Surname	Date	Tutor
First name(s)		

BioWelsh

GCE A LEVEL

BW-A2-3.3-W1

TOPIC WORKSHEET 1 – 3.3 RESPIRATION

BIOLOGY – A2 unit 3

Energy, Homeostasis and the Environment

Suggested time: 3 hours 20 minutes

For Tutor's use only

Question	Maximum Mark	Mark Awarded	Question	Maximum Mark	Mark Awarded
1.	10		9.	11	
2.	10		10.	10	
3.	10		11.	9	
4.	10		12.	10	
5.	12		13.	9	
6.	9		14.	9	
7.	10		15.	9	
8.	11		Total	149	

ADDITIONAL MATERIALS

In addition to this worksheet, you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name and the date in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you are working on screen, write your answers on paper and number each one clearly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question. The worksheet is out of **149** marks.

The assessment of the quality of extended response (QER) will take place in question **15**.

The quality of written communication will affect the awarding of marks.

This worksheet is written by BioWelsh in the style of the WJEC A level Biology examination, following the WJEC specification (topic 3.3). It is not an official WJEC paper.

Tutor only

Answer **all** questions.

1. The breakdown of glucose in a liver cell begins in the cytoplasm. **Image 1.1** shows the first stages of aerobic respiration. The letters **W**, **X**, **Y** and **Z** represent four different compounds.

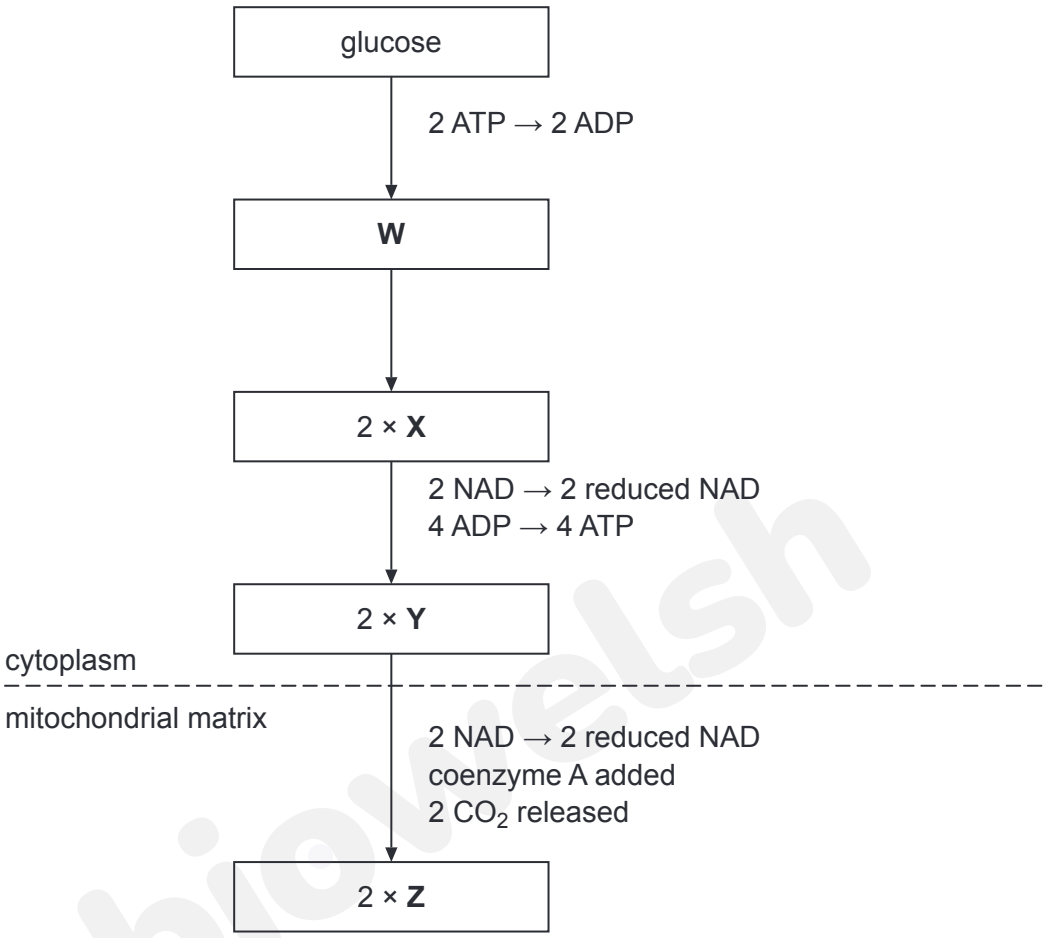

Image 1.1

(a) Complete **Table 1.2** by giving the number of carbon atoms in **one** molecule of each compound. [2]

Table 1.2

Compound	W	X	Y	Z
Number of carbon atoms	.....	.....	.....	.....

(b) Name compounds **Y** and **Z**. [2]

Y .....

Z .....

Tutor only

(c) Explain why **two** molecules of ATP are used at the start of the pathway, even though the aim of respiration is to make ATP. [2]

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(d) Using **Image 1.1**, calculate the net number of ATP molecules produced from **one** molecule of glucose by the time two molecules of **Y** have been formed. [1]

Net ATP = ...

(e) Describe what happens to compound **Y** in the link reaction. [3]

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2. **Image 2.1** is a transmission electron micrograph of two mitochondria from a mammalian lung cell.

