Haemoglobin and Oxygen Transport: AQA A Level Biology Exam Questio

15 questions · 36 marks · about 47 minutes. Answer in the spaces, then check the mark schemes at the end.

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Question 1 · AS Paper 2 · June 2024 · Q09.1 · 5 marks

0 9 . 1 Describe the role of haemoglobin (Hb) in the loading, transport and unloading of oxygen.

[5 marks]

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Question 2 · A level Paper 3 · June 2018 · Q04.1 · 2 marks

0 4 . 1 Binding of one molecule of oxygen to haemoglobin makes it easier for a second oxygen molecule to bind.

Explain why.

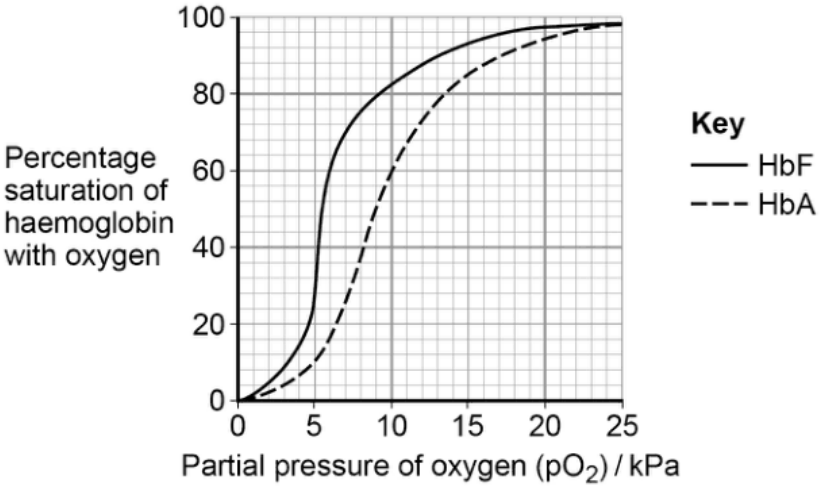
[2 marks]

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Question 3 · AS Paper 2 · June 2017 · Q05.1 · 2 marks

0 5 **Figure 5** shows the oxyhaemoglobin dissociation curves for fetal haemoglobin (HbF) and adult haemoglobin (HbA).

Figure 5



0 5 . 1 Explain how changes in the shape of haemoglobin result in the S-shaped (sigmoid) oxyhaemoglobin dissociation curve for HbA.

[2 marks]

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Question 4 · AS Paper 2 · June 2017 · Q05.2 · 2 marks

0 5 . 2 At birth 98% of the haemoglobin is HbF. By the age of 6 months, the HbF has usually completely disappeared from the baby's blood and been replaced by HbA.

Use **Figure 5** to explain why this change is an advantage for the baby.

[2 marks]

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Sickle cell disease (SCD) is caused by production of faulty HbA. This results in a reduced ability to transport oxygen to tissues. Scientists investigated the use of a substance called hydroxyurea to treat babies with SCD. Hydroxyurea changes the concentration of HbF in the blood.

The scientists carried out an investigation with 122 babies who had SCD. Each baby was given hydroxyurea for 41 months. The scientists then found the mean change in the concentration of HbF in the babies' blood.

Their results are shown in **Table 1**.

Table 1

Mean concentration of HbF in the babies' blood / arbitrary units	
Before treatment with hydroxyurea (±1 standard deviation)	**After treatment with hydroxyurea (±1 standard deviation)**
7.6 (±4.5)	19.1 (±6.5)

0 5 . 3 The scientists concluded that treatment with hydroxyurea would increase the concentration of oxygen in the blood of babies with SCD.

Suggest how **Figure 5** and **Table 1** support this conclusion.

[3 marks]

[Extra space]

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Question 6 · AS Paper 2 · June 2019 · Q02.1 · 2 marks

0 2 . 1 Describe and explain the effect of increasing carbon dioxide concentration on the dissociation of oxyhaemoglobin.

[2 marks]

Question 7 · A level Paper 3 · November 2020 · Q06.1 · 2 marks

0 6 . 1 Describe the advantage of the Bohr effect during intense exercise.

[2 marks]

Question 8 · information from earlier in the question

When a substance called BPG binds to haemoglobin, it reduces the affinity of haemoglobin for oxygen.

