# GCSE CRITERIA FOR SCIENCE

## 1. INTRODUCTION

1.1 These criteria define the subject-specific essentials for GCSE specifications in science subjects. Specifications must also meet the requirements of the regulatory authorities' general requirements, including the Common and GCSE criteria.

1.2 Any specification that contains significant elements of the sciences must be consistent with the relevant parts of these criteria, and should appropriately develop students' skills, knowledge and understanding of how science works.

## 2. AIMS

2.1 All specifications should give students opportunities to:

- develop their interest in, and enthusiasm for, science;
- develop a critical approach to scientific evidence and methods;
- acquire and apply skills, knowledge and understanding of how science works and its essential role in society;
- acquire scientific skills, knowledge and understanding necessary for progression to further learning.

## 3. SPECIFICATION CONTENT

3.1 All specifications should include a rationale which clearly reflects the approach taken within the specification. This approach should include an emphasis on one or more of:

- evaluating evidence and the implications of science for society;
- explaining, theorising and modelling in science;
- procedural and technical knowledge of science practice.

3.2 All specifications must specify the skills, knowledge and understanding on which assessment will be based.

3.3 All GCSE specifications in science subjects should build appropriately on the knowledge, understanding and skills set out in the National Curriculum key stage 3 science programmes of study for England, Wales and Northern Ireland.

3.4 Study of science specifications, either singly or in combination, should provide access to further learning in science-related areas at level 3.

3.5 Specifications must present content in a coherent and concise manner which aids teaching, learning and assessment.

3.6 Specifications with the title **GCSE Science** should consist of the skills, knowledge and understanding of how science works:

(i) **data, evidence, theories and explanations**
- a) the collection and analysis of scientific data
- b) the interpretation of data, using creative thought, to provide evidence for testing ideas and developing theories
- c) many phenomena can be explained by developing and using scientific theories, models and ideas
- d) there are some questions that science cannot currently answer, and some that science cannot address

(ii) **practical and enquiry skills**
- a) planning to test a scientific idea, answer a scientific question, or solve a scientific problem
- b) collecting data from primary or secondary sources, including the use of ICT sources and tools
- c) working accurately and safely, individually and with others, when collecting first-hand data
- d) evaluating methods of data collection, and considering their validity and reliability as evidence

(iii) **communication skills**
- a) recalling, analysing, interpreting, applying and questioning scientific information or ideas
- b) using both qualitative and quantitative approaches
- c) presenting information, developing an argument and drawing a conclusion, using scientific, technical and mathematical language, conventions and symbols and ICT tools

(iv) **applications and implications of science**
- a) the use of contemporary scientific and technological developments and their benefits, drawbacks and risks
- b) how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions
- c) how uncertainties in scientific knowledge and scientific ideas change over time and the role of the scientific community in validating these changes.

3.7 All specifications with the title **GCSE Science** should set the skills, knowledge and understanding, outlined in paragraph 3.6, entirely in the context of:

(i) **organisms and health**
- a) organisms are interdependent and adapted to their environments
- b) variation within species can lead to evolutionary changes and similarities and differences between species can be measured and classified
- c) the ways in which organisms function are related to the genes in their cells
- d) chemical and electrical signals enable body systems to respond to internal and external changes, in order to maintain the body in an optimal state
- e) human health is affected by a range of environmental and inherited factors, by the use and misuse of drugs and by medical treatments

(ii) **chemical and material behaviour**
- a) chemical change takes place by the rearrangement of atoms in substances
- b) there are patterns in the chemical reactions between substances
- c) new materials are made from natural resources by chemical reactions
- d) the properties of a material determine its uses

(iii) **energy, electricity and radiations**
- a) energy transfers can be measured and their efficiency calculated, which is important in considering the economic costs and environmental effects of energy use
- b) electrical power is readily transferred and controlled, and can be used in a range of different situations
- c) radiations, including ionising radiations, can transfer energy
- d) radiations in the form of waves can be used for communication

(iv) **environment, Earth and universe**
- a) the effects of human activity on the environment can be assessed using living and non-living indicators
- b) the surface and the atmosphere of the Earth have changed since the Earth's origin and are changing at present
- c) the solar system is part of the universe, which has changed since its origin and continues to show long-term changes.

