1.92	-1.01
0.73	-0.37	1.13	-0.58	1.53	-0.80	1.93	-1.02
0.74	-0.38	1.14	-0.59	1.54	-0.80	1.94	-1.02
0.75	-0.38	1.15	-0.59	1.55	-0.81	1.95	-1.03
0.76	-0.39	1.16	-0.60	1.56	-0.82	1.96	-1.04
0.77	-0.39	1.17	-0.61	1.57	-0.82	1.97	-1.04
0.78	-0.40	1.18	-0.61	1.58	-0.83	1.98	-1.05
0.79	-0.40	1.19	-0.62	1.59	-0.83	1.99	-1.05
0.80	-0.41	1.20	-0.62	1.60	-0.84	2.00	-1.06

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
2.01	-1.06	2.41	-1.29	2.81	-1.52	3.21	-1.75
2.02	-1.07	2.42	-1.29	2.82	-1.52	3.22	-1.76
2.03	-1.07	2.43	-1.30	2.83	-1.53	3.23	-1.76
2.04	-1.08	2.44	-1.31	2.84	-1.54	3.24	-1.77
2.05	-1.09	2.45	-1.31	2.85	-1.54	3.25	-1.78
2.06	-1.09	2.46	-1.32	2.86	-1.55	3.26	-1.78
2.07	-1.10	2.47	-1.32	2.87	-1.55	3.27	-1.79
2.08	-1.10	2.48	-1.33	2.88	-1.56	3.28	-1.79
2.09	-1.11	2.49	-1.33	2.89	-1.57	3.29	-1.80
2.10	-1.11	2.50	-1.34	2.90	-1.57	3.30	-1.81
2.11	-1.12	2.51	-1.35	2.91	-1.58	3.31	-1.81
2.12	-1.13	2.52	-1.35	2.92	-1.58	3.32	-1.82
2.13	-1.13	2.53	-1.36	2.93	-1.59	3.33	-1.82
2.14	-1.14	2.54	-1.36	2.94	-1.59	3.34	-1.83
2.15	-1.14	2.55	-1.37	2.95	-1.60	3.35	-1.84
2.16	-1.15	2.56	-1.37	2.96	-1.61	3.36	-1.84
2.17	-1.15	2.57	-1.38	2.97	-1.61	3.37	-1.85
2.18	-1.16	2.58	-1.39	2.98	-1.62	3.38	-1.85
2.19	-1.16	2.59	-1.39	2.99	-1.62	3.39	-1.86
2.20	-1.17	2.60	-1.40	3.00	-1.63	3.40	-1.87
2.21	-1.18	2.61	-1.40	3.01	-1.64	3.41	-1.87
2.22	-1.18	2.62	-1.41	3.02	-1.64	3.42	-1.88
2.23	-1.19	2.63	-1.41	3.03	-1.65	3.43	-1.88
2.24	-1.19	2.64	-1.42	3.04	-1.65	3.44	-1.89
2.25	-1.20	2.65	-1.43	3.05	-1.66	3.45	-1.90
2.26	-1.20	2.66	-1.43	3.06	-1.66	3.46	-1.90
2.27	-1.21	2.67	-1.44	3.07	-1.67	3.47	-1.91
2.28	-1.22	2.68	-1.44	3.08	-1.68	3.48	-1.91
2.29	-1.22	2.69	-1.45	3.09	-1.68	3.49	-1.92
2.30	-1.23	2.70	-1.46	3.10	-1.69	3.50	-1.93
2.31	-1.23	2.71	-1.46	3.11	-1.69	3.51	-1.93
2.32	-1.24	2.72	-1.47	3.12	-1.70	3.52	-1.94
2.33	-1.24	2.73	-1.47	3.13	-1.71	3.53	-1.94
2.34	-1.25	2.74	-1.48	3.14	-1.71	3.54	-1.95
2.35	-1.25	2.75	-1.48	3.15	-1.72	3.55	-1.96
2.36	-1.26	2.76	-1.49	3.16	-1.72	3.56	-1.96
2.37	-1.27	2.77	-1.50	3.17	-1.73	3.57	-1.97
2.38	-1.27	2.78	-1.50	3.18	-1.74	3.58	-1.97
2.39	-1.28	2.79	-1.51	3.19	-1.74	3.59	-1.98
2.40	-1.28	2.80	-1.51	3.20	-1.75	3.60	-1.99

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
3.61	-1.99	4.01	-2.23	4.41	-2.48	4.81	-2.73
3.62	-2.00	4.02	-2.24	4.42	-2.49	4.82	-2.74
3.63	-2.00	4.03	-2.25	4.43	-2.49	4.83	-2.75
3.64	-2.01	4.04	-2.25	4.44	-2.50	4.84	-2.75
3.65	-2.02	4.05	-2.26	4.45	-2.51	4.85	-2.76
3.66	-2.02	4.06	-2.27	4.46	-2.51	4.86	-2.77
3.67	-2.03	4.07	-2.27	4.47	-2.52	4.87	-2.77
3.68	-2.03	4.08	-2.28	4.48	-2.53	4.88	-2.78
3.69	-2.04	4.09	-2.28	4.49	-2.53	4.89	-2.79
3.70	-2.05	4.10	-2.29	4.50	-2.54	4.90	-2.79
3.71	-2.05	4.11	-2.30	4.51	-2.54	4.91	-2.80
3.72	-2.06	4.12	-2.30	4.52	-2.55	4.92	-2.80
3.73	-2.06	4.13	-2.31	4.53	-2.56	4.93	-2.81
3.74	-2.07	4.14	-2.31	4.54	-2.56	4.94	-2.82
3.75	-2.08	4.15	-2.32	4.55	-2.57	4.95	-2.82
3.76	-2.08	4.16	-2.33	4.56	-2.58	4.96	-2.83
3.77	-2.09	4.17	-2.33	4.57	-2.58	4.97	-2.84
3.78	-2.09	4.18	-2.34	4.58	-2.59	4.98	-2.84
3.79	-2.10	4.19	-2.35	4.59	-2.60	4.99	-2.85
3.80	-2.11	4.20	-2.35	4.60	-2.60	5.00	-2.86
3.81	-2.11	4.21	-2.36	4.61	-2.61	5.01	-2.86
3.82	-2.12	4.22	-2.36	4.62	-2.61	5.02	-2.87
3.83	-2.12	4.23	-2.37	4.63	-2.62	5.03	-2.87
3.84	-2.13	4.24	-2.38	4.64	-2.63	5.04	-2.88
3.85	-2.14	4.25	-2.38	4.65	-2.63	5.05	-2.89
3.86	-2.14	4.26	-2.39	4.66	-2.64	5.06	-2.89
3.87	-2.15	4.27	-2.40	4.67	-2.65	5.07	-2.90
3.88	-2.16	4.28	-2.40	4.68	-2.65	5.08	-2.91
3.89	-2.16	4.29	-2.41	4.69	-2.66	5.09	-2.91
3.90	-2.17	4.30	-2.41	4.70	-2.66	5.10	-2.92
3.91	-2.17	4.31	-2.42	4.71	-2.67	5.11	-2.93
3.92	-2.18	4.32	-2.43	4.72	-2.68	5.12	-2.93
3.93	-2.19	4.33	-2.43	4.73	-2.68	5.13	-2.94
3.94	-2.19	4.34	-2.44	4.74	-2.69	5.14	-2.95
3.95	-2.20	4.35	-2.45	4.75	-2.70	5.15	-2.95
3.96	-2.20	4.36	-2.45	4.76	-2.70	5.16	-2.96
3.97	-2.21	4.37	-2.46	4.77	-2.71	5.17	-2.96
3.98	-2.22	4.38	-2.46	4.78	-2.72	5.18	-2.97
3.99	-2.22	4.39	-2.47	4.79	-2.72	5.19	-2.98
4.00	-2.23	4.40	-2.48	4.80	-2.73	5.20	-2.98

