**Schola Europaea** / Office of the Secretary-General

**Pedagogical Development Unit**

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# Chemistry Syllabus – S4-S5

## Approved by the Joint Teaching Committee at its meeting on 7 and 8 February 2019 in Brussels

Entry into force on 1 September 2019 for S4
on 1 September 2020 for S5

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## 1. General Objectives

The European Schools have the two objectives of providing formal education and of encouraging pupils' personal development in a wider social and cultural context. Formal education involves the acquisition of competences (knowledge, skills and attitudes) across a range of domains. Personal development takes place in a variety of spiritual, moral, social and cultural contexts. It involves an awareness of appropriate behaviour, an understanding of the environment in which pupils live, and a development of their individual identity.
These two objectives are nurtured in the context of an enhanced awareness of the richness of European culture. Awareness and experience of a shared European life should lead pupils towards a greater respect for the traditions of each individual country and region in Europe, while developing and preserving their own national identities.
The pupils of the European Schools are future citizens of Europe and the world. As such, they need a range of competences if they are to meet the challenges of a rapidly-changing world. In 2006 the European Council and European Parliament adopted a European Framework for Key Competences for Lifelong Learning. It identifies eight key competences which all individuals need for personal fulfilment and development, for active citizenship, for social inclusion and for employment:

1. Literacy competence;
2. Multilingual competence;
3. Mathematical competence and competence in science, technology and engineering;
4. Digital competence;
5. Personal, social and learning to learn competence;
6. Civic competence;
7. Entrepreneurship competence;
8. Cultural awareness and expression competence.

The European Schools' syllabi seek to develop all of these key competences in the pupils.

## 2. Didactical Principles

The didactical principles of the European Schools are formulated in the teaching standards of the European Schools (ref: 2012-09-D-11-en-4). For delivery the teaching standards state that the teacher:

- Uses teaching skills and creativity to inspire and motivate pupils
- Delivers well-structured lessons
- Makes an effective use of teaching time
- Employs a variety of teaching and learning methods, including technology, appropriate to the content
- Motivates pupils to be actively involved in their own learning
- Demonstrates good subject and curriculum knowledge including their national and European dimensions

The eight competences for chemistry are knowledge, comprehension, application, analysis, experimental work, digital competences, communication and team work.

To teach the competences for chemistry according to the teaching standards of the European Schools an inquiry-based approach to teaching and learning is strongly recommended in S4-S5. The learning objectives listed in this syllabus, especially the competences concerning experimental work, digital and information competency, communication and team work cannot be achieved without a large focus on practical work.

## 3. Learning Objectives

Learning is not just getting more content knowledge. With learning in school, content is used to give the pupils competences to be prepared for society and work. Learning objectives for student performance therefore arise out of three dimensions: the European Framework for Key Competences for Lifelong Learning outlined in section 1, the academic competences outlined in 3.1 and the Cross-cutting concepts (Interdisciplinary Connections) in 3.2. This way we hope that the pupils will become prepared to a lifelong learning.

### 3.1. Competences

| | **Competency** | **Key Concepts** |
|---|---|---|
| **1.** | **Knowledge** | The student displays a comprehensive knowledge of facts |
| **2.** | **Comprehension** | The student displays a thorough command and use of concepts and principles in science |
| **3.** | **Application** | The student makes connections between different parts of the syllabus and applies concepts to a wide variety of unfamiliar situations and makes appropriate predictions |
| **4.** | **Analysis** | The student is capable of detailed and critical analysis and explanations of complex data |
| **5.** | **Experimental work** | The student can formulate hypotheses and plan and carry out investigations using a wide range of techniques while being aware of ethical issues<br>*Suggested verbs: evaluate, measure, investigate, design, test, prove* |
| **6.** | **Digital and information Competences** | The student can consistently and independently find and assess the reliability of information on scientific subjects, on- and offline and can independently use appropriate software for science tasks |
| **7.** | **Communication (oral and written)** | The student can communicate logically and concisely using correct scientific vocabulary and demonstrates excellent presentation skills |
| **8.** | **Teamwork** | The student works well in a team |

