A SIMPLE METRIC CONVERSION TABLE.

CHANGING METRIC UNITS INTO ENGLISH EQUIVALENTS.

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EVERYONE who has had occasion to convert metric quantities into American units has had ample proof of the fact that such calculations are often difficult and always cumbersome. This is because double conversions are often required, and existing tables are not adapted to such operations. Suppose, for instance, it is required to know the equivalent of a given number of kilogrammes per hectare in pounds per acre; to find this it is necessary first to divide the equivalent of a kilo in pounds by the equivalent of a hectare in acres, and second to multiply the given number of kilos by this quotient. No wonder the average reader goes on without trying to make the calculation. The same roundabout operation is required for the conversion of kilos per hectoliter into pounds per bushel, hectoliters per hectare into bushels per acre, pressure in kilos per square centimeter into pounds per square inch, and for many other measures constantly occurring in technical and agricultural literature, which only too often are left untranslated and only imperfectly realized.

All double conversions such as those noted above are easily performed by a single operation; merely by multiplying by the factors given in the following list. These multiplications are of course made by simple inspection in using a slide rule.

Example: Suppose it is required to convert a yield of grain of 48 hectoliters per hectare into bushels per acre. All that is required is to multiply 48 by 1.1484, the conversion factor given below, making 55.12, the answer in bushels per acre.

I. AGRICULTURAL AND TECHNICAL MEASURES.*

1. Kilogrammes per hectare to pounds per acre, multiply by	0.8922 —
2. Hectoliters per hectare to bushels per acre, multiply by	1.1484 —
3. Hectoliters per hectare to gallons per acre, multiply by	10.6906 +
4. Kilogrammes per hectoliter to pounds per bushel, multiply by	1.2871 +
5. Pressure, kilos per square centimeter to pounds per square inch, multiply by	14.2234 —
6. Kilogrammes per cubic meter to pounds per cubic foot, multiply by	0.0624 +
7. Kilogrammes per cubic meter to pounds per cubic yard, multiply by	1.6855 +

II. FRENCH PRICES (1 franc=193 cents).

Francs per hectare to dollars per acre, multiply by	0.078
Francs per hectoliter to dollars per bushel, multiply by	0.068
Francs per kilogramme to dollars per pound, multiply by	0.088 (**)
Francs per meter to dollars per yard, multiply by	0.176 (**)
Francs per liter to dollars per gallon, multiply by	0.731 (**)
Francs per cubic meter to dollars per cubic yard, multiply by	0.1475

III. GERMAN PRICES (1 mark=23.8 cents).

Marks per hectare to dollars per acre, multiply by	0.096
Marks per hectoliter to dollars per bushel, multiply by	0.084
Marks per kilogramme to dollars per pound, multiply by	0.108 (**)
Marks per meter to dollars per yard, multiply by	0.218 (**)
Marks per liter to dollars per gallon, multiply by	0.901 (**)
Marks per cubic meter to dollars per cubic yard, multiply by	0.182

APPROXIMATE DOUBLE CONVERSIONS BY RULE OF THUMB.

Often an approximation such as can be obtained readily by the use of the rules of thumb given below is accurate enough for the purpose in view. In case of yields per acre and other agricultural measures, the rule of thumb will give results within the limit of accuracy of the original measure. The purpose of these rules is to enable the general reader to calculate quickly and without the aid of a slide rule the metric

quantities most commonly encountered in the reading of scientific and technical literature.

At first sight these rules seem complex, but on using them the complexity is found to be in the explanation, not in the operation itself. For the most part the operations are limited either to multiplication or division by some multiple of ten which amounts merely to a change of the decimal point, or else to multiplication or division by some simple integer such as 3 or 4.

The rules of thumb are given first in English, then in algebraic summary, and an example is worked out, first in full according to the summary, and then in abbreviated form as would be done by one accustomed to using the rule.

RULES OF THUMB FOR CONVERSION OF METRIC MEASURES.

1. Kilogrammes per Hectare to Pounds per Acre.

(Conversion factor 0.892182.)

