3 **(a)** Fig. 3.1 is a diagram representing a mitochondrion located in the cytoplasm of an animal cell.

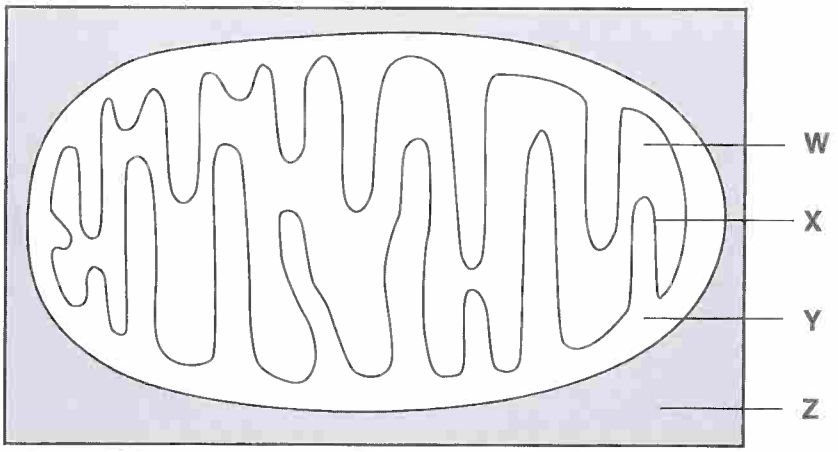

Fig. 3.1

(i) Use the letters **W** to **Z** to identify the region in Fig. 3.1 where each of the following occurs.

You may use each letter once, more than once or not at all.

link reaction .....

glycolysis .....

electron transport chain .....

Krebs cycle ..... **[4]**

(ii) Why does aerobic respiration yield fewer molecules of ATP than the theoretical maximum?

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

(b) Explain why the incomplete breakdown of glucose in **anaerobic** respiration produces less ATP than aerobic respiration.

In your answer, you should use appropriate technical terms, spelled correctly.

..... [5]

[Total : 11]

5 (a) Humans harvest a wide range of fruits and vegetables as food. Cellular respiration supplies energy and forms part of the natural ripening process in fruits and vegetables. This ripening process may continue after the fruits and vegetables are harvested, as the cells continue to respire.

The rate of cellular respiration after harvesting affects the shelf-life of fruits and vegetables as it can lead to changes in food quality. After harvesting, some fruits and vegetables enter a dormant (inactive) state while others remain active during storage.

Table 5.1 contains data that show the respiration rate of a selection of fruits and vegetables stored at different temperatures after harvesting. The respiration rate is measured by the rate of carbon dioxide produced.

Fruits and vegetables	Respiration rate (mg CO_2 kg^{-1} h^{-1})				
	at 0 °C	at 5 °C	at 10 °C	at 15 °C	at 20 °C
Apple	3	6	9	15	20
Asparagus	60	105	215	235	270
Blackberry	19	36	62	75	115
Cauliflower	17	21	34	44	69
Onion	3	5	7	7	8
Orange	4	6	8	18	28
Parsnip	12	13	22	37	n/a*
Potato	n/a*	12	16	17	22
Turnip	8	10	16	23	25

* no data were collected at these temperatures

Table 5.1

(i) Describe the pattern of respiration shown by cauliflower at increasing storage temperatures of 0 °C to 20 °C.

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..... [2]

(ii) Discuss what the data in Table 5.1 indicate about the best conditions for storage of fruits and vegetables.

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

(iii) Identify, with reasons, which fruit or vegetable listed in Table 5.1 is **least** likely to spoil during storage.

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

(iv) Which fruit or vegetable listed in Table 5.1 is likely to be the most difficult to keep fresh during storage? Give a reason for your answer.

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

(b) Respiration can be aerobic or anaerobic.

(i) Certain parasites live in the blood of mammals.

Suggest why, even though blood carries oxygen, these parasites are adapted to respire anaerobically.

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

(ii) The anaerobic respiration pathway in animal cells can be reversed, but the anaerobic respiration pathway in yeast cells cannot be reversed.