### 3.2. Cross-cutting concepts

The list of cross cutting competences places the learning objectives within a larger context which i. e. can form the basis of a cross-curricular projects. The tentative list to be taught is based on the next generation science standards in the United States (National Research Council, 2013):

| | Concept | Description |
|---|---|---|
| **1.** | **Patterns** | Observed patterns of forms and events guide organisation and classification, and they prompt questions about relationships and the factors that influence them |
| **2.** | **Cause and effect** | Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering |
| **3.** | **Scale, proportion and quantity** | In considering phenomena, it is critical to recognise what is relevant at different size, time, and energy scales, and to recognise proportional relationships between different quantities as scales change |
| **4.** | **Systems and system models** | Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding the world. Often, systems can be divided into subsystems and systems can be combined into larger systems depending on the question of interest |
| **5.** | **Energy and matter** | Tracking energy and matter flows, into, out of, and within systems helps one understand their system’s behaviour |
| **6.** | **Structure and function** | The way an object is shaped or structured determines many of its properties and functions |
| **7.** | **Stability and change** | For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand |

# 4. Content

## 4.1. Topics

| | Subtopic | Suggested % teaching time in S4/5 |
|---|---|---|
| S4.1 | Fundamental concepts and skills | 25% |
| S4.2 | Reactivity | 10% |
| S4.3 | Petroleum, plastic and pollution | 15% |
| S5.1 | Electrochemistry | 12½% |
| S5.2 | Quantitative approach of a reaction | 12½% |
| S5.3 | Food and chemistry | 12½% |
| S5.4 | Acids and alkalis | 12½% |

## 4.2. Tables

The table below contains the contents of the S4/5 chemistry syllabus.

- Column 1: subtopics
- Column 2: content
- Column 3: learning objectives, these are compulsory
- Column 4: key contexts, phenomena and activities, these are recommendations

## Topic 4.1: Fundamental concepts and skills (structure of matter)

<table>
<tr><th>Subtopic S4.1</th><th>Content</th><th>Learning Objectives (and limitations)</th><th>Key contexts, phenomena and activities</th></tr>
<tr><td>Introduction</td><td>What is chemistry?<br>Safety<br>Chemistry apparatus</td><td>Safety in executing chemical experiments and using the correct apparatus.</td><td>Additional safety rules and instruction will be given when appropriate throughout the course.</td></tr>
<tr><td>Elements and Atoms</td><td>Historic perspective<br><br>Bohr atomic model<br><br><br><br><br><br>Elements<br><br>Isotopes<br><br>Isotopic mass and relative atomic mass</td><td>Understand the historic development of atomic models, from Democritus to Bohr.<br><br>Construct and use graphic descriptions of an atom consisting of protons, electrons and neutrons.<br><br>Recognise that the number of protons defines the elements<br><br>Write the notations for the atomic (or charge) number (Z) and mass number (A)<br><br>Apply the notation of an element: $^{A}_{Z}X$<br><br>Recognise that isotopes of the same element have different masses<br><br>Explain that the relative atomic mass of an element depends on the relative abundance of its isotopes</td><td>Give the students awareness of the fact that:
<table>
<tr><th>Particle</th><th>Relative Mass</th><th>Relative Charge</th></tr>
<tr><td>Proton</td><td>1</td><td>+1</td></tr>
<tr><td>Neutron</td><td>1</td><td>0</td></tr>
<tr><td>Electron</td><td>5x 10$^{-4}$</td><td>-1</td></tr>
</table>
and
<table>
<tr><th>Particle</th><th>Mass/kg</th><th>Charge/C</th></tr>
<tr><td>Proton</td><td>1,67x10$^{-27}$</td><td>1,60x10$^{-19}$</td></tr>
<tr><td>Neutron</td><td>1,67x10$^{-27}$</td><td>0</td></tr>
<tr><td>Electron</td><td>9,10x10$^{-31}$</td><td>-1,60x10$^{-19}$</td></tr>
</table>
<br>Rutherford gold foil experiment to explain the size of atoms and of subatomic particles, PhET simulation, https://phet.colorado.edu/en/simulations, ‘Rutherford scattering’<br><br>Use PhET simulation ‘Build an atom’<br><br>Use PhET simulation ‘Isotopes and atomic mass’</td></tr>
</table>

