Past-paper walk-through

Transport of oxygen and carbon dioxide ▪ 8.2

eXercise

Questions in this set

- 9700/11 N25 Q31 ▪ 1 mark
- 9700/12 N25 Q33 ▪ 1 mark
- 9700/12 N25 Q34 ▪ 1 mark
- 9700/13 N25 Q32 ▪ 1 mark
- 9700/14 N25 Q33 ▪ 1 mark
- 9700/21 N25 Q2 ▪ 12 marks
- 9700/22 N25 Q6 ▪ 9 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 31

9700/11 N25 ▪ Q31 ▪ 1 mark

31 The body maintains an average normal blood pH of 7.4.

Which row describes the conditions that would increase the dissociation rate of haemoglobin the most during periods of intense exercise?

	blood pH	blood CO_2 partial pressure / kPa
A	7.2	5.6
B	7.2	9.5
C	7.6	5.6
D	7.6	9.5

Solution 31

Answer: **B**

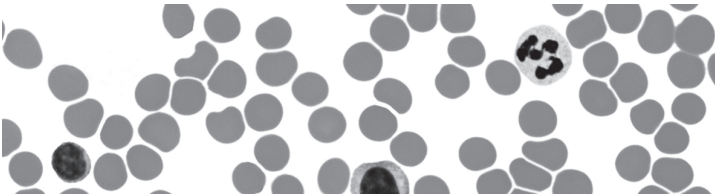
Why

- Haemoglobin releases oxygen more readily when carbon dioxide is high and pH is low – the Bohr effect.
- Intense exercise produces the most CO_2 and the lowest pH.
- So the row with pH 7.2 and the highest CO_2 partial pressure gives the greatest dissociation.

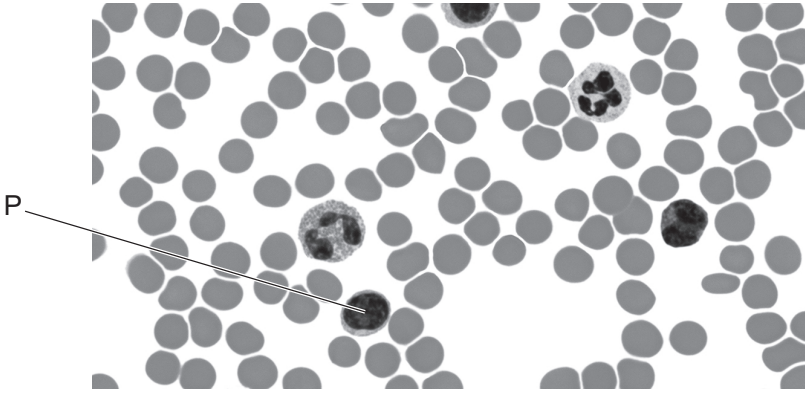
Question 33

9700/12 N25 ▪ Q33 ▪ 1 mark

33 The photomicrograph shows cells found in mammalian blood.



Question 33



What is cell P?

Question 33

A lymphocyte

B monocyte

C neutrophil

D red blood cell

Solution 33

Answer: **A**

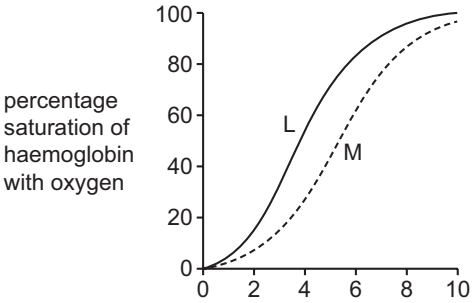
Why

- A lymphocyte is small with a very large round nucleus filling almost the whole cell.
- A monocyte is larger with a bean-shaped nucleus, and a neutrophil has a lobed nucleus.
- A red blood cell has no nucleus at all.

Question 34

9700/12 N25 ▪ Q34 ▪ 1 mark

34 The diagram shows the Bohr shift in actively respiring cells.



Question 34

partial pressure of oxygen / kPa

What causes the shift from L to M?

