F212: Module 1: Biological Molecules
From June 2009-January 2013
Questions

(a) describe how hydrogen bonding occurs between water molecules, and relate this, and other properties of water, to the roles of water in living organisms
(b) describe, with the aid of diagrams, the structure of an amino acid;
(c) describe, with the aid of diagrams, the formation and breakage of peptide bonds in the synthesis and hydrolysis of dipeptides and polypeptides;
(d) explain, with the aid of diagrams, the term *primary structure;*
(e) explain, with the aid of diagrams, the term *secondary structure* with reference to hydrogen bonding
(f) explain, with the aid of diagrams, the term *tertiary structure*, with reference to hydrophobic and hydrophilic interactions, disulfide bonds and ionic interactions;
(g) explain, with the aid of diagrams, the term *quaternary structure*, with reference to the structure of haemoglobin;
(h) describe, with the aid of diagrams, the structure of a collagen molecule;
(i) compare the structure and function of haemoglobin (as an example of a globular protein) and collagen (as an example of a fibrous protein);
(j) describe, with the aid of diagrams, the molecular structure of alpha-glucose as an example of a monosaccharide carbohydrate;
(k) state the structural difference between alpha- and beta-glucose;
(l) describe, with the aid of diagrams, the formation and breakage of glycosidic bonds in the synthesis and hydrolysis of a disaccharide (maltose) and a polysaccharide (amylose);
(m) compare and contrast the structure and functions of starch (amylose) and cellulose;
(n) describe, with the aid of diagrams, the structure of glycogen;
(o) explain how the structures of glucose, starch (amylose), glycogen and cellulose molecules relate to their functions in living organisms;
(p) compare, with the aid of diagrams, the structure of a triglyceride and a phospholipid;
(q) explain how the structures of triglyceride, phospholipid and cholesterol molecules relate to their functions in living organisms;
(r) describe how to carry out chemical tests to identify the presence of the following molecules: protein (biuret test), reducing and non-reducing sugars (Benedict's test), starch (iodine solution) and lipids (emulsion test);
(s) describe how the concentration of glucose in a solution may be determined using colorimetry

4 **(a)** Lipids form an important part of a balanced diet but if too many lipids are consumed this can result in obesity.

What is meant by the term *balanced diet*?

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..... **[2]**

(b) **(i)** Lipids are used for energy storage and as a respiratory substrate.

List **three** other roles of lipids in the human body.

1 .....

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2 .....

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3 .....

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[3]

(ii) Other than obesity, outline why a diet high in lipids might have a negative effect on the health of an individual.

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..... **[3]**

(c) Two examples of lipid molecules are triglycerides and phospholipids.

Identify **two** differences and **two** similarities in the **structures** of triglycerides and phospholipids.

Write your answers in the appropriate boxes in the table below.

	Triglyceride	Phospholipid
Difference		
Difference		
Similarity		
Similarity		

[4]

(d) It is possible to test for the presence of lipids in a food sample.

(i) Name the test used to identify the presence of lipids.

.....[1]

(ii) Describe how you would carry out this test on a food sample.

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.....[3]

(iii) State the expected result if lipid is present in the food sample.

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.....[1]

[Total: 17]

6 **(a)** Glucose is a hexose sugar and is a monomer in many carbohydrates.

Name the precise group of carbohydrate molecules of which glucose is an example.

.....[1]

(b) Fig. 6.1 represents the structure of a **β-glucose** molecule.

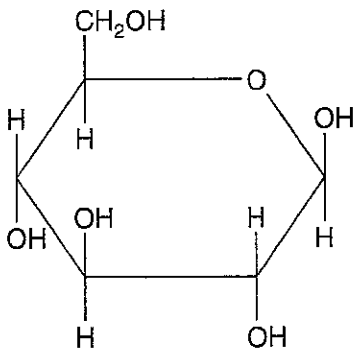

Fig. 6.1

(i) Use Fig. 6.1 to draw a similar representation of an **α-glucose** molecule in the space provided below.

