2021 ASSESSMENT MATERIALS

A- Level
BIOLOGY

Exchange of Substances, Energy Transfers, Responses of Organisms

Total number of marks: 49

0 1 . 1 Suggest and explain how the interaction between the muscles labelled in **Figure 1** could cause the pupil to constrict (narrow).

Radial muscles relax and circular muscles contract. **[2 marks]**

0 4 **Figure 3** shows the banding pattern of a single sarcomere.

Figure 3

0 4 . 1 Explain the banding pattern shown in **Figure 3**.

[3 marks]

1 0 Guillain–Barré syndrome is a rare disease in which the immune system damages the myelin sheath of neurones. Myelin sheath damage can cause a range of symptoms, for example numbness, muscular weakness and muscular paralysis. Sometimes, neurones of the autonomic nervous system are affected, causing heart rate irregularities.

Huntington's disease is a disorder caused when a protein called huntingtin damages the brain. Huntingtin is produced because of a dominant, mutant allele.

The first successful drug trial to reduce concentrations of huntingtin in the human brain involved 46 patients. The patients received the drug for 4 months. The concentration of huntingtin was reduced in all the patients. The drug was injected at the base of the spine into the cerebrospinal fluid bathing the brain and spinal cord. The drug contains single-stranded DNA molecules. These single-stranded molecules inhibit the mRNA needed to produce huntingtin.

Symptoms of Huntington's disease can start at any time, but usually develop between 30 and 50 years of age. The likelihood and age when symptoms start are linked to the number of CAG base sequence repeats in the gene for Huntington's disease. However, recent studies have suggested that epigenetics may also affect the age when symptoms first start.

1 0 . 1 Damage to the myelin sheath of neurones can cause muscular paralysis (lines 2–4).

Explain how.

Myelin sheath insulates nerve fibres and increases the speed of action potential conduction. In demyelinated neurones, impulse conduction is impaired and the conduction of action potential is slower. Action potentials jump between regions called Nodes of Ranvier which contain high concentrations of sodium ion channels, which are located between myelin sheaths. **[3 marks]**

04.1

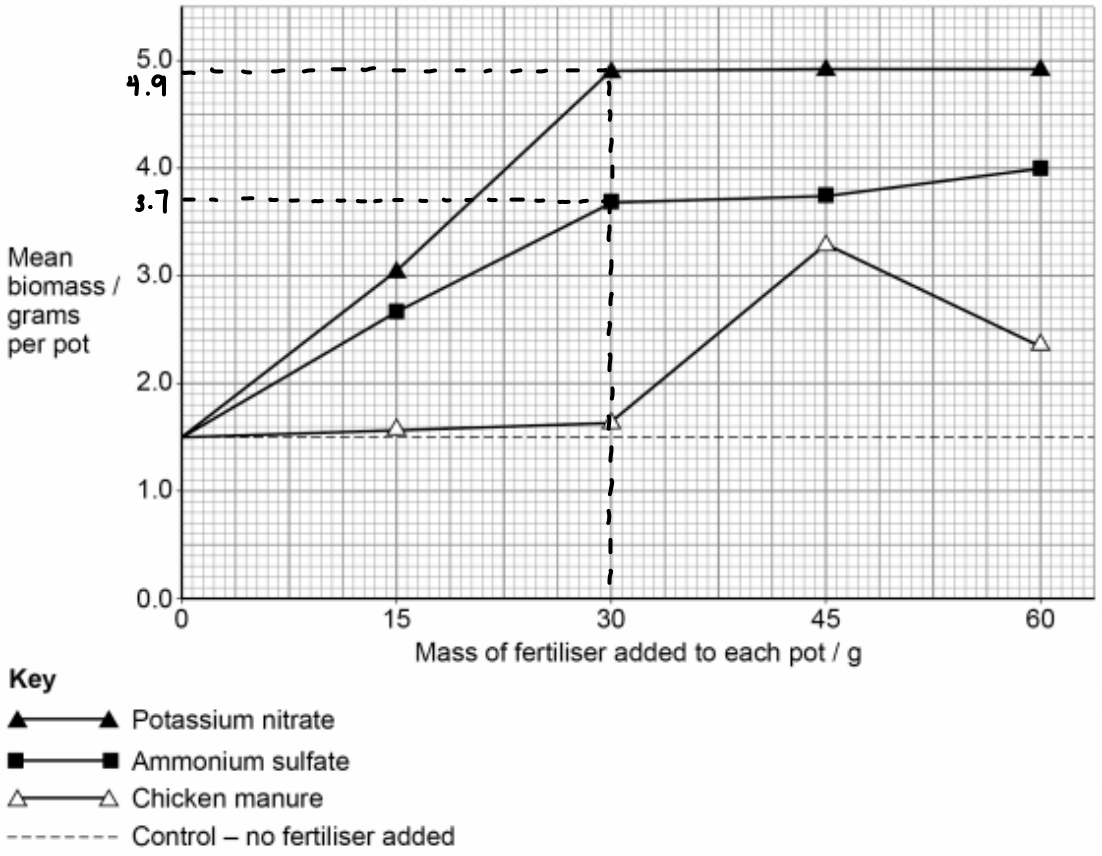
The 2 horizontal lines represent the Z-discs. Next to the Z discs there is a light area which contains only actin filaments, which are the thin filaments. The darkest area is when the thin and thick (myosin) filaments overlap. The area in the middle is relatively lighter as it only contains thick filaments.

