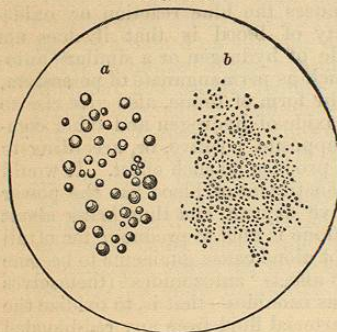


ance it imparts to urine, prevents its being confounded with pus. Day's test for pus consists in adding a drop or two of oxidized tincture of guaiacum to the urine or other liquid, when a clear blue color is produced. It is necessary to moisten dry pus with water before applying the test. The test-liquid is made by exposing a saturated alcoholic solution of guaiacum to the air until it has absorbed a sufficient quantity of oxygen to give it the property of turning green when placed in contact with iodide of potassium. Day's test for mucus consists in the application, first, of oxidized tincture of guaiacum, which by itself undergoes no change in the presence of mucus, and then in the addition of carbolic acid or creasote, which quickly changes the color of the guaiacum to a bright blue. Neither carbolic acid nor creasote alone will render guaiacum blue. In testing for mucus on cloths or when it is mixed with blood, it is necessary to use the carbolic acid pure, but when the mucus is in a liquid state it is better to use carbolic acid diluted with alcohol.

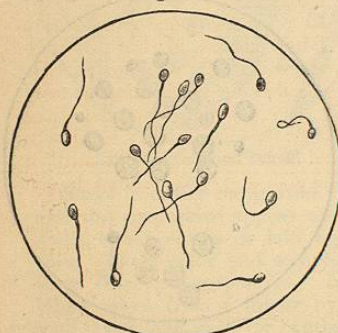
Saliva.—Saliva is an aqueous fluid containing less than 1 per

Fig. 60.



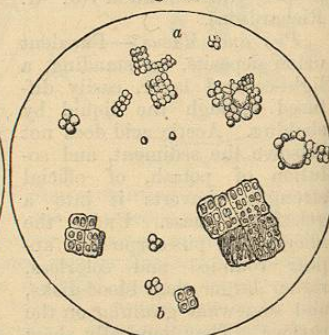
Fat-Globules.

Fig. 61.



Spermatozoa.

Fig. 62.



Sarcina ventriculi.

cent. of solid matter, of which one-third is an albumenoid substance termed *ptyalin* (from *πτύελον*, *spittle*), a body that has power of converting starch into dextrin and grape-sugar. Alkaline salts, including a trace of sulphocyanate of potassium, and calcareous compounds are also present.

Day's test for saliva in urine, etc. is similar to that for mucus, with the exception that the blue reaction produced by the oxidized tincture of guaiacum and alcoholic solution of carbolic acid is highly intensified by the addition of Robbins's aqueous or ethereal solution of peroxide of hydrogen.

Fatty matter occurs either as minute globules partially diffused through the urine (as shown at *a*, Fig. 60) or in more intimate emulsion (as at *b*). When present in larger quantity it collects as a sort of scum on the surface after standing.

Spermatozoa are liable to escape notice on account of their small size and extreme transparency. Suspected urine should be allowed to settle some hours in a conical test-glass, and the drop at the bottom examined under a high power. The drawing (Fig. 61) shows their tadpole-like appearance.

Sarcina ventriculi is a bacterium of a very rare occurrence in urine, though not unfrequent in vomited matters. The upper figures (*a*, Fig. 62) are copied from Dr. Thudichum's drawing (from urine); the larger fronds (*b*) are from vomited matter.

Extraneous bodies, such as hair, wool, or fragments of feathers, are often found in urinary deposits, and ludicrous mistakes have been made by observers not on their guard in respect to such casual admixtures.

EXAMINATION OF URINARY CALCULI.

The term *calculus* is the diminutive of *calx*, a lime- or chalk-stone.

Knowledge of the composition of a calculus or urinary deposit affords valuable diagnostic aid to the physician; hence the importance of a correct analysis of these substances.

Nature of Calculi.—Urinary calculi have the same composition as unorganized urinary sediments. They consist, in short, of sediments that have been deposited slowly within the bladder, particle on particle, layer on layer, the several substances becoming so compact as to be less easily acted on by reagents than when deposited after the urine has been passed—the urates less readily soluble in warm water, the calcic phosphate insoluble in acetic acid until it has been dissolved in hydrochloric acid and reprecipitated by an alkali.

