Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE AS

B400U10-1

O21-B400U10-1

MONDAY, 11 OCTOBER 2021 – MORNING

BIOLOGY – AS component 1
Basic Biochemistry and Cell Organisation

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**12**	
2.	**16**	
3.	**9**	
4.	**13**	
5.	**16**	
6.	**9**	
Total	**75**	

B400U101
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. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

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**.

The quality of written communication will affect the awarding of marks.

OCT21B400U10101

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

Answer **all** *questions.*

1. Water provides an ideal environment for many living organisms due to its unique properties. It is involved in many of the processes that maintain life.

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

Water has unequal sharing of electrons (unequal charges) across the molecule: the oxygen atom is slightly negative (δ−) and the hydrogen atoms are slightly positive (δ+).

(ii) Explain why water is described as a universal solvent. [2]

Water can dissolve polar (charged) molecules and ions, as the δ+ and δ− regions of water molecules attract and surround them.

So minerals, oxygen and CO_2 can dissolve in the water and be transported.

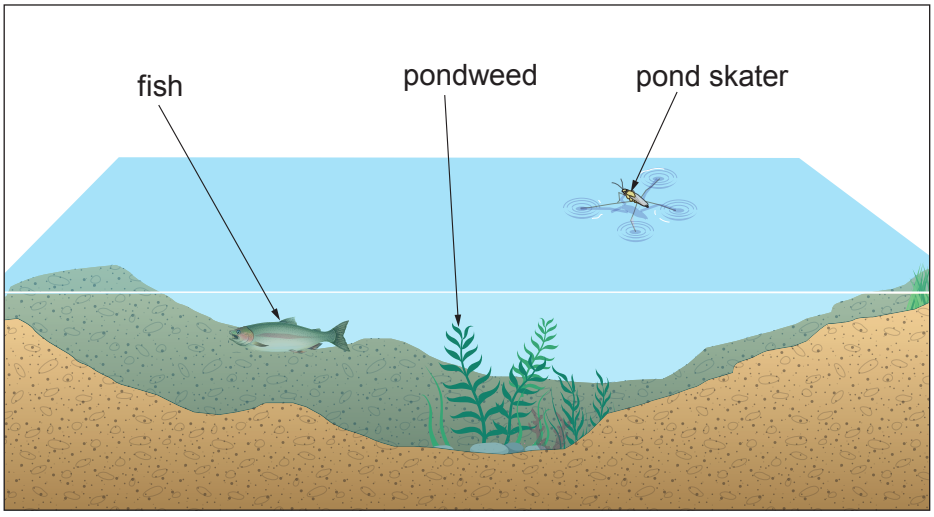
© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

Image 1.1 shows a typical pond.

Image 1.1



(b) With reference to **image 1.1**, use your knowledge of the **properties of water** to explain each of the following statements.

(i) The temperature of the pond stays relatively constant throughout the year. [2]

Water has a high specific heat capacity, so a large input of energy is needed to raise the temperature of the water.

(ii) Fish and plants can survive when the pond freezes over. [2]

Ice is less dense than water so it floats, and it forms an insulating layer on top of the pond, so the water below does not freeze.

(iii) Pond skaters can live on the surface of the pond. [2]

Hydrogen bonds form between water molecules (cohesion), which are stronger at the surface, creating surface tension that supports the pond skater.

(iv) Pondweed can grow underwater. [2]

Water is transparent, so light can penetrate for photosynthesis.

Carbon dioxide and minerals dissolved in the water can be absorbed for photosynthesis.

12

B400U101
03

© WJEC CBAC Ltd.

