Version 1.0

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

General Studies 6761
Specification A

GSA5 Science, Mathematics and Technology

Mark Scheme

2005 examination – June series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Unit 5 Question 1
(GSA5 Science, Mathematics and Technology)

This component is an objective test for which the following list indicates the correct answers used in marking the candidates' responses.

1.1	**D**	**1.11**	**D**
1.2	**C**	**1.12**	**D**
1.3	**B**	**1.13**	**C**
1.4	**B**	**1.14**	**B**
1.5	**C**	**1.15**	**C**
1.6	**D**	**1.16**	**B**
1.7	**A**	**1.17**	**C**
1.8	**A**	**1.18**	**B**
1.9	**D**	**1.19**	**C**
1.10	**D**	**1.20**	**D**

Unit 5 Question 2
(GSA5/2 Science, Mathematics & Technology)

INTRODUCTION

The nationally agreed assessment objectives in the QCA Subject Criteria for General Studies are:

AO1 Demonstrate relevant knowledge and understanding applied to a range of issues, using skills from different disciplines.

AO2 Communicate clearly and accurately in a concise, logical and relevant way.

AO3 Marshal evidence and draw conclusions; select, interpret, evaluate and integrate information, data, concepts and opinions.

AO4 Demonstrate understanding of different types of knowledge and of the relationship between them, appreciating their limitations.

All mark schemes will allocate a number or distribution of marks for some or all of these objectives for each question according to the nature of the question and what it is intended to test.

Note on AO2

In all instances where quality of written communication is being assessed this must take into account the following criteria:

- select and use a form and style of writing appropriate to purpose and complex subject matter;
- organise relevant information clearly and coherently, using specialist vocabulary when appropriate; and
- ensure text is legible and spelling, grammar and punctuation are accurate, so that meaning is clear.

Note on AO4

In previous General Studies syllabuses, there has been a focus on the knowledge and understanding of facts (AO1), and the marshalling and evaluation of evidence (AO3) – on what might be called 'first-order' knowledge. AO4 is about understanding what counts as knowledge; about how far knowledge is based upon facts and values; and about standards of proof – what might be called 'second-order' knowledge.

By 'different types of knowledge' we mean *different ways of getting knowledge*. We might obtain knowledge by fine measurement, and calculation. This gives us a degree of certainty. We might obtain it by observation, and by experiment. This gives us a degree of probability. Or we might acquire it by examination of documents and material remains, or by introspection – that is, by canvassing our own experiences and feelings. This gives us a degree of possibility. In this sense, knowledge is a matter of degree.

Questions, or aspects of them, which are designed to test AO4 will therefore focus on such matters as:

- analysis and evaluation of the nature of the knowledge, evidence or arguments, for example, used in a text, set of data or other form of stimulus material;
- understanding of the crucial differences between such things as knowledge, belief or opinion, and objectivity and subjectivity in arguments;
- appreciation of what constitutes proof, cause and effect, truth, validity, justification, and the limits to these;
- recognition of the existence of personal values, value judgements, partiality and bias in given circumstances;
- awareness of the effects upon ourselves and others of different phenomena, such as the nature of physical, emotional and spiritual experiences, and the ability to draw upon and analyse first-hand knowledge and understanding of these.

GENERAL MARK SCHEME FOR A2 ESSAYS

The essay questions in General Studies A are designed to test the four assessment objectives (see INTRODUCTION above) as follows:

AO1 – 6 marks AO2 – 5 marks AO3 – 7 marks AO4 – 7 marks **Total – 25 marks**

Each answer should be awarded two separate marks, comprising a mark out of 20 for content (Assessment Objectives 1, 3 and 4) and a mark out of 5 for communication (Assessment Objective 2).

The mark for content should be awarded on the basis of the overall level of the candidate's response in relation to the following general criteria and descriptors for each level.