Preliminary Treatment.—If the calculus is whole, saw it in two through the centre, and notice whether it is built up of distinct layers or apparently consists of one substance. If the latter, use about a grain of the sawdust for the analysis; if the former, carefully scrape off portions of each layer and examine them separately. If the calculus is in fragments, select fair specimens of about half a grain or a grain each, and reduce to a fine powder by placing on a hard surface and crushing under the blade of a knife.

Analysis.—Commence the analysis by heating a portion, about the size of a pin's head, on platinum foil, in order to ascertain whether organic matter, inorganic matter, or both are

present. If both, the ash is examined for inorganic substances and a fresh portion of the calculus for uric acid by the murexid test. (In the absence of uric acid any slight charring may be considered to be due to indefinite animal matter.) If composed of organic matter only, the calculus will in nearly all cases be uric acid, the indications being confirmed by applying the murexid test, in a watch-glass, to another fragment half the size of a small pin's head. If inorganic only, the ash on the platinum foil may be examined for phosphates, and a separate portion of the calculus for oxalates. Even a single drop of liquid obtained in any of these experiments may be filtered by placing it on a filter not larger than a sixpence and previously moistened with water, and adding three or four drops of water one after the other as each passes through the paper; or a drop of mixture may be placed on a fragment of damped filter-paper on a glass slide, the latter then tilted, and a clear drop be drained off from the paper on to the slide ready for the addition of a reagent. If the calculus is suspected to contain more than one substance, boil about half a grain of the powder in half a test-tubeful of distilled water for a few minutes, and pour it on a small filter; then proceed according to the following Table:—

<i>Insoluble.</i>		<i>Soluble.</i>
Phosphates, oxalate of calcium, and free uric acid.		Urates.
Boil with two or three drops of hydrochloric acid, and filter.		These will probably be redeposited as the solution cools. Small quantities may be detected by evaporating the solution to dryness. They are tested for ammonium, sodium, calcium, and the uric radical by the appropriate reagents.
<i>Insoluble.</i>	<i>Soluble.</i>	
Uric acid. Apply the murexid test (p. 358).	Phosphates and oxalate of calcium.	
	Add excess of ammonia, and then excess of acetic acid; filter.	
<i>Insoluble.</i>	<i>Soluble.</i>	
Oxalate of calcium.	Phosphates. They may be reprecipitated by ammonia.	

Varieties of Calculi.—Calculi composed entirely of uric acid are common; a minute portion heated on platinum foil chars, burns,

and leaves scarcely a trace of ash. The phosphates frequently occur together, forming what is known as the *fusible calculus* from the readiness with which a fragment aggregates, and even fuses to a bead, when heated on a loop of platinum wire in the blowpipe-flame. The phosphates may, if necessary, be further examined by the method described in connection with urinary deposits. Oxalate of calcium often occurs alone, forming a dark-colored calculus having a very rough surface, hence termed the *mulberry calculus*. Smaller calculi of the same substance are called, from their appearance, *hempsed calculi*. Calculi of *cystin* are rarely met with. *Xanthin* (from *ξανθος*, *xanthos*, yellow, in allusion to the color it yields with nitric acid) less often occurs as a calculus. The earthy concretions, or *chalk-stones*, which frequently form in the joints of gouty persons are composed chiefly of urates, the sodium salt being that most commonly met with. *Gall-stones*, or *biliary calculi*, occasionally form in the gall-bladder; they contain *cholesterin* (from *χολή*, *cholē*, bile, and *στερεός*, *stereos*, solid), a fatty substance of alcoholoid constitution, soluble in rectified spirit or ether, and crystallizing from such solutions in well-defined, square, scaly crystals. Phosphatic and other calculi of many pounds weight are occasionally found in the stomach and larger intestines of animals.

QUESTIONS AND EXERCISES.

907. In breathing, how much carbon (in the form of carbonic acid gas) is exhaled from the lungs every twenty-four hours?
908. How may the presence of carbonic acid gas in expired air be demonstrated?
909. Mention an experiment showing the escape of moisture from the lungs during breathing.
910. State the method of testing for albumen in urine.
911. Give the test for sugar in urine.
912. What is the average composition of healthy urine?
913. Give the tests for urea.
914. Write the rational formulæ of some compound ureas in which methyl or ethyl displaces hydrogen.
915. Describe an artificial process for the production of urea, giving equations.
916. Sketch out a plan for the chemical examination of urinary sediments.
917. A deposit is insoluble in the supernatant urine or in acetic acid; of what substance may it consist?
918. Which compounds are indicated when a deposit redissolves on warming it with the supernatant urine?
919. Name the salts insoluble in warmed urine, but dissolved on the addition of acetic acid.
920. Mention the chemical characters of cystin. At what stage of analysis would it be recognized?

