12. Energy and Respiration

12.1 Energy

Paper 4

Question Paper

1 During aerobic respiration, cells respire substrates such as glucose to produce ATP.

Some events that occur during aerobic respiration are:

- The respiratory substrate breaks down into smaller and smaller molecules. These series of reactions are described as catabolism.
- Coenzymes take part in various reactions. In some reactions, coenzymes are reduced or oxidised.
- Carbon dioxide is released.

(b) A new hand-held technological device shows the main type of respiratory substrate being used in the cells of a person.

The device consists of a carbon dioxide sensor and air-flow meter. The person inhales through the device for a fixed time and then exhales into it.

The device calculates the respiratory quotient (RQ) value to show whether the cells are mainly respiring carbohydrates or lipids.

(i) Explain how the device calculates the RQ value **and** how this shows whether the cells are mainly respiring carbohydrates or lipids.

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(ii) State the difference in the relative energy values of carbohydrates and lipids as respiratory substrates, **and** explain the reasons for the difference.

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.... [3]

2 **(a)** The respiratory quotient (RQ) values for different respiratory substrates can be calculated.

Table 5.1 shows:

- the formulae of four respiratory substrates
- the number of oxygen molecules (O_2) needed to completely respire each substrate to carbon dioxide and water.

Table 5.1

respiratory substrate	formula	number of oxygen molecules needed for respiration
beta-hydroxybutyric acid	$C_4H_8O_3$	4.5
glucose	$C_6H_{12}O_6$	6.0
malic acid	$C_4H_6O_5$	3.0
oleic acid	$C_{18}H_{34}O_2$	25.5

Using Table 5.1, name the respiratory substrate with the highest RQ and the respiratory substrate with the lowest RQ.

respiratory substrate with the **highest** RQ .....

respiratory substrate with the **lowest** RQ .....

[2]

3 Respiration is a process that results in the synthesis of ATP. The ATP can be used within the cell for energy-requiring reactions and processes.

There are four stages in aerobic respiration: glycolysis, the link reaction, the Krebs cycle and oxidative phosphorylation.

(a) The ATP synthesised in respiration can be used to make larger and more complex biological molecules from smaller molecules.

Name the type of reaction that occurs when larger more complex biological molecules are made from smaller molecules.

..... [1]

(c) State the precise locations of substrate-linked phosphorylation reactions in aerobic respiration.

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..... [1]

4 **(a)** All organisms respire. The ATP produced as a result of respiration is used as the energy currency of the cell.

(i) Outline **two** examples of movement in cells that use ATP.

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..... [2]

(ii) ATP cannot be stored in cells so it has to be continually re-synthesised to meet the demands of an organism.

A person with a total quantity of 0.2 moles of ATP needs to hydrolyse 150 moles of ATP per day.

Calculate how many times the total quantity of 0.2 moles of ATP has to be re-synthesised per hour to meet the demand of 150 moles per day.

Show your working and give your answer to the nearest whole number.

answer = ... [2]

(iii) Name the stages in which chemiosmosis occurs in respiration and in photosynthesis.

respiration .....

photosynthesis .....

[2]

5 **(a)** ATP is needed for many metabolic processes in living organisms.

(i) Describe the properties of ATP that make it suitable for its role as the universal energy currency.

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(ii) Suggest why ATP is needed for protein synthesis.

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6 **(a)** Define the term respiratory quotient (RQ).

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..... [2]

(b) Fig. 7.1 summarises the respiration of an organic substance, **A**, in aerobic conditions.

(i) Complete Fig. 7.1 in the spaces provided.

$C_{18}H_{32}O_2$ + ...O_2 ⟶ ..... CO_2 + $16H_2O$

substance **A**

Fig. 7.1 [2]

(ii) Calculate the RQ for substance **A**.

Write your answer to **two** decimal places.

RQ = ... [1]

(iii) Use your calculated RQ value to suggest the group of compounds to which substance **A** belongs.

..... [1]

7 **(b)** The rufous hummingbird, *Selasphorus rufus*, feeds on the nectar produced by flowers. Nectar is a liquid containing sugars. Hummingbirds hover to maintain a position next to a flower while they feed. This requires a lot of energy.

Fig. 6.2 is a rufous hummingbird.



Fig. 6.2

Hummingbirds that have not fed for some time have a respiratory quotient (RQ) value of 0.7. After feeding their RQ value is 1.0.

(i) Define the term *respiratory quotient*.

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(ii) Explain why a hummingbird that has not fed for some time has an RQ value of 0.7, while a hummingbird that has fed has an RQ value of 1.0.

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..... [2]

(iii) When animals exercise they can respire substrates obtained directly from their diet, as well as respiring substrates from energy stores.

An investigation worked out the percentage of respiration that used substrates obtained directly from the diet of humans and hummingbirds as they exercised.

Fig. 6.3 shows the results of this investigation.

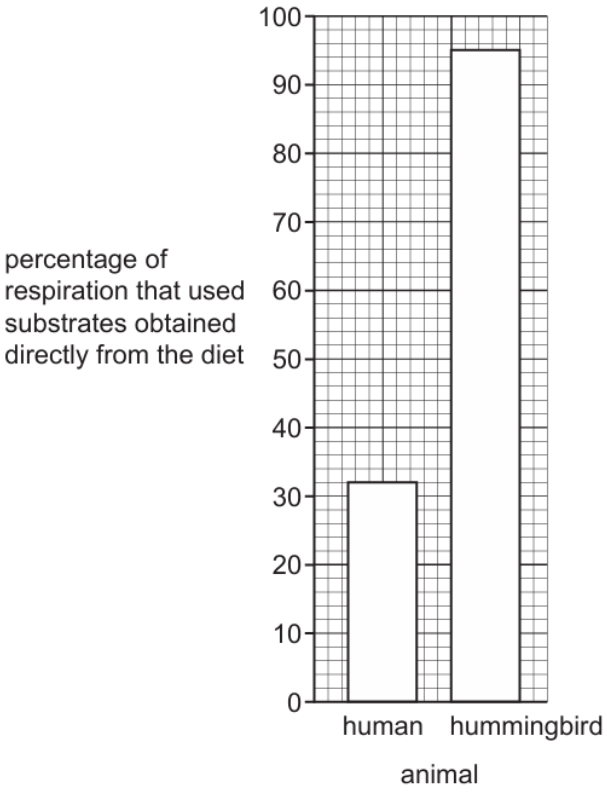


Fig. 6.3

Fig. 6.3 shows that hummingbirds have a higher percentage of respiration that uses substrates obtained directly from the diet.

Calculate how many times greater this figure is for hummingbirds compared to humans.

Show your working and write your answer to **two** decimal places.

answer = ... [2]

(iv) Suggest the benefits to a hummingbird of obtaining most of its respiratory substrates from its diet while exercising.

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