1 Carrots are root vegetables that are eaten by many organisms.

An investigation was carried out to study the respiration rate of carrots.

100 g of carrot cubes were placed in a plastic bag containing air. The bag containing the carrot cubes was stored at 1 °C for three days.

All other variables were kept constant.

The percentages of oxygen and carbon dioxide in the bag were measured at the start of the investigation and at the end.

The results are shown in the table below.

Stage of the investigation	Percentage of each gas in the bag (%)	
	Oxygen	Carbon dioxide
Start	21.0	0.04
End	5.3	8.14

(a) (i) Suggest **two** variables, other than temperature, that need to be kept constant in this investigation so that valid results can be collected.

(2)

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(ii) Explain the role of oxygen in the cells of the carrot cubes.

(3)

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(b) Explain how the carrots produce carbon dioxide at the start of this investigation.

(4)

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(c) The investigation was repeated at storage temperatures of 5 °C and 10 °C.

The table below shows the change in percentage of carbon dioxide in the bag at the end of the investigation compared with the start of the investigation for all three storage temperatures.

Storage temperature / °C	Change in percentage of carbon dioxide (%)
1	+ 8.
5	+ 14.
10	+ 16.

Explain the effect of temperature on the change in the percentage of carbon dioxide in the bag.

(3)

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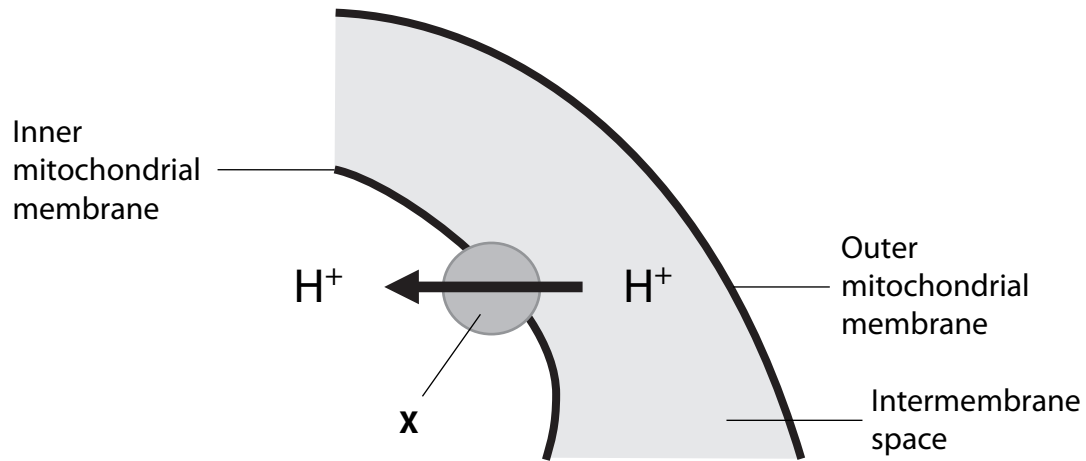(d) Suggest why the carrot tissue could survive when no oxygen was left in the bag.

(1)

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(Total for Question 1 = 13 marks)

2 The diagram below shows part of the process of chemiosmosis in a mitochondrion.

Inner
mitochondrial
membrane

Outer
mitochondrial
membrane

H$^+$

H$^+$

X

Intermembrane
space

(a) Name the enzyme labelled **X** involved in chemiosmosis.

(1)

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(b) Explain how a high concentration of hydrogen ions (H$^+$) is maintained in the
intermembrane space.

(3)

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(c) Describe the role of the hydrogen ion concentration gradient in making available
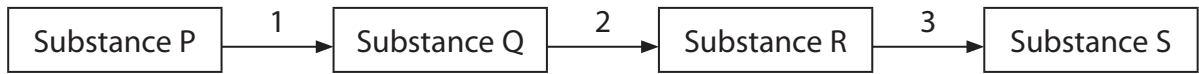an accessible supply of energy for biological processes.

(2)

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(Total for Question 2 = 6 marks)

3 Respiration is a metabolic process which consists of many steps.

(a) The diagram below shows a metabolic process consisting of three steps.

Each letter represents a different substance and each number a different enzyme.

Substance P	1 →	Substance Q	2 →	Substance R	3 →	Substance S

Describe and explain the functions of enzymes in this metabolic process.

