	In degrees Centigrade.	In degrees Fahrenheit.
Mercury	— 39.4	— 39
Potassium	+ 62.5	+ 144.5
Sodium	97.6	207.7
Tin	227.8	442
Bismuth	264	507
Lead	325	617
Zinc	411.6	773
Antimony	621	1150
Silver	1023	1873
Copper	1091	1996
Gold	1102	2016
Cast iron	1530	2786

QUESTIONS AND EXERCISES.

934. On what fundamental laws are the operations of quantitative analysis based?

935. What is the general nature of *gravimetric* quantitative analysis?

936. Describe the general principle of *volumetric* quantitative analysis.

937. How are variations in atmospheric pressure quantitatively determined?

938. Explain the construction and mode of action of a mercurial barometer.

939. In what respect does a wheel-barometer differ from an instrument in which the readings are taken from the top of the column of mercury?

940. Describe the principle of action of an aneroid barometer.

941. On what general principles are thermometers constructed?

942. What material is employed in making thermometers?

943. Why is mercury selected as a thermometric indicator?

944. Describe the manufacture of a mercurial thermometer.

945. How are thermometers graduated?

946. Give formulæ for the conversion of the degrees of one thermometric scale into those of another, (*a*) when the temperature is above the freezing-point of water, (*b*) below 32° F., but above 0° F., and (*c*) below 0°.

947. Name the degree C. equivalent to 60° F.

948. What degree C. is represented by — 4° F.?

949. Mention the degree F. indicated by 23° C.

950. Convert 100° R. into degrees C. and F.

951. State the boiling-points of alcohol, chloroform, ether, mercury, and water on either thermometric scale.

952. Describe the details of manipulation in estimating the melting-point of fats.

953. In what respect do pyrometers differ from thermometers?

954. Mention the melting-points of glacial acetic acid, oil of theobroma, lard, suet, and wax.

955. Give the fusing-points of tin, lead, zinc, copper, and cast-iron.

Quantitative Determination of Weight.

Definitions.

All bodies, celestial and terrestrial, attract each other, the amount of attraction being in direct proportion to the quantity of matter of which they consist, and in inverse proportion to the squares of their distances. This is *gravitation*. When gravitation in certain directions is exactly counterbalanced by gravitation in opposite directions, a body (*e. g.* the earth) remains suspended in space. Such a body in relation to other bodies has gravity, but not weight. *Weight* is the effect of gravity, being the excess of gravitation in one direction over and above that exerted in the opposite direction. Weight, truly, in any terrestrial substance is the excess of attraction which it and the earth have for each other over and above the attraction of each in opposite directions by the various heavenly bodies. But, practically, the weight of any terrestrial substance is the effect of the attraction of the earth only. *Specific* weight is the definite or precise weight of a body in relation to its bulk; it is more usually but not quite correctly termed *specific gravity*—gravity belonging to the earth, and not, in any sensible degree, to the substance.

QUESTIONS.

956. What is understood by gravitation?

957. State the difference between weight and gravity.

958. Mention a case in which a body has gravity, but no apparent weight.

959. Practically, what causes the weight of terrestrial substances?

Weights and Measures.

The Balance.—The balance used in the quantitative operations of analytical chemistry must be accurate and sensitive. The points of suspension of the beam and pans should be polished steel or agate knife-edges working on agate planes. It should turn easily and quickly, without too much oscillation, to $\frac{1}{500}$ or $\frac{1}{600}$ of a grain or $\frac{1}{10}$ of a milligramme, when 1000 grains or 50 or 60 grammes are placed in each scale. (Grammes are weights of the metric system, a description of which is given on the next two or three pages.) The beam should be light and strong, capable of supporting a load of 1500 grains or 100 grammes; its oscillations are observed by help of a long index attached to its centre, and continued downward for

some distance in front of the supporting pillar of the balance. The instrument should be provided with screws for purposes of adjustment, a mechanical contrivance for supporting the beam above its bearing when not in use or during the removal or addition of weights, spirit-levels to enable the operator to give it a horizontal position, and be enclosed in a glass case to protect from dust. It should be placed in a room the atmosphere of which is not liable to be contaminated by acid fumes, in a situation free from vibration, and a vessel containing lumps of quicklime should be placed in the case to keep the enclosed air dry and prevent the formation of rust on any steel knife-edges or other parts. During weighing the doors of the balance should be shut, in order that currents of air may not unequally influence the pans.

The Weights.—These should be preserved in a box having a separate compartment for each. They must not be lifted directly with the fingers, but by a small pair of forceps. If grain-weights, they should range from 1000 grs. to $\frac{1}{10}$ gr., a $\frac{1}{10}$ weight being fashioned of gold wire to act as a "rider" on the divided beam, and thus indicate by its position 100ths and 1000ths of a grain. From $\frac{1}{10}$ to 10 grs. the weights may be of platinum; thence upward, to 1000 grs., of brass. The relation of the weights to each other should be decimal. Metric decimal weights may range from 1000 grammes to 1 gramme of brass, and thence downward to 1 centigramme of platinum, a gold centigramme rider being employed to indicate milligrammes and tenths of a milligramme.

