Sample, and date of manufacture.	Date of, and original assay.	Assay 7/5/17.	Loss percent.	Assay 7/18.	Loss percent from original.	Remarks.
A^1.......	...	...	..	0.444	..	Boric acid formula, slightly alkaline to phencl-phthalein.
A^2....... 11/16	0.706 1/5/17	0.614	13%	0.433	39%	Boric acid formula, cork good, bleached.
A^3....... 11/16	0.54 1/5/17	...	..	0.349	36.4%	Boric acid formula, diluted to be about 0.5%, amber g. s. b.
B........ 1/5/17	0.515 1/5/17	0.49	5%	0.405	21.4%	Dakin's, cork good, bleached.
C........ 3/12/17	0.506 3/12/17	0.428	15.4%	0.273	46.0%	Dakin's, cork porous and decidedly bleached.
D........ 3/22/17	0.513 3/22/17	0.465	9.4%	0.322	37.0%	Dakin's, cork very poor, bleached.
E........ 6/25/17	0.462 6/25/17	0.462	0.0%	(Sample lost)		Dakin's, 10 days, hot weather. No loss.
F........ 7/5/17	...	0.53	(Sample lost)		..	Dakin's, fresh lot.
G^1....... (Rec'd 3/16)	...	...	..	0.348×10	55%	Commercial brand, assay as per label, 7.7% NaOCl.
G^2....... (Rec'd 7/18)	...	...	..	0.500×10		Commercial brand, received a few days before assaying, assay as per label, 4.05% NaOCl.

Ordinary care only was exercised with stoppers, as some corks were better than others. It will be seen from the table that where the sample was well stoppered it did not fall below the lower limit of variation permissible, in six months.

The commercial, so-called stabilized, product lost strength, apparently, at about the same rate as Dakin's Solution, Daufresne formula.

THE USE OF LOGARITHMS AND ANTILOGARITHMS IN PHARMACEUTICAL ASSAYING.*

BY H. L. THOMPSON.

It has been my experience in teaching the subject of pharmaceutical assaying that one of the most difficult, tedious and nerve-racking parts of it is the performance of the mathematical calculations involved. As a result, I have attempted to instruct my students in the use of logarithms and antilogarithms, and after six years of such performance, there have resulted the following facts:

1st. As far as accuracy, the results obtained by using logarithms and antilogarithms is 0.01%, and that is considerably beyond the average accuracy in practice.

2nd. The time and labor saved by the use of logarithms and antilogarithms is about one-tenth or less than that used by the method of ratio and proportion, and the multiplication and long division of three or four decimal figures out to the third or fourth decimal place as required in determining strengths of drugs, chemicals and their preparations.

* Contributed to Section on Practical Pharmacy and Dispensing, A. Ph. A., Chicago meeting, 1918.

3rd. The continual use of logarithms and antilogarithms has brought forth five general formulas, two for standardizing volumetric solutions, two for volumetric assay, and one for gravimetric and electrolytic assay.

Just what are logarithms and antilogarithms can not be explained in a better way than to first define a logarithm and an antilogarithm, show a logarithm table and an antilogarithm table, and then explain their use.

(If one is fully acquainted with the use of logarithms and antilogarithms, the following paragraphs may be omitted, and the use of the general standardization formulas and general assay formulas may be considered. See paragraph, Explanation of terms used in the formulas.)

LOGARITHM OF A NUMBER.

Let "a" be a certain fixed number, "n" any other number, and let "x" represent the exponent of "a" required to produce "n." Then "x" is the logarithm of "n" to the base "a."

As equations: if $a^x = n$; then $x = \log_a n$.

Hereafter are given some very simple tables of logarithms.

No.	Logarithm Base = 2.	n.	Log_{10} n.	n.	Log_{10} n.
1/16	—4	0.0001 =	—4	1	0.0000
1/8	—3	0.001	—3	2	0.3010
1/4	—2	0.01	—2	3	0.4771
1/2	—1	0.1	—1	4	0.6021
1	0	1.0	0	5	0.6990
2	1	10.0	1	6	0.7782
4	2	100.0	2	7	0.8451
8	3	1000.0	3	8	0.9031
16	4	10000.0	4	9	0.9542

LAWS OF OPERATIONS WITH LOGARITHMS.

Since a logarithm is an exponent, the laws of operation for logarithms are the same as those for exponents.

Let "x" be the logarithm of "m," "y" that of "n;" the base being "a."

Then $\log_a m = x$; or $a^x = m$;

$\log_a n = y$; or $a^y = n$.

Hence $mn = a^{x+y}$ and $m/n = a^{x-y}$;

or $\log_a mn = x + y = \log_a m + \log_a n$;

and $\log_a m/n = x - y = \log_a m - \log_a n$.

We have therefore the rules:

I. The logarithm of a product equals the sum of the logarithm of the factors.

II. The logarithm of a fraction equals the logarithm of the numerator minus the logarithm of the denominator.

Also, if as before,

$\log_a m = x$, so that $m = a^x$;

then, if p and q be any real numbers

$m^p = a^{px}$ and $q/m = a^{x/q}$.

Hence $\log_a m^p = px = p \log_a m$;

and $\log_a m = x/q = 1/q \log_a m$.

There are therefore two additional rules:

III. The logarithm of any power of a number equals the exponent of the power times the logarithm of the number.

IV. The logarithm of any root of number equals the logarithms of the number divided by the index of the root.

(Rule III contains Rule IV, since the power in question may be fractional.)

The following facts regarding logarithms should also be carefully noted:

(*a*) In any system the logarithm of the base is 1; for $a^1 = a$. Therefore $\log_a a$ 1.

(*b*) In any system the logarithm of 1 is 0; for $a^0 = 1$. Therefore $\log_a 1 = 0$.

(*c*) In any system whose base is greater than unity, the logarithm of 0 is $-\infty$. For if $a^x = m$, and $a > 1$, then if x is a large negative number m will be small. As x increases indefinitely, always being n negative, m approaches zero. That is, $a^{-\infty} = 0$; if $a > 1$. Therefore $\log 0 = -\infty$.

(*d*) A negative number has no (real) logarithm, the base being positive.

(*e*) As a number varies from 0 to $+\infty$, its logarithm varies from $-\infty$ to $+\infty$, the base being greater than 1.

When the number is greater than 1, its logarithm is positive, and when the number is less than 1, its logarithm is negative.

A photo of Logarithms of Numbers and Antilogarithms accompanies this article.

EXPLANATION OF THE TABLES AND THEIR USE.

Logarithms of Numbers.—This table gives the decimal part, or mantissa, of the logarithms of every positive number containing not more than three significant figures. The mantissas of the logarithms of numbers containing more than three significant figures are to be obtained by interpolation or the use of the proportional parts. The integral part, or characteristics, of the logarithm must be supplied by the computer, according to the position of the decimal point in the number.

RULES FOR CHARACTERISTICS.

(*a*) When a number has "n" significant figures to the left of the decimal point, the characteristic of its logarithm is $n - 1$.

(*b*) When the number is a decimal with "n" ciphers between the decimal point and the first digit which is not zero, the characteristic of its logarithm is $9 - n$, and -10 must be supplied to complete the logarithm.

The reason for these rules will become evident when we consider an example.

Find log 631. In the table find 63 in the left hand column and run across the page horizontally to the column headed one. There we find that the mantissa of log 631 = 0.8000.

Now 631 lies between 100 and 1000, *i. e.*, between 10^2 and 10^3.

Hence, by definition of a logarithm, log 631 must lie between 2 and 3.

Therefore the characteristic is 2, and log 631 = 2.8000.

This, of course, is not the exact logarithm of 631, but only its value to four decimal places.

Writing the last equation in exponential form, we have

$$631 = 10^{2.8000}.$$

Multiplying both sides by 10, $6310 = 10 \times 10^{2.8000} = 10^{3.8000}$

Hence, log 6310 = 3.8000.

Multiplying again by 10, $63100 = 10 \times 10^{3.8000} = 10^{4.8000}$. Hence log 63100 = 4.8000. Therefore, where a number is multiplied by 10, the characteristic of its logarithm is increased by 1; the mantissa remains unchanged.

Dividing the above equations successively by 10, we obtain

$$63.1 = 10^{2.8000} + 10 = 10^{1.8000}$$
$$6.31 = 10^{1.8000} + 10 = 10^{0.8000}$$
$$0.631 = 10^{0.8000} + 10 = 10^{0.8000-1}$$
$$0.0631 = 10^{0.8000-1} + 10 = 10^{0.8000-2}$$
$$0.00631 = 10^{0.8000-2} + 10 = 10^{08000-3} \text{ and so on.}$$

As logarithmic equations these are:

$$\log 63.1 = 1.8000$$
$$6.31 = 0.8000$$
$$0.631 = 0.8000 - 1 = 9.8000 - 10$$
$$0.0631 = 0.8000 - 2 = 8.8000 - 10$$
$$0.00631 = 0.8000 - 3 = 7.8000 - 10, \text{ and so on.}$$

The second form of the lst three equations is used for convenience in computations; it is in accordance with Rule *b*.