[2]

(ii) The cells of living organisms require glucose.

State and explain **two** ways in which the glucose molecule is well suited to its function in living organisms.

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.....[2]

(c) Deoxyribose is a pentose sugar that is a component of the double-stranded DNA molecule.

Describe the structural relationship between deoxyribose and the other components of the DNA molecule.

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..... **[3]**

(d) Cellulose is a carbohydrate.

A student described the structure of cellulose as follows:

> The cellulose molecule is insoluble.
> It contains only the elements carbon, hydrogen and oxygen.
> It is made up of α-glucose subunits.
> The glucose subunits are linked by 1-4 glycosidic bonds formed by hydrolysis reactions.
> It also has some 1-6 glycosidic bonds.
> It is made of many long chains.
> The chains have branches.

(i) Identify **three** mistakes made by the student when describing the structure of cellulose.

1 .....

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2 .....

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3 .....

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[3]

(ii) Suggest the name of a molecule that closely matches the student's description.

..... **[1]**

[Total: 12]

4 Fig. 4.1 shows a representation of part of a carbohydrate molecule called agarose.

One of the subunits of agarose is a sugar called galactose.

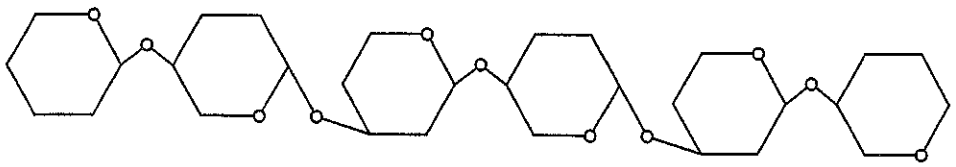

Fig. 4.1

(a) (i) Identify the type of carbohydrate molecule of which the carbohydrate agarose is an example.

.....[1]

(ii) Starch contains a carbohydrate called amylose. Amylose does not contain galactose.

Using the information in Fig. 4.1, identify **one** similarity and **one further** difference in structure between agarose and amylose.

similarity .....

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difference .....

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.....[2]

(b) Agarose forms part of a more complex carbohydrate called agar, which is used as a growth medium for bacteria. Bacteria cannot break down the agarose in agar.

Suggest why bacteria cannot break down agarose.

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.....[1]

(c) A student wished to demonstrate experimentally that bacteria cannot break down agarose.

The student used a culture of *E.coli* bacteria which had been grown in a solution containing starch.

Two tubes, **A** and **B**, were set up as follows:

Tube **A**: contained 0.1 cm^3 of the *E.coli* culture and 5 cm^3 of a nutrient solution in which agarose was the only carbohydrate.

Tube **B**: contained 5 cm^3 of a nutrient solution in which agarose was the only carbohydrate.

Both tubes were incubated at 30 °C for 2 hours.

A sample from each tube was then tested for the presence of reducing sugar.

The results are shown in Table 4.1.

Table 4.1

source of sample	conclusion from test
tube **A**	very small amount of reducing sugar present
tube **B**	no reducing sugar present

(i) Explain the purpose of tube **B**.

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..... **[2]**

(ii) The student wrote the following conclusion:

My experiment showed that bacteria must be able to break down agarose. This is because reducing sugar was present in tube **A**.

Suggest an alternative explanation for the presence of reducing sugar in tube **A** that is **not** consistent with the student's conclusion.

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..... **[1]**

(iii) Suggest **two** ways in which the **reliability** of the experiment could be improved.

1 .....

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2 .....

..... [2]

(d) (i) The student did **not** have access to a colorimeter when testing solutions for the presence of reducing sugar.

Describe how the student could carry out a chemical test for reducing sugar **and** suggest how he could estimate the amount of reducing sugar in the sample from tube **A**.

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..... [5]

(ii) Another student suggested that the agarose may have been broken down to a **non-reducing** sugar.

