A-LEVEL
BIOLOGY

7402/2 Paper 2
Report on the Examination

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General Comments

This exam paper proved very effective in terms of producing a wide distribution of marks. Most of the questions on this paper were very good discriminators, enabling the best students to fully display their skills across the full range of assessment objectives. There were some exceptional responses with students displaying an excellent understanding of the assessed content. As in previous years, at the lower end of the distribution there was little evidence of progression beyond GCSE. It was pleasing to note that many of the two-mark questions, including some of the calculations, were very effective discriminators. Compared with last year, there were fewer questions omitted by students and fewer questions where the percentage of students obtaining maximum marks was very low.

There was little evidence of any general misinterpretation of questions although in questions 09.2, 10.3 and 10.5 some students did not focus on the main points required. Compared with last year, there was an improvement in the overall performance on questions related to the assessment of practical skills. This was slightly surprising considering the advanced information provided last year. Nevertheless, this supports the view that the paper this year was more accessible.

Similar to last year, the incorrect use of abbreviations caused problems for students. Abbreviations for biological terms and chemical compounds are only accepted in answers when they are also used in the specification. The distal convoluted tubule and phosphocreatine are not abbreviated in the specification. Consequently, DCT and PCr were not accepted this year unless the full name was also provided in the answer. Another perennial problem was the imprecise use of scientific terminology preventing some students from accessing some marking points. This was particularly evident in questions 02.1, 05.1, 10.3, 10.5 and questions assessing AO3. Examiners also commented on there being far more examples of poor handwriting this year making it very difficult to assess the responses provided by some students.

Question 1

01.1 This question was a very good discriminator. Approximately 30% of students obtained maximum marks and 66% at least three of the four marks available. Almost 97% of students obtained at least one mark, invariably by referring to the drawing of a pencil line on the chromatography paper. Weaker responses often confused the chlorophyll solution with the solvent, adding chlorophyll solution to the beaker and a dot of solvent to the origin. The solvent and chlorophyll solution were sometimes mixed together and applied to the origin or poured into the beaker. Water was occasionally used instead of solvent **A**. However, most students did indicate that the chlorophyll solution should be added to the paper at the pencil line. Fewer students clearly indicated that the level of the solvent should be below the pencil line (mark point 3) or that the paper should be removed before (or immediately when) the solvent reached the top of the paper.

01.2 Despite 61% of students failing to obtain a mark, this question was still an effective discriminator. Nevertheless it was surprising that many students, who could describe some details of paper chromatography in question 01.1, were unable to explain why different pigments separated during paper chromatography. Students who did appreciate that pigments can have different solubilities in different solvents invariably obtained both marks. Acceptable alternatives for solubility occurred less frequently, eg ‘dissolves’, ‘affinity’ and ‘polarity’. There were a few detailed explanations which included reference to the ‘mobile’ and ‘stationary’ phases. Very few students obtained one mark, which was awarded when

the response referred to solubility 'in solutions' rather than 'in solvents'. Students who did not obtain a mark often stated that solvent **B** was 'stronger' or 'more concentrated' than solvent **A**. Other common incorrect responses included the pigments having different wavelengths or the chlorophyll being 'more digested/hydrolysed' by solvent **B**.

Question 2

02.1 This question was an excellent discriminator even though only approximately 7% obtained maximum marks and 30% scored zero. Many students could recall some details of synaptic transmission but failed to gain marks due to the use of imprecise terminology and/or the omission of key words. Students often referred to calcium ions being prevented from entering the 'synapse' or 'presynaptic membrane' rather than the synaptic knob or presynaptic neurone. Although many students appreciated that calcium ions cause synaptic vesicles to move to the presynaptic membrane, many failed to mention that no/less glutamate would be released or stated that the release of vesicles was prevented. However, the diffusion of (no/less) glutamate across the synaptic cleft/gap was often credited in better responses. A significant number of students omitted 'receptor' and/or postsynaptic 'membrane' making mark point 4 inaccessible. Similarly, some students referred to sodium ion channels opening but did not refer to (no/less) sodium ions entering. Consequently, only one in five students obtained at least four marks and only 55% at least two marks of the five marks available.

