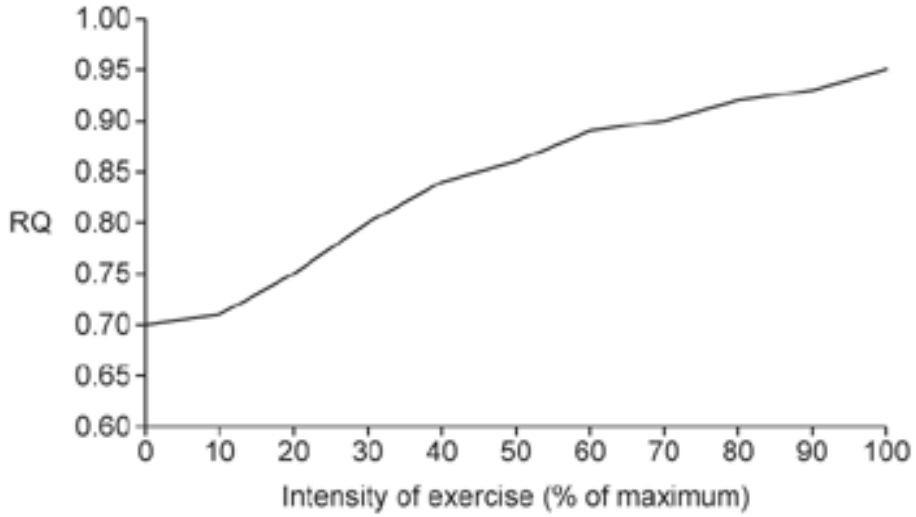
1. The graph shows how the respiratory quotient (RQ) of an athlete changed during exercise, from rest (0%) up to 100% maximum effort.



i. State the **two** measurements that you would need to make during the experiment to calculate RQ.

1 _____

2 _____ **[1]**

ii. Explain what the graph shows about the respiratory substrate(s) used at different intensities of exercise.

_____

_____

_____

_____

_____

_____

_____

_____ **[3]**

2. Which option about the relative energy values of different foods is **not** correct?

A Carbohydrates have lower energy values because they have a higher oxygen content.

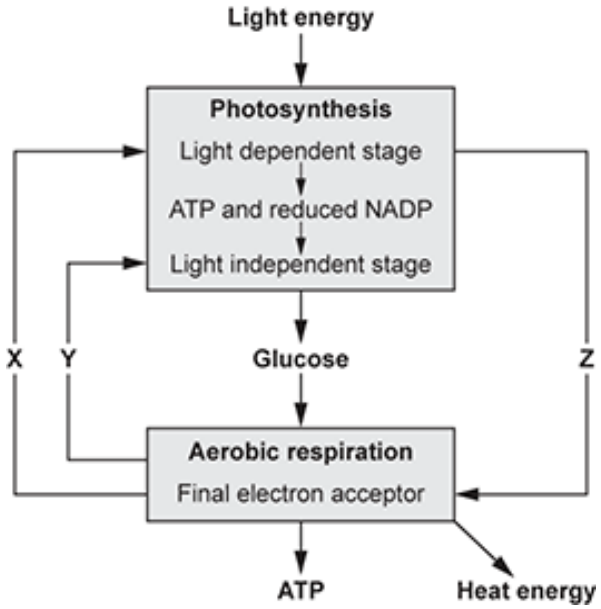
B Food that has a mixture of carbohydrate, lipid and protein, e.g. chocolate, has a higher energy value than the same mass of sugar.

C Lipids have energy values lower than proteins because they have a low ratio of hydrogen and carbon atoms to oxygen atoms.

D Proteins and carbohydrates have similar energy values.

Your answer ☐ **[1]**

3. The figure shows the relationship between photosynthesis and aerobic respiration.



i. Identify the molecules labelled **X**, **Y** and **Z** in the figure

X _____

Y _____

Z _____ **[2]**

ii. Use the information in the figure to explain how plants are able to survive in a sealed glass container, such as a terrarium or bottle garden, for many months or even years.

_____

_____

_____

_____

[3]

4(a). Outline why cellular respiration is necessary in cells that are carrying out DNA replication.

[1]

(b). Chemiosmosis is a mechanism that is thought to occur in both respiration and photosynthesis.

i. Evidence for chemiosmosis during photosynthesis can be demonstrated by:

- isolating chloroplasts from plant cells
- placing the chloroplasts in an acidic solution, in the dark
- shining light onto the chloroplasts in the solution
- measuring the final pH of the solution.

Explain what is likely to happen to the pH of the solution when light is shone on the chloroplasts.