A Carbonic acid dissociates to release protons that bind to oxyhaemoglobin, affecting the conformation of haemoglobin to reduce its affinity for oxygen.

B Hydrogencarbonate ions produced by carbonic anhydrase alter the charge of oxyhaemoglobin, reducing its ability to bind oxygen.

C Hydrogen ions combine with chloride ions in tissue fluid to produce hydrochloric acid, distorting oxyhaemoglobin and causing it to lose bound oxygen.

D A low concentration of oxygen in actively respiring cells causes oxyhaemoglobin to release oxygen more quickly down the concentration gradient.

Solution 34

Answer: **A**

Why

- Respiring tissue releases CO_2, which forms carbonic acid in the blood.
- The acid dissociates and the protons bind to haemoglobin, changing its shape.
- That lowers its affinity for oxygen, shifting the curve to the right – the Bohr shift.

Question 32

9700/13 N25 ▪ Q32 ▪ 1 mark

32 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.

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

Solution 32

Answer: **C**

Why

- Needing a *higher* oxygen partial pressure for 50% saturation means the curve has shifted right.
- A right shift means haemoglobin's affinity for oxygen has decreased.
- Lower affinity means oxygen is released more readily to the tissues.

Question 33

9700/14 N25 ▪ Q33 ▪ 1 mark

33 Which statement correctly describes the Bohr shift?

A the decrease in affinity of haemoglobin for oxygen that occurs when pH is lowered

B the increase in affinity of haemoglobin for oxygen that occurs when oxygen concentration rises

C the increase in affinity of haemoglobin for oxygen that occurs when pH is at an optimum

D the release of oxygen from oxyhaemoglobin in the absence of carbonic acid

Solution 33

Answer: **A**

Why

- The Bohr shift is the effect of carbon dioxide, and so of pH, on haemoglobin.
- More CO_2 means a lower pH.
- That lowers haemoglobin's affinity for oxygen, so oxygen is released more readily where it is needed.

Question 2

9700/21 N25 ▪ Q2 ▪ 12 marks

2 **(a)** Haemoglobin is a globular protein containing haem groups.

Explain how the presence of haem groups allows the haemoglobin molecule to transport oxygen.

Question 2

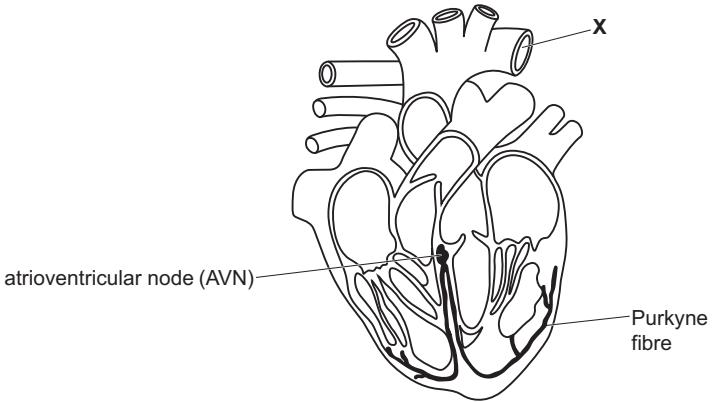
(b) In certain situations, such as during intense exercise, a person may breathe very quickly and deeply. This is known as hyperventilation.

This hyperventilation causes more carbon dioxide to be exhaled. As a result, there is a lower concentration of carbon dioxide in the blood that passes through the capillary network in respiring tissues. This increases the affinity of haemoglobin for oxygen so that there is a decrease in the release of oxygen from red blood cells.

Explain why a decrease in the concentration of carbon dioxide in the blood passing through respiring tissues leads to a decrease in the release of oxygen from red blood cells.

Question 2

(c) Fig. 2.1 is a diagram of a section through the heart.