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

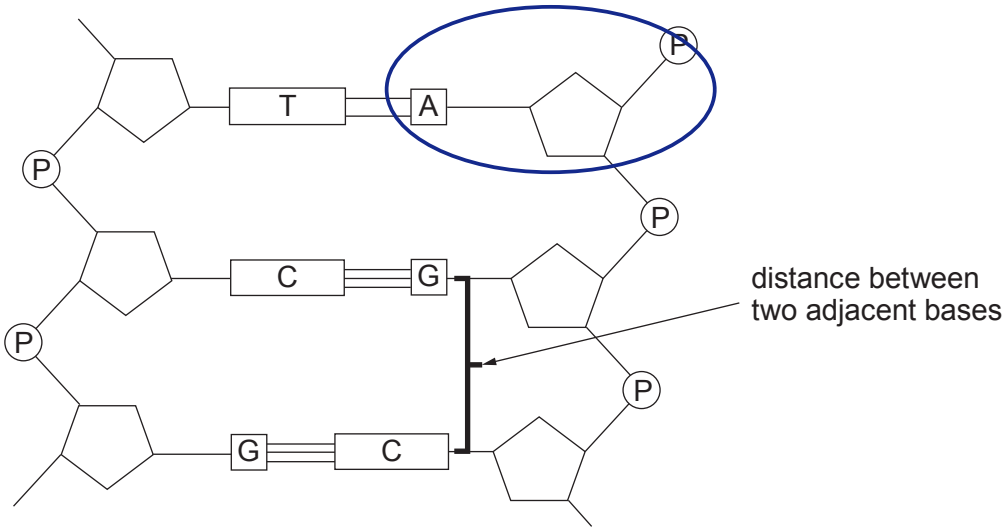
© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

2. DNA molecules comprise two polynucleotide strands linked by hydrogen bonds between the base pairs. A short section of DNA is shown in **image 2.1**.

Image 2.1



(a) (i) **Draw a ring** around **one** nucleotide. [1]

(ii) Each turn of the double helix contains 10 pairs of bases. A one metre length of DNA has 2.94×10^8 turns.
Calculate the distance between two adjacent bases as shown in **image 2.1**. **Give your answer in nm.** [3]

Total length of DNA = 1 m = 1 × 10^9 nm

Length of one turn = 1 × 10^9 / 2.94 × 10^8 = 3.4 nm

Distance between bases = 3.4 / 10 = 0.34 nm

Distance between base pairs = ..0.34.. nm

B400U101 05

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

Table 2.2 shows some mRNA base sequences together with their corresponding amino acids.

Table 2.2

mRNA base sequence	Amino acid
UAG	stop codon
UUU	Phe
GAC	Asp
CUC	Leu
GUU	Val
AUG	Met
UAU	Tyr
ACC	Thr
CGU	Arg
GAU	Asp
ACA	Thr

(b) (i) Using the data from **table 2.2** explain why the genetic code is described as degenerate. [1]

Some amino acids are coded for by more than one codon, e.g. Asp is coded for by both GAC and GAU (Thr by ACC and ACA).

(ii) A section of bases in an mRNA molecule is shown in **table 2.3**. Use **table 2.2** to complete **table 2.3** to show:

I. the base sequence of the DNA template from which the mRNA was transcribed; [1]

II. the amino acid sequence coded for by this mRNA molecule. [1]

Table 2.3

DNA base sequence	*TAC*	*CAA*	*ATA*	*TGG*	*CTA*	*ATC*
mRNA base sequence	AUG	GUU	UAU	ACC	GAU	UAG
Amino acid sequence	*Met*	*Val*	*Tyr*	*Thr*	*Asp*	*Stop*

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(iii) A change in the order of bases in the genetic code is known as a mutation. In the following example a change in a single base in the code is shown.

Original mRNA sequence	AUG GUU UAU ACC GAU UAG
mRNA sequence following mutation	AUG GUU UAG ACC GAU UAG

Explain why the polypeptide produced from the mutated mRNA sequence would be non-functional. [2]

UAU (Tyr) becomes UAG, a stop codon, so a shorter (incomplete) polypeptide is made with a changed primary structure. This changes the folding and tertiary structure (3D shape) of the protein, e.g. the active site shape of an enzyme, so it cannot function.