Explain why, using your knowledge of the differences between the two pathways.

In your answer, you should use appropriate technical terms, spelled correctly.

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

[Total: 14]

5 **(a)** Adenosine tri-phosphate (ATP) is an important product of respiration. The ATP molecule is made up of five sub-units, as shown in Fig. 5.1.

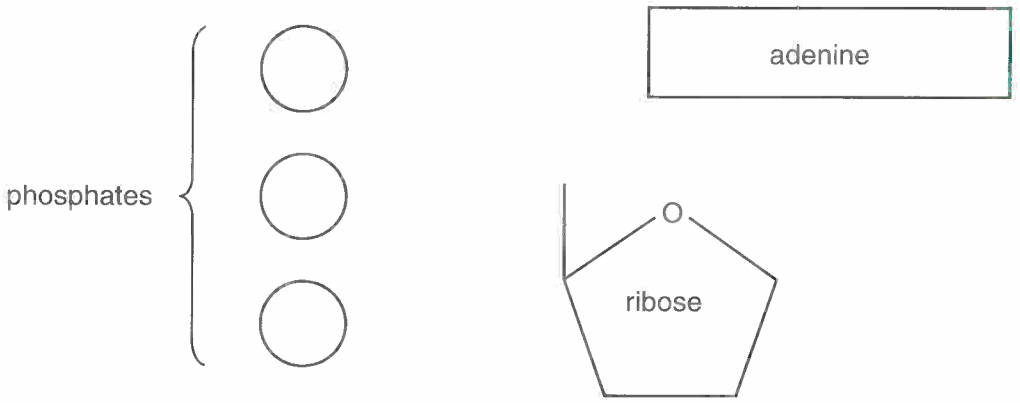

Fig. 5.1

(i) In the space below, indicate how these sub-units are joined in a molecule of ATP.

[2]

(ii) Suggest the type of reaction that removes a phosphate group from an ATP molecule.

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

(b) The formation of ATP is now widely accepted as being achieved by the process of **chemiosmosis**.

Various pieces of evidence have been documented to support this theory. Three of these are described below.

1 In isolated mitochondria that have had their outer membranes removed, electron transfer takes place but the mitochondria are unable to produce ATP.

2 The pH of the inter-membrane space is lower than the pH inside the rest of the mitochondrion.

3 The outer mitochondrial membrane is permeable to protons.
If isolated mitochondria are supplied with ADP and inorganic phosphate and placed in a solution of pH 8, no ATP is produced. If, however, these mitochondria are placed in an acidic solution, ATP is produced.

Identify the pieces of evidence above, **1**, **2** or **3**, that supports each of the following statements about the theory of chemiosmosis.

Write '**none**' if a statement is not supported by any of the pieces of evidence above.

(i) Electron transfer occurs on the inner membrane of the mitochondrion. ..... **[1]**

(ii) Protons are actively pumped across the inner mitochondrial membrane into the inter-membrane space. ..... **[1]**

(iii) Protons accumulate in the inter-membrane space. ..... **[1]**

[Total: 6]

5 **(a)** Glycolysis is the initial stage of cellular respiration.

(i) State **precisely** where in the cell glycolysis occurs.

..... [1]

(ii) Outline the process of glycolysis.

In your answer, you should use appropriate technical terms, spelled correctly.

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..... [4]

(b) Yeast cells can carry out **anaerobic** respiration.

Fig. 5.1 outlines the process of anaerobic respiration in yeast.

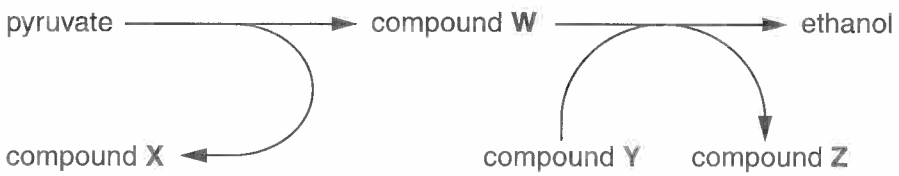

Fig. 5.1

Identify the compounds **W** to **Z**.

