might be employed. Ammonia cannot be useful, as an antidote, by its chemical properties merely, since hydrocyanate of ammonia is a powerful poison.

(*c.*) *Cold affusion* has been strongly recommended by Herbst (*Archiv. f. Anat. et Phys.* 1828; quoted by Dr. Christison), and is admitted by Orfila to be a valuable remedy, though he thinks it inferior to chlorine. Herbst says that its efficacy is almost certain when it is employed before the convulsive stage of poisoning is over, and that it is often successful even in the stage of insensibility and paralysis.

(*d.*) *Artificial respiration* ought never to be omitted. Of its efficacy I am convinced from repeated experiments on animals. I once recovered a rabbit by this means only, after the convulsions had ceased, and the animal was apparently dead. It is an operation easily effected, and will be found a powerful assistant to chlorine or ammonia, by enabling it to get into the lungs when natural respiration is suspended. To produce respiration, make powerful pressure with both hands on the anterior surface of the chest, the diaphragm being at the same time pushed upward by an assistant. Inspiration is effected by the removal of the pressure and the consequent resiliency of the ribs.

Other remedies (as turpentine) have been recommended, but they will not bear comparison (if, indeed, they possess any efficacy) with those now mentioned. Blood-letting has been advised, in vigorous subjects, when respiration has been established, and the skin is livid (Devergie, *Méd. Lég.* t. ii. p. 825).

Order 8.—Phosphorus and Phosphoric Acid.

Phos'phorus —Phos'phorus.

History.—This substance was discovered in 1669, by Brandt, an alchymist at Hamburgh; and received its name from being luminous in the dark (from φῶς, *light;* and φέρω, *I carry*).

Natural History.—Phosphorus is found in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—Phosphorus is comparatively rare in the mineral kingdom. Various phosphates are found native, but in small quantities: those of lime, lead, iron, copper, manganese, uranium, and yttria, may be mentioned as examples. Phosphate of lime is an important constituent of the organic exuviæ entombed in the fossiliferous rocks.

(*b.*) *In the organized kingdom.*—Phosphoric acid, free, or combined with lime, potash, or iron, is found in various vegetables (Decandolle, *Phys. Végét.* pp. 383, 387, and 390). Phosphorus is a constituent of animals: in some cases it is in combination with oxygen, and a base, as in the bones, urine, &c.: in other instances, as in the brain, it is uncertain in what form it exists.

Preparation.—Phosphorus is procured from bone-ash (*sub-* or $\frac{2}{3}$ *phosphate of lime*), by digesting it in sulphuric acid; by which sulphate and superphosphate of lime are procured: the first, for the most part, precipitates, while the latter remains in solution. The solution is to be evaporated nearly to dryness, then mixed with charcoal, dried, and distilled in an earthen retort. The charcoal abstracts the oxygen

from the phosphoric acid of the superphosphate, setting free the phosphorus, which is volatilized.

PROPERTIES.—It is a pale yellow, semitransparent, crystallizable, highly combustible solid. Mitscherlich says the crystals are rhombic dodecahedrons; so that they belong to the regular or tessular system. Light, especially violet light, reddens it.

Its sp. gr. is 1·77.—At ordinary temperatures it is flexible, but at 32° is brittle. It melts at 105°, and boils at 550° F. It gives off a small quantity of vapour at ordinary temperatures. In the atmosphere its fumes are luminous in the dark, in consequence of a slow combustion: they have the odour of garlic. By keeping in water, phosphorus becomes coated by a white substance, by some regarded as an oxide, by others as the hydrate of phosphorus. Phosphorus is insoluble in water, but soluble in ether, and the oils both fixed and volatile. It may be reduced to powder by melting it under water, and shaking in a closed vessel until cold. Its equivalent by weight is 16.

CHARACTERISTICS.—Phosphorus in substance is easily recognized by its waxy appearance; by its fuming in the air, and being phosphorescent or luminous in the dark; by friction or gentle heat causing it to inflame; and, lastly, by its burning with a most intense white light and a white smoke of phosphoric acid. A solution of phosphorus in oil or ether, may be known by its garlicky odour, and, when rubbed on the skin, by its rendering the latter luminous in the dark.

PHYSIOLOGICAL EFFECTS.—(*a.*) *On vegetables.*—According to Marcet it is poisonous to plants.