QUESTION CONTINUES ON THE NEXT PAGE

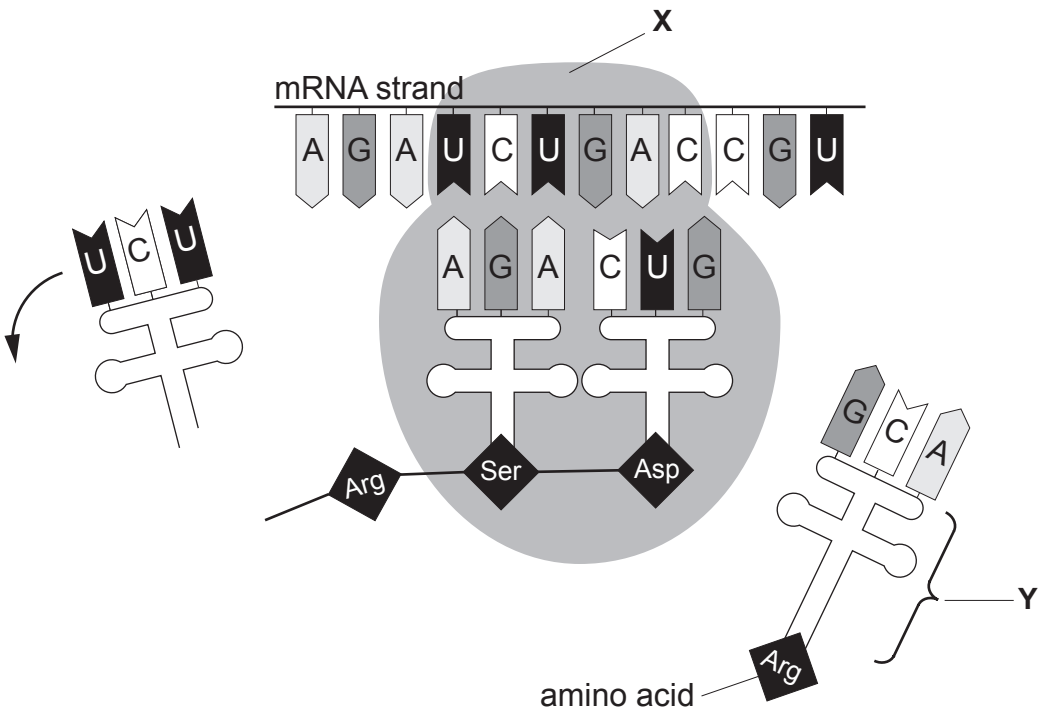
B400U101 07

© WJEC CBAC Ltd.

Examiner only

Image 2.4 shows the process by which mRNA is used to synthesise a polypeptide.

Image 2.4



(c) (i) Name structures **X** and **Y**. [2]

X Ribosome

Y Transfer RNA (tRNA)

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(ii) Name and describe the process shown in **image 2.4**. [5]

The process is translation.

Each tRNA carries a specific amino acid and brings it to the ribosome.

The anticodon of the tRNA binds to the complementary codon on the mRNA by complementary base pairing (A to U, C to G).

The ribosome has two binding sites, so a second tRNA brings a second amino acid alongside the first.

A peptide bond forms between the two amino acids by a condensation reaction.

The ribosome moves along the mRNA by one codon and this repeats until a stop codon is reached.

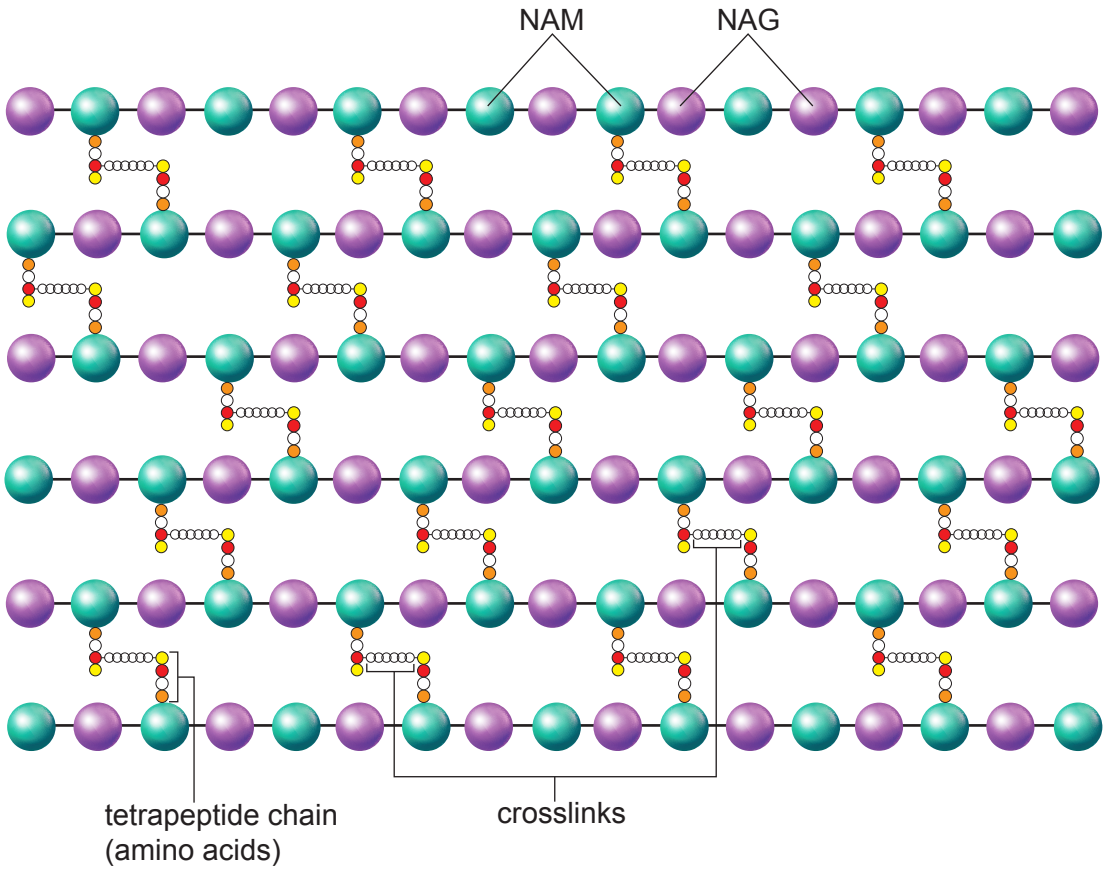
© WJEC CBAC Ltd.

