BIOLOGY

Paper 9700/01
Multiple Choice

Question Number	*Key*	*Question Number*	*Key*
1	**B**	21	**A**
2	**A**	22	**A**
3	**A**	23	**B**
4	**A**	24	**C**
5	**C**	25	**C**
6	**B**	26	**D**
7	**B**	27	**A**
8	**B**	28	**C**
9	**B**	29	**C**
10	**A**	30	**B**
11	**A**	31	**D**
12	**D**	32	**A**
13	**D**	33	**C**
14	**B**	34	**A**
15	**C**	35	**B**
16	**B**	36	**A**
17	**A**	37	**B**
18	**B**	38	**B**
19	**D**	39	**D**
20	**C**	40	**D**

General comments

The mean score was 25.9 (65%) and there was a very good spread of scores, the standard deviation being 7.6. Four questions were answered correctly by 80% or more of candidates – **Questions 5, 8, 17 and 39**. Only three questions proved difficult with 40% or fewer candidates answering correctly – **Questions 21, 24,** and **27.**

Comments on specific questions

Question 2

From practical experience, candidates should know that plan diagrams do not show individual cells or cell contents.

Question 4

The relative difficulty of this item might be due to lack of practical experience in using eyepiece graticules. The candidates needed to calculate the actual size of the eyepiece graticule in micrometres and then measure the size of the pollen tube and divide by four in order to get the growth rate per hour.

Question 6

Although this question is presented in an unusual format, many candidates were able to correctly answer it. However, a significant number of less able candidates thought that the polymer could be broken down by dissolving in water.

Question 7

Many weaker candidates were confused about the structural features of cellulose, collagen, glycogen and triglyceride.

Question 8

The structure of amylopectin was well understood by most candidates.

Question 10

Although covalent bonds are found in the primary and tertiary structure of proteins, only the primary structure would remain unchanged when the protein is treated with urea. All other bonds in the tertiary structure would be broken.

Question 12

Only the more able candidates knew that β glucose was the break down product of cellulose.

Question 13

Only the more able candidates realised that all three statements described ways in which enzyme catalysed reactions could be regulated.

Question 14

Apart from cholesterol, the fluidity of the cell surface membranes is controlled by the degree of saturation of the fatty acid tails of the phospholipid molecules.

Question 16

A large number of weaker candidates thought that facilitated diffusion was the answer. In facilitated diffusion, molecules are still able to pass through the cell surface membrane, but do so through special proteins. Molecules that are too large to pass in move by endocytosis.

Question 21

Only the more able candidates realised that from the piece of double-stranded DNA containing 120 nucleotides, only one strand of 60 nucleotides is used for transcription and translation.

Question 22

Although most candidates realised that uracil should be in the answer; many only gave the mRNA codon, not the tRNA anticodon.

Question 24

Many candidates found this question difficult. The amount of hormones detected is dependent upon the cell surface area, because this will determine the number of glycoproteins and glycolipids which are detectors for hormones.

Question 25

Whilst the majority of candidates knew the relative positions of the phloem and xylem in the roots and stem, they were unsure of the positions in the leaf. This may be due to lack of practical experience in studying slides using the light microscope.

Question 27

A surprising number of candidates incorrectly thought that carbon dioxide combines with haemoglobin to form carboxyhaemoglobin.

Question 31

Many weaker candidates confused the tidal volume with the vital capacity.

Question 34

Although this question was presented in an unusual format, candidates answered it well.

Question 37

Less able candidates did not appreciate that the only correct statement was **B**. The second exposure to the antigen probably occurred at day 22 or 23, certainly not day 24.

Question 39

Only just over half of the less able candidates could correctly match the definitions to the terms community and population.

BIOLOGY

Paper 9700/02

AS Structured Questions

General comments

There were many encouraging responses to all 6 questions from the well prepared candidates, with good use made of previous papers and their mark schemes. Disappointingly there were some low scores from some candidates (and sometimes Centres), and even the most able candidates occasionally had some difficulty with **Questions 2(b), 2(c), 3(b), 4(c)**, **5(d)** and **6(d)**, often where they were required to produce extended prose in answer to a question. Difficulties with **Questions 2(b)** and **2(c)** may be linked to a lack of practical experience, whilst those encountered in **Question 4(c)** were often centre-specific.

As in previous sessions, candidates continue to lose marks by not using their biological knowledge to answer the actual question set. For example, in **Question 2(c)**, candidates were asked to "explain" not "describe" the results of the enzyme investigation shown in Table 2.

Again, in answer to **Question 3(b)**, candidates were asked to outline what happens to a chromosome between the end of anaphase and the start of the next mitosis, not describe all the events of telophase and interphase including references to nuclear membranes and even cell walls.

Other candidates were far too imprecise in their answers; for example, in **Question 3(a)(ii)**, where candidates were asked to state the role of the centromere. Many referred to the centromere as the site of the attachment of the spindle rather than a spindle fibre/microtubule.

Again, in **Question 3(c)**, candidates were required to state what happens to the chromosome number during egg formation and explain why the change is necessary. Many in their explanation referred to the maintaining of genetic stability or the need to restore the correct number in the next generation rather than, for example, referring precisely to the need to restore the diploid number at fertilisation / avoid chromosome number doubling in each generation.

Candidates should be aware of the significance of the use of bold type face in questions, for example, **Question 3(b)** referred to a **chromosome** - not a nucleus or cell, whilst **Question 5(b)** required an explanation of the antibody concentrations in person **A** only – not persons **A** and **B**.

Candidates should try and write within the lines of the paper and take note of the mark allocation. Many were using all the available blank pages and spaces at the sides and bottoms of pages to elaborate on their answers as, for example, in **Questions 2(c)** and **4(b)**.

There were two common misinterpretations of the rubric. In **Question 4(c)** there was a tendency to answer the question "Explain why water and sucrose need to be transported ....." so there were numerous accounts of the need for water and sucrose by the plant in addition to explanations of the functions of xylem and phloem. An explanation as to why multicellular plants require transport systems was actually required. **Question 6(d)** also caused problems for several candidates. Here some candidates described the results whilst others explained how glucose enters cells by facilitated diffusion when candidates were required to use information in Fig. 6.2 to support the idea that glucose enters by facilitated diffusion.

A good proportion of the lower scoring candidates could improve their performance if they prepared and revised in depth and used good scientific terminology. Although attempts were made at every section, little attention was paid to the mark allocation. There were sufficient marking points to allow candidates to demonstrate their knowledge and understanding and differentiation was evident. Most candidates appeared to have had sufficient time.

