CHAPTER XX.

METRIC SYSTEM.

332. The **metric system** of weights and measures is a system based on a certain unit of length called the *meter*, all other units of the system being derived from the meter by use of the decimal scale.

The **meter** is the length of a certain platinum bar kept in the archives of the International Bureau of Weights and Measures at Lèvres (approximately 39.37 inches).

It was intended to make the meter equal $\frac{1}{10000000}$ part of the distance from earth's equator to its pole, but the relation is not exact, owing to a slight error in the original computation.

333. Derived Units.—Other units are derived from the meter taken as the fundamental unit, in two different ways:

(1) By use of 10 as a multiplier or divisor.

The size of the units derived thus is indicated by the prefixes, **deka-**, **hekto-**, **kilo-**, **myria-**, meaning 10, 100, 1000, 10000, respectively; and by **deci-**, **centi-**, **milli-**, meaning $\frac{1}{10}$, $\frac{1}{100}$, $\frac{1}{1000}$, respectively.

It is to be observed that the decimal *divisions* of the unit are expressed by *Latin* prefixes; the decimal *multiples* by *Greek* prefixes.

(2) By taking a certain portion of space or matter, determined by the metric unit of length, and making a new unit of this portion of space or matter.

Thus the volume of 1 cubic decimeter = the *liter*;
the volume of 1 cubic meter = the *stere*;
the weight of 1 cubic centimeter of water = the *gram*.

These new units, taken as primary units, may in turn be multiplied or divided in the decimal scale; hence, we have

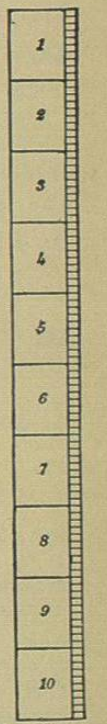
the various tables for metric weights and measures which are about to be given.

In these tables, only those units printed in **black letters** are much used in practice (just as in U. S. money only the dollar and cent are much used), the other units serving for computation, or other theoretic purposes merely.

334. I. **Measures of Length.**—The primary unit of length, as has been said, is the meter.

TABLE OF LENGTH.

10 **millimeters** (mm.)	= 1 **centimeter** (cm.).
10 centimeters	= 1 decimeter (dm.).
10 decimeters	= 1 **meter** (m.).
10 meters	= 1 dekameter (Dm.).
10 dekameters	= 1 hektometer (Hm.).
10 hektometers	= 1 **kilometer** (Km.).
10 kilometers	= 1 myriameter (Mm.).



1 Decimeter.

EXERCISE 163.

ORAL.

How many:

1. Meters in a kilometer? In a Dm.? In 5 Hm.?
2. Centimeters in a meter? In a Hm.? In 8 dm.?
3. mm. in a cm.? In 3 m.? In 5 dm.?
4. cm. in 800 mm.? In 4 m.? In ½ m.?
5. dm. in 25 m.? In 500 cm.? In 12 Dm.?
6. m. in 300 cm.? In 8000 dm.? In 15 Hm.?
7. m. in 3.5 Dm.? In 3.5 dm.? In 7 cm.?
8. cm. in 1.2 dm.? In 1.2 mm.? In 11 m.?
9. Hm. in 7 m.? In 70 Km.? In 77 cm.?
10. Km. in 300 Hm.? In 56 Dm.? In 8 m.?
11. The pupil may now state his own rule for changing metric quantities from one denomination to a higher, and his other rule for changing to a lower unit. A thorough mastery of this process by sufficient drill renders all the rest of metric system questions comparatively easy.

335. II. **Measures of Area.**—The unit of area is the square meter.

TABLE OF SQUARE MEASURE.

100 **sq. millimeters** (sq. mm.)	= 1 **sq. centimeter** (sq. cm.).
100 sq. cm.	= 1 sq. decimeter (sq. dm.).
100 sq. dm.	= 1 **sq. meter** (sq. m.).
100 sq. m.	= 1 sq. dekameter (sq. Dm.).
100 sq. Dm.	= 1 sq. hektometer (sq. Hm.).
100 sq. Hm.	= 1 **sq. kilometer** (sq. Km.).
100 sq. Km.	= 1 sq. myriameter (sq. Mm.).

336. III. **Measures of Land Surface.**—The ratio, 100, between two successive units of square measure is too great for many practical purposes, as in measuring *land*. Hence, a new unit, the *are*, is selected, which is increased or decreased with 10 as a scale.

Square Centimeter.

The unit of land measure is the **are** (pronounced "air"), which equals 100 square meters.

TABLE OF LAND MEASURE.

10 centares (ca.)	= 1 **deciare** (da.).
10 deciares	= 1 are (a.).
10 ares	= 1 dekare (Da.).
10 dekares	= 1 **hektare** (Ha.).

EXERCISE 164.