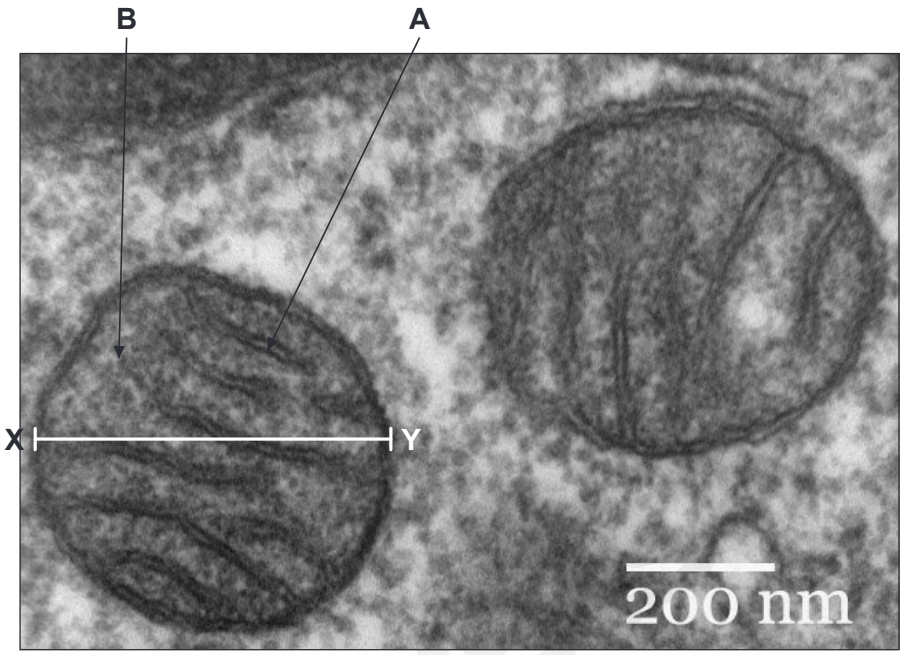

Image 2.1

(a) Identify the structures labelled **A** and **B**. [2]

A .....

B .....

(b) Using the scale bar, calculate the actual diameter of the mitochondrion along the line **X**–**Y**. Give your answer in nm. Show your working. [2]

Diameter = ... nm

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Table 2.2 shows the percentage of the cell volume occupied by mitochondria in three types of mammalian cell.

Table 2.2

Type of cell	Percentage of cell volume occupied by mitochondria
heart muscle	35
liver	22
skeletal muscle of the thigh	5

(c) (i) Explain why heart muscle cells have a much greater volume of mitochondria than skeletal muscle cells. [2]

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(ii) Suggest why liver cells also contain a large volume of mitochondria. [1]

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(d) Mature human red blood cells have no mitochondria. Explain how these cells produce ATP and suggest **one** advantage of red blood cells having no mitochondria. [3]

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3. Acetyl coenzyme A enters the Krebs cycle. **Image 3.1** shows a simplified Krebs cycle. The numbers **1** to **4** show four steps in the cycle.

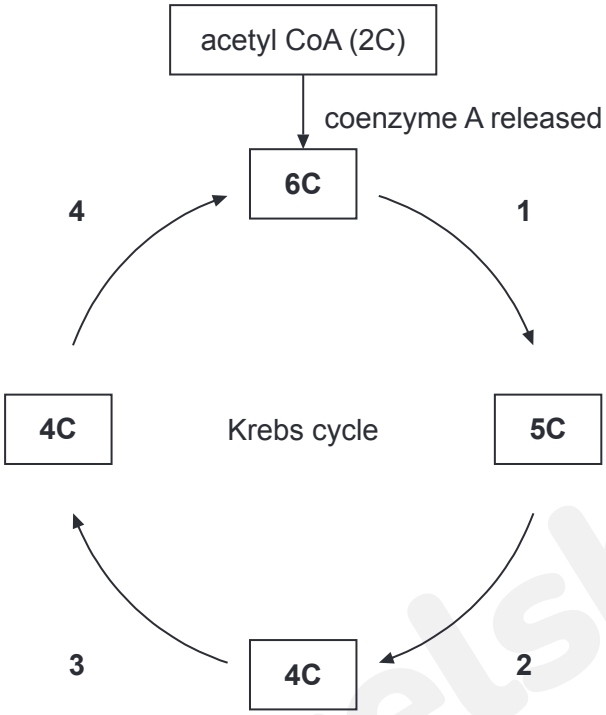

Image 3.1

(a) State **precisely** where in a eukaryotic cell the Krebs cycle takes place. [1]

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(b) Identify the **two** steps at which carbon dioxide is released. Give a reason for your answer. [2]

Steps .....

Reason .....

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Tutor only

(c) Complete **Table 3.2** to show the number of molecules produced by the Krebs cycle from **one** molecule of glucose. [2]

Table 3.2

Product	Number of molecules from one glucose
reduced NAD	.....
reduced FAD	.....
ATP	.....
carbon dioxide	.....

(d) Explain why it is important that the 4C compound is regenerated. [2]

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(e) Oxygen is not used in any step of the Krebs cycle. Explain why the Krebs cycle stops when a cell is deprived of oxygen. [3]

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4. **Image 4.1** shows part of a membrane from a mitochondrion. **J**, **K** and **L** are proteins in the membrane. **P** and **Q** are the regions on either side of the membrane.