0 7 A scientist investigated the effects of different fertilisers on the growth of spinach plants. The scientist:

- set up a large sample of identical pots of soil
- added different masses of different fertilisers to selected pots
- did not add fertiliser to the control pots
- planted the same number of young spinach plants in each pot
- after 20 days, determined the biomass of spinach plants in each pot.

The results the scientist obtained after 20 days are shown in **Figure 4**.

Figure 4



0 7 . 1 Calculate how many times greater the mean growth rate per day was using 37.5 g potassium nitrate than using 37.5 g ammonium sulfate.

Assume the mean biomass of the spinach plants at the start of the investigation was 0.5 g per pot.

[1 mark]

mean growth rate with potassium nitrate : $\frac{4.9-0.5}{20} = 0.22$

mean growth rate with ammonium sulfate : $\frac{3.7-0.5}{20} = 0.16$

$\frac{0.22}{0.16} = 1.375$

Answer 1.375

0 7 . 2 Using all the information, evaluate the effect on plant growth of adding the different fertilisers to the soil.

[5 marks]

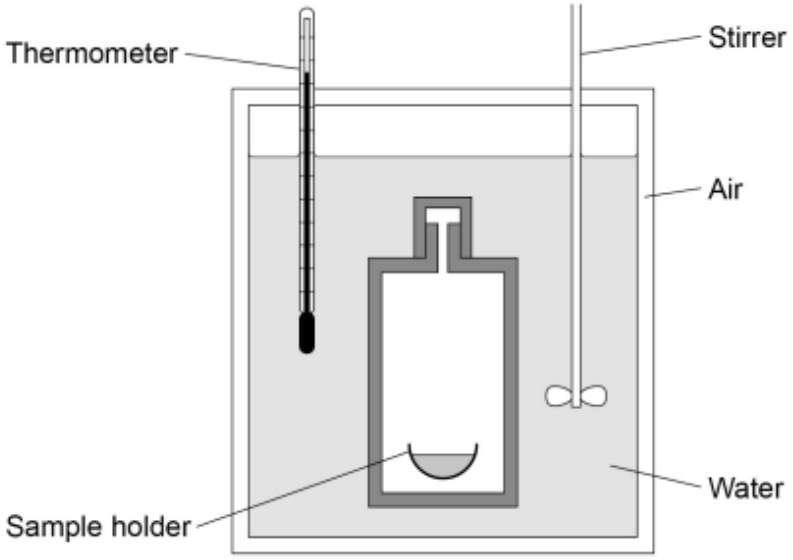
For both potassium nitrate and ammonium sulfate, there is a significant increase in mean biomass when up to 30g is added. Above 30g, there is little effect in the mean growth rate when more fertiliser is added. When chicken manure is used, there is no significant difference from the control when 30g or less is used. For chicken manure, mean biomass peaks when 45g is used and decreases when more fertiliser is used. All 3 fertilisers increases the growth of spinach plants, with potassium nitrate having the greatest effect, followed by ammonium sulfate and chicken manure.

0 2 . 1 Describe the role of saprobionts in the nitrogen cycle.

Saprobionts are involved in ammonification. They break down protein to amino acids and remove the amino groups, and use the products of decomposition for respiration. **[2 marks]**

0 3 **Figure 2** shows one type of calorimeter.