02.2 Approximately 12% of students obtained both marks and 55% at least one mark for this question. Although many students realised that the drug would be hydrolysed or digested if taken orally, far fewer students referred to enzymes or to the effect of acid on the drug. However, when enzymes were named they were mostly correct. Similarly, there was an appreciation that injecting into the cerebrospinal fluid would be 'quicker' or 'more direct' but many students omitted a reference to synapses or the spinal cord. Only rarely was it mentioned that the drug (molecule) may be too large to be directly absorbed.

02.3 It was pleasing that this calculation proved to be an effective discriminator. Almost 50% of students obtained both marks and approximately 13% of students obtained one mark. Answers that only gained one mark were mainly as a result of carrying out the correct calculation but without the correct order of magnitude (eg 47 232) or omitting to multiply by 24 (ie 1.968×10^{-6}). A common error was to just multiply 3×10^{-9} by 82 to give 2.46×10^{-7}, without taking the 8 days into account. Sometimes 82 was divided by (24×8) before multiplying by 3, or 3 was divided by $(82 \times 24 \times 8)$.

02.4 The majority of students, 80%, obtained at least one of the two marks available for this question. The most frequently credited responses referred to the subjectivity of pain sensitivity or pain tolerance and the need to have a (valid) comparison. Some students stated 'to determine if the results were significant', without any reference to 'difference'. These responses were not credited. Other frequent incorrect responses included to determine the accuracy or reliability of the results.

Question 3

03.1 This was another two-mark calculation which was an effective discriminator. Approximately 70% of students obtained at least one mark and 40% both marks. The answer of 11.95 was most frequently given to gain two marks. Only rarely was this rounded to 12.

A common response to gain one mark was 1195. In terms of alternatives for one mark, 1.05 was more often awarded than 13. Two correct figures for the two stores, 13 and 1.05, were sometimes incorrectly subtracted to give 11.5. Occasionally 1.05 and 13 were added together, rather than subtracted, to give 14.05, or divided to give 12.4. Common incorrect answers included 1300 + 105 = 1405 and 105 – 13 = 92.

03.2 This five-mark evaluation question proved to be an outstanding discriminator, which produced some excellent responses, sometimes including all the alternatives on the mark scheme. However, approximately 21% of students failed to gain a mark. Often these responses simply described the results with no reference to whether there was a significant difference between any of the results. Some of these responses referred to the length of the error bars without any reference to overlap or no overlap. Others considered the error bars to represent the range in the results. In terms of correctly interpreting **Figure 2**, the most frequently obtained marks were for noting the significant difference between **P** and **Q** and the converse between **R** and **S**. Invariably, these students gained mark point 4 for explaining what overlap or no overlap of standard deviations indicated in terms of a significant difference. Fewer students gained mark point 3 for outlining the significant difference in production between **S** and **Q**. It was pleasing to note that far fewer students referred to 'results being significant' or 'results not being significant' compared with previous years. Some students included some irrelevant details such as comparing (**R** and **S**) with (**P** and **Q**). In terms of the design of the investigation, the most frequently awarded marks related to using only tomatoes (one crop species) and only one species of mycorrhiza. Better responses often referred to the use of sterile soil, the investigation being done in greenhouses or the importance of a large sample size. However, these responses had often already exceeded maximum marks. Approximately 15% of students gained maximum marks and 58% at least three of the five marks available. Answers frequently referred to 60 days not being long enough for this investigation, which was not credited.

03.3 This question was not a particularly effective discriminator. Approximately 50% of students obtained at least one mark and 12% both marks. There was certainly considerable confusion and some alarming misconceptions in the weaker responses. A significant number suggested that sterilisation would remove nutrients or ensure that the nutrient concentration or pH would be standardised. Several responses suggested that pesticides would be removed rather than pests. A common response, not credited in isolation, was that 'harmful bacteria' would be removed. Common correct responses included the removal of other mycorrhizae/fungi, pests, pathogens and removing competition. Far fewer students referred to the removal of specific groups of bacteria (eg nitrogen-fixing) or the removal of seeds/spores.

03.4 This question was also not a particularly effective discriminator. Approximately 80% of students obtained at least one mark and 25% both marks. The most accessible mark point related to (crop) production/growth/mass being affected (if the recommended concentration of fertiliser was not used). The idea that mycorrhizae/water would be the only variable or that the same concentration of fertiliser would be used (an alternative for the same mark point) was also frequently credited. However, although the other mark points were credited, they appeared far less frequently. A very common incorrect response was that using too much fertiliser could lead to leaching and/or eutrophication, the students not realising that the tomatoes were grown in pots in greenhouses. Other frequent responses not credited included reference to 'a fair test' or 'the plant being killed'.

