COEFFICIENTS AND LOGARITHMS FOR CHEMICAL ANALYSIS.

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THE use of coefficients and logarithms greatly minifies the labour of calculations, as by their means, in the former, a multiplication by a decimal, and the latter, an addition of two logarithms, obviate the necessity of the old "rule of three," and reference to atomic tables.

Thus by the old method: .5525 grammes of FeSO_4 yields .1576 Fe_2O_3 , what is the percentage of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$.

$$\begin{array}{rcllcl} \text{as } 556 \text{ (2 FeSO}_4\cdot 7\text{H}_2\text{O)} = 160 \text{ (Fe}_2\text{O}_3\text{)} \text{ then} & & & & \\ 160 & : & 556 & : : & .1576 = .54766 \\ .5525 & : & .54766 & : : & 100 = 99.123 \% \\ \text{or } \frac{556 \times .1576}{160} = .54766 ; & & \frac{.54766 \times 100}{.5525} = 99.123 \text{ Fe SO}_4 \cdot 7\text{H}_2\text{O} \end{array}$$

By making the preliminary calculation $556 \div 160$, the coefficient may be obtained, namely, 3.475, which means that the weight of the resultant $\text{Fe}_2\text{O}_3 \times 3.475 = \text{Fe SO}_4 \cdot 7\text{H}_2\text{O}$, thus—

$$\begin{array}{l} .5525 \text{ FeSO}_4 = .1576 \text{ Fe}_2\text{O}_3 \times 3.475 = .54765 \\ \text{then } \frac{.54765 \times 100}{.5525} = 92.123 \% \text{ FeSO}_4\cdot 7\text{H}_2\text{O} \end{array}$$

This reduces a sum of two multiplications and two divisions to a sum of a multiplication and a division.

Often in analysis, the result is required in terms of element, not in combination; to this the same rule applies:—in

.1576 Fe_2O_3 , what is the quantity of Fe?

By the rule of three method $\frac{112 \times .1576}{160} = .11032$, but if the coefficient be obtained

$$\frac{112}{160} = .7, \text{ then } .1576 \times .7 = .11032.$$

In volumetric analysis the ordinary rule of three may in like manner be dispensed with; every c.c. of $\text{NaHO} = .04$ gram. of NaHO (40 in 1000 = .04 in 1) = .06 gramme of acetic, .049 gramme of sulphuric acid, etc., as supposing 12.5 grammes of vinegar are taken, which = 7.3 c.c. Standard "Soda" Solution, then $7.3 \times .06 = .438$ grm. acetic acid in the 12.5 grammes of vinegar and the percentage $\frac{.438 \times 100}{12.5} = 3.504$.

This is manifestly more simple than

$$\begin{array}{l} 60 \times 7.3 + 1000 = .438 \\ .438 \times 100 + 12.5 = 3.504 \% \end{array}$$

This considerably shortens labour, but in the case when the quantity taken is comprehended in five or six figures, and the coefficient in as many, the multiplication becomes long and tedious; moreover, liable to error. Here logarithms come to our aid, the only necessity being a table of logarithms from 1 — 10,000.

The method of using logarithms is most simple :—

To multiply, add the logarithms.

To divide, subtract the logarithms.

There are two parts in logarithms, the characteristic or integral part, and the mantissa or decimal part. The decimal part remains the same for the same figures, but the characteristic is changed according to the value of the number, thus :—

100,000	=	5.000000	Log. of 45297	=	4.6560694
10,000	=	4.000000	4529.7	=	3.6560694
1,000	=	3.000000	452.97	=	2.6560694
100	=	2.000000	45.297	=	1.6560694
10	=	1.000000	4.5297	=	.6560694
1	=	.000000	.45297	=	—1.6560694
.1	=	—1.000000	.045297	=	—2.6560694
.01	=	—2.000000	.0045297	=	—3.6560694
.001	=	—3.000000	.00045297	=	—4.6560694
.0001	=	—4.000000	.000045297	=	—5.6560694 etc.