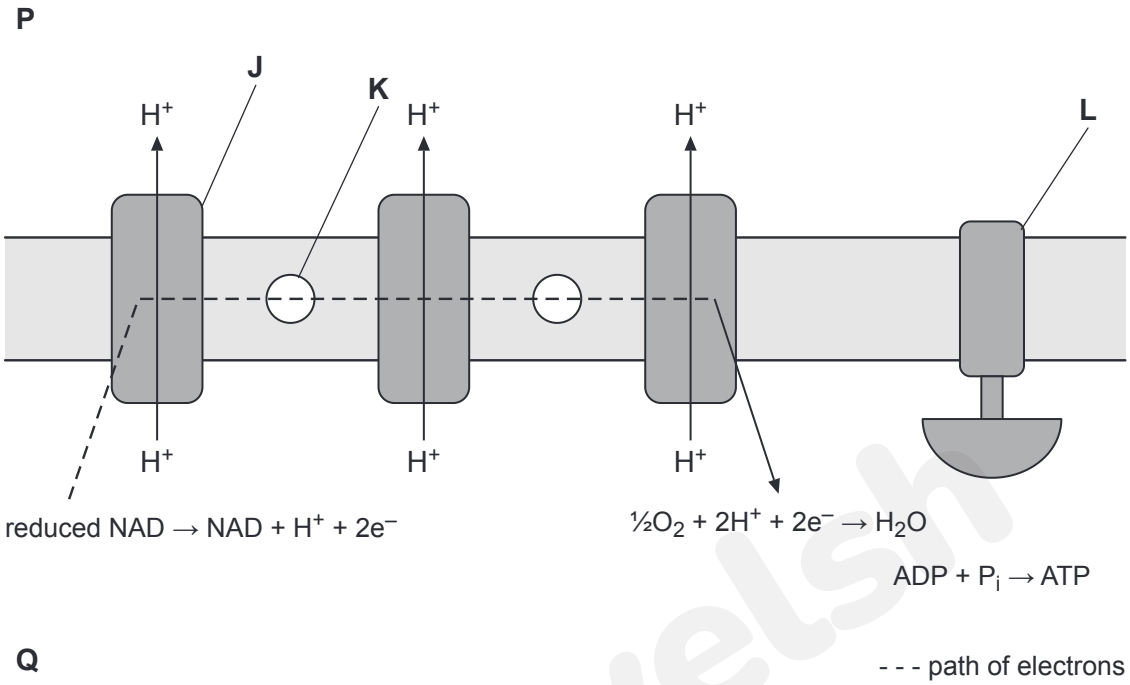

Image 4.1

(a) Name the membrane and the regions **P** and **Q**. [2]

Membrane .....

P .....

Q .....

(b) On **Image 4.1**, draw an arrow labelled **H** through **L** to show the direction in which protons move through it. [1]

(c) Describe how the flow of electrons along the chain leads to the production of ATP. [4]

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Tutor only

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(d) Suggest why the membrane shown in **Image 4.1** must be impermeable to protons except through **L**. [2]

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(e) State the role of oxygen in the process shown in **Image 4.1**. [1]

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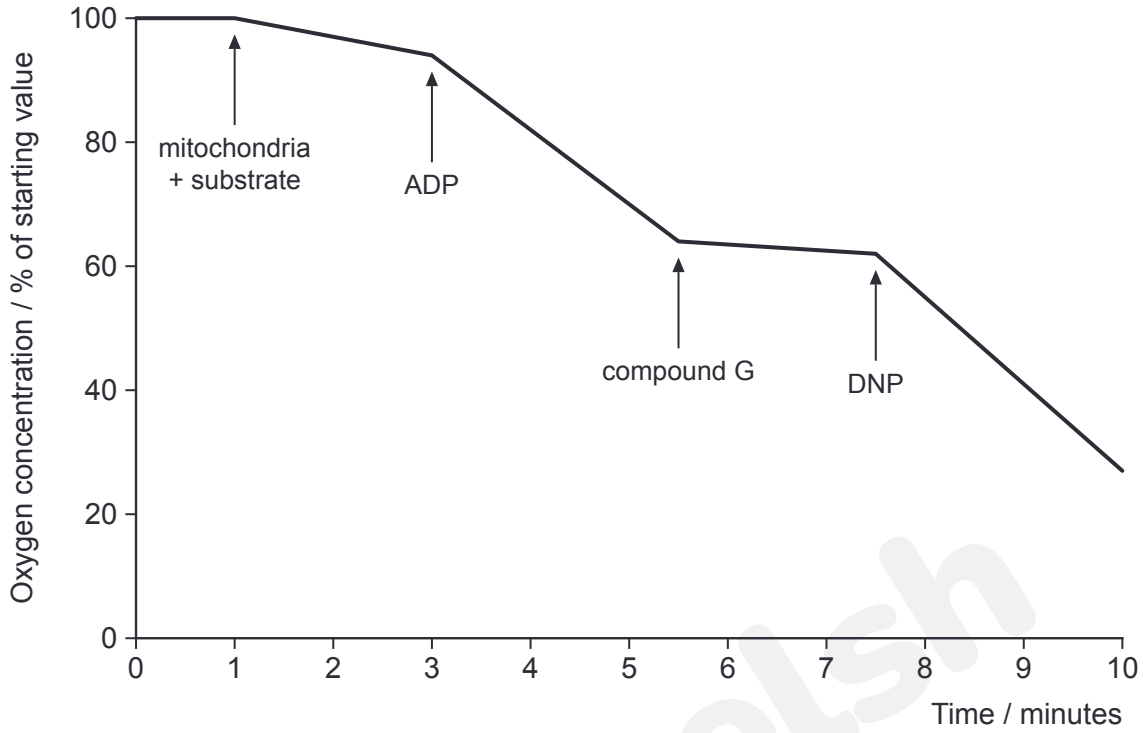
5. Mitochondria were isolated from liver cells and placed in a buffered solution containing phosphate. An oxygen electrode recorded the oxygen concentration of the solution. Substances were added at the times shown by the arrows on **Graph 5.1**.



