

TOLC-B syllabus

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Basic Mathematics

The Basic Mathematics module is intended to test the student’s basic preparation, which is required for all degree courses in the science area, even those that make relatively less use of mathematics. The same module can be found in both the TOLC-S and TOLC-B tests, as it provides important information for all the above-mentioned degree courses. However, it is worth remembering that the mathematical knowledge and skills that are tested in this module are only a part of those that it is good to have at the entrance to degree courses such as those in Mathematics or Physics. It is therefore suggested that those interested in such courses read the Reference Framework for Mathematics, which can be found on the Orientazione project website and which provides a more complete indication of the preparation that may be useful.

In order to answer the questions in this module, it is necessary to understand the text of the questions and answers and to reason about the information provided, using mathematical knowledge that is included in the first three or four years of the curricula of all secondary schools. The specific knowledge required is grouped in six nuclei. The general skills of understanding, representing, reasoning, modelling and problem-solving are described in three further cross nuclei. The questions are constructed in such a way that a calculator is not required, and its use is not permitted during the test. It should be noted that in a single question, there may be concepts that are indicated in the syllabus in several nuclei. The terms and symbols that are used vary from those most frequently used in school and in early university lessons.

For each core, there is a description of skills and abilities to work with the concepts that are useful for answering the questions, linking them appropriately. In the Reference Framework for Mathematics developed by the Orientazione Project, there is a more detailed description of the topics and skills indicated in the syllabus, set in a broader framework and accompanied by several examples of questions and exercises that may be useful for students to assess and possibly improve their preparation. The Reference Framework of Logic, Reasoning and Problems may also be

useful for these purposes.

Numbers

In order to answer the questions involving the topics of this nucleus, it is necessary to work with numbers, with confidence and flexibility, using different representations of the numbers themselves and choosing those that are most useful depending on the situation and goals. The use of a calculator is not permitted during the test, as it is never necessary to answer the questions; instead, it is useful to be able to do simple calculations by mind, possibly helping the working memory with paper and pencil to perform elementary algorithms and to note down partial results. Among various equivalent procedures for performing calculations, it is important to choose the most efficient and simplest ones; to this end, the meaning and properties of operations and ordering must be known and coordinated. The ability to make estimates, besides being useful in itself, allows one to quickly assess the plausibility of the result of calculations and thus provides a useful control tool.

- Addition and multiplication operations between integers, fractions, decimal numbers. Sorting. Properties of operations and ordering. Subtraction and division. Concept of rational number. Representations of numbers on a line. Real numbers
- Integer division with remainder. Divisors and multiples of an integer; greatest common divisor (GCD) and least common multiple (LCM) of two or more positive integers
- Power with integer exponent of a number and properties of powers. Positive integer root of a positive number. Power with rational exponent of a positive number
- Estimates and approximations. Percentages. Calculation and transformation of simple expressions.

Algebra

In order to answer the questions involving the topics of this core, it is necessary to work with literal expressions and transform them appropriately according to the goals. Given equations must also be transformed in such a way as to obtain equivalent equations that can be solved more easily or from which the relevant information on solutions can be obtained. The same consideration applies to inequalities and systems. Knowledge of simple procedures and algorithms is important, but it is very important to recognise some simple structures that expressions can have, to see their properties and consequently to choose an effective operations strategy. A student is also expected to be able to use algebra as a tool to represent and pro-

cess ideas or information, and thus to model and tackle problems in different contexts. In particular, in order to answer certain types of questions, it is necessary to translate the problem and the information provided by the text into an equation (or inequality or system); it is then necessary to transform and possibly solve the equation; finally, it is necessary to interpret in terms of the initial problem the meaning of the algebraic operations that have been performed.

- Literal expressions: manipulation and evaluation
- Concept of solution and 'set of solutions' of an equation, an inequality, a system of equations and/or inequalities. First and second degree equations and inequalities. Linear systems.

Geometry

In order to answer the questions involving the topics of this core, it is necessary to understand and use descriptions and representations of elementary geometric figures and their simple combinations, and to apply on them appropriate reasoned transformations, decompositions and recompositions. To analyse the properties of a certain geometric configuration, it is often useful to use different representations and both synthetic and analytical point of view, and to put together the information that can be obtained from the different approaches. Skills that are very useful in guiding representation and reasoning are the mental visualisation of geometric objects and the ability to imagine, when looking at a figure, even features that are not explicitly drawn but that complete it and allow one to understand its meaning.