When the characteristics are positive, addition and subtraction are made in the ordinary way :—

$$\begin{array}{rcl} 2.6560694 & + & 1.5010593 = 4.1571287 \\ 2.6560694 & - & 1.5010593 = 1.1550101 \\ 1.5010593 & - & 2.6560694 = -2.8449899 \end{array}$$

Addition: When the characteristics are negative, take their sum and make it negative :—

$$\begin{array}{r} -3.5000992 \\ -2.3780343 \\ \hline -5.8781335 \end{array}$$

When the characteristics are mixed, take their difference, the resultant being positive or negative, according to which is greater :—

$$\begin{array}{rcl} 3.5000992 & & 4.8780343 \\ -2.3780343 & & -3.5000992 \\ \hline 1.8781335 & & 2.3781335 \end{array}$$

In the second example, $8 \times 5 = 13$, the 1 being carried to the 4, making it $5 - 3 = 2$.

Subtraction of Negative or mixed characteristics :—

This is accomplished in the same way as algebraic subtraction as $a - (-a) = a + a$; change the sign to + and add.

$$\begin{array}{rcl} 3.5000992 & & \\ -3.3780342 & & \\ \hline 6.1220650 & & \\ -2.5000992 & & -4.3780342 \\ -3.3780342 & & -2.5000992 \\ \hline 1.1220650 & & -3.8779350 \end{array}$$

In the last example $3 - 5$ leaves -1 to be carried to the upper figure, thus -4 and $-1 = -5 + 2 = -3$.

The methods of applying these rules to analysis are as follows :—

To find the quantity of metal in a given compound, or the quantity of salt representing the compound, add the log. of the weight found to the log. in the table, and find the number corresponding to the resulting log.

For instance, how much Fe is there in .1576 Fe_2O_3 ?

$$\begin{array}{rcl} \text{Log. .1576} & \dots & = -1.1975562 \\ \text{Tabular log. of Fe} & \dots & = -1.8450980 \\ \hline & & -1.0426542 \end{array}$$

On referring to the tables the number corresponding to log. 1.0426542 (namely .11032) will be found.

If the exact log. cannot be found in the table for ordinary analysis, the number corresponding to the next higher log. will suffice, the difference hardly ever extending beyond the 5th figure: if greater accuracy is desired take out the next lower log. and the five figures belonging to it: subtract this log. from the original log. and find the proportional part equal to the difference, the number corresponding to the proportional part becomes the sixth figure of the number. If the difference is not exactly found in the proportional parts (which are generally placed in the margin of the log. tables) take the next lower part, the number corresponding to which becomes the sixth figure in the number; subtract this proportional part from the difference of the two logs, add a cypher to the difference obtained and find the proportional part and corresponding number, which becomes the seventh figure. Wanted the number corresponding to log. .8872900.

	.8872900	
7.7142 =	.8872853	Next lower log.
	<hr/>	
	47	
8 =	45	pro. part.
	<hr/>	
	20	
3 =	17	pro. part.
	<hr/>	
	30	
5 =	28	pro part.
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Ans. 7.7142835 etc.

To find percentages (gravimetric): Log. weight of substance found + tabular log + log. of 100 — log. of weight of original substance. .5525 Ferrous Sulphate = .1576 Fe_2O_3 , what is the per cent. of $\text{FeSO}_4\cdot 7\text{H}_2\text{O}$?

Log. of 100	..	2.0000000
Log. of .1576	..	—1.1975562
Tab. Log.	..	.5409548
		<hr/>
		1.7385110
Log. .5525	..	—1.7423323
		<hr/>

$$1.9961787 = 99.123 \text{ } \frac{\circ}{\circ}.$$

(Volumetric.)

