Pre-IB Integrated Mathematics and Science Course

Our summer pre-IB course is designed to help students who have just completed their IGCSE or IB-MYP studies, and are preparing for the big jump to IB-level studies where the scope of knowledge required is broader and deeper, leading to much more challenging exams.

At Akademia, we have chosen to avoid the "let's staple a bunch of past paper questions and call it a course" approach. Instead, we have put together a coherent story of science and maths - we want our students to build on their IGCSE–level knowledge and develop a firm grasp of basic scientific principles, such as mass, charge, motion, force, energy, and their interactions, on the subatomic, atomic, cellular and macroscopic scale, in order to assist them in understanding more challenging and complex concepts covered by the IB course. We also want to well–prepare students for **independent multiple–step problem solving**, a skill that will prove highly useful throughout a student's IB diploma studies.

Students and parents will be given **free** consultations, over the phone or in person, in order for us to identify the course participants' background, strengths and weaknesses. A 12-hour course will then be tailored by our course experts, based on the students' IB subject selection, aspirations, topics of interest, and our own recommendations.

The time allocated for each topic can vary but, by their nature, the courses will be heavy on fundamental topics in each respective science, and cross-references between subjects will be made in order to allow students to connect scientific principles to multiple related disciplines. Students with a strong mathematical background will also receive a healthy dose of technical mathematical terms, such as differentiation and integration, within this course, during the discussion of various scientific phenomena.

Suitable especially for student taking 2 or more sciences in IB, this course is available as 1-to-1 lessons or as small groups, and can be conducted in English, Cantonese, or a mix of Cantonese and English, upon request. The lesson will be interactive, and frequent references to real-life situations will be made. Able students will be presented not just IB–style problem, but also tougher problems that are commonly encountered within admission aptitude tests from prestigious institutes (e.g. Cambridge and Oxford), as well as medical admission tests such as BMAT and UKCAT.

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The typical content of this preparatory course can include, but are not limited, to the following guidelines:

1. IB Physics

Typical topics that can be included in our physics course include:

A) Basic mathematical manipulations

- function graph types, and non-calculator graph sketching
- concept of order of magnitude
- problem solving using ratios and proportions
- gradients and areas of graphs and their significance, with or without link to calculus
- introduction to logarithms
- establishing and using straight-line plots
- physical unit interconversions

B) Concepts of motion

- distance, displacement, velocity, acceleration and their relations
- interpretation of motion graphs
- analysis of linearly-accelerated motion, including the importance in assigning directions
- 2-dimensional motions, including the importance of x-y independence in projectile applications

C) Forces and applications

- Mechanical, gravitational, electrostatic and magnetic forces
- Link between force and motion – velocity and acceleration
- Newton laws, free-body diagrams, resolution of force vectors in 2D situations
- Friction and drag

D) Mechanical energy

- Concept of work done
- Definition of mechanical energies – kinetic energy and different types of potential energies
- Energy interconversion examples and problem solving

E) Electrostatics and electricity

- Charge as a fundamental quantity
- Concept of electric force and field
- Force and motion of charges
- Concept of electrostatic potential energy, circuit voltage and electrostatic voltage

F) Thermal concepts

- Explaining heat energy in terms of particle behaviour
- Conservation of heat energy
- Application in mixing
- Ideal gas properties at the molecular level

G) Electromagnetic waves and mechanical waves

- Interaction of electromagnetic waves with matter
- Wave phenomena: reflection, refraction, diffraction, interference and polarization
- Examples of mechanical wave-like motion and oscillations

2. IB Chemistry

Typical contents of the chemistry section of our preparatory course can include:

A) Behaviour of sub-atomic particles within atoms

- The structure of an atom
- The nature of electrostatic force
- The roles of protons, electrons and shells

- Interaction between matter and light (electromagnetic radiation)
- Elements as atoms vs. as substances
- Atomic properties based on electrostatic forces
- A qualitative understanding of energetics and stability – application of electron arrangements

B) Chemical bonding

- The nature of the chemical bond – ionic, covalent bonding as the extremes, visiting the grey areas
- The concept of the formula unit
- Bonding-structure relationships
- Introduction to intermolecular forces, and explanation of everyday phenomena

C) Quantum chemistry

- The need to invoke electron energy sublevels as a new atomic model
- Application of energy sublevels and orbitals – discussion of ionisation energies, deviations from octet rule, molecular shapes, intermolecular forces, polarity and polarisability.