W .....

X .....

Y .....

Z .....

[4]

(c) In South-East Asia the main source of commercial sugar is the palm, *Borassus flabellifer*. Sap of this species has a high sugar content. Yeasts and bacteria, however, can contaminate the sap as it is collected and ferment the sugar, producing ethanol. This contamination makes it less suitable as a source of sugar.

A study was carried out to investigate the effect of three treatments traditionally used to reduce fermentation during the collection of the sap. The sap is treated in one of the following ways:

- with a weak alkaline solution (treatment **A**)
- with bark from the tree *Vateria copallifera* (treatment **V**)
- with bark from the tree *Careya arborea* (treatment **C**)

The sap was collected from the palm trees over a 60-hour period. Samples of the collected sap were taken at 15 hour intervals. In each sample, the concentration of alcohol and the number of bacteria were recorded.

The results are shown in Table 5.1.

Treatment	Sample time (hours)	Alcohol concentration (%)	Number of bacteria ($10^6 cm^{-3}$)
Control (no treatment)	15	0.2	19
	30	3.5	800
	45	5.2	2200
	60	2.6	3400
A	15	0.0	3
	30	0.1	4
	45	0.2	5
	60	0.3	7
V	15	0.2	110
	30	1.1	2900
	45	1.2	2400
	60	1.8	2000
C	15	0.4	230
	30	1.1	160
	45	1.3	3
	60	3.6	40

Table 5.1

(i) With reference to Table 5.1, describe the effect of the different treatments on the alcohol concentration of the treated samples compared with the control samples.

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..... [2]

(ii) Suggest a reason for the difference in alcohol concentration **at 60 hours** between the two bark treatments **V** and **C**.

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..... [1]

(iii) To be used as a source of commercial sugar, the sap needs to be as uncontaminated as possible.

Suggest, with a reason, which of the treatments shown in Table 5.1 would be the best for use with sap so that it is suitable as a source of commercial sugar.

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..... [2]

[Total: 14]

Answer **all** the questions.

1 Organisms require energy in order to carry out essential metabolism. Organisms are able to release energy by carrying out both aerobic and anaerobic respiration.

(a) Complete the table to compare **anaerobic** respiration in mammals and yeast.

	mammal	yeast
name of hydrogen acceptor after glycolysis		
is CO_2 produced?		
name of final product		

[3]

(b) Suggest **one** benefit of anaerobic respiration to an organism.

.....

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

[Total: 4]

