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A handbook of chemical manipulation

Williams, Charles Greville

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Appendix

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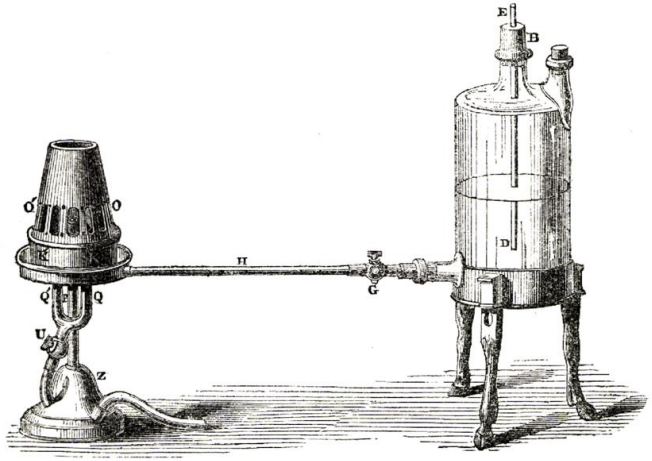
APPENDIX.

967. *Production of high temperatures.*—M. H. Sainte-Claire Deville* having been occupied for a considerable time with researches which involve the use of excessively high temperatures, has constructed two sets of apparatus for the purpose of enabling chemists to produce extreme heat with considerable economy of time and material. The first is a peculiar kind of lamp without a wick; the fuel is oil of turpentine; and, in order to effect complete combustion of the very large quantity of carbon contained in it, he sends a blast of air through the burner by means of bellows. The heat obtained is so intense, that a platinum wire of half a millimetre† in diameter may be fused in the flame. Felspar becomes perfectly fluid, and even the emerald shows signs of fusion when heated in a small platinum crucible. The engraving, fig. 389, represents the apparatus on a scale of one-fifth the real size.

Fig. 389.

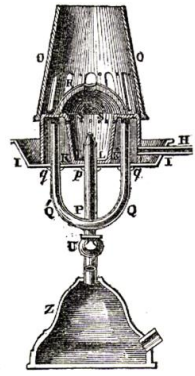


* Ann. de Chim. et de Phy. [3] xlvi. 182.

† A table for the conversion of millimetres into inches will be found at the end of the volume.

968. The flask, D, is so arranged that by the aid of the tube, E D, the turpentine is retained at a constant level. The section, fig. 390, represents the burner and the contrivance by which the air is shut in; it consists of a reservoir, K K, of stout copper, which communicates with the turpentine bottle, D, by means of the tube, H. The annular space, K K, is closed at the bottom by a circular copper tray, I I, which is intended to hold water for the purpose to be described presently. The burner, K K, has on the side next the air-tube, P, a row of holes, eight in number, at S S; they may be from 3 to 4 millimetres in diameter. The lamp is surmounted by a loose copper dome, R, which is supported by a depression or groove on the top of the burner. At its upper part it is pierced with an aperture to allow of the egress of the flame. A chimney, 75 millimetres high, and somewhat conical, is cut away at its lower part, so as to form the large apertures seen at O O. These apertures permit a large quantity of air to pass. On the top of the chimney is to be placed the triangle of platinum, which supports the crucible to be heated.

Fig. 390.



969. The upper extremity of the pipe, P *p*, has a jet attached, pierced with an aperture two and a quarter millimetres in diameter. This jet may be replaced by others, according to the size of the crucible to be heated. The aperture of the jet is placed 5 millimetres below the holes, S S. The tubes, Q *q* and Q′ *q* (which carry the air over the surface of the turpentine in the lamp), are united at their lower extremity into one tube, which is attached to the stopcock, U. The upper extremities of the tubes, Q *q* and Q′ *q*, are seen to pass through the tray, I I, ascending in the interior of the burner nearly to the top. The reservoir, Z, communicates with a pair of bellows of sufficient power to force air into the lamp with a pressure equal to that exerted by a column of mercury 7 or 8 centimetres in height.

970. The first operation, preparatory to using the lamp, is to establish the level of the turpentine by means of the tube, D, fig. 389. It is necessary that the lower extremity of D should be exactly 5 millimetres below the level of the apertures, S S, in order to prevent the turpentine in the burner from overflowing and becoming inflamed, which, although not presenting any danger, would cause some trouble.

To set the apparatus at work, water is to be poured into the tray or

cup, I I, which latter is to heated with a lamp until it has boiled for some time, so as to heat the turpentine; the stopcock, U, may then be partly opened and air sent in; at the same time a lamp-flame is brought near the holes, O O, to ignite the inflammable vapour. When the lighted vapour burns steadily, the stopcock, U, may be further opened, and the bellows are to be worked to their full power. In a few moments after the ignition of the vapour the stopcock, G, fig. 389. is to be opened. A few trials must be made to ascertain the conditions necessary for obtaining the maximum temperature. It is unnecessary to apply a lamp-flame to the water in the tray, I I, during the whole of the operation, as the heat of the combustion is more than sufficient for the purpose.

To extinguish the lamp, it is sufficient to close the stopcocks U and G*.

971. *Forge for high temperatures.*—M. Deville has also described an apparatus by means of which he has obtained very remarkable results, owing not only to the excessively high temperatures reached, but perhaps still more to the power of resistance to heat possessed by his vessels. The furnace described by him is, in principle, not very unlike that described by Faraday in his 'Chemical Manipulation.' It is proper to mention that the last-named philosopher distinctly mentions that it was want of sufficiently refractory vessels that prevented the full powers of his furnace from being employed. Pure platinum was melted many years ago by the blast-furnace belonging to the Royal Institution. That used by M. Deville, however, not only melted but even volatilized platinum in such quantity that, according to him, it must have entered into ebullition.

The furnace consists of a baked clay cylinder, E E, fig. 391, 18 centimetres in diameter, placed upon an iron plate, F F, pierced with holes at O O O, fig. 392. This plate rests upon a hemispherical cavity, B, which is placed in communication with the bellows by means of the tube seen in the engraving. M. Deville uses small pieces of cinder, free from clinkers, as fuel. To use the furnace, the crucible is placed on the centre of the iron plate, and is covered with ignited charcoal to the height of about 5 or 6 centimetres; the rest of the furnace is then filled up with pieces of coke or cinders of the size of nuts. As the heat rises on working the bellows, the descent of the fuel is assisted by means of an iron rod, and more fuel is to be added to keep the furnace full. During the whole time of the experiment the coals on the upper part of the furnace remain cold. The highest tem-

* These lamps may be obtained of M. Wiesnegg of Paris, who has made several for the Normal School.

perature commences about 2 or 3 centimetres above the plate F, and extends upwards about 7 or 8 centimetres. Above this zone of elevated

Fig. 391.

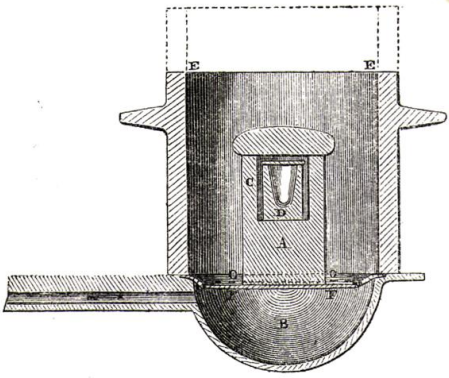
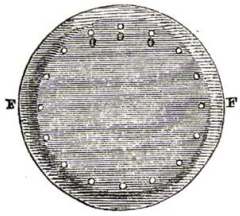


Fig. 392.



temperature the heat decreases with excessive rapidity, the cooling being due to the transformation of carbonic acid into carbonic oxide, which gas, in M. Deville's apparatus, burns with a flame 2 metres long.

972. *Crucibles for high temperatures.*—M. Deville uses three kinds of crucibles for his blast-furnace, namely, lime, carbon, or alumina. The lime-crucibles are simply pieces of well-burned slightly hydraulic lime, A, fig. 391, shaped with a saw or knife into a prism 8 or 10 centimetres wide, and 12 or 15 centimetres high. If the utmost degree of heat is not required, the crucible containing the assay may be placed within another, D, fig. 391. Both the concentric crucibles have covers also made of lime. The bottom of the inner crucible should be 5 or 6 centimetres above that of the outer one. They are placed at once on the plate of the furnace, without the intervention of a piece of baked earth or tile as is usually recommended.

973. If the utmost degree of heat is required, only one crucible is to be used, the aperture made in it not exceeding 2 or 3 centimetres in diameter, and 5 or 6 deep.

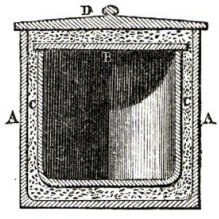
974. In some experiments M. Deville uses crucibles made by means of the lathe from the graphite of gas-retorts. They must not exceed 1 decimetre in height, because the zone of maximum temperature does not reach above 8 centimetres.

When it becomes necessary to remove the sulphur, iron, silica, and alumina from these crucibles, they are to be placed in one made of clay, through the bottom of which a porcelain tube passes, and is well

luted with fire-clay softened with water and mixed with cow-hair. The crucible being heated to redness, a stream of chlorine is passed through to remove the impurities.

These carbon crucibles, B, fig. 393, are not heated directly, but are to be enclosed inside one of lime, A A, the space, C C, between the two being tightly packed with alumina which has previously been heated to whiteness. The lime crucible has a cover, D, fitted to it.

Fig. 393.



975. M. Deville also uses crucibles made of alumina. To make them, he takes some ammonia-alum, and, after exposing it to a temperature only just sufficient to expel the volatile matters, kneads the alumina so prepared with water and some alumina which has been heated to whiteness for a long time. The pasty mass is to be moulded into a shape, dried and burnt.

976. It is somewhat curious that platinum which has been melted by means of the furnace described, when hammered into foil does not effect the combination of hydrogen with oxygen.