- Most common plane and space figures (segments, straight lines, planes, angles, triangles, quadrilaterals, circumferences, parallelepipeds, prisms, pyramids, cylinders, cones, spheres), with their characterising properties and graphic representations
- Pythagorean Theorem
- Properties of similar triangles
- Elementary language of geometric transformations (symmetries, rotations, translations, similarities)
- Sine, cosine and tangent of an angle, obtained from the relationship between the sides of a right-angled triangle
- Perimeter and area of the most common plane figures. Volume of elementary solids. Calculation of area and volume by sum and difference of figures

- Cartesian coordinates in the plane and description of simple subsets of the plane using coordinates. Slope of a segment and equation of a straight line. Equations of straight lines that are parallel or perpendicular to a given line. Intersection of straight lines and representation of the solutions of a system of first degree equations
- Distance between two points and equation of a circumference given its centre and radius.

Functions and graphs

In order to answer the questions involving the topics of this core, it is necessary to relate the information obtained from different representations of the same function; for example, thanks to the information that can be read on the graph of a function f , to determine the solutions of an inequality of the type $f(x) > 0$ or to establish that the value $f(x)$ cannot be expressed by a formula of a given type. It is necessary to be aware of how the behaviour varies and how the graph of functions of a certain family changes as the parameters that define them vary. To answer the questions and to connect the properties of the different families of elementary functions, it is very useful to quickly visualise the graph of the functions $x \mapsto af(x)$, $x \mapsto f(x - a)$, $x \mapsto f(x) + g(x)$ from the graph of the functions $x \mapsto f(x)$ and $x \mapsto g(x)$. Finally, it is important to use the language of functions to express relationships between quantities describing a natural phenomenon and their variations, in different contexts.

- Language and notations for functions. Graph of a function. Composition of functions. Existence and uniqueness of solutions of equations of the type $f(x) = a$, invertible functions and inverse function
- relative maxima and minima, monotonic intervals of a function
- Characteristic properties, graph and behaviour of the following families of functions of a real variable: power functions and root functions; polynomial functions of first and second degree; functions of the type $x \mapsto 1/(ax + b)$ with a and b assigned constants; absolute value function; exponential functions and logarithmic functions in different bases; sine function and cosine function
- definition of logarithm and elementary algebraic properties of the exponential and logarithm functions based on the properties of power elevation
- Equations and inequalities expressed by functions, for example $f(x) = g(x)$, $f(x) > a$.

Combinatorics and probability

In order to count the elements of a set, it is necessary to represent them in some suitable way and to have suitable systematic listing and counting strategies.

The calculation of the probability of an event is only required in the case of random phenomena for which the possible events are finite in number. In such a situation, it is necessary to find an appropriate representation of the set of events and, in this representation, an appropriate description and decomposition of the event of interest in terms of simpler events whose probability is known.

- Representation and counting of finite sets
- Disjoint events. Independent events. Probability of the union event of disjoint events. Probability of the intersection event of independent events
- Description of events in simple paradigmatic situations: tossing a coin, rolling a die, drawing from an urn. Tree diagrams
- Conditional probability.

Means and variability

In order to answer the questions involving the topics of this core, it is necessary that in simple situations a student is able to read, interpret and relate different representations of a set of data, which refer to characteristics of a given population, identifying some essential features.

- Qualitative and quantitative variables (discrete and continuous). Absolute and relative frequency
- Representations of distributions (tables, bar graphs, pie charts, histograms, ...). Mean and median.

Understanding and representing

- Understand texts that use, also contextually, languages and representations of different types
- Depending on the situation and goal, use different representations of the same mathematical object
- Understand and use elementary notations of set language and terms such as: element, belongs, subset, union, intersection.

Reasoning

- In a certain situation and given certain premises, determine whether a statement is true or false
- Denying a given statement
- Understand and know how to use terms and phrases such as: for each, all, none, some, at least one, if... then..., necessary condition, sufficient condition, necessary and sufficient condition.