3 Fig. 3.1 represents some of the reactions that take place in a leaf cell of a flowering plant.

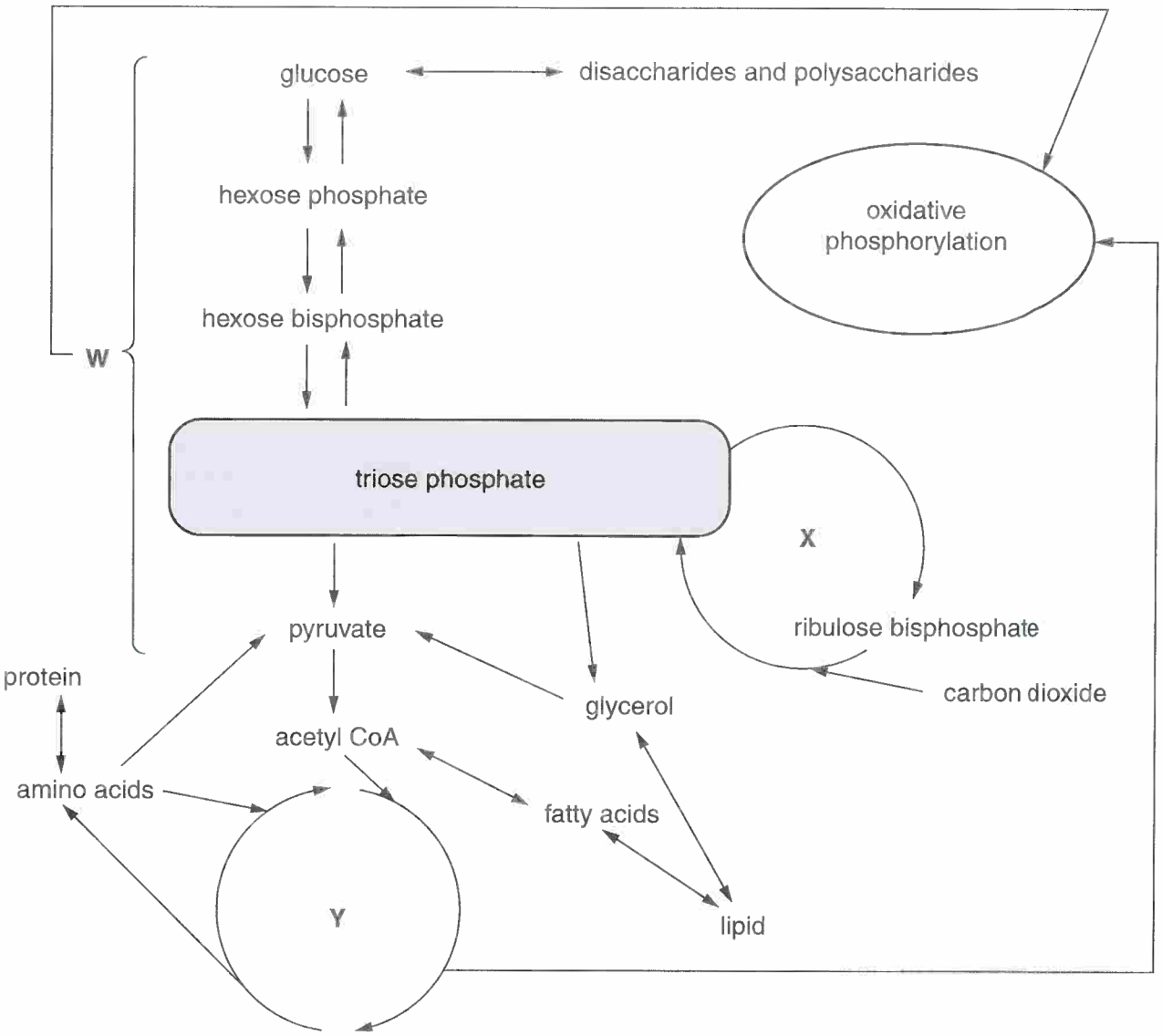

Fig. 3.1

(a) (i) Name the reaction pathways indicated by the letters **W**, **X** and **Y**.

W .....

X .....

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

(ii) Triose phosphate is a compound that is central to the metabolism of this cell.

Explain how **the three** reaction pathways (**W**, **X** and **Y**) are able to work independently of each other in the same leaf cell.

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..... [3]

(iii) Identify which of **these three** reaction pathways (**W**, **X** and **Y**) are associated with:

photosynthesis .....

aerobic respiration..... [2]

(iv) Fig. 3.1 shows that compounds from two of the three pathways are used in oxidative phosphorylation.

State the products of oxidative phosphorylation.

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..... [2]

(b) Explain the role of coenzymes in this leaf cell, with respect to the metabolic reactions outlined in Fig. 3.1.

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..... [3]

[Total: 13]

4 One way of calculating the rate of respiration is to measure the volume of oxygen taken up over a period of time.

A student carried out an experiment to investigate the effect of temperature on the rate of respiration in soaked (germinating) pea seeds and dry (dormant) pea seeds.

A simple piece of apparatus called a respirometer was used, as shown in Fig. 4.1.

