APPENDIX.

Nº I.

OF WATER.

WATER is an agent of great importance, independent of the part it sustains in the magnificent operations of Nature. Its efficacy in the cure of diseases is indubitable; yet it is not admitted into the list of materia medica of any of the British Pharmacopœias, either in the state in which it is most commonly procured, or that in which it holds in solution substances from which it receives new properties, and is rendered capable of producing important changes in the animal œconomy. In the first state it is denominated COMMON WATER; in the second, MINERAL WATER: and under both of these forms, it is necessary that its qualities and effects should be known to the medical practitioner.

I. COMMON WATER.

The usual appearance of water is too well known to require description. It retains its fluidity under the ordinary pressure of the atmosphere, at any degree of temperature between 32 and 212° [1], Fah.: but under 32° it crystallizes and becomes solid, or is changed into ice; and above 212° [2] assumes an aëriform character, or becomes steam, expanding to 1698 times its ordinary bulk. One cubic inch of pure water at 60°, and under a pressure of the atmosphere indicated by 30° of the barometer, weighs 252·422 grains, or $\frac{1}{12}$dth of a grain less than two hundred and fifty-two grains and a half.

Although water is almost universally diffused over the surface of the earth, yet it is not found perfectly pure in any place; which is owing to its great solvent powers enabling it to take up a portion of many things with which it must come into contact in its natural state. These impregnations, however, are not sufficient in general to give it any very sensible taste or odour, or to render it unfit for the ordinary purposes of life; and it is in this state that common water is usually obtained. Common water varies considerably according to the source whence it is derived, and other circumstances; but all the varieties may be reduced under the three following heads:

1. Rain Water—*Aqua pluvialis.*
2. Spring Water—*Aqua fontana.*
3. River Water—*Aqua fluviatilis.*

1. RAIN WATER is the purest kind of natural water; but it, nevertheless, contains in solution, in every 100 cubic inches, about $3\frac{1}{2}$ cubic inches of air, rather more oxygenous than common atmospherical air, and about one cubic inch of carbonic acid gas, besides minute portions of carbonate of lime and muriate of lime. Its specific gravity scarcely differs from that of distilled water; and after precipitating the muriate of lime, by dropping into it a little barytic water, and exposing it to the atmosphere until the precipitate be totally deposited, it is sufficiently pure for most pharmaceutical purposes. [3] When rain water, however, is collected in towns, or from the roofs of houses, it contains a small portion of sulphate of lime, soot, and other impurities, and requires to be boiled and filtered before dropping in the barytic water.

Snow water, when newly melted, is destitute of air, which is the reason that fish cannot live in it; but when allowed to remain for some time exposed to the atmosphere, it does not differ in its qualities from rain water.

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[1] This degree varies according to the pressure of the atmosphere. Thus, in Gemmilaro's hut, on the side of Etna, about 11332 feet from the level of the sea, Dr. Irvine found that water boiled at 191°. Vide *Letters on Sicily*, 8vo. p. 153.

[2] Guy Lussac.

[3] Morveau, *Annales de Chimie*, xxiv. 320.

2. SPRING WATER, if it has not filtered through a very soluble soil, is almost as pure as rain water. The best springs are those which rise through sand or gravel, at a small depth.[1] It generally contains, besides the above-mentioned ingredients, a small portion of muriate of soda.

Well or pump water, which is spring water obtained by digging to a considerable depth, is by no means so pure. It is commonly distinguished by a property named hardness, implying an incapability of dissolving soap [2]; which is owing to its containing many earthy salts, the principal of which is sulphate of lime. It, also, contains more carbonic acid gas than common spring water. Many of the foreign ingredients contained in hard water are simply suspended in it; for pump water is rendered softer and purer by only passing it through a filtering stone. The best mode of freeing hard water of its earthy salts, is first to boil it; then, after it has cooled, to drop into it an alkaline carbonate; and lastly, to filter it. It cannot be employed for pharmaceutical purposes.

3. RIVER WATER, when the stream is rapid, and runs over a pebbly or siliceous channel, is as pure as the softer spring water; but when the current is slow, and the bed clayey, it approaches nearer to the nature of well water, and frequently contains putrefied vegetable and animal matters, as is generally the case in the water of lakes and marshes.

Such are the foreign ingredients contained in *common water*. Boiling frees it from air and gases, and precipitates many of the earthy salts: but distillation in glass vessels frees it entirely from them, and it is obtained almost perfectly pure, transparent, colourless, insipid, and inodorous.

The varieties of water enumerated above may be almost indiscriminately employed as diluents, the small proportion of foreign ingredients they contain, occasioning no difference in their diluent properties. When the quantity of sulphate of lime and aluminous matter, however, is very considerable, as is the case in many pump waters, there is some reason for concluding that deleterious effects may arise from the use of the water; although it may be doubted whether the scrophulous and glandular swellings, peculiar to some populous towns, can be justly ascribed to this cause.[3] Even a few of the waters which are regarded as mineral waters owe more to the diluent property of the water for their efficacy, than to the impregnations they contain. This is particularly the case with the Malvern spring, which has been found to contain very little foreign matter. The diluting power of water is much modified by temperature; warm or tepid water being a much better diluent than cold water.

The medicinal properties of water as a diluent were well known to the ancients; and cold water, used as a drink in fevers, was the principal remedy of the father of physic in these complaints. The temperature of 60° is the proper degree, when it is intended that water should produce its diluent effects without the aid of heat. Under 45° it produces a sedative and astringent effect; above 60° and under 100°, it relaxes the fibres of the stomach, and is apt to induce nausea, particularly when bulk is added to this range of temperature; but at a higher temperature, the stimulus of heat, in the same manner as the addition of other stimulants, prevents that effect. Simple water may supersede the use of all other diluents; but animal and vegetale infusions are generally employed, or toast and water (*infusum panis tosti*), which is more agreeable to most palates, and is an excellent diluent in fevers and inflammatory diseases. The temperature of water as a diluent should be regulated by the nature of the disease: in internal hæmorrhagies the temperature should not exceed 45°, but it may be 60° in fevers; unless in the cold stage of the paroxysm of fever, when thirst should be allayed by tepid or warm water, or other bland fluids; and the same precaution is necessary when the sweat has become general and profuse. In cases in which there exists a morbid increase of bile disturbing the functions of the stomach and irritating the bowels, the temperature of the water used as drink may be from 90° to 114°; and in some cases of dyspepsia, which are at-

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[1] The water conveyed to Hodsdon, in Hertfordshire, rises through a fine white sand, and is so pure that Dr. Hales affirms it left no incrustation in a boiler which had been in constant use for fifteen years. *Statical Essays*, ii. 242.