Figure 2



A calorimeter can be used to determine the chemical energy store of biomass.
A known mass of biomass is fully combusted in a calorimeter. The heat energy released from this combustion increases the temperature of the water in the calorimeter. The increase in the temperature of a known volume of water is recorded.

0 3 . 1 Other than the thermometer, explain how **two** features of the calorimeter shown in **Figure 2** would enable a valid measurement of the total heat energy released. **[2 marks]**

The stirrer ensures that the temperature throughout water is constant. The calorimeter is enclosed to reduce heat lost to the environment.

0 3 . 2 A 2 g sample of biomass was fully combusted in a calorimeter.

The volume of water in the calorimeter was 100 cm^3

The increase in temperature recorded was 15.7 °C

4.18 J of energy are needed to increase the temperature of 1 cm^3 of water by 1 °C

Use this information to calculate the heat energy released in kJ per g of biomass.

Show your working.

[2 marks]

Total energy released = 4.18 × 100 × 15.7

= 6562.6 J

energy released per g = 6562.6 ÷ 2 ÷ 1000

= 3.2813 kJg^{-1}

Answer 3.2813 kJg^{-1}

Plants and algae produce fuels called biofuels. Scientists have used *Chlorella* to produce biofuel. *Chlorella* is a genus of single-celled photosynthetic alga. *Chlorella* can be grown in open ponds and fermenters.

0 3 . 3 In natural ecosystems, most of the light falling on producers is **not** used in photosynthesis.

Suggest **two** reasons why.

[2 marks]

Some of the light is of a different wavelength and are reflected. Some of the light does not fall on chloroplast, so does not get absorbed and passes through the plant.

0 3 . 4 The light absorbed by chlorophyll is used in the light-dependent reaction.

Name the **two** products of the light-dependent reaction that are required for the light-independent reaction.

[2 marks]

1 NADP

2 ATP

0 3 . 5 *Chlorella* cells can divide rapidly. A culture of 2000 *Chlorella* cells was set up in a fermenter. The cells divided every 90 minutes.

You can assume that there were no limiting factors and that no cells died during the 24 hours.

Calculate the number of cells in the culture after 24 hours.

Give your answer in standard form.

Show your working.

[2 marks]

90 mins = 1.5 hours

24 hours = 16 x 1.5 hours

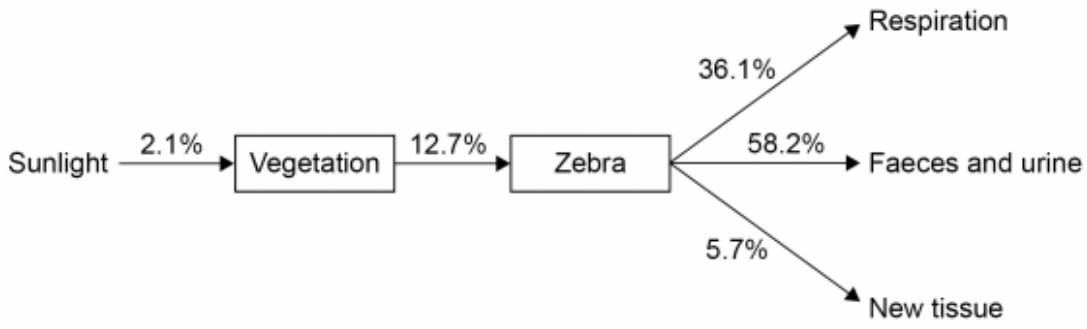
$2000 \times 2^{16} = 131072000$

$= 1.31 \times 10^{8}$

Answer 1.31×10^{8}

Figure 1 shows percentages of energy transferred from sunlight to a zebra in a grassland ecosystem.

Figure 1



0 1 . 2 Use **Figure 1** to calculate the percentage of sunlight energy that would be transferred into the faeces and urine of a zebra. Give your answer to 3 significant figures.

[1 mark]

2.1 % × 12.7 % × 58.2 %

= 0.155 %

Answer = 0.155 %

0 1 . 3 In this ecosystem the net productivity of the vegetation is 24 525 kJ m^{-2} $year^{-1}$

Use this information and **Figure 1** to calculate the energy stored in new tissues of the zebra in kJ m^{-2} $year^{-1}$

24525 × 12.7% × 5.7 % = 177.536 ≈ 178 kJ m^{-2} $year^{-1}$ **[2 marks]**

0 4 . 3 In muscles, pyruvate is converted to lactate during prolonged exercise.