Comments on Individual Questions

Question 1

There were many high scoring answers to this question, though some candidates failed to gain more than a few marks.

(a) The vast majority of candidates were able to match the appropriate letters to each of the functions listed. Some confused **D** as making ribosomes rather than giving **E** - the nucleolus or **C** - the mitochondrion. **D** - the endoplasmic reticulum - is where ribosomes are attached and carry out protein synthesis. There were occasional difficulties with "a site of transcription" - **G**, and "packages proteins" into lysosomes - **J**.

(b) In explaining why gas exchange occurs in alveoli and not in the bronchus, some candidates made the effort to write good comparative sentences and needed more lines on which to answer. Centres may wish to note that generally candidates need only make correct reference to one of the two in order to gain marks. Many candidates referred to the thin epithelium of the alveolus without emphasising the short diffusion distance. Statements such as "makes diffusion easier" or "so diffusion happens faster" were not credited. Reference was often made to both blood capillaries and mucus without adequate qualification e.g. well supplied with blood capillaries and a thinner layer of mucus compared with the bronchus. In addition weaker candidates referred to thin tissues and membranes or gave descriptions of gas exchange. Several candidates wrote at length about the ability of the alveoli to stretch and recoil during ventilation. Candidates who scored less well ignored the features of the alveoli and concentrated instead on the structure of the bronchus with numerous accounts of cartilage rings preventing expansion or the cilia hindering gas exchange.

(c) In describing the likely appearance of the lining of the bronchus in a heavy smoker, excellent responses made reference to the lack of/damaged cilia with much mucus being produced and scar tissue being formed. This particular question referred to the lining of the bronchus but weaker candidates again often attempted to describe the bronchial wall with details of cartilage, elastic fibres and smooth muscle or the effects of smoking in general in terms of bronchitis, emphysema and lung cancer.

Question 2

There were some good responses to this question with part **(c)** being the most difficult to answer for several candidates.

(a) In describing how enzymes take part in chemical reactions, able candidates mentioned enzymes as being catalysts with an active site, complementary in shape to the substrate, so forming an enzyme-substrate complex. Many candidates referred to the lowering of the activation energy but only exceptionally was the role of R groups in the active site detailed correctly. Weaker candidates used the phrase "lock and key", occasionally "induced fit" but without adequate explanation, were confused with the location of the active site, it apparently being found on the substrate, and generally wrote about factors affecting enzyme activity which the question clearly did not require.

(b) (i) Not all candidates concluded that a positive result with iodine solution indicated the presence of starch. Many thought that positive meant the enzyme had worked and starch had been broken down. There were also numerous accounts of a description of a positive result for the presence of starch and "the solution turned blue-black" was commonly seen.

(ii) Only the best candidates correctly explained why some of the extract was boiled as an indication that an enzyme was involved in the reaction, the enzyme being denatured by high temperature. There were only occasional references to a control. Several thought that boiling the extract was linked with investigating the effect of temperature on enzyme activity and that it enhanced the test with iodine solution while some linked the boiling with softening the potato to facilitate the extraction of the enzyme. Weaker candidates made inappropriate reference to the effect of boiling on starch, buffer and even potassium dihydrogen phosphate solutions, ignoring the reference to extract in the question, whilst others suggested the boiling would increase the chances of collision between the molecules of the tube contents.

(c) Weaker candidates simply described the results without explanation in terms of, for example, any starch breakdown/conversion to glucose (1-) phosphate, the activity of the enzyme at pH 6.5 compared with pH 2.0, the denaturation of the enzyme/bonds broken at high temperatures. The most able candidates referred to the above and other acceptable points in their answers with correct reference to the appropriate tube letter. A significant number of candidates attempted to explain the results without reference to the four labelled test tubes **A** to **D**. Several candidates incorrectly indicated that denaturation by boiling in tube **C** breaks all the bonds within the protein i.e. hydrogen, ionic, disulphide and hydrophobic interactions. It was apparent from the explanations given that many candidates had wrongly concluded that the presence of glucose 1-phosphate was a positive result and totally reversed the explanations that were required for each tube. Able candidates who had made this mistake then suggested the results were anomalous, the student had made a mistake in the investigation or the enzyme was unusual in working in a low pH and high temperature. Where answers were good they were a treat to read.

Question 3

There were some encouraging answers to this question, though **(b)** and **(c)** caused some candidates difficulty. The introduction to the question was forgotten by a significant minority of candidates who based some of their answers on humans.

(a)(i) Almost without exception candidates stated 6 as the diploid chromosome number of the female Indian muntjac deer. Weaker candidates often stated 12 presumably thinking that Fig. 3.1 was the haploid set. The number 3 was seen fairly frequently and occasionally 46. Some candidates wrote 2n.

(ii) Most candidates could name **X** as the centromere, though not all clearly stated its role in holding the chromatids together/as a site of attachment for a microtubule/spindle fibre. As mentioned under General Comments, it was not uncommon for weaker candidates to imprecisely refer to chromosomes being held together, to the spindle and chromosomes moving apart or made inappropriate reference to centromeres dividing. Some thought **X** was the centriole.

(iii) Almost all candidates shaded in a pair of homologous chromosomes, though some did not understand the significance of the word homologous and shaded inappropriately by shading only a pair of sister chromatids or more than one pair of homologous chromosomes.

(iv) There were no real problems here, with many candidates drawing one of the chromosomes as it would appear during anaphase, with sister chromatids having separated at the duplicated centromere, two daughter chromosomes now being shown with their centromeres leading the way to opposite poles. Several candidates produced text book drawing of several chromosomes undergoing anaphase of mitosis, (only one was required), others had daughter chromosomes moving to the same poles. Occasionally candidates inaccurately drew daughter chromosomes of different sizes separating during anaphase, drew the chromosome as a single line or two parallel lines with no evidence of the position of the centromere. It was disappointing that a good number of candidates had failed to learn the stages of mitosis sufficiently to be able to gain the mark for centromeres leading.

(b) In outlining what happens to a chromosome between the end of anaphase and the start of the next mitosis, many able candidates referred to the chromosomes unravelling/uncoiling/forming chromatin, occasionally mentioned semi-conservative replication to form new DNA and exceptionally referred to transcription and the formation of mRNA. Weaker candidates gave a description of post anaphase changes, other than those involving chromosomes, to include reforming of the nuclear membrane, cytokinesis and even referred to cell wall formation.