Modelling, problem solving

- Formulate a situation or problem in mathematical terms
- Solve a problem by adopting simple strategies, combining different knowledge and skills, making logical deductions and simple calculations.

Biology

The Biology section of TOLC-B is intended to test the student's basic preparation required for admission to degree courses in Life Sciences. It consists of 10 thematic cores that cover all the main aspects of biology. To answer the questions, candidates must know the meaning of the terms identifying living systems and their functional processes. In addition, the questions test the students' ability to use basic knowledge of the main life processes of cells and organisms. In some questions, it is also necessary to be able to interpret simple diagrams, drawings or images to identify the structures illustrated, or to understand the life processes and interactions schematised. The level of detail required is based on secondary school texts. The analysis of non-textual parts (pictures, drawings, diagrams) is of great importance to acquire a mental image of structures and processes.

Each thematic core of this syllabus is provided with a short foreword explaining the knowledge and skills required to solve the questions. The same topics are covered in greater depth and with more examples in the Biology Quadro di Riferimento per la Biologia on Progetto Orientazione.

Biological Molecules

This section deals with the chemical composition of living matter and includes preliminary knowledge indispensable for the study of cell organisation at university level. The questions test students' knowledge of the biological importance of water and the main classes of compounds that make up living matter. Candidates are expected to be able to link the characteristics of biological molecules with their functions and localisation in the cellular environment.

- Water and its characteristics, hydrophilic and hydrophobic substances
- Carbohydrates (carbohydrates or sugars): monosaccharides or simple sugars (glucose, fructose, ribose and deoxyribose), disaccharides (sucrose, lactose), polysaccharides (glycogen, starch, cellulose)
- Lipids (fats): fatty acids, triglycerides, phospholipids and cholesterol
- Proteins: amino acids, polypeptide chains, primary, secondary, tertiary and quaternary structure
- Nucleic acids: nucleotides, DNA, RNA.

Cell organisation

This thematic core covers the fundamental aspects of cell organisation, the basis of all life processes in organisms. In order to answer the questions, candidates must know the differences between the main types of cell organisation and be able to associate the structure of organelles and cellular constituents with their functions. Candidates must be able to recognise cells and their main parts in schematic drawings and pictures.

- Differences between prokaryotic and eukaryotic cells
- General characteristics and functions of the main components of the eukaryotic cell: plasma membrane, nucleus, ribosomes, endomembrane system (endoplasmic reticulum, Golgi apparatus, lysosomes), mitochondria, cytoskeleton
- Differences between animal and plant eukaryotic cells (cell wall, chloroplasts and other plastids, vacuoles)
- Evolution of the eukaryotic cell: endosymbiotic theory on the origin of mitochondria and chloroplasts.

Fundamentals of genetics

The thematic core concerns the structure of genetic material in prokaryotes and eukaryotes, and how inherited traits are transmitted and expressed. To answer the questions, candidates must know the differences between DNA and RNA, and be able to recognise them even in simplified representations; be able to apply Mendel's laws; know the main processes that regulate the flow of information in cells; be able to use the terminology that identifies them appropriately and consistently. It is also necessary to have understood the correspondence between nucleotide language and amino acid language defined by the genetic code.

- Mendelian genetics
- Structure of chromosomes in prokaryotes and eukaryotes; definition of genome
- Encoding of genetic information in DNA and RNA molecules
- Genes and the genetic code
- General characteristics of the processes of replication (duplication), transcription, translation.

Mitosis and Meiosis. Hints on gametogenesis, fertilisation and development

This section covers the mechanisms of cell division that ensure the fair distribution of genetic material between daughter cells, and underlie the processes that regulate the growth, reproduction and embryonic development of multicellular organisms. Candidates must be able to distinguish the processes of cell division in prokaryotes and eukaryotes, to identify the phases of mitotic and meiotic divisions and to recognise the main events that occur in the different phases also by interpreting drawings and images.

- Cell division in prokaryotes and eukaryotes. Mitosis and meiosis. Cytokinesis
- Cell cycle
- Gametogenesis and fertilisation
- Early stages of fertilised egg development (segmentation and gastrulation).

Elements of animal and human anatomy and physiology

The topics included in this thematic core concern the hierarchical levels of multi-cellular organisation, the structural and functional characteristics of the main animal tissues and the main systems and apparatuses of man. Candidates must be able to correctly associate structure and function with the different levels of organisation.

