Biology A

A Level Circulation in animals
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Please note that you may see slight differences between this paper and the original.

Candidates answer on the Question paper.

OCR supplied materials:
Additional resources may be supplied with this paper.

Other materials required:
- Pencil
- Ruler (cm/mm)

Duration: Not set

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions, unless your teacher tells you otherwise.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Where space is provided below the question, please write your answer there.
- You may use additional paper, or a specific Answer sheet if one is provided, but you must clearly show your candidate number, centre number and question number(s).

INFORMATION FOR CANDIDATES

- The quality of written communication is assessed in questions marked with either a pencil or an asterisk. In History and Geography a *Quality of extended response* question is marked with an asterisk, while a pencil is used for questions in which *Spelling, punctuation and grammar and the use of specialist terminology* is assessed.
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **83**.
- The total number of marks may take into account some 'either/or' question choices.

1. Pressure must be maintained as blood flows through organs and vessels of the circulatory system.

Describe **two** features of the circulatory system that could affect blood pressure.

1

2

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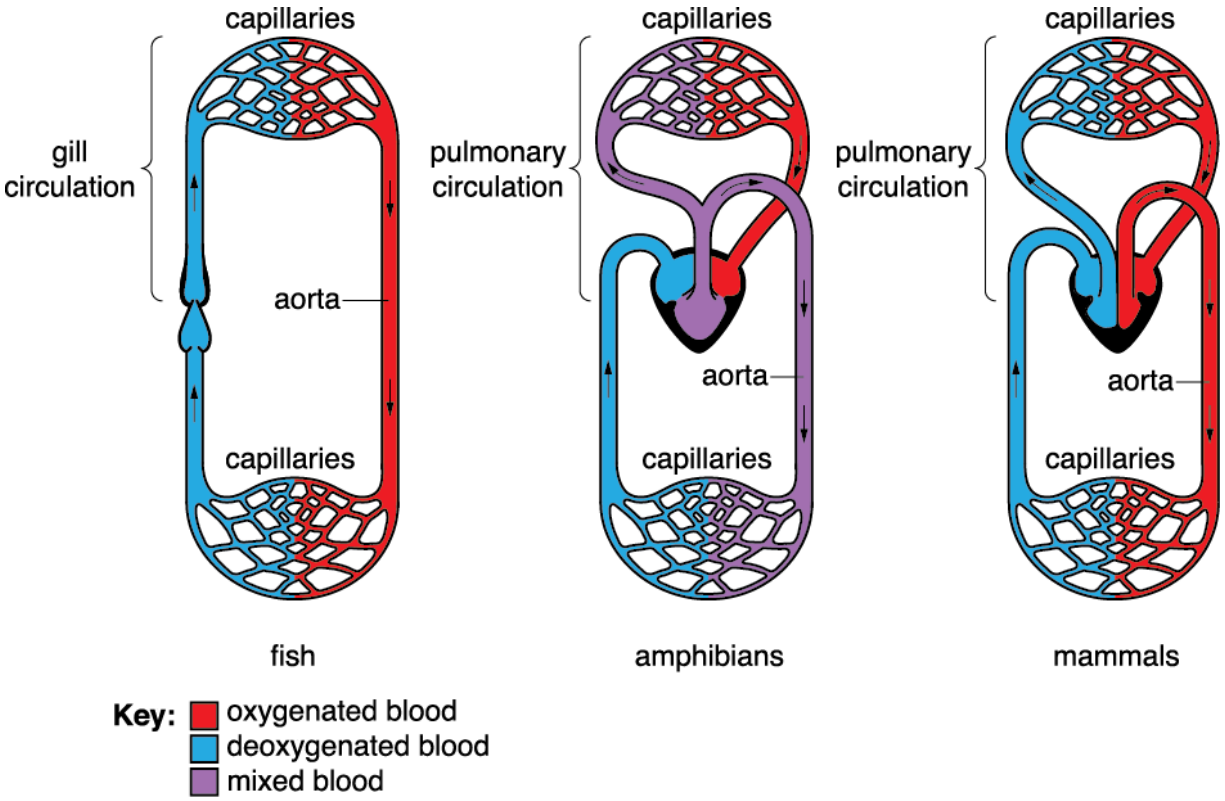
[2]

2. The figure shows the circulatory systems of three groups of animals.



(i) What type of circulatory system is shown in **all** these animals?

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[1]

(ii) How does the circulatory system of a fish compare to that of a mammal?

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[1]

3. The aquatic crustacean *Daphnia magna* has a heart that pumps a blood-like liquid called haemolymph around the body cavity.

Which of the statements, **A** to **D**, describes the circulatory system of *Daphnia magna?*

A single closed

B single open

C double open

D double closed

Your answer ☐ [1]

4. The table below shows a series of statements about systemic and pulmonary circulation.

Row	Systemic circulation	Pulmonary circulation
A	higher pressure	lower pressure
B	equal pressure	equal pressure
C	lower pressure	higher pressure
D	medium pressure	absent

Which of the rows, **A** to **D**, correctly describes a closed, double circulatory system?

Your answer ☐

[1]

5. The hormone ecdysone is synthesised in the prothoracic glands found in the upper thorax of some invertebrates and is released into haemolymph. It is then transported to cells near the surface of the body and causes the loss of the exoskeleton so that a new exoskeleton can form.

Which of the following statements explains how ecdysone is able to act on cells near the surface of the body?

1 Ecdysone is synthesised by specialised neurosecretory cells.
2 Ecdysone is soluble in haemolymph because it is a polar molecule.
3 Ecdysone is complementary to cell surface receptors on cells throughout the body of some invertebrates.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

6. A student was investigating the effect of cell size on the rate of diffusion into model cells. They had two cubes of agar containing phenolphthalein indicator as shown in Fig. 21.2.

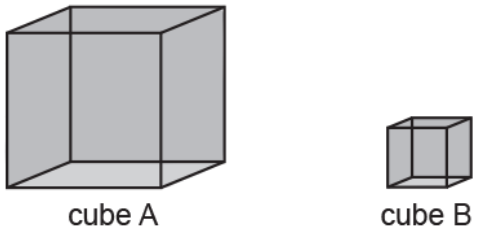

Fig. 21.2

The student placed the cubes in beakers of dilute hydrochloric acid, which caused the indicator to become colourless. They then measured how much of each cube became colourless over time.

(i) State **two** ways the student could have ensured they had confidence in their results.