921. Describe the microscopical appearance of the following urinary deposits: Uric acid, cystin, triple phosphate, earthy phosphates, urates, oxalate of calcium, carbonate of calcium, hippuric acid, tubercasts, epithelial *débris*, blood, pus, mucus, fat, spermatozoa, sarcina, extraneous bodies.

922. How are Day's tests for blood, pus, and saliva applied?

923. What is the general, physical, and chemical nature of urinary calculi?

924. How are urinary calculi prepared for chemical examination?

925. Draw out a chart for the chemical examination of urinary calculi.

926. Why is the "fusible calculus" so called? and what is its composition?

927. State the characters of "mulberry" and "hempseed" calculi.

928. What are the "chalk-stones" of gout and "gall-stones" or "biliary calculi"?

THE GALENICAL PREPARATIONS OF THE PHARMACOPŒIAS.

The preparation of Abstracts, Cerates, Confections, Decoctions, Elixirs, Enemas, Extracts, Glycerins, Infusions, Inhalations, Juices, Liniments, Lozenges or Troches, Mixtures, Ointments, Pills, Plasters, Poultices, Powders, Spirits, Suppositories, Syrups, Tinctures, Triturations, and Wines includes a number of mechanical rather than chemical operations, and belongs to the domain of pure Pharmacy. The medical or pharmaceutical pupil will have had ample opportunity of practically studying those compounds before working at experimental chemistry, and will probably have prepared many of them according to the directions of the Pharmacopœias; if not, he is referred to the pages of the last edition of those works for details.

Among the extracts of the British Pharmacopœia, however, there are five (namely, those of Aconite, Belladonna, Hemlock, Henbane, and Lettuce) which are not simply evaporated infusions, decoctions, or tinctures, like most others, but are evaporated juices from which vegetable albumen, the supposed source of fermentation and decay, has been removed, and chlorophyll (the green coloring-matter of plant-juice) retained, practically unimpaired in tint. For educational practice either of the above-named five raw materials may be employed; but in order

that attention may be concentrated on the process by which the extracts are prepared, rather than on any one of the extracts themselves, it suffices to make an extract of some ordinary green vegetable, such as cabbage or turnip-tops. Bruise the green leaves of a good-sized cabbage in a mortar, and press out the juice: heat it gradually to 130° F., and remove the green flocks of chlorophyll which separate, by filtration through calico. When the liquor has all passed through the filter, set the chlorophyll aside for a time, heat the strained liquor to 200° F. to coagulate albumen; remove the latter by filtration and throw it away; evaporate the filtrate by a water-bath to the consistence of thin syrup; then add to it the chlorophyll, and, stirring the whole together assiduously, continue the evaporation at a temperature not exceeding 140° F. until the extract is of a suitable consistence for forming pills. A higher temperature than that indicated would cause the alteration of the chlorophyll to a dark-brown substance, any such extract used in pharmacy no longer having the green tint which custom and the British Pharmacopœia demand.

QUESTIONS AND EXERCISES.

929. Enumerate the different classes into which official galenical preparations may be divided.

930. Describe the general process for the preparation of green extracts:—

Aconite.	Hemlock.
Belladonna.	Henbane.
Lettuce.	

931. Why is vegetable albumen excluded in the preparation of green extracts?

932. How may chlorophyll be removed from vegetable juices, and again be introduced into their evaporated residues, without destroying its color?

933. For what reason is exposure of chlorophyll to a boiling temperature avoided in the manufacture of green extracts?

THE CHEMICAL PREPARATIONS OF THE PHARMACOPŒIAS.

The process by which every official chemical substance is prepared has already been described, and the strict chemical character of the processes illustrated by experiments and explained by aid of equations. Should the reader, in addition, desire an intimate acquaintance with those details of manipulation on which the successful and economic manufacture of chemical substances depends, he is advised to prepare, if he has not done so already, a few ounces of each of the salts mentioned in the Pharmacopœias or commonly used in Pharmacy. An additional guide in these operations will be the Pharmacopœia itself.

