Model Answers: Hard

1a

(a) Processes **A** and **B** represent:

- **A** = substrate-linked phosphorylation
  AND
- **B** = chemiosmosis; [1 mark]

[Total: 1 mark]

1b

(b) Differences between substrate-linked phosphorylation and chemiosmosis include:

Any **three** of the following:

- Substrate-linked phosphorylation/(process) **A** transfers a phosphate from a substrate molecule directly to ADP (to form ATP) **WHILE** chemiosmosis/(process) **B** uses an electron transport chain to establish a proton concentration gradient for ATP synthase to phosphorylate ADP; [1 mark]
- Energy is provided directly by another chemical reaction for substrate-linked phosphorylation/(process) **A WHILE** chemiosmosis/(process) **B** uses energy released by the movement of hydrogen ions/protons moving down a concentration gradient; [1 mark]
- Substrate-linked phosphorylation/(process) **A** occurs in the cytoplasm of cells / matrix of mitochondria **WHILE** chemiosmosis/(process) **B** occur across the inner mitochondrial membrane / thylakoid membrane of chloroplasts; [1 mark]
- A small amount of ATP / 4-6 per glucose molecule is produced during substrate-linked phosphorylation/(process) **A WHILE** a large amount of ATP / 32-34 per glucose molecule is produced during chemiosmosis/(process) **B**; [1 mark]

[Total: 3 marks]

It is important to take note of the different ways in which ATP can be generated. Remember that for questions asking you to contrast processes, you need to discuss the most important differences between them. Think of how and where they occur and also what is produced during each process to guide you during the formulation of an answer.

1c

(c) The reason chemiosmosis cannot occur in the absence of oxygen is because…

Any **three** of the following:

- Chemiosmosis/(process) **B** requires a proton gradient produced by the electron transport chain; [1 mark]
- The electron transport chain cannot occur **OR** no electron flow can occur without oxygen; [1 mark]
- NAD cannot reform **OR** no oxidation of NADH can occur (without oxygen); [1 mark]
- Oxygen is the final electron/proton/hydrogen ion acceptor (in the electron transport chain); [1 mark]

[Total: 3 marks]

Without oxygen the electron transport chain cannot occur, as oxygen acts as the final electron acceptor. Without oxygen, these electrons have nowhere to go. In the absence of oxygen the coenzymes NADH and $FADH_2$ cannot be oxidised to reform NAD and FAD, therefore leaving them unable to transport hydrogen ions.

1d

d) The reasons why such a large mass of ATP is produced would be...

- ATP cannot be stored (in the body) **OR** it is an immediate energy source; [1 mark]
- Only a small amount of energy is released by ATP at any time (therefore requiring large amounts of ATP to meet energy demands); [1 mark]

[Total: 2 marks]

2a

(a) The difference in the amount of energy released by different respiratory substrates can be explained as follows:

Any **six** of the following:

- Lipids releases the most/highest amount of energy per gram **OR** carbohydrates releases the least amount of energy; [1 mark]
- Fatty acids/lipids contain long hydrocarbon chains which releases a large amount of hydrogen atoms when (lipid is) broken down; [1 mark]
- (These hydrogen atoms are) transported by NAD and FAD to mitochondrial (inner) membrane; [1 mark]
- (The large number of hydrogen atoms) split into a large number of protons and electrons; [1 mark]
- More electrons are moved down electron transport chain, releasing more energy to pump protons into intermembrane space; [1 mark]
- This creates a greater proton/chemiosmotic gradient; [1 mark]
- (Which) produces more ATP via chemiosmosis; [1 mark]

[Total: 6 marks]