ORAL.

How many:

1. Sq. m. in a sq. Hm.? In a sq. Km.? In an are?
2. Sq. cm. in a sq. m.? In a sq. dm.? In 7 sq. m.?
3. Centares in an are? In a Da.? In 15 a.?
4. Ares in 25 Ha.? In 500 ca.? In 7 ca.?
5. Ares in $\frac{1}{2}$ Ha.? In 63 Da.? In 63 da.?
6. Ha. in 3 a.? In 303 a.? In 36 ca.?
7. Sq. dm. in 16 sq. m.? In 16 sq. cm.? In 106 sq. cm.?
8. Sq. m. in 2 sq. Dm.? In 22 sq. dm.? In 22 sq. cm.?
9. Sq. m. in 5 a.? In 75 a.? In 83 Ha.?
10. a. in 15 Ha.? In 35 ca.? In 35 Da.?

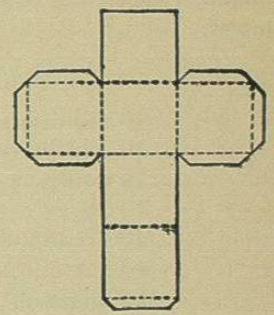
(To be continued by the teacher.)

337. IV. **Measures of Volume.**—The **cubic meter** is the unit of volume.

TABLE OF CUBIC MEASURE.

1000 cubic millimeters	= 1 **cubic centimeter** (cu. cm.).
1000 cu. cm.	= 1 cubic decimeter (cu. dm.).
1000 cu. dm.	= 1 **cubic meter** (cu. m.).

Let the student form a cubic centimeter by cutting out a piece of pasteboard of the shape indicated in the figure, cutting it half through at the dotted lines, then folding together in the shape of a cube and pasting with mucilage.



338. V. **Measures of Wood, etc.**—The ratio, 1000, between two successive units in the above table is too great for many practical purposes, as in measuring *wood*. Hence, a new unit, the *stere*, is taken, which is multiplied and divided according to the scale of 10.

The unit of wood measure is the **stere** (pronounced "stair"), which equals one cubic meter.

TABLE OF WOOD MEASURE.

10 millisteres (ms.)	= 1 **centistere** (cs.).
10 centisteres	= 1 decistere (ds.).
10 decisteres	= 1 **stere** (s.).

EXERCISE 165.

ORAL.

How many:

1. Cu. cm. in a cu. m.? In 16 cu. dm.? In 38 cu. mm.?
2. Cu. cm. in 6 cu. mm.? In 3 cu. m.? In 75 cu. dm.?
3. Cu. m. in 76 cu. dm.? In 768 cu. cm.? In 500 cu. mm.?

4. cs. in 1 stere? In 3 ds.? In 35 ds.?
5. St. in 3 ds.? In 75 cs.? In 8 cs.? In 800 ds.?
6. Cu. m. in 53 st.? In 25 ds.? In 6 cs.?
7. St. in 14 cu. dm.? In 240 cu. cm.? In 240 cs.?
8. Let the pupil construct a cu. dm. and a cu. cm. from pasteboard. Let him clearly see how the lengths of their edges compare; how the areas of their faces compare; and how their volumes compare.

339. VI. **Measures of Capacity.**—The **liter** (pronounced "leeter") is the unit of capacity. It equals a cubic decimeter; that is, the volume of a cube whose edge is $\frac{1}{10}$ of a meter.

TABLE OF CAPACITY.

10 milliliters (ml.)	= 1 **centiliter** (cl.).
10 centiliters	= 1 deciliter (dl.).
10 deciliters	= 1 **liter** (l.).
10 liters	= 1 dekaliter (Dl.).
10 dekaliters	= 1 **hektoliter** (Hl.).
10 hektoliters	= 1 kiloliter (Kl.).
10 kiloliters	= 1 myrialiter (Ml.).

EXERCISE 166.

ORAL.

How many:
1. Liters in a Kl.? In a Hl.? In 5 Dl.? In 75 dl.?
2. Dl. in 7 Kl.? In 40 Hl.? In 7 l.? In 58 dl.?
3. Liters in a cubic meter? In 206 cu. cm.?
4. cl. in 3 l.? In 1 Hl.? In 55 ml.?
5. Hl. in 25 Kl.? In 6 l.? In 44 Dl.? In 325 cl.?
6. dl. in 3 Dl.? In 15 l.? In 77 cl.? In 156 ml.?
7. l. in 30 cu. dm.? In 6 cu. cm.? In 45 cu. m.?
8. Let the pupil construct a liter out of pasteboard.

340. VII. **Measures of Weight.**—The **gram** is the unit of weight. It is the weight of a cubic centimeter of distilled water at its greatest density; that is, when at a temperature of 39.2° Fahrenheit.

TABLE OF WEIGHT.