Graph 5.1

(a) Calculate the mean rate of oxygen uptake between 3 and 5.5 minutes. Give the units. [2]

Rate = ...

(b) Explain why the rate of oxygen uptake increased when ADP was added. [2]

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(c) Compound G binds to ATP synthetase and stops protons passing through it. Explain the effect of compound G shown in **Graph 5.1**. [3]

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Tutor only

(d) DNP carries protons across the inner mitochondrial membrane. Explain why oxygen uptake increased after DNP was added, even though no ATP was made. [3]

(e) In the 1930s, DNP was sold as a slimming drug but was later banned. Suggest why taking DNP caused weight loss. [2]

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Tutor only

6. **Table 6.1** shows the number of molecules of ATP, reduced NAD and reduced FAD produced directly by each stage of aerobic respiration from **one** molecule of glucose.

Table 6.1

Stage	ATP	reduced NAD	reduced FAD
glycolysis	2	2	0
link reaction	0	2	0
Krebs cycle	2	6	2

(a) Each reduced NAD produces 3 ATP and each reduced FAD produces 2 ATP in the electron transport chain. Use **Table 6.1** to calculate the maximum number of ATP molecules produced from **one** molecule of glucose. Show your working. [2]

Number of ATP = ...

(b) The complete oxidation of one mole of glucose releases 2880 kJ. The hydrolysis of one mole of ATP releases 30.6 kJ. Calculate the efficiency of aerobic respiration. Give your answer to **1 decimal place**. [2]

Efficiency = ... %

(c) Calculate the efficiency of anaerobic respiration, which produces 2 ATP from one molecule of glucose. Give your answer to **1 decimal place**. [1]

Efficiency = ... %

(d) State what happens to the energy that is not transferred to ATP and suggest **one** benefit of this to a mammal. [2]

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Tutor only

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(e) Scientists estimate that cells actually make about 30 ATP from each molecule of glucose. Suggest **two** reasons why the actual yield is lower than the value you calculated in part (a). [2]

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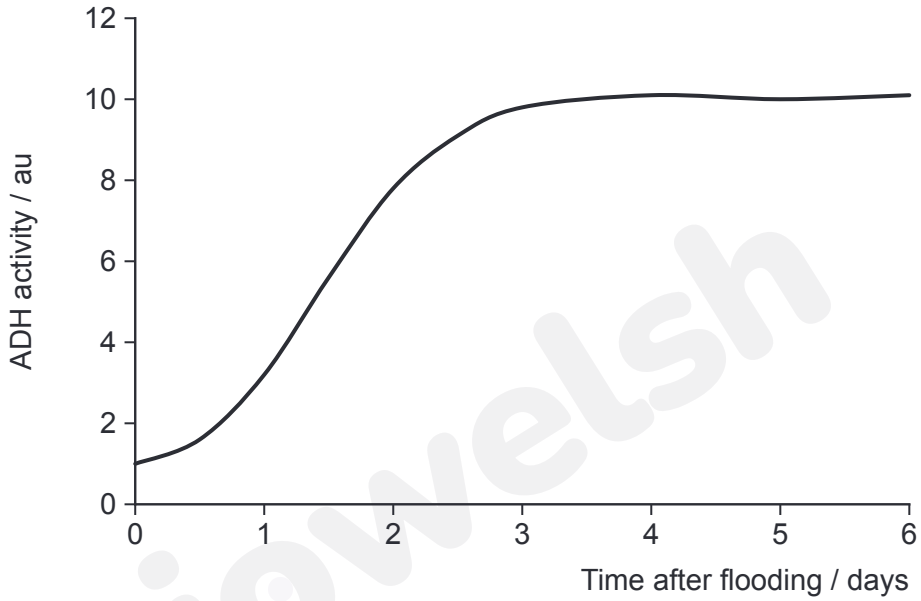
Tutor only

7. Rice is often grown in paddy fields that are flooded with water. When the soil is flooded, the oxygen concentration around the roots falls and the root cells respire anaerobically. In plants, the final step of anaerobic respiration is catalysed by the enzyme alcohol dehydrogenase (ADH):

ethanal + reduced NAD → ethanol + NAD

Graph 7.1 shows the activity of ADH in the roots of rice plants after their field was flooded.



Graph 7.1

(a) Describe the changes in ADH activity shown in **Graph 7.1**. [2]

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(b) Explain how the increase in ADH activity allows the root cells to continue to produce ATP. [3]

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Tutor only

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(c) Name the 3-carbon compound that is converted into ethanal and the other product of this reaction. [2]

3-carbon compound .....

Other product .....

(d) Rice roots contain a tissue with large air spaces that connect the roots to the leaves. Suggest how this tissue helps rice plants to grow in flooded fields. [2]

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(e) Suggest why the roots of many plants other than rice are damaged if the soil stays flooded for a long time. [1]

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Tutor only

8. A student investigated the effect of temperature on the rate of respiration of yeast. **Image 8.1** shows the apparatus used. The volume of carbon dioxide collected in the gas syringe in 5 minutes was recorded at five temperatures.