3.8 The treatment of each area of content in paragraph 3.7 should be similar, or of comparable demand, to the indicative content within Appendix A.

3.9 At least half of each specification with the title **GCSE Additional Science** should set the skills, knowledge and understanding, outlined in paragraph 3.6, in the context of the following content. The remainder of each specification should set the skills, knowledge and understanding, outlined in paragraph 3.6, in the context of a balance of further appropriate scientific content.

(i) **Biology**

a) **Cells and growth**
Chemical reactions essential for life and growth take place inside cells. Differences between plant and animal cells lead to different patterns of growth and development.

b) **Energy flow and element cycles**
Plant biomass provides energy and nutrients for other organisms. Through the consumption of organisms and decay, energy flows through the biosphere and chemical elements are recycled within it.

(ii) **Chemistry**

a) **Structure and bonding**
The outer electrons of atoms are involved in chemical reactions. The structure and properties of a substance are strongly dependent on the nature of the bonding which results from the forces between the electrons and nuclei of atoms.

b) **Chemical synthesis**
Raw materials are converted into new and useful substances by chemical reactions. The theoretical yield of a chemical reaction can be calculated.

(iii) **Physics**

a) **Forces and motion**
Forces arise from interactions between objects. The balance, or otherwise, of these forces on an object affects its movement. Energy transfers can occur due to these interactions though the total energy remains constant.

b) **Nuclear changes**
Nuclear changes within unstable atoms cause random emissions of particles. Nuclear changes also cause the emission of energy in the form of useful and dangerous radiation.

3.10 The treatment of each area of content in paragraph 3.9 should be similar, or of comparable demand, to the indicative content set out in Appendix B.

3.11 Taken together, **GCSE Science** and **GCSE Additional Science** should be equivalent to the GCSE Double Award: Science, offered under the previous GCSE criteria for science. They should, therefore, provide comparable preparation for further study of science at level 3.

3.12 All specifications with the title **GCSE Applied Science (Double Award)** should set the skills, knowledge and understanding, outlined in paragraph 3.6, and content in paragraph 3.7, in appropriate vocational contexts. Any additional content selected should provide appropriate vocational contexts.

3.13 All specifications with the title **GCSE Additional Applied Science** should develop the skills, knowledge and understanding, outlined in paragraph 3.6, through content selected to provide appropriate vocational contexts.

3.14 At least half of each specification with the title **GCSE Biology**, **GCSE Chemistry** and/or **GCSE Physics** should include the appropriate skills, knowledge and understanding defined in paragraph 3.6, and the content in paragraphs 3.7 and 3.9. The remainder of each specification should consist of further biology, chemistry or physics, as appropriate. Taken together, the three qualifications should cover all the knowledge, skills and areas of content defined in paragraphs 3.6, 3.7 and 3.9.

3.15 Specifications in the sciences with other titles should use appropriate content to develop the skills, knowledge and understanding of how science works, outlined in paragraph 3.6.

## 4. KEY SKILLS

4.1 All specifications in the sciences should provide opportunities for developing and generating evidence for assessing the Key Skills listed below. Where appropriate, these opportunities should be directly cross-referenced, at specified level(s), to the criteria listed in Part B of the Key Skills specifications:

- communication
- information and communication technology
- application of number
- improving own learning and performance
- working with others
- problem solving.

## 5. ASSESSMENT OBJECTIVES

5.1 Specifications must require that all candidates demonstrate the following assessment objectives in the context of the prescribed skills, knowledge and understanding. Within the assessment objectives, candidates should be required to use communication skills, including ICT, as specified in 3.6 (iii), using scientific conventions (including chemical equations) and mathematical language (including formulae), where appropriate.