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
5.21	-2.99	5.61	-3.25	6.01	-3.52	6.41	-3.78
5.22	-3.00	5.62	-3.26	6.02	-3.52	6.42	-3.79
5.23	-3.00	5.63	-3.26	6.03	-3.53	6.43	-3.80
5.24	-3.01	5.64	-3.27	6.04	-3.54	6.44	-3.80
5.25	-3.02	5.65	-3.28	6.05	-3.54	6.45	-3.81
5.26	-3.02	5.66	-3.28	6.06	-3.55	6.46	-3.82
5.27	-3.03	5.67	-3.29	6.07	-3.56	6.47	-3.82
5.28	-3.04	5.68	-3.30	6.08	-3.56	6.48	-3.83
5.29	-3.04	5.69	-3.30	6.09	-3.57	6.49	-3.84
5.30	-3.05	5.70	-3.31	6.10	-3.58	6.50	-3.84
5.31	-3.06	5.71	-3.32	6.11	-3.58	6.51	-3.85
5.32	-3.06	5.72	-3.32	6.12	-3.59	6.52	-3.86
5.33	-3.07	5.73	-3.33	6.13	-3.60	6.53	-3.87
5.34	-3.07	5.74	-3.34	6.14	-3.60	6.54	-3.87
5.35	-3.08	5.75	-3.34	6.15	-3.61	6.55	-3.88
5.36	-3.09	5.76	-3.35	6.16	-3.62	6.56	-3.89
5.37	-3.09	5.77	-3.36	6.17	-3.62	6.57	-3.89
5.38	-3.10	5.78	-3.36	6.18	-3.63	6.58	-3.90
5.39	-3.11	5.79	-3.37	6.19	-3.64	6.59	-3.91
5.40	-3.11	5.80	-3.38	6.20	-3.64	6.60	-3.91
5.41	-3.12	5.81	-3.38	6.21	-3.65	6.61	-3.92
5.42	-3.13	5.82	-3.39	6.22	-3.66	6.62	-3.93
5.43	-3.13	5.83	-3.40	6.23	-3.66	6.63	-3.93
5.44	-3.14	5.84	-3.40	6.24	-3.67	6.64	-3.94
5.45	-3.15	5.85	-3.41	6.25	-3.68	6.65	-3.95
5.46	-3.15	5.86	-3.42	6.26	-3.68	6.66	-3.95
5.47	-3.16	5.87	-3.42	6.27	-3.69	6.67	-3.96
5.48	-3.17	5.88	-3.43	6.28	-3.70	6.68	-3.97
5.49	-3.17	5.89	-3.44	6.29	-3.70	6.69	-3.97
5.50	-3.18	5.90	-3.44	6.30	-3.71	6.70	-3.98
5.51	-3.19	5.91	-3.45	6.31	-3.72	6.71	-3.99
5.52	-3.19	5.92	-3.46	6.32	-3.72	6.72	-3.99
5.53	-3.20	5.93	-3.46	6.33	-3.73	6.73	-4.00
5.54	-3.20	5.94	-3.47	6.34	-3.74	6.74	-4.01
5.55	-3.21	5.95	-3.48	6.35	-3.74	6.75	-4.02
5.56	-3.22	5.96	-3.48	6.36	-3.75	6.76	-4.02
5.57	-3.22	5.97	-3.49	6.37	-3.76	6.77	-4.03
5.58	-3.23	5.98	-3.50	6.38	-3.76	6.78	-4.04
5.59	-3.24	5.99	-3.50	6.39	-3.77	6.79	-4.04
5.60	-3.24	6.00	-3.51	6.40	-3.78	6.80	-4.05

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
6.81	-4.06	7.21	-4.33	7.61	-4.61	8.01	-4.90
6.82	-4.06	7.22	-4.34	7.62	-4.62	8.02	-4.91
6.83	-4.07	7.23	-4.35	7.63	-4.63	8.03	-4.91
6.84	-4.08	7.24	-4.35	7.64	-4.63	8.04	-4.92
6.85	-4.08	7.25	-4.36	7.65	-4.64	8.05	-4.93
6.86	-4.09	7.26	-4.37	7.66	-4.65	8.06	-4.93
6.87	-4.10	7.27	-4.37	7.67	-4.66	8.07	-4.94
6.88	-4.10	7.28	-4.38	7.68	-4.66	8.08	-4.95
6.89	-4.11	7.29	-4.39	7.69	-4.67	8.09	-4.96
6.90	-4.12	7.30	-4.40	7.70	-4.68	8.10	-4.96
6.91	-4.13	7.31	-4.40	7.71	-4.68	8.11	-4.97
6.92	-4.13	7.32	-4.41	7.72	-4.69	8.12	-4.98
6.93	-4.14	7.33	-4.42	7.73	-4.70	8.13	-4.98
6.94	-4.15	7.34	-4.42	7.74	-4.71	8.14	-4.99
6.95	-4.15	7.35	-4.43	7.75	-4.71	8.15	-5.00
6.96	-4.16	7.36	-4.44	7.76	-4.72	8.16	-5.01
6.97	-4.17	7.37	-4.44	7.77	-4.73	8.17	-5.01
6.98	-4.17	7.38	-4.45	7.78	-4.73	8.18	-5.02
6.99	-4.18	7.39	-4.46	7.79	-4.74	8.19	-5.03
7.00	-4.19	7.40	-4.47	7.80	-4.75	8.20	-5.03
7.01	-4.19	7.41	-4.47	7.81	-4.76	8.21	-5.04
7.02	-4.20	7.42	-4.48	7.82	-4.76	8.22	-5.05
7.03	-4.21	7.43	-4.49	7.83	-4.77	8.23	-5.06
7.04	-4.22	7.44	-4.49	7.84	-4.78	8.24	-5.06
7.05	-4.22	7.45	-4.50	7.85	-4.78	8.25	-5.07
7.06	-4.23	7.46	-4.51	7.86	-4.79	8.26	-5.08
7.07	-4.24	7.47	-4.51	7.87	-4.80	8.27	-5.08
7.08	-4.24	7.48	-4.52	7.88	-4.81	8.28	-5.09
7.09	-4.25	7.49	-4.53	7.89	-4.81	8.29	-5.10
7.10	-4.26	7.50	-4.54	7.90	-4.82	8.30	-5.11
7.11	-4.26	7.51	-4.54	7.91	-4.83	8.31	-5.11
7.12	-4.27	7.52	-4.55	7.92	-4.83	8.32	-5.12
7.13	-4.28	7.53	-4.56	7.93	-4.84	8.33	-5.13
7.14	-4.28	7.54	-4.56	7.94	-4.85	8.34	-5.14
7.15	-4.29	7.55	-4.57	7.95	-4.85	8.35	-5.14
7.16	-4.30	7.56	-4.58	7.96	-4.86	8.36	-5.15
7.17	-4.31	7.57	-4.59	7.97	-4.87	8.37	-5.16
7.18	-4.31	7.58	-4.59	7.98	-4.88	8.38	-5.16
7.19	-4.32	7.59	-4.60	7.99	-4.88	8.39	-5.17
7.20	-4.33	7.60	-4.61	8.00	-4.89	8.40	-5.18

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
8.41	-5.19	8.81	-5.48	9.21	-5.77	9.61	-6.07
8.42	-5.19	8.82	-5.48	9.22	-5.78	9.62	-6.08
8.43	-5.20	8.83	-5.49	9.23	-5.79	9.63	-6.09
8.44	-5.21	8.84	-5.50	9.24	-5.80	9.64	-6.09
8.45	-5.21	8.85	-5.51	9.25	-5.80	9.65	-6.10
8.46	-5.22	8.86	-5.51	9.26	-5.81	9.66	-6.11
8.47	-5.23	8.87	-5.52	9.27	-5.82	9.67	-6.12
8.48	-5.24	8.88	-5.53	9.28	-5.83	9.68	-6.12
8.49	-5.24	8.89	-5.54	9.29	-5.83	9.69	-6.13
8.50	-5.25	8.90	-5.54	9.30	-5.84	9.70	-6.14
8.51	-5.26	8.91	-5.55	9.31	-5.85	9.71	-6.15
8.52	-5.27	8.92	-5.56	9.32	-5.85	9.72	-6.15
8.53	-5.27	8.93	-5.57	9.33	-5.86	9.73	-6.16
8.54	-5.28	8.94	-5.57	9.34	-5.87	9.74	-6.17
8.55	-5.29	8.95	-5.58	9.35	-5.88	9.75	-6.18
8.56	-5.29	8.96	-5.59	9.36	-5.88	9.76	-6.18
8.57	-5.30	8.97	-5.60	9.37	-5.89	9.77	-6.19
8.58	-5.31	8.98	-5.60	9.38	-5.90	9.78	-6.20
8.59	-5.32	8.99	-5.61	9.39	-5.91	9.79	-6.21
8.60	-5.32	9.00	-5.62	9.40	-5.91	9.80	-6.21
8.61	-5.33	9.01	-5.62	9.41	-5.92	9.81	-6.22
8.62	-5.34	9.02	-5.63	9.42	-5.93	9.82	-6.23
8.63	-5.35	9.03	-5.64	9.43	-5.94	9.83	-6.24
8.64	-5.35	9.04	-5.65	9.44	-5.94	9.84	-6.25
8.65	-5.36	9.05	-5.65	9.45	-5.95	9.85	-6.25
8.66	-5.37	9.06	-5.66	9.46	-5.96	9.86	-6.26
8.67	-5.38	9.07	-5.67	9.47	-5.97	9.87	-6.27
8.68	-5.38	9.08	-5.68	9.48	-5.97	9.88	-6.28
8.69	-5.39	9.09	-5.68	9.49	-5.98	9.89	-6.28
8.70	-5.40	9.10	-5.69	9.50	-5.99	9.90	-6.29
8.71	-5.40	9.11	-5.70	9.51	-6.00	9.91	-6.30
8.72	-5.41	9.12	-5.71	9.52	-6.00	9.92	-6.31
8.73	-5.42	9.13	-5.71	9.53	-6.01	9.93	-6.31
8.74	-5.43	9.14	-5.72	9.54	-6.02	9.94	-6.32
8.75	-5.43	9.15	-5.73	9.55	-6.03	9.95	-6.33
8.76	-5.44	9.16	-5.74	9.56	-6.03	9.96	-6.34
8.77	-5.45	9.17	-5.74	9.57	-6.04	9.97	-6.34
8.78	-5.46	9.18	-5.75	9.58	-6.05	9.98	-6.35
8.79	-5.46	9.19	-5.76	9.59	-6.06	9.99	-6.36
8.80	-5.47	9.20	-5.77	9.60	-6.06	10.00	-6.37

