XXX. A new table of the quantities of acid in sulphuric acid of different densities, constructed for the use of manufacturers; being the result of experiments made with the strongest sulphuric acid of commerce. The specific gravities taken at the temperature of 60°

Samuel Parkes F.L.S.

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XXX. *A New Table of the Quantities of Acid in Sulphuric Acid of different Densities, constructed for the Use of Manufacturers; being the Result of Experiments made with the strongest Sulphuric Acid of Commerce. The specific Gravities taken at the Temperature of 60°.*
By SAMUEL PARKES, F.L.S.

To Mr. Tilloch.

SIR, HAVING been applied to by several persons in different parts of the kingdom, for instructions respecting a mode of ascertaining the quantity of acid in diluted sulphuric acid, I invariably referred them to Dr. Kirwan's Table, which was published in the year 1793 in the fourth volume of the Transactions of the Royal Irish Academy. This however always proved unsatisfactory, inasmuch as few manufacturers understood how to accommodate that table to the common oil of vitriol, or make it applicable to any practical purpose. This has arisen from the circumstance of Dr. Kirwan having taken sulphuric acid, as it exists in sulphate of potass, instead of the strongest oil of vitriol, for his standard of real acid. Having, in my own business, found the inconvenience of this, I several years ago formed a Table for my private use, from the sulphuric acid of commerce, by diluting that acid with several successive portions of water; a table which I have ever since employed with great advantage. But as this table was formed at a temperature above the mean temperature of the atmosphere, and its range was too confined to be of use in every instance, I resolved to undertake the formation of a new one that would be more generally useful, and that should descend by regular gradations down to the lowest point of dilution that any consumer of sulphuric acid would be likely to require*. Having now, at no small expense of time and labour, completed this Table, I shall be obliged if you will have the goodness to insert it in the next Philosophical Magazine, as I conceive that it will be acceptable and useful to many individuals in various branches of trade and manufacture.

In making this table, I might have taken *purified* sulphuric acid, *i. e.* such as had undergone a second distillation; but as this is an article which is never employed but for philosophical purposes, I thought it better to make use of the

* The first line of the Table shows the specific gravity of a mixture of one part water and 100 parts of strong sulphuric acid. The latter, the specific gravity of one part of sulphuric acid mixed with 100 parts of water.

common acid, and to take as good a sample of that kind as I could possibly procure. I have therefore chosen some of my own manufacture, made in the usual way, and concentrated, as is common in large manufactories, by steaming it in a boiler of lead, and finishing it in a retort of glass. When I began the experiment, the atmosphere of the room was at 60° *, and the acid was of the specific gravity of 1.8494, which, at this temperature, is as strong as it is ever sold.

In order to form the annexed Table, I proceeded as follows :

I first accurately weighed ten thousand grs. of this acid into a stoppered bottle of glass, and then added to it 100 grains of pure water†. When the mixture was become cool, after having been sufficiently agitated, the specific gravity of it was taken, and the result forms the first line of the Table. In this way I continued to dilute the acid with successive portions of water, taking care to let it rest a sufficient time between each addition of the water, that a complete union between the acid and the water might take place; having found by experiment that a mixture of sulphuric acid and water, even after it has become cold, requires several hours for it to arrive at the maximum of condensation. I took also the precaution of keeping it in stoppered bottles, that it might not imbibe water from the atmosphere, and frequently agitated it during each interval. And, in order to attain as great accuracy as possible, I procured a gravity bottle larger than usual, one that holds nearly ten ounces of water, and with a stem so small that at the part to which the fluid rises when properly filled, a single drop of the liquor will occasion a rise of nearly one sixteenth of an inch.

* The balance which I made use of in these experiments, is so delicate that it will turn with the 20th part of a grain; and as the acids will erode the common scale-dishes, if dropt upon them, and endanger the accuracy of a result, I have long been in the habit of using those made with Wedgwood's ware, and such were employed in making this Table. Those parts of the Table which have a star opposite to them, were made by actual experiment—the intermediate ones were the results of calculation.

* For the difference which is occasioned in the specific gravity of sulphuric acid by change of temperature, consult Nicholson's Journal, quarto, vol. iii. page 211.

† In diluting sulphuric acid, it is usual, and safer, to add the acid by degrees to the water, and not the water to the acid; but with this very small quantity of water, such caution was not necessary.