Describe how the test for reducing sugar could be modified to investigate this hypothesis.

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..... **[3]**

[Total: 17]

Answer **all** the questions.

1 Biological molecules are held together by a variety of bonds.

(a) The diagram in Fig. 1.1 represents an amino acid.

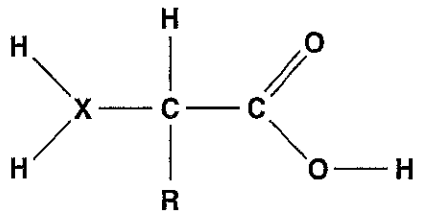

Fig. 1.1

(i) One of the atoms that make up an amino acid has been replaced with the letter **X**.

State the chemical symbol of the atom represented by the letter **X** in Fig. 1.1.

..... **[1]**

(ii) Name the polymer formed from a chain of amino acids.

..... **[1]**

(iii) Name the bond that is formed when two amino acids are joined together. Describe the formation of this bond.

name of bond .....

description of formation

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..... **[3]**

(b) Fig. 1.2 shows a hydrogen bond between two water molecules.

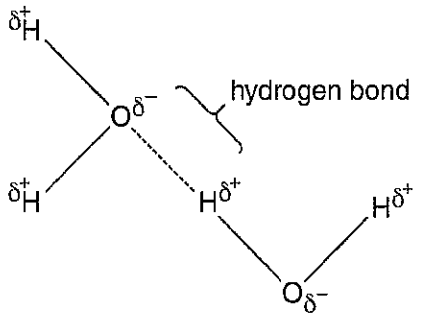

Fig. 1.2

(i) Many of the physical properties of water arise as a result of these hydrogen bonds.

Describe ways in which the physical properties of water allow organisms to survive over a range of temperatures.

In your answer you should make clear links between the properties of water and the survival of organisms.

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..... **[9]**

(ii) List **three other** examples of where hydrogen bonds are found in biological molecules.

1 .....

2 .....

3 ..... **[3]**

[Total: 17]

