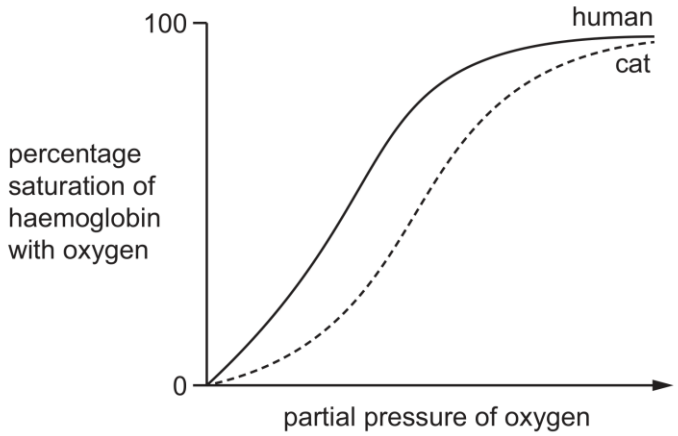
8. Transport in Mammals

8.2 Transport of oxygen and carbon dioxide

Paper 1

Question Paper

1 The graph shows how changes in oxygen concentration affect the percentage oxygen saturation of human haemoglobin and cat haemoglobin under normal physiological conditions. The partial pressure of carbon dioxide was kept constant at 5.0 kPa and the temperature was kept constant at 37 °C.



Which conclusion is supported by the graph?

A The affinity of cat haemoglobin for oxygen is greater than the affinity of human haemoglobin for oxygen.

B At high partial pressures of oxygen, cat haemoglobin picks up oxygen more easily than human haemoglobin picks up oxygen.

C At low partial pressures of oxygen, oxygen is released more easily from cat haemoglobin than from human haemoglobin.

D The shift in the oxygen dissociation curve caused by the Bohr effect is larger for cat haemoglobin than for human haemoglobin.

2 Which statement is correct about how oxygen combines with haemoglobin?

A Combining all four oxygen molecules with haemoglobin does **not** affect the shape of haemoglobin.

B One oxygen molecule can combine with each haem group of the haemoglobin molecule.

C The first oxygen molecule to combine with haemoglobin does **not** affect the shape of haemoglobin.

D The third oxygen molecule to combine with haemoglobin makes it more difficult for the fourth oxygen molecule to combine with haemoglobin.

3 Some babies are born with a hole between the right and left atria. These babies are found to have an increased number of red blood cells.

What is the reason for this increase in red blood cells in these babies?

A Blood is pumped faster, which causes more blood to circulate in the heart.

B More blood is needed in the heart because the pressure is lower.

C Their haemoglobin has a higher affinity for oxygen.

D There is a lower oxygen concentration in the body of the newborn baby.

4 An increase in carbon dioxide in human blood shifts the oxyhaemoglobin dissociation curve to the right.

What is the explanation for this effect?

A An increase in carbon dioxide concentration increases the breathing rate.

B Carbon dioxide is more soluble than oxygen and displaces it.

C Diffusion of carbon dioxide between the alveoli and the blood is more rapid.

D Increasing the H^+ concentration decreases haemoglobin affinity for oxygen.

5 Which statement is correct?

A In a red blood cell, CO_2 can combine with haemoglobin to form haemoglobinic acid.

B Carbonic anhydrase is an enzyme that catalyses the reaction between CO_2 and H_2O.

C At the lungs, carbon dioxide is released when carbonic acid and water react together.

D The greater the concentration of CO_2 in the blood, the higher the affinity of haemoglobin for oxygen.

6 Which reactions would be slowed down by an inhibitor of carbonic anhydrase?

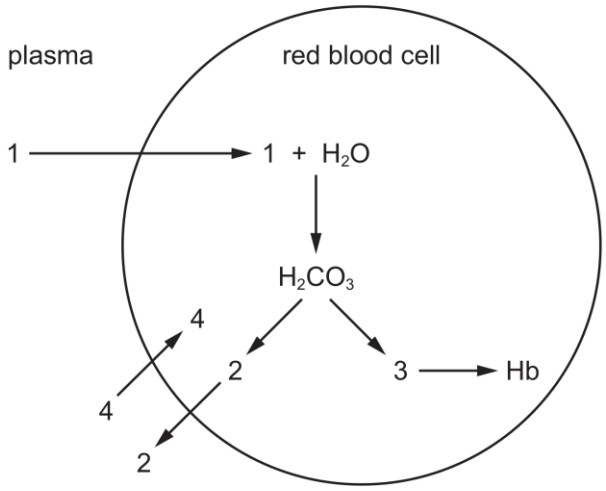
1 CO_2 + haemoglobin → carbaminohaemoglobin

2 $CO_2 + H_2O \rightarrow H_2CO_3$

3 $H_2CO_3 \rightarrow H^+ + HCO_3^-$

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

7 The diagram shows some of the events that happen between the plasma and the red blood cells in the circulatory system.



What do the numbers 1, 2, 3 and 4 represent?