[2]

ii. André Jagendorf provided evidence for chemiosmosis in an experiment carried out in the 1960s.

In his experiment, Jagendorf:

- broke open chloroplasts to expose thylakoids, in the dark
- placed the thylakoids into a solution buffered at pH 4 (solution 1)
- after a short time period, transferred some of these thylakoids to a new solution buffered at pH 4 that contained ADP and P_i (solution 2)
- transferred other thylakoids from solution 1 to a new solution buffered at pH 8 that contained ADP and P_i (solution 3).

ATP production was measured in solution 2 and solution 3.

Explain what you would expect to observe in solution 2 and solution 3 after the transfer of the thylakoids.

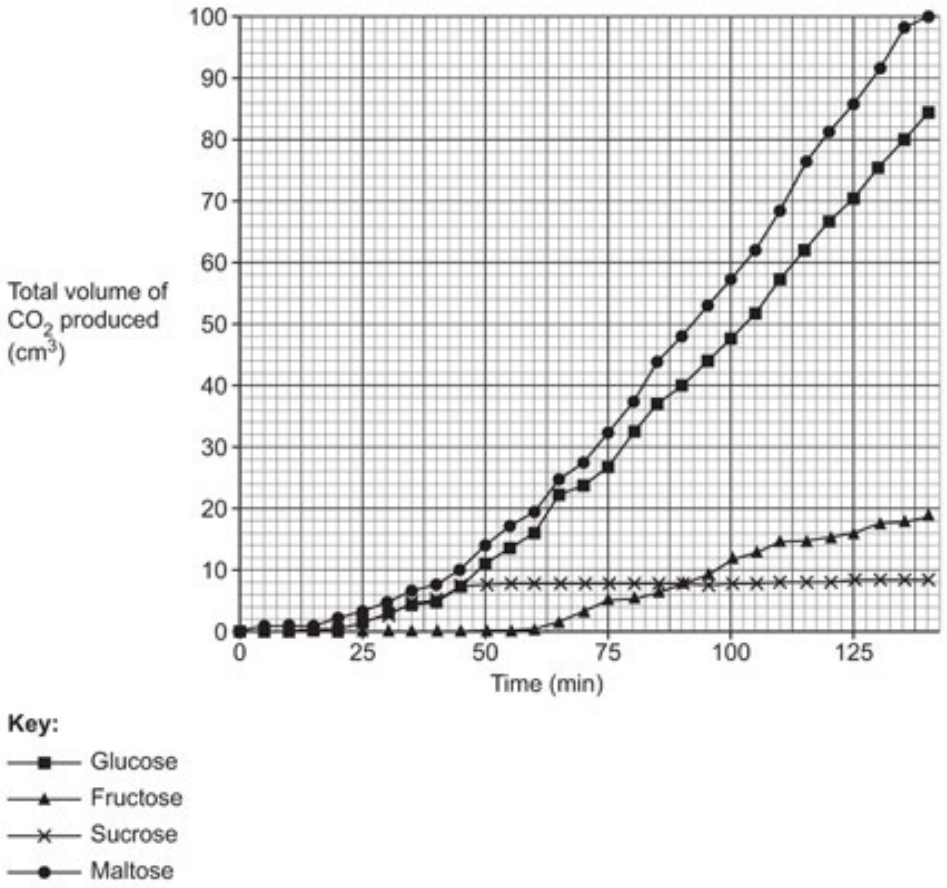
---**[2]**

5(a). Yeast can respire aerobically or anaerobically.

A student investigated how the type of respiratory substrate affects the rate of aerobic respiration in yeast.

Four different populations of yeast were provided with fructose, glucose, maltose or sucrose as a respiratory substrate. The student measured the CO_2 produced by each population over 150 minutes.

The student's results are shown in the figure below.



i. Compare CO_2 production when the substrate is glucose and CO_2 production when the substrate is maltose.

[2]

ii. The student wrote a note:

'The CO_2 production with fructose is approximately the same as the CO_2 production with sucrose'.

Explain whether you agree with the student's note.

[2]

(b). A student plans to compare the rate of anaerobic respiration in two species of yeast.

i. The student uses glucose as the respiratory substrate in their experiment.

The student produces a 0.01 mol dm^{-3} glucose solution for each yeast population. This is the method that they use to produce each 0.01 mol dm^{-3} glucose solution:

- Make two 10-fold dilutions from a 1.0 mol dm^{-3} stock solution.
- In each dilution, use a measuring cylinder to measure the volume of water and a dropping pipette to transfer the glucose solutions.