(*b.*) *On animals generally.*—Water impregnated with phosphorus, acts as an aphrodisiac to drakes (Alph. Leroy, quoted by Bayle, *Biblioth. de Thérap.* t. ii. p. 28). Phosphuretted oil acts as a stimulant to horses: blood drawn from a vein had a phosphoric odour (Pilger, quoted by Bayle). If phosphuretted oil be injected into the jugular vein, or into the cavity of the pleura of a dog, white vapours of phosphorus are evolved from the mouth, and death shortly takes place. The phosphorous acid inflames the lungs in its passage through the delicate pulmonary vessels. Introduced into the stomach of animals, phosphorus acts as a caustic poison. The corrosion is supposed to depend on the action of the phosphorous acid (formed by the combination of the phosporus with the oxygen of the air contained in the alimentary canal) on the tissue with which it is in contact.—(Orfila, *Toxicol. Génér.*)

(*c.*) *On man.*—In *small doses*, phosphorus acts as a powerful and diffusible stimulant, exciting the nervous, vascular, and secreting organs. It creates an agreeable feeling of warmth at the epigastrium, increases the frequency and fulness of the pulse, augments the heat of skin, heightens the mental activity and the muscular powers, and operates as a powerful sudorific and diuretic. Its aphrodisiac operation has been recognized by Alphonse Leroy, and Bouttatz (Bayle, *op. cit.*), by experiments made on themselves. In *somewhat larger doses* it causes burning pain, vomiting and purging, with extreme sensibility of the stomach, which lasts for several days (see an experiment made by Sundelin on himself, *Handb. d. Heilm.* 2er. Bd. s. 213). In *still larger doses*, it causes inflammation of the stomach and bowels. Its activity as a caustic poison depends, according to Orfila, on its absorbing oxygen, and thus

becoming converted into an acid which acts as a corrosive, like the other mineral acids. Hence, therefore, etherial and oleaginous solutions are more active poisons, inasmuch as the oxidation of the phosphorus is effected more rapidly. Comparatively small doses have in some cases proved fatal. In Dr. Christison's *Treatise on Poisons* are references to several cases: in one $1\frac{1}{2}$ grains, in another instance 3 grains, caused death. Cases, however, are reported, in which 6, 10, and even 12 grains have been swallowed without any hurtful effects; but doubts have been entertained as to the correctness of the statements. Thus the authors of the *Dictionnaire de Matière Médicale* think that the phosphorus employed in these cases must have undergone some chemical change. I once administered 16 grains of phosphorus to a man without any injurious effect; and, judging from its physical characters, I should say the phosphorus was that usually met with in commerce. The man here alluded to was Chabert, some years ago renowned in London under the name of the "*Fire King*." I carefully weighed out 16 grains, placed them in a spoon, and put them in his mouth; and he washed them down with a tumblerful of water. He offered to take this dose daily. How he counteracted the ill effects, I know not; but I suspect he excited vomiting, for within ten minutes after swallowing the phosphorus, he left the room for about a quarter of an hour.

Uses.—In this country, phosphorus is rarely employed, and, therefore, it will be unnecessary to enter minutely into its uses. It has been strongly recommended in those cases attended with great prostration of the vital powers, as in the latter stages of typhus fever, dropsies, &c.; in some chronic diseases of the nervous system, as epilepsy, paralysis, melancholy, mania, amaurosis, &c., when these occur in debilitated subjects. In some of the exanthemata, as measles, it has been administered to promote the re-appearance of the eruption when this, from some cause, had receded from the skin; in impotentia virilis of old and debilitated subjects; in cholera, &c. Paillard recommends phosphorus as a caustic, in the place of moxa, than which, he says, it is more convenient and safer. (*Med. Gaz.* vol. ii. p. 254).

Administration.—Phosphorus cannot be given with safety in the solid form. It may be administered dissolved in ether, and formulæ for the preparation of an ethereal solution (*tinctura etherea cum phosphoro*, Fr. Cod.) will be found in Magendie's *Formulaire*, and in the French *Codex*. But some objections have been raised to its use. It is said that upon the evaporation of the ether the phosphorus will be set free, and may inflame the stomach. A solution of phosphorus in fixed oil (*Oleum phosphoratum*, Ph. Boruss.) is, therefore, more commonly employed. Magendie's formula for this is the following:—Digest, during fifteen days, in a dark place, one part by weight of phosphorus, cut in very small pieces, in sixteen parts of olive or almond oil, in a stoppered bottle. To communicate an aromatic flavour, a few drops of the essence of bergamot may be added to the decanted liquid. The solution is termed *aromatic phosphorized oil* (*huile phosphorée aromatisée*). Of this oil from 25 to 30 drops may be given in 24 hours: it may be administered in some mucilaginous liquid, or in an emulsion.

