

2.4. PRODUCTION OF PHOSPHORUS AND PHOSPHORIC ACIDS

Electrothermal phosphorus production. The device of electric furnaces. Physico-chemical basis for the production of phosphorus from natural phosphates. Scheme for obtaining elemental phosphorus. Processes for the processing of phosphorus into phosphoric and polyphosphoric acids. Acidic methods of processing phosphorus raw materials. Extraction phosphoric acid and methods for its concentration. Hydrothermal processing of phosphates

Mass fraction of phosphorus in the earth's crust is 0.08%. The most important phosphorus minerals found in nature are *fluorapatite* $Ca_5(PO_4)_3F$ and *phosphorite* $Ca_3(PO_4)_2$.

Phosphorus is one of the most important elements of plant nutrition, as it is a part of proteins. If nitrogen in the soil can be replenished by fixing it from the air, then phosphates can only be added to the soil in the form of fertilizers. The main sources of phosphorus are phosphorites, apatites, vivianite and waste from the metallurgical industry - thomas slag, phosphate slag.

Phosphorus forms several allotropic modifications, which differ markedly in properties.

White phosphorus is a soft crystalline substance. It is composed of P_4 molecules. It melts at a temperature of 44.1°C. It is very soluble in CS_2 - carbon disulfide, highly poisonous and flammable. By heating white phosphorus, red phosphorus is obtained. It is a mixture of several modifications that have different lengths of molecules. The color of red phosphorus depending on the method and conditions of production can vary from light red to purple and dark brown. Its melting point is 585-600°C.

The most stable modification is *black phosphorus*, which is similar in appearance to graphite. Red and black phosphorus unlike white phosphorus do not dissolve in carbon disulfide, are not poisonous and are not flammable. Phosphorus is chemically more active than nitrogen. The chemical activity of phosphorus depends on the allotropic modification in which it is found. So, the most active white phosphorus, and the least active black phosphorus.

White phosphorus corresponds to the designation- P_4 , which corresponds to the composition of its molecules. The red and black phosphorus modifications are usually written as P . The same symbol is used if the modification is unknown.

The phosphorus production process consists of the following main stages: preparation of raw materials; sublimation of phosphorus in electric furnaces; purification of furnace gas from dust; condensation of phosphorus.

In the production of phosphorus, the initial ore is preliminarily subjected to heat treatment, in which the decomposition of mineral impurities, the combustion of organic components of the ores, and the destruction of the crystalline structure of the basic substance occur. These processes are accompanied by dehydration and decarbonization.

The raw materials for the production of phosphorus are natural phosphates - apatites and phosphorites, coke or anthracite. Depending on the amount of silica in the feedstock, sand or crushed quartz is introduced into the charge to obtain slags of a certain composition. Raw materials, since the process for producing phosphorus is heterogeneous, is crushed to pieces from 5 to 60 mm and mixed. For completeness of recovery in the mixture, there is approximately 10% excess carbon material. Furnaces for the production of phosphorus operate at an overpressure of 5-15 mm water column and therefore must be carefully sealed. In case of the powerful furnaces, self-sintering electrodes are used.

In industry, phosphorus is obtained from calcium phosphate $Ca_3(PO_4)_2$, which is isolated from phosphorites and fluorapatites. The production method is based on the reaction of reduction of $Ca_3(PO_4)_2$ to phosphorus. Coke (carbon) is used as a reducing agent. To bind calcium compounds, silica sand SiO_2 is added to the reaction system. The process is carried out in electric furnaces (production is referred to as electrothermal).