

Syllabus of the International Junior Science Olympiad - IJSO

國際國中科學奧林匹亞競賽命題大綱

A. General science skills 一般性的科學技能

As a general prerequisite the students should be familiar with and be able to

- employ and explain scientific methods,
- use scientific terminology,
- put forward hypotheses,
- devise and accurately describe methods/experiments to test hypotheses,
- assess the validity of different sources of information and be aware that data might be inaccurate or even wrong,
- adequately represent data in tables, diagrams and graphs,
- interpret data.

作為一般性的前提，學生應該要熟悉並且有能力能夠：

- 採用和解釋科學方法，
- 使用科學術語，
- 提出假設(說)，
- 設計出、並且能準確地描述所採用的方法/實驗，來檢驗假設(說)，
- 評估不同來源資訊的有效性，並有資料可能不準確甚或錯誤的認知，
- 適度地以表格、圖解、圖示或圖表來呈現，
- 詮釋資料。

B. Content Knowledge in Natural Sciences and Mathematics 自然科學與數學的學科內容知識

1. Particles, waves and matter 粒子、波、以及物質

Matter is structured from the smallest particle to the size of the universe. The microscopic structure of matter is responsible for the features we observe macroscopically. The students should be aware of this structure and be familiar with the following concepts:

物質，由小至最小的粒子，大到宇宙所構成。物質的微觀結構，是讓我們能觀察宏觀世界、事物的一個指引與途徑。學生們應該知道、了解這種結構，並熟悉以下的概念：

- What things are made of 事物是由甚麼所構成(組成)
 - o Structure of particles and atoms 粒子與原子的結構
(*neutrons, protons, electrons, nature of bonding*) (中子, 質子, 電子, 成鍵的本質)
 - o Elements, isotopes and compounds 元素, 同位素與化合物
 - o Composition of molecules, chemical substances 分子與化學物質的組成
 - o Mixtures, colloids and suspensions 混合物, 膠體(溶液), 與懸浮液
- Periodic table - concept, organization and structure 週期表 - 概念, 組成與結構
- States of matter and its properties 物質的狀態和其性質
 - o Solids, liquids, gases and plasmas - characteristics and differences 固體, 液體, 氣體和等離子體 - 特性與不同之處
 - o Lattices as a special form of solid matter 晶格, 一種特殊的固態物質型態
 - o Properties of matter 物質的性質 (*density, volume, electrical conductivity, insulators and conductors, elastic behavior, thermal expansion, (specific) heat capacity, defining properties of metals, non-metals, alloys* 密度, 體積, 電傳導性, 絕緣體與導體, 彈性行為, 熱膨脹性, 比熱, 定義金屬、非金屬、與合金的性質)
 - o Phase transitions and their influence on the properties of matter 相變以及其對物質性質所帶來的影響 (*latent heat, phase diagrams, change of volume and density* 潛熱, 相圖, 體積與密度的改變)
 - o Water and its different phases 水, 以及其各種不同的水相
- Waves 波

- o Frequency, wavelength, speed of propagation and its relation 頻率，波長，傳播的速度以及其相關性
- o Difference between transversal and longitudinal waves 橫向與縱向波之間的區別
- o Superposition of waves 波的疊合
- o Classical Doppler effect 古典都普勒效應
- Sound 聲音 (*Sound as longitudinal pressure wave, perception of sound* 作為縱向壓力波，對聲音的知覺)
- Light 光
 - o Wave and particle interpretation of light 解釋光的波與粒子二象性
 - o Propagation and speed of light in vacuum and media, refractive index 在真空與介質中光的傳播與速度，折射率
 - o Connection between wavelength and color, electromagnetic spectrum 波長與顏色之間的關聯，電磁頻譜
 - o Reflection and refraction of light at mirrors and lenses 光在鏡子與鏡片中的反射與折射 (*angle of incident and reflected beams, Snell's law, total internal reflection* 入射角，反射光束，司乃耳定律，全內反射)
 - o Formation of images with mirrors and lenses 透過鏡子與鏡片的成像 (*focal length, thin lens formula, magnification, magnifying glasses, microscopes, telescopes, glasses* 焦距，薄透鏡公式，放大率，放大鏡，顯微鏡，望遠鏡，鏡片)

2. Energy 能量(源)

Energy is essential in our everyday life as energy conversion is the reason for many dynamical phenomena in our world. Energy is therefore one of the main concepts in science. The students are expected to know about the following topics:

能量(源)是日常生活中所必須與必要的，因為能量轉換是我們世界中許多動力現象的原因。因此，能量是許多科學主要概念中的其中一個。學生們被期望要知道了解以下的主題：

- Nature of energy and energy conservation 能量的本質與節能
- Various forms of energy 各種形式的能量 (*bonding energy, kinetic energy, potential energy, heat, activation energy, energy stored in a spring* 鍵(結)能，動能，位(勢)能，熱能，活化能，彈簧的儲能)
- Transfer of energy 能量的轉移(傳遞) (*e.g. mechanisms of heat transfer, transfer of energy via waves* 如：熱傳導(遞)機制，透過波的能量轉移)
- Energy conversion / transformation and its efficiency 能量的轉換以及其效率 (*e.g. conversion between potential and kinetic energy, bonding energy and temperature or the loss of energy to the environment by radiation* 如：位能與動能間的轉換，鍵能與溫度或環境中因輻射造成的能量損失)
- Sources of energy 能量的來源 (*e.g. for animals, plants, societies and engines. Fossil and renewable energy sources* 如：動物，植物，社會以及引擎。化石與可再生能源的來源)
- Power 功率 (*e.g. muscular power, power output of engines or stars, power dissipation in resistors* 如：肌瞬發力，引擎或星體的輸出功率，電阻器中的功率散逸(消耗))

3. Interactions 互動

Conversion of energy and our perception of the world around us are only possible due to interactions. The students should know about and be able to work with the following concepts:

透過互動，才有可能產生能量的轉化，以及我們對環繞我們的世界產生知覺或感受。學生們應該要了解知道並且有能力能夠處理以下的概念：

- Forces 力
 - o Nature of forces and types of forces 力的本質與力的種類 (*gravitational force, electrostatic force, magnetic force, static and dynamic frictional forces, buoyancy, Van-der-Waals force* 重力，靜電力，磁力，靜與動摩擦力，浮力，凡德瓦爾力)
 - o Mass and weight, centre of mass 質量與重量，質量中心(質心)
 - o Newton's laws, inertial systems 牛頓定律，慣性系統
 - o kinematics of a point mass: linear and circular motion 點質量運動學：線性與圓周運動 (*position, speed, acceleration, angular frequency, centripetal force, Kepler's laws, movement of the earth around the sun* 位置，速度，加速度，角頻率，向心力，克普勒定律，地球繞太陽運動)

- o Momentum and change of momentum 動量與動量的變化 (*linear momentum, elastic and inelastic collisions, conservation of momentum in closed systems* 線性動量，彈性與非彈性碰撞，封閉系統內的動量守恆)
- o Levers 槓桿
- o Elastic forces, Hooke's law and simple harmonic motions 彈力，虎克定律與簡諧運動
- o Pressure 壓力 (*atmospheric pressure, static pressure in liquids* 大氣壓力，液體的靜壓力)
- Electric, magnetic and gravitational fields 電場，磁場與重力場。
- Type of chemical bonding - nature, structure and strength 化學結合的種類- 本質，結構與力度 (*covalent and ionic bonds, hydrogen bonding and van-der-Waals interaction* 共價鍵與離子鍵，氫鍵與凡德瓦爾作用)
- Chemical Reactions 化學反應
 - o Chemical equations - balancing and stoichiometry 化學反應式 – 平衡與計量法
 - o Types of chemical reactions 化學反應的種類 (*acid/base neutralizations, redox reactions, thermal decompositions* 酸鹼中和，氧化還原反應，熱分解)
 - o Basic and most common reactions for determination of unknown substances 測定未知物質的基本與最常見的反應
 - o Rate of reactions, factors affecting reaction rate like catalysts, temperature and concentration 反應速率，影響反應速率的因素如催化劑，溫度與濃度
 - o Dynamic equilibrium and Le Chatelier's principle 動態平衡與勒沙特列原理
 - o Common ion effect 普通的離子反應
- Diffusion, osmosis and surface tension 擴散，滲透與表面張力
- Principle of thin layer and paper chromatography 薄層層析與濾紙層析原理
- Effects of radiation on organisms 輻射對生物(有機體)所產生的影響(輻射效應)
- Forms of communication 通訊的形式 (*e.g. function of hormones and pheromones in living organisms* 如: 活的生物(有機體)的荷爾蒙與費洛蒙的功能)

4. Structure, properties and functions 結構，性質(屬性)與功能

The different constituents of a system usually have specific properties which allow them to fulfill their function in the intended way. The students should know the structure of the following components and understand in which way they fulfill their functions

一個系統中不同的構成物(成分)通常各自擁有特定的性質(屬性)，使得他們能夠以預期的方式來執行與達成他們的功能。學生們必須要知道以下組成物(成分)的結構，以及他們透過甚麼方式來執行並達成他們的功能

