

OCR A-LEVEL BIOLOGY B • H422

BIOLOGY



EXAM QUESTION PACK

4.1.1 CELLULAR RESPIRATION

SCORE

/155

PERCENTAGE

%

STEMUP

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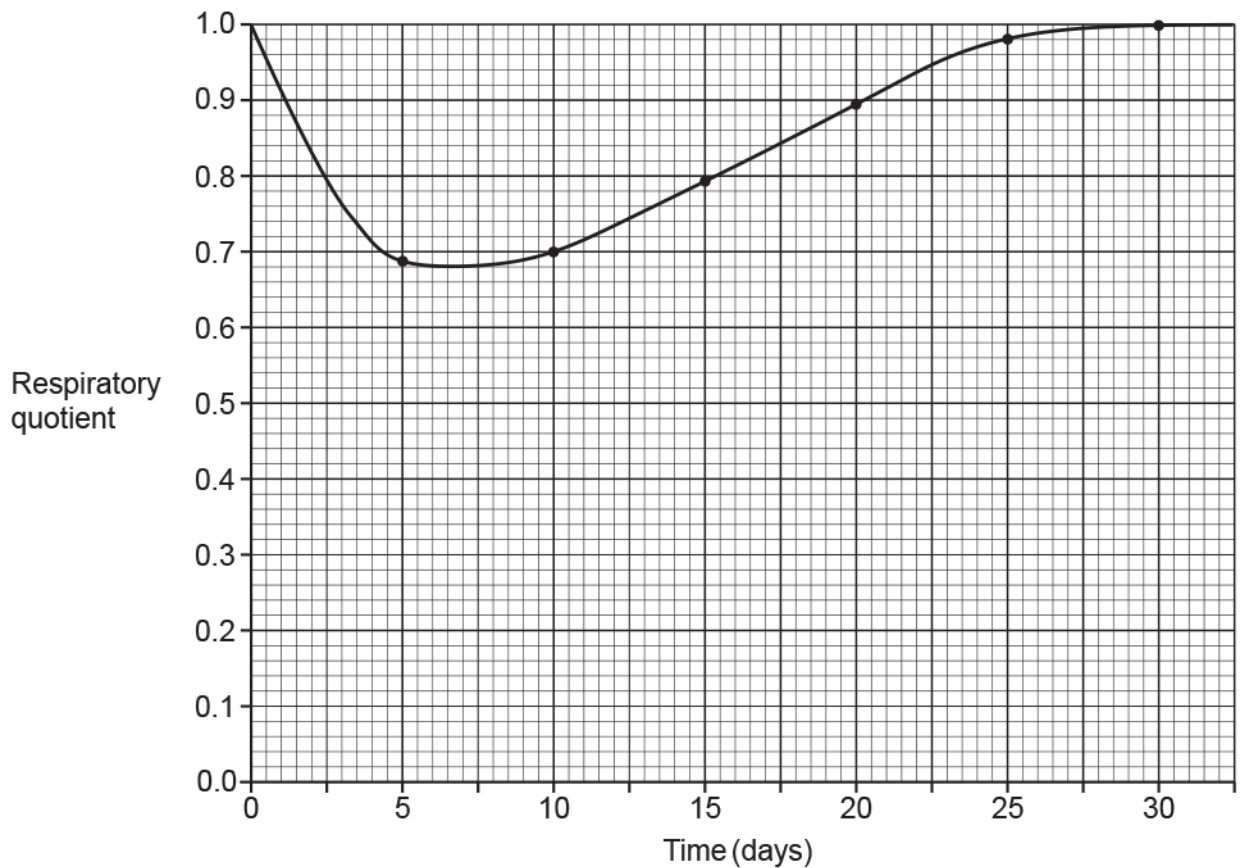
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- 1(a) Barley is a widely grown cereal in the UK. The production of barley malt involves germinating the barley grains (seeds) and then drying them.

The graph shows the results of an investigation into changes in respiratory quotient (RQ) of barley seeds during the first 30 days of germination.



- (i) Name the apparatus that could have been used to measure RQ in this investigation.

[1]

- (ii) Barley grains contain about 12% by mass of storage proteins. A student stated that the graph was evidence that these proteins are used as respiratory substrates throughout germination.

Suggest whether the student's statement is likely to be correct.

[2]

(iii) Describe how you could extend this experiment to test the student's hypothesis.

[2]

(iv) What can you conclude from the graph about the respiratory substrates, other than protein, that are used during germination?

[3]

(b) After being used in brewing, spent grain can be used as an animal feed.

Approximately 50% by mass of the fatty acids in spent grain are linoleic acid, $C_{18}H_{32}O_2$.

(i) Calculate the respiratory quotient, RQ, of linoleic acid when respired aerobically.

RQ = ... [2]

(ii) State the effect on RQ if the linoleic acid were respired by a mixture of aerobic and anaerobic respiration.
Explain your answer.

----- [2]

2(a) Fig. 6 shows the reactions of one stage of respiration.

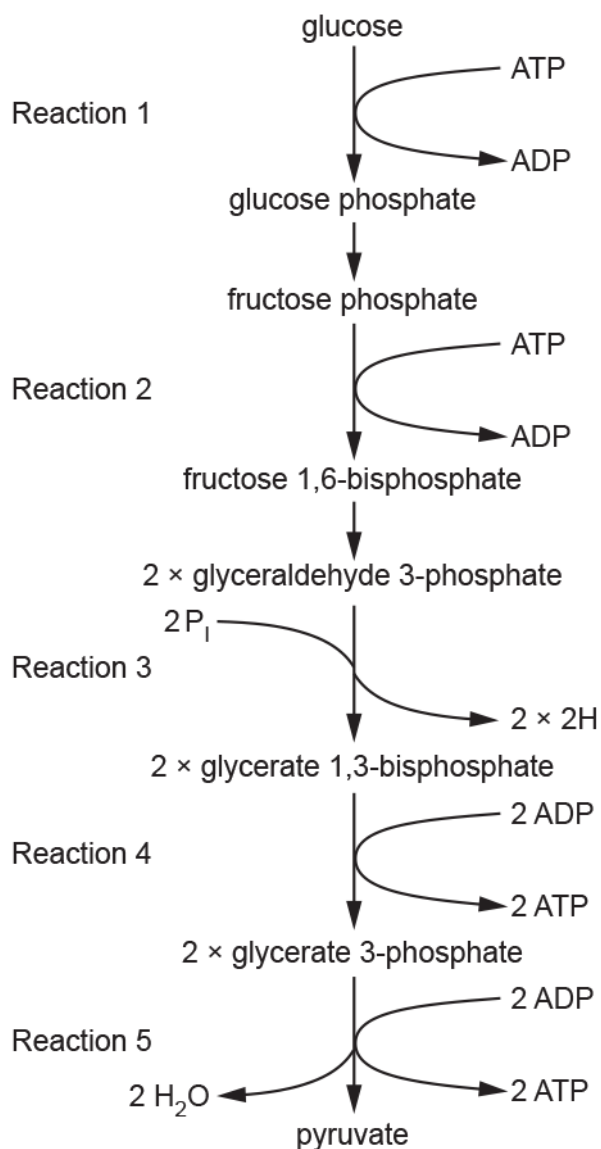


Fig. 6

(i) Name the stage of respiration shown in Fig. 6.

[1]

(ii) State the location in the cell where the reactions in Fig. 6 occur.

[1]

(iii) Complete the following table by placing a tick (✓) in the appropriate boxes to show which reactions include substrate level phosphorylation, hydrolysis or a dehydrogenase enzyme.

Reaction	Substrate level phosphorylation occurs	Hydrolysis reaction occurs	Dehydrogenase enzyme is used
1			
2			
3			
4			
5			

[3]

(iv) Reactions 1 and 2 in Fig. 6 illustrate how ATP is used to phosphorylate molecules.

Phosphorylation of glucose prevents it from being able to diffuse out of the cell.

Suggest **one** other effect of glucose phosphorylation that is important in the process shown in Fig. 6.

[1]

(b) Complete the following passage using the correct words or terms.

In the link reaction, coenzyme A accepts two carbons from
to form acetyl coenzyme A. At the same time and
..... are formed. This is an example of oxidative
decarboxylation. Acetyl coenzyme A enters the Krebs cycle and reacts with oxaloacetate to
form which is then converted back to oxaloacetate.

[4]

3 α -glucose is an example of a monosaccharide sugar.

Which of the options, **A** to **D**, is **not** a property of monosaccharides?

- A** general formula $C_nH_{2n}O_n$
- B** soluble in water
- C** can be hydrolysed into simpler molecules
- D** have OH groups that can form hydrogen bonds with other molecules

Your answer

[1]

4 ATP contains three phosphate groups, a nitrogenous base and a pentose sugar.

Which of the rows, **A** to **D**, is correct for ATP?

	Nitrogenous base	Pentose sugar
A	adenosine	ribose
B	adenine	ribose
C	adenine	deoxyribose
D	adenosine	deoxyribose

Your answer

[1]

5(a) The chemiosmotic theory was first proposed by Peter Mitchell in 1961. It has since been confirmed by experiments using isolated mitochondria.

One of the experiments was conducted as follows:

- Mitochondria were isolated from liver cells.
- The mitochondria were transferred to a buffer solution.
- The solution was poured into glass dishes, labelled A to D, to which ADP, Pi (inorganic phosphate) and other substances were added.
- Oxygen was excluded from dish B.
- After a period of time, the dishes were checked for the presence of ATP.

The results of the experiment are shown in the table below.

	Contents of dish	ATP present?
Dish A	mitochondria + ADP + Pi + acetyl CoA	yes
Dish B	mitochondria + ADP + Pi + acetyl CoA	no
Dish C	mitochondria + ADP + Pi + low concentration of acid (H^+)	no
Dish D	mitochondria + ADP + Pi + high concentration of acid (H^+)	yes

(i) Describe what is meant by the term chemiosmosis.

[1]

(ii) Using your knowledge of mitochondrial respiration, explain the results for dishes B and C.

[4]

(b) Mitochondria are small eukaryotic organelles that generate ATP for cellular activity.

The image below is an electron micrograph of a mitochondrion. Two structures are labelled X and Y.



The volume of buffered mitochondria solution in each dish was controlled.

State **one** other variable in the experiment **and** explain why it should be controlled.

variable -----

explanation -----

[2]

(c) The experiment was extended by adding different metabolic intermediates to the dishes, such as succinate and oxaloacetate. Production of ATP was then measured quantitatively.

(i) Name a technique that can determine the concentration of a known molecule in a solution by measuring light absorbance.

----- [1]

(ii) Suggest an appropriate unit for quantitative ATP measurement.

----- [1]

6 Which of the following statements is/are true of anaerobic respiration in **both** animal **and** yeast cells?

- 1: Pyruvate is produced in glycolysis.
- 2: Reduced NAD is oxidised.
- 3: Two molecules of ATP are produced net, per glucose molecule.

