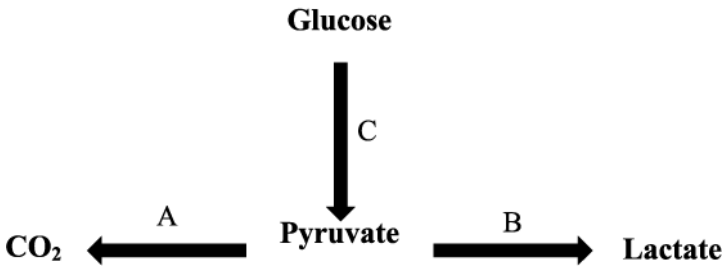
1(a). Cells need to maintain a supply of ATP in order to function properly. A number of metabolic pathways in the cell are linked to the formation of ATP.

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

Fig. 33.1



(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]

2.

(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]

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

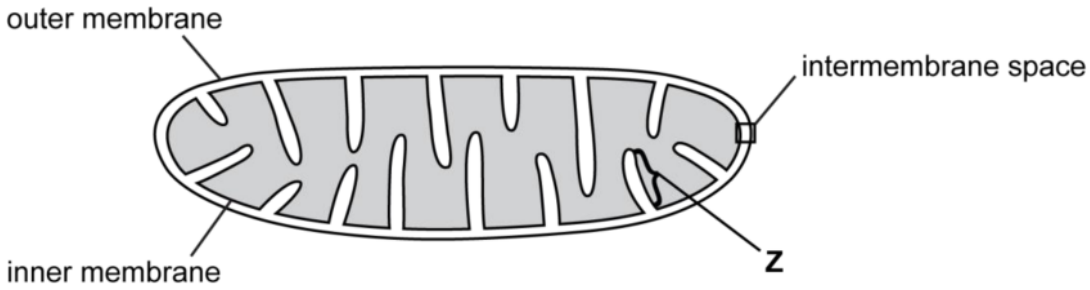


Fig. 36.1

(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]

4(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 (CO_2) gas to make it fizzy.
- Live yeast remaining in the sealed bottles of cider produce this CO_2.

Name the process by which live yeast cells make CO_2 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]

5(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.

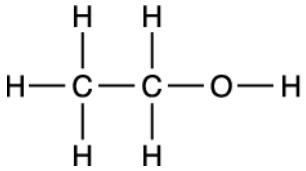
---

[1]

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

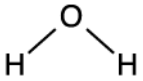
The figure shows the molecular structures of three of the possible products of respiration in yeast.

Molecule **X**



Molecule **Y**

Molecule **Z**



(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 $C_6H_{12}O_6$ (glucose) in yeast.