From the number of kilogrammes subtract one-tenth of itself, and from the remainder in turn subtract one-hundredth of itself. This gives the number of pounds per acre to within one pound in 753 (too little).

Summary.

a = kilos per hectare.
 $b = 1/10$ of a .
 $c = a - b$.
 $d = 1/100$ of c .
 $e = c - d$, Ans. in pounds per acre (too small by 1/753).

Example.

I. Worked out in full.	II. Abbreviated form.
10) 268.4 kilos per hectare.	268.4
26.84	26.84
—	—
100) 241.56	241.56
2.4156	2.415
—	—
239.1444 Ans. pounds per acre	239.14 Ans.
(should be 239.462).	

1a. Kilos per Hectare to Pounds per Acre (closer approximation).

(Conversion factor 0.892182.)

In case very large quantities per hectare are to be converted into pounds per acre it may be desirable to use the following rule, giving a much closer approximation than the one printed above:

From the number of kilos per hectare subtract one-tenth of itself, and from the remainder in turn subtract one-hundredth of itself, giving the first approximation. Then to the original number add one-tenth of itself, divide this sum by 1,000, and add the quotient to the first approximation. This gives the number of pounds per acre to within 1 in 10,885 (too small).

Summary.

a = kilos per hectare.
 $b = 1/10$ of a .
 $c = a - b$.
 $d = 1/100$ of c .
 $e = c - d$, first approximation.
 $f = a + b$.
 $g = 1/1,000$ of f .
 $h = e + g$, Ans. in pounds per acre (too small by 1/10885).

Example.

268.4 kilos per hectare.	268.4
26.84	26.84
—	—
241.56	295.24
2.4156	.2952 = g
—	—
239.1444 first approx.	
.2952	
—	
239.4396 Ans. pounds per acre (should be 239.4616).	

2. Hectoliters per Hectare to Bushels per Acre.

(Conversion factor, 1.148398).

To the number of hectoliters per hectare add one-tenth of itself and one-half of this tenth. This gives the number of bushels per acre to within one in 717 (too much).

Summary.

a = hectoliters per hectare.
 $b = 1/10$ of a .
 $c = 1/2$ of b .
 $d = a + b + c$, Ans. bushels per acre (too large by 1/717).

I. Worked out in full.	II. Abbreviated form.
10) 266.5 hectoliters per hectare	266.5
2) 26.65	26.65
13.325	13.325
—	—
306.475 Ans. bushels per acre	306.47 Ans.
(should be 306.048).	

3. Hectoliters per Hectare to Gallons per Acre.

(Conversion factor, 10.690642.)

To the number of hectoliters per hectare add ten times itself and from the sum subtract one-third of the original number. This gives the number of gallons per acre to within one part in 446 (too small).

Summary.

a = hectoliters per hectare.
 $b = 10$ times a .
 $c = a + b$.
 $d = 1/3$ of a .
 $e = c - d$, Ans. gallons per acre (too small by 1/446).

Example.

I. Worked out in full.	II. Abbreviated form.
87.6 hectol. per hectare.	876.0
876.0	87.6
—	—
963.6	3) 87.6
29.2	29.2
—	—
934.4 Ans. gals. per acre	934.4 Ans.
(should be 936.5).	

In using the shortened form the product obtained by multiplying the original number by 10 is written above this number so the latter can be divided by three without rewriting.

3a. Hectoliters per Hectare to Gallons per Acre (closer approximation).

(Conversion factor, 10.690642.)

When large yields are to be converted from metric to American measure the following rule may be followed; it gives a much closer approximation than the rule given above:

To the number of hectoliters per hectare add ten times itself for the first approximation; then take one-tenth of the original number, multiply it by 3, and to the product add one-hundredth of the original number; finally subtract this sum from the first approximation. This gives the number of gallons per acre to within one in 16,723 (too small).

Summary.

a = hectoliters per hectare.
 $b = 10$ times a .
 $c = a + b$, first approximation.
 $d = 1/10$ of a .
 $e = 3$ times d .
 $f = 1/100$ of a (1/10 of d).
 $g = e + f$.
 $h = c - g$, Ans. gallons per acre (too small by 1/16,723).