- Hierarchy of multicellular organisation
- Structure and functions of the four main tissues: epithelial, connective, muscular and nervous
- Structure and functions of the main human systems and apparatuses: integumentary, muscular, skeletal, digestive, respiratory, circulatory, excretory, reproductive, nervous.

Elements of plant biology

This thematic core test the knowledge about the structure and life processes of plants, which is also essential for understanding the functioning of ecosystems. The questions require the knowledge of the structure and function of the main plant parts and the general characteristics of the main life processes.

- Root, stem, leaf, flower, fruit, seed
- Chlorophyll photosynthesis
- Water and nutrient uptake; transpiration.

Biodiversity, classification, evolution

The thematic core concerns the principles underlying the systematics and classification of living, the meaning of biodiversity and the mechanisms of evolution. Questions require to recognise the general characteristics of organisms belonging to the three domains into which living are grouped and the fundamental mechanisms of biological evolution.

- Principles of classification and phylogeny
- Biological nomenclature (e.g. *Homo sapiens*, *Quercus robur*)

- Distinctive features of Bacteria, Archaea, Eukarya (unicellular and multi-cellular). Notes on viruses
- Mechanisms of evolution: genetic variability, natural selection, adaptation, speciation, extinction.

Elements of bioenergetics

The section includes elementary knowledge on the main processes of cell metabolism. The questions test the candidate's ability to recognise the processes of energy conversion, storage, utilization, and exchange. Some questions consist of solving simple problems on the efficiency of metabolic processes or the effect of enzymes in metabolic reactions.

- Energy flows and biological significance of photosynthesis, respiration, glycolysis, fermentation
- Catabolism and anabolism
- Autotrophic and heterotrophic metabolism
- Enzymatic catalysis
- Energy content of major foods.

Elements of ecology

This thematic core covers the main interactions between organisms and between organisms and the environment, considered at different levels of biological organisation. Candidate is expected to know the role of autotrophs and heterotrophs in the functioning of ecosystems, to be able to interpret a food chain and energy transfers between trophic levels, and to recognise the differences between the main biotic interactions.

- Individuals, populations, communities and ecosystems
- Primary and secondary production
- Trophic chains (autotrophs/producers and heterotrophs/consumers)
- Biotic interactions (differences between competition, predation, parasitism, mutualism and commensalism).

Elements of Biotechnology

The topics included in this thematic core cover the theoretical foundations of methodologies using living organisms for the production of goods and services. Candidates must be able to recognise the basic steps of the main methods used in biotechnology. To answer the questions, candidates must be able to recognise the steps required to cultivate microbial cells, animal and plant cells and tissues in vitro, recognise the steps required to produce genetically modified organisms, and be able to interpret the results of simple experiments involving the manipulation of genetic material.

- Genetic engineering: techniques based on DNA manipulation, GMOs
- Animal, plant and microbial biotechnology: use of organisms on the basis of phenotype (artificial selection) or metabolic characteristics (fermentation)
- Biotechnology applications in agriculture, the environment and biomedicine.

Physics

The Physics section syllabus is deliberately limited to the fundamental knowledge expected at the end of almost all secondary school curricula and no further in-depth study is required. It is appropriate to emphasise the fundamental nature of certain mathematical skills related to the modelling of natural phenomena, in particular: i) the use of graphic representations and functional models related at least to direct and inverse proportionality, linear dependence, increasing and decreasing quadratic proportionality, sinusoidal, exponential and logarithmic dependencies; ii) the recognition of proportionality relations between quantities used in laws, both in algebraic and graphic exercises. It is also essential to know how to use: the International System units of measurement (SI), including prefixes, and the practical units most frequently used in science, scientific notation, the concept of order of magnitude, vector calculus limited to composition and decomposition of vectors and the scalar and vector product.

In order to answer the questions in this module, it is necessary to understand the text of questions and answers and be able to think about the information provided, linking it through the appropriate laws. The specific knowledge required is collected in eight thematic nuclei. The questions are constructed in such a way that a calculator is not required, nor permitted during the test. It should be noted that a single question may involve multiple concepts indicated in the syllabus in several different thematic nuclei.

