Paper 3 – Section A

General comments

- Ensure you read the whole paper before starting to answer questions.
- Consider the wording carefully to gain a full understanding of the specific details required in each section of the response.
- Surface area to volume ratio calculations, and then using these to plot a graph, proved difficult.

<table>
<tr><th></th><th>Answer</th><th>Marks</th><th>Marker's Report</th></tr>
<tr><td>1a</td><td>200s</td><td>1</td><td>A wide range of times was provided, and most were accepted.</td></tr>
<tr><td>b</td><td>
<table>
<tr><th>dimensions of agar cube / mm</th><th>surface area / mm^2</th><th>surface area / mm^3</th><th>surface area:volume ratio</th><th>distance from surface to the centre of agar cube / mm</th></tr>
<tr><td>2x2x2</td><td>24</td><td>8</td><td>3.00</td><td>1</td></tr>
<tr><td>4x4x4</td><td>96</td><td>64</td><td>1.50</td><td>2</td></tr>
<tr><td>6x6x6</td><td>216</td><td>216</td><td>1.00</td><td>3</td></tr>
<tr><td>8x8x8</td><td>384</td><td>512</td><td>0.75</td><td>4</td></tr>
<tr><td>10x10x10</td><td>600</td><td>1000</td><td>0.60</td><td>5</td></tr>
</table>
</td><td>3</td><td>Many candidates failed to read the instructions to "calculate", and hence recorded the surface area:volume ratios in formats that were not suitable for use when plotting a graph.

Candidates who performed well had clear, accurate calculations, recording data that was suitable for plotting the graph in (d), and standardized to a consistent number of decimal places.

Those who performed less well used the format 3:1, 3:2, 3:3, 3:4, 3:5. They also did not simplify the ratios to their lowest values.</td></tr>
<tr><td>c</td><td></td><td>2</td><td>Mostly well answered, as both ratio format and calculated</td></tr>
</table>

	surface area:volume ratio (either column)	**time taken for whole cube to change colour / s**	formats were accepted. Candidates were also not penalized for inconsistent decimal places (for the first column) to avoid double penalty. Recording of time taken should be to a consistent number of decimal places. Whole numbers, 1 dp or 2 dp were accepted as the question did not specify the degree of accuracy.
	3:1 / 3.00	40	
	3:2 / 1.50	94	
	1:1 / 1.00	203	
	3:4 / 0.75	338	
	3:5 / 0.60	455	
d	- Axes: Correct plot of surface area/volume ratio value as x-axis and time taken as y-axis - Scale: Proper scale where graph takes more more than half of space given - Plot: values are plotted accurately - Line: smooth curve more appropriate	2	Many good graphs were seen, showing an understanding of the need to have a linear scale and an understanding of the construction of a linear scale, drawing a smooth curve and the use of the x-axis for the independent variable and the y-axis for the dependent variable. Weaker students still confused the axes. Some still extrapolated the lines. A line of best fit was requested. Many drew a straight line when a smooth curve would have been more appropriate. There should be a “0” recorded at the intersection between x- and y-axes.
e	As surface area to volume ratio increases, the time taken for the whole cube to change colour decreases (at a decreasing rate).	1	Values must be quoted when describing the trend. Some answers showed confusion about rate of change.

f	Key variable 1: The concentration of hydrochloric acid used. Explanation: Concentration of acid would affect the pH/concentration of H^+ ions. The higher the H^+ ion concentration, the lower the pH of the acid/steeper the concentration gradient of H^+ ions, increasing rate of diffusion, which leads to shorter time taken for the agar block to change colour. Key variable 2: The composition of agar Explanation: Composition of agar affects the permeability of agar (to H^+ ions). If agar is more permeable, rate of diffusion will be greater, hence decreasing time taken for cube to change colour. Key variable 3: The amount of movement of the plastic vials containing the cube and hydrochloric acid. Explanation: All the plastic vials were not moved, shaked, or stirred once hydrochloric acid was added. Any amount of movement or shaking of the vials would increase the rate of diffusion and decrease the time taken for the agar block to change colour.	Any 2, 2 marks	A challenging question for many. Many candidates recognized the variables that were to be kept constant, but many found it difficult to articulate an appropriate explanation for why the variables should be kept constant. Good responses gave **detailed, well written explanations that linked the variable to the parameter it would affect, and how it would in turn affect rate of diffusion and time taken for colour change.** The use of a colorimeter is not appropriate and indicated a lack of understanding of the use of a colorimeter.
g	Key source of error 1: There was a time delay in starting the stop-watch. The diffusion of acid would already have started taking place as soon as hydrochloric acid was placed in the vial containing the 1000mm^3 cube. Hence, the actual time taken for the cubes to change colour is more than recorded. Improvement: <u>Stagger</u> the start times of each cube so that the time taken can be recorded accurately. Key source of error 2: Only one agar cube was used for each volume. This may not account for the variations in agar specimens that may be inherent during the preparation of the agars. Improvement: Use 3 agar blocks in each vial and record the average time taken. Alternatively, repeat the experiment 2 times and take average of the time taken. [note: these are biological replicates, not technical replicates, hence it is an accepted answer] Key source of error 3: Determination of the exact time point of colour change is by individual visual perception, hence it is subjective. Improvement: Compare the colour change using a colour chart. [do not use colorimeter as it is not practical to do so in this situation]	1 1 1	Some suggested the use of vernier calipers to measure the agar blocks as the use of ruler was less accurate. However, use of ruler was used in the preparation of a fixed dimension of the cube, hence it would be good enough. Only critique the use of a ruler if it is a tool used for measuring the dependent variable. Many suggested the use of a colorimeter but did not consider the practicality of using one. Comparing to a colour chart would be more appropriate in this situation.

