B1aD Cell Structure and Microscopy: Exam Drill

AQA 8464 · Calculator allowed · about 90 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 State the three parts of the cell theory that are relevant to most GCSE biology practical work.

(a) Give one of the three parts of the cell theory. **(1)**

(Total for Question 1 is 1 mark)

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2 A student uses a light microscope to view a plant cell. Name two parts of the microscope the student adjusts to bring the cell into focus and to increase magnification.

(a) Name the adjustment used to bring the image into sharp focus. **(1)**

(b) Name the part the student changes to increase magnification of the specimen. **(1)**

(Total for Question 2 is 2 marks)

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3 State two differences between prokaryotic and eukaryotic cells. Give one difference in internal structure and one difference in size.

(a) Give one internal structural difference. **(1)**

(b) Give one size difference, using typical size ranges. **(2)**

(Total for Question 3 is 3 marks)

4 A student images a cheek cell using a light microscope. The eyepiece lens magnification is 10x and the objective lens used is 40x. Calculate the total magnification. Show substitution and give the final answer with a unit.

(a) Substitute the magnifications into the equation total magnification = eyepiece x objective. **(1)**

(b) Calculate the total magnification and give the answer with a unit. **(2)**

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(Total for Question 4 is 3 marks)

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5 A micrograph of a pollen grain includes a scale bar labelled 5 micrometres that measures 2.0 mm on the printed image. Calculate the magnification of the image. Show your working and give the magnification as a decimal to two significant figures, followed by the symbol x.

(a) Convert the image measurement to micrometres and set up the magnification ratio (image size / actual size). **(1)**

(b) Calculate the magnification and give the final answer to two significant figures with the unit x. **(3)**

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(Total for Question 5 is 4 marks)

6 Required practical: a student investigates how cell size affects the time taken for substances to diffuse across a sheet of agar jelly. The student uses cubes of agar dyed with phenolphthalein; each cube is placed in acid and the time for the colour to change throughout is measured. The student uses cube edge lengths 1.0 mm, 2.0 mm and 4.0 mm and obtains times 12 s, 48 s and 192 s respectively. Explain whether the results support a relationship between cube size and diffusion time, and state one improvement to make the experiment fair.

(a) Explain how the results support or contradict a proportional relationship between linear size and diffusion time. Use the data in your answer. **(3)**

(b) State one improvement to make the experiment fair and reduce random error. **(1)**

(Total for Question 6 is 4 marks)

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7 A student measures cell sizes from a light microscope image. Their ruler on the image shows 50 micrometres equals 5.0 mm on the printout. They measure a cell as 8.0 mm on the printout. Calculate the actual size of the cell in micrometres. Show substitution and give the final answer with units.

(a) Set up the ratio to convert the measured image length to actual size. **(1)**

(b) Calculate the actual size and give the answer with units. **(2)**

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(Total for Question 7 is 3 marks)

8 Explain how differences between a light microscope and a transmission electron microscope (TEM) affect the choice of microscope for viewing detailed internal structure of organelles. In your answer discuss magnification, resolution and sample preparation.

(Total for Question 8 is 6 marks)

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9 A student is calibrating a light microscope using a stage micrometer. The stage micrometer line spacing is 0.01 mm. Using an objective lens, 50 of these stage divisions measure 25.0 mm on the printed image. Calculate the image scale factor in micrometres per mm on the printout, then calculate how many micrometres correspond to 1.5 mm on the printout. Show working and give the final answer with units.

(a) Calculate the actual length that corresponds to the 50 stage divisions, in micrometres, and find the scale factor in micrometres per mm on the printout. **(3)**

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(b) Using the scale factor, calculate the actual size that corresponds to 1.5 mm on the printout. **(3)**

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(Total for Question 9 is 6 marks)

10 Error analysis: A student reports that their measured diameter of a cell is larger than the accepted value. Suggest two plausible sources of error or bias in the microscopy method that could explain the larger measured diameter, and for each suggest a way to reduce or check the error.

(a) Source of error 1, explanation and way to reduce it. **(3)**

(b) Source of error 2, explanation and way to reduce it. **(3)**

(Total for Question 10 is 6 marks)

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11 A biology student measures the area of an irregularly shaped stomatal pore on an image by counting square grid units. Each grid square on the image is 5.0 micrometres by 5.0 micrometres in actual size. They count 18 full squares and 6 half squares. Calculate the area of the pore in square micrometres. Show working and give the final answer with units.