1 ----------

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2 ----------

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[2]

(ii) In Fig. 21.2, Cube A is 10 mm along each side and Cube B is 4 mm along each side.
Calculate the surface area to volume ratio (SA:V) for both cubes A and B.

Show your working. Give your answers to **one** decimal place.

Cube A ----------

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[2]

(iii) Explain why the surface area to volume ratio of an organism determines whether it needs a circulatory system.

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[3]

7. Pressure varies in different parts of the mammalian circulatory system.

	Blood in aorta	Tissue fluid	Lymph	Blood in vena cava
Pressure				

Which of the following options, **A** to **D**, correctly completes the table above?

A	high	high	low	low
B	high	low	high	low
C	high	low	low	low
D	high	low	low	high

Your answer

[1]

8. State the correct term for the following definition.

A type of circulatory system that does not keep the blood within blood vessels.

[1]

9. In humans, a circulatory system is needed to transport substances around the body by mass transport.

Explain why humans need a mass transport system.

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[2]

10. The first table contains a number of statements that can be used to explain some features of the mammalian heart and blood vessels.

A	Both atria pump blood into the ventricles.
B	The pressure is very high.
C	The left ventricle wall creates higher pressure than the right ventricle wall.
D	The pressure fluctuates a lot.
E	Mammals have a double circulatory system.
F	The muscle contracts to maintain blood pressure.
G	The ventricles are larger than the atria.

The second table lists some structural features of the heart or blood vessels.

Select the most appropriate statement, **A** to **G**, to explain each feature.

The first one has been completed for you.

Structural features of the heart or blood vessels	Statement (A to G)
The wall of the left ventricle is two to three times thicker than the wall of the right ventricle.	C
Small arteries have muscular walls.	
The wall of the left atrium is the same thickness as the wall of the right atrium.	
Arteries close to the heart have a lot of elastic tissue in their walls.	
There is a septum that divides the left side of the heart from the right.	

[4]

11. The blood circulatory system of a mammal undergoes changes at, or soon after, birth.

(i) One of these changes is that the foramen ovale, a hole in the septum between the right and left atria, closes. In the fetus, the foramen ovale allows blood to flow directly from the right atrium to the left atrium.

Suggest why the foramen ovale is open in the fetus before birth.

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[2]

(ii) Another change occurring after birth is that fetal haemoglobin is replaced with adult haemoglobin.

State one difference between fetal haemoglobin and adult haemoglobin **and** give one reason why this difference is essential to the fetus.

difference

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reason

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[2]

12(a). * Describe how the structure of llama hamoglobin is likely to be different from that of camel haemoglobin with reference to the four levels of protein structure.

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[6]

(b). Haemoglobin is a protein that carries oxygen in the blood of all mammals. The structure of haemoglobin can vary slightly between species.

Fig. 4.1 shows a llama, a relative of the camel.

Fig. 4.1

- Llamas live at high altitudes and camels live at low altitudes.
- At high altitudes the partial pressure of oxygen is low.
- Llama and camel haemoglobin consists of 2 α subunits and 2 β subunits.
- Each subunit contains a haem group and is able to bind to one molecule of oxygen.

- In the β subunits, one amino acid present in camel haemoglobin has been replaced by a different amino acid in llama haemoglobin.

Fig. 4.2 shows dissociation curves for llama haemoglobin and camel haemoglobin.

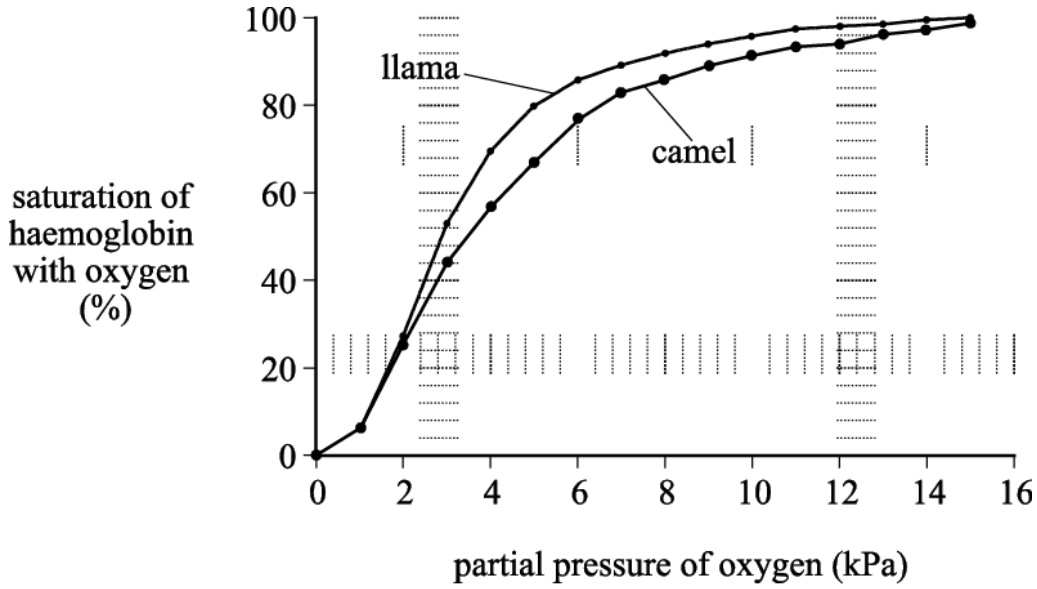

Fig. 4.2

(i) State the partial pressure of oxygen that results in a saturation of 50% in llama haemoglobin.

Answer_____ [1]

(ii) Explain why it is important for the survival of the llama that the llama haemoglobin dissociation curve is to the left of the camel haemoglobin dissociation curve.

_____

_____

_____ [2]

13. Carbon dioxide release during respiration can affect the % oxygen saturation of haemoglobin.

The tertiary structure of haemoglobin is affected when carbon dioxide reacts with water to form carbonic acid. This reaction releases hydrogen ions.

Which of the statements, **A** to **D**, explains this change?

A The release of hydrogen ions causes the pH to rise, which reduces haemoglobin's affinity for oxygen.

B The release of hydrogen ions causes the pH to rise, which increases haemoglobin's affinity for oxygen.

C The release of hydrogen ions causes the pH to fall, which increases haemoglobin's affinity for oxygen.

D The release of hydrogen ions causes the pH to fall, which reduces haemoglobin's affinity for oxygen.