	1	2	3	4
A	Cl^-	HCO_3^-	H^+	CO_2
B	CO_2	HCO_3^-	H^+	Cl^-
C	HCO_3^-	Cl^-	CO_2	H^+
D	CO_2	H^+	HCO_3^-	Cl^-

8 Sulthiame is a molecule that inhibits carbonic anhydrase.

Which effect would sulthiame have inside a red blood cell in muscle tissue that is respiring at a high rate?

A a decrease in the rate of formation of haemoglobinic acid

B a decrease in the pH

C an increase in the rate of the chloride shift

D an increase in the dissociation of oxyhaemoglobin

9 The partial pressure of oxygen in blood vessels in different parts of the body affects the percentage saturation of each haemoglobin molecule with oxygen.

blood vessel	partial pressure of oxygen / kPa	saturation of each haemoglobin molecule with oxygen / %
vein in active muscle	4	25
vein in resting muscle	7	75
arteriole in lungs	12	100

Which statement explains the difference in saturation between a resting and an active muscle?

A A small decrease in partial pressure causes two atoms of oxygen to leave each haemoglobin molecule because the oxygen dissociation curve is sigmoid shaped.

B A small decrease in partial pressure between 4 kPa and 7 kPa causes two molecules of oxygen to leave each haemoglobin molecule because the oxygen dissociation curve is steep.

C Loading of oxygen is slower between 4 kPa and 7 kPa due to binding of one oxygen molecule to each haemoglobin molecule making the next one harder to bind.

D Loading of oxygen is faster between 4 kPa and 7 kPa due to binding of one oxygen molecule to each haemoglobin molecule making the next one easier to bind.

10 Which statements about the Bohr shift are correct?

1 The shift is accelerated by the action of carbonic anhydrase.

2 A decrease in blood pH will cause oxyhaemoglobin to dissociate.

3 A decrease in carbon dioxide concentration will cause more oxygen to bind to haemoglobin.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

11 Which statement is correct about a red blood cell that has just entered a capillary in a respiring muscle?

A There is a net decrease in chloride ions.

B There is a net decrease in haemoglobinic acid.

C There is a net increase in carbonic anhydrase.

D There is a net increase in carbaminohaemoglobin.

12 Which reactions take place in the capillaries surrounding an alveolus?

1 carbon dioxide + water $\rightarrow$ carbonic acid

2 carbon dioxide + haemoglobin $\rightarrow$ carbaminohaemoglobin

3 haemoglobinic acid $\rightarrow$ haemoglobin + hydrogen ions

4 hydrogencarbonate ions + hydrogen ions $\rightarrow$ carbonic acid $\rightarrow$ carbon dioxide + water

A 1 and 2 **B** 3 and 4 **C** 3 only **D** 4 only

13 Which statement explains the importance of the chloride shift in red blood cells (RBC)?

A Carbon dioxide diffuses from blood plasma into RBC and chloride ions diffuse out of RBC to maintain a balance of positive and negative ions.

B Hydrogencarbonate ions diffuse into plasma from RBC and chloride ions diffuse into RBC to maintain a balance of positive and negative ions.

C Carbon dioxide in RBC together with chloride ions stimulate the release of oxygen from haemoglobin to allow increased levels of respiration.

D Hydrogencarbonate ions diffuse into RBC from plasma and chloride ions diffuse into plasma to maintain a balance of positive and negative ions.

14 Which row shows the change in concentration of some substances in red blood cells when carbon dioxide diffuses from active cells?

	carbonic anhydrase	hydrogencarbonate ions	hydrogen ions
A	decreases	no change	no change
B	increases	increases	increases
C	no change	decreases	increases
D	no change	increases	increases

15 Red blood cells may contain a molecule known as 2,3-bisphosphoglycerate (2,3-BPG).

When 2,3-BPG binds to haemoglobin, a higher partial pressure of oxygen is needed to bring about 50% saturation of haemoglobin with oxygen.

Which statements about the effect of 2,3-BPG are correct?

1 2,3-BPG in red blood cells causes the oxygen dissociation curve to shift to the right.