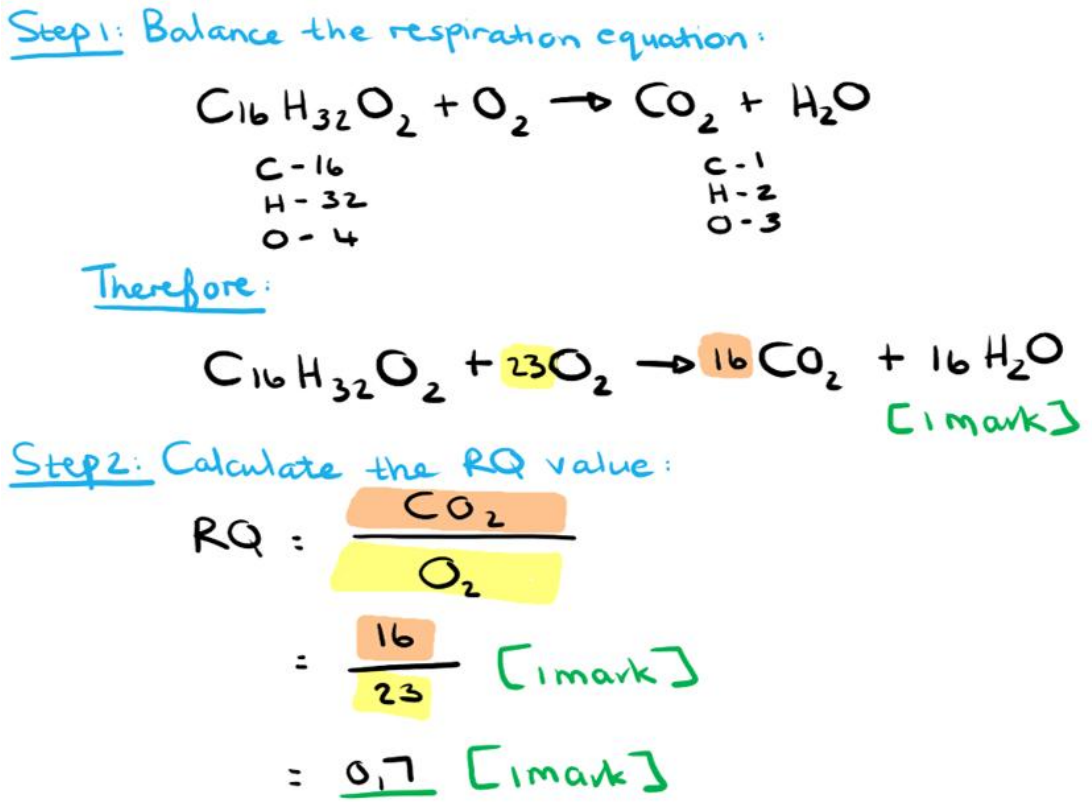
The amount of energy released by the respiratory substrates are linked to the hydrogen content of the molecules. The higher the hydrogen content, the greater the proton gradient created across the inner mitochondrial membrane and the more ATP can be synthesised as a result. Lipids have the highest hydrogen content from the respiratory substrates in Table 4.1, due to the long hydrocarbon chains that make up the fatty acids. When they are broken down during respiration, they release the hydrogen atoms which ultimately generates the greatest amount of ATP.

2b

b) Calculating the RQ value of palmitic acid:

- Balance the equation: $C_{16}H_{32}O_2 + 23O_2 \rightarrow 16CO_2 + 16H_2O$; [1 mark]
- 16 ÷ 23; [1 mark]
- 0.7; [1 mark]

[Total: 3 marks]



2c

(c) The difference in RQ values for palmitic acid and glucose is due to the following:

Any **two** of the following:

- Palmitic acid has a higher hydrogen content than glucose **OR** glucose has a lower hydrogen content than palmitic acid; [1 mark]
- (Therefore) the breakdown of palmitic acid produces more ATP (than glucose) **OR** breakdown of glucose produces less ATP; [1 mark]
- (This means) more oxygen is required to break palmitic acid down (in the last step of oxidative phosphorylation) **OR** less oxygen is required to break glucose down; [1 mark]

[Total: 2 marks]

From part (c) it was calculated that palmitic acid has a lower RQ value than glucose. The reason for this is that it requires more oxygen to break palmitic acid down due to its high hydrogen content. The higher the amount of oxygen used, the lower the RQ value for that substrate will be.

