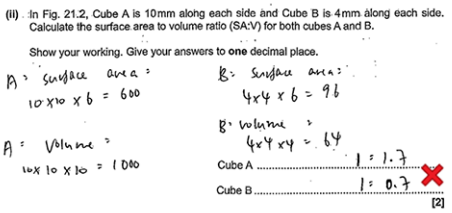
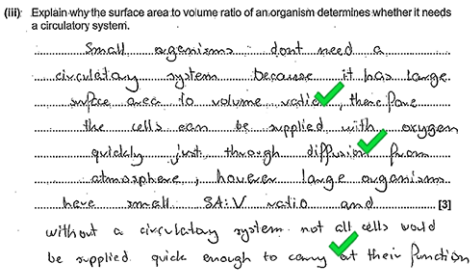
Mark scheme - Transport in Animals

24		i	reference to SA:V ratio ✓ SA:V jellyfish is 7:1 and sea bass is 1:3 ✓ correct explanation with ref. to <u>diffusion distance</u> ✓	3 (AO3.2)	**ALLOW** SA:V ratio for surface area to volume ratio **ALLOW** fish / larger organism, for sea bass **ALLOW** Latin names **ALLOW** SA:V ratio is (much / 21 times) larg<u>er</u> / high<u>er</u>, in jellyfish (than in sea bass) **ORA** **ALLOW** jellyfish is 7:1 and sea bass 0.3:1 e.g. more cells in sea bass so <u>distance</u> oxygen has to travel is too great for <u>diffusion</u> alone
		ii	single (circulatory system / circulation) ✓	1 (AO1.1)	**IGNORE** closed **DO NOT ALLOW** open
		iii	blood, stays in / is enclosed by / is transported in, (named) vessels ✓	1 (AO1.1)	
		iv	*any two from:* sea bass single vs. mammal double ✓ sea bass blood goes through heart once vs. mammal twice ✓ sea bass 1 atrium and 1 ventricle vs. mammal 2 atria and 2 ventricles ✓	2 max (AO2.1)	**ALLOW** mammal has pulmonary and systemic circulations **CREDIT** sea bass 2 chambers vs. mammal 4 chambers OR sea bass heart no septum vs. mammal heart has a septum
			Total	**7**	

25			high metabolic, demands / rate ✓ need, large oxygen / rapid oxygen, supply ✓ diffusion, not sufficient / too slow / distance too far ✓ (to) maintain, steep / AW, concentration / diffusion, gradient(s) ✓ surface area to volume ratio is (usually) low ✓ (named) metabolite(s) needed by cells / (named) waste(s) removed from cells ✓	**3 max**	*give credit to examples used in the correct context* **ALLOW** high rate of respiration **IGNORE** not efficient **ALLOW** SA:V / surface area relative to volume **ALLOW** nutrients / hormones **IGNORE** oxygen **ALLOW** toxins **Examiner's Comments** The mark points in **Q16(c)** were accessible to candidates across the ability range and there were some extremely confident responses showing a good understanding of this topic. Many candidates linked mark points three and five describing how the small SA:V would mean that diffusion distances would be too great. Stronger candidates consolidated this by explaining that such animals also have high metabolic rates and/or high oxygen demands.
			Total	**3**	
26		i	repeat (readings) ✓ calculate mean ✓	2 max	

			identifying anomalies ✓ use statistical test to identify difference ✓		this could be mean distance/size of colourless area, or mean time if cube allowed to go completely colourless **ALLOW** calculate standard deviation **Examiner's Comments** 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
		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 **Examiner's Comments** 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 = 10 x 10 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.

		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
					
					Examiner's Comments
					
					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

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td>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.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>7</td><td></td></tr>
<tr><td>27</td><td></td><td></td><td>B</td><td>1</td><td>Examiner's Comments

This question required basic mathematical skills, as required in the specification, to select the correct answer. A significant proportion of candidates were unable to perform the calculations correctly.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>28</td><td></td><td></td><td>Using a ‘best-fit’ approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme.

Once the level is located, award the higher or lower mark.