LOGARITHMS OF NUMBERS

Natural numbers	0	1	2	3	4	5	6	7	8	9	Proportional Parts								
											1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7

LOGARITHMS OF NUMBERS

Natural numbers	0	1	2	3	4	5	6	7	8	9	Proportional Parts								
											1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4

Logarithms	0	1	2	3	4	5	6	7	8	9	Proportional Parts								
											1	2	3	4	5	6	7	8	9
.00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
.01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
.02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
.03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
.04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
.05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
.06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
.07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
.08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
.09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
.10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
.11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
.12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
.13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
.14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
.15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
.16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
.17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
.18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
.19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
.20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
.21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
.22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
.23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
.24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
.25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
.26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
.27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
.28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
.29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
.30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
.31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
.32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
.33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
.34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
.35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
.36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
.37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
.38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
.39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
.40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
.41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
.42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
.43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
.44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
.45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
.46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
.47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
.48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5	6	6
.49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5	6	6

Logarithms	0	1	2	3	4	5	6	7	8	9	Proportional Parts								
											1	2	3	4	5	6	7	8	9
.50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
.51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
.52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
.53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
.54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
.55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
.56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
.57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
.58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
.59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
.60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
.61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
.62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
.63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
.64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
.65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
.66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
.67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
.68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
.69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
.70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	11
.71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
.72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11
.73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
.74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	12
.75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12
.76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
.77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
.78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
.79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
.80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
.81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
.82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	14
.83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
.84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
.85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	15
.86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
.87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
.88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	16
.89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	16
.90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	17
.91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
.92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	17
.93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
.94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
.95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
.96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	19
.97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
.98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
.99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20

Logarithms of Numbers and Antilogarithms

To discuss Rules *a* and *b* more generally, let "m" be any number. Then by the definition of a logarithm, when

	m lies between	log m lies between
(1)	1 and 10	0 and 1
(2)	10 and 100	1 and 2
(3)	100 and 1000	2 and 3
(4)	1000 and 10000	3 and 4, and so on.

Therefore, when "m" has

(1) 1 digit to the left of the decimal point, log m $= 0 + \ldots.;$

(2) 2 digits to the left of the decimal point, log m $= 1 + \ldots.;$

(3) 3 digits to the left of the decimal point, log m $= 2 + \ldots.;$

(4) 4 digits to the left of the decimal point, log m $= 3 + \ldots.;$ and so on.

Hence Rule *a*.

In the case of decimal numbers,

	when m lies between	log m lies between
(1)	1.0 and 0.1	0 and —1
(2)	0.1 and 0.01	—1 and —2
(3)	0.01 and 0.001	—2 and —3
(4)	0.001 and 0.0001	—3 and —4 and so on.

That is, when "m" is a decimal number in which

(1) no cipher follows the decimal point, log m $= 9 \pm \ldots - 10;$

(2) 1 cipher follows the decimal point, log m $= 8 + \ldots - 10;$

(3) 2 ciphers follow the decimal point, log m $= 7 + \ldots - 10;$

(4) 3 ciphers follow the decimal point, log m $= 6 + \ldots - 10;$ and so on.

Hence Rule *b*.

INTERPOLATION.

Interpolation is the process of calculating numbers intermediate between those given in a table.

Find log 3784.

From the table, mantissa of log of 379 = 0.5786

From the table, mantissa of log of 378 = 0.5775

0.0011 = difference.

Assuming that the increase in the logarithm is proportional to increase in the number, we have

mantissa of log 3784 $= 0.5775 + 0.4 \times 0.0011 = 0.5779$.

The result here given to the nearest unit in the fourth decimal place 0.4×0.0011 being taken equal to 0.0004 in place of 0.00044.

PROPORTIONAL PARTS.

For convenience in interpolation, the tabular differences are subdivided into tenths and tabulated under the heading Proportional Parts. In the table given, it is the average of the differences given for the mantissas in one row across the page.

For the fourth figure, add the proportional part given under its column opposite the row of the first two significant figures to the mantissa of the first three significant figures. Thus:

1. Log 543.2 = ?

mantissa of log 543 = 0.7348

prop. part for 0.2 = 2

Log 543.2 = 2.7350

2. Log $(251.9)^{2/3}$ = ?

mantissa of log 251 = 0.3997

prop. part for 0.9 = 15

log 251.9 = 2.4012

2

3)4.8024

1.6008

Since log $(251.9)^{2/3} = 2/3 \log 251.9$,

therefore, $\log (251.9)^{2/3} = 1.6008$,

or solving $(251.9)^{2/3} = 3.988+$.

3. Log of 0.07127 = ?

$$\begin{aligned} &\text{mantissa of log } 712 &= 0.8525 \\ &\text{prop. part for } 7 &= \quad\;\; 4 \\ \hline &\log 0.07127 &= 8.8529 - 10 \end{aligned}$$

4. Log of $\sqrt[3]{(0.08163)^4}$ = ?

$$\sqrt[3]{(0.08163)} = (0.08163)^{4/3} = 4/3 \log (0.08163)$$

$$\begin{aligned} &\text{mantissa of } 816 = &= 0.9117 \\ &\text{Prop. part of } 3 &= \quad\;\; 2 \\ \hline &\text{Log } 0.08163 &= 8.9119 - 10 \end{aligned}$$

$$4(8.9119 - 10) = 35.6456 - 40 = 25.6456 - 30$$

$$1/3(25.6456 - 30) = 8.5489 - 10.$$

NOTE.—When a logarithm which is followed by —10 is to be divided by a number, add and subtract a multiple of ten so that the quotient will come out in a form followed by —10.

Thus: $1/4\,(8.244 - 10) = 1/4(38.2448 - 40) = 9.5612 - 10.$

ANTILOGARITHMS.

The number whose logarithm is "x" is called the antilogarithm of "x." Thus, if x = log m, then m = antilog x.

Given a logarithm, to obtain the corresponding number (antilogarithm).

1. Log m = 0.4806. m = ?

Find the first three figures in the mantissa in the antilog table similar to logarithm table only remember that zero in the mantissa before the other figures must be considered, and then add the proportional part of the fourth figure of the mantissa.

In the table of antilogarithms, find 0.48 in the left hand column and run across the page horizontally to the column headed 0. There we find that antilog of 0.480 = 3020. Add to this the proportional part under 6, which is 4. This makes the four figures 3024.

Now the characteristic tells how to place the decimal point counting from the left of the four figures, point off

1 place to the right for the characteristic 0
2 places to the right for the characteristic 1
3 places to the right for the characteristic 2
4 places to the right for the characteristic 3

If the characteristic is 9 — . . . — 10 place decimal in front of figures.
If the characteristic is 8 — . . . — 10 place decimal 1 place to the left.
If the characteristic is 7 — . . . — 10 place decimal 2 places to left.
If the characteristic is 6 — . . . — 10 place decimal 3 places to left.

2. Log m = 7.0959 — 10. m = ?

$$\begin{aligned} &\text{anti'og } 0.095 &= 1245 \\ &\text{prop. part } 0 &= \quad\; 3 \\ \hline &\text{antilog } 7.0959 - 10 &= 0.001248 \end{aligned}$$

Sometimes there is a deficiency or excess of 1 in the fourth decimal, but in all pharmaceutical and chemical assaying, weighing, measuring, etc., if an accuracy of 0.1% is desired, the 4 place table will suffice, but if greater accuracy is desired the 5, 6 or the 10 place logarithms are needed. But for the most part 4 place decimal work is regarded good scientific work.

EXPLANATION OF TERMS USED IN FORMULAS.

I use the terms N/1, N/2, N/10 and N/50 as titles, and if the solution say N/2 H_2SO_4 is absolutely accurate and exact, I write it N/2 H_2SO_4 1.000, and if otherwise, then N/2 H_2SO_4 0.99, or N/2 H_2SO_4 1.111 as the case may be. This is the C. F. or correction factor.

C. F. means the correction factor of a standard volumetric solution or the percent, upon the given normality. There is considerable difficulty experienced in obtaining absolutely accurate volumetric solutions, because of the influence of changes in temperature, humidity and pressure upon them, and the keeping qualities of these solutions. I have adopted the method of standardizing volumetric solutions just at the time of use, when running some pharmaceutical and chemical analyses, and the factor I determine I call the correction factor of the empirical solution, I am using, upon the given normality of that solution.

R. F. equals ratio factor, a ratio merely between two chosen solutions, regardless of whether they are absolutely standard or not, and the factor is always determined at the time of use.

E. F. equivalent factor, which depends entirely upon the normality of the standard volumetric solution chosen, and assumes that the normality chosen is 100% or has the C. F. of 1.000.

N/a and N/b are algebraic expressions, the a and the b must be given their proper values, and the C. F. of N/a, and E. F. of N/a, their proper values, so that the working of the formulas is possible. Where one formula leads on to the next, it is more convenient to carry over the logarithm of the numbers used, than to find the antilog.

These things will be brought out more clearly by example. (See Example, close of paper.)

There are two formulas for standardizing volumetric solutions:

Formula I.—General Standardization Formula—Solid.