[2] Soap when agitated with hard water is decomposed; the alkali of the soap uniting with the acid of the earthy salts, while the oil and earths combine, and form new nearly insoluble soaps, which swim in a curdy form on the surface of the water.

[3] Percival ascribes the glandular swellings common in Manchester to this cause. See *Essays*, i. 291.

tended with the sensation of coldness at the stomach, and with cold extremities, a cupful of water, taken as hot as it can be drunk, affords very considerable relief. In cases of redundant bile, by drinking half a pint of tepid water every morning before breakfast, and taking immediately afterwards moderate exercise, the acrid bile is diluted, and its passage through the bowels assisted, without the irritation, which in its undiluted state it always excites; and it produces the same benefit in cholera morbus in the commencement of the disease, the stomach being rendered by it more fit to receive opiates and other remedies. Some medicines, as sudorifics, diuretics, and emetics, scarcely produce their effects, unless their operation be assisted by copious dilution with water, or watery fluids.

Water is also an external remedy of great importance, but its effects are much modified by the degree of temperature at which it is applied.

COLD WATER, or of a temperature under 70°, gives the sensation of cold to the skin, and is applied under the form of *bath* and of *affusion*.

The cold Bath, (*balneum frigidum*,) is water of any temperature, from 42° to 85° of Fahrenheit. When the body is immersed in it, it first induces the sensation of cold, excites shivering, renders the skin pale, and contracts it so as to produce the papillous appearance denominated goose skin (*cutis anserina*); the respiration at the same time is quickened and rendered irregular, producing sobbing; and the pulse is diminished in force and velocity, but is also rendered firmer and more regular. If the immersion be not long continued, re-action takes place on coming out of the bath, a glow, or agreeable sensation of heat, is felt over the whole body, the tone and vigour of the muscles are increased, a buoyancy of spirit and aptitude for action succeed, and a sense of general refreshment is experienced by the bather. The protraction, however, of the immersion for a considerable space of time, particularly if the temperature of the bath be under 50°, is not followed by this re-action, but the cold water operates as a powerful sedative; the action of the heart and arteries becomes languid, the pulse ceases at the wrist, the animal heat is rapidly diminished, and a sensation of coldness at the stomach is felt, which is succeeded by faintness, delirium, torpor, and death. Sometimes these unpleasant effects are experienced in some degree, even when the immersion is not protracted, and the temperature of the bath is not under 60°; in which case cold bathing proves always hurtful, and ought not to be repeated: but when the contrary effects are experienced, it is found to be useful in many diseases of debility, particularly in scrophula, if the water be impregnated with salt, or sea-bathing be resorted to. The debilitated, however, in whom the use of sea-bathing produces these effects, when it is employed before breakfast, are not always affected in the same manner when it is used after breakfast, or when the stomach is full: but on the contrary receive the same benefit from it as those with whom it agrees at all times. The use of cold water as a general bath is never employed with a view of producing its sedative effects: but for this purpose it is partially applied, either by the immersion of the affected parts, or by means of cloths dipped in very cold water, and laid over or near the parts. It is used as a remedy in active uterine hæmorrhagies, burns and scalds, and in local inflammations, even when arising from general disease, as gout and acute rheumatism, when the surface of the pained part appears red and inflamed.

The cold affusion, or the suddenly pouring cold water over the whole surface of the body, operates as a powerful remedy, although its effects as such are of short duration. They are produced by the suddenness of the application affecting the nervous energy, and by the shock rousing the dormant sensibility, so as to induce a new action, as it were, of the nervous system, dissolving the spasm on the extreme vessels of the surface, carrying off a large portion of morbid heat by general evaporation, and the remainder by insensible perspiration; thence restoring the healthy action of the exhalants and the capillaries. In typhus fever this mode of applying cold water has been productive of the best effects.[1] It should be applied in the first hot stage of the disease, if possible, and repeated every time the morbid heat returns. If the water can be impregnated with salt, so much the better; but when the disease is advanced, its temperature should not

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[1] The cold affusion was employed by Antonius Musa, physician to Augustus, when that emperor was affected with a bowel complaint, which had resisted every other remedy. *Vide Q. Horatii F. Epistol. lib.* xv. *ad Num. Valam. C. Suelon. Tranq. Octavius Aug.* ii. *cap.* 81. *p.* 104. Cold affusions in the fevers of Asia are also prescribed by the Koran, and used in India by the Mahomedan and Hindoo physicians in various diseases.

be more than 26°[1] under the heat of the body. It often stops suddenly the disease, if it be used during the three first days, and sometimes so late even as the fifth; but after this period it can be regarded as an useful auxiliary only even when properly employed. In tetanus, Currie affirms[2] that the cold affusion also proves useful, particularly when the shock is considerable, and applied during the convulsions. It is, however, in idiopathic tetanus only that it proves useful, no advantage being obtained from using it in tetanus arising from wounds.[3] Its utility has also been proved in many of the exanthemata; for instance, during the hot stage of the eruptive fever of small-pox; and we can bear ample testimony to its efficacy in scarlatina maligna, when the heat rises to above 100°.[4] This remedy, however, is productive of much mischief when misapplied; and therefore it is necessary to observe that it is contra-indicated in the cold stage of fevers, and when a sense of chilliness is present, although the thermometer indicate the real heat to be more than natural. It is also said to be improper in fevers, when diarrhœa or dysentery are present; after the sweating stage in intermittents is formed; after the eruption is completely formed in confluent small-pox; and in symptomatic fever occasioned by great local inflammation: but Dr. Nicoll has found it useful in India, in remittent and intermittent fevers accompanied with *dysentery;* when the heat of the surface has exceeded 98° Fahrenheit; for as in these cases the dysenteric symptoms seem to depend on the degree of febrile excitement, the cold water, by producing a solution of these, allays the griping and tenesmus, and natural stools follow. The affusion should always, in such cases, be preceded by bleeding and other depletory[5] means. The water should be dashed from a height of ten or twenty feet; and its temperature should be nearly that of the air at the time. The cold affusion, in the form of the shower-bath, is advantageously employed as a stimulant and tonic in diseases of general debility, when no fever or increased heat is present. I know of no remedy so generally useful in those affections which are known by the name of nervous complaints.

WARM WATER, or of a temperature from 86° to 100°, gives the sensation of warmth to the body, and is applied both locally and generally, in the form of vapour, fomentation, and bath. Water is found in a state of nature combined with different quantities of caloric within the above range of temperature. In the Buxton hot springs the temperature is about 82°; at Bristol it is from 76° to 84°; and at Bath the range is from 110° to 114°.[6] The necessary degree of temperature, however, is generally obtained by artificially heating the water.