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
10.01	-6.37	10.41	-6.68	10.81	-6.99	11.21	-7.30
10.02	-6.38	10.42	-6.69	10.82	-7.00	11.22	-7.31
10.03	-6.39	10.43	-6.70	10.83	-7.00	11.23	-7.32
10.04	-6.40	10.44	-6.70	10.84	-7.01	11.24	-7.32
10.05	-6.40	10.45	-6.71	10.85	-7.02	11.25	-7.33
10.06	-6.41	10.46	-6.72	10.86	-7.03	11.26	-7.34
10.07	-6.42	10.47	-6.73	10.87	-7.04	11.27	-7.35
10.08	-6.43	10.48	-6.73	10.88	-7.04	11.28	-7.36
10.09	-6.43	10.49	-6.74	10.89	-7.05	11.29	-7.36
10.10	-6.44	10.50	-6.75	10.90	-7.06	11.30	-7.37
10.11	-6.45	10.51	-6.76	10.91	-7.07	11.31	-7.38
10.12	-6.46	10.52	-6.76	10.92	-7.07	11.32	-7.39
10.13	-6.47	10.53	-6.77	10.93	-7.08	11.33	-7.40
10.14	-6.47	10.54	-6.78	10.94	-7.09	11.34	-7.40
10.15	-6.48	10.55	-6.79	10.95	-7.10	11.35	-7.41
10.16	-6.49	10.56	-6.80	10.96	-7.11	11.36	-7.42
10.17	-6.50	10.57	-6.80	10.97	-7.11	11.37	-7.43
10.18	-6.50	10.58	-6.81	10.98	-7.12	11.38	-7.43
10.19	-6.51	10.59	-6.82	10.99	-7.13	11.39	-7.44
10.20	-6.52	10.60	-6.83	11.00	-7.14	11.40	-7.45
10.21	-6.53	10.61	-6.83	11.01	-7.14	11.41	-7.46
10.22	-6.53	10.62	-6.84	11.02	-7.15	11.42	-7.47
10.23	-6.54	10.63	-6.85	11.03	-7.16	11.43	-7.47
10.24	-6.55	10.64	-6.86	11.04	-7.17	11.44	-7.48
10.25	-6.56	10.65	-6.86	11.05	-7.18	11.45	-7.49
10.26	-6.56	10.66	-6.87	11.06	-7.18	11.46	-7.50
10.27	-6.57	10.67	-6.88	11.07	-7.19	11.47	-7.51
10.28	-6.58	10.68	-6.89	11.08	-7.20	11.48	-7.51
10.29	-6.59	10.69	-6.90	11.09	-7.21	11.49	-7.52
10.30	-6.60	10.70	-6.90	11.10	-7.21	11.50	-7.53
10.31	-6.60	10.71	-6.91	11.11	-7.22	11.51	-7.54
10.32	-6.61	10.72	-6.92	11.12	-7.23	11.52	-7.54
10.33	-6.62	10.73	-6.93	11.13	-7.24	11.53	-7.55
10.34	-6.63	10.74	-6.93	11.14	-7.25	11.54	-7.56
10.35	-6.63	10.75	-6.94	11.15	-7.25	11.55	-7.57
10.36	-6.64	10.76	-6.95	11.16	-7.26	11.56	-7.58
10.37	-6.65	10.77	-6.96	11.17	-7.27	11.57	-7.58
10.38	-6.66	10.78	-6.97	11.18	-7.28	11.58	-7.59
10.39	-6.66	10.79	-6.97	11.19	-7.29	11.59	-7.60
10.40	-6.67	10.80	-6.98	11.20	-7.29	11.60	-7.61

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
11.61	-7.62	12.01	-7.93	12.41	-8.26	12.81	-8.58
11.62	-7.62	12.02	-7.94	12.42	-8.26	12.82	-8.59
11.63	-7.63	12.03	-7.95	12.43	-8.27	12.83	-8.60
11.64	-7.64	12.04	-7.96	12.44	-8.28	12.84	-8.60
11.65	-7.65	12.05	-7.97	12.45	-8.29	12.85	-8.61
11.66	-7.66	12.06	-7.97	12.46	-8.30	12.86	-8.62
11.67	-7.66	12.07	-7.98	12.47	-8.30	12.87	-8.63
11.68	-7.67	12.08	-7.99	12.48	-8.31	12.88	-8.64
11.69	-7.68	12.09	-8.00	12.49	-8.32	12.89	-8.64
11.70	-7.69	12.10	-8.01	12.50	-8.33	12.90	-8.65
11.71	-7.70	12.11	-8.01	12.51	-8.34	12.91	-8.66
11.72	-7.70	12.12	-8.02	12.52	-8.34	12.92	-8.67
11.73	-7.71	12.13	-8.03	12.53	-8.35	12.93	-8.68
11.74	-7.72	12.14	-8.04	12.54	-8.36	12.94	-8.69
11.75	-7.73	12.15	-8.05	12.55	-8.37	12.95	-8.69
11.76	-7.74	12.16	-8.05	12.56	-8.38	12.96	-8.70
11.77	-7.74	12.17	-8.06	12.57	-8.38	12.97	-8.71
11.78	-7.75	12.18	-8.07	12.58	-8.39	12.98	-8.72
11.79	-7.76	12.19	-8.08	12.59	-8.40	12.99	-8.73
11.80	-7.77	12.20	-8.09	12.60	-8.41	13.00	-8.73
11.81	-7.77	12.21	-8.09	12.61	-8.42	13.01	-8.74
11.82	-7.78	12.22	-8.10	12.62	-8.43	13.02	-8.75
11.83	-7.79	12.23	-8.11	12.63	-8.43	13.03	-8.76
11.84	-7.80	12.24	-8.12	12.64	-8.44	13.04	-8.77
11.85	-7.81	12.25	-8.13	12.65	-8.45	13.05	-8.78
11.86	-7.81	12.26	-8.13	12.66	-8.46	13.06	-8.78
11.87	-7.82	12.27	-8.14	12.67	-8.47	13.07	-8.79
11.88	-7.83	12.28	-8.15	12.68	-8.47	13.08	-8.80
11.89	-7.84	12.29	-8.16	12.69	-8.48	13.09	-8.81
11.90	-7.85	12.30	-8.17	12.70	-8.49	13.10	-8.82
11.91	-7.85	12.31	-8.17	12.71	-8.50	13.11	-8.82
11.92	-7.86	12.32	-8.18	12.72	-8.51	13.12	-8.83
11.93	-7.87	12.33	-8.19	12.73	-8.51	13.13	-8.84
11.94	-7.88	12.34	-8.20	12.74	-8.52	13.14	-8.85
11.95	-7.89	12.35	-8.21	12.75	-8.53	13.15	-8.86
11.96	-7.89	12.36	-8.22	12.76	-8.54	13.16	-8.87
11.97	-7.90	12.37	-8.22	12.77	-8.55	13.17	-8.87
11.98	-7.91	12.38	-8.23	12.78	-8.56	13.18	-8.88
11.99	-7.92	12.39	-8.24	12.79	-8.56	13.19	-8.89
12.00	-7.93	12.40	-8.25	12.80	-8.57	13.20	-8.90