Log. of c.c. used + tabular log. + log. 100 — log. of original weight taken:—
12.5 grammes of Vinegar = 7.3 c.c. Standard Soda Solution, then

Log. 100	..	2.0000000
Log. 7.3	..	.8633229
Tabular log.	..	—2.7781513
		<hr/>
		1.6414742
Log. 12.5	..	1.0969100
		<hr/>

$$.5445642 = 3.504 \text{ } \frac{\circ}{\circ}.$$

The following is a table of coefficients and logarithms required in ordinary analysis,*

* The second column represents simply the *terms* in which the bodies found are required, thus: Al_2O_3 in terms of Al, having no reference to molecules, etc., when it would become $\text{Al}_2\text{O}_3 - \text{Al}_2$. The calculations are based on the atomic weights of most recent determination.

others that may from time to time be required may be easily obtained, either by dividing the molecular weights or subtracting the logs., thus—

$$\text{Al}_2\text{O}_3 (103) \text{ obtained, Al}_2 (55) \text{ required } 55 \div 103 = \cdot 533987$$
$$\text{or Log. } 103 = 2 \cdot 0128372, \text{ and log. } 55 = 1 \cdot 7403627$$
$$\begin{array}{r} 1 \cdot 7403627 \\ 2 \cdot 0128372 \\ \hline \end{array}$$

Found	Log. — 1·7275255	or coeff. ·533983		Element.
Al ₂ O ₃	Sought Al	Co-efficient. ·53398	Logarithm. —1·7275250	Al
	Al ₂ 3SO ₄ K ₂ SO ₄ 24H ₂ O	9·2136	·9644294	
	Al ₂ 3SO ₄ (NH ₄) ₂ SO ₄ 24H ₂ O	8·8058	·9447688	
	Al ₂ Cl ₆	2·6019	·4152906	
	Al ₂ 3SiO ₂ (Clay)	2·7475	·4389377	
	K ₂ Al ₂ Si ₆ O ₁₀ (Felspar)	4·4757	·6508610	
(NH ₄ Cl) ₂ PtCl ₄	NH ₃	·076577	—2·8840983	Am
	NH ₄	·081081	—2·9089191	
	N ₃ H ₁₁ C ₃ O ₅	·24312	—1·8858386	
	NH ₄ Cl	·24099	—1·3819990	
	NH ₄ NO ₃	·36036	—1·5567366	
	(NH ₄) ₂ SO ₄	·2973	—1·4731949	
Pt.	N ₃ H ₁₁ C ₃ O ₅	·53693	—1·7299177	
	NH ₄ Cl	·54872	—1·7393508	
	NH ₄ NO ₃	·82051	—1·9140839	
	(NH ₄) ₂ SO ₄	·67692	—1·8305373	
	(NH ₄) ₂ HPO ₄	·67692	—1·8305373	
BaSO ₄	(NH ₄) ₂ SO ₄	·56652	—1·7532152	
Mg ₂ P ₂ O ₇	(NH ₄) ₂ HPO ₄	·59459	—1·7742176	
Sb ₂ S ₃	Sb	·71429	—1·8538746	Sb
	KSbOC ₄ H ₄ O ₆	1·9226	·2838889	
	KSbOC ₄ H ₄ O ₆ H ₂ O	1·9762	·2958309	
Sb ₂ O ₃	Sb	·83333	—1·9208187	
As ₂ S ₃	As	·60975	—1·7851518	As
MgNH ₄ AsO ₄	As ₂ O ₃	·54395	—1·7355590	
Mg ₂ As ₂ O ₇	As ₂ O ₃	·63871	—1·8053035	
BaCO ₃	Ba	·69577	—1·8424657	Ba
BaSO ₄	Ba	·5878	—1·7692296	
	BaO	·65665	—1·8173339	
	BaO ₂	·72532	—1·8605297	
	BaH ₂ O ₂	·73391	—1·8656428	
	BaH ₂ O ₂ 8H ₂ O	1·3519	·1309446	
	BaCO ₃	·84549	—1·9271085	
	BaCl ₂	·8927	—1·9507055	
	BaCl ₂ 2H ₂ O	1·0472	·0200296	
	Ba2NO ₃	1·1202	·0492956	
Bi ₂ O ₃	Bi	·89655	—1·9525745	Bi
	BiC ₆ H ₅ O ₇	1·7112	·2333008	
	BiONO ₃ H ₂ O	1·3103	·1173707	
	Bi(NH ₃) ₃ C ₆ H ₅ O ₇	1·8879	·2759790	
Bi ₂ S ₃	Bi	·8125	—·9098234	
	(Bi ₂ O ₂ CO ₃) ₂ H ₂ O	1·0973	·0403254	