Question 4

04.1 Considering this was a one-mark question, it had a high discrimination index. Approximately 58% of students correctly named the type of gene interaction as epistasis or epistatic. Common incorrect answers included codominance and epigenetics.

04.2 This question was not an effective discriminator. Over two-thirds of students correctly identified the phenotype. Students who did not obtain this mark frequently omitted to include 'female' in the phenotype.

04.3 This question incorrectly included 'Phenotype' rather than 'Genotype' in the genetic diagram. Consequently, extensive monitoring of the answers provided by students was carried out at the standardisation meetings, during sampling and throughout the marking of this question. There was no evidence that this error adversely affected students. Nevertheless, the mark scheme accepted correct genotypes and phenotypes irrespective of which answer lines they were placed on the genetic diagram. In the published version of the question paper, the error has been corrected.

Despite 44% of students obtaining all three marks, the question was still a very good discriminator. Approximately 28% of students obtained two marks; these students omitted the sex of the offspring or included the sex in the phenotype but combined 'male white' and 'female white' when determining the ratio of the offspring. These errors resulted in a 2:1:1 phenotypic ratio rather than 1:1:1:1. Approximately 8% of students obtained one mark by providing the correct gametes but then failing to complete a correct genetic cross.

04.4 Although an effective discriminator, it was disappointing that approximately 70% of students did not gain a mark. Approximately 22% obtained both marks, most frequently for 0.8 and occasionally for 80%. The most common error was to assume that p or p^2 was 36% or 0.36. A minority of students gained one mark by correctly indicating that q^2 (or ff) = 64%. However, they then carried out an incorrect calculation or calculated the frequency or percentage of heterozygotes in the population.

Question 5

05.1 In terms of students obtaining maximum marks, this question proved to be the most demanding on the exam paper. Only 2.6% of students gained all three marks. Approximately two-thirds of students gained at least one mark, usually for indicating that cones are involved in colour vision. Unfortunately, this mark point was often negated when students referred to red/green/blue cones, ie omitting the term 'sensitive'. Some students incorrectly suggested that rods are involved in colour vision. Mark point 2 was rarely achieved. Students did not refer to different wavelengths being absorbed but instead referred to different colours being absorbed. Several students incorrectly suggested that the pigments in the different photoreceptors were blue, green, and red in colour. References to photosynthetic rather than photoreceptive pigments also appeared. Despite there being several alternatives for mark point 3, far fewer students obtained this mark than expected. Some responses just stated that both red-sensitive and green-sensitive photoreceptors were stimulated but without any mention of absorption or the relative amounts. There were also incorrect references to the absorption of red light and green light, or colours merging to produce orange. Although impulses being sent to the brain was mentioned, the idea of more from red-sensitive photoreceptors than green-sensitive photoreceptors was often

omitted. Reference to blue/green/red photoreceptors, ie omitting 'sensitive', was also penalised here if this had not been previously disqualified.

05.2 Approximately 59% of students correctly identified the statement associated with high sensitivity to light in the retina.

05.3 This five-mark question proved to be one of the most effective discriminators on the exam paper. Approximately 21% of students gained maximum marks and 82% at least one mark. Most responses focused on allopatric speciation. A minority of students referred to sympatric speciation but did not relate this to the overlap in distribution, or referred to the overlap but not sympatric speciation. Most students obtained a mark for 'mutations' although this was occasionally disqualified when students suggested that changes in the environment caused the mutations. Many students gained mark point 2 for associating allopatric speciation with isolation/separation. Fewer students obtained mark point 1 for linking geographical isolation with different altitudes. Many students suggested that geographical isolation was due to rivers, floods, earthquakes and, most frequently, mountains. Most students referred to reproductive isolation or the separation of gene pools, but only better responses indicated that this was due to different species of pollinators/distributions/altitudes. However, the mark points for different environments (or selection pressures), change in allele frequency and different species no longer producing fertile offspring were awarded on a more regular basis. Consequently, 36% of students achieved at least four marks and 52% at least three marks on this question. Interestingly, several students suggested that differences in oxygen concentrations at different altitudes would act as a selection pressure. Weaker responses often simply repeated the information in the stem concerning the different pollinators and the different distributions of the flower species. These responses often included irrelevant information such as the wavelengths of light used for photosynthesis, cone cells of the pollinators, succession, crossing over and random fertilisation.