Weights and Measures of the U. S. Pharmacopœia.—"The working formulæ of the United States Pharmacopœia are now so constructed that, in their practical application, any system of weights or (in certain cases measures) may be used." "The weights and measures referred to by physicians in prescribing, and used by pharmacists in dispensing medicines, are, in the United States, either those of the 'apothecaries' or troy system of weights and the wine measure, or those of the metric system."

Troy Weights.—These are derived from the *troy pound*, and are exhibited in the following table, with their signs annexed:—

One pound,	℔	= 12 ounces	= 5760 grains.
One ounce,	℥	= 8 drachms	= 480 grains.
One drachm,	ʒ	= 3 scruples	= 60 grains.
One scruple,	℈	. . . . .	= 20 grains.
One grain,	gr.	. . . . .	= 1 grain.

It is highly important that persons engaged in preparing medicines should be provided with troy weights. But those who are not so provided can make their avoirdupois weights available as substitute for troy weights by bearing in mind that 42.5 grains, added to the avoirdupois ounce, will make it equal to the troy ounce, and that 1240 grains, deducted from the avoirdupois pound, will reduce it to the troy pound.

Measures.—These are derived from the *wine gallon*, and are given in the following table, with their signs annexed:—

One gallon,	C	= 8 pints	= 61,440 minims.
One pint,	O	= 16 fluidounces	= 7,680 minims.
One fluidounce,	f℥	= 8 fluidrachms	= 480 minims.
One fluidrachm,	f ʒ	. . . . .	= 60 minims.
One minim,	♏	. . . . .	= 1 minim.

Relation of Troy Weight and Wine Measure.

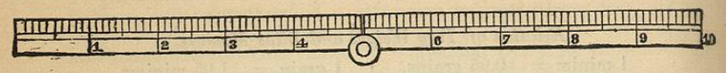
1 minim	= 0.95 grains.	1 grain	= 1.05 minims.
1 f℥	= 56.96 "	1 ℥	= 63.2 "
1 f ʒ	= 455.69 "	1 ʒ	= 505.6 "

The Metric System of weights (the word *metric* is from the Greek *μέτρον, metron*, measure) is greatly to be preferred to all others, the relation of the metric weights of all denominations to measures of length, capacity, and surface being so simple as to be within the perfect comprehension of a child; while under the British and American plans the weights have no such relation either with each other or with the various measures. Moreover, the metric system is in perfect harmony with the universal method of counting; it is a decimal system.

[It is perhaps impossible to realize, much more express, the advantages we enjoy from the fact that in every country of the world the system of numeration is identical. That system is the decimal. Whatever language a man speaks, his method of numbering is decimal; his talk concerning number is decimal; his written or printed signs signifying number are decimal. With the figures, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0 he represents all possible variation in number, the position of a figure in reference to its companions alone determining its value, a figure on the left hand of any other figure in an allocation of numeral symbols (for example, 1871) having ten times the value of that figure, while the figure on the right hand of any other has a tenth of the value of that other. When the youngest pupil is asked how many units there are in 1871, he smiles at the simplicity of the question, and says 1871. How many tens? 187, and 1 over. How many hundreds? 18, and 71 over. How many thousands? 1, and 871 over. But if he is asked how many scruples there are in 1871 grains, how many drachms, how many ounces, he first inquires which drachms or which ounces are meant—avoirdupois ounces, troy ounces, or wine ounces—and then brings out his slate and pencil. And so with the pints or gallons in 1871 fluidounces, or the feet and yards in 1871 inches, or the pence, shillings, and pounds in 1871 farthings; to say nothing of cross questions, such as the value of 1871 articles at 2 dollars and 20 cents per dozen, or of the perplexity caused by the varying values of several individual weights or of measures of length, capacity, and surface in different parts of the country. What is desired is, that there should be an equally simple decimal relation among weights and measures and coins as already universally exists among numbers. This condition of things having already been introduced into most other countries, there is no good reason why it should not be accomplished in the United States and Great Britain.]

The Metric System of weights and measures is founded on the metre. The engraving (Fig. 66) represents a pocket folding-meas-

Fig. 66.



The Decimetre.

ure, the tenth part of a metre in length, divided into ten centimetres, and each centimetre into 10 millimetres.

The units of the system with their multiples and submultiples are as follows:—

Units.

Length.—The *Unit of Length* is the Metre, derived from the measurement of the quadrant of a meridian of the earth. (Practically, it is the length of certain carefully-preserved bars of metal from which copies have been taken.)

Surface.—The *Unity of Surface* is the Are, which is the square of ten metres.

Capacity.—The *Unity of Capacity* is the Litre, which is the cube of a tenth part of a metre.