Example.

87.6 hectoliters per hectare	8.76
876.	3
—	—
963.6 first approx.	26.28
27.156	.876
—	—
936.444 Ans. gallons per acre	27.156 = g .
(should be 936.500).	

4. Kilogrammes per Hectoliter to Pounds per Bushel.

(Conversion factor, 1.287133.)

To the number of kilogrammes per hectoliter add one-fourth of itself and one-tenth of this fourth. This gives the number of pounds to the bushel to within one part in 106 (too small).

Summary.

a = kilos per hectoliter.
 $b = 1/4$ of a .
 $c = 1/10$ of b .
 $d = a + b + c$, Ans. pounds per bushel (too small by 1/106).

Example.

4) 49.8 kilos per hectare.	
12.45	
1.245	
—	
63.49 Ans. pounds per bushel (should be 64.099).	

Inasmuch as it is very difficult to determine accurately the exact weight of grain, etc., in a given measure of volume, it is believed that the above approximation is sufficiently accurate for all ordinary purposes.

*The paragraphs under this first division are numbered to correspond with the rules of thumb (to be given below) for making these same conversions.

**Tables of Equivalents of the United States Customary and Metric Weights and Measures, third edition, 4to, pp. 1-50. Washington (Bureau of Standards), November 1, 1906.

4a. *Kilogrammes per Hectoliter to Pounds per Bushel*
(closer approximation).

(Conversion factor, 1.287133.)

In case greater accuracy is required than is given by the above rule of thumb, for example, in calculating the legal weights per bushel of various grains, etc., the following modification, giving very great accuracy, may be employed:

To the number of kilogrammes per hectoliter add one-fourth of itself for the first approximation; then to this sum add one-tenth of the fourth just calculated above and one-hundredth of the first approximation itself. This gives the number of pounds per bushel to within 1 in 3,507 (too large).

Summary.

- a = kilos per hectoliter.
 $b = \frac{1}{4}$ of a .
 $c = a + b$.
 $d = 1/10$ of b .
 $e = 1/100$ of c .
 $f = c + d + e$, Ans. pounds per bushel (too large by 1/3507).

Example.

- 4) 49.8 kilos per hectoliter.
 12.45

 62.25 first approx.
 1.245

 62.25

 64.1175 Ans. pounds per bushel (should be 64.0992).

5. *Pressure in Kilogrammes per Square Centimeter to Pounds per Square Inch.*

(Conversion factor, 14.223398.)

Multiply the number of kilogrammes per square centimeter by 10, divide the product by 2, and add the quotient to the product to obtain the first approximation; then divide the first approximation by 20 and subtract this quotient from the first approximation. This gives the pressure in pounds per square inch to within one part in 535 (too large).

Summary.

- a = pressure in kilos per square centimeter.
 $b = 10$ times a .
 $c = \frac{1}{2}$ of b .
 $d = b + c$, first approximation.
 $e = 1/20$ of d .
 $f = d - e$, Ans. pounds per square inch (too large by 1/535).

Example.

- I. Worked out in full. II. Abbreviated form.
 38.7 kilos per sq. cm. 2) 387
 2) 387 193.5
 193.5

 20) 580.5 first approx. 20) 580.5
 29.025 29.025

 551.475 Ans. pounds per square inch (should be 550.43).

6. *Kilogrammes per Cubic Meter to Pounds per Cubic Foot.*

(Conversion factor, 0.062428.)

Take one-tenth of the number of kilogrammes per cubic meter, divide by 2 and divide this quotient in turn by 4; add these last two quotients. This gives the number of pounds per cubic foot to within 1 part in 865 (too large).

Summary.

- a = kilos per cubic meter.
 $b = 1/10$ of a .
 $c = \frac{1}{2}$ of b .
 $d = \frac{1}{4}$ of c .
 $e = c + d$, Ans. pounds per cubic foot (too large by 1/865).

Example.