2 The binding of 2,3-BPG to haemoglobin reduces the Bohr effect.

3 The binding of 2,3-BPG to haemoglobin lowers the affinity of the haemoglobin for oxygen.

4 When 2,3-BPG is not present, oxyhaemoglobin is less likely to unload oxygen.

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 3 and 4

16 Carbon dioxide is continually produced by respiring cells. It diffuses into red blood cells and dissociates into hydrogen ions (H^+) and hydrogen carbonate ions (HCO_3^-). HCO_3^- then diffuses out of the cell in exchange for chloride ions (Cl^-) in the chloride shift.

What is the importance of the chloride shift?

A It helps to maintain a neutral pH in the red blood cell by acting as a buffer.

B It maintains a balance of positive and negative charge between the cell and the plasma.

C It causes the oxygen dissociation curve to shift to the left, releasing more oxygen.

D It prevents carbon dioxide combining with haemoglobin, allowing haemoglobin to combine with oxygen.

17 Which mechanism accounts for the way most of the carbon dioxide is transported in blood?

A Carbon dioxide dissolves in plasma and is carried in solution.

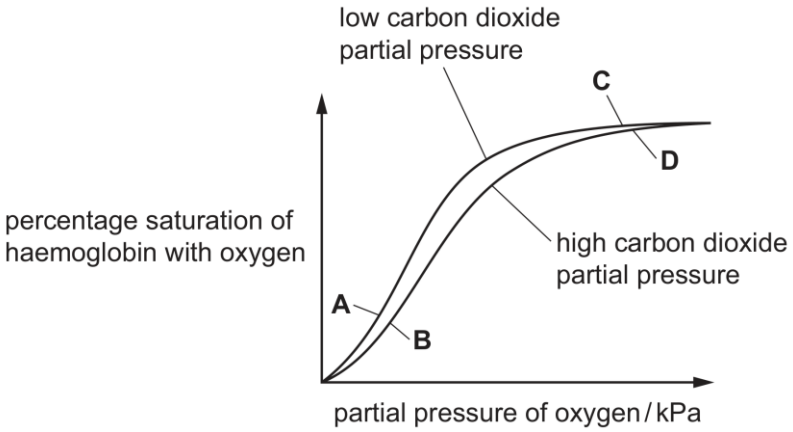
B Carbon dioxide is converted to carbaminohaemoglobin inside red blood cells.

C Carbon dioxide is converted to carboxyhaemoglobin inside red blood cells.

D Carbon dioxide is converted to hydrogencarbonate ions inside red blood cells.

18 The graph shows the dissociation curves for haemoglobin at two different partial pressures of carbon dioxide.

At which position on the graph, **A**, **B**, **C**, or **D**, is the concentration of haemoglobinic acid lowest in red blood cells?



19 What is the main reaction occurring in blood capillaries at the gas exchange surface in a human lung?

A Carbonic acid dissociates into carbon dioxide and hydrogen ions.

B Carbonic anhydrase converts carbon dioxide into hydrogencarbonate ions.

C Carbon dioxide combines with haemoglobin to form carbaminohaemoglobin.

D Carbon dioxide is produced from hydrogencarbonate ions by carbonic anhydrase.