Level of response	**Mark range**	**Criteria and descriptors for Assessment Objectives 1, 3 and 4:** knowledge, understanding, argument and illustration, evaluation.
LEVEL 4	16 – 20 (5)	**Good response to the demands of the question:** sound knowledge of material (AO1); clear understanding and appreciation of topic, nature of knowledge involved and related issues (AO4); valid arguments and appropriate illustrations, coherent conclusion (AO3).
LEVEL 3	11 – 15 (5)	**Competent attempt at answering the question:** relevant knowledge (AO1); reasonable understanding and appreciation of topic, nature of knowledge involved and related issues (AO4); some fair arguments and illustrations, attempt at a conclusion (AO3).
LEVEL 2	6 – 10 (5)	**Limited response to the demands of the question:** only basic knowledge (AO1); modest understanding and appreciation of topic, nature of knowledge involved and related issues (AO4); limited argument and illustration, weak conclusion (AO3).
LEVEL 1	1 – 5 (5)	**Inadequate attempt to deal with the question:** very limited knowledge (AO1); little understanding and appreciation of topic, nature of knowledge involved and related issues (AO4); little or no justification or illustration, inadequate overall grasp (AO3).
LEVEL 0	0	**No response or relevance to the question.**

The mark for communication (AO2) should be awarded using the following scale and criteria.

5 marks	Clear and effective organisation and structure, fluent and accurate expression, spelling, punctuation and grammar.
4 marks	Clear attempt at organisation and structure, generally fluent and accurate expression, spelling, punctuation and grammar.
3 marks	Some organisation and structure evident, variable fluency, occasional errors in expression, punctuation and grammar.
2 marks	Limited organisation and structure, little fluency, a number of errors in expression, spelling, punctuation and grammar.
1 mark	Lacking organisation, structure and fluency, frequent errors in expression, spelling, punctuation and grammar.
0 marks	No response.

Note: A totally irrelevant response (Level 0) should also receive 0 marks for communication. A brief and inadequate response (Level 1) should be awarded not more than 2 marks and a limited response (Level 2) normally not more than 3 marks for communication. Responses at Level 3 and 4 for content may be awarded up to 5 marks for communication.

1 Discuss how science and technology have made intensive farming an efficient way of producing food.

Examine the concerns that have arisen as a consequence.

- Intensive agriculture is the primary subsistence pattern of large-scale, populous societies. It results in a high rate of food production per acre compared to other patterns. Intensive agriculture was originally made possible by **water management** systems and the **domestication of large animals** for pulling ploughs. This allowed farmers to get below the top soil to bring buried nutrients up to the surface.
- Our natural and semi-natural landscapes have been a source both of sustenance and delight for generations yet they are under intense and growing pressure.
- The trend towards **bigger fields** has resulted in fewer hedgerows and trees.
- Increasing **mechanisation** and the use of ever larger machines has brought a dramatic drop in the number of people working in agriculture.
- The availability of commercially produced **fertilizers**, **pesticides** and **herbicides** has made a big contribution to intensive farming.
- **Crop rotation** is a neat way of returning nutrients to the soil by regularly changing the crop grown on a piece of land. Including a legume crop, such as peas or beans, in the rotation helps build up nitrates in the soil because the roots contain bacteria which are capable of fixing nitrogen from the air.
- Farms have become more like industrial factories, with vast single-crop fields, rather than the traditional ideal of a diverse landscape, busy with people and rich in wildlife.
- Britain's flower-rich meadows once provided a rich wildlife habitat but as intensification has progressed some 97% of the country's meadowland has been built over or ploughed up for crop monocultures.
- The transition to intensive farming brought a number of major social changes e.g. permanent settlements, surplus crops sold at market.
- Today, the efficiency of the system has meant that far fewer people are needed to produce the food for everybody else – particularly true of mechanised grain farming and ranching.
- Concerns over livestock may include overcrowding, over-production, reliance on drugs, growth promotion, unwise breeding policies, reduction in the numbers of local abattoirs, early weaning, long journeys, export of live animals, inadequate disease controls, too much politics.
- Concerns over arable/horticultural farming may include agro-chemical inputs, overproduction/overcropping, soil degradation, incorrect use of chemicals, ecology destruction, hedgerow/pond removal, overlarge enterprises controlling land use, subsidies influencing cropping, set-aside, gmf, pollution, too much politics.
- Some would argue that intensive farming in the UK has gone so far against nature that disaster is imminent. Perhaps the fault of cheap food policies practised by successive governments since WWII.

2 The skin is the body's biggest organ.

Explain the function of skin and the scientific principles involved in steps taken to protect it.