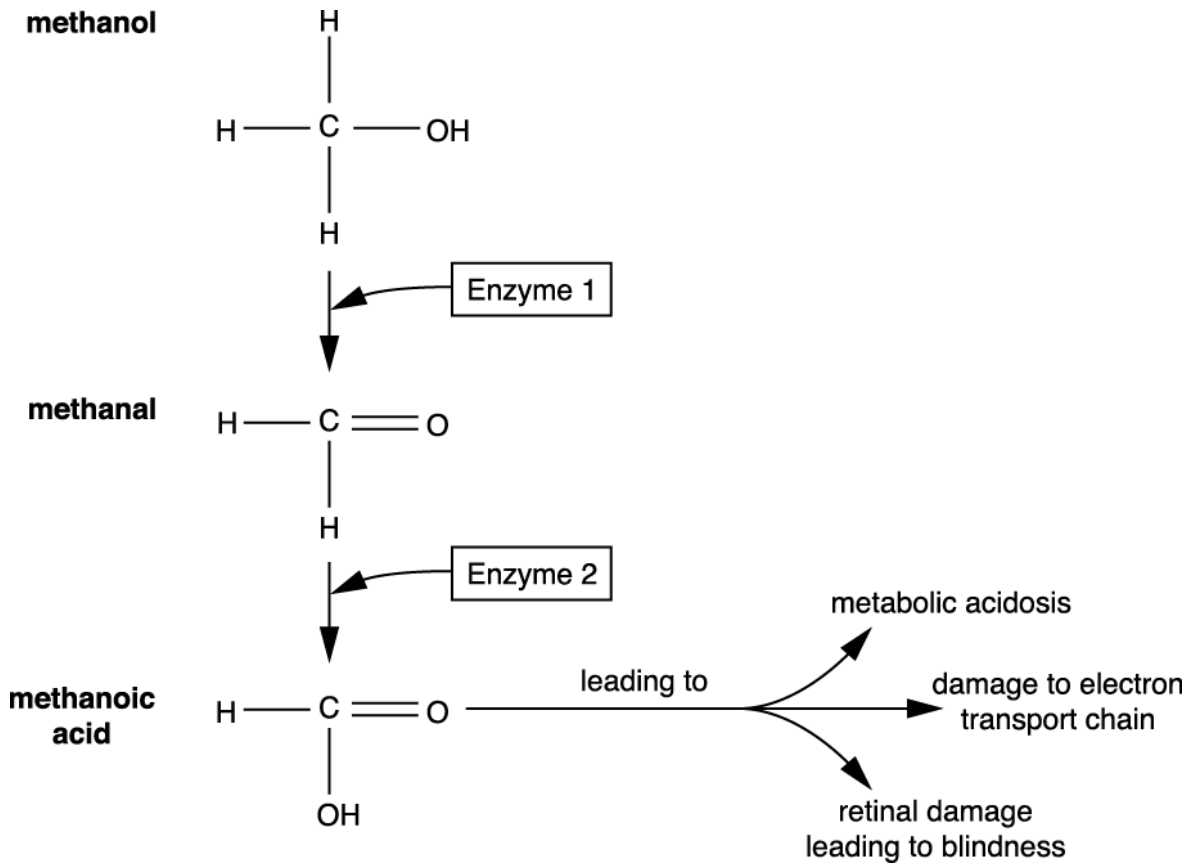
---

[3]

6. 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?

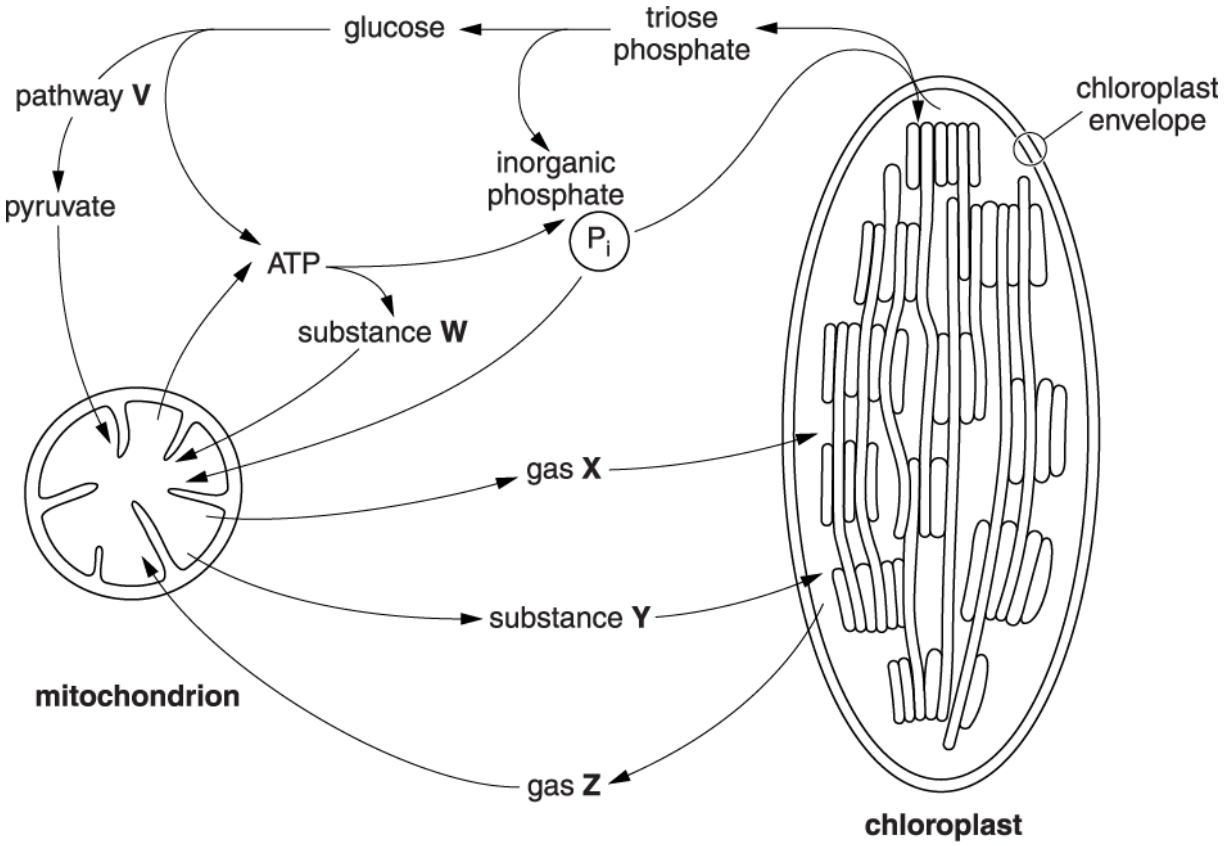
Explain your answer.