20 Which reactions take place in blood that is passing through active tissues?

1 $HbO_8 \rightarrow Hb + 4O_2$

2 $HbO_8 + H^+ \rightarrow HHb + 4O_2$

3 $HCO_3^- + H^+ \rightarrow H_2CO_3$

4 $H_2O + CO_2 \rightarrow H_2CO_3$

A 1, 2, 3 and 4

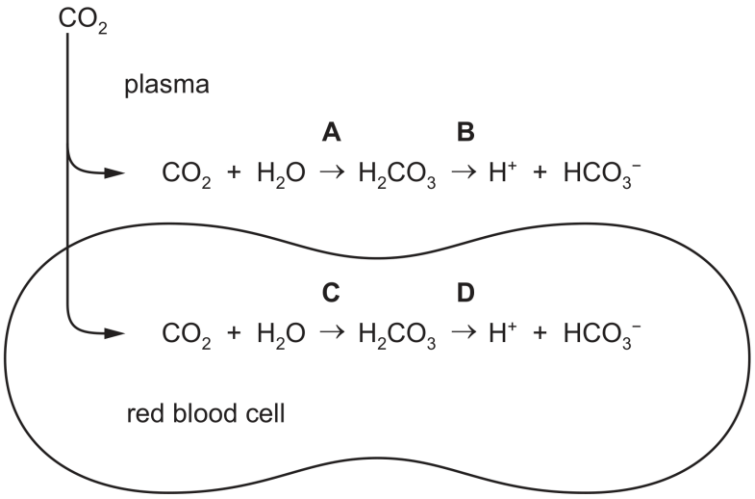
B 1, 2 and 4 only

C 1, 3 and 4 only

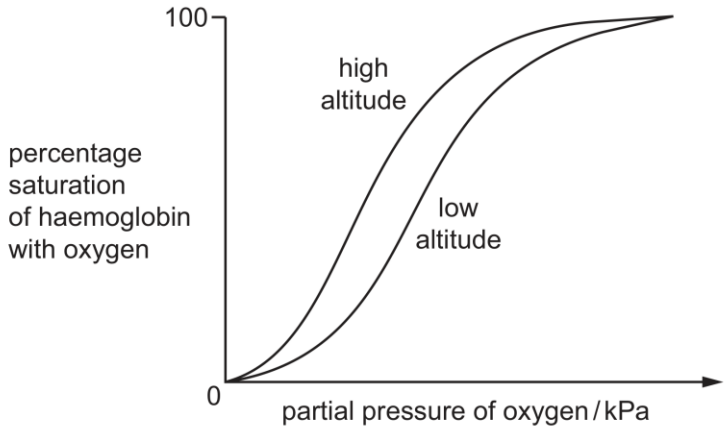
D 2 and 3 only

21 The diagram shows some of the reactions of carbon dioxide when it enters the blood from cells in a metabolically active tissue.

Which reaction is catalysed by the enzyme carbonic anhydrase?



22 The graph shows the oxygen dissociation curves for haemoglobin in animals that live at high altitude and animals that live at low altitude.



What explains the oxygen dissociation curve at **high** altitude?

A Haemoglobin has a higher affinity for oxygen.

B Haemoglobin releases oxygen more readily.

C The change in partial pressure of carbon dioxide causes a Bohr effect.

D The decrease in percentage of carbon dioxide causes the curve to shift to the left.

23 Which statements about the formation of haemoglobinic acid are correct?

1 It can only occur with the dissociation of oxygen from haemoglobin.

2 It removes excess hydrogen ions, preventing blood from becoming too acidic.

3 It is linked to the action of carbonic anhydrase.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 only **D** 2 and 3 only

24 What explains how the maximum volume of oxygen is taken up as blood passes through the capillaries of the lungs?

A Each haemoglobin molecule can temporarily bind to four oxygen atoms.

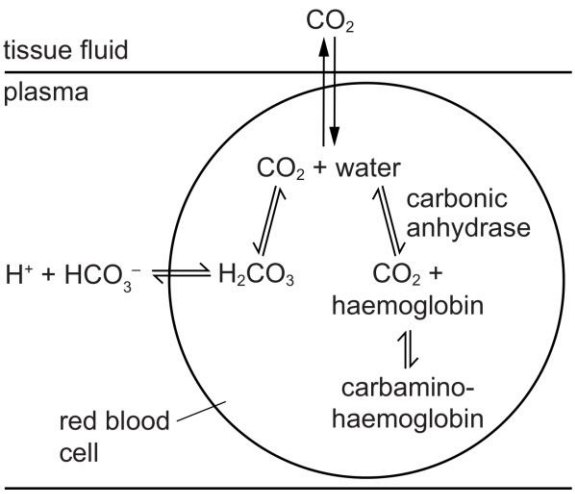
B The dissociation of carbon dioxide from carboxyhaemoglobin allows more haemoglobin to be available for binding oxygen.

C The binding of the first oxygen molecule to haemoglobin decreases the affinity of haemoglobin for binding other oxygen molecules.

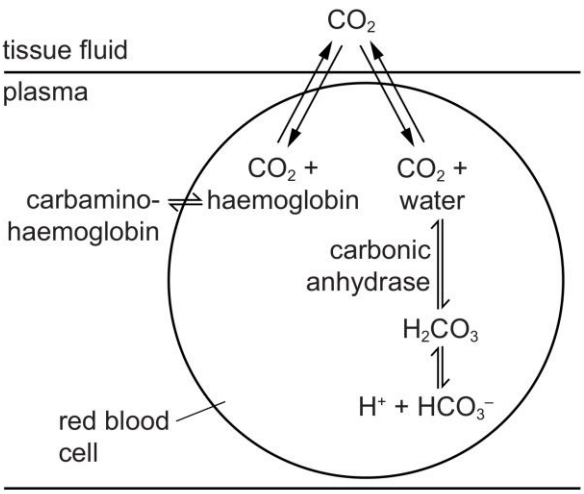
D Oxyhaemoglobin formation increases the ability of red blood cells to transport oxygen.