3a

(a)

(i) The volumes of potassium hydroxide (KOH) are different in tubes 1 and 2 because...

- The mung bean seeds take up space in tube 2; [1 mark]
- So more KOH in tube 1 keeps the air volume the same in both tubes; [1 mark]

(ii) An experimental modification to allow the volumes of potassium hydroxide (KOH) to be kept the same in tubes 1 and 2 is:

- To use inert material in tube 1 of the same overall volume as the mungbean seeds; [1 mark]

Accept named inert material such as glass beads, gravel, for marking point 2

[Total: 3 marks]

3b

(b) The distance, to the nearest mm, that the liquid in the U-tube moved in the 20 minute period of their investigation is calculated as follows:

- Convert the rate to volume of water that moved (13.33 mm^3); [1 mark]
- Use the equation $\pi r^2 h$ to calculate h; [1 mark]
- h = 17mm; [1 mark]

16.97 / 16.9 mm; [2 marks max.]

Allow full marks for the correct answer with no working shown

[Total: 3 marks]

You are expected to recall and use the volume of a cylinder equation, where r is the radius and h is the distance or height of the cylinder; applied to this question h is the distance travelled.

The experimenters used 10g of active mungbean seeds and recorded their respiration over a 20-minute period.

They calculated a rate of movement of the liquid in the U-tube of $4mm^3\ hr^{-1}\ g^{-1}$.

Calculate how far the liquid in the U-tube moved in the 20-minute period of their investigation.

Step 1: multiply the rate by 10 because they used 10g of seeds: $4 \times 10 = 40\ mm^3\ hr^{-1}\ 10g^{-1}$

Step 2: divide the rate by 3 because there are 3 lots of 20 minutes in one hour

$40 \div 3 = 13.3\ mm^3\ 20min^{-1}\ 10g^{-1}$

This is the volume of the capillary tube that the coloured water moved through during the experiment. [1 mark]

Step 3: use the volume of a cylinder $\pi r^2 h$

$13.3\ mm^3 = \pi r^2 h$ [1 mark]

(we know the radius is ½ mm from the question)

$13.3 = \pi \times 0.5^2 h$ (rearrange)

$h = \frac{13.3}{\pi \times 0.5^2} = 16.97 = 17\ mm$ [1 mark]

3c

(c) The respiratory quotient (RQ) of the mungbean seeds is calculated as follows:

- Rate of 4 equates to the rate of oxygen consumption **AND** rate of -0.72 equates to the net rate of CO_2 production; [1 mark]

- ; [1 mark]

[Total: 2 marks]

The scientists run a respirometer with KOH, CO_2 gets absorbed by the KOH and the coloured liquid moves up. Then they run the respirometer without KOH, and the level of coloured liquid moves up again (tube 2 side), though only slightly. This means that less CO_2 is produced than O_2 is consumed. An RQ of <1 is found when less CO_2 is liberated than the volume of O_2 consumed. This is why the coloured liquid moves **up** slightly on the side of tube 2 (and down on the side of tube 1). This suggests that we should **subtract** the rate of 0.72 $mm^3\ hr^{-1}\ g^{-1}$ from the rate of 4 $mm^3\ hr^{-1}\ g^{-1}$ in order to come up with an RQ value of <1.

3d

(d) The value of RQ from part (c) suggest that the mung beans were respiring, as their main food group(s)...

- Lipids **AND** carbohydrates; [1 mark]
- Carbohydrates would have been closer to 1, lipids closer to 0.7, so this value is in between; [1 mark]

OR

- Proteins (only); [1 mark]
- Proteins' RQs tend to be around 0.8; [1 mark]

[Total: 2 marks]

Don't forget to explain your answer here, as requested by the command words in the question.