Suggest **two** ways in which the student can reduce the percentage error in their measurements when producing the glucose solutions.

1

2

[2]

ii. Complete the sentences using appropriate words or phrases.

This is the method that the student uses in their experiment:

- To avoid contamination, place the yeast in glucose solutions that are produced using .....water.
- Culture each species of yeast in different flasks.
- Ensure anaerobic conditions by using a .....flask.
- Use the rate of CO_2 production as a measure of respiration rate.
- Standardise all other variables.
- Repeat the measurements with 10 populations from each species and calculate two means and two .....
- Analyse the data using a Student's *t*-test.

[3]

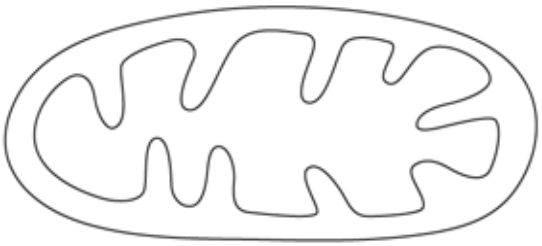
6. Vitamins are molecules that are consumed in the diet of animals and have essential roles in the body.

Vitamin B_2 is used by the body to make FAD. Vitamin B_3 is used by the body to make NAD.

i. A mitochondrion is shown in the figure below.

Label this figure to show the locations where FAD gains H atoms and where FAD releases H atoms during respiration.

- Use the letter **E** to show where FAD gains H atoms.
- Use the letter **F** to show where FAD releases H atoms.



[2]

ii. The table lists features that are correct for FAD, NAD, both or neither.

Complete the table by adding a tick (✓) to a box where the feature is correct and a cross (✗) where the feature is incorrect. You should add either a tick or a cross to every box in the table.

Feature	**FAD**	**NAD**
Is a prosthetic group		
Is reduced in the link reaction		
Oxidises molecules in the electron transport chain		

[2]

iii. ATP is produced in respiration. Some of these molecules of ATP are used to release energy for processes in respiration. For example, ATP is used in the early stages of glycolysis.

Suggest **one other** way in which ATP contributes to the process of respiration.

[1]

7. Erythrocytes are formed from bone marrow stem cells. During this process they lose most of their organelles.

Which statement about respiration in erythrocytes is correct?

A Oxygen bound to haemoglobin is used by erythrocytes in aerobic respiration.
B They do not respire because their cell surface membrane is impermeable to glucose.
C They respire aerobically because they always have adequate supplies of oxygen.
D They respire anaerobically because they do not have mitochondria.

Your answer ☐ **[1]**

8. *Muscle contraction requires energy in the form of ATP.

Describe the different sources of the ATP that is used in muscle contraction during strenuous exercise.

[6]

9(a). *Oplegnathus insignis* is a fish species that lives in salt water. It may be suitable for use in fish farming.

Scientists investigated the growth of *O. insignis* at different temperatures to help decide on the optimum temperature for farming.

Fig. 20.1 shows a diagram of the respirometer the scientists used.

The diagram shows a single fish, but the respirometer is large enough to hold many.

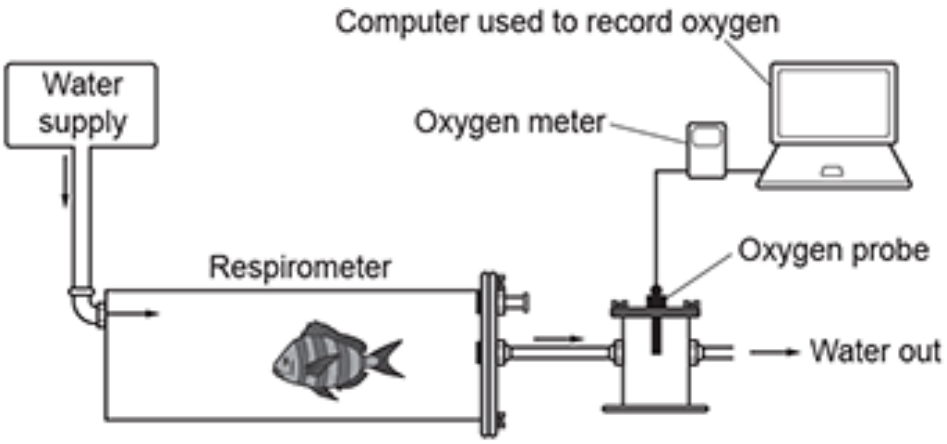


Fig. 20.1

i. Suggest **two** modifications the researcher would need to make to this apparatus to investigate the effect of temperature on the rate of respiration.