- A 1, 2 and 3 are correct
- B Only 1 and 2 are correct
- C Only 2 and 3 are correct
- D Only 1 is correct

Your answer

☐

[1]

7 Which of the options, **A** to **D**, is the number of molecules of triose phosphate required to produce **two** molecules of glucose?

- A 1
- B 2
- C 4
- D 8

Your answer

☐

[1]

8 Which of the options, **A** to **D**, is the net gain in ATP molecules following the glycolysis of **one** glucose molecule?

- A** 1
- B** 2
- C** 4
- D** 6

Your answer

[1]

9(a) Aerobic respiration involves a series of reactions.

The table below gives three types of reaction involved in aerobic respiration.

Complete the table by inserting, for each type of reaction:

- **one** metabolic pathway in which the reaction occurs
- the precise location of the metabolic pathway in the cell.

For example, dehydrogenation is a reaction of the Krebs cycle, which occurs in the mitochondrial matrix. The first row has been done for you.

Type of reaction	Metabolic pathway	Precise location in cell
Dehydrogenation	Krebs cycle	mitochondrial matrix
Oxidative decarboxylation		
Substrate level phosphorylation		

[2]

(b)

(i) The unbalanced equation for the aerobic respiration of a substrate is shown below.



Balance the equation above by writing the correct numbers in the blank spaces.

[1]

(ii) Calculate the respiratory quotient (RQ) of this respiratory substrate. Give your answer to **two** significant figures.

RQ = ----- [2]

(iii) Suggest **one** reason for an RQ greater than 1 in an organism respiring aerobically.

----- [1]

(c) * A respirometer is used to investigate the rate of respiration.

Fig. 34 shows the setup of a respirometer with two chambers.

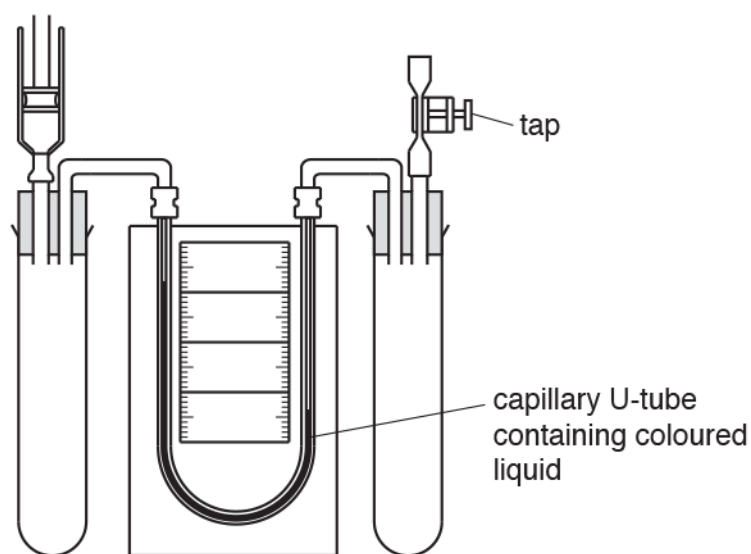


Fig. 34

Discuss how the respirometer in Fig. 34 can be used to calculate the RQ of germinating peas.

[6]

10 Proton pumps establish electrochemical gradients, which are required for ATP production.

Which of the options, **A** to **D**, are regions of a plant cell into which protons are pumped?

- A chloroplast stroma and mitochondrial intermembrane space
- B chloroplast stroma and mitochondrial matrix
- C thylakoid space and mitochondrial intermembrane space
- D thylakoid space and mitochondrial matrix

Your answer ☐

[1]

11(a) A researcher investigated the effect of water temperature on the metabolic rate of a fish species.

For this investigation, the researcher used a type of respirometer attached to data-logging equipment containing an electronic sensor.

The electronic sensor measured any changes in the oxygen concentration of the water, which were used to calculate the metabolic rate of the fish.

Each of the following was included in the procedure for this investigation:

- Ten individual fish of the same species were used.
- The rate of oxygen consumption of each fish was measured.
- The temperature of the water was changed and the measurements repeated.
- After each set of measurements, the respirometers were flushed (cleaned and rinsed with hot water).

The rate of oxygen consumption was also measured in clean, empty respirometers. These measurements of oxygen consumption were too small to affect the outcome of the experiment.

(i) The oxygen concentration of water can be measured using a number of different methods.

Give **one** advantage of using an electronic sensor with a data-logger.

----- [1]

(ii) State **two** of the control variables necessary in this experiment.

----- [2]

(iii) Suggest why the respirometers were flushed after each experiment.

----- [1]

(b) Table 3.1 shows some of the results from this investigation.

Temperature of water in respirometer (°C)	Mean metabolic rate (mg O ₂ kg ⁻¹ hour ⁻¹)
10	86.0
16	131.6

Table 3.1

The standard deviation, *s*, for both means is 8.3.

A Student *t*-test can be performed to compare the mean metabolic rate at each temperature and determine if the two are significantly different from each other.

(i) State the null hypothesis for this test.

----- [1]

(ii) Calculate the variance (*s*²) for these means.

Answer = ----- [1]

(iii) Using the formula below, calculate the *t* value for the data in Table 3.1.

$$t = \frac{|\bar{x}_A - \bar{x}_B|}{\sqrt{\frac{s_A^2}{n_A} + \frac{s_B^2}{n_B}}}$$

Show your working. Give your answer to **three decimal places**.

$$t = \text{-----} [3]$$

(iv) Using Table 3.2 and your answer to (b)(iii), comment on the mean metabolic rates for 10 °C and 16 °C.

Degrees of freedom	Level of probability		
	0.05	0.1	0.001
8	2.306	3.355	5.041
10	2.228	3.169	4.587
18	2.101	2.878	3.922
20	2.086	2.845	3.850

Table 3.2

- (c) The background research for this investigation into the effect of temperature on the metabolic rates of fish included information about increasing surface sea temperatures.

It has been predicted that surface sea temperatures will continue to increase throughout the 21st century.

Suggest **two** limitations of trying to link the results of this laboratory investigation with the likely consequences on marine fish as surface sea temperatures increase.

----- [2]

- 12 Oxidative phosphorylation is the process in which the transfer of electrons from reduced NAD or reduced FAD to oxygen results in the production of ATP.

Which of the options, **A** to **D**, is the number of ATP molecules gained from the oxidation of **two** molecules of reduced NAD?

- A 2
- B 3
- C 4
- D 5

Your answer

[1]

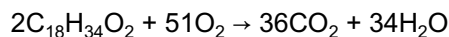
- 13 Which of the options, **A** to **D**, correctly identifies the products of anaerobic respiration in yeast?

- A CO₂, NAD, ATP and ethanol
- B CO₂, NAD, ADP and lactic acid
- C CO₂, reduced NAD, ATP and ethanol
- D CO₂, reduced NAD, ADP and lactic acid

Your answer

[1]

- 14 The balanced equation for the aerobic respiration of a substrate is given below.



Which of the statements, **A** to **D**, gives the correct respiratory quotient (RQ) and identity of this substrate?

- A RQ = 0.68, and the substrate is a carbohydrate
- B RQ = 0.71, and the substrate is a fatty acid
- C RQ = 0.76, and the substrate is a carbohydrate
- D RQ = 1.00, and the substrate is a fatty acid

Your answer

[1]

- 15 Acetyl coenzyme A (Acetyl CoA) combines with choline to produce acetylcholine.

Which of the options, **A** to **D**, is an enzyme in which mutations may affect production of acetylcholine?

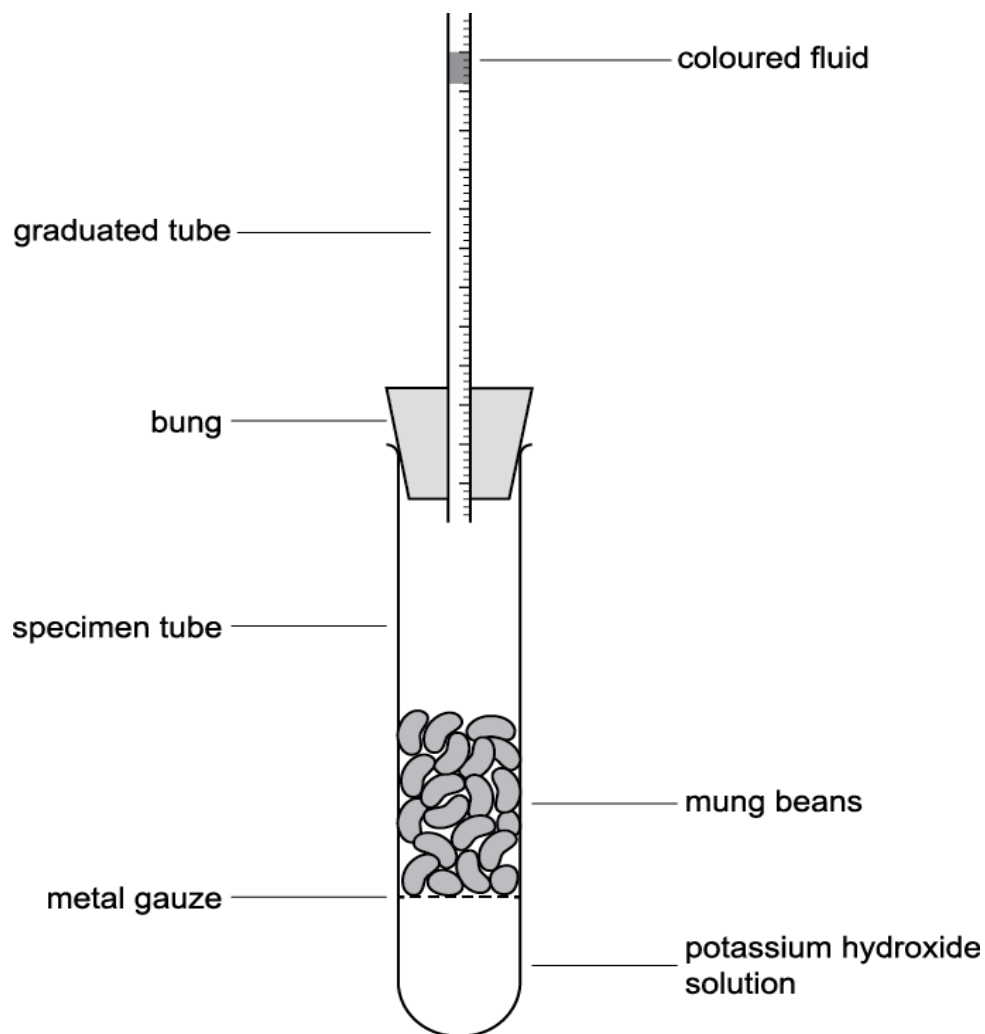
- A carbonic anhydrase
- B lactate dehydrogenase
- C pyruvate decarboxylase
- D ribulose biphosphate carboxylase

Your answer

[1]

- 16 A respirometer was used to investigate the rate of respiration in germinating mung beans.