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

• The science content determines the level.</td><td>6 (AO2.1)</td><td>Indicative scientific points may include…
As this is a comparison BOTH fish and mammals must be mentioned
Similarities

• Both are closed systems / blood in blood vessels
• Both have a heart
• Both carry oxygen using haemoglobin
• Both have arteries / veins / capillaries

Differences:

<table>
<tr><td>Fish</td><td>Mammal</td></tr>
<tr><td>Single circulation / blood though heart once</td><td>Double circulation / blood through heart twice Pulmonary and systemic circulations</td></tr>
<tr><td>One atrium and 1 ventricle / 2 chambers (in heart) / no septum in heart</td><td>Two atria and 2 ventricles / 4 chambers (in heart) / heart has a septum</td></tr>
<tr><td>Blood passes through 2 sets of capillaries (before returning to heart)</td><td>Blood passes through 1 set of capillaries (before returning to heart)</td></tr>
<tr><td>Blood pressure is lower (to organs)</td><td>Blood maintained at higher pressure</td></tr>
</table>
</td></tr>
</table>

- **The communication statement determines the mark within a level.**

Level 3 (5–6 marks)
Full and detailed comparison of the circulatory systems of a fish and mammal.

There is a well-developed comparison including a range of features. The information presented is relevant and clearly explained.

Level 2 (3–4 marks)
Detailed comparison of the circulatory systems of a fish and mammal.

There is a reasonable attempt at comparison including a small range of features. The information presented is mostly relevant and clearly explained.

Level 1 (1–2 marks)
Some correct comparison of the circulatory systems of a fish and mammal.

The information is basic and communicated in an unstructured way. The information is supported by limited explanations which may be unclear.

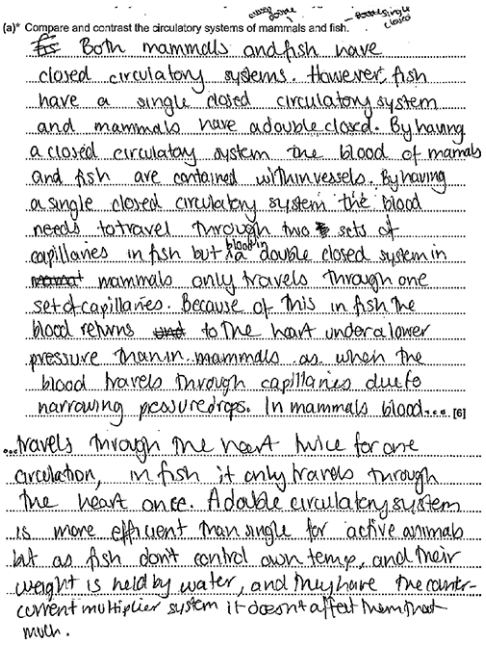
0 marks
No response or no response worthy of credit.

	2 circulations with different pressures / can have high pressure in systemic circulation
Less efficient at transporting / supplying oxygen to tissues	More efficient at transporting / supplying oxygen to tissues
(Fulfils needs) as fish are 'cold blooded' / have a low oxygen demand / low metabolic rate	(Fulfils needs) as mammals need to maintain a constant body temperature / have a high oxygen demand / high metabolic rate

Examiner's Comments

This Level of Response question assessed AO1 in the context of comparing circulatory systems in mammals and fish. There were some excellent concise responses as shown by the Level 3 exemplar where candidates expressed their knowledge of closed circulations either double as in the mammal or single as in the fish. Level 3 responses included other similarities and differences, such as differences in heart structure or metabolic rate, to provide a well-balanced comparison. It was a common error for candidates to confuse the circulation of a fish with that of an insect describing an open circulation. Reponses that included lengthy detail about gaseous exchange systems rather than circulatory systems were credited with the lower communications mark within a level.