(c) Most candidates realised this was a question about meiosis and stated that the chromosome number is halved/6-3/diploid to haploid/2n-n during the formation of eggs. A few candidates referred inappropriately to 23/46-23 chromosomes. Weaker candidates sometimes stated that the chromosome number would double. Only the better candidates could explain why this reduction was necessary in terms of ensuring the diploid number is restored at fertilisation/avoiding the doubling of chromosome numbers in every generation. There were some vague references to maintaining genetic stability, even restoring the chromosome number to 46, and incorrect reference to crossing over and increased genetic variation.

Question 4

There were many encouraging answers to this question, with part **(b)** causing difficulty for some Centres.

(a)(i) Almost all candidates with reference to Fig. 4.1 named the leaf/mesophyll/palisade as the source and the root / storage organ as a sink. Several candidates appropriately named flower/fruit/seed amongst other acceptable answers for a sink. Some candidates incorrectly mentioned chloroplasts and starch grains as sources and sinks, whilst others gave 'sunlight', 'carbon dioxide', 'vacuoles' and 'plasmodesmata'.

(ii) Not all candidates precisely named **C** as a sieve, (tube) element / cell, often inappropriately giving sieve/phloem, tube. In naming **D** most candidates correctly gave companion cell. Weaker candidates often gave xylem and phloem as their answers for **C** and **D**.

(b) There was a tendency for the quality of answers to be Centre-specific. Many candidates' answers were complete guesswork or gave details of older hypotheses. In explaining how sucrose travels from the source to cell **C**, able candidates clearly referred to the role of the companion cells in loading sucrose at source, with detail of the pumping out of H^+ and the co-transport of sucrose and correct reference to the role of plasmodesmata. In explaining how sucrose then travels from **C** to the sink, the most able made correct reference to the absorption of water by osmosis, build up of hydrostatic pressure and mass flow due to a difference in pressure between source and sink, resulting from the sucrose being unloaded at the sink. As in previous examinations weaker responses inaccurately referred to translocation in the sieve tube apparently by active transport or diffusion of sucrose down a concentration gradient. Several candidates had sucrose moving down a water potential gradient by osmosis. A few candidates continue to write in error about the cohesion-tension hypothesis. Many candidates still do not seem to be aware of the detail of translocation by mass flow.

(c) In explaining why multicellular plants require transport systems, the better candidates appreciated the idea that because of the reduced surface area : volume ratio and distances being too great for diffusion, cells requiring water/sucrose at a distance from site of absorption/production require bulk transport systems. Weaker candidates simply referred to the size of plants and diffusion being difficult without adequate explanation. As mentioned earlier there were very few who correctly understood the requirements of the question. Some who did, then wrote about unicellular organisms not requiring transport systems.

Question 5

A significant number of candidates produced disappointing answers to this question particularly in parts **(b)** and **(d)**.

(a) The most able candidates named the type of immunity shown by **A** and **B** in Fig. 5.1 as passive artificial and active artificial respectively. A significant number of candidates omitted the word artificial in both **A** and **B** or reversed the two types of immunity. The term natural immunity was often stated.

(b) (i)(ii) No real problem shown by the good candidates who appreciated that the antibody concentration in person **A** would decrease because of the breakdown or even the excretion of antibodies and not increase because no antigen had entered the body, there being no immune response in terms of antibody production by B cells/plasma cells. Weaker responses included inappropriate reference to antibody concentration changes in person **B** – as well as/or instead of **A**. A significant number of candidates referred to antibodies dying, being killed or used up. Common misunderstandings included the assumption that immunisations were carried out to remove the tetanus antigen with accounts of the immune response occurring.

(c) Candidates were asked to sketch (a line) on Fig. 5.1 to show what would happen to the antibody concentration if person **B** received a booster vaccination at day 60. The best candidates produced a line drawn on the graph indicating a faster increase and reaching a higher peak of concentration than in the primary response. Weaker candidates sketched a secondary response almost identical to the primary response given. Others had no peak to their response. Occasionally the candidates sketch line did not join up with that given on Fig. 5.1 or started from 0 antibody concentration/arbitrary units at 60 days.

(d) Few candidates were able to clearly and fully explain why the experimenters measured only the concentration of antibodies to tetanus. The best candidates were able to refer to specific antibodies (for tetanus) in terms of the variable region and that there may be other infections at the same time, possibly recent blood transfusions or even previous vaccinations, that would result in different antibodies in the blood for persons **A** and **B**. Weaker candidates did not appreciate that different antigens have different antibodies, simply thought the experimenters were only interested in antibodies to tetanus or repeated the question in their own words.

Question 6

Overall there was a sound level of response, with part **(d)** being least well understood.

(a) There is still confusion re: the width of the plasma (cell surface) membrane as being 7.0nm. Several candidates gave 0.7nm or 7.0μm. A significant number of candidates omitted to answer **(a)**.

(b) Only the best candidates could clearly and accurately outline the function of the labelled (**K-N**) components of the plasma membrane. **K** and **L** were usually well known, followed by **M** and far fewer for **N**. "Large" molecules were commonly mentioned in outlining the function of **K**, **M** was often just noted as being the "phospholipid bilayer" without further elaboration, with only a proportion of candidates noting that the bracket was for the hydrophobic core area. Many candidates assumed **N** was the phosphate head of a phospholipid and tried to give a role based on this. A typical correct response referred to the movement of ions (**K**), acting as a surface antigen (**L**), allows passing of lipid soluble substances (**M**) and regulates fluidity (**N**), amongst many other alternative correct responses. Many candidates insisted on naming the components as well as giving a function. Weaker responses included vague references to fluidity and membrane stability in **L, M** and **N** or reference to movement of substances without suitable qualification in terms of ions, lipid soluble compounds, water soluble molecules or similar.

(c) The Examiners were looking for some reference to glucose molecules being too large/water soluble/polar in explaining why glucose cannot pass across the phospholipid bilayer of membranes by simple diffusion. Many thought that glucose was non-polar. It was not uncommon for candidates to inappropriately describe the mechanism of facilitated diffusion in answering this question or give only one correct feature of glucose before inappropriately explaining that a membrane protein was required for facilitated diffusion.