25 Which diagram shows the events that occur during transport of carbon dioxide by the blood?

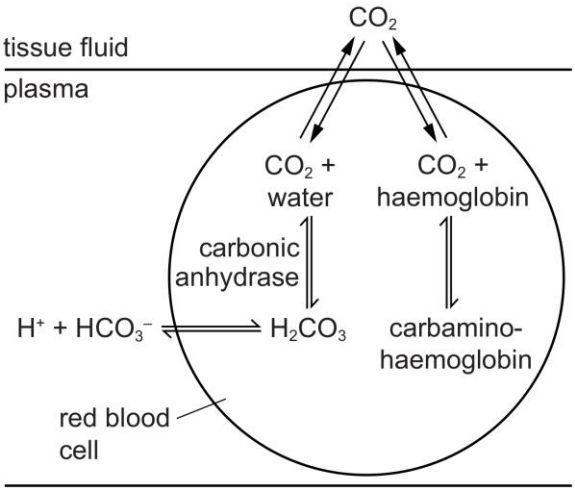
A



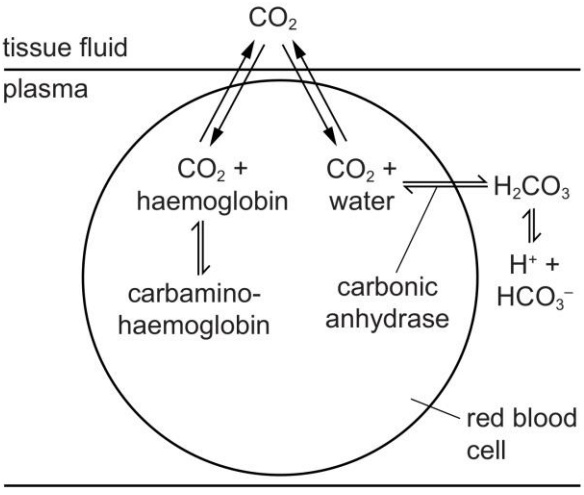
B



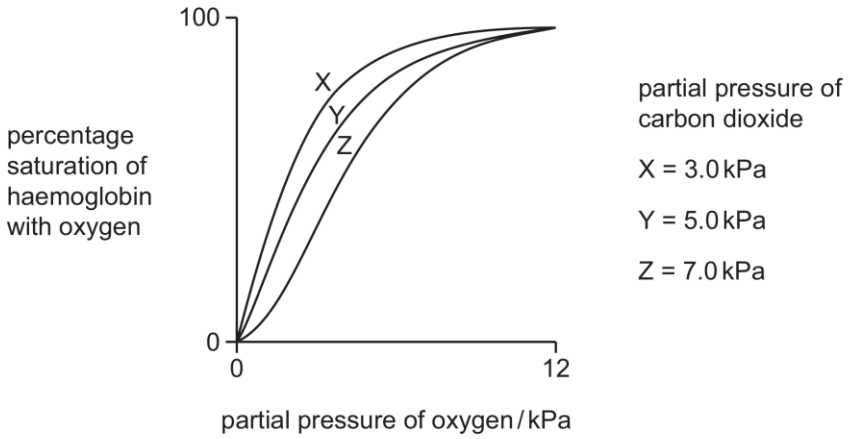
C



D



26 The graph shows the effect of three different partial pressures of carbon dioxide on the oxygen dissociation curve for human haemoglobin.



What effect does decreasing the partial pressure of carbon dioxide have on haemoglobin?

A It is less efficient at taking up oxygen and less efficient at releasing oxygen.

B It is less efficient at taking up oxygen and more efficient at releasing oxygen.

C It is more efficient at taking up oxygen and less efficient at releasing oxygen.

D It is more efficient at taking up oxygen and more efficient at releasing oxygen.

27 What is correct about the transport of carbon dioxide by blood?

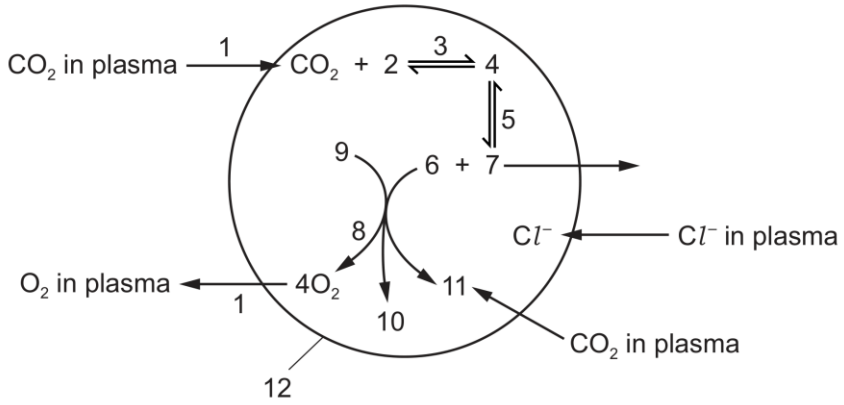
1 The enzyme carbonic anhydrase catalyses the formation of carbonic acid in red blood cells.