If red oxide of manganese is mixed with charcoal from sugar, but in quantity insufficient for complete reduction, and the whole be heated in a lime-crucible, the metal is obtained in a single brittle button of a reddish colour like bismuth. The pulverulent metal, when heated a little above the ordinary atmospheric temperature, decomposed water, as has also been observed by M. Regnault. The button of metal was accompanied by crystals apparently of the formula Mn^2O^3, CaO.

977. Oxide of chromium, heated with a quantity of carbon insufficient for complete reduction to a temperature sufficiently high to volatilize platinum, gave a melted mass, but not a button. The chromium thus prepared is so hard that it cut glass like a diamond, and if it were less brittle might be used for that purpose. Hydrochloric acid attacks chromium with facility, dilute sulphuric acid but slightly, and nitric acid, either strong or diluted, does not act upon it at all.

978. Nickel, when obtained in a pure button, was found to possess extraordinary ductility, and a tenacity greater than that of iron.

An iron and a nickel wire of the same diameter were tried with weights, and it was found that while 60 kilogrammes ruptured the first, it took 90 to break the second. See also § 780.

979. Cobalt prepared from the oxalate and well fused was examined as to its physical properties, and it was ascertained that a wire of the same diameter as the iron and nickel ones mentioned above, required

115 kilogrammes to break it, consequently it is nearly twice as tenacious as iron.

Silica was partially, but not perfectly, fused in the furnace.

Fig. 394.

980. *Determination of vapour-densities at varying pressures.*—In endeavouring to ascertain the constitution of certain hydrocarbons, I was led to determine the amount of influence exerted by pressure on the volumes of vapours. M. Regnault has occupied himself with the same subject, but the only notice I have seen of his experiments is in the extended memoir of M. Wurtz, "Sur les Ammoniaques composées." In that paper he gives tables of the vapour-densities of methylamine and ethylamine at varying temperatures and pressures. The experiments were made by M. Izarn, in Regnault's laboratory, with an apparatus not yet described, but made on the model of the eudiometer described at p. 325.

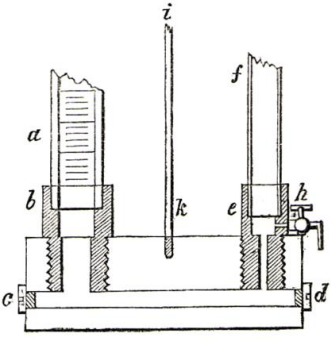
981. The instrument used by me is of the simplest character, and, when once constructed, is even easier to use than the ordinary apparatus of M. Gay-Lussac. A determination of a vapour-density at the pressure of the atmosphere can be made in half an hour, and at three pressures in one hour.

982. For this purpose the gas-jar, *a b*, fig. 394, is accurately graduated, and cemented at its lower extremity into a steel cap ending in a screw. The jar is only half the diameter at the lower end that it is at the upper; this is in order to make the effect of small pressures on the bulk of the gas more evident. The jar is to be filled with hot mercury, the air-bubbles removed with a wire, and then inverted in the mercurial trough. The small glass globule containing the fluid is then passed underneath the edge of the jar, and rises to the top of the mercury. The steel foot, *c d*, fig. 394, must now be held under the surface of the metal in the trough, while the lower end of the jar, *a b*, is screwed into its place. The pressure-tube, *e f*, is now inserted, and then the rod, *i k*, which is merely intended to enable the arrangement to be plunged into the water in the cylinder. A jet of steam from a small boiler is to be sent to the bottom of the water in the cylinder, until the desired temperature is attained. The exact degree can easily be maintained by more or less opening the tap of the steam-pipe. The

temperature is observed by two thermometers at *g* and *l*. As soon as the heat has risen a little, the bulb containing the fluid (the density of the vapour of which is to be determined) bursts, and the mercury slowly falls in *a b*, and of course rises in the pressure-tube, *e f*. By means of a rod carrying a deep notch at one end, the tap, *h*, is now to be opened, so as to allow the mercury to run out of the pressure-tube until it stands at or nearly the same level in both limbs. The difference of level is to be read off with a cathetometer. By a very simple calculation the vapour-density may now be found at, or very nearly, the atmospheric pressure. If it be desired to take the vapour-density at a pressure less than that of the atmosphere, it is merely necessary to use only sufficient substance to partly fill *a b* with vapour.

983. If, on the other hand, it be desired to make the experiment at a pressure greater than that of the atmosphere, it suffices to pour mercury into *f e* to the desired extent.

Fig. 395.



984. The steel foot into which the tubes, *a b*, *e f*, and the rod, *i k*, are inserted, is shown on a larger scale in fig. 395; the lettering is the same in both engravings.

985. The results of the experiments made with this instrument belong to my paper which is not yet published, but I may quote the following values obtained with a specimen of propyl extracted from the products of the destructive distillation of the Torbane-hill mineral.

VAPOUR-DENSITY OF PROPYL AT VARYING PRESSURES.

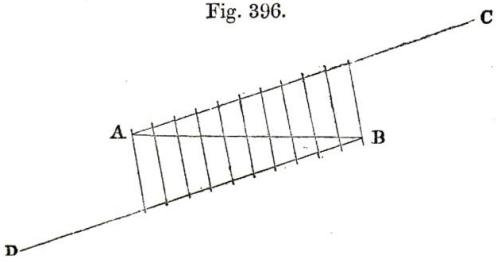
Theory 2·976 = 4 volumes.

Temperature, Centigrade.	Pressure, millimetres.	Density.
100°	772·1	2·963
97°	870·6	3·005
97°	943·8	3·022
98°·7	1013·0	3·032

986. From the above Table, it is plain that the density augments with the pressure, although I am of opinion that the difference between the first two determinations is too great. It will be necessary to repeat the experiments several times before considering the amount of increase of density established; I merely therefore give the above as an illustration of the method of proceeding.

987. *Lines divided into equal parts.*—It constantly happens in laboratories where gas analyses are made, that it becomes necessary to accurately and rapidly divide a line into a given number of equal parts. Among the methods which may be adopted, there are two which more especially possess the requisites of simplicity and accuracy. The first is as follows:—From one end, A, of the given line, A B, draw the line A C, making any angle with A B. From the other end, B, draw the

Fig. 396.

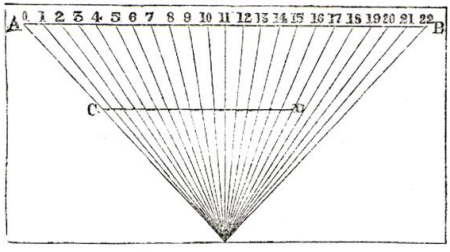


line B D, making A B D the same angle as A B C. The length to which the lines A C and B D are drawn is immaterial. Then point off on the line A C as many equal spaces (commencing from A) as the line A B is to be divided into. In the same manner point off an equal number of spaces on the line B D. Then draw parallel lines joining the spaces marked off, taking care to connect the last point on A C with the first point on B D. In this manner the line A B will be accurately divided into the desired number of equal parts.

988. Another method is that used by Bunsen. On a plate of glass is drawn with a writing-diamond a line A B divided into a greater number of equal parts than is likely to be required in practice. From the divisions on this line other lines are drawn, all converging to a point, as in fig. 397.

989. Then supposing it be required to divide an inch into 17 equal parts, find that portion of the system of lines where seventeen are required to make up an inch; in the case cited this will be at C D. In the same manner it is always possible to find some portion of the scale where the desired number of parts will be found to occupy the required space.

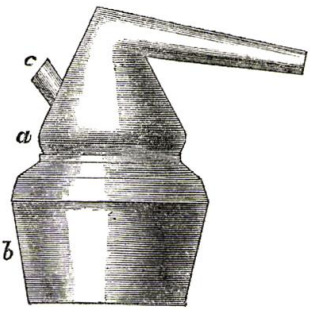
Fig. 397.



990. *Stills for destructive distillation and other purposes.*—One of the most convenient pieces of distillatory apparatus for operations requiring either high or low temperatures, may be made from a common glue-pot. The contrivance is, moreover, especially useful in distilling organic matters at high temperatures with caustic potash, as, for example, the preparation of aniline from indigo, chinoline and its associated bases from cinchonine, &c.

In fig. 398, *a* represents a copper head made to slip tightly into the aperture of the glue-pot, *b*. A small tubulature, *c*, permits the passage of a thermometer, or the addition of any substance during the progress of the distillation. The seams in the head are all brazed. The juncture of the head with the pot is luted with almond and linseed-meal.

Fig. 398.



991. If it be desired to distil with a glass tube to carry the products into the condenser, or, on the other hand, to cohobate in the manner shown in fig. 208, I have the copper cover, fig. 399, attached to the pot. It is to be luted in the same manner as the head, fig. 398.

Fig. 399.

992. Supposing it be required to distil at a very gentle heat, such

as that of boiling water, I attach another head, somewhat smaller than that shown in fig. 398, to the water-bath of the glue-pot. The arrangement with this mode of distilling, is seen in section in fig. 400.

It is very desirable to observe the precautions mentioned in §§ 351, 378, regarding the proper angle of "dip" for the beak of the still.

993. *Supports for U-tubes.*—In supporting these useful pieces of apparatus I use the arrangement seen in fig. 401. A small wooden screw (made with the instrument described in § 689) presses against a piece of wood, *a*, which in its turn clamps the U-tube to the upright board, *b c*, which is mortised into a wooden foot, *c d*.

994. Dr. Anderson adopts a plan for supporting U-tubes, when required for lecture illustration, which has a very neat appearance; it is not, however, so well adapted for experiments of research as the last, owing to its being less steady. Two stout brass wires, *a b* and *c d*, fig. 402, are

Fig. 400.

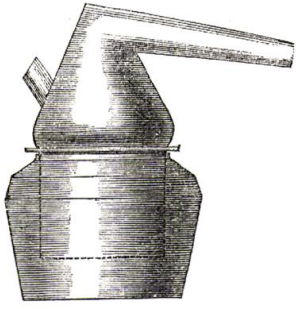


Fig. 401.