The diagram below shows how the respirometer was set up.



An identical respirometer (not shown) was set up as a control, to confirm that any movement of the coloured fluid was due to respiration.

Which of the options, A to D, should be a feature of the control respirometer?

- A absence of potassium hydroxide solution
- B dried mung beans instead of germinating mung beans
- C pure carbon dioxide inside the specimen tube
- D used in conditions with no light

Your answer

[1]

17(a) This question is based on the Advance Notice article **CATALASE**.

Fig. 1.1 shows how reactive oxygen species (ROS) are formed during respiration in mitochondria.

Explain how some of the reactions that take place during respiration result in the release of the electrons and hydrogen ions responsible for the formation of ROS.

[4]

(b) Fig. 1.2 summarises the glyoxylate cycle in peroxisomes. This cycle converts fatty acids to carbohydrates. The glyoxylate cycle is a modification of the Krebs cycle.

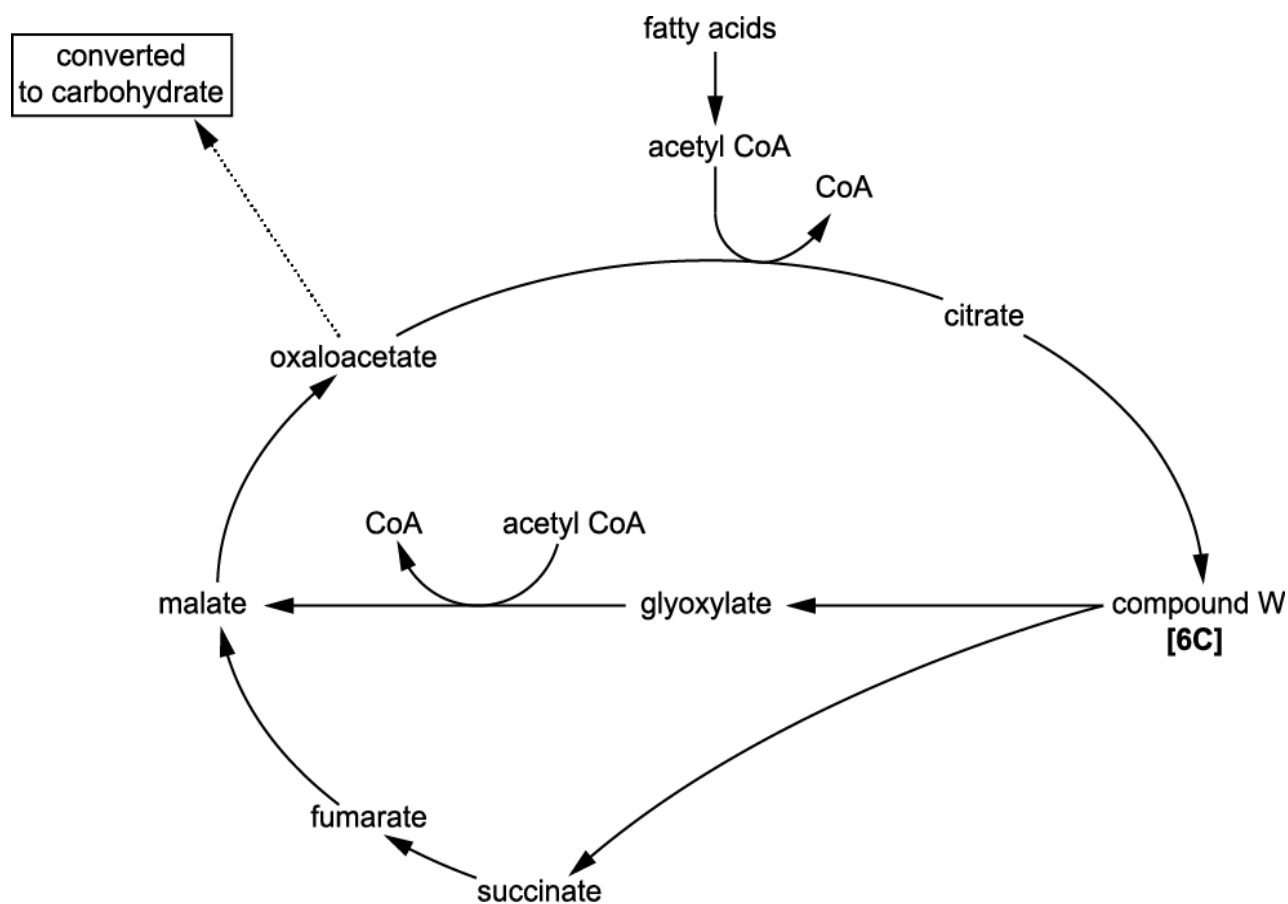


Fig. 1.2

Identify the following from the information given in Fig. 1.2:

(i) a 6-carbon compound other than compound W

-----[1]

(ii) the number of carbons present in glyoxylate

-----[1]

(iii) a 4-carbon compound other than oxaloacetate

-----[1]

- (iv) In the **Krebs cycle**, the conversion of compound **W** to succinate results in the production of an excretory product.

Give the name of this product.

-----[1]

18(a) In recent years, the organisers of the Campaign for Real Ale (CAMRA) have reported a large increase in the number of 'microbreweries'. These are small scale beer producers who concentrate on the taste and quality of the beer they produce.

Beer-making requires yeast cells to respire the sugars found in an extract made from germinated barley grains.

Yeast cells carry out both aerobic and anaerobic respiration.

- (i) Identify one product of **both** aerobic and anaerobic respiration in yeast cells that is essential in beer production.

-----[1]

- (ii) Identify one product of anaerobic respiration in yeast cells that is **not** produced in aerobic respiration.

-----[1]

- (b) Both aerobic and anaerobic respiratory pathways begin in the cytoplasm.

In the cytoplasm, hexose sugars are broken down in a series of steps to form a three-carbon compound. This compound is then metabolised further to allow cells to make some ATP.

- (i) Outline how ATP is made **in the cytoplasm** of yeast and human cells from the metabolism of a three-carbon compound.



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

[3]

- (ii) State **one** anabolic process that occurs in the **nucleus** of both human and yeast cells for which ATP is required.

[1]

- 19 *Spirulina* are photosynthetic bacteria belonging to a group known as the Cyanobacteria. Unlike other Cyanobacteria, *Spirulina* do not fix nitrogen.

Spirulina are widely grown in some parts of the world for use as food for humans and animals.

Fig. 3.1, shows the green bacterial 'mats' being harvested. Once harvested these are dried and processed.



Fig. 3.1

Spirulina is also sold in the United Kingdom as a dietary supplement in the form of capsules, tablets or powder.

Fig. 3.2 below is an extract from a leaflet promoting the benefits of *Spirulina* as a dietary supplement.

- *Spirulina* is one of the most concentrated and nutritious food sources in nature.
- *Spirulina* contains all the amino acids.
- *Spirulina* is a rich source of many vitamins such as B3 (nicotinamide), B9 (folate), C and D.
- *Spirulina* is rich in all essential minerals.
- *Spirulina* is rich in essential fatty acids.
- *Spirulina* is a good source of antioxidants.

Fig. 3.2

Using the information given in Fig. 3.2 about the substances found in *Spirulina*:

- (i) identify **one** substance which is necessary for the synthesis of haemoglobin;

-----[1]

- (ii) identify **one** substance which forms part of a respiratory co-enzyme;

-----[1]

- (iii) identify **one** substance which may prevent DNA damage;

-----[1]

- (iv) identify **one** substance which is recommended in routine pre-conceptual care.

-----[1]

20 The ability of the body to take in, transport and use oxygen is known as the VO_2 max.

- One consequence of taking regular aerobic exercise is that the VO_2 max increases.
- Some athletes use illegal methods such as taking recombinant erythropoietin to increase their VO_2 max.

(i) State the organelle where aerobic respiration takes place **and** the stage of aerobic respiration that requires oxygen.

Organelle

Stage of aerobic respiration

.....

[2]

(ii) Explain why the use of recombinant erythropoietin increases the VO_2 max.

.....

.....

.....

.....

.....

[2]

21(a) The energy necessary for carrying out any form of activity comes from the breakdown of the carbohydrates and fats, which are consumed in the diet.

A balanced diet contains enough of these substances, along with protein and the essential minerals and vitamins, to meet the needs of an individual.

Carbohydrates and fats can both be respiratory substrates.

Define the term *respiratory substrate*.

-----[1]

(b) The type of respiratory substrate being utilised by organisms can be deduced from calculating the RQ value.

Table 5.1 shows RQ values obtained for different combinations of carbohydrates and fats.

RQ value	Percentage contribution of respiratory substrate	
	Carbohydrate (%)	Fat (%)
0.70	0.0	100.0
0.75	14.7	85.3
0.80	31.7	68.3
0.85	48.8	51.2
0.90	65.9	34.1
0.95	82.9	17.1
		0.0

Table 5.1

Complete Table 5.1 by inserting the correct figures into the final row. One has already been inserted for you.

The answers to this question should be written in Table 5.1.

[2]

(c) RQ values can be determined from measurements made on humans using sophisticated electronic equipment.

Historically, several pieces of apparatus were required to determine RQ values experimentally.

The steps required and some of the apparatus used are as follows:

- exhaled air is collected in a gas-proof bag
- exhaled and inhaled air is analysed using a gas analyser
- breathing rate and volume are measured.

From calculating the RQ value, the relative percentage of carbohydrate and fat being used as respiratory substrates by a person can be deduced.

(i) What apparatus could be used for measuring both breathing rate and volume?

-----[1]

(ii) Suggest **two** variables that should be taken into account during an investigation into the effect of **exercise intensity** on RQ values in 18-year-old males.

1

2

[2]

(iii) Suggest a **biological** reason why the results will only provide an **estimate** of the percentage contribution of fat and carbohydrate as respiratory substrates.

-----[1]

- (d) Fats can only be used as a respiratory substrate if conditions within the muscles remain aerobic **and** if some carbohydrate is available.

This is often summarised by fitness trainers in the saying:

‘Fats burn in a carbohydrate flame’.

- (i) Suggest why fats can only be broken down in aerobic respiration.