- 986.4 kilos per cubic meter.
 2) 986.4

 4) 49.32
 12.33

 61.65 Ans. pounds per cubic foot (should be 61.579).

7. *Kilogrammes per Cubic Meter to Pounds per Cubic Yard.*

(Conversion factor, 1.685565.)

To the number of kilogrammes per cubic meter add one-half of itself and one-third of this half for the first approximation; to this sum add one-hundredth of itself and one-thousandth of itself. This gives the number of pounds per cubic yard to within one in 2,981 (too small).

Summary.

- a = kilos per cubic meter.
 $b = \frac{1}{2}$ of a .
 $c = 1/3$ of b .
 $d = a + b + c$, first approx.
 $e = 1/100$ of d .
 $f = 1/1000$ of d (1/10 of e).

$g = d + e + f$, Ans. pounds per cubic yard (too small by 1/2981).

Example.

- 2) 2632 kilos per cubic meter.
 3) 1316
 438.666

 4386.666
 43.866

 4386

 4434.919 Ans. pounds per cubic yard (should be 4436.407).

EXACT CONVERSION OF METERS INTO FEET BY RULE OF THUMB.

By the law of July 28, 1866, the legal equivalent of the meter in this country was fixed as 39.37 inches, and this action has been construed as basing the foot on the standard meter preserved in Paris and not on the yard measure preserved in London, which is the legal standard for England and the British colonies.

One good result of this rather arbitrary interpretation of the law is to make the American foot and the meter exactly commensurable. As will be shown below, it is possible to take advantage of this commensurability in converting meters into feet by a simple rule of thumb.

Rule.

Multiply the number of meters by 10 and divide by 3 for the first approximation; then divide the original number by 20 and the quotient in turn by 20, add the two quotients and subtract the sum from the first approximation. This gives the number of feet exactly!

Summary.

- a = meters.
 $b = 10$ times a .
 $c = 1/3$ of b , first approximation.
 $d = 1/20$ of a .
 $e = 1/20$ of d .
 $f = d + e$.
 $g = c - f$ Ans. feet (exact).

Example.

- I. Worked out in full.
 4368 meters. 20) 4368 218.4
 10 10.92

 20) 218.4
 10.92

 3) 43680 10.92 229.32 = f

 14560 first approx.
 229.32

 14330.68 Ans. feet (exactly correct).
 II. Abbreviated form.
 3) 43680 20) 436.8

 14560 20) 218.4
 229.32 10.92

 14330.68 Ans. 229.32 = f

In working the method by the abbreviated form a zero is added for the multiplication by 10, and in dividing the first time by 20 the decimal point is set over one place to the left in the dividend and the divisor cut down to 2; finally in making the second division by 20 the quotient is set one place to the right, so as to be ready to add to the first quotient without rewriting. This setting one place to the right of the quotient obtained by dividing by 2 gives the right sum if the decimal point is written just under the one above.

With a little practice it is possible to convert meters into feet very quickly, and as the method is absolutely accurate it can be applied to very large numbers. When we reflect that the only alternative without the use of cumbersome tables is to multiply the number of meters by the imperfect number 3.280833333+ it can be realized how much simpler it is to use the rule of thumb.

CARBON TETRACHLORIDE.

CARBON tetrachloride possesses, in comparison with carbon disulphide, benzene, gasoline and other petroleum products used for the extraction of oils and fats, the advantages of freedom from inflammability, which reduces the danger of fire and the cost of insurance, and of small latent heat of evaporation, facility of condensation, great dissolving power and lack of tendency to form emulsions with fats, all of which properties effect economies in the quantity of solvent or of fuel required.

Oil extracted from seeds by means of carbon tetrachloride does not retain any flavor of the solvent, and the oil cake may be fed to cattle.

The action of the tetrachloride on metal vessels is most marked when water is present. The metals least attacked are galvanized iron, copper, cast iron, tinplate, brass and sheet iron, in the order given. Gal-

vanized iron should be employed in the interior of apparatus, but copper or lead pipes and bronze cocks may be used.