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Question 8 · A level Paper 3 · June 2022 · Q01.5 · 2 marks

0 1 . 5 Suggest and explain when it would be an advantage to a human for BPG to bind to haemoglobin.

[2 marks]

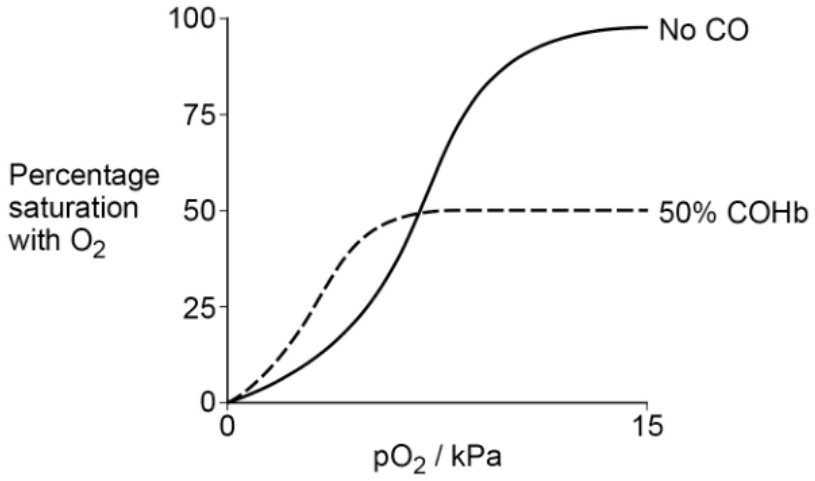
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0 7 . 1 Carbon monoxide (CO) is released during incomplete combustion of fossil fuels.

Figure 7 shows the dissociation curve for oxyhaemoglobin when:

- **not** exposed to CO
- exposed to CO such that 50% of the oxygen binding sites are occupied by CO (50% COHb).

Figure 7



Using **Figure 7**, what can you conclude about how exposure to CO affects the loading and unloading of oxygen by haemoglobin?

Explain your answer.

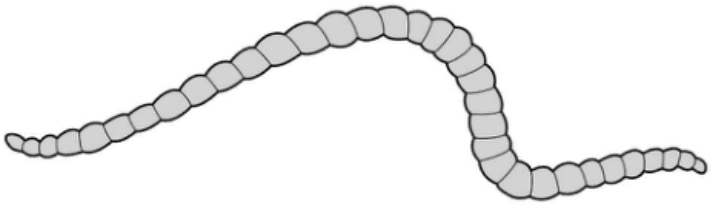
[3 marks]

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0 3 Tubifex worms are small, thin animals that live in water. They have no specialised gas exchange or circulatory system.

Figure 2 shows a tubifex worm.

Figure 2

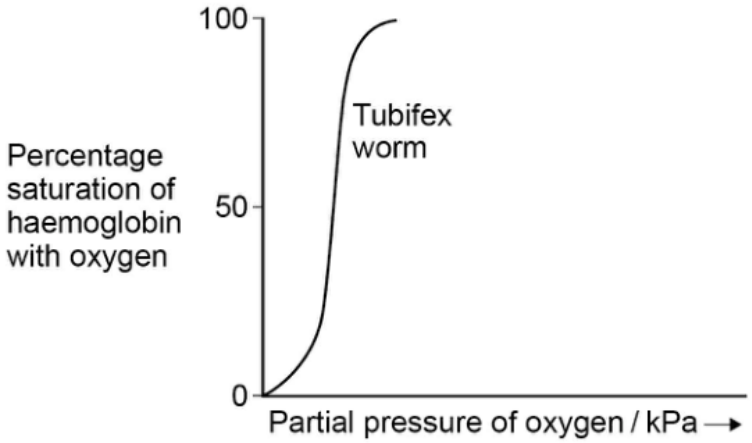


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0 3 . 3 Most species of tubifex worms live at the bottom of ponds, lakes and rivers where the partial pressure of oxygen is low. Pollution of water by sewage can cause the partial pressure of oxygen to fall below 0.2 kPa.

Figure 3 shows the oxyhaemoglobin dissociation curve for a species of tubifex worm found in a river polluted with sewage.

Figure 3



The species of tubifex worm in **Figure 3** has 50% saturation of their haemoglobin with oxygen at 0.08 kPa.

Explain how this enables this species to survive in water polluted with sewage.