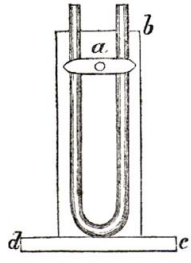
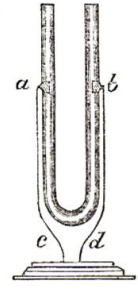


Fig. 402.



fixed at their lower extremities into a foot. On their upper ends they carry small semicircular brass pieces, *a b*, which hold the U-tube. The wires are somewhat nearer together than the width of the tube, so that a little force is required to insert it in its place, thus giving greater firmness to the apparatus.

995. *Compression pipettes.*—Some of my experiments rendering it frequently necessary to separate small quantities of hydrocarbons from fuming nitric acid, with which they had been treated, I found it very inconvenient to draw them off with a pipette in the usual manner, owing to the unpleasant effect of inhaling the fumes of the acid. I then adopted the plan, common in Continental laboratories, of using a pipette having a vulcanized india-rubber ball attached to its upper extremity. If the orifice of the pipette is sufficiently small, no diffi-

culty will be found in adjusting the smallest quantities with the greatest accuracy.

996. *Simple decanting apparatus.*—In making researches, it constantly happens that crops of crystals are obtained in the bottoms of beakers, and it is equally often required to drain the mother-liquid off without disturbing the deposit. The methods usually adopted in the laboratory to meet this end are most imperfect. It is a common proceeding to place the beaker (containing the crystals) in a sloping position on the top of another beaker; but it not unfrequently happens that a vibration of the table causes it to slip, and much delay and annoyance are thus caused. To avoid this, I made the little apparatus represented in figs. 403, 404, and 405. The beaker, *a*, fig. 403, is

Fig. 403.

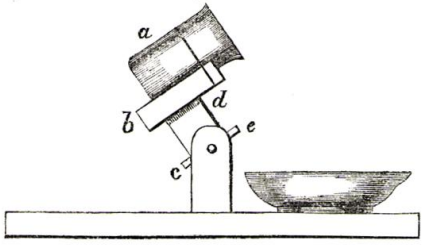


Fig. 404.

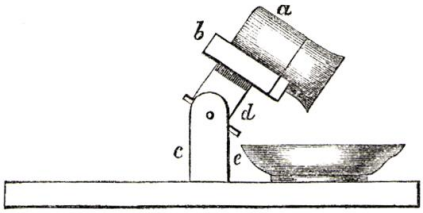
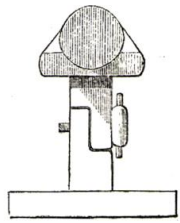


Fig. 405.



fastened by a strong vulcanized india-rubber ring to a deeply-grooved table, *b*. The circular groove in *b* is made of long radius, so as to hold steadily variously-sized beakers. The table is supported by a square rod, *d*, having its lower end jointed to another rod, *c*, in such a manner that it permits of a circular motion, which can be arrested in any position by the screw, *e*. This joint is precisely on the same principle as that in the arm of the support for vapour-densities shown in fig. 141, § 247. The figures 403 and 404 show the beaker in the

two principal positions, while fig. 405 gives a front view, illustrating the position of the two pieces of which the joint is composed. The screw is only cut on half the rod attached to the handle, *e*, the other part passing smoothly through one of the pieces of wood, like fig. 141, § 247. The entire apparatus can easily be made by any person with the tools described in §§ 688 and 689.

997. *Small press for squeezing fluids out of preparations.*—In organic chemistry, the substances produced during experiments are often contaminated with oily or other kinds of fluid impurities which are usually removed by pressure between folds of filtering-paper. A small screw press can easily be made, which, by permitting greater pressure to be applied than could be given by the hands, will greatly facilitate the purification of substances. It frequently happens, that a steady pressure for a long time is the best way of removing the impurities, as, if sufficient paper be used, it becomes gradually but perfectly absorbed; and by this mode of operating there is less danger of introducing organic matter from the paper than when repeated pressure with the fingers is employed, especially as in the latter mode of proceeding the papers require more frequent renewal.

998. *Cement for glass and metal for temperatures up to* 212°.—For cementing glass tubes, necks of balloons, &c. into metal mountings, where the apparatus is to be exposed to heat, a mixture of equal parts of red- and white-lead is preferable to white-lead alone. If the cemented pieces, after the junctures are made, be placed for a few days on the sand-bath, the mixture becomes extremely hard. If possible, the glass should be roughened, and a little tow wrapped round the part where it is to be applied.

999. *Apparatus for obtaining the electric spark in damp rooms.*—The precautions necessary for obtaining an electric spark of sufficient power to inflame gaseous mixtures, have been alluded to in §§ 551 and 555. The electrophorus, which possesses certain advantages over the electrical machine, has been described in § 657. If, however, the room in which the experiments are made is both cold and damp (and such rooms are best adapted for researches on gases), we must adopt a different method of obtaining the spark*. For this purpose, a large porcelain tube, 3 feet long and $1\frac{1}{2}$ inch thick, is used as the substitute for an electrical machine. It is to be excited by rubbing with a piece of the best silk covered with amalgam. Only half of that portion of the silk in contact with the tube has amalgam on it.

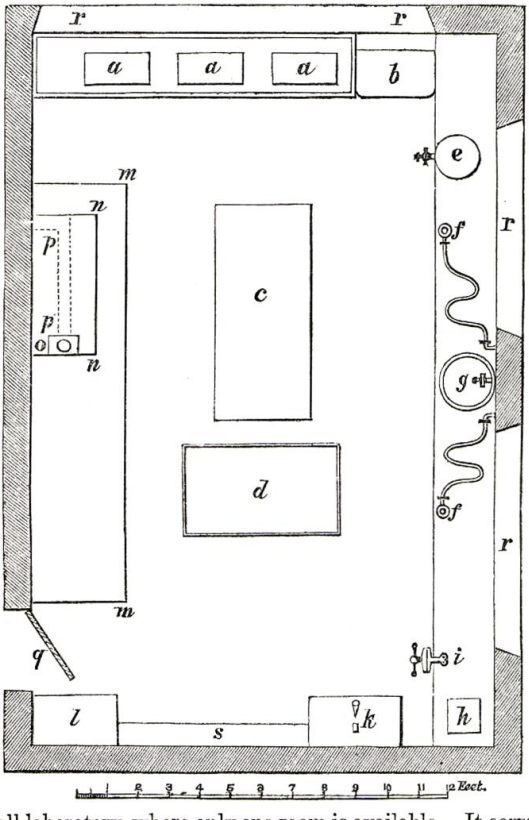
1000. The Leyden jar is made from a small cylinder about 3 inches high and 1 inch in diameter; the inside is covered with tinfoil in the

* BUNSEN.—Gasometry, p. 46.

usual manner, but the outer coating is made of platinum-foil to prevent amalgamation. To charge the jar, it is merely necessary to hold the porcelain tube in front of the iron wire with which it is mounted, and employ brisk friction with the silk and amalgam. Only a few seconds are required to obtain a sufficient charge. The amalgam is made by heating two parts of mercury with one part of thin zinc-foil, to which one part of zinc is added while stirring. It is to be melted, and stirred several times before being applied to the silk.

1001. *Explanation of figs.* 406 *and* 407.—Fig. 406 represents a plan

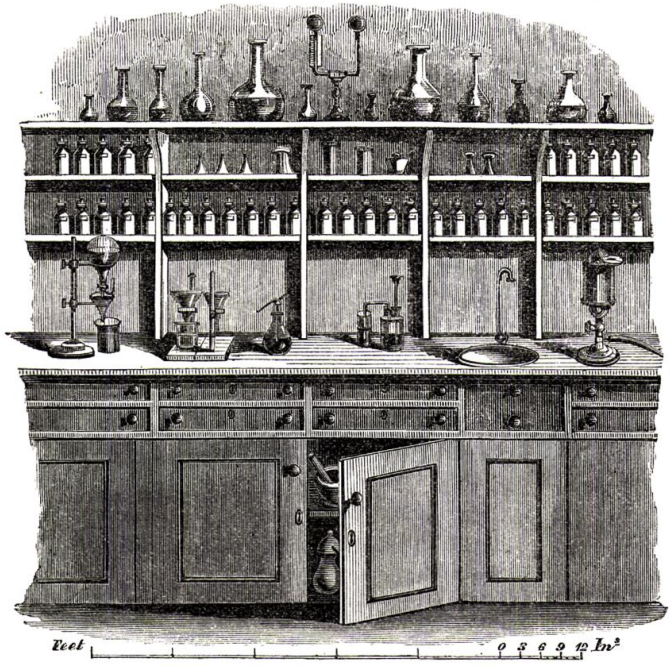
Fig. 406.



of a small laboratory, where only one room is available. It corresponds

in most points with the description given in § 1. One or two differences will be found, but these arise from the fact of the arrangement in the plan having been found more practically convenient. The three balances, *a a a*, are protected in the manner described in § 6. The desk, *b*, is placed close beside them, as that has been ascertained to be a more advantageous position than that alluded to in § 7. A large and heavy table, *c*, occupies a central position, while another, *d*, has a beading round it, to adapt it for experiments with the mercurial trough. The stoneware barrel, *e*, serves to hold distilled water (§ 8). Two gas-lights, *f f*, are attached by means of vulcanized india-rubber tubing with the gas-pipe. A porcelain basin, *g*, is sunk in the bench, and has a tap over it to supply common water. The basin has a plug

Fig. 407.



at the bottom, to enable the water to run away. The position of the water-bath (§ 12) is seen at *h*. A strong vice, *i*, is screwed to the

bench close to the blowpipe-table, *k*. A vapour or sulphuretted hydrogen closet is placed at *l*.

1002. A large hood, *m m*, covers a slightly raised brick flooring (§ 11), on which is placed a table-furnace *n n*; *p p* shows the direction of the flue beneath the sand-bath. The fireplace, and its rings (§ 29), are seen at *o*. The arrangement of the table-furnace is somewhat different from that seen in fig. 1, because the latter is intended to be adapted to a common fireplace. The entrance is seen at *q*. The windows are represented at *r r r r*.

