| Surname | Centre Number | Candidate Number |
|---|---|---|
| Other Names | | 2 |

# GCE AS

B400U10-1

S18-B400U10-1

# BIOLOGY – AS component 1
## Basic Biochemistry and Cell Organisation

THURSDAY, 24 MAY 2018 – AFTERNOON

1 hour 30 minutes

| For Examiner's use only | | |
|---|---|---|
| **Question** | **Maximum Mark** | **Mark Awarded** |
| **1.** | **6** | |
| **2.** | **12** | |
| **3.** | **9** | |
| **4.** | **21** | |
| **5.** | **18** | |
| **6.** | **9** | |
| **Total** | **75** | |

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01

**ADDITIONAL MATERIALS**

In addition to this paper you will require a calculator and a ruler.

**INSTRUCTIONS TO CANDIDATES**

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page at the back of the booklet, taking care to number the question(s) correctly.

**INFORMATION FOR CANDIDATES**

The number of marks is given in brackets at the end of each question or part-question.

The assessment of quality of extended response (QER) will take place in question **6**.

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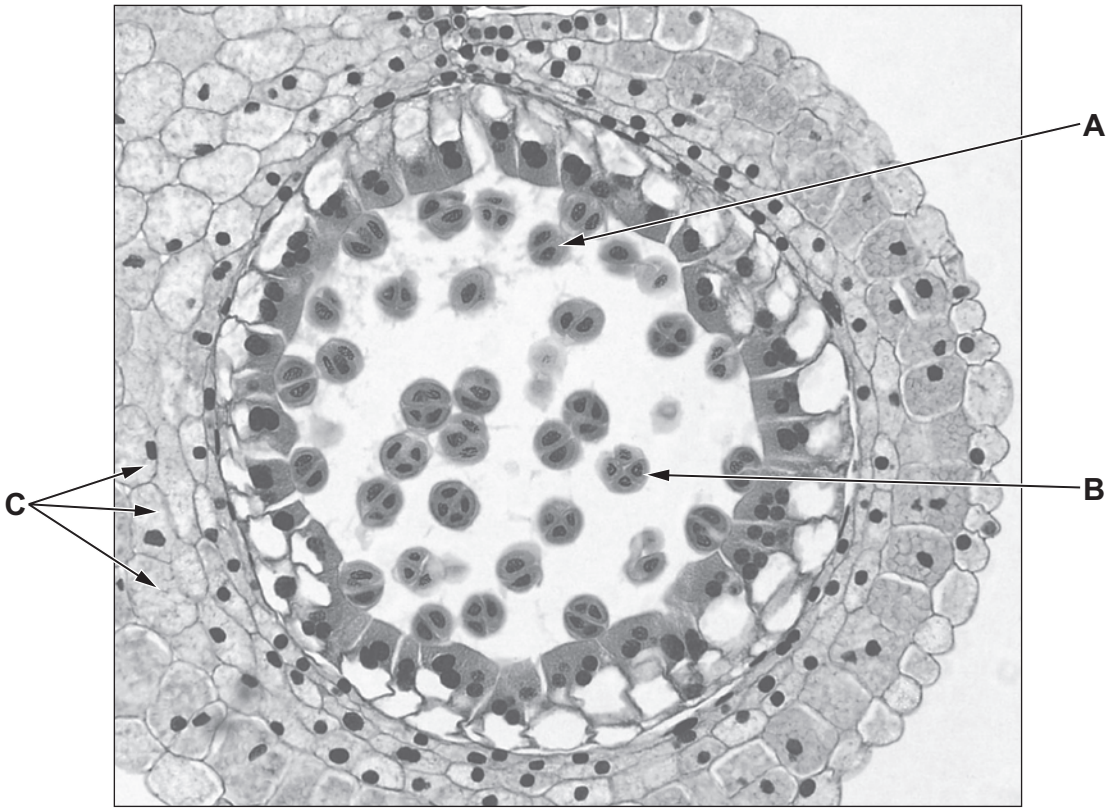
*Answer* **all** *questions.*

**1.** Mitosis and meiosis are both forms of nuclear division. Both types of nuclear division are involved in the production of gametes.

*(a)* Image **1** below shows a section through part of an anther of *Lilium sp.* showing stages in the production of pollen grains.

