Lecture 1. Introduction. Importance and development of the chemical industry in Kazakhstan. Structure and functional elements of chemical production.
The technical and economic indicators.

The word technology comes from two Greek words techne and logos.

Techne means art, skill, craft, or the way, manner, or means by which a thing is gained.

Logos means word, the utterance by which inward thought is expressed, a saying, or an expression.

So, literally, technology means words or discourse about the way things are gained.

Chemical engineering is a branch of engineering that applies the natural sciences and life sciences together with mathematics and economics to production, transformation, transportation and proper usage of chemicals, materials and energy.

Chemical engineering as a science has:

the object of studying is chemical industry;

the subject matter is the methods and processes of processing the raw materials into useful products;

purpose of the studying is the creation of appropriate methods of manufacturing products necessary for the person;

*research methods* are experimental, modeling and systems analysis.

Chemical industry		
Mining Chemistry (extraction of mining and chemical raw materials)	**Basic chemistry**	**Chemistry of Organic Synthesis**
• potassium salts • boiled salts • phosphorites • apatites • natural sulfur • Glauber sulfur	• production bases, acids, alkalis; • production of mineral fertilizers	• production of synthetic rubber • production of synthetic resins and plastics • production of chemical fibers • production of household cleaning products • pharmaceuticals • perfume and cosmetic industry • production of tires

*Importance and development of the chemical industry in Kazakhstan

*The leading sectors within Kazakhstan are **inorganic chemicals** and **petrochemicals**.

*Actively developing sectors include **glasswork**, **ceramic** and **cement production**, and the manufacture of **paint** and **household** products.

Some major chemicals producers
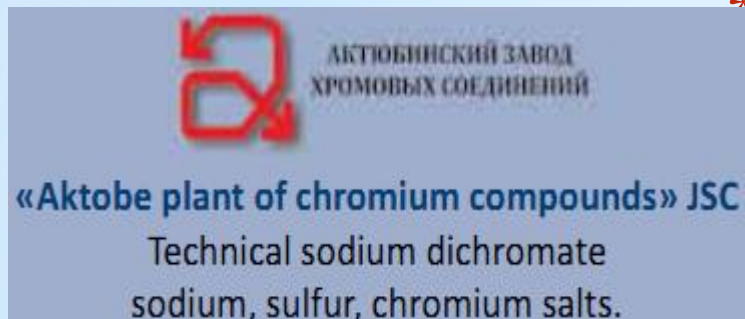
«Aktobe plant of chromium compounds» JSC. The main products of the plant: technical sodium dichromate, technical potassium dichromate, metallurgical chromium oxide, chromic anhydride, include: basic chromium sulfate, pigment chromium oxide, dry chrome tanning agent, sodium, sulfur, chromium salts.

«KazAzot» LLP based at the chemical complex of Caspian Mining Metallurgical Plant is a leading producer of nitrogenous fertilizers and ammonium nitrate.

LLP "Kazphosphate" - the leading producer of phosphates and phosphate fertilizers.

«Ulba Fluor Complex» LLP
hydrofluoric acid

* «Ulba Fluor Complex» LLP is a vertically integrated company combining mining and mineral processing and production of hydrofluoric acid.

«Kaustik» JSC
hydrochloric acid
sodium hypochlorite
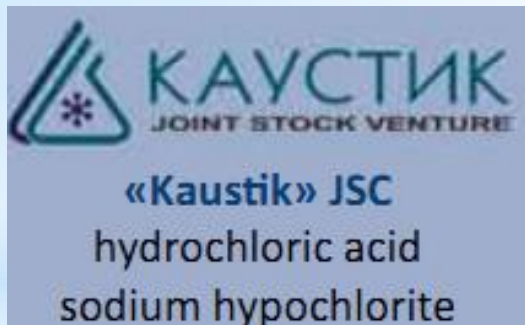
* «Kaustik» JSC is located in Pavlodar city. The main products of the plant: caustic soda, liquid chlorine, hydrochloric acid, and sodium hypochlorite.

* Petrochemicals

The major petrochemical plants are located in **Atyrau**, **South Kazakhstan** and **Pavlodar oblasts**.