Your answer [ ] **[1]**

14. Organs that contain muscle cells, such as the heart, need large quantities of oxygen for aerobic respiration.

- Haemoglobin and myoglobin are protein molecules that are involved in supplying oxygen to cells.
- Haemoglobin is found in erythrocytes (red blood cells), enabling them to transport oxygen to respiring heart muscle.
- Myoglobin is found in heart muscle cells as an oxygen store.

(i) Explain why the heart is described as an organ.

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[1]

(ii) Outline how the structure of haemoglobin enables it to transport oxygen.

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[3]

(iii) Myoglobin is described as having a tertiary structure.

What is meant by *tertiary structure*?

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[2]

15(a). Haemoglobin is found in erythrocytes. Unlike other vertebrates, the mature erythrocytes of mammals lack nuclei and other membrane-bound organelles.

(i) Explain **one** advantage and **one** disadvantage of the lack of nuclei and other membranebound organelles to mammalian erythrocytes.

Advantage _____

_____

Disadvantage _____

_____ [2]

(ii) Viruses do not use erythrocytes as host cells, whereas the malarial pathogen *Plasmodium* spends part of its life cycle inside erythrocytes.

Suggest why.

_____

_____

_____

_____

_____ [2]

(iii) Explain why erythrocytes do **not** make use of any of the oxygen that they are transporting.

_____

_____

_____

_____

_____ [2]

(b). In mammalian blood, oxygen is mainly transported combined with haemoglobin. The presence of haemoglobin greatly increases the oxygen carrying capacity of blood.

- 100 cm^3 of plasma contains 0.3 cm^3 of oxygen when fully saturated.
- 100 cm^3 of blood contains 20.1 cm^3 of oxygen when fully saturated.

Calculate the percentage increase in oxygen carried in fully saturated **blood** compared with oxygen carried in fully saturated **plasma**.

Show your working.

Answer = _____ % **[2]**

(c). Oxygenated blood returns from the lungs to the heart before being pumped around the body.

- Normal cardiac output is 5 dm^3 min^{-1}.
- 100 cm^3 of blood contains 20.1 cm^3 of oxygen when fully saturated.

Calculate the volume (cm^3) of oxygen being transported to the tissues per minute.

Show your working and give your answer to **four significant figures**.

Answer = _____ cm^3 **[2]**

(ii) With reference to the structure of blood vessels, explain why oxygen is **not** released until the blood reaches the capillaries.

_____

_____

_____

_____

_____ **[2]**

16. Erythrocytes contain haemoglobin, which is a globular protein.

Blood vessel walls contain collagen, which is a fibrous protein.

Describe the differences between globular and fibrous proteins using haemoglobin and collagen as examples.

In your answer you should refer to collagen and haemoglobin.

[8]

17. A patient was sent for a blood test, known as the haemoglobin A1C (HbA1C) test.

- Glucose combines with haemoglobin in the bloodstream to form a 'glycosylated haemoglobin' molecule, HbA1C.
- The concentration of HbA1C is directly proportional to the mean concentration of glucose in the blood over an eight to twelve week period.

Suggest why a single HbA1C test cannot indicate accurately the mean blood glucose concentration for a period longer than twelve weeks.

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[2]

18. Most carbon dioxide is transported as hydrogencarbonate ions in the plasma.

Hydrogencarbonate ions are produced in the erythrocytes and diffuse into the plasma.

(i) Describe how the hydrogencarbonate ions are **produced** in the erythrocytes.

In your answer you should use appropriate technical terms, spelled correctly.

[4]

(ii) High concentrations of carbon dioxide in the blood reduce the amount of oxygen transported by haemoglobin.

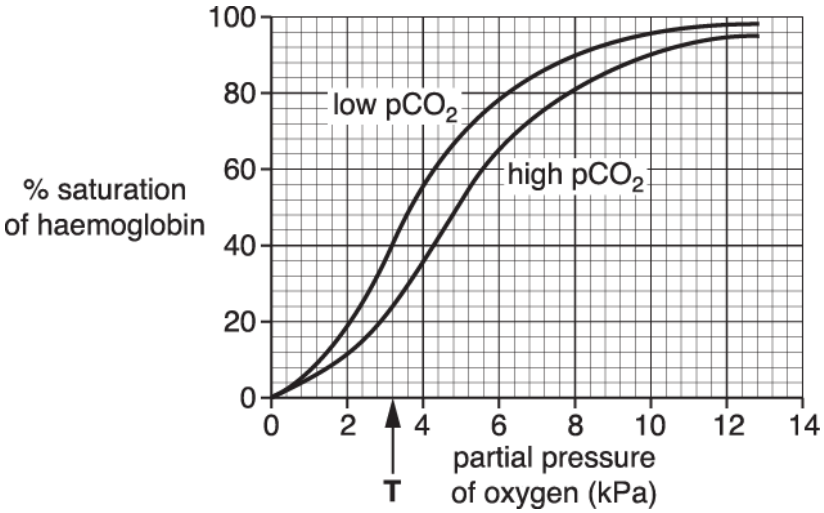
Name this effect and explain why it occurs.

name _____

explanation _____

[3]

19. The figure shows the oxygen dissociation curves at different carbon dioxide concentrations.



(i) What name is given to a change in the oxygen dissociation curve due to increasing carbon dioxide concentration?

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[1]

(ii) Letter **T** in the figure indicates the partial pressure of oxygen in actively respiring tissues.

Explain why the blood off-loads more oxygen to actively respiring tissues than to resting tissues.

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[2]

20. The following events occur when carbon dioxide enters an erythrocyte in a capillary.

1 Hydrogencarbonate ions diffuse into the plasma from the erythrocyte.
2 Dissociation of carbonic acid.
3 Carbon dioxide reacts with water forming carbonic acid.
4 Chloride ions diffuse into erythrocyte from plasma.

In which sequence do they occur?

	First step →			Final step
A	2	4	1	3
B	3	2	1	4
C	3	1	4	2
D	2	3	4	1

Your answer ☐

[1]

21. Blood contains erythrocytes. Erythrocytes are full of haemoglobin.

Describe the role of haemoglobin in transporting oxygen around the body.

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[3]

22. Complete the following statements about proteins using the most appropriate terms.

- The secondary structure of a protein may contain many regions folded in zig-zag patterns known as _____ _____.
- The secondary structure of a protein is determined by the arrangement of _____ bonds, which stabilise the structure.
- The _____ structure of collagen is described as a left-handed helix because of the direction in which the polypeptide twists.
- Polypeptides known as alpha (α) and beta (β) _____ form part of the _____ _____ structure of haemoglobin.