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
13.21	-8.91	13.61	-9.24	14.01	-9.57	14.41	-9.90
13.22	-8.91	13.62	-9.24	14.02	-9.58	14.42	-9.91
13.23	-8.92	13.63	-9.25	14.03	-9.59	14.43	-9.92
13.24	-8.93	13.64	-9.26	14.04	-9.59	14.44	-9.93
13.25	-8.94	13.65	-9.27	14.05	-9.60	14.45	-9.94
13.26	-8.95	13.66	-9.28	14.06	-9.61	14.46	-9.95
13.27	-8.96	13.67	-9.29	14.07	-9.62	14.47	-9.95
13.28	-8.96	13.68	-9.29	14.08	-9.63	14.48	-9.96
13.29	-8.97	13.69	-9.30	14.09	-9.64	14.49	-9.97
13.30	-8.98	13.70	-9.31	14.10	-9.64	14.50	-9.98
13.31	-8.99	13.71	-9.32	14.11	-9.65	14.51	-9.99
13.32	-9.00	13.72	-9.33	14.12	-9.66	14.52	-10.00
13.33	-9.01	13.73	-9.34	14.13	-9.67	14.53	-10.00
13.34	-9.01	13.74	-9.34	14.14	-9.68	14.54	-10.01
13.35	-9.02	13.75	-9.35	14.15	-9.69	14.55	-10.02
13.36	-9.03	13.76	-9.36	14.16	-9.69	14.56	-10.03
13.37	-9.04	13.77	-9.37	14.17	-9.70	14.57	-10.04
13.38	-9.05	13.78	-9.38	14.18	-9.71	14.58	-10.05
13.39	-9.05	13.79	-9.39	14.19	-9.72	14.59	-10.05
13.40	-9.06	13.80	-9.39	14.20	-9.73	14.60	-10.06
13.41	-9.07	13.81	-9.40	14.21	-9.74	14.61	-10.07
13.42	-9.08	13.82	-9.41	14.22	-9.74	14.62	-10.08
13.43	-9.09	13.83	-9.42	14.23	-9.75	14.63	-10.09
13.44	-9.10	13.84	-9.43	14.24	-9.76	14.64	-10.10
13.45	-9.10	13.85	-9.44	14.25	-9.77	14.65	-10.11
13.46	-9.11	13.86	-9.44	14.26	-9.78	14.66	-10.11
13.47	-9.12	13.87	-9.45	14.27	-9.79	14.67	-10.12
13.48	-9.13	13.88	-9.46	14.28	-9.79	14.68	-10.13
13.49	-9.14	13.89	-9.47	14.29	-9.80	14.69	-10.14
13.50	-9.15	13.90	-9.48	14.30	-9.81	14.70	-10.15
13.51	-9.15	13.91	-9.49	14.31	-9.82	14.71	-10.16
13.52	-9.16	13.92	-9.49	14.32	-9.83	14.72	-10.16
13.53	-9.17	13.93	-9.50	14.33	-9.84	14.73	-10.17
13.54	-9.18	13.94	-9.51	14.34	-9.84	14.74	-10.18
13.55	-9.19	13.95	-9.52	14.35	-9.85	14.75	-10.19
13.56	-9.19	13.96	-9.53	14.36	-9.86	14.76	-10.20
13.57	-9.20	13.97	-9.54	14.37	-9.87	14.77	-10.21
13.58	-9.21	13.98	-9.54	14.38	-9.88	14.78	-10.22
13.59	-9.22	13.99	-9.55	14.39	-9.89	14.79	-10.22
13.60	-9.23	14.00	-9.56	14.40	-9.89	14.80	-10.23

A_o	$-A_r$	A	A_o	$-A_r$	A	A_o	$-A_r$	A	A_o	$-A_r$	A
14.81	-10.24		15.21	-10.58		15.61	-10.92		16.01	-11.27	
14.82	-10.25		15.22	-10.59		15.62	-10.93		16.02	-11.27	
14.83	-10.26		15.23	-10.60		15.63	-10.94		16.03	-11.28	
14.84	-10.27		15.24	-10.61		15.64	-10.95		16.04	-11.29	
14.85	-10.27		15.25	-10.61		15.65	-10.96		16.05	-11.30	
14.86	-10.28		15.26	-10.62		15.66	-10.96		16.06	-11.31	
14.87	-10.29		15.27	-10.63		15.67	-10.97		16.07	-11.32	
14.88	-10.30		15.28	-10.64		15.68	-10.98		16.08	-11.33	
14.89	-10.31		15.29	-10.65		15.69	-10.99		16.09	-11.34	
14.90	-10.32		15.30	-10.66		15.70	-11.00		16.10	-11.34	
14.91	-10.33		15.31	-10.67		15.71	-11.01		16.11	-11.35	
14.92	-10.33		15.32	-10.67		15.72	-11.02		16.12	-11.36	
14.93	-10.34		15.33	-10.68		15.73	-11.03		16.13	-11.37	
14.94	-10.35		15.34	-10.69		15.74	-11.03		16.14	-11.38	
14.95	-10.36		15.35	-10.70		15.75	-11.04		16.15	-11.39	
14.96	-10.37		15.36	-10.71		15.76	-11.05		16.16	-11.40	
14.97	-10.38		15.37	-10.72		15.77	-11.06		16.17	-11.40	
14.98	-10.38		15.38	-10.73		15.78	-11.07		16.18	-11.41	
14.99	-10.39		15.39	-10.73		15.79	-11.08		16.19	-11.42	
15.00	-10.40		15.40	-10.74		15.80	-11.09		16.20	-11.43	
15.01	-10.41		15.41	-10.75		15.81	-11.09		16.21	-11.44	
15.02	-10.42		15.42	-10.76		15.82	-11.10		16.22	-11.45	
15.03	-10.43		15.43	-10.77		15.83	-11.11		16.23	-11.46	
15.04	-10.44		15.44	-10.78		15.84	-11.12		16.24	-11.47	
15.05	-10.44		15.45	-10.78		15.85	-11.13		16.25	-11.47	
15.06	-10.45		15.46	-10.79		15.86	-11.14		16.26	-11.48	
15.07	-10.46		15.47	-10.80		15.87	-11.15		16.27	-11.49	
15.08	-10.47		15.48	-10.81		15.88	-11.15		16.28	-11.50	
15.09	-10.48		15.49	-10.82		15.89	-11.16		16.29	-11.51	
15.10	-10.49		15.50	-10.83		15.90	-11.17		16.30	-11.52	
15.11	-10.49		15.51	-10.84		15.91	-11.18		16.31	-11.53	
15.12	-10.50		15.52	-10.84		15.92	-11.19		16.32	-11.53	
15.13	-10.51		15.53	-10.85		15.93	-11.20		16.33	-11.54	
15.14	-10.52		15.54	-10.86		15.94	-11.21		16.34	-11.55	
15.15	-10.53		15.55	-10.87		15.95	-11.21		16.35	-11.56	
15.16	-10.54		15.56	-10.88		15.96	-11.22		16.36	-11.57	
15.17	-10.55		15.57	-10.89		15.97	-11.23		16.37	-11.58	
15.18	-10.55		15.58	-10.90		15.98	-11.24		16.38	-11.59	
15.19	-10.56		15.59	-10.90		15.99	-11.25		16.39	-11.60	
15.20	-10.57		15.60	-10.91		16.00	-11.26		16.40	-11.60	