Examiner only

3. The main structural component of many bacterial cell walls is peptidoglycan.
The molecular structure of peptidoglycan is illustrated in **image 3.1**. NAG and NAM are sugars that make up the polysaccharide chain component of peptidoglycan.

Image 3.1

Polysaccharide chain



© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(a) Using **image 3.1** and your knowledge of plant cell wall structure, identify **four** differences in the structure of bacterial and plant cell walls. [4]

Bacterial cell wall	Plant cell wall
Made of peptidoglycan (murein)	Made of cellulose
Polysaccharide chains of NAM and NAG	Chains of β-glucose
Contains (tetrapeptide) chains of amino acids	Contains no amino acids
Cross-links between amino acid chains, no hydrogen bonds	No amino acid cross-links; hydrogen bonds between β-glucose chains

(b) Bacterial cells are hypertonic to their environments. Suggest how the structure of the bacterial cell wall enables bacteria to survive in such environments. [3]

Bacterial cells have a lower water potential than their environment (a higher concentration of solutes inside the cell).

Water enters the cell by osmosis, down the water potential gradient.

The peptidoglycan wall is strong (cross-linked) and withstands the expansion of the cell contents, creating a pressure potential, so it prevents the cell from bursting.

Some antimicrobial agents kill bacteria by disrupting the formation of the cross-links between the amino acid chains in peptidoglycan.

(c) Suggest how the action of these anti-microbial agents could kill bacteria. [2]

Without cross-links the cell wall is weak and cannot withstand the expansion as water enters by osmosis.

So the cell will burst (lyse).

B400U101 11

9

© WJEC CBAC Ltd.

Examiner only

4. **Image 4.1** shows an electron micrograph of part of an epithelial cell from the small intestine. **Image 4.2** shows a section through a capillary.

Image 4.1

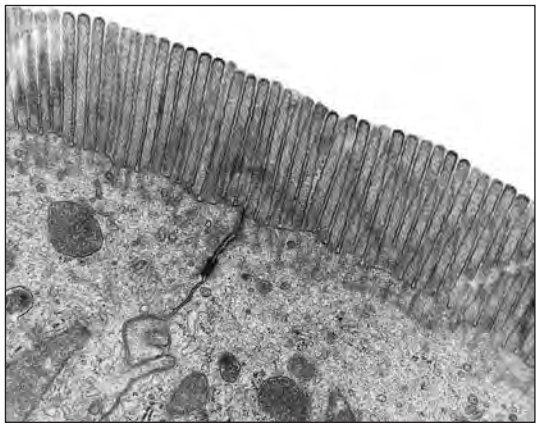
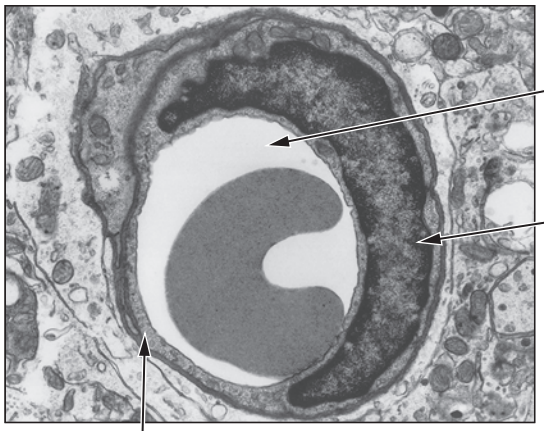