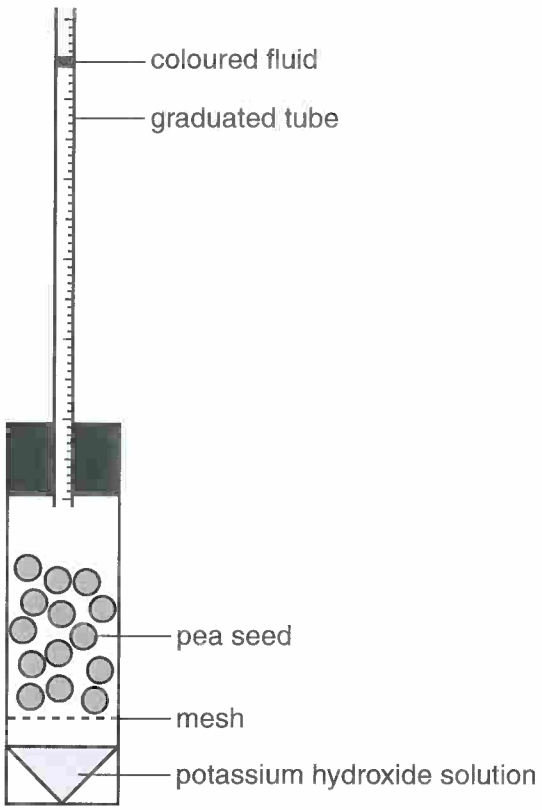

Fig. 4.1

The potassium hydroxide solution in this apparatus absorbs carbon dioxide. If the apparatus is kept at a constant temperature, any changes in the volume of air in the respirometer will be due to oxygen uptake.

(a) State the stage or stages of aerobic respiration during which:

(i) carbon dioxide is produced

.....

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

(ii) oxygen is used.

.....

..... [1]

(b) The student set up three respirometers, **A**, **B** and **C**, in water baths at two different temperatures. The respirometers were left for 10 minutes in order to equilibrate.

The contents of each respirometer are shown in Table 4.1.

Table 4.1

temperature (°C)	respirometer	contents
15	**A**	30 soaked pea seeds
	B	glass beads + 30 dry pea seeds
	C	glass beads
25	**A**	30 soaked pea seeds
	B	glass beads + 30 dry pea seeds
	C	glass beads

At each temperature, respirometer **C,** which contained only glass beads, was a control.

Respirometer **B**, at each temperature, also contained some glass beads.

(i) Suggest why, at each temperature, respirometer **B** contained **some** glass beads.

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

(ii) Suggest how the student determined the quantity of glass beads to place in respirometer **B** at each temperature.

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

QUESTION 4(c) STARTS ON PAGE 12

(c) After the student had left each respirometer to equilibrate, a small volume of coloured fluid was introduced into each graduated tube.

The respirometers were then left in the appropriate water baths for 20 minutes and maintained at the correct temperature. During this time, the coloured fluid in the graduated tube moved.

The level of the coloured fluid in each respirometer was recorded at the start of the experiment and after 20 minutes.

The results are summarised in Table 4.2.

Table 4.2

temperature (°C)	respirometer	reading at start (cm^3)	reading after 20 minutes (cm^3)	difference (cm^3)	corrected difference (cm^3)	rate of oxygen uptake ($cm^3 min^{-1}$)
15	**A**	0.93	0.74	0.19	0.16	0.008
	B	0.93	0.86	0.07	0.04	0.002
	C	0.91	0.88	0.03		
25	**A**	0.94	0.63	0.31	0.27	
	B	0.93	0.84	0.09	0.05	0.003
	C	0.95	0.91	0.04		

(i) Table 4.2 is incomplete.

Calculate the missing value for the rate of oxygen uptake for soaked pea seeds (**A**) at **25 °C**.

Show your working.

Answer = ... $cm^3 min^{-1}$ **[2]**

(ii) Explain why there is an increased rate of respiration in soaked seeds at 25 °C compared with soaked seeds at 15 °C.

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

(iii) Suggest a reason for the difference in the rate of respiration between soaked and dry pea seeds.

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

[Total: 12]

QUESTION 5 STARTS ON PAGE 14

3 The compound 2,3,5-triphenyl-tetrazolium chloride (TTC) is an electron acceptor. TTC will diffuse into actively respiring cells and accept electrons from the electron transport chain.