5.2 **Assessment objective 1 (AO1): Knowledge and understanding of science and how science works**

Candidates should be able to:

a) demonstrate knowledge and understanding of the scientific facts, concepts, techniques and terminology in the specification

b) show understanding of how scientific evidence is collected and its relationship with scientific explanations and theories

c) show understanding of how scientific knowledge and ideas change over time and how these changes are validated.

5.3 **Assessment objective 2 (AO2): Application of skills, knowledge and understanding**

Candidates should be able to:

a) apply concepts, develop arguments or draw conclusions related to familiar and unfamiliar situations

b) plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem

c) show understanding of how decisions about science and technology are made to different situations, including contemporary situations and those raising ethical issues

d) evaluate the impact of scientific developments or processes on individuals, communities or the environment.

5.4 **Assessment objective 3 (AO3): Practical, enquiry and data-handling skills**

Candidates should be able to:

a) carry out practical tasks safely and skilfully

b) evaluate the methods they use when collecting first-hand and secondary data

c) analyse and interpret qualitative and quantitative data from different sources

d) consider the validity and reliability of data in presenting and justifying conclusions.

## 6. SCHEMES OF ASSESSMENT

6.1.1 All GCSE specifications in the sciences should be unit based.

6.1.2 All specifications in the sciences should include a minimum external assessment weighting of 25%.

6.1.3 All specifications in the sciences should include a minimum internal assessment weighting of 25%.

6.2 Assessment units should have only one form of assessment, ie internal or external.

6.3 The assessment objectives listed in Section 5 must be weighted within the following ranges:

| **Assessment objectives** | |
|---|---|
| AO1: Knowledge and understanding of science and how science works | 20-40% |
| AO2: Application of skills, knowledge and understanding | 30-55% |
| AO3: Practical, enquiry and data-handling skills | 20-40% |

6.5 Attainment on single award qualifications will be reported on an eight-grade scale from A* to G.

6.6 Attainment on the GCSE Applied Science (Double Award) will be on a 15-grade scale: A*A*, A*A, AA, AB, BB, BC, CC, CD, DD, DE, EE, EF, FF, FG, and GG.

## 7. GRADE DESCRIPTIONS

**Grade F**

Candidates demonstrate a limited knowledge and understanding of science content and how science works. They use a limited range of the concepts, techniques and facts from the specification, and demonstrate basic communication and numerical skills, with some limited use of technical terms and techniques.

They show some awareness of how scientific information is collected and that science can explain many phenomena.

They use and apply their knowledge and understanding of simple principles and concepts in some specific contexts. With help they plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem, using a limited range of information in an uncritical manner. They are aware that decisions have to be made about uses of science and technology and, in simple situations familiar to them, identify some of those responsible for the decisions. They describe some benefits and drawbacks of scientific developments with which they are familiar and issues related to these.

They follow simple instructions for carrying out a practical task and work safely as they do so.

Candidates identify simple patterns in data they gather from first-hand and secondary sources. They present evidence as simple tables, charts and graphs, and draw simple conclusions consistent with the evidence they have collected.

**Grade C**

Candidates demonstrate a good overall knowledge and understanding of science content and how science works, and of the concepts, techniques, and facts across most of the specification. They demonstrate knowledge of technical vocabulary and techniques, and use these appropriately. They demonstrate communication and numerical skills appropriate to most situations.

They demonstrate an awareness of how scientific evidence is collected and are aware that scientific knowledge and theories can be changed by new evidence.

Candidates use and apply scientific knowledge and understanding in some general situations. They use this knowledge, together with information from other sources, to help plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem.

They describe how, and why, decisions about uses of science are made in some familiar contexts. They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

They carry out practical tasks safely and competently, using equipment appropriately and making relevant observations, appropriate to the task. They use appropriate methods for collecting first-hand and secondary data, interpret the data appropriately, and undertake some evaluation of their methods.

Candidates present data in ways appropriate to the context. They draw conclusions consistent with the evidence they have collected and evaluate how strongly their evidence supports these conclusions.

**Grade A**

Candidates demonstrate a detailed knowledge and understanding of science content and how science works, encompassing the principal concepts, techniques, and facts across all areas of the specification. They use technical vocabulary and techniques with fluency, clearly demonstrating communication and numerical skills appropriate to a range of situations.