[1]

7(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]

8(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]

9. Some of the carbohydrates found in dairy products are broken down in the digestive system to form glucose. Glucose is then absorbed into the bloodstream.

(i) Describe how glucose is transported in the bloodstream.

---

[1]

(ii) Glucose is used by cells as a respiratory substrate.

What makes glucose a good respiratory substrate?

---

[2]

The concentration of glucose in the blood varies. People with the condition diabetes mellitus need to measure the concentration of glucose in their blood regularly.

Fig. 1.3 shows a blood glucose meter which can be used to measure the concentration of glucose in the blood.

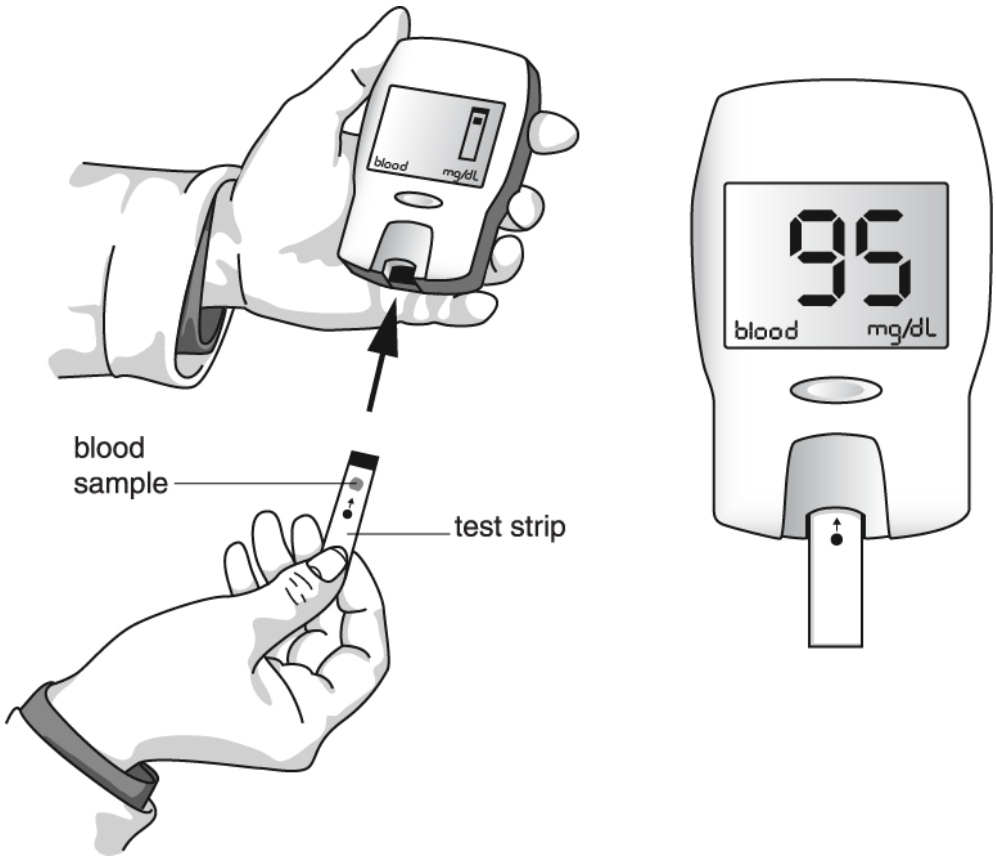


Fig. 1.3

10. 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]**

11(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]

12(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.