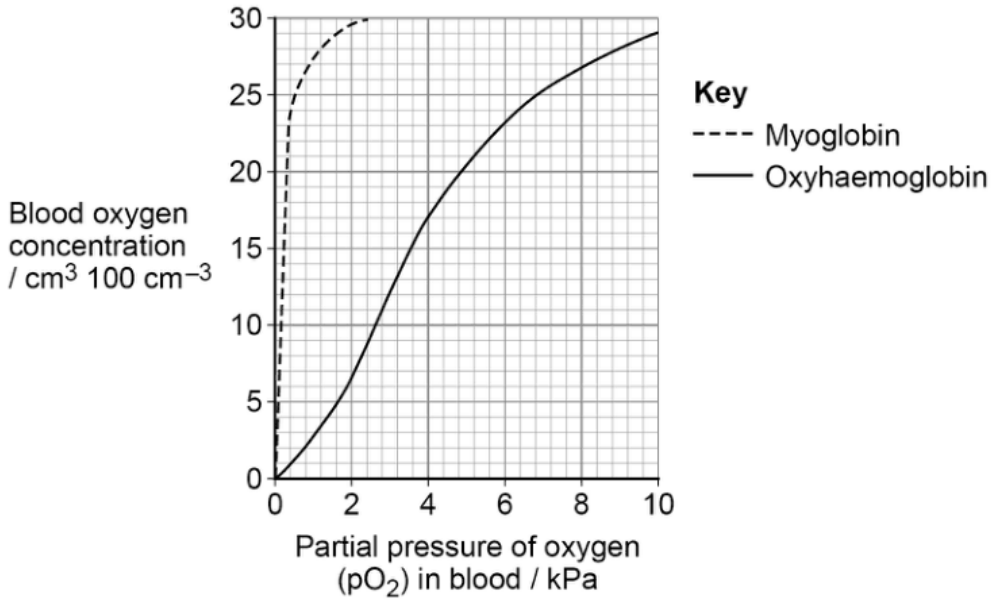
[2 marks]

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Seals are diving mammals. They fill their lungs with air before they dive and hold their breath during the dive.

Figure 3 shows the dissociation curves for seal oxyhaemoglobin and seal myoglobin. Myoglobin is an oxygen-carrying protein found in muscles.

Figure 3



0 2 . 2 Use information in **Figure 3** to explain how the seal's myoglobin dissociation curve shows the seal is adapted for diving.

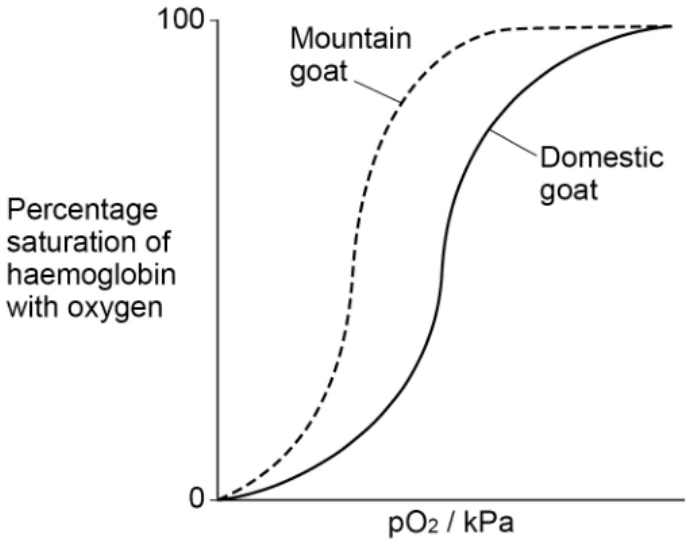
[2 marks]

[Extra space]

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Figure 2 shows the oxyhaemoglobin dissociation curve for two species of goat.

Figure 2



0 1 . 4 The mountain goat lives at high altitudes where the pO_2 is lower than where the domestic goat lives.

Use **Figure 2** to explain how the mountain goat is adapted to living at high altitudes.

[2 marks]

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Question 13 · information from earlier in the question

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

Question 13 · A level Paper 1 · June 2019 · Q09.3 · 2 marks

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]

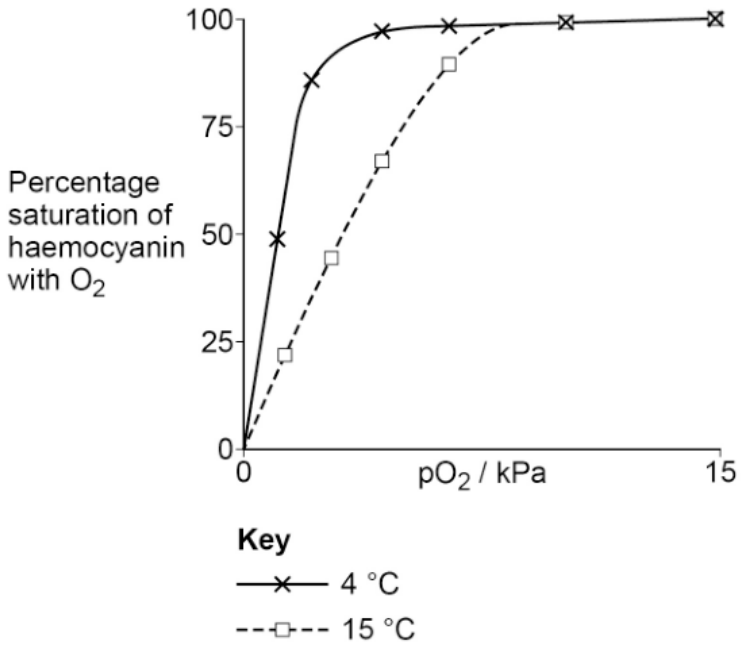
[Extra space]

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0 6 . 1 Crab blood contains the respiratory pigment haemocyanin.

Figure 3 shows the dissociation curve for oxyhaemocyanin in a species of crab at two temperatures.

Figure 3



Crabs use gills for gas exchange.

Use **Figure 3** to explain how the increase in temperature affects the ability of haemocyanin to load or unload oxygen at the gills **and** in tissues.

Refer to high pO_2 and low pO_2 in your answer.

[2 marks]

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

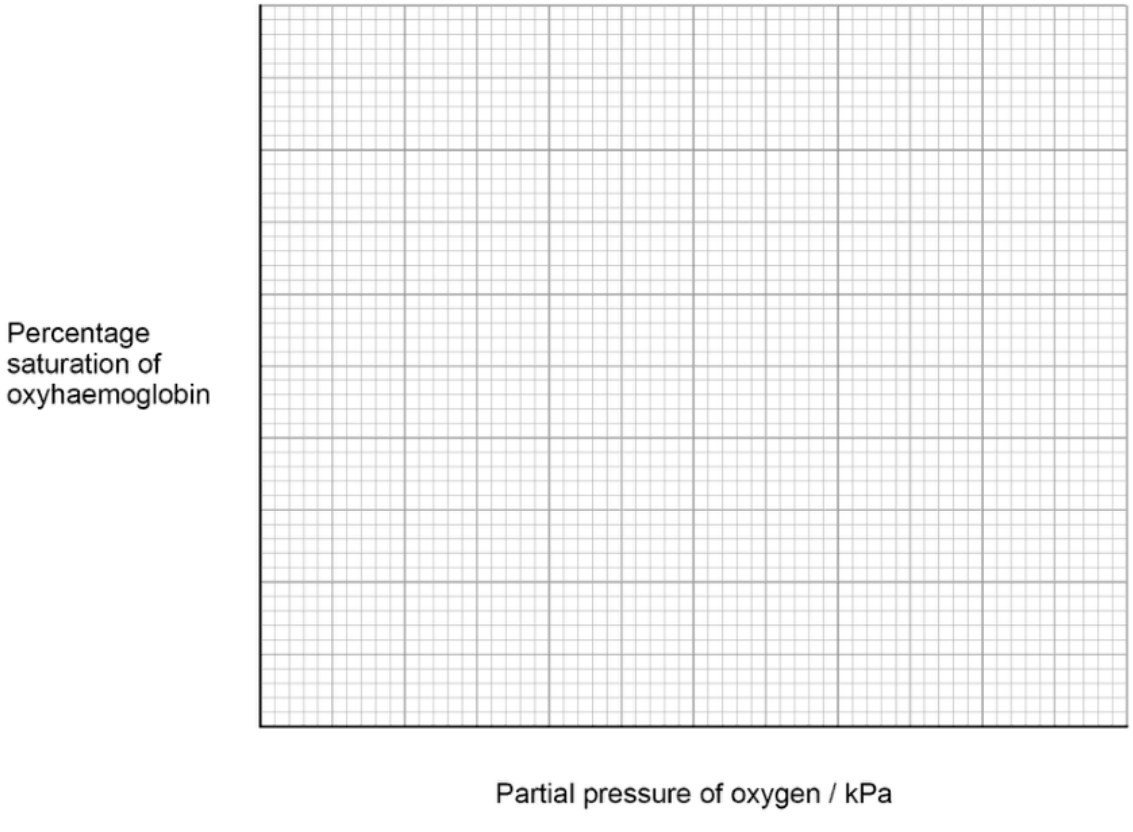
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0 9 . 1 Plot the haemoglobin saturation data from **Table 7** and use these points to sketch the full oxyhaemoglobin dissociation curves for a horse and a mouse.

[3 marks]



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Mark schemes

Question 1 · AS Paper 2 · June 2024 · Q09.1 · 5 marks

09.1	1. (Hb) loads/associates/binds oxygen in the lungs; 2. At high partial pressure of oxygen; 3. Binding of an oxygen (molecule to Hb) makes binding of another oxygen (molecule) easier; 4. (Oxygen transported as) oxyhaemoglobin in red blood cells; 5. (Hb) unloads/dissociates oxygen in the (respiring) cells/tissues; 6. At low partial pressure of oxygen **OR** At high partial pressure of carbon dioxide;	5 max (5 x AO1)

2. and 6. Accept pO_2 for partial pressure of oxygen.

6. Accept pCO_2 for partial pressure of carbon dioxide.

Question 2 · A level Paper 3 · June 2018 · Q04.1 · 2 marks

04.1	1. Binding of first oxygen changes tertiary / quaternary (structure) of haemoglobin; 2. Creates / leads to / uncovers second / another binding site **OR** Uncovers another iron / Fe / haem group to bind to;	2	Ignore ref. to 'positive cooperativity' unqualified Ignore ref. to named bonds 1. Accept conformational shift caused 2. Reject ref. to active site

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Question 3 · AS Paper 2 · June 2017 · Q05.1 · 2 marks

05.1	1. First oxygen binds (to Hb) causing change in shape; 2. (Shape change of Hb) allows more O_2 to bind (easily) / greater saturation with O_2 OR Cooperative binding;	2	

Question 4 · AS Paper 2 · June 2017 · Q05.2 · 2 marks

05.2 1. (HbA has) lower affinity for O_2 at low partial pressures; 2

OR

(HbA has) lower affinity for oxygen at pp found in tissues;

2. Easier unloading of O_2 for (aerobic) respiration;

Question 5 · AS Paper 2 · June 2017 · Q05.3 · 3 marks

05.3 1. A large/significant increase in HbF; 3

2. (HbF has) higher affinity for O_2 (than faulty HbA);

3. Higher proportion of HbF in blood so more oxygen carried;

OR

More oxygen carried after treatment;

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Question 6 · AS Paper 2 · June 2019 · Q02.1 · 2 marks

02.1	1. Increases/more oxygen dissociation/unloading **OR** Deceases haemoglobin's affinity for O_2; 2. (By) decreasing (blood) pH/increasing acidity;	2	1. Accept more readily 1. Accept releases more O_2 2. Reject if reference made to active site

Question 7 · A level Paper 3 · November 2020 · Q06.1 · 2 marks

06.1	1. Increases dissociation of oxygen; 2. For <u>aerobic</u> respiration at the tissues/muscles/cells **OR** Anaerobic respiration delayed at the tissues/muscles/cells **OR** Less lactate at the tissues/muscles/cells;	2	1. Accept unloading/ release/reduced affinity for dissociation

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Question 8 · A level Paper 3 · June 2022 · Q01.5 · 2 marks

01.5	1. During exercise **OR** At low pO_2 (in the tissues); 2. (Allowing) **more** oxygen for respiration **OR** (Allowing) **more** aerobic respiration **OR** To delay anaerobic respiration;	2 (2 x AO3)	1. Accept 'high altitude' or 'lack of red blood cells' for 'exercise' 1. Accept when there is a high pCO_2 (in the tissues) 1. Accept at low concentration of O_2 (in the tissues) 2. Accept descriptions of aerobic respiration, eg more oxygen to act as a terminal electron acceptor 2. Accept oxygen can unload/dissociate eas**ier**/**more** readily for respiration

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07.1	1. Less (oxygen) loaded at high pO_2 (compared with no CO) **OR** Maximum Hb saturation is 50% (oxygen); 2. (At low pO_2) Hb has higher affinity (for oxygen); 3. Hb has more oxygen at low pO_2 **OR** Hb unloads less oxygen at low pO_2;

3 (1 x AO2, 2 x AO3)	Ignore references to 'binding sites occupied by CO' 1. Accept 'in lungs' for 'high pO_2' 1. Accept 'levels (off)' OR 'plateau at 50%' for maximum 1 Accept 'only 50%' for 'maximum (of) 50%' 3. Accept 'in (respiring) cells/tissues' for 'low pO_2/cells' 3. Ignore 'more loading of oxygen at low pO_2' 3. Accept 'less readily' for less

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Question 10 · AS Paper 2 · June 2016 · Q03.3 · 2 marks

03.3	1. High/50% saturation (with oxygen) below (pO_2 of) 0.2 kPa; 2. (Oxygen) for respiration;	2	1. Accept: fully saturated **or** above 50% saturation below 0.2kPa. 1. Accept: any number between 0.08 and 0.2 kPa

Question 11 · AS Paper 2 · June 2019 · Q02.2 · 2 marks

02.2	1. High(er) affinity for O_2 (than haemoglobin) **OR** Dissociates oxygen less readily **OR** Associates more readily; 2. Allows (aerobic) respiration when diving/at low(er) pO_2 **OR** Provides oxygen when haemoglobin unloaded **OR** Delays anaerobic respiration/lactate production;	2

1. Accept holds O_2 at lower ppO_2

2. Accept acts as an oxygen store

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Question 12 · AS Paper 2 · June 2025 · Q01.4 · 2 marks

01.4	1. Loads/associates with oxygen more readily at low(er) partial pressures **OR** Has a higher affinity for oxygen at lower partial pressures; 2. (Supplies tissues with sufficient) oxygen for respiration;

2 (2 x AO2)	1. Accept low(er) pO_2 for lower partial pressures 1. Accept low(er) KPa

Question 13 · A level Paper 1 · June 2019 · Q09.3 · 2 marks

9.3	1. Mouse <u>haemoglobin/Hb</u> has a lower affinity for oxygen **OR** For the same pO_2 the mouse <u>haemoglobin/Hb</u> is less saturated **OR** At oxygen concentrations found in tissue mouse <u>haemoglobin/Hb</u> is less saturated; 2. **More** oxygen can be dissociated/released/unloaded (for metabolic reactions/respiration);	2	1. For 'Hb is less saturated' accept 'less oxygen will be bound to Hb'. 2. Accept 'oxygen dissociated/released/unloaded **more** readily/easily/quickly' 2. Reject 'oxygen loaded more readily/easily/quickly' or 'more oxygen loaded'

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06.1	1. At low pO_2/in tissues, Hc unloads more O_2 at high(er) temperature/15°C **OR** At low pO_2/in tissues, Hc (O_2) affinity decreased at high(er) temperature/15°C; 2. At high pO_2/in gills, temperature (change) has no effect on (O_2) loading **OR** At high pO_2/in gills, temperature (change) has no effect on (changing) Hc (O_2) affinity;

2 (2 x AO2)	Accept pO_2 figures below 7 for 'low pO_2' Accept pO_2 figures above 7 for 'high pO_2' 1 Reject references at low pO_2/tissues to Hc being loaded 1. Accept reference at low pO_2/tissues to unloading less readily/has high(er) affinity at low(er) temperature/ 4°C 1. Accept 'more readily'/quicker' for 'more oxygen' 2 Reject references at high pO_2/gills to Hc being unloaded

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Question 15 · A level Paper 1 · June 2019 · Q09.1 · 3 marks

9.1	1. y axis 0 – 100 in linear scale **and** x axis minimum 1 to 8 in linear scale **and** both axes use at least half size of grid; 2. Correct plots for 50% and 25% for both animals; 3. Both curves levelling off (at higher partial pressures and at percentage saturations ≤100%);	3	1. If tick marks are used on the axis, they must be accurate to within ± half a small square. 2. 25% - 1.9, 3.3 and 50% - 3.2 and 6.5 2. Accept plot ± half a small square.

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