Found.	Sought.	Co-efficient.	Logarithm.	Element.
AgBr	Br	·42560	—1·6290016	Br
CaSO ₄	Ca	·29411	—1·4685098	Ca
CaCO ₃	Ca	·4	—1·6020600	
	CaCl ₂	1·11	·0453230	
	CaCl ₂ ·2H ₂ O	1·47	·1673173	
	Ca(OH) ₂	·74	—1·8692317	
	CaO	·56	—1·7481880	
	CaS	·72	—1·8573325	
	CaSO ₄	1·36	·1335389	
	CaSO ₄ ·2H ₂ O	1·72	·2355284	
CaCO ₃	CO ₂	·44	—1·6434527	C
CO ₂	C	·27273	—1·4357329	
BaCO ₃	CO ₂	·22312	—1·3485385	
CdS	Cd	·77741	—1·8906501	Cd
	CdSO ₄ ·4H ₂ O	1·9445	·2888079	
	CdBr ₂ ·4H ₂ O	2·3889	·3781980	
AgCl	Cl	·24724	—1·3931187	Cl
	HCl	·25421	—1·4051926	
Cr ₂ O ₃	Cr	·68661	—1·8367101	Cr
Co ₃ O ₄	CO	·73361	—1·8654652	Co
CuO	Cu	·79849	—1·9022695	Cu
	CuSO ₄	2·0076	·3026772	
	CuSO ₄ ·5H ₂ O	3·1411	·4970818	
	Cu(NO ₃) ₂ ·3H ₂ O	3·0403	·4829164	
	C ₂₇ H ₂₂ O ₁₇ (Tannin)	·3061	—·4858633	
H ₂ O	H	·11111	—1·0457531	H
AgI	I	·54049	—1·7327887	I
Fe ₂ O ₃	Fe	·7	—1·8450980	Fe
	FeSO ₄	1·9	·2787536	
	FeSO ₄ ·2H ₂ O	2·215	·3273589	
	FeSO ₄ ·7H ₂ O	3·475	·5409548	
	Fe ₂ HO	1·3375	·1262938	
	Fe ₂ Cl ₆	2·0312	·3077527	
	Fe ₂ (NO ₃) ₆	3·025	·4807254	
PbO	Pb	·92825	—1·9676650	Pb
	Pb(C ₂ H ₃ O ₂) ₂ ·3H ₂ O	1·6996	·2303467	
	PbCO ₃	1·19673	·0782030	
	PbI ₂	2·0673	·3154035	
	Pb(NO ₃) ₂	1·4843	·1715217	
PbSO ₄	Pb	·68317	—1·8345288	
	Pb(C ₂ H ₃ O ₂) ₂ ·3H ₂ O	1·2508	·0961879	
	PbCO ₃	·88119	—1·9450696	
	PbI ₂	1·5215	·1822720	
	Pb(NO ₃) ₂	1·0924	·0383817	
PbCrO ₄	Pb	·63978	—1·8060985	
	Pb(C ₂ H ₃ O ₂) ₂ ·3H ₂ O	1·1716	·0687794	
	PbCO ₃	·82661	—1·9173007	
	PbI ₂	1·4271	·1544984	
	Pb(NO ₃) ₂	1·0248	·0106391	
Mg ₂ P ₂ O ₇	Mg	·21621	—1·3348757	Mg
	MgSO ₄ ·7H ₂ O	2·2162	·3456090	
	MgO	·36036	—1·5567366	
	MgCO ₃ ·Mg ₂ HO ₄ H ₂ O	·86036	—1·9346802	
MgO	Mg	·6	—1·7781513	
	MgCO ₃ ·Mg ₂ HO ₄ H ₂ O	2·3875	·3779070	