Question 2

Fig. 2.1

(i) Describe and explain how the tunica media (middle layer of the wall) of blood vessel **X** adapts the blood vessel for its function.

Question 2

(ii) Describe the role of the atrioventricular node (AVN) and the Purkyne tissue in the cardiac cycle.

Question 2

[Total: 12]

Solution 2

(a) Mark scheme

- any two from:
- (each haem contains) an, iron ion / ferrous ion / Fe2+ ; A iron / iron atom
- (each haem) binds to / AW, an oxygen molecule / two oxygen atoms ;
- A forms a bond only if, iron ion / ferrous ion / Fe2+, stated
- 2
- 9700/21
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Solution 2

(b) Mark scheme

- any three from:
- less carbon dioxide diffuses into red blood cells ;
- less carbon dioxide reacts with water ;
- less carbonic acid is formed ;
- less, dissociation of carbonic acid / formation of hydrogen ions and hydrogen carbonate ions ;
- less haemoglobinic acid is formed ;
- A description e.g. H+ binds to haemoglobin

Solution 2

- less oxygen (released from haem) diffuses out of red blood cells (to respiring tissues) ;
- ref. to carbaminohaemoglobin ;
- AVP ; e.g. ref. to change in shape of haemoglobin when H+ binds
- 3

Solution 2

(c)(i) Mark scheme

- idea that blood vessel X carries (oxygenated blood) at high pressure (to body tissues) ;
- A ref. to systemic circulation
- any two from:
- difference
- high proportion of elastic fibres (and low proportion of smooth muscle) ;
- explanation
- (elastic fibres allow X to) expand / stretch, qualified ;

Solution 2

- e.g. to accommodate / AW, blood from ventricular, systole / contraction
- with, surges / pulses, of blood leaving heart
- to prevent, bursting / rupture
- recoil of elastic fibres, detail ;
- e.g.to allow surges / pulses, to continue
- idea of allowing continued flow of blood to tissues
- maintains, onward pressure / high pressure of blood
- if no marks gained in this section allow one mark for:
- stretch and recoil with one detail
- or

Solution 2

- ref. to two correct details but stretch and recoil not stated
- 3
- 9700/21
- October/November 2025

Solution 2

(c)(ii) Mark scheme

- allow, impulses / wave of excitation, for electrical impulses R nerve impulses once and allow ecf
- must attempt AVN and Purkyne tissue to gain max
- any four from:
- both involved in, co-ordination / control, of, systole / contraction, of, heart / heart muscle / cardiac muscle / ventricles ;
- AVN
- only pathway for impulses to travel from atria to ventricles ; AW

Solution 2

- A impulses must pass through AVN for ventricular, contraction / systole
- allow, a delay / 0.1 s, for impulse to pass from atria to ventricles ;
- so, ventricles contract after atria contract / ventricular systole occurs after atrial systole ;
- allows atria to (fully) empty before, ventricles (begin to) contract / ventricular systole
- or
- allows blood to fill ventricles before ventricular, contraction / systole ;
- Purkyne tissue
- carries / transmits / AW, impulse(s), (down septum), to base of ventricles / through walls of the ventricles ;

Solution 2

- for ventricular systole / AW ;
- ventricular muscles contract / AW, together / at same time / simultaneously / from the base upwards / from apex of heart ;
- 4
- 9700/21
- October/November 2025

Question 6

9700/22 N25 ▪ Q6 ▪ 9 marks

6 In the pulmonary circulation of a mammal, deoxygenated blood becomes oxygenated when red blood cells pass through alveolar capillaries and haemoglobin within the cells combines with oxygen.

The blood returns to the heart to be pumped around the systemic circulation.

(a) Describe the sequence of events occurring in the heart that allows blood returning in the pulmonary circulation to then enter the systemic circulation.

You should include in your description:

- the names of the relevant blood vessels of the pulmonary circulation and systemic circulation that are connected to the heart
- reference to blood pressure changes that cause the opening and closing of valves.