(a) Calculate the total number of equivalent full squares counted. **(1)**

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(b) Calculate the area of one square in square micrometres and then the pore area. Give the final answer with units. **(5)**

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(Total for Question 11 is 6 marks)

12 A student compares two staining methods to make cell walls more visible. Method A produces clear cell walls but also causes some shrinkage of cells. Method B preserves cell shape but gives lower contrast. Evaluate which method is better for measuring cell dimensions and suggest which would be better when studying cell wall thickness. In your answer consider accuracy and artefacts and give a justified conclusion.

(Total for Question 12 is 6 marks)

Mark scheme · B1aD Cell Structure and Microscopy: Exam Drill

Question 1

- (a) **B1** one correct statement: eg all living things are made of cells, or cells are the basic unit of life, or all cells come from pre-existing cells, oe
- **(a) Answer: Example: All living things are made of cells.**

Question 2

- (a) **B1** coarse focus knob or fine focus knob
- **(a) Answer: Coarse focus knob (or fine focus knob).**
- (b) **B1** objective lens (eg rotate to a higher power objective) or changing to a higher-power eyepiece
- **(b) Answer: Rotate to a higher power objective lens.**

Question 3

- (a) **B1** eukaryotes have membrane-bound organelles, including a nucleus; prokaryotes do not, oe
- **(a) Answer: Eukaryotes have membrane-bound organelles such as a nucleus; prokaryotes do not.**
- (b) **B1** prokaryotic cells are smaller, typically 0.5 to 5 micrometres
- (b) **B1** eukaryotic cells are larger, typically 10 to 100 micrometres, oe
- **(b) Answer: Prokaryotes about 0.5 to 5 micrometres; eukaryotes about 10 to 100 micrometres.**

Question 4

- (a) **M1** substitutes: total magnification = 10 x 40
- **(a) Answer: Total magnification = 10 x 40**
- (b) **M1** performs the multiplication: 10 x 40
- (b) **A1** gives 400x cao
- **(b) Answer: 400x**

Question 5

- (a) **M1** converts 2.0 mm to 2000 micrometres and sets up magnification = 2000 / 5
- **(a) Answer: Image size = 2.0 mm = 2000 micrometres; magnification = 2000 / 5**
- (b) **M1** performs division: 2000 / 5
- (b) **A1** gives 400 as the calculated magnification
- (b) **A1** gives answer to two significant figures and includes unit: 400x cao
- **(b) Answer: 400x**

Question 6

- (a) **M1** uses the data to show time increases with cube size, eg 1.0 mm -> 12 s, 2.0 mm -> 48 s, 4.0 mm -> 192 s
- (a) **M1** identifies relationship: when linear size doubles (1.0 to 2.0 mm) time quadruples (12 to 48), and when size doubles again (2.0 to 4.0 mm) time quadruples (48 to 192), oe
- (a) **A1** concludes that diffusion time is proportional to the square or fourth power of size or explicitly: time scales as size^2 or size^? with evidence provided (accept explanation that time increases as area or volume increases) cao
- **(a) Answer: The data show that doubling edge length from 1.0 to 2.0 mm increases time from 12 s to 48 s (4x) and doubling again to 4.0 mm increases time to 192 s (4x again), so diffusion time increases faster than linear size and is proportional to the square of linear dimension in this data set; therefore the results support a strong, non-linear relationship between cube size and diffusion time.**
- (b) **B1** one valid improvement: repeat each measurement and take an average, use more precise timing, ensure same concentration and temperature of acid, cut cubes to exact sizes, or use automated detection of colour change, oe
- **(b) Answer: Repeat each timing several times and use the average to reduce random error.**

Question 7

- (a) **M1** states magnification or scale: 5.0 mm on image corresponds to 50 micrometres actual, so conversion factor is 50 micrometres / 5.0 mm
- **(a) Answer: Scale: 5.0 mm = 50 micrometres, so 1.0 mm = 10 micrometres; actual size = 8.0 mm x 10 micrometres/mm**
- (b) **M1** performs multiplication: 8.0 x 10
- (b) **A1** gives 80 micrometres cao
- **(b) Answer: 80 micrometres**