(d) Only the most able candidates could explain, using the information in Fig. 6.2, how the results of the investigation supported the idea that glucose enters cells by facilitated diffusion. Such candidates explained that because the rate of uptake is only dependent on glucose concentration at low concentration, eventually reaching a constant rate of uptake, that simple diffusion could not be the mechanism. They explained the plateau in terms of no more transport proteins being available / all proteins being in use. A few explained how the results could not have supported active transport. Weaker responses made reference to "uptake stops", "concentration inside and outside equal" or "no more glucose needed".

(e) Many candidates appreciated that active transport differs from facilitated diffusion in that the former uses ATP to move substances against a concentration gradient. A significant number of candidates simply referred to the energy requirement or the movement from low to high concentration in active transport, when both ideas were required.

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Paper 9700/31

Advanced Practical Skills 1

General comments

The paper was new in both style and duration, but still proved to be accessible to the majority of candidates, who demonstrated good knowledge and understanding of the practical skills that were tested. The paper also discriminated well between weaker and more able candidates, whilst at the same time allowing all candidates to demonstrate their ability in answering questions. The trend towards drawing less text book diagrams continued and most candidates made a genuine attempt to draw what they could see and interpreted well what they saw through the microscope. This is to be applauded. There was no evidence that candidates ran out of time and almost every candidate completed every question.

Where candidates did make errors, it was mainly due to a failure to read the question properly. Candidates would be well advised to read all questions most carefully before attempting them, and to revisit the question when they have finished answering it to make sure that they have covered specifically what the question was asking.

Candidates are reminded that the syllabus requires the use of pencil for the lines on tables, graphs and drawings. This makes it easier for candidates to correct any errors that they make.

Comments on specific questions

Question 1

This question proved to be accessible to most candidates who performed well. Most candidates produced a good table of data and went on to produce a correct conclusion.

(a) Most candidates scored both marks on this question. Credit was given for showing that after time the iodine no longer turned blue-black and that this was due to the fact that the starch had been hydrolysed by the amylase into the reducing sugar, maltose.

(b) Candidates were given credit for successfully preparing the space by producing a table (hand-drawn spreadsheet), which for this kind of experimental data is likely to be the only appropriate way of organising the data. Candidates would be well advised in future to produce a complete table in which there are clear, unbroken lines between all the cells, and a boundary indicating the edge of the table. Credit was given for showing the concentration of the lead nitrate before the observations and having the correct units in the table header and not in each cell with each data item. Common errors included making up units that did not exist in the information provided such as molarities, rather than simply using percentage concentration. Additional credit was given for having at least three dilutions, two readings for each dilution, mean calculated, estimating the degree of colour or time taken with the data correctly relating to the concentrations of lead nitrate. In part **(b)(ii)** credit was given for correctly describing that increasing concentrations of lead nitrate increased the inhibition of the enzyme amylase.

(c) Parts **(i)** and **(ii)** were not so well done. Many candidates wrote about how to measure pH rather than control it and very few went on to show the depth of their experience of practical work by writing about using a buffer solution. In part **(ii)** candidates were required to identify two significant sources of error and both were required before credit was given. Many candidates identified one source correctly, but not two. Credit was given for any two of: difficulty in judging colour or time, inaccuracies of equipment, inaccuracies in preparing solutions, temperature control, and the need to wash equipment out if being reused.

(d) Most candidates scored an easy mark for part **(i)** by correctly stating that the result was anomalous or should have been lower. A few went on to give a much more complex and often incorrect answer and failed to score. Part **(ii)** was not done well. Many failed to take cues from the provided data about the number of significant figures that were appropriate. A common error was rounding incorrectly to 19.6 rather than rounding up to 19.7 or 20. The graph tended to be very Centre specific with more able or well-trained candidates scoring three marks. However errors were common with axes being drawn the wrong way round (presumably indicating that candidates do not know which is the dependent and which the independent variable, or the rule about which variable goes on which axis), not labelled correctly with units, not being to scale or using some obscure complex scale that made accurate plotting almost impossible. Candidates should know that all graph questions will allow candidates to use a sensible and accurate scale on both axes. Candidates would also be well advised to follow the syllabus in plotting points using a cross or a tiny dot within a circle (⊙, the dot should be no larger than 1 mm diameter). Candidates should **not** use a dot alone (·) or filled circle (●) in order to ensure that examiners can give credit where it is due for correct plotting.

(e) Credit was awarded to those candidates who correctly identified the pattern or relationship between lead nitrate and amylase. However, all too often candidates did not answer the question and wrote about the transmission of light. This was not answering the question, and failed to score.

(f) Many students failed to say whether the hypothesis was correct or in error and thus lost the first mark. More able candidates stated that the hypothesis was not completely correct and then went on to explain why.

(g) This should have been three easy marks but many candidates only scored one or two marks. Credit would have been given for using more accurate equipment such as a graduated pipette, using a buffer, having more replicates and different concentrations, or using a water bath or a colour chart. Credit was not given for making major changes to the experiment such as changing the concentration of the enzyme or using different inhibitors.

Question 2

It was clear that Centres are spending more time teaching candidates the skills of how to determine the magnification of drawings. However, more emphasis needs to be placed on the correct use of equipment such as eyepiece graticules and stage micrometers. Centres are requested to retain the stage scales for use in future sessions so that CIE can move towards replacing only a proportion of these each session for established Centres.

(a) Many candidates still do not know how to draw plan diagrams. This immediately meant that they were restricted to a maximum of one mark for part **(i)**. Good answers used simple lines to show the upper epidermis thicker than the lower epidermis, the correct proportions of palisade and mesophyll layers, and the presence of vascular bundles. In part **(ii)** credit was given for drawing a line across their drawing and correctly measuring it to within 1 mm and measuring the thickness of the specimen to be less than 1 mm and more than 0.1 mm. Further credit was then given for dividing the measurement from the drawing by the measurement from the slide. Part **(iii)** should have been an easy mark with answers between ± 0.2 – 0.5 mm. Answers outside this range or with incorrect units were not credited. Neither were answers without the ± symbol. Part **(iv)** was well answered with credit being given for parallax error, thickness of ruler lines, or insufficient divisions on the ruler. Other creditable answers included difficulties in focusing on both the specimen and the ruler at the same time.