Where the laboratory is attached to a University School of Medicine, or other place where the science is taught, a very different arrangement must be adopted. The room must be much larger; there must be a special chamber appropriated to the balances, and the working-benches should be fitted up in an entirely different manner. It will be proper to have the working places for the students at right angles to the windows, instead of parallel to them: each place should have a gas-light and a basin, with its tap for supplying water. It is convenient to have the tap rise a distance of about a foot from the table, and then bend down again in the manner seen in fig. 407, such an arrangement affording great facility for the filling of beakers, tall cylinders, &c. with water. The disposition of shelves, &c. in a student's working-bench, may be gathered from an inspection of fig. 407.

TABLE I.—For the Conversion of Degrees on the Centigrade Thermometer into Degrees of Fahrenheit's Scale.

Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
− 50°	−58°·0	−6°	21°·2	38°	100°·4	82°	179°·6
− 49	−56·2	−5	23·0	39	102·2	83	181·4
− 48	−54·4	−4	24·8	40	104·0	84	183·2
− 47	−52·6	−3	26·6	41	105·8	85	185·0
− 46	−50·8	−2	28·4	42	107·6	86	186·8
− 45	−49·0	−1	30·2	43	109·4	87	188·6
− 44	−47·2	0	32·0	44	111·2	88	190·4
− 43	−45·4	+1	33·8	45	113·0	89	192·2
− 42	−43·6	2	35·6	46	114·8	90	194·0
− 41	−41·8	3	37·4	47	116·6	91	195·8
− 40	−40·0	4	39·2	48	118·4	92	197·6
− 39	−38·2	5	41·0	49	120·2	93	199·4
− 38	−36·4	6	42·8	50	122·0	94	201·2
− 37	−34·6	7	44·6	51	123·8	95	203·0
− 36	−32·8	8	46·4	52	125·6	96	204·8
− 35	−30·0	9	48·2	53	127·4	97	206·6
− 34	−29·2	10	50·0	54	129·2	98	208·4
− 33	−27·4	11	51·8	55	131·0	99	210·2
− 32	−25·6	12	53·6	56	132·8	100	212·0
− 31	−23·8	13	55·4	57	134·6	101	213·8
− 30	−22·0	14	57·2	58	136·4	102	215·6
− 29	−20·2	15	59·0	59	138·2	103	217·4
− 28	−18·4	16	60·8	60	140·0	104	219·2
− 27	−16·6	17	62·6	61	141·8	105	221·0
− 26	−14·8	18	64·4	62	143·6	106	222·8
− 25	−13·0	19	66·2	63	145·4	107	224·6
− 24	−11·2	20	68·0	64	147·2	108	226·4
− 23	− 9·4	21	69·8	65	149·0	109	228·2
− 22	− 7·6	22	71·6	66	150·8	110	230·0
− 21	− 5·8	23	73·4	67	152·6	111	231·8
− 20	− 4·0	24	75·2	68	154·4	112	233·6
− 19	− 2·2	25	77·0	69	156·2	113	235·4
− 18	− 0·4	26	78·8	70	158·0	114	237·2
− 17	+ 1·4	27	80·6	71	159·8	115	239·0
− 16	3·2	28	82·4	72	161·6	116	240·8
− 15	5·0	29	84·2	73	163·4	117	242·6
− 14	6·8	30	86·0	74	165·2	118	244·4
− 13	8·6	31	87·8	75	167·0	119	246·2
− 12	10·4	32	89·6	76	168·8	120	248·0
− 11	12·2	33	91·4	77	170·6	121	249·8
− 10	14·0	34	93·2	78	172·4	122	251·6
− 9	15·8	35	95·0	79	174·2	123	253·4
− 8	17·6	36	95·8	80	176·0	124	255·2
− 7	19·4	37	98·6	81	177·8	125	257·0

TABLE I. (*continued.*)

Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
126°	258°8	175°	347°0	224°	435°2	273°	523°4
127	260·6	176	348·8	225	437·0	274	525·2
128	262·4	177	350·6	226	438·8	275	527·0
129	264·2	178	352·4	227	440·6	276	528·8
130	266·0	179	354·2	228	442·4	277	530·6
131	267·8	180	356·0	229	444·2	278	532·4
132	269·6	181	357·8	230	446·0	279	534·2
133	271·4	182	359·6	231	447·8	280	536·0
134	273·2	183	361·4	232	449·6	281	537·8
135	275·0	184	363·2	233	451·4	282	539·6
136	276·8	185	365·0	234	453·2	283	541·4
137	278·6	186	366·8	235	455·0	284	543·2
138	280·4	187	368·6	236	456·8	285	545·0
139	282·2	188	370·4	237	458·6	286	546·8
140	284·0	189	372·2	238	460·4	287	548·6
141	285·8	190	374·0	239	462·2	288	550·4
142	287·6	191	375·8	240	464·0	289	552·2
143	289·4	192	377·6	241	465·8	290	554·0
144	291·2	193	379·4	242	467·6	291	555·8
145	293·0	194	381·2	243	469·4	292	557·6
146	294·8	195	383·0	244	471·2	293	559·4
147	296·6	196	384·8	245	473·0	294	561·2
148	298·4	197	386·6	246	474·8	295	563·0
149	300·2	198	388·4	247	476·6	296	564·8
150	302·0	199	390·2	248	478·4	297	566·6
151	303·8	200	392·0	249	480·2	298	568·4
152	305·6	201	393·8	250	482·0	299	570·2
153	307·4	202	395·6	251	483·8	300	572·0
154	309·2	203	397·4	252	485·6	301	573·8
155	311·0	204	399·2	253	487·4	302	575·6
156	312·8	205	401·0	254	489·2	303	577·4
157	314·6	206	402·8	255	491·0	304	579·2
158	316·4	207	404·6	256	492·8	305	581·0
159	318·2	208	406·4	257	494·6	306	582·8
160	320·0	209	408·2	258	496·4	307	584·6
161	321·8	210	410·0	259	498·2	308	586·4
162	323·6	211	411·8	260	500·0	309	588·2
163	325·4	212	413·6	261	501·8	310	590·0
164	327·2	213	415·4	262	503·6	311	591·8
165	329·0	214	417·2	263	505·4	312	593·6
166	330·8	215	419·0	264	507·2	313	595·4
167	332·6	216	420·8	265	509·0	314	597·2
168	334·4	217	422·6	266	510·8	315	599·0
169	336·2	218	424·4	267	512·6	316	600·8
170	338·0	219	426·2	268	514·4	317	602·6
171	339·8	220	428·0	269	516·2	318	604·4
172	341·6	221	429·8	270	518·0	319	606·2
173	343·4	222	431·6	271	519·8	320	608·0
174	345·2	223	433·4	272	521·6		

TABLE II.—Elastic Force of Aqueous Vapour in inches of Mercury for Fahrenheit's Thermometer.

Temp. Fahr.	Force. Inches of Mercury.	Temp. Fahr.	Force. Inches of Mercury.	Temp. Fahr.	Force. Inches of Mercury.	Temp. Fahr.	Force. Inches of Mercury.
0	0·051	32	0·186	63	0·570	94	1·562
1	0·053	33	0·193	64	0·590	95	1·610
2	0·056	34	0·200	65	0·611	96	1·660
3	0·058	35	0·208	66	0·632	97	1·712
4	0·060	36	0·216	67	0·654	98	1·764
5	0·063	37	0·224	68	0·676	99	1·819
6	0·066	38	0·233	69	0·699	100	1·874
7	0·069	39	0·242	70	0·723	101	1·931
8	0·071	40	0·251	71	0·748	102	1·990
9	0·074	41	0·260	72	0·773	103	2·050
10	0·078	42	0·270	73	0·799	104	2·112
11	0·081	43	0·280	74	0·826	105	2·176
12	0·084	44	0·291	75	0·854	106	2·241
13	0·088	45	0·302	76	0·882	107	2·307
14	0·092	46	0·313	77	0·911	108	2·376
15	0·095	47	0·324	78	0·942	109	2·447
16	0·099	48	0·336	79	0·973	110	2·519
17	0·103	49	0·349	80	1·005	111	2·593
18	0·107	50	0·361	81	1·036	112	2·669
19	0·112	51	0·375	82	1·072	113	2·747
20	0·116	52	0·389	83	1·106	114	2·826
21	0·121	53	0·402	84	1·142	115	2·908
22	0·126	54	0·417	85	1·179	116	2·992
23	0·131	55	0·432	86	1·217	117	3·078
24	0·136	56	0·447	87	1·256	118	3·166
25	0·142	57	0·463	88	1·296	119	3·257
26	0·147	58	0·480	89	1·337	120	3·349
27	0·153	59	0·497	90	1·380	121	3·444
28	0·159	60	0·514	91	1·423	122	3·542
29	0·165	61	0·532	92	1·468	123	3·641
30	0·172	62	0·551	93	1·514	124	3·743
31	0·179						

TABLE V.—According to Magnus.

Degrees of the Mercurial Thermometer.	Degrees of the Air-thermometer.	Degrees of the Mercurial Thermometer.	Degrees of the Air-thermometer.
100	100·00	250	245·39
150	148·74	300	294·51
200	196·49	330	320·92

TABLE III.—Elastic Force of Aqueous Vapour in Millimetres of Mercury for Centigrade Thermometer.