----- [2]

- (ii) Name the carbohydrate compound stored in muscle cells and briefly describe one method used by athletes to increase this store.

carbohydrate compound -----

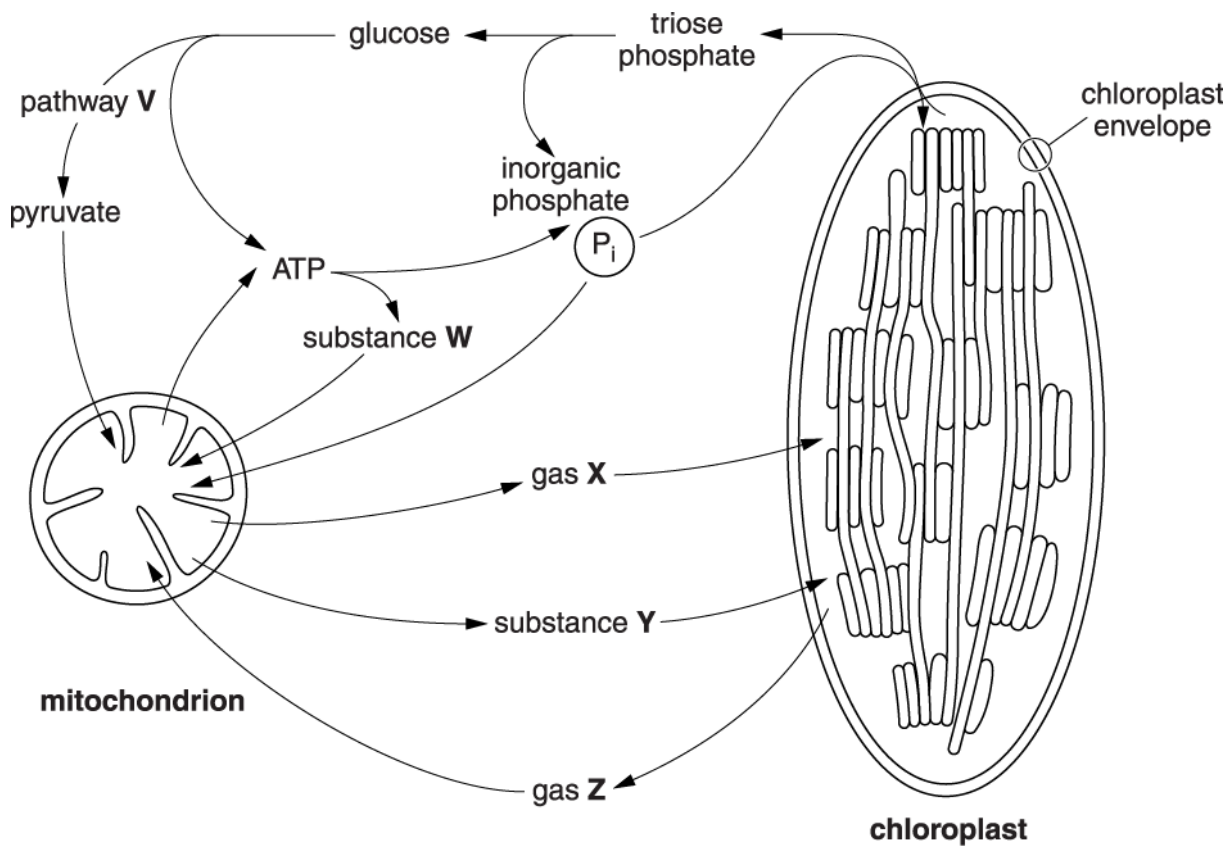
method -----

----- [3]

22(a) All living organisms respire in order to produce ATP, which is essential for a variety of biological processes.

Respiration in both plant cells and animal cells depends on the products of photosynthesis.

Fig. 3.1 shows some of the exchanges that take place in plant cells during bright sunlight.



Key

P_i = inorganic phosphate

Fig. 3.1

In which tissue in a plant leaf would a cell containing the organelles shown in Fig. 3.1 be found?

----- [1]

(b) Using Fig. 3.1, **name** the following:

(i) gas X _____

gas Z _____

[1]

(ii) substance Y _____

[1]

(iii) substance W _____

[1]

(c) Two groups of enzymes, **carboxylases** and **decarboxylases**, are essential to the exchanges that happen within the plant cell.

On Fig. 3.1, **write the letter C** exactly where a carboxylase is located in the cell and **write the letter D** exactly where a decarboxylase is located.

The answers to this question should be written on Fig. 3.1.

[2]

(d) Identify **one** substance in **addition** to those shown in Fig. 3.1 that is produced in pathway V, and which will enter the mitochondrion.

_____ [1]

(e) ATP is often referred to as '*the universal energy currency*'.

State **one** advantage of using ATP to provide energy for biological processes.

_____ [1]

23(a) The World Health Organisation has identified ways that alcohol can cause harm. One of these ways relates to the **quality** of the alcohol consumed.

The term 'alcohol' covers a range of chemicals. The alcohol present in beers, wines and spirits is ethanol. Ethanol is produced by yeast cells from the breakdown of carbohydrates.

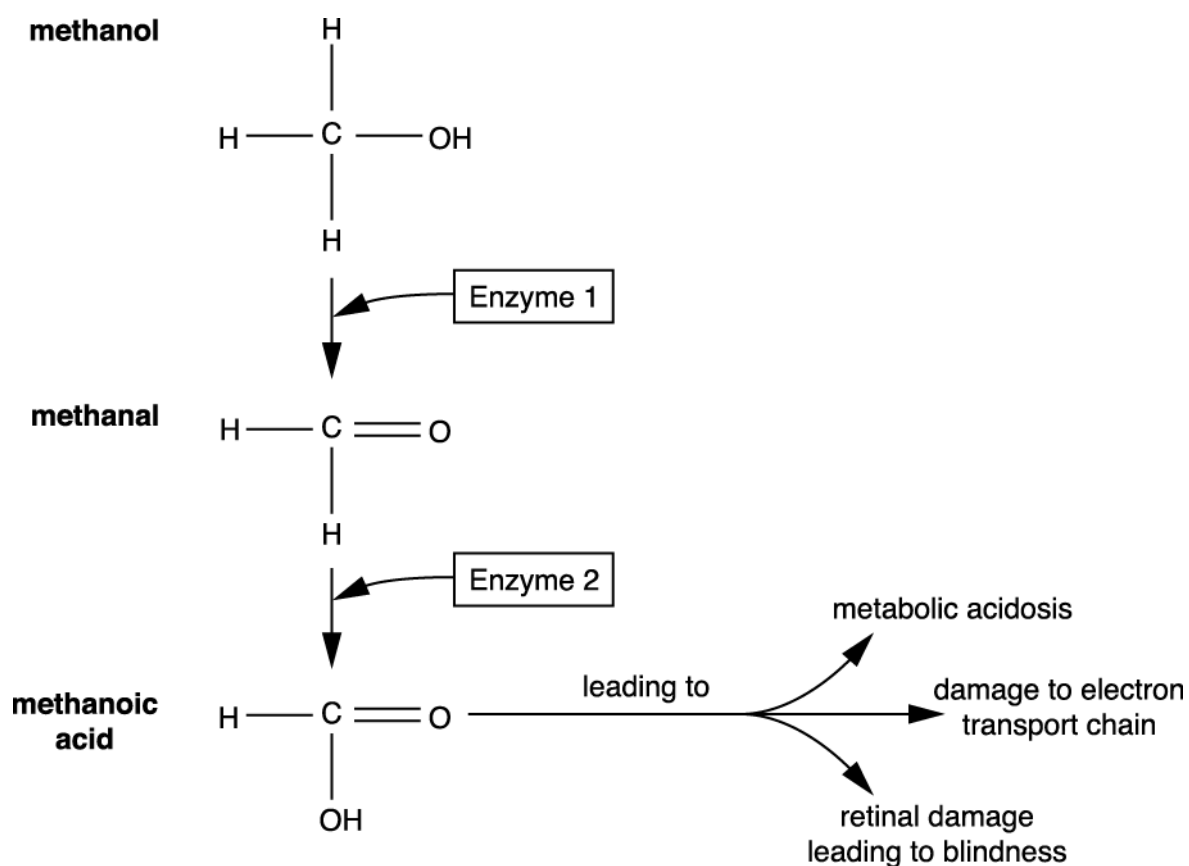
Name the metabolic pathway that produces ethanol.

[1]

(b) Methanol is an alcohol that can contaminate homemade or illegally produced alcoholic drinks.

Methanol is not toxic, but it is metabolised in liver cells to produce toxic substances such as **methanal** and **methanoic acid**.

The metabolic pathway for methanol breakdown is shown in the figure.



(i) Metabolic acidosis refers to the build up of organic acids in the blood plasma.

The methanoic acid formed from the metabolism of methanol is only slowly broken down, leading to a build up of this acid in the blood plasma.

Using the information in the figure, suggest one further organic acid that also builds up in the blood plasma. Explain your suggestion.

Name of acid _____

Explanation _____

_____ [3]

- (ii) Enzyme 1 in the figure is alcohol dehydrogenase. Alcohol dehydrogenase also breaks down ethanol in liver cells.

Using your knowledge of enzyme activity, suggest why administering ethanol is one method of treating methanol poisoning.

_____ [2]

- (iii) There are several different alleles that code for the production of alcohol dehydrogenase in humans. The activity of the enzyme varies with the allele. Some of these alleles are linked to an increased risk of alcohol dependency.

What type of dependency is associated with variation in the alleles for alcohol dehydrogenase?

Explain your answer.

_____ [1]

24(a) Respiration occurs in all living cells and requires a continuous supply of respiratory substrates.

Explain the meaning of the term *respiratory substrate*.

[2]

(b) ATP is produced by oxidative phosphorylation in the mitochondria.

The terms listed below relate to oxidative phosphorylation.

	NAD	water	ATP synthase
oxygen	protons (H ⁺ ions)		inner mitochondrial membrane
matrix	inorganic phosphate		intermembrane space

Identify the term from the list above that corresponds to each of the following features of oxidative phosphorylation.

A term can be used once, more than once or not at all.

(i) The final electron acceptor.

[1]

(ii) The location of the electron transport chain complex.

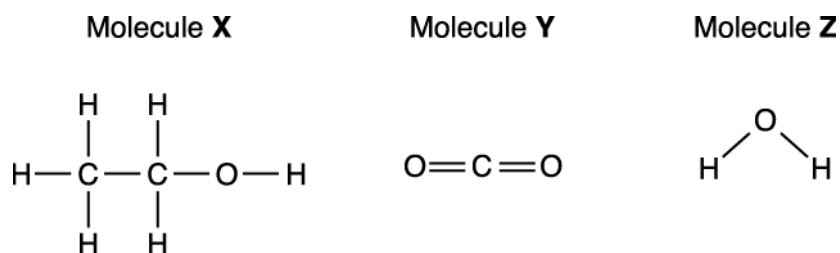
[1]

(iii) The membrane-bound protein involved in the phosphorylation of ADP.

[1]

- (c) The energy content of a molecule is partly determined by the number of C–H bonds that the molecule contains.

The figure shows the molecular structures of three of the possible products of respiration in **yeast**.



- (i) Name molecule X.

-----[1]

- (ii) Using the information in the figure, explain why anaerobic respiration is less efficient than aerobic respiration in the breakdown of $\text{C}_6\text{H}_{12}\text{O}_6$ (glucose) in yeast.

-----[3]

25(a) The farmer produces prize-winning cider which is bottled on the farm.

- To make the perfect cider, it must contain just the right volume of carbon dioxide (CO₂) gas to make it fizzy.
- Live yeast remaining in the sealed bottles of cider produce this CO₂.