**Image 1**




(i) It was concluded that structure **A** had just completed meiosis I and structure **B** had just completed meiosis II. Explain how you would draw these conclusions from the photomicrograph. [1]

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(ii) The cells labelled **C** are in interphase. Explain why nuclei are only visible in some cells and, where nuclei are visible, why they appear to be of different sizes. [2]

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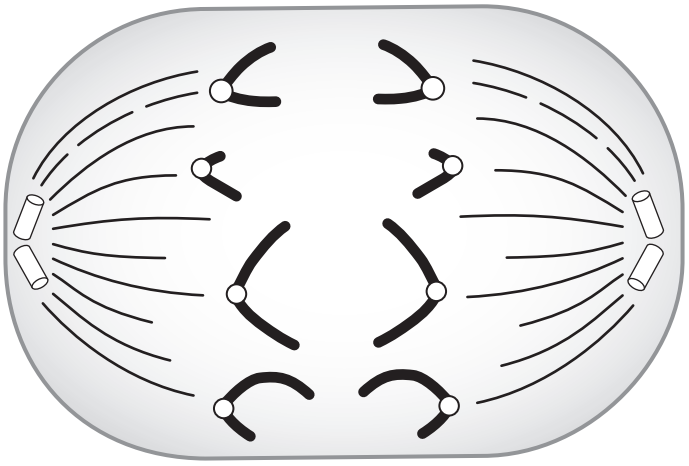
*(b)* A drawing was made of an animal cell during anaphase. The diploid number in this cell is eight.



Deduce whether this cell is undergoing anaphase of mitosis, anaphase I of meiosis or anaphase II of meiosis. Explain your answer. [3]

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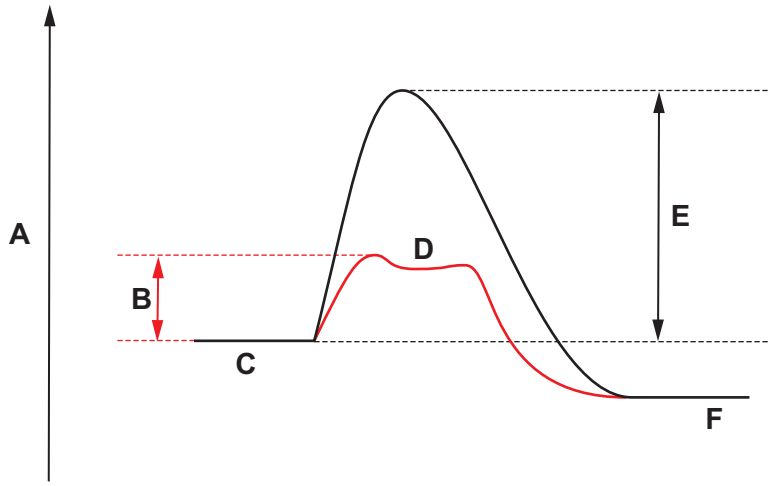
**2.** Enzymes catalyse reactions by lowering the activation energy of a reaction. This is shown in the graph below.




*(a)* Using letters from the graph, identify the following: [2]

- the energy level of the products of an enzyme catalysed reaction .....
- the activation energy of an enzyme catalysed reaction .....
- the energy level of an enzyme-substrate complex .....

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*(b)* Adenylate kinase (ADK) is a globular protein that acts as an enzyme involved in the regeneration of ATP in muscle. There are several types of this enzyme. One form catalyses the following reaction:

$$2ADP \longrightarrow AMP + ATP$$

*(AMP = adenosine monophosphate)*

(i) Suggest why the activity of ADK would be an advantage to muscle. [1]

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(ii) The 'lock and key' model of enzyme action was first proposed in 1894 by Emil Fischer and provides a simple explanation of how enzymes and substrates interact. However, ADK interacts with its substrates by the induced fit mechanism proposed in 1958 by Daniel Koshland.