Temperature. Cent.	Force of the Aqueous Vapour in Millimetres.	Temperature. Cent.	Force of the Aqueous Vapour in Millimetres.	Temperature. Cent.	Force of the Aqueous Vapour in Millimetres.	Temperature. Cent.	Force of the Aqueous Vapour in Millimetres.
0	4·525	11	9·751	22	19·675	33	37·473
1	4·867	12	10·421	23	20·909	34	39·630
2	5·231	13	11·130	24	22·211	35	41·893
3	5·619	14	11·882	25	23·582	36	44·268
4	6·032	15	12·677	26	25·026	37	46·758
5	6·471	16	13·519	27	26·547	38	49·368
6	6·939	17	14·409	28	28·148	39	52·103
7	7·436	18	15·351	29	29·832	40	54·969
8	7·964	19	16·345	30	31·602		
9	8·525	20	17·396	31	33·464		
10	9·126	21	18·505	32	35·419		

TABLE IV.—Comparison of the Degrees of the Mercurial with those of the Air-thermometer.—According to Regnault.

Air-thermometer.	Mercurial Thermometer.	Air-thermometer.	Mercurial Thermometer.
0	0	250	250·0
50	50·2	300	301·2
100	100·0	325	326·9
150	150·0	350	353·3
200	200·0		

[TABLE V.—*See* opposite page.]

TABLE VI.—According to Dulong and Petit.

Degrees of the Mercurial Thermometer.	Degrees of the Air-thermometer.	Degrees of the Mercurial Thermometer.	Degrees of the Air-thermometer.
105	104·8	220	216·2
110	109·6	230	225·9
120	119·5	240	235·4
130	129·2	250	245·0
140	139·0	260	254·6
150	148·7	270	264·0
160	158·4	280	273·5
170	168·0	290	283·2
180	177·7	300	292·7
190	187·4	320	311·6
200	197·0	340	330·5
210	206·7	350	340·0

TABLE VII.—Correction to be applied to Barometers with *brass scales*, extending from the cistern to the top of the mercurial column, to reduce the observation to 32° Fahrenheit.

Temp.	Inches.																Temp.
	20	20·5	21	21·5	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27	27·5	
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
°																	°
0	·051	·053	·054	·055	·056	·058	·059	·060	·061	·063	·064	·065	·067	·068	·069	·071	0
1	·049	·051	·052	·053	·054	·056	·057	·058	·059	·061	·062	·063	·064	·065	·067	·068	1
2	·048	·049	·050	·051	·052	·054	·055	·056	·057	·058	·060	·061	·062	·063	·064	·066	2
3	·046	·047	·048	·049	·050	·052	·053	·054	·055	·056	·057	·059	·060	·061	·062	·063	3
4	·044	·045	·046	·047	·048	·050	·051	·052	·053	·054	·055	·056	·057	·058	·059	·061	4
5	·042	·043	·044	·045	·046	·048	·049	·050	·051	·052	·053	·054	·055	·056	·057	·058	5
6	·040	·042	·042	·044	·044	·046	·047	·048	·049	·050	·051	·052	·053	·054	·055	·056	6
7	·039	·040	·041	·042	·042	·044	·044	·046	·046	·047	·048	·049	·050	·051	·052	·053	7
8	·037	·038	·039	·040	·041	·041	·042	·043	·044	·045	·046	·047	·048	·049	·050	·051	8
9	·035	·036	·037	·038	·039	·039	·040	·041	·042	·043	·044	·045	·046	·046	·047	·048	9
10	·033	·034	·035	·036	·037	·037	·038	·039	·040	·041	·042	·042	·043	·044	·045	·046	10
11	·031	·032	·033	·034	·035	·035	·036	·037	·038	·039	·039	·040	·041	·042	·042	·043	11
12	·030	·030	·031	·032	·033	·033	·034	·035	·036	·036	·037	·038	·039	·039	·040	·041	12
13	·028	·029	·029	·030	·031	·031	·032	·033	·033	·034	·035	·036	·036	·037	·038	·038	13
14	·026	·027	·027	·028	·029	·029	·030	·031	·031	·032	·033	·033	·034	·035	·035	·036	14
15	·024	·025	·026	·026	·027	·027	·028	·029	·029	·030	·030	·031	·032	·032	·033	·033	15
16	·022	·023	·024	·024	·025	·025	·026	·026	·027	·028	·028	·029	·029	·030	·030	·031	16
17	·021	·021	·022	·022	·023	·023	·024	·024	·025	·025	·026	·026	·027	·027	·028	·028	17
18	·019	·019	·020	·020	·021	·021	·022	·022	·023	·023	·024	·024	·025	·025	·025	·026	18
19	·017	·018	·018	·018	·019	·019	·020	·020	·021	·021	·021	·022	·022	·023	·023	·024	19
20	·015	·016	·016	·016	·017	·017	·018	·018	·018	·019	·019	·020	·020	·020	·021	·021	20

21	·014	·014	·014	·015	·015	·015	·015	·016	·016	·017	·017	·017	·018	·018	·018	·019	21
22	·012	·012	·012	·013	·013	·013	·013	·014	·014	·014	·015	·015	·015	·016	·016	·016	22
23	·010	·010	·010	·011	·011	·011	·011	·012	·012	·012	·012	·013	·013	·013	·013	·014	23
24	·008	·008	·009	·009	·009	·009	·009	·010	·010	·010	·010	·010	·011	·011	·011	·011	24
25	·006	·007	·007	·007	·007	·007	·007	·007	·008	·008	·008	·008	·008	·008	·009	·009	25
26	·005	·005	·005	·005	·005	·005	·005	·005	·005	·006	·006	·006	·006	·006	·006	·006	26
27	·003	·003	·003	·003	·003	·003	·003	·003	·003	·003	·003	·003	·004	·004	·004	·004	27
28	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	28
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
29	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	·001	29
30	·003	·003	·003	·003	·003	·003	·003	·003	·003	·003	·003	·004	·004	·004	·004	·004	30
31	·005	·005	·005	·005	·005	·005	·005	·005	·005	·006	·006	·006	·006	·006	·006	·006	31
32	·006	·006	·007	·007	·007	·007	·007	·007	·008	·008	·008	·008	·008	·008	·008	·009	32
33	·008	·008	·008	·009	·009	·009	·009	·010	·010	·010	·010	·010	·011	·011	·011	·011	33
34	·010	·010	·010	·011	·011	·011	·011	·012	·012	·012	·012	·013	·013	·013	·013	·014	34
35	·012	·012	·012	·013	·013	·013	·013	·014	·014	·014	·015	·015	·015	·015	·016	·016	35
36	·013	·014	·014	·014	·015	·015	·016	·016	·016	·017	·017	·017	·017	·018	·018	·019	36
37	·015	·016	·016	·016	·017	·017	·018	·018	·018	·019	·019	·019	·020	·020	·021	·021	37
38	·017	·017	·018	·018	·019	·019	·020	·020	·020	·021	·021	·022	·022	·023	·023	·023	38
39	·019	·019	·020	·020	·021	·021	·022	·022	·023	·023	·024	·024	·024	·025	·025	·026	39
40	·021	·021	·022	·022	·023	·023	·024	·024	·025	·025	·026	·026	·027	·027	·028	·028	40
41	·022	·023	·024	·024	·025	·025	·026	·026	·027	·027	·028	·029	·029	·030	·030	·031	41
42	·024	·025	·025	·026	·027	·027	·028	·028	·029	·030	·030	·031	·031	·032	·033	·033	42
43	·026	·027	·027	·028	·029	·029	·030	·031	·031	·032	·032	·033	·034	·034	·035	·036	43
44	·028	·029	·029	·030	·031	·031	·032	·033	·033	·034	·035	·035	·036	·037	·037	·038	44
45	·030	·030	·031	·032	·033	·033	·034	·035	·035	·036	·037	·038	·038	·039	·040	·041	45
46	·031	·032	·033	·034	·035	·035	·036	·037	·038	·038	·039	·040	·041	·042	·042	·043	46
47	·033	·034	·035	·036	·036	·037	·038	·039	·040	·041	·041	·042	·043	·044	·045	·046	47
48	·035	·036	·037	·038	·038	·039	·040	·041	·042	·043	·044	·045	·045	·046	·047	·048	48
49	·037	·038	·039	·040	·040	·041	·042	·043	·044	·045	·046	·047	·048	·049	·050	·050	49
50	·038	·039	·040	·041	·042	·043	·044	·045	·046	·047	·048	·049	·050	·051	·052	·053	50

TABLE VII. (*continued.*)

Temp.	Inches.																Temp.
	20	20·5	21	21·5	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27	27·5	
51°	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	51°
52	·040	·041	·042	·043	·044	·045	·046	·047	·048	·049	·050	·051	·052	·053	·054	·055	52
53	·042	·043	·044	·045	·046	·047	·048	·049	·050	·052	·053	·054	·055	·056	·057	·058	53
54	·044	·045	·046	·047	·048	·049	·050	·052	·053	·054	·055	·056	·057	·058	·059	·060	54
55	·046	·047	·048	·049	·050	·051	·052	·054	·055	·056	·057	·058	·059	·060	·062	·063	55
56	·047	·049	·050	·051	·052	·053	·055	·056	·057	·058	·059	·060	·062	·063	·064	·065	56
57	·049	·050	·052	·053	·054	·055	·057	·058	·059	·060	·061	·063	·064	·065	·066	·068	57
58	·051	·052	·054	·055	·056	·057	·059	·060	·061	·062	·064	·065	·066	·068	·069	·070	58
59	·053	·054	·055	·057	·058	·059	·061	·062	·063	·065	·066	·067	·069	·070	·071	·073	59
60	·055	·056	·057	·059	·060	·061	·063	·064	·065	·067	·068	·070	·071	·072	·074	·075	60
61	·056	·058	·059	·061	·062	·063	·065	·066	·068	·069	·070	·072	·073	·075	·076	·077	61
62	·058	·060	·061	·062	·064	·065	·067	·068	·070	·071	·073	·074	·075	·077	·078	·080	62
63	·060	·061	·063	·064	·066	·067	·069	·070	·072	·073	·075	·076	·078	·079	·081	·082	63
64	·062	·063	·065	·066	·068	·069	·071	·072	·074	·076	·077	·079	·080	·082	·083	·085	64
65	·063	·065	·067	·068	·070	·071	·073	·075	·076	·078	·079	·081	·082	·084	·086	·087	65
66	·065	·067	·068	·070	·072	·073	·075	·077	·078	·080	·082	·083	·085	·086	·088	·090	66
67	·067	·069	·070	·072	·074	·075	·077	·079	·080	·082	·084	·085	·087	·089	·090	·092	67
68	·069	·071	·072	·074	·076	·077	·079	·081	·083	·084	·086	·088	·089	·091	·093	·095	68
69	·071	·072	·074	·076	·078	·079	·081	·083	·085	·086	·088	·090	·092	·094	·095	·097	69
70	·072	·074	·076	·078	·080	·081	·083	·085	·087	·089	·090	·092	·094	·096	·098	·100	70
	·074	·076	·078	·080	·082	·083	·085	·087	·089	·091	·093	·095	·096	·098	·100	·102	