[5]

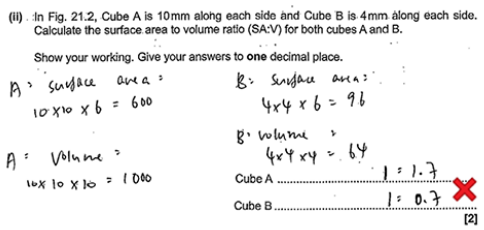
END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			force of ventricular contractions; strength of elastic recoil (of blood vessels); resistance to blood flow / AW;	2 max	ACCEPT lumen diameter of blood vessels qualified e.g. narrower lumen would increase pressure CREDIT *idea of* vasodilation or vasoconstriction occurring IGNORE reference to cardiovascular disease Examiner's Comments In this question, the context of blood pressure measurements provided candidates with the opportunity to demonstrate their knowledge of the circulatory system and respond to 'How Science Works' style questions involving the sphygmomanometer. A wide range of responses were seen in this part. Some candidates identified a factor, for example, lumen size of a vessel, but did not qualify their response with a description to gain credit for the marking point.
			Total	2	
2		i	closed ✓	1	DO NOT CREDIT incorrect additional answers Examiner's Comments Most candidates answered this correctly.

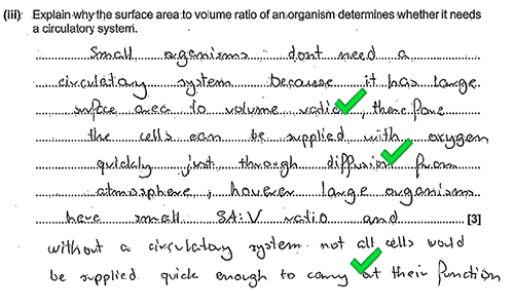
Question			Answer/Indicative content	Marks	Guidance
		ii	the fish has a single (circulation) **and** the mammal has a double (circulation) ✓	1	ACCEPT descriptions of the circulations, but **both** must be described to be awarded the mark. e.g. deoxygenated and oxygenated blood passes separately through the mammalian heart but only deoxygenated blood through the fish heart in a circuit of the body the blood passes through the heart twice in mammals but once in fish ACCEPT single (fish circulatory system) versus a double (mammalian circulatory system) DO NOT CREDIT double versus single Examiner's Comments This question was quite well answered, although those candidates who chose to describe the circulations (rather than stating single for the fish and double for the mammal) frequently only described one. It was interesting to note that a significant number of candidates referred to 'pumps' rather than hearts, although some stated that the fish did not have a heart.
			Total	2	
3			B ✓	1	Examiner's Comments Candidates should be well aware that insects have a single open circulatory system. *Daphnia* are small crustaceans closely related to insects. Most candidates were able to spot this link and give the correct response.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
4			A	1	
			Total	1	
5			C ✓	1	Examiner's Comments Option A provided a distractor and common incorrect response to the correct option C in this question, as statement 1 relating to the cells synthesising ecdysone, would not form part of an explanation for the site of action of the hormone.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
6		i	repeat (readings) ✓ calculate mean ✓ identifying anomalies ✓ use statistical test to identify difference ✓	2 max	this could be mean distance/size of colourless area, or mean time if cube allowed to go completely colourless ALLOW calculate standard deviation <u>Examiner's Comments</u> The question asks how the student could ensure confidence in the results. Confidence is a qualitative judgement expressing the extent to which a conclusion is justified by the quality of the evidence. The majority of candidates gained one mark here for repeating the readings. Only the more able candidates gained a second mark. This second mark was usually credited for calculating a mean. Many candidates described how the student could improve the validity of the results. Definitions of the terms associated with practical work are available in the practical skills handbook. Key: OCR support Identifiable issue or misconception

Question			Answer/Indicative content	Marks	Guidance
		ii	cube A = 0.6 (: 1) ✓ cube B = 1.5 (: 1) ✓	2 max	**ALLOW** 1 mark for 600 : 1000 **and** 96 : 64 6 : 10 **and** 3 : 2 : 5 **and** 3 : 2 (as correct ratios but not expressed correctly) Allow these ratios if written anywhere in the answer space. **DO NOT ALLOW** if units given <u>Examiner's Comments</u> This question asked for the surface area to volume ratio of two cubes to be calculated. Less able candidates have always struggled with this concept and this still seems to be true. Surface area to volume ratios should always be calculated as a surface area to one unit of volume (0.6 :1 rather than 0.6). Less able candidates often calculated it the other way around – a volume for one unit of surface area. Exemplar 1  (ii) In Fig. 21.2, Cube A is 10mm along each side and Cube B is 4mm along each side. Calculate the surface area to volume ratio (SA:V) for both cubes A and B. Show your working. Give your answers to **one** decimal place. A: surface area = 10x10 x 6 = 600 A: Volume = 10x 10 x 10 = 1000 B: surface area: 4x4 x 6 = 96 B: volume = 4x4 x4 = 64 Cube A ..... 1 : 1.7 Cube B ..... 1 : 0.7 [2] As seen in Exemplar 1, candidates often know how to calculate the surface area and the volume. Less able candidates then struggle to put these two components together properly to calculate the surface area to volume ratio. This exemplar shows the ratio stated incorrectly as a volume to one unit of surface area.

Question			Answer/Indicative content	Marks	Guidance

		iii	large(r) organism has small(er) SA : Vol ratio ✓
			(rate of) diffusion (too) slow /
			diffusion distance (too) long ✓
			for (sufficient), delivery / uptake of, oxygen / nutrients
			OR
			for (sufficient) removal of (named) waste products ✓
			for, (aerobic) respiration / metabolic demands ✓
				2 max	ALLOW ORA for first three mark points
					
					<u>Examiner's Comments</u>
					
					Many candidates knew that large organisms have a small surface area to volume ratio. These candidates successfully linked the concept of a small surface area to volume ratio with the need for a circulatory system. More able candidates could explain the need in terms of a slower rate of diffusion which meant that insufficient oxygen reached the tissues for respiration or metabolism. Less able candidates often confused the concept of a surface area to volume ratio, with surface area.
					
					Exemplar 2
					
					 
					(iii) Explain why the surface area to volume ratio of an organism determines whether it needs a circulatory system.
					Small organisms dont need a circulatory system because it has large surface area to volume ratio, therefore the cells can be supplied with oxygen quickly just through diffusion from atmosphere ; however large organisms have small SA:V ratio and [3]
					without a circulatory system not all cells would be supplied quick enough to carry out their function
					
					This exemplar is a good response because it clearly explains that a small organism has a large surface area to volume ratio. This allows rapid diffusion. But in a larger organism with a small surface area to volume ratio, the cells will not be supplied quickly enough.