Weight.—The *Unity of Weight* is the Gramme, which is the weight of that quantity of distilled water, at its maximum density (4° C.), which fills a cube of the one-hundredth part of the metre.

Table.

Note.—Multiples are denoted by the Greek words "Deca," Ten, "Hecto," Hundred, "Kilo," Thousand.
Subdivisions, by the Latin words "Deci," One-tenth, "Centi," One-hundredth, "Milli," One-thousandth.

Quantities.	Length.	Surface.	Capacity.	Weight.
1000	Kilo-metre	. . .	Kilo-litre	Kilo-gramme.
100	Hecto-metre	Hectare	Hecto-litre	Hecto-gramme.
10	Deca-metre	. . .	Deca-litre	Deca-gramme.
1 (Units)	**METRE**	**ARE**	**LITRE**	**GRAMME.**
.1	Deci-metre	. . .	Deci-litre	Deci-gramme.
.01	Centi-metre	Centiare	Centi-litre	Centi-gramme.
.001	Milli-metre	. . .	Milli-litre	Milli-gramme.

When the Metric Method is exclusively adopted these units and this table, comprising the entire system of weights and measures, represent all that will be essential to be learned in lieu of the numerous and complicated tables hitherto in use. Adopting the style of elementary books on arithmetic, the Tables may be expanded in the following manner:—

10 Milligrammes make 1 Centigramme.
10 Centigrammes " 1 Decigramme.
10 Decigrammes " 1 Gramme.
10 Grammes " 1 Decagramme.
10 Decagrammes " 1 Hectogramme.
10 Hectogrammes " 1 Kilogramme.

10 Millilitres make 1 Centilitre,
etc.

10 Millimetres make 1 Centimetre,
etc.

Abbreviations.—Metre = *m.*; decimetre = *dm.*; centimetre = *cm.*; millimetre = *mm.*; kilometre = *km.* Square metre = m^2.; cubic metre = m^3.; and so on. Litre = *l.*; decilitre = *dl.*; and so on. Kilogramme = *kg.*; dekagramme = *dkg.*; gramme = *g.*; decigramme = *dg.*; centigramme = *cg.*; milligramme = *mg.*

The following approximate equivalents of metrical units should be committed to memory:—

1 Metre = 3 feet 3 inches and 3 eighths.
1 Are = a square whose side is 11 yards.
1 Litre = $1\frac{3}{4}$ pints.
1 Gramme = $15\frac{1}{2}$ grains.

The Kilometre is equal to 1100 yards.
The Hectare = $2\frac{1}{2}$ acres nearly.
The Metric Ton of 1000 Kilogrammes = 19 cwt. 2 qrs. 20 lbs. 10 oz.
The Kilogramme = 2 lbs. $3\frac{1}{4}$ oz. nearly.

For *exact* equivalents in many forms see pages 539 and 540. A litre of water at 39° F. weighs 15432 grains; at 50° F., 15429 grains; at 60° F., it weighs 15418 grains; at 70° F., 15403 grains; and at 80° F., 15383 grains (Pile). (The word *gramme* is, in English, frequently written *gram*, which too closely resembles the word *grain*.)

Decimal Coinage.—In most countries where the metric system of weights and measures is employed a decimal division of coins is also adopted. This course, conjoined with the ordinary decimal method of enumerating, which, fortunately, is in universal use, renders calculations of all kinds most simple—easy to an extent which cannot be conceived in countries like England, where the operations of weighing, measuring, paying, and counting have only the most absurdly intricate relations to each other.

The General Council under whose authority the British Pharmacopœia is issued encourages medical practitioners and pharmacists in the adoption of the metric system, and gives the annexed statement of metric weights and measures:—

WEIGHTS AND MEASURES OF THE METRICAL SYSTEM.

(From the British Pharmacopœia of 1867.)

Weights.

1 Milligramme	= the thousandth part of one grm.,	or 0.001	grm.
1 Centigramme	= the hundredth "	0.01	"
1 Decigramme	= the tenth "	0.1	"
1 Gramme	= weight of a cubic centimetre of water at 4° C.	1.0	"
1 Decagramme	= ten grammes	10.0	"
1 Hectogramme	= one hundred grammes	100.0	"
1 Kilogramme	= one thousand grammes	1000.0	(1 kilo.)

Measures of Capacity.

1 Millilitre	=	1	cub. centim.,	or the meas. of 1	gram.	of water.
1 Centilitre	=	10	" "	10	"	"
1 Decilitre	=	100	" "	100	"	"
1 Litre	=	1000	" "	1000	"	(1 kilo.).

Measures of Length.

1 Millimetre	= the thousandth part of one metre,	or 0.001	metre.
1 Centimetre	= the hundredth "	0.01	"
1 Decimetre	= the tenth "	0.1	"
1 Metre	= the ten-millionth part of a quarter of the meridian of the earth.		