(4)

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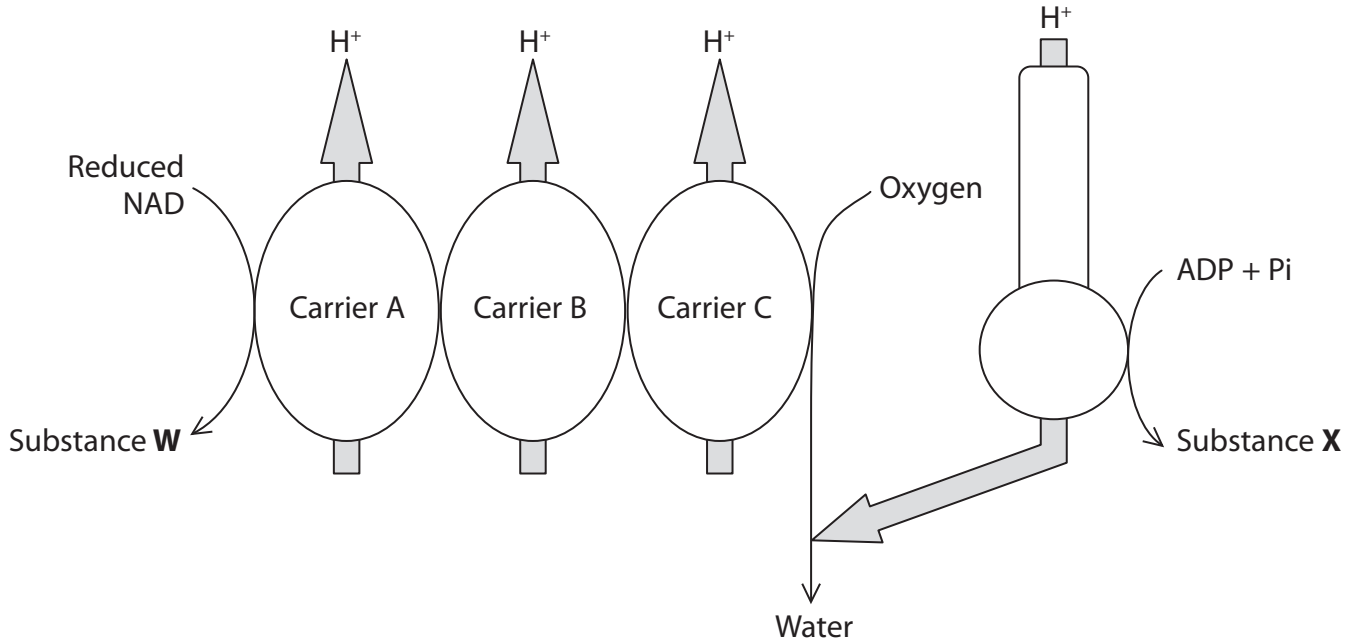
(b) The diagram below shows the electron transport chain, which is part of aerobic respiration.

(i) Using the information in the diagram, name substance **W** and explain how it is formed.

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(ii) Name substance **X**.
Explain the link between the formation of substance **X** and the H$^+$ shown on the diagram.
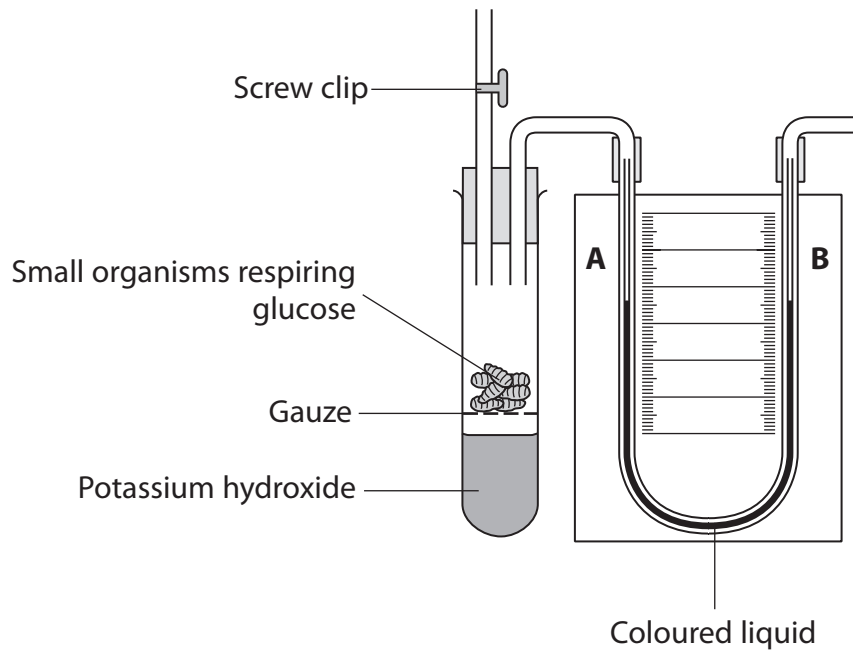
(3)

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(c) The diagram below shows a respirometer used to measure the rate of aerobic respiration in small organisms.