«Neftekhim LTD» LLP
methyl-tert-butyl (MTB)
polypropylene

«High Industrial Lubricants & Liquids Corporation»
lubricants FASTROIL.

- **«Neftekhim LTD» LLP** is a major manufacturer of methyltert-butyl and polypropylene. It sources the main raw material for production (propane, propylene and butane-butylene fraction) from the neighboring «Pavlodar Petrochemical Plant» JSC where oil refining is conducted.
- **«High Industrial Lubricants & Liquids Corporation»** is a major producer of high class lubricants under the brand FASTROIL.

Chemical production and chemical process

Chemical production is a set of processes and operations carried out in machines and apparatus for processing raw materials by chemical reactions into the necessary products**.**

General requirements for chemical production:

- Obtaining the necessary product in the production;

- Environmental safety;

- Safety and maintainability;

- Maximum use of raw materials and energy;

- Maximum labor productivity.

Structure and functional elements of chemical production
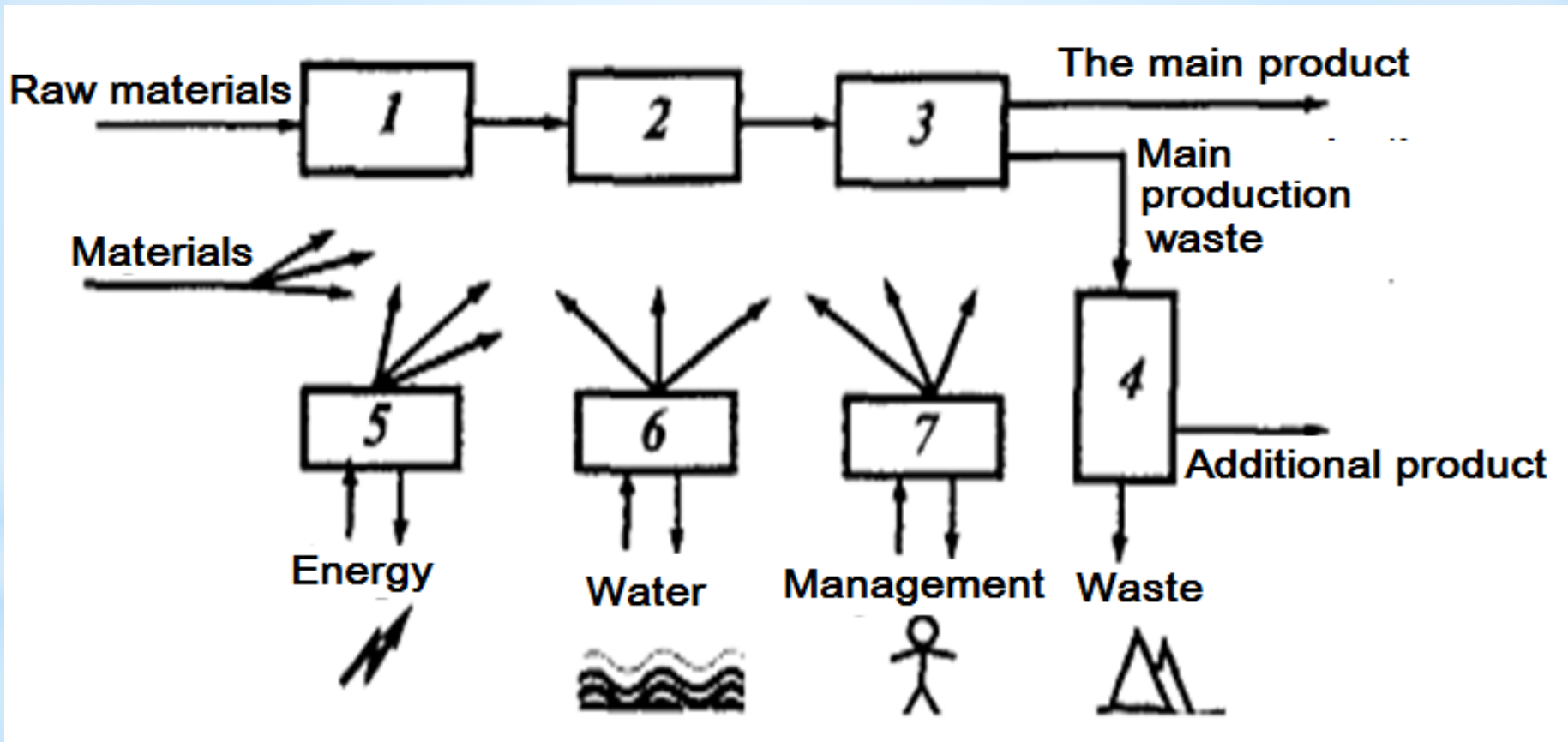
1 - preparation of raw materials, 2 - processing of raw materials; 3 – main product recovery, 4 - sanitation and waste management; 5 - energy system; 6 - preparation of auxiliary materials and water preparation, and 7 - management system

