6) analyse the risks related to producing nuclear power on the example of specific examples;
7) analyse the possibilities for the use of renewable energy sources, as well as the problems accompanying them;
8) use evaluated sources of information to analyse energy resources and their uses.

Learning content

Problems with energy production around the world; energy resources and global energy management; modern technology in energy management; environmental problems accompanying production and use of energy.

Keywords: energy management, energy security, renewable and non-renewable energy sources, alternative energy production, fossil fuels, hydropower, nuclear, wind, solar, biological, tidal, wave and geothermal power, energy crisis, Kyoto Protocol, emissions quota.

Practical work and use of ICT

Using evaluated sources of information to analyse energy management in a given country.

2.3. Chemistry

2.3.1. Learning and educational objectives

Chemistry lessons at the upper secondary school level are designed for students to:

1) further develop their interested in chemistry and other sciences and understand the role of chemistry in the development of societies, in modern technology and in our everyday life, and become motivated for lifelong learning;
2) further develop their scientific and technological literacy, as well as creativity and a systematic way of thinking, and solve problems of chemistry using scientific methods;
3) identify, evaluate and use different sources to obtain information on chemistry and analyse and critically assesses this information;
4) develop, from studying chemistry and other science subjects, an integrated scientific worldview and obtain a systematic overview of the main definitions of chemistry and the rules governing the main chemical processes, and be able to use the vocabulary of chemistry in an appropriate manner;
5) carrying out chemistry investigations in a safe manner, and be able to use chemical reagents economically and safely in a laboratory, as well as in everyday life;
6) make competent decisions on the basis of scientific, economic, social, environmental, political, ethical and moral perspectives and predict the possible consequences of their decisions;
7) value a responsible attitude towards the environment and value healthy and sustainable ways of life; and
8) gain an overview of professions linked to chemistry and use their knowledge and skills from chemistry in planning their careers.

2.3.2. Description of the subject

Chemistry plays an important role in enhancing students' scientific and technological literacy. The chemistry taught in upper secondary school is based on the use of chemical knowledge, skills, attitudes and values acquired in basic school; it is linked to physics, biology, mathematics and other subjects taught in upper secondary school, while at the same time supporting the learning and teaching of other subjects. By studying chemistry, students develop several important competencies and achieve an enhanced positive attitude towards chemistry and other sciences, while also understanding the importance of the sciences in the economic, technological and cultural development of human societies. The students develop a responsible attitude towards their immediate environment and learn to value healthy and sustainable lifestyles. The knowledge, skills and attitudes gained from chemistry and other science lessons form the basis for internally motivated lifelong learning. The students develop scientific and technological literacy and an integrated scientific worldview corresponding to the upper secondary level and gain an overview of the main laws and theories associated with chemical processes, future trends in chemistry and professions linked to chemistry, thus helping them make career decisions.

Knowledge of chemistry is predominantly learned through exploratory tasks, where students learn skills of problem-setting, framing hypotheses, planning experiments and the determination of observations, carrying out the experimentation, analysing and interpreting the results. In solving chemical problems at the upper secondary level, the main focus is on understanding the problem discussed, analysing the results and arriving at conclusions, rather than learning by heart and routine training of mathematical algorithms of standard problems. Another important aspect is to develop skills in identifying various sources of information, including the Internet, and analysing and critically assessing the information obtained from these sources, as well as oral and written presentations of investigatory outcomes, involving appropriate forms of presentation. Technological equipment and ICT are used in all stages of the learning process.

In studying chemistry, the focus is on building links between this subject and other sciences, but also on processes taking place in nature (including humans) and relationships between humans and natural as well as artificial materials. Applying the knowledge and skills learned in solving everyday problems, making competent and ethical decisions and estimating the possible consequences of these decisions are all skills that are taught.

The curriculum is presented as problem-based and student-centred and linked to everyday life. The learning process is based on the individual traits of the students and their different talents, and attention is paid to developing intrinsic of the students. To achieve this, various types of active learning approaches – problem learning and exploratory learning, project learning, discussions, brainstorming, educational visits et al. – are used. Curricular activities using active learning principles help the students to develop their higher mental processes.