The production of many chemical and galenical substances on a commercial scale can only be successfully carried on in manufacturing laboratories and with some knowledge of the circumstances of supply and demand, value of raw material and of by-products, etc.; for the technical preparation of such substances requires much knowledge beyond even a thorough acquaintance with Chemistry. Still, in the present day, commercial Chemistry and Pharmacy can best hope for success when founded on the working out of abstract scientific principles. The problem of manufacturing success is now only solved with certainty by sound and wisely-applied science.

Memorandum.—The next subject of experimental study will be determined by the nature of the student's future pursuits. In most cases the operations of quantitative analysis will engage attention. These should be of a volumetric and gravimetric character; for details concerning them see the following pages.

QUANTITATIVE ANALYSIS.

INTRODUCTORY REMARKS.

General Principles.—The proportions in which chemical substances unite with each other in forming compounds are definite

and invariable (p. 47). Quantitative analysis is based on this law. When, for example, aqueous solutions of a salt of silver and a chloride are mixed, a white curdy precipitate is produced containing chlorine and silver in atomic proportions; that is, 35.4 parts of chlorine to 107.7 of silver. No matter what the chloride or what the salt of silver, the resulting chloride of silver is invariable in composition. The formula AgCl is a convenient picture of this compound in these proportions. The weight of a definite compound being given, therefore, the proportional amounts of its constituents can be ascertained by simple calculation. Suppose, for instance, 8.53 parts of chloride of silver have been obtained in some analytical operation; this amount will contain 2.11 parts of chlorine and 6.42 of silver; for if 143.1 (the molecular weight) of chloride of silver contain 35.4 (the atomic weight) of chlorine, 8.53 of chloride of silver will be found to contain 2.11 of chlorine:—

$$\begin{array}{rcl}
 143.1 & : & 35.4 \\
 & & 8.53 \\
 & & \hline
 & & 1.062 \\
 & & 17.70 \\
 & & \hline
 & & 283.2 \\
 143.1 &) & 301.962(2.11 \\
 & & 286.2 \\
 & & \hline
 & & 15.76 \\
 & & 14.31 \\
 & & \hline
 & & 1.452 \\
 & & 1.431 \\
 & & \hline
 & & 21
 \end{array}
 \qquad x = 2.11.$$

And if 143.1 of chloride of silver contain 107.7 of silver, 8.53 of chloride of silver will contain very nearly 6.42 of silver. To ascertain, for example, the amount of silver in a substance containing, say, nitrate of silver, all that is necessary is to take a weighed quantity of the substance, dissolve it, precipitate the whole of the silver by adding hydrochloric acid or other chloride till no more chloride of silver falls, collect the precipitate on a filter, wash, dry, and weigh. The amount of silver in the dried chloride, ascertained by calculation, is the amount of silver in the quantity of substance on which the operation was conducted; a rule-of-three sum gives the quantity per cent., the form in which the results of quantitative analysis are usually stated. Occasionally a constituent of a substance admits of being isolated and weighed in the uncombined state. Thus the amount of mercury in a substance may be determined by separating and weighing the mercury in a metallic condition; if occurring as calomel (HgCl) or corrosive sublimate (HgCl_2), the proportion of chlorine may then be ascertained by calculation ($\text{Hg} = 199.7$; $\text{Cl} = 35.4$).

Nature of Gravimetric Quantitative Analysis.—As above stated, a body may be isolated and weighed, and its quantity thus ascertained, or it may be separated and weighed in combination with another body

whose combining proportion is well known; this is quantitative analysis by the *gravimetric* method.

Nature of Volumetric Quantitative Analysis.—Volumetric operations depend for success on some accurate initial gravimetric operation. A weighed amount of a pure salt is dissolved in a given volume of water or other fluid, and thus forms a *standard solution*. Accurately measured quantities of such a solution will obviously contain just as definite amounts of the dissolved salt as if those amounts were actually weighed in a balance, and, as measuring occupies less time than weighing, the volumetric operations can be conducted with great economy of time as compared with the corresponding gravimetric operations. Quantitative analysis by the *volumetric* method consists in noting the volume of the standard liquid required to be added to the substance under examination before a given effect is produced. Thus, for instance, a solution of nitrate of silver of known strength may be used in experimentally ascertaining an unknown amount of chlorine in any substance. The silver solution is added to a solution of a definite quantity of the substance until flocks of chloride of silver cease to be precipitated: every 107.7 parts of silver added (or 169.7 of nitrate of silver: $\text{Ag}=107.7$, $\text{N}=14$, $\text{O}_3=48$; total 169.7) indicates the presence of 35.4 of chlorine or an equivalent quantity of any chloride. The preparation of standard solutions, such as that of nitrate of silver, to which allusion is here made, requires considerable care, but when made certain analyses can, as already indicated, be executed with far more rapidity and ease than by gravimetric processes.