3 A number of different biological molecules are represented in Fig. 3.1.

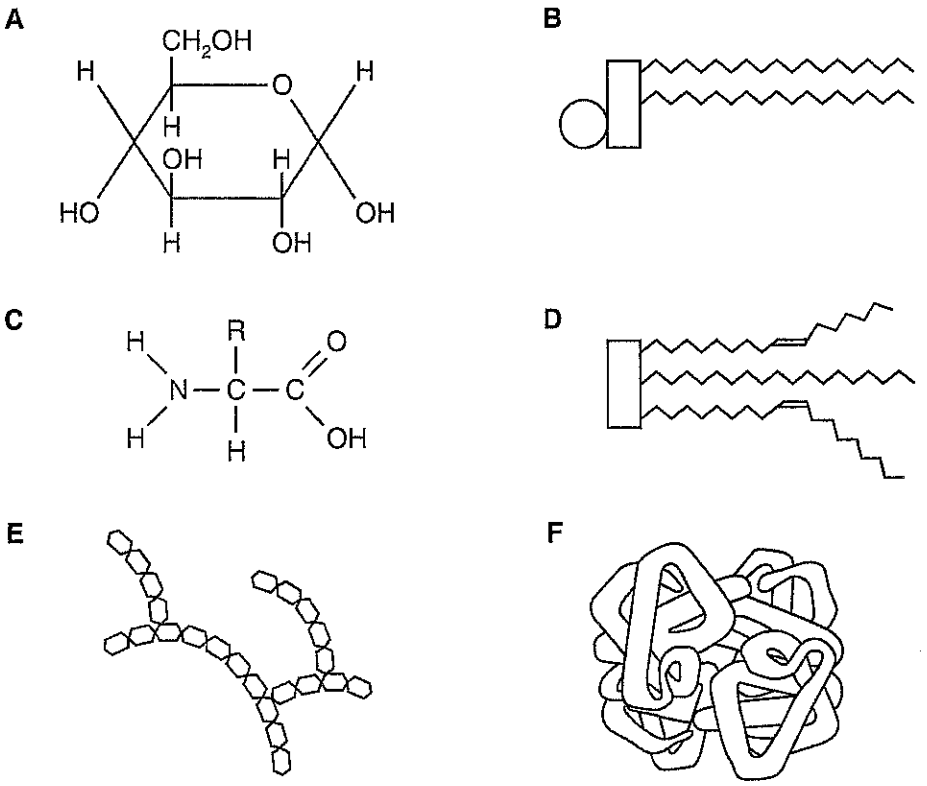

Fig. 3.1

(a) (i) State the letter of the molecule shown in Fig. 3.1 that represents:

a triglyceride .....

a monosaccharide .....

a protein ..... **[3]**

(ii) State the letter of the molecule shown in Fig. 3.1 that contains:

phosphate .....

glycosidic bonds .....

peptide bonds .....

disulfide bonds ..... **[4]**

(b) Molecule **E** shown in Fig. 3.1 is part of the carbohydrate molecule glycogen.

Explain why glycogen makes a good storage molecule.

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..... **[3]**

(c) **(i)** When glycogen is hydrolysed, molecule **A** shown in Fig. 3.1 is produced.

State the **precise name** of molecule **A** ..... **[1]**

(ii) State **one** function of molecule **A.**

.....

..... **[1]**

(iii) State the letter of a molecule shown in Fig. 3.1, other than molecule **E**, that is used as a storage molecule.

..... **[1]**

QUESTION 3(d) STARTS ON PAGE 10

(d) Cellulose is a carbohydrate molecule found in plants.

Complete the table below to give three **differences** in the **structures** of glycogen and cellulose.

One difference has been done for you.

glycogen	cellulose
no hydrogen bonding	*hydrogen bonding*

[3]

[Total: 16]

7 (a) Haemoglobin is a globular protein.

Describe the structure of a haemoglobin molecule.

In your answer, you should include details of the secondary, tertiary and quaternary structure of the molecule.

[7]

(b) Describe the ways in which the structure of collagen is **similar** to the structure of haemoglobin.

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..... **[4]**

[Total: 11]

QUESTION 8 STARTS ON PAGE 24

Answer **all** the questions.

1 **(a)** Milk is considered to be a complete food containing most of the components of a balanced diet.

A student carried out a series of food tests on a sample of milk. The student's observations and conclusions are shown in Table 1.1.

(i) Complete Table 1.1 by

- naming the molecule being tested for
- stating whether this molecule is present or absent.

The first row has been completed for you.

Table 1.1

reagent	observation	molecule being tested for	present or absent
ethanol and water	white emulsion	lipid	present
Benedict's solution	brick-red precipitate		
biuret I and II	lilac colour		
iodine solution	yellow / brown		

[3]

(ii) Although the student entered 'present' for lipid in the first row of the table, he was unsure whether the result was correct.

Suggest why the student was unsure if the positive result for lipid was correct for the milk sample.

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..... **[1]**

(iii) Triglycerides are a type of lipid found in milk.

Describe the structure of a triglyceride molecule.

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..... [3]

(b) State **three** roles of lipids in living organisms.

1 .....

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2 .....

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3 .....

..... [3]

(c) Human populations with diets high in animal fats have a lower life expectancy than those with diets high in vegetable oils.

(i) Suggest **one** difference between lipids from animals and those from plants.

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..... [1]

2 Fig. 2.1 represents a water molecule.

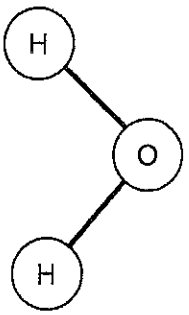

Fig. 2.1

(a) Water molecules are polar. As a result, they attract each other.

Draw a second water molecule on Fig. 2.1.