You **do not** need to include details of control of the cardiac cycle.

Question 6

(b) Fig. 6.1 is a drawing of a haemoglobin molecule to show its globular structure.

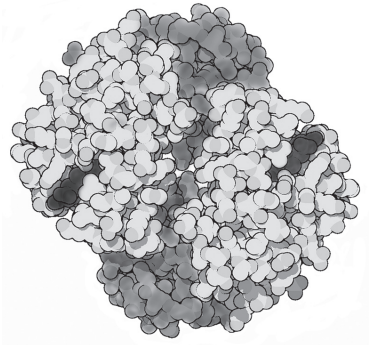

Fig. 6.1

Question 6

Question 6

(i) Describe the quaternary structure of a haemoglobin molecule.

Question 6

(ii) Outline how a haemoglobin molecule can become fully saturated with oxygen to form oxyhaemoglobin.

Question 6

[Total: 9]

Solution 6

(a) Mark scheme

- ▪
- consider all mps to award if response clearly addresses events in the left side
-
- mps 1,2,6,7,8 must be in the context of the left side of the heart
- ▪
- otherwise allow mp 3, 4, and 5 to max 3 – these mark points are inset to the right
- any five from:
- 1

Solution 6

- blood enters (heart) via / in, pulmonary vein(s) ;
- 2
- blood exits heart to aorta ;
- R arota
- 3
- blood flows from atrium to ventricle ;
- 4
- atrial, systole / contraction, then, ventricular, systole / contraction ;
- A atrium contracts then ventricle contracts
- 5

Solution 6

- pressure in ventricle, increases / gets higher ;
- I high pressure
- 6
- bicuspid / (left) atrioventricular valve closes ; A mitral valve
- R if in context of events in the atrium
- 7
- semilunar / aortic, valve opens ; ecf from arota in mp 2
- R if in context of events in the atrium
- 8

Solution 6

- bicuspid / (left) atrioventricular, valve closes when (blood) pressure in ventricle higher than atrium
- or
- semilunar / aortic, valve opens when (blood) pressure in ventricle higher than aorta ; A aortic valve
- 5
- unclear
- attempts / mixed
- right and left
- sides
- 9700/22

Solution 6

- October/November 2025

Solution 6

(b)(i) Mark scheme

- if no marks gained allow one mark for four, polypeptides / polypeptide chains
- two, (identical) alpha / α, chains / globins, and two, (identical) beta / β, chains / globins ;
- A subunits / polypeptides, for chains
- R beta-pleated sheets / globulin
- plus one from;
- each, chain / globin / polypeptide, incorporates / contains / AW, a haem (group) ;
- A four haem groups

Solution 6

- A molecule for polypeptide if mp1 gained
- A ferrous ion / Fe2+ / iron (ion / atom), within porphyrin (ring) for haem group
- A prosthetic group with, ferrous ion / Fe2+ / iron (ion / atom)
- hydrogen bonds / hydrophobic interactions / ionic bonds, between, chains / polypeptides / globins ;
- context is interactions between chains R if disulfide bond also stated
- 2

Solution 6

(b)(ii) Mark scheme

- oxygen binds to, iron ion / ferrous ion / Fe2+ ;
- A oxygen bonds / oxygen forms a bond, only if, iron ion / ferrous ion / Fe2+ stated
- A oxygen binds to, iron / iron atom / haem (group)
- R if more than one oxygen molecule binds to one iron ion
- detail of saturated ; e.g.
- total of 4 oxygen molecules / 8 oxygen atoms (bind per haemoglobin molecule)
- each, chain / globin / polypeptide, binds one oxygen molecule R bonds
- ref. to cooperative binding / allostery A description

Solution 6

- ref. to (fully saturated molecule is) in, high partial pressures of oxygen / high concentration of oxygen ;
- ref. to T / tense, state to, R / relaxed, state
- 2