| Subtopic S4.1 | Content | Learning Objectives (and limitations) | Key contexts, phenomena and activities |
|---|---|---|---|
| Periodic table | Periodic table, periods, groups | **Arrange** elements according to their atomic number (up to Z=20)<br><br>**Understand** that electron arrangement in an atom is related to its position in the periodic table and that number of electron shells is determined by period number or name of shells: K,L,M,N<br><br>**Draw** Lewis representation of atoms<br><br>**Explain** reactivity of elements as a consequence of the electron arrangement in the outer shell, (groups I, II, XIII to XVI, XVII and XVIII);<br><br>**Recall** the name and location of the following groups in the periodic table: alkali metals, alkaline-earth metals, halogens and noble gases<br><br>**Group** elements according to physical and chemical properties;<br><br>**Connect** properties of elements to their position in the periodic table: | Flame spectroscopy<br><br>Elements in the same group have similar chemical properties because they have the same number of electrons in their outer shell<br><br>Reactivity of alkali and earth alkaline metals with air and water<br><br>Reactivity of halogens |
| Chemical bonds | Ionic bond | **Use** the octet rule to **explain** the formation of ions<br><br>**Understand** that ionic bond is the electrostatic attraction between ions of opposite charge;<br><br>Ability to **describe and illustrate** ionic lattice **using** for instance NaCl as a model;<br><br>Being able to **explain** that ionic compound formula shows the ratio of positive and negative ions;<br><br>**Describe** the properties of compounds formed by ionic bonds: e.g. melting point, solubility, and conductivity of electricity; | Conductivity of ionic solutions<br><br>Precipitation of halogen compounds (e.g. AgX) |
| | Covalent bond | Being able to **draw** a schematic representation of a covalent bond, showing one or more pairs of electrons between the atoms; | Practical comparing ionic and covalent compounds<br><br>Simplified molecule representations showing polar and non-polar covalent bonds: H-Cl, O=O and N≡N; |

| Subtopic S4.1 | Content | Learning Objectives (and limitations) | Key contexts, phenomena and activities |
|---|---|---|---|
| | | **Explain** covalent bond formation with the aid of the octet rule;<br><br>**Understand** that the covalent bond **i**s the electrostatic attraction between a pair of electrons and positively charged nuclei.<br><br>**Give** examples of molecules formed through covalent bond(s);<br><br>**Describe** the properties of compounds formed by covalent bonds:.e.g. melting point, solubility and non-conductivity of electricity; | |
| | Electronegativity<br><br><br>Polarization | **Explain** electronegativity of atoms in terms of the ability to attract bonding pair electrons in a covalent bond;<br><br>**Explain** polarization as a result of the asymmetric distribution of the bonding electrons and the structure of the molecule;<br><br>**Identify** simple polar and non-polar molecules | Discuss the polarity of water in relation to its structure<br><br>Show the effect of a charged rod held near a stream of water<br>PhET simulation 'Molecule polarity' |
| Solutions | Ionic solution and molecular solution | **Define** what a solution is<br><br>**Illustrate** the different properties (conductivity) between molecular and ionic solutions<br><br>**Define** concentration (mass/volume) | Compare the conductivity of solutions with different concentrations<br><br>PhET simulation 'Sugar and salt solutions'<br><br>PhET simulation 'Concentration'<br><br>Relate the colour intensity of a solution to its concentration (e.g. Cu(II), permanganate) |