Exemplar 2

					 (a)* Compare and contrast the circulatory systems of mammals and fish. Both mammals and fish have closed circulatory systems. However fish have a single closed circulatory system and mammals have a double closed. By having a closed circulatory system the blood of mamals and fish are contained within vessels. By having a single closed circulatory system the blood needs to travel through two sets of capillaries in fish but a double closed system in mammals only travels through one set of capillaries. Because of this in fish the blood returns to the heart under a lower pressure than in mammals as when the blood travels through capillaries due to narrowing pressure drops. In mammals blood... [6] ...travels through the heart twice for one circulation, in fish it only travels through the heart once. A double circulatory system is more efficient than single for active animals but as fish don't control own temp, and their weight is held by water, and they have the counter-current multiplier system it doesn't affect them that much. This exemplar shows an excellent Level 3 response for Science content. Many candidates were able to complete their responses within the space allocated with very few using the additional pages at the end of the question paper.
			Total	**6**	
29	a	i	closed ✓	1	**DO NOT CREDIT incorrect additional answers** **Examiner's Comments** Most candidates answered this correctly.
		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.
	b		**Level 3 (5–6 marks)** • Describes both frog and mammalian circulations • Gives some detail on the relative effectiveness of the two systems. *There is a well-developed line of reasoning which is clear and logically structured, relates to Figs 5.1 and 5.2 and uses scientific terminology at an appropriate level.* *All the information presented is relevant and forms a continuousnarrative.* Awarding at this Level = L3 & 5 ticks ✓ ✓ ✓ ✓ ✓ Communication = ✓ or ✗ **Level 2 (3–4 marks)** • Describes the mammalian or frog circulation. • Attempts a description of the circulation of the other organism. • Comments on the effectiveness of the two systems. *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information*	6	***In summary:*** *Read through the whole answer. (**Be prepared to recognise and credit unexpected approaches where they show relevance.**)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, **Level 1**, **Level 2** or **Level 3**, **best describes the overall quality of the answer**.* *Then, award the higher or lower mark within the level, according to the **Communication Statement** (shown in italics):* • *award the higher mark where the Communication Statement has been met.* • *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.*** **Use the green dot in the margin to indicate places where good scientific points are made about the 2 circulations.** **Use a highlight square in the margin to indicate places where good scientific points are made about the relative effectiveness.** **Indicative scientific points may include but are not limited to:** *circulations* **19** both are double circulations **20** blood from mammalian heart transported

			presented is mostly relevant. Awarding at this Level = L2 & 3 ticks ✓ ✓ ✓ Communication = ✓ **or** ✗ ..... **Level 1 (1–2 marks)** • **either** Describes the mammalian **or** frog circulation. **or** Comments on the effectiveness of the two circulatory systems. *The information is communicated with some structure but may include a small amount of irrelevant material and some inappropriate use of scientific language.* Awarding at this Level = L1 & 1 tick ✓ Communication = ✓ **or** ✗ ..... **0 marks** No response or no response worthy of credit.		separately to lungs and body **21** oxygenated and deoxygenated blood never mix **22** blood from frog heart transported to lungs and body together **23** blood going to the body in the frog is, partially oxygenated / mixed **24** oxygenated blood only separate when returning from lungs **25** reference to the spiral valve partly separating oxygenated and deoxygenated blood **26** flow of blood through the hearts described **27** ref to differences between structure of frog and mammalian hearts *effectiveness of circulation* **28** both can be considered to be effective **29** frog could be considered to be less effective **30** frog has less oxygen available for the body cells **31** circulation is effective enough for the frog's needs **32** frog has lower metabolic rate **33** frog maintains body temperature by other means **34** frog heart may beat faster (to compensate) **35** frog oxygenates blood at skin / mouth **36** frog circulation may limit its size **37** frog circulation developed from that of tadpole **38** mammalian body cells get maximum available O_2 **39** mammal has higher metabolic rate **40** mammal (uses metabolism to) maintain body temperature **Examiner's Comments** This was a Level of Response question which was challenging as it dealt with some unfamiliar material and produced a wide spread of marks. The candidates often did well with part or full descriptions of the frog and mammalian circulatory systems but responses often lacked effective accounts of comparative efficiency. The vast majority of candidates recognised that blood is 'mixed' in amphibians but not in mammals. There were some good descriptions of the mammalian circulation, which at times also went on to describe amphibian circulation

					well. Some thought that the frog has an open circulatory system or sometimes a triple one. Many candidates attempted to explain why the mammalian circulation is effective in terms of the separation of oxygenated and deoxygenated blood and some linked this to the oxygen concentration gradient in respiring tissues. A few linked this to differences in the metabolic rates of the two organisms. A minority of candidates discussed the relative carbon dioxide concentration gradients in the lungs or respiring tissues. Some candidates wrote about pressure differences - blood can be under higher pressure in the mammalian systemic circulation so can travel faster around body. Some references to maintaining body temperature were seen, but candidates often used simple non-scientific terms such as cold blooded. Some gained full marks by discussing the relative effectiveness of mammalian and amphibian circulation.
			Total	**8**	
3 0			***Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.*** ***In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1****,* ***Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* ○ *award the higher mark where the Communication Statement has been met.* ○ *award the lower mark where aspects of the Communication*	6 (AO2.3 AO2.4 AO3.1)	For highest band need a **correct reference to Fig. 2.3** and explanation of how the **structure** of each blood vessel is suited to its **function** for each of the three blood vessels **(arteries, veins and capillaries).** **Indicative points can include:** <u>*Correct reference to data in* ***Fig. 2.3***</u> Artery has: smaller lumen, smaller diameter, less collagen, more elastic tissue and more muscle (than vein) ORA. Correct use of figures from **Fig. 2.3** for comparisons. Capillary has: no muscle, no elastic tissue, no collagen tissue, is only one cell thick. The lumen diameter of 9.5 μm is slightly bigger than the red blood cell diameter of 8 μm. <u>*Artery*</u> **Function:** carry blood away from the heart under high pressure (so they have to withstand this pressure and force). **Structure:** (Thicker) elastic layer / elastin, enables them to withstand, pressure / force. (Thicker) elastic layer / elastin, enables them to, stretch recoil.