The National Convention for revising the Pharmacopœia of the United States also recognizes the metric system of weights and measures by giving, in the last (sixth) edition of the Pharmacopœia, Tables of the units of the metrical system with their multiples and submultiples, similar to the foregoing, and the following Tables showing the relation to each other of the metrical and troy systems. In some parts of the text of the work the metric system is that actually employed.

TABLES OF WEIGHTS AND MEASURES.

A.—MEASURES OF LENGTH.

I. Relation of Metric to United States Measures of Length.

1 Metre	=	39.370432 inches.
1 Decimetre	=	3.937043 "
1 Centimetre	=	0.393704 "
1 Millimetre	=	0.039370 "

II. Relation of United States to Metric Measures of Length.

1 Yard (or 36 Inches) = 0.91439 Metre.
1 Foot (or 12 Inches) = 30.40 Centimetres.

Inches.		Centimetres.	Inches.		Centimetres.	Inch.		Centimetre.
11	=	27.9	5	=	12.7	$\frac{1}{2}$	=	12.5
10	=	25.4	4	=	10.2	$\frac{1}{4}$	=	6.25
9	=	22.9	3	=	7.6	$\frac{1}{8}$	=	3.12
8	=	20.3	2	=	5.1	$\frac{1}{16}$	=	1.54
7	=	17.8	1	=	2.5	$\frac{1}{25}$	=	1.00
6	=	15.2						

B.—MEASURES OF CAPACITY.

III. Relation of Metric to United States Fluid Measures.

Cubic Centim.		Fluidounces.	Cubic Centim.		Fluidrachms.	Cubic Centim.		Minims.
1,000	=	33.81	15	=	4.06	0.40	=	6.49
950	=	32.12	10	=	2.71	0.35	=	5.68
900	=	30.43	9	=	2.43	0.30	=	4.87
850	=	28.74	8	=	2.16	0.25	=	4.06
800	=	27.05	7	=	1.89	0.20	=	3.25
750	=	25.36	6	=	1.62	0.19	=	3.08
700	=	23.67	5	=	1.35	0.18	=	2.92
650	=	21.98	4	=	1.08	0.17	=	2.76
600	=	20.29				0.16	=	2.60
550	=	18.59	Cubic Centim.		Minims.	0.15	=	2.43
500	=	16.90	3	=	48.69	0.14	=	2.27
450	=	15.22	2	=	32.46	0.13	=	2.11
400	=	13.53	1	=	16.23	0.12	=	1.95
350	=	11.84	0.95	=	15.42	0.11	=	1.79
300	=	10.14	0.90	=	14.61	0.10	=	1.62
250	=	8.45	0.85	=	13.80	0.09	=	1.46
200	=	6.76	0.80	=	12.98	0.08	=	1.30
150	=	5.07	0.75	=	12.17	0.07	=	1.14
100	=	3.38	0.70	=	11.36	0.06	=	0.97
30	=	1.01	0.65	=	10.55	0.05	=	0.81
			0.60	=	9.74	0.04	=	0.65
Cubic Centim.		Fluidrachms.	0.55	=	8.93	0.03	=	0.49
25	=	6.76	0.50	=	8.12	0.02	=	0.32
20	=	5.41	0.45	=	7.30	0.01	=	0.16

IV. Relation of United States to Metric Fluid Measures.

Minims.		Cubic Centim.	Minims.		Cubic Centim.	Minims.		Cubic Centim.
1	=	0.06	8	=	0.49	15	=	0.92
2	=	0.12	9	=	0.55	16	=	0.99
3	=	0.18	10	=	0.62	17	=	1.05
4	=	0.25	11	=	0.68	18	=	1.11
5	=	0.31	12	=	0.74	19	=	1.17
6	=	0.37	13	=	0.80	20	=	1.23
7	=	0.43	14	=	0.86	21	=	1.29

RELATION OF UNITED STATES TO METRIC FLUID MEASURES.—*Cont.*

Minims.		Cubic Centim.	Fluidrachms.		Cubic Centim.	Fluidounces.		Cub. Centim.
22	=	1.36	3	=	.11.09	11	=	325.25
23	=	1.42	4	=	14.79	12	=	354.82
24	=	1.48	5	=	18.48	13	=	384.40
25	=	1.54	6	=	22.18	14	=	413.97
26	=	1.60	7	=	25.88	15	=	443.54
27	=	1.66	8	=	29.57	16	=	473.11
28	=	1.73	9	=	33.27	17	=	502.69
29	=	1.79	10	=	36.97	18	=	532.26
30	=	1.85	11	=	40.66	19	=	561.93
35	=	2.16	12	=	44.36	20	=	591.50
40	=	2.46	13	=	48.06	21	=	621.08
45	=	2.77	14	=	51.75	22	=	650.65
50	=	3.08	15	=	55.45	23	=	680.22
55	=	3.39	16	=	59.10	24	=	709.80
60	=	3.70				25	=	739.37
70	=	4.31	Fluidounces.			26	=	768.94
80	=	4.93	3	=	88.67	27	=	798.51
90	=	5.54	4	=	118.24	28	=	828.09
100	=	6.16	5	=	147.81	29	=	857.66
110	=	6.78	6	=	177.39	30	=	887.23
120	=	7.39	7	=	206.96	31	=	916.80
			8	=	236.53	32	=	946.38
			9	=	266.10	64	=	1892.75
			10	=	295.68	128	=	3785.51

C.—WEIGHTS.