The general application of warm water is obtained by means of baths. When the greater part of the entire body is immersed, the water constitutes properly a bath (*balneum*); but when half only is immersed, it is a half bath (*semicupium*). These may be either,

a. The hot bath (*balneum calidum*), from 97° to 100°.
b. The tepid bath (*balneum tepidum*), from 86° to 97°.
c. The vapour bath (*balneum vaporis*), from 100° to 130°.

The two first differ in temperature only; but the last, from the water being applied in a very minutely divided state, acts with much greater effect than water in the liquid form. The operation of the first of these forms of applying water is stimulant; it augments the action of the heart and arteries, renders the skin red, quickens respiration, and produces a copious flow of sweat: but the others, although they excite the sensation of heat, yet lessen the frequency of the pulse, relax powerfully the skin and simple solids, and diminish generally increased excitement. It has been a question of some interest, whether water be ever taken into the body by the cutaneous absorbents? That it is taken in has been denied by many philosophers, and facts brought forward to support the opinion. Dr. Currie and Dr. Pearson, after half an hour's immersion in the Buxton bath, at 82°, found that the weight of the body was rather diminished than increased;

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1 Currie—*Reports on Cold Water*, i. 31. 2 *Ibid.* i. 138. 3 *Ibid.* i. 159.

4 Currie gives the following results of the affusion:—The heat of the body in fever, as indicated by the thermometer, being 103°, was by it reduced to 98° in half an hour; and the pulse from 112 to 80 beats, (vol. i. 22.); the heat 101° was reduced to 99°; and the pulse from 112 to 98 in the same time. The heat 106° was reduced to 98°; and the pulse from 130 to 90. Vol. i. 46.

5 *Lond. Med. Repository*, vol. ix. p. 123.

6 The temperature of the Cross Bath pump is 110°; the King's Bath, 112°; and the Hot Bath, 114°.

and in a case of disphagia, in which neither food nor drink was taken by the mouth for a considerable time, the patient, when put into the tepid bath, felt his thirst alleviated, and received much comfort, without his weight being at all increased. Dr. Currie supposed, that the abatement of thirst in this case arose from the relaxation of the exhalants of the surface produced by the bath, and those of the stomach sympathizing; and that although the exhalants terminate by open mouths, which pierce the epidermis, yet as the mouths of the absorbents terminate under it, and do not come into contact with the open air; so while the epidermis remains unirritated and entire, no absorption of fluid can therefore take place from the surface. Many experiments made by Seguin are also in favour of the opinion that no cutaneous absorption is effected in the bath. Among others, he immersed venereal patients in baths containing oxymuriate of mercury in solution, and found that while the cuticle remained entire, no salivation, nor other effect of the mercury on the system, was apparent; but the specific effect of the remedy always took place when the epidermis was injured or destroyed, as in itch. It must, however, be observed, that in the case of disphagia the urine flowed as if drink had been taken by the mouth; a circumstance which Currie supposes to depend on the absorption from the atmosphere by the lungs. This, however, is an assumed position; the free exhalation from the lungs is evident, but it is by no means proved that any absorption takes place. It is true that the weight of the body in the above case was diminished; but from the sum of this loss we must abstract the cutaneous exhalation of the part of the body not immersed, the pulmonary exhalation, and the weight of the egesta; and were a supposition to be admitted as argument, it might be suggested that the relaxant power of the warm water acting on the epidermis as on inert matter, may open a way through it to the mouths of the absorbents. The question is still undecided, and fortunately it is not of much importance in a practical point of view.

Warm and vapour baths [1] are efficaciously employed in acute rheumatism, inflammation of the abdominal viscera, of the kidneys, bladder, and uterus; in suppression of urine, and in spasmodic affections, particularly those to which infants are liable, arising from dentition and other irritations. The general relaxation produced by their use has been taken advantage of, also, for assisting the reduction of strangulated hernia; for, although the effect be not topical as it regards the hernial tumour, yet the general relaxation produced gives a disposition to all the parts to regain their proper place. The tepid bath is found to be very useful in the rigidities which follow some acute diseases, as gout and rheumatism, *nodosities of the joints* [2], and, according to some, the rigidities attendant on old age. [3] Its effects in promoting the natural excretions by the skin render it very serviceable in promoting the cure of herpetic eruptions; in slight cases of lepra the use of it with friction is all that is required; and in all cutaneous foulnesses it is a most important auxiliary. It has, also, been found very beneficial in cases of insanity. In general the period of immersion should not be less than twenty minutes, nor exceed one hour. [4]

The partial application of warm water as a remedy is made by means of

1. *a.* The foot bath (*pediluvium*);
   b. The hip bath (*coxæluvium*); and
   c. The hand bath (*manuluvium*).

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[1] A very simple and convenient vapour bath for military practice has been recommended by my friend Dr. A. Nicoll. It may be formed of a common beer or spirit barrel, with a false bottom, placed about a foot from the bottom of the cask, that is, the end on which it is standing, and perforated with numerous small holes. A gun barrel connected with the spout of a tea-kettle placed on a fire, is to be introduced into an opening in the side of the cask between the real and false bottom; and the patient, being seated on the false bottom, the steam or vapour from the boiling kettle soon surrounds him by rising through the holes. It must be prevented from escaping by means of a blanket, which should cover the open end of the cask, and apply closely round the neck of the patient.

[2] Haygarth, *Clinical History of Diseases*, 8vo. Lond. 1805.

[3] Tepid bathing with friction is said by one author, "vitam sæpe per plures menses, interdum etiam per aliquot annos, protraxisse." — Gregory, *Conspectus Med.* ii. 100.

[4] The Arabian physicians used the vapour bath in a singular mode, in scrophulous affections, which they denominated Bother, "ponatur sub puero olla plena aquâ calidâ, in principio apparitionis pustularum, ut attrahat ab interioribus superfluum humorem ad corporis superficiem." *Rhazes de Morbis Infant.* cap. 19. by Willan, p. 31.

2. *d.* Fomentations of vegetable decoctions; and
e. Flannel cloths wrung out of boiling water, by which the moisture is applied in a state of vapour.

These partial baths are useful in the same diseases for which the general baths are employed; but are better adapted for relieving the rigidity of single joints, and topical inflammation; and the hip bath has lately been found to be very beneficial in suppressed menstruation, and for relieving the pains of cancer in utero.