- Skin is the covering of the body of a vertebrate. It is loaded with sensors and it has a very tough layered design allowing it to handle abrasion and sunlight.
- A man's skin has an area of approximately 20 square feet (17 square feet for a woman).
- In mammals the outer layer (epidermis) is dead and protective – its cells are being constantly rubbed away and replaced from below. In a life time we shed approximately 40lbs of skin. A new epidermis appears about every 40 days.
- The dead cells are created in the innermost and *living* layer of the epidermis, known as the Malpighian Layer. This is where the sun affects the skin during tanning (basal cells known as melanocytes produce melanin – a pigment that creates the brown of suntanning) and it is where basal cell carcinoma (cancer) starts.
- The lower layer (dermis) contains blood vessels, nerves, hair roots, and sweat and sebaceous glands – it is supported by a network of fibrous and elastic cells in the subcutaneous fatty layer.
- There are erector muscles in each follicle (to make hair stand on end).
- The skin has an important role in warming (through shivering) or cooling the body (through perspiring/sweating).
- Sweat glands are distributed over the whole body in the dermis layer of the skin. When stimulated, the cells excrete a fluid which is mainly water – similar in composition to blood plasma. Sweat has a high concentration of sodium chloride and a low concentration of potassium. It also does not contain the proteins and fatty acids that are normally found in plasma.
- Melanomas are a form of cancer caused by UV radiation damage to melanocytes.
- Sunlight arrives on earth as infrared light (heat), visible light and UV light –
  UVA, known as black light, which causes tanning
  UVB, which causes damage in the form of sunburn
  UVC, which is filtered out by the atmosphere and never reaches earth
  99% of sun's UV radiation at sea level is UVA. UVB causes most of the problems related to sun exposure e.g. ageing, wrinkles and cancer – however, research has implicated UVA as well.
- Sunscreens contain chemicals that absorb UV radiation and turn it into heat instead of letting it reach skin cells, but the melanin is not triggered so there is no tan.
- Sweat produced under the arms is from a different type of gland – apocrine as opposed to ecrine – and does contain proteins and fatty acids – which make it thicker and give it a yellowish colour. Although sweat itself has no odour, bacteria metabolise the proteins and fatty acids to produce an unpleasant odour. Hence, deodorants and antiperspirants are needed for underarms, but not the whole body.
- There may be some discussion of the industry in skin care aimed mainly at women, but there are barrier creams used in certain activities to prevent skin reactions. There may be discussion of the popularity of tattooing and piercing.

3 Explain what is meant by nanotechnology.

Discuss the possible future of this technology and comment upon why its impact on society appears to have provoked so little public reaction.

- A field of science whose goal is to control individual atoms and molecules to create computer chips and other devices that are thousands of times smaller than current technologies permit – in a length scale of approximately 1-100 nm (1000 000 000nm = 1metre). The technology includes integration of nanoscale structures into larger material components, systems and architectures that are used in manufacturing, health care, the environment and national security.
- The creation of tools, materials and machines that will eventually enable us "to snap together the fundamental building blocks of nature easily, inexpensively and in most of the ways permitted by the laws of physics". Described by one scientist as, so far, like building with Lego bricks whilst wearing boxing gloves.
- The timeline of nanotech history usually begins with a talk given by Richard Feynman in 1959 titled "There's Plenty of Room at the Bottom". The next milestone was in 1981 when MIT graduate student, K. Eric Drexler published an article "Protein design as a pathway to molecular manufacturing" followed by his definitive book in 1986 "Engines of Creation".
- We are still at the dawn of nanotechnology and the US government thinks this technology could lead to the next industrial revolution.
- With powerful tools like the **scanning tunnelling microscope** (STM) and processes like **molecular beam epitaxy** (a way to build layered materials by "spray painting with atoms") and brave new materials like **fullerenes,** the potential for innovation is vast.
- Nanotubes may look like a bit of rolled up microscopic chicken wire but this honeycomb lattice of carbon atoms is the stuff of engineers' dreams. Their electrical properties mean that nanotubes can be made into metals or semiconductors depending on how you roll up the sheet of carbon atoms. Roll the carbon the way you roll a cigarette with the edges touching along their length and the nanotube acts like a tiny metal wire conducting electricity. Wind the tube askew, like a paper straw, and you have a miniature semiconductor that could replace silicon transistors, the building blocks of chips.
- Most American cars and many European ones contain nanotubes – 60% of American cars have fuel lines containing nanotubes. Their high conductivity dissipates any electric charge that may build up and generate a dangerous spark as the fuel flows past the nylon walls of the fuel line. The Renault Clio and Megane have nanotubes in their plastic wing panels so conductive that they can be earthed while the car is sprayed with paint droplets charged up to 20 000V – the droplets seek ground instead of floating away – making spray-painting more efficient and less polluting.
- There is a contrast between the way this technology has been received compared to e.g. GMF technology – perhaps due to a perception of hard materials science compared to the emotive area of food science. It may just be a question of relative knowledge awareness and the way the media or pressure groups have treated these areas.