71	·076	·078	·080	·082	·083	·085	·087	·089	·091	·093	·095	·097	·099	·101	·102	·104	71
72	·078	·080	·082	·084	·085	·087	·089	·091	·093	·095	·097	·099	·101	·103	·105	·107	72
73	·079	·081	·083	·085	·087	·089	·091	·093	·095	·097	·099	·101	·103	·105	·107	·109	73
74	·081	·083	·085	·087	·089	·091	·093	·095	·097	·099	·102	·104	·106	·108	·110	·112	74
75	·083	·085	·087	·089	·091	·093	·095	·098	·100	·102	·104	·106	·108	·110	·112	·114	75
76	·085	·087	·089	·091	·093	·095	·097	·100	·102	·104	·106	·108	·110	·112	·114	·117	76
77	·087	·089	·091	·093	·095	·097	·100	·102	·104	·106	·108	·110	·112	·115	·117	·119	77
78	·088	·091	·093	·095	·097	·099	·102	·104	·106	·108	·110	·113	·115	·117	·119	·122	78
79	·090	·092	·095	·097	·099	·101	·104	·106	·108	·110	·113	·115	·117	·119	·122	·124	79
80	·092	·094	·096	·099	·101	·103	·106	·108	·110	·113	·115	·117	·119	·122	·124	·126	80
81	·094	·096	·098	·101	·103	·105	·108	·110	·112	·115	·117	·119	·122	·124	·126	·129	81
82	·095	·098	·100	·103	·105	·107	·110	·112	·114	·117	·119	·122	·124	·126	·129	·131	82
83	·097	·100	·102	·104	·107	·109	·112	·114	·117	·119	·121	·124	·126	·129	·131	·134	83
84	·099	·101	·104	·106	·109	·111	·114	·116	·119	·121	·124	·126	·129	·131	·134	·136	84
85	·101	·103	·106	·108	·111	·113	·116	·118	·121	·123	·126	·128	·131	·133	·136	·139	85
86	·103	·105	·108	·110	·113	·115	·118	·120	·123	·126	·128	·131	·133	·136	·138	·141	86
87	·104	·107	·109	·112	·115	·117	·120	·123	·125	·128	·130	·133	·136	·138	·141	·143	87
88	·106	·109	·111	·114	·117	·119	·122	·125	·127	·130	·133	·135	·138	·141	·143	·146	88
89	·108	·111	·113	·116	·119	·121	·124	·127	·129	·132	·135	·137	·140	·143	·146	·148	89
90	·110	·112	·115	·118	·121	·123	·126	·129	·131	·134	·137	·140	·142	·145	·148	·151	90
91	·111	·114	·117	·120	·122	·125	·128	·131	·134	·136	·139	·142	·145	·148	·150	·153	91
92	·113	·116	·119	·122	·124	·127	·130	·133	·136	·139	·141	·144	·147	·150	·153	·156	92
93	·115	·118	·121	·124	·126	·129	·132	·135	·138	·141	·144	·147	·149	·152	·155	·158	93
94	·117	·120	·122	·125	·128	·131	·134	·137	·140	·143	·146	·149	·152	·155	·157	·161	94
95	·118	·121	·124	·127	·130	·133	·136	·139	·142	·145	·148	·151	·154	·157	·160	·163	95
96	·120	·123	·126	·129	·132	·135	·138	·141	·144	·147	·150	·153	·156	·159	·162	·165	96
97	·122	·125	·128	·131	·134	·137	·140	·143	·146	·149	·152	·156	·159	·162	·165	·168	97
98	·124	·127	·130	·133	·136	·139	·142	·145	·148	·152	·155	·158	·161	·164	·167	·170	98
99	·125	·129	·132	·135	·138	·141	·144	·147	·151	·154	·157	·160	·163	·166	·169	·173	99
100	·127	·130	·134	·137	·140	·143	·146	·150	·153	·156	·159	·162	·165	·169	·172	·175	100

TABLE VII. (*continued.*)

Temp.	Inches.							Temp.	Inches.						
	28	28·5	29	29·5	30	35·5	31		28	28·5	29	29·5	30	30·5	31
	+	+	+	+	+	+	+		−	−	−	−	−	−	−
0°	·072	·073	·074	·076	·077	·078	·080	51°	·056	·057	·058	·059	·060	·061	·062
1	·069	·071	·072	·073	·074	·076	·077	52	·059	·060	·061	·062	·063	·064	·065
2	·067	·068	·069	·070	·072	·073	·074	53	·061	·063	·064	·065	·066	·067	·068
3	·064	·065	·067	·068	·069	·070	·071	54	·064	·065	·066	·067	·068	·070	·071
4	·062	·063	·064	·065	·066	·067	·068	55	·066	·068	·069	·070	·071	·072	·073
5	·059	·060	·061	·062	·063	·065	·066	56	·069	·070	·071	·073	·074	·075	·076
6	·057	·058	·059	·060	·061	·062	·063	57	·071	·073	·074	·075	·076	·078	·079
7	·054	·055	·056	·057	·058	·059	·060	58	·074	·075	·077	·078	·079	·081	·082
8	·052	·053	·054	·054	·055	·056	·057	59	·076	·078	·079	·080	·082	·083	·085
9	·049	·050	·051	·052	·053	·054	·054	60	·079	·080	·082	·083	·085	·086	·087
10	·047	·047	·048	·049	·050	·051	·052	61	·081	·083	·084	·086	·087	·089	·090
11	·044	·045	·046	·046	·047	·048	·049	62	·084	·085	·087	·088	·090	·091	·093
12	·042	·042	·043	·044	·045	·045	·046	63	·086	·088	·089	·091	·093	·094	·096
13	·039	·040	·040	·041	·042	·043	·043	64	·089	·090	·092	·094	·095	·097	·098
14	·037	·037	·038	·038	·039	·040	·040	65	·091	·093	·095	·096	·098	·100	·101
15	·034	·035	·035	·036	·036	·037	·038	66	·094	·096	·097	·099	·101	·102	·104
16	·032	·032	·033	·033	·034	·034	·035	67	·096	·098	·100	·102	·103	·105	·107
17	·029	·030	·030	·031	·031	·032	·032	68	·099	·101	·102	·104	·106	·108	·109
18	·026	·027	·027	·028	·028	·029	·029	69	·101	·103	·105	·107	·109	·110	·112
19	·024	·024	·025	·025	·026	·026	·027	70	·104	·106	·108	·109	·111	·113	·115
20	·021	·022	·022	·023	·023	·023	·024								

21	·019	·019	·020	·020	·020	·021	·021	71	·106	·108	·110	·112	·114	·116	·118
22	·016	·017	·017	·017	·018	·018	·018	72	·109	·111	·113	·115	·117	·119	·120
23	·014	·014	·014	·015	·015	·015	·015	73	·111	·113	·115	·117	·119	·121	·123
24	·011	·012	·012	·012	·012	·012	·013	74	·114	·116	·118	·120	·122	·124	·126
25	·009	·009	·009	·009	·009	·010	·010	75	·116	·118	·120	·122	·125	·127	·129
26	·006	·006	·007	·007	·007	·007	·007	76	·119	·121	·123	·125	·127	·129	·131
27	·004	·004	·004	·004	·004	·004	·004	77	·121	·123	·126	·128	·130	·132	·134
28	·001	·001	·001	·001	·001	·001	·001	78	·124	·126	·128	·130	·133	·135	·137
	—	—	—	—	—	—	—	79	·126	·128	·131	·133	·135	.137	·140
29	·001	·001	·001	·001	·001	·001	·001	80	·129	·131	·133	·136	·138	·140	·143
30	·004	·004	·004	·004	·004	·004	·004								
								81	·131	·134	·136	·138	·141	·143	·145
31	·006	·006	·007	·007	·007	·007	·007	82	·134	·136	·138	·141	·143	·146	·148
32	·009	·009	·009	·009	·009	·010	·010	83	·136	·139	·141	·143	·146	·148	·151
33	·011	·012	·012	·012	·012	·012	·012	84	·139	·141	·144	·146	·149	·151	·154
34	·014	·014	·014	·015	·015	·015	·015	85	·141	·144	·146	·149	·151	·154	·156
35	·016	·017	·017	·017	·018	·018	·018								
								86	·144	·146	·149	·151	·154	·156	·159
36	·019	·019	·020	·020	·020	·021	·021	87	·146	·149	·151	·154	·157	·159	·162
37	·021	·022	·022	·022	·023	·023	·024	88	·149	·151	·154	·157	·159	·162	·165
38	·024	·024	·025	·025	·026	·026	·026	89	·151	·154	·156	·159	·162	·165	·167
39	·026	·027	·027	·028	·028	·029	·029	90	·153	·156	·159	·162	·164	·167	·170
40	·029	·029	·030	·030	·031	·031	·032								
								91	·156	·159	·162	·165	·167	·170	·173
41	·031	·032	·033	·033	·034	·034	·035	92	·158	.161	·164	·167	·170	·172	·175
42	·034	·034	·035	·036	·036	·037	·037	93	·161	·164	·167	·170	·172	·175	·178
43	·036	·037	·038	·038	·039	·040	·040	94	·163	·166	·169	·172	·175	·177	·180
44	·039	·040	·040	·041	·042	·042	·043	95	·166	·169	·172	·175	·178	·180	·183
45	·041	·042	·043	·044	·044	·045	·046								
								96	·168	·171	·174	·178	·181	·183	·186
46	·044	·045	·045	·046	·047	·048	·049	97	·171	·174	·177	·180	·183	·186	·189
47	·046	·047	·048	·049	·050	·151	·051	98	·173	·176	·179	·183	·186	·188	·191
48	·049	·050	·051	·052	·052	·053	·054	99	·176	·179	·182	·185	·188	·191	·194
49	·051	·052	·053	·054	·055	·056	·057	100	·178	·181	·184	·188	·191	·194	·197
50	·054	·055	·056	·057	·058	·059	·060								

TABLE VIII.—Correction to be applied to Barometers, the scales of which are engraved on *glass*, to reduce the observations to 32° Fahr.