When TTC accepts electrons and becomes reduced, it changes from colourless to pink. The tissues in which this reaction takes place will be stained a pink colour.

(a) State the **precise** location of the electron transport chain in the cell.

.....[1]

(b) A student carried out an investigation into the respiratory activity of plant tissue. She used three groups of germinating broad bean seeds. These were first treated as shown in Table 3.1.

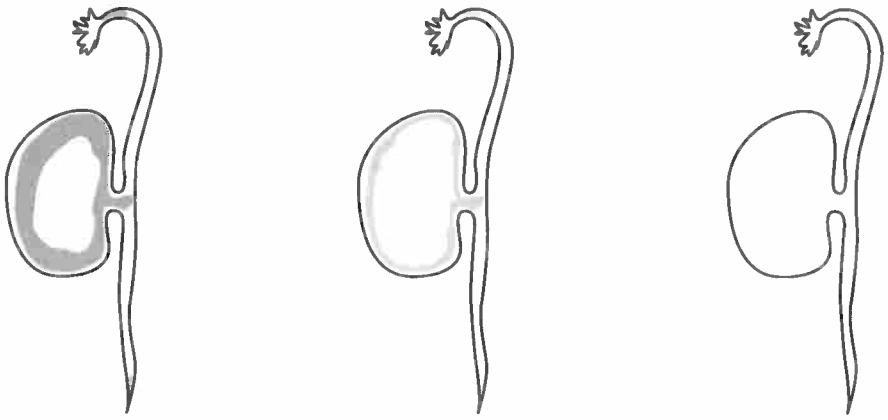
Table 3.1

seed	treatment
group **A**	kept at 22 °C for 24 hours before the investigation
group **B**	kept at 6 °C for 24 hours before the investigation
group **C**	kept at 22 °C for 24 hours and then placed in water at 90 °C for 5 minutes before the investigation

The groups of seeds were then sliced longitudinally and placed, cut surface down, in a shallow dish containing a small volume of TTC solution. The cut surfaces remained in contact with the solution for 10 minutes.

The seeds were then removed from the dish. The excess TTC solution was wiped off and the cut surfaces of the seeds in each group were observed.

The appearance of the seeds in each group is shown in Fig. 3.1. The shaded areas are the regions where the tissues have stained a pink colour.



seeds in group A seeds in group B seeds in group C

Fig. 3.1

(i) Describe the differences observed in the seeds in groups **A**, **B** and **C**.

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..... [1]

(ii) Suggest reasons for the results observed in the seeds in group **A**.

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..... [2]

(iii) Suggest reasons for the difference in the amount of staining observed in the seeds in groups **B** and **C** when compared to those in group **A**.

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..... [2]

(c) If oxygen is not present or is in short supply, respiration can take an anaerobic pathway **after glycolysis**. In plant cells, this pathway is the same as the one used in yeast cells.

(i) Name the hydrogen acceptor in this pathway.

..... [1]

(ii) Name the intermediate compound in this pathway.

..... [1]

(iii) Name the products of this pathway.

..... [1]

(iv) Explain why this pathway is important for the plant cell.

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..... [2]

[Total: 11]

Answer **all** the questions.

1 **(a)** Fig. 1.1 represents a molecule of ATP.