Name the process by which live yeast cells make CO₂ in a sealed bottle.

-----[1]

(b) Flow cytometry is another technique that can be used for counting cells.

Compare the suitability of both techniques for counting the number of yeast cells in this population.

-----[3]

26(a) Fig. 36.1 shows the structure of a mitochondrion.

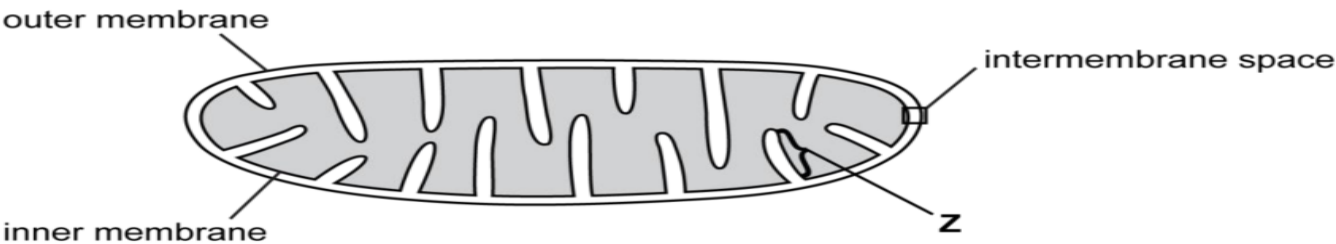


Fig. 36.1

(i) Identify **Z** in Fig. 36.1 **and** outline its role in the function of the mitochondrion.

----- **[2]**

(ii) State the importance of the intermembrane space for mitochondrial function.

----- **[1]**

- (b) The paragraph below, extracted from a biology textbook, is about the role of cytochrome C and the mitochondrion in the process of apoptosis.

Cytochrome C is an electron carrier in the electron transport chain.

The mitochondrion plays a role in apoptosis, as follows:

- Proteins are inserted into the outer membrane of the mitochondrion.
- The proteins assemble to form large, open pores through which protons can diffuse.
- Cytochrome C moves out of the intermembrane space and into the cytoplasm.
- Cytochrome C activates proteins that mediate apoptotic events.

Questions (b) (i) to (iii) should be answered using the information in the paragraph and your knowledge of respiration.

- (i) Explain why chemiosmosis stops during apoptosis.

----- [2]

- (ii) Suggest why the electron transport chain is interrupted during apoptosis.

----- [2]

- (iii) Suggest why apoptosis has no effect on the oxidation of reduced NAD and reduced FAD.

----- [1]

- (i) Iron is essential for the activity of the nitrogen-fixing enzyme, nitrogenase.

Iron is present as ions in soil water but is not taken up by root nodules directly.

Describe how iron ions in soil water reach the root nodules.

[3]

- (ii) *P. sativum* provides the nitrogen-fixing bacteria with a four-carbon molecule that can be oxidised to produce oxaloacetate and reduced NAD.

State the metabolic pathway in which oxaloacetate is an intermediate.

[1]

- 28 The statements below relate to biological characteristics of the respiratory pigments.

Which of the following statements is / are correct?

- Statement 1:** At any partial pressure of oxygen, myoglobin has a lower oxygen saturation level than adult haemoglobin.
- Statement 2:** The oxygen dissociation curves for fetal and adult haemoglobin are sigmoidal due to the cooperative binding of oxygen.
- Statement 3:** Haemoglobin releases oxygen more readily at low pH.

- A 1, 2 and 3 are correct
- B Only 1 and 2 are correct
- C Only 2 and 3 are correct
- D Only 1 is correct

Your answer

☐

[1]

29 Which of the options, **A** to **D**, is **not** a coenzyme?

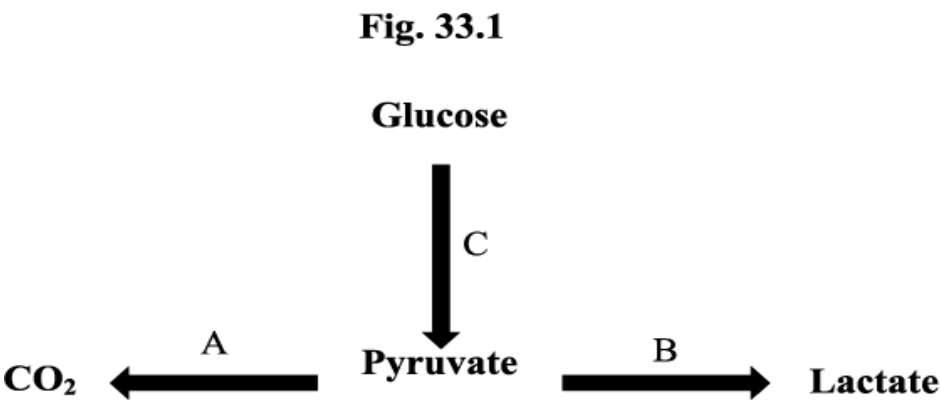
- A ATP
- B FAD
- C NAD
- D NADP

Your answer

[1]

30(a) Cells need to maintain a supply of ATP in order to function properly. A number of metabolic pathways in the cell are linked to the formation of ATP.

Fig. 33.1 shows three metabolic pathways, A, B and C.



(i) Suggest which metabolic pathway(s) is represented by pathway A and state precisely where A might occur in a eukaryotic cell.

----- [2]

(ii) In which of the three pathways and by what mechanism does the formation of ATP from ADP occur?

Pathway(s) -----

Mechanism ----- [2]

(b)

- (i) The enzyme lactate dehydrogenase (LDH) catalyses pathway C. When the blood supply to any tissue is limited, LDH concentrations increase in cells.

Explain why LDH concentrations in cells increase when the blood supply to tissues is limited.

----- [2]

- (ii) A heart attack occurs when blood vessels supplying the cardiac muscle become narrowed or blocked. This can lead to the death of cardiac muscle cells.

One indicator that a heart attack has occurred is a rise in concentrations of LDH in **blood plasma**.

Suggest why the death of cardiac muscle cells results in a rise in LDH concentrations in blood plasma.

----- [2]

- 31 Cellular respiration occurs in different regions of a cell.

In which region is FADH_2 produced?

- A Cytoplasm
- B Outer mitochondrial membrane
- C Inner mitochondrial membrane
- D Mitochondrial matrix

Your answer

[1]

32 The following reactions all occur in mitochondria during aerobic respiration:

- 1 decarboxylation of pyruvate
- 2 reduction of NAD
- 3 substrate level phosphorylation of ATP.

Which reaction(s) take place outside the mitochondria in yeast cells?

- A 1, 2 and 3
- B Only 1 and 2
- C Only 2 and 3
- D Only 1

Your answer

☐

[1]

33 Organisms can be classified into taxa by analysing and comparing some of their molecules.

The molecules below are all involved in respiration.

Which would be the most appropriate molecule to study in order to classify organisms into taxa?

- A ATP synthase
- B Acetyl coenzyme A
- C NAD
- D FAD

Your answer

☐

[1]

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1	a	i	respirometer ✓	1(AO1.2)	
		ii	protein could be the respiratory substrate between 0 – 5 days / 10 – 25 days ✓ it is not the respiratory substrate at , start of germination / after 25 days ✓ RQ < 1.0 or >0.7(2) might be due to mixture of substrates ✓	max 2(AO3.2)(AO3.2)(AO3.2)	
		iii	measure protein content at different times ✓ e.g. using Biuret test / test strips ✓	2(AO3.3)(AO3.3)	
		iv	at time zero / start of germination , (named) carbohydrate was being respired ✓ between 5 and 10 days , fats / oils , are being respired ✓ from ~25 days onwards carbohydrate is being respired ✓ between 0 – 5 days / 10 – 25 days , a mixture of substrates are being respired ✓	max 3(AO3.2)(AO3.2)(AO3.2)(AO3.2)	
	b	i	FIRST CHECK ON ANSWER LINE If answer = 0.72 award 2 marks evidence of use of CO ₂ /O ₂ (regardless of correct values) ✓ 18 / 25 = 0.72 ✓	2(AO2.2)(AO2.2)	Working: Balanced equation = C ₁₈ H ₃₂ O ₂ + 25O ₂ → 18CO ₂ + 16H ₂ O calculation of RQ = 18 / 25 = 0.72 ALLOW ECF from incorrectly balanced equation

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance																								
		ii	RQ would increase ✓ because less oxygen would be used ✓	2(AO2.1)																									
			Total	12																									
2	a	i	glycolysis ✓	1 AO 1.1	ALLOW glycolytic pathway																								
		ii	cytoplasm ✓	1 AO 1.1	ALLOW cytosol																								
		iii	<table><tr><td></td><td>Substrate level phosphorylation</td><td>Hydrolysis</td><td>Dehydrogenase-enzyme</td></tr><tr><td>1</td><td></td><td>✓</td><td></td></tr><tr><td>2</td><td></td><td>✓</td><td></td></tr><tr><td>3</td><td></td><td></td><td>✓</td></tr><tr><td>4</td><td>✓</td><td></td><td></td></tr><tr><td>5</td><td>✓</td><td></td><td></td></tr></table>		Substrate level phosphorylation	Hydrolysis	Dehydrogenase-enzyme	1		✓		2		✓		3			✓	4	✓			5	✓			3 AO 2.1	One mark for each correct column.
	Substrate level phosphorylation	Hydrolysis	Dehydrogenase-enzyme																										
1		✓																											
2		✓																											
3			✓																										
4	✓																												
5	✓																												
		iv	increases energy of glucose / reduces activation energy of reaction ✓	1 AO 2.1																									
	b		pyruvate ✓ carbon dioxide ✓ reduced NAD / NADH ✓ citrate ✓	4 AO 1.1	ALLOW mp2 and 3 in either order.																								
			Total	10																									
3			C	1 AO1.1																									
			Total	1																									
4			B	1 AO1.1																									
			Total	1																									