Your drawing should show:

- the bond(s) between the two molecules
- the name of the bond
- the charges on each atom. **[3]**

(b) Ponds provide a very stable environment for aquatic organisms.

Three properties of water that contribute to this stability are as follows:

- the density of water decreases as the temperature falls below 4 °C so ice floats on the top of the pond
- it acts as a solvent for ions such as nitrates (NO_3^-)
- a large quantity of energy is required to raise the temperature of water by 1 °C.

Explain how these three properties help organisms survive in the pond.

In your answer you should make clear the links between the behaviour of the water molecules and the survival of the organisms.

..... [8]

(c) Water is important in many biological reactions.

Complete Table 2.1 by writing an appropriate term next to each description.

Table 2.1

description	term
the type of reaction that occurs when water is added to break a bond in a molecule	
the phosphate group of a phospholipid that readily attracts water molecules	

[2]

[Total: 13]

4 **(a)** Amino acids are the basic building blocks for proteins. Fig. 4.1 shows the amino acid cysteine.

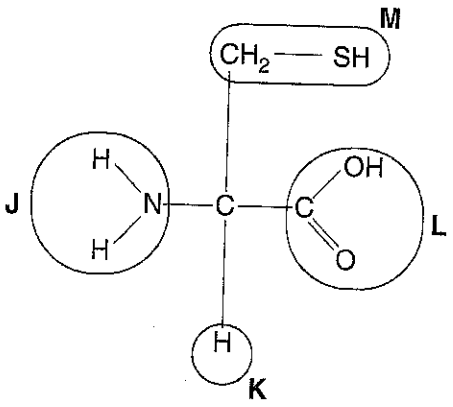

Fig. 4.1

(i) Complete the table by selecting the letter, **J**, **K**, **L** or **M**, that represents the following groups in cysteine.

group	letter
carboxyl	
R group	
amine group	

[3]

(ii) The primary structure of a protein consists of a chain of amino acids.

Describe how a second amino acid would bond to cysteine in forming the primary structure of a protein.

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..... **[3]**

(b) Each amino acid has a different R group.

Describe how these R groups can interact to determine the **tertiary** structure of a protein.

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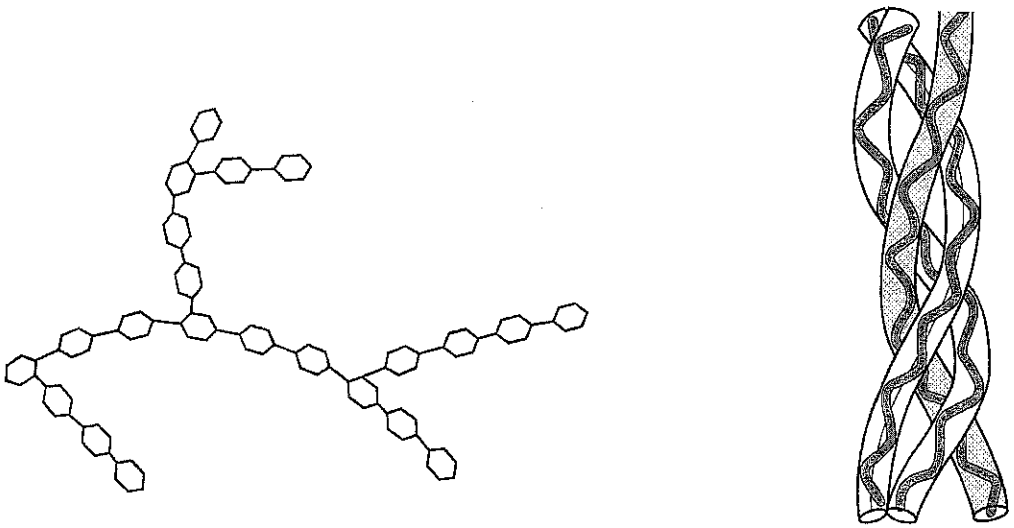
..... **[4]**

(c) Fig. 4.2 shows the structure of two polymers, glycogen and collagen, that are found in mammals.



glycogen

collagen

Fig. 4.2

(i) Complete the table below to give three **differences** between the **structure** of glycogen and collagen.

glycogen	collagen

[3]

(ii) Collagen is found in the ligaments which hold bones together at joints.