10 milligrams (mg.)	= 1 **centigram** (cg.).
10 centigrams	= 1 decigram (dg.).
10 decigrams	= 1 **gram** (g.).
10 grams	= 1 dekagram (Dg.).
10 dekagrams	= 1 hektogram (Hg.).
10 hektograms	= 1 **kilogram** (Kg.).
10 kilograms	= 1 myriagram (Mg.).
10 myriagrams	= 1 quintal.
10 quintals	= 1 metric ton.

EXERCISE 167.

ORAL.

How many:
1. Grams in a Kg.? In 5 Hg.? In 87 dg.?
2. cg. in 4 g.? In 31 Dg.? In 7 mg.? In 70 g.?
3. dg. in 15 g.? In 17 Hg.? In 36 mg.? In 360 g.?
4. Kg. in 50 g.? In $\frac{1}{2}$ g.? In 7 Dg.? In 4 dg.?
5. Grams in weight of 1 cu. m. of water? In 7 cu. dm. water?
6. Kg. in 30 cu. m. water? In 16 cu. Km. of water?
7. cg. in 1 cu. cm. of water? In 13 cu. dm. of water?

NOTATION, NUMERATION, REDUCTION.

341. The methods of **notation** and **numeration** used in the metric system have been indicated in general already. With respect to **notation** it should be further remarked that

(1) Of the abbreviations used, those for units larger than the primary units begin with capital letters; the others with small letters.

(2) The place occupied by each unit with reference to the decimal point (when the scale is 10) should be fixed in mind. Thus, for the meter,

Mm.	Km.	Hm.	Dm.	m.	dm.	cm.	mm.
5	8	7	2	3	4	8	6

(3) In writing a metric number for which the scale is 100, the number of units of each denomination must occupy two

places (by the aid of zeroes if necessary); when the scale is 1000, three places. Thus, 35 sq. Km. 8 sq. Hm. 17 sq. m. is written 35080017 sq. m.

With respect to **numeration** or *reading* metric numbers, it should be remarked that a metric number may be read in either of two ways:

(1) *By specifying each unit.*

Thus, 37.56 m. may be read as "3 dekameters 7 meters 5 decimeters 6 centimeters," or

(2) *By reading the entire number as an abstract number, and then affixing the name of the primary unit.* According to this method the above number would read "thirty-seven and fifty-six hundredths meters."

342. Reduction.—*A metric number is reduced to a lower denomination by moving the decimal point to the right, one place for each reduction of the unit when the scale is 10; two places when the scale is 100; three places when the scale is 1000.*

Thus, 6.728 m. = 672.8 cm.

A metric number is reduced to a higher denomination by moving the decimal point to the left, correspondingly to the above rule.

Thus, 8596.2 mm. = 8.5962 m.

It is often an advantage, instead of making a single direct reduction, to make two steps of the reduction, by

(1) Converting the number of *given* units into *primary* units, and

(2) Converting the number of *primary* units into *required* units.

Ex. Convert 938765.23 dm. into kilometers.

We first change decimeters into meters, and then convert meters into kilometers.

Hence, 938765.23 dm. = 93876.523 m. = 93.876523 Km.

EXERCISE 168.

Reduce

1. 7.324 Km. to dm. To Dm. To cm.

2. 36.08 Dg. to Kg. To cg. To dg.

3. 712.45 sq. m. to sq. cm. To sq. Hm. To Ha.

4. 503.217 dl. to ml. To Dl. To Kl.

5. 55.171 ca. to Ha. To a. To sq. Dm.

6. .025 cu. m. to cu. cm. To l. To dst.

7. 5.3 st. to dst. To cu. dm. To st.

8. 12.345 Km. to Dm. To dm. To mm.

9. 3267.1 cg. to Dg. To Kg. To mg.

10. 106.73 dl. to ml. To Dl. To Kl.

11. 8.3 cu. cm. to cu. m. To l. To cu. mm.

12. 46.71 Dl. to cu. m. To cu. cm. To dl.

13. 500.7 Hg. to mg. To dg. To Kg.

14. 375.5 a. to Ha. To ca. To sq. Dm.

15. 40 Ha. to a. To sq. m. To ca. To sq. Dm.

16. 345.75 m. to cm. To Hm. To Km. To mm.

17. 863200 sq. cm. to sq. m. To Ha. To sq. Dm.

18. 385 l. to cl. To cu. m. To cu. Km.

19. How many Kgs. in the weight of 75 l. of water? Of 1 cu. m. of water? Of 170 cu. mm. of water? Of 35 cu. cm. of water? Of 11 Kl. of water?

20. How many l. of water are needed to weigh 75 Kg.? To weigh 5000 Kg.? To weigh 30 g.? To weigh 58.7 cg.? To weigh 138.75 Dg.?