Explain how the induced fit mechanism differs from the lock and key model. [2]

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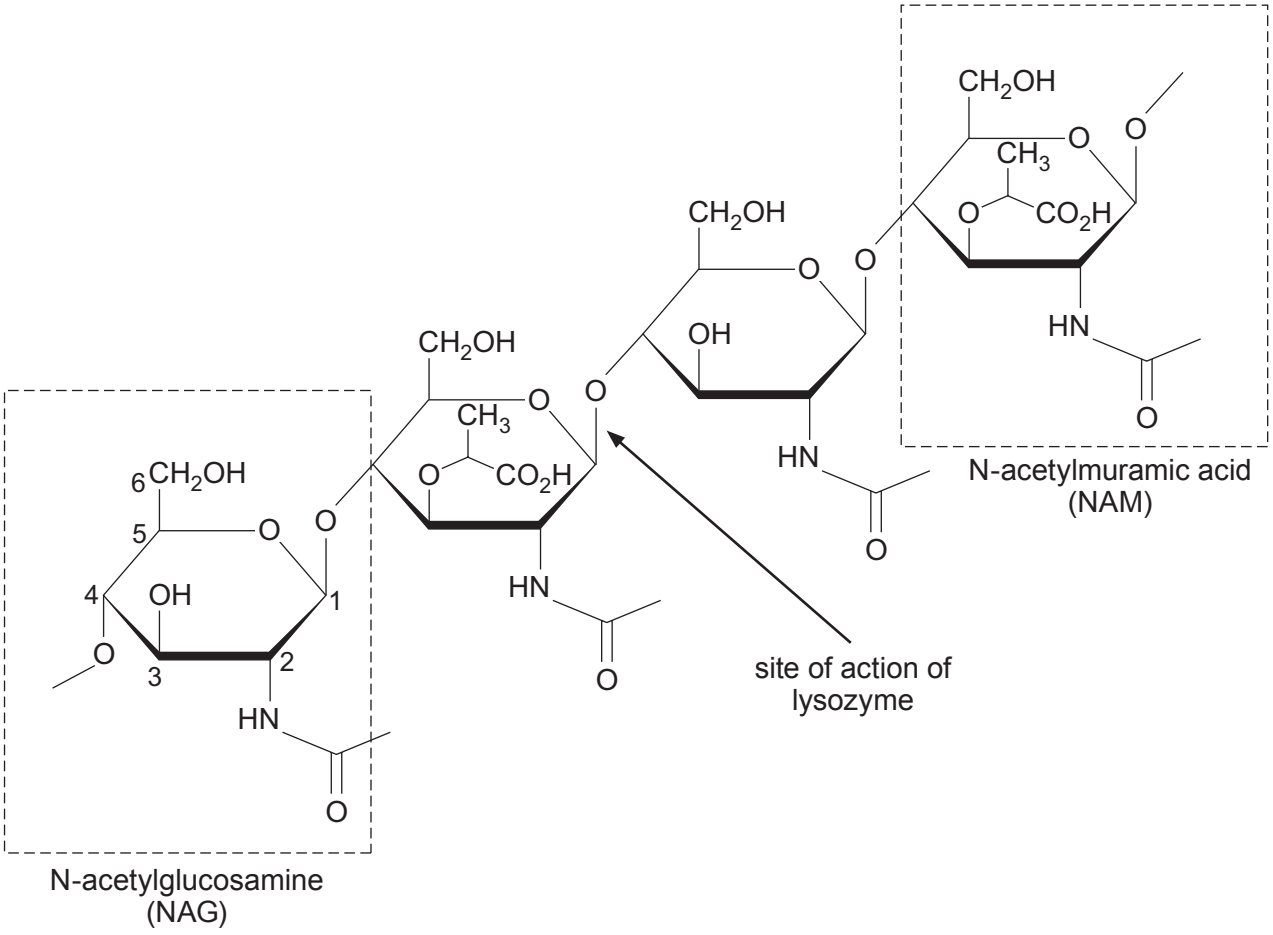
*(c)* Lysozyme is an enzyme which also forms enzyme-substrate complexes through the induced fit mechanism and can function both intra- and extra-cellularly. It catalyses the hydrolysis of a bond in the peptidoglycan component of the cell walls of some bacteria. This is shown in the diagram below. The carbon atoms have been numbered on one molecule of NAG (N-acetylglucosamine).