			Statement have been missed. • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.*** **Level 3 (5–6 marks)** *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* Full and detailed description of how the structure of the blood vessel is suited to its function for all three types of blood vessels (arteries, veins and capillaries) and correct reference to the data in Fig. 2.3. **Level 2 (3–4 marks)** *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* A fairly good description of how the structure of the blood vessel is suited to its function for all three types of blood vessels, arteries, veins and capillaries, and correct reference to the data in Fig. 2.3 **Level 1 (1–2 marks)** *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.* Some description of how the structure of the blood vessel is suited to its function for all three types of blood vessels, arteries, veins and capillaries, and some reference to the data in Fig. 2.3.		Ref. elastic layer evens out surges from the pumping of the heart and allows a continuous flow of blood (Windkessel effect). Collagen provides, structure / support. Collagen maintains shape and volume (limiting stretch). Smooth muscle contracts and relaxes to, change the size of the lumen / control blood pressure. Smooth muscle provides strength to withstand the pressure. <u>*Veins*</u> **Function:** Veins carry blood back to the heart. No, pulse / surge from heart. Blood in veins is under less pressure (than in arteries). Needs to move against gravity. **Structure:** Thinner elastic layer (no, stretch / recoil / pulse). Have valves to prevent backflow of blood. More collagen than arteries to give structural support as they carry large volumes of blood. <u>*Capillaries*</u> **Function:** Allow substances, to be exchanged / diffuse, between blood and, tissue fluid / surrounding cells. **Structure:** Walls are one cell thick. Short diffusion distance. Only large enough to allow red blood cells to travel through in single file (to increase contact of RBCs with capillary wall). Small enough to form network needed to exchange substances.

			0 marks *No response or no response worthy of credit.*		
			Total	**6**	
3 1	a		tunica intima (1) OR endothelium (1)	1	**ALLOW** tunica interna
	b		0.15 ± 0.05 (1) (1) (1)	3	*If incorrect answer given* **ALLOW** 1 mark for calculating artery lumen ÷ vein lumen **ALLOW** 1 mark for correctly calculating artery or vein cross section *Max 2 if answer is given to more than 4 significant figures*
	c		(in arteries) small lumen maintains pressure (1) (in veins) low resistance / friction needed because of, low pressure / slow flow (1) *further detail* *idea that* same flow rate is achieved by having a larger volume / cross sectional area (1) *idea that* large cross section compared to circumference means fewer particles colliding with wall / low friction / less resistance (1)	3	**ALLOW** *idea that* small volume compared to wall surface means molecules in blood more likely to collide with wall
			Total	**7**	
3 2	a	i	(water potential) decreases / more negative ✓	1 (AO1.1)	
		ii	large plasma proteins cannot, pass out through capillary wall / leave the blood, but other solutes can ✓ imbalance of large plasma proteins between blood and tissue fluid results in oncotic pressure ✓	2 (AO2.1)	