2 Carbon dioxide diffuses from active cells to red blood cells and reacts with water.

3 Carbonic acid dissociates forming hydrogen ions that combine with haemoglobin to form carbaminohaemoglobin.

A 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 3 only

28 The diagram is a summary of the role of haemoglobin in the transport of carbon dioxide.



Which set of labels is correct?

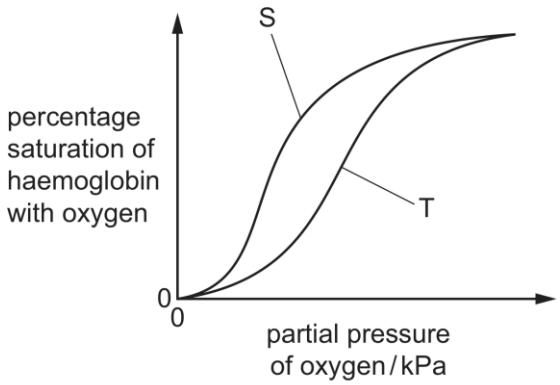
A 1 = facilitated diffusion, 4 = carbonic acid, 7 = hydrogencarbonate ions

B 2 = water, 8 = dissociation, 10 = carbaminohaemoglobin

C 3 = carbonic anhydrase, 9 = oxyhaemoglobin, 11 = carbaminohaemoglobin

D 5 = carbonic anhydrase, 6 = hydrogen ions, 12 = red blood cell

29 The graph shows the oxygen dissociation curves of haemoglobin from two species of mammal, S and T.



Which statements could explain the difference in the oxygen dissociation curves of species S and species T?

1 Species T has a lower haemoglobin concentration in its red blood cells than species S.

2 The haemoglobin in species T has a lower affinity for oxygen than the haemoglobin in species S.

3 Species T lives at higher altitudes than species S.

A 1, 2 and 3 **B** 1 and 2 only **C** 2 only **D** 3 only

30 Athletes often move from low altitude to high altitude to train for a race.

Which statements about the effect of training at high altitude are correct?

1 Higher concentrations of carbon dioxide stimulate greater oxygen dissociation.

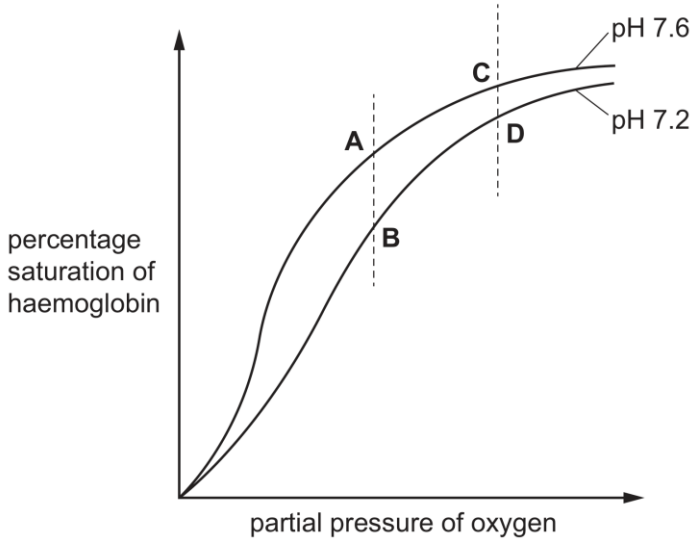
2 Lower concentrations of oxygen stimulate the uptake of more oxygen by red blood cells.

3 Lower partial pressures of oxygen stimulate higher production of red blood cells.

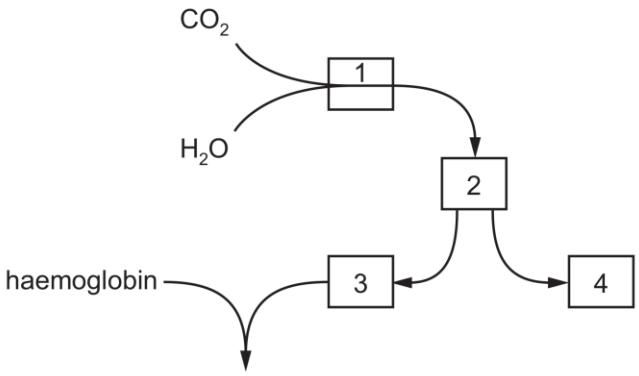
A 1 and 2 only **B** 2 and 3 only **C** 1 only **D** 3 only

31 The graph shows the oxygen haemoglobin dissociation curves at pH 7.6 and at pH 7.2.

Which point on the graph shows the percentage saturation of haemoglobin in the blood leaving an active muscle?