D) Reaction types and energetics

- Macroscopic properties of substances
- Reaction types
- Equation and half-equation balancing
- Introduction to energy calculations
- Thermodynamic and kinetic stability

E) Mole calculations and analysis

- Chemical counting principles
- Reaction stoichiometry – converting masses and volumes into moles
- Moles in chemical analysis

3. Biology IB

Typical contents of the biology section of our preparatory course can include:

A) Introduction to biochemistry

- Particles of chemistry: ions and molecules
- Molecules of life: chemical and biological properties of water and nutrient molecules

B) The cell

- Introduction to organelles
- Structure-function relationships at a sub-cellular and cellular level
- Division of cells
- Enzymes and regulation of metabolic activities
- Cell-mediated movement of substances

C) Proteins, DNA and Genetics

- DNA as the main genetic material
- The preservation of genetic information during DNA replication
- Translation and transcription as mechanisms of protein synthesis during gene expression

D) Carbohydrates, fats and energetics

- Energy within biological systems: ATP and bonds in respiratory substrates
- Photosynthesis and respiration

E) Organ systems

- Overview of animal organ systems
- Structure-function relationships at an organ level
- Increased surface area – the ultimate solution of all biological problems

F) Biological data interpretation

- Data analysis
- Correlation and causation
- Statistical tests – normal distribution, t-tests and chi-squared tests

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4. Mathematics IB

A) Basic algebra

- Facile simultaneous equations and polynomial equation solving
- Algebra skills
- Index, exponents, logarithms
- Ratios and proportions

B) Functions

- Domain, range, inverse, applications
- Graphs of basic mathematical models

C) Introduction to calculus

- Meaning of differentiation and integration
- Basic algebraic manipulations

Akademia's take on general multiple–step problem solving

During their IGCSE studies, students are often asked the following types of questions on exam papers, often in a guided form that has the question split into smaller parts, each part featuring a concept that students should be familiar with. Students will not be offered nearly as much guidance in written assessment during their IB diploma studies. Typical questions that students will encounter in the course are shown below. One of the main objectives of our course is to help students tackle the following types of questions without guidance.

Physics

1) A 1.5 kg rock is dropped, starting from rest, from 20 meters above the ground. There is an average air resistance of 11 Newtons acting against the rock. Calculate the momentum of the rock just before it lands.

2) A 400–gram sample of ice at –13 ^{o}C is placed on a heater which supplies thermal energy at an average rate of 500 W. Calculate the time that it will take the bring the sample of ice to become water that's on the verge of boiling (specific heat capacity of ice = 2.1 J g^{-1} K^{-1}, specific latent heat of fusion of ice = 334 J g^{-1}, specific heat capacity of water = 4.2 J g^{-1} K^{-1}).

3) A 6.0–Volt battery is connected to a light bulb and a resistor in series. The light bulb has a fixed resistance of 12 Ohms while the variable resistor has its resistance values ranging from 4 to 60 Ohms. Calculate the maximum power output of the light bulb.

Chemistry

1) A 1.00–gram sample of impure oxalic acid, $(COOH)_2$ (relative molecular mass = 90) is dissolved in a 100.0 cm^3 volumetric flask. 25.00 cm^3 portions of this solution require an average of 40.00 cm^3 of 0.100 mol dm^{-3} NaOH for an exact neutralization. Assuming that the impurities are chemically inert, calculate the purity of oxalic acid in the sample.

2) A student would like to obtain the compound ethyl ethanoate. He has access to ethene as the only carbon–containing compound, but he may use any other non–carbon–containing chemicals. Design a multiple–stage process that allows him to obtain ethyl ethanoate from ethene.

Mathematics

1) The angle of elevation from a boat at sea to the top of a cliff is measured to be 14^{o}. If the boat moves 100 meters directly away from the cliff, the angle of elevation becomes 9^{o}. Calculate the height of the cliff.

2) A starting culture of 1000 bacteria is kept under growing conditions for 40 minutes, after which the population has become 3000. Assuming exponential growth, how long will it further take for the population to reach 5000?

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