Log Gm. of Standard — log E. F. of Standard for N/a sol. — log mils N/a sol. used = Log C. F. N/a sol. Find antilog.

This formula is used for determining the correction factor of a volumetric solution upon its normality, when standardized against a weighed amount of standard, which is a solid, as N/2NaOH against $KHC_4H_4O_6$; N/2 H_2SO_4 against Na_2CO_3; N/10 HCl as AgCl; and N/10 H_2SO_4 as $BaSO_4$, etc. Here the N/a sol. means N/2 or N/10 as the case may be. The E. F. of N/a means E. F. for N/2 or N/10 sol. C. F. 1.000, and this is given by the fundamental law underlying volumetric chemical analysis that all substances always combine in the same proportion by weight.

Insert the proper values for Gm. of standard, for mils N/a sol., for E. F. of N/a sol., and apply Formula I; the result is the desired C. F. of the N/a sol.

Formula IIa.—(a = b).

Log mils N/a sol. + log C. F. N/a sol. — log mils N/b sol. = log. C. F. of N/b sol. Find antilog.

Formula IIa'.—(a = b).

Log mils N/*a* sol. — log mils N/b sol. = log. R. F. N/a sol. against N/a sol. Find antilog.

Formula IIa".—(a = b).

Log R. F. N/b sol. + log C. F. N/a sol. = log C. F. N/b sol. Find antilog.

Formula IIb.—(a > b) × 5.

Log mils N/a sol. + log C. F. N/a sol. + log c — log mils N/b sol. = log C. F. N/b sol.. Find antilog.

Formula IIb'.—(a — b).

Log mils N/a sol. — log mils N/b sol. = log R. F. N/b sol. in terms of N/a sol. Find antilog.

Log mils N/a sol. + log c — log mils N/b sol = log R. F. N/b sol. in terms of N/b sol. Find antilog.

Formula IIb″.—(a > b).

Log R. F. N/b sol. + log c + log C. F. N/a sol. = log C. F. N/b sol. Find antilog.

Log R. F. N/b sol. as N/b + log C. F. N/a sol. = log C. F. of N/b sol. Find antilog.

Formula IIc.—(a < b).

Log mils N/a sol. + log C. F. N/a sol. — log C — log mils N/b sol. = log C. F. N/b sol. Find antilog.

Formula IIc′.—(a > b).

Log mils N/a sol. — log mils N/b sol. = log R. F. N/b sol. as N/a. Find antilog.

Log mils N/a sol. — log mils N/b sol. — log c = log R. F. N/b sol. as N/b. Find antilog.

Formula IIc″.—(a > b).

Log R. F. N/b sol. as N/a — log c + log C. F. N/a sol. = log C. F. N/b sol. Find antilog.

Log R. F. N/b sol. as N/b + log C. F. N/a sol. = log C. F. N/b sol. Find antilog.

In the above formulas the Formula II*a* is the most general, and the others modifications of it to meet the different cases.

The one volumetric solution here is standardized against another, the latter having a known correction factor from Formula I, then after properly placing the data, and applying Formula II, the result gives C. F. of the N/a sol. The several forms of Formula II cover changes in normality as N/2 to N/10, N/10 to N/50, and *vice versa*, where blank tests are run, and where one solution depends upon another standard solution for its correction factor at the time of use.

Formula IIIa.—General Assay Formula Direct Titration.

Log mils *N*/a sol. + log C. F. N/a sol. + log E. F. N/a sol. + log 100 — log. wt. substance taken = log % w/w. Find antilog.

% w/w = absolute percentage, or percent by weight.

Formula IIIb.

Log mils N/a sol. + log C. F. N/a sol. + log E. F. N/a sol. + log 100 — log vol. substance taken = log % w/v. Find antilog.

% w/v = percentage concentration, or percent weight to volume.

The foregoing Formula III applies to all direct titrations, and is also used after Formula IV in residual titrations for all crude drugs, chemicals and their preparations which are assayed volumetrically. The two forms cover the cases of desired % w/w or % w/v. Placing the values properly will give the desired results.

Formula IV and its several modifications apply to residual titrations, where volumetric solutions of like or unlike normality are used, and after determining the difference, further calculations are carried out then by use of Formula III*a* or III*b*.

Formula IVa.—(a = b).

Log mils N/a sol. + log C. F. N/a sol. = log mils N/a sol. C. F. 1.000. Find antilog.

Log mils N/b sol. + log C. F. N/b sol. = log mils N/b sol. C. F. 1.000. Find antilog.

Subtract the antilogs, and the result equals mils used by substance. Then apply Formula III*a* or III*b* as required.

Formula IVb.—(a > b).

Log mils N/a sol. + log C. F. N/a sol. + log c = log mils N/b sol. used in excess. Find antilog.

Log mils N/a sol. + log C. F. N/b sol. = log mils N/b sol. used in residual titration. Find antilog.

Subtract the antilogs and the result equals the mils used by the substance. Then apply Formula III*a* or III*b*, as required.

Formula IVb′ from IVb.—(a > b).

Log mils N/b sol. C. F. 1.000 — log c = log mils N/a sol. C. F. 1.000. Find antilog. Then apply III*a* or III*b* as required, using N/a E. F.

Formula IVc.—(a < b).

This is the same as IV*b*, only values of a and b are *vice versa*, therefore changes signs + to —, and — to +. Then apply Formula III*a* or III*b*.

There is one formula for gravimetric and electrolytic analyses. I have used this because the U. S. P. states how much of any substance should be present as such and such a weight, and so these formulas will give the percentage if the values are properly placed.

Formula Va.

Let m = wt. of sub. obtained, and w = wt. of sub. taken, then log m + log 100 — log w = log % w/w.

Formula Vb.

Log m + log 100 — log V = log % w/v. c = vol. taken.

It will be noticed that I introduced log of 100 or 2.000 into Formulas III and V. This is done to make the % be expressed with its sign. If one desires that it is expressed as a decimal fraction, omit the log of 100. I have found the latter method too confusing, and so I have retained log 100 and after the figures place the % sign.

1. In order to use any empirical solution, I have tabulated for class and laboratory use the volumetric solutions of the U. S. P. and after them their abbreviations, and the formulas to be applied.

It has been my experience that N/2, N/10 and N/50 solutions will suffice for nearly all the volumetric analyses, and therefore I have only listed those.

Tenth Normal Barium Hydroxide, N/10 $Ba(OH)_2$
IIa against N/10 HCl
IIb against N/2 HCl

Tenth Normal Bromine, N/10 Br
IIa against N/10 $Na_2S_2O_3$ — 5

Half Normal Hydrochloric Acid, N/2 HCl
I against Na_2CO_3
I as AgCl
IIa against N/2 KOH or N/2 NaOH
IIc against N/10 KOH or N/10 NaOH

Tenth Normal Hydrochloric Acid, N/10 HCl
I against Na_2CO_3
I as AgCl
IIa against N/10 KOH or N/10 NaOH
IIb against N/2 KOH or N/1 NaOH
IIc against N/50 KOH or N/50 NaOH

Tenth Normal Iodine, N/10 I
IIa against N/10 $Na_2S_2O_3$

Tenth Normal Oxalic Acid, N/10 $H_2C_2O_4.2H_2O$
IIa against N/10 $K_2Cr_2O_7$ or N/10 $Na_2Cr_2O_7$

Tenth Normal Potassium Dichromate or Sodium Dichromate, N/10 $K_2Cr_2O_7$
N/10 $Na_2Cr_2O_7$
I against pure iron, Fe
IIb against N/10 KOH or N/10 NaOH. (c = 3)
IIa against N/10 $Na_2S_2O_3$

Half Normal Potassium Hydroxide, N/2 KOH
I against $KHC_4H_4O_6$
IIa against N/2 HCl or N/2 H_2SO_4
IIc against N/10 HCl or N/10 H_2SO_4

Tenth Normal Potassium Hydroxide, N/10 KOH
I against $KHC_4H_4O_6$
IIa against N/10 HCl or N/10 H_2SO_4
IIb against N/2 HCl or N/2 H_2SO_4

Fiftieth Normal Potassium Hydroxide, N/50 KOH
I against $KHC_4H_4O_6$
IIa against N/50 HCl or N/50 H_2SO_4
IIb against N/10 HCl or N/10 H_2SO_4

Half Normal Alcoholic Potassium Hydroxide, N/19 KOH al.
I against $KHC_4H_4O_6$
IIa against N/2 HCl or N/2 H_2SO_4
IIc against N/10 HCl or N/10 H_2SO_4

Tenth Normal Potassium Permanganate, N/10 $KMnO_4$
I against $Na_2C_2O_4$
IIa against N/10 Oxalic Acid, or N/10 Thiosulphate

Tenth Normal Potassium Sulphocyanate, N/10 KCNS
I against NaCl
IIa against N/10 $AgNO_3$; N/10 HCl; N/10 NaCl
IIb against N/2 HCl

Tenth Normal Silver Nitrate, N/10 $AgNO_3$
I against NaCl or as AgCl
IIa against N/10 KCNS; N/10 HCl; N/19 NaCl

