28.11 - Other inorganic acids and other inorganic oxygen compounds of non-metals.

- Other inorganic acids :

2811.11 - - Hydrogen fluoride (hydrofluoric acid)

2811.19 - - Other

- Other inorganic oxygen compounds of non-metals :

2811.21 - - Carbon dioxide

2811.22 - - Silicon dioxide

2811.29 - - Other

This heading covers mineral acids and anhydrides and other oxides of non-metals. The most important are listed below according to their non-metal component (*) :

(A) COMPOUNDS OF FLUORINE

(1) **Hydrogen fluoride** (HF). Obtained by the action of sulphuric acid on natural calcium fluoride (fluorite) or on cryolite. It is purified by treatment with potassium carbonate or by distillation (it sometimes contains small quantities of silicates and of fluorosilicic acid as impurities). In the anhydrous state, hydrogen fluoride is an extremely hygroscopic liquid (boiling point 18/20 °C); it fumes in a humid atmosphere. In the anhydrous state and in concentrated solution (hydrofluoric acid) it burns deeply into the skin and carbonises organic matter. It is presented in metal bottles lined with lead, gutta-percha or ceresine wax, or in rubber or plastic containers; the very pure acid is kept in silver flasks.

Its uses include etching on glass, manufacturing ashless filter paper, preparation of tantalum, of fluorides, scouring and pickling foundry pieces, in organic synthesis, or as a control in fermenting processes.

(2) **Fluoroacids**. These include :

(a) **Tetrafluoroboric acid** (fluoroboric acid) (HBF_4).

(b) **Hexafluorosilicic acid** (fluorosilicic acid) (H_2SiF_6), e.g., in aqueous solutions obtained as by-products in the manufacture of superphosphates, or from silicon fluorides. It is used for the electrolytic refining of tin and lead, for preparing fluorosilicates, etc.

(B) COMPOUNDS OF CHLORINE

The most important of these compounds are powerful oxidising and chlorinating agents, used in bleaching and in organic synthesis. They are, as a rule, unstable. They include :

(1) **Hypochlorous acid** (HClO). A product dangerous to inhale, exploding on contact with organic matter. The gas is presented in aqueous solutions, yellow or occasionally reddish.

(*) In the following order : fluorine, chlorine, bromine, iodine, sulphur, selenium, tellurium, nitrogen, phosphorus, arsenic, carbon, silicon.

(2) **Chloric acid** ($HClO_3$). This acid exists only as colourless or yellowish aqueous solutions.

(3) **Perchloric acid** ($HClO_4$). This product, more or less highly concentrated, gives various hydrates. It attacks the skin. Used in analyses.

(C) COMPOUNDS OF BROMINE

(1) **Hydrogen bromide** (HBr). A colourless gas with a strong, pungent odour. It may be put up under pressure, or in the form of aqueous solutions (hydrobromic acid) which decompose slowly in the air (especially under the action of light). Hydrobromic acid is used to prepare bromides and in organic synthesis.

(2) **Bromic acid** ($HBrO_3$). Exists only in aqueous solutions; used in organic synthesis.

(D) COMPOUNDS OF IODINE

(1) **Hydrogen iodide** (HI). A colourless, suffocating gas, readily decomposed. It is presented in corrosive, aqueous solutions (hydriodic acid) which fume in damp air when concentrated. Used in organic synthesis as a reducing agent or as a medium for fixing iodine.

(2) **Iodic acid** (HIO_3) and **its anhydride** (I_2O_5), prismatic crystals or in aqueous solutions. Used in medicine or as an absorbent agent in gas masks.

(3) **Periodic acid** ($HIO_4 . 2H_2O$). Similar properties to iodic acid.

(E) SULPHUR COMPOUNDS

(1) **Hydrogen sulphide** (H_2S). A highly toxic, colourless gas with the foetid odour of rotten eggs. Presented under pressure in steel cylinders or in aqueous solution (hydrosulphuric acid). It is used in analysis, for purifying sulphuric or hydrochloric acids, for obtaining sulphur dioxide or regenerated sulphur, etc.

(2) **Peroxosulphuric acids** (persulphuric acids), presented in crystalline form :

(a) Peroxodisulphuric acid ($H_2S_2O_8$) and its anhydride (S_2O_7).

(b) Peroxomonosulphuric acid (Caro's acid) (H_2SO_5), extremely hygroscopic; a powerful oxidising agent.

(3) **Thionic acids**. These exist only in aqueous solution : dithionic acid ($H_2S_2O_6$); trithionic acid ($H_2S_3O_6$); tetrathionic acid ($H_2S_4O_6$); pentathionic acid ($H_2S_5O_6$).