The chemistry taught in upper secondary school extends the knowledge, skills and expertise acquired in basic school. Compared with the basic school curriculum, the chemistry at upper secondary school considers the phenomena and processes of chemistry more profoundly, exactly and systematically, paying more attention to building connections. Inductive learning is complemented with deductive learning. Students learn to draw conclusions based on knowledge gained, find associations between different phenomena and apply their learning in new situations. The educational activities are directed towards fostering the intellect, skills and creativity of the students. Other important aspects are to develop the skill of working independently and the ability to use different sources of information and to distinguish between what is significant and what is insignificant. In studying chemistry, as with other science subjects, the development of the students' personality – independence, intellect and teamwork skills as well as responsibility and working habits – are important.

2.3.3. Learning outcomes in upper secondary school

Learning outcomes describe the satisfactory level of achievements for a student in upper secondary school.
Chemistry lessons at the upper secondary school level are designed for students to:

1) further develop interest in chemistry and other sciences, understand the role of chemistry in the economic, technological and cultural development of societies, and become motivated for lifelong learning;
2) apply scientific methods in solving chemistry problems, develop their ability to thinking logically and creatively, analyse and arrive at conclusions;
3) use various (including electronic) sources of information to obtain information on chemistry and be able to analyse and critically evaluate this information;
4) gain a systematic overview of the laws and theories in chemical processes and be able to use the vocabulary of chemistry in an appropriate manner;
5) apply skills of carrying out experiments to solve more complicated problems and use chemical reagents economically and safely in a laboratory and in everyday life;
6) make competent decisions related to everyday issues and evaluate the possible consequences of their actions;
7) understand the interrelations of nature, technology and society and their effect on the environment and sustainable development of society, value a responsible attitude towards the environment and healthy and sustainable ways of life; and
8) gain an overview of professions linked to chemistry and use their knowledge and skills in chemistry in planning their career.

2.3.4. Learning Outcomes and Learning Content of the Courses

2.3.4.1. 1st course

2.3.4.1. 1st course "Fundamentals of Chemistry"

Introduction

Learning outcomes

By the end of the course, students are expected to have the capacity to:

1) have an overview of the historical development of chemistry;
2) differentiate between qualitative and quantitative analysis and research methods in Physics and Chemistry;

Learning content

The development of chemistry as a science. Physical and chemical research methods in Chemistry. Chemistry-related career-choices.

Keywords: chemical analysis, qualitative analysis, quantitative analysis, chemical synthesis.

Practical work and use of ICT: study trip to a chemistry-related company, educational institution etc.

Subject structure

Learning outcomes

By the end of the course, students are expected to have the capacity to:

1) describe the placement of electrons in the outer electron layer of an atom (single electrons, electron pairs) depending on the placement of the element in the periodic table (in case of elements from group A);
2) explain changes in the properties of metals and non-metals in the periodic table (group A) in relation to the changes in the atomic structure;
3) determine the maximum and minimum oxidation levels of group A chemical elements according to the placement of the element in the periodic table and write the formulas for the model compounds of these elements;

4) on the basis of model examples, explain the nature of a covalent, ionic, metallic and hydrogen bond;
5) evaluate the polarity of a covalent bond on the basis of the placement of the elements forming the bond in the periodic table;
6) describe and evaluate the effect of the mutual impact of chemical bonds and molecules (also hydrogen bond) to the properties of substances.

Learning content
Modern understanding of the structure of an atom. Information in the periodic table and interpreting it. Types of chemical bonds. Hydrogen bond. Intermolecular forces. The relationship between the physical properties of a substance and the structure of a substance.
Keywords: atomic orbital, orbital, non-polar covalent bond, polar covalent bond, partial charge, hydrogen bond.
Practical work and use of ICT: investigating the structure of simpler molecules and comparing them with the use of molecule models or computer programmes.

Why and how do chemical reactions occur
Learning outcomes
By the end of the course, students are expected to have the capacity to:
1) associate a chemical reaction with particles crossing over to a more permanent state;
2) explain the thermal effects of chemical reactions on the basis of changes in energy occurring when chemical bonds are formed or disintegrated;
3) analyse the effects of factors affecting the speed of a chemical reactions and explain the changes in the speed of chemical processes in everyday life;
4) understand that in case of reversible reaction, there will be an equilibrium of opposite reactions, and bring relevant examples from everyday life and technology.

