Syllabus
Course Program

SURFACE PHENOMENA END DISPERSED SYSTEMS

Specialty
161 Chemical technologies and engineering

Institute
Institute of Education and Science in Chemical Technologies and Engineering

Educational program
Technology of oil, gas and solid fuel refining

Department
Physical Chemistry (194)

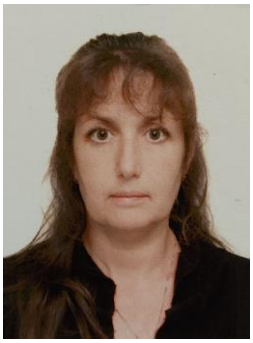
Level of education
Bachelor's level

Course type
Special (professional), Mandatory

Semester
4

Language of instruction
English

Lecturers and course developers



Yuliia Zhelavska

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Candidate of Technical Sciences (PhD), Associate Professor of the Physical Chemistry Department

Associate Professor of the Physical Chemistry Department, of the Institute of Education and Science in Chemical Technologies and Engineering, completed PhD degree in technical electrochemistry, author of publications in journals indexed in Scopus international science databases, Web of Science and professional editions of Ukraine, patents of Ukraine for invention and utility model, participant in many international scientific conferences, teaching disciplines in English, basic courses: Physical chemistry of dispersed systems, Physical chemistry, Surface phenomena and dispersed systems.

More about the lecturer on the department's website

General information

Summary

The course "Surface Phenomena and Disperse Systems" is aimed at forming basic knowledge of surface phenomena and dispersed systems that allow applying new achievements of colloidal chemistry for analysis and prediction of inorganic and organic substances properties at introduction of innovative chemical technologies in industry.

Course objectives and goals

The purpose of the course is for students to acquire professional knowledge about the essence of colloidal processes, which are the basis of chemical industry technologies.

Format of classes

Lectures,, laboratory works, consultations, calculation tasks, independent work, form of control – exam.

Competencies

SC 12 – The ability to use modern materials, technologies and designs of devices in the chemical industry Engineering.

Learning outcomes

LR 04 – Carry out qualitative and quantitative analysis of inorganic and organic origin substances, using appropriate methods of general and inorganic, organic, analytical, physical and colloidal chemistry

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 32 hours, laboratory classes - 32 hours, self-study - 56 hours.

Course prerequisites

Higher mathematics, physics, general and inorganic chemistry, organic chemistry

Features of the course, teaching and learning methods, and technologies

Learning methods that are used in the process of conducting classes, as well as independent works:
visual: illustrative, cartographic and demonstration material;
interactive: use of computer equipment and office and specialized programs during conducting lectures and laboratory classes;
verbal: lectures in their traditional presentation, lectures-disputes, lectures-conversations;
practical: laboratory works, which are performed in the traditional version by each student individually or in subgroups of 2-3 students; or accompanied by the showing of video films, composition graphic schemes;
educational and cognitive: excursions to enterprises and institutions of the chemical industry;
game: solving situational tasks;
reproductive and problem-searching: performance of individual tasks (calculation tasks and multimedia presentations).

Program of the course

Topics of the lectures

Topic 1. Concept of surface phenomena and dispersed systems
The spread of surface phenomena and dispersed systems in nature and their meaning in folklore economy Main features: heterogeneity, high dispersion, large specific area surface Changes in properties with changes in the dispersion of the specific surface area.
Dispersed systems as heterogeneous thermodynamic non-equilibrium systems that are not subject to phase rule Excess surface (free) energy as a cause of thermodynamic (aggregative) instabilities of the majority of colloidal systems.
Classification of dispersed systems according to the size of particles of the dispersed phase, aggregate state of the dispersed phase and the dispersed medium, the nature of the interaction between the dispersed phase and environment, mechanical properties.
The concept of high molecular weight compounds of the Navy. The similarity of a number of properties of solutions of the Navy and colloidal solutions. Application of knowledge in the field of surface phenomena and dispersed systems for chemical technology and engineering.
Topic 2. Surface phenomena and adsorption.
Surface tension as a measure of surface free energy. Thermodynamic functions of the surface layer. Wetting phenomenon. Edge corner. Hydrophobicity and hydrophilicity of surfaces. Flotation. adhesion, adhesion work. Cohesion, the work of cohesion. Methods of determining surface tension.
Adsorption isotherm and empirical Freundlich isotherm equation. Analysis and solution of this equation. Adsorption as an isothermal process. Concept of integral and differential heat adsorption.