Image 4.2



(a) Fick's law of diffusion can be summarised as:

$$\text{Rate of diffusion} = \frac{\text{surface area} \times \text{difference in concentration}}{\text{length of the diffusion path}}$$

Using **images 4.1** and **4.2**, explain how the two cells are adapted to increase the rate of diffusion.

(i) Epithelial cell from small intestine. [1]

It has microvilli, which increase the surface area for diffusion of the products of digestion.

(ii) Capillary endothelial cell. [1]

It is very thin (flattened), so it reduces the length of the diffusion path into and out of the capillary.

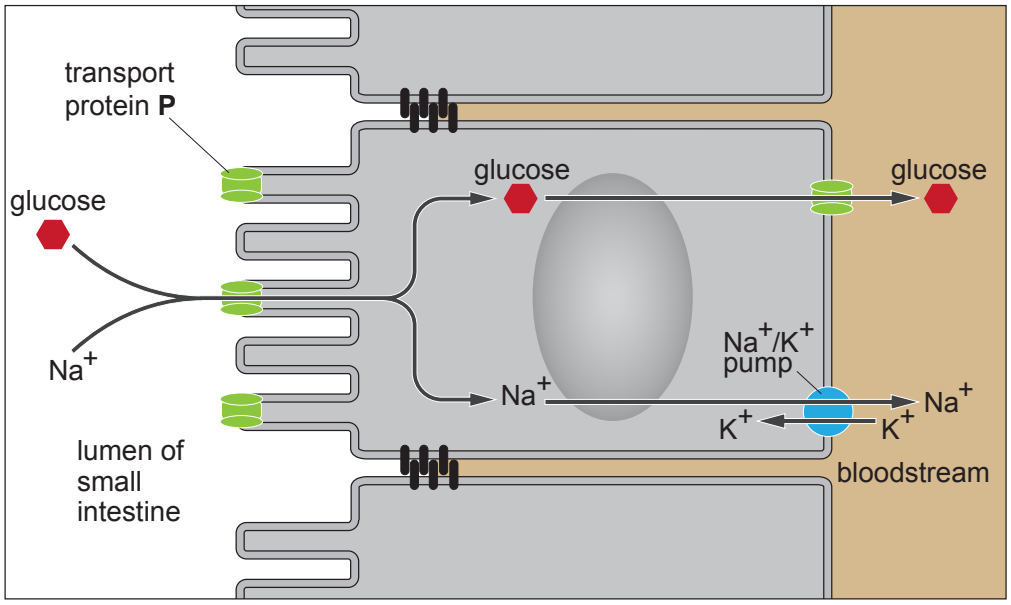
© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(b) **Image 4.3** shows how glucose and sodium ions are transported from the lumen of the small intestine into the bloodstream in a villus.

Image 4.3



Glucose is transported through a transmembrane carrier protein from the cytoplasm of the epithelial cell into the bloodstream.

(i) Name the process by which glucose moves from the cytoplasm of the epithelial cell into the bloodstream. [1]

Facilitated diffusion

(ii) The movement of glucose from the lumen of the intestine into the epithelial cell is dependent on a concentration gradient of sodium ions between the lumen of the intestine and the cytoplasm of the epithelial cell.

I. Explain how the concentration gradient of sodium ions is maintained and how this enables the movement of glucose into the epithelial cell. [4]

The Na^+/K^+ pump transports Na^+ out of the epithelial cell into the bloodstream by active transport (using ATP). This reduces the Na^+ concentration in the cytoplasm of the epithelial cell, maintaining the gradient. There is a high Na^+ concentration in the lumen from dietary sources. Na^+ diffuses into the cell through protein P, taking glucose with it by cotransport.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

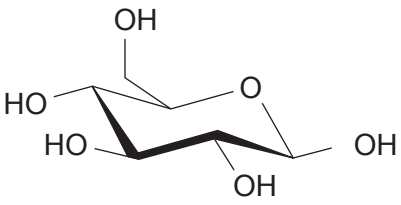
II. The movement of glucose from the cell to the bloodstream also requires a concentration gradient. Explain how this is maintained. [1]

Blood flow removes the absorbed glucose, lowering the glucose concentration in the bloodstream.