Since

Since I concluded these experiments it occurred to me, that it might be useful to some manufacturers to know the quantity of acid per cent. in diluted acid of any given strength; I have therefore calculated the quantity in each, and annexed it. The column of *ounces* and *drachms* is added for the use of those who are accustomed to this mode of reckoning, and also for those who are not conversant with the usual method of stating specific gravities; and is calculated on the supposition of the wine pint holding exactly sixteen ounces avoirdupois of pure water*.

The sulphuric acid which is consumed in these kingdoms amounts I believe to upwards of three thousand tons annually; the greater part of which is used in a state of dilution. For the purposes of dissolving iron or zinc, it should be diluted with at least five or six times its weight of water. Sulphuric acid is consumed in large quantities by bleachers, for making the oxymuriate of lime, and these people always use it in a state of dilution. The calico printers also expend large sums in the purchase of this acid, which they use in various states of dilution, for making what they call sours.

To these, and other manufacturers, this Table will be of use, not only in assisting them in the formation of acid of any given strength, but it will enable them at any time to ascertain whether their servants have observed due care in making the different preparations; which is a matter of great moment—for it often happens, that for want of this the printer and manufacturer suffer great loss, and the goods sustain an irreparable injury.

I need scarcely add that the oil of vitriol-makers themselves, may also derive great benefit from attending to this Table.

I am, sir, yours, &c.

Goswell-street Chemical Works,
London, Sept. 2, 1812.

SAMUEL PARKES.

* It is a convenient way of measuring, to have a glass bottle with a narrow neck, holding rather more than a pint of water, with a mark on the stem exactly at the place to which the water ascends when it contains exactly 16 ounces avoirdupois of that fluid. It was formerly understood that the standard wine pint was the exact measure of 16 ounces of pure water; but some experiments made in the year 1688, before the Lord Mayor and the Board of Excise, decided, that the sealed wine gallon of Guildhall contains only 224 cubic inches, though by the fifth of Queen Ann, chap. vii. § 7, it is called 231 inches. This decision makes the wine pint to hold only .970 of an avoirdupois pound of water; but as it is generally thought right, for all common purposes still to consider it of the capacity of 16 ounces avoirdupois, I have taken it at that in this instance.

A Table of the Specific Gravities of Sulphuric Acid, when diluted with different Portions of Water, at the Temperature 60°.

	Drachms of Water.	Specific Gravity.	Weight of the Wine Pint.		Acid per Cent.
			Oz.	Drms.	
100 Drachms Sulp. Acid. Sp. Grav. 1·8494, Or, 29 oz. 9½ Drachms, the Weight, Avoirdupois, of the Wine Pint.	* 1	1·8484	29	9¼	99·009
	* 2	1·8465	29	8¾	98·039
	* 3	1·8445	29	8¼	97·087
	* 4	1·8416	29	7½	96·153
	* 5	1·8387	29	6¾	95·238
	6	1·8358	29	6	94·339
	* 7	1·8319	29	5	93·457
	8	1·8270	29	3¾	92·509
	9	1·8222	29	2½	91·743
	* 10	1·8163	29	1	90·909
	11	1·8104	28	15½	90·090
	12	1·8046	28	14	89·285
	13	1·7988	28	12½	88·495
	14	1·7929	28	11	87·719
	* 15	1·7880	28	9¾	86·956
	16	1·7821	28	8	86·206
	17	1·7744	28	6¼	85·470
	18	1·7666	28	4¼	84·745
	19	1·7588	28	2¼	84·033
	20	1·7510	28	0¼	83·333
	* 21	1·7431	27	14¼	82·644
	22	1·7353	27	12¼	81·967
	23	1·7275	27	10¼	81·300
	24	1·7207	27	8½	80·645
	25	1·7138	27	6¾	80·000
	26	1·7070	27	5	79·365
	* 27	1·7002	27	3¼	78·740
	28	1·6933	27	1½	78·125
	29	1·6865	26	15¾	77·519
	30	1·6796	26	14	76·923
	31	1·6728	26	12¼	76·335
	32	1·6660	26	10½	75·757
	* 33	1·6582	26	8½	75·187
	34	1·6523	26	7	74·626
	35	1·6464	26	5½	74·074
	36	1·6406	26	4	73·529
	37	1·6348	26	2½	72·992