## Topic 4.2: Reactivity

| Subtopic S4.2 | Content | Learning Objectives | Key contexts, phenomena and activities |
|---|---|---|---|
| Reactivity | Chemical reaction | **Define** a chemical reaction<br><br>**Describe** a chemical reaction in terms of energy and mass conservation; | Simulation of collision between atoms leading to a reaction (PhET ‘Reactions and rates’) |
| | Chemical equation | **Write** chemical reactions as a balanced equation of reactants and products; | Use online methods to practice balancing of equations of different types (combustion, decomposition and addition) (PhET ‘Balancing chemical equations’) |
| | Activation energy | **Discuss** and **explain** activation energy as the process of breaking and forming bonds; | Combustion of carbon |
| | Exo- and endothermic processes | **Explain** the difference between an exothermic and an endothermic reaction | Dissolving sodium hydroxide (NaOH) or magnesium sulfate ($MgSO_4$) in water are exothermic processes, whereas the mixing of the solid hydrated barium hydroxide ($Ba(OH)_2).8H_2O$ with ammonium chloride ($NH_4Cl$) is an endothermic reaction |
| | Reaction rate | **Discuss** and being able to **predict** how the factors (concentration, temperature and active surface) affect the rate of reaction | Explain reactions with the aid of an energy diagram and balanced equations;<br><br>Reaction between sodium thiosulfate ($Na_2S_2O_3$) and dilute hydrochloric acid (HCl)<br><br>Reaction of zinc metal and diluted acid<br>Dehydration of sucrose<br><br>Decomposition of hydrogen peroxide |
| | Catalysts | **Explain** that a catalyst lowers the activation energy of a reaction; | |

## Topic 4.3: Petroleum, plastic and pollution

| Subtopic S4.3 | Content | Learning Objectives | Key contexts, phenomena and activities |
|---|---|---|---|
| Crude oil | Fossil fuels | **Understand** origin and process of formation. **Define** organic compounds. | |
| | Fractional distillation | **Explain** how crude oil components are separated into useful fractions | Demonstration of fractional distillation.<br><br>Discuss principle of fractional distillation related to boiling point. |
| | Hydrocarbons | **Name** (up to $C_{10}$) alkanes and simple alkenes according to the IUPAC nomenclature<br><br>**Write** molecular, structural, and line formula of hydrocarbons | Use molecular models to represent molecules (Molymod), 3-D computer models/virtual reality |
| | Structural isomers | **Explain** that with a specific molecular formula different structural formulae exist (at least for alkanes) | |
| | Fuels as source of energy | **Describe** complete combustion of fossil fuels | Qualitative study of energy released in the combustion of different fuels |
| | Fossil fuels and pollution | **Identify** products of complete combustion<br><br>**Link** $CO_2$ production with greenhouse effect<br><br>**Link** greenhouse effect to global warming and climate change | Experiment testing products of combustion<br><br>Simulation of greenhouse effect using a model |
| Plastic | Polymers | **Explain** the structure of polymers in terms of a repeating unit<br><br>Through experimentation **identify** key properties of some common polymers.<br><br>**Link** these properties to their use.<br><br>**Illustrate** ubiquity of plastic products and its consequences on human health and pollution | Demonstration of synthesis of Bakelite. Synthesis of Nylon 6,6, and slime<br><br>Density, chemical resistance to acids and bases, thermoplasticity, etc.<br><br>Research the Great Pacific Garbage Patch, biodegrability, microplastics, total mass of yearly plastic production. Can exposure to plastic harm our health? Exploring alternative materials such as plant-based, animal-based, bio-mass based polymers, etc. |