Positions 1-3 - actually chemical production.

Preparation of raw materials includes its pretreatment - crushing, removal of impurities, mixing of the components and so on.

Processes of preparation depends on the type of feedstock and the conversion conditions.

The prepared raw material undergoes a series of transformations (position 2 in Fig. 1.1), resulting in a production of the desired product. Since the original natural raw materials usually contain impurities transformation may be incomplete and may be formed other substances, therefore it is necessary to allocate the main product from the resulting mixture to purify it from impurities

Production wastes can contain harmful components that are dangerous to release in environment, and helpful, which is impractical to throw out. Therefore, an essential element in the chemical industry is a sanitation and waste production

The chemical industry consumes a lot of energy to ensure the processing of raw materials into products. Therefore, an important element of the chemical-technological system is an energy system (Pos. 5 Fig. 1.1). The energy consumed in the production of the product and to provide the conditions for its production. The energy system must provide not only the distribution of energy by stage of production, but also the possibility of returning it after use.

The chemical industry uses auxiliary materials. These include, for example, sorbents for the purification and separation products; substances with which creates an environment necessary for the processes, and others. Of particular water takes place - it is used to cool the process streams, steam generation, dissolving and diluting the process stream. Preparation of support materials, especially water treatment (pos. 6 in Fig. 1.1) - is also very important and difficult part of the chemical industry. As auxiliary materials and water providing process, but are usually not included in the end-products, the system must provide training their recovery properties after cycle operations involving them and return them to the production.

Complex chemical production can not be operated without control system (Pos. 7 Fig. 1.1). It provides monitoring of the production of the process under the best conditions, protection against unwanted (emergency) situations, start and stop of a complex system. This element is an automated process control system

* Components of chemical production

Alternating component:

• **Raw materials of** chemical engineering are natural materials used in production;

• **Auxiliary materials for** ensuring the technological process;

• **Products (main and additional),** as a result of processing of raw materials. Products of production can be used as consumer products then they lose their original properties and become waste, and as intermediate products for further processing into other products;

• **Wastes production** are remains of raw materials, intermediate products, minor product;

• **Energy for** ensuring the functioning production.

Permanent components are placed in production (equipment, construction) or are involved in it (the staff) on all or nearly all the period of its existence.

They include:

• equipment (machines, advices, vessels, pipeline);

• monitoring and control devices;

• building construction (buildings);

• wait staff (workers, operators, engineers and other production workers).

Composition of chemical production

1 Chemical production;

2 The raw materials, products, intermediates, wastes storage;

3 The raw materials, products, intermediates and waste transport;

4 wait staff cutting and forming Department;

5 Management, providing and security system.

* Types of processes and operations

*The mechanical and hydro-mechanical processes;

*Heat exchange processes;

*Mass transfer processes;

*Chemical processes;

*The energy processes;

*Informational controlling processes.

Mechanical and hydromechanical processes - the change of shape and size of the material and its move, merge and stream separation. These transactions are carried out crushers, granulators, mixers, separators, filters, cyclones, compressors, pumps.

Heat exchanger processes - change the stream temperature, its heat content, convert substance into another phase. (heat exchangers , evaporators, condensers, sublimator.)