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
16.41	-11.61	16.81	-11.96	17.21	-12.31	17.61	-12.66
16.42	-11.62	16.82	-11.97	17.22	-12.32	17.62	-12.67
16.43	-11.63	16.83	-11.98	17.23	-12.33	17.63	-12.68
16.44	-11.64	16.84	-11.99	17.24	-12.34	17.64	-12.69
16.45	-11.65	16.85	-12.00	17.25	-12.35	17.65	-12.70
16.46	-11.66	16.86	-12.00	17.26	-12.36	17.66	-12.71
16.47	-11.66	16.87	-12.01	17.27	-12.36	17.67	-12.72
16.48	-11.67	16.88	-12.02	17.28	-12.37	17.68	-12.73
16.49	-11.68	16.89	-12.03	17.29	-12.38	17.69	-12.73
16.50	-11.69	16.90	-12.04	17.30	-12.39	17.70	-12.74
16.51	-11.70	16.91	-12.05	17.31	-12.40	17.71	-12.75
16.52	-11.71	16.92	-12.06	17.32	-12.41	17.72	-12.76
16.53	-11.72	16.93	-12.07	17.33	-12.42	17.73	-12.77
16.54	-11.73	16.94	-12.07	17.34	-12.43	17.74	-12.78
16.55	-11.73	16.95	-12.08	17.35	-12.43	17.75	-12.79
16.56	-11.74	16.96	-12.09	17.36	-12.44	17.76	-12.80
16.57	-11.75	16.97	-12.10	17.37	-12.45	17.77	-12.81
16.58	-11.76	16.98	-12.11	17.38	-12.46	17.78	-12.81
16.59	-11.77	16.99	-12.12	17.39	-12.47	17.79	-12.82
16.60	-11.78	17.00	-12.13	17.40	-12.48	17.80	-12.83
16.61	-11.79	17.01	-12.14	17.41	-12.49	17.81	-12.84
16.62	-11.80	17.02	-12.14	17.42	-12.50	17.82	-12.85
16.63	-11.80	17.03	-12.15	17.43	-12.51	17.83	-12.86
16.64	-11.81	17.04	-12.16	17.44	-12.51	17.84	-12.87
16.65	-11.82	17.05	-12.17	17.45	-12.52	17.85	-12.88
16.66	-11.83	17.06	-12.18	17.46	-12.53	17.86	-12.89
16.67	-11.84	17.07	-12.19	17.47	-12.54	17.87	-12.89
16.68	-11.85	17.08	-12.20	17.48	-12.55	17.88	-12.90
16.69	-11.86	17.09	-12.21	17.49	-12.56	17.89	-12.91
16.70	-11.87	17.10	-12.22	17.50	-12.57	17.90	-12.92
16.71	-11.87	17.11	-12.22	17.51	-12.58	17.91	-12.93
16.72	-11.88	17.12	-12.23	17.52	-12.58	17.92	-12.94
16.73	-11.89	17.13	-12.24	17.53	-12.59	17.93	-12.95
16.74	-11.90	17.14	-12.25	17.54	-12.60	17.94	-12.96
16.75	-11.91	17.15	-12.26	17.55	-12.61	17.95	-12.97
16.76	-11.92	17.16	-12.27	17.56	-12.62	17.96	-12.97
16.77	-11.93	17.17	-12.28	17.57	-12.63	17.97	-12.98
16.78	-11.93	17.18	-12.29	17.58	-12.64	17.98	-12.99
16.79	-11.94	17.19	-12.29	17.59	-12.65	17.99	-13.00
16.80	-11.95	17.20	-12.30	17.60	-12.66	18.00	-13.01

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
18.01	-13.02	18.41	-13.37	18.81	-13.73	19.21	-14.09
18.02	-13.03	18.42	-13.38	18.82	-13.74	19.22	-14.10
18.03	-13.04	18.43	-13.39	18.83	-13.75	19.23	-14.11
18.04	-13.05	18.44	-13.40	18.84	-13.76	19.24	-14.12
18.05	-13.05	18.45	-13.41	18.85	-13.77	19.25	-14.13
18.06	-13.06	18.46	-13.42	18.86	-13.78	19.26	-14.14
18.07	-13.07	18.47	-13.43	18.87	-13.79	19.27	-14.15
18.08	-13.08	18.48	-13.44	18.88	-13.80	19.28	-14.16
18.09	-13.09	18.49	-13.45	18.89	-13.80	19.29	-14.16
18.10	-13.10	18.50	-13.46	18.90	-13.81	19.30	-14.17
18.11	-13.11	18.51	-13.46	18.91	-13.82	19.31	-14.18
18.12	-13.12	18.52	-13.47	18.92	-13.83	19.32	-14.19
18.13	-13.13	18.53	-13.48	18.93	-13.84	19.33	-14.20
18.14	-13.13	18.54	-13.49	18.94	-13.85	19.34	-14.21
18.15	-13.14	18.55	-13.50	18.95	-13.86	19.35	-14.22
18.16	-13.15	18.56	-13.51	18.96	-13.87	19.36	-14.23
18.17	-13.16	18.57	-13.52	18.97	-13.88	19.37	-14.24
18.18	-13.17	18.58	-13.53	18.98	-13.89	19.38	-14.25
18.19	-13.18	18.59	-13.54	18.99	-13.89	19.39	-14.25
18.20	-13.19	18.60	-13.54	19.00	-13.90	19.40	-14.26
18.21	-13.20	18.61	-13.55	19.01	-13.91	19.41	-14.27
18.22	-13.21	18.62	-13.56	19.02	-13.92	19.42	-14.28
18.23	-13.21	18.63	-13.57	19.03	-13.93	19.43	-14.29
18.24	-13.22	18.64	-13.58	19.04	-13.94	19.44	-14.30
18.25	-13.23	18.65	-13.59	19.05	-13.95	19.45	-14.31
18.26	-13.24	18.66	-13.60	19.06	-13.96	19.46	-14.32
18.27	-13.25	18.67	-13.61	19.07	-13.97	19.47	-14.33
18.28	-13.26	18.68	-13.62	19.08	-13.98	19.48	-14.34
18.29	-13.27	18.69	-13.63	19.09	-13.98	19.49	-14.35
18.30	-13.28	18.70	-13.63	19.10	-13.99	19.50	-14.35
18.31	-13.29	18.71	-13.64	19.11	-14.00	19.51	-14.36
18.32	-13.29	18.72	-13.65	19.12	-14.01	19.52	-14.37
18.33	-13.30	18.73	-13.66	19.13	-14.02	19.53	-14.38
18.34	-13.31	18.74	-13.67	19.14	-14.03	19.54	-14.39
18.35	-13.32	18.75	-13.68	19.15	-14.04	19.55	-14.40
18.36	-13.33	18.76	-13.69	19.16	-14.05	19.56	-14.41
18.37	-13.34	18.77	-13.70	19.17	-14.06	19.57	-14.42
18.38	-13.35	18.78	-13.71	19.18	-14.07	19.58	-14.43
18.39	-13.36	18.79	-13.71	19.19	-14.07	19.59	-14.44
18.40	-13.37	18.80	-13.72	19.20	-14.08	19.60	-14.44

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
19.61	-14.45	20.01	-14.82	20.41	-15.18	20.81	-15.55
19.62	-14.46	20.02	-14.83	20.42	-15.19	20.82	-15.56
19.63	-14.47	20.03	-14.83	20.43	-15.20	20.83	-15.57
19.64	-14.48	20.04	-14.84	20.44	-15.21	20.84	-15.57
19.65	-14.49	20.05	-14.85	20.45	-15.22	20.85	-15.58
19.66	-14.50	20.06	-14.86	20.46	-15.23	20.86	-15.59
19.67	-14.51	20.07	-14.87	20.47	-15.24	20.87	-15.60
19.68	-14.52	20.08	-14.88	20.48	-15.25	20.88	-15.61
19.69	-14.53	20.09	-14.89	20.49	-15.25	20.89	-15.62
19.70	-14.54	20.10	-14.90	20.50	-15.26	20.90	-15.63
19.71	-14.54	20.11	-14.91	20.51	-15.27	20.91	-15.64
19.72	-14.55	20.12	-14.92	20.52	-15.28	20.92	-15.65
19.73	-14.56	20.13	-14.93	20.53	-15.29	20.93	-15.66
19.74	-14.57	20.14	-14.94	20.54	-15.30	20.94	-15.67
19.75	-14.58	20.15	-14.94	20.55	-15.31	20.95	-15.68
19.76	-14.59	20.16	-14.95	20.56	-15.32	20.96	-15.68
19.77	-14.60	20.17	-14.96	20.57	-15.33	20.97	-15.69
19.78	-14.61	20.18	-14.97	20.58	-15.34	20.98	-15.70
19.79	-14.62	20.19	-14.98	20.59	-15.35	20.99	-15.71
19.80	-14.63	20.20	-14.99	20.60	-15.35	21.00	-15.72
19.81	-14.64	20.21	-15.00	20.61	-15.36	21.01	-15.73
19.82	-14.64	20.22	-15.01	20.62	-15.37	21.02	-15.74
19.83	-14.65	20.23	-15.02	20.63	-15.38	21.03	-15.75
19.84	-14.66	20.24	-15.03	20.64	-15.39	21.04	-15.76
19.85	-14.67	20.25	-15.04	20.65	-15.40	21.05	-15.77
19.86	-14.68	20.26	-15.04	20.66	-15.41	21.06	-15.78
19.87	-14.69	20.27	-15.05	20.67	-15.42	21.07	-15.79
19.88	-14.70	20.28	-15.06	20.68	-15.43	21.08	-15.79
19.89	-14.71	20.29	-15.07	20.69	-15.44	21.09	-15.80
19.90	-14.72	20.30	-15.08	20.70	-15.45	21.10	-15.81
19.91	-14.73	20.31	-15.09	20.71	-15.46	21.11	-15.82
19.92	-14.73	20.32	-15.10	20.72	-15.46	21.12	-15.83
19.93	-14.74	20.33	-15.11	20.73	-15.47	21.13	-15.84
19.94	-14.75	20.34	-15.12	20.74	-15.48	21.14	-15.85
19.95	-14.76	20.35	-15.13	20.75	-15.49	21.15	-15.86
19.96	-14.77	20.36	-15.14	20.76	-15.50	21.16	-15.87
19.97	-14.78	20.37	-15.14	20.77	-15.51	21.17	-15.88
19.98	-14.79	20.38	-15.15	20.78	-15.52	21.18	-15.89
19.99	-14.80	20.39	-15.16	20.79	-15.53	21.19	-15.90
20.00	-14.81	20.40	-15.17	20.80	-15.54	21.20	-15.91