Tenth Normal Sodium Chloride, N/19 NaCl
I as AgCl
IIa against N/10 $AgNO_3$

Half Normal Sodium Hydroxide, N/2 NaOH
I against $KHC_4H_4O_6$
IIa against N/2 HCl or N/2 H_2SO_4
IIc against N/10 HCl or N/10 H_2SO_4

Tenth Normal Sodium Hydroxide, N/10 NaOH
I against $KHO_4H_4O_6$
IIa against N/10 HCl or N/19 H_2SO_4
IIb against N/2 HCl or N/2 H_2SO_4
IIc against N/50 HCl or N/50 H_2SO_4

Fiftieth Normal Sodium Hydroxide, N/50 NaOH
I against $KHC_4H_4O_6$
IIa against N/50 HCl or N/50 H_2SO_4
IIb against N/10 HCl or N/10 H_2SO_4

Tenth Normal Sodium Thiosulphate, N/10 $Na_2S_2O_3$
I against Iodine
IIa against N/10 = $K_2Cr_2O_7$; N/10 $Na_2Cr_2O_7$; N/10 $KMnO_4$

Half Normal Sulphuric Acid, N/2 H_2SO_4
I against Na_2CO_3
IIa against N/2 KOH or N/2 NaOH
IIc against N/10 KOH or N/10 NaOH

Tenth Normal Sulphuric Acid, N/10 H_2SO_4
I against Na_2CO_3
IIa against N/10 KOH or N/10 NaOH
IIb against N/2 KOH or N/2 NaOH
IIc against N/50 KOH or N/50 NaOH

Fiftieth Normal Sulphuric Acid, N/50 H_2SO_4
I against Na_2CO_3
IIa against N/50 KOH or N/50 NaOH
IIb against N/10 KOH or N/10 NaOH

Copper Sulphate Solution of Fehling's, $CuSO_4$
I against Sugar
IIc against N/10 Thiosulphate (10 Cc. = 27.75 Cc. N/10 Thio.)

Iodo Bromide Test Solution, IBr T. S.
IIc against N/10 Thiosulphate

2. For use in class and in the laboratory, I have tabulated all the assays of the U. S. P. and N. F., volumetrically, gravimetrically, and electrolytically, and after the Latin abbreviation give the formula to be applied.

The list is as follows:

U. S. P. IX.

Volumetric	Latin Abbreviation.	Formula.
1	Aceton.	IVa & IIIa
2	Acid. Acet.	IIIa
3	Acid. Acet. Dil.	IIIa
4	Acid. Acet. Glac.	IIIa
5	Acid. Benz.	IIIa
6	Acid. Bor.	IIIa
7	Acid. Cit.	IIIa
8	Acid. Hydriod. Dil.	IIIa
9	Acid. Hydrobrom. Dil.	IIIa
10	Acid. Hydrochlor.	IIIa
11	Acid. Hydrochl. Dil.	IIIa
12	Acid. Hydrocyan. Dil.	IIIa
13	Acid. Hypophos.	IIIa
14	Acid. Hypophos. Dil.	IIIa
15	Acid. Lact.	IIIa
16	Acid. Nitric.	IIIa
17	Acid. Phos.	IVa & IIIa
18	Acid. Phos. Dil.	IVa & IIIa
19	Acid. Salicyl.	IIIa
20	Acid. Sulph.	IIIa
21	Acid. Sulph. Arom.	IIIa
22	Acid. Sulph. Dil.	IIIa
23	Acid. Tart.	IIIa
24	Acid. Trichloracet.	IIIa
25	Aconit.	IVb & IIIa
26	Ammon. Benz.	IIIa
27	Ammon. Brom.	IVa & IIIa
28	Ammon. Carb.	IIIa
29	Ammon. Chlor.	IVa & IIIa
30	Ammon. Iod.	IVa & IIIa
31	Ammon. Salicyl.	IIIa
32	Antimon, et Pot. Tart.	IIIa
33	Aq. Ammon.	IIIa
34	Aq. Ammon. Fort.	IIIa
35	Arg. Nit.	IIIa
36	Arg. Nit. Fus.	IIIa
37	Arg. Ox.	IIIa
38	Arsen. Iod.	IIIa
39	Arsen. Triox.	IIIa
40	Bellad. Fol.	IVb & IIIa
41	Bellad. Rad.	IVb & IIIa
42	Benzaldehyd.	IIIa, Blank IIa
43	Betaeucain. Hydrochl.	IIIa
44	Caffein. Sod. Benz.	IIIa for Sod. Benz.
45	Calc. Brom.	IVa & IIIa
46	Calc. Carb. Praec.	IVa & IIIa
48	Calc. Chlor.	IVa & IIIa
49	Calc. Hypophos.	IVa & IIIa
49	Calc. Lact.	IIIa
50	Calc. Sulphid. Crud.	IVa & IIIa
51	Calx.	IVa & IIIa
52	Cglx. Chlorin	IIIa
53	Chloral. Hydrat.	IVa & IIIa
54	Chrom. Triox.	IIIa
55	Cret. Praep.	IVa & IIIa
56	Cupr. Sulph.	IIIa
57	Emp. Bellad.	IVb & IIIa
58	Ext. Aconit.	IVb & IIIa
59	Ext. Bellad. Fol.	IVb & IIIa
60	Ext. Hyoscyam.	IVb & IIIa
61	Ext. Nuc. Vom.	IVb & IIIa
62	Ext. Opii	IVb & IIIa
63	Ext. Physostig.	IVb & IIIa
64	Ext. Stramon.	IVb & IIIa
65	Ferr. Carb. Sacch.	IIIa
66	Ferr. Chlor.	IIIa
67	Ferr. & Ammon. Cit.	IIIa for Fe
68	Ferr. & Quin. Cit.	IIIa for Fe
69	Ferr. Phos.	IIIa
70	Ferr. Sulph.	IIIa
71	Ferr. Sulph. Exsic.	IIIa
72	Ferr. Sulph. Gran.	IIIa
73	Ferr. Reduct.	IIIa
74	Fldext. Aconit.	IVb & IIIb
75	Fldext. Bellad. Rad.	IVb & IIIb
76	Fldext. Hyoscyam.	IVb & IIIb
77	Fldext. Ipecac.	IVb & IIIb
78	Fldext. Nuc. Vom.	IVb & IIIb
79	Fldext. Pilocarp.	IVb & IIIb
80	Hydrarg. Chlor. Mite	IVa & IIIa
81	Hydrarg. Iod. Flav.	IVa & IIIa
82	Hydrarg. Oxid. Flav.	IIIa
83	Hydrarg. Oxid. Rub.	IIIa
84	Hydrarg. Salicyl.	IVa & IIIa
85	Hydrarg.	IIIa
86	Hydrarg. cum. Cret.	IIIa
87	Hyoscyam.	IVb & IIIa
88	Iodum.	IIIa
89	Ipecac.	IVb & IIIa
90	Liq. Acid. Arsen.	IIIa
91	Liq. Ammon. Acet.	IVa & IIIa
92	Liq. Arsen. et Hydrarg. Iod.	IIIa
93	Liq. Calc.	IIIb
94	Liq. Ferr. Chlor.	IIIa
95	Liq. Ferr. Subsulph.	IIIa