(4) **Aminosulphonic acid** (sulphamic acid) ($SO_2(OH)NH_2$). Obtained by dissolving urea in sulphuric acid, sulphur trioxide or oleum; crystalline, slightly soluble in water but readily soluble in alcohol. Used for the manufacture of fire-proof textile dressings, in tanning and electroplating and in organic synthesis.

(5) **Sulphur dioxide** (SO_2). Obtained by combustion of sulphur, by roasting natural sulphides (particularly iron pyrites), or by roasting natural calcium sulphate (e.g., anhydrite) with clay and coke. It is a colourless, suffocating gas.

Sulphur dioxide is presented either liquefied under pressure in steel bottles, or in aqueous solution; in the latter commercial form it is often wrongly called " sulphurous acid ".

A powerful reducing and bleaching agent, sulphur dioxide has many uses, e.g., bleaching animal textiles, straw, feathers or gelatin, the sulphite process in sugar refining, preservation of fruit or vegetables, the preparation of acid sulphites for the treatment of wood pulp, manufacture of sulphuric acid, or as a disinfectant (for wine mutage). Liquid sulphur dioxide, which lowers the temperature on evaporation, is used in refrigerating plant.

(6) **Sulphur trioxide** (sulphuric anhydride) (SO_3). A white solid in needle-shaped crystals somewhat similar to asbestos in appearance. Fumes in damp air; absorbs and reacts violently with water. It is presented in airtight sheet-iron containers or in glass or stoneware carboys, which are fitted with a device containing inorganic absorbent matter. It is used for preparing oleums (heading 28.07) and alums (heading 28.33).

(7) **Disulphur trioxide** (S_2O_3). Deliquescent green crystals, decomposed by water and soluble in alcohol; used as a reducing agent in the manufacture of synthetic dyes.

(F) SELENIUM COMPOUNDS

(1) **Hydrogen selenide** (H_2Se). A nauseous gas, dangerous to inhale because it paralyses the olfactory nerve. Presented in unstable aqueous solutions.

(2) **Selenious acid** (H_2SeO_3) **and its anhydride** (SeO_2). Hexagonal white crystals, deliquescent, very soluble in water; used in the enamel industry.

(3) **Selenic acid** (H_2SeO_4). White crystals, anhydrous or hydrated.

(G) TELLURIUM COMPOUNDS

These are hydrogen telluride (H_2Te) (in aqueous solutions), tellurous acid (H_2TeO_3) and its anhydride (TeO_2) (white solids), and telluric acid (H_2TeO_4) (colourless crystals) and its anhydride (TeO_3) (orange-coloured solid).

(H) NITROGEN COMPOUNDS

(1) **Hydrogen azide** (hydrazoic acid) (HN_3). Colourless, toxic liquid with a suffocating odour; very soluble in water; unstable, with explosive properties. Its salts (azides) fall in **heading 28.50**, and not in sub-Chapter V.

(2) **Dinitrogen oxide** (nitrous oxide) (N_2O). Sweet-tasting gas, soluble in water and presented in liquid form. Used in the gaseous state as an anaesthetic, and in the liquid or solid state as a refrigerating agent.

(3) **Nitrogen dioxide** (nitroxyl, nitrous vapours, " nitrogen peroxide ") (NO_2). Colourless liquid at 0 ºC, orange-brown at higher temperatures; boiling point about 22 ºC (when it gives off red fumes). This is the most stable nitrogen oxide. A powerful oxidising agent.

(IJ) PHOSPHORUS COMPOUNDS

(1) **Phosphinic acid** (hypophosphorous acid) (H_3PO_2). Lamellar crystals, melting at about 25 ºC, oxidising on exposure to air; a powerful reducing agent.

(2) **Phosphonic acid** (phosphorous acid) (H_3PO_3). Deliquescent crystals melting at about 71 ºC, soluble in water. Also **its anhydride** (P_2O_3 or P_4O_6), crystals which melt at about 24 ºC, and turn first yellow then red when exposed to light, gradually decomposing.

(K) ARSENIC COMPOUNDS

(1) **Diarsenic trioxide** (arsenic sesquioxide, arsenious oxide, white arsenic) (As_2O_3). Wrongly known as " arsenious acid ". Obtained by roasting arseniferous ores of nickel and silver or arsenical pyrites. It may sometimes contain impurities (arsenic sulphide, sulphur, antimonous oxide, etc.).

Commercial arsenic (III) oxide is generally a crystalline white powder, odourless and highly poisonous (flowers of arsenic). The vitreous anhydride takes the form of transparent, amorphous masses; the porcelanic anhydride is in opaque, interlocking, octahedral crystals.