Antidotes.—In poisoning by phosphorus, our objects are to prevent or stop the oxidation of the phosphorus, and to neutralize the resulting

acid as fast as it is formed. To fulfil the first of these indications, large quantities of mild demulcent liquids are to be exhibited, so as to envelop the phosphorus and exclude it from the air contained in the alimentary canal. Magnesia should be given, in order to neutralize the phosphorous and phosphoric acids. Parts burned with phosphorus are to be washed with a weak alkaline solution, to remove any adhering acid which might serve to keep up irritation.

Ac'idum Phosphor'icum.—Phos'phoric Ac'id.

History.—Phosphoric acid was first distinguished by Marggraf, in 1740.

Natural History.—(See Phosphorus).

Preparation.—In the London Pharmacopœia, dilute phosphoric acid (the only officinal form of phosphoric acid) is ordered to be prepared by adding an ounce of phosphorus to four fluidounces of nitric acid, mixed with ten fluidounces of distilled water, in a glass retort placed in a sand-bath; then apply heat until eight fluidounces are produced. Let these be again put into the retort that eight fluidounces may distil, which are to be rejected. Evaporate the remaining liquor in a platinum capsule until only two ounces and six drachms remain. Lastly, add to the acid, when it is cold, as much distilled water as may make it accurately measure twenty-eight fluidounces.

In this process six equivalents or 96 parts of phosphorus react on five equivalents or 270 parts of real nitric acid, and abstract fifteen equivalents or 120 parts of oxygen, with which they form six equivalents or 216 parts of phosphoric acid, while five equivalents or 150 parts of the binoxide of nitrogen are evolved.

INGREDIENTS REACTING.			RESULTS.	
5 eq. Nitric Acid 270	5 eq. Nitrogen	70	5 eq. Binox. Nitrogen . .	150
	10 eq. Oxygen.	80		
	15 eq. Oxygen.	120	6 eq. Phosphoric Acid . .	216
6 eq. Phosphorus		96		

If strong nitric acid be employed, instead of the dilute acid ordered in the Pharmacopœia, the re-action is so energetic that an explosion and combustion are sometimes the consequence. In such cases some nitrate of ammonia is usually developed: the ammonia being formed by the union of the nitrogen of the acid with the hydrogen of the water.

Properties.—The aqueous solution of phosphoric acid (*acidum phosphoricum dilutum*, Ph. L.) prepared as above, is a colourless and odourless liquid. It possesses the usual characteristics of an acid; that is, it is sour to the taste, reddens litmus, and neutralizes bases. Its sp. gr., according to Mr. Phillips, is 1·064. By evaporation it acquires the consistence of treacle (*hydrated phosphoric acid*): and when exposed to a higher temperature, it loses water and becomes *pyrophosphoric acid.* At a dull red heat a further evolution of water takes place, and a compound is formed, called *metaphosphoric acid:* this is fusible, and by cooling concretes into a transparent solid, called *glacial phosphoric acid.*

Characteristics.—If phosphoric acid be saturated with an alkali (soda) so as to form a soluble phosphate, it may be distinguished from all

other acids by the following characters: it throws down, with the soluble salts of lime, lead, and baryta, white precipitates (phosphates) soluble in nitric acid: with the nitrate of silver it causes a yellow precipitate (subsesquiphosphate of silver) soluble in nitric acid and in ammonia: hydrosulphuric acid causes no change of colour or precipitate with it: if the soluble phosphate be heated to redness, it is converted into a pyrophosphate, which gives, with the nitrate of silver, a white precipitate (pyrophosphate of silver).

Purity.—Diluted phosphoric acid, prepared according to the Pharmacopœia, generally, if not invariably, contains traces of nitric acid. Sulphuric acid may be recognized by chloride of barium, which produces with it a white precipitate insoluble in nitric acid. Hydrochloric acid is detected by nitrate of silver, which causes a white precipitate also insoluble in nitric acid, but soluble in ammonia. The presence of metallic matter may be known by hydrosulphuric acid. Saturated with carbonate of soda, no phosphate insoluble in water should be thrown down.