U. S. P. IX (*Continued*).

Volumetric	Latin Abbreviation.	Formula.
96	Liq. Ferr. Persulph.	IIIa
97	Liq. Formaldehyd.	IVa & IIIa
98	Liq. Hydrog. Diox.	IIIa
99	Liq. Iod. Co.	IIIa
100	Liq. Plumb. Subacet.	IVa & IIIa
101	Liq. Pot. Arsen.	IIIa
102	Liq. Pot. Cit.	IIIa
103	Liq. Pot. Hydrox.	IIIa
104	Liq. Sod. Chlorinat.	IIIa
105	Liq. Sod. Arsen.	IIIa
106	Liq. Sod. Glycerophos.	IIIa
107	Liq. Sod. Hydrox.	IIIa
108	Liq. Zinc. Chlor.	IVa & IIIa
109	Lith. Brom.	IVa & IIIa
110	Lith. Carb.	IVa & IIIa
111	Lith. Cit.	IIIa
112	Magm. Mag.	IVa & IIIa
113	Mag. Carb.	IVa & IIIa
114	Mag. Oxid.	IVa & IIIa
115	Mag. Oxid. Pond.	IVa & IIIa
116	Mangan. Diox. Praec.	IVa & IIIa
117	Mass. Ferr. Carb.	IIIa
118	Mass. Hydrarg.	IIIa
119	Methyl Salicyl.	IVa & IIIa
120	Nux Vom.	IVa & IIIa
121	Ol. Amygd. Amar.	IVa & IIIa
122	Ol. Limon.	IVa & IIIa
123	Ol. Menth. PiP.	IVa & IIIa
124	Ol. Rosmar.	IVa & IIIa
125	Ol. Santal.	IVa & IIIa
126	Ol. sinap. Vol.	IVa & IIIa
127	Opii Pulv.	IVb & IIIa
128	Opium	IVb & IIIa
129	Opium Deod.	IVb & IIIa
130	Opium. Gran.	IVb & IIIa
131	Paraform.	IVa & IIIa
132	Phenol.	IVa & IIIa
133	Phenol. Liq.	IVa & IIIa
134	Physostig.	IVb & IIIa
135	Pilocarp.	IVb & IIIa
136	Plumb. Acet.	IVa & IIIa
137	Plumb. Oxid.	IVa & IIIa
138	Pot. Acet.	IIIa
139	Pot. Bicarb.	IIIa
140	Pot. Bitart.	IIIa
141	Pot. Brom.	IVa & IIIa
142	Pot. Carb.	IIIa
143	Pot. Chlor.	IVa & IIIa
144	Pot. Cit.	IIIa
145	Pot. et. Sod. Tart.	IIIa
146	Pot. Hydrox.	IIIa
147	Pot. Hypophos.	IVa & IIIa
148	Pot. Iod.	IVa & IIIa
149	Pot. Nitras.	IVa & IIIa
150	Pot. Permang.	IIIa
151	Pulv. Eff. Co.	IVa & IIa for $NaHCO_3$ IIIa for $KNaC_4H_4O_6$
152	Sod. Acet.	IIIa
153	Sod. Arsen.	IIIa
154	Sod. Arsen. Exsic.	IIIa
155	Sod. Benz.	IIIa
156	Sod. Bicarb.	IIIa
157	Sod. Bor.	IIIa
158	Sod. Brom.	IIIa
159	Sod. Cacodyl.	IIIa
160	Sod. Carb. Monohyd.	IIIa
161	Sod. Chlor.	IVa & IIIa
162	Sod. Cit.	IIIa
163	Sod. Cyan.	IVa & IIIa
164	Sod. Glycerophos.	IIIa
165	Sod. Hydrox.	IIIa
166	Sod. Hypophos.	IVa & IIIa
167	Sod. Iod.	IVa & IIIa
168	Sod. Nitris	IIIa
169	Sod. Perbor.	IIIa
170	Sod. Phenolsulph.	IVa & IIIa
171	Sod. Phos.	IVa & IIIa
172	Sod. Phos. Exsic.	IVa & IIIa
173	Sod. Salicyl.	IIIa
174	Sod. Sulphis Exsic.	IVa & IIIa
175	Sod. Thiosulph.	IIIa
176	Stramon.	IVb & IIIa
177	Stront. Brom.	IVa & IIIa
178	Stront. Iod.	IVa & IIIa
179	Stront. Salicyl.	IIIa
180	Syr. Acid. Hydriod.	IVa & IIIa
181	Syr. Ferr. Iod.	IVa & IIIa
182	Theobrom. Sodio-Sal.	IIIa
183	Thymol. Iod.	IIIa
184	Thyroid. Sicc.	IIIa
185	Tr. Aconit.	IVb & IIIb
186	Tr. Bellad. Fol.	IVb & IIIb
187	Tr. Ferr. Chlor.	IIIa
188	Tr. Hyoscy.	IVb & IIIb
189	Tr. Iodi	IIIb
190	Tr. Nux Vom.	IVb & IIIb
191	Tr. Opii	IVb & IIIb
192	Tr. Opii Deod.	IVb & IIIb
193	Tr. Physostig.	IVb & IIIb
194	Tr. Stramon.	IVb & IIIb
195	Zinc. Carb.	IIIa
196	Zinc. Chlor.	IVa & IIIa
197	Zinc. Oxid.	IIIa
198	Zinc. Stear.	IVa & IIIa

U. S. P. IX (*Continued*).

	Gravimetric Latin Abbreviation.	Formula.
1	Alum. as AlO_3	Va
2	Alum. Exsic.	Va
3	Asafoet.	Va
4	Bism. Betanaph. as Betanaphthol	Va
	Bism. Betanaph. as Bi_2O_3	Va
5	Bism. et Ammon. Cit. as Bi_2O_3	Va
6	Bism. Subcarb. as Bi_2O_3	Va
7	Bism. Subgal. as Bi_2O_3	Va
8	Bism. Subnit. as Bi_2O_3	Va
9	Bism. Subsalicyl. as Bi_2O_3	Va
10	Caffein. Cit. as Caffeine	Va
11	Caff. Sod. Benz. as Caffeine	Va
12	Calc. Glycerophos. as CaO	Va
13	Canthar. as cantharidin	Va
14	Cinch. as cinchona	Va
15	Cinch. Rub. cinchona	Va
16	Colch. Corm. as colchicine	Va
17	Colch. Sem. as cochicine	Va
18	Collod. as pyroxylin	Va
19	Diastase	50 × starch
20	Ext. Colch. as colchicine	Va
21	Ext. Hydrast. as hydrastine	Va
22	Ferr. et Quin. Cit. as quinine	Va
23	Fldext. Cinchon. as cinchona	Vb
24	Fldext. Colch. Sem. as colchicine	Vb
25	Fldext. Guran. as caffeine	Vb
26	Fldext. Hydrast. as hydrastine	Vb
27	Glycer. Hydrast. as hydrastine	Vb
28	Guaran. as caffeine	Va
29	Hydrarg. Chlor. Corr. as HgS	Va
30	Hydrarg. Ammon. as HgS	Va
31	Hydrastis as hydrastine	Va
32	Jalap as resin	Va
33	Lin. Camph. as camphor	Polariscope
34	Liq. Iod. Co. for KI	Va
35	Liq. Mag. Cit. as magnesium pyrophosphate	Va
36	Magma Bis. as Bi_2O_3	Va
37	Mag. Sulph. as magnesium pyrophosphate	Va
38	Malt	5x starch
39	Pancreat.	25x starch
40	Pepsin	300x egg albumen
41	Podophyl. for resin	Va
42	Pot. sulphurat. for S	Va
43	Quin. et Urea Hydrochlor. for quinine	Va
44	Quin. Tann. for quinine	Va
45	Scam. Rad. for resin	Va
46	Sod. Sulphas as $BaSO_4$	Va
47	Sp. Camphor as camphor	Polariscope
48	Sulphur Bot. as $BaSO_4$	Va
49	Sulphur Praec. as $BaSO_4$	Va
50	Sulphur Sublim. as $BaSO_4$	Va
51	Tr. Cinchon. as quinine	Vb
52	Tr. Cinchon. Co. as quinine	Vb
53	Tr. Colch. Sem. as colchicine	Vb
54	Tr. Hydrast. as hydrastine	Vb
55	Tr. Iodi for Ki	Vb
56	Toxitabel. Hydrarg. Chlor. Corr. as HgS	Va
57	Ung. Hydrarg. Dil.	Va
58	Ung. Hydrarg. Dil.	Va
59	Uran. Nit. as U_3O_8	Va
60	Zinc. Acet. as ZnO	Va
61	Zinc. Phenolsulph. as ZnO	Va
62	Zinc. Sulph. as ZnO	Va
63	Zinc. Valer. as ZnO	Va
64	Zinc. as ZnO	Va

	Electrolytic Latin Abbreviation.	Formula.
1	Hydrarg. Chlor. Cor.	Va
2	Hydrarg. Chlor. Mit.	Va
3	Hydrarg. Iod. Flav.	Va
4	Hydrarg. Iod. Rub.	Va
5	Hydrarg. Oxid. Flav.	Va
6	Hydrarg. Oxid. Rub.	Va
7	Hydrarg. Salicyl.	Va
8	Hydrarg.	Va
9	Hydrarg. Ammon.	Va
10	Hydrarg. cum Cret.	Va
11	Toxitabel. Hydrarg. Chlor. Corr.	Va
12	Zinc. Acet.	Va
13	Zinc. Phenolsulph.	Va
14	Zinc. Sulph.	Va
15	Zinc. Valer.	Va
16	Zinc.	Va

VOLUMETRIC ASSAYS IN THE NATIONAL FORMULARY.

	Latin Abbreviation.	Formula.
1	Ext. Conii	IVb & IIIa
2	Ext. Ignat.	IVb & IIIa
3	Ferr. Oxid. Sacch.	IIIa
4	Fldext. Conii	IVb & IIIa
5	Fldext. Stramon.	IVb & IIIa
6	Liq. Ferr. Acet.	IIIa
7	Liq. Ferr. Cit.	IIIa
8	Liq. Hydrarg. Nit.	IIIa
9	Sulphur. Iod.	IIIa
10	Tr. Opii Crocat.	IVb & IIIb
11	Vin. Ipecac	IVb & IIIb

VOLUMETRIC ASSAYS IN THE NATIONAL FORMULARY (*Continued*).