Mass exchanger processes - implement a phase transfer components, changing the component composition of streams without the appearance of new substances . (disstilyators, absorbers, adsorbers, distillation columns, extractors, crystallizers, dryers).

Chemical processes - chemical transformations, they fundamentally change the component composition of streams and materials. These processes proceed in chemical reactors.

Energy processes - energy conversion and obtaining energy carrier. They include turbines, generator, drives to produce mechanical energy.

Control and management processes allow to measure the state of stream, monitor the status of devices and machines, also to manage the processes, changing the conditions of their occurrence . They include sensors (temperature, pressure, composition , etc.) , actuating mechanisms (valves, gate valves, switches, etc.), also devices for generating and converting the signals, information and computing devices.

Technological indicators determine the quality of chemical, technological process

Productivity of the device (process) (P) is the quantity of produced product or recycled materials per unit of time:

$$P = G / \tau,$$

where **P** - productivity (kg/h, t/day, m3/day); **G** - amount of product (t, kg, m3); **τ** - time (hour, day, year).

The maximum possible productivity of the device (under optimal conditions) is called **capacity (C)**:

$$C = P_{opt},$$

where **C** – capacity of the device (in kg/h, t/day).

Intensity unit (process) (I) is productivity per unit of useful volume or per unit of useful area.

$$I = P/V_u = G/ V_u\tau$$
$$I' = P/S_u = G/ S_u\tau,$$

where I – Intensity (kg/m^3·h, kg/m^2·h); V_u – useful volume unit; S_u – useful area unit

The percentage yield is the ratio between the actual yield and the theoretical yield multiplied by 100%.

$$\eta = G_{pr}/G_{teor},$$

where **Gpr -** amount of the actual product **/ Gteor -** the theoretical amount of the product

Consumption of each type of raw material per unit of the desired product is called a **consumption coefficient (A).**
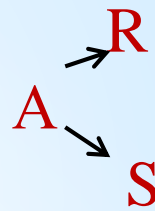
A = Q/G,

where **Q – c**onsumption of raw material; **G -** quantity of product.

Consumption coefficient expressed in tonnes per tonne $t \cdot t^{-1}$, of cubic meters per tonne $m^3 \cdot t^{-1}$, of kilowatt-hours per tonne $kVt \cdot h \cdot t^{-1}$ etc.

The degree of conversion (X): The fraction (or percentage) of the reactants that actually reacted during the reaction..

$$\% \text{Conversion} = \frac{\text{amount of reactant converted}}{\text{amount of reactant supplied}} \times 100$$

Selectivity φ is the ratio of the amount of the desired product to total obtained products.

If in the process parallel reactions occur $A \begin{smallmatrix} \nearrow R \\ \searrow S \end{smallmatrix}$ and the desired product is the R, the selectivity is

$$\varphi_R = \frac{N_R}{N_R + N_S}$$

Where N_R - the amount of product R, N_S - the amount of product S.

Economic indicators
determine the economic efficiency of production

1. Specific capital costs (Ksp) are the ratio of the total cost of installation (shop) to its annual capacity:

$$K_{sp} = K/C,$$

where K_{sp} – specific capital costs (tg·year/t);
К – capital costs (tg);
N – capacity of installation (t/year).

$$K_{sp} = a \cdot N^{-0.4},$$

where *a* is coefficient depending on the nature of the chemical industry, it is found for each product using practical data.

*2. **Prime cost** means sum of direct material costs, direct labour costs and direct expenses.

*3. **Labour productivity** is amount of products produced per unit of time (usually a year) per worker.

Operational indicators

characterize the changes that occur in the chemical-process and production during the operation of equipment when the manifestation deviation from the specified terms and conditions

***Reliability** is characterized by average time of trouble-free operation or the number of emergency shutdowns of equipment or production in general for a certain period of time. This indicator depends on the quality of the equipment and its validity of operation.

***Safety** is probability inviting infliction of harm or disruption to the wait staff, equipment and environment, population.

*Social indicators

*determine comfort of work on this production and its impact on the environment

- **The harmlessness service**
- **Degree of automation and mechanization**
- **Environmental safety**