(b) Answers to part **(b)(i)** were very Centre specific. Common errors included drawing far too many cells, when just four would have been sufficient, and then not maximising the space available. There are still a proportion of candidates who draw textbook drawings and some even drew the stomata as if they were viewing the surface of the leaf. This clearly indicates a lack of skill in using a microscope and representing their observations on paper. Good answers from candidates included four cells drawn with two guard cells and two epidermal cells, and their drawing also matching what was visible from the slide. Many candidates also failed to score for part **(ii)**. These should have been two easy marks for drawing cells that were both wider and thicker than the epidermal cells drawn in part **(i)**. Candidates would be well advised to understand what is meant by drawing to scale. This is a skill that many need to practice.

(c) Most candidates scored at least two marks on this section. Credit was given for correctly using a structure to display their comparisons. Candidates should use lines clearly to distinguish between different pairs of similarities/differences and to link the pair, for example in a table, in a Venn diagram or using linked boxes. Credit was given for showing similarities or differences for each feature paired opposite each other, using lines to make the connection. Too many candidates simply wrote down a description and did not answer the question by comparing and contrasting the two specimens. Other candidates gave two unrelated lists of features in varied orders, which could not be credited as it could not be clear to the examiner which feature the candidate considered paired with which. Questions that ask students to compare require the student to provide two linked statements, one for each specimen. Some students simply drew a drawing and this could not be credited. Credit was given for noting that stomata were found on both lower surfaces, not on the upper epidermis, none were found round the midrib and the numbers of epidermal cells between the stomata were greater in **T1**. Part **(ii)** was generally well done with most candidates stating that the leaf was rolled, hairs were present or a thick upper cuticle existed, all to reduce transpiration from the leaf.

BIOLOGY

Paper 9700/32

Advanced Practical Skills

General comments

The paper was new in both style and duration but still proved to be accessible to the majority of candidates, who demonstrated good knowledge and understanding of the practical skills that were tested. The paper also discriminated well between weaker and more able candidates, whilst at the same time allowing all candidates to demonstrate their ability in answering questions. The trend towards drawing less text book diagrams continued and most candidates made a genuine attempt to draw what they could see and interpreted well what they saw through the microscope. This is to be applauded. There was no evidence that candidates ran out of time and almost every candidate completed every question.

Where candidates did make errors, it was mainly due to a failure to read the question properly. Candidates would be well advised to read all questions most carefully before attempting them, and to revisit the question when they have finished answering it to make sure that they have covered specifically what the question was asking.

Candidates are reminded that the syllabus requires the use of pencil for the lines on tables, graphs and drawings. This makes it easier for candidates to correct any errors that they make..

Comments on specific questions

Question 1

This question proved to be accessible to most candidates who performed well. Most candidates produced a good table of data and went on to produce a correct conclusion.

(a) Most candidates scored one or two marks on this question. Credit was given for stating that the Benedict's solution changed colour, that this was due to the presence of a reducing sugar, and then relating the colour change to the concentration of the reducing sugar present. Candidates who wrote solely about how the Benedict's test was performed scored no marks as they were not answering the question. Candidates are well advised to read questions most carefully.

(b) Candidates were given credit for successfully preparing the space by producing a table (hand-drawn spreadsheet), which for this kind of experimental data is likely to be the only appropriate way of organising the data. Candidates would be well advised in future to produce a complete table in which there are clear, unbroken lines between all the cells, and a boundary indicating the edge of the table. Credit was given for showing the concentration of the glucose before the observations and having the correct units in the table header and not in each cell with each data item. Common errors included making up units that did not exist in the information provided such as molarities, rather than simply using percentage concentration. Additional credit was given for having at least three dilutions, two readings for each dilution, estimating the degree of colour, and the data correctly relating to the concentrations of glucose. In part **(b)(ii)** credit was given for correctly using the colour-change described in part **(a)** with the correct reading from their table of data.

(c) Parts **(i)** and **(ii)** were not so well done. Many candidates failed to state that they would keep the volumes of both reactants the same and instead gave vague answers about keeping volumes the same without being specific. In part **(ii)** candidates were required to identify two significant sources of error and both were required before credit was given. Many candidates identified one source correctly, but not two. Credit was given for any two of: difficulty in judging colour, inaccuracies of equipment, inaccuracies in preparing solutions, time spent boiling, and the need to have a temperature above 80°C.

(d) This should have been three easy marks but many candidates only scored one or two marks. Credit would have been given for using more accurate equipment such as a graduated pipette, using a colour chart or water bath, weighing precipitates or having more replicates. Credit was not given for making major changes to the experiment such as testing for different foods or testing at a range of temperatures.

(e) Most candidates scored an easy mark for part **(i)** by correctly stating that the result was anomalous or should have been lower. A few went on to give a much more complex and often incorrect answer and failed to score. Part **(ii)** was not done well. Many failed to take cues from the provided data about the number of significant figures that were appropriate. A common error was rounding incorrectly to 9.6 rather than rounding up to 9.7 or 10. The graph tended to be very Centre specific with more able or well-trained candidates scoring three marks. However errors were common with axes being drawn the wrong way round (presumably indicating that candidates do not know which is the dependent and which the independent variable, or the rule about which variable goes on which axis), not labelled correctly with units, not being to scale or using some obscure complex scale that made accurate plotting almost impossible. Candidates should know that all graph questions will allow candidates to use a sensible and accurate scale on both axes. Candidates would also be well advised to follow the syllabus in plotting points using a cross or a tiny dot within a circle (⊙, the dot should be no larger than 1 mm diameter). Candidates should **not** use a dot alone (•) or filled circle (●) in order to ensure that examiners can give credit where it is due for correct plotting.

(f) Credit was awarded to those candidates who correctly identified the pattern or relationship between pH and amylase.

(g) Many students failed to say whether the hypothesis was correct or in error and thus lost the first mark. More able candidates stated that the hypothesis was not completely correct and then went on to explain why.

Question 2

It was clear that Centres are spending more time teaching candidates the skills of how to determine the magnification of drawings. However more emphasis needs to be placed on the correct use of equipment such as eyepiece graticules and stage micrometers. Centres are requested to retain the stage scales for use in future sessions so that CIE can move towards replacing only a proportion of these each session for established Centres.