Question 6

06.1 This was another extremely effective discriminator even though only 11% gained all three marks and 58% at least one mark. The most frequent correct responses referred to microvilli providing a large surface area and to many mitochondria producing ATP for active transport. Some responses referred to the types of transport proteins in the cell-surface membrane but did not include their roles. When the roles of carrier/channel/co-transport proteins had been described, only the better responses suggested that 'many' of these proteins would be present. Although the omission of 'many' was only penalised once, this proved to be a very effective discriminator. The weakest responses did not relate to features of the cells but to the proximal convoluted tubule itself, for example "one cell thick", "good blood supply". There was also the usual confusion between microvilli and villi, with features of the latter being described.

06.2 Considering this was a one-mark question, it proved to be a very good discriminator. Approximately 42% of students correctly referred to the collecting duct and distal convoluted tubule. A few students used 'DCT' which is not an acceptable abbreviation as it is not used in the specification. Many incorrect answers correctly included the collecting duct, but then referred to a variety of incorrect structures. In order of descending frequency, the parts of the nephron incorrectly named were the loop of Henle, the descending/ascending limb, proximal convoluted tubule, glomerulus, medulla and cortex. The weakest responses referred to axons, neurones and cellular structures. Approximately 9% of students omitted this question, the highest percentage on this exam paper.

06.3 This question proved to be very accessible and a very good discriminator. Approximately 50% of students gained both marks and 35% gained a single mark. Students who obtained one mark often did so by referring to 'complementary structures' rather than 'tertiary structure/shape'. However, these students also included those who had been penalised for referring to 'active site', 'substrate', etc, indicating a lack of understanding. It was pleasing to note that, this year, far fewer students made such errors compared with previous years.

06.4 Rather surprisingly, this three-mark question proved to be the second most effective discriminator on the exam paper. Only 10% of students obtained maximum marks, almost 20% obtained two marks and 28% one mark. The most frequently awarded mark point was for stating that ADH increased the (re)absorption of water. Several students provided extensive (unnecessary) details of this process, including the role of enzymes and aquaporins. Students often stated that the blood pressure would increase but most did not link this to an increase in blood volume to gain mark point 3. The reference to blood pressure in the question was used by some students to include irrelevant details on how the heart affected blood pressure. However, most disappointing was that very few students correctly named the location of the blood pressure receptors. The hypothalamus and pituitary gland were very common incorrect responses. In the case of the hypothalamus, students were most likely thinking about osmoreceptors. Other incorrect locations included the medulla, brain, liver, pancreas and the Pacinian corpuscle.

Question 7

07.1 Again it was surprising how effectively this two-mark recall question performed as a discriminator, especially as 87% of students obtained at least one mark and 40% obtained both marks. Most students realised that 'abiotic' was one of the required biological terms, closely followed by 'community'. Fewer students indicated that 'niche' had been omitted, with 'habitat' or 'population' as common incorrect responses. However, it was recalling the term 'carrying' (capacity) which caused most difficulty for students. Many students suggested the missing term was 'maximum', with climax, population and ecosystem also suggested.

07.2 This question was a rather poor discriminator, the least effective on the exam paper. Approximately 69% of students obtained both marks and 96% at least one mark. The most frequent correct answers related to conserving species and habitats. References to rainforests removing carbon dioxide and providing oxygen were also common responses. The importance of rainforests in terms of tourism and as a source of medicines occurred less frequently. Reducing soil erosion and eutrophication were very rarely mentioned.

07.3 Approximately 80% of students obtained at least one mark for this question, however only 5% obtained all three marks. Nevertheless, it was an effective discriminator. Many students considered the inability to digest certain foods and the removal of faeces as separate mark points. A significant number of students incorrectly referred to faeces as an excretory product. The mark scheme required the loss of heat energy to be linked with respiration, which made this mark point inaccessible to most students. Weaker responses included vague statements such as 'energy is lost in waste' and displayed little progression from GCSE. Some students included photosynthesis and decomposition as sources of energy loss.