	b	i	Jv = (4.5 − 0.15) − 0.75 (4.2 − 0.03) = 1.22 (kPa) ✓ out of capillary / outward ✓	2 (AO2.2)	**ALLOW** 1.2 / 1.2225 / 1.223 **ALLOW** into tissue fluid
		ii	reduction in albumin concentration reduces (capillary) oncotic pressure ✓ (so) increase the net driving force ✓	2 (AO2.2)	
		iii	***student is correct because…*** net driving force, is higher / has increased ✓ (so) more tissue fluid formed ✓ ***student is incorrect because …….*** kidney damage could lead to more loss of water (in urine) ✓ no information about, hydrostatic pressure / tissue oncotic pressure, in patients ✓ single patient could respond atypically ✓ (inflammation leading to) reduction in value of reflectance factor could increase, albumin / protein, in tissue fluid ✓	max 4 (AO3.1)	**ALLOW** less, fluid / water, returned to blood **ALLOW** reduction in σ could increase oncotic pressure in tissue fluid
	c		<table><tr><th>Statement</th><th>True</th><th>False</th></tr><tr><td>Lymph is similar in composition to tissue fluid but has more oxygen.</td><td></td><td>✓</td></tr><tr><td>Tissue fluid does not contain lymphocytes because they are too large to pass through capillary wall.</td><td></td><td>✓</td></tr></table>	2 (AO1.1)	**IGNORE** crosses

			Lymph contains more protein than tissue fluid because of antibody production by plasma cells. ✓ 3 correct ✓✓ 2 correct ✓		
			Total	**13**	
3 3			***Please refer to the marking instruction point 10 for guidance on how to mark this question.*** ***In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1, Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* • *award the higher mark where the Communication Statement has been met.* • *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.***		

			Level 3 (5–6 marks) A clear description how the non-specific defences cause all or nearly all of the observed responses (making reference to clotting and scab formation, inflammation **and** swelling of lymph node). All observations are clearly explained in full and with a clear link between each observation and each explanation. *There is a logical thread linking each observation in the correct time line as the immune system comes into action. Specialist terms are used throughout.* **Level 2 (3–4 marks)** A clear description of the non-specific responses that cause some of the observed responses (making reference to clotting and scab formation, one to do with inflammation of the cut **and / or** swelling of lymph node). Some explanations are provided but these may not link clearly to the observation or may not be complete explanations. *The information is clear and concise using a number of scientific terms appropriately.* **Level 1 (1–2 marks)** A limited description of the non-specific responses covering at least one of the observations (to do with clotting and scab formation, inflammation of the cut or swelling of the lymph node). Explanations are given for the observation but the explanations are not clear and there is no clear link between the observation and the explanation. *There is a logical structure to the answer. The explanation, though*	6	**Indicative scientific points may include:** **bleeding stops:** • exposure (of blood / platelets) to collagen in damaged, blood vessel / tissue causes clotting response • many factors involved in clotting process • soluble fibrinogen converted to insoluble fibres • mesh of fibres traps cells and platelets • clot prevents bleeding • clot dries out to produce scab • scab protects against entry of pathogens **swelling / redness / tenderness**: • infection by pathogen • detection by mast cells • release of, histamine / cell signals, cause response • arterioles dilate allowing more blood to area causing redness • more tissue fluid forms causing swelling (oedema) • phagocytes attracted to area • phagocytosis of pathogens **discomfort in armpits:** • excess tissue fluid drained to lymph vessels • pathogens in tissue fluid enter lymph fluidz • transported along lymph system to lymph nodes • activity of phagocytes (and lymphocytes) causes, swelling of lymph nodes / discomfort in armpit

			basic, is clear. **0 marks** No response or no response worthy of credit.		
			Total	**6**	
3 4			**Level 3 (5-6 marks)** Correctly describes similarities **and** differences between the processes *There is a well-developed line of reasoning, which is clear and logically-structured and uses scientific terminology at an appropriate level. All the information presented is relevant and forms a continuous narrative.* **Level 2 (3-4 marks)** Correctly describes a similarity and a difference between the processes *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented is mostly relevant.* **Level 1 (1-2 marks)** Correctly describes similarities or differences between the processes *The information is communicated with only a little structure. Communication is hampered by the inappropriate use of technical terms.* **0 marks** No response or no response worthy of credit.	**6**	**Indicative scientific points may include** *Similarities:* • Small molecules are filtered from/diffuse out of the blood. • Both processes occur in capillaries. • Large molecules/proteins/ cells, remain in the blood. • High (hydrostatic) pressure in both processes. • Many molecules (e.g. water, sugars, ions) are reabsorbed back into capillaries. • Blood vessels become narrower to maintain (hydrostatic) pressure • Hydrostatic pressure greater than oncotic pressure in both • Neutrophils / lymphocytes, can pass through in both • Both involve basement membranes *Differences:* • Filtrate enters the Bowman's capsule and then the PCT in the kidney, but tissue fluid bathes cells/enters intercellular space. • Molecules that are not reabsorbed by capillaries form urine in the kidney, but molecules that are not reabsorbed from tissue fluid will, enter cells / form lymph. • Blood filtered through 3(named) layers in ultrafiltration, but only 1 (named) layer in formation of tissue fluid • knot of capillaries in ultrafiltration but a network of capillaries in formation of tissue fluid **Examiner's Comments**