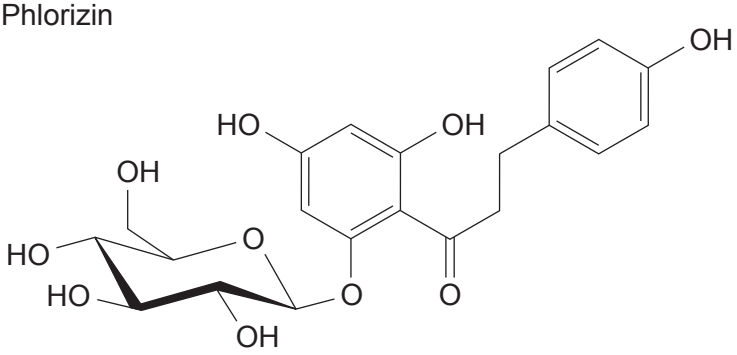
(c) Phlorizin is an inhibitor of glucose uptake by epithelial cells. The structures of glucose and phlorizin are shown in **image 4.4**.

Image 4.4

Glucose



Phlorizin



(i) Suggest how phlorizin would affect the uptake of glucose in the small intestine by transport protein **P** in **image 4.3**. Explain your answer. [3]

It slows down (reduces) the rate of glucose uptake.

Phlorizin has a similar shape to glucose (it contains a glucose ring), so it fits into transport protein P as it is complementary to the binding site.

So it competes with glucose and prevents glucose from entering the transport protein.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(ii) Most cells take in glucose for metabolism using glucose transport proteins like those in epithelial cells. Cancer cells have an extremely high requirement for glucose.

Some scientists have suggested that phlorizin could be used as a drug to treat cancer by blocking the cells' ability to take in glucose.

Using your knowledge of cancer cells, suggest why this treatment might reduce the growth of tumours. [2]

Cancer cells divide continuously (uncontrolled mitosis), so they have a higher demand for glucose for respiration to release energy (ATP). Blocking glucose uptake stops them having enough ATP to keep dividing, so tumour growth slows.

13

© WJEC CBAC Ltd.

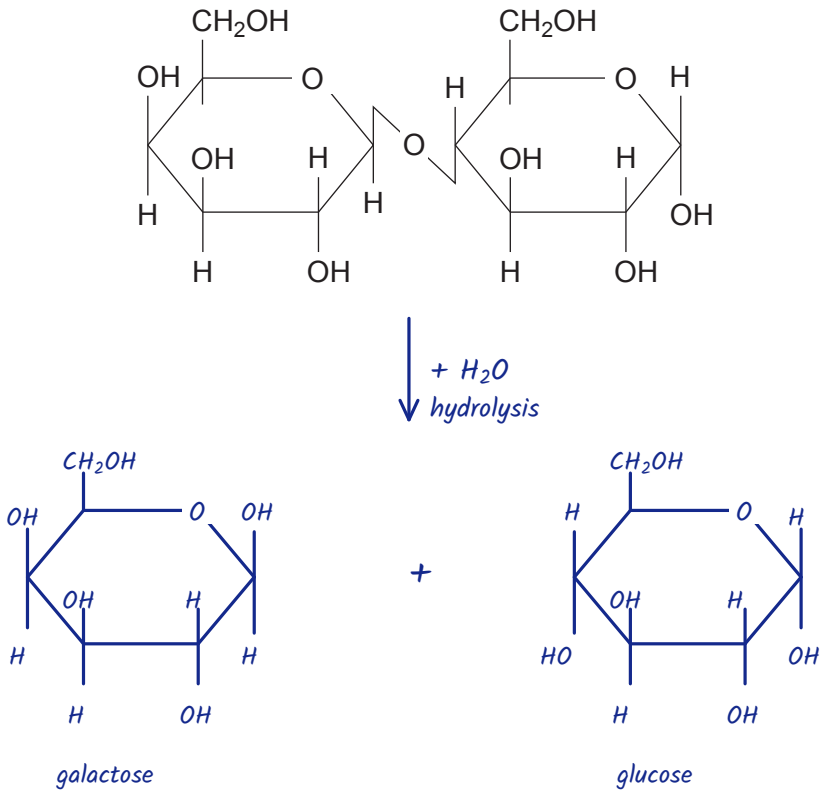
stemup.co.uk

Examiner only

5. Lactose is a disaccharide found in milk. Some people are intolerant to lactose and would suffer stomach pain if they drank normal milk because they are unable to digest lactose.