The nature of adsorption forces. Adsorption at the solid-gas interface. Theory of monomolecular adsorption Langmuir. Analysis and solution of the Langmuir equation. Concept of polymolecular adsorption. Polyani and BET theories

Topic 3. Adsorption at the solution-gas and solid-gas boundaries.

Surface-active surfactants. Derivation of the Gibbs adsorption equation. Superficial measure activity according to Rebinder. Shyshkovsky's equation. The transition from the Gibbs equation to Langmuir equation. The concept of diphilicity of molecules. Duclos-Traube rule.
Hydrophilic and hydrophobic adsorbents. Energy characteristics of gas and steam adsorption by solid bodies. Adsorbents and their characteristics. Lyotropic series of ions. Ion exchange adsorption of strong electrolytes, its practical application. Adsorption: physical and chemical, active and passive, localized and non-localized.

Topic 4. Electrokinetic properties of colloidal systems.

Reiss's experiments. Electrokinetic phenomena: electrophoresis, electroosmosis. Micelle and colloid particles structure. Electric double layer formation. The electric double layer structure according to Helmholtz-Peren, Stern and Gui-Chapman and Stern. Complete thermodynamic potential jump. Electrokinetic potential. Isoelectric point.

Topic 5. The effect of various factors on the electrokinetic potential magnitude.

Dependence of the electrokinetic potential on the electrolytes concentration, valence and radius ion-coagulant, temperature, pH of the dispersion medium. The Schulze-Hardy rule in coagulation of dispersed systems by electrolytes. Recharging surface of the colloidal particle. Ion exchange in the outer shell of the electric double layer. Lyotropic series of ions. Determination of electrokinetic potential by methods of electroosmosis and electrophoresis

Topic 6. Obtaining and cleaning dispersed systems.

Dispersed systems preparation by methods of physical and chemical condensation. Mechanism and kinetics condensation Production of colloidal systems by the dispersion method. Electrical methods dispersion. Dispersion using ultrasound. Peptization as a method of obtaining sol. Ultrafiltration, dialysis, electrodialysis and their importance for cleaning dispersed systems.

Topic 7 Molecular kinetic and optical properties of colloidal systems.

Brownian motion, its thermal nature. The theory of Brownian motion developed by Einstein. Average particle displacement. Diffusion. The derivation of Einstein's equation establishing the relationship between the diffusion coefficient and particle radius, temperature and viscosity of the system. The relationship between the diffusion coefficient and average particle displacement. The physical meaning of the diffusion coefficient: Fick's first law. The role of diffusion in processes of dissolution, adsorption, etc.

Topic 8. Optical properties.

The Tyndall effect. Rayleigh's theory of light scattering. Rayleigh's equation, its analysis, application limits. Ultramicroscopy and electron microscopy. Nephelometry. Fluorescence. Features light absorption by colloidal systems. The Lambert-Bere-Bougere law in relation to dispersed systems Practical ignificance of knowledge of the theory of light scattering by dispersed systems.

Topic 9. Stabilization of dispersed systems.

Aggregative stability of dispersed systems. Stability factors. Stabilization and types of stabilizers: electrical, solvation, structural-mechanical and entropic. Basic theories of sustainability dispersed systems

Topic 10. Coagulation of dispersed systems.

Coagulation of colloidal systems, present and hidden. Coagulation threshold. Coagulation rule. Slow and rapid coagulation. Kinetics of rapid coagulation according to Smolukhovskyi. Mechanism of coagulation. Chemical, adsorption and electrostatic coagulation with electrolytes, their disadvantages. Physical theory coagulation of Deryagin, Landau, Fairway and Overbeck - DLFO. Neutralization and concentration coagulation according to Deryagin. Forces of repulsion and attraction, their dependence on distance interacting particles. Potential curves, energy barrier, near and far coagulation. The main phenomena observed during coagulation: irregular series, habituation, synergism and antagonism in the action of ions.

Topic 11. Structure formation in dispersed systems.

Properties of coagulation systems. Structuring and the influence of various factors on it.
Thixotropy, creep, relaxation period Viscosity. Equations of Newton and Poiseuille. Einstein's equation. Dependence of dispersed systems viscosity from the concentration and shape of colloidal particles. Anomaly of viscosity. Shvedov-Bingham's equation. Basic rheological curves: viscosity and flow curves,

their analysis. Rheological parameters and methods of their measurement. The main types of models of structural systems. Condensation and crystallization structures. Transition of coagulation structures to condensation-crystallization structures during technological processes.

Topic 12. High molecular compounds and their properties.