State **two** properties of collagen that make it suitable for this purpose.

1 .....

2 ..... **[2]**

[Total: 15]

3 In the search for new biofuels, research has been done into the digestion of wood waste by fungi.

The cellulase enzymes produced by the fungi break cellulose into sugars. These sugars can then be converted into ethanol, a biofuel.

Fig. 3.1 shows the stages in this digestion process.

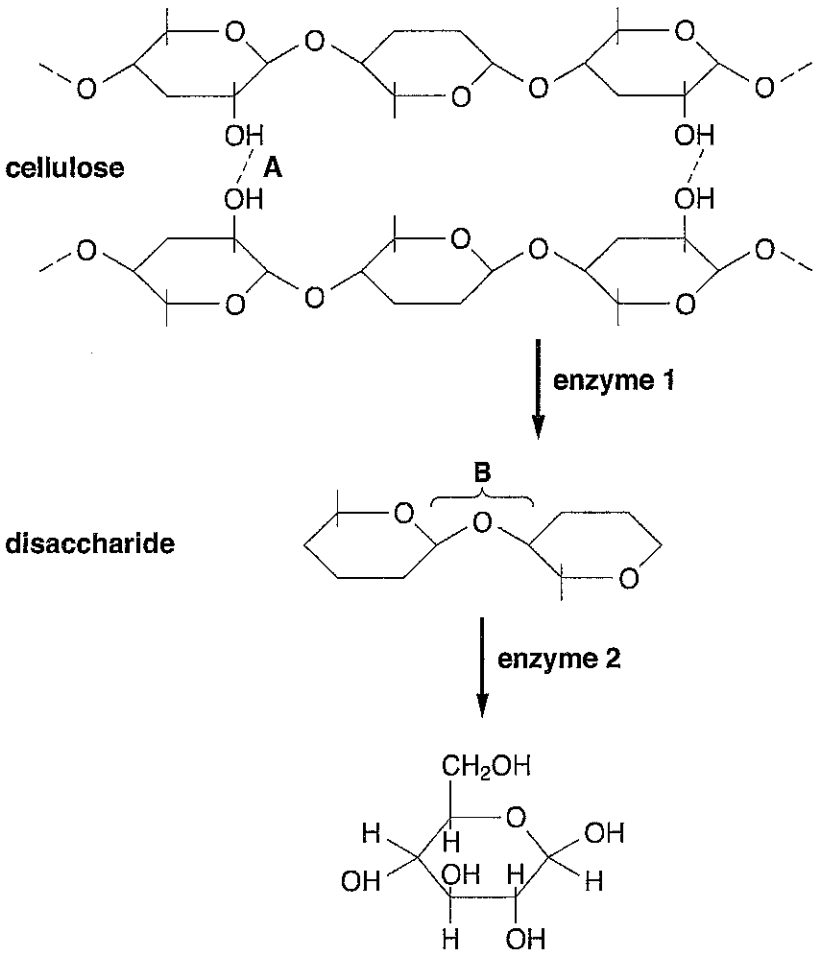


Fig. 3.1

(a) (i) Name bonds **A** and **B** shown in Fig. 3.1.

A .....

B ..... **[2]**

(ii) State how bond **B** is broken in the digestion of the disaccharide.

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..... **[1]**

(iii) Name the sugar that is the **final** product of this digestion process.

..... **[1]**

(b) Explain why **different** enzymes are involved in each stage of the digestion process.