- Cells 細胞
 - o Basic structure of cells and its constituents 細胞的基本結構與其組成物(成分)
 - o differences between animal, plant cells and bacteria 動、植物細胞與細菌的不同之處
 - o Basic concepts of the biochemistry of molecules - carbohydrates, proteins, lipids and nucleic acids 分子生物化學的基礎概念 – 碳水化合物，蛋白質，脂質與核酸
- Parts of the body 身體的各部
 - o Anatomy and function of main organs and tissues in animals and humans (*lung, heart, kidney, liver, digestive system, sensory organs, skin, blood*) 動物與人類身體中主要器官與組織的解剖與功能 (肺，心，腎，肝，消化系統，感官，皮膚，血液)
 - o Properties of muscles 肌肉的性質(屬性)
- Homogeneous and heterogeneous catalysts 均相與非均相催化劑
- Acids and bases 酸與鹼
 - o Properties of acids and bases 酸與鹼的性質(屬性)
 - o pH values and neutralization PH值與酸鹼中和

- o Indicators 指示劑
- o Formation and effect of acidic rain 酸雨的形成與其所產生的影響
- o Electrolysis 電解 (*migration of ions, Faraday constant, electrochemical cells* 離子的遷移，法拉第常數，電化電池)

5. Systems 系統

Things in life are organized in open or closed systems. It is therefore important to not only look at the components of a system and its interdependencies but also at the system as a whole. The students should be able to employ the concepts of

生命中的事物是由開放或封閉的系統所組織形成的。因此，重要的是，不僅要觀察了解系統的組成物以及其相互依賴性；同時，也要把系統視為一個整體。學生們應該要能夠運用的概念包括

- Continuity principles in closed systems/cycles 在封閉系統/循環中的連續性原理
- Equilibriums 平衡 (*e.g. of forces, chemical/ionic equilibrium, thermo dynamical equilibrium, ecosystems in equilibrium* 如: 力平衡，化學/離子平衡，熱動力平衡，生態平衡)
- Scales of nature 自然的規模 (*e.g. in biological systems, astrophysics* 如: 在生物系統，天體物理學)
- Basic concepts about cycles in nature 自然界中循環的基本概念 (*carbon cycle, water cycle, Nitrogen cycle, oxygen cycle, ozone cycle, renewable and non-renewable natural resources, earth's climate* 碳循環，水循環，氮循環，氧循環，臭氧循環，可再生與不可再生的自然資源，地球的氣候)
- Ecology 生態
 - o Levels of organization in the biosphere 生物圈中的組織層級
 - o Factors affecting ecosystems 影響生態系統的因素 (abiotic and biotic 無生命與有生命的)
 - o Interactions between organisms 生物(有機體)的互動 (*e.g. competition, predation, mutualism* 如: 競爭，掠奪補食行為，互利共生)
 - o Producers, consumers and decomposers 生產者，消費者與分解者
 - o Food chains, food webs 食物鏈，食物網
 - o Basic principles of conservation of biodiversity 維持(保存)生物多樣性的基本原則
 - o Factors affecting growth of populations, typical growth-curves for populations 影響人口成長的因素，典型的人口成長曲線
- Pollution effects of different modes of power generation 不同型式的發電系統所產生的污染效應
- Organisms as systems 生物(有機體)系統
 - o Transformation of matter and energy in organisms 生物(有機體)中物質與能量的改變與轉化
 - o Basic knowledge of digestive, circulatory, respiratory, excretory, nervous, immune and endocrine systems 消化，循環，呼吸，排泄，神經，免疫與內分泌系統的基本知識
- Plant physiology 植物生理學
 - o Respiration and exchange of gases 呼吸與氣體的交換
 - o Absorption by roots, diffusion, osmosis 根部的吸收，擴散作用，滲透作用
 - o Photosynthesis 光合作用。
 - o Tropism of plants 植物的向性
- Electric Circuits 電路
 - o Components of circuits 電路的組成 (*resistors and wires, bulbs, voltage sources, Ammeters, Voltmeters, capacitors* 電線與電阻，燈泡，電壓來源，安培計(電流表)，電壓計(伏特計)，電容器)
 - o Ohm's law, charge, current, voltage 歐姆定律，電荷，電流，電壓(伏特數)
 - o Series and parallel circuits, Kirchhoff's laws 串聯與並聯，基爾霍夫定律
 - o Difference between AC and DC currents/voltages 直流與交流電/伏特的不同
 - o Qualitative knowledge of electromagnetic induction and Lenz's law 電磁感應與楞次定律的量化知識

- o Basic principles of generators and motors 發電機與馬達的基本原理
- Thermo dynamical systems 熱動力學系統 (*absolute temperature, ideal gas law, isothermal, isochoric and isobaric processes, Hess's law, combustion cycles* (絕對)溫度, 理想氣體定律, 等溫、等容及等壓過程, 赫士定律, 燃燒循環)
- Astrophysical systems 天體物理系統 (*main characteristics of stars, planets, moons, comets, asteroids, solar systems, galaxies* 恆星, 行星, 月亮, 彗星, 小行星, 太陽系, 銀河系的主要特徵)