Each nucleus describes the skills and abilities needed to work with physical concepts and quantities, which, if linked appropriately, are useful for answering the questions. In the "Quadro di Riferimento" (Reference Framework) for Physics, which can be found on the ORIENTAZIONE project website, a more detailed description of the topics and skills indicated in the syllabus can be found, set in a broader framework and accompanied by several examples of questions and exercises that can be useful for assessing and possibly improving one's preparation.

Physical quantities and measurement

Physical quantities are fundamental for modelling physical phenomena and for making quantitative comparisons between models and physical reality. To successfully address the questions relating to this nucleus, it is necessary to be able to: work with the values of physical quantities using the SI units of measurement appropriately; use scientific notation, also to make estimates of orders of magnitude; recognise and estimate uncertainties, characterise them mathematically, link their definition to experimental aspects of measurement representation. It is also important to be able to recognise the graphical representations of the main functional models commonly used to express relationships between physical quantities.

- Main physical quantities (distinguished between fundamental and derived) and their units of measurement in the SI
- Prefixes used for multiples and submultiples, and their written form as powers of 10 in scientific notation
- Conversion from units of measurement used in everyday life to SI units, and vice versa
- Distinction between measurement, estimation and order of magnitude
- Concept of measurement uncertainty, and distinction between systematic and random errors
- Approximation of the numerical value of a quantity and truncation according to the significant digit
- Graphical representations and basic functional models: direct and inverse proportionality, linear dependence, quadratic and reciprocal of square dependence, sinusoidal periodic dependence, exponential and logarithmic dependencies.

Point particle Kinematics and Dynamics

The point particle is a useful abstraction that, in many concrete cases and under appropriate conditions, makes it possible to describe (through kinematics), explain and predict (through dynamics) the main aspects of the motion of real objects in a simple manner. To successfully tackle the questions related to this nucleus, one must be familiar with the main concepts useful to describe motion (position, displacement, trajectory, velocity, acceleration) and with those inherent to the variation of a body's state of motion (force and mass). One must also be familiar with the concepts of work and energy, which are closely linked to that of force. One must also be able to apply this knowledge in order to: calculate the velocity and acceleration of a body from information on position and time; determine or estimate the kinematic parameters of the most common types of motion, based on their graphical representations; apply the relationship between force and acceleration to determine one, given the other, and vice versa, using the units of measurement appropriately; be able to use the principle of conservation of mechanical energy to solve simple problems relating to the motion of a body.

- Description of motion: position, trajectory, displacement, time instant and time interval. Velocity and acceleration of a body with their corresponding units of measurement
- Uniform linear motion and uniformly accelerated linear motion, described using graphs of position, velocity and acceleration as a function of time
- Free-falling motion of a body
- Uniform circular motion (period, frequency, linear and angular velocity, centripetal acceleration and algebraic links between them)
- Inertia principle
- Concept of Force and Second Law of Dynamics (Static and dynamic friction force, normal forces, elastic force, gravitational force, tension of an ideal string)
- Concept of work of a force, power, kinetic energy, and work-energy principle
- Potential energy (gravitational and elastic) and the mechanical energy conservation principle.

Fluid mechanics

The mechanical properties of fluids (both the static ones and those related to their motion and the motion of objects within them) are of crucial importance for living systems, from the microscopic scale up to that of ecosystems. To successfully address the questions related to this nucleus, it is necessary to be familiar with the knowledge listed below and to be able to apply it to simple phenomena that can be observed in everyday life, such as: communicating vessels, buoyancy, flow in pipelines. Special familiarity is required with the concepts of density and pressure and the appropriate use of their units, including those in practical use that are not part of the SI.

- Quantities for describing fluids at rest: density, pressure
- Laws governing hydrostatic and related phenomena: Pascal's Law, Stevin's Law, Archimedes' principle
- Quantities, concepts, and laws for fluids dynamics: flow (laminar, turbulent), flow of a pipeline, Continuity law for incompressible fluids.

