2.7 Cellular Respiration

Question Paper

Course	DP IB Biology
Section	2. Molecular Biology
Topic	2.7 Cellular Respiration
Difficulty	Hard

Time allowed: 70

Score: /55

Percentage: /100

Question 1a

a)

A Sports Scientist was investigating aerobic respiration in an athlete. The equation below summarises how ATP is produced, using energy from the oxidation of glucose, for this particular athlete.

glucose + oxygen + (ADP + Pi) → carbon dioxide + water + ATP

170 g 124.4 dm^3 17.25 kg 124.4 dm^3 107 g 17.25 kg

Calculate the mass of ATP produced per dm^3 of oxygen for the athlete.

[3 marks]

[3 marks]

Question 1b

b)

The Sports Scientist then decided to measure the volume of oxygen consumed and the mass of ATP produced by the athlete when they ran different length races.

Some of the results for the athlete are shown in the table below.

Length of race/m	Volume of oxygen consumed in cell respiration during race/dm^3	Mass of ATP produced/kg
1500	40	
10 000	160	
25 000		48.545
42 000		95.703

Complete the table by calculating the missing values.

[2 marks]

[2 marks]

Question 1c

c)
The Sports Scientist estimated that during a 100 m race, 95 g of ATP would be needed by the athlete, but the athlete only consumed 0.6 dm^3 of oxygen.

i)
Calculate the difference in grams between the mass of ATP required for a 100 m race and the mass of ATP produced from 0.6 dm^3 of oxygen.

[2 marks]

ii)
Deduce how the remaining ATP required for the 100 m race is being produced.

[1 mark]

[3 marks]

Question 2a

a)
Mitochondrial diseases in humans cause their mitochondria to malfunction. Individuals that suffer from mitochondrial diseases are only able to endure an intense exercise for a short period of time.

Explain why this is.

[2 marks]

[2 marks]

Question 2b

b)

A group of researchers wanted to investigate ATP production in the preparation of isolated mitochondria taken from a person with mitochondrial disease. They suspended the mitochondria in an isotonic solution and added ADP, phosphate and a respiratory substrate. Oxygen was supplied throughout the preparation.

Explain why the solution used was isotonic.

[2 marks]

[2 marks]

Question 2c

c)

Researchers measured the rate of CO_2 production by three groups of insects of the same species at 15 °C, 25 °C and 35 °C. The mean mass of each group of insects was also recorded. Their results can be seen in the table below.

Temperature / °C	Mean mass / g	Rate of CO_2 release / $\mu dm^3\ min^{-1}$	Rate of CO_2 release per gram / $\mu dm^3\ g^{-1}\ min^{-1}$
15	0.051	0.15	
25	0.050	0.39	
35	0.052	0.61	

i)

Calculate the rate of carbon dioxide release per gram for each temperature in the table. Give your answer to two decimal places.

[1 mark]

ii)

Sketch a graph of your values against temperature.

[2 marks]

[3 marks]

Question 2d

d)

i)
Describe the effect of temperature on the rate of CO_2 release for these insects.

[1 mark]

ii)
Explain this effect.

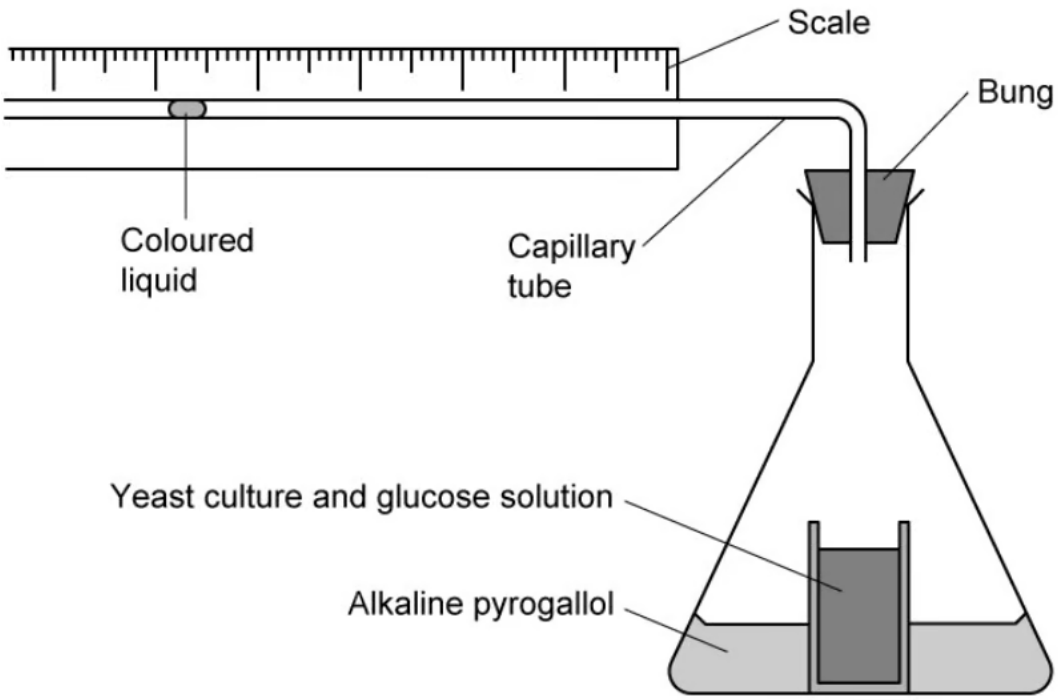
[2 marks]