(a) Many candidates still do not know how to draw plan diagrams. This immediately meant that they were restricted to a maximum of one mark for part **(i)**. Good answers used simple lines to show the position of the root cap, the area undergoing mitosis and the fact that the pro vascular tissue was narrower than the cortex. In part **(ii)** credit was given for dividing the number of stage scale divisions by the number of eyepiece divisions and further credit for multiplying this answer by 0.1 and then by the number of eyepiece divisions. Good candidates were able to correctly calculate the width of the cell and had a clear understanding of what they were doing. However all too often candidates used the data incorrectly and went on to use inappropriate units. Candidates would be well advised not to keep switching units particularly when they are told the size of each division in mm. This only leads to errors and loss of marks. Part **(iii)** should have been an easy mark with answers between ± 0.2μm – 0.5μm. Answers outside this range or with incorrect units were not credited. Neither were answers without the ± symbol. Part **(iv)** was well answered with credit being given for thickness of scale lines, or insufficient divisions on the scale. Other creditable answers included difficulties in aligning the two scales and keeping them parallel to one another.

(b) Most candidates scored at least two marks on this section. Credit was given for correctly using a structure to display their comparisons. Candidates should use lines clearly to distinguish between different pairs of similarities/differences and to link the pair, for example in a table, in a Venn diagram or using linked boxes. Credit was given for showing similarities or differences for each feature paired opposite each other, using lines to make the connection. Too many candidates simply wrote down a description and did not answer the question by comparing and contrasting the two specimens. Other candidates gave two unrelated lists of features in varied orders, which could not be credited as it could not be clear to the examiner which feature the candidate considered paired with which. Questions that ask students to compare require the student to provide two linked statements, one for each specimen. Some students simply drew a drawing and this could not be

credited. Credit was given for noting that mitosis was only taking place in **R1** and that the cells in **R1** were shorter, narrower, had a central nucleus with no visible nucleolus. Part **(ii)** was not well done with most candidates saying that the root grew in length due to cell division, rather than by cells elongating due to the absorption of water.

(c) Answers to part **(c)** were very Centre specific. Common errors included not maximising the space available and drawing textbook drawings. This clearly indicates a lack of skill in using a microscope and representing their observations on paper. Good answers from candidates included two large cells drawn with nuclear material and cell walls clearly shown. Credit was also given for two correct labels and presenting clear sharp pencilled drawings showing two different stages of cell division.

BIOLOGY

Paper 9700/04
A2 Structured Questions

General comments

This paper was the first in the new format and so it is difficult to compare it directly with previous papers, though the layout was very similar to the old paper 4. It was, however, thought to be slightly harder than the previous paper 4 but provided a very good range of marks with good candidates being able to score highly.

This paper provided a range of question types and demands which proved to be generally accessible to candidates. They were able to show their knowledge and understanding together with their ability to apply this to new situations. The variety of questions proved to be a good discriminator producing a very wide range of marks, particularly **Questions 3**, **5** and **7**. Well prepared candidates were able to interpret the data, accurately describing trends, drawing conclusions and quoting figures. Likewise the free response questions provided an opportunity for candidates to demonstrate their knowledge and understanding: part **(a)** was generally high scoring whereas part **(b)** discriminated well between candidates. Candidates from many Centres had been thoroughly prepared while others struggled to recall basic factual material or to apply their knowledge appropriately.

Comments on specific questions

Section A

Question 1

Candidates demonstrated a good understanding of the reasons why the gorilla has become endangered and the role of zoos, i.e. a good grasp of conservation issues.

(a) Most noted the problem of being hunted or killed but this was not always qualified in terms of a reason why this occurs. Other common responses included the loss of habitat or food shortage but few mentioned war, sale of young or disease problems.

(b) (i) This was the least well answered section of **Question 1**. Candidates tended to focus on the word 'protection', only discussing the protective benefits of being in captivity rather than the idea of helping to prevent extinction. Ante or post natal care and the use of IVF were appreciated but surprisingly few referred to attempts to increase numbers or the possibility of reintroducing the gorilla into the wild.

(ii) This part scored well with candidates appreciating the problems of stress or behavioural changes that could lead to a reduction in successful reproduction. Many realised that gorillas released into the wild would have difficulty finding food or interacting with others of their species. Vague references to 'problems adapting to the wild' were not sufficient to score.

Question 2

This was well answered by nearly all candidates although some wasted time by giving extraneous details of the processes although they could still gain good marks. The main error amongst knowledgeable candidates was to give intermediates rather than products. A few incorrectly referred to NADP or NADPH.

Question 3

(a) (i) This question appeared to discriminate in terms of basic mathematical competence. Although the majority measured this correctly, a bewildering number of candidates failed to do so. In many cases they appeared not to have a ruler or a calculator (essential at this level). Care should be taken to quote the correct units and candidates should be aware that ratios require 2 figures and should in this case have been given to 2 decimal places not rounded up to 2:1. Perhaps candidates are unfamiliar with ratios that are not whole figures.

(ii) While responses correctly described the different effects shown by the strains to the antibiotic, few attempted an explanation. It was expected that reference would be made to mutation resulting in the resistance shown by C or the production of varying amounts of enzyme capable of inactivating the penicillin (penicillinase) produced by the different strains.

(iii) The idea of natural selection is well understood, so the resistants surviving and reproducing were frequently described. Better responses noted that penicillin was the selective agent and that resistants pass on the **allele** for resistance and the frequency of this **allele** increases. Candidates should be reminded that the use of the term 'gene' is not sufficient here. Very rarely was a reference made to plasmids (horizontal transmission), candidates seeming to have little knowledge of the idea of both 'vertical' and 'horizontal' methods of transmission amongst bacteria.

(b) This discriminated well between candidates. Responses from several Centres showed an excellent grasp of the idea of competitive inhibition of the enzyme or worked this out from the question. This did not always lead on to describe the reduction in the formation of crosslinks in the peptidoglycan cell wall causing weakness and subsequent bursting of the cell. If weakening the cell wall was mentioned this was not always linked to cell lysis, while some candidates described the action of antibiotics other than penicillin affecting cell membranes or translation. Knowledge of the action of penicillin is a clear requirement of section S (d) in the syllabus.

Question 4

(a) This was well understood with many candidates scoring 3 or 4. The detection of a change in the glucose concentration of the blood was often missed or, if mentioned, the hypothalamus was incorrectly stated as the structure doing the detecting.

(b) The role of reverse transcriptase was well known but many candidates lost a mark by referring to the production of DNA rather than cDNA (complementary DNA). DNA polymerase was not so well explained, with few details beyond 'forms DNA' or vague descriptions. There were, however, many references to double stranded cDNA. It was good to note that many understood the role of a restriction enzyme and managed to give three valid points. Ligase enzyme was fairly well explained though some candidates still think that the enzyme joins complementary bases together rather than sealing the gaps in the sugar-phosphate backbone.