For fomentations it is the practice to employ vegetable decoctions; but the best of these can be regarded only as vehicles for retaining the heat and moisture. At all times, flannel cloths wrung out of boiling water are superior; both because the water is applied in the form of vapour, and also, while they continue as long warm, they do not wet the bed and linen of the patient. The flannel cloths should be each about two yards long, with the ends sewed together; so that by means of two sticks, one being at each end, turned in opposite directions, they may be wrung much dryer, when taken out of the boiling water, than could be effected by the hands. The principal circumstance to be attended to in the application of fomentations is the frequent renewal of them, in order that a steady and constant heat may be applied to the fomented part.

II. MINERAL WATERS. [1]

It has been already noticed, that although no natural water is found in a state of absolute purity, yet that in general the quantity of foreign matters is not sufficient to give it any very sensible taste or odour. In some instances, however, these are so considerable, and of such a nature, as to prevent the water from forming a part of the nourishment of animals; in which case it is denominated a MINERAL WATER, and can be useful to mankind only in a medicinal point of view.

The substances found in mineral waters may be arranged under four heads.

I. AIR and GASES:
1. Atmospheric Air, (*very common.*) It is generally in the proportion of $\frac{1}{25}$ of the bulk of the water.
2. Oxygen Gas (*rare*) [2]
3. Azotic Gas. (*Buxton* [3], *Harrowgate* [4], *Lymington Priors.*) [5]
4. Sulphureted Hydrogen Gas, (*Harrowgate, Moffat.*)

II. ACIDS, in a free state:
1. Carbonic Acid, (*very common.*) [6]
2. Sulphurous Acid, (*some hot springs in Italy.*)
3. Boracic Acid, (*some lakes in Italy.*)

III. ALKALIES and EARTHS:
1. Soda, (*Geyzer, Rykum, hot springs in Iceland.*) [7]
2. Silica, (*Geyzer, Rykum, Carlsbad, Pongues, Pu.*) [8]
3. Lime, (*doubtful.*)

IV. COMPOUND SALTS:
1. Sulphate of Soda, (*very common.*)
2. ——— Ammonia, (*some volcanic springs.*)
3. ——— Lime, (*very common.*) [9]
4. ——— Magnesia, (*Epsom and many other springs.*) [10]
5. ——— Alumina, (*very rare.*)
6. ——— Iron, (*volcanic springs.*)
7. ——— Copper, (*waters from copper mines.*)
8. Nitrate of Potash, (*some springs in Hungary, rare.*)
9. ——— Lime, (*some springs in Arabia.*) [11]
10. ——— Magnesia, (*rare.*)
11. Muriate of Potash, (*Uhleaborg, Sweden, rare.*) [12]
12. ——— Soda, (*very common.*)
13. ——— Ammonia, (*some springs in Italy and Siberia.*)
14. ——— Barytes, (*very uncommon.*)
15. ——— Lime, (*very common.*)

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[1] The greater part of the chemical observations on mineral waters has been taken from Thomson's System of Chemistry.

[2] First detected by Scheele. [3] Dr. Pearson. [4] Dr. Garnet. [5] Dr. Lambe. [6] Dr. Brownrigg. [7] Dr. Black. [8] Dr. Bergman. [9] Dr. Lister, in 1682. [10] Dr. Grew, in 1610. [11] Dr. Home, in 1756. [12] Julin.

16. Muriate of Magnesia, (*very common.*)
17. ———— Alumina, (*uncommon.*) [1]
18. ———— Manganese, (*Lymington Priors.*) [2]
19. ———— Carbonate of Potash, (*rare.*)
20. ———— Soda, (*very common.*)
21. ———— Ammonia, (*rare.*)
22. ———— Lime, (*very common.*)
23. ———— Magnesia, (*very common.*)
24. ———— Alumina, (*doubtful.*)
25. ———— Iron, (*common.*)
26. Hydrosulphuret of Lime. } (*not uncommon in sulphureous springs.*)
27. ———————— Soda. }
28. Sub-borate of Soda, (*lakes in Persia and Thibet.*)

These substances are not all contained in any mineral water, seldom more than five or six being present together; and they are generally in very minute quantity, the character and properties of the water depending on one or two ingredients which predominate. This allows mineral waters to be arranged into the four following classes: 1. ACIDULOUS WATERS; 2. CHALYBEATE WATERS; 3. SULPHUREOUS WATERS; 4. SALINE WATERS. We shall first give a sketch of the physical characters and medicinal properties of each of these classes; and then describe the method of determining the ingredients, and their proportions, contained in any mineral water.

1. ACIDULOUS WATERS—owe their properties chiefly to carbonic acid. They sparkle when drawn from the spring, or when poured into a glass; have an acidulous taste, and become vapid when exposed to the air. Besides free carbonic acid, on the presence of which these qualities depend, acidulous waters contain generally also carbonates of soda, of lime, of magnesia, and of iron; and sometimes muriate of soda. They may be divided into *thermal* or *warm acidulous waters*, and *cold acidulous waters*; the temperature of the former, however, does not exceed 72°, while that of the latter is generally about 55°.

The most celebrated springs of this class are Pyrmont, Seltzer, Spa, and Carlsbad. They are tonic and diuretic; and in large doses produce a sensible degree of exhilaration. They all afford a grateful and moderate stimulus to the stomach; but the Pyrmont, Spa, and Carlsbad, containing carbonate of iron, are especially useful in all cases of impaired digestion; while those which contain alkaline carbonates, as the Carlsbad and Seltzer, are more particularly employed as palliatives in calculous affections.

2. CHALYBEATE WATERS—owe their properties to iron in combination generally with carbonic acid; and as this is usually in excess, they are often acidulous as well as chalybeate. The metal is found also in the form of a sulphate, but the instances of this are very rare.

Chalybeate waters have a styptic or inky taste; they are, when newly drawn, transparent, and strike a black with tincture of nut-galls; but an ochrey sediment soon falls, and the water loses its taste. If the iron be in the state of sulphate, however, no sediment falls; and the black colour is produced by the above test, even after the water has been boiled and filtered. There are many chalybeates in Great Britain; but the most celebrated are Tunbridge, Brighton, and Peterhead: the Cheltenham spring also contains carbonate of iron; but on account of the large proportion of saline matter, and its strong purgative properties, it is not ranked in this class. The Spa springs also belong to this class.

Chalybeate waters are powerful tonics, and are employed in dyspepsia, scrophulous affections, cancer, amenorrhœa, chlorosis, and the other diseases of debility for which the artificial preparations of iron are used. Much of the benefit derived from the use of chalybeate waters depends on the extreme division of the metallic salts they contain, as well as the vehicle in which it is held in solution; while at the same time their operation is much modified by the carbonic acid by which the iron is suspended. When the water is a carbonated chalybeate, the water should be drank the moment it is drawn from the spring: but the same precaution is not necessary with those containing sulphate of iron.