(i) State the difference between an intra- and an extra-cellular enzyme. [1]

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(ii) The molecule shown in the diagram is a part of a peptidoglycan molecule. Explain why a peptidoglycan cannot be classified as a true polysaccharide. [1]

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(iii) NAG and NAM can exist as alpha or beta isomers. State what is meant by an isomer. [1]

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(iv) Identify which isomers of NAG and NAM are found in this molecule. Explain your answer. [1]

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(v) In plant cells, cellulose carries out the same function as the peptidoglycan in bacterial cell walls. Peptidoglycan molecules can be cross-linked by the formation of peptide bonds between NAM molecules in adjacent chains.

Describe how the structure of cellulose molecules enables cross-linking and explain why cross-linking of molecules of the polymer shown in the diagram would result in a stronger cell wall. [3]

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**3.** Protein synthesis involves two stages, transcription and translation. Different types of RNA are involved in each stage.

*(a)* The table below shows the percentages of the different types of RNA present in a rabbit body cell.

| RNA | Percentage of total RNA |
|---|---|
| RNA present in nucleus | 11.5 |
| mRNA | 3.5 |
| rRNA | 69.5 |
| tRNA | 15.5 |

(i) Name the organelle that would contain the greatest percentage of RNA. Explain your answer. [1]

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(ii) The total mass of RNA in a typical rabbit cell contains about 50 000 000 000 nucleotides.

Calculate the approximate number of nucleotides contained in the tRNA of a typical rabbit cell. **Give your answer in standard form to two significant figures.** [3]

Number of nucleotides in tRNA = .....

(iii) Explain why there would be large numbers of different mRNA molecules in a rabbit cell but only a maximum of 64 different tRNA molecules. [3]

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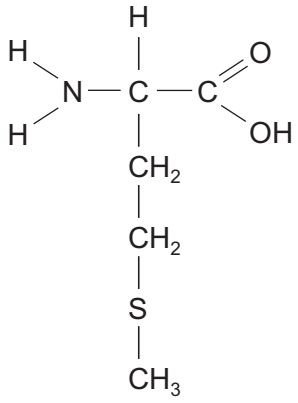
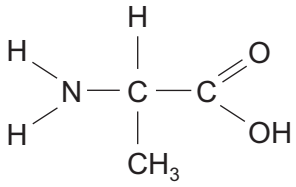
*(b)* During translation amino acids can be joined together in different sequences. The drawings below show the structural formulae of the amino acids methionine and glycine.

methionine




glycine




Methionine and glycine can bond together in two different ways:

| methionine – glycine | or | glycine – methionine |
|---|---|---|

Name the bond that would join these amino acids and with reference to the structure of the molecules, explain why two different dipeptides could be formed. [2]

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**4.** All organisms need certain elements for healthy growth. Plants obtain most of their essential elements by uptake of mineral ions from the soil. The vascular bundles of plants contain xylem vessels that transport water and minerals from the roots to all other parts of the plant.

The photomicrograph below shows a section through the vascular bundle of a plant.

*(a)* (i) State if this is a transverse or a longitudinal section. Explain your answer. [2]

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(ii) **Label a xylem vessel on the photomicrograph above** and explain why a group of xylem vessels form a tissue rather than an organ. [2]

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*(b)* The movement of water through xylem vessels partly relies on the polar nature of water molecules.

(i) Explain why water is a polar molecule. [2]

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(ii) With reference to the polar nature of water molecules, explain how the loss of water from leaves enables water to be transported upwards through xylem vessels. [4]

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*(c)* The table below shows the concentrations of some ions in the xylem and phloem in a plant grown under laboratory conditions.

| Substance | Concentration / mmol $dm^{-3}$ | |
|---|---|---|
| | Xylem | Phloem |
| magnesium | 1.1 | 3.7 |
| nitrate | 7.1 | 0.6 |
| phosphate | 0.7 | 6.6 |

(i) Describe **one** use made by a plant of the ions listed below: [2]

Magnesium .....

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Nitrate .....

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(ii) Explain how the data supports the following hypotheses regarding **lateral transport** of ions between xylem and phloem.

