Model Answers: Medium

1a

a) The apparatus was left like this for 12 minutes because...

Any **two** of the following:

- It allows for an equilibrium to be reached **OR** for the apparatus to equilibrate; [1 mark]
- Allows for expansion / pressure change within the apparatus; [1 mark]
- Allows the respiration rate of seeds to stabilise; [1 mark]

[Total: 2 marks]

You would not get a mark for saying it allows time for the seeds to **acclimatise**. This is more relevant to experiments where the temperature is being manipulated.

1b

b) The teacher did not use a temperature of 35˚C because...

- The optimum temperature / temperature for normal growth of seeds is roughly 25°C; [1 mark]
- A higher temperature would cause the enzymes involved in respiration to become denatured; [1 mark]

[Total: 2 marks]

If the enzymes for respiration become denatured by high temperatures then the rate of respiration will dramatically decrease.

1c

c) The coloured liquid in the U-tube will move towards...

- Tube 2; [1 mark]
- Because oxygen is taken up / used by seeds in tube 2; [1 mark]
- CO_2 given out by the seeds is absorbed by the KOH solution; [1 mark]
- So the volume/pressure (in tube 2) decreases; [1 mark]

[Total: 4 marks]

As **tube 2** contains the seeds it will be the tube that is **using up oxygen** and producing carbon dioxide. The presence of **KOH solution** means the **carbon dioxide produced** by the seeds **does not replace the oxygen** the seeds have consumed in terms of volume/pressure.

1d

d) The rate of oxygen consumption by the seeds was...

- $0.85 - 0.53 = 0.32\ cm^3$ (in 12 minutes)
- $0.32 \times 5 = 1.6\ cm^3$ (in 60 minutes); [1 mark]
- $1.6 \div 1.8$
- $0.89\ cm^3\ g^{-1}\ hour^{-1}$; [1 mark]

Full marks awarded for the correct answer only.

[Total: 2 marks]

① Work out oxygen consumed in experiment
Syringe reading at 0 minutes = $0.85\ cm^3$
Syringe reading at 12 minutes = $0.53\ cm^3$
$0.85 - 0.53 = 0.32\ cm^3$ oxygen consumed
② Work out oxygen consumed in 60 minutes
$60 \div 12 = 5$
$5 \times 0.32 = 1.6\ cm^3\ hour^{-1}$ [1 mark]
③ Divide by weight (1.8g)
$1.6 \div 1.8 = 0.89\ cm^3\ g^{-1}\ hour^{-1}$ [1 mark]
The numbers from step ① of this calculation were taken from Table 1.1

1e

e) ATP is formed in the mitochondria by...
Any **six** of the following:

- The Krebs cycle / link reaction produces reduced coenzyme/NAD/FAD; [1 mark]
- Hydrogen atoms are donated by reduced NAD and FAD; [1 mark]
- Hydrogen atoms split into protons and electrons; [1 mark]
- The high-energy electrons release energy as they move through the electron transport chain; [1 mark]
- Which is used to transport protons across the inner mitochondrial membrane to form a concentration gradient between the intermembrane space and the matrix; [1 mark]
- The protons return to the matrix via facilitated diffusion through the channel protein ATP synthase; [1 mark]
- The movement of protons down their concentration gradient provides energy for ATP synthesis; [1 mark]
- ATP forms from ADP + Pi (in oxidative phosphorylation); [1 mark]
- Oxygen combines with protons and electrons at the end of the electron transport chain to form water **OR** oxygen is the final electron acceptor; [1 mark]

[Total: 6 marks]

There are a lot of possible marks up for grabs here. For a 6 marker question like this, it is vital that you include as much relevant detail as you can remember to ensure you get the most marks possible.

2a

a) Individuals with mitochondrial disease can only endure intense exercise for a short period of time because...

- (Mitochondria) is the site of aerobic respiration; [1 mark]
- Mitochondria produce ATP / release energy that is required for muscles (to contract during exercise); [1 mark]

[Total: 2 marks]

You will not get the second mark for this question if you say that mitochondria **make/produce** energy as this is incorrect. Energy cannot be produced or made, it can only be transferred or released into different forms e.g. from glucose to ATP.

2b

b) The parts of the mitochondrion labelled **A** and **B** are as follows...