3. SULPHUREOUS WATERS—derive their character chiefly from sulphureted hydrogen gas; which in some of them is uncombined, while in others it is united with lime or an alkali. They are transparent when newly drawn from the spring, and have the

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[1] Dr. Withering. [2] Bergman.

fœtid odour of rotten eggs, which is gradually lost from exposure to the air, and the water becomes turbid. When they are strongly impregnated with the gas, they redden infusion of litmus, and exhibit some other of the characteristics of acids; and even in a weak state blacken silver and lead. Besides containing sulphureted hydrogen gas, they are not unfrequently, also, impregnated with carbonic acid. They generally contain muriate of magnesia or other saline matters, which modify their powers as a remedy.

The most important sulphureous springs in this island are those of Kilburn, Harrowgate, and Moffat; on the continent Aix la Chapelle and Barege; which are resorted to chiefly for the cure of cutaneous eruptions, and are applied locally as well as drunk. They are slightly sudorific and diuretic, and are apt to occasion in some patients head-ach of short duration, directly after they are drunk. The are also employed for curing visceral and scrophulous obstructions, torpor of the intestines, and some dyspeptic and hypochondriac cases.

4. SALINE MINERAL WATERS — owe their properties altogether to saline compounds. Those which predominate, and give their characters to the waters of this class, are either,

1. Salts, the basis of which is lime;
2. Muriates of soda and magnesia;
3. Sulphate of magnesia;
4. Alkaline carbonates; particularly carbonate of soda.

They are mostly purgative, the powers of the salts they contain being very much increased by the large proportion of water in which they are exhibited. The most celebrated saline springs are those of Cheltenham and Leamington, in England; Pitcaithly, in Scotland; and Sedlitz, on the Continent. They are employed in diseases which require continued and moderate intestinal evacuations; such as dyspepsia, hypochondriasis, chronic hepatitis, jaundice, and strumous swellings. They are more grateful to the stomach when carbonic acid also is present; and when they contain iron, as in the case of the Cheltenham spring, their tonic powers combined with their purgative qualities render them still more useful in dyspeptic complaints and amenorrhœa.

To this class the water of the ocean belongs. The quantity of saline matter SEA WATER contains varies in different latitudes: thus between 10° and 20° it is rather more than $\frac{1}{24}$th; at the equator it is $\frac{1}{25}$th; and at 57° north it is only $\frac{1}{27}$th. The saline ingredients in 10,000 parts of sea water, according to the last analysis of Dr. Murray[1], are, muriate of soda, 220·01; muriate of lime, 7·84; muriate of magnesia, 42·08; and sulphate of soda, 33·16. When brought up from a great depth, its taste is purely saline; but when taken from the surface it is disagreeably bitter, owing perhaps to the animal and vegetable matters suspended in it. Its specific gravity varies from 1·0269 to 1·0285; and it does not freeze until cooled down to 28·5° Fahrenheit. Its medicinal properties are the same as those of the saline purging waters, but more powerful; and as a bath, its efficacy is much superior to that of fresh water.

The general effects of mineral waters are modified by temperature, whether they be taken internally, or externally applied. In some springs, as those of Bath, Matlock, and Buxton, their virtues depend almost altogether on temperature; and in others, as Malvern, which has been found to contain scarcely any foreign matter, the simple diluent power of the pure water seems to produce the benefit that results from drinking them. Some of the good effects of all of them, however, must be allowed to proceed from change of scene, relaxation from business, amusement, temperance, and regular hours; and in these circumstances the drinking the waters at the springs possesses advantages which cannot be obtained from artificial waters, however excellent the imitations may be; nor even from the natural waters when bottled and conveyed to a distance from the springs.

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1 *Edinburgh Transactions*, vol. viii. p. 205. The water was taken from the Frith of Forth, and was of the specific gravity 1·029.

Table of the more celebrated Mineral Waters, showing the Ingredients contained in a given Quantity of each Water.

	Names of the Springs.	Quantity of Water.	Gases.				Carbonates of				Sulphates of				Muriates of				Silica.	Alumina.	Resins.	Temperature.
			Oxygen.	Carbonic Acid.	Sulph. Hydr.	Nitrogen.	Soda.	Lime.	Magnesia.	Iron.	Soda.	Lime.	Magnesia.	Iron.	Soda.	Lime.	Magnesia.	otas h.				
		grains.	cubic inches.	cubic inches.	cubic inches.	cubic inches.	grs.	grs.	grs.	grs.	grains.	grains.	grs.	grs.	grains.	grs.	grs.	grs.	grs.	grs.	grs.	
Acidulous.	Seltzer [1]	8949	·435	13·068	—	—	5·22	78·3	6·32	—	—	—	—	—	13·74	—	—	—	—	—	—	cold
	Pyrmont [1]	8950	—	19·6	—	—	—	4·3	9·8	0·70	—	8·38	5·44	—	1·7	—	—	—	—	—	—	cold
	Spa [1]	8933	—	9·8	—	—	1·85	1·85	4·35	0·70	—	—	—	—	0·21	—	—	—	—	—	—	cold
	Carlsbad [2]	25320	—	50·	—	—	38·5	12·5	—	0·1¼	66·75	—	—	—	32·5	—	—	—	2·25	—	—	165°
	Kilburn [10]	138240	—	84·	36·	—	—	2·4	1·25	3¼	18·2	13 0	91·0	—	6·0	0·6	2·8	—	—	—	6·	cold
Sulphurous.	Harrowgate [14]	103643	—	8·	19·	7·	—	18·5	5·5	—	—	—	0·5	—	615·5	3·	9·1	—	—	—	—	cold
	Moffat [14]	103643	—	1·	10·	4·	—	—	—	—	—	—	—	—	3·6	—	—	—	—	—	—	cold
	Aix la Chapelle [3]	8940	—	—	13·06	—	—	15·25	5·89	—	—	—	—	—	6·21	—	—	—	—	—	—	143°
	Enghein [5]	92160	—	18·5	70·	—	—	21·4	1·35	—	—	33·3	5·8	—	2·4	—	8·0	—	—	—	—	cold
Saline.	Sedlitz	58309	—	8·	—	—	—	6·7	21·	—	—	41·1	1444	—	—	—	36·5	—	—	—	—	cold
	Cheltenham [6]	103643	—	30·3	3·	12·	—	—	12·5	5·	48·0	40·	—	—	5·	—	12·5	—	—	—	—	cold
	Plombieres	—	—	—	—	—	4·4	1·	—	—	4·7	—	—	—	0·5	—	—	—	2·6	—	—	cold
Chalybeate.	Tunbridge [3]	103643	1·4	10·6	—	4·	—	—	—	1·	—	1·25	—	—	0·5	—	2·25	—	—	—	—	cold
	Brighton [4]	58309	—	18·	—	—	—	—	—	—	—	32·7	—	11·2	12·2	—	6·	—	1·12	—	—	cold
	Toplisz [7]	22540	—	—	—	—	13·5	16·5	—	32·5	—	—	—	—	61·3	28·5	—	—	—	15·1	—	cold
Calcareous, nearly pure.	Bath [8]	15360	—	2·4	—	—	—	1·6	—	·004	3·	18·	—	—	6·6	—	—	—	0.4	—	—	114°
	Buxton [9]	58309	—	—	—	2·	—	10·5	—	—	—	2·5	—	—	1·5	—	—	—	—	—	—	82°
	Bristol [11]	58309	—	30·3	—	—	—	13·5	—	—	11·2	11·7	—	—	4·	—	7·25	—	—	—	—	74°
	Matlock	58309	—	—	—	—	—	—	—	—	—	minute portion	—	—	—	—	—	—	—	—	—	66°
	Malvern	58309	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	cold