Explain why converting pyruvate to lactate allows the continued production of ATP by anaerobic respiration.

[2 marks]

NADH is oxidised back to NAD^+. NAD^+ is needed for glycolysis in which ATP is produced.

0 8 Scientists investigated the effect of a heat treatment on mass transport in barley plants.

- They applied steam to one short section of a leaf of the heat-treated plants. This area is shown by the arrows in **Figure 9**.
- They did not apply steam to the leaves of control plants.
- They then supplied carbon dioxide containing radioactively-labelled carbon to each plant in the area shown by the rectangular boxes in **Figure 9**.
- After 4 hours, they:
  - found the position of the radioactively-labelled carbon in each plant. These results are shown in **Figure 9**.
  - recorded the water content of the parts of the leaf that were supplied with radioactively-labelled carbon dioxide. These results are shown in **Table 4**.

Figure 9

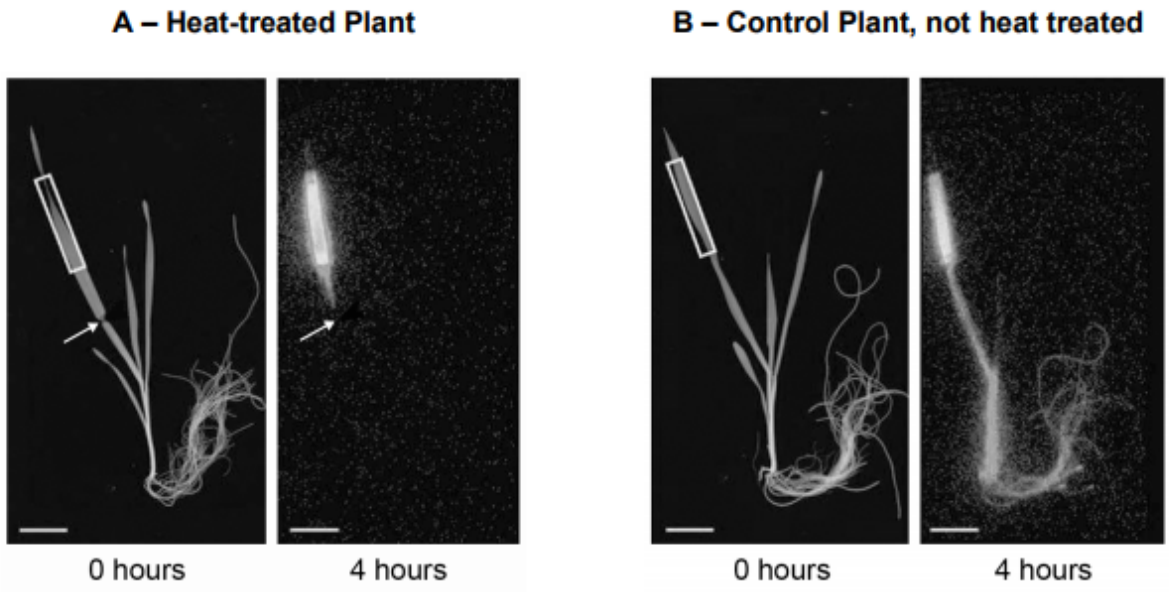


Table 4

Plant from which the leaf was taken	Water content of leaf / % of maximum (± 2 standard deviations)
Heat-treated Plant A	84.6 (±11.3)
Control Plant, not heat treated B	92.8 (±8.6)

0 8 . 1 The scientists concluded that this heat treatment damaged the phloem.

Explain how the results in **Figure 9** support this conclusion. **[2 marks]**

In the heat treated plant, radioactively labelled CO_2 is only found in the leaf whereas in the control it is found in other parts of the plant. This shows that CO_2 is taken in through the leaves and not transported through the phloem to other parts of the plant.