6. Development and Evolution 發展與演化

Living organisms are not static and undergo constant change and adaption. The students are expected to show proficiency in the following areas:

活著的生物體(有機體)並非靜態的, 而是不斷在做經常性的變化與適應。學生們被期望要在以下的領域範疇中展現:

- Strategies of environmental adaptation 環境適應的策略 (*characteristics of adaptation, structural, physiological and behavioral adaptation* 適應的特徵, 結構性、生理性與行為性的適應)
- Theory of evolution 演化理論 (*natural selection, neo-Darwinian revolution, evidence of evolution* 自然選擇(天擇), 新達爾革命, 演化的證據)
- Cell cycle and cell division 細胞循環與細胞分裂 (*basic principles of meiosis, mitosis, haploidy and diploidy* 減數分裂, 有絲分裂, 單倍體與雙倍體的基本原理)
- Reproduction in humans, animals and plants 人類, 動物與植物的生殖(繁殖)
 - o principles of creation of new life 創造新生命的原理
 - o human reproductive organs and sex cells 人類生殖器官與生殖細胞
 - o changes that take place in boy's and girl's bodies during puberty 發生在青春期男女身體上的變化
 - o basic principles of plant reproduction 植物生殖的基本原理 (asexual and sexual 無性與有性生殖)
 - o basic knowledge of the development of fetus during pregnancy 懷孕期間胚胎發展的基本知識
- Genes, chromosomes and genetics 基因, 染色體與基因工程學 (*Mendel's laws, mutations, inheritance of genetic characteristics* 孟德爾定律, 突變, 基因特徵的遺傳)
- Diseases 疾病
 - o cause and transmission of diseases 疾病的產生與傳染 (*microorganisms causing common diseases, viruses, genetic defects* 微生物所導致的常見疾病, 病毒, 基因缺陷(失))
 - o immune systems 免疫系統
 - o principles of vaccination 預防接種的原則
 - o antibiotics such as the penicillin group 抗生素如盤尼西林(青黴素)類

7. Mathematics skills 數學的能力

The emphasis of the tests should be on natural sciences. Nevertheless mathematics is an indispensable tool to the natural sciences. The students should therefore know about and be able to make use of equations involving 測驗所要強調的應該是自然科學。然而, 對自然科學而言, 數學的運用是一個不可或缺的工具。學生們因此應該要知道並且有能力能夠運用與使用的方程式包括

- equations involving
 - o fractions 分數
 - o logarithms and exponential functions 對數與指數函數
 - o powers and roots 次方與方根
 - o polynomials 多項式 (e.g. solving quadratic equations 如: 解二次方程式)
 - o trigonometric functions 三角函數
- transformations of equations to obtain linear relations 變換方程式以獲得線性關係
- plots of functions 函數的繪製圖
- simple geometry 簡易幾何學 (geometry of triangles and circles, areas and volumes of basic planar forms and

solids 三角與圓形的幾何學，基本平面形狀與立體圖形的面積與體積)

- basic vector algebra 基礎向量代數 (decomposition and addition of vectors 向量的分解與加法)
- simple statistics 簡易統計學 (mean values, standard deviations, basic notion of probabilities 平均值，標準差，機率的基本概念)
- error estimation 誤差估計 (*by means of standard deviation or Min-Max analysis, difference between accuracy and precision* 藉由標準差或極小化極大分析，正確與精確的不同)
- rounding of numbers and representing data with the proper number of digits / significant figures 數字的四捨五入以及用適當的位數 / 有效的位數來表示資料

C. Laboratory Skills 實驗室技能

The content knowledge and general science skills part of the Syllabus provide the basis for all the experimental problems. In addition the students should be familiar with laboratory work. They should in particular be able to 本大綱中部分的學科內容知識與一般性科學技能，提供了所有實驗方面試題的準則。除此之外學生們應該要熟悉實驗室工作。他們特別應該要能夠:

- work in the laboratory following safety regulations 在實驗室工作時遵守安全規範
- employ basic techniques for measuring the quantities mentioned in part B 使用基本技術來測量B部分所提到各種的數據與量
- make observations using the five senses 使用五個感官作觀察
- identify and use basic laboratory equipment 能夠識別與使用基本實驗設備
- use more sophisticated equipment if proper instructions are given 若在適當的指示給予下，使用更精密的設備器材
- collect data from an experiment being aware that instruments affect measurements 知道工具會影響測量當由一個實驗中收集資料
- identify error sources and estimate their effects 找到誤差來源並估計他們所帶來的影響