4 The Sony Walkman, the Sony Discman and the Apple iPod illustrate an analogue to digital progression in mobile music listening.

Explain the scientific principles underlying one of these devices.

Discuss how analogue to digital progression has made recorded music more accessible.

- A Walkman was a battery driven tape cassette player with output to audio earphones. A capstan driven by the motor and a pinch wheel move the tape past the heads from one spool to the other. A pressure pad presses the tape against the replay heads (two U-shaped cores) – a wire is wound around each core causing it to act as an electromagnet. When recording, two stereo electric signals are amplified and go to the pair of coils in the head. They produce magnetic fields that magnetize the particles in the tape. On replay, the magnetic particles in each track produce a pair of stereo signals in the coils that go to an amplifier and the earphones to reproduce the sound. The music is accessed serially and the tape can be fast forwarded or fast rewound.
- A CD contains a spiral track of binary codes in the form of sequences of minute pits. The disc is only 12cm across but the track is thinner than a hair and has a length of several kilometres. The disc rotates at a playing speed which varies from 500 rpm at the centre where the track starts to 200rpm at the edge. The linear speed of the disc is constant as it passes over the optical read-out system that decodes the tracks. Left-hand and right-hand stereo sound codes are recorded alternately and the pits also contain codes that control the motor speed and give timings. A system of mirrors and lenses fires a laser beam at the spiral track on the underside of the disc. As the disc rotates the beam moves across the disc from the centre to the edge. A light sensitive photo diode produces on-off code signals. A DAC changes the signal to one that can be amplified to the earphones.
- The Apple iPod is an example of an MP3 device. MPEG compression systems have been developed to fit video and movie data into smaller spaces. A subsystem to compress sound is called MPEG Audio Layer-3, shortened to MP3. This format helps to reduce the number of bytes in a song. The goal of the MP3 format is to compress a CD-quality song by a factor of 10 to 14, losing as little of the CD sound quality as possible. This means songs can be downloaded quickly and occupy a small amount of space. An MP3 device uses solid state memory (the iPod has a microdrive − basically a miniature hard disc typically 10 gigabytes in size) instead of a physical medium like a tape or a CD. The player pulls the song byte by byte from memory, decompresses the MP3 encoding, runs the decompressed bytes through a DAC and amplifies the analogue signal to earphones. The player plugs into a computer's USB port, firewire port or parallel port to transfer data. A CD collection can be converted into MP3 format by using Ripper and Encoder software. An iPod can store 2000 songs in a 6.5 ounce device with a battery that gives about ten hours of uninterrupted play.
- Many candidates will be able to bring their personal experiences of making their own CD, using a midi synthesiser or mixing their own tracks to this question and may be band members or disc jockeys. They may be able to give a convincing account of how large a part music plays in their lives and how digital devices have made music accessible to them and their friends.

5 Explain the concept of biodiversity.

Discuss whether the initial loss of a small number of species would ultimately lead to mass extinction.