- **A** = The matrix **AND B** = Intermembrane space **OR** crista(e); [1 mark]

[Total: 1 mark]

For your exam, you will be expected to know the structure of a mitochondrion including: outer membrane, intermembrane space, inner membrane, matrix and cristae.

2c

c) Mitochondria that lack cristae....

- Would produce less ATP; [1 mark]
- (Because) there is a smaller amount of internal mitochondrial membrane / smaller surface area of the membrane/cristae; [1 mark]
- Meaning there are fewer electron transport chains (for oxidative phosphorylation);
  [1 mark]

[Total: 3 marks]

Remember that the electron transport chain spans the inner membrane. You are used to seeing diagrams of single transport chains in textbooks, in reality, there are many of them distributed throughout the cristae.

2d

d) The net production of ATP and reduced NAD is...

- 2 molecules of ATP **AND** 2 molecules of reduced NAD / NADH; [1 mark]

[Total: 1 mark]

Four molecules of ATP are produced during glycolysis, but two are used as part of the reaction so the overall gain is two.

3a

a) The role of the coenzymes in the synthesis of ATP...

- NAD/FAD are reduced by the addition of hydrogen **OR** hydrogen attaches to NAD/FAD; [1 mark]
- (The coenzymes) transfer hydrogen ions to the inner mitochondrial membrane; [1 mark]
- Which is the site of the electron transport chain and oxidative phosphorylation (for the production of ATP); [1 mark]

[Total: 3 marks]

Remember hydrogen is made up of a hydrogen ion (proton) and an electron.

3b

b) The link reaction is described as an oxidative decarboxylation reaction because...

- Pyruvate is decarboxylated / carbon dioxide is removed from pyruvate; [1 mark]
- Pyruvate is oxidised by the removal of hydrogen / dehydrogenation of pyruvate occurs; [1 mark]

[Total: 2 marks]

Decarboxylation is the removal of carbon and oxidation can be the removal of hydrogen, loss of elections, or addition of oxygen.

3c

c) The number of carbon atoms at each stage is...

Two marks in total for all four stages

- **A** = 2C compound
- **B** = 6C compound
- **C** = 5C compound
- **D** = 4C compound

*If only two or three stages are correct then award **one** mark only*

[Total: 2 marks]

3d

d) The number of reduced NAD and FAD molecules produced at each stage are...

One mark for each correct column:

Stage of respiration	Number of NAD molecules	Number of FAD molecules
Glycolysis	2	0
Link reaction	2	0
Krebs cycle	6	2
Oxidative Phosphorylation	0	0
	[1 mark]	[1 mark]

[Total: 2 marks]

Note that the question asks for the number of molecules **per glucose**. Because glucose is split into two during glycolysis, the remaining stages of respiration **occur twice** for each molecule of glucose entering respiration.

4a

a) Table 1 should be completed as follows...

description	number
location of ATP synthase	7; [1 mark]
transports hydrogen atoms	4; [1 mark]
nucleotide with a purine base	9 **OR** 4; [1 mark]
location of substrate-linked phosphorylation	2; [1 mark]
enters the Krebs cycle	10; [1 mark]
produced by oxidation of triose phosphate	3; [1 mark]

[Total: 6 marks]

4b

b) The respiration of glucose in anaerobic conditions produces less ATP than in aerobic conditions because...

Any **five** of the following:

- (Anaerobic condition) only involves glycolysis / conversion of glucose into pyruvate; [1 mark]
- (Glycolysis only) produces 2 molecules of ATP (net gain per glucose molecule); [1 mark]
- (ATP only comes from) substrate-linked phosphorylation; [1 mark]
- Pyruvate is converted to lactate; [1 mark]
- Lactate is energy-rich; [1 mark]
- Oxygen is not available as the final electron acceptor; [1 mark]
- Electron transport chain / chemiosmosis / oxidative phosphorylation does not occur; [1 mark]
- (During aerobic respiration) most ATP is produced in the electron transport chain / chemiosmosis / oxidative phosphorylation; [1 mark]
- No (ATP is produced during) substrate-linked phosphorylation in the Krebs cycle (as the Krebs cycle does not occur); [1 mark]

***Accept** substrate-level phosphorylation for marking points 3 and 9.*

[Total: 5 marks]

5a

a) i) The precise location of glycolysis in the cell is the...

- Cytoplasm; [1 mark]

a) ii) In Fig. 6.1 there is...