[3 marks]

Question 3a

a)

A researcher used the apparatus shown below to measure the rate of respiration in yeast. The researcher placed the flask in a water bath with the bung open (so that the yeast culture reached a constant temperature), before adding the alkaline pyrogallol, inserting the bung and starting the investigation. In an alkaline solution, pyrogallol absorbs oxygen from the air.



When the researcher inserted the bung and began the experiment, the coloured liquid initially moved to the right. After a period of time, the coloured liquid slowed, stopped and reversed its direction, moving to the left.

Use the diagram above and your knowledge of respiration to explain these observations.

[5 marks]

[5 marks]

Question 3b

b)
When the coloured liquid in part (a) moved to the left, the researcher measured that the coloured liquid moved 1.8 cm in 16 hours. The internal diameter of the capillary tubing was 1.3 mm. The volume of the capillary tubing is given by $\pi r^2 l$, where l = length.

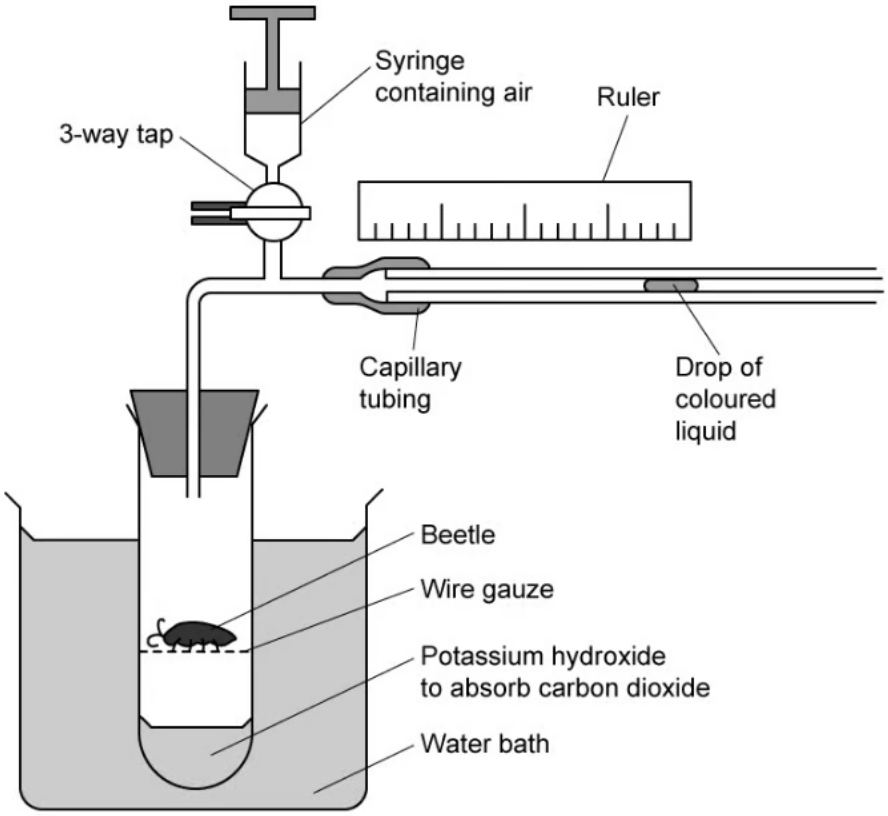
Calculate the volume of gas produced and from this, the rate of gas production in $mm^3\ hr^{-1}$. Show your working and give your answer to an appropriate number of significant figures.