- Biodiversity is a shorthand for the extraordinarily rich abundance of life on earth. A label for both the unbelievably diverse range of species and the ecosystems within which they live.
- With nuclear weapons, humanity now has the power to destroy life on earth, but we don't really need nuclear weapons for this task – we are already destroying species simply by practising our everyday lifestyles. Our population and rate of resource consumption are growing and causing increasingly serious problems of pollution and habitat destruction.
- Why is biodiversity so important? Surely we can afford to let a few thousand more species become extinct: after all, extinction is a natural process? True, but the scale and speed of extinction today is on an unprecedented level. It is 1000 to 10000 times faster than the natural rate. It is predicted that we may lose 10 to 20 percent of the species alive today in the next fifty years.
- The relationships between human activity and biodiversity are often subtle and complex.
- Some ecosystems have almost entirely disappeared e.g. the tall grass prairies of north America. Forests which covered 40 percent of the earth's land surface now cover just 27 percent. Rainforests are particularly rich in ranges of different species.
- One third to one half of the earth's land surface has now been altered by human activity of one sort or another – the notion of "wilderness" is becoming outmoded.
- Many scientists think we are now witnessing a spasm of extinction – a mass extinction event – the greatest since the dinosaurs were wiped out c65 million years ago.
- As global climate change shifts temperatures across the planet, species may not be able to adapt quickly enough. According to UNEP species will have to migrate 10 times as fast as after the last ice age. Many won't make it! Species that do up and move will move at different rates breaking up existing communities.
- After habitat destruction the biggest threat to biodiversity is invasion by alien species – these have arrived mainly by trade, tourism and biocontrol e.g. the Galapagos Islands now has almost as many introduced species as native ones.
- Biodiversity is good for humans and by destroying it we could bring the axe down on our own heads. Rural communities in more than 60 countries get much of their meat from wild animals. Overpopulation, famine and the spread of high powered rifles are killing off these creatures e.g. in the Congo, conflict has put pressure on antelopes, gorillas and chimpanzees. This bush meat trade is growing very fast.
- Fewer species will mean fewer potential medicines. Three quarters of the top 150 prescription drugs in the USA are lab versions of chemicals found in plants, fungi, bacteria and vertebrates. The WHO estimates that more than 60% of the world's population relies on plants for primary healthcare.

6 Discuss ways in which the study of mathematics is critical to the growth of a thriving technological society.

- "Mathematics is the door and the key to the sciences" – Roger Bacon in 1266 illustrates the importance of mathematics to sciences and hence technology.
- Mathematics has often been considered as either the servant or the queen of the sciences. Indeed mathematics may be defined as the science of spatial and mechanical relationships.
- Prehistoric human beings probably learned to count to at least ten on their fingers. The Chinese, Hindus, Mayans, Babylonians and Egyptians all devised methods of counting and measuring that were of practical importance in their everyday lives. Pythagoras established geometry amongst the Greeks. Our present decimal numerals are based on a Hindu-Arabic system that reached Europe about AD 200.
- Pythagoras found a basic relation between musical harmony and mathematics. This led to the view that not only the sounds of nature but all its characteristic dimensions must be simple numbers that produce harmonies. For the Pythagoreans, the movements of the heavens were the music of the spheres. The Babylonians built the Hanging Gardens and then Egyptians built the pyramids because these two cultures realised that there is a builder's set square in which the numerical relations dictate and make the right angle. Pythagoras raised this knowledge out of the world of empirical fact and into the world of mathematical proof in about 550BC.
- The pre-eminence of astronomy was due to the fact that observed motions of the stars turned out to be calculable and from an early time lent themselves to mathematics. The progress of physics and more recently biology has hinged equally on finding formulations of their laws that can be displayed as mathematical models.
- During the Dark Ages, the Moslem empire stretched from Spain to the borders of China and India and was responsible for the spread of many ideas. One of the Greek ideas that the Moslems elaborated and spread was the astrolabe – a primitive observational device which, when coupled with star maps, could carry out an elaborate scheme of computations that could determine latitude, sunrise and sunset, the time for prayer and the direction of Mecca. For a long time the astrolabe was the pocket watch and the slide rule of the earth.
- Western mathematics began to develop from the fifteenth century when geometry was revived by the coordinate geometry of Descartes; Pascal and Fermat developed probability theory, John Napier invented logarithms, Isaac Newton and Gottfried Leibniz developed calculus. In Russia, Lobachevsky developed non-Euclidean geometry which was taken further by Georg Riemann and later used by Einstein in his relativity theory.
- The electronic computer is a powerful mathematical tool which can create and manipulate mathematical models of systems in science, technology and commerce.
- Mathematics is the most elaborated and sophisticated of the sciences including the logical idea of proof, the empirical idea of exact laws of nature, the emergence of the concept of operations and the movement from a static to dynamic description of nature.
- Candidates may come up with many modern versions of the astrolabe as illustrations of a thriving technological society.