They demonstrate a good understanding of the relationships between data, evidence and scientific explanations and theories. They are aware of areas of uncertainty in scientific knowledge and explain how scientific theories can be changed by new evidence.

Candidates use and apply their knowledge and understanding in a range of tasks and situations. They use this knowledge, together with information from other sources, effectively in planning a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem.

Candidates describe how, and why, decisions about uses of science are made in contexts familiar to them, and apply this knowledge to unfamiliar situations. They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

They choose appropriate methods for collecting first-hand and secondary data, interpret and question data skilfully, and evaluate the methods they use. They carry out a range of practical tasks safely and skilfully, selecting and using equipment appropriately to make relevant and precise observations.

Candidates select a method of presenting data appropriate to the task. They draw and justify conclusions consistent with the evidence they have collected and suggest improvements to the methods used that would enable them to collect more valid and reliable evidence.

**APPENDIX A**

## INDICATIVE CONTENT FOR GCSE SCIENCE AND GCSE BIOLOGY/CHEMISTRY/PHYSICS SPECIFICATIONS

The skills, knowledge and understanding of how science works (paragraph 3.6) should be set in the context of the following four areas of content.

| **Areas of content** *(para 3.7 in the criteria)* | **INDICATIVE CONTENT** |
|---|---|
| **3.7 (i)** | **Organisms and health** |
| a) | To stay alive, organisms need a supply of energy and materials from their surroundings and from the other living organisms there. There is often competition between organisms for resources. |
| b) | Individuals within a species can have characteristics that promote more successful reproduction and rearing. Over generations, the combined effects of changes to genes, environmental changes and natural selection can produce changes within species, and new species. Systematic study of the similarities and differences between species, and classification of organisms, helps understanding of evolutionary and ecological relationships. |
| c) | The nucleus of a cell contains chromosomes that carry the genes and control the cell's activity. In sexual reproduction, each parent contributes half the genes. In asexual reproduction, producing clones, all the genes come from one parent. Genetic modification offers possibilities for treatment of diseases and to produce organisms with particular characteristics. |
| d) | Hormones regulate the functions of organs and cells, for example, the sex organs. Mechanisms, such as blood-clotting or reflex and conscious actions, help safeguard the body. |
| e) | When new medical treatments are devised, they have to be extensively trialled and tested before being used. The human body has defence mechanisms against the harmful effects of micro-organisms. Medical treatments against diseases caused by these include immunisation and antibiotics. The use and misuse of substances, such as solvents, alcohol, tobacco and other drugs, can affect the normal functioning of body systems, affecting mental as well as physical health. |
| **3.7 (ii)** | **Chemical and material behaviour** |
| a) | All chemical elements are made up of atoms which consist of nuclei and electrons. Different elements have different properties that relate to the structure of their atoms. Atoms join in different ways to make compounds. No atoms are lost or made in chemical change. |
| b) | Similar elements or similar compounds react in similar ways. Knowledge of chemical reactions is useful in predicting what will happen in other reactions, and in deciding how to make a new material. |
| c) | All materials are obtained or made from substances in the Earth's crust, sea or atmosphere or from living things, eg oil and plastics, metals, biomass. The production and disposal of materials can have environmental impacts. |
| d) | Materials differ in their properties and so are suitable for different purposes. New materials are developed to meet specific requirements, eg 'smart materials', nanotechnology. |
| **3.7 (iii)** | **Energy, electricity and radiations** |
| a) | Energy transfers can be measured, eg temperature changes, and modified, eg by insulation. Energy use can be costed. The economic and environmental effects of energy use can be compared and evaluated, eg alternative ways of keeping a home at a suitable temperature. |
| b) | Electricity is transferred from power stations to consumers and is widely used because it can readily transfer energy to devices which produce movement, heating, light and sound. |
| c) | Electromagnetic radiation can transfer energy from a source to a receiver or detector through a vacuum. When radiation strikes an object, including living material, some energy may pass through it, some may be reflected and some absorbed. Radioactive materials emit ionising radiation all the time. |
| d) | Radiowaves, microwaves, infra-red and visible light can carry information over large and small distances. Information can be processed to improve the effectiveness of a communication system. |