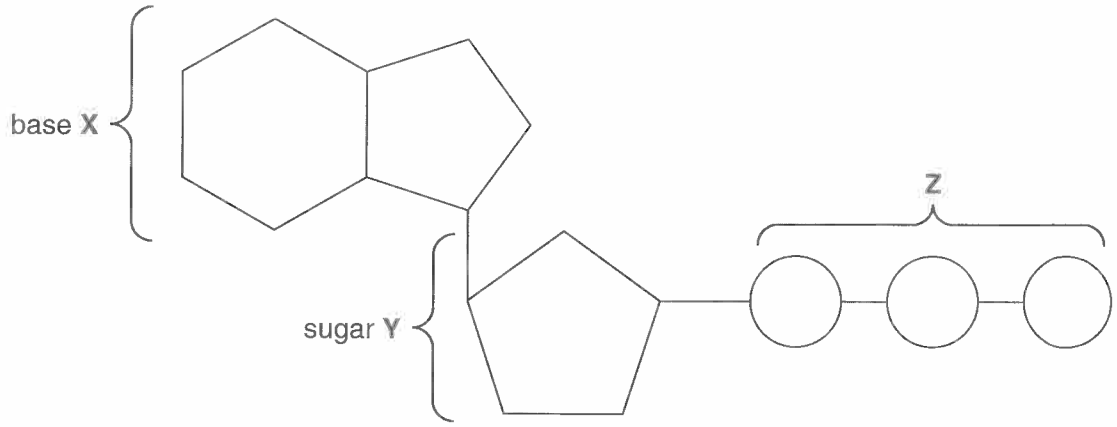

Fig. 1.1

(i) Name the parts of the ATP molecule labelled **X**, **Y** and **Z**.

X .....

Y .....

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

(ii) With reference to Fig. 1.1, describe and explain the role of ATP in the cell.

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

(b) Fig. 1.2 is an electron micrograph of a mitochondrion from an animal cell.

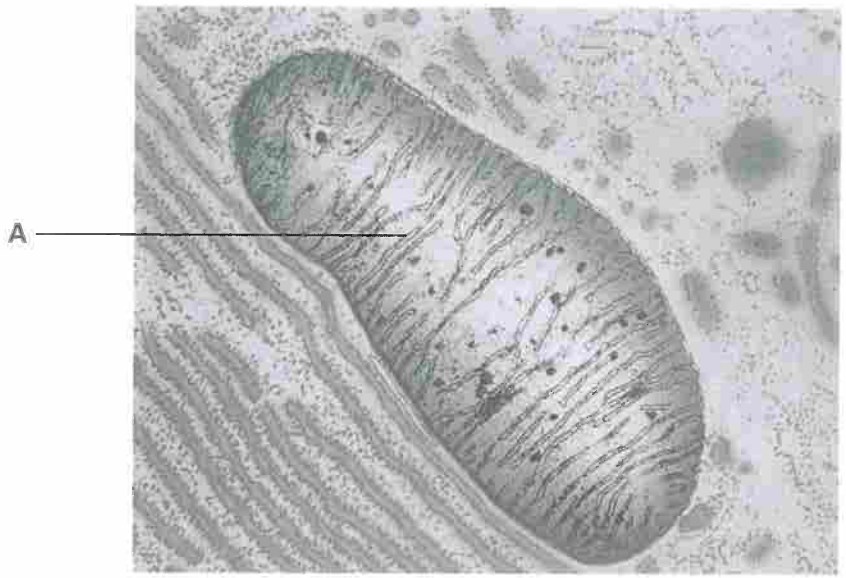

Fig. 1.2

(i) Name the structure labelled **A**.

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

(ii) Name the specific process that is carried out by structure **A** in the mitochondrion.

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

(c) Some animals conserve energy by entering a state of torpor (a short period of dormancy), in which they allow their body temperature to fall below normal for a number of hours.

In an investigation into torpor in the Siberian hamster, *Phodopus sungorus*, the animal's respiratory quotient (RQ) was measured before and during the period of torpor.

The respiratory quotient is determined by the following equation:

$$RQ = \frac{\text{volume of carbon dioxide produced}}{\text{volume of oxygen consumed in the same time}}$$

RQ values for different respiratory substrates have been determined and are shown in Table 1.1.

Table 1.1

substrate	RQ
carbohydrate	1.0
lipid	0.7
protein	0.9

(i) Initially, the RQ value determined for the hamster was 0.95, but as the period of torpor progressed, its RQ value decreased to 0.75.

What do these values suggest about the substrates being respired by the hamster during the period of the investigation?

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

(ii) Describe the way in which an endothermic animal, such as a mammal, normally prevents its body temperature from decreasing when the external temperature decreases.

In your answer, you should use appropriate technical terms, spelt correctly.

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..... **[5]**

[Total: 16]