

PEARSON EDEXCEL A-LEVEL BIOLOGY B • 9B10

BIOLOGY



EXAM QUESTION PACK

TOPIC 4: EXCHANGE AND TRANSPORT
TRANSPORT OF GASES IN THE BLOOD

SCORE

/59

PERCENTAGE

%

STEMUP

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Q1.

The Northern elephant seal is a mammal found in the Eastern Pacific Ocean.



In the nineteenth century, Northern elephant seals were hunted and this reduced the population to about 20 seals.

The seals were listed as an Appendix II species when CITES was established in the 1970s.

The population has now recovered to over 100 000 individuals.

The seals in this population have developed health problems, including a high mortality rate for newborn pups, deformities and weak immune systems.

Northern elephant seals are able to dive to great depths and hold their breath for up to two hours.

The tables show data for four diving mammals.

Species	Maximum time holding breath / min	Maximum diving depth / m	Mass of animal / kg
bottlenose dolphin	5	20	200
harbour seal	17	19	24
Weddell seal	82	400	400
Northern elephant seal	119	437	400

Species	Volume of oxygen in body / $\text{cm}^3 \text{ kg}^{-1}$	Concentration of haemoglobin in blood / g dm^{-3}	Total blood volume / $\text{cm}^3 \text{ kg}^{-1}$	Percentage of stored oxygen in different body tissues		
				lungs	blood	muscle
bottlenose dolphin	36	14	71	34	27	39
harbour seal	57	21	132	13	54	33
Weddell seal	87	210	173	5	66	29
Northern elephant seal	97	216	207	4	71	25

(i) Calculate the total mass of haemoglobin in a Northern elephant seal.

(3)

* (ii) Analyse the data to explain how marine mammals are adapted for diving.

[illegible]

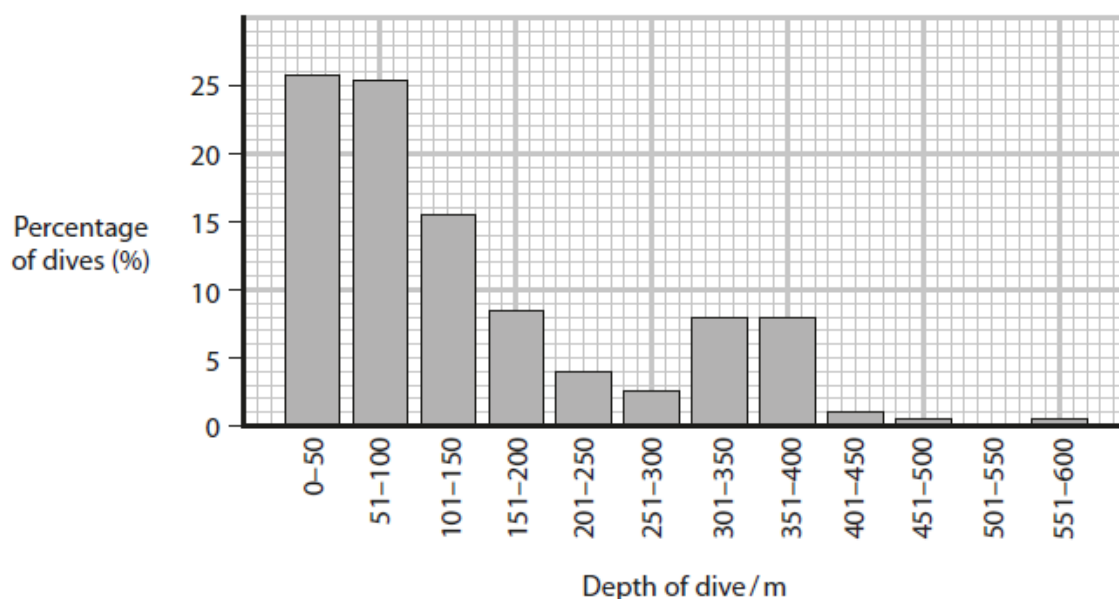
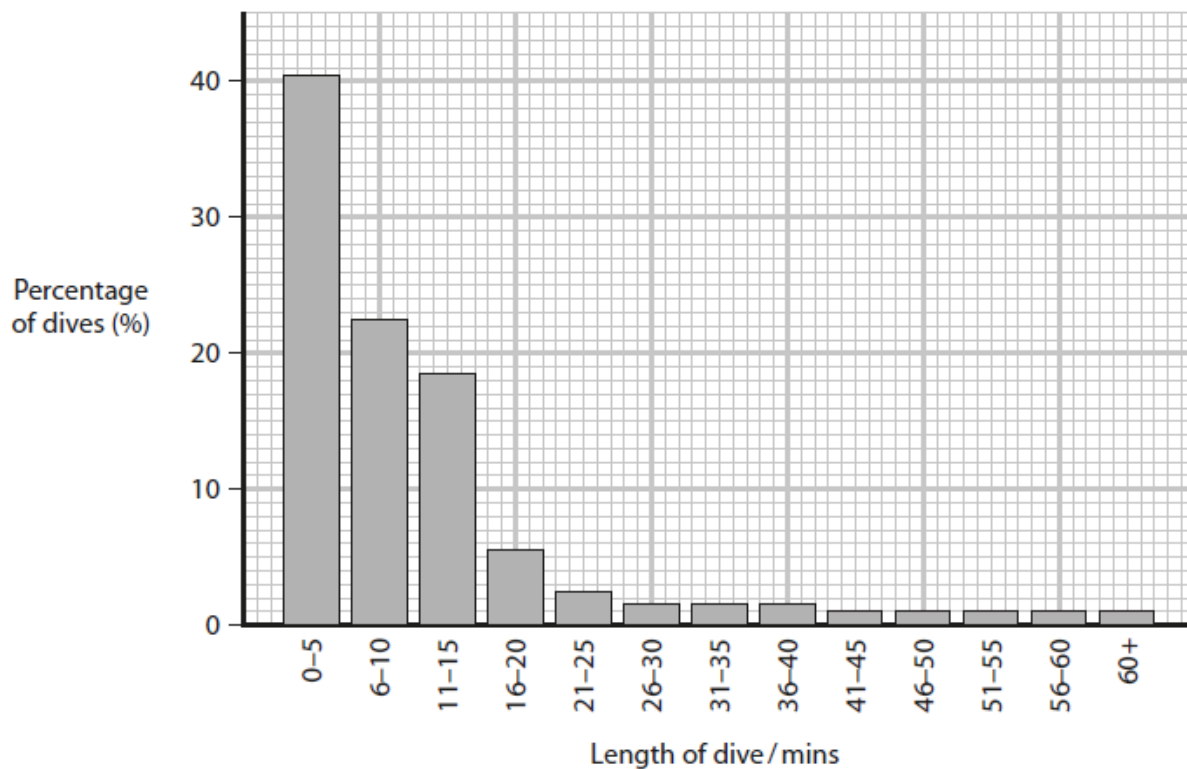
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Q2.

Weddell seals spend a lot of their time swimming underwater, diving to find food and diving to avoid predators.

However, they do have to come to the surface to breathe.

The graphs give some information about dives by Weddell seals.



Comment on the conclusions that can be made about the dives of these seals.

(4)

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(Total for question = 4 marks)

Q3.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Weddell seals spend a lot of their time swimming underwater, diving to find food and diving to avoid predators.

However, they do have to come to the surface to breathe.

Weddell seals carry higher concentrations of oxygen in their bodies than humans.

(i) The haemoglobin of Weddell seals is adapted to carry higher levels of oxygen than the haemoglobin of humans, at each partial pressure of oxygen.

Which row of the table describes the haemoglobin of the Weddell seal?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

Weddell seals.

lungs	12	3
blood	10	58
muscle	2	23
body fluids, other than in the blood	2	2

during deep dives.

Analyse the data to explain the differences between these two mammals.

(6)

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page. There are no margins, text, or other markings on the paper.

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(Total for question = 7 marks)

Q4.

Malaria causes serious problems for pregnant women. They often suffer from a condition known as anaemia in which the ability of the blood to carry oxygen is significantly reduced.

Explain how malaria causes anaemia.

(2)

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(Total for question = 2 marks)

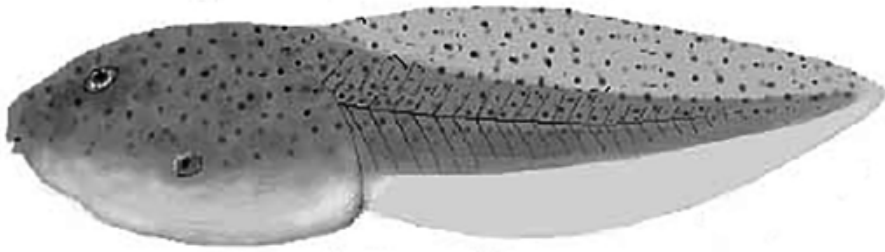
Q5.

The adult American bullfrog, *Rana catesbeiana*, can live in water or on land.

Adult frogs lay eggs in water where they are fertilised.

The fertilised eggs develop into tadpoles that live only in water.

The photograph shows a tadpole.



(i) Human activity can cause pollution that reduces the oxygen concentration in water.

Explain why a low oxygen concentration in the water would lower the pH of the blood of the tadpole.

(3)

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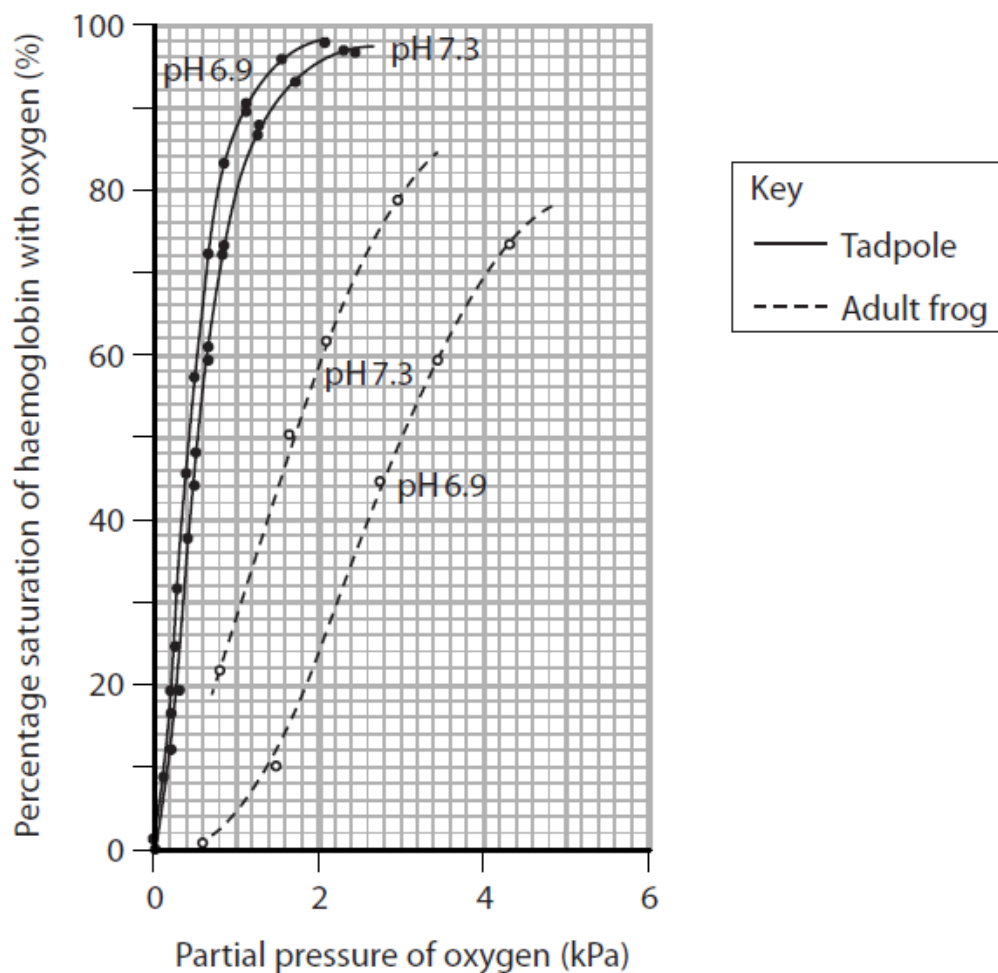
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*(ii) The graph shows the effect of pH on the oxygen dissociation curves of haemoglobin for adult frog blood and tadpole blood.



The adult frog can either live on land or in water. The tadpole always lives in water.

Discuss how the shape and position of the dissociation curves reflect the habitat in which these animals live.

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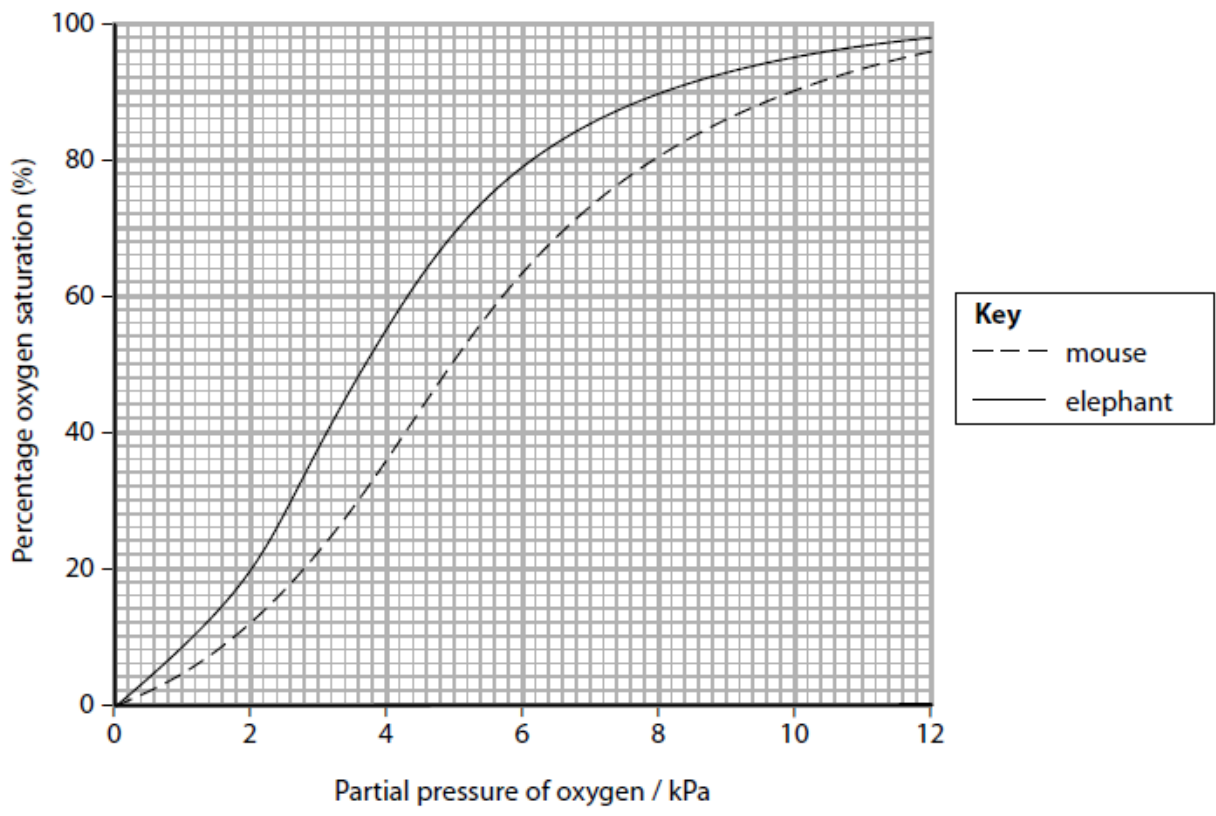
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(Total for question = 12 marks)

Q6.

The graph below shows the oxygen haemoglobin dissociation curves for a blood sample from an elephant and a mouse.



(a) Use the information in the graph to determine the difference in percentage saturation between elephant haemoglobin and mouse haemoglobin at a partial pressure of oxygen of 4 kPa.

(1)

Answer

*(b) Explain the effect that body size has on the metabolic rate of these two mammals.

(6)

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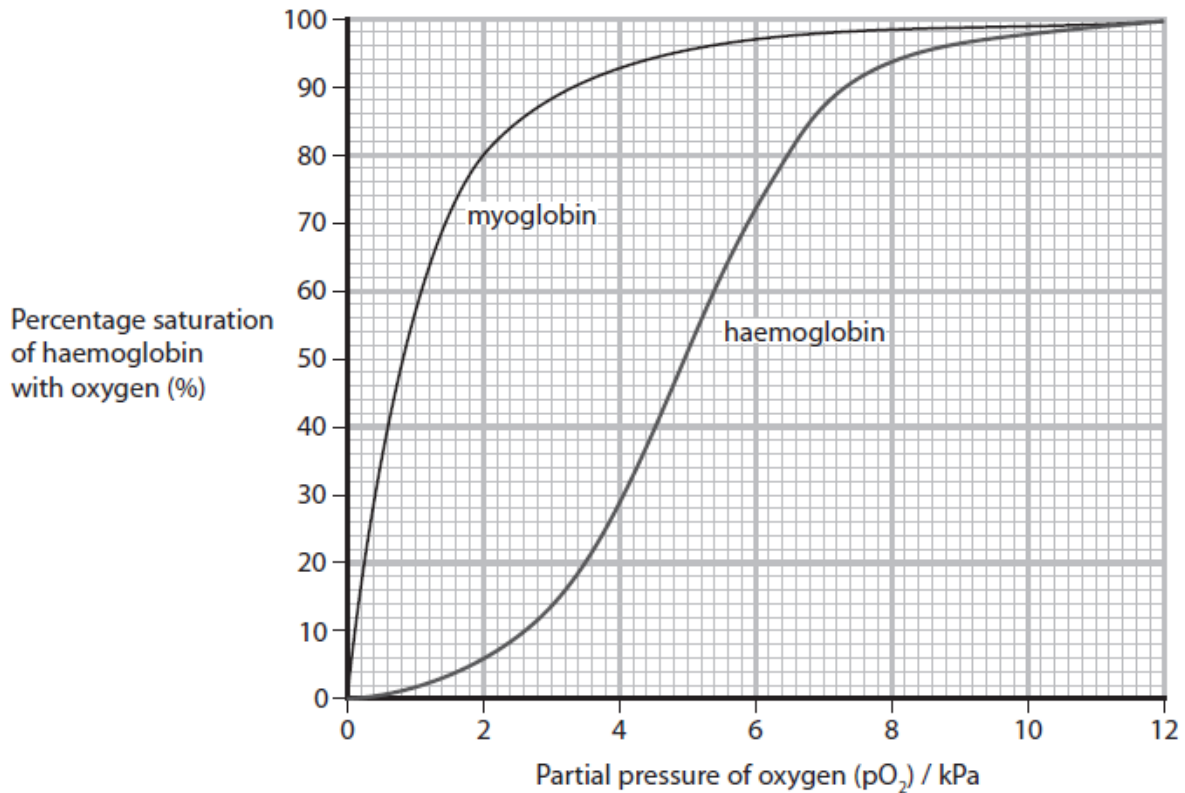
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(Total for question = 7 marks)

Q7.

The graph shows the oxygen dissociation curves of human haemoglobin and human myoglobin.



(i) Calculate the volume of oxygen bound to haemoglobin at a partial pressure of oxygen of 6 kPa in 100 cm³ blood.

The concentration of haemoglobin is 15 g per dm³ blood.

When fully saturated, there is 1.36 cm³ oxygen per g of haemoglobin.

(3)

Answer

(ii) Explain why the oxygen dissociation curves for haemoglobin and myoglobin are different.

(4)

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(Total for question = 7 marks)

Q8.

The photograph shows a glacier that is melting. As the glacier gradually melts, it leaves behind bare rock.



melting glacier

(Source: © CHARLES D. WINTERS/SCIENCE PHOTO LIBRARY)

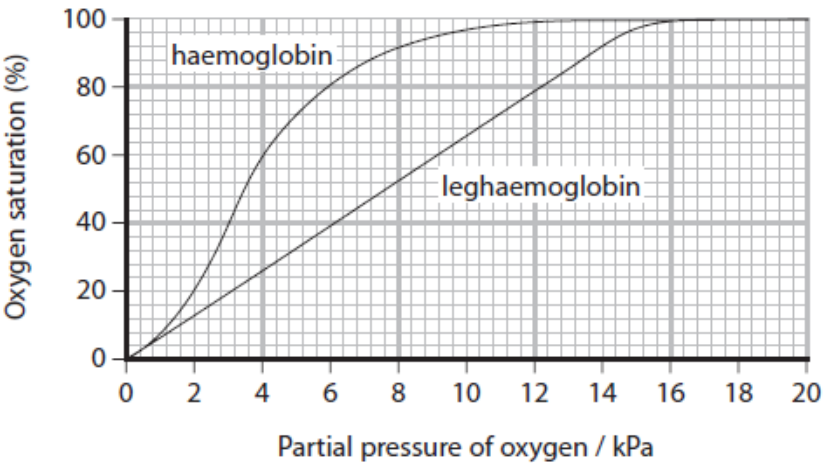
Scientists sampled the soil from areas that had been uncovered for different lengths of time after the glacier ice had melted.

The table shows the results from the samples.

Length of time since glacier melted / years	Soil depth / cm	Mass of nitrate in soil / mg m^{-2}	Mass of leaf litter that falls to ground each year / $\text{g m}^{-2} \text{yr}^{-1}$
5	5.2	3.8	1.5
15	6.4	4.1	1.7
40	7.0	5.3	12.8
100	9.2	21.8	277.0
150	10.8	35.4	335.0
200	15.1	53.3	277.0
250	16.2	61.4	261.0

The roots of some of the plants growing around the glacier were found to contain an oxygen binding protein called leghaemoglobin.

The graph shows the oxygen dissociation curve for leghaemoglobin and the oxygen dissociation for haemoglobin.



(i) Leghaemoglobin is a protein that is similar in structure to myoglobin. Both of these proteins have one subunit.

Explain how the oxygen dissociation curve shows that the structure of leghaemoglobin is more similar to myoglobin than to haemoglobin.

(3)

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(ii) Explain how leghaemoglobin enables these plants to grow in waterlogged and compact soils.

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(Total for question = 6 marks)

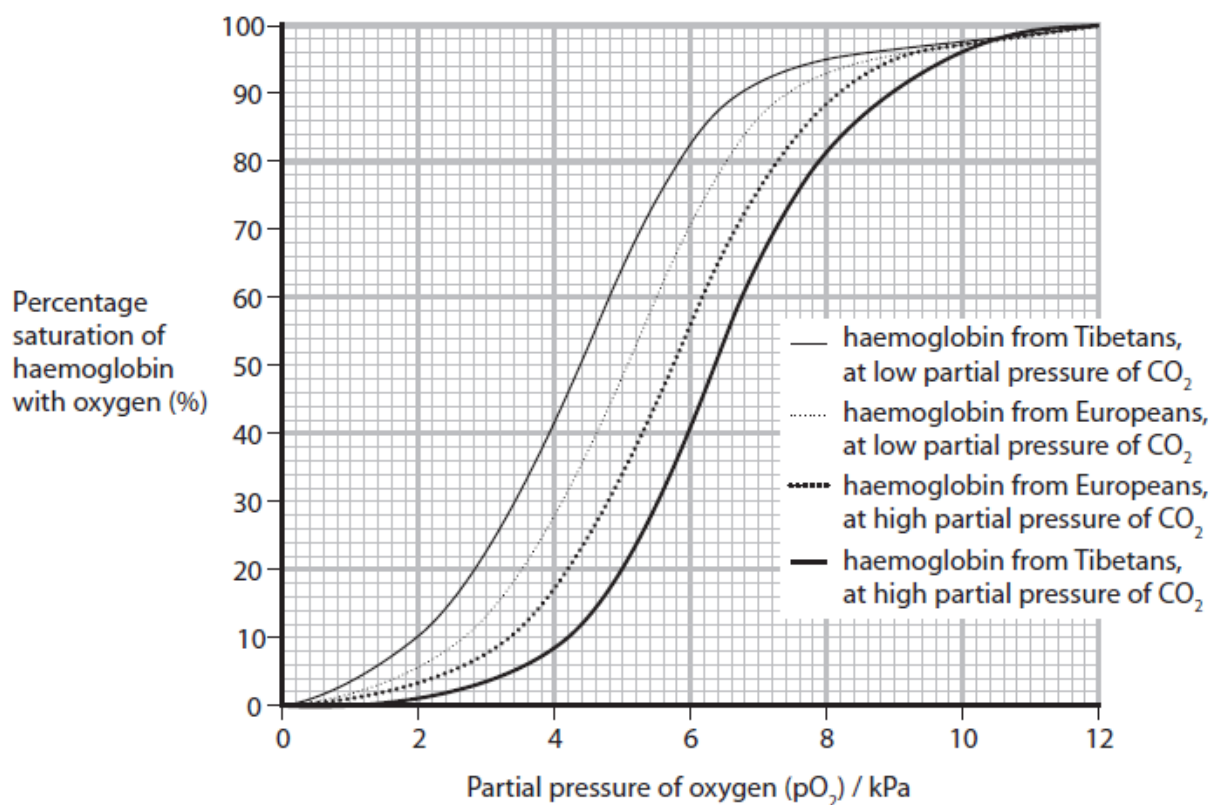
Q9.

In an investigation, the oxygen dissociation of haemoglobin from Tibetan people and European people was compared.

The Tibetan people were living at high altitude.

The European people were living at low altitude.

The graph shows the results of this investigation.



Comment on the oxygen dissociation curves of the Tibetan people.

(4)

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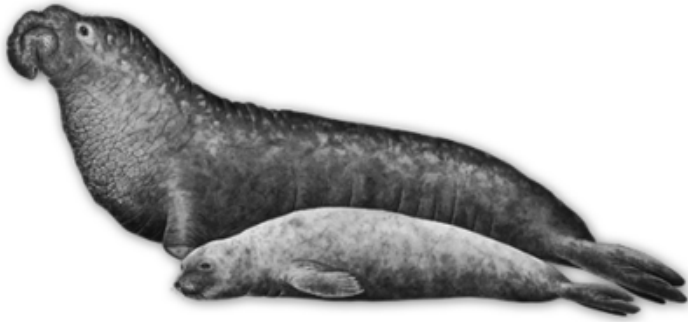
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(Total for question = 4 marks)

Q10.

The Northern elephant seal is a mammal found in the Eastern Pacific Ocean.



In the nineteenth century, Northern elephant seals were hunted and this reduced the population to about 20 seals.

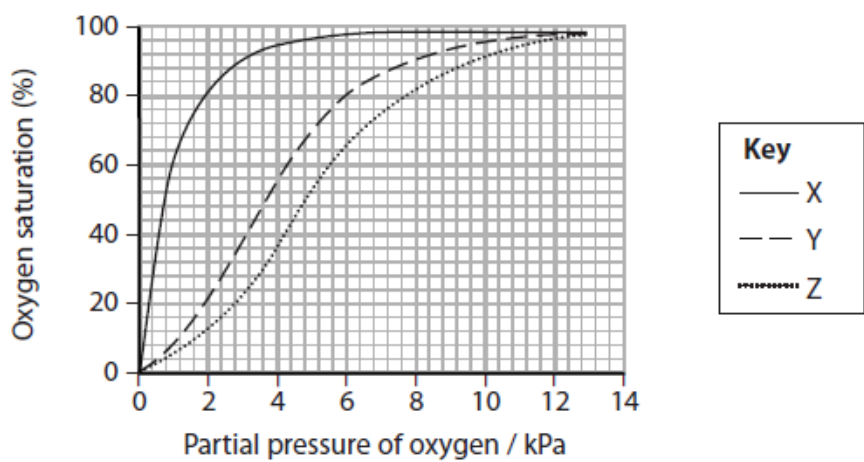
The seals were listed as an Appendix II species when CITES was established in the 1970s.

The population has now recovered to over 100 000 individuals.

The seals in this population have developed health problems, including a high mortality rate for newborn pups, deformities and weak immune systems.

Northern elephant seals have a high concentration of haemoglobin in their blood.

The graph shows the oxygen dissociation curves for myoglobin, adult haemoglobin and fetal haemoglobin.



Which of the rows correctly matches each curve with myoglobin, adult haemoglobin and fetal haemoglobin?

(1)

	Myoglobin	Adult haemoglobin	Fetal haemoglobin
☒ A	X	Y	Z
☒ B	X	Z	Y
☒ C	Y	Z	X
☒ D	Z	X	Y

(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	- total blood volume in one seal (1) - conversion of g dm^{-3} to g cm^{-3} (1) - total mass of haemoglobin (concentration of haemoglobin x volume of blood in a seal) (1)	<u>Example of calculation:</u> $400 \times 207 = 82800 \text{ cm}^3$ Accept calculation of total haemoglobin per $\text{cm}^3 \text{ kg}^{-1}$ blood: $207 \times 216 = 44712$ Accept calculation of concentration of haemoglobin in one seal: $216 \times 400 = 86400$ $216 \div 1000 = 0.216 \text{ g cm}^{-3}$ $0.216 \times 82800 = 17885 \text{ g}$ Correct answer with no working gains full marks Accept for two marks a correct answer with no units / wrong units Accept for three marks: $17884.8 \text{ g} / 17880 \text{ g} / 17890 \text{ g} / 17900 / 18000 \text{ g} / 17.8848 \text{ kg} / 17.885 \text{ kg} / 17.89 \text{ kg} / 17.9 \text{ kg} / 18 \text{ kg}$	(3)

Question Number	Indicative content
(ii) *	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. <u>A: Depth and diving:</u> • positive correlation between maximum depth and maximum time holding breath • weak positive correlation between mass of animal and depth • weak correlation between maximum time holding breath and mass of mammal • because diving deeper requires larger oxygen storage as can't breathe underwater • aerobic respiration requires oxygen to release energy <u>B: Blood and muscle:</u> • positive correlation between volume of oxygen in body and maximum depth • positive correlation between concentration of haemoglobin in blood and maximum depth • no correlation between oxygen stored in muscle and maximum depth • all the mammals must possess myoglobin acting as an oxygen store in muscle • bottlenose dolphin and harbour seal have more oxygen stored in lungs / Weddell seal and Northern elephant seal have less oxygen stored in lungs • oxygen stored in lungs results in more buoyancy so deeper diving mammals have less stored in lungs • combined effect of high blood volume and haemoglobin concentration results in very high blood oxygen storage • more oxygen stored in blood so higher haemoglobin concentration and blood volume in animals that dive deeper • all have similar proportions of oxygen stored in muscle <u>Quantitative analysis</u> • Q1: quoting of data to support explanation • Q2: manipulation of data to support explanation, for example, determining total haemoglobin concentrations in mammals.

Level	Marks	
0	0	No awardable content
1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. Level 1: Description of some patterns from at least one of A or B
2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. The discussion shows some linkages and lines of scientific reasoning with some structure. Level 2: Description of patterns with explanation from at least one of A or B
3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. Level 3: Detailed description and explanation of patterns from both A and B with quantitative analysis (Q)

Q2.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to four of the following: - as the length of the dive increases and the depth of the dive increases, the percentage decreases (1) - appropriate conclusion about percentage and length of dive (1) - no information about how long the longest dive lasts (1) - appropriate conclusion about depth of dive (1) - no information on the length of time that dives at different depths last (1)	NB piece together e.g. most dives last less than 16 to 20 minutes some dives can last as long as an hour e.g. most dives are up to 100 to 200 metres some dives may be as deep as 600 metres	(4)

Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	The only correct answer is A <i>B is incorrect because the haemoglobin would have a higher affinity for oxygen</i> <i>C is incorrect because the curve would be to the left</i> <i>D is incorrect because the curve would be to the left</i>		(1)

Question Number	Indicative content	
* (ii)	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content • less oxygen stored in seal's lungs • so that more is delivered to the body • reduces buoyancy • cannot be replenished as diving • lungs of seal must be able to diffuse oxygen into blood faster • therefore {larger surface area / faster blood flow} • blood of seal carries more oxygen • because their haemoglobin has a higher affinity for oxygen • blood of seal carries more oxygen because they release erythrocytes from the spleen • therefore can supply more oxygen to muscles for aerobic respiration • to release ATP for muscle contraction • muscles of seal have more myoglobin • therefore can store more oxygen until oxygen tensions are very low • so that aerobic respiration can take place • to release ATP for muscle contraction • anaerobic respiration would not supply enough ATP for muscle contraction	Level 1: 1 mark = 1 comparison 2 marks = 3 comparisons Level 2: 3 marks = 1 set of data simply explained 4 marks = 2 sets of data simply explained Level 3: 5 marks = 3 sets of data explained with links to diving and muscles 6 marks = 4 sets of data explained with links to diving and muscles

	• body fluids store the same level of oxygen • because they do not have a role in storing oxygen • small concentrations in body fluids, as oxygen is dissolved in it for diffusion into cells	
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Q4.

Question Number	Correct Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • malarial {parasite/merozoite} {invades/destroys} red blood cells (1) • therefore reduced haemoglobin {red cell count} which causes anaemia (1)		(2)

Q5.

Question Number	Answer	Mark
(i)	An explanation that makes reference the following: • anaerobic respiration takes place (1) • therefore {lactic acid / lactate} is produced (1) • because pyruvate reduced / NADH oxidised / NADH converted to NAD⁺ / NADH donates H⁺ or proton or e⁻ (1)	(3)

Question Number	Indicative content
* (ii)	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Description: D shape of curve is sigmoid / S-shaped tadpole curves are steeper tadpole curves are further to the left than frog curves lower pH moves curve to left in tadpole lower pH moves curve to the right in frog tadpole curves are closer together than frog curves reference to correct comparative % ONCE Explanation: E at higher ppO_2 blood more saturated / as ppO_2 increases saturation increases at lower ppO_2 blood less saturated / as ppO_2 decreases saturation decreases tadpole is more saturated at lower ppO_2 tadpole more dissociation with change in ppO_2 tadpole has higher % saturation than frog tadpole blood has greater affinity than blood movement lowers pH in blood Bohr shift in frog conformational change makes binding easier steep part of curve means small change in ppO_2 causes large change in percentage saturation top part of curve represents situation in gills or lungs bottom part of curve represents situation in tissues Habitat: H less oxygen in water than in air / ppO_2 in water lower than ppO_2 in air (lowering pH) tadpole is more able to obtain oxygen from polluted water (lowering pH) frog more able to release oxygen to tissues during exercise / activity / movement adaptations allow tadpole / frog to survive harder to move in water than on land

Level	Marks	
0	0	No awardable content
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. 1 to 3 from D, E or H
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure. 1H and 4 to 6 in total
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts.
		Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. 2H and 7 to 9 plus in total

Q6.

Question Number	Correct Answer	Additional guidance	Mark
(a)	56 - 36 = 20 (1)		(1)

Question Number	Indicative content	
(b)*	Answers will be credited according to the candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The Indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • Dissociation curve for mouse haemoglobin is to the right of the curve for elephant haemoglobin • Mouse haemoglobin has a lower affinity for oxygen • Mouse haemoglobin allows more dissociation • Mouse has bigger surface area to volume ratio • Mouse loses more heat / needs to regenerate more heat • Maintenance of body temperature • Mouse has higher metabolic rate • Mouse needs more oxygen • Accept converse answers for elephant	
Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.
Level 2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts to provide the explanation being presented. Lines of argument occasionally supported through the application of relevant evidence (scientific ideas, processes, techniques and procedures). The explanation shows some linkages and lines of reasoning with some structure.
Level 3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts to provide the explanation being presented. Line(s) of argument supported throughout by sustained application of relevant evidence (scientific ideas, processes, techniques and procedures). The explanation shows a well-developed and sustained line of reasoning which is clear, coherent and logically structured.

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	- correct value from graph (1) - correct calculation of oxygen in 1 g of haemoglobin (1) - correct calculation of oxygen in 100 cm³ of blood (1)	72 % $72 / 100 \times 1.36 = 0.9792$ 1.47 / 1.469 / 1.4688 cm³ Correct answer gains full marks	3

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to four of the following: - myoglobin (is on the left because) has a higher affinity for oxygen / binds more tightly to oxygen (1) - therefore it acts as a store for oxygen / only releases oxygen when oxygen is low (1) - haemoglobin is sigmoidal / S shaped / myoglobin is not S shaped (1) - as oxygen binds cooperatively (1) - so that the affinity varies depending on how much oxygen is bound (1)	Accept converse for oxygen e.g. haemoglobin releases oxygen more easily Accept correct description	4

Q8.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to three of the following points: • (leghaemoglobin / myoglobin) is not S shaped / is linear / is a straight line (1) • because (leghaemoglobin / myoglobin) affinity for oxygen does not alter (1) • because (with leghaemoglobin) there is no cooperative binding (1) • (leghaemoglobin) binds to one molecule (of oxygen) (1)	Accept converse for haemoglobin Accept converse for haemoglobin Accept converse for haemoglobin Accept shape change to subunits / conformation change Accept (leghaemoglobin / myoglobin) has only one oxygen binding site Accept haemoglobin has four binding sites / binds to four molecules of oxygen	3 exp

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following points: • (waterlogged soil has) little / low / less / no oxygen (1) • (leghaemoglobin) provides oxygen for respiration (1) • which enables active uptake of mineral ions / named mineral ion (1) • such as (calcium) to make calcium pectate / (nitrate) to make amino acids / (magnesium) to make chlorophyll (1)	Accept binds to / stores oxygen for respiration Accept other correct active processes e.g. synthesis of amino acids / protein synthesis / mitosis Accept other correct examples of minerals with functions	3 exp

Q9.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to four of the following: - the (Tibetan haemoglobin) has a higher affinity for oxygen (1) - so that it is more saturated at lower pressures of oxygen (1) - with high carbon dioxide, the Tibetan haemoglobin has a lower affinity for oxygen (than Europeans) (1) - because it has a {more pronounced / bigger} Bohr shift / shift to the right (1) - so that it will release oxygen more easily (1)	Accept converse Accept oxygen concentrations Accept can bind oxygen at low pressures /can bind oxygen when at altitude where there is less partial pressure of oxygen Accept with higher carbon dioxide, Tibetan haemoglobin is less saturated (than European haemoglobin)	4

Q10.

Question Number	Answer	Additional Guidance	Mark
	The only correct answer is B (X,Z,Y) A is not correct because adult haemoglobin is Z, not Y and fetal haemoglobin is Y, not Z C is not correct because myoglobin is X, not Y and fetal haemoglobin is Y, not X D is not correct because myoglobin is X, not Z, and adult haemoglobin is Z, not X		(1)