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
21.21	-15.91	21.61	-16.28	22.01	-16.65	22.41	-17.02
21.22	-15.92	21.62	-16.29	22.02	-16.66	22.42	-17.03
21.23	-15.93	21.63	-16.30	22.03	-16.67	22.43	-17.04
21.24	-15.94	21.64	-16.31	22.04	-16.68	22.44	-17.05
21.25	-15.95	21.65	-16.32	22.05	-16.69	22.45	-17.06
21.26	-15.96	21.66	-16.33	22.06	-16.70	22.46	-17.07
21.27	-15.97	21.67	-16.34	22.07	-16.71	22.47	-17.08
21.28	-15.98	21.68	-16.35	22.08	-16.72	22.48	-17.09
21.29	-15.99	21.69	-16.36	22.09	-16.73	22.49	-17.10
21.30	-16.00	21.70	-16.37	22.10	-16.74	22.50	-17.11
21.31	-16.01	21.71	-16.38	22.11	-16.75	22.51	-17.12
21.32	-16.02	21.72	-16.38	22.12	-16.75	22.52	-17.13
21.33	-16.02	21.73	-16.39	22.13	-16.76	22.53	-17.14
21.34	-16.03	21.74	-16.40	22.14	-16.77	22.54	-17.15
21.35	-16.04	21.75	-16.41	22.15	-16.78	22.55	-17.15
21.36	-16.05	21.76	-16.42	22.16	-16.79	22.56	-17.16
21.37	-16.06	21.77	-16.43	22.17	-16.80	22.57	-17.17
21.38	-16.07	21.78	-16.44	22.18	-16.81	22.58	-17.18
21.39	-16.08	21.79	-16.45	22.19	-16.82	22.59	-17.19
21.40	-16.09	21.80	-16.46	22.20	-16.83	22.60	-17.20
21.41	-16.10	21.81	-16.47	22.21	-16.84	22.61	-17.21
21.42	-16.11	21.82	-16.48	22.22	-16.85	22.62	-17.22
21.43	-16.12	21.83	-16.49	22.23	-16.86	22.63	-17.23
21.44	-16.13	21.84	-16.50	22.24	-16.87	22.64	-17.24
21.45	-16.14	21.85	-16.50	22.25	-16.88	22.65	-17.25
21.46	-16.14	21.86	-16.51	22.26	-16.88	22.66	-17.26
21.47	-16.15	21.87	-16.52	22.27	-16.89	22.67	-17.27
21.48	-16.16	21.88	-16.53	22.28	-16.90	22.68	-17.28
21.49	-16.17	21.89	-16.54	22.29	-16.91	22.69	-17.28
21.50	-16.18	21.90	-16.55	22.30	-16.92	22.70	-17.29
21.51	-16.19	21.91	-16.56	22.31	-16.93	22.71	-17.30
21.52	-16.20	21.92	-16.57	22.32	-16.94	22.72	-17.31
21.53	-16.21	21.93	-16.58	22.33	-16.95	22.73	-17.32
21.54	-16.22	21.94	-16.59	22.34	-16.96	22.74	-17.33
21.55	-16.23	21.95	-16.60	22.35	-16.97	22.75	-17.34
21.56	-16.24	21.96	-16.61	22.36	-16.98	22.76	-17.35
21.57	-16.25	21.97	-16.62	22.37	-16.99	22.77	-17.36
21.58	-16.26	21.98	-16.63	22.38	-17.00	22.78	-17.37
21.59	-16.26	21.99	-16.63	22.39	-17.01	22.79	-17.38
21.60	-16.27	22.00	-16.64	22.40	-17.01	22.80	-17.39

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
22.81	-17.40	23.21	-17.77	23.61	-18.14	24.01	-18.52
22.82	-17.41	23.22	-17.78	23.62	-18.15	24.02	-18.53
22.83	-17.42	23.23	-17.79	23.63	-18.16	24.03	-18.54
22.84	-17.42	23.24	-17.80	23.64	-18.17	24.04	-18.55
22.85	-17.43	23.25	-17.81	23.65	-18.18	24.05	-18.56
22.86	-17.44	23.26	-17.82	23.66	-18.19	24.06	-18.57
22.87	-17.45	23.27	-17.83	23.67	-18.20	24.07	-18.58
22.88	-17.46	23.28	-17.84	23.68	-18.21	24.08	-18.59
22.89	-17.47	23.29	-17.84	23.69	-18.22	24.09	-18.60
22.90	-17.48	23.30	-17.85	23.70	-18.23	24.10	-18.61
22.91	-17.49	23.31	-17.86	23.71	-18.24	24.11	-18.61
22.92	-17.50	23.32	-17.87	23.72	-18.25	24.12	-18.62
22.93	-17.51	23.33	-17.88	23.73	-18.26	24.13	-18.63
22.94	-17.52	23.34	-17.89	23.74	-18.27	24.14	-18.64
22.95	-17.53	23.35	-17.90	23.75	-18.28	24.15	-18.65
22.96	-17.54	23.36	-17.91	23.76	-18.29	24.16	-18.66
22.97	-17.55	23.37	-17.92	23.77	-18.30	24.17	-18.67
22.98	-17.56	23.38	-17.93	23.78	-18.30	24.18	-18.68
22.99	-17.56	23.39	-17.94	23.79	-18.31	24.19	-18.69
23.00	-17.57	23.40	-17.95	23.80	-18.32	24.20	-18.70
23.01	-17.58	23.41	-17.96	23.81	-18.33	24.21	-18.71
23.02	-17.59	23.42	-17.97	23.82	-18.34	24.22	-18.72
23.03	-17.60	23.43	-17.98	23.83	-18.35	24.23	-18.73
23.04	-17.61	23.44	-17.99	23.84	-18.36	24.24	-18.74
23.05	-17.62	23.45	-17.99	23.85	-18.37	24.25	-18.75
23.06	-17.63	23.46	-18.00	23.86	-18.38	24.26	-18.76
23.07	-17.64	23.47	-18.01	23.87	-18.39	24.27	-18.77
23.08	-17.65	23.48	-18.02	23.88	-18.40	24.28	-18.77
23.09	-17.66	23.49	-18.03	23.89	-18.41	24.29	-18.78
23.10	-17.67	23.50	-18.04	23.90	-18.42	24.30	-18.79
23.11	-17.68	23.51	-18.05	23.91	-18.43	24.31	-18.80
23.12	-17.69	23.52	-18.06	23.92	-18.44	24.32	-18.81
23.13	-17.70	23.53	-18.07	23.93	-18.45	24.33	-18.82
23.14	-17.70	23.54	-18.08	23.94	-18.45	24.34	-18.83
23.15	-17.71	23.55	-18.09	23.95	-18.46	24.35	-18.84
23.16	-17.72	23.56	-18.10	23.96	-18.47	24.36	-18.85
23.17	-17.73	23.57	-18.11	23.97	-18.48	24.37	-18.86
23.18	-17.74	23.58	-18.12	23.98	-18.49	24.38	-18.87
23.19	-17.75	23.59	-18.13	23.99	-18.50	24.39	-18.88
23.20	-17.76	23.60	-18.14	24.00	-18.51	24.40	-18.89