## Topic 5.1: Electrochemistry

| **Subtopic S5.1** | **Content** | **Learning Objectives** | **Key contexts, phenomena and activities** |
|---|---|---|---|
| Redox reactions | Redox reactions as an exchange of electrons | **Define** redox reactions as the loss and gain of electrons (limited to monoatomic ions and diatomic molecules)<br><br>**Illustrate** the redox reaction as the exchange of electrons at atomic level (collision of ions in solutions with metal strips)<br><br>**Define** oxidation as a loss of electrons and reduction as a gain of electrons<br><br>**Understand** that reduction and oxidation occur simultaneously<br><br>**Assign** oxidation numbers (limited to monoatomic ions and diatomic molecules)<br><br>**Identify** the oxidising agent and the reducing agent<br><br>**Write** half-equations and **balance** the complete reaction using half-equations<br><br>**Compare** the reactivity of common metals (activity series)<br><br>**Predict** the reaction products using the activity series | Introduce redox reactions through simple experiments. For example:<br>●Iron nail in copper sulphate solution<br>●Copper wire in silver nitrate solution<br>●Active metals in an acidic solution<br><br>Use computer simulations to visualise the exchange of electrons (e.g. chemdemos.uoregon.edu et al.) |
| Electrochemical Cells | Galvanic cell | **Construct** a simple cell and a battery by connecting simple cells in series<br><br>**Describe** the galvanic cell as a device that converts chemical energy into electrical energy<br><br>**Draw** and **identify** the components of a simple cell and **state** their functions: **describe** the transfer of electrons from the negative to the positive electrode via an external circuit, **recognise** at which electrode oxidation and reduction respectively occur | Use an experimental approach to construct an activity series<br><br>Verify the predictions experimentally<br><br>A historical approach is possible (Galvani, Volta, Daniell)<br><br>Construct different cells and batteries |

| Subtopic<br>S5.1 | Content | Learning Objectives | Key contexts, phenomena and activities |
| --- | --- | --- | --- |
| | Electrolytic cell | **Describe** the electrolytic cell as a device that converts electrical energy into chemical energy<br><br>**Write** the balanced equation for the cell | Introduce the electrolytic cell through an experimental approach, for example electrolysis of potassium iodide solution with carbon electrodes<br><br>Copper plating experiment |

## Topic 5.2: Quantitative approach of a reaction

| **Subtopic S5.2** | **Content** | **Learning Objectives** | **Key contexts, phenomena and activities** |
|---|---|---|---|
| Quantitative approach of a reaction | Mole, molar mass and molar volume | **Define** that one mole of a substance contains the *same number of particles ($N_A$)* as the *atoms in 12 grams of carbon-12*<br><br>**Explain** the *conversion between number of particles to number* of moles.<br><br>**Calculate** Molar Mass using atomic mass<br><br>**Use** the formula: m = n x M or mass (g)= number of moles x molar mass (g $mol^{-1}$)<br><br>**Explain** that one mole of gas has always the same volume at temperature and pressure given<br><br>**Use** the formula: $V = n \times V_M$ | Avogadro constant is equal to: $N_A = 6.02 \times 10^{23}$ particle per mole<br><br>Estimation of the number of rice grains using a balance<br><br>Measure the molar volume of a gas |
| | Concentration of a solution and dilution | **Define** that the concentration is equal to the amount of moles in a given *volume.*<br><br>**Prepare** a solution with a given concentration starting from a solid<br><br>**Use** one dilution formula e.g.:<br>$c_1V_1 = c_2V_2$<br><br>**Prepare** a solution with a given concentration starting from a standard solution | Use computer simulations such as PhET "Concentration" and "Molarity"<br><br>Make and use a calibration curve (spectroscopy or conductivity) |
| | Prediction of reactions results | **Explain** the difference between stoichiometric proportion for a reaction and cases with a reactant in excess<br><br>**Calculate** number of moles produced and of reactant in excess for a given reaction | Show by experimental approach that increasing the amount of only one reactant doesn't change the final amount of product. Also use computer simulation PhET "Reactants, products and leftovers"<br><br>Compare the theoretical mass and the experimental value obtained in the synthesis of $Cu(OH)_2(s)$ or $BaSO_4(s)$<br>Same for a gas: e.g. acid with magnesium metal |