Temp.	Inches. 28·0.	Inches. 28·5.	Inches. 29·0.	Inches. 29·5.	Inches. 30·0.	Inches. 30·5.	Inches. 31·0.	Inches. 31·5.
25	+·017	+·017	+·017	+·018	+·018	+·018	+·019	+·019
30	+·005	+·005	+·005	+·005	+·005	+·005	+·005	+·005
35	−·007	−·007	−·007	−·008	−·008	−·008	−·008	−·008
40	−·019	−·020	−·020	−·020	−·021	−·021	−·021	−·022
45	−·031	−·032	−·032	−·033	−·033	−·034	−·035	−·036
50	−·043	−·044	−·045	−·046	−·046	−·047	−·048	−·049
55	−·055	−·056	−·057	−·058	−·059	−·060	−·061	−·062
60	−·067	−·068	−·069	−·071	−·072	−·074	−·075	−·076
65	−·079	−·081	−·082	−·083	−·085	−·086	−·088	−·089
70	−·091	−·093	−·094	−·096	−·098	−·100	−·101	−·103
75	−·103	−·105	−·106	−·109	−·111	−·114	−·116	−·118

TABLE IX.—Correction to be added to Barometers for Capillary Action.

Diameter of Tube.	Correction for	
	Unboiled Tubes.	Boiled Tubes.
inch.	inch.	inch.
0·60	0·004	0·002
0·50	0·007	0·003
0·45	0·010	0·005
0·40	0·014	0·007
0·35	0·020	0·010
0·30	0·028	0·014
0·25	0·040	0·020
0·20	0·060	0·029
0·15	0·088	0·044
0·10	0·142	0·070

TABLE X.

Grms.	Grains.	Deci-grms.	Grains.
1	15·4346	1	1·5434
2	30·8692	2	3·0869
3	46·3038	3	4·6304
4	61·7384	4	6·1738
5	77·1730	5	7·7173
6	92·6076	6	9·2607
7	108·0422	7	10·8042
8	123·4768	8	12·3476
9	138·9114	9	13·8911

TABLE XI.

Centi-grammes.	Grains.	Milli-grammes.	Grains.
1	·1543	1	·0154
2	·3086	2	·0308
3	·4630	3	·0463
4	·6173	4	·0617
5	·7717	5	·0771
6	·9260	6	·0926
7	1·0804	7	·1080
8	1·2347	8	·1234
9	1·3891	9	·1389

TABLE XII.—For conversion of millimetres into inches, and inches into millimetres.

Inches into millimetres.	1 25·39954	2 50·79908	3 76·19862	4 101·5982	5 126·9977	6 152·3972	7 177·7968	8 203·1963	9 228·5959
Millimetres into inches.	·03937079	·07874158	·11811237	·15748316	·19685395	·23622474	·27559553	·31496632	·35433711

TABLE XIII.

One kilogramme . . . . 15434 grains.	One pound avoirdupois . . 7000 grains.
One cubic centimetre . . . 0·0610 cubic inch.	One ounce avoirdupois . . 437·5 grains.
One litre . . . . . 61·0271 cubic inches	One pound troy . . . . 5760·0 grains.

One ounce troy 480·0 grains.

TABLE XIV.—Boiling-points of water at different pressures.

Boiling-point. °Fahr.	Barometer. Inches.	Boiling-point. °Fahr.	Barometer. Inches.	Boiling-point. °Fahr.	Barometer. Inches.
184	16·676	195	21·124	206	26·529
185	17·047	196	21·576	207	27·068
186	17·421	197	22·030	208	27·614
187	17·803	198	22·498	209	28·183
188	18·196	199	22·965	210	28·744
189	18·593	200	23·454	211	29·331
190	18·992	201	23·937	212	29·922
191	19·407	202	24·441	213	30·516
192	19·822	203	25·014	214	31·120
193	20·254	204	25·468	215	31·730
194	20·687	205	25·992		

TABLE XV.—Expansion of gases by heat (Regnault). Between 30° and 212° F. 1000 parts become

Hydrogen	1366·13
Carbonic oxide . . .	1366·88
Atmospheric air . . .	1367·06
Nitrogen	1366·82
Hydrochloric acid . .	1368·12
Carbonic acid	1370·99
Protoxide of nitrogen .	1371·95
Cyanogen	1387·67
Sulphurous acid . . .	1390·28

XVI.

TABLES showing the Specific Gravity of Liquids at the temperature of 55° F., corresponding to the degrees of Beaumé's Hydrometer.

For Liquids lighter than water.

Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.
10 =	1·000	17 =	0·949	23 =	0·909	29 =	0·874	35 =	0·842
11	0·990	18	0·942	24	0·903	30	0·867	36	0·837
12	0·985	19	0·935	25	0·897	31	0·861	37	0·832
13	0·977	20	0·923	26	0·892	32	0·856	38	0·827
14	0·970	21	0·922	27	0·886	33	0·852	39	0·822
15	0·963	22	0·915	28	0·880	34	0·847	40	0·817
16	0·955								

For Liquids heavier than water.

Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.
0 =	1·000	15 =	1·114	30 =	1·261	45 =	1·455	60 =	1·717
3	1·020	18	1·140	33	1·295	48	1·500	63	1·779
6	1·040	21	1·170	36	1·333	51	1·547	66	1·848
9	1·064	24	1·200	39	1·373	54	1·594	69	1·920
12	1·089	27	1·230	42	1·414	57	1·659	72	2·000

TABLE XVII.—Weight of one cubic centimetre of atmospheric air at different temperatures from 0° to 300° C. (grammes).

0°	0·001293						
1	0·001288	21°	0·001201	41°	0·001124	61°	0·001057
2	0·001284	22	0·001197	42	0·001121	62	0·001053
3	0·001279	23	0·001193	43	0·001118	63	0·001050
4	0·001275	24	0·001189	44	0·001114	64	0·001047
5	0·001270	25	0·001185	45	0·001111	65	0·001044
6	0·001266	26	0·001181	46	0·001108	66	0·001041
7	0·001261	27	0·001177	47	0·001105	67	0·001038
8	0·001257	28	0·001173	48	0·001102	68	0·001035
9	0·001252	29	0·001169	49	0·001098	69	0·001032
10	0·001248	30	0·001165	50	0·001095	70	0·001029
11	0·001243	31	0·001161	51	0·001091	71	0·001026
12	0·001239	32	0·001157	52	0·001088	72	0·001023
13	0·001234	33	0·001154	53	0·001084	73	0·001020
14	0·001230	34	0·001150	54	0·001081	74	0·001017
15	0·001225	35	0·001146	55	0·001077	75	0·001014
16	0·001221	36	0·001142	56	0·001074	76	0·001011
17	0·001217	37	0·001138	57	0·001070	77	0·001008
18	0·001213	38	0·001134	58	0·001067	78	0·001005
19	0·001209	39	0·001131	59	0·001063	79	0·001002
20	0·001205	40	0·001128	60	0·001060	80	0·001000

TABLE XVII. (*continued.*)

81°	0·000997	126°	0·000884	171°	0·000794	216°	0·000721
82	0·000994	127	0·000882	172	0·000793	217	0·000719
83	0·000992	128	0·000880	173	0·000791	218	0·000718
84	0·000989	129	0·000878	174	0·000789	219	0·000716
85	0·000986	130	0·000876	175	0·000788	220	0·000715
86	0·000983	131	0·000874	176	0·000786	221	0·000713
87	0·000980	132	0·000871	177	0·000784	222	0·000712
88	0·000977	133	0·000869	178	0·000782	223	0·000710
89	0·000974	134	0·000867	179	0·000781	224	0·000709
90	0·000972	135	0·000865	180	0·000779	225	0·000708
91	0·000969	136	0·000863	181	0·000777	226	0·000706
92	0·000967	137	0·000860	182	0·000776	227	0·000705
93	0·000964	138	0·000858	183	0·000774	228	0·000703
94	0·000962	139	0·000856	184	0·000772	229	0·000702
95	0·000959	140	0·000854	185	0·000770	230	0·000701
96	0·000956	141	0·000852	186	0·000769	231	0·000699
97	0·000953	142	0·000850	187	0·000767	232	0·000698
98	0·000951	143	0·000848	188	0·000765	233	0·000697
99	0·000948	144	0·000846	189	0·000763	234	0·000695
100	0·000946	145	0·000844	190	0·000762	235	0·000694
101	0·000943	146	0·000842	191	0·000760	236	0·000692
102	0·000941	147	0·000840	192	0·000758	237	0·000691
103	0·000938	148	0·000838	193	0·000757	238	0·000690
104	0·000936	149	0·000836	194	0·000755	239	0·000689
105	0·000933	150	0·000834	195	0·000754	240	0·000688
106	0·000931	151	0·000832	196	0·000752	241	0·000686
107	0·000928	152	0·000830	197	0·000751	242	0·000685
108	0·000926	153	0·000828	198	0·000749	243	0·000683
109	0·000923	154	0·000826	199	0·000748	244	0·000682
110	0·000921	155	0·000824	200	0·000746	245	0·000681
111	0·000919	156	0·000822	201	0·000744	246	0·000679
112	0·000916	157	0·000821	202	0·000743	247	0·000678
113	0·000914	158	0·000819	203	0·000740	248	0·000677
114	0·000911	159	0·000817	204	0·000739	249	0·000675
115	0·000909	160	0·000815	205	0·000737	250	0·000674
116	0·000907	161	0·000813	206	0·000736	251	0·000673
117	0·000905	162	0·000811	207	0·000734	252	0·000672
118	0·000903	163	0·000809	208	0·000733	253	0·000670
119	0·000900	164	0·000807	209	0·000731	254	0·000669
120	0·000898	165	0·000806	210	0·000730	255	0·000668
121	0·000896	166	0·000804	211	0·000728	256	0·000666
122	0·000894	167	0·000802	212	0·000727	257	0·000665
123	0·000891	168	0·000800	213	0·000725	258	0·000664
124	0·000889	169	0·000798	214	0·000724	259	0·000663
125	0·000887	170	0·000796	215	0·000722	260	0·000662