Its uses include preserving hides or zoological specimens (sometimes it is used mixed together with soap); as a rat poison; for the manufacture of fly-papers; preparation of certain opacifiers, vitrifiable enamels or mineral greens such as Scheele's green (copper arsenite) or Schweinfurt green (copper acetoarsenite); in small doses, as a medicament (in the treatment of dermatitis, malaria or asthma).

(2) **Diarsenic pentaoxide** (As_2O_5). Obtained by the oxidation of arsenic trioxide or by the dehydration of arsenic acid; it is a highly poisonous white powder which dissolves slowly in water, giving arsenic acid. It is used for the manufacture of arsenic acid, as an oxidising agent, etc.

(3) **Arsenic acids**. The name " arsenic acid " is given to ortho-arsenic acid ($H_3AsO_4.½H_2O$) and other hydrates of arsenic pentaoxide (pyro- or meta-arsenic acids, etc.). They crystallise in colourless needles and are deadly poisons.

Arsenic acid is used for the manufacture of synthetic dyes (fuchsine, etc.), arsenates and organic derivatives of arsenic used as medicaments or insecticides.

The heading **excludes** arsenic hydrides (e.g., AsH_3) (**heading 28.50**).

(L) CARBON COMPOUNDS

(1) **Carbon monoxide** (CO). Toxic, colourless and tasteless gas; put up under pressure. Its reducing properties are utilized, *inter alia*, in metallurgy.

(2) **Carbon dioxide** (CO_2). Incorrectly called " carbonic acid ". Obtained by the combustion of carbon, or by heating calcareous substances or treating them with acids.

It is a colourless gas, one and a half times heavier than air; it extinguishes flames. Carbon dioxide can be presented either as a liquid (compressed in steel cylinders), or as a solid (compressed cubes in insulated containers, " carbonic snow " or " carbonic ice ").

It is used in metallurgy, in sugar manufacture or for aerating beverages. Liquid CO_2 is used for raising beer, for the preparation of salicylic acid, in fire extinguishers, etc. Solid CO_2 is used as a coolant (down to -80 °C).

(3) **Hydrogen cyanide** (hydrocyanic acid, prussic acid) (HCN). Obtained by the action of sulphuric acid on a cyanide, or by the action of catalysts on mixtures of ammonia and hydrocarbons.

It is a very toxic, colourless liquid with an odour of bitter almonds. Miscible with and less dense than water; it keeps badly when impure or in weak solution.

Hydrocyanic acid is used in organic synthesis (e.g., for the production of acrylonitrile by reaction with acetylene) and as a parasiticide.

(4) **Isocyanic, thiocyanic or fulminic acids**.

(M) SILICON COMPOUNDS

Silicon dioxide (pure silica, silicic anhydride, etc.) (SiO_2). Obtained by treating silicate solutions with acids, or by decomposing silicon halides by the action of water and heat.

It can be either in amorphous form (as a white powder " silica white ", " flowers of silica ", " calcined silica "; as vitreous granules – " vitreous silica "; in gelatinous condition – " silica frost ", " hydrated silica "), or in crystals (tridymite and cristobalite forms).

Silica resists the action of acids; fused silica is therefore used to make laboratory apparatus and industrial equipment which can be suddenly heated or cooled without breaking (see General Explanatory Note to Chapter 70). Finely powdered silica is used, e.g., as a filler for various types of natural and synthetic rubber and other elastomers, as a thickening or thixotropic agent for various plastics, printing ink, paints, coatings and adhesives. Fumed silica (made by combustion of silicon tetrachloride or trichlorosilane in hydrogen-oxygen furnaces) is also used in chemi-mechanical polishing of silicon wafers and as a free-flow or anti-settling agent for a variety of materials.Activated silica gel is employed to dry gases.

The heading **excludes** :

(a) Natural silica (**Chapter 25**, except varieties constituting precious or semi-precious stones - see the Explanatory Notes to **headings 71.03** and **71.05**).

(b) Colloidal suspensions of silica are generally classified in **heading 38.24** unless specially prepared for specific purposes (e.g., as textile dressings of **heading 38.09**).

(c) Silica gel with added cobalt salts (used as a humidity indicator) (**heading 38.24**).

(N) COMPLEX ACIDS

This heading also covers chemically defined complex acids consisting of two or more non-metal mineral acids (e.g., chloro-acids), or of a non-metal acid and a metal acid (e.g., tungstosilicic, tungstoboric acids), not specified or included in other headings of this Chapter.

Since antimony is deemed in the Nomenclature to be a metal, antimonic acid and antimony oxides fall in **heading 28.25**.