Question 8

- **Level 3** (5-6): A clear, detailed explanation linking magnification, resolution and preparation to the choice of TEM for detailed internal structure; uses comparative statements and gives consequences for observed detail.
- **Level 2** (3-4): A partial explanation including at least two relevant points (for example resolution and magnification) with some link to viewing organelles.
- **Level 1** (1-2): Simple statements about one or two differences without clear linking to microscope choice.
- **Indicative content:**
  - TEM has much higher resolution than light microscope because electrons have much shorter wavelength, so TEM can show internal organelle detail that light microscopes cannot
  - TEM can have much higher useful magnification (hundreds of thousands x) compared with light microscope (typically up to about 1500x), allowing smaller structures to be seen
  - Sample preparation for TEM requires thin slicing, fixing and staining with heavy metals and must be done in vacuum; this can create artefacts and is time consuming
  - Light microscopes require simpler preparation (wet mount, staining) and can view living cells, whereas TEM requires dead, fixed samples
  - Consequence: choose TEM to investigate fine internal structure of organelles; choose light microscope for general cell organisation and living processes

Question 9

- (a) **M1** converts stage micrometer divisions: 50 x 0.01 mm = 0.50 mm actual
- (a) **M1** converts 0.50 mm to micrometres: 0.50 x 1000 = 500 micrometres
- (a) **A1** calculates scale factor: 500 micrometres corresponds to 25.0 mm on printout so 500 / 25.0 = 20 micrometres per mm cao
- **(a) Answer: Scale factor = 20 micrometres per mm on the printout**
- (b) **M1** multiplies 1.5 mm by scale factor 20 micrometres per mm
- (b) **A1** gives 30 micrometres cao
- (b) **A1** gives correct units: micrometres cao
- **(b) Answer: 30 micrometres**

Question 10

- (a) **M1** identifies a plausible source of error: poor focus or parallax making edges appear blurred and larger
- (a) **M1** explains how this increases measured diameter: blurred edges reduce precision and lead to overestimation
- (a) **A1** suggests reduction: improve focusing, use fine focus and calibration, or use higher magnification and repeat measurement, oe
- **(a) Answer: Poor focus or parallax could blur the cell edges and make diameter appear larger; reduce by refocusing carefully with fine focus, use higher magnification and repeat measurements.**
- (b) **M1** identifies a plausible source: incorrect calibration or parallax in reading the scale on the image
- (b) **M1** explains how this leads to larger value: wrong conversion factor will scale up measured mm to micrometres
- (b) **A1** suggests reduction: recalibrate using stage micrometer, check scale consistency, or have a second person measure independently, oe
- **(b) Answer: Incorrect calibration of the image scale could cause a systematic overestimate; reduce by recalibrating with a stage micrometer and checking measurements independently.**

Question 11

- (a) **M1** adds full and half squares: 18 + (6 x 0.5) = 21 full squares
- **(a) Answer: 21 full squares equivalent**
- (b) **M1** calculates area of one square: 5.0 micrometres x 5.0 micrometres = 25 square micrometres
- (b) **M1** multiplies by number of squares: 21 x 25
- (b) **A1** gives 525 as numerical product
- (b) **A1** gives correct units: square micrometres cao
- (b) **A1** presents final answer: 525 square micrometres cao
- **(b) Answer: 525 square micrometres**

Question 12

- **Level 3** (5-6): A balanced evaluation comparing accuracy and artefacts of both methods, stating which method is better for measuring dimensions and which for wall thickness, and giving a justified conclusion.
- **Level 2** (3-4): Some comparison with at least one justification and one consideration of artefacts or accuracy.
- **Level 1** (1-2): Simple judgement with limited justification or only one method discussed.
- **Indicative content:**
  - Method A increases contrast making cell walls easier to see so may increase measurement precision but causes shrinkage which reduces accuracy of true dimensions
  - Method B preserves shape so gives more accurate dimensions but lower contrast may reduce ability to see wall boundaries precisely
  - For measuring cell dimensions Method B is probably better because it reduces systematic shrinkage artefact; however if contrast is too poor measurements may be imprecise so combining with mild contrast enhancement could be best
  - For studying cell wall thickness Method A may be better because the high contrast makes thin walls visible, but corrections for shrinkage should be considered or use calibration against known standards
  - Overall justified conclusion could state a preference depending on priority: choose B for true size measurements, choose A for visualising thin walls, or perform both and compare