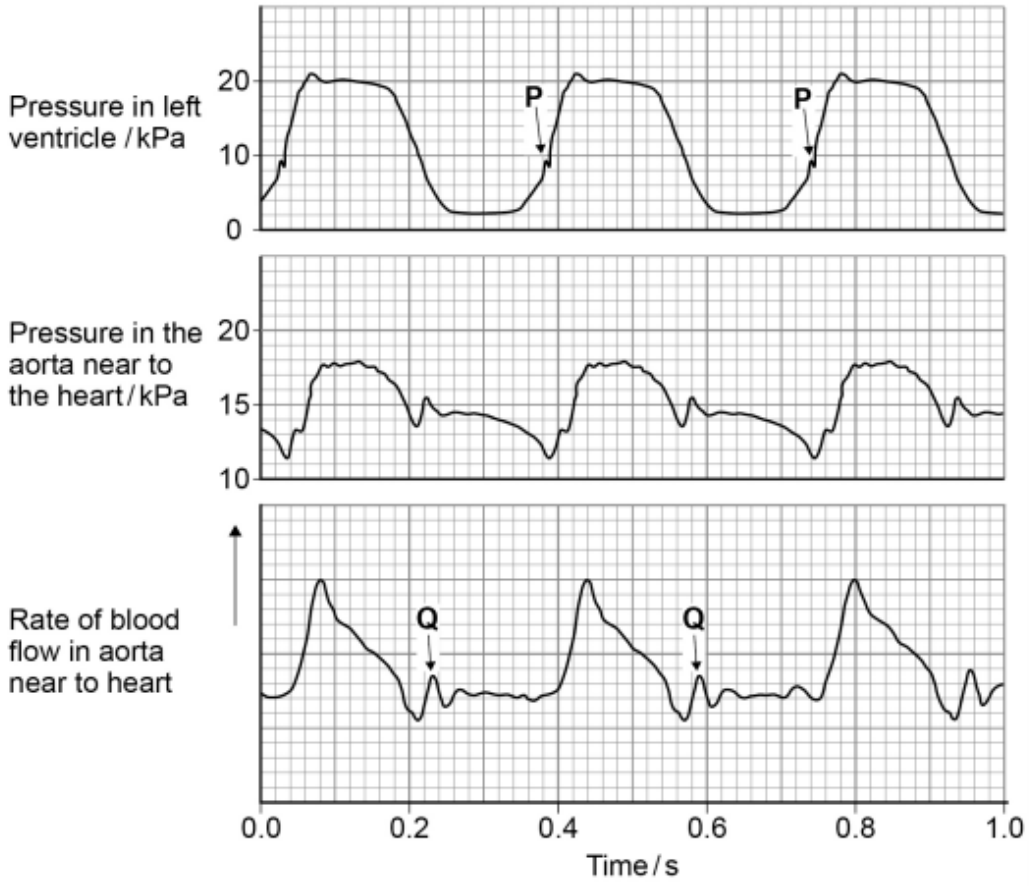
0 8 . 2 The scientists also concluded that this heat treatment did not affect the xylem.

Explain how the results in **Table 4** support this conclusion.

Although the mean water content for control is higher, the standard deviations overlap, suggesting there is no significant difference. water travels in the xylem so this shows that xylem is not damaged. **[2 marks]**

0 3 **Figure 3** shows pressure and blood flow during the cardiac cycle in a dog.

Figure 3



0 3 . 1 At **P** on **Figure 3**, the pressure in the left ventricle is increasing. At this time, the rate of blood flow has not yet started to increase in the aorta.

Use evidence from **Figure 3** to explain why.

Pressure in aorta near to the heart is still low. Aortic valve has not opened yet. **[2 marks]**

0 3 . 2 At **Q** on **Figure 3** there is a small increase in pressure **and** in rate of blood flow in the aorta.

Explain how this happens **and** its importance.

The aortic valve has closed so pressure increases. This forces blood through the semilunar valve. **[2 marks]**

0 3 . 3 A student correctly plotted the right ventricle pressure on the same grid as the left ventricle pressure in **Figure 3**.

Describe **one** way in which the student's curve would be similar to and **one** way it would be different from the curve shown in **Figure 3**.

The cycle will be the same but the pressure will always be lower in the right ventricle. **[2 marks]**

0 3 . 4 Use information from **Figure 3** to calculate the heart rate of this dog.

[1 mark]

3 beat s^{-1} = (3 × 60) beats min^{-1}

= 180

Heart rate 180 beats $minute^{-1}$

0 9 A scientist investigated the affinity for oxygen of horse haemoglobin and mouse haemoglobin.