	Latin Abbreviation.	Formula.		Gravimetric Latin Abbreviation.	Formula.
12	Acid. Formic.	IIIb	1	Fldext. Cinchon. Aq. as quinine	Vb
13	Ammon. Hypophos.	IVa & IIIa			
14	Ammon. Phos.	IVa & IIIa	2	Fldext. Colch. Corm. as colchicine	Vb
15	Antimon. Oxid.	IIIa			
16	Antimon. Sulphuret.	IIIa	3	Glycer. Bism. as Bi_2O_3	Vb
17	Bromium	IIIa	4	Liq. Alumin. Acet. as Al_2O_3	Vb
18	Conium	IVb & IIIa	5	Liq. Alumin. Subacet. as Al_2O_3	Vb
19	Ferr. Glycerophos.	IIIa	6	Vin. Colch. Sem. as colchicine	Vb
20	Ferr. Hypophos.	IIIa	7	Alum. Chlor. as Al_2O_3	Va
21	Ferr. Lact.	IIIa	8	Alum. Sulph. as Al_2O_3	Va
22	Ferr. Pyrophos.	IIIa	9	Caff. Tost. as caffeine	Va
23	Ignat.	IVb & IIIa	10	Kola as caffeine	Va
24	Lith. Salicyl.	IIIa	11	Mangan. Cit. Sol. as Mn_3O_4	Va
25	Magnes. Chlorid.	IVa & IIIa	12	Mangan. Glycerophos. Sol. as Mn_3O_4	Va
26	Mangan. Hypophos.	IVa & IIIa			
27	Ol. Bergam.	IVa & IIIa	13	Mangan. Sulph. as Mn_3O_4	Va

As 4 place logarithms are sufficiently accurate for almost all of the present pharmaceutical assaying, the E. F. of substances for N/2, N/10 and N/50 solutions, as found in U. S. P., can be easily changed into their corresponding logarithms. I have likewise made a list of these logarithmic equivalents, but have not put them into the body of this paper, because applying the rule for logarithms it is easy to find the one that is needed, or many chemical annuals give those values, but for convenience in pharmaceutical assaying I have listed them under headings N/2, N/10 and N/50 instead of under each volumetric solution, and have appended them to this paper, at the very close.

It may still appear useless and too far-fetched and beyond the average intellect of the pharmacy student to apply such a mathematical training to pharmaceutical assaying. Let me state, in closing, that when I presented this a year ago last summer to the conference of instructors at the University of Wisconsin, under the leadership of Dr. Edward Kremers, I was asked by Mr. Roland Kremers if I really taught such engineering rules to the pharmacy students. In reply, I said "I really did," and I still do so. It has been my peculiar experience, as a pharmacy student, to have been well grounded in engineering physics and mathematics, and these, combined with chemistry, pharmacology, physiology and pharmacy, have given me a little insight into some of the complexities found in pharmaceutical assaying.

If I can calculate the results correctly from the standardization of a volumetric solution to the assay of a crude drug, chemical, or their preparations by direct or residual titration inside of 5 to 10 minutes, once the data are obtained, and the tables at hand, I feel that the method is certainly a time and labor saving device, as well as accurate, and one that can be rechecked quickly. However, when I have several hundred mathematical calculations in pharmaceutical assaying to look over and correct, I personally use the slide rule, and it takes but a moment to see where errors and blunders have been made.

I could also append the discussion of experimental error, mathematical error; such as absolute error; percentage of error; and probable error; which is involved in all pharmaceutical assaying, but I have purposely omitted it from this paper because it would make it quite lengthy, and is also an entirely different phase, yet very important in pharmaceutical assaying, and tells why some things are really difficult, and the accuracy that can be attained.

In order to show by concrete example how these formulas apply, consider the following example:

Given—4.704 Gm. $KHC_4H_4O_6$ require 45.82 mils N/2 NaOH for neutralization.

Also—48.75 mils N/2 H_2SO_4 neutralize 42.96 mils N/2 NaOH.

In assaying a sample of hydrated chloral, 3.039 Gm. of it, after the addition of 50 mils N/2 NaOH, standardized a above, in excess, upon residual titration, required 22.35 mils N/2 H_2SO_4.

What is the % strength of the hydrated chloral?

1st. Apply Formula I to get C. F. of N/2 NaOH.

log 4.704	0.6725	1 mil N/2 NaOH =○= 0.09407 = 8.9734 — 10
— log E. F. 0.09407	8.9734 — 10	
	1.6991	
— log mils — 45.82	1.6611	
= log C. F. N/2 NaOH	0.0380	= 1.091

2nd. Apply Formula IIa to get C. F. of N/2 H_2SO_4.

log 42.96	1.6320	
+ log 1.091	0.0380	
	1.5940	
— log 48.75	1.6879	
= log C. F. N/2 H_2SO_4	9.9061 — 10 = 0.8056	

3rd. Apply Formula IVa for residual titration.

log 50	1.6990	
+ log 1.091	0.0380	antilog or no.
	1.7370	= 54.58 mils N/2 NaOH 1.000 used in excess
log 22.35	1.3493	
+ log 0.8056	9.9061 — 10	
	1.2554	= 18.01 mils N/2 H_2SO_4 1.000 mils used in residual titration
		36.57 mils N/2 sol. 1.000 used by hydrated chloral

4th and lastly. Apply Formula IIIa for % of hydrated chloral.

log 3657	1.5630	
+ log 0.08270	8.9175 — 10	
+ log 100	2.0000	
	2.4805	
— log 3.039	0.4827	
= log %	1.9978	= 99.5%

LOGARITHMIC EQUIVALENTS.

No.	Chemical.	Formula.	N/2 Equivalent	Logarithm.
1	Acetic Acid	$HC_2H_3O_2$	0.03002	8.4774—10
2	Acetic Anhydride	$(CH_3CO)_2$	0.02551	8.4067—10
3	Ammonia Gas	NH_3	0.00852	7.9304—10
4	Ammonium Acetate	$NH_4C_2H_3O_2$	0.03854	8.5860—10
5	Ammonium Carbonate	$(NH_4)_2CO_3$	0.02402	8.3804—10
6	Ammonium Carbonate (U. S. P.)	$NH_4HCO_3.NH_4NH_2CO_2$	0.02619	8.4181—10
7	Ammonium Chloride	NH_4Cl	0.02675	8.4273—10
8	Barium Hydroxide	$Ba(OH)_2 + 8H_2O$	0.07888	8.8969—10
9	Benzaldehyde	C_7H_6O	0.05300	8.7243—10
10	Boric Acid	H_3BO_3	0.03101	8.4915—10
11	Borneol	$C_{10}H_{18}O$	0.07707	8.8869—10
12	Bornyl Acetate	$C_{10}H_{17}C_2H_3O_2$	0.09808	8.9916—10
13	Calcium Carbonate	$CaCO_3$	0.02502	8.3982—10
14	Calcium Hydroxide	$Ca(H)_2$	0.01852	8.2677—10
15	Calcium Lactate	$Ca(C_3H_5O_3)$ anhydrous	0.05454	8.7367—10
16	Calcium Oxide	CaO	0.01402	8.1467—10
17	Cinnamic Aldehyde	C_9H_8-O	0.03302	8.5188—10
18	Citral	$C_{10}H_{16}O$	0.07600	8.8808—10
19	Citric Acid, crystallized	$H_3O_6H_5O_7 + H_2O$	0.03502	8.5443—10
20	Formaldehyde	CH_2O	0.01501	8.1762—10
21	Hydrated Chloral	$C_2HOCl_3 + H_2O$	0.08270	8.9175—10
22	Hydrobromic Acid	HBr	0.04047	8.6070—10
23	Hydrochloric Acid	HCl	0.01824	8.2610—10
24	Hydriodic Acid	HI	0.06397	8.8060—10
25	Hypophosphorous Acid	HPH_2O_2	0.03303	8.5189—10
26	Lactic Acid	$HC_3H_5O_3$	0.04503	8.6535—10
27	Lead Acetate, crystallized	$Pb(C_2H_3O_2)_2 + 3H_2O$	0.09480	8.9768—10
28	Lead Subacetate, assumed as	$PB_2O(C_2H_3O_2)_2$	0.06853	8.8359—10
29	Lithium Carbonate	Li_2CO_3	0.01847	8.2664—10
30	Lithium Citrate, anhydrous	$Li_3C_6H_5O_7$	0.03498	8.5438—10
31	Lithium Citrate, crystallized	$Li_3C_6H_5O_7 + 4H_2O$	0.04699	8.6720—10
32	Lithium Salicylate	$LiC_7H_5O_3$	0.07199	8.8572—10
33	Magnesium Carbonate	$(MgCO_3)_4Mg(OH)_2 + 5H_2O$	0.02429	8.3854—10
34	Magnesium Hydroxide	$Mg(OH)_2$	0.01480	8.1703—10
35	Magnesium Oxide	MgO	0.01008	8.0033—10
36	Menthol	$C_{10}H_{20}O$	0.07808	8.8925—10
37	Menthyl Acetate	$C_{10}H_{19}C_2H_3O_2$	0.09909	8.9959—10
38	Methyl Salicylate	$CH_3.C_7H_5O_3$	0.07603	8.8810—10
39	Nitric Acid	HNO_3	0.03151	8.4984—10
40	Oxalic Acid	$H_2C_2O_4 + 2H_2O$	0.03153	8.4987—10
41	Paraformaldehyde	$(CH_2O)_3$	0.01501	8.1764—10
42	Phosphoric Acid	H_3PO_4 to form K_2HPO_4 P. T. S.	0.02452	8.3896—10
43	Potassium Acetate	$KC_2H_3O_2$	0.04906	8.6907—10
44	Potassium Bicarbonate	$KHCO_3$	0.05006	8.6995—10
45	Potassium Bitartrate	$KHC_4H_4O_6$	0.09407	8.9734—10
46	Potassium Carbonate	K_2CO_3	0.03455	8.5384—10
47	Potassium Citrate, anhydrous	$K_3C_6H_5O_7$	0.05106	8.7081—10
48	Potassium Citrate, crystallized	$K_3C_6H_7O + H_2O$	0.05406	8.7329—10
49	Potassium Hydroxide	KOH	0.02806	8.4481—10
50	Pot. & Sod. Tartrate, anhydrous	$KNaC_4H_4O_6$	0.05253	8.7204—10
51	Pot. & Sod. Tartrate, crystallized	$KNaC_4H_4O_6 + 4H_2O$	0.07055	8.8485—10
52	Santalol	$C_{15}H_{26}O$	0.11111	9.0457—10
53	Sodium Acetate, anhydrous	$NaC_2H_3O_2$	0.04101	8.6129—10

LOGARITHMIC EQUIVALENTS (*Continued*).