Thermodynamics

Thermodynamics is relevant to the understanding of many natural phenomena and situations; both in its aspect of studying the transformations of energy between different forms (first principle) and the limitations of these transformations (second principle). The ideal gas the most useful simple physical system for becoming familiar with thermodynamic concepts and laws. Therefore, in order to successfully address the questions related to this nucleus, one must be able to: quantitatively describe the state of the ideal gas and its transformations through the correct use of state variables (P , V , T); apply the algebraic formulation of the first principle of thermodynamics to determine energy exchanges during simple transformations of the ideal gas; predict the direction of a spontaneous transformation on the basis of the second principle of thermodynamics. For this nucleus too, particular importance is attributed to the correct use of the measurement units of the quantities involved, also with reference to commonly used units not included in the SI (e.g. litre, atmosphere, calorie).

- Concept of an ideal gas and quantities used to define its state: pressure, volume, temperature
- Kelvin and Celsius thermometric scales
- Ideal gas Law (equation of state)

- Heat as a form of energy exchange. Thermodynamic definition of work. First principle of thermodynamics
- Qualitative aspects of the second principle of thermodynamics, with reference to the limitations of conversion between mechanical and thermal energy.

Electrostatics and electric currents

This nucleus concerns the concept of electric point charge, the interactions between charges at rest, their collective motion; as well as how different materials behave towards electric charge. To successfully tackle questions related to this nucleus, one must: be able to determine, in simple situations, the forces acting on point-like electric charges; know the concept of electric field as a property of space that accounts for the interaction at a distance between charges; know the concept of electrostatic potential difference between two points in space and apply it to the solution of simple problems involving charge motion (note that this aspect is closely linked to the last point of nucleus 2 "Point particle Kinematics and Dynamics" which is a prerequisite to this one); know and apply Ohm's law in order to determine the current intensity in a conductor, given the potential difference at its ends, and vice versa; be able to recognise the dissipative effects of the flow of electric current in a conductor.

- Phenomena of electrification and electric charge
- Phenomenology of electrostatic interactions between point charges and Coulomb's Law
- Concept of electric field and simple examples: electric field of one or many point charges and uniform electric field
- Electrostatic potential energy, electrostatic potential and potential difference (Voltage)
- Electrical behaviour of materials: insulators and conductors
- Electric current as charges in motion; electric current intensity
- Electrical resistance and Ohm's first law
- Joule effect.

Oscillations and waves

Wave phenomena are omnipresent in nature; therefore, a basic knowledge of them is indispensable for approaching the empirical sciences. Waves are characterised by a dual periodicity: both spatial and temporal. Therefore, their understanding implies the knowledge of periodic phenomena, such as harmonic oscillatory motion. To successfully address the questions related to this nucleus, one must: be able to describe and recognise periodic oscillatory motion using verbal, algebraic and graphic language; know and be able to use the algebraic relationships between the characteristic parameters of periodic oscillatory motion; be able to recognise wavelength and period of a wave as expressions of its dual periodicity in space and time; know and be able to use the algebraic relationship between wavelength, frequency and propagation velocity of a wave.

- Periodic motions and their description: period and frequency
- Simple harmonic motion: period, frequency, pulsation, amplitude, velocity and acceleration as a function of time; kinetic and potential energy
- Waves as periodic phenomena in both space and time
- Characteristic quantities of waves and algebraic relationships between them: amplitude, frequency, wavelength, propagation velocity.

Magnetism

To successfully address the questions relating to this nucleus, it is necessary to: know and be able to describe the behaviour of a permanent magnet, both in the presence of another permanent magnet and in the presence of ferromagnetic and non-ferromagnetic materials; be familiar with the graphical representation of the effect of a magnet on the surrounding space in terms of field lines; have a qualitative knowledge of the magnetic effects of electric currents flowing in wires; recognise the action of a magnetic field on a moving charge and be able to qualitatively describe this motion in simple situations.

- Phenomenology of interactions between permanent magnets; similarities and differences with electrostatic interactions; intrinsically dipolar nature of magnets
- Magnetic properties of materials: ferromagnetic and non-ferromagnetic
- Magnetic field concept and graphical description of the magnetic field of a bar magnet

- Magnetic effects of electric currents and graphical description of the magnetic field generated by constant intensity current flowings in simple cases: very long wire and solenoid, traversed by an electric current of constant intensity
- Lorentz force: qualitative description of the motion of point charges in uniform magnetic fields and the role of the quantities involved.

