

Scientific Thinking

1. Mathematical Thinking

- Interpret graphs given an example
- Predict changes in variables in simple formulae
- Use formulae by substituting values and calculating the result
- Solve problems with symbols in place of variables, including simultaneous equations
- Put numbers in the correct order, including decimals and negative numbers
- Work with orders of magnitudes and conversions

2. Procedural Thinking

- Follow a procedure/protocol/algorithm correctly (for example by using a flow chart)
- Predict the outcome of a perturbation in an interconnected system
- Apply the concept of collecting elements from different sets
- Compare a set of data with a scientific theory that can be confirmed or disproved by data
- Select relevant data
- Choose the most effective concept map to summarise a text

3. Visual Thinking

- Demonstrate three-dimensional thinking ability
- Find complementary shapes
- Recognise mirror images
- Identify different visual patterns, including based on a description or an example
- Demonstrate careful observations, including localising objects in relation to other objects
- Describe a picture or a set of elements

Academic Literacy

Characteristics of the texts:

- **CEFR level:** C1 and above (text and items)
- **Sources:** adapted from real-world sources, about scientific topics
- **Text length:** approximately 700 words

Abilities tested:

- **Critical Thinking**, e.g. drawing reasoned conclusions and implications from data, statements, principles, judgements, beliefs or opinions.
- **Local expeditious reading**, e.g. scanning and searching for specific details.
- **Global expeditious reading**, e.g. skimming for gist, searching for key ideas.
- **Global careful reading**, e.g. comprehending main ideas, connecting ideas from different paragraphs and understanding how different paragraphs relate to each other.
- **Word- and sentence-level processes**, e.g. word recognition, meaning of a preposition.

Biology

1. The chemistry of living organisms

- The biological importance of weak interactions.
- Organic molecules in organisms and their functions: amino acids, proteins, enzymes, sugars, lipids and nucleic acids.
- Properties of water and significance for life: polarity, hydrogen bonds, cohesion, surface tension, capillarity, specific heat capacity, latent heat of vaporisation.

2. The cell as the basis of life

- Cell theory and cell size; prokaryotic and eukaryotic cells; animal and plant cells.
- General properties and structure of viruses.
- The structure and function of the cell membrane, and transport across the membrane.
- Cellular structures and organelles and their specific functions.
- The cell cycle and cell division: mitosis and meiosis.
- Structure of chromosomes in prokaryotes and eukaryotes, and chromatin in eukaryotes. Karyotypes (autosomes and sex chromosomes).

3. Bioenergetics

- ATP as the energy currency of cells.
- Redox reactions in living organisms.
- Glycolysis, the Krebs cycle, electron transport chain and oxidative phosphorylation.
- Aerobic and anaerobic respiration.
- Alcoholic and lactic fermentation.
- General sources of energy for the cell, including amino acids and lipids.

4. Reproduction and inheritance

- Life cycles, asexual and sexual reproduction, and fertilisation.
- Mendel's laws and their applications.
- Extensions to Mendel's laws: incomplete dominance, codominance, multiple alleles. Inheritance of blood groups (ABO and Rhesus factor).
- Genetic information flow: DNA replication, transcription, the genetic code and protein synthesis.
- Genes and the regulation of gene expression.
- Monogenic and multifactorial inheritance.
- Inheritance patterns in humans: autosomal and sex-linked, dominant and recessive.
- Mutations; natural and artificial selection.
- Evolutionary theories and the genetic basis of evolution.

5. Anatomy and physiology of animals and humans

- Animal tissues: epithelial tissue, connective tissue, muscle tissue and nervous tissue.
- Basic human anatomy and physiology: the circulatory, respiratory, digestive, nervous, skeletal, muscular, endocrine, lymphatic, integumentary, urinary and reproductive systems.
- Homeostasis, for example: regulation of body temperature, blood glucose, osmoregulation, blood pressure, calcium balance, acid–base balance, and oxygen and carbon dioxide levels.

Chemistry

1. Structure of matter and the periodic table

- Atoms, molecules, isotopes, elements and compounds
- Atomic number, mass number, quantum numbers and electronic configuration (Pauli exclusion principle, Hund's rule, Aufbau principle)
- Periodic table: groups, periods, metals/non-metals/metalloids, periodic properties (atomic/ionic radius, ionisation energy, electron affinity)
- States of matter, heterogeneous and homogeneous systems
- Ideal gases, Avogadro's law and Dalton's law

2. Chemical bonding and properties of matter

- Ionic, covalent and metallic bonding
- Electronegativity and polarity of chemical bonds
- Basic molecular geometry: VSEPR theory
- Introduction to hybridisation (sp , sp^2 , sp^3) to understand the geometry of simple molecules
- Intermolecular forces: London dispersion forces, dipole-induced dipole, dipole-dipole, hydrogen bonding
- Ionic, metallic, covalent and molecular solids
- Atomic and molecular mass, Avogadro's number, mole, molar mass