Question 8

08.1 Approximately 15% of students obtained all three marks and 54% obtained at least two marks for this question. Most students were able to obtain mark point 3, for explaining that a tumour developed due to rapid/uncontrollable cell division. This resulted in only 8% of students failing to obtain at least one mark. Many students also realised that a mutation had occurred, although a significant number referred to epigenetic changes. Others simply repeated the information in the stem, ie an alteration in the *KRAS* gene had occurred, without further qualification. Mark point 2, relating to the K-Ras protein, caused problems for a significant number of students. Many of these students suggested that no protein or a non-functional protein was produced. Other misconceptions included the protein causing the formation of the oncogene, or the oncogene being formed instead of the protein. The uncontrolled cell division was sometimes outlined as the cause of the mutation. Weaker responses also referred to changes in the amino acids in the gene rather than in the protein. The best responses displayed an excellent understanding of the processes involved, referring either to changes in the K-Ras protein or to the production of more K-Ras protein causing the tumour to develop.

08.2 Despite showing a good distribution of marks, this five-mark question did not discriminate as effectively as expected. Approximately 9% of students obtained maximum marks and 94% at least one mark. The mark points relating to interpreting the data on the mean survival time of CRC patients proved accessible to most students. Consequently, 54% of students obtained at least three marks. The most frequent mark awarded was that group **B**/metformin had the highest survival time, followed by group **A**/untreated having the lowest survival time. Using the probability values from the statistical test to determine whether the differences were significant proved to be more challenging for many students. However, compared with previous years, students did show a better understanding of probability values. The best responses recognised that groups **A** and **B** showed a significant difference in survival time (compared with the control) and that group **C** showed no significant difference. Sometimes only the significance of the difference for **A** or **B** was given, preventing the awarding of mark point 4. Although some students did refer to 'results being significant/not significant', most then qualified this statement by indicating if the results were higher or lower, and therefore were not penalised. Common misconceptions relating to probability included 'the higher the probability value, the higher the significance' and referring to differences in results being valid rather than significant.

Question 9

09.1 All parts of question 9 proved to be excellent discriminators. It was surprising that only two-thirds of students were able to obtain at least one of the two marks available for this question. Usually, this was for identifying restriction endonuclease/enzyme as the enzyme required to remove STRs from a sample of DNA. Incorrect responses included reverse endonuclease, DNA endonuclease, reverse transcriptase, DNA helicase, DNA polymerase, DNA ligase and RNA polymerase. Approximately 28% of students gained both marks by indicating that the DNA would be cut at a specific base sequence or recognition/restriction site. A few students referred to palindromic sequences. A significant number of students did not obtain this mark as they only stated that the enzyme cut the DNA at a 'specific site'. Weaker responses referred to the enzymes being complementary to a base sequence. There was considerable variety in responses scoring zero. Common errors included the use of heat, electrophoresis, DNA probes, fluorescent gene markers, PCR and splicing.

09.2 Approximately a third of students gained both marks and 54% obtained at least one mark. It was evident that some students had not focused their responses on knowing the base

sequences for the process of PCR. These students often stated that the base sequence was required to identify which restriction enzymes (or incorrectly named enzymes) were needed to cut out the STRs. Some students suggested that the base sequence was needed to identify which probes could bind or referred to promoter regions, or to start and stop codons. Some students, who realised that PCR was involved, suggested that knowing the base sequence enabled the correct DNA nucleotides to join to form a complementary strand during DNA replication. Students gaining a single mark usually did so for referring to primers. Unfortunately, some students simply stated they were complementary without any reference to base sequence. Students gaining mark point 2 often referred to the complementary base sequence and to primers providing a starting sequence for DNA/Taq polymerase. Very few students mentioned that primers prevented the DNA strands from re-joining.

09.3 It was pleasing that this two-mark calculation had a high discrimination index. Approximately 34% of students obtained both marks and almost 7% one mark for showing working which included 2^{50}. Many incorrect responses included 12^{50} in the calculation. Other common errors included using 4^{50}, 24^{50}, 12×50^2, $12 \times 50 \times 4$, $12 \times 50 \times$ (a variety of other numbers, for example 2, 4, 50).