21. Change 42.3 Hl. to dl. To cu. cm. To cu. m. Find its weight (if water) in g. In Kg.

OPERATIONS WITH METRIC NUMBERS.

343. Addition.—Metric numbers may be added in the same way as any other decimal numbers. It is necessary in all cases to reduce to the same denomination the metric numbers which are to be added.

Ex. Add 37 cm., 36.26489 Hm., 3 Km.

We reduce to meters all the numbers to be added.

37 cm. = 0.37 m.
36.26489 Hm. = 3626.489 m.
3 Km. = 3000. m.
6626.859 m., *Sum.*

344. Subtraction.

Ex. Subtract 387.92 cg. from 5.827 Dg.

Reducing both numbers to grams and subtracting.

5.827 Dg. = 58.27 g.
387.92 cg. = 3.8792 g.
54.3908 g., *Difference.*

345. Multiplication.

Ex. Find the area of a rectangular field which is 0.5 Km. long and 27.8 m. wide.

0.5 Km. = 500 m.
Area = 27.8 × 500 sq. m. = 13900.0 sq. m.
= 1.39 Ha., *Area.*

346. Division.

Ex. 1. Divide 21.856 Dm. by 3.2 cm.

21.856 Dm. = 218.56 m.
3.2 cm. = .032 m.
218.56 ÷ .032 = 6830, *Quotient.*

Ex. 2. How high must a box be in order that it may hold 30 liters, if it is 50 cm. long and 2 dm. wide?

Since 1 l. = 1 cu. dm.,
30 l. = 30 cu. dm. = volume of the box.

Since 50 cm. = 5 dm.,
the area of base of the box = 5 × 2 sq. dm. = 10 sq. dm.
Height of the box = volume ÷ area of base
= 30 ÷ 10 = 3.
∴ Height = 3 dm.

EXERCISE 169.

Add:

1. 3.6 m. + 45 cm. + .06 Km. + 3.2 Dm.
2. 7 a. + 120 ca. + .08 Ha.
3. 9 cu. dm. + 300 cu. mm. + 50.6 cu. m.
4. 4.81 dg. + 325.1 mg. + 14.78 Dg. + 1.31 Kg.
5. 43 cl. + 7.1 Hl. + 305 ml. + 2.5 Kl. + 27.8 l.
6. 75.38 Ha. + 438.1 a. + 9587 ca.
7. 9.03 m. + 903 mm. + 9030 cm. + 90.3 Dm. + 0.903 Km.

8. 307.5 dg. + 48.091 g. + 385.61 mg. + 7 Kg. + 9.9 Dg.
9. 17 cu. dm. + 385 cu. cm. + 4128 cu. mm. + 30.9 cu. m.
10. 14 l. + 1.403 Kl. + 378.12 cl. + 99 Hl. + 14 dl.
11. 77 cu. cm. + 32.3 l. + 9.5 dl. + 307.5 cu. dm. + 4 Dl.
12. 38 sq. Dm. + 19.3 Ha. + 1435 sq. m. + 281.5 a.

Subtract:

13. 7.3 cm. from .08 Km.
14. .46 Hl. from 8769.1 cl.
15. 5.7 sq. dm. from .09 Ha.
16. 3.57 g. from 2.538 Kg.

17. What is the difference between 7 Hm. 5 Dm. 3 m. 4 cm. and 8 Km. 3 Hm. 4 dm. 2 mm.?

18. What is the difference between 8 Kl. 5 l. 7 dl. 4 ml. and 7 Hl. 2 Dl. 1 l. 5 cl.?

19. From 57.3128 Kl. take 4875.625 cu. cm.

Multiply:

20. 3 Dm. 5 m. 4 cm. by 5.
21. 7 Kg. 3 Hg. 2 Dg. 7 dg. 8 cg. by 35.
22. Find the total length of 19 poles, each 7 m. 4 cm. 3 mm. long.
23. Find the entire weight of 40 casks, each weighing 4 Kg. 7 Dg. 5 g.
24. Find the total area of 32 fields, each containing 36 Ha. 8 a.
25. Find the entire capacity of 16 cans, each containing 4.037 Hl. Change result to cu. meters.

Find the area of a surface:

26. 3.02 m. × 25 cm.
27. 94.5 Km. × 6.8 m.
28. 3.6 mm. × 7.5 Hm.
29. 8.8 dm. × 2.4 Dm.

Divide:

30. 1800 dl. by 90 Dl.
31. 540 Ha. by 6 a.
32. 3.8 cu. m. by 1.9 cu. mm.
33. 77 sq. mm. by 5 sq. Dm.

34. 17 Km. 4 Dm. 5 m. 6 cm. 5 mm. by 5.
35. 130 Ha. 9 a. 4 ca. by 8.
36. 28 Kg. 9 Hg. 4 dg. 3 mg. by 25.