Composition.—Pure anhydrous phosphoric acid is thus composed:—

	Eq.	Eq. Wt.	Per Cent.	Berzelius.	Dulong.	Davy.
Phosphorus	1	16	44·44	44·05	44·8	42·6
Oxygen	1½	20	55·56	55·95	55·2	57·4
Phosphoric Acid	1	36	100·00	100·00	100·0	100·0

Mr. Phillips says, that 100 grains of the dilute acid of the Pharmacopœia saturate 42 grains of [crystallized] carbonate of soda. If the whole of the free acid were phosphoric, the composition of the dilute acid would be as follows:—

Phosphoric Acid	10·5
Water	89·5
Dilute Phosphoric Acid	100·0

Physiological Effects. (*a.*) *On vegetables.*—This acid is poisonous to plants (Gœppert, quoted by Decandolle, *Phys. Végét.*)

(*b.*) *On animals.*—Very few experiments have hitherto been made with it on animals. Orfila (*Toxicolog. Génér.*) found that a strong solution of it acted like sulphuric acid. Thrown into the veins of a dog, it coagulated the blood and killed the animal within ten minutes. Introduced into the stomach, it acted as a powerfully corrosive poison.

(*c.*) *On man.*—Diluted phosphoric acid produces the usual effects of the diluted mineral acids, and which I have before noticed (pp. 80, 84, and 96). It is, therefore, denominated tonic and refrigerant, and may be employed wherever the mineral acids are indicated. It is milder, more assimilable, and, therefore, less likely to disagree with the digestive organs than sulphuric acid, with which, in its action, it is usually compared. These qualities it perhaps derives from its being, as Burdach (*Arzneimittellehre*, Bd. 3, S. 395, 1809) expresses it, "less heterogeneous to the human organism, since it has a considerable share in the composition of it." The same authority also observes, that besides fulfilling the indications of the mineral acids, "it much exalts the excitability when the organism is weak."

Various effects have been ascribed to this acid, which require to be further investigated ere they are admitted. Thus Hecker (*Arzneimittel.* Bd. 2. S. 305) says, it has a specific operation on the nervous system, in virtue of which it possesses the power of allaying pain and spasm. Lentin (*Beitrage zur ausüb. Heilk.* Bd. 2. S. 139) considers it to be endowed with a specific power of influencing secreting surfaces and the bones, whereby it is enabled to ameliorate various morbid conditions of these parts. Sundelin (*Heilmittell*, Bd. 2, S. 234) regards it as a stimulant and tonic to the sexual organs. Various effects have been ascribed to it by Herder (*Hufeland's Journ.* Bd. 9, St. 3, S. 148).

Uses.—Phosphoric acid has been employed in the same cases in which sulphuric and other mineral acids have been used, and under the same regulations. It may be employed for a longer period, without disturbing the digestive functions, than the other agents of this class.

It has been used in certain cases rather on theoretical than practical grounds. Thus its power of dissolving phosphate of lime has led to its employment in those forms of lithiasis attended with phosphatic deposits in the urine,—in ossification of the arteries and cardiac valves,—and in exostosis and other osseous tumours. Lentin used it as a local agent to check caries, from a notion that this disease depends on a deficiency of phosphoric acid in the part affected. Woulff applied it to promote the formation of bone.

There are several other diseases against which this acid has been administered. Thus it has been given in blenorrhœa and leucorrhœa, when the secreted fluid was thin and acrid (Sundelin),—in profuse suppuration, to diminish the quantity and improve the quality of the secreted matter,—in hysterical affections of young and irritable subjects, Sundelin has found it useful,—in impotency of the male (Berends),—in diabetes, and in jaundice.

Administration.—Internally the dilute phosphoric acid should be given in doses of from ten minims to half a drachm, properly diluted. Mixed with eight or ten times its volume of water, it may be employed as a wash in caries.

Antidotes.—(See *Sulphuric Acid.*)

Order 9.—Sulphur and its non-metallic Compounds.

Sul'phur.—Sul'phur or *Brimstone.*

History.—Sulphur has been known from the most remote periods of antiquity. It is mentioned by Moses (*Genesis*, xix. 24), Homer (*Iliad*, lib. xvi.) and other ancient writers.

Natural History.—It is found in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.—Native* or *virgin sulphur* occurs in two forms: either imbedded in rocks (*common native sulphur*), or produced by sublimation (*volcanic sulphur*). In Sicily it is found in beds in a blue clay formation, which, in the opinion of Dr. Daubeny, is more recent than chalk, but is of the same age with the gypsum beds in the neighbourhood of Paris. Solfatara (called by the ancients *Forum Vulcani* or the *Court of Vulcan*), a kind of half-extinct volcano, in the vicinity of