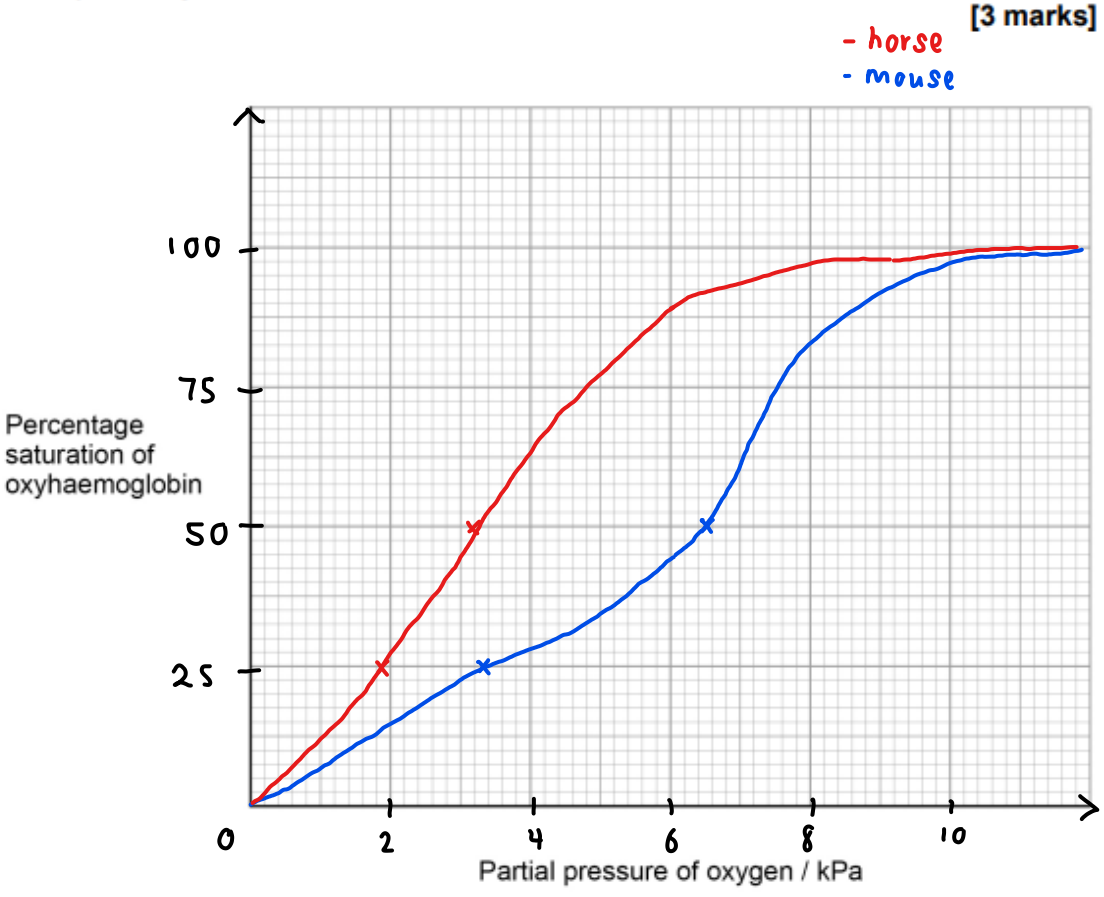
Some of their results are shown in **Table 7**.

Table 7

Animal	Partial pressure of oxygen when haemoglobin is 50% saturated / kPa	Partial pressure of oxygen when haemoglobin is 25% saturated / kPa	Body mass of one animal / g
Horse	3.2	1.9	550 000
Mouse	6.5	3.3	23

0 9 . 1 Plot the haemoglobin saturation data from **Table 7** and use these points to sketch the full oxyhaemoglobin dissociation curves for a horse and a mouse.

[3 marks]



0 9 . 2 The following equation can be used to estimate the metabolic rate of an animal.

$$\text{Metabolic rate} = 63 \times BM^{-0.27}$$

BM = body mass in grams

Use this equation to calculate how many times faster the metabolic rate of a mouse is than the metabolic rate of a horse.

[2 marks]

horse = $63 \times 550000^{-0.27}$

= 1.77599...

≃ 1.78

mouse = $63 \times 23^{-0.27}$

= 27.019

≃ 27.0

$\frac{27.0}{1.78} = 15.213$

≃ 15.2

Answer = 15.2 times faster

0 9 . 3 The data in **Table 7** show differences between the oxyhaemoglobin dissociation curve for a mouse and the oxyhaemoglobin dissociation curve for a horse.

Suggest how these differences allow the mouse to have a higher metabolic rate than the horse.

[2 marks]

At the same partial pressure of oxygen, the percentage saturation of haemoglobin is lower for mouse, which means more oxygen is released from haemoglobin and available for respiration.