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
24.41	-18.90	24.81	-19.28	25.21	-19.65	25.61	-20.03
24.42	-18.91	24.82	-19.28	25.22	-19.66	25.62	-20.04
24.43	-18.92	24.83	-19.29	25.23	-19.67	25.63	-20.05
24.44	-18.93	24.84	-19.30	25.24	-19.68	25.64	-20.06
24.45	-18.94	24.85	-19.31	25.25	-19.69	25.65	-20.07
24.46	-18.94	24.86	-19.32	25.26	-19.70	25.66	-20.08
24.47	-18.95	24.87	-19.33	25.27	-19.71	25.67	-20.09
24.48	-18.96	24.88	-19.34	25.28	-19.72	25.68	-20.10
24.49	-18.97	24.89	-19.35	25.29	-19.73	25.69	-20.11
24.50	-18.98	24.90	-19.36	25.30	-19.74	25.70	-20.12
24.51	-18.99	24.91	-19.37	25.31	-19.75	25.71	-20.13
24.52	-19.00	24.92	-19.38	25.32	-19.76	25.72	-20.14
24.53	-19.01	24.93	-19.39	25.33	-19.77	25.73	-20.15
24.54	-19.02	24.94	-19.40	25.34	-19.78	25.74	-20.16
24.55	-19.03	24.95	-19.41	25.35	-19.79	25.75	-20.17
24.56	-19.04	24.96	-19.42	25.36	-19.80	25.76	-20.18
24.57	-19.05	24.97	-19.43	25.37	-19.81	25.77	-20.19
24.58	-19.06	24.98	-19.44	25.38	-19.82	25.78	-20.20
24.59	-19.07	24.99	-19.45	25.39	-19.82	25.79	-20.20
24.60	-19.08	25.00	-19.45	25.40	-19.83	25.80	-20.21
24.61	-19.09	25.01	-19.46	25.41	-19.84	25.81	-20.22
24.62	-19.10	25.02	-19.47	25.42	-19.85	25.82	-20.23
24.63	-19.11	25.03	-19.48	25.43	-19.86	25.83	-20.24
24.64	-19.11	25.04	-19.49	25.44	-19.87	25.84	-20.25
24.65	-19.12	25.05	-19.50	25.45	-19.88	25.85	-20.26
24.66	-19.13	25.06	-19.51	25.46	-19.89	25.86	-20.27
24.67	-19.14	25.07	-19.52	25.47	-19.90	25.87	-20.28
24.68	-19.15	25.08	-19.53	25.48	-19.91	25.88	-20.29
24.69	-19.16	25.09	-19.54	25.49	-19.92	25.89	-20.30
24.70	-19.17	25.10	-19.55	25.50	-19.93	25.90	-20.31
24.71	-19.18	25.11	-19.56	25.51	-19.94	25.91	-20.32
24.72	-19.19	25.12	-19.57	25.52	-19.95	25.92	-20.33
24.73	-19.20	25.13	-19.58	25.53	-19.96	25.93	-20.34
24.74	-19.21	25.14	-19.59	25.54	-19.97	25.94	-20.35
24.75	-19.22	25.15	-19.60	25.55	-19.98	25.95	-20.36
24.76	-19.23	25.16	-19.61	25.56	-19.99	25.96	-20.37
24.77	-19.24	25.17	-19.62	25.57	-20.00	25.97	-20.38
24.78	-19.25	25.18	-19.63	25.58	-20.01	25.98	-20.39
24.79	-19.26	25.19	-19.63	25.59	-20.01	25.99	-20.39
24.80	-19.27	25.20	-19.64	25.60	-20.02	26.00	-20.40

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
26.01	-20.41	26.41	-20.80	26.81	-21.18	27.21	-21.56
26.02	-20.42	26.42	-20.80	26.82	-21.19	27.22	-21.57
26.03	-20.43	26.43	-20.81	26.83	-21.20	27.23	-21.58
26.04	-20.44	26.44	-20.82	26.84	-21.21	27.24	-21.59
26.05	-20.45	26.45	-20.83	26.85	-21.22	27.25	-21.60
26.06	-20.46	26.46	-20.84	26.86	-21.23	27.26	-21.61
26.07	-20.47	26.47	-20.85	26.87	-21.23	27.27	-21.62
26.08	-20.48	26.48	-20.86	26.88	-21.24	27.28	-21.63
26.09	-20.49	26.49	-20.87	26.89	-21.25	27.29	-21.64
26.10	-20.50	26.50	-20.88	26.90	-21.26	27.30	-21.65
26.11	-20.51	26.51	-20.89	26.91	-21.27	27.31	-21.66
26.12	-20.52	26.52	-20.90	26.92	-21.28	27.32	-21.67
26.13	-20.53	26.53	-20.91	26.93	-21.29	27.33	-21.68
26.14	-20.54	26.54	-20.92	26.94	-21.30	27.34	-21.69
26.15	-20.55	26.55	-20.93	26.95	-21.31	27.35	-21.69
26.16	-20.56	26.56	-20.94	26.96	-21.32	27.36	-21.70
26.17	-20.57	26.57	-20.95	26.97	-21.33	27.37	-21.71
26.18	-20.58	26.58	-20.96	26.98	-21.34	27.38	-21.72
26.19	-20.59	26.59	-20.97	26.99	-21.35	27.39	-21.73
26.20	-20.60	26.60	-20.98	27.00	-21.36	27.40	-21.74
26.21	-20.60	26.61	-20.99	27.01	-21.37	27.41	-21.75
26.22	-20.61	26.62	-21.00	27.02	-21.38	27.42	-21.76
26.23	-20.62	26.63	-21.01	27.03	-21.39	27.43	-21.77
26.24	-20.63	26.64	-21.01	27.04	-21.40	27.44	-21.78
26.25	-20.64	26.65	-21.02	27.05	-21.41	27.45	-21.79
26.26	-20.65	26.66	-21.03	27.06	-21.42	27.46	-21.80
26.27	-20.66	26.67	-21.04	27.07	-21.43	27.47	-21.81
26.28	-20.67	26.68	-21.05	27.08	-21.44	27.48	-21.82
26.29	-20.68	26.69	-21.06	27.09	-21.45	27.49	-21.83
26.30	-20.69	26.70	-21.07	27.10	-21.46	27.50	-21.84
26.31	-20.70	26.71	-21.08	27.11	-21.46	27.51	-21.85
26.32	-20.71	26.72	-21.09	27.12	-21.47	27.52	-21.86
26.33	-20.72	26.73	-21.10	27.13	-21.48	27.53	-21.87
26.34	-20.73	26.74	-21.11	27.14	-21.49	27.54	-21.88
26.35	-20.74	26.75	-21.12	27.15	-21.50	27.55	-21.89
26.36	-20.75	26.76	-21.13	27.16	-21.51	27.56	-21.90
26.37	-20.76	26.77	-21.14	27.17	-21.52	27.57	-21.91
26.38	-20.77	26.78	-21.15	27.18	-21.53	27.58	-21.92
26.39	-20.78	26.79	-21.16	27.19	-21.54	27.59	-21.92
26.40	-20.79	26.80	-21.17	27.20	-21.55	27.60	-21.93

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
27.61	-21.94	28.01	-22.33	28.41	-22.71	28.81	-23.10
27.62	-21.95	28.02	-22.34	28.42	-22.72	28.82	-23.11
27.63	-21.96	28.03	-22.35	28.43	-22.73	28.83	-23.12
27.64	-21.97	28.04	-22.36	28.44	-22.74	28.84	-23.13
27.65	-21.98	28.05	-22.37	28.45	-22.75	28.85	-23.14
27.66	-21.99	28.06	-22.38	28.46	-22.76	28.86	-23.15
27.67	-22.00	28.07	-22.39	28.47	-22.77	28.87	-23.16
27.68	-22.01	28.08	-22.40	28.48	-22.78	28.88	-23.17
27.69	-22.02	28.09	-22.41	28.49	-22.79	28.89	-23.18
27.70	-22.03	28.10	-22.41	28.50	-22.80	28.90	-23.19
27.71	-22.04	28.11	-22.42	28.51	-22.81	28.91	-23.20
27.72	-22.05	28.12	-22.43	28.52	-22.82	28.92	-23.21
27.73	-22.06	28.13	-22.44	28.53	-22.83	28.93	-23.21
27.74	-22.07	28.14	-22.45	28.54	-22.84	28.94	-23.22
27.75	-22.08	28.15	-22.46	28.55	-22.85	28.95	-23.23
27.76	-22.09	28.16	-22.47	28.56	-22.86	28.96	-23.24
27.77	-22.10	28.17	-22.48	28.57	-22.87	28.97	-23.25
27.78	-22.11	28.18	-22.49	28.58	-22.88	28.98	-23.26
27.79	-22.12	28.19	-22.50	28.59	-22.89	28.99	-23.27
27.80	-22.13	28.20	-22.51	28.60	-22.90	29.00	-23.28
27.81	-22.14	28.21	-22.52	28.61	-22.91	29.01	-23.29
27.82	-22.15	28.22	-22.53	28.62	-22.92	29.02	-23.30
27.83	-22.16	28.23	-22.54	28.63	-22.93	29.03	-23.31
27.84	-22.16	28.24	-22.55	28.64	-22.94	29.04	-23.32
27.85	-22.17	28.25	-22.56	28.65	-22.94	29.05	-23.33
27.86	-22.18	28.26	-22.57	28.66	-22.95	29.06	-23.34
27.87	-22.19	28.27	-22.58	28.67	-22.96	29.07	-23.35
27.88	-22.20	28.28	-22.59	28.68	-22.97	29.08	-23.36
27.89	-22.21	28.29	-22.60	28.69	-22.98	29.09	-23.37
27.90	-22.22	28.30	-22.61	28.70	-22.99	29.10	-23.38
27.91	-22.23	28.31	-22.62	28.71	-23.00	29.11	-23.39
27.92	-22.24	28.32	-22.63	28.72	-23.01	29.12	-23.40
27.93	-22.25	28.33	-22.64	28.73	-23.02	29.13	-23.41
27.94	-22.26	28.34	-22.65	28.74	-23.03	29.14	-23.42
27.95	-22.27	28.35	-22.66	28.75	-23.04	29.15	-23.43
27.96	-22.28	28.36	-22.67	28.76	-23.05	29.16	-23.44
27.97	-22.29	28.37	-22.67	28.77	-23.06	29.17	-23.45
27.98	-22.30	28.38	-22.68	28.78	-23.07	29.18	-23.46
27.99	-22.31	28.39	-22.69	28.79	-23.08	29.19	-23.47
28.00	-22.32	28.40	-22.70	28.80	-23.09	29.20	-23.48