TABLE XVII. (*continued.*)

26°	0·000660	27°	0·000648	28°	0·000636	29°	0·000625
262	0·000659	272	0·000647	282	0·000635	292	0·000624
263	0·000658	273	0·000646	283	0·000634	293	0·000623
264	0·000657	274	0·000645	284	0·000633	294	0·000622
265	0·000655	275	0·000643	285	0·000631	295	0·000621
266	0·000654	276	0·000642	286	0·000630	296	0·000620
267	0·000653	277	0·000641	287	0·000629	297	0·000619
268	0·000652	278	0·000640	288	0·000628	298	0·000618
269	0·000651	279	0·000639	289	0·000627	299	0·000617
270	0·000650	280	0·000638	290	0·000626	300	0·000616

TABLE XVIII.—Specific Gravity and Absolute Weight of several Gases.

	Specific gravity: atmospheric air = 1·0000.	One litre (1000 cubic centimetres) of gas at 0° C. and 0·76 metre bar. pressure weight. Grammes.
Atmospheric air	1·0000	1·29363
Oxygen	1·10563	1·43028
Hydrogen	0·06910	0·08939
Water, vapour of	0·62192	0·80453
Carbon, vapour of	0·82922	1·07270
Carbonic acid	1·52024	1·96663
Carbonic oxide	0·96743	1·25150
Phosphorus, vapour of	4·33452	5·60727
Sulphur, vapour of	6·63378	8·58165
Hydrosulphuric acid	1·17475	1·51969
Iodine, vapour of	8·76760	11·34203
Bromine, vapour of	5·52605	7·14866
Chlorine	2·45052	3·17007
Nitrogen	0·96776	1·25192
Ammonia	0·58753	0·76005

TABLE XIX.—Showing the Quantity of Absolute Alcohol in Spirits of different Specific Gravities, according to Lowitz.

100 Parts.		Specific Gravity.		100 Parts.		Specific Gravity.	
Alcohol.	Water.	At 68°.	At 60°.	Alcohol.	Water.	At 68°.	At 60°.
100	0	0·791	0·796	95	5	0·805	0·809
99	1	0·794	0·798	94	6	0·808	0·812
98	2	0·797	0·801	93	7	0·811	0·815
97	3	0·800	0·804	92	8	0·813	0·817
96	4	0·803	0·807	91	9	0·816	0·820

TABLE XIX. (*continued.*)

100 Parts.		Specific Gravity.		100 Parts.		Specific Gravity.	
Alcohol.	Water.	At 68°.	At 60°.	Alcohol.	Water.	At 68°.	At 60°.
90	10	0·818	0·822	44	56	0·927	0·930
89	11	0·821	0·825	43	57	0·930	0·933
88	12	0·823	0·827	42	58	0·932	0·935
87	13	0·826	0·830	41	59	0·934	0·937
86	14	0·828	0·832	40	60	0·936	0·939
85	15	0·831	0·835	39	61	0·938	0·941
84	16	0·834	0·838	38	62	0·940	0·943
83	17	0·836	0·840	37	63	0·942	0·945
82	18	0·839	0·843	36	64	0·944	0·947
81	19	0·842	0·846	35	65	0·946	0·949
80	20	0·844	0·848	34	66	0·948	0·951
79	21	0·847	0·851	33	67	0·950	0·953
78	22	0·849	0·853	32	68	0·952	0·955
77	23	0·851	0·855	31	69	0·954	0·957
76	24	0·853	0·857	30	70	0·956	0·958
75	25	0·856	0·860	29	71	0·957	0·960
74	26	0·859	0·863	28	72	0·959	0·962
73	27	0·861	0·865	27	73	0·961	0·963
72	28	0·863	0·867	26	74	0·963	0·965
71	29	0·866	0·870	25	75	0·965	0·967
70	30	0·868	0·872	24	76	0·966	0·968
69	31	0·870	0·874	23	77	0·968	0·970
68	32	0·872	0·875	22	78	0·970	0·972
67	33	0·875	0·879	21	79	0·971	0·973
66	34	0·877	0·881	20	80	0·973	0·974
65	35	0·880	0·883	19	81	0·974	0·975
64	36	0·882	0·886	18	82	0·976	0·977
63	37	0·885	0·889	17	83	0·977	0·978
62	38	0·887	0·891	16	84	0·978	0·979
61	39	0·889	0·893	15	85	0·980	0·981
60	40	0·892	0·896	14	86	0·981	0·982
59	41	0·894	0·898	13	87	0·983	0·984
58	42	0·896	0·900	12	88	0·985	0·986
57	43	0·899	0·902	11	89	0·986	0·987
56	44	0·901	0·904	10	90	0·987	0·988
55	45	0·903	0·906	9	91	0·988	0·989
54	46	0·905	0·908	8	92	0·989	0·990
53	47	0·907	0·910	7	93	0·991	0·991
52	48	0·909	0·912	6	94	0·992	0·992
51	49	0·912	0·915	5	95	0·994	
50	50	0·914	0·917	4	96	0·995	
49	51	0·917	0·920	3	97	0·997	
48	52	0·919	0·922	2	98	0·998	
47	53	0·921	0·924	1	99	0·999	
46	54	0·923	0·926	0	100	1·000	
45	55	0·925	0·928				

TABLE XX.—Showing the Quantity of Absolute Alcohol by Weight in Mixtures of Alcohol and Water of different Specific Gravities, according to Mr. Drinkwater.

Sp. Gr. at 60° Fahr.	Alcohol per cent. byweight.	Sp. Gr. at 60° Fahr.	Alcohol per cent. byweight.	Sp. Gr. at 60° Fahr.	Alcohol per cent. byweight.	Sp. Gr. at 60° Fahr.	Alcohol per cent. byweight.
1·0000	0·00	·9959	2·22	·9918	4·64	·9877	7·30
·9999	0·05	·9958	2·28	·9917	4·70	·9876	7·37
·9998	0·11	·9957	2·34	·9916	4·76	·9875	7·43
·9997	0·16	·9956	2·37	·9915	4·82	·9874	7·50
·9996	0·21	·9955	2·45	·9914	4·88	·9873	7·57
·9995	0·26	·9954	2·51	·9913	4·94	·9872	7·64
·9994	0·32	·9953	2·57	·9912	5·01	·9871	7·71
·9993	0·37	·9952	2·62	·9911	5·07	·9870	7·68
·9992	0·42	·9951	2·68	·9910	5·13	·9869	7·85
·9991	0·47	·9950	2·74	·9909	5·20	·9868	7·92
·9990	0·53	·9949	2·79	·9908	5·26	·9867	7·99
·9989	0·58	·9948	2·85	·9907	5·32	·9866	8·06
·9988	0·64	·9947	2·91	·9906	5·39	·9865	8·13
·9987	0·69	·9946	2·97	·9905	5·45	·9864	8·20
·9986	0·74	·9945	3·02	·9904	5·51	·9863	8·27
·9985	0·80	·9944	3·08	·9903	5·58	·9862	8·34
·9984	0·85	·9943	3·14	·9902	5·64	·9861	8·41
·9983	0·91	·9942	3·20	·9901	5·70	·9860	8·48
·9982	0·96	·9941	3·26	·9900	5·77	·9859	8·55
·9981	1·02	·9940	3·32	·9899	5·83	·9858	8·62
·9980	1·07	·9939	3·37	·9898	5·89	·9857	8·70
·9979	1·12	·9938	3·43	·9897	5·96	·9856	8·77
·9978	1·18	·9937	3·49	·9896	6·02	·9855	8·84
·9977	1·23	·9936	3·55	·9895	6·09	·9854	8·91
·9976	1·29	·9935	3·61	·9894	6·15	·9853	8·98
·9975	1·34	·9934	3·67	·9893	6·22	·9852	9·05
·9974	1·40	·9933	3·73	·9892	6·29	·9851	9·12
·9973	1·45	·9932	3·78	·9891	6·35	·9850	9·20
·9972	1·51	·9931	3·84	·9890	6·42	·9849	9·27
·9971	1·56	·9930	3·90	·9889	6·49	·9848	9·34
·9970	1·61	·9929	3·96	·9888	6·55	·9847	9·41
·9969	1·67	·9928	4·02	·9887	6·62	·9846	9·49
·9968	1·73	·9927	4·08	·9886	6·69	·9845	9·56
·9967	1·78	·9926	4·14	·9885	6·75	·9844	9·63
·9966	1·83	·9925	4·20	·9884	6·82	·9843	9·70
·9965	1·89	·9924	4·27	·9883	6·89	·9842	9·78
·9964	1·94	·9923	4·33	·9882	6·95	·9841	9·85
·9963	1·99	·9922	4·39	·9881	7·02	·9840	9·92
·9962	2·05	·9921	4·45	·9880	7·09	·9839	9·99
·9961	2·11	·9920	4·51	·9879	7·16	·9838	10·07
·9960	2·17	·9919	4·57	·9878	7·23		