Learning content
Reaction activation, active collisions. Exothermic and endothermic reactions. The speed of a chemical reaction and influencing factors. Chemical equilibrium and it shifting (introduction of the Le Chatelier principle).
Keywords: reaction activation energy, reaction thermal effect, reaction speed, catalyser, catalysation, reversible reaction, irreversible reaction, chemical equilibrium.
Practical work and using ICT:
1) investigating the factors affecting the speed of a chemical reaction;
2) investigating the thermal effects of a chemical reaction;
3) explaining the operating principle of a car exhaust gas catalyser on the basis on online information;
4) studying the shifts in chemical equilibrium, including with the use of a computer model.

Dissolution process, chemical reactions in solutions
Learning outcomes
By the end of the course, students are expected to have the capacity to:
1) describe the creation of solutions (in case of ionic and covalent substances);
2) differentiate between electrolytes and non-electrolytes and strong and weak electrolytes;
3) explain the concepts of acid and base on the basis of proteolytical theory;
4) calculate molecular concentration;
5) create formula for interionic reactions (in molecular and ionic form);

6) evaluate and justify the environment created in the solution by dissolving different substances in water

Learning content
Dissolution process of substances. Electrolytes and non-electrolytes; strong and weak electrolytes. Proteolytical theory of acids and bases. Molecular concentration (introduction). Interionic reactions in solutions, the conditions of their course. pH. Environment in the solution of a hydrolysing salt.
Keywords: hydrating, electrolyte, non-electrolyte, strong electrolyte, weak electrolyte, acid, base, molecular concentration, salt hydrolysis.
Practical work and using ICT:
1) investigating the thermal effects of dissolution;
2) comparing the conductivity of different solutions (lightness of a light bulb or Vernier sensor); comparing the pH conductivity of weak and strong acids and bases;
3) investigating the reactions between ions;
4) investigating the environment of the water based solutions of different substances (pH of solutions)
5) specifying the concentration of a solution by titration (e.g. specifying the temporary water hardness, specifying the alkaline concentration in cleaning agents or specifying the acid concentration in battery acid etc.).

2.3.4.2. 2nd course „Inorganic substances“
Metals
Learning outcomes
By the end of the course, students are expected to have the capacity to:
1) associate the chemical properties of studied metals with the position of the element in the periodic table and their position in the period and compile corresponding reaction equations (metal reacting with a non-metal, water, diluted acid and salt solution);
2) describe the possible practical applications of the studied metals and their alloys;
3) know the most common natural metal compounds and their applications:
4) explain the principle of producing metals by reducing metal compounds and corrosion in the oxidation of metals;
5) explain the reversed energetic effect of corrosion and metal production, analyse the options for preventing corrosion;
6) analyse the general principles of redox processes (e.g. electrolysation, corrosion and in case of a chemical source of electrical current);
7) solve calculus tasks according to reaction equations, considering the yield and additions.

Learning content
Overview of the characteristic physical and chemical properties of metals. Comparison of the chemical activity of metals; reactivity series of metals. Metals and their compounds in everyday life and nature. Redox processes related to metals: producing metals from ore, electrolysis, corrosion, chemical electricity supply (without requiring reaction equations). Calculating yield and additions in molar calculations based on a reaction equation.
Keywords: alloy, ore, electrolysis, corrosion, chemical electricity supply, yield.
Practical work and use of ICT:
1) comparing the physical properties and chemical reactivity of metals;
2) investigating and comparing factors affecting the corrosion of metals and options for preventing corrosion;
3) investigating producing metals, electrolysis and chemical electricity supply with animations:
4) preparing an overview (report) on the production of one metal and producing/using its alloys.

Non-metals

Learning outcomes

By the end of the course, students are expected to have the capacity to:

1) associate the chemical properties of most common non-metals and their model compounds with the placement of the element in the periodic table;
2) write equations of characteristic reactions of the studied non-metals and their compounds;
3) describe the importance of the studied non-metals and their compounds in nature and/or the possibilities for applying them in practice.

Learning content

Overview of the physical and chemical properties of non-metals depending on the placement of the element in the periodic table. Comparison of the chemical reactivity of non-metals. Studying some non-metals and their compounds (chosen freely, on the example of natural and/or industrial processes).

Keywords: allotropy.

Practical work and use of ICT: producing non-metals and/or their common compounds, investigating and comparing their properties.