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
5	a	i	passage / diffusion, of hydrogen ions / protons, across the inner mitochondrial membrane / via ATP synthase ✓	1 AO1.1	ALLOW passage / diffusion, of ions down concentration gradient through a partially-permeable membrane
		ii	<i>Dish B absence of oxygen.</i> oxygen is (final) electron acceptor ✓ (without oxygen) water cannot be formed ✓ <i>Dish C low concentration of acid (H⁺).</i> H⁺ / protons, not pumped across inner membrane (through enzyme complexes) ✓ H⁺ / proton, gradient not generated (across inner membrane) ✓ ATP synthase not able to generate ATP (through oxidative phosphorylation) ✓	max 4 AO1.2 3.2	ALLOW No oxygen therefore there is no final electron acceptor
	b		temperature ✓ affects enzyme activity / high temperature may denature ✓ OR same source of cells ✓ different cells have different respiration rates ✓	max 2 AO3.4	
	c	i	colorimetry / colorimeter ✓	1 AO2.3	ALLOW use spectrophotometer / spectrophotometry
		ii	Any 1 from: any mass e.g. gram / dm⁻³ / mg / µg OR any moles or molecules per volume, e.g. nmol cm⁻³ / mmol cm⁻³ / molecules cm⁻³ ✓	1 AO2.4	ALLOW cm⁻³, dm⁻³ ALLOW e.g. g / cm³
			Total	9	
6			A	1 AO1.2	
			Total	1	
7			C	1 AO2.6	
			Total	1	
8			B	1 AO1.2	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance									
9	a		<table><tr><td>Dehydrogenation</td><td>Krebs cycle</td><td>mitochondrial matrix</td></tr><tr><td>Oxidative decarboxylation</td><td>link reaction OR Krebs / TCA / citric acid cycle</td><td>mitochondrial matrix</td></tr><tr><td>Substrate level phosphorylation</td><td>glycolysis OR Krebs / TCA / citric acid cycle</td><td>cytoplasm OR mitochondrial matrix</td></tr></table>	Dehydrogenation	Krebs cycle	mitochondrial matrix	Oxidative decarboxylation	link reaction OR Krebs / TCA / citric acid cycle	mitochondrial matrix	Substrate level phosphorylation	glycolysis OR Krebs / TCA / citric acid cycle	cytoplasm OR mitochondrial matrix	1	
		Dehydrogenation	Krebs cycle	mitochondrial matrix										
		Oxidative decarboxylation	link reaction OR Krebs / TCA / citric acid cycle	mitochondrial matrix										
Substrate level phosphorylation	glycolysis OR Krebs / TCA / citric acid cycle	cytoplasm OR mitochondrial matrix												
	b	i	$C_{16}H_{32}O_2 + 23 O_2 \rightarrow 16 CO_2 + 16 H_2O \checkmark$	1	ALLOW multiples of the correct balanced numbers. For example, $2 C_{16}H_{32}O_2 + 46 O_2 \rightarrow 32 CO_2 + 32 H_2O$									
		ii	0.70 ✓✓	2	16/23 = 1 mark 0.7 = 1 mark ALLOW ECF from (i)									
		iii	conversion of carbohydrates to lipids ✓	1										

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
	c	Summary of instructions to markers: <i>Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)</i> <i>Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.</i> <i>Then, award the higher or lower mark within the level, according to the Communication Statement (shown in <i>italics</i>):</i> ◦ <i>award the higher mark where the Communication Statement has been met.</i> ◦ <i>award the lower mark where aspects of the Communication Statement have been missed.</i> • <i>The science content determines the level.</i> • <i>The Communication Statement determines the mark within a level.</i> Level 3 (5–6 marks) A detailed discussion that includes the measurement of volume changes with and without sodium/potassium hydroxide and an appreciation that these measurements are used together to calculate RQ. There are descriptions of multiple controlled variables. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) A good discussion that includes the measurement of volume changes with sodium/potassium hydroxide. There is at least one description of a controlled variable. <i>There is a line of reasoning presented with</i>	6	Indicative scientific points may include: use of respirometer • time to equilibrate apparatus • control, e.g. glass beads / dried peas • sodium hydroxide (NaOH) / potassium hydroxide (KOH) / soda lime • change in volume due to O₂ consumed • repeat in absence of, sodium hydroxide (NaOH) / potassium hydroxide (KOH) / soda lime / water instead • change in volume due to CO₂ produced minus O₂ consumed • ref to calculation of RQ using changes in volume with AND without, sodium hydroxide (NaOH) / potassium hydroxide (KOH) / soda lime • $RQ = \frac{\text{(with NaOH + without NaOH)}}{\text{with NaOH}}$ • ref to repeats

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
	<i>some structure. The information presented is in the most-part relevant and supported by some evidence.</i> Level 1 (1–2 marks) A limited discussion that includes the measurement of volume changes with sodium/potassium hydroxide only OR at least one description of a controlled variable. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit.		controlled variables • volume / mass, of, glass beads / dried peas • volume of, sodium hydroxide / water • temperature <u>Examiner's Comments</u> It is important for candidates to remember that Paper 1 includes a significant percentage of AO2 and AO3 assessment objectives which include the application of knowledge and understanding of scientific ideas in a practical context. Candidates found this question demanding and lower ability candidates demonstrated a poor understanding of the respirometer and how it would be used to measure respiration rates. A few candidates thought that the syringe was for pumping oxygen into the apparatus and some thought it was for measuring the gas released. In both cases candidates did not understand the crucial point that to measure oxygen uptake, the carbon dioxide released must be absorbed. The other important consideration in this experiment is that variables must be very carefully controlled as fluctuations in temperature and pressure alter the position of the dye in the manometer tube. In a double chambered respirometer such as this, one side should contain the organism and the other should contain the same volume of glass beads as a control. This compensates for any changes in pressure that would move the manometer fluid. The question asked how the apparatus could be used so candidates were expected to include reference to setting up, controlling variables and how measurements would be taken. Only the most able candidates were able to extend this into a discussion of how the RQ could be calculated.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					Exemplar 8 <i>Germinating peas respire aerobically from the breakdown of starch contained within their seeds. This means that if the germinating seeds are placed in one tube, atop a solution of $K(OH)$ to absorb the CO_2 produced, then the volume of oxygen produced would equal the displacement of the liquid in the capillary tube would equal the volume of oxygen uptake. Similarly in another identical apparatus set, the volume of CO_2 production can be calculated, if the $K(OH)$ is not present by calculating the difference in oxygen O_2 uptake CO_2 produced (positive liquid displacement) - (O_2 uptake), these two values can be used to calculate $RQ = \frac{V_{CO_2}}{V_{O_2}}$</i> [6] This answer has several features of a Level 2 response It describes the principles on which the respirometer works but makes no mention of the second tube. The answer refers to carrying out the experiment twice but makes little comment about controlling external variables such as temperature. Exemplar 9 <i>In the first tube we fill $NaOH$ at the bottom (as this absorbs CO_2) and we place the germinating peas in a cage just above the $NaOH$. As the germinating peas respire O_2 is taken in so the fluid in the manometer rises. In the other test tube we place $NaOH$ at the bottom and something to resemble the germinating peas (like glass beads which are the same weight). This makes RQ more valid as any changes in the movement of the manometer fluid not due to O_2 production vs. like pressure or temperature will be cancelled out.</i> This part answer has much more focus on the practical details of setting up the apparatus and incorporates the idea of the second test tube as a control. This moves the answer up to a level 3. Further detail on how the RQ would be calculated were included in the rest of the response.
			Total	12	
10			C	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
11	a	i	Mark first answer only. Any one from: <i>idea of continuous readings ✓</i> <i>idea of measured <i>in situ</i> / no need for taking samples out of experimental vessel ✓</i> greater degree of precision ✓ produces quantitative data ✓ objective / not subjective ✓ smaller % error ✓ results can be stored for later, use / processing ✓ time intervals can be varied / time intervals can be more frequent ✓ initial recording time / start time, can be delayed ✓	1 max	ALLOW apparatus remains permanently set up ALLOW no risk of further oxygen dissolving in the water as sample is processed / analysed DO NOT ALLOW greater degree of accuracy / improved accuracy DO NOT ALLOW reduces error unqualified OR doesn't make human error Examiner's Comments For Q3(a)(i), given the question states 'Give one...', only the first response is considered. Several candidates gave answers including the terms 'accurate' and 'precise' which was not credited due to a lack of clarity in the understanding of the terms. Centres should ensure candidates can distinguish between accuracy and precision as well as repeatability and validity.
		ii	Mark first two answers only: age (of fish) ✓ sex (of fish) ✓ mass (of fish) ✓ food, mass / quantity / type ✓ volume of / mineral ion content in / other organisms in, water ✓	2 max	DO NOT ALLOW species of fish as this is given in the question ALLOW size of fish Examiner's Comments Similarly for Q3(a)(ii) only the first 2 answers were considered due to the stem of the question. Many candidates referred to the species of the fish but this was already given in the question. Some candidates were vague in their answers referring to just the 'water used'.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	Any one from: to remove, any respiring / photosynthesising microbes / microbial growth (which would interfere with respirometer readings) ✓ <i>idea of</i> to reset the respirometer to zero ✓	1 max	Microbes must be stated as either respiring or photosynthesising to gain credit Examiner's Comments Q3(a)(iii) was a difficult question with only a few candidates gaining credit here for references to recalibrating the apparatus being the most common correct answer. Many candidates referred incorrectly to (unqualified) debris or differences in oxygen content of the water.
	b	i	there is no (significant) difference between the means (metabolic rate at different temperatures / at 10 °C & 16 °C) ✓	1	Examiner's Comments In Q3(b)(i) candidates were not confident in expressing the null hypothesis: many did not refer to both the 'significant' difference and the 'mean' in their answer. Several candidates incorrectly implied in their answer that the test was assessing the difference in the temperatures (rather than the mean metabolic rate).
		ii	68.89 ✓	1	ALLOW 68.9 Examiner's Comments Some candidates seemed to find Q3(b)(ii) difficult and did not appreciate they had to square the value.
		iii	12.285 ✓✓✓	3	ALLOW e.c.f. throughout from 3(b)(ii) for 3 marks <i>For calculations using 68.89 from Q3b(ii):</i> ALLOW 12.291 or 12.284 (as candidate has rounded before the final the step in either case) OR 12.2849 or 12.29 for 2 marks (wrong number of d.p.) ALLOW one mark for correct substitution $t = \frac{ 86.0 - 131.6 }{\sqrt{\frac{68.89}{10} + \frac{68.89}{10}}} \quad t = \frac{ 131.6 - 86.0 }{\sqrt{\frac{68.89}{10} + \frac{68.89}{10}}}$ ALLOW one mark for correct calculation (d.p. not critical here)