V. RELATION OF METRIC TO APOTHECARIES' OR TROY WEIGHT.

Grammes.		Grains.	Grammes.		Grains.	Grammes.		Grains.
0.0010	=	0.015	0.0125	=	0.193	0.120	=	1.852
0.0013	=	0.019	0.0150	=	0.231	0.130	=	2.006
0.0015	=	0.023	0.0200	=	0.309	0.140	=	2.161
0.0020	=	0.031	0.0250	=	0.386	0.150	=	2.315
0.0025	=	0.039	0.0300	=	0.463	0.160	=	2.469
0.0030	=	0.046	0.0350	=	0.540	0.170	=	2.623
0.0035	=	0.054	0.0400	=	0.617	0.180	=	2.778
0.0040	=	0.062	0.0450	=	0.694	0.190	=	2.932
0.0045	=	0.069	0.050	=	0.772	0.200	=	3.086
0.0050	=	0.077	0.055	=	0.849	0.210	=	3.241
0.0055	=	0.085	0.060	=	0.926	0.220	=	3.395
0.0060	=	0.093	0.065	=	1.003	0.230	=	3.549
0.0065	=	0.100	0.070	=	1.080	0.240	=	3.704
0.0070	=	0.108	0.075	=	1.157	0.250	=	3.858
0.0075	=	0.116	0.080	=	1.235	0.260	=	4.012
0.0080	=	0.123	0.085	=	1.312	0.270	=	4.167
0.0085	=	0.131	0.090	=	1.389	0.280	=	4.321
0.0090	=	0.139	0.095	=	1.466	0.290	=	4.475
0.0095	=	0.147	0.100	=	1.543	0.300	=	4.630
0.0100	=	0.154	0.110	=	1.698	0.310	=	4.784

RELATION OF METRIC TO APOTHECARIES' OR TROY WEIGHT.—*Cont.*

Grammes.		Grains.	Grammes.		Grains.	Grammes.		Grains.
0.320	=	4.938	13	=	200.621	39	=	601.862
0.330	=	5.093	14	=	216.053	40	=	617.294
0.340	=	5.247	15	=	231.485	50	=	771.617
0.350	=	5.401	16	=	246.918	60	=	925.941
0.360	=	5.556	17	=	262.350	70	=	1080.264
0.370	=	5.710	18	=	277.782	80	=	1234.588
0.380	=	5.864	19	=	293.215	90	=	1388.911
0.390	=	6.019	20	=	308.647	100	=	1543.235
0.400	=	6.173	21	=	324.079	125	=	1929.044
0.500	=	7.716	22	=	339.512	150	=	2314.852
0.600	=	9.259	23	=	354.944	200	=	3086.470
0.700	=	10.803	24	=	370.376	250	=	3858.087
0.800	=	12.346	25	=	385.809	300	=	4629.705
0.900	=	13.889	26	=	401.241	333	=	5144.118
1	=	15.432	27	=	416.673	350	=	5401.322
2	=	30.865	28	=	432.106	400	=	6172.940
3	=	46.297	29	=	447.538	450	=	6944.557
4	=	61.729	30	=	462.970	500	=	7716.174
5	=	77.162	31	=	478.403	600	=	9259.409
6	=	92.594	32	=	493.835	700	=	10802.644
7	=	108.026	33	=	509.268	750	=	11574.262
8	=	123.459	34	=	524.700	800	=	12345.879
9	=	138.891	35	=	540.132	900	=	13889.114
10	=	154.323	36	=	555.565	1000	=	15432.350
11	=	169.756	37	=	570.997			
12	=	185.188	38	=	586.429			