(a) **Image 5.1** shows the structure of lactose.

Image 5.1



(i) **Complete image 5.1** to show how the molecule would be broken down into two monosaccharides. [2]

(ii) Name the bond which is broken in the digestion of lactose. [1]

(1-4) glycosidic bond

(iii) Explain why glucose and galactose are known as structural isomers of one another. [1]

They have the same chemical (molecular) formula, $C_6H_{12}O_6$, but a different molecular structure (arrangement of atoms).

© WJEC CBAC Ltd.

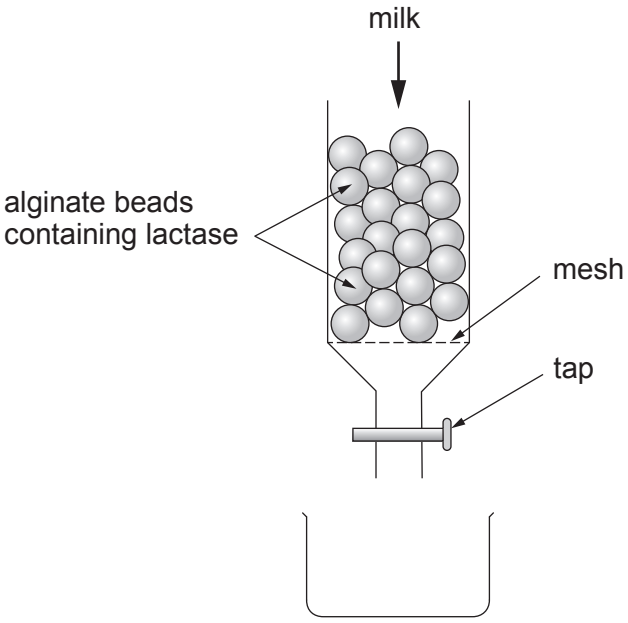
stemup.co.uk

Examiner only

Milk may be treated to break down the lactose into its constituent monosaccharides, glucose and galactose, by passing it down a column of the enzyme lactase immobilised in alginate beads.

Image 5.2 shows the experimental set-up used by a student to investigate the effect of changing bead diameter on the rate of hydrolysis of lactose.

Image 5.2



The following method was used to prepare the alginate beads.

- Mix 9.5 cm^3 of 2% sodium alginate solution and 0.5 cm^3 of lactase solution in a small beaker.
- Place 100 cm^3 1.5% calcium chloride solution into a clean beaker.
- Using a pipette with a 0.2 cm diameter, drop the alginate and lactase mixture into the calcium chloride to form beads.
- Remove the beads from the calcium chloride solution and rinse with distilled water.
- Repeat the method with pipettes of diameters 0.3, 0.4, and 0.5 cm.

The beads were then placed in a column as shown in **image 5.2** and the rate of lactose hydrolysis at room temperature for each diameter bead was measured.

(b) (i) Suggest why it is important to rinse the beads with distilled water before use. [1]

To wash off any excess enzyme and calcium chloride from the surface of the beads.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(ii) Explain why the same solution of alginate and lactase was used to make all the different sizes of bead. [1]

To ensure all the bead sizes have the same concentration of lactase.

(iii) Carrying out the experiment at room temperature reduces reproducibility. Explain why and suggest how this could be improved. [2]

Room temperature varies, changing enzyme activity; use a thermostatically controlled water bath.

Table 5.3 shows the mean volume of the beads produced together with the number of beads of each diameter that can be made from 10 cm^3 sodium alginate / enzyme mix.