Question 5

(a) (i) The idea of air spaces was known, but it was rare to see further detail for a second mark. Some concentrated on biochemical features, such as tolerance to ethanol. Many included a reference to oxygen here and not in the next section. There was little reference to mesophyll/cortex or the spaces being formed by cell death.

(ii) There was more scope for scoring full marks here as many realised that there would be a lack of oxygen in the conditions and that the air spaces would allow oxygen to reach the cells for aerobic respiration.

(b) (i) Those candidates who were relating the two relevant features generally stated the qualitative relationship. Few gave relevant figures, many simply relating the internode length to the day rather than to the depth of water.

(ii) Some answered this well, although others simply concentrated on how good the plant was at photosynthesising or saying how well the plant would grow in flooded conditions. The most common point awarded was the idea of access to air/oxygen/carbon dioxide. Despite concentrating on photosynthesis, few candidates mentioned that a part of the plant would be above water and have more direct access to light.

(iii) Candidates found this question quite hard as they had to compare a graph at the top of the page with one at the bottom. Consequently many answers were just a written account of the data without making comments on the relationship.

(c) (i) Too many candidates responded using the terms in the question, for example 'it regulates plant growth'.

(ii) This question involved comparing one graph with another on a previous page. Most candidates just concentrated on Fig. 5.3 and described the role of gibberellins without referring to Fig. 5.2. Consequently they were unable to access three of the last four marking points. It was often difficult to disentangle what the candidate was trying to say. Weaker candidates seemed to be uncertain exactly what they were meant to be explaining and many candidates described the effect of ethene without mentioning gibberellin.

Question 6

(a) Many candidates were able to correctly identify the germinal epithelium and the Graafian follicle. Some vague answers referred to ovarian tissue or oocytes.

(b) (i) It was good to see that the vast majority of candidates were able to name cell C as a primary oocyte.

(ii) Some appeared to miss this question and no label line was drawn. Several drew a line but it ended in a follicle rather than the primary oocyte itself while others labelled the oocyte of the Graafian follicle.

(iii) Most candidates were able to name the types of cell division. However it should be noted that exact spelling is necessary for the words mitosis and meiosis. Unfortunately some candidates lost a mark because of inaccurate spelling.

(iv) There were some good explanations, but those who did not score well lacked precision, and therefore did not present the information clearly and unambiguously. Chromatids were not always mentioned and, if they were, the qualification of non-sister or between homologous chromosomes was not given.

Question 7

This proved a difficult question for some candidates and became a very good discriminator.

(a) Most had a good idea as to the meaning of 'codominance' but had difficulty in explaining that both alleles had an effect on the phenotype in the heterozygous state and that the new phenotype was unlike that of the homozygotes.

(b) Most candidates were aware of the underlying genetics in this question but, as in **Question 3**, the words 'gene' and 'allele' were often incorrectly interchanged. Many diagrams were given without a key and so it was difficult to give credit. Some mistakenly described the possibility of a son marrying a carrier and producing a son with haemophilia rather than stating that the daughter would be a carrier and could pass the allele on to her son.

(c) (i) Those who were able to understand that the male was homogametic and that the colour phenotype concerned codominance usually went on to score full marks for this question. Some credit was given to candidates who made the mistake of treating the male as heterogametic but went on to produce a correct genetic diagram. Some marks were lost due to gamete symbols being separated for both genes.

(ii) Many candidates were able to appreciate the need for a test cross and then went on to analyse possible results. A surprisingly small number stated that the blue male would have to be heterozygous and concentrated on the barred/non-barred feature.

Question 8

(a) Many candidates gave a clear statement that humans would be doing the selecting for the benefit of humans and then gave an example. Fewer went on to say that the offspring would need to be selected and that this would need repetition over several generations despite being guided to this by the graph in part **(b)**. Some candidates even suggested that artificial selection meant that different species should be crossed, for example a mule is the result of a horse and donkey cross.

(b) (i) It was disappointing to note that so many were unable to calculate a simple percentage change using whole numbers. As with **Question 3(a)** more practice is perhaps required as a potential 5 marks were available in this paper for calculations.

(ii) Most candidates recognised that genetic and environmental variation may be explanations but few were familiar with the idea of polygenes. Mention of sampling or experimental error was rarely given.

Section B

Question 9

(a) It was pleasing to note that many candidates had a good knowledge of the structure and functioning of a synapse and subsequently score well with many obtaining maximum marks.

(b) This question became more of a discriminator with only the better candidates being able to score all six marks. Most answers referred to the synapse being important in one-way transmission and there were references to its use in memory and learning. Better candidates were able to describe summation and adaptation.

Question 10

(a) Many candidates displayed an excellent knowledge of the detailed structure of the chloroplast and some used a labelled diagram to assist their description.

(b) As with part **(b)** of **Question 9** this question was able to distinguish between better and weaker candidates. Due to the format of the mark scheme candidates were required to state a feature of the palisade cell and then say how this feature adapted the cell for photosynthesis. Good candidates were able to do this whilst weaker ones simply described the structure of the cells.

BIOLOGY

Paper 9700/05

Planning, Analysis and Evaluation

General comments

There was a wide range of performance by the candidates. Some showed a good understanding of the principles of planning, analysis and evaluation. Others were able to analyse but did not appear very confident in planning or evaluating. **Question 2(a)** in particular suggested that some candidates are uncertain of the difference between planning how to use a piece of apparatus rather than understanding how the apparatus functions. There also appears to be some misunderstanding of terminology used for evaluation, in particular reliability, accuracy and significance.

In many Centres candidates tended to write too much irrelevant information, using all of the blank spaces as well as additional paper. Candidates need to select only the relevant information. Similarly, for questions that specify a number of responses, such as **Question 3(a)**, **3(b)** and **3(c)**, candidates should not give more than the required number.

The skills used for presenting and interpreting information in tables and graphs are required for this paper. Many candidates in **Question 1(a)** did not appear to be able to devise a suitable scale or label axes correctly. In **Question 3(b)** many candidates did not appear to recognise the orientation of the table data.

Comments on specific questions

Question 1

Overall this question was well answered by most candidates. The main errors were the result of poor skills in graph drawing and misreading of Table 1.2. Relatively few candidates made arithmetic errors when using the formulae in parts **(iii)** and **(v)**.