32 The diagram shows the pathway for the transport of carbon dioxide that occurs in red blood cells.



Which row is correct?

	1	2	3	4
A	carbaminohaemoglobin	haemoglobinic acid	hydrogen ions	hydrogencarbonate ions
B	carbonic anhydrase	carbonic acid	hydrogen ions	hydrogencarbonate ions
C	carboxyhaemoglobin	carbonic anhydrase	carbonic acid	carbon dioxide
D	haemoglobinic acid	carbonic acid	hydrogencarbonate ions	hydrogen ions

33 Which statement about oxygen combining with haemoglobin is correct?

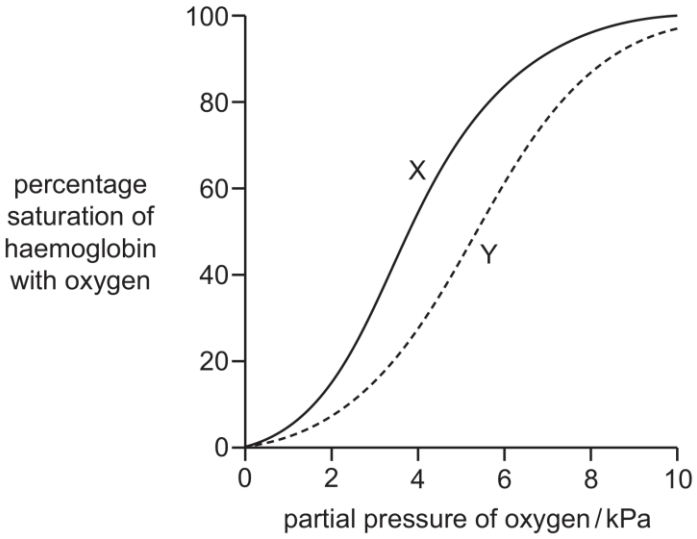
A All oxygen molecules which combine stop the haemoglobin molecule changing shape.

B Four oxygen molecules can combine with each haem group.

C The first oxygen molecule to combine does not affect the shape of haemoglobin.

D The second oxygen molecule to combine makes it easier for the third to combine.

34 The diagram shows the Bohr effect.



What causes the shift from X to Y?

A decreased concentration of carbon dioxide and high pH

B decreased concentration of carbon dioxide and low pH

C increased concentration of carbon dioxide and high pH

D increased concentration of carbon dioxide and low pH

35 When active tissues have high carbon dioxide concentrations, oxyhaemoglobin releases oxygen to these tissues.

What encourages this release in the presence of high concentrations of carbon dioxide?

1 carboxyhaemoglobin forms more readily

2 oxyhaemoglobin dissociates more readily

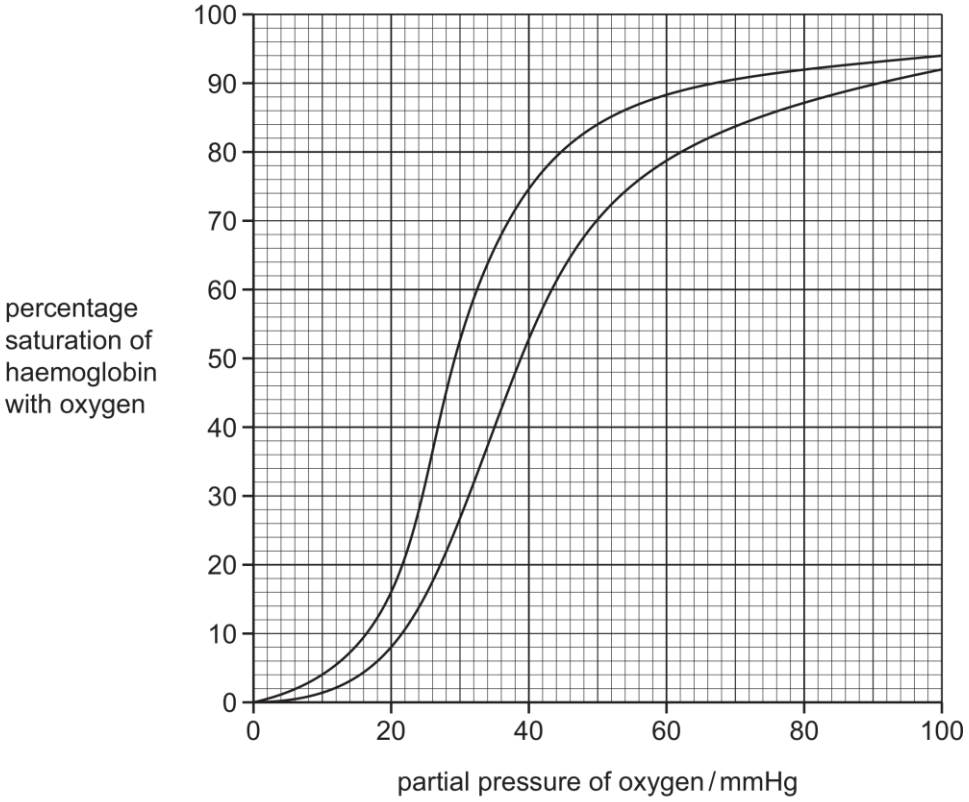
3 haemoglobin needs higher concentrations of oxygen to become saturated