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..... **[3]**

QUESTION 3 CONTINUES ON PAGE 8

(c) Fig. 3.2 shows the effect of changing pH on the rate of activity of **enzyme 2.**

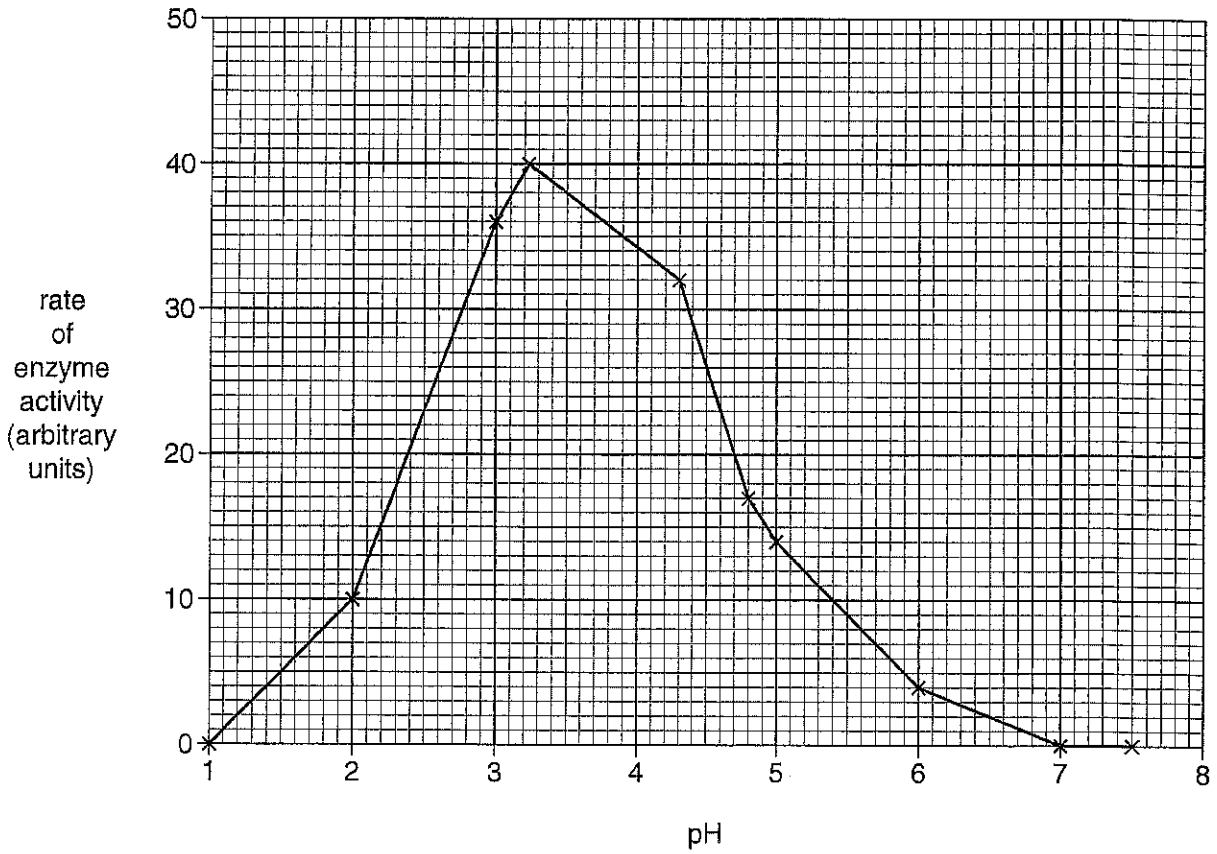

Fig. 3.2

(i) Explain why the activity of **enzyme 2** falls to zero at pH 7.

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..... **[3]**

(ii) State **two** factors that should have been controlled when investigating the effect of pH on the activity of **enzyme 2.**

1 .....

2 ..... **[2]**

(d) The activity of an enzyme can be measured by testing for the concentration of its product at regular intervals.

Describe how the concentration of a reducing sugar can be measured using a colorimeter.

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[Total: 18]