(a) (i) Some candidates produced excellent frequency histograms using suitable and clearly plotted scales. However, there were a number of poorly presented histograms. The main errors were unsuitable scales, for example, on the y axis using 3 or 4 units per cm square and 7 or 9 units per 2 cm square and on the x axis, scales that were not correctly related to the origin. Plotting marks could not be awarded for these scales; otherwise plotting was almost always accurate. The quality of the histograms was variable. Many candidates clearly did not use a ruler to draw the histogram as lines were irregular and side lines often incomplete. Some candidates drew differently sized zones, rather than the usual standard width. A number of candidates drew bar charts and line graphs.

(ii) The majority of candidates gave a correct answer. The most common error was to state **n = 6.**

(iii) Almost all candidates used the formula correctly to derive the expected answer. Candidates who had an incorrect value for **n** were given credit for a correct application of the formula using this value.

(iv) The answers were more variable. While the majority of candidates were aware that standard deviation is a measure of the spread of a set of values, only better answers linked this to the mean value. The most common errors were 'variation of each measurement from one another' and 'the measurement of the range of marks.' Other candidates confused standard deviation with significance, reliability or accuracy.

(v) As in part **(iii)** the majority of the candidates used the formula to derive a correct answer. Those candidates who carried forward incorrect values of **n** were given credit for a correct use of the formula.

(b) The majority of candidates did not make the expected connection between the number of seeds and the chance of pollination. There were a great many answers about environmental factors, but these were usually too vague. For example, if lack of light was suggested, some explanation of why this could influence seed number was expected. Other candidates appeared to have missed that the genotypes were the same and gave answers related to meiosis and random assortment

Question 2

(a) There were some good answers to this question, but overall the quality of answers was poor, particularly in part **(a)**. Many candidates wrote extensively, but failed to gain marks as their answers did not address the question being asked.

(i) The answers were very variable. Good answers gained between 6-8 marks. The majority of the answers gained between 3-4 marks. There were a number of reasons for these relatively low scores. The most common were either; a candidate wrote extensively about how the apparatus works, or wrote a hypothesis, followed by a long list of all the different types of variable. It appeared in some cases that candidates were following a learned pattern of 'carrying out an investigation', without applying this to the actual question. In most of these answers, candidates did not explain how they would use the apparatus.

Most candidates were aware that the movement of the dye was measured, although in some cases time was not measured. Similarly, most candidates knew that repeat measurements should be taken, although only better answers stated that a minimum of 3 is usual and that an average or mean is calculated. However, very few candidates planned how the apparatus could be used to compare two organisms.

Candidates also appeared to understand that some variables need to be standardised. There was a tendency to list environmental factors without considering which were relevant to the investigation. For example, pH and light intensity were frequently stated. Only better answers showed an understanding that mass was a critical factor and so should be standardised. A common error was to refer to volume or number of organisms. There were some poor choices and incorrect selection of suitable organisms, particularly invertebrates. Common unsuitable invertebrates included earthworms, shrimps and in a few cases rats, mice and snakes. Procedures for introducing the organisms also indicated that some candidates lacked experience of this type of apparatus, for example, introducing the organisms via the rubber tubing.

The need to equilibrate the apparatus with the organism before taking readings, the need to close the clip before taking any measurements and to reset by opening the clip were only mentioned in better answers. Many candidates did not appreciate that a control is not necessary for a comparison and so used glass beads or dead organisms for a series of measurements.

A common misconception was that both oxygen uptake and carbon dioxide release needed to be measured.

(ii) The majority of candidates predicted that invertebrates would have the fastest rate of respiration. The explanations however tended to be related to oxygen consumption rather than energy requirement. A common misconception was that invertebrates have more metabolic processes than plants. There is also an assumption that the metabolism of invertebrates is always faster than that of a plant. Some candidates did not appear to understand the meaning of 'predict' and so described how the fluid would move in the capillary tubing.

(b)(i) The majority of candidates gave a correct answer. The only common errors were to refer to a ratio without making it clear how the calculation of RQ is carried out.

(ii) Most candidates gave a correct answer for invertebrates, but fewer for germinating seeds. The common incorrect answers were related to using protein, using a mixture of carbohydrate and fat, or carrying out aerobic and anaerobic respiration. Poorer answers stated that oxygen was the substrate for invertebrates and carbon dioxide for plants.

Question 3

There were some good answers to this question, but the majority were poor. There appeared to be two main reasons; misreading the question and misunderstanding the term reliability.

(a) The most common correct answers were references to temperature linked to the use of a temperature controlled room or oven and pH linked to the use of a buffer. Candidates who chose substrate were often too imprecise as they referred to an equal amount, rather than a concentration or volume. Candidates who chose enzyme often ignored the fact that the enzyme was immobilised. Candidates who know that the alginate beads were important to standardising the enzyme concentration referred to the size of the beads more often than the number.

Many candidates did not appear to have read the question as they identified variables, but did not explain how they were controlled. Some candidates did not appear to understand the meaning of 'controlled' as they described how to vary both the enzyme and substrate. Other candidates attempted to control the product concentration.

(b) The ability of the candidates to identify anomalous results was very variable. All of the anomalies in the table were selected equally. A number of candidates had clearly spent some time calculating the anomalies from the data. Common errors were either the result of misreading the table or misunderstanding the question. Many candidates read the table as rows rather than columns and so tended to choose 12 and 12 of student **B**. Other candidates seemed to choose pairs of figures, one anomalous and the other acceptable, for example 13 and 18 of student **E** or 62 and 68 of student **D**.

(c) (i) The majority of candidates gave a correct answer. Good answers referred to the overall pattern of the results. Poorer answer tended to focus on a set of figures from one of the students. Candidates should be encouraged to look for general trends.

(ii) Few candidates appeared to understand what is meant by reliability. There was a great deal of confusion between accuracy, precision, significance and reliability. Many candidates answered as though reliability has the same meaning as a control. Very few realised that the hypothesis was based on only two concentrations and two repeat measurements that were not averaged.

The most common correct answer was to obtain an average of more results. Candidates, who realised that more repeats were needed, often failed to mention an average. Few candidates appeared to understand that the main reason for doing repeats is to increase the certainty of results or remove anomalies.

Although many candidates did realise that the range should be extended, their answers were not precise enough. Candidates were expected to realise that at least 5 different concentrations should be tested, which ideally would be doubled each time.

A great many answers were incorrect, often a repetition of the answers in **(a)** or a description of further controls. Other candidates referred to using a statistical test.