			Total	**7**	

Question			Answer/Indicative content	Marks	Guidance
7			C	1	**Examiner's Comments** This question required candidates to draw on their knowledge of the various parts of the circulatory system in a way in which they may not have done previously. The most common error was to think that the blood in the vena cava was under high pressure.
			Total	**1**	
8			open (circulatory system) ;	1	**Mark the first answer for each question part.** If the answer is correct and a further answer is given that is incorrect or contradicts the correct answer then = **0 marks** **Examiner's Comments** This term was well known to the majority of candidates.
			Total	**1**	
9			(humans are) large / multicellular, organisms; (humans have) low SA:Vol; *idea of* a longer diffusion distance (so) substances needed could not be supplied quickly enough;	2 max	**ACCEPT** humans have many cells **Examiner's Comments** In this question, the context of blood pressure measurements provided candidates with the opportunity to demonstrate their knowledge of the circulatory system and respond to 'How Science Works' style questions involving the sphygmomanometer. This part surprisingly saw few candidates refer to humans as being 'large' or having a 'small SA:V' and examiners noted that 'why humans need a mass transport system' appeared to be a poorly understood concept.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
10			F; A; B or D; E;	4	Examiner's Comments Most candidates did well here. The most frequent incorrect response was to write B (the pressure is very high) to explain why small arteries have muscular walls (first row).
			Total	4	

Question			Answer/Indicative content	Marks	Guidance
11		i	lungs not, functioning / filled with air; blood / haemoglobin, is, not oxygenated in the lungs / oxygenated in placenta (therefore) pulmonary circuit / lungs, bypassed;	2 max	ACCEPT fetus not breathing ACCEPT ref to 'single circulation' ACCEPT little blood goes to, lungs / pulmonary circuit DO NOT ACCEPT no blood goes to lungs Examiner's Comments Examiners were looking for definite statements about the flow of blood in the fetus such as 'less blood flows to the lungs' or 'the pulmonary circuit is by-passed'. Many candidates were rather vague making statements such as 'no need for blood to flow to the lungs' or 'the fetus gets oxygen from its mother' without mention of haemoglobin or the placenta. Other common mistakes included references to mother and fetus sharing blood, or that 'the fetus doesn't respire so there is no deoxygenated blood'! Many candidates answered this question carelessly because they did not recognise that the placenta is the only source of oxygen for the fetus. A large number of candidates did not discuss the lungs at all in their response, not appreciating that the fetus cannot breathe in utero. Instead they made statements such as 'the heart is not developed enough to pump blood' or more worryingly 'the mother pumps blood around their body so they don't have to'.

Question			Answer/Indicative content	Marks	Guidance
		ii	EITHER *Difference:* (fetal haemoglobin) higher affinity for oxygen /described/ ORA; *Reason:* (fetal haemoglobin) must be able to bind to oxygen, in low(er) partial pressure / in placenta/ when adult oxyhaemoglobin dissociates / when adult haemoglobin dissociates from oxygen; OR *Difference:* (fetal haemoglobin) contains gamma sub-units; *Reason:* creates high(er) affinity for oxygen;	2	ACCEPT able to become more saturated than adult haemoglobin at low pO_2 IGNORE gets more saturated at low pO_2 (ie no comparison to adult haemoglobin) IGNORE ref to saturation curve CREDIT 'associate with / combine with / loads' for bind IGNORE pick up / take up / gains / absorbs / attracts / attaches / saturates DO NOT CREDIT oxygen dissociates or haemoglobin dissociates Examiner's Comments The majority of candidates knew that fetal haemoglobin has a higher affinity for oxygen than adult haemoglobin. Those who did not achieve this mark stated that fetal haemoglobin had 'a high affinity' or failed to make it clear that it was the affinity for oxygen. Fewer candidates achieved the second mark where examiners were looking for a clear explanation of the reason for this difference using correct technical terminology.
			Total	4	

Question			Answer/Indicative content	Marks	Guidance
12	a		**Level 3 (5–6 marks)** Describes differences and similarities of llama and camel haemoglobin at all four levels of protein structure with correct reference to bonding. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Describes differences and similarities of llama and camel haemoglobin in some levels of protein structure with some reference to bonding. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Describes a difference or similarity of llama and camel haemoglobin at a level of protein structure. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points include:** • difference in primary structure • different amino acid / polypeptide sequence • one amino acid changed. • amino acid change could cause change to secondary structure • initial coiling or folding of polypeptide chain • α-helix • β-pleated sheet • hydrogen bonding. • amino acid change could cause change to tertiary structure • further coiling of secondary structure • ionic bonding • disulphide bonds • hydrophilic / hydrophobic bonds • 3D shape. • amino acid change has not changed quaternary structure • alpha and beta subunits still able to form haemoglobin in both camel and llama.
	b	i	2.8 (kPa)	1	**ALLOW** answer in the range of 2.8–3.0 kPa
		ii	(llama) haemoglobin needs higher affinity for oxygen (1) (so) can pick up oxygen at lower partial pressure (of oxygen) (1)	2	
			Total	**9**	