[1] Bergman. [2] Klaproth. [3] Babington. [4] Marcet. [5] Fourcroy. [6] Fothergill. [7] John.
[8] Phillips. [9] Pearson. [10] Schmesser.—*Phil. Trans.* lxxxii. 127. [11] Carrick. [14] Garnet,—*Sanders on Mineral Waters*, 514. 33.

Such are the known contents of the most celebrated mineral waters. Many more have been analysed, but it is unnecessary to introduce an account of them in this place; and I consider it to be of more importance to describe the method of determining the nature and proportion of the substances, or the analysis of mineral waters, one of the most difficult parts of practical chemistry.

METHOD OF ANALYSING MINERAL WATERS.[1]

THE first circumstance to be attended to in the chemical examination of any mineral water, is to determine the gross weight of the substances held in solution. This is to be done by first ascertaining the specific gravity of the mineral water; then subtracting from it the specific gravity of distilled water, (both expressed in whole numbers) multiplying the remainder by 1·4. The product is the gross saline contents, in a quantity of the water denoted by the number employed to indicate the specific gravity of distilled water.[2] Thus, if the specific gravity of the mineral water be 1·079, as that of distilled water is 1·000, the remainder, after the subtraction of the latter from the former, in whole numbers, will be 79, which multiplied by 14 makes 1106; and therefore 110·6 is the sum of the saline contents of 1000 parts of the water; or 11·06 are contained in 100 parts. The next step is to ascertain the particular substances, and the proportion of each, contained in the water.

1. The AERIAL or GASEOUS BODIES are to be first separated by boiling for a quarter of an hour, as much of the water as will fill two-thirds of a glass retort, connected with an inverted jar, divided into cubic inches and tenths, full of mercury, and placed in a mercurial trough. The air and gases will pass over into the jar, and depress the mercury; and when cool, after subtracting the air of the retort, the quantity of air expelled from the water may be easily determined.

The only gaseous bodies contained in water are atmospheric air, oxygen gas, azotic gas, carbonic acid gas, sulphureted hydrogen gas, and sulphurous acid: of which the following cannot exist together in the same water.

Oxygen gas and sulphureted hydrogen gas.
Sulphureted hydrogen gas and sulphurous acid.

If sulphureted hydrogen gas be present, it must be first separated; then the sulphurous acid, and carbonic acid gas; and lastly, the oxygen and azotic gases.

a. *Sulphureted hydrogen gas* is known to be contained in water by its peculiar odour, by the water becoming turbid when exposed to the air and depositing sulphur, by its reddening the infusing of litmus fugaciously, blackening paper dipped in a solution of lead, and precipitating nitrate of silver black or brown. It may be separated from the air obtained from water during boiling, by carrying the jar into a tub of warm water and introducing nitric acid, which absorbs the sulphureted hydrogen. The bulk of this gas contained in any water is determined by filling a jar three-fourths with the water, inverting it in a water-trough, and introducing nitrous gas at intervals, as long as red fumes appear, or the hepatic odour continues; when the jar is turned up and the air blown out. The nitrous gas in this operation mixing with the common air in the upper part of the jar forms nitrous acid, which renders the water turbid, by decomposing the sulphureted hydrogen and precipitating sulphur. The bulk of hepatic gas is determined by the weight of the sulphur thrown down, one grain indicating the presence of 3·83 cubic inches of the gas.

b. *Sulphurous acid gas* is ascertained by the same tests as discover the presence of sulphuric acid and water; (*which see.*)

c. *Carbonic acid gas* is detected by lime-water occasioning a precipitate soluble with effervescence in muriatic acid; by reddening fugaciously tincture of litmus, and losing this property when boiled.

To estimate the bulk of these gases, introduce into the air obtained by boiling the water, a solution of pure potash, and agitate the whole gently. These acid gases will be absorbed, and any other gases left; after which the bulk of the residuum must be estimated, and subtracted from the bulk of the whole to obtain that of the acid gases absorbed. Evaporate next the potash slowly, nearly to dryness; and by leaving it exposed to the atmosphere, sulphate of potash will be formed, which

[1] The following observations on this important subject are chiefly extracted from the System of Chemistry of Dr. Thomson.

[2] This useful formula was invented by Mr. Kirwan. See *Essay on Mineral Waters*, 145.

may be separated by dissolving the potash in diluted muriatic acid, and filtering the solution. 100 grains of sulphate of potash indicate 42·72 cubic inches of sulphureous acid gas, which being subtracted from the bulk of the gas absorbed by the potash, leaves the bulk of the carbonic acid gas.

d. *Oxygen gas*, after the above gases are separated, may be examined by means of the solution of sulphate of iron saturated with nitrous gas.[1] A small graduated tube filled with the air to be examined is to be plunged into this solution, and moved backwards and forwards for a few minutes. The whole of the oxygen is rapidly absorbed, and by marking the greatest absorption, its bulk in a given quantity of the air is ascertained.

e. *Azotic* or *nitrogen gas* is discovered by not being at all affected by eudiometrical processes.