Modern Physics

The modern physical model of the atomic and subatomic world is the result of several decades of conceptual evolution, straddling the 19th and 20th centuries. The discovery and interpretation of radioactivity, and the progressive recognition of the corpuscular nature of light, were closely intertwined with this evolution. To successfully address the questions related to this nucleus, it is necessary to: know how to describe the atom, the atomic nucleus and their constituents; know how to describe the simplest radioactive decays, interpreting them with reference to the constituents of the atomic nucleus; know the exponential nature over time of radioactive decay and know how to estimate the timescales that characterise it, by analysing graphical representations; know qualitatively the dual wave and corpuscular nature of light, and recognise that in particular situations it behaves as if it were made up of particles called photons; know and be able to use in simple cases the algebraic relationship between the characteristic physical quantities of the photon.

- Atomic model, energy levels and transitions
- Constitution of the atomic nucleus and main radioactive decays
- Analytical and graphic description of exponential radioactive decay
- Dual wave and corpuscular nature of light and the concept of the photon: relationship between frequency, wavelength, and energy. Electromagnetic spectrum, Photoelectric effect.

Chemistry

Macroscopic properties of matter

The macroscopic properties of matter are the observable properties of matter itself; understanding their variations allows us to interpret how matter changes. To successfully address the questions in this nucleus it is necessary to know and understand the different states of aggregation of matter and the quantities that describe them, to be able to recognise the physical and chemical transformations between the different states and the fundamental laws that regulate them.

- State of matter and physical changes
- Particle model of matter
- Macroscopic properties of gases, liquids and solids
- Homogeneous and heterogeneous mixtures
- Separation of mixtures
- Chemical transformations
- Fundamental laws in chemistry (Lavoisier, Proust, Gay-Lussac, Avogadro).

Microscopic properties of matter and composition of substances

The microscopic properties of matter refer to the particle composition of matter (atoms, protons, neutrons, and electrons). The study of the particle model allows us to understand the properties of materials (metals, ionic substances, solids, and covalent molecular structures), their interactions and their uses. To successfully address the questions in this nucleus it is necessary to know the structure of the atoms and their constituents, to be able to write the electronic configuration and to determine the valence electrons; to be able to identify the type of bond that exists between atoms and to distinguish ionic substances from covalent compounds; to learn about bonding theories and intermolecular forces.

- The structure of the atom
- Simple substances, compounds and ions
- Lewis structures (electron dot structures)
- Atomic mass and relative atomic mass (A_r), relative molecular mass (M_r)
- Types of chemical bond: ionic, covalent and metallic. Polarity of the chemical bond
- Intermolecular forces and hydrogen bonds
- Oxidation number and atomic valence
- Molecular geometry (VSEPR theory) and hybridization.

Chemical reactions and stoichiometry

Chemical reactions allow the transformation of matter to be described in detail; stoichiometry describes the proportions between atoms in molecules and between reactants and products in chemical reactions. To successfully address the questions in this nucleus it is necessary to be able to read, write and balance chemical reactions correctly; to know and be able to work with the units of measurement needed to determine the quantities of substances involved in a process or chemical transformation; to know the formulation of the fundamental laws of chemistry and to be able to apply them.

- Balancing of chemical reactions
- Definition of the concept of mole and the Avogadro constant
- Mass to mole conversions
- Concepts of limiting reagent and theoretical yield
- Relationship between the number of moles (chemical amount) and mass in the reaction patterns
- Units of measurement for concentration (mol dm^{-3} , g dm^{-3} , percentage composition) and their calculations

Periodic trends and atomic structure

Many properties of simple substances and atoms show a periodic trend, and knowing the position of atoms in the periodic table allows us to predict their properties. To successfully address questions in this nucleus it is necessary to know the structure of the periodic table and how to relate the electronic configuration of an element to its position in the periodic table; to be able to describe periodic trends and use them to predict the properties of atoms and their reactivity.

- The periodic table of the elements
- Periods and groups
- Periodic properties
- Atomic models and quantum numbers
- Electronic configuration of atoms: Aufbau principle and the Pauli exclusion principle.