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

36 The graph shows oxygen dissociation curves of haemoglobin at two different carbon dioxide concentrations.

The partial pressure of oxygen in the lungs is 100 mmHg.

The partial pressure of oxygen in metabolically active tissues is 35 mmHg.



What is the percentage saturation of haemoglobin with oxygen at the lungs and in metabolically active tissues?

	percentage saturation of haemoglobin with oxygen	
	lungs	metabolically active tissue
A	92	40
B	92	66
C	94	40
D	94	66

37 Which effect could be due to a reduced concentration of carbonic anhydrase?

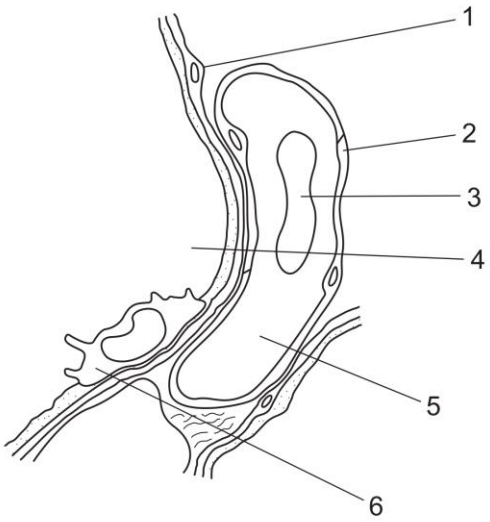
A Carbaminohaemoglobin concentrations will decrease.

B Less oxygen is released from oxyhaemoglobin for active tissues.

C The pH of the blood will be lowered.

D The rate of dissociation of carbonic acid is increased.

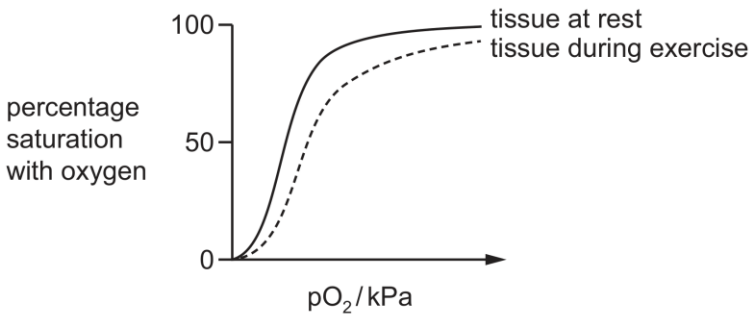
38 The diagram shows a magnified section of part of the lungs containing specialised tissues.



Which row is correct for structures labelled 1 to 6?

	contains high proportion of		
	carbonic anhydrase	HCO_3^- ions	lysosomes
A	1	3	4
B	2	4	5
C	3	5	6
D	4	6	1

39 The graph shows two oxygen dissociation curves, one for a tissue at rest and one for the same tissue during exercise.



What factors have caused the difference in the position of the dissociation curve during exercise compared with the dissociation curve for the tissue at rest?

1 increase in pH

2 decrease in pH

3 increase in haemoglobin affinity for O_2

4 decrease in haemoglobin affinity for O_2

A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

40 Which of these statements about the formation of haemoglobinic acid are correct?

1 It can only occur with the dissociation of oxygen from haemoglobin.

2 It removes excess hydrogen ions preventing blood becoming too acidic.

3 It is linked to the action of carbonic anhydrase.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 only **D** 2 and 3 only