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
29.21	-23.49	29.61	-23.87	30.01	-24.26	30.41	-24.65
29.22	-23.50	29.62	-23.88	30.02	-24.27	30.42	-24.66
29.23	-23.50	29.63	-23.89	30.03	-24.28	30.43	-24.67
29.24	-23.51	29.64	-23.90	30.04	-24.29	30.44	-24.68
29.25	-23.52	29.65	-23.91	30.05	-24.30	30.45	-24.69
29.26	-23.53	29.66	-23.92	30.06	-24.31	30.46	-24.70
29.27	-23.54	29.67	-23.93	30.07	-24.32	30.47	-24.71
29.28	-23.55	29.68	-23.94	30.08	-24.33	30.48	-24.72
29.29	-23.56	29.69	-23.95	30.09	-24.34	30.49	-24.73
29.30	-23.57	29.70	-23.96	30.10	-24.35	30.50	-24.74
29.31	-23.58	29.71	-23.97	30.11	-24.36	30.51	-24.74
29.32	-23.59	29.72	-23.98	30.12	-24.37	30.52	-24.75
29.33	-23.60	29.73	-23.99	30.13	-24.38	30.53	-24.76
29.34	-23.61	29.74	-24.00	30.14	-24.39	30.54	-24.77
29.35	-23.62	29.75	-24.01	30.15	-24.40	30.55	-24.78
29.36	-23.63	29.76	-24.02	30.16	-24.41	30.56	-24.79
29.37	-23.64	29.77	-24.03	30.17	-24.41	30.57	-24.80
29.38	-23.65	29.78	-24.04	30.18	-24.42	30.58	-24.81
29.39	-23.66	29.79	-24.05	30.19	-24.43	30.59	-24.82
29.40	-23.67	29.80	-24.06	30.20	-24.44	30.60	-24.83
29.41	-23.68	29.81	-24.07	30.21	-24.45	30.61	-24.84
29.42	-23.69	29.82	-24.08	30.22	-24.46	30.62	-24.85
29.43	-23.70	29.83	-24.09	30.23	-24.47	30.63	-24.86
29.44	-23.71	29.84	-24.10	30.24	-24.48	30.64	-24.87
29.45	-23.72	29.85	-24.10	30.25	-24.49	30.65	-24.88
29.46	-23.73	29.86	-24.11	30.26	-24.50	30.66	-24.89
29.47	-23.74	29.87	-24.12	30.27	-24.51	30.67	-24.90
29.48	-23.75	29.88	-24.13	30.28	-24.52	30.68	-24.91
29.49	-23.76	29.89	-24.14	30.29	-24.53	30.69	-24.92
29.50	-23.77	29.90	-24.15	30.30	-24.54	30.70	-24.93
29.51	-23.78	29.91	-24.16	30.31	-24.55	30.71	-24.94
29.52	-23.79	29.92	-24.17	30.32	-24.56	30.72	-24.95
29.53	-23.79	29.93	-24.18	30.33	-24.57	30.73	-24.96
29.54	-23.80	29.94	-24.19	30.34	-24.58	30.74	-24.97
29.55	-23.81	29.95	-24.20	30.35	-24.59	30.75	-24.98
29.56	-23.82	29.96	-24.21	30.36	-24.60	30.76	-24.99
29.57	-23.83	29.97	-24.22	30.37	-24.61	30.77	-25.00
29.58	-23.84	29.98	-24.23	30.38	-24.62	30.78	-25.01
29.59	-23.85	29.99	-24.24	30.39	-24.63	30.79	-25.02
29.60	-23.86	30.00	-24.25	30.40	-24.64	30.80	-25.03

$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A	$A_o - A_r$	A
30.81	-25.04	31.21	-25.43	31.61	-25.81	32.01	-26.20
30.82	-25.05	31.22	-25.44	31.62	-25.82	32.02	-26.21
30.83	-25.06	31.23	-25.44	31.63	-25.83	32.03	-26.22
30.84	-25.07	31.24	-25.45	31.64	-25.84	32.04	-26.23
30.85	-25.08	31.25	-25.46	31.65	-25.85	32.05	-26.24
30.86	-25.08	31.26	-25.47	31.66	-25.86	32.06	-26.25
30.87	-25.09	31.27	-25.48	31.67	-25.87	32.07	-26.26
30.88	-25.10	31.28	-25.49	31.68	-25.88	32.08	-26.27
30.89	-25.11	31.29	-25.50	31.69	-25.89	32.09	-26.28
30.90	-25.12	31.30	-25.51	31.70	-25.90	32.10	-26.29
30.91	-25.13	31.31	-25.52	31.71	-25.91	32.11	-26.30
30.92	-25.14	31.32	-25.53	31.72	-25.92	32.12	-26.31
30.93	-25.15	31.33	-25.54	31.73	-25.93	32.13	-26.32
30.94	-25.16	31.34	-25.55	31.74	-25.94	32.14	-26.33
30.95	-25.17	31.35	-25.56	31.75	-25.95	32.15	-26.34
30.96	-25.18	31.36	-25.57	31.76	-25.96	32.16	-26.35
30.97	-25.19	31.37	-25.58	31.77	-25.97	32.17	-26.36
30.98	-25.20	31.38	-25.59	31.78	-25.98	32.18	-26.37
30.99	-25.21	31.39	-25.60	31.79	-25.99	32.19	-26.38
31.00	-25.22	31.40	-25.61	31.80	-26.00	32.20	-26.39
31.01	-25.23	31.41	-25.62	31.81	-26.01	32.21	-26.40
31.02	-25.24	31.42	-25.63	31.82	-26.02	32.22	-26.41
31.03	-25.25	31.43	-25.64	31.83	-26.03	32.23	-26.42
31.04	-25.26	31.44	-25.65	31.84	-26.04	32.24	-26.43
31.05	-25.27	31.45	-25.66	31.85	-26.05	32.25	-26.44
31.06	-25.28	31.46	-25.67	31.86	-26.06	32.26	-26.45
31.07	-25.29	31.47	-25.68	31.87	-26.07	32.27	-26.46
31.08	-25.30	31.48	-25.69	31.88	-26.08	32.28	-26.47
31.09	-25.31	31.49	-25.70	31.89	-26.09	32.29	-26.48
31.10	-25.32	31.50	-25.71	31.90	-26.10	32.30	-26.49
31.11	-25.33	31.51	-25.72	31.91	-26.11	32.31	-26.50
31.12	-25.34	31.52	-25.73	31.92	-26.12	32.32	-26.51
31.13	-25.35	31.53	-25.74	31.93	-26.13	32.33	-26.52
31.14	-25.36	31.54	-25.75	31.94	-26.14	32.34	-26.53
31.15	-25.37	31.55	-25.76	31.95	-26.15	32.35	-26.54
31.16	-25.38	31.56	-25.77	31.96	-26.16	32.36	-26.55
31.17	-25.39	31.57	-25.78	31.97	-26.17	32.37	-26.56
31.18	-25.40	31.58	-25.79	31.98	-26.18	32.38	-26.57
31.19	-25.41	31.59	-25.80	31.99	-26.19	32.39	-26.58
31.20	-25.42	31.60	-25.81	32.00	-26.20	32.40	-26.59

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U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

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The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

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Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

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Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

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