Quantitative Determination of (a) Atmospheric Pressure, (b) Temperature, and (c) Weight.—The quantitative analysis of solids and liquids often involves quantitative determinations of atmospheric pressure, temperature, and weight. These processes will now be explained, after which an outline of volumetric and gravimetric quantitative analysis will be given. The scope of this work precludes any attempt to describe all the little mechanical details observed by quantitative analysts; essential operations, however, are so fully treated that expert manipulators will meet with little difficulty.

Quantitative Determination of Atmospheric Pressure.

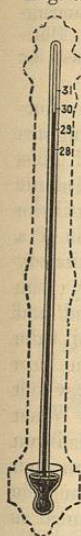
The Barometer.—The analysis of gases and vapors involves determinations of the varying pressure of the atmosphere as indicated by the *barometer* (from $\beta\acute{\alpha}\rho\omicron\varsigma$, *baros*, weight, and $\mu\acute{\epsilon}\tau\rho\omicron\nu$, *metron*, measure).

The *ordinary mercurial barometer* is a glass tube 33 or 34 inches long, closed at one end, filled with mercury, and inverted in a small cistern or cup of mercury (fig. 63). The mercury remains in the tube, owing to the weight or pressure of the atmosphere on the exposed surface of the liquid, the average height of the column being nearly 30 inches. In the popular form of the instrument, the wheel-barometer, the cistern is formed by a recurvature of the tube (fig. 64); on the exposed surface of the mercury a float is placed, from which a thread passes over a pulley and moves an index whenever

the column of mercury rises or falls. As supplied to the public, these barometers are usually enclosed in ornamental frames with thermometers attached. In the wheel-

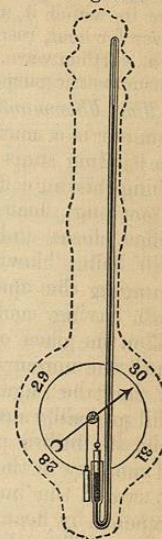
barometer the glass tube and contained column of mercury are altogether enclosed, the index alone being visible. In the other variety the upper end of the glass tube and mercurial column are exposed, and the height of the mercury is ascertained by direct observation.

Fig. 63.



Barometer.

Fig. 64.



Barometer.

The *aneroid barometer* (from $\acute{\alpha}$, *a*, without, and $\nu\eta\rho\omicron\varsigma$, *neros*, fluid) consists of a small, shallow, vacuous metal drum, the sides of which approach each other when an increase of atmospheric pressure occurs, their elasticity enabling them to recede toward their former position on a decrease of pressure. This motion is so multiplied and altered in direction by levers, etc. as to act on a hand traversing a plate on which are marked numbers corresponding with those showing the height of the mercurial column of the ordinary barometer by which the aneroid was adjusted. The *Bourdon barometer* (from the name of the inventor) is a modified aneroid, containing, in the place of the round metal box, a flattened vacuous tube of metal bent nearly to a circle. These barometers are also useful for measuring the pressure in steam-boilers, etc. Under the name of *pressure-gauges* they are sold to indicate pressure of 500 pounds and upward per square inch. From their portability (they can be made of 1 to 2 inches in diameter and 1 inch thick) they are excellent companions for travellers wishing to know the height of hills, mountains, and other elevations.

For further information concerning the influence of pressure on the volume of a gas or vapor see page 547; and for descriptions of the methods of analyzing gases refer to Ganot's *Physics* (translated by Atkinson), Miller's *Chemical Physics*, and "Analysis of Gases" in Watt's *Dictionary of Chemistry*.

Quantitative Determination of Temperature.