No.	Chemical.	Formula.	N/2 Equivalent	Logarithm.
54	Sodium Acetate, crystallized	$NaC_2H_3O_2 + 3H_2O$	0.06804	8.8328—10
55	Sodium Benzoate	$NaC_7H_5O_2$	0.07202	8.8574—10
56	Sodium Bitartrate	$NaHC_4H_4O_6 + H_2O$	0.09503	8.9778—10
57	Sodium Bicarbonate	$NaHCO_3$	0.04200	8.6232—10
58	Sodium Borate, anhydrous	$Na_2B_4O_7$	0.05050	8.7033—10
59	Sodium Borate, crystallized	$Na_2B_4O_7 + 10H_2O$	0.09554	8.9802—10
60	Sodium Cacodylate, anhydrous	$Na(CH_3)_2AsO_2$	0.08000	8.9031—10
61	Sodium Carbonate, anhydrous	Na_2CO_3	0.02650	8.4232—10
62	Sodium Carbonate, monohydrated	$Na_2CO_3 + H_2O$	0.03100	8.4914—10
63	Sodium Citrate, anhydrous	$Na_3C_6H_5O_7$	0.04301	8.6336—10
64	Sodium Citrate, crystallized	$Na_3C_6H_5O_7 + 2H_2O$	0.04901	8.6903—10
65	Sodium Glycerophosphate	$Na_2C_3H_7PO_6$	0.10805	8.0336—10
66	Sodium Hydroxide	$NaOH$	0.02000	8.3010—10
67	Sodium Salicylate	$NaC_7H_5O_3$	0.08002	8.9032—10
68	Sodium Tartrate, neutral	$Na_2C_4H_4O_6 + 2H_2O$	0.05752	8.7599—10
69	Strontium Salicylate, anhydrous	$Sr(C_7H_5O_3)$	0.09043	8.9563—10
70	Strontium Salicylate, crystallized	$Sr(C_7H_5O_3) + 2H_2O$	0.09943	8.9975—10
71	Sulphuric Acid	H_2SO_4	0.02452	8.3896—10
72	Sulphuric Anhydride	SO_3	0.02002	8.3014—10
73	Tartaric Acid, crystallized	$H_2C_4H_4O_6$	0.03751	8.5741—10
74	Trichloracetic Acid	CCl_3COOH	0.08170	8.9122—10
75	Zinc Oxide	ZnO	0.02034	8.3083—10

No.	Chemical.	Formula.	N/10 Equivalent	Logarithm.
1	Acetone		0.0009675	7.9857—10
2	Aconite ether soluble alkaloids		0.0645	8.8096—10
3	Aconitine	$C_{34}H_{47}O_{11}N$	0.06454	8.8099—10
4	Allyl-iso-thiocyanate	C_3H_5SCN	0.004956	7.6951—10
5	Ammonium Gas	NH_3	0.0017033	7.2311—10
6	Ammonium Benzoate	$NH_4C_7H_5O_2$	0.01391	8.1433—10
7	Ammonium Bromide	NH_4Br	0.009796	7.9911—10
8	Ammonium Chloride	NH_4Cl	0.005350	7.7284—10
9	Ammonium Iodide	NH_4I	0.014496	8.1614—10
10	Ammonium Salicylate	$NH_4C_7H_5O_3$	0.015508	8.1906—10
11	Antimony and Potassium Tartrate, crystallized	$K(SbO)C_4H_4O_6 + {}^1/_2H_2O$	0.016617	8.2206—10
12	Arsenic, in arsenous compounds	As	0.003748	7.5737—10
13	Arsenic Iodide	AsI_3? AsI_5	0.022786	8.3577—10
14	Arsenic Trioxide (Arsenous Acid)	As_2O_3	0.004948	7.6944—10
15	Arsenous Iodide	AsI_3	0.015191	8.1815—10
16	Atropine	$C_{17}H_{23}O_3N$	0.028919	8.4612—10
17	Barium Hydroxide	$Ba(OH)_2 + 8H_2O$	0.015776	8.1981—10
18	Benzoic Acid	$C_7H_6O_2$	0.015776	8.1981—10
19	Betaeucaine Hydrochloride	$C_{15}H_{21}ON.HCl$	0.028365	8.4529—10
20	Bromine	Br	0.007992	7.9026—10
21	Brucine	$C_{23}H_{26}O_4N_2$	0.039423	8.5957—10
22	Calcium Bromide, anhydrous	$CaBr_2$	0.0099955	7.9998—10
23	Calcium Bromide, crystallized	$CaBr_2 + 2H_2O$	0.0011798	7.0719—10
24	Calcium Carbonate	$CaCo_3$	0.0050035	7.6993—10
25	Calcium Chloride, anhydrous	$CaCl_2$	0.00555	7.7443—10
26	Calcium Chloride	$CaCl_2 + 2H_2O$	0.0073511	7.8664—10
27	Calcium Hydroxide	$Ca(OH)_2$	0.037045	7.5687—10
28	Calcium Hypophosphite	$Ca(PH_2O_2)_2$	0.002836	7.4527—10
29	Calcium Oxide	CaO	0.0028035	7.4478—10

LOGARITHMIC EQUIVALENTS (*Continued*).

No.	Chemical.	Formula.	N/10 Equivalent	Logarithm.
30	Calcium Sulphide, crude	CaS	0.003607	7.5571—10
31	Cephaeline	$C_{14}H_{19}O_2N$	0.023316	8.3678—10
32	Chlorine	Cl	0.003546	7.5497—10
33	Chromium Trioxide	CrO_3	0.003333	7.5228—10
34	Cinchonidine	$C_{19}H_{22}ON_2$	0.029420	8.4686—10
35	Cinchonine	$C_{19}H_{22}ON_2$	0.029420	8.4686—10
36	Cocaine	$C_{17}H_{21}O_4N$	0.030318	8.4817—10
37	Coniine	$C_8H_{17}N$	0.012715	8.1045—10
38	Copper Sulphate, anhydrous	$CuSO_4$	0.015964	8.1045—10
39	Copper Sulphate, crystallized	$CuSO_4 + 5H_2O$	0.024972	8.3974—10
40	Emetine	$C_{15}H_{21}O_2N$	0.024718	8.3931—10
41	Ferrous Bromide	$FeBr_2$	0.010784	8.0317—10
42	Ferrous Carbonate	$FeCO_3$	0.011584	8.0637—10
43	Ferrous Iodide	FeI_2	0.015484	8.1897—10
44	Ferrous Oxide	FeO	0.007184	7.8563—10
45	Ferrous Sulphate, anhydrous	$FeSO_4$	0.015191	8.1815—10
46	Ferrous Sulphate, crystallized	$FeSO_4 + 7H_2O$	0.027802	8.4440—10
47	Hydrastine	$C_{21}H_{21}O_6N$	0.038318	8.5834—10
48	Hydrochloric Acid	HCl	0.003647	7.5619—10
49	Hydrocyanic Acid, 1st ppt.	HCN	0.005404	7.7327—10
50	Hydrocyanic Acid, $KCrO_4$	HCN	0.002702	7.4316—10
51	Hydrobromic Acid	HBr	0.008093	7.9081—10
52	Hydriodic Acid	HI	0.012793	8.1069—10
53	Hydrogen Dioxide	H_2O_2	0.0017008	7.2306—10
54	Iodine	I	0.012692	8.1035—10
55	Iodine (Thymol Iodide)	I	0.002115	7.3253—10
56	Iron	Fe	0.002792	7.4458—10
57	Iron in Ferrous Compounds	Fe	0.005584	7.7469—10
58	Iron, in Ferric Compounds	Fe	0.005584	7.7469—10
59	Ipecac eth.	Ether soluble alkaloids	0.0240	8.3802—10
60	Lactic Acid	$HC_3H_5O_3$	0.009005	7.9544—10
61	Lead	Pb	0.010355	8.0151—10
62	Lead Acetate	$Pb(C_2H_3O_2)_2$	0.016257	8.2110—10
63	Lead Oxide	PbO	0.011155	8.0476—10
64	Lead Peroxide	PbO_2	0.011955	8.0778—10
65	Lead Subacetate	$Pb_2O(C_2H_3O_2)_2$	0.013706	8.1370—10
66	Lithium Bromide	LiBr	0.008686	7.9388—10
67	Lithium Chloride	LiCl	0.004240	7.6274—10
68	Manganese Dioxide	MnO_2	0.0043465	7.6382—10
69	Mercuric Iodide	HgI_2	0.022722	8.3562—10
70	Mercuric Nitrate	$Hg(NO_3)_2$	0.016231	8.2103—10
71	Mercury Oxide	HgO	0.01083	8.0347—10
72	Mercurous Chloride	HgCl	0.023606	8.3731—10
73	Mercurous Iodide	HgI	0.032752	8.5152—10
74	Mercury	Hg	0.01003	8.0012—10
75	Mercury (in mercurous compounds)	Hg	0.02006	8.3023—10
76	Morphine, anhydrous	$C_{17}H_{19}O_3N$	0.028516	8.4551—10
77	Morphine, crystallized	$C_{17}H_{19}O_3N + H_2O$	0.030318	8.4817—10
78	Mydriatic alkaloids, combined	Combined alkaloids	0.02892	8.4611—10
79	Nux Vomica	Combined alkaloids	0.0364	8.5611—10
80	Orcin	$C_7H_6(OH)_2$	0.002068	7.3156—10
81	Oxalic Acid	$H_2C_2O_4 + 2H_2O$	0.0063025	7.7996—10
82	Oxygen	O	0.0008	6.9031—10