<table>
<tr><td></td><td></td><td></td><td>Many suggested human errors which clearly are not sources of error inherent in the experiment.

Candidates who performed less well included generic statements about human error during timing or described a change to the procedure such as changing the size of the cubes to make them easier to cut.</td></tr>
<tr><td>h</td><td>
<table>
<tr><td>Agar blocks</td><td>Cells</td><td>Discussion of why agar blocks may not be suitable for investigating diffusion into cells</td></tr>
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Written suggested answer:
Unlike agar blocks which have determined lengths at each side, cells are often irregularly shaped, hence it is not as easy to measure the surface area:volume ratio of cells.

Unlike agar blocks cells have partially permeable cell surface membranes that would affect the rate of diffusion of substances into them. Different levels of permeability of the cell membranes would affect rate of diffusion.

Agar blocks are non-living substances, unlike cells, which have active nuclei and mitochondria, which may allow cells to carry out active transport on top of diffusion, hence further steps would need to be taken on cells in order to investigate rate of diffusion in cells effectively and accurately.</td><td>1

1

1</td><td>Candidates who performed well articulated clearly the comparisons about size, shape and surface area. Candidates who performed less well produced confused answers with many cellular details and processes that were not appropriate for this question.

There is a need to describe the impact of a range of differences, not just one.</td></tr>
<tr><td>2ai</td><td>- Pencil, Smooth unbroken lines, no shading
- Clear labelling of the distribution of root hairs
- Length of specimen clearly indicated
- Title provided</td><td>4</td><td>Candidates who performed less well omitted the title and the length of specimen. They also did not indicate the root hairs even though question clearly specified to do so.</td></tr>
</table>

			Some labelled the very end of the root as a root hair.
2aii	Magnification = length of drawing/length of specimen = 6.3/2.6 = 2.4x (2 s.f) 1 mark for worked solutions 1 mark for 2sf	2	Some misconceptions about significant figures were seen.
2bi	E F B D A C	2	
2bii	- 4 chromosomes, each single chromatids, being pulled to opposite ends of poles - Spindle fibres connected to chromosomes at centromeres - Size of 4 chromosomes must be similar	3	Many demonstrated a misunderstanding as they drew only the splitting of 1 chromosome into 2 sister chromatids. However, question indicated to draw **a pair**.
2ci	In anaphase of the meiosis I, homologous chromosomes separate/no splitting of sister chromatids, while in anaphase of mitosis, the sister chromatids separate.	1	
2cii	- The first division of meiosis leads to a reduction in the number of chromosomes by half, making the cells haploid. - This is important in the production of haploid sex cells/gametes and ensures a constant number of chromosomes after fertilisation in successive generations. OR - The first division of meiosis leads to a exchange of genetic material during the processes of crossing over/independent assortment - This is important for adaptation and survivability of the species.	2	Many indicated the wider significance of meiosis in terms of gene variation and adaptation for survival. However, the question specified “the first division of meiosis”.
2di	The leaves of the plant are stained a dark red, which fades into red and a lighter pink down the stem. The lower portion of the stem is light pink in colour. The roots of the plant is stained a dark red in colour. [Any 1 suitably stained part of the plant.]		Most responses could name a suitably stained part of the plant.
2dii	- Oxidation/breakdown of glucose in aerobic respiration to release energy for the cells		Note that there was an emphasis

	- Allowing cells to carry out mitosis <u>quickly</u> and efficiently for actively dividing cells.		given in the question for 'actively dividing cells', hence it is not sufficient merely to indicate the role of mitochondria in respiration and release of energy. A reference to the <u>speed</u> of mitosis is crucial. Use of the term "produce energy" is still a common mistake.
2e	(An investigation can be performed by growing 7 seeds over a period of 14 days, and harvesting the plants at different stages of germination and growth.) The independent variable is the time interval, in days, at which plant/seedling is harvested and stained. The dependent variable is the colour distribution observed at the roots after staining with TTC. Steps to describe the experiment provided: - Prepare 7 seeds of the same plant and grow them under similar conditions in a controlled environment at a fixed room temperature, watering daily with the same volume of water and provide same amount of light exposure to all seeds. - After 2 days, harvest the first seedling and soak in solution of TTC for 1 hour. - Then, remove seedling first TTC and observe the stain on the roots by placing the plant on a white tile. Perform the same TTC staining for the rest of the 6 plant specimens, by harvesting after 4, 6, 8, 10, 12, and 14 days, at the same time of the day. Repeat the experiment <u>2 more times</u> to generate more reliable data, then <u>take average readings</u>. Record the data on a suitable table. Plot data on a graph of colour and distribution of stain against time of harvest (in days).	1 1 1 1 1 [max 5]	Many responses were good, producing well-constructed plans. Weaker responses only listed the types of variables and spent time on a conclusion that was not required. Common errors included not repeating enough times (2 times) to generate more reliable data, growing the seeds in TTC, growing seeds in soil and digging them up at regular intervals and then replanting.