- Phosphorylation = steps 1 **AND** 3; [1 mark]
- Oxidation = step 5; [1 mark]
- ATP is made in step 5 by = substrate-linked phosphorylation; [1 mark]

***Accept** substrate-level phosphorylation for marking point 3.*

*The **list rule** should be applied here.*

[Total: 4 marks]

The **list rule** refers to the idea that in any question that requires a list of answers, **extra answers that are incorrect** will **cancel out marks** that might otherwise have been awarded for a correct answer, e.g. for marking point 1 if you write "1, 3, and 4" this will score 0 marks as 4 is an additional answer and is incorrect.

In general it is sensible to avoid giving additional answers if you are at all unsure (though in this particular question it is difficult to apply this rule as the question hasn't told you how many answers are required for each mark!).

5b

b) The glucose and oxygen requirements of these cancer cells differ from normal cells by...

Any **two** of the following:

- Cancer cells need/use more glucose; [1 mark]
- Cancer cells need/use less oxygen; [1 mark]
- Cancer cells get little energy / a small amount of ATP per glucose (molecule); [1 mark]

[Total: 2 marks]

Remember to read the question stem carefully here. The question clearly states that cancer cells obtain most of their ATP from glycolysis, even if oxygen is available, so references to increased aerobic respiration or a need for more oxygen would not be correct.

6a

a) Table 2 can be completed to show the correct order of the stages as follows...

correct order	letter of stage
1	E
2	I
3	F
4	A
5	G
6	J
7	B
8	K
9	C/H
10	H/C
11	D

- 8 answers correct; [4 marks]
- 6 or 7 answers correct; [3 marks]
- 4 or 5 answers correct; [2 marks]
- 2 or 3 answers correct; [1 mark]
- 0 or 1 answer correct; [0 marks]

[Total: 4 marks]

6b

b) The role of NAD in respiration in aerobic conditions is...

Any **four** of the following:

- It acts as / is a coenzyme; [1 mark]
- It aids dehydrogenase (enzymes); [1 mark]
- It carries hydrogen/H; [1 mark]
- (H is transported to) the electron transport chain / inner mitochondrial membrane/cristae / oxidative phosphorylation; [1 mark]
- (It is involved in) redox / reduction and oxidation reactions; [1 mark]
- 2.5/3 ATP (molecules are) produced per NAD; [1 mark]

[Total: 4 marks]

The simplest way of describing the role of NAD is to state that it is a **hydrogen carrier**; it carries hydrogen to where it is needed during the reactions of respiration, specifically to enable **oxidative phosphorylation** on the **inner mitochondrial membrane**.

Note that coenzymes are non-enzyme molecules that **aid the function of enzymes**. NAD is a coenzyme that aids the function of **dehydrogenase** enzymes, e.g. during glycolysis hydrogen is removed from triose phosphate (by the action of dehydrogenase enzymes) and transferred to NAD.

6c

c) i) The total number of molecules of carbon dioxide removed in the link reaction and Krebs cycle for each molecule of glucose respired is...

- 6; [1 mark]

c) ii) Carbon dioxide is transported in the blood mainly as hydrogen carbonate ions and not as carbonic acid because...

Any **one** of the following:

- Hydrogen carbonate prevents / carbonic acid would cause a decrease in blood pH; [1 mark]
- Carbonic acid dissociates (to give hydrogen carbonate ions and hydrogen ions); [1 mark]

***Accept** references to the role of carbonic anydrase in regulating blood pH for marking point 2, e.g. "carbonic anhydrase catalyses the (reversible) reaction $CO_2 + H_2O \leftrightarrow HCO_3^- + H^+$ to regulate pH"*

[Total: 2 marks]
i) The wording of part i) here makes this question seem more difficult than it really is; you just need to work out the number of carbon dioxide molecules **produced** (by being removed from other molecules within the reaction) during each part of the respiration reaction.

For each molecule of pyruvate that enters the link reaction, **1 molecule** of carbon dioxide is produced **AND** for each molecule of acetate that enters the Krebs cycle, **2 molecules** of carbon dioxide are produced:

1 + 2 = **3 molecules** of carbon dioxide

Each molecule of glucose is converted into **two** molecules of pyruvate, so for every molecule of glucose that enters aerobic respiration the link reaction occurs **twice**, and the Krebs cycle turns **twice**.

3 x **2** = **6 molecules** of carbon dioxide