LOGARITHMIC EQUIVALENTS (*Continued*).

No.	Chemical.	Formula.	N/10 Equivalent	Logarithm.
83	Phenol	C_6H_5OH	0.001568	7.1953—10
84	Phosphoric Acid	H_3PO_4	0.0032687	7.5144—10
85	Pilocarpine Physostigmine	$C_{15}H_{21}O_2N_3$	0.027520	8.4396—10
86	Pilocarpine	$C_{11}H_{16}O_2N_2$	0.020815	8.3185—10
87	Potassium Bitartrate	$KHC_4H_4O_6$	0.018814	8.2744—10
88	Potassium Bromate	$KBrO_3$	0.0027837	7.4446—10
89	Potassium Bromide	KBr	0.011902	8.0755—10
90	Potassium Chloride	KCl	0.007456	7.8726—10
91	Potassium Chlorate	$KClO_3$	0.0020427	7.3102—10
92	Potassium Cyanide, 1st ppt.	KCN	0.013022	8.1145—10
93	Potassium Dichromate	$K_2Cr_2O_7$	0.0049033	7.6905—10
94	Potassium Hydroxide	KOH	0.005611	7.7491—10
95	Potassium Hypophosphite	KPH_2O_2	0.003472	7.5406—10
96	Potassium Iodide	KI	0.016602	8.2201—10
97	Potassium Nitrate	KNO_3	0.010111	8.0047—10
98	Potassium Permanganate	$KMnO_4$	0.0031606	7.4998—10
99	Potassium Sulphite, crystallized	$K_2SO_4 + 2H_2O$	0.009715	7.9874—10
100	Potassium Sulphocyanate	KCNS	0.009718	7.9876—10
101	Quinine, anhydrous	$C_{20}H_{24}O_2N_2$	0.032421	8.5107—10
102	Resorcinol	$C_6H_5(OH)_2$	0.001834	7.2634—10
103	Salicylic Acid	$HC_7H_5O_3$	0.013805	8.1402—10
104	Silver	Ag	0.010788	8.0331—10
105	Silver Nitrate	$AgNO_3$	0.016989	8.2227—10
106	Silver Oxide	AgO	0.011588	8.0641—10
107	Sodium Arsenate, anhydrous	Na_2HAsO_4	0.0092985	7.9684—10
108	Sodium Arsenate, crystallized	$Na_2HAsO_4 + 7H_2O$	0.015604	8.1931—10
109	Sodium Bisulphite	$NaHSO_3$	0.005204	8.7163—10
110	Sodium Bromide	NaBr	0.010292	8.0123—10
111	Sodium Carbonate, anhydrous	Na_2CO_3	0.00530	7.7243—10
112	Sodium Chloride	NaCl	0.005846	7.7668—10
113	Sodium Chlorate	$NaClO_3$	0.0017743	7.2490—10
114	Sodium Cyanide, 1st ppt.	NaCN	0.009802	7.9913—10
115	Sodium Hydroxide	NaOH	0.004001	7.6022—10
116	Sodium Hypophosphite	$NaPH_2O_2 + H_2O$	0.0035357	7.6022—10
117	Sodium Iodide	NaI	0.014992	8.1759—10
118	Sodium Nitrate	$NaNO_3$	0.008501	7.9295—10
119	Sodium Nitrite	$NaNO_2$	0.0034505	7.5379—10
120	Sodium Oxalate	$Na_2C_2O_4$	0.0067	7.8261—10
121	Sodium Phenolsulphonate, anhydrous	$NaC_6H_5O_4S$	0.004903	7.6905—10
122	Sodium Phenolsulphonate, crystallized	$NaC_6H_5O_4S + 2H_2O$	0.0058035	7.7637—10
123	Sodium Phosphate, anhydrous	Na_2HPO_4	0.004735	7.6754—10
124	Sodium Phosphate, crystallized	$Na_2HPO_4 + 12H_2O$	0.011941	8.760 —10
125	Sodium Sulphite	Na_2SO_3	0.00634	7.8021—10
126	Sodium Thiosulphate, anhydrous	$Na_2S_2O_3$	0.015814	8.1990—10
127	Sodium Thiosulphate, crystallized	$Na_2S_2O_3 + 5H_2O$	0.024822	8.3949—10
128	Strontium Bromide	$SrBr_2 + 6H_2O$	0.017779	8.2500—10
129	Strontium Chloride	$SrCl_2 + 6H_2O$	0.013332	8.1249—10
130	Strontium Iodide	$SrI_2 + 6H_2O$	0.022479	8.3517—10
131	Strychnine	$C_{21}H_{22}O_2N_2$	0.033420	8.5240—10
132	Sulphuric Acid	H_2SO_4	0.0049045	7.6906—10
133	Sulphur Dioxide	SO_2	0.0032035	7.5056—10
134	Zinc Chloride	$ZnCl_2$	0.0068145	7.8334—10
135	Zinc Oxide	ZnO	0.0040685	7.6094—10

LOGARITHMIC EQUIVALENTS (*Concluded*).

No.	Chemical.	Formula.	N/50 Equivalent	Logarithm.
1	Aconitine	$C_{34}H_{47}O_{11}N$	0.012097	8.1109—10
2	Atropine	$C_{17}H_{23}O_3N$	0.0057838	7.7622—10
3	Cinchona	Combined alkaloids of	0.0061841	7.7913—10
4	Cinchonidine	$C_{19}H_{22}ON_2$	0.005884	7.7697—10
5	Cinchonine	$C_{19}H_{22}ON_2$	0.005884	7.7697—10
6	Cocaine	$C_{17}H_{22}ON_2$	0.0060636	7.7828—10
7	Coniine	$C_8H_{17}N$	0.002543	7.4053—10
8	Hydrastine	$C_{21}H_{21}O_6N$	0.0076636	7.8844—10
9	Ipecac	Combined alkaloids	0.0049034	7.6815—10
10	Morphine, anhydrous	$C_{17}H_{19}O_3N$	0.0057032	7.7561—10
11	Morphine, crystallized	$C_{17}H_{19}O_3N + H_2O$	0.0060636	7.7828—10
12	Physostigmine	$C_{15}H_{21}O_2N_3$	0.005504	7.7407—10
13	Pilocarpine	$C_{11}H_{16}O_2N_2$	0.004163	7.6194—10
14	Quinine	$C_{20}H_{24}O_2N_2$	0.0062842	7.7983—10
15	Strychnine	$C_{21}H_{22}O_2N_2$	0.006684	7.8251—10
16	Potassium Bitartrate	$KHC_4H_4O_6$	0.0037628	7.5755—10
17	Potassium Hydroxide	KOH	0.0011222	7.0500—10
18	Sodium Hydroxide	NaOH	0.0008002	6.9032—10
19	Sulphuric Acid	H_2SO_4	0.0009809	6.9916—10

DEPARTMENT OF PHARMACY,
UNIVERSITY OF NEBRASKA.

MEETING OF AMERICAN METRIC ASSOCIATION.

A metric meeting given by the New York Academy of Sciences and the American Metric Association was held at the American Museum of Natural History, New York, on Monday evening, November 4th.

The speakers were Dr. Robert Lowie, who presented the development of numbers and measurements from the times of primitive peoples to modern civilization, describing interestingly the early use of numbers and the mathematical notion in folk-lore; Mr. Howard Richards, Jr., who discussed the right usage of metric weights and measures; and Dr. Chester A. Reeds, who gave a geologist's estimation of the decimal method of computation in comparison with the systems used in America.

These papers were discussed by Dr. William Jay Schieffelin, Mr. Maximilian Toch, Mr. A. A. Cary, Dr. H. V. Arny and Mr. John Francis.