37. A field containing 56 Ha. is 35 Dm. long. Find its width. If it had been 26 Dm. 5 cm. long, find its width.

38. How many cu. m. in a box 30.6 dm. × 204 cm. × 0.5 Dm.?

39. How many liters in a box 3 m. × 8 dm. × 5 cm.?

40. A tank 12 m. × 75.8 dm. × 1.05 Dm. is full of water. Find its weight in Kg.

41. A vat is 4 m. × 36 dm. × 250 cm. Find its capacity in Kl. Find in Kg. the weight of water it will contain.

42. A box 15 dm. long and 80 cm. wide contains a cu. m. How deep is it?

43. A room is 5.2 m. long, 4.5 m. wide, 3.2 m. high. Find cost of plastering it at 42 cents per sq. m. Find No. of Kl. of air in the room.

44. A bin 7.4 m. × 3.6 m. × 2.5 m. will contain how many Hl. of grain? How many steres of wood?

45. What cost a pile of wood 12.3 m. long, 5.2 m. wide, and a Dm. high, at $3.50 a stere?

46. A cellar is 12.4 m. × 9.6 m. × 8.5 m. How many cu. m. of earth were removed in digging it? How many steres of wood might be piled in it? How many liters of water would it contain? What does this volume of water weigh in kilograms? How many Hl. of corn would the cellar hold?

47. How many liters in a cube whose edges are all 20 cm.?

48. A tank contains 9600 Kg. of water. It is 32 m. long and 1.2 m. deep. How wide is it?

49. A bar of metal is 3 m. × 2.8 m. × 1.5 m. and weighs 4.5 times as much as an equal volume of water. Find the weight of this bar (Kg.).

A certain vat is 14 m. × 10.8 m. × 9.5 m.

50. Find its capacity in steres. In liters. In Kl.

51. Find the weight of water it will contain.

52. Find the weight of tar it will contain, if tar is 1.8 as heavy as water.

53. Find the value of wheat it will hold at $2.40 a Hl.

54. Find the total area of its 6 faces in ares.

55. Find the edge of a cubical cistern of same contents.

56. If a piece of ore weighs 45 Kg., and of this 675 g. are silver, what per cent. of the ore is silver?

57. If a certain wine contains 12.8% alcohol, and 2.1% extract, the rest being water, what % is there of water? How many Kg. of water are there in 50 l. of the wine? How many cu. cm. of extract?

58. Divide 0.005 cu. dm. by 0.02, and express the quotient as a decimal of a cu. m.

59. A bin which holds 70 Hl. stands on a base 26 dm. × 2 m. How high is it?

METRIC EQUIVALENTS.

347. Direct Equivalents.—The following table shows the relation between different important metric units and the units of weight and measure in common use in the United States and Great Britain. The table should be committed to memory, the equivalents printed in black letters being of especial importance.

1 meter	**= 39.37 in. = 1.1 yd.**	**($39\frac{3}{8}$ in. approx.).**
1 kilometer	**= .6214 mile**	**($\frac{5}{8}$ mi. approx.).**
1 sq. meter	= 1.196 sq. yd.	($1\frac{1}{5}$ sq. yd. approx.).
1 hektare	**= 2.471 acres**	**($2\frac{1}{2}$ A. approx.).**
1 cu. meter	= 1.308 cu. yd.	($1\frac{1}{3}$ cu. yd. approx.).
1 stere	= .2759 cord	($\frac{3}{11}$ cd. approx.).
1 liter	**= 1.057 liquid quart**	**($1\frac{1}{16}$ l. qt. approx.).**
1 liter	**= .9081 dry quart**	**($\frac{9}{10}$ d. qt. approx.).**
1 liter	= 61.022 cu. in.	(61 cu. in. approx.).
1 hektoliter	= 2.8376 bushels	($2\frac{5}{6}$ bush. approx.).
1 hektoliter	= 26.417 gallons	($26\frac{2}{5}$ gal. approx.).
1 gram	= 15.432 grains	($15\frac{2}{5}$ gr. approx.).
1 kilogram	**= 2.2046 pounds av.**	**($2\frac{1}{5}$ lb. av. approx.).**
1 metric ton	**= 1.1023 ton**	**($1\frac{1}{10}$ T. approx.).**

348. The **inverse equivalents**, showing the value of units in use in the United States and Great Britain in terms of the metric units, are also often useful.