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

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]**

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a	i	*Pathway*: Krebs cycle / link reaction *Location*: 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	*idea that* (muscle) cell surface / plasma, membrane is, damaged / AW *idea that* LDH, diffuses, out of cytoplasm / into blood plasma	2	
			Total	8	
2		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	
3	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	

Question			Answer/Indicative content	Marks	Guidance
			Total	8	

Question			Answer/Indicative content	Marks	Guidance
4	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		*marks only awarded for **comparative** statements* • 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**	

Question			Answer/Indicative content	Marks	Guidance
5	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.

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

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
		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		IGNORE ref. to lactic acid
		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;		ORA for anaerobic respiration ORA for anaerobic respiration DO NOT CREDIT energy produced

Question			Answer/Indicative content	Marks	Guidance
			Total	9	
6		i	lactic acid; electron transport chain, inhibited / damaged OR no / less aerobic respiration; anaerobic respiration product is lactate;	3	
		ii	*Idea that* methanol and ethanol are similar shapes; *Idea that* ethanol binds to active site of, enzyme / alcohol dehydrogenase; *idea that* 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
		iii	physiological / physical (dependency) (*no mark*) AND *idea that* 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	6	

Question			Answer/Indicative content	Marks	Guidance
7	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 IGNOREDo not penalise incorrect formatting (e.g. CO2, O2)
		ii	Y water;	1	ACCEPT H_2O 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.

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 / $NADH_2$ / NADH and H^+ / red NAD **Examiner's Comments** The common error was the suggestion of either NADP or NADPH.
	e		*idea that* 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** *idea that* 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	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>8</td><td>a</td><td></td><td>(substances) broken down / AW, (by respiratory enzymes) to release energy;</td><td>1</td><td>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.</td></tr>
<tr><td></td><td>b</td><td></td><td><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></td><td>2</td><td>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.</td></tr>
<tr><td></td><td>c</td><td>i</td><td>spirometer;</td><td>1</td><td>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</td></tr>
</table>

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	*idea that* fats contain, large number of, hydrogen (atoms) / carbon hydrogen bonds; hydrogen and oxygen form water (in aerobic respiration); *idea that* metabolic pathway (for fat respiration) is in mitochondria; (mitochondria) use oxygen as terminal acceptor (for hydrogen ion / electron);	2	IGNORE DO NOT CREDIT H^+

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	

Question			Answer/Indicative content	Marks	Guidance
9		i	dissolved in plasma OR in solution in plasma;	1	ACCEPT in plasma because (glucose) is polar Examiner's Comments This question incorporated a range of assessment objectives (AOs 1, 2 and 3) with a biochemical thread running throughout. Some questions were in the context of the procedure for testing for blood glucose. (i) was generally well-answered with candidates understanding the need to state that glucose was transported 'dissolved' in the plasma rather than just stating 'in the plasma'. However, in (ii), some candidates gave answers which referred to glycogen rather than glucose by offering responses which referred to the fact that glucose was a good respiratory substrate because it could be converted to glycogen for storage. Some candidates are still incorrectly stating that energy is 'produced', 'made' or 'created' which could not be credited.
		ii	*idea that* (glucose) is easily broken down (by cells); (to) produce ATP / release energy;	2	
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
10		i	*organelle* mitochondrion; *stage in aerobic respiration* 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	*idea that* RhEPO increases production of, erythrocytes / red blood cells / more haemoglobin; Increased oxygen, transport / carrying capacity / AW;	2	
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
11	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.

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^+ / $NADH_2$ / 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 bisphosphate 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.

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	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>12</td><td>a</td><td></td><td>
<table>
<tr><th>Dehydrogenation</th><th>Krebs cycle</th><th>mitochondrial matrix</th></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>
</td><td>1</td><td></td></tr>
<tr><td></td><td>b</td><td>i</td><td>$C_{16}H_{32}O_2$ + 23 O_2 → 16 CO_2 + 16 H_2O ✓</td><td>1</td><td>ALLOW multiples of the correct balanced numbers.
For example, 2 $C_{16}H_{32}O_2$ + 46 O_2 → 32 CO_2 + 32 H_2O</td></tr>
<tr><td></td><td></td><td>ii</td><td>0.70 ✓✓</td><td>2</td><td>16/23 = 1 mark
0.7 = 1 mark
ALLOW ECF from (i)</td></tr>
<tr><td></td><td></td><td>iii</td><td>conversion of carbohydrates to lipids ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td></td></tr>
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