Carbon tetrachloride is made by several processes in which carbon disulphide is acted upon by chlorine, directly or indirectly. The direct action takes place only at high temperatures and in presence of catalyzers. In the indirect method sulphur chloride or some similar compound is employed, with or without a catalyzer.

Cote has devised a process and an apparatus for the continuous production of carbon tetrachloride from chlorine, carbon and sulphur. Carbon disulphide and sulphur chloride are formed as intermediate products. The apparatus resembles the continuous distilling and rectifying apparatus of modern spirit distilleries. In one vertical cylinder or "column," which is filled with coke impregnated with manganese chloride, carbon disulphide and chlorine come together and form sulphur chloride, with a little carbon tetrachloride. The mixture flows into a second column, filled with coke impregnated with sulphide of iron, where it encounters a fresh stream of carbon disulphide. The resultant product consists of carbon tetrachloride mixed with a little sulphur chloride and containing free sulphur in solution. This mixture passes into a third column filled with metal balls and heated to 260 deg. F. The carbon tetrachloride and sulphur chloride are immediately converted into vapor in which form they pass into the fourth, or rectifying column, while the sulphur is melted and flows into an electrically heated furnace, where it combines with carbon to form carbon disulphide, which goes directly to the first two columns to recommence the cycle.

From the rectifying column the carbon tetrachloride passes into a vessel where it is distilled, in presence of water, to remove the last traces of sulphur chloride, and thence to a condensing and cooling worm.

An electric furnace is employed because the process was devised especially for the utilization of the chlorine evolved in the electrolytic production of soda.

In a radically different method, invented by H. S. Blackmore, of Mount Vernon, U. S. A., carbon tetrachloride is produced by the action of calcium hypochlorite upon calcium carbide and hydrochloric acid. In practice a mixture of 18 parts of chloride of lime and 3 parts of calcium carbide is exposed to the action of a current of hydrochloric acid gas, diluted with nitrogen in order to moderate the intensity of the reaction. The calcium carbide may be replaced by gaseous or vaporized hydrocarbons which should be mixed with the hydrochloric acid gas and directed upon the chloride of lime. On the other hand, the chloride of lime may be replaced by other oxidizing agents, or even by oxygen, provided that the operation is conducted at a dull red heat, at which hydrogen exhibits a greater affinity for oxygen than for carbon. Carbon tetrachloride is also produced by the action of the electric arc upon a fused mixture of calcium chloride and wood charcoal. The bromide, iodide, and fluoride of carbon can be produced by analogous methods.

Naphthalene is an annoying waste product in gas works, where it condenses in great quantities in the pipes. A small proportion of the product is used to destroy insects and protect fabrics from moths, and this was practically the only use made of the substance when Chenier, in 1904, conceived the idea of employing it as fuel for automobiles. Naphthalene is very rich in carbon and its price is only one-fourth that of gasoline, but its employment as a carbureter presents a number of difficulties which automobile engineers are now endeavoring to overcome. As naphthalene ($C_{10}H_8$) contains more carbon than even benzol (C_6H_6)—93.7 per cent in place of 92.3 per cent—its complete combustion is a matter of some difficulty. In the air it burns with a very smoky flame and deposits much of its carbon as soot. Yet it requires less air than benzol requires for complete combustion. Naphthalene is a solid at ordinary temperatures. It melts at 174½ deg. F. and boils at 424½ deg. F. In order to produce an explosive mixture of naphthalene and air the naphthalene must be heated above its melting point. The carbureting can then be effected by methods similar to those used for gasoline and other liquids. For this purpose the carbureter is usually heated by the exhaust gases. The air should also be heated before it comes into contact with the naphthalene. The quantity of air admitted to the cylinder should be regulated very carefully, as the slightest deficiency prevents complete combustion. The motor should be run with a volatile fuel until the carbureter has become heated and the naphthalene melted. These conditions make the employment of naphthalene troublesome, but they do not destroy its great advantage in point of economy. In comparative tests made in 1907 naphthalene produced nearly one-third more power than an equal weight of carbureted alcohol.