| **Areas of content** *(para 3.7 in the criteria)* | **INDICATIVE CONTENT** |
|---|---|
| **3.7 (iv)** | **Environment, Earth and universe** |
| a) | Human activity has measurable effects on the whole biosphere. These are due to population, use of resources, industrial processes, and levels of pollution and waste. Understanding of these effects is based on field measurements of biotic and abiotic factors. Planning is needed at local, regional and global levels to manage sustainability. |
| b) | Changes in the outer layer of the Earth result from the movement of tectonic plates. This causes slow changes, such as the position of continents and rapid changes, eg volcanic eruptions. The atmosphere originated from gases escaping from the Earth's interior; it has changed as living organisms have evolved. |
| c) | Exploration of the solar system and the galaxies in the universe can be carried out on the Earth and from space. Current evidence suggests the universe is expanding and that it began with a 'big bang'. |

**APPENDIX B**

**INDICATIVE CONTENT FOR GCSE ADDITIONAL SCIENCE AND GCSE BIOLOGY/CHEMISTRY/PHYSICS SPECIFICATIONS**

The skills, knowledge and understanding of how science works (paragraph 3.6) should be set in the context of the following three areas of content.

| **Areas of content** *(para 3.9 in the criteria)* | **INDICATIVE CONTENT** |
|---|---|
| **(i)** | **Biology** |
| a) | The essential chemical reactions of protein synthesis and respiration are catalysed by enzymes inside living cells.<br><br>Mitosis enables organisms to grow, replace worn out cells and repair damaged tissues. Most animal cells lose the ability to differentiate at an early stage but many plant cells retain it, enabling plants to regenerate from undifferentiated cells in suitable conditions. Animals tend to grow to a finite size whereas many plants are able to grow continuously. |
| b)<br>. | Plants produce biomass by photosynthesis, using carbon dioxide from the air, mineral salts from the soil, and energy from the Sun.<br><br>Energy released during respiration enables processes to take place inside living organisms. As an organism grows, it takes in chemicals and incorporates elements from these into its own body structure. When it dies, it decays and the elements within it are recycled. |
| **(ii)** | **Chemistry** |
| a) | Metals conduct because there are relatively free electrons in a giant structure of atoms. When outer electrons are shared with adjacent atoms, strong (covalent) bonds are formed. This can lead to stable molecules (eg $O_2$, $N_2$) and hard giant structures (eg diamond). Atoms can lose or gain electrons to form charged ions. The attraction between these results in strong giant structures which conduct when molten or in solution. There are also weak forces between molecules (eg $CO_2$, iodine and in nanomaterials). |
| b) | Chemical reactions are of various types, such as oxidation, reduction, neutralisation, precipitation, displacement, polymerisation, electrolysis and thermal decomposition. Reactions can be observed as reversible, and may reach equilibrium. They may also be observed as exothermic or endothermic.<br><br>The theoretical yield of a chemical reaction can be calculated but the actual yield will almost always be less than this. It is important for sustainable development and for economy to reduce waste and to choose reactions with high yield, high atom economy and non-vigorous conditions (ie low energy consumption and dissipation). |
| **(iii)** | **Physics** |
| a) | All forces arise from interactions and come in pairs. Motion, including circular motion, can be described using the concepts of velocity and acceleration. The concept of change of momentum can be used to relate an object's motion to the forces acting on it in a particular situation. Applying forces to objects can cause changes in energy (eg stretching a spring or accelerating a car). |
| b) | Radioactive elements contain unstable atoms that emit radiation from their nuclei as they decay. Some unstable atoms undergo nuclear fission with the emission of a great deal of energy. The nuclei of some atoms can be made to join in the process of nuclear fusion. Fusion is the source of energy release in stars. Background radioactivity originates from minerals in the Earth, from space, and from artificially created radioactive materials. |