VI. THE RELATION OF APOTHECARIES' (OR TROY) TO METRIC WEIGHT.

Grains.		Grammes.	Grains.		Grammes.	Grains.		Grammes.
$\frac{1}{64}$	=	0.00101	$\frac{1}{4}$	=	0.01620	14	=	0.90718
$\frac{1}{60}$	=	0.00108	$\frac{1}{3}$	=	0.02160	15	=	0.97198
$\frac{1}{50}$	=	0.00130	$\frac{1}{2}$	=	0.03240	16	=	1.037
$\frac{1}{48}$	=	0.00135	$\frac{3}{4}$	=	0.04860	17	=	1.102
$\frac{1}{40}$	=	0.00162	1	=	0.06480	18	=	1.166
$\frac{1}{36}$	=	0.00180	$1\frac{1}{2}$	=	0.09720	19	=	1.231
$\frac{1}{32}$	=	0.00202	2	=	0.12960	20	=	1.296
$\frac{1}{30}$	=	0.00216	$2\frac{1}{2}$	=	0.16200	21	=	1.361
$\frac{1}{25}$	=	0.00259	3	=	0.19440	22	=	1.426
$\frac{1}{24}$	=	0.00270	4	=	0.25920	23	=	1.458
$\frac{1}{20}$	=	0.00324	5	=	0.32399	24	=	1.555
$\frac{1}{18}$	=	0.00360	6	=	0.38879	25	=	1.620
$\frac{1}{16}$	=	0.00405	7	=	0.45359	26	=	1.685
$\frac{1}{15}$	=	0.00432	8	=	0.51839	27	=	1.749
$\frac{1}{12}$	=	0.00540	9	=	0.58319	28	=	1.814
$\frac{1}{10}$	=	0.00648	10	=	0.64799	29	=	1.869
$\frac{1}{8}$	=	0.00810	11	=	0.71297	30	=	1.944
$\frac{1}{8}$	=	0.01080	12	=	0.77759	40	=	2.592
$\frac{1}{6}$	=	0.01296	13	=	0.84239	50	=	3.240

RELATION OF APOTHECARIES' (OR TROY) TO METRIC WEIGHT.—*Cont.*

Drachms.		Grammes.	Ounces.		Grammes.	Ounces.		Grammes.
l	=	3.888	1½	=	46.655	11	=	342.138
2	=	7.776	2	=	62.207	12	=	373.250
3	=	11.664	3	=	93.310	13	=	404.345
4	=	15.552	4	=	124.414	14	=	435.449
5	=	19.440	5	=	155.517	15	=	466.552
6	=	23.328	6	=	186.621	16	=	497.656
7	=	27.216	7	=	217.724	17	=	528.759
			8	=	248.823	18	=	559.863
Ounces.			9	=	279.931	19	=	590.966
1	=	31.103	10	=	311.035	20	=	622.070

VII. RELATION OF METRIC TO AVOIRDUPOIS WEIGHT.

	Avoirdupois Ounces and Grains.			Avoirdupois Ounces and Grains.			Avoirdupois Ounces and Grains.		
Grammes.		Oz.	Grs.	Grammes.	Oz.	Grs.	Grammes.	Oz.	Grs.
28.35	=	1		50	= 1	334	500	= 17	279
29	=	1	10	60	= 2	50½	550	= 19	175
30	=	1	25½	70	= 2	205	600	= 21	72
31	=	1	41	80	= 2	359	650	= 22	405½
32	=	1	56½	90	= 3	76½	700	= 24	303
33	=	1	72	100	= 3	230½	750	= 26	198½
34	=	1	87½	150	= 5	127	800	= 28	96
35	=	1	103	200	= 7	24	850	= 29	429
36	=	1	118	250	= 8	358	900	= 31	326½
37	=	1	133½	300	= 10	255	950	= 33	222
38	=	1	149	350	= 12	151½	1000	= 35	120
39	=	1	164½	400	= 14	48			
40	=	1	180	450	= 15	382			

VIII. RELATION OF AVOIRDUPOIS TO METRIC WEIGHT.

Avoirdupois Ounces.		Grammes.	Avoirdupois Ounces.		Grammes.	Avoirdupois Pounds.		Grammes.
$\frac{1}{16}$	=	1.772	7	=	198.447	1	=	453.592
$\frac{1}{8}$	=	3.544	8	=	226.796	2	=	907.18
$\frac{1}{4}$	=	7.088	9	=	255.146	3	=	1360.78
$\frac{1}{2}$	=	14.175	10	=	283.496	4	=	1814.37
1	=	28.350	11	=	311.846	5	=	2267.96
2	=	56.699	12	=	340.195	6	=	2721.55
3	=	85.049	13	=	368.544	7	=	3175.14
4	=	113.398	14	=	396.894	8	=	3628.74
5	=	141.748	15	=	425.243	9	=	4082.33
6	=	170.098				10	=	4535.92

The following Tables, from the British Pharmacopœia and the Diary of Messrs. De La Rue, will be found useful for reference:—

WEIGHTS AND MEASURES OF THE BRITISH PHARMACOPŒIA OF 1867.

WEIGHTS.

1 Grain	gr.		
1 Ounce	oz.	=	437.5 grains.
1 Pound	lb. = 16 ounces	=	7000 "

MEASURES OF CAPACITY.

1 Minim	min.		
1 Fluidrachm	fl. dr.	=	60 minims.
1 Fluidounce	fl. oz.	=	8 fluidrachms.
1 Pint	O.	=	20 fluidounces.
1 Gallon	C.	=	8 pints.

MEASURES OF LENGTH.

1 line = $\frac{1}{12}$ inch.