Question			Answer/Indicative content	Marks	Guidance
13			D ✓	1	Examiner's Comments This question tests understanding of the Bohr effect. Candidates find this a difficult topic and many link more hydrogen ions to higher pH. Those that understand the pH scale then incorrectly link a fall in pH to a rise in affinity of haemoglobin for oxygen. Only the most able candidates reliably got this correct.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
14		i	made of different types of tissue;	1	CREDIT named tissues Examiner's Comments (i) was well answered but the remainder of this question proved to be more challenging, as have biochemical questions in previous sessions.
		ii	has four polypeptide chains AND (4) haem / iron?containing (prosthetic) groups; each haem group can carry, one oxygen molecule / O_2 OR each haemoglobin molecule can carry four oxygen molecules; *idea of* reversible binding / AW OR cooperative binding / AW;	3	ACCEPT Fe^{2+} for 'iron' LOOK FOR descriptions of reversible binding e.g. 'binds ....released' OR descriptions of cooperative binding. Examiner's Comments In part (ii), only a small number of candidates achieved full marks with very few references to either cooperative binding or to reversible binding of oxygen molecules. Weaker candidates referred to oxygen atoms or simply to oxygen. Some good descriptions of tertiary structure were seen although some candidates just listed the bonds involved without saying what these actually did to the protein molecule.
		iii	*idea of* further, folding / twisting , of secondary structure / polypeptide; into (specific) 3D shape; held by, named bond(s) / bonds between R groups;	2 max	e.g. ionic, disulfide, hydrophobic / hydrophilic interactions IGNORE hydrogen unless it is bonding between R groups as hydrogen bonds appears in different levels of structure.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
15	a	i	*advantages* A1 more space for / can contain more / can carry more, haemoglobin / oxygen ✓ A2 can squeeze through capillaries easily ✓ *disadvantages* D1 limited life span / cannot divide / cannot reproduce / cannot undergo mitosis ✓ D2 no, protein synthesis / repair ✓ D3 no respiration, in / by, mitochondria **or** no mitochondria for respiration **or** limited respiration / no aerobic respiration / only anaerobic respiration ✓	max 2	Mark **first answer** only for advantage and disadvantage. A1 **DO NOT CREDIT** in context of larger surface area **ACCEPT** 'Hb' for haemoglobin D1 max time of 120 days / 4 months D3 **DO NOT CREDIT** 'no mitochondria so no respiration' (as some respiration will still take place) **ACCEPT** 'ATP release' or 'energy provided' instead of 'respiration' e.g. no energy being provided from mitochondria ATP is not released by mitochondria **DO NOT CREDIT** ref to producing / creating, energy **Examiner's Comments** Most candidates stated that lack of a nucleus left more space for oxygen/haemoglobin but a significant number referred wrongly to an increase in surface area. The short life span of erythrocyte was commonly stated as a disadvantage but very few candidates realised their inability to carry out protein synthesis. Many candidates simply re-stated that erythrocytes had no membrane-bound organelles or a nucleus without any further qualification. A common misunderstanding was that the erythrocyte would be unable to respire, failing to realise that anaerobic respiration does still take place. A significant number said that erythrocytes would be unable to defend themselves from infection without a nucleus, or could not control cell activities

Question			Answer/Indicative content	Marks	Guidance
					or what entered or left the cell.
		ii	*virus* virus is unable to / cannot, replicate / reproduce, on its own / outside a host cell **or** virus requires host cell, machinery / DNA / RER / ribosomes, for protein synthesis **or** virus does not contain, RER / ribosomes, for protein synthesis ✓ – *Plasmodium* *idea that Plasmodium is* using the host cell to hide from the immune system **or** for *Plasmodium* to complete its life cycle **or** for *Plasmodium* to use as a source of food (for, growth / reproduction) ✓	2	**IGNORE** ref to the erythrocyte not having membrane-bound organelles without ref to the need of the virus to use them inside the cell Must be a clear statement **ACCEPT** needs / has to use, host cell to, replicate / reproduce **ACCEPT** 'malarial pathogen' for *Plasmodium* **IGNORE** eukaryotic / protoctist **IGNORE** it has its own, DNA / nucleus / protein synthesis apparatus **IGNORE** ref to just, part / stage, of life cycle **IGNORE** ref to organelles **Examiner's Comments** This was a challenging question for many, and several failed to specify which organism they were talking about. Candidates often understood that viruses couldn't use erythrocytes for reproduction but failed to make the link that viruses must use the host cell to replicate. Candidates restated the question describing that part of the Plasmodium life cycle took place in the red blood cell but failed to realise it did not complete its life cycle. Commonly, candidates said that the Plasmodium used the erythrocyte for transport and as a source of oxygen. Many candidates spoke of Plasmodium using the erythrocyte

Question			Answer/Indicative content	Marks	Guidance
					because it is injected directly into the blood by the mosquito. Only the most able candidates described how Plasmodium could evade the immune response within the red blood cell.
		iii	1 oxygen is bound to haemoglobin (while being transported) ✓ 2 lack mitochondria ✓ 3 (therefore) no aerobic respiration ✓ 4 (moved by mass flow so) doesn't need, energy / ATP, to move **or** needs less, energy / ATP (for metabolic processes) ✓	2	1 **ACCEPT** 'it' for 'oxygen' **ACCEPT** 'Hb' for haemoglobin 3 **ACCEPT** only respires anaerobically **IGNORE** ref to energy 4 **DO NOT CREDIT'** does not need, energy / ATP' unqualified **DO NOT CREDIT** 'makes / produces, energy' **Examiner's Comments** Most candidates scored 1 mark for lack of mitochondria although some candidates just referred to no organelles or no organelles for respiration. Very few candidates made the connection with aerobic respiration and the majority of candidates believed that erythrocytes could not respire at all and just had a completely passive role. Many candidates referred to the pointless nature of using the oxygen that they are supposed to be carrying to other tissues, more of a philosophical attitude than biological one.

Question			Answer/Indicative content	Marks	Guidance
	b		6 600 ✓✓	2	Correct answer = 2 marks If answer is incorrect, ALLOW 1 mark for seeing 20.1 – 0.3 = 19.8 **or** (20.1 – 0.3) ÷ *x* **or** 19.8 ÷ *x* where *x* = any number Examiner's Comments This was a challenging question with no more than a third of candidates knowing how to carry out the percentage change calculation correctly. A large proportion of candidates failed to work out the difference as the first step (so missed the calculation mark) and if they did calculate it, candidates then offered this as the % difference, without the division and ×100 part of the calculation. This mathematical skill should be specifically practised.
	c	i	1005 ✓✓	2	Correct answer = 2 marks If answer is incorrect then ALLOW 1 mark for any ref to 201 × 5 (e.g. 2.01 × 5 or 2.01 × 50 or 0.201 × 0.5 etc) Examiner's Comments Many candidates understood the need to multiply 5 × 20.1 and gained one working mark for this or a variation of it, but many were clearly struggling with the conversion into different units of different magnitude and the correct answer was only gained by a few.