## Topic 5.3: Food and Chemistry

| Subtopic<br>S5.3 | Content | Learning Objectives | Key contexts, phenomena and activities |
|---|---|---|---|
| Alcohols | Alcohols as a class of organic substances, analogous to alkanes with an additional functional group: the hydroxyl group | **Define** that the functional group is an atom or group of atoms responsible for the characteristics of a particular compound<br><br>**Recognise** the hydroxyl functional group (-OH)<br><br>**Define** and **name** alcohols up to C6, according to the IUPAC nomenclature<br><br>**Carry out** the oxidation of ethanol to ethanoic acid<br><br>**Explain** that all alcohols are oxidized into carboxylic acids (limited to primary alcohols) | Oxidation of ethanol with acidic permanganate solution<br><br>Oxidation of propan-1-ol or butan-1-ol<br><br>Obtain information on the different health risks posed by ethanol |
| Carboxylic acids | Formation<br>Functional group<br>Nomenclature | **Recognise** the functional group of a carboxylic acid<br><br>**Define** and **name** carboxylic acids up to C6, according to the IUPAC nomenclature | Illustrate acidic behaviour of carboxylic acids through conductivity, pH measurements, use of indicators |
| | Esterification | **Identify** the ester functional group,<br><br>W**rite** the equation of the esterification reaction | Synthesise banana flavour by esterification |
| Carbohydrates | Glucose | **Recognise** the alcoholic functional groups in a molecule of glucose (only linear structure) | |
| | Fermentation | **Write** the balanced equation:<br>$C_6H_{12}O_6(aq) \rightarrow 2\ C_2H_5OH(aq) + 2CO_2(g)$ | |

| Subtopic<br>S5.3 | Content | Learning Objectives | Key contexts, phenomena and activities |
|---|---|---|---|
| Triglycerides | Fats and oils | **Recognise** the ester functional groups in a triglyceride.<br><br>**Distinguish** between fats and oils.<br><br>**Distinguish** between saturated and unsaturated triglycerides (fats) and between cis- and trans- unsaturated fats<br><br>**Name** the health benefits of cis- unsaturated fats and the health risks related to trans- and saturated fats | Research activities on the presence of cis-, trans- and saturated fats in food |

## Topic 5.4: Acids and alkalis (bases)

| **Subtopic S5.4** | **Content** | **Learning Objectives** | **Key contexts, phenomena and activities** |
|---|---|---|---|
| Acids and Bases in water | Definition | **Define** an acid and a base using the Brønsted-Lowry theory. (limited to strong acids and bases)<br><br>**Name** and **write** the formula of some common acids and bases | |
| | Dissociation in water | **Write** the dissociation reactions in water which supplies hydrogen ions ($H^+$). In aqueous solution this is written as:<br><br>$HA + H_2O \rightarrow H_3O^+ + A^-$<br><br>$B + H_2O \rightarrow BH^+ + HO^-$ | PhET simulations "Acid-Base solutions" |
| | Acidity of a solution | **Explain** the pH-scale as a measure of the concentration of $H_3O^+$ ions in aqueous solutions.<br><br>**Link** pH with the acidic, neutral or basic properties of aqueous solutions<br><br>**Use** acid/base indicators, universal indicator (liquid or paper) and pH meter to **determine** the pH of aqueous solutions<br><br>**Explain** the impact of dilution on the pH-values. | Knowledge of the equation pH = -log [$H_3O^+$] is not required (is left for S6/7). The range 0-14 provides sensible (but not absolute) "bookends" for the scale.<br><br>Experimental approach: Measure the pH of beverages and/or other household solutions<br><br>Show experimentally that a tenfold dilution results in pH change of 1 unit.<br><br>Experimental approach: pH of water with and without $CO_2$ using a soda stream |
| | Environmental problem of $CO_2$ | **Explain** the acidic properties of $CO_2$ using this equation:<br>$CO_2 + H_2O \rightarrow H_2CO_3$ | Environmental consequences of acid rain, ocean acidification |
| Acid/Base reactions | Neutralisation | **Write** the <u>equation</u> of the reaction between a strong monoprototic acid and a strong monoprotic base | |