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Found.	Sought.	Co-efficient.	Logarithm.	Element.
MgCO ₃	Mg	·28571	—1·4559254	
	MgSO ₄	1·4285	·1548802	
	MgSO ₄ ·7H ₂ O	2·9285	·4666452	
	MgCl ₂ ·6H ₂ O	2·4167	·3832227	
MnO	Mn	·77465	—1·8891055	Mn
Mn ₃ O ₄	Mn	·72031	—1·8575194	
Hg	HgI ₂	2·2700	·3560259	Hg
	HgO	1·0800	·0334238	
	HgCl	1·1775	·0709609	
	HgCl ₂	1·355	·1319393	
	HgSO ₄	1·48	·1702617	
	NH ₂ HgCl	1·2575	·099508	
HgS	Hg	·86207	—1·9355425	
	HgI ₂	1·9569	·2915686	
	HgO	·93089	—1·9689450	
	HgCl	1·0151	·0065088	
	HgCl ₂	1·1681	·0674800	
	HgSO ₄	1·2761	·1058847	
HgO	Hg	·92592	—1·9665735	
NiO	Ni	·78667	—1·8957926	Ni
	NiSO ₄ ·7H ₂ O	3·7467	·5736489	
(NH ₄ Cl) ₂ PtCl ₄	N	·063063	—2·7997746	N
Pt	N	·14155	—1·1509099	
AgCN	CN	·19410	—1·2880255	
	HCN	·20156	—1·3044043	
NH ₃	N	·82353	—1·9156794	
NH ₄ Cl	N	·26168	—1·4177705	
H ₂ O	O	·88889	—1·9488480	O
P ₂ O ₅	P	·43662	—1·6401036	P
Ca ₃ 2PO ₄	PO ₄	·6129	—1·7873896	
MgP ₂ O ₇	P ₂ O ₅	·63964	—1·8059356	
	PO ₄	·85585	—1·9323977	
U ₄ O ₄ P ₂ O ₇	P ₂ O ₅	·19910	—1·2990713	
	PO ₄	·15844	—1·1998648	
(KCl) ₂ PtCl ₄	K	·1605	—1·2054750	K
	KHO	·23045	—1·3625767	
	K ₂ CO ₃	·28395	—1·4532419	
	K ₂ CO ₃ + 16 % Aq	·33802	—1·5289424	
	KHCO ₃	·41152	—1·6143909	
	KNO ₃	·41564	—1·6187173	
	K ₂ SO ₄	·35802	—1·5539073	
	KCl	·30658	—1·4865438	
	K ₂ C ₂ H ₃ O ₂	·40329	—1·6056175	
KHO	K	·69642	—1·8428712	
K ₂ SO ₄	K	·44828	—1·6515494	
KCl	K	·52445	—1·7197041	
BaSO ₄	K ₂ SO ₄	·74678	—1·8731927	
AgCl	Ag	·75276	—1·8766565	Ag
	AgNO ₃	1·1847	·0736084	
NaCl	Na	·39316	—1·5945719	Na
Na ₂ SO ₄	Na	·32394	—1·5104646	
	Na ₂ SO ₄ ·10H ₂ O	2·2676	·355564	
Na ₂ CO ₃	Na	·43396	—1·6374497	
	Na ₂ CO ₃ ·10H ₂ O	2·9681	·4310580	
NaHCO ₃	Na ₂ CO ₃	·63116	—1·8001395	
BaSO ₄	Na ₂ SO ₄	·60944	—1·7849238	

Found.	Sought.	Co-efficient.	Logarithm.	Element.
As ₂ S ₃	S	·39024	—1·5913318	S
	H ₂ S	·41483	—1·6178702	
	S	·13734	—1·1377970	
	SO ₃	·34335	—1·5357371	
	SO ₁	·412	—1·6148972	
BaSO ₄	H ₂ SO ₄	·42041	—1·6236730	Sn
	Sn	·78667	—1·8957926	
	SnCl ₄	1·7333	·2388737	
ZnO	Zn	·80260	—1·9044992	Zn
	ZnSO ₄ ·7H ₂ O	3·5432	·5493957	
	ZnCO ₃ (Zn2HO)H ₂ O	1·3641	·1348462	
	ZnCl	1·679	·2250539	
	Zn(C ₆ H ₅ SO ₄) ₂ ·H ₂ O	5·2963	·7239726	
	Zn(C ₅ H ₉ O ₂) ₂	3·2963	·5180267	
	ZnS	·67031	—1·8262757	
BaSO ₄	ZnSO ₄ ·7H ₂ O	1·2318	·0905402	
	ZnSO ₄	·69099	—·8394710	

ALKALOIDS.