2. ALKALIES, and ALKALINE, EARTHY, and METALLIC CABONATES. Alkalies, even in minute quantities, are discovered in water by rendering infusion of turmeric or paper stained with it brown.[2] When the change is permanent, the fixed alkalies may be supposed to be present; when fugacious, the alkali is ammonia. An infusion of Brazil-wood is rendered blue by the alkalies; but this also is the case with the alkaline and earthy carbonates[3], and the addition of sulphuric acid produces effervescence. Tincture of nutgalls discovers iron; the colour is violet if alkaline carbonates or earthy salts be also present; dark purple indicates other alkaline salts; purplish red, sulphureted hydrogen gas; and whitish and then black, sulphate of lime. Boiling the water precipitates the earthy and metallic carbonates.

The following substances of this class set down in the first column are incompatible, or cannot exist in mineral waters, with the salts placed in the opposite column.

Alkalies - - - - - -	Fixed alkaline sulphates.
	Alum.
	Sulphate of magnesia.
	——— of iron.
Alkaline carbonates - -	Muriate of barytes.
	——— of lime.
	——— of magnesia.
	Nitrate of lime.
Earthy carbonates - -	Sulphate of iron.
	Muriate of barytes.
Carbonate of magnesia -	Sulphate of lime.
	Alum.
	Muriate of lime.

a. *Alkalies and their carbonates* are ascertained to be present in mineral waters by the tests already mentioned; and by the water, after being boiled, throwing down a precipitate on the addition of muriate of magnesia. The volatile nature of ammonia easily distinguishes it if present, which is very seldom; and the best test for determining whether the fixed alkali be potash or soda is muriate of platina[1], which forms an immediate precipitate with potash or any salt containing it, but is not at all affected by soda. The quantity of an alkali is determined by saturating it with sulphuric acid, and noting the quantity of real acid[4] necessary; setting down, for every 100 grains of real acid used, 121·48 of potash, or 78·32 of soda; and the loss of weight produced by the effervescence on dropping in the acid, being added to the above, shows the quantity of an alkaline carbonate.

b. *Earthy carbonates.* If the water contains sulphureted hydrogen gas, this must be separated by exposing the water for a considerable time to the air, before the quantities of the earthy carbonates can be estimated. After thus exposing it, boil the water for fifteen minutes, filter it when cold; and treat what remains on the filter with muriatic acid, which will dissolve the carbonates of lime, of magnesia, and of iron. The residuum, which may contain carbonate of alumina, and perhaps sulphate of lime, is to be dried in a red heat, and its weight noted; and then boiled in a solution of carbonate of soda. The soda is next to be saturated with

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[1] Dr. Henry.

[2] This test is sufficiently delicate to detect soda when it amounts to $\frac{1}{2217}$th part only of the water.

[3] Sulphate of lime likewise produces the same effect.

[4] For a rule to determine the quantity of real acid in a diluted acid, see introduction.

muriatic acid, and the mixture boiled for half an hour, which precipitates carbonate of lime and alumina. This precipitate being dried, the lime is to be separated by acetic acid, and the alumina that remains dried and weighed; so that by subtracting its weight from the original weight the proportion of sulphate of lime is ascertained.

To estimate the contents of the muriatic solution, add to it ammonia as long as it throws down a reddish precipitate, which is the iron united with a portion of magnesia. The magnesia is to be separated by acetic acid, the precipitate being previously dried by exposure to the air, in a heat of 200°, and the solution added to the muriatic solution; and to determine the weight of the iron, it is to be redissolved in muriatic acid, then precipitated by an alkaline carbonate, and dried and weighed.

Sulphuric acid is now to be added to the muriatic solution; and the sulphate of lime, thus obtained, is to be heated to redness, and weighed; setting down for every 100 grains of it 74 of carbonate of lime. From the solution the magnesia is lastly to be separated by subcarbonate of soda, dried and weighed; then evaporate the remaining solution to dryness, and wash the residue with distilled water so as to dissolve the muriate of soda. This residue is subcarbonate of magnesia, the weight of which, when dried, must be added to the former; which gives the entire weight of the subcarbonate of magnesia.

3. MINERAL ACIDS exist in mineral water sometimes uncombined, but more generally combined with alkalies and earths, forming sulphates.

a. SULPHURIC ACID is readily detected by muriate of barytes, when it does not exceed the millionth part of the water. To render this test certain, however, the muriate must be diluted; the alkaline carbonates, if the water contain any, must be previously saturated with muriatic acid; and the precipitate must be insoluble in muriatic acid. The hydro-sulphurets are precipitated by muriate of barytes, but their presence is easily detected by their odour.

The proportion of sulphuric acid is easily estimated by saturating it with barytes water, and heating the precipitate to ignition; every 100 grains of this sulphate of barytes indicate 34 of real sulphuric acid.

b. The *Sulphates* contained in mineral waters are six in number, and are incompatible with the following salts placed in the opposite column.

Fixed alkaline sulphates	Nitrates of lime and of magnesia. Muriates of lime and of magnesia.
Sulphate of lime - -	Alkalies. Carbonate of magnesia. Muriate of barytes.
Alum - - - - -	Alkalies. Muriate of barytes. Nitrate, muriate, carbonate of lime. Carbonate of magnesia.
Sulphate of magnesia -	Alkalies. Muriate of barytes. Nitrate, muriate of lime.
Sulphate of iron - -	Alkalies. Muriate of barytes. Earthy carbonates.

b. 1. *Sulphate of soda.*—To detect this salt, first evaporate the water to one half, and add lime-water as long as any precipitate falls. This precipitates all the earths except sulphate of lime, which may be separated by evaporating the fluid till it becomes concentrated, then adding a little alcohol, and after filtration a little oxalic acid. If lime-water produces a precipitate in the water thus treated, immediately, or after a little alcohol be added, either sulphate of potash or of soda is present. To determine which, add acetate of barytes, which will precipitate sulphate of barytes; then filter and evaporate the filtered fluid to dryness, and dissolve the residue by digesting it in alcohol, and evaporate to dryness. If the sulphate be sulphate of potash, the dry salt thus obtained being acetate of potash, will deliquesce; but if it be sulphate of soda, the acetate will effloresce.