General Principles.—As a rule, all bodies expand on the addition and contract on the abstraction of heat, the alteration in volume being constant and regular for equal increments or decrements of temperature. The extent of this alteration in a given substance, expressed in parts or degrees, constitutes the usual method of intelligibly stating, with accuracy, precision, and minuteness, a particular condition of warmth or temperature—that is, of sensible

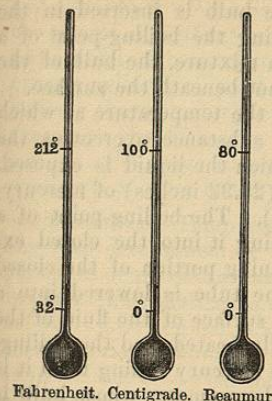
heat. The substance commonly employed for this purpose is mercury, the chief advantages of which are that it will bear a high temperature without boiling, a low temperature without freezing, does not adhere to glass to a sufficient extent to "wet" the sides of any tube in which it may be enclosed, and, from its good conducting-power for heat, responds rapidly to changes of temperature. Platinum, earthenware, alcohol, and air are also occasionally used for thermometric purposes.

The Thermometer.—The construction of an accurate thermometer is a matter of great difficulty, but the following are the leading steps in the operation:—Select a piece of glass tubing having a fine capillary (*capillus*, a hair) bore and about a foot long; heat one extremity in the blowpipe-flame until the orifice closes and the glass is sufficiently soft to admit of a bulb being blown; heat the bulb to expel air, immediately plunging the open extremity of the tube into mercury; the bulb having cooled, and some mercury having entered and taken the place of expelled air, again heat the bulb and tube until the mercury boils and its vapor escapes through the bore of the tube: again plunge the extremity under mercury, which will probably now completely fill the bulb and tube. When cold the bulb is placed in melting ice. The top of the column of mercury in the capillary tube should then be within an inch or two of the bulb; if higher, some of the mercury must be expelled by heat; if lower, more metal must be introduced as before. The tube is now heated near the open end and a portion drawn out until the diameter is reduced to about one-tenth. The bulb is next warmed until the mercurial column rises above the constricted part of the tube, which is then rapidly fused in the blowpipe-flame and the extremity of the tube removed.

The instrument is now ready for *graduation*. The bulb is placed in the steam just above some rapidly boiling water (a medium having, *ceteris paribus*, an invariable temperature), and when the position of the top of the mercurial column is constant (the flask containing the water and steam being jacketed to prevent loss of heat by radiation), a mark is made on the tube by a scratching diamond or a file. This operation is repeated with melting ice (also a medium having an invariable temperature). The space between these two marks is divided into a certain number of intervals termed *degrees*. Unfortunately, this number is not uniform in all countries: in England it is 180, as proposed by Fahrenheit; in France 100, as proposed by Celsius (the Centigrade scale), a number generally adopted by scientific men; in some parts of the Continent the divisions are 80 for the same interval, as suggested by Reaumur. Whichever be the number selected, similar markings should be con-

tinued beyond the boiling- and freezing-points as far as the length of the stem admits. They may be made on the stem itself or on any wood, metal, or earthenware frame on which the stem is mounted.

Fig. 65.
Thermometric Scales.



Thermometric Scales (fig. 65).—On the Centigrade (C.) and Reaumur (R.) scales the freezing-point of water is made zero, and the boiling-point 100 and 80 respectively; on the Fahrenheit (F.) scale the zero is placed 32 degrees below the congealing-point of water, the boiling-point of which becomes, consequently, 212. Even on the Fahrenheit system, temperatures below the freezing-point of water are often spoken of as "degrees of frost;" thus 19 degrees as marked on the thermometer would be regarded as "13 degrees of frost." It is to be regretted that the freezing-point of water is not universally regarded as the zero-point, and that the number of intervals between that and the boiling-point is not everywhere the same.

The degrees of one scale are easily converted into those of another if their relations be remembered—namely: 180 (F.), 100 (C.), 80 (R.); or 18, 10, and 8; or, best, 9, 5, and 4.

Formulae for the Conversion of Degrees of one Thermometric Scale into those of another.

F = Fahrenheit.
R = Reaumur.
C = Centigrade.
D = The observed degree.

If above the freezing-point of water (32° F; 0° C; 0° R),

F into C $(D - 32) \div 9 \times 5$,
F " R $(D - 32) \div 9 \times 4$,
C " F $D \div 5 \times 9 + 32$,
R " F $D \div 4 \times 9 + 32$.

If below freezing, but above 0° F (−17° 77 C; −14° 22 R),

F into C $-(32 - D) \div 9 \times 5$,
F " R $-(32 - D) \div 9 \times 4$,
C " F $32 - (D \div 5 \times 9)$,
R " F $32 - (D \div 4 \times 9)$.