1 yd.	= .9144 m.	($\frac{9}{10}$ m.).
1 mi.	= 1.609 Km.	($1\frac{3}{5}$ Km.).
1 sq. yd.	= .8361 sq. m.	($\frac{5}{6}$ sq. m.).
1 acre	= .4047 Ha.	($\frac{2}{5}$ Ha.).
1 cu. yd.	= .7645 cu. m.	($\frac{3}{4}$ cu. m.).
1 cord	= 3.624 st.	($3\frac{2}{3}$ st.).
1 liquid qt.	= .9463 l.	($\frac{15}{17}$ l.).
1 dry qt.	= 1.101 l.	($1\frac{1}{9}$ l.).
1 bush.	= .3524 Hl.	($\frac{6}{17}$ Hl.).
1 grain	= .0648 g.	($\frac{5}{77}$ g.).
1 lb. av.	= .4536 Kg.	($\frac{5}{11}$ Kg.).
1 ton	= .9072 T.	($\frac{10}{11}$ T.).

Ex. 1. Reduce 30 m. to feet.

$$30 \text{ m.} = 39.37 \text{ in.} \times 30$$
$$= \frac{30 \times 39.37}{12} \text{ ft.} = \frac{393.7}{4} \text{ ft.} = 98.425 \text{ ft.}$$

Ex. 2. Find the area in hektares and also in acres of a field 50 Dm. long and 175 m. wide.

50 Dm. = 500 m.
Area = 175 × 500 sq. m. = 87500 sq. m.
= 8.75 Ha. (since 10000 sq. m. = 1 Ha.)
= 2.471 A. × 8.75
= 21.62125 A., *Result.*

EXERCISE 170.

Change:

1. 5 mi. to Km.
2. 13 bu. to Hl.
3. 56 A. to Ha.
4. 45 gal. to l.
5. 20 cd. to st.
6. 13 cu. yd. to cu. m.
7. 60 lb. to Kg.
8. 50 Hl. to bu.
9. 25 Hm. to rds.
10. 30 m. to ft.
11. 32 st. to cd.
12. 425 a. to A.
13. 126 l. to gal.
14. 325 l. to pk.

15. 100 Kg. to cwt.
16. 40 cu. m. to bu.
17. 9 Kl. to bu.
18. 72 rd. to Hm.
19. 25 lb. to g.
20. 5 cu. m. to cu. ft.
21. 95 a. to sq. rd.
22. 8 t. to Kg.
23. 7 l. to pk.
24. 109 cu. cm. to cu. in.
25. 40 sq. m. to sq. ft.
26. 30 gal. to dl.
27. 4 a. to sq. yd.
28. 16 mm. to in.
29. 85 ml. to pts. (oats).
30. 43 pt. to cl. (milk).

31. 2 mi. 45 rd. to Km.
32. 4 bu. 3 pk. 3 qt. to Hl.
33. 3 gal. 2 qt. 1 pt. to l.
34. 40 A. 100 sq. rd. 6 sq. yd. to Ha.
35. 3 T. 15 cwt. 40 lb. to Kg.
36. 7.53 Ha. to acres and lower denominations.
37. 18.32 Hl. to bushels and lower denominations.
38. 7528 Kg. to tons and lower denominations.
39. 87.538 l. to gal. and lower denominations.
40. 24.25 Km. to miles and lower denominations.

Find the weight of:

41. 17 l. of water in pounds.
42. 28 Kl. of water in tons.
43. 6 cu. m. of water in tons.
44. 1000 gal. of water in Kg.
45. 25 cu. yd. of water in Hg.
46. 1 cu. in. of water in g.

47. How many cu. yds. in a room 3 Dm. × 25 m. × 120 dm.

48. How many tons of water will a cistern 26 m. × 20 m. × 155 dm. contain?

49. A box contains 35.2 l., and its lid is 0.44 m. × 25 cm. What is its height in inches?

50. A vat is 4.5 m. long and 18 cm. deep. It will hold 605.88 lbs. of water. What is its width in decimeters?

51. If I buy 360 bu. of wheat at $.95 a bushel, and sell it at $2.95 a hektoliter, how much do I gain?

52. A bin is 19 ft. × 12 ft. × 5 ft. How many Hl. will it contain?

53. How many acres in a field 75 m. long and 64 m. wide?

54. Atmospheric pressure is about 1 Kg. per sq. cm. How many pounds is that to the square foot?

55. From the datum that a liter of water weighs a Kg., compute the weight of a cubic foot of water in pounds.

56. If a train travels 50 miles an hour, how many meters is it moving each second?

57. Change your height and weight to equivalent metric units.

58. How many Kg. will a standard bbl. of water weigh?

59. A cubic inch of a certain material weighs 2½ oz. How many Kg. in the weight of a block of it 11 yds. × 25 ft. × 16 ft.?

60. The circumference of a wheel is 4 m. 5 mm. How many revolutions will it make in 20 miles?

61. Explain how to construct the table of inverse equivalents (§ 348) from the table of direct equivalents (§ 347). By the use of only one table, what two rules will enable one to make any changes whatever from either system to the other?

62. The inside measurements of a cubical vessel are each 23 inches. How many liters of water will it contain? What will this water weigh in pounds?