2.3.4.3. 3rd course Organic compounds

Hydrocarbons and their derivates

Learning outcomes

By the end of the course, students are expected to have the capacity to:

1) use different methods of depicting molecules (simplest structural formula, two-dimensional i.e. classical structural formula, graphic representation of molecules);
2) use the principles of systematic nomenclature on the example of alkanes; associate the prefixes or suffixes of systematic names with the studied chemical classes, determine the chemical class of based on the molecular structure or name;
3) evaluate the physical properties (solubility in different solvents and boiling temperature) on the basis of the molecular structure (capacity to form hydrogen bonds);
4) compare the chemical properties of saturated, unsaturated and aromatic hydrocarbons, write simpler reaction equations about the halogenation reactions of alkanes, alkenes and arenes an hydrogenation and catalytic hydration of alkenes (without reaction mechanisms);
5) describe the properties of more important hydrocarbons and their derivates, their applications in everyday life and dangers related to their use;
6) depict a section of a polymer produced from an alkene.

Learning content

Structure of carbon compounds and the ways of depicting it. Alkanes, nomenclature principles, isomers. Dependence of physical properties of substituted alkanes (halogen compounds, alcohols, primary amines) of their structure. Comparison of the chemical properties of unsaturated and aromatic hydrocarbons and alkanes. Chain polymerisation. Hydrocarbons and their derivates in nature and industry (introduction).

Keywords: isomerism, substituted hydrocarbon, alkane i.e. saturated hydrocarbon, unsaturated hydrocarbon, aromatic compound, chain polymerisation.

Practical work and use of ICT:

1) investigating the structure of the molecules hydrocarbons and their derivates and comparing them with the use of molecular models and/or computer programs:
2) investigating the intermolecular forces by comparing the enthalpy of vaporization;
3) mutual impact of hydrophilic and hydrophobic substances to water.

Organic substances around us

Learning outcomes

By the end of the course, students are expected to have the capacity to:

1) determine the chemical class of a substance on the basis of the molecular structure;
2) describe the properties of more important carboxyl acids and their importance in everyday life and nature;
3) explain the relationship between alcohols, aldehydes and carboxyl acids;
4) compare the chemical properties of carboxyl acids and inorganic acids and compile corresponding reaction equations;
5) describe the chemical processes in the body accompanying alcohol intoxication and the social problems associated with it;
6) compare the formation and hydrolysis reactions of esters and compile corresponding equations;
7) depict a section of a condensation polymer derived from source compounds;
8) explain in principle the structure of biomolecules (polysaccharides, proteins and fats).

Learning content

Aldehydes as the oxidation derivates of alcohols. Substituted carboxyl aids (amino acids, hydroxide acids) and functional derivates of carboxyl acids (esters, amides). Polycondensation. Organic compounds in living organisms: fats, saccharides, proteins).

Keywords: substituted carboxyl acid, functional derivates of carboxyl acids, hydrolysis, polycondensation.

Practical work and use of ICT:

1) investigating an comparing the level of oxidation of an alcohol and aldehyde;
2) investigating the strength of carboxyl acids and comparison to other acids;
3) producing and hydrolysis of esters;
4) investigating the hydrolysis of saccharides (e.g. starch) and its products;
5) investigating the behaviour of proteins (e.g. egg white water solution) with regard to acids, bases, salt solutions and heating;
6) investigating the behaviour of soap and synthetic washing products and comparing them in case of water of different acidity and added salts.

2.4. Physics

2.4.1. Learning and educational objectives

Physics lessons at the upper secondary school level are designed for students to:

1) develop their scientific and technological literacy, creativity and systematic way of thinking when describing and explaining natural phenomena;
2) be interested in physics and other natural science and be aware of the need for physics-related professions in the development of a sustainable society;
3) give value to physics as the most general science investigating the causal associations in nature and as an important cultural component;
4) understand the importance of models in studying natural objects, the development of models and their inevitable constraints;
5) collect and process information, distinguishing reliable information from noise and scientific information from unscientific information;
6) be able to solve essential qualitative and quantitative physics tasks and implement natural science methods when solving problem tasks;
7) understand the relationship between physics and technology;
8) use the knowledge and skills acquired in physics when solving natural science, technology and everyday problems and making justified decisions.