**Hypothesis 1.** Nitrate is transported from xylem to phloem by diffusion through plasmodesmata. [2]

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**Hypothesis 2.** Phosphate is transported from xylem to phloem by active transport and must cross a cell membrane in the process. [3]

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*(d)* (i) Fick's Law states that the rate of diffusion of a substance is affected by the surface area, the concentration gradient and the distance the substance travels. His law can be used to calculate the time taken for a substance to diffuse using the formula below:

$$\text{time taken to diffuse} = \text{distance}^2 \times \frac{1}{\text{diffusion coefficient}}$$

Use this formula to calculate the distance (in μm) between a xylem vessel and a phloem sieve tube given that: [3]

time taken to diffuse = 5s
diffusion coefficient (at 20°C) = $5 \times 10^4\ \mu m^2\ s^{-1}$

distance = ..... μm

(ii) Explain why an increase in temperature will result in a decrease in time taken to diffuse across a cell membrane. [1]

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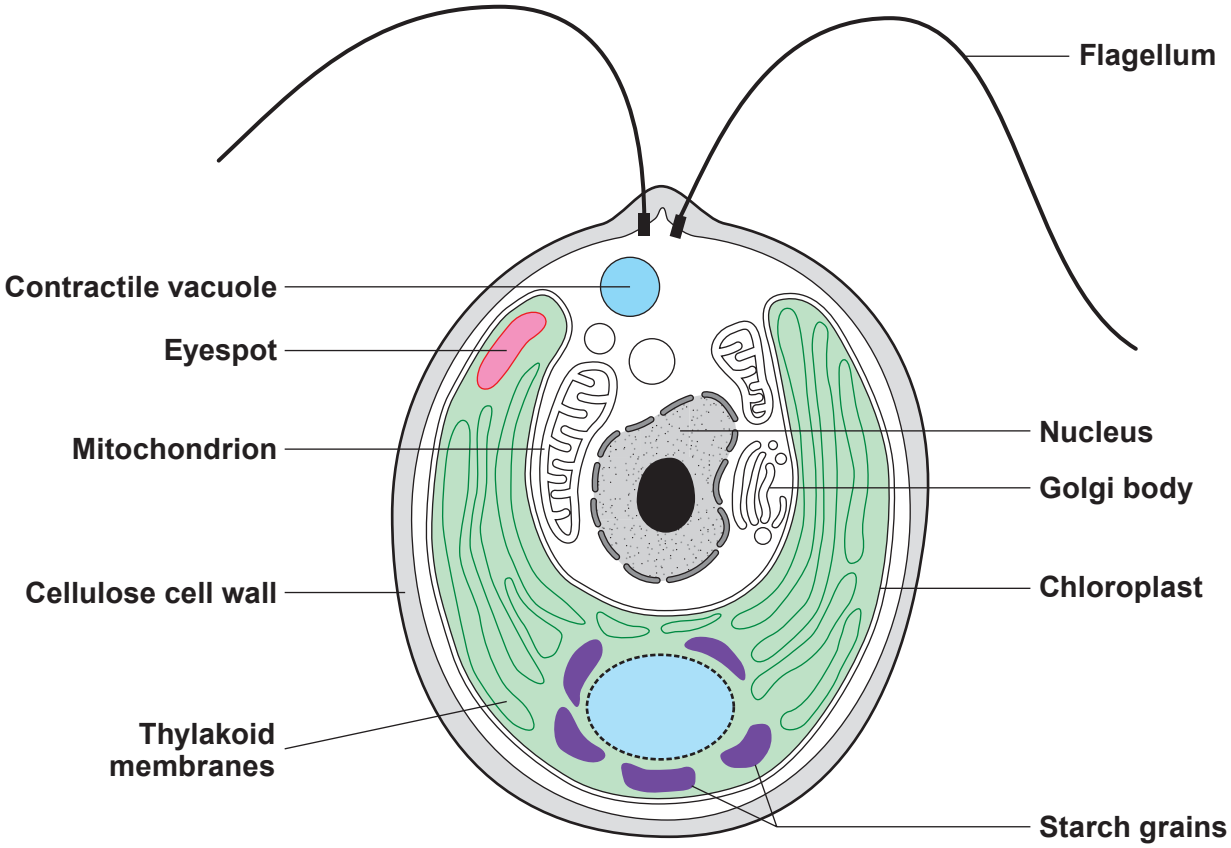
**5.** The classification of protoctistan eukaryotes changes frequently. *Chlamydomonas reinhardtii* is now classified as a protoctistan but has previously been classified as an animal and a plant. The diagram below shows the structure of this organism.