					This was the more difficult of the Level of Response questions, but examiners saw the full range of marks credited. Those candidates who took the lead from the question and organised their answer into similarities and then differences gave significantly more coherent responses and were credited communication marks. Those who jumped around in their thinking, which was reflected in the poor organisation of the answers, lost the communication mark. Similarly, some listed features of the 2 systems independently and made little attempt to compare them and the communication mark was deducted. Similarities were more common – most candidates identified high hydrostatic pressure, small molecules to leave and large molecules (e.g. proteins) held back as similarities. Hence the majority of candidates succeeded in reaching at least L1 with 2 similarities. Correct differences were less common. The most common differences mentioned were the differences in number of filtering layers, and the location of the 2 processes. Common misconceptions seen involved misunderstanding the role of oncotic pressure in both and lack of awareness that ultrafiltration occurred at the Bowman's capsule and nowhere else in the kidney tubule. Weaker candidates confused ultrafiltration with selective reabsorption, and/or the formation of tissue fluid with its reabsorption and therefore wrote irrelevant answers. A tip for candidates would be to use sub headings to ensure they are covering both areas of the question. **Exemplar 3**

6 The process of ultrafiltration in the kidney shares similarities with the formation of tissue fluid.

(a)* Describe the similarities and differences between ultrafiltration and the formation of tissue fluid.

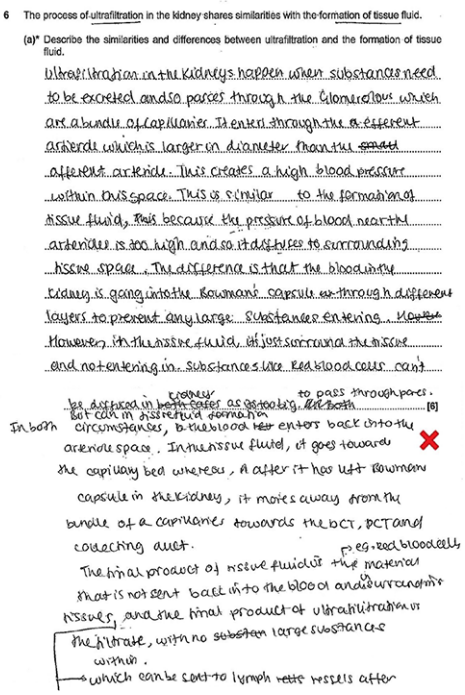
Both processes rely on hydrostatic pressure to push out the contents of the capillary by mass flow. However in ultrafiltration this pressure is built by a narrower efferent capillary than afferent. Both capillary walls contain gaps or pores/fenestrations to allow only small molecules through like glucose, ions (Na+, K+). However the process of ultrafiltration/ultrafiltration has a basement membrane and podocytes which mean molecule bigger than a molecular mass of 69 000 cannot pass through. So, lymphocytes and small proteins can pass through to tissue fluid but not into the nephron. The leakiness of the capillary at sites of tissue fluid formation can be altered by the production of histamine whereas the glomerulus does not. The process of ultrafiltration only occurs at the glomerulus, but tissue fluid is formed all over the body. (eg the nephron) [6]

Tissue fluid is drained into the lymphatic system but the nephron leads to the ureter then to the bladder. The formation of tissue fluid has a pressure working against hydrostatic pressure called oncotic pressure whereas, ultrafiltration does not.

L2

This candidate achieved a Level 3 for this response. It fulfilled the need for several similarities (both processes involve hydrostatic pressure and filtering of small molecules through capillary walls) and several differences (location of the processes, and what happens to the molecules following the two processes). Generally, the response is well organised, despite the incorrect statements about oncotic pressure and histamine.