3. Chemical reactions and equilibrium

- Types of chemical reactions: synthesis, decomposition, substitution, combustion, acid-base
- Chemical equations and their balancing
- Basic stoichiometric calculations
- Molar concentration and basic stoichiometry in aqueous solution
- Chemical equilibrium and Le Chatelier's principle
- Osmosis and osmolarity

4. Acids and bases

- Acids and bases according to Arrhenius and Brønsted-Lowry
- Concept and definition of pH
- Neutralisation reactions
- Strength of acids and bases
- Salt hydrolysis
- Buffer solutions and Henderson-Hasselbalch equation

5. Oxidation-reduction reactions and introductory organic chemistry

- Oxidation numbers
- Oxidising agents and reducing agents
- Balancing simple redox reactions
- C-C bonds, structural formulae and the concept of isomerism

Mathematics

1. Arithmetic and algebra

- Sets of numbers: natural numbers, integers, rational numbers, real numbers.
- Operations and their properties; absolute value; proportions and percentages.
- Powers with integer and rational exponents, roots, logarithms (base 10 and base e) and their properties.
- Algebraic expressions, algebraic identities, expansion of powers of binomials, factorisation of polynomials. Algebraic fractions.
- Linear and quadratic equations and inequalities (including rational ones), simple systems of linear equations.
- Concept of function, domain and codomain, sign of a function, monotonicity, maxima and minima.
- Polynomial and rational functions, exponential, logarithmic and trigonometric functions.
- Composition of functions and inverse functions.
- Basic exponential, logarithmic and trigonometric equations and inequalities.
- Graphical representation of functions and recognition of simple symmetries.

2. Analytical geometry and trigonometry

- Distance between two points, midpoint, equation of a line.
- Conditions for parallelism and perpendicularity, distance from a point to a line.
- Equations of the circle and the parabola (brief mention of ellipse and hyperbola without full treatment).
- Measurement of angles in degrees and radians.
- Sine, cosine and tangent functions, and standard values.
- Main trigonometric identities (sum, difference, double angle) and the solution of triangles.

3. Logic and mathematical reasoning

- Basic elements of propositional logic: propositions, logical connectives, truth tables.
- Basic elements of predicate logic: predicates, quantifiers and their laws.
- Evaluation of logical expressions.
- Rules of inference.
- Proof by contradiction.

4. Probability

- Random experiments, events, frequencies and probability.
- Independent events, mutually exclusive events.
- Conditional probability.
- Law of total probability.
- Bayes' theorem.

5. Statistics

- Qualitative variables (nominal, ordinal) and quantitative variables (discrete, continuous).
- Absolute, relative and percentage frequencies, and their graphical representation. Cumulative frequencies.
- Mean, mode, median.
- Range, variance and standard deviation.
- Percentiles.

Physics

1. Measures and Kinematics:

- Direct and indirect measures, fundamental and derived quantities, physical dimensions of quantities, scalars and vectors.
- The CGS System of Units and the International System (SI) of units of measurement, nomenclature of multiples and submultiples.
- Position, displacement, velocity, acceleration.
- Uniform rectilinear and circular motion.
- Uniformly accelerating rectilinear motion.
- Harmonic motion.

2. Dynamics:

- Forces and moments.
- Mass, gravitational acceleration, weight, Newton's law of universal gravitation.
- The 1st, 2nd and 3rd law of motion.
- Work, kinetic energy, potential energy, and the principle of conservation of energy; friction.
- Impulse, momentum, and the principle of conservation of momentum.
- Angular momentum and conservation of angular momentum.

3. Fluid mechanics and Optics:

- Density, gauge and absolute pressure, and their units of measurement (SI and non-SI).
- Pascal's principle and Archimedes' principle.
- Stevin's law and the Bernoulli equation.
- Fermat principle.
- Reflection, refraction and Snell's law.
- Prisms, mirrors and lenses, interference, diffraction.

4. Thermodynamics:

- Thermometry and calorimetry, thermal capacity and specific heat capacity.
- Modes of heat propagation, changes of state and latent heats.
- Ideal gas laws.
- First and second laws of thermodynamics.
- Entropy.
- Thermodynamic cycles, efficiency of a thermal machine.

5. Electrostatics and Electrodynamics:

- Coulomb's law, electric field, Gauss's law, and potential.
- Capacitors and electrical resistances (in series and in parallel), direct current, Ohm's laws, Kirchhoff's principles.
- Electric generators, work, power, Joule effect.
- Magnetic field, the Lorentz force, the Ampère's law.
- Electromagnetic induction and alternating currents.
- Electromagnetic waves: wavelength, frequency, energy.