| Subtopic<br>S5.4 | Content | Learning Objectives | Key contexts, phenomena and activities |
|---|---|---|---|
| | Titration | **Define** conditions for a titration reaction: no secondary reaction, fast, complete<br><br>**Carry out** a titration of a strong monoprotic acid with a strong monoprotic base using an acid-base indicator.<br><br>**Draw** a labelled diagram of the apparatus needed to perform a titration. | Experimental approach: Titration of a household item (descaler, drain cleaner…) |

## 5. Assessment

For each level there are attainment descriptors written by the competencies, which give an idea of the level that students have to reach. They also give an idea of the kind of assessments that can be done.

With the competencies are verbs that give an idea of what kind of assessment can be used to assess that goal. In the table with learning objectives these verbs are used and put bold, so there is a direct link between the competencies and the learning objectives.

Pupils should be assessed in a broad variety of ways throughout the year, to give a wide-ranging picture of each pupil's attainments, strengths, and areas for further work.

Formative assessment should include the following:

- Lab reports
- Presentations
- Tests of subject content
- Tests of practical skills
- Auto- and peer evaluation

Assessing content knowledge can be done by written questions where the student has to respond on. Partly that can be done by multiple choice but competencies as constructing explanations and engaging in argument as well as key competencies as communication and mathematical competence need open questions or other ways of assessing.

An assignment where students have to use their factual knowledge to make an article or poster about a (broader) subject can be used to also judge the ability to critically analyse data and use concepts in unfamiliar situations and communicate logically and concisely about the subject.

Students have to be able to do an (experimental) inquiry. An (open) inquiry should be part of the assessments. Assessing designing and inquiry can be combined with other subjects.

Digital competence can be assessed by working with spreadsheets, gathering information from internet, measuring data with measuring programs and hardware, modelling theory on the computer and comparing the outcomes of a model with measured data. Do combine this with other assessments where this competence is needed.

In The European Schools system it is important to harmonise teaching and learning between language sections. It is recommended to harmonise planning and assessment. The summative assessment, the S5 chemistry exam, must always be completely harmonised between the language sections.

For all assessment the marking scale the European Schools shall be applied, grades in S1 S3, whole and half marks in S4 and S5.

## 5.1. Attainment descriptors – Chemistry

| | **A** (9.0-10 – Excellent) | **B** (8.0-8.9 – Very good) | **C** (7.0-7.9 – Good) | **D** (6.0-6.9 – Satisfactory) | **E** (5.0-5.9 – Sufficient) | **F** (3.0-4.9 – Failed/Weak) | **FX** (0-2.9 – Failed/Very weak) |
|---|---|---|---|---|---|---|---|
| **Knowledge** | Displays comprehensive knowledge of facts | Displays a very broad knowledge of facts . | Displays a broad knowledge of facts | Displays a reasonable knowledge of facts and definitions. | Recalls main names, facts and definitions. | Displays little recall of factual information | Displays very little recall of factual information. |
| **Comprehension** | and a thorough command and use of concepts and principles in science. | and a good command and use of concepts and principles in science. | and good understanding of main concepts and principles in science. | and understanding of basic concepts and principles in science. | Understands only basic concepts and principles in science | and a limited understanding of concepts and principles in science. | Shows very little understanding of scientific principles and concepts. |
| **Application** | Makes connections between different parts of the syllabus and applies concepts to a wide variety of unfamiliar situations and makes appropriate predictions. | Makes some connections between different parts of the syllabus and applies concepts and principles to unfamiliar situations. | Is capable of using knowledge in an unfamiliar situation. | Is capable of using knowledge in a familiar situation. | and can use basic knowledge in a familiar situation. | / | / |
| **Analysis** | Is capable of detailed and critical analysis and explanations of complex data. | Analyses and explains complex data well. | Produces good analysis and explanations of simple data. | Produces basic analysis and explanations of simple data. | Given a structure can analyse and explain simple data. | Can use data only with significant guidance. | Fails to use data adequately. |

