Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A LEVEL

2400U10-1

S19-2400U10-1

BIOLOGY – AS unit 1
Basic Biochemistry and Cell Organisation

TUESDAY, 21 MAY 2019 – AFTERNOON

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	10	
2.	15	
3.	14	
4.	18	
5.	14	
6.	9	
Total	80	

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ADDITIONAL MATERIALS

A calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
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 pages 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 the quality of extended response (QER) will take place in question 6.
The quality of written communication will affect the awarding of marks.

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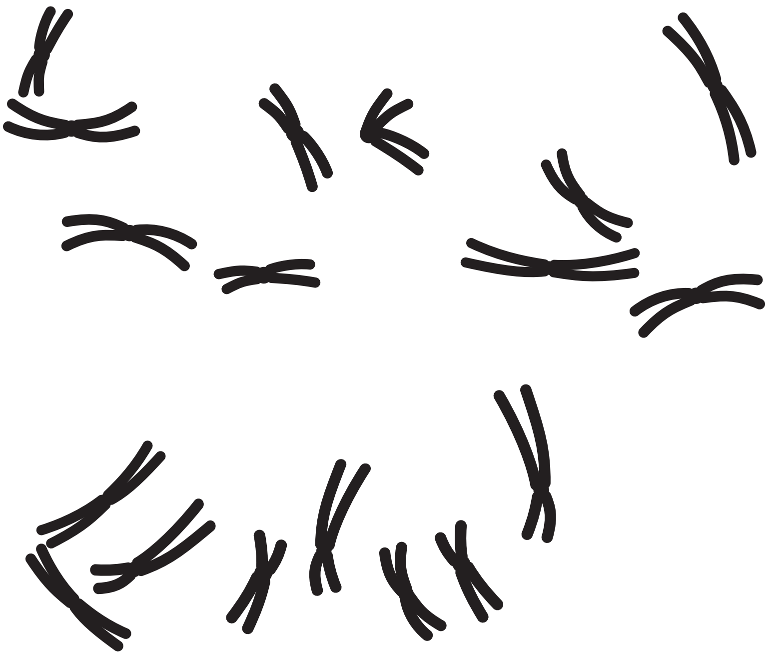
Answer **all** *questions.*

1. *(a)* The diagram below shows the chromosomes from a single cell of a Chinese daisy, *Aster shennongjiaensis*, during prophase of mitosis.



(i) State the **haploid** number of chromosomes in this species. [1]

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(ii) State the evidence from the diagram that the cell is undergoing mitosis and not meiosis. [1]

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(iii) When the tissues from the plant were removed they were stained before being viewed under the microscope. Explain how this makes the chromosomes visible. [1]

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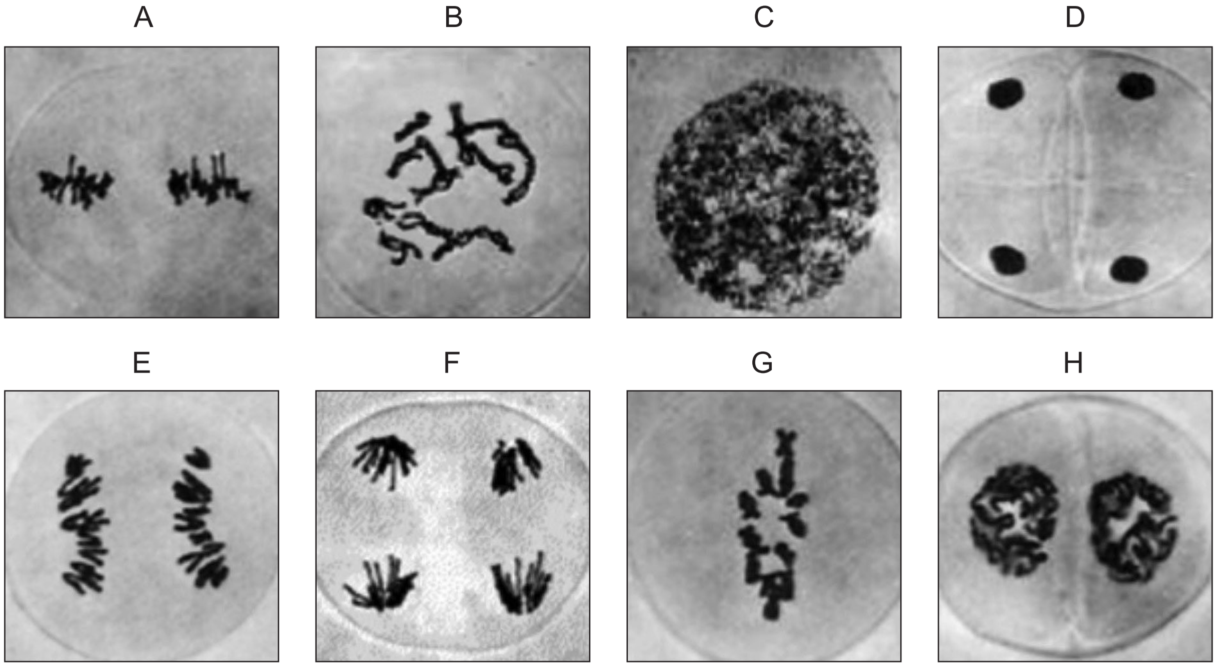
(b) The photomicrographs below show different stages of meiosis in a different plant species.