If below 0° F (−17° 77 C; −14° 22 R),

F into C $-(D + 32) \div 9 \times 5$,
F " R $-(D + 32) \div 9 \times 4$,
C " F $-(D \div 5 \times 9) - 32$,
R " F $-(D \div 4 \times 9) - 32$.

For all degrees:

$$\begin{array}{lcl} \text{C into R} & & D \div 5 \times 4. \\ \text{R " C} & & D \div 4 \times 5. \end{array}$$

In ascertaining the temperature of a liquid the bulb of a thermometer is simply inserted and the degree noted. In determining the boiling-point also the bulb is inserted in the liquid, if a pure substance. In taking the boiling-point of a liquid which is being distilled from a mixture, the bulb of the thermometer should be near to but not beneath the surface.

The "boiling-point" of a liquid is the temperature at which the elasticity of the vapor of the substance overcomes the atmospheric or other pressure to which the liquid is exposed. If the pressure is equal to 760 mm. (29.92 inches) of mercury, water will boil at 100° C. (212° F.). The boiling-point of a drop of a fluid is taken by introducing it into the closed extremity of a small U-tube, the remaining portion of the closed limb being filled with mercury. The tube is lowered into a bath, the open limb being above the surface of the fluid of the bath. The bath is slowly and equally heated, and the boiling-point of the liquid, indicated by the mercury falling until it is level in the two limbs, taken by a thermometer whose bulb is close to the U-tube.

The following are the boiling-points of a few substances met with in pharmacy:—

	Centigrade.	Fahrenheit.
Alcohol, absolute	78.3	173
" 84 per cent.	79.5	175
" 49 per cent. (proof spirit)	81.4	178.5
" amylic	132.2	270
Benzol	80.6	177
Bromine	63.0	145.4
Benzoic acid	239.0	462
Carbolic acid	187.8	370
Chloroform	61	142
Ether (B. P.) (below)	40.5	105
" pure	35	95
Mercury <i>in vacuo</i> (as in a thermometer)	304	580
" in air (barom. at 30 inches)	350	662
Water (barom. at 29.92 inches)	100	212
" { " 29.33 " }	99.5	211
" { " 28.74 " }	99	210
Saturated solutions of—		
Cream of tartar	101	214
Common salt	106.6	224
Sal ammoniac	113.3	236
Nitrate of sodium	119	246
Acetate of sodium	124.4	256
Chloride of calcium	179.4	355

By "gentle heat," U. S. P., is meant any temperature between about 32° C. and 38° C. (about 90° and 100° F.).

To Determine Melting-points of Fat.—Heat a fragment of the substance (spermaceti or wax, for example) till it liquefies, and then draw up a small portion into a thin glass tube about the size of a knitting-needle. Immerse the tube in cold water contained in a beaker, and slowly heat the vessel till the thin opaque cylinder of solid fat melts and becomes transparent; a delicate thermometer placed in the water indicates the point of change to the fifth of a degree. Remove the source of heat and note the congealing-point of the substance; it will be identical with or close to the melting-point.

Pyrometers.—Temperatures above the boiling-point of mercury are determined by ascertaining to what extent a bar of platinum or porcelain has elongated. The bar is enclosed in a cavity of a suitable case, a plug of platinum or porcelain placed at one end of the bar, and the whole exposed in the region the temperature of which is to be found. After cooling, the distance to which the bar has forced the plug along the cavity is accurately measured and the corresponding degree of temperature noted. The value of the distance is fixed for low temperatures by comparison with a mercurial thermometer, and the scale carried upward through intervals of equivalent length. Such thermometers are conventionally distinguished from ordinary instruments by the name *pyrometer* (from *πυρ*, *pur*, fire, and *μέτρον*, *metron*, measure).

The following are melting-points of substances official in the British Pharmacopœia:—

	In degrees Centigrade.	In degrees Fahrenheit.
Acetic acid, glacial	8.9	48
" " " congeals at	1.1	34
Benzoic acid	120	248
Carbolic acid	35	95
Oil of theobroma (about)	32	90
Phosphorus	43.3	110
Prepared lard (about)	38	100
" suet	39.5	103
Spermaceti (not under)	38	100
White wax	65.5	150
Yellow wax	60	140

The order of fusibility of a few of the metals is as follows:—

	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