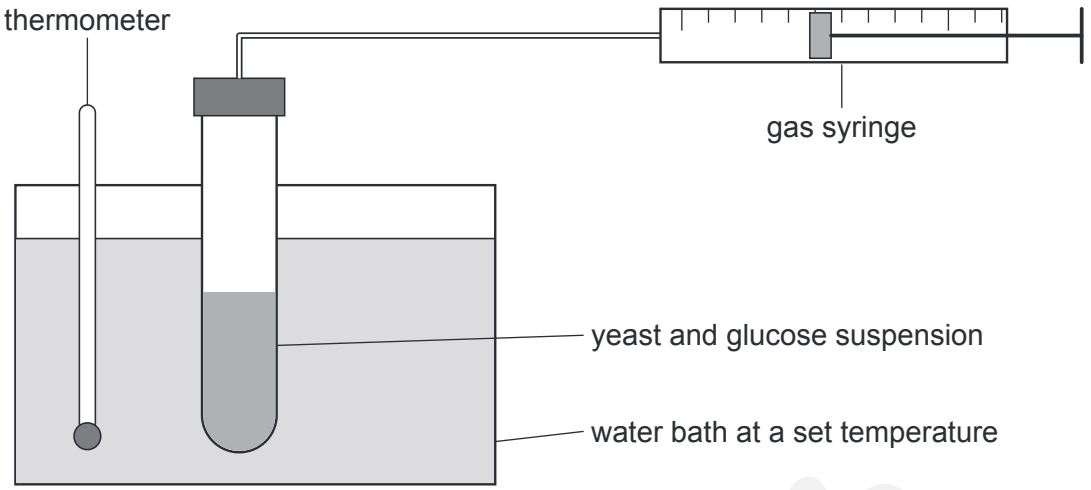

Image 8.1

Table 8.2 shows the volume of carbon dioxide collected in 5 minutes in three trials at each temperature.

Table 8.2

Temperature / °C	Trial 1 / cm^3	Trial 2 / cm^3	Trial 3 / cm^3	Mean / cm^3
20	3.2	3.4	3.0	3.2
30	7.8	8.2	8.0	.....
40	14.6	15.2	9.1	.....
50	6.4	6.0	6.2	6.2
60	0.4	0.2	0.3	0.3

(a) (i) Identify the anomalous result in **Table 8.2**. [1]

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(ii) Complete **Table 8.2** by calculating the missing mean values. Do **not** include the anomalous result. [2]

(b) State the independent variable and **two** variables that should have been controlled. [2]

Independent variable .....

Controlled variables .....

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Tutor only

(c) Explain why the tube was left in the water bath for 10 minutes before the gas syringe was connected. [1]

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(d) Explain the results between 40 °C and 60 °C. [3]

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(e) Carbon dioxide is soluble in water. Explain how this affects the results and suggest how the method could be improved to reduce this effect. [2]

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Tutor only

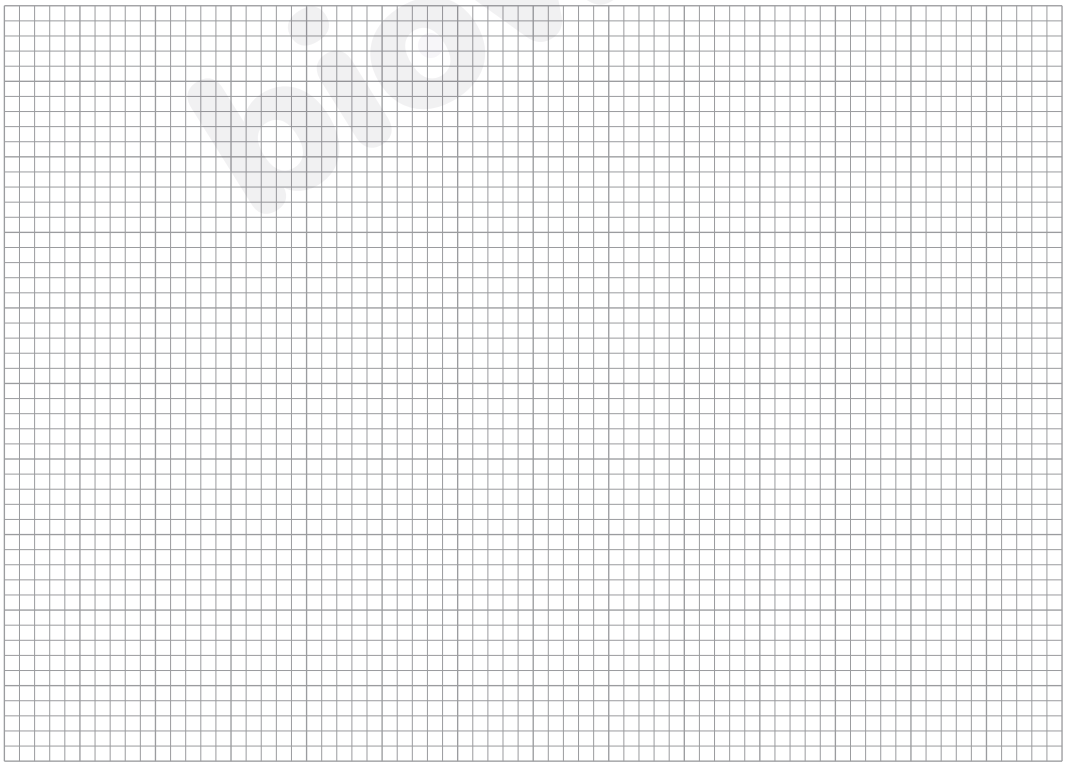
9. Methylene blue is a blue dye that becomes colourless when it is reduced. It can accept hydrogen atoms removed by dehydrogenase enzymes during respiration. A student added methylene blue to yeast suspensions containing different concentrations of glucose and recorded the time taken for the blue colour to disappear. The tubes were kept at 30 °C and were not shaken.