1 inch = $\frac{1}{39.1393}$ seconds-pendulum.

12 " = 1 foot.
36 " = 3 feet = 1 yard.

Length of pendulum vibrating seconds of mean time in the latitude of London in a vacuum at the level of the sea . . . . . } 39.1393 inches.

(1 cubic inch of distilled water at 62° F. and 30 inches barom. = 252.458 grains.)

RELATION OF BRITISH MEASURES TO WEIGHTS.

1 Minim is the measure of			0.91	grain of water.
1 Fluidrachm	"		54.68	grains of water.
1 Fluidounce	"	1 ounce or	437.5	"
1 Pint	"	1.25 pounds or	8750.0	"
1 Gallon	"	10 pounds or	70,000.0	"

(Gtt. = *guttæ*, drops. The term "drop" indicates a quantity which is indefinite, and should only be used when approximativeness is alone desired.)

RELATION OF WINE MEASURES TO CUBIC MEASURE.

One Gallon	= 231.	Cubic Inches.
One Pint	= 28.875	Cubic Inches.
One Fluidounce	= 1.80468	Cubic Inches.
One Fluidrachm	= 0.22558	Cubic Inch.
One Minim	= 0.00375	Cubic Inch.

Metrical Measures of Length.

	In English inches.	In English feet = 12 inches.	In English yards = 3 feet.	In English fathoms = 6 feet.	In English miles = 1760 yards.
Millimetre	0.03937	0.003281	0.0010936	0.0005468	0.0000006
Centimetre	0.39371	0.032809	0.0109363	0.0054682	0.0000062
Decimetre	3.93708	0.328090	0.1093633	0.0546816	0.0000621
Metre	**39.37079**	3.280899	1.0936331	0.5468165	0.0006214
Decametre	393.70790	32.808992	10.9363310	5.4681655	0.0062138
Hectometre	3937.07900	328.089920	109.3633100	54.6816550	0.0621382
Kilometre	39370.79000	3280.899200	1093.6331000	546.8165500	0.6213824
Myriometre	393707.90000	32808.992000	10936.3310000	5468.1655000	6.2138244

1 inch = 2.539954 centimetres. 1 foot = 3.0479449 decimetres.
1 yard = 0.9143835 metre. 1 mile = 1.6093149 kilometres.

Metrical Measures of Surface.

	In English square feet.	In Eng. sq. yards = 9 square feet.	In English poles = 272.25 sq. feet.	In English roods = 10890 sq. feet.	In English acres = 43560 sq. feet.
Centiare, or square metre	10.764299	1.196033	0.0395383	0.0009885	0.0002471
Are, or 100 square metres	1076.429934	119.603326	3.9538290	0.0988457	0.0247114
Hectare, or 10,000 square metres	107642.993418	11960.332602	395.3828959	9.8845724	2.4711431

1 square inch = 6.4513669 square centimetres. 1 square foot = 9.2899683 square decimetres.
1 square yard = 0.83609715 square metre or centiare. 1 acre = 0.40467102 hectare.

Metrical Measures of Capacity.

	In cubic inches.	In cubic feet = 1728 cubic inches.	In pints = 34.65923 cubic inches.	In gallons = 8 pints = 277.27384 cubic inches.	In bushels = 8 gallons = 2218.19072 cubic inches.
Millilitre, or cubic centimetre	0.06103	0.000035	0.00176	0.0002201	0.0000275
Centilitre, or 10 cubic centimetres	0.61027	0.000353	0.01761	0.0022010	0.0002751
Decilitre, or 100 cubic centimetres	6.10271	0.003532	0.17608	0.0220097	0.0027512
Litre, or cubic decimetre	61.02705	0.035317	**1.76077**	0.2200967	0.0275121
Decalitre, or centistere	610.27052	0.353166	17.60773	2.2009668	0.2751208
Hectolitre, or decistere	6102.70515	3.531658	176.07734	22.0096677	2.7512085
Kilolitre, or stere, or cubic metre	61027.05152	35.316581	1760.77341	220.0966767	27.5120846
Myriolitre, or decastere	610270.51519	353.165807	17607.73414	2200.9667675	275.1208459

1 cubic inch = 16.386176 cubic centimetres. 1 cubic foot = 28.315312 cubic decimetres. 1 gallon = 4.535926 litres.

Metrical Measures of Weight.