A Table of the Specific Gravities of Sulphuric Acid. 165

	Drachms of Water.	Specific Gravity.	Weight of the Wine Pint.		Acid per Cent.
			Oz.	Drms.	
100 Drachms Sulp. Acid. Sp. Grav. 1·8494, Or, 29 oz. 9½ Drachms, the Weight, Avoirdupois, of the Wine Pint.	38	1·6289	26	1	72·463
	39	1·6230	25	15½	71·942
	*40	1·6171	25	14	71·428
	41	1·6113	25	12½	70·921
	42	1·6054	25	11	70·422
	43	1·5995	25	9½	69·930
	44	1·5937	25	8	69·444
	*45	1·5879	25	6½	68·965
	46	1·5820	25	5	68·493
	47	1·5761	25	3½	68·027
	48	1·5703	25	2	67·567
	49	1·5645	25	0½	67·114
	50	1·5585	24	15	66·666
	51	1·5526	24	13½	66·225
	52	1·5478	24	12¼	65·789
	53	1·5429	24	11	65·359
	*54	1·5390	24	10	64·935
	55	1·5351	24	9	64·516
	56	1·5312	24	8	64·102
	57	1·5273	24	7	63·694
	58	1·5234	24	6	63·291
	59	1·5195	24	5	62·893
	60	1·5156	24	4	62·500
	61	1·5117	24	3	62·111
	*62	1·5078	24	2	61·728
	63	1·5039	24	1	61·349
	64	1·5000	24	0	60·975
	65	1·4960	23	15	60·606
	66	1·4921	23	14	60·240
	67	1·4882	23	13	59·880
	68	1·4843	23	12	59·523
	69	1·4804	23	11	59·171
	*70	1·4765	23	10	58·823
	71	1·4726	23	9	58·481
	72	1·4687	23	8	58·139
	73	1·4648	23	7	57·803
	74	1·4609	23	6	57·471
	75	1·4570	23	5	57·142
	76	1·4531	23	4	56·818
	77	1·4502	23	3¼	56·497
	*78	1·4473	23	2½	56·179

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	Drachms of Water.	Specific Gravity.	Weight of the Wine Pint.		Acid per Cent.
			Oz.	Drms.	
100 Drachms	79	1·4433	23	1½	55·865
Sulp. Acid.	80	1·4395	23	0½	55·555
Sp. Grav.	81	1·4365	22	15¼	55·248
1·8494,	82	1·4336	22	15	54·945
Or. 29 oz.	83	1·4306	22	14¼	54·644
9½ Drachms,	84	1·4276	22	13½	54·347
the Weight,	85	1·4257	22	12¾	54·054
Avoirdupois,	*86	1·4218	22	12	53·763
of the Wine	87	1·4189	22	11¼	53·475
Pint.	88	1·4160	22	10½	53·191
	89	1·4130	22	9¾	52·910
	90	1·4101	22	9	52·631
	91	1·4072	22	8½	52·356
	92	1·4042	22	7½	52·083
	93	1·4013	22	6¾	51·813
	*94	1·3984	22	6	51·546
	95	1·3955	22	5¼	51·282
	96	1·3926	22	4½	51·020
	97	1·3906	22	4	50·761
	98	1·3886	22	3½	50·505
	99	1·3867	22	3	50·256
	*100	1·3848	22	2½	50·000
	105	1·3730	21	15½	48·780
	*110	1·3632	21	13	47·619
	115	1·3535	21	10½	46·511
	*120	1·3437	21	8	45·454
	125	1·3359	21	6	44·444
	*130	1·3281	21	4	43·478
	135	1·3203	21	2	42·553
	*140	1·3125	21	0	41·666
	145	1·3056	20	14¼	40·816
	*150	1·2988	20	12½	40·000
	155	1·2919	20	10¾	39·215
	*160	1·2851	20	9	38·461
	165	1·2783	20	7¼	37·735
	170	1·2724	20	5¾	37·037
	175	1·2676	20	4½	36·363
	*180	1·2627	20	3¾	35·714
	185	1·2568	20	1¾	35·087
	190	1·2520	20	0½	34·482
	195	1·2470	19	15¼	33·898