Table 9.1

Concentration of glucose / %	Time for blue colour to disappear / s	Rate / 1000 ÷ time
0.0	no change after 900	0.0
0.5	420	2.4
1.0	240	.....
2.0	130	.....
4.0	125	8.0

(a) Complete **Table 9.1** by calculating the missing rates. Give your answers to **1 decimal place**. [2]

(b) Plot a graph of rate against concentration of glucose on the grid below. Join the points with straight lines. [4]



Tutor only

(c) Explain why the methylene blue lost its colour. [2]

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(d) Explain why the rate changes very little between 2.0 % and 4.0 % glucose. [2]

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(e) Suggest why the tubes were **not** shaken during the experiment. [1]

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Tutor only

10. The respiratory quotient (RQ) of a respiratory substrate is calculated using the formula:

RQ = volume of carbon dioxide produced ÷ volume of oxygen absorbed

Image 10.1 shows a respirometer used to measure the respiration of germinating sunflower seeds.

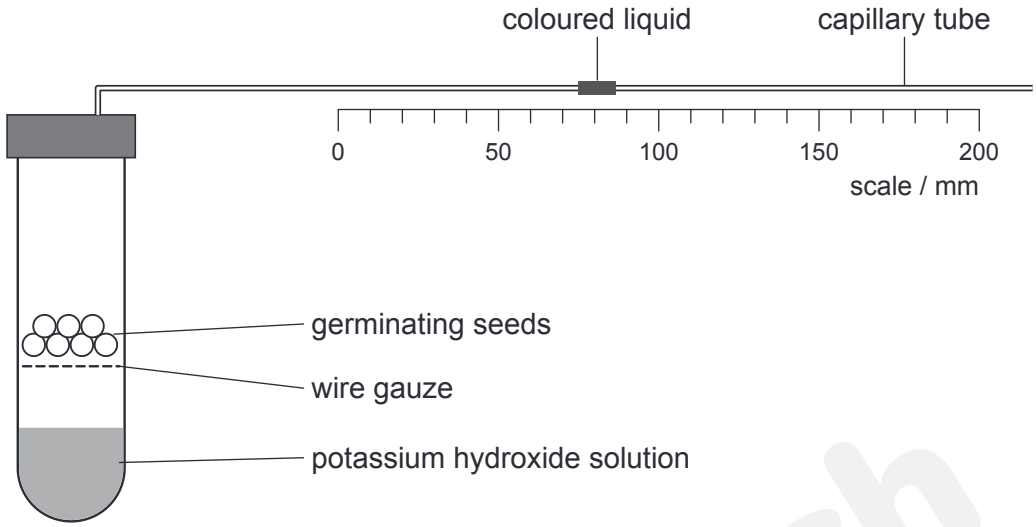

Image 10.1

With potassium hydroxide solution in the tube, the coloured liquid moved 38 mm towards the seeds in 20 minutes. The radius of the bore of the capillary tube was 0.5 mm.

(a) Explain why the coloured liquid moved towards the seeds. [2]

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(b) The volume of a cylinder is $\pi r^2 h$, where $\pi = 3.14$. Calculate the volume of oxygen absorbed by the seeds per hour. Give your answer to **1 decimal place**. [3]

Volume = ... $mm^3\ hour^{-1}$

Tutor only

(c) The experiment was repeated with water in place of the potassium hydroxide solution. The coloured liquid moved 11 mm towards the seeds in 20 minutes. Calculate the RQ of the seeds. Give your answer to **2 decimal places**. [2]

RQ = ...

(d) Use your answer to part (c) to suggest the main respiratory substrate of the seeds. Give a reason for your answer. [2]

Substrate .....

Reason .....

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(e) Suggest a suitable control for this experiment. [1]

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Tutor only

11. Lipids and proteins can also be used as respiratory substrates. **Image 11.1** shows how they enter the respiratory pathway. **A**, **B** and **C** are processes.