The proportion of the alkaline sulphates is found by precipitating their acid, by nitrate of barytes, from the water purified as above. If soda be the base of the salt contained in the water, for every 100 grains of this precipitate ignited, set down 61·2 grains of dried sulphate of soda; if potash be the base, for 100 grains of ignited precipitate set down 74·8 of dry sulphate of potash.

b. 2. *Sulphate of lime* is detected by an immediate precipitate being formed by oxalic acid, or oxalate of potash, which, although a less sensible, is, nevertheless, a more accurate test. To determine its quantity, first saturate any earthy carbonates that may be present with nitric acid; then evaporate the fluid to a few ounces; and having precipitated the sulphate of lime by means of proof spirit, dry and weigh it.

b. 3. *Alum* is detected by carbonate of magnesia, muriate of lime, muriate of magnesia, or succinate of ammonia. Twelve grains of alumina precipitated by carbonate of magnesia, heated to incandescence, indicate 100 grains of crystallized alum, or 49 of the dried salt.

b. 4. *Sulphate of magnesia* may be detected in any water (previously freed from any alum or uncombined acids it might have contained) by hydro-sulphuret of strontian, which produces an immediate precipitate with this salt, and with no other. If no other earthy sulphate be present, the sulphuric acid may be separated by a barytic salt; every 100 grains of the ignited precipitate indicating 51 grains of dried sulphate of magnesia. If sulphate of iron be present, mix the water with a portion of argil, and expose it for some days to the air, during which time oxyd of iron and sulphate of alumina are precipitated, leaving the sulphate of magnesia alone in solution; which may be then estimated by the above method.

b. 5. *Sulphate of iron* is detected by tincture of galls striking a black colour with the water after it has been boiled, and has cooled. Its quantity may be estimated by precipitating the iron by prussiate of potash.[1]

c. MURIATIC ACID, either uncombined or combined, in mineral waters is detected by nitrate of silver, which forms with it a white precipitate, insoluble in nitric acid; but the alkaline carbonates, if any, must be first saturated by nitric acid; and any sulphuric acid removed by nitrate of barytes. The proportion of uncombined muriatic acid is ascertained by saturating it with barytic water, and then precipitating the barytes by sulphuric acid. For every 100 grains of the ignited precipitate set down 21 grains of real muriatic acid.

d. The *Muriates* contained in mineral waters are incompatible with the following articles in the second column.

Muriate of barytes .	Sulphates. Alkaline carbonates. Earthy carbonates.
Muriate of lime . .	Sulphates, except of lime. Alkaline carbonates. Carbonate of magnesia.
Muriate of magnesia .	Fixed alkaline sulphates. Alkaline carbonates.

d. 1. *Muriates of soda and of potash* are detected in water by acetate of silver: but any earthy nitrates and muriates must first be decomposed by sulphuric acid, and the sulphates separated by alcohol and nitrate of barytes. To ascertain whether the precipitate be muriate of soda or of potash, evaporate to dryness, then dissolve the acetate in alcohol, and again evaporate to dryness. If it be acetate of potash the salt will deliquesce, but if acetate of soda, it will effloresce. To estimate the quantity of these salts, if they be unaccompanied by other salts, it is only necessary to dry and weigh the precipitate by nitrate of silver; setting down for every 100 grains of muriate of silver thus thrown down, 52 of muriate of potash; and 41 of muriate of soda. If alkaline carbonates be present, they must be first saturated with sulphuric acid, and sulphate of silver used to precipitate the muriatic acid.

d. 2. *Muriate of Barytes* is detected by sulphuric acid. It is rarely found.

d. 3. *Muriate of Lime.* To detect this salt the water must be first freed from the sulphates, then filtered, evaporated to dryness, the dry mass treated with alcohol, and the residue, after evaporating the alcohol, dissolved in water. If this

[1] To make the calculation, the weight of a precipitate produced by the prussiate in a solution of a given weight of sulphate of iron in water must be previously determined.

solution yields a precipitate with acetate of silver, the water contained muriate of lime.

d. 4. *Muriate of magnesia* is detected by separating the sulphates, and proceeding as in the former case. If the aqueous solution of the dry mass treated with alcohol afford no precipitate with carbonate of lime; and if sulphuric acid and evaporation, with the addition of a little alcohol, occasion no precipitate, the solution contains only muriate of magnesia.

d. 5. *Muriate of alumina* is detected by first saturating any alkali the water may contain with nitric acid, and separating any sulphuric acid by nitrate of barytes; and then adding carbonate of lime, which produces a precipitate if this salt be present. This process also precipitates muriate of iron and of manganese, if any be present.

To estimate the quantities of these muriates, which may all be contained in the same water, the earths, after separating any sulphates that may be present, are to be precipitated by barytes water, and redissolved in muriatic acid. They are then to be separated by the rules already mentioned, and separately weighed. For every 50 grains of lime, set down 100 of dried muriate of lime; for 30 grains of magnesia, 100 of muriate of magnesia; and for 21·8 grains of alumina, 100 of muriate of alumina. The barytes of the muriate of barytes, which the addition of the barytes-water had formed in the mineral water by precipitating the earths, is now to be separated by sulphuric acid, and its muriatic acid expelled by heat; after which the muriate of soda which the water originally contained, is to be obtained by evaporation.

e. NITRIC ACID never exists in an uncombined state in mineral waters; and even the nitrates are comparatively of rare occurrence.

f. The *nitrates* are incompatible with the salts, in the second column of the following table.

Nitrate of lime . . .	Alkaline carbonates. Sulphates, except of lime. Carbonates of magnesia and alumina.
Nitrate of magnesia . . .	Fixed alkaline sulphates.

f. 1. *Nitrate of Potash* may occur in mineral waters in conjunction with sulphates and muriates; the former of which must be decomposed by acetate of barytes, and the latter by acetate of silver, before the nitrates can be estimated. After these previous steps, filter the water, then evaporate it to dryness, and treat the residue with alcohol; which dissolves the acetates, and leaves the nitre.

f. 2. *Nitrate of Lime* is detected by first concentrating the water, and separating the sulphates by alcohol; then filtering and distilling off the alcohol, and separating any muriatic acid by acetate of silver; afterwards, filtering again, evaporating to dryness, and dissolving the residue in alcohol, which must be also distilled off, and the dried residue dissolved in water. If oxalic acid detect lime in this solution, the mineral water contains nitrate of lime; the quantity of which may be estimated by precipitating with sulphuric acid, and calculating the quantity of lime contained in the sulphate; and for every 35 grains of lime setting down 100 grains of dry nitrate of lime.

f. 3. *Nitrate of Magnesia* is detected by nearly the same means; but to the last watery solution, instead of oxalic acid add potash, as long as any precipitate appears. Filter this solution; evaporate and treat the dry mass with alcohol. If a residue of nitre remains, the mineral water contained nitrate of magnesia.

Such is the general method of ascertaining the components of mineral waters, and the proportion of the ingredients contained in any particular water. To render the analysis complete, many minutiæ must necessarily be attended to; but the detail of these would far exceed the limits which a work of this kind can admit of; and, after all, much must depend upon the ingenuity and expertness of the operator.