Coloured liquid

Potassium hydroxide absorbs carbon dioxide.
The table below describes three different situations.
Place a cross in the box ☒ that correctly shows the movement of the coloured liquid in the U-shaped tube for each situation.
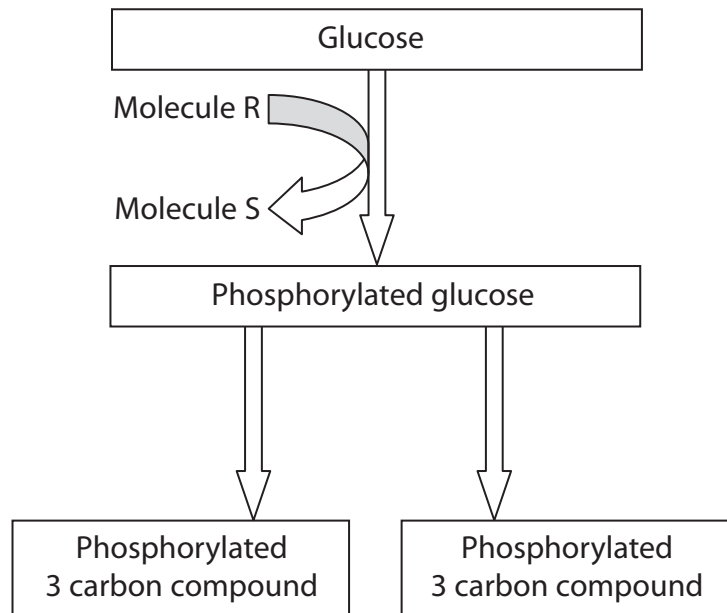
(3)

Situation	Movement of coloured liquid		
	towards A	**towards B**	**does not move**
Screw clip is open	☒	☒	☒
Screw clip is closed	☒	☒	☒
Potassium hydroxide is replaced with water and screw clip is closed	☒	☒	☒

(Total for Question 3 = 13 marks)

4 Respiration is a vital process in living organisms.
All organisms carry out glycolysis. The Krebs cycle also occurs in some organisms.

(a) The diagram below shows some of the stages in glycolysis, using the hexose sugar glucose.

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                    ┌──────────────────────────┐
                    │         Glucose          │
                    └──────────────────────────┘
     Molecule R ┌─┐       │
                 ╲       │
                  ╲      │
     Molecule S ◁──      │
                    ┌──────────────────────────┐
                    │   Phosphorylated glucose  │
                    └──────────────────────────┘
                        │                │
                        ▽                ▽
          ┌──────────────────┐  ┌──────────────────┐
          │  Phosphorylated  │  │  Phosphorylated  │
          │ 3 carbon compound│  │ 3 carbon compound│
          └──────────────────┘  └──────────────────┘
```

Name the molecules R and S shown in the diagram.

(2)

Molecule R ....

Molecule S ....

(b) The diagram below shows some of the stages in the Krebs cycle.

Acetyl CoA

4 carbon compound

6 carbon compound

5 carbon compound

1 × molecule T

6H

2H
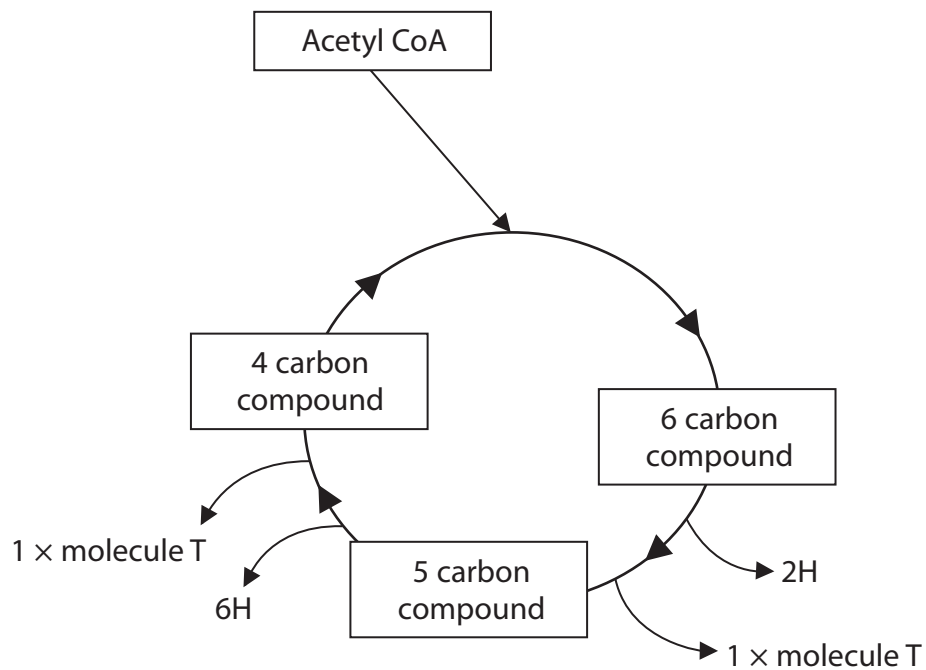
1 × molecule T

(i) Name molecule T and use the information in the Krebs cycle diagram to give a reason for your answer.

(2)

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(ii) Using information in the diagram, suggest what would happen in the Krebs cycle if acetyl CoA became unavailable.

(3)

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(c) The hydrogen (H) from the Krebs cycle enters the electron transport chain and oxidative phosphorylation occurs.

Explain what is meant by the term **oxidative phosphorylation**.

(3)

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(Total for Question 4 = 10 marks)