09.4 This question was an excellent discriminator. A third of students obtained both marks and a third one mark. Many students referred to differences in length/mass for one mark. Few students included the alternative, ie number of nucleotides/repeats/bases for the same mark point. The mark for (negative) charge was awarded less frequently. The best responses highlighted the negative charge of the phosphate groups in DNA. There were also valid references to polarity. Some students incorrectly referred to a positive charge or referred to the charge on R groups or amino acids. The reference to amino acids rather than bases/nucleotides was evident in weaker responses. Incorrect features of STRs mentioned included sticky ends, hydrogen bonding and solubility.

Question 10

10.1 Apart from 10.2, all parts of question 10 were excellent discriminators. Approximately 46% of students gained both marks for this question and 72% at least one mark. Many students obtained a mark for the role of ATP in breaking (or forming) actinomyosin bridges. Unfortunately, quite a few students referred to myofibril rather than myosin, negating this mark point. Some responses omitted actin, simply indicating that myosin was removed from the myosin binding site. However, it was pleasing to note that few students used the term ‘active site’ for ‘binding site’. The movement or change in shape of the myosin head was also awarded on a regular basis. However, several students omitted any reference to (myosin) ‘head’ (or ‘arm’), making this mark point inaccessible. Weaker responses included incorrect statements concerning the interaction between ATP, calcium ions and tropomyosin. Better responses included details relating to the movement of actin filaments for mark point 3. The role of ATP in the active transport of calcium ions was less often included.

10.2 Approximately 28% of students obtained the mark for this calculation.

10.3 This question was a very good discriminator despite only 11% of students obtaining all five marks and 78% obtaining at least one mark. A significant number of students did not relate the different types of muscle fibres to different types of exercise limiting their maximum to three marks, which was achieved by 42% of students. However, there was considerable variety in the combination of mark points awarded to students. Only a minority of students

related the wrong type of exercise to the type of fibre. Students frequently associated the type of muscle fibre with aerobic or anaerobic exercise which was not part of the required explanation. Approximately 60% of students obtained at least two marks, often by indicating that creatine is used to form phosphocreatine. Fewer of these students provided sufficient detail on how phosphocreatine is used to form ATP. Abbreviations for phosphocreatine are not in the specification and should not be used in examinations. However, the most frequently awarded mark was for the use of glucose in respiration. Better responses included the storage of glucose as glycogen, although starch as the storage compound was also encountered. Weaker responses confused glycogen with glucagon and the terms glycolysis, glycogenolysis, glycogenesis and gluconeogenesis. These weaker responses often included lots of irrelevant details on muscle contraction, digestion of carbohydrates or the action of insulin and glucagon.

10.4 Although only 10% of students obtained all three marks and 64% at least one of the marks, this question was a very effective discriminator. The most frequently awarded mark was for the use of glucose or fatty acids in respiration to produce ATP. However, weaker responses often stated 'respiration provided energy' which was not sufficient. The second most frequently awarded mark point was for glucose entering (muscle) cells. Again, several students did not provide sufficient detail, eg only stating that glucose entered the cell-surface membrane or referred to glucose entering the blood. Only better responses included reference to the process involved in moving glucose or fatty acids across a membrane. However, the least accessible mark point was the use of fatty acids in the Krebs cycle which was often only referred to in responses which had already achieved the maximum three marks. A significant number of students described fatty acids entering mitochondria and being converted to glucose and then being used in respiration.

10.5 This question was the most effective discriminator on the exam paper. It was also pleasing to note that, considering it was the last question on the exam paper, only 2% of students omitted this question. The most frequently awarded marks were mark point 1 for chemoreceptors and mark point 4 for SAN. However, only 68% of students achieved at least one mark and 55% at least two marks in this question. Unfortunately, some students having referred to chemoreceptors then stated that they detected an increase in pH. Several students suggested that chemoreceptors sent 'an impulse' to the cardiac centre rather than 'impulses'. As outlined in the mark scheme and the examiner's report when this topic was last assessed, 'an impulse' is incorrect. Students referring to 'signals' or 'messages' were also penalised, but only once, for either mark point 2 or mark point 3. Only the best responses included references to the frequency of impulses for mark point 4. A significant number of responses referred to how the heart beat is coordinated or how a high concentration of carbon dioxide was produced.

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Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.