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					$\frac{45.6}{\sqrt{13.78}} \quad \text{OR} \quad \frac{45.6}{3.71}$ <i>For calculations using 68.9 from Q3b(ii):</i> ALLOW 12.284 OR ALLOW 12.291 or 12.284 (as candidate has rounded before the final the step in either case) OR 12.2840 or 12.28 for 2 marks (wrong number of d.p.) ALLOW one mark for correct substitution $t = \frac{ 86.0 - 131.6 }{\sqrt{\frac{68.9}{10} + \frac{68.9}{10}}} \quad t = \frac{ 131.6 - 86.0 }{\sqrt{\frac{68.9}{10} + \frac{68.9}{10}}}$ ALLOW one mark for correct calculation (d.p. not critical here) $\frac{45.6}{\sqrt{13.78}} \quad \text{OR} \quad \frac{45.6}{3.71}$ Examiner's Comments Many candidates gained full marks on Q3(b)(iii). However common mistakes were: not squaring the SD to give the variance in the formula; rounding too early; and not giving the answer to the specified three decimal places. As stated in the Maths Skills Handbook rounding should only occur in the final step of a multi-step calculation. There was evidence that some candidates did not understand the significance of the modulus symbol (noted in the question paper erratum) despite adding this to their written paper.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iv	Any three from: degrees of freedom is 18 ✓ the $t_{\text{calculated}}$ value is greater than the t_{critical} value at 5% ($p = 0.05$) / AW ✓ the $t_{\text{calculated}}$ value is (also) greater than the t_{critical} value at 1%/0.1% ($p = 0.01/0.0001$) / AW ✓ (so the researcher can) reject the null hypothesis ✓ the difference in (mean) metabolic rate is not due to chance / there is a significant difference in the mean metabolic rate ✓	3 max	ALLOW e.c.f. throughout from 3(b)(iii) for 3 marks ALLOW 2 marks maximum if the incorrect degrees of freedom have been used ALLOW correct reference to using 5% probability level ALLOW 12.291 is greater than 2.101 ALLOW 12.291 is greater than 2.878 OR 3.922 Examiner's Comments Responses to Q3(b)(iv) showed that few candidates could calculate the degrees of freedom correctly; in these cases error carried forward was applied to give a maximum of 2 marks. Candidates were not confident in their expressions referring to the $t_{\text{calculated}}$ and t_{critical} values. This is an area where candidates would benefit from more practice and training when completing PAG assessments. Candidates should appreciate that statistical tests do not prove/disprove a hypothesis. Likewise hypotheses are not correct/wrong/invalid; instead the terms accepted or rejected should be used appropriately.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c		Mark first two answers only. Any two from: <i>For laboratory investigation:</i> only one species of fish has been investigated ✓ only two temperatures investigated ✓ small sample size ✓ temperature affects the solubility of oxygen ✓ smaller volume of water, is less thermally stable / may vary in salinity (due to evaporation) ✓ correct reference to acclimatisation period ✓ aquatic plants affect oxygen concentration ✓ (fish) have different food / fed at regular intervals ✓ fish in oceans will be affected by wider fluctuations in temperatures (as lab is controlled) ✓ temperature fluctuations at the ocean surface will be greater than at depths ✓ (fish naturally) have different, feeding / habitat depths ✓ AVP ✓	2 max	ALLOW ORA throughout for marine fish <i>in situ</i> ALLOW aquatic plants affect oxygen availability e.g. idea that increasing sea surface temperatures may affect growth or populations of other marine organisms e.g. metabolic rates of fish in laboratory conditions may be affected by stress e.g. (as temperature increases) marine fish may migrate Examiner's Comments The most common answers for Q3(c) were either the small sample size (10 fish) or only one species of fish being investigated. Some candidates also referred to acclimatisation period. Again candidates should appreciate that they need to only provide 2 suggestions given the wording of the question and it will be the first 2 responses that are marked (not selected from an extensive list).
			Total	14	
12			D ✓	1	Examiner's Comments A straightforward question but most candidates did not recall the information needed for a correct response.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
13			A ✓	1	Examiner's Comments Only the candidates who understood that the reduced NAD is oxidised in anaerobic respiration could respond correctly, with option C being a very tempting distractor.
			Total	1	
14			B ✓	1	Examiner's Comments If candidates knew the equation for the respiratory quotient, this was an easy mark.
			Total	1	
15			C ✓	1	
			Total	1	
16			B ✓	1	
			Total	1	
17	a		1 NADH produced from glycolysis and Krebs ✓ 2 FADH produced from Krebs cycle ✓ 3 <i>idea that</i> NADH / FADH are co-enzymes for dehydrogenase enzymes ✓ 4 hydrogen (atom) passed to acceptor ✓ 5 hydrogen (atom) split into, proton / H ⁺ and electron /e- ✓ 6 electrons passed from carrier to carrier in inner(mitochondrial) membrane and then to oxygen ✓ 7 <i>idea that</i> carriers accepting electrons become reduced / carriers donating electrons become oxidised ✓	max 4	mp1 Reference to both glycolysis and Krebs needed mp 1 and 2 ALLOW 'reduced NAD' or 'reduced FAD' mp 4 and 5 DO NOT ALLOW hydrogen molecule / H ₂
	b	i	citrate ✓	1	
		ii	2 ✓	1	
		iii	malate / fumarate / succinate ✓	1	
		iv	carbon dioxide ✓	1	ALLOW CO ₂
			Total	8	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
18	a	i	carbon dioxide / CO ₂ ;	1	Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks Examiner's Comments This question looked at the respiratory activity of yeast cells in terms of aerobic and anaerobic respiration. Candidates were asked to identify one product of both aerobic and anaerobic respiration in yeast cells essential in beer production followed by one product of anaerobic respiration in yeast cells not produced in aerobic respiration. Candidates were then asked to outline how ATP is made in the cytoplasm from the metabolism of a three-carbon compound, and finally asked to name an anabolic process which takes place in the nucleus of both yeast and human cells. This question test mainly AO1. In part (i) the majority of candidates stated incorrect answers such as NAD, pyruvate, ethanol.
		ii	ethanol;	1	Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks Examiner's Comments Part (ii) was also incorrectly answered by many candidates, often the intermediates ethanal or lactate given as incorrect products.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	triose phosphate is, oxidised to pyruvate OR triose phosphate is dehydrogenated to produce pyruvate OR triose phosphate is converted to pyruvate (by a series of steps) producing / AW, reduced NAD; (during these steps) ATP is produced by substrate level phosphorylation;	2	ACCEPT NADH / NADH + H⁺ / NADH₂ / red NAD ACCEPT 'ATP produced directly' IGNORE ATP production unqualified Examiner's Comments A lot of candidates only gained one mark in this part, either for the conversion of triose phosphate into pyruvate or stating substrate level phosphorylation. Very few gained the full three marks. Many assumed the three-carbon compound was pyruvate either going into the Krebs cycle via the link reaction (cytoplasm was emboldened in the question) or forming ethanol or lactate with the regeneration of NAD. The impression was that the early stages of glycolysis, glucose to hexose biphosphate were clear, but from then on most candidates were not clear about the steps involved and moved directly to pyruvate, bypassing triose phosphate. Some candidates got a mark for formation of ATP through substrate level phosphorylation.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		i	QWC;	1	DO NOT CREDIT abbreviations for QWC mark DO NOT CREDIT if terms used in incorrect context e.g. 'pyruvate converted to triose phosphate' Use 3 terms from: triose phosphate dehydrogenated / ase oxidised substrate level phosphorylation Use a GREEN DOT to identify where a term has been credited. Insert a tick (✓) against the pencil icon if the QWC is awarded and a cross (x) if not.
		ii	DNA replication; RNA synthesis;	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks CREDIT transcription DO NOT CREDIT protein synthesis / translation
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
19		i	amino acid(s);	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks ALLOW iron IGNORE mineral unqualified (as given in question)
		ii	(Vitamin) B3 / nicotinamide;	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks
		iii	antioxidant(s) / vitamin C;	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks
		iv	(Vitamin) B9 / folate / folic acid;	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
20		i	<i>organelle</i> mitochondrion; <i>stage in aerobic respiration</i> oxidative phosphorylation;	2	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks ACCEPT mitochondria IGNORE ref to matrix or cristae IGNORE electron transport chain / chemiosmosis Examiner's Comments Most candidates seem to know that aerobic respiration takes place in the mitochondrion and that oxidative phosphorylation was the stage requiring oxygen instage requiring oxygen in (i). The most common error was referring to the electron transport chain. In part (ii) most candidates knew that RhEPO increases erythrocyte production enabling increased oxygen transport.
		ii	<i>idea that</i> RhEPO increases production of, erythrocytes / red blood cells / more haemoglobin; Increased oxygen, transport / carrying capacity / AW;	2	
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance																								
21	a		(substances) broken down / AW, (by respiratory enzymes) to release energy;	1	Look for idea of breakdown (in a metabolic pathway or named pathway) for energy release e.g. 'A substance broken down (in glycolysis or Krebs) to make ATP' = 1 mark DO NOT CREDIT reference to energy production Examiner's Comments This required an understanding of respiratory substrates as energy sources in terms of their RQ value. The measurement and variables that need to be taken into account in a named investigation was also tested. The reason for the breakdown of fats aerobically and the method used by athletes preparing for a sporting event also needed to be explained and described. Either the substance was broken down or energy was released, the two were often not linked. Many candidates also lost marks for stating that energy was produced as a consequence. The majority gaining marks gained them for stating that ATP was produced as a result of the breakdown.																								
	b		<table><tr><th>RQ value</th><th>Carbohydrate (%)</th><th>Fat (%)</th></tr><tr><td>0.70</td><td>0.0</td><td>100.0</td></tr><tr><td>0.75</td><td>14.7</td><td>85.3</td></tr><tr><td>0.80</td><td>31.7</td><td>68.3</td></tr><tr><td>0.85</td><td>48.8</td><td>51.2</td></tr><tr><td>0.90</td><td>65.9</td><td>34.1</td></tr><tr><td>0.95</td><td>82.9</td><td>17.1</td></tr><tr><td>1.00 ;</td><td>100.0 ;</td><td>0.0</td></tr></table>	RQ value	Carbohydrate (%)	Fat (%)	0.70	0.0	100.0	0.75	14.7	85.3	0.80	31.7	68.3	0.85	48.8	51.2	0.90	65.9	34.1	0.95	82.9	17.1	1.00 ;	100.0 ;	0.0	2	Award 1 mark if both figures are correct but have the wrong number of decimal places Examiner's Comments There were rarely incorrect figures given but a lot of candidates made errors with the decimal places therefore losing a mark.
RQ value	Carbohydrate (%)	Fat (%)																											
0.70	0.0	100.0																											
0.75	14.7	85.3																											
0.80	31.7	68.3																											
0.85	48.8	51.2																											
0.90	65.9	34.1																											
0.95	82.9	17.1																											
1.00 ;	100.0 ;	0.0																											
	c	i	spirometer;	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks																								

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	body mass / BMI; ref to health / smoking; duration / type of activity; ref to diet composition; AVP;;	2	e.g. fitness level OR resting heart rate / BMR / lethnicity / how often they exercise / muscle to fat ratio
		iii	(because) protein / amino acids, also used (in respiration);	1	Examiner's Comments A large number of Candidates gave respirometer in answer to (i). It needs stressing to candidates that respiration is not the same as breathing. Very few candidates suggested proteins as an additional possible substrate in (ii).
	d	i	<i>idea that</i> fats contain, large number of, hydrogen (atoms) / carbon hydrogen bonds; hydrogen and oxygen form water (in aerobic respiration); <i>idea that</i> metabolic pathway (for fat respiration) is in mitochondria; (mitochondria) use oxygen as terminal acceptor (for hydrogen ion / electron);	2	IGNORE DO NOT CREDIT H⁺