	In English grains.	In troy ounces = 480 grains.	In avoirdupois lbs. = 7000 grains.	In cwts. = 112 lbs. = 784000 grains.	Tons = 20 cwts. = 15680000 grains.
Milligramme	0.01543	0.000032	0.0000022	0.0000000	0.0000000
Centigramme	0.15432	0.000322	0.0000220	0.0000002	0.0000000
Decigramme	1.54323	0.003215	0.0002205	0.0000020	0.0000001
Gramme	**15.43235**	0.032151	0.0022046	0.0000197	0.0000010
Decagramme	154.32349	0.321507	0.0220462	0.0001968	0.0000098
Hectogramme	1543.23488	3.215073	0.2204621	0.0019684	0.0000984
Kilogramme	15432.34880	32.150727	2.2046213	0.0196841	0.0009842
Myriogramme	154323.48800	321.507267	22.0462126	0.1968412	0.0098421

1 grain = 0.064799 gramme. 1 troy oz. = 31.103496 grammes. 1 lb. avd. = 0.453593 kilogr. 1 cwt. = 50.802377 kilogrs.

QUESTIONS AND EXERCISES.

960. Mention some advantages of a decimal system of weights and measures.
961. What is the name of the chief unit of the metric decimal system of weights and measures?
962. Mention the names of the metric units of surface, capacity, and weight, and state how they are derived from the unit of length.
963. How are multiples of metric units indicated?
964. State the designations of submultiples of metric units.
965. How many metres are there in a kilometre?
966. How many millimetres in a metre?
967. How many grammes in 5 kilogrammes?
968. How many milligrammes in 13½ grammes?
969. In 1869 centigrammes how many grammes?
970. In a metre measure 5 centimetres wide and 1 centimetre thick, how many cubic centimetres?
971. How many litres are contained in a cubic metre of any liquid?
972. State the British equivalent of the metre.
973. How many square yards in an are?
974. How many fluidounces in a litre?
975. How many ounces in a kilogramme?
976. Give the relation of a metric ton (1000 kilos.) to a British ton.
977. How many grains are there in 1 ton?
978. How many ounces in 1 ton?
979. How many grains of water in 1 fluidrachm?
980. How many minims in 1 pint?
981. How many grains in 1 pint of water?
982. Whence is the British unit of length derived?

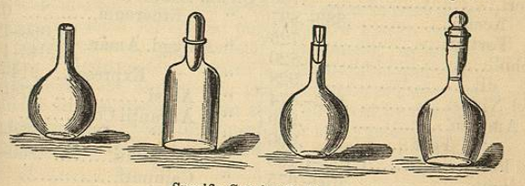
Specific Weight or Specific Gravity.

The *specific weight* of a substance is its weight in comparison with weights of similar bulks of other substances. This comparative heaviness of *solids and liquids* is conventionally expressed in relation to water: they are considered as being lighter or heavier than water. Thus, water being regarded as unity = 1, the relative weight, or specific weight, of ether is represented by the figures .720 (it is nearly three-fourths, .750, the weight of water), oil of vitriol by 1.843 (it is nearly twice, 2.000, as heavy as water). The specific weight of substances is, moreover, by generally accepted agreement, the weight of similar volumes at 15° C. (59° F.), except in the case of alcohol and wine, which are at present taken at 15.6° C. (60° F.), to maintain consistency with United States laws and regulations; for the weight of a definite volume of any substance will vary according to temperature, becoming heavier when cooled and lighter when heated, different bodies (gases excepted) differing in their rate of contraction and expansion. While, then, specific weight—or, conventionally, *specific gravity*—is truly the comparative weight of equal bulks, the numbers which in America commonly represent specific gravities are the comparative weights of equal bulks at 15° C. (59° F.), water being taken as unity.* The standard of comparison for gases was formerly air, but is now usually hydrogen.

Specific Gravity of Liquids.

Procure any small bottle holding from 100 to 1000 grains (fig. 67) and having a narrow neck; counterpoise it in a delicate balance; fill it to about halfway up the neck with pure distilled water having a temperature of 15° C.; ascertain the weight of the water, and, for convenience, add or subtract a drop or two, so that the weight shall be a round number of grains; mark the neck by a diamond or file-point at the part cut by the lower edge of the curved surface of the water. Consecutively fill up the bottle to the neck-mark with several other liquids, cooled or warmed to 15° C., first rinsing out the bottle once or twice with a small quantity of each liquid, and note the weights; the respective figures will represent the relative weights of equal bulks of the liquids. If the capacity of the bottle is 10, 100, or 1000 grains, the resulting weights will, without calculation, show the specific gravities of the

Fig. 67. Fig. 68. Fig. 69. Fig. 70.



Specific-Gravity Bottles.

liquids; if any other number, a rule-of-three sum must be worked out to ascertain the weight of the liquids as compared with 1 (or 1.000) of water. Bottles conveniently adjusted to

* The true weight of the body is its weight in air plus the weight of an equal bulk of air, and minus the weight of a bulk of air equal to the bulk of brass or other weights employed; or, in other words, its weight *in vacuo* uninfluenced by the buoyancy of the air; but such a correction of the weight of a body is seldom necessary, or, indeed, desirable. *Density* is sometimes improperly regarded as synonymous with *specific gravity*. It is true that the density of a body is in exact proportion to its specific gravity, but the former is more correctly the comparative bulk of equal weights, while specific gravity is the comparative weight of equal bulks.