(i) State which organ of the plant could have been used to obtain the photomicrographs above. [1]

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(ii) Place the photomicrographs in the correct order. Some letters have been done for you. [1]

C					A	F	D

(iii) Use your knowledge of cell division to describe **two** differences between the stages labelled **E** and **F**. [2]

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(iv) With reference to photomicrographs **B** and **G**, state how meiosis contributes to genetic variation in the species and explain why this is important. [3]

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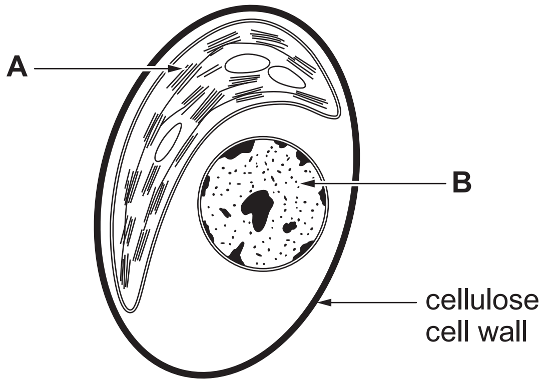
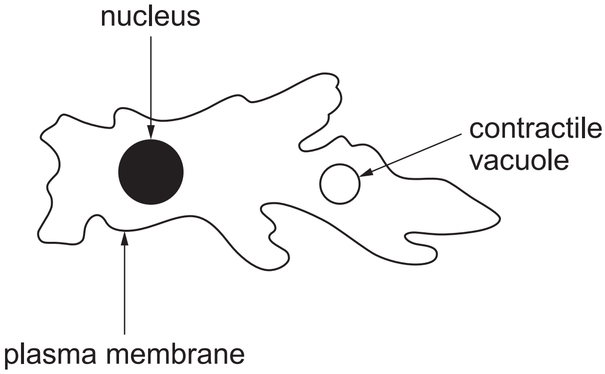
2. The diagrams below show two unicellular protoctistans (not drawn to scale) that inhabit fresh water ponds. The presence of solutes in the cytoplasm of their cells makes them hypertonic to their environment.

Chlorella



Amoeba



(a) Name organelles **A** and **B**. [1]

organelle **A**: ....

organelle **B**: ....

(b) *Amoeba* contains structures called contractile vacuoles which expel excess water from the cell. It can be seen that the contractile vacuole first increases in size, then migrates to and fuses with the plasma membrane. Scientists have recently discovered proteins within the membrane of these vacuoles that can pump ions into it.

(i) Use your knowledge of osmosis to explain why contractile vacuoles are necessary for the survival of the *Amoeba*. [4]

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(ii) Identify **two** *other* organelles which must be present in large numbers in the *Amoeba* in order for this process to occur. Explain your answer for each organelle. [4]

Organelle 1 ....

Explanation ....

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Organelle 2 ....

Explanation ....

....