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	glycogen; carbo(hydrate)depletion / described (for around 10 days before event); (followed by) carbo(hydrate)loading / described (for around 3 days before event);	3	Correct spelling only CREDIT a description of diet high in protein and low in carbohydrate or foods which meet this description DO NOT CREDIT 'eat only protein' for 'carbodepletion' CREDIT a description referring to foods high in carbohydrate such as rice, pasta etc. Examiner's Comments Many candidates struggled and seemed to find part (i) hard and few seemed aware that fats contained a large number of hydrogen atoms, or the involvement of oxygen in the formation of water. Some of the more able candidates recognised the fact that oxygen was a terminal hydrogen ion acceptor even if they did not make the earlier links. Most candidates knew that glycogen was the carbohydrate storage compound in part (ii), and that carbohydrate depletion should be followed by carbohydrate loading within specified time limits. Unfortunately many candidates lost a marking point, as they did not distinguish between the two stages putting the whole procedure under the description of carbohydrate loading.
			Total	12	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
22	a		palisade / mesophyll;	1	CREDIT spongy mesophyll DO NOT CREDIT cell (s)) Examiner's Comments This required an understanding of the links between photosynthesis and respiration. Both in terms of both the reactants involved and their locations. The role of ATP in the release of energy for biological processes was also covered. Candidates generally found this question challenging. It tested AO1 throughout. The location of the chloroplast caused a lot of problems. Stroma was a commonly given incorrectly as though the candidate was locating it within the cell rather than the tissue. In many cases where the palisade layer was identified the candidate lost the mark for placing the chloroplast within a cell rather than tissue.
	b	i	X carbon dioxide AND Z oxygen;	1	Both responses correct for 1 mark. ACCEPT CO ₂ ACCEPT O ₂ IGNORE Do not penalise incorrect formatting (e.g. CO2, O2)
		ii	Y water;	1	ACCEPT H ₂ O Do not penalise incorrect formatting (H2O)
		iii	W adenosine diphosphate;	1	ACCEPT ADP Examiner's Comments Most candidates knew the gases, and got them the right way round, in part (i), but only the better candidates worked out that the substance was water in part (ii). ADP was answered correctly by almost all candidates.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c		letter C within stroma of the chloroplast; letter D within matrix of the mitochondrion;	2	Majority of the letter must be in the correct area Award a maximum of 1 mark if BOTH letters appear within the correct organelle but not in the correct region Examiner's Comments A large number of candidates placed the enzymes outside of both organelles, not appreciating the significance of the enzyme reactions and their locations.
	d		reduced NAD;	1	CREDIT NADH / NADH₂ / NADH and H⁺ / red NAD Examiner's Comments The common error was the suggestion of either NADP or NADPH.
	e		<i>idea that</i> it is an immediate energy source; small molecule; soluble; can be easily regenerated / can be re-phosphorylated; releases energy in, fixed / small, quantities;	1	DO NOT CREDIT 'reference to energy production' CREDIT <i>idea that</i> energy is released , when phosphate is removed / ATP is converted to ADP in a onestep process that it releases (around) 30.5 kJ Examiner's Comments Correct answers focused mainly on the regeneration of ATP or its use as an immediate energy source. Many candidates are still losing marks for stating energy is 'produced'.
			Total	8	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
23	a		anaerobic respiration;	1	Mark the first answer ACCEPT 'fermentation' in this context Examiner's Comments While many candidates did answer correctly some just stated 'glycolysis', again indicating a basic misconception as to what constitutes anaerobic respiration and what is glycolysis.
	b	i	lactic acid; electron transport chain, inhibited / damaged OR no / less aerobic respiration; anaerobic respiration product is lactate;	3	
		ii	<i>Idea that</i> methanol and ethanol are similar shapes; <i>Idea that</i> ethanol binds to active site of, enzyme / alcohol dehydrogenase; <i>idea that</i> less methanol converted to toxic product;	2 max	ACCEPT methanol has a similar structure to ethanol Mp2 ACCEPT ethanol acts as a competitive inhibitor OR ethanol forms an enzyme substrate complex

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	physiological / physical (dependency) (<i>no mark</i>) AND <i>idea that</i> more active/efficient enzyme / alcohol broken down, faster / AW;	1	DO NOT CREDIT 'psychological' even if the explanation of tolerance is correct. CREDIT reverse argument – less active / efficient enzyme / alcohol broken down, more slowly / AW Examiner's Comments In part (i) although lactic acid was given as an answer, many candidates ignored the instruction to use the figure and failed to spot the damage to the electron transport chain. Part (ii) discriminated well with good candidates using their knowledge of complementary shape and active sites. However, weaker candidates confused which compound would have the active site and what compounds would bind and it was not uncommon to see references to methanol having an active site. Many correctly identified the form of dependency in part (iii) but then gave a general description rather than linking it back to the alleles and the effect on alcohol dehydrogenase activity.
			Total	7	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
24	a		molecule, broken down / hydrolysed (during respiration); energy released / ATP produced;	2 Enter text here.	IGNORE substance CREDIT compound / named molecule (e.g. glucose, lipids proteins) DO NOT CREDIT energy / ATP energy, produced Examiner's Comments This focused on respiratory biochemistry in terms of initially defining a respiratory substrate, followed by identifying participant molecules and structures involved in oxidative phosphorylation. Candidates were also asked to identify a molecule and explain why anaerobic respiration is less efficient than aerobic respiration in yeast based on the molecular structures of ethanol, carbon dioxide and water. Candidates were told that the energy content of a molecule is based on the number of C-H bonds it contains. The question tested both AO1 and AO2. Candidates generally lost the first mark for references to substance or substrate rather than molecule or compound. A few candidates still lost marks for stating that energy was produced. Many candidates correctly identified possible respiratory substrates as glucose, lipid or proteins.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	oxygen;	1	CREDIT correct formula (O^2) Examiner's Comments This focused on respiratory biochemistry in terms of initially defining a respiratory substrate, followed by identifying participant molecules and structures involved in oxidative phosphorylation. Candidates were also asked to identify a molecule and explain why anaerobic respiration is less efficient than aerobic respiration in yeast based on the molecular structures of ethanol, carbon dioxide and water. Candidates were told that the energy content of a molecule is based on the number of C-H bonds it contains. The question tested both AO1 and AO2. Oxygen was correctly identified as the final electron acceptor in (i) by the majority of candidates. The inner mitochondrial membrane was also correctly identified as the location of the electron transport chain in (ii) by most candidates. In (iii) most candidates identified ATP synthase correctly as the membrane bound protein involved in the phosphorylation of ADP. The most common mistake was inorganic phosphate.
		ii	inner mitochondrial membrane;	1	CREDIT cristae
		iii	ATP synthase;	1	CREDIT ATP synthetase ALLOW phonetic spelling

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c	i	ethanol;	1	IGNORE alcohol Examiner's Comments This focused on respiratory biochemistry in terms of initially defining a respiratory substrate, followed by identifying participant molecules and structures involved in oxidative phosphorylation. Candidates were also asked to identify a molecule and explain why anaerobic respiration is less efficient than aerobic respiration in yeast based on the molecular structures of ethanol, carbon dioxide and water. Candidates were told that the energy content of a molecule is based on the number of C-H bonds it contains. The question tested both AO1 and AO2. Common errors in (i) were ethanal, lactic acid and pyruvate. Anaerobic oxidation was considered by many candidates to be less efficient due to less ATP produced in (ii), based on their theoretical knowledge of glycolysis and oxidative phosphorylation, rather than on the information provided. More perceptive candidates did note that there were C-H bonds present in ethanol compared to none in carbon dioxide and water. Only a very small number of candidates mentioned that more or less C-H are broken.
		ii		Max 3	CREDIT correct formulae throughout IGNORE ref. to lactic acid
		ii	X (and Y) / ethanol (and carbon dioxide), product of anaerobic respiration; Y and Z / carbon dioxide and water, products of aerobic respiration; no C - H bonds present in, Y and Z / carbon dioxide and water OR		ORA for anaerobic respiration ORA for anaerobic respiration DO NOT CREDIT energy produced
		ii	C – H bonds present in X / ethanol; (so) more C - H bonds broken during aerobic respiration; more ATP produced / energy released, in aerobic respiration;		

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	9	
25	a		anaerobic respiration	1	ALLOW fermentation Some candidates may recognise that a small volume of dissolved oxygen will be introduced during the bottling process and that the yeast will use this oxygen to start with and then change to anaerobic respiration.
	b		<i>marks only awarded for comparative statements</i> • haemocytometer is simpler / cheaper equipment ORA (1) • haemocytometer requires less training for operative ORA (1) • repeats easier to carry out to find mean / average with haemocytometer ORA (1) • haemocytometer takes a shorter time to prepare sample for counting ORA (1) • haemocytometer any mistakes in counting magnified many times ORA (1) • haemocytometer each count must be completed manually / no way to speed up counting and flow cytometer once prepared is automated process (1) • haemocytometer can differentiate between living and dead cells once stained and flow cytometer cannot differentiate between living and dead cells / cell count would be too high because dead cells counted (1)	3	IGNORE references to hazards / safety as both methylene blue and fluorescent stains have similar hazards and risk assessments ALLOW gives a large standard error (or S.E.M.) 2 ALLOW flow cytometer counts dead cells / doesn't only count living cells unlike haemocytometer when cells stained
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
26	a	i	Z: crista(e) (1) large surface area, for oxidative phosphorylation / ATP production (1)	2	
		ii	establish, H^+ / proton gradient, across inner membrane	1	
	b	i	H^+ / electrochemical gradient / proton motive force, lost (1) ATP synthase stops / ATP not produced / uncoupling of electron transport from ATP synthesis (1)	2	
		ii	less / loss of, cytochrome C (from intermembrane space) (1) reduction in / loss of, electron transfer / shuttling between, complexes / carriers (1)	2	DO NOT ALLOW ref to moving of cytochrome C without idea of loss / deficiency in intermembrane space
		iii	(reduced NAD / reduced FAD) oxidised on inner membrane / inner membrane not affected (1)	1	
			Total	8	
27		i	any 3 from: (active transport) into root hairs (1) apoplast / symplast pathway (1) through epidermis / cortex layers (1) via xylem vessel to (root) nodule (1)	3	
		ii	Krebs cycle	1	ALLOW TCA cycle / citric acid cycle
			Total	4	
28			C	1	
			Total	1	
29			A	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
30	a	i	<i>Pathway:</i> Krebs cycle / link reaction <i>Location:</i> matrix, of mitochondria	2	DO NOT ALLOW 'matrix' unqualified
		ii	Pathways A and B substrate level phosphorylation	2	
	b	i	(limited blood supply) reduced oxygen available ref to, increased / more, anaerobic respiration	2	IGNORE reference to glucose DO NOT ALLOW anaerobic respiration alone – need the idea of more anaerobic respiration
		ii	<i>idea that</i> (muscle) cell surface / plasma, membrane is, damaged / AW <i>idea that</i> LDH, diffuses, out of cytoplasm / into blood plasma	2	
			Total	8	
31			D	1	
			Total	1	
32			A	1	
			Total	1	
33			A	1	
			Total	1	