A Table of the Specific Gravities of Sulphuric Acid. 167

	Drachms of Water.	Specific Gravity.	Weight of the Wine Pint.		Acid per Cent.
			Oz.	Drms.	
100 Drachms Sulp. Acid. Sp. Grav. 1·8494, Or, 29 oz. 9½ Drachms, the Weight, Avoirdupois, of the Wine Pint.	*200	1·2421	19	14	33·333
	210	1·2343	19	12	32·258
	*220	1·2265	19	10	31·250
	230	1·2187	19	8	30·303
	*240	1·2129	19	6½	29·411
	250	1·2060	19	4¾	28·571
	*260	1·1992	19	3	27·777
	270	1·1933	19	1½	27·027
	*280	1·1875	19	0	26·315
	290	1·1825	18	14¾	25·641
	*300	1·1776	18	13½	25·000
	310	1·1728	18	12¾	24·390
	320	1·1679	18	11	23·809
	330	1·1630	18	9¾	23·255
	*340	1·1582	18	8½	22·727
	350	1·1552	18	7¾	22·222
	360	1·1523	18	7	21·739
	370	1·1494	18	6¼	21·276
	*380	1·1464	18	5½	20·833
	390	1·1426	18	4½	20·408
	400	1·1338	18	2¼	20·000
	*420	1·1328	18	2	19·230
	440	1·1279	18	0¾	18·518
	*460	1·1240	17	15¾	17·857
	480	1·1181	17	14¾	17·241
	*500	1·1132	17	13	16·666
	*550	1·1054	17	11	15·384
	*600	1·0966	17	8¾	14·285
	*650	1·0898	17	7	13·333
	*700	1·0839	17	5½	12·500
	*750	1·0781	17	4	11·764
	*800	1·0732	17	2¾	11·111
	*850	1·0693	17	1¾	10·526
	*900	1·0664	17	1	10·000
	*950	1·0625	17	0	9·523
	*1000	1·0602	16	15½	9·090
	*1100	1·0546	16	14	8·333
	*1200	1·0507	16	18	7·692
	*1300	1·0488	16	12¾	7·142
	*1400	1·0458	16	11¾	6·666
	*1500	1·0429	16	11	6·250

	Drachms of Water.	Specific Gravity.	Weight of the Wine Pint.		Acid per Cent.
			Oz.	Drms.	
100 Drachms	1600	1·0390	16	10	5·882
Sulp. Acid.	1700	1·0370	16	9½	5·555
Sp. Grav.	*1800	1·0351	16	9	5·263
1·8494,	1900	1·0337	16	8⅝	5·000
Or, 29 oz.	*2000	1·0322	16	8¼	4·761
9½ Drachms,	*2250	1·0283	16	7¼	4·255
the Weight,	*2500	1·0254	16	6½	3·846
Avoirdupois,	*2750	1·0234	16	6	3·508
of the Wine	*3000	1·0214	16	5½	3·225
Pint.	*3500	1·0185	16	4¾	2·777
	*4000	1·0166	16	4¼	2·439
	*4500	1·0146	16	3¾	2·173
	*5000	1·0127	16	3¼	1·960
	5500	1·0117	16	3	1·785
	*6000	1·0107	16	2¾	1·639
	6500	1·0102	16	2⅝	1·515
	*7000	1·0098	16	2¼	1·408
	7500	1·0093	16	2⅓	1·315
	*8000	1·0088	16	2¼	1·234
	8500	1·0083	16	2⅓	1·162
	*9000	1·0078	16	2	1·098
	9500	1·0073	16	1⅞	1·041
	*10000	1·0068	16	1¾	0·990

XXXI. *An Account of some Experiments on the Combinations of different Metals and Chlorine, &c.* By JOHN DAVY, Esq. Communicated by Sir HUMPHRY DAVY, Knt. LL.D. Sec. R. S.

[Concluded from p. 91.]

5. *On the Relation between the Proportion of Oxygen and Chlorine in Combination with several Metals.*

ERRORS being very common in chemical analyses, even in those conducted most skilfully and carefully, all possible means should be taken to discover them; and no means, I think, promise to be more effectual for this purpose, than the general analogy of definite proportions. From a great variety of facts, it appears that oxygen and chlorine combine with bodies in the ratio of 7·5 to 33·6. With one part