Question			Answer/Indicative content	Marks	Guidance
		ii	1 arteries / arterioles, have thick wall or capillary wall is, thin / one cell thick / only endothelium ✓ 2 no diffusion (through artery wall) or diffusion distance (too) large for artery or diffusion occurs (through capillary wall) or short diffusion distance for capillary ✓	2	1 ACCEPT artery walls have, elastic fibres / muscle / collagen / (more) layers IGNORE ref to veins / venules DO NOT CREDIT ref to cell wall Note: ‘artery walls too thick for diffusion to take place’ = 2 marks Examiner's Comments Many candidates made reference to elastic tissue and muscle tissue in arteries and arterioles but did not gain credit because they failed to specify the wall. Some candidates just referred to ‘blood vessels’ as stated in the question, without naming them. A significant number referred to cell walls of the different vessels. The majority of candidates referred to capillaries as being one cell thick, with no reference to their walls. Most candidates gained credit for diffusion in connection with capillaries.
			Total	12	

Question	Answer/Indicative content	Marks	Guidance
16	*Globular* **G1** ball (shaped) / spherical / AW; **G2** hydrophilic / (R-)groups / regions, on outside (of 3-D structure) / hydrophobic (R-)groups on inside; **G3** form H-bonds with water; **G4** soluble; **G5** example of globular protein (other than haemoglobin);	7 max	**G1 IGNORE** round / globular **G5 ACCEPT** (named) enzyme / hormone / antibody / channel / carrier **G5 IGNORE** metabolic / transport
	H1 haemoglobin, <u>carries / transports</u>, / oxygen / carbon dioxide;		**H1 ACCEPT** references to buffering
	H2 haemoglobin contains, prosthetic group / haem / Fe^{2+} / iron ion (to allow oxygen to be carried);		**H2 IGNORE** Fe^{3+}
	H3 (polypeptide chains within) haemoglobin have tertiary structure (in a ball shape);		**H3 ACCEPT** haemoglobin has tertiary structure
	F1 *Fibrous* linear / long (chain);		**F1 ACCEPT** straight / rope-like **F1 IGNORE** strand
	F2 (chains can) form (H) bonds with adjacent, chains (within a molecule);		**F2 IGNORE** fibre / fibril **F2 ACCEPT** 'strand' as AW for 'chain' for **F2** only **F2 ACCEPT** crosslink as AW for bond for **F2** only
	F3 insoluble / few hydrophilic groups;		**F2 DO NOT CREDIT** molecule as 'AW' for 'chain' **F2 IGNORE** attractions / (named) covalent bonds
	F4 strong / provide strength;		**F4 IGNORE** flexible / inelastic / withstands pressure
	F5 have <u>structur</u>al role;		
	C1 collagen has high proportion of glycine, so chains can lie close together / AW;		

Question	Answer/Indicative content	Marks	Guidance
	C2 collagen forms, crosslinks / covalent bonds, between molecules; C3 crosslinks / ends of molecules, are staggered to avoid, weak points / AW; C4 collagen forms part of, tendon / cartilage / ligament / bone / connective tissue / bronchi / bronchioles / trachea / skin;		C2 ACCEPT (micro / macro) fibrils / fibres, as AW for molecules C3 ACCEPT (micro / macro) fibrils / fibres, as AW for molecules C4 IGNORE blood vessel / artery / vein, wall C4 IGNORE lips
	QWC - use of haemoglobin and collagen as examples	1	AWARD if any H mark and any C mark are awarded Examiner's Comments This question differentiated well between candidates and many scored highly. Observations on each marking point were as follows: • G1: Some candidates described the shape of globular proteins as 'round' and were not credited. • G2: Some referred to hydrophobic and hydrophilic 'interactions' rather than parts of the molecule. • G3: Almost nobody mentioned forming H-bonds with water. • G4 and F3: These were very commonly awarded but a few candidates got the solubility the wrong way round. • G5: This was only seen occasionally with enzymes being the most common suggestion. • H1: This was regularly given but some candidates just mentioned 'binding' to oxygen, rather than transporting or carrying it. • H2: This was frequently given but some responses just mentioned 'iron'. • H3: This was rarely given. Candidates often discussed primary, secondary, tertiary and quaternary structures for both proteins. • F1: This was given often for both 'long' and 'rope like'.

Question			Answer/Indicative content	Marks	Guidance
					• F2 and C2: F2 was easier, and given slightly more often, but it was clear that many candidates had not learned the specific nature of the bonds within collagen. • F4 and F5: Around half of candidates got both of got these marks. • C1: Many candidates acknowledged that glycine formed a high proportion of the structure, but failed to link this to the chains being able to lie closely together. • C3: This was attempted by a minority of candidates but with regard to strength rather than avoiding weak points. • C4: Many candidates just repeated what was in the question, giving blood vessels as an example. Of those that were awarded the mark, 'tendons' was most frequent, followed by 'bone' and 'skin'. • QWC: This was often awarded and where it wasn't it was usually for want of a C mark. Many candidates stated that haemoglobin was made of α and β glucose. It is worth noting that such errors as this usually result in fewer marks for candidates. On this occasion the mark scheme was more forgiving.
			Total	8	

Question			Answer/Indicative content	Marks	Guidance
17			1 HbA1C / glycosylated Hb, contained within, red blood cell(s) / erythrocyte(s); red blood cells / erythrocyte(s), have limited life span / live for 8 to 12 weeks **or** red blood cells / erythrocyte(s), break down after, 12 weeks / 3 months; 3 HbA1C / glycosylated Hb, broken down, in liver / by hepatocytes / by Kupffer cells;	2 max	**CREDIT** RBC / rbc for 'red blood cell' throughout **3 IGNORE** ref to recycling **Examiner's Comments** Some candidates were able to gain a mark for understanding that red blood cells would only last for a maximum of 12 weeks after which they would be replaced. Candidates failed to gain credit for being too vague, for example stating 'blood cells' rather than RBC's, and several referred to 'haemoglobin' rather than glycosylated haemoglobin. Those candidates who did mention HBA1C being broken down failed to state that it was broken down in the liver. Many candidates commented that eating habits would vary during this period, with different amounts of glucose being consumed on different days, or varying amounts of exercise, which might cause the mean concentration to alter. Others stated that a single test would not allow a mean to be calculated or anomalous results to be identified.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
18		i		3 max	**CREDIT** mark points taken from equations or flow charts e.g. $CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$ this = mp 2 and 4 to award mp 3 and 5 correctly located annotations needed **ACCEPT** correct symbols and formulae throughout (but **NOT** for QWC mark) **CON** If name and formula contradict e.g. hydrogencarbonate ions = H_2CO_3
			1 carbon dioxide, enters / diffuses into, erythrocytes ; 2 (carbon dioxide) combines / reacts, with water ; 3 correct ref to **carbonic anhydrase;** 4 forms **carbonic acid ;** 5 (carbonic acid) **dissociates** to form hydrogencarbonate ions *and*, **hydrogen ions** / **protons** ;		**ACCEPT** red blood cells **Note:** correct context is it catalyses, combination of carbon dioxide and water / formation of carbonic acid **IGNORE** if linked to dissociation of carbonic acid **IGNORE** carbolic / carboxylic **ACCEPT** splits / broken down **ACCEPT** bicarbonate ions **Note:** both products must be ions produced from dissociation of a compound (not dissociation of hydrogencarbonate ions)