*(a)* With reference to the diagram, explain why this organism has, at different times, been classified as an animal and a plant. [2]

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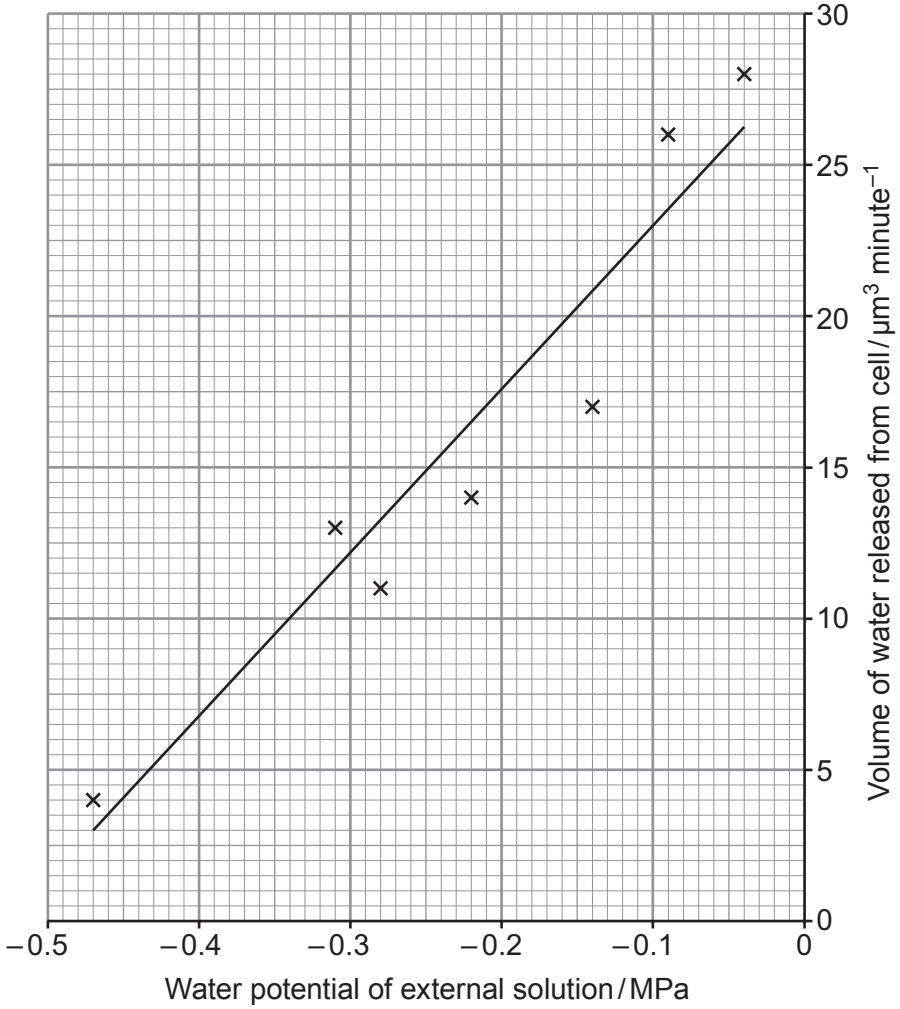
*(b)* *Chlamydomonas* lives in freshwater. When viewed under a light microscope, the contractile vacuoles are seen to fill and empty on a regular basis. They are involved in regulating the water content of the cell.
The graph shows the volume of water released from a cell of *Chlamydomonas* per minute at different water potentials of external solution.
A line of best fit is drawn.




(i) The diameter of a contractile vacuole reaches a maximum of 2 µm.
Calculate the volume of a contractile vacuole and use this to calculate the number of times the contractile vacuole fills and empties each minute at an external water potential of –0.24 MPa. **Give your answer to one decimal place.** [3]

volume of sphere = $\frac{4}{3}\pi r^3$;
$\pi$ = 3.142

Volume of contractile vacuole = .....

Number of times the contractile vacuole fills and empties each minute = .....

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(ii) Explain why the volume of water released from a cell of *Chlamydomonas* increases as the water potential of the external solution increases. [4]

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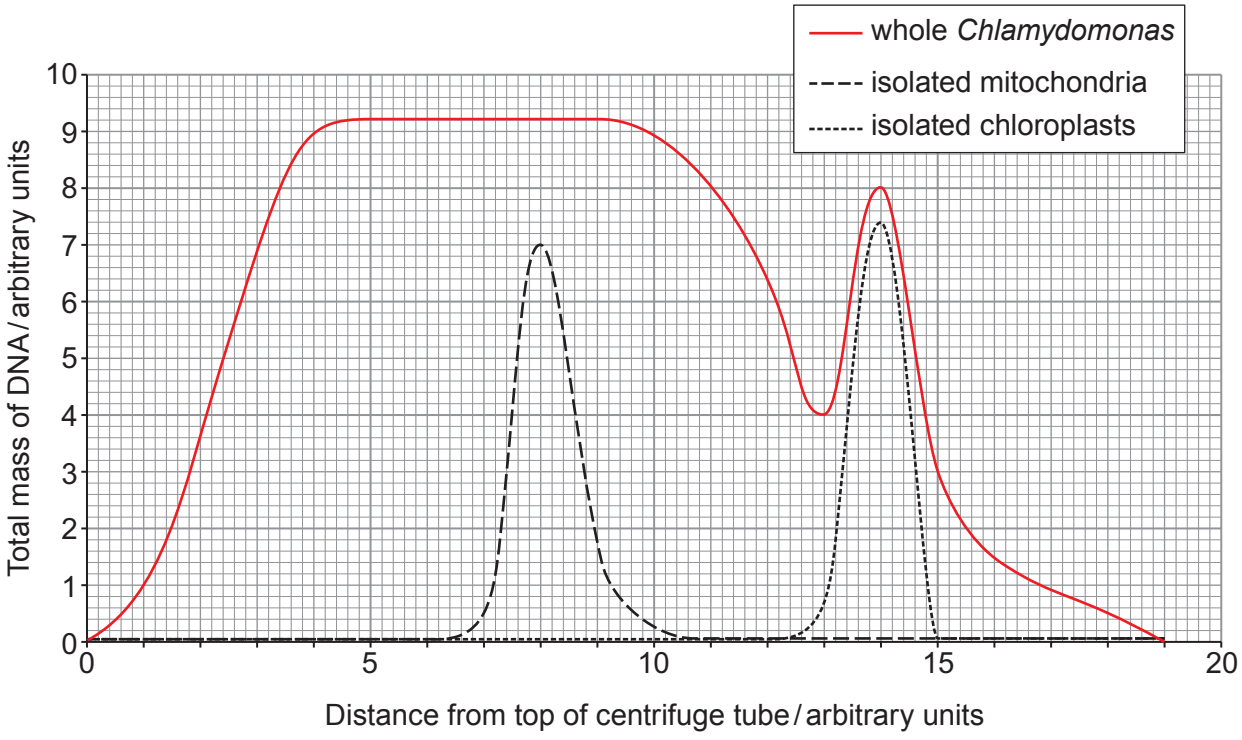
(c) The nuclear DNA of *Chlamydomonas reinhardtii* contains approximately 120 million base pairs arranged in 17 chromosomes of varying length. The mitochondrial DNA contains nearly 16 000 base pairs and the chloroplast DNA a further 203 000 base pairs.

DNA was extracted from whole *Chlamydomonas* and also from isolated mitochondria and chloroplasts. The samples were spun separately in an ultracentrifuge. The results are plotted on the graph below.



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(i) The cytoplasm of *Chlamydomonas* was found to contain an enzyme that partially digests the chromosomes. Explain how the presence of this enzyme could be a reason for the results obtained for the whole *Chlamydomonas* extract. [2]

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(ii) To improve the quality of data obtained using this method, the scientists added an inhibitor of the enzyme that digests the chromosomes of *Chlamydomonas*. Suggest how this change would affect the data obtained. [3]

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(iii) Explain why keeping the whole *Chlamydomonas* extract **on ice** in a **buffer** would also improve the quality of data. [2]

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(iv) Both mitochondria and chloroplasts are believed to have evolved from prokaryotes. What evidence does the graph provide that could support this hypothesis? Explain your answer. [2]

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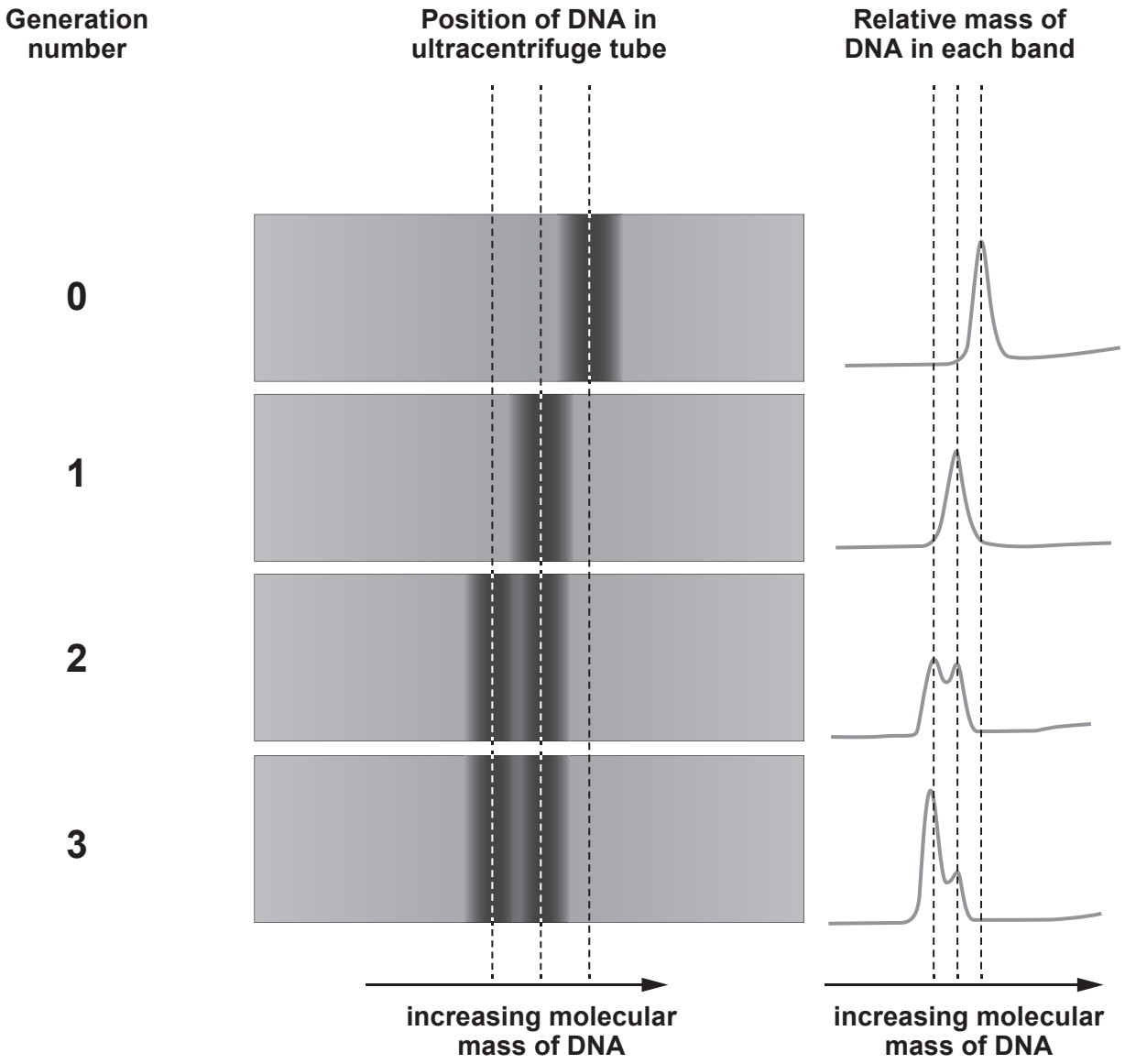
**6.** In 1958, Matthew Meselson and Franklin Stahl conducted a series of experiments that demonstrated that DNA replication is semi-conservative.

The images below show some of their results.




Other theories of DNA replication included:

- conservative replication, in which the original DNA is retained as a double stranded molecule; and
- dispersive replication, where the original DNA is split into many fragments which are then dispersed throughout the replicated molecules.

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Using your own knowledge of Meselson and Stahl's experiments, explain how their experiment and the results shown in the image supported the theory of semi-conservative replication. Predict how the results would have differed if the other theories had been correct. Explain your answer. [9 QER]

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**END OF PAPER**

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