The structure of the molecules of high molecular weight compounds (HMC). Aggregative state of polymers. Swelling and dissolution of HMC. The influence of the pH of the environment and various impurities on the degree of swelling of the HMC. Pressure and heat swelling Solvation of polymers in solution. The phenomenon of association and the formation of a new phase in concentrated solutions of polymers. Thermodynamics of dissolution of the HMC. High molecular weight electrolytes (polyelectrolytes). The industrial value of solutions of HMC and dispersed polymers.

Topic 13. Colloidal surfactants.

Classification of colloidal surfactants. Examples of semi-colloidal systems are solutions of soaps, dyes, tannins. Forms in which soaps can be in solution. Transition molecular form into colloid and vice versa. The structure of soap micelles according to Hartley and McBain. Thermodynamics of semicolloidal systems. Concept of hydrophilic-lipophilic balance. Stabilizing and washing effect of soap. Stabilization. The role of soap micelles during emulsion polymerization.

Topic 14. Systems with a liquid dispersion medium.

Suspensions, their stabilization. Polydispersity of suspensions. Technological suspensions and pastes of mineral and of organic substances in aqueous and organic environments. Thixotropy of suspensions. Application suspensions in technology.

Emulsions: direct and reverse; diluted, concentrated and gelatinous. Reversibility of phases. Decay emulsions Foams; liquid and solid. Foam structure. Lifetime, multiplicity of foams. Emulsions in chemical industry Solid foams. Positive and negative value of foaming in chemical production Foam stabilizers. Methods of determining foam stability. Destruction of foam.

Topic 15. Systems with a gaseous dispersion medium.

Aerosols. Obtaining, properties and means of destruction. The reasons for their aggregative and sedimentation instability. Mists and smokes. Methods of synthesis and disintegration of these systems. Modern methods of gas purification. Aerosols in the national economy, nature and technology; their positive and negative value.

Protection of the environment from dust, smoke, etc. Powders, fluidity, ability to coagulate. Physico-chemical basics of powder processing. Importance of properties of powders in the chemical industry

Topic 16. Systems with a solid dispersion medium. Colloidal and chemical aspects of protection environment.

Natural porous substances, synthetic foams, foam concrete, filled with rubber, pigmented lacquer coatings, etc. Methods of industrial water purification: sedimentation, coagulation, flotation, ultrafiltration Methods of cleaning fumes and dust: centrifugation, electrofiltration, electrophoresis.

Topics of the workshops

Practical classes within the discipline are not provided.

Topics of the laboratory classes

Laboratory work №1. " Determination of specific adsorption on surface "solid body - solution".
Laboratory work №2. " Determination of surface-active substances adsorption on the surface of "solution - gas ".
Laboratory work №3. " Swelling kinetics of high molecular weight compounds "
Laboratory work №4. " Determination of the Huggins viscometric constant of polymer solutions "
Laboratory work №5. " Study of micelle formation in solutions of surface-active substances "
Laboratory work №6. " Determination of the coagulation threshold of sol with electrolytes "
Laboratory work №7. " Study of electrokinetic phenomena in colloidal systems "

Self-study

The discipline involves the performance of a calculation task, the purpose of which is an in-depth study individual topics of the course. The calculation task is drawn up in a written report.

Course materials and recommended reading

1. Birdi, K. S. (2016). Handbook of Surface and Colloid Chemistry. Boca Raton : Taylor & Francis. https://www.academia.edu/37255205/Handbook_of_Surface_and_Colloid_Chemistry_3rd_Ed
2. A.V. Djenyuk, N.D. Sakhnenko, Yu. A. Zhelavska, L.O. Sheina. Physical chemistry of dispersed systems. Laboratory practicum. – Kharkiv: FOP Panov A.N, 2021. – 92 c. http://web.kpi.kharkov.ua/fchem/wp-content/uploads/sites/30/2020/02/Practicum-I.pdf
3. S.I. Rudneva, N.D. Sakhnenko, A.V. Djenyuk. Physical chemistry: Practical course. – Kharkiv: FOP Panov http://web.kpi.kharkov.ua/fchem/wp-content/uploads/sites/30/2020/02/Physical-Chemistry.pdf.

Assessment and grading

Criteria for assessment of student performance, and the final score structure

100% of the final score consists of assessment results in the form of an exam (40%), ongoing assessment (60%).
Exam: written assignment (3 questions on theory) and oral presentation.
Current assessment: 2 control works (according to 15%), protection of laboratory works (10%) and calculation task (20%).

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	Date, signature	Head of the department Mykola SAKHNENKO
	Date, signature	Guarantor of the educational program Irina SENKEVICH