Exemplar 4

					6 The process of ultrafiltration in the kidney shares similarities with the formation of tissue fluid. (a)* Describe the similarities and differences between ultrafiltration and the formation of tissue fluid.  In this case, we have a similarity- the high pressure needed in both processes- and a difference - where the processes occur- so it achieves a Level 1. It is not easy to pick out these points as the terminology used is not clear. There is also a lot of irrelevant material and so this response loses its communication mark.
			Total	**6**	
3 5		i	<table><tr><th>Important role</th><th>Ion</th></tr><tr><td>Production of nitrate ions by bacteria</td><td>NH_4^+</td></tr><tr><td>Loading of phloem</td><td>H^+</td></tr><tr><td>DNA structure</td><td>PO_4^{3-}</td></tr><tr><td>Cofactor for amylase</td><td>Cl^-</td></tr></table> ✓ ✓	2	**Additional incorrect answer in a cell = 0 marks** Symbols must be fully correct all three correct = 2 marks one or two correct = 1 mark none correct = 0 marks **Examiner's Comments** Most candidates could identify one or two ions associated with the roles. The least-known ion was chloride ion as a cofactor for amylase.
		ii		2	Statements must: • **name the end** of the capillary

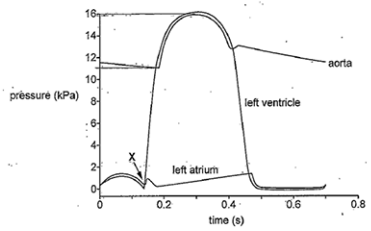
			at arterial end **AND** hydrostatic / 4.6, is great**er** than, oncotic / −3 **AND** (fluid / plasma) moves, **out** / from, (capillary) ✓ at venous end **AND** hydrostatic / 2.3, is low**er** than, oncotic / −3 **AND** (tissue fluid) moves **into** (capillary) ✓		make a **comparative** statement about the two pressures in the capillary (using name or number) • state the **direction of movement** of fluid. **ALLOW** bigger / higher / more, for 'greater' **ALLOW** ORA oncotic / −3, less than hydrostatic / 4.6 **ALLOW** ORA fluid moves into tissues **IGNORE** osmosis **ALLOW** smaller / less, for 'lower' **ALLOW** ORA oncotic / −3, more than hydrostatic / 2.3 **ALLOW** ORA fluid moves, out of / from, tissues **IGNORE** osmosis **Examiner's Comments** This question targeted a quantitative understanding of a theoretical process. Candidates needed to present an analysis of the figures in the question to explain why fluid moves out of the capillary at the arterial end and back in at the venous end. Memorised answers that not fully explain the net effect of the two opposing pressures did not score. Lower scoring answers ignored oncotic pressure and just discussed the difference between hydrostatic pressure at both ends of capillary.
			Total	**4**	
36			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**	
37		i	*any two from:* aorta ✓ pulmonary (artery) ✓ coronary (artery / arteries) ✓	2 max (AO1.1)	

		ii	septum ✓	1 (AO1.1)	
		ii i	*any three from:* left ventricle wall should be thicker than right (not same) ✓ label 'right ventricle' should be (left / right) atrium ✓ label 'tricuspid valve' should be semi-lunar valve ✓ idea that drawing is wrong way round so left ventricle should be on the right side of the page ✓	3 max (AO3.4)	**IGNORE** drawing quality errors **IGNORE** structures omitted from drawing **ALLOW** RV should be at correct label location described **ALLOW** tricuspid valve should be at correct label location described **DO NOT ALLOW** left and right ventricles should be switched **ALLOW** LV should be labelled RV
			Total	**6**	
38		i	**A** = sinoatrial node / SA node / SAN ✓ **B** = right, atrium / atria ✓ **C** = (inferior) vena cava ✓ **D** = semilunar valve ✓ **E** = bicuspid / (left) atrioventricular / (left) AV, valve ✓	5 (AO1.1)	**DO NOT ALLOW** sinoarterial **ALLOW** aortic valve **ALLOW** mitral valve **DO NOT ALLOW** tricuspid
		ii	autonomic ✓	1 (AO1.1)	**ALLOW** parasympathetic / sympathetic
			Total	**6**	
39	a		<table><tr><th>Source of blood</th><th>Valve that controls blood flow</th><th>Destination of blood</th></tr><tr><td>right ventricle</td><td>right semilunar valve</td><td>pulmonary, artery/arteries ✓</td></tr><tr><td>left atrium</td><td>left atrioventricular / bicuspid / mitral (valve)</td><td>left ventricle ✓</td></tr></table>	2 (AO2.1)	**IGNORE** 'lungs' **ALLOW** left atrial ventricular (valve)
	b		blood, leaks / AW, from left to right ventricle (during ventricular systole) ✓ (more) oxygenated blood delivered to lungs ✓	4 max (AO2.1)	**ALLOW** