Questions

Q1.

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

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

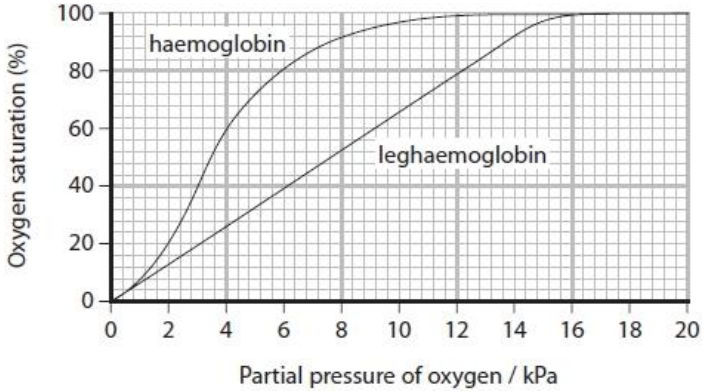
Scientists sampled the soil from areas that had been uncovered for different lengths of time after the glacier ice had melted.

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 / g m^{-2} 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.

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

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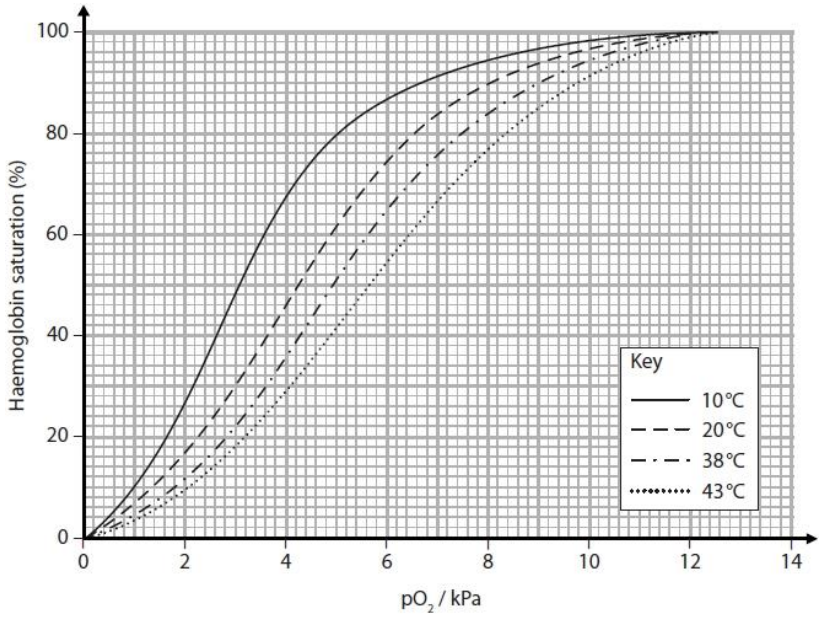
(Total for question = 6 marks)

Q2.

Scientists also investigated the effect of temperature on the percentage saturation of haemoglobin with oxygen, using blood from an Asian elephant.

The oxygen dissociation curves are shown in the graph.



(i) In the alveolar capillaries, the partial pressure of oxygen is 12 kPa at a temperature of 38 °C and haemoglobin is fully saturated with oxygen.

In active muscle tissue, the partial pressure of oxygen is 2 kPa at a temperature of 43 °C. Use the graph to determine the percentage saturation of haemoglobin in active muscle tissue.

(1)

Answer ..... %

(ii) When 1g of haemoglobin is fully saturated it carries 1.3 cm^3 of oxygen.

Calculate the volume of oxygen released by 1 g of haemoglobin to this active muscle tissue.
Show your working.

(2)

Answer .....

(iii) Scientists extracted the genes for mammoth haemoglobin and used them to produce mammoth haemoglobin.

The oxygen dissociation curve for mammoth haemoglobin at 38 °C was found to be the same as for the Asian elephant at 38 °C.
Lowering the temperature did not shift the oxygen dissociation curve.
Explain how these observations show that this haemoglobin enabled mammoths to be adapted for life in cold Arctic regions.

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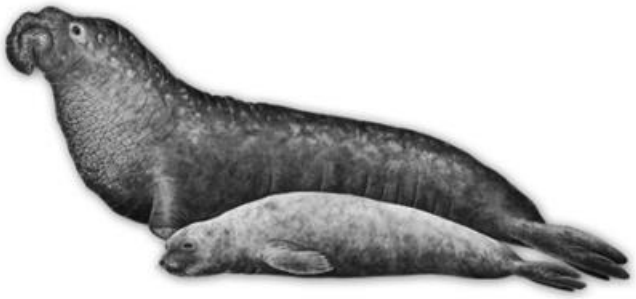
(Total for question = 6 marks)

Q3.

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 / $cm^3\ kg^{-1}$	Concentration of haemoglobin in blood / $g\ dm^{-3}$	Total blood volume / $cm^3\ kg^{-1}$	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)

Answer .....

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

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(Total for question = 9 marks)

Q4.

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)

	Position of oxygen dissociation curve compared with human haemoglobin	Affinity for oxygen compared with human haemoglobin
☐ **A**	to the left	higher
☐ **B**	to the left	lower
☐ **C**	to the right	higher
☐ **D**	to the right	lower

*(ii) The table shows how much oxygen is stored in different parts of the body of humans and Weddell seals.

Part of body	Total oxygen stored / a.u. kg^{-1} body tissue	
	humans	Weddell seals
lungs	12	3
blood	10	58
muscle	2	23
body fluids, other than in the blood	2	2

Weddell seals also store erythrocytes in their spleen that are released into the bloodstream during deep dives.

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

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(Total for question = 7 marks)

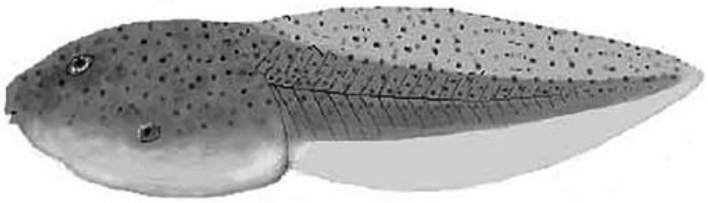
Q5.

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.

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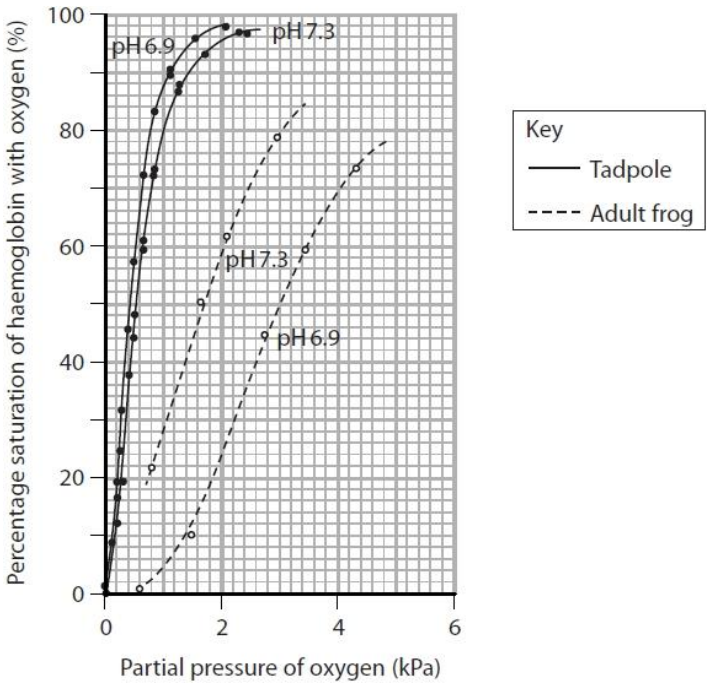
*(ii) The graph shows the effect of pH on the oxygen dissociation curves of haemoglobin for adult frog blood and tadpole blood.



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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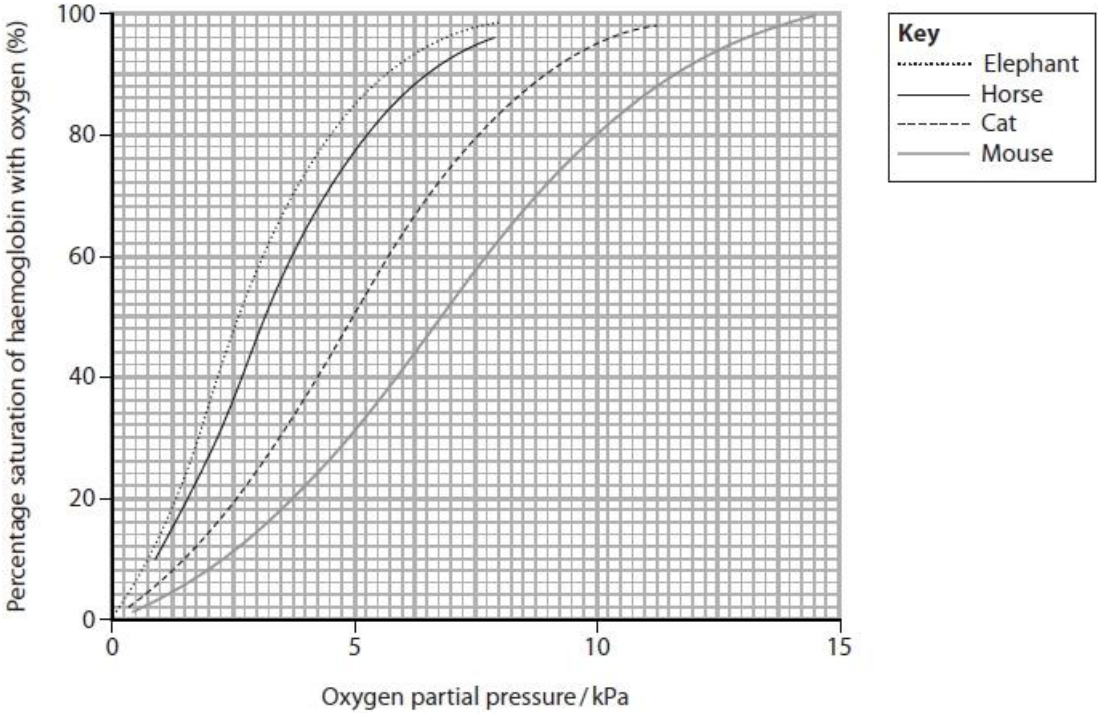
(Total for question = 12 marks)

Q6.

The graph shows the oxygen dissociation curves of haemoglobin from four species of mammal.



Explain why the dissociation curve for mouse haemoglobin is to the right-hand side of the dissociation curve for elephant haemoglobin.

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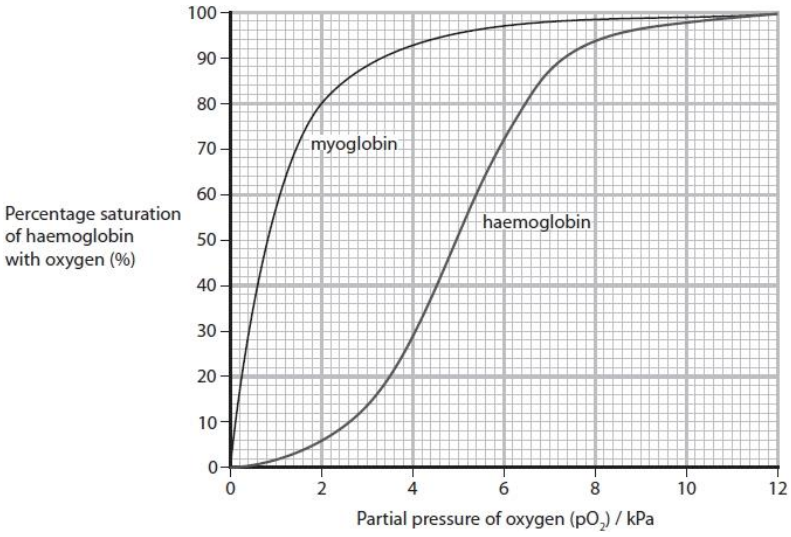
(Total for question = 3 marks)

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 cm^3 blood.

The concentration of haemoglobin is 15 g per dm^3 blood.
When fully saturated, there is 1.36 cm^3 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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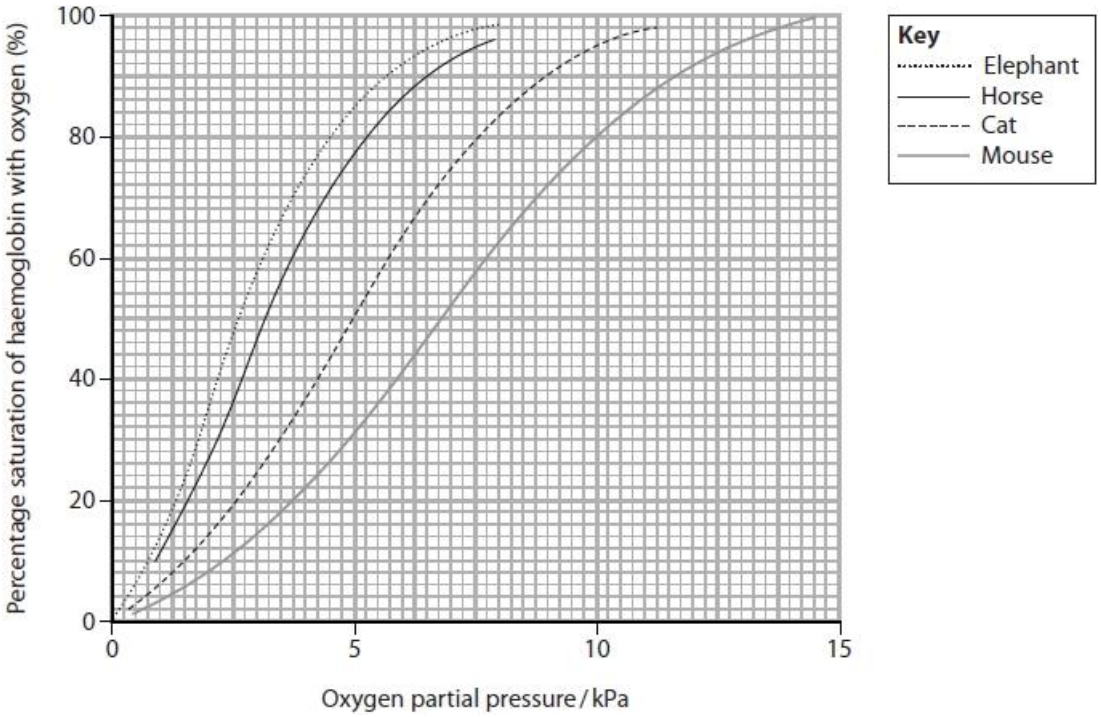
(Total for question = 7 marks)

Q8.

The graph shows the oxygen dissociation curves of haemoglobin from four species of mammal.



Some species of horse live at high altitudes where the partial pressure of oxygen is very low.

Draw a curve on the graph to show the oxygen dissociation curve of these horses.

(Total for question = 1 mark)

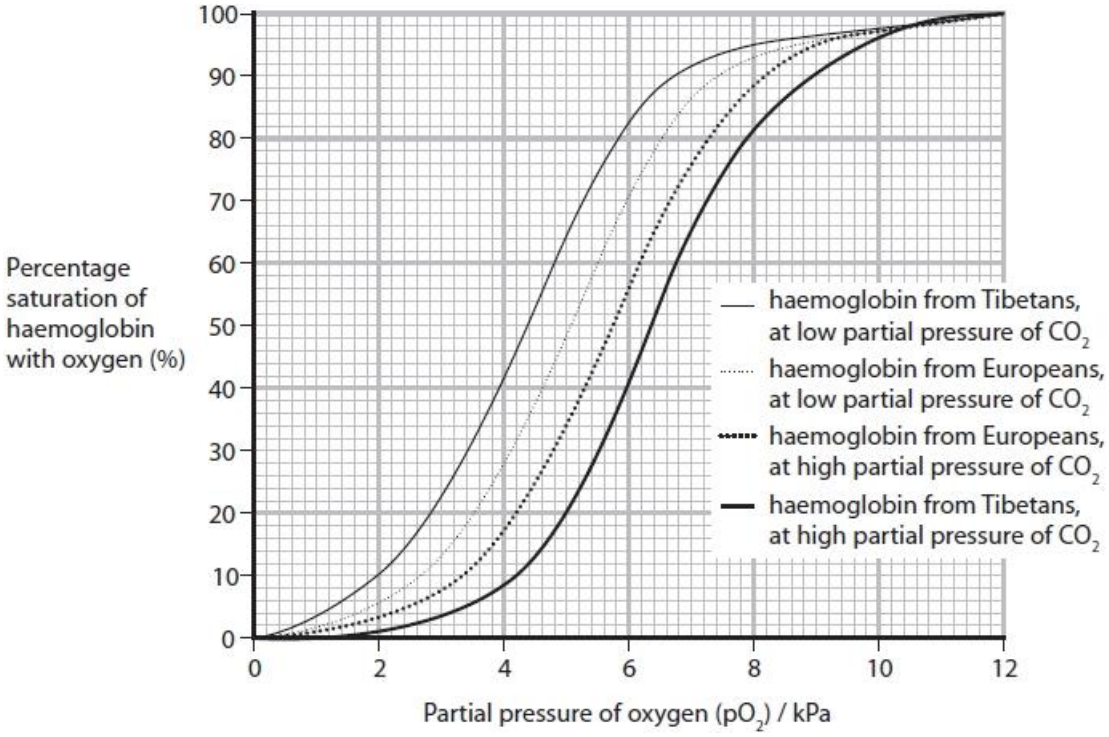
Q9.

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.

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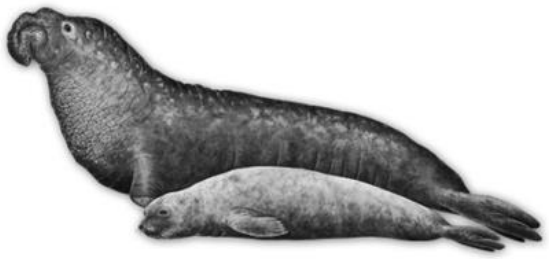
(Total for question = 4 marks)

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.

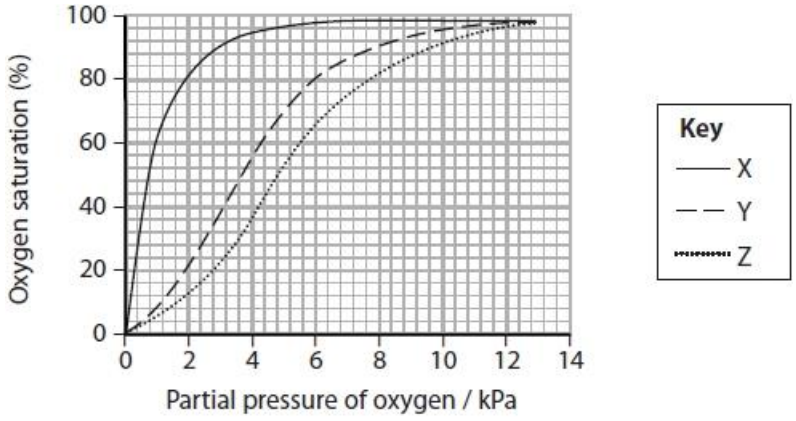
The seals were listed as an Appendix II species when CITES was established in the 1970s.

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?

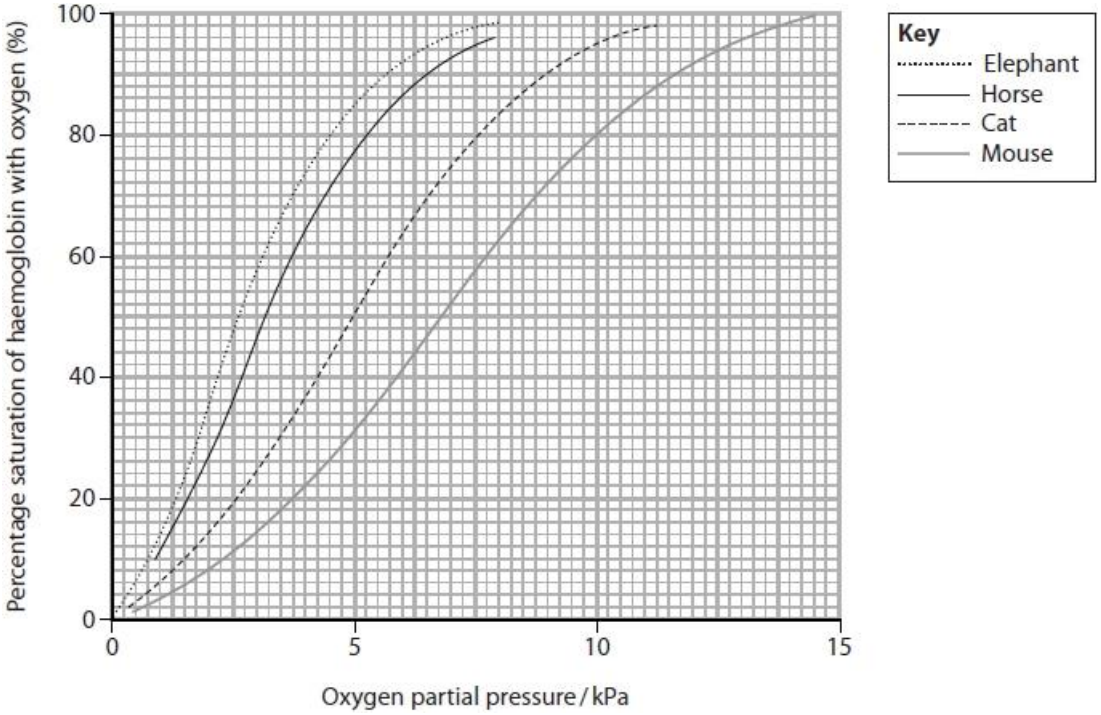
(1)

	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)

Q11.

The graph shows the oxygen dissociation curves of haemoglobin from four species of mammal.



Calculate how much more oxygen is released as the partial pressure falls from 10 kPa to 5 kPa in the mouse than in the cat.

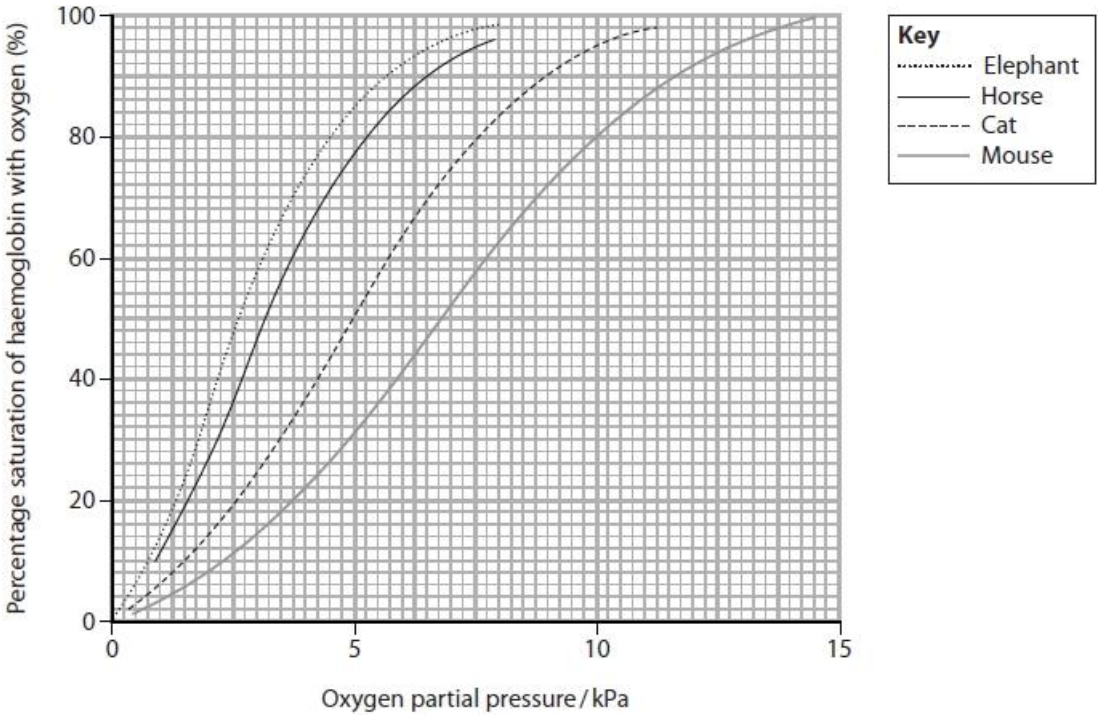
(3)

Answer .....

(Total for question = 3 marks)

Q12.

The graph shows the oxygen dissociation curves of haemoglobin from four species of mammal.



Explain the shape of the haemoglobin dissociation curve.

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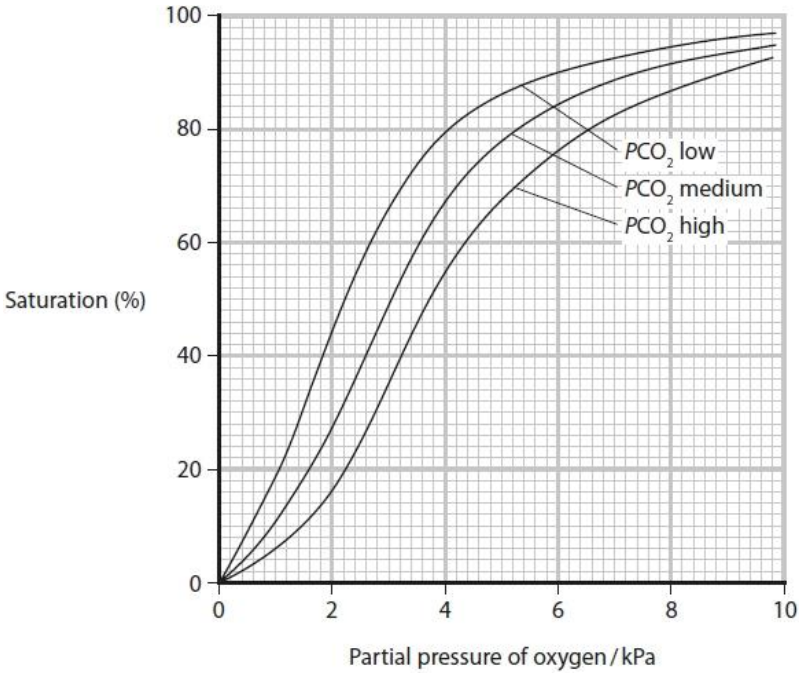
(Total for question = 3 marks)

Q13.

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 ☒.

Haemoglobin transports oxygen within the blood.

The graph shows the relationship between the partial pressure of oxygen and the saturation of haemoglobin with oxygen at three partial pressures of carbon dioxide.



(i) The curve moves to the right when more carbon dioxide is present.

This move to the right is due to the

(1)

- ☒ **A** Bohr effect
- ☒ **B** chloride shift
- ☒ **C** dissociation curve
- ☒ **D** oxygen debt

(ii) Explain why the curves are S-shaped.

(2)

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(iii) Calculate the difference between the percentage change in saturation of haemoglobin with oxygen as the partial pressure of oxygen changes from 8 kPa to 2 kPa for low carbon dioxide compared with high carbon dioxide.

(2)

Difference ..... %

(iv) Analyse the data to explain the advantage to the mammal of the curve moving to the right.

(3)

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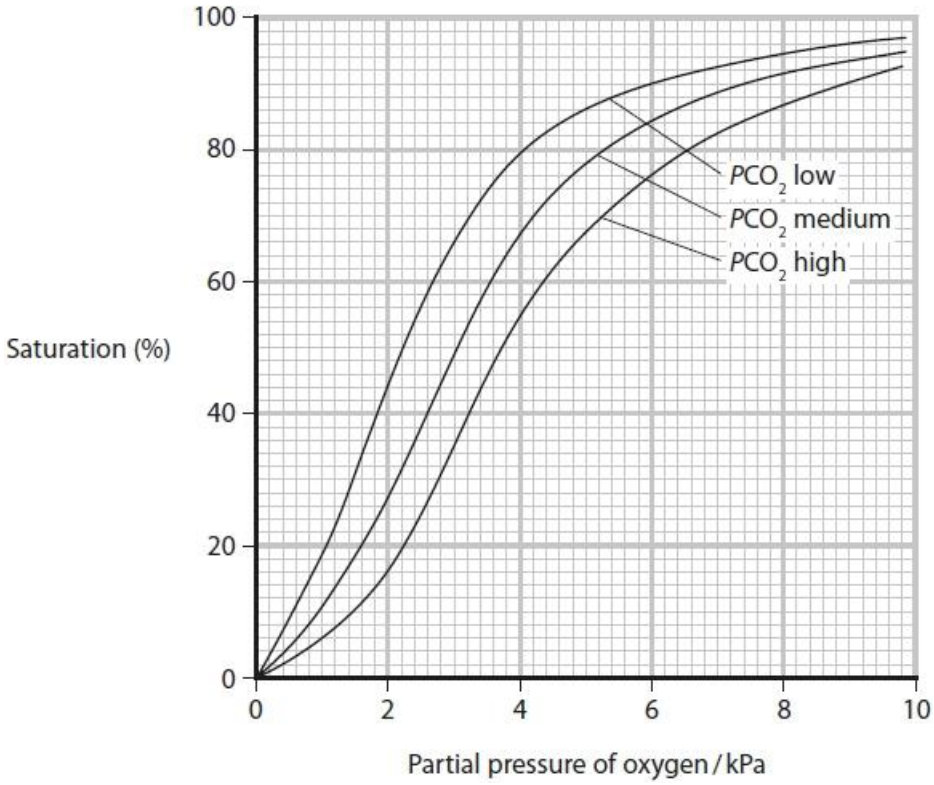
(Total for question = 8 marks)

Q14.

Haemoglobin transports oxygen within the blood.

The graph shows the relationship between the partial pressure of oxygen and the saturation of haemoglobin with oxygen at three partial pressures of carbon dioxide.



Mammals that live at high altitudes are in an environment with a lower partial pressure of oxygen.

Explain the position of the haemoglobin dissociation curve for mammals that live at high altitude.

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(Total for question = 2 marks)

Mark Scheme

Q1.

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

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	• correct reading from graph	= 10(%)	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: • correct subtraction of percentages • correct calculation of volume	<u>Example of Calculation</u> ECF from part (i) 100% - 10 % = 90% 1.3 – 0.13 = 1.17 (90 ÷ 100) x 1.3 = 1.2 **cm^3** ALLOW 1.17 **cm^3** no units or incorrect units gains ONE mark only correct response with no working gains full marks	**(2)**

Question Number	Answer		Additional Guidance	Mark
(iii)	An explanation that makes reference to the following: • affinity of haemoglobin for oxygen does not change • therefore oxygen is still released • therefore heat is still produced by respiration	(1) (1) (1)	ALLOW the converse ACCEPT haemoglobin does not bind to oxygen tightly when cold / haemoglobin binds to oxygen more weakly (than elephants) when cold	**(3)**

Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	• total blood volume in one seal (1)	Example of calculation: 400 x 207 = 82800 cm^3 **Accept** calculation of total haemoglobin per cm^3 kg^{-1} blood: 207 × 216 = 44712 **Accept** calculation of concentration of haemoglobin in one seal: 216 × 400 = 86400	
	• conversion of g dm^{-3} to g cm^{-3} (1)	216 ÷ 1000 = 0.216 g cm^{-3}	
	• total mass of haemoglobin (concentration of haemoglobin x volume of blood in a seal) (1)	0.216 x 82800 = 17885 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 g / 17880 g / 17890 g / 17900/ 18000 g / 17.8848 kg / 17.885 kg / 17.89 kg / 17.9 kg / 18 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)**

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	**The only correct answer is A** ***B*** *is incorrect because the haemoglobinwould have a higher affinity for oxygen* ***C*** *is incorrect because the curve would beto the left* ***D*** *is incorrect because the curve would beto the left*		(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 genericmark 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 simplyexplained 4 marks = 2 sets of data simplyexplained **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	

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 $pp0_2$ 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	Answer	Additional Guidance	Mark
	An explanation that that makes reference to three of the following: • mouse (haemoglobin) {releases more oxygen / lower affinity / dissociates more / is less saturated} at the same ppO_2 / mouse (haemoglobin) is saturated at a higher ppO_2 (1) • mice {cells / tissues} need more oxygen / mice have higher {respiration rate / metabolic rate} (1) • because mice have larger surface area to volume ratio (1) • therefore mice lose more heat (1)	**ACCEPT** converse for all Mps	**(3)**

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 cm^3 of blood (1)	72 % 72 / 100 X 1.36 = 0.9792 1.47 / 1.469 / 1.4688 cm^3 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
	• curve drawn to the left of the horse curve		(1)

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)**

Q11.

Question Number	Answer	Additional Guidance	Mark
	• correct values read from graphs (1) • subtraction for cat and for mouse (1) • difference calculated (1)	**example of calculation** cat 95 and 50 mouse 80 and 31 cat 45% mouse 49% 49 – 45 = 4 **ACCEPT** 2 marks if incorrect values read from graph	**(3)**

Q12.

Question Number	Answer	Additional Guidance	Mark
	An explanation that that makes reference to three of the following: • (haemoglobin) {saturated / high affinity / associates} at high ppO_2 OR (haemoglobin) {less saturated / low affinity / dissociates} at low ppO_2 (1) • binding of the first oxygen molecule is difficult (1) • changes shape of haemoglobin molecule (1) • therefore facilitates binding of other oxygen molecules (1)	**IGNORE** concentration of oxygen	**(3)**

Q13.

Question Number	Answer	Mark
(i)	**The only correct answer is A Bohr effect** **B** is not correct because it is not the chloride shift **C** is not correct because it is not the dissociation curve **D** is not correct because it is not the oxygen debt	**(1)**

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to two of the following: • binding of the first oxygen molecule to haemoglobin changes the shapeof haemoglobin molecule (1) • therefore facilitates binding of other oxygen molecules (1)	allow easier faster binding	**(2)**

Question Number	Answer	Additional guidance	Mark
(iii)	• reading values of graph (1) • calculation (1) 71-51=20%	low carbon dioxide 95-44=51 allow readings 94 or 95 and 44 or 45 49, 50 or 51 high carbon dioxide 87 -16 = 71 allow readings 87 and 16 or 17 sosubtraction 70, 71 allow answer 19 or 20 or 21allow TE for mp 2	**(2)**

Question Number	Answer	Additional guidance	Mark
(iv)	An explanation that makes reference to three of the following: • as these respiring cells / tissues are releasing are releasing CO_2(1) • so that haemoglobin has a lower affinity for oxygen (1) • so it unloads its oxygen / dissociates at higher partial pressureof oxygen (1) • thus, more oxygen is released to be used in aerobic respiration(1)	allow haemoglobin is less saturated	**(3)**

Q14.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following • curve lies to left of normal (1) • therefore haemoglobin has to have a higher affinityfor oxygen at lower partial pressures (1)	allow heamoglobin has a higher saturation at lower partial pressures	**(2)**