| | **A** (9.0-10 – Excellent) | **B** (8.0-8.9 – Very good) | **C** (7.0-7.9 – Good) | **D** (6.0-6.9 – Satisfactory) | **E** (5.0-5.9 – Sufficient) | **F** (3.0-4.9 – Failed/Weak) | **FX** (0-2.9 – Failed/Very weak) |
|---|---|---|---|---|---|---|---|
| **Experimental work** | Formulates hypotheses, plans and carries out investigations using a wide range of techniques while being aware of ethical issues. | Plans and carries out experiments using appropriate techniques, being aware of safety issues. | Follows a written procedure safely and makes and records observations, presenting them using different techniques. | Follows a written procedure safely and records observations. | Follows a written procedure safely and makes basic observations. | Has difficulty following instructions without supervision. | Is not able to safely follow a written procedure. |
| **Digital and Information Competences*** | Can consistently independently find and assess the reliability of, information on scientific subjects, on- and offline.<br><br>Can independently use appropriate software for science tasks. | Can usually independently find and assess the reliability of, information on scientific subjects, on- and offline.<br><br>Can use appropriate software for science tasks with some assistance. | Can often independently find and assess the reliability of, information on scientific subjects, on- and offline.<br><br>Can use appropriate software for science tasks with assistance. | With aid, can find and assess the reliability of, information on scientific subjects, on- and offline.<br><br>Can use appropriate software for science tasks given structured assistance. | Can retrieve information on scientific subjects when directed to reliable sources, on- and offline.<br><br>Can follow structured instructions to use appropriate software for science tasks. | Generally unable to find, or to assess the reliability of, information on scientific subjects, on- and offline.<br><br>Has great difficulties using appropriate software for science tasks even with assistance. | Unable to find, or to assess the reliability of, information on scientific subjects, on- or offline.<br><br>Unable to use appropriate software for science tasks even with assistance. |

* This competence is part of the European Digital Competence Framework (https://ec.europa.eu/jrc/en/digcomp)

| | **A** (9.0-10 – Excellent) | **B** (8.0-8.9 – Very good) | **C** (7.0-7.9 – Good) | **D** (6.0-6.9 – Satisfactory) | **E** (5.0-5.9 – Sufficient) | **F** (3.0-4.9 – Failed/Weak) | **FX** (0-2.9 – Failed/Very weak) |
|---|---|---|---|---|---|---|---|
| **Communication (oral and written)** | Communicates logically and concisely using scientific vocabulary correctly. Demonstrates excellent presentation skills. | Communicates clearly using scientific vocabulary correctly. Demonstrates very good presentation skills. | Communicates clearly most of the time using scientific vocabulary correctly. Demonstrates good presentation skills. | Uses basic scientific vocabulary, and descriptions show some structure. Demonstrates satisfactory presentation skills. | Uses basic scientific vocabulary, but descriptions may lack structure or clarity. Demonstrates satisfactory presentation skills. | Generally produces descriptions that are insufficient or incomplete with a poor use of scientific vocabulary. Lacks acceptable presentation skills. | Has very poor communication and presentation skills. |
| **Teamwork** | Shows initiative – a team leader. | Works constructively in a team. | Works well in a team. | Works satisfactorily in a team. | and participates in team work | Needs assistance when working in a team. | Does not work in a team. |