(c) Although *Chlorella* lives in the same habitat as *Amoeba*, it does not possess a contractile vacuole. Describe and explain how the structure of the cell wall of *Chlorella* allows it to survive in this environment. [4]

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(d) Bacteria, such as *Cyanophyceae* also inhabit fresh water ponds.
Describe **two** differences between the structure of *Chlorella* and *Cyanophyceae*. [2]

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3. *(a)* A student wanted to investigate the concentration of casein in milk powder. Casein is an insoluble protein found in milk. When milk powder is mixed with water it forms an opaque (cloudy) suspension. The enzyme trypsin breaks down the casein into soluble peptides, forming a transparent solution.

To begin with the student needed to construct a calibration curve from known concentrations of milk powder suspensions. He was provided with the following:

- 10 cm^3 suspensions made from milk powder at concentrations of 1%, 2%, 3%, 4% and 5% in separate test tubes with a buffer
- 1% trypsin solution

The milk suspensions and trypsin solution were placed separately in a thermostatically controlled water bath at 30 °C. Once both the milk suspensions and trypsin solution were at the correct temperature, he transferred 2 cm^3 of trypsin to each of the suspensions of milk powder and timed how long it took for the suspensions to become transparent.

(i) Using your knowledge of enzymes, explain why:

I. it was necessary for a buffer to be added to the solutions; [2]

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II. all test tubes were placed in a thermostatically controlled water bath. [2]

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The table below shows the results.

Concentration of milk powder suspension / %	Time taken for milk powder suspension to become transparent / s					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	mean
1	49	51	55	52	53	52.0
2	66	64	62	61	63	63.2
3	88	77	73	81	84	80.6
4	91	87	93	86	99	....
5	96	109	108	111	105	105.8

(ii) Calculate the mean time taken for the 4% milk powder suspension to become transparent. **Write your answer in the table.** [1]

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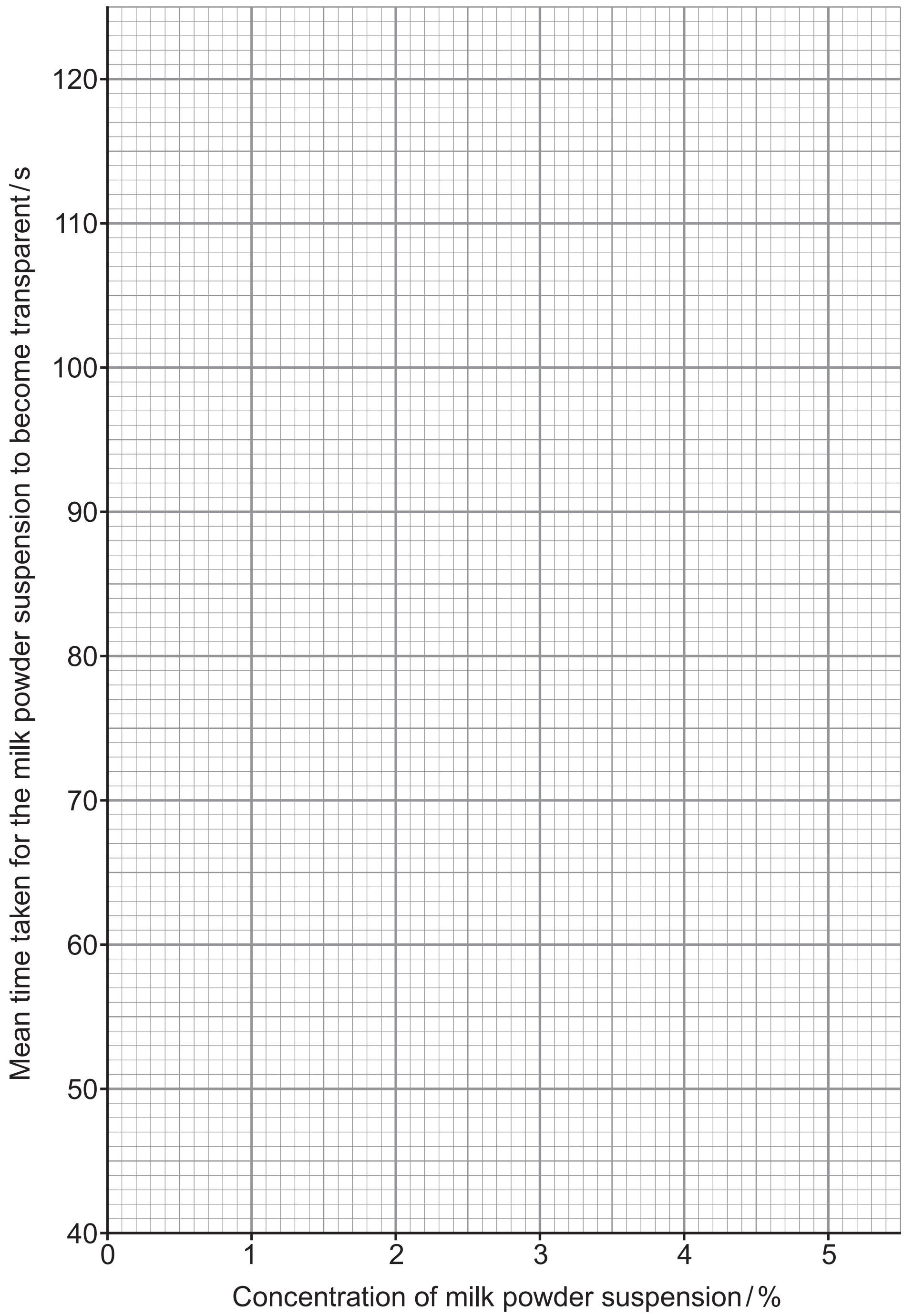
(iii) Plot the mean data on the graph paper provided. **Range bars should also be added to the graph.** [4]