[Calculated from Formulæ given by Husemann and Hilger in *Die Pflanzenstoffe*, 1884.]

		Coeff.	Log.
Au	Atropine C ₁₇ H ₂₃ NO ₃ ·HCl·AuCl ₃	3·1973	·5047834
	Berberine C ₂₀ H ₁₆ NO ₄ ·HCl·AuCl ₃	3·4262	·5348127
	Cinchonine C ₂₀ H ₂₄ N ₂ O·2HCl·AuCl ₃	3·4797	·5415418
	Cinchonidine C ₁₉ H ₂₂ N ₂ O·2HCl·2AuCl ₃	2·419	·3936359
	Hyoscyamine C ₁₇ H ₂₃ NO ₃ ·HCl·AuCl ₃	3·1974	·5047970
	Quinine C ₂₀ H ₂₄ N ₂ O ₂ ·2HCl·2AuCl ₃	2·5514	·4067786
	Strychnine C ₂₇ H ₂₂ N ₂ O ₂ ·HCl·AuCl ₃	3·4262	·5348127
	Theine C ₈ H ₁₀ N ₄ O ₂ ·HCl·AuCl ₃	2·7141	·4336258
	Theobromine C ₇ H ₈ N ₄ O ₂ ·HCl·AuCl ₃	2·6439	·4222450
	Veratrine C ₃₂ H ₅₂ N ₂ O ₈ ·HCl·AuCl ₃	4·7386	·6756501
Pt	Berberine C ₂₀ H ₁₆ NO ₄ ·HCl·PtCl ₄	3·6282	·5596912
	Brucine C ₂₃ H ₂₆ N ₂ O ₄ ·HCl·PtCl ₄	3·9359	·5950441
	Cinchonine C ₂₀ H ₂₄ N ₂ O·2HCl·2PtCl ₂	2·341	·3694014
	Cinchonidine C ₁₉ H ₂₂ N ₂ O·2HCl·2PtCl ₄	2·6692	·4263811
	Codeine C ₁₈ H ₂₇ NO ₃ ·HCl·PtCl ₂	3·0846	·4891989
	Coniine C ₈ H ₁₅ N·HCl·PtCl ₂	2·1923	·3409000
	Morphine C ₁₇ H ₁₉ NO ₃ ·HCl·PtCl ₂	3·0128	·4789703
	Narceine C ₂₃ H ₂₉ NO ₃ ·HCl·PtCl ₂	3·9257	·5939171
	Narcotine C ₂₅ H ₂₃ NO ₇ ·HCl·PtCl ₂	3·6692	·5645714
	Nicotine C ₁₀ H ₁₄ N ₂ ·2HCl·2PtCl ₂ (variable)	1·9667	·2937381
	Papaverine C ₂₀ H ₂₁ NO ₄ ·HCl·PtCl ₂	3·2897	·5171563
	Quinidine C ₂₀ H ₂₄ N ₂ O ₂ ·2HCl·2PtCl ₂	2·3820	·3769418
	Strychnine C ₂₇ H ₂₂ N ₂ O ₂ ·HCl·PtCl ₂	3·2641	·5137635
	Thebain C ₁₅ H ₂₁ NO ₃ ·HCl·PtCl ₄	3·5102	·5453319
	Theine C ₈ H ₁₀ N ₄ O ₂ ·HCl·PtCl ₂	2·5462	·4058925
	Theobromine C ₇ H ₈ N ₄ O ₂ ·HCl·PtCl ₂	2·4743	·3934524

(To be continued.)