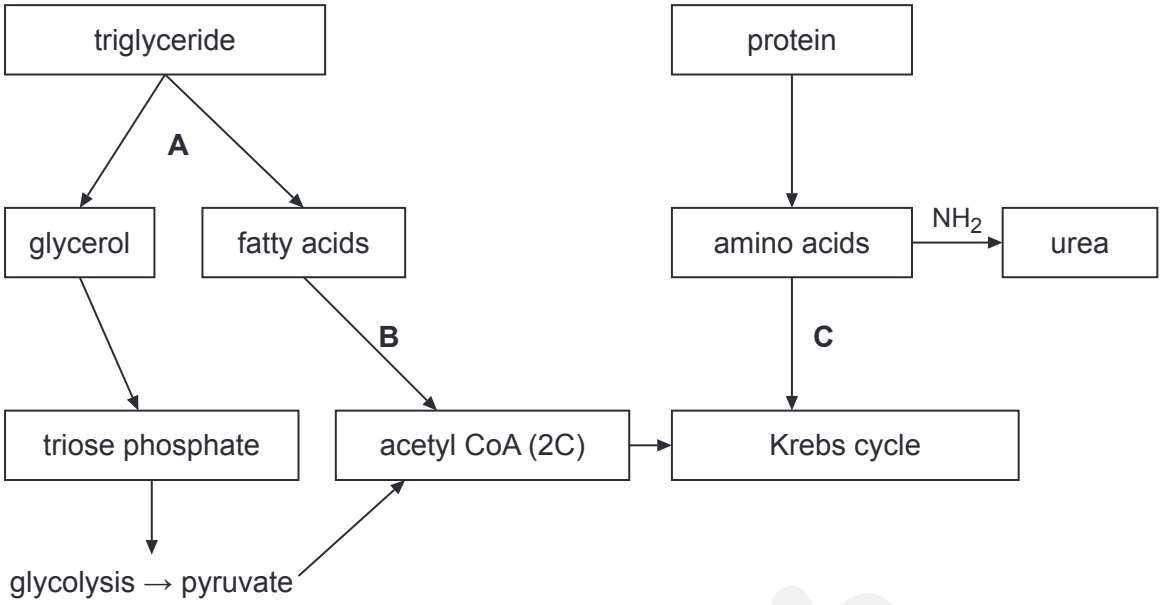

Image 11.1

(a) Name processes **A** and **C**. [2]

A .....

C .....

(b) State where process **C** takes place in a mammal and what happens to the amino group that is removed. [2]

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(c) In process **B**, fatty acids are broken into 2-carbon fragments. State the number of acetyl CoA molecules formed from **one** molecule of a fatty acid containing 16 carbon atoms. [1]

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Tutor only

Table 11.2 shows the energy released when one gram of each respiratory substrate is respired.

Table 11.2

Respiratory substrate	Energy released / kJ g^{-1}
carbohydrate	17
lipid	39
protein	17

(d) Explain why lipids release more energy per gram than carbohydrates. [2]

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(e) Bar-tailed godwits are wading birds that fly non-stop for about 11 000 km from Alaska to New Zealand. Before the flight, fat can make up more than half of their body mass. Suggest why these birds store fat rather than glycogen as their main fuel for the flight. [2]

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Tutor only

12. ATP is described as the universal energy currency of cells. **Image 12.1** shows the structure of a molecule of ATP.

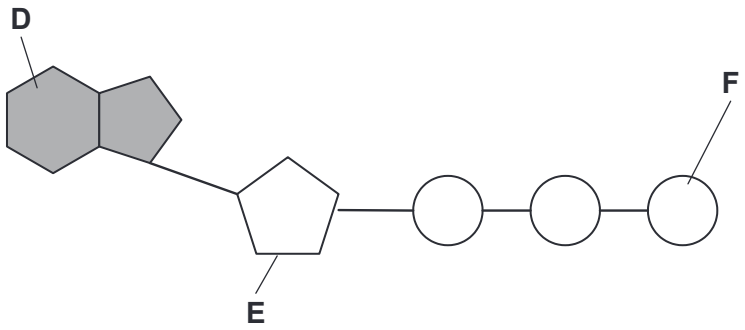

Image 12.1

(a) Identify the parts of the molecule labelled **D**, **E** and **F**. [2]

D .....

E .....

F .....

(b) Name the enzyme in the inner mitochondrial membrane that catalyses the synthesis of ATP. [1]

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(c) Explain why ATP, rather than glucose, is used as the immediate source of energy in cells. [3]

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Tutor only

(d) An adult human contains about 50 g of ATP at any one time but hydrolyses about 50 kg of ATP each day. Calculate the mean number of times each molecule of ATP is regenerated from ADP each hour. [2]

Number of times = ... per hour

(e) Suggest why cells store energy as glycogen or fat rather than as ATP. [2]

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Tutor only

13. Rotenone is used as a pesticide. It blocks the transfer of electrons from reduced NAD to the first proton pump of the electron transport chain. Cyanide binds to the final carrier of the chain, which passes electrons to oxygen.

Mitochondria were supplied with either malate, which is oxidised in the Krebs cycle to produce reduced NAD, or succinate, which is oxidised to produce reduced FAD. Reduced FAD passes its electrons to the chain after the first proton pump. **Table 13.1** shows the results.

Table 13.1

Substance added	Oxygen uptake with malate / au	Oxygen uptake with succinate / au
none	80	95
rotenone	4	92
cyanide	2	3

(a) Describe the effect of rotenone shown in **Table 13.1**. [2]

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(b) Explain why rotenone does **not** stop oxygen uptake when succinate is the substrate. [3]

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(c) Explain why cyanide stops oxygen uptake with both substrates. [2]

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Tutor only

(d) Suggest why cyanide poisoning is quickly fatal in humans, even though cells can still carry out glycolysis. [2]