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Turn over.

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(b) The student was then provided with two different suspensions of milk powder, **X** and **Y**, of unknown casein concentration. He carried out the same procedure and obtained the following mean results: **X** took 61 seconds to clear and **Y** took 97 seconds to clear.

(i) Estimate the percentage concentration of casein in these two suspensions. [1]

X: .... **Y**: ....

(ii) The student had more confidence in the estimate for suspension **X** than the estimate for suspension **Y**. Use the graph to explain the reason for this statement. [2]

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(iii) Suggest **two** sources of inaccuracy in this experiment. [2]

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4. Haemoglobin exhibits quaternary structure and consists of four subunits, two subunits called alpha-globin and two subunits called beta-globin.

(a) Define quaternary structure. [1]

(b) (i) The beta-globin molecule consists of 146 amino acids. State the minimum number of mRNA nucleotides required to code for this molecule. [1]

(ii) The genetic code is a triplet code and is degenerate. The table below shows the **mRNA codons**, that code for specific amino acids.

Second letter

First letter	U	C	A	G	**Third letter**
U	UUU UUC: Phenyl-alanine UUA UUG: Leucine	UCU UCC UCA UCG: Serine	UAU UAC: Tyrosine UAA: Stop codon UAG: Stop codon	UGU UGC: Cysteine UGA: Stop codon UGG: Tryptophan	U C A G
C	CUU CUC CUA CUG: Leucine	CCU CCC CCA CCG: Proline	CAU CAC: Histidine CAA CAG: Glutamine	CGU CGC CGA CGG: Arginine	U C A G
A	AUU AUC AUA: Isoleucine AUG: Methionine initiation codon	ACU ACC ACA ACG: Threonine	AAU AAC: Asparagine AAA AAG: Lysine	AGU AGC: Serine AGA AGG: Arginine	U C A G
G	GUU GUC GUA GUG: Valine	GCU GCC GCA GCG: Alanine	GAU GAC: Aspartic acid GAA GAG: Glutamic acid	GGU GGC GGA GGG: Glycine	U C A G

Use the table to explain why it is necessary that the code is a triplet code and why the code is said to be degenerate. [2]

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(iii) The table below shows part of the DNA sequence that codes for beta-globin and the corresponding mRNA codons, tRNA anticodons and the amino acid sequence of the molecule.

Complete the table. [4]

	Codon position number					
	3	4	5	6	7	8
DNA coding strand	GAC	....	....	CTC	CTC	....
mRNA codons	....	ACU	....	GAG	GAG	....
tRNA anticodons	....	....	GGA	CUC	CUC	....
Amino acid sequence	....	....	....	Glutamic acid	Glutamic acid	Lysine

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(c) Describe the events which take place in the production of the beta-globin molecule after the ribosome has attached to the mRNA. [5]

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(d) A mutation, where a single base was substituted by a different base, resulted in glutamic acid being replaced by valine at position 6 in the beta-globin molecule. Use the information provided to determine the mutated DNA base sequence at position 6 on the coding strand of DNA. [1]

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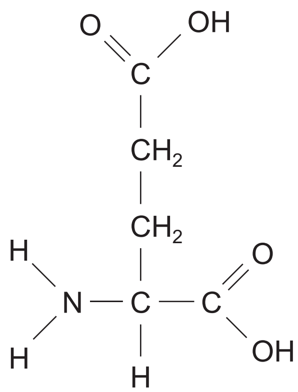
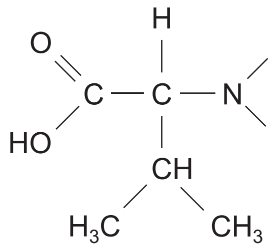
(e) The diagrams below show the structures of glutamic acid and valine.



glutamic acid



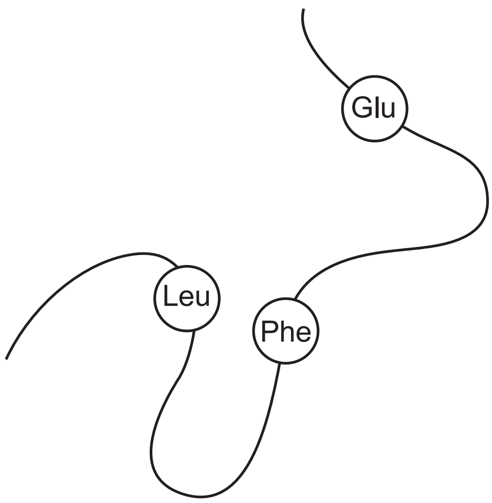
valine

(i) **Draw a circle** around the R-groups of these **two** amino acids. [1]

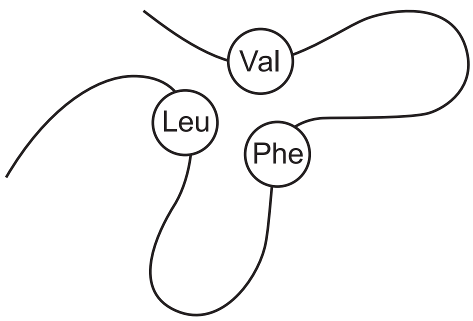
The R-group of glutamic acid is polar whereas the R-group of valine is non-polar. This affects the 3D structure of the resulting beta-globin molecule, as shown in the diagram below.

Key:

Glu – glutamic acid
Val – valine
Leu – leucine
Phe - phenylalanine



Section of beta-globin molecule in a person **without** mutation



Section of beta-globin molecule in a person **with** mutation

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(ii) Valine interacts with phenylalanine and leucine in the beta-globin molecule. Phenylalanine and leucine both have non-polar R-groups. Explain how the properties of these amino acids mean that valine interacts with phenylalanine and leucine but glutamic acid does not. [3]

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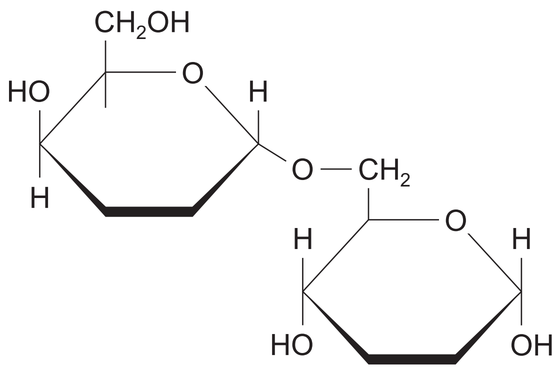
5. Melibiose is a reducing sugar that is formed from galactose and glucose and is thirty times sweeter than sucrose.

(a) The diagram below shows the structure of melibiose.



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

(ii) State the type of reaction that occurs when this molecule is broken down into two monosaccharides. [1]

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(iii) Describe a biochemical test that could be used to determine the presence of a reducing sugar such as melibiose. [2]

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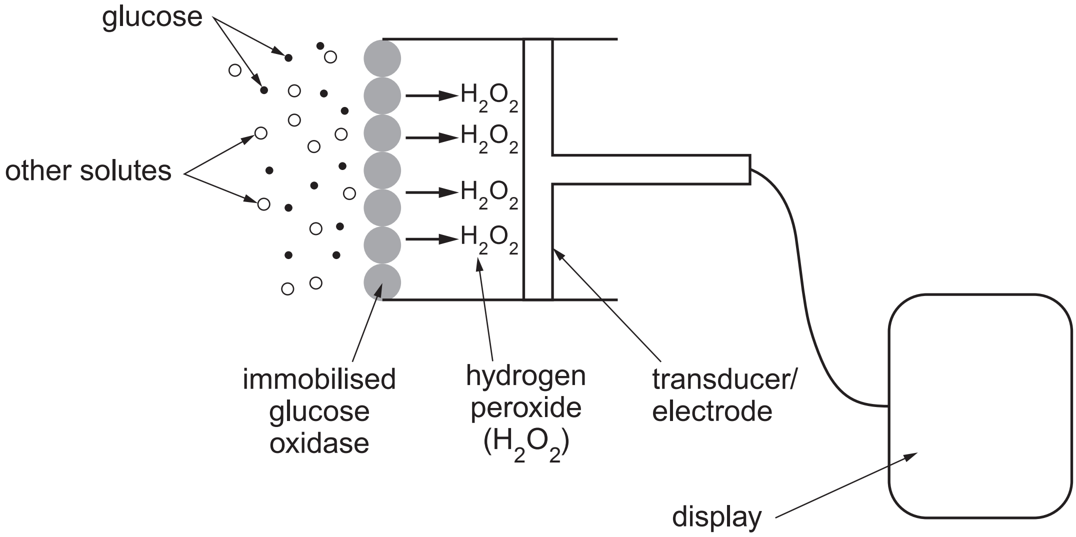
(b) Biosensors make use of immobilised enzymes to detect specific molecules in a mixture. The diagram below shows a possible structure of a biosensor that could be used to detect the presence of glucose in a urine sample.



Within the biosensor, the glucose oxidase catalyses the following reaction:

$$\text{glucose} + \text{oxygen} \xrightarrow{\text{glucose oxidase}} \text{gluconic acid} + \text{hydrogen peroxide}$$

The concentration of hydrogen peroxide is detected by the transducer and converted into an electrical signal, shown as a measurement on the display.

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(i) Using your knowledge of enzymes explain why this biosensor will only detect the presence of glucose. [3]

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(ii) With reference to the information given, explain how the biosensor could be used to give a measurement of the glucose concentration. [2]

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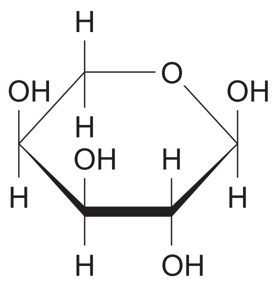
(c) Arabinose is a monosaccharide that can also be used as a sweetener. The diagram below shows the structural formula of arabinose.



Arabinose

Experiments have shown that arabinose can inhibit glucose oxidase and therefore affect the accuracy of the biosensor. Using the information provided in part *(a)* and the diagram above, explain why the contamination of a urine sample with arabinose would affect the accuracy of the biosensor. [4]

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6. The following extracts are adapted from articles published on the Internet.

Hidden ocean found on Saturn's icy moon, Enceladus, could potentially support life.

Enceladus harbours a big ocean of liquid water beneath its icy crust that may be capable of supporting life as we know it. Researchers said that the water is about 10 kilometres deep and lies beneath a shell of ice 30 to 40 km thick. Furthermore, it is in direct contact with a rocky sea floor, theoretically making possible all kinds of complex chemical reactions – such as the kind that may have led to the rise of life on Earth.

NASA finds more evidence that the ocean on Enceladus could support alien life.

NASA's Cassini spacecraft orbiting the moon has analysed the plumes of gas forced out through fissures in the ice. These plumes have been found to contain four of the six most important elements of life on Earth – carbon, hydrogen, nitrogen and oxygen – only phosphorus and sulfur have not been detected.

Describe the structure of water and explain how the properties of water would be essential to supporting life on Enceladus. Explain how the absence of phosphorus and sulfur would prevent the formation of biochemical molecules essential for life on Earth. [9 QER]

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