63. How many quarts of milk will a box 3 dm. × 24 cm. × 15 cm. contain? How many quarts of corn?

64. Bought a farm of 220 acres at $60 an acre. For what must I sell it per Ha. to gain 20%?

65. Bought 560 bushels of grain at $1.70 per Hl. and sold it at 90 cents per bushel. What was my total gain and my gain %?

66. How many gallons in a tank 4.6 m. × 3 m. × 25 dm.?

67. A road 84 Km. long is 12 m. wide. What is the land worth at $15 an acre?

68. Bought wood at $4.40 a cord and sold it at $1.50 a stere. Did I gain or lose? What %?

69. The scale of a map is 1 to 80000. The distance between two cities on the map is 15 cm. How many miles between the cities?

70. On a map which is drawn on the scale of half an inch to the mile, 2 cities are 30 cm. apart. How many Km. are they really apart? How many miles?

71. When milk sells for 8 cents a quart, what is a Kl. of it worth?

72. If a pound of butter is worth 5 qts. of milk, how many liters of milk should a Kg. of butter be worth?

73. If a sq. rod of land is worth a stere of wood, how many Ha. of the same land are worth 500 cords of the same wood?

74. A cistern is 6 m. × 54 dm. × 4.5 m. Determine

(*a*) how many liters of water it will contain.
(*b*) what they will weigh in tons.
(*c*) how many gallons it will contain.
(*d*) how many bushels it will contain.
(*e*) how many steres of wood can be piled into it.
(*f*) how many ares in the sum of all its faces.
(*g*) how many rods in the sum of all its edges.

349. The **specific gravity** of a body is the ratio between the weight of the body and the weight of an equal bulk of water.

Since a kilogram is the weight of a liter, or cubic decimeter, of water, the metric system affords peculiar advantages in dealing with problems relating to specific gravity.

Ex. A bar of iron 5 dm. long, 4 cm. wide, and 10 mm. thick, has a specific gravity of 7.8. Find its weight in kilograms and pounds.

4 cm. = 0.4 dm., 10 mm. = 0.1 dm.
Volume of bar = 5 × 0.4 × 0.1 cu. dm.
= 0.2 cu. dm.

Weight of an equal volume of water = 0.2 Kg.
" " the bar of iron = 0.2 Kg. × 7.8 = 1.56 Kg.
= 1.56 lb. × 2.2046 = 3.439 lb. } *Result.*

EXERCISE 171.

1. A block of stone contains 50 cu. dm. What is its weight (sp. gr. 6.6)? Answer in Kg. and in lbs.

2. An irregular stone (sp. gr. 6.5) weighs 11.7 Kg. How many cu. m. in its volume? How many cu. ft.?

3. The sp. gr. of lead is 11.3; how many tons of lead in a bar 4 m. × 3 m. × 2 m.?

4. How many cu. ft. in the wood of a brush-heap (sp. gr. 0.7), which weighs 27.3 Kg.?

5. What is the weight of a granite shaft (sp. gr. 3.2) 8 m. × 75 dm. × 620 cm.? (Answer in metric tons.)

6. A bar of iron (sp. gr. 7.8) is 12 ft. × 3 ft. × 2 ft. Find its weight in Kg.

7. A coil of gold wire (sp. gr. 19.3) weighs a ton. How many cu. dm. in the coil? How many cu. in.?

8. A sheet of zinc weighs 300 Kg. (sp. gr. 7). How many cu. dm. in the zinc?

9. A bar of steel 35 m. long and 2.6 sq. dm. on the end, weighs how many pounds? (Sp. gr. 7.8.)

10. If a bar of metal containing 86 cu. dm. weighs 1267.64 lbs., what is its sp. gr.?

11. If a cubic meter of copper weighs 19580 lbs., find its sp. gr.

12. If a cubic meter of cork weighs 660 lbs., find its sp. gr.

13. A tank 8 m. × 6 m. × 45 dm. contains 178.2 tons of oil. What is the sp. gr. of the oil?

14. A cubic yard of a certain substance weighs as much as a cubic meter of water. What is its sp. gr.?

15. A liter of a certain liquid weighs as much as a gallon of water. Find its sp. gr.

16. A cubic foot of ice weighs 27.84 Kg. Find its sp. gr.

17. What is the sp. gr. of silver, when 12 cu. dm. of silver weigh 277.2 lbs.?

18. What is the sp. gr. of air when the air in a room 7.2 m. × 6.5 m. × 35 dm. weighs 212.94 Kg.?

19. State carefully and correctly a rule for each case:

(*a*) given volume and sp. gr., to find weight.

(*b*) given volume and weight, to find sp. gr.

(*c*) given weight and sp. gr., to find volume.

20. A vessel when empty weighs 2.5 Kg., and when full of mercury (sp. gr. 13.5) it weighs 121502.5 Kg. Find the capacity of the vessel.