Compounds, properties and nomenclature. Solutions and solution properties

The nomenclature of the compounds allows them to be uniquely identified. To successfully address the questions in this nucleus it is necessary to have acquired the correct terminology and to know how to assign the IUPAC and traditional nomenclature to the compounds and ions; to understand the properties of compounds and how they behave in aqueous solution; to know the properties of solutions and to be able to work with the necessary units of measurement.

- Formulas and nomenclature (IUPAC and traditional) of the main inorganic compounds
- Electrolytes, not electrolytes and solubility
- Properties of solutions (conductivity, colligative properties)
- Chemical properties of metals.

Thermodynamics and kinetics

Thermodynamics and kinetics study the movement of particles and the exchange of energy between atoms and molecules, and they can be linked to chemical balances. To successfully address questions in this nucleus it is necessary to know the relationships between matter and energy and to distinguish between reactions that absorb or release energy (endothermic and exothermic); to know the properties of gases and the relationship between the speed of the molecules and properties such as the concentration, temperature and pressure of the interacting species; to understand the meaning of a state of equilibrium and to know and be able to handle the quantities that describe it; to distinguish between the concepts of spontaneity and the rate of a chemical reaction; to know the concepts of activation energy and the role of catalysis.

- Ideal gas laws
- Partial pressure
- Laws of thermodynamics (internal energy, enthalpy, entropy and Gibbs free energy)
- Exothermic and endothermic reactions
- Dynamic chemical balance (equilibrium constant and reaction quotient)
- Activation energy and role of catalysis, reaction rate and its dependence on temperature and pressure.

Acids and Bases

Acids and bases are chemical compounds that have specific characteristics and give rise to reactions that are fundamental to understanding many biochemical phenomena. To successfully address the questions in this nucleus it is necessary to know how to identify an acidic or basic substance, to know its properties, to know how to write and handle relative equilibria in solution, to know how to calculate the pH value; to know the acid-base theory and the use of indicators.

- Definitions of acids and bases and acid–base reactions
- Strength of acids and bases, pH calculation and pH indicators
- Neutralization reactions and salt formation
- pH of saline solutions (acid and basic hydrolysis) and buffer solutions

Oxidations and reductions

Reduction–oxidation (redox) reactions involve the transfer of electrons and the change in the oxidation state of the species involved, and they play an important role in numerous biological phenomena. To successfully address the questions in this nucleus it is necessary to know how to calculate the oxidation state of an atom within a chemical compound, to recognize a redox reaction and to know how to balance it by identifying the species that gain and lose electrons (oxidants and reducers).

- Redox reactions and interpretive models
- Identification of the oxidant and the reducing agent (scale of redox potentials) in a simple chemical redox transformation or in a reaction pattern
- Balancing simple redox reaction patterns.

Organic chemistry

Organic chemistry studies carbon compounds other than carbon monoxide, carbon dioxide and carbonates. To successfully address the questions in this nucleus it is necessary to know and distinguish the different classes of hydrocarbons and the main organic compounds by identifying the functional group that characterises them and assigning them the correct nomenclature.

- Origin and characteristics of hydrocarbons
- Carbon hybridization
- Structure and nomenclature of the main organic compounds
- Combustion reactions
- Isomerism, relationship between structure and property
- Alkanes, alkenes, alkynes, cycloalkanes
- Benzene and aromatic compounds
- Alcohols, aldehydes, ketones and carboxylic acids.

Applied chemistry

Applied Chemistry allows us to identify, describe and predict the chemical reactions underlying the most important biological, environmental and industrial processes. To successfully address the questions in this nucleus it is necessary to know the main chemical transformations related to everyday life and environmental and sustainability issues; to know how to read and interpret a label and to know the main safety rules for handling chemical products in everyday use.

- Measurements, units of measurement and uncertainties in experimental measures
- Chemical transformations in everyday life
- Correct reading of commercial product labels (beverages, food, chemicals)
- Main environmental issues (acid rain, greenhouse effect, smog...)
- Safety regulations.

English section

Depending on the result obtained in the test, the grid below shows the initial preparation level and how to improve your results, if necessary.

POINTS	RECOMMENDED ENGLISH COURSE
≤ 6	Take a beginner English course (A1)
7 – 16	Take a first level English course (A2)
17 – 23	Take an intermediate English course (B1)
24 – 30	Take the B1 level English exam with no need to take a course