[4 marks]

[4 marks]

Question 3c

c)
The researcher then wanted to measure and compare the rate of aerobic respiration in different species of beetle (with different masses) using the experimental set-up shown below.



i)
Outline the different measurements that the researcher would need to take in order to calculate the aerobic respiration rate and to accurately compare these respiration rates between different beetle species.

[4 marks]

ii)
Suggest suitable units of respiration rate, based on the different measurements that the researcher would need to take.

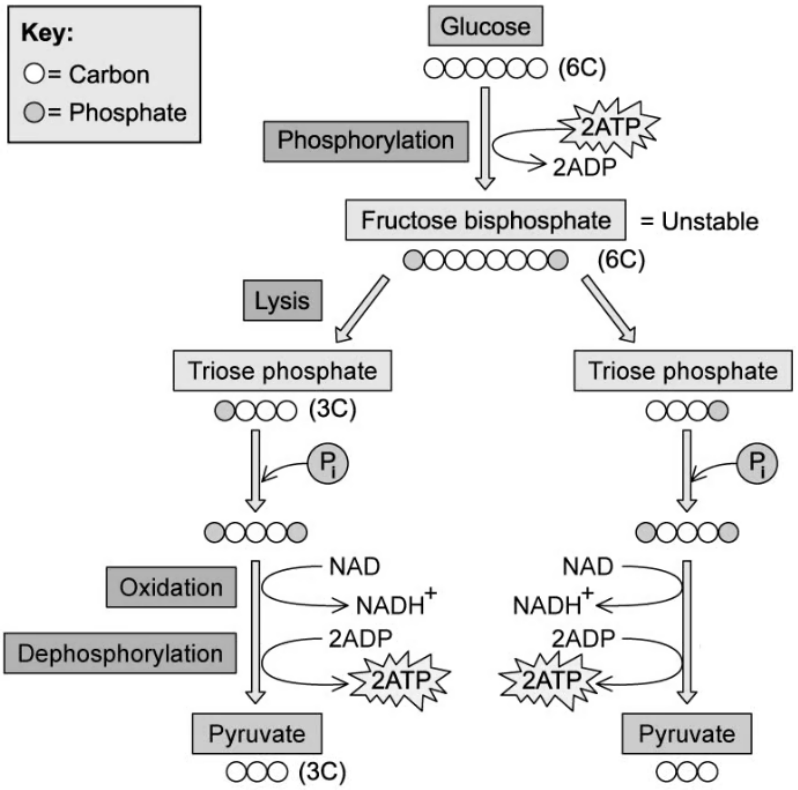
[1 mark]

[5 marks]

Question 4a

a)

The diagram below shows the process of glycolysis. Glycolysis is the first stage of respiration. It takes place in the cytoplasm of the cell and involves trapping glucose in the cell by phosphorylating the molecule and then splitting the glucose molecule in two.



Give the net ATP production from glycolysis.

[1 mark]

[1 mark]

Question 4b

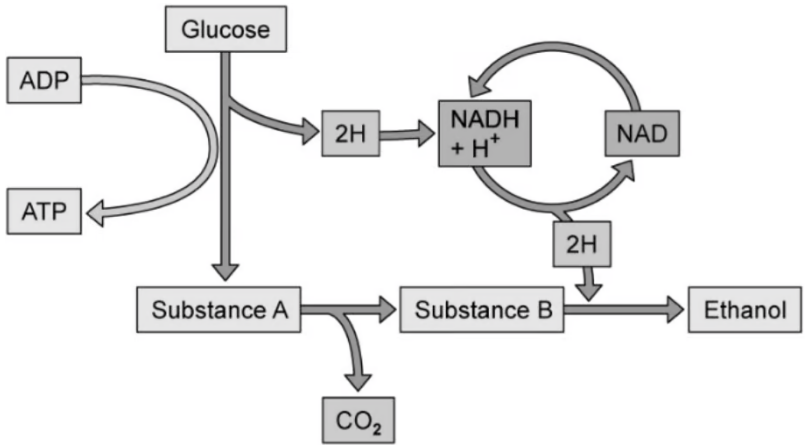
b)
Explain how temperature influences the rate of ATP production in respiration.

[3 marks]

[3 marks]

Question 4c

c)
Identify the overall process that is occurring as shown in the diagram below and the condition under which this process must be occurring.



[2 marks]

[2 marks]

Question 5a

One mark is available for clarity of communication throughout this question.

a)
Scientists investigated the effect of exercise on muscle fibres in mice. The mice were split into two groups. Group **A** undertook regular exercise for 8 weeks, Group **B** was not exercised. After 8 weeks the scientists compared how long each group of mice could carry out prolonged exercise.

i)
Identify which group was able to exercise for longer periods

[1 mark]

ii)
Using the idea of respiration, explain the scientists' findings.

[5 marks]

[6 marks]

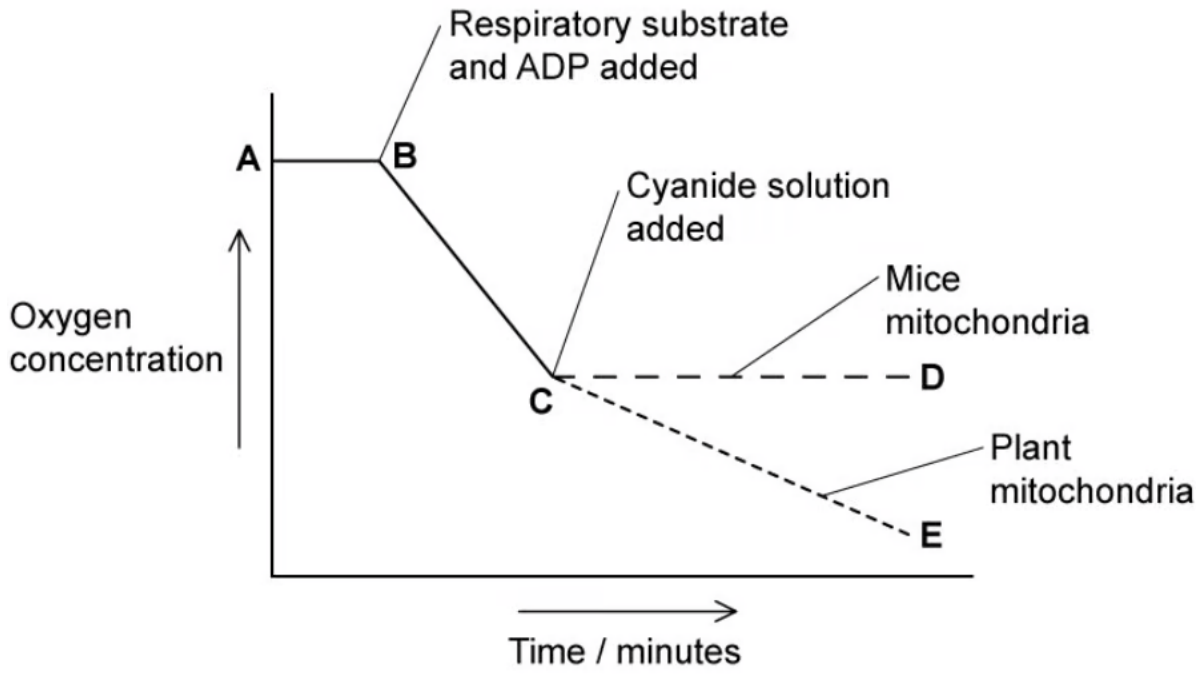
Question 5b

b)

The scientists then investigated the effect of cyanide on the uptake of oxygen in mitochondria isolated from mice cells. Cyanide acts as an inhibitor of several enzymes involved in respiration. The scientists compared the mice's mitochondria with mitochondria isolated from plant cells. They prepared a flask of suspension of each type of mitochondria and recorded the oxygen concentration in each flask over time.

- After 10 minutes they added ADP and a respiratory substrate to each suspension.
- After 20 minutes they added cyanide to each suspension.

Their results are shown in the graph below. During time **A** to **C** the results of the two flasks overlap.



i)

Describe the differences in results between lines **C** to **D** (mice mitochondria) and **C** to **E** (plant mitochondria).

[2 marks]

ii)

Explain these differences.

[2 marks]

[4 marks]

Question 5c

c)
Compare and contrast aerobic respiration and anaerobic respiration.

[7 marks]

[7 marks]