1

2

[2]

ii. Suggest **one** advantage of using a computer to collect data.

[1]

iii. A constant flow of water past the oxygen probe allows continuous monitoring of oxygen concentration.

Explain **one** other reason why it is necessary to maintain a constant flow of water in the respirometer.

[2]

iv. Suggest and explain **one** other precaution that the scientists should take to ensure that the results obtained using this apparatus are valid.

[2]

(b). The scientists studied the effect of living at different temperatures on respiration in young fish at different stages of growth.

High oxygen consumption in fish is associated with a fast growth rate.

Their results are shown in **Fig. 20.2**.

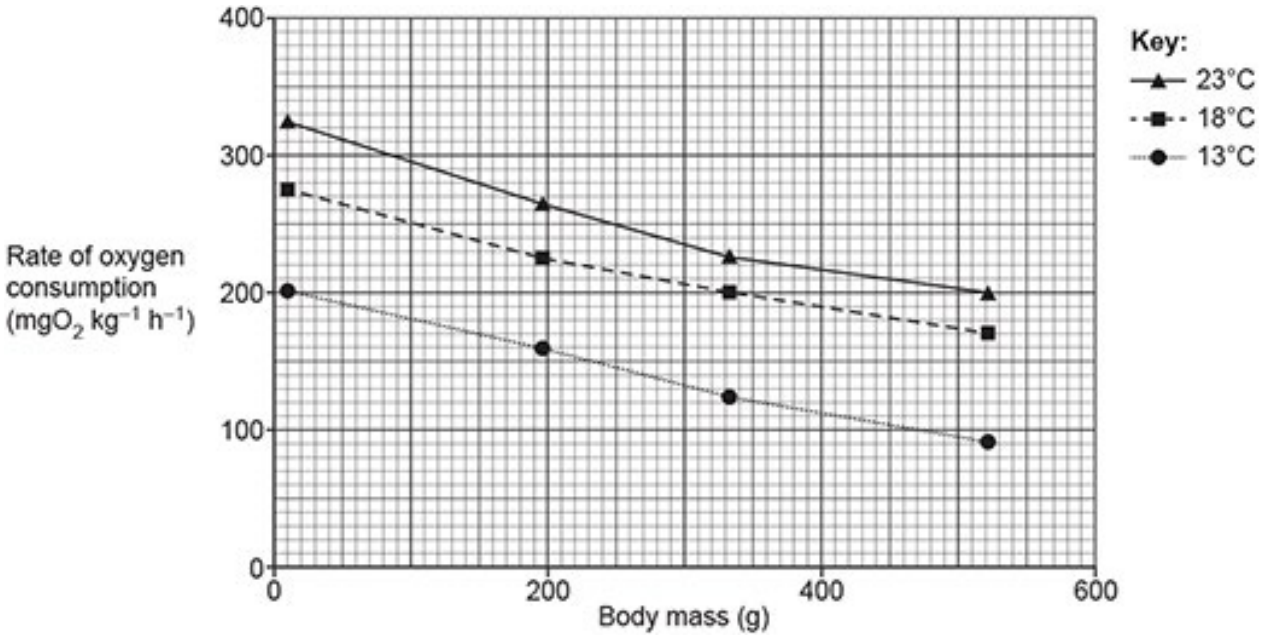


Fig. 20.2

i. Calculate the Q_{10} for respiration in the largest fish.

Give your answer to **3** significant figures.

Q_{10} = ... **[2]**

ii. The scientists concluded that the best temperature for farming of *O. insignis* was 18 °C.

Evaluate their conclusion.

[4]

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10. Kendal Mint Cake is made from sugar, flavoured with peppermint, and was famously taken on the 1953 ascent of Mount Everest.

Which statement describes why climbers now prefer to take chocolate?

A Chocolate contains fat. Fat stores and releases less energy per gram than sugar.
B Chocolate contains fat. Fat stores and releases more energy per gram than sugar.
C Fat contains more oxygen than glucose.
D Glucose can be digested more rapidly than fat.

Your answer ☐ **[1]**

11. Linoleic acid is a fatty acid found in sunflower oil.

The equation for oxidation of linoleic acid is:

Linoleic acid: $C_{18}H_{32}O_2 + 25\ O_2 \rightarrow 18\ CO_2 + 16\ H_2O$

What is the respiratory quotient (RQ) of linoleic acid?

A 0.33
B 0.72
C 1.00
D 1.39

Your answer ☐ **[1]**

END OF QUESTION PAPER