21. An empty vessel weighs 3.3 lbs., and when full of milk weighs 22.1078 lbs. How many liters will the vessel contain? (Sp. gr. milk 1.03.)

22. A vessel holding a Dl. weighs when empty 2.4 Kg., and when full of oil 22 lbs. Find sp. gr. of the oil.

23. Find the weight in grams of a pint of sulphuric acid (sp. gr. = 1.8.)

24. If a bar of copper (sp. gr. 8.9) is 1.2 m. × 0.4 cm. × 0.6 mm., find its weight in ounces. In grams.

25. If a bar is 3 dm. × 6.4 cm. × 55 mm., how many coins, each weighing 4.5 grams, can be made from it (sp. gr. = 12.3)?

26. If sulphuric acid has a sp. gr. of 1.84, how many liters are there in 14 Kg. of the acid?

27. A tank 2.5 m. × 12.6 dm. × 75 cm. is $\frac{2}{3}$ full of tar (sp. gr. 2.5). Find in pounds the weight of the tar.

28. A glass inkstand, in the form of a cube, 8 cm. on each edge, contains a dl. of ink. If glass is 3 times as heavy as water, what ought the empty inkstand weigh? (Ans. in Kg.)

29. A box 3.8 m. × 3.5 m. × 50 cm. contains a liquid 0.92 times as heavy as water. Find the weight of the liquid when the box is $\frac{3}{4}$ full. Find the total weight if the other part be filled with water.

30. If 100 cu. in. of air weigh 31 g., find the sp. gr. of air. Find also the weight in Kg. of a cubic meter of air.

31. A Kg. of gold (sp. gr. 19.36) is beaten into sheets 0.01 mm. thick. How many ares will it cover?

32. If sea-water is 2.8% salt, and has a sp. gr. of 1.025, how many Kg. of salt can be obtained from 1000 cu. m. of sea-water?

33. A rectangular block of an alloy is 3.4 m. × 16 dm. × 25 cm. If the sp. gr. of the alloy is 15, and the block contains 6.12 Kg. of brass, what per cent. of it is brass

34. A rectangular vessel, 10 cm. wide and 3 cm. deep, contains 3 Kg. of sea-water (sp. gr. 1.025). How long is the vessel?

35. A mixture is formed by diluting 1 l. of nitric acid with 2 l. of water. If the sp. gr. of the acid is 1.5, what is the weight of the mixture? What % of this weight is nitric acid?

36. It being given that a cu. in. equals 16.39 cu. cm., how many cu. in. of gold (sp. gr. 19.3) weigh 100 Kg.?

37. A tank containing a certain volume of liquid, which weighs .962 as much as an equal volume of water, is emptied at the rate of 25 l. per hour. At the end of 3 hours the tank contains 163.2 Kg. of the liquid. What was the weight in Kg. of the liquid in the tank at first? What was its volume in gallons?

38. What must be the height of a tank whose bottom is 1 m. 2 dm. × 7 dm., and which holds 414.54 Kg. of oil (sp. gr. 1.05)?

39. If 20 cu. cm. of iron weigh as much as 144 cu. cm. of water, what will be the weight in Kg. of an iron cube 21 cm. on each edge? Of a cubic meter of iron?

40. A block of wood is 0.1 m. × 0.15 m. and weighs 3 Kg. Find its 3d dimension (sp. gr. 0.8).

CHAPTER XXI.

ARITHMETICAL HISTORY.

HISTORY OF NUMERATION AND NOTATION.

350. Number Groups.—Arithmetic begins with the making of units into groups, and the dealing with number by some group method. The first grouping of units in almost all savage tribes is done by aid of the fingers, either of one hand or of both hands, or by use of all the fingers and the toes. Hence the first number groups were fives, tens, or twenties.

For instance, one South African tribe uses three persons for numeration purposes, the first to count units on his fingers, the second to count tens, and the third hundreds.

Five is the primary number group among tribes who do not count much beyond twenty, as those in North Siberia, in New Hebrides, and the Esquimaux; twenty was the primary group among the Phœnicians, Basques, Aztecs, and is so among most of the tribes of South America, and some of those of North America. Ten is the usual base among primitive peoples in the rest of the world. However, the Maories of New Zealand use eleven as a base (thus, for them, the symbols 13 would mean one 11 and 3 units, or 14).

The Indo-European races seem to have used twelve as a base to a great extent, owing probably to the fact that two, three, four, and six will all divide it exactly. Twelve is in fact the best practical base, but ten is now too well established to make possible a general change to twelve.

The ancient Babylonians used sixty as a base, for a reason which will be given later.

351. Number Words.—Owing to the difficulty which savage peoples have in forming and using abstract language, the number words used by them do not always correspond to the groups formed by them by the aid of their fingers and