Question			Answer/Indicative content	Marks	Guidance
		i	QWC ;	1	Any two technical terms from the list below used appropriately and spelled correctly : carbonic acid carbonic anhydrase, dissociates (or derivatives of this word) hydrogen ions / protons Examiner's Comments The best candidates could describe the formation of hydrogencarbonate ions in two or three lines and achieve the QWC mark by the third line. Good responses were clear and succinct – often accompanied by correct symbols and equations. A common misconception was that hydrogen or hydrogen ions reacted with carbon dioxide, or possibly haemoglobin. Another common misconception was that hydrogecarbonate ions dissociate to form hydrogencarbonate ions and hydrogen. This is an area where weaker candidates need further support to fully understand.

Question			Answer/Indicative content	Marks	Guidance
		ii		3 max	**Maximum 2 marks if effect not named correctly**
			Name 1 Bohr (effect / shift) ;		**ACCEPT** phonetic spelling
			*Explanation (**any 2** of the following marks)*		
			2 reduces affinity (of Hb) for oxygen ;		**IGNORE** ref to 'curve shifting'
			3 formation of haemoglobinic acid / hydrogen ions interact with haemoglobin ;		**ACCEPT** hydrogen ions, combine / bind, with Hb **ACCEPT** HHb for haemoglobinic acid **ACCEPT** $H^+ + Hb \rightarrow HHb$
			4 prevents, fall in pH / build-up of H^+, in cells **OR** provides buffering effect ;		
			5 alter, structure / shape, of haemoglobin ;		
			6 ***more*** oxygen released where, needed / more respiration / carbon dioxide concentration high ;		**ACCEPT** causes **more** oxygen to leave (oxy)haemoglobin / high**er** levels of oxygen released **IGNORE** ref to oxygen released more quickly or more easily **Note:** do not give a mark for 'more ***oxygen*** dissociates' as this implies oxygen is forming ions / atoms
			7 CO_2 binds to haemoglobin forming carbaminohaemoglobin ;		(as this explains reduced oxygen transport)
					Examiner's Comments Most candidates could name the Bohr effect. Far fewer were able to successfully explain why it occurs. Better candidates started their response where part c) finished, with hydrogen ions having an effect on the haemoglobin. They also related it to part b) by stating that the affinity of the haemoglobin for oxygen is reduced and therefore more oxygen is released where the carbon dioxide concentration is high.
			Total	**7**	

Question			Answer/Indicative content	Marks	Guidance
19		i	Bohr (effect / shift) ✓	1	Correct spelling only ACCEPT bohr / Bohr's / bohr's Examiner's Comments The vast majority of candidates answered (and spelled) Bohr effect/shift correctly.
		ii	*in actively respiring tissues* 1 more / high levels of, carbon dioxide (produced) **or** high pCO_2 ✓ 2 lowered affinity of haemoglobin for oxygen✓ 3 (CO_2 results in) dissociation of carbonic acid / increase of H^+, leading to the release of oxygen ✓ 4 more oxygen released at same pO_2 / suitable data quote from graph ✓	max 2	*If symbols used must be correct e.g. CO_2 not CO^2* 1 ACCEPT ORA for resting tissue 2 ACCEPT 'Hb' for haemoglobin ACCEPT weaker affinity 4 (at, T / 3.2 kPa O_2) drops from 40% to 24% saturation / 16% reduction Examiner's Comments Most candidates described the actively respiring cells' 'need' for oxygen and that it is released because the tissues require it. They also stated that actively respiring tissues have a low partial pressure of oxygen (as they use up oxygen), but failed to make the link to more CO_2 being produced. A worrying number of candidates thought that resting tissues did not respire or need any oxygen at all, and some thought that respiring tissues themselves have a higher affinity for oxygen. The more able candidates described the effect of increased carbon dioxide in terms of H^+ from carbonic acid causing dissociation of oxygen from haemoglobin.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
20			B	1	
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
21			1 (haemoglobin has) high affinity for oxygen ; 2 oxygen binds to haemoglobin in, lungs / alveoli / high pO_2 ; 3 oxyhaemoglobin ; 4 oxygen released, in tissues / where needed / where pO_2 is low / where respiration is occurring ;	3 max	ACCEPT haem group / iron ions for haemoglobin ACCEPT high, oxygen tension / concentration ACCEPT attaches / combines / loads / associates / becomes more saturated IGNORE picks up / oxygenated DO NOT CREDIT reacts with ACCEPT unloads / dissociates from Hb Note: do not give a mark for '*oxygen* dissociates' as this implies oxygen is forming ions / atoms ACCEPT low, oxygen tension / concentration IGNORE gives up / drops off IGNORE ref to high carbon dioxide concentration Examiner's Comments Most candidates scored some marks when asked about the role of haemoglobin in the transport of oxygen. The command word 'describe' requires a reasonable level of detail in the response. Examiners were looking for the idea of either loading or unloading oxygen linked to where this occurred. Good responses made statements such as: 'oxygen combines with haemoglobin in the lungs where the oxygen tension was high'. Again the use of appropriate scientific terms such as 'loading' or 'binding' enabled better candidates to score where others did not. Candidates also need to be specific in their statements – haemoglobin has 'a high affinity for oxygen' rather than just 'an affinity'. Also, oxygen 'dissociates from haemoglobin' rather than just 'dissociates'. The latter implies that the oxygen molecule splits into two smaller particles. Candidates must also be encouraged to read the question carefully, as many responses gave details of the structure of the haemoglobin molecule and how it loads oxygen which were not required.

Question			Answer/Indicative content	Marks	Guidance
			Total	3	
22			beta– / β- / B / b, pleat(ed sheet) / fold; hydrogen / H; secondary; subunits / chains; quaternary;	5	 DO NOT CREDIT H^+ / H_2 ACCEPT 2° IGNORE tertiary / fibrous ACCEPT globins IGNORE strands / units / peptides ACCEPT 4° IGNORE globular Examiner's Comments Few candidates scored full marks for this question. The most common incorrect answer was to describe the left-handed twisting of the polypeptide chain as an aspect of tertiary, rather than secondary, structure. Collagen has an atypical structure that many candidates find confusing and textbooks often do little to clarify.
			Total	5	