Table 5.3

Diameter of bead / cm	Mean volume of one bead / cm^3	Number of beads made from 10 cm^3 sodium alginate / enzyme mix
0.2	0.0042	2380
0.3	0.014	710
0.4	0.034	290
0.5	0.065	150

(c) (i) I. Calculate the mean volume of the 0.2 cm diameter beads.
Volume of a sphere = $\frac{4}{3}\pi r^3$
Where π = 3.142
Express your answer to 2 significant figures.
Write your answer in the table. [3]

$r = 0.2 / 2 = 0.1$ cm

$V = 4/3 \times 3.142 \times 0.1^3 = 0.0041893 = 0.0042$ cm^3

II. Calculate the number of these beads that could be made using the above method from 10 cm^3 of the sodium alginate / enzyme mix.
Write your answer in the table. [2]

Number of beads = 10 / 0.0042 = 2380.95

= 2380 whole beads

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(ii) Predict the relationship between bead diameter and rate of hydrolysis. Explain your answer. [3]

The smaller the bead diameter, the higher the rate of hydrolysis of lactose.

Smaller beads have a larger surface area to volume ratio, and as there are more beads from the same volume, the overall surface area is larger. So more lactase molecules are near the surface and lactose diffuses into the beads more easily, so there is a higher chance of enzyme-substrate complexes forming.

16

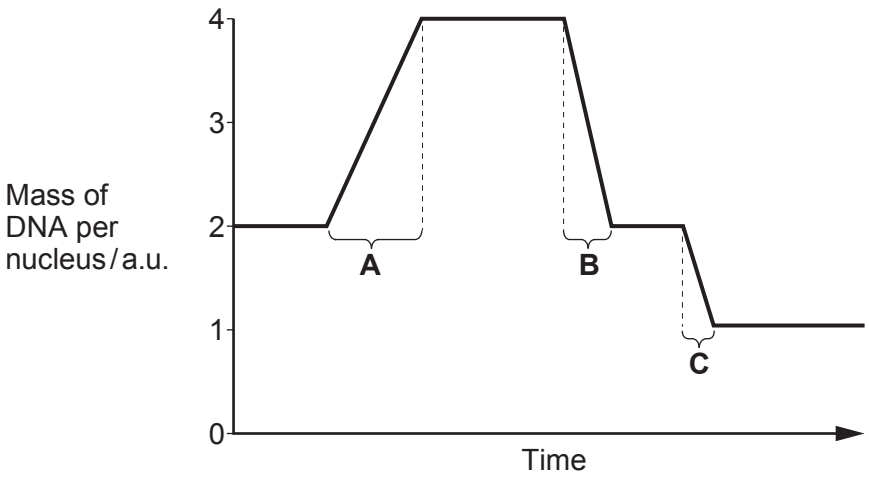
© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

6. **Image 6.1** shows the changes which take place in the mass of DNA within the nucleus of a single cell during one type of cell division.

Image 6.1



Identify, with an explanation, the type of cell division taking place.
Describe the changes in the mass of DNA that take place in stages **A**, **B** and **C**.
Explain the significance of this type of cell division to the survival of the species. [9 QER]

This is meiosis. The graph shows that the mass of DNA per nucleus at the end (1 a.u.) is half the mass at the start (2 a.u.), so the daughter cells contain half the DNA of the parent cell. There are also two separate falls in DNA mass, showing two stages of division (meiosis I and meiosis II), whereas mitosis has only one division and keeps the DNA mass at 2 a.u.

Stage A: during interphase (S phase) the DNA is replicated, so the mass of DNA doubles from 2 to 4 a.u. Each chromosome now consists of two identical sister chromatids.

Stage B: this is the first meiotic division. Homologous chromosomes pair up and then the homologues separate to opposite poles, so the mass of DNA is halved from 4 to 2 a.u. in each new nucleus.

Stage C: this is the second meiotic division. The chromatids of each chromosome separate to opposite poles, so the mass of DNA halves again from 2 to 1 a.u. Four daughter cells are produced, which are haploid, containing one chromosome from each homologous pair.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

Significance: meiosis produces haploid gametes, so when two gametes fuse at fertilisation the diploid chromosome number is restored each generation. Meiosis also produces genetic variation. Crossing over during prophase I exchanges sections between non-sister chromatids of homologous chromosomes, producing new combinations of alleles. Random (independent) assortment of homologous pairs on the equator during metaphase I, and random assortment of the non-identical sister chromatids in metaphase II, produces many different combinations of chromosomes in the gametes.

This genetic variation means that some individuals have advantageous characteristics, so if the environment changes some will survive and reproduce (natural selection). Variation therefore promotes the survival of the species.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

.....

.....

.....

9

END OF PAPER

© WJEC CBAC Ltd.

stemup.co.uk

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only

© WJEC CBAC Ltd.

stemup.co.uk