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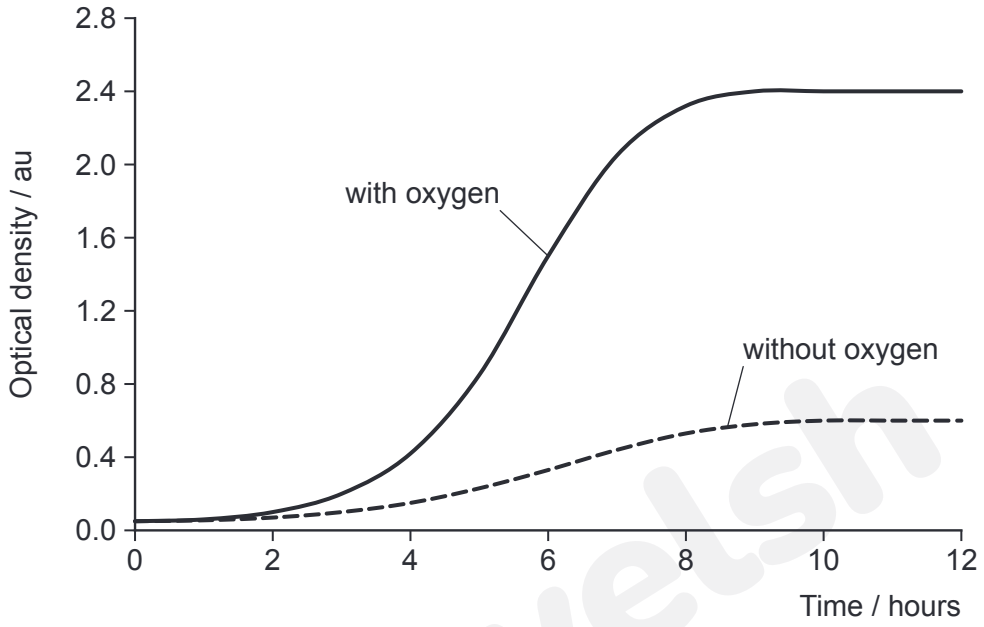
Tutor only

14. *Escherichia coli* is a bacterium that can respire aerobically or anaerobically. Two flasks containing the same volume of nutrient broth with glucose were inoculated with *E. coli*. Air was bubbled through one flask. Nitrogen was bubbled through the other. **Graph 14.1** shows the growth of the populations.



Graph 14.1

(a) Describe **two** differences between the growth of the two populations. [2]

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(b) Using your knowledge of the energy budget of glucose, explain the difference in the final size of the two populations. [3]

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Tutor only

(c) *E. coli* has no mitochondria. State where the electron transport chain is found in a bacterial cell. [1]

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(d) Suggest **two** reasons why the population with oxygen stopped increasing after 9 hours. [2]

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(e) The pH of the broth in the flask without oxygen fell during the experiment. Suggest why. [1]

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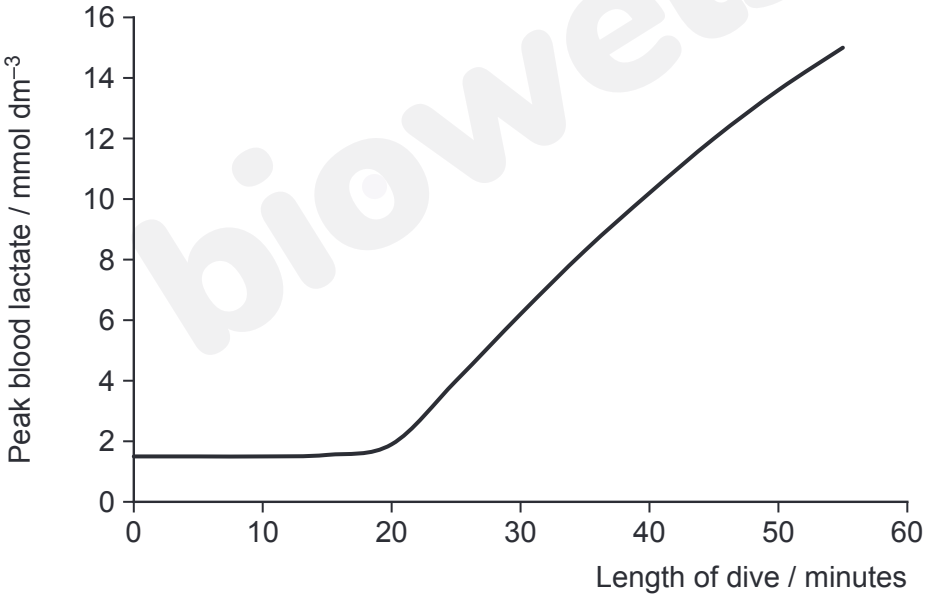
Tutor only

15. Weddell seals hunt fish beneath the sea ice around Antarctica, as shown in **Image 15.1**. Most of their dives last less than 20 minutes, but some last for more than 45 minutes. During a dive, a seal cannot breathe. Its muscles contain large amounts of myoglobin, which stores oxygen, and blood flow to the muscles is reduced.

Image 15.1

Graph 15.1 is a model of how the peak concentration of lactate in the blood after a dive changes with the length of the dive.



Graph 15.1

Using your knowledge of the electron transport chain, explain why aerobic respiration in the muscle cells stops when the oxygen stored in the muscles has been used. Explain how the muscle cells continue to produce ATP after this point and describe the consequences for the energy budget of glucose. Use **Graph 15.1** to suggest why most dives last less than 20 minutes and why seals rest at the surface after long dives. [9 QER]

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END OF WORKSHEET

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A Tutor Meets Tutee project

BioWelsh worksheets are written and checked by Tutor Meets Tutee tutors for WJEC A level Biology students.

Mark this worksheet with the BioWelsh mark scheme **BW-A2-3.3-W1** (MS).

Acknowledgements

Image 2.1: Photo: Louisa Howard, public domain (Wikimedia Commons). Letters and line X–Y added.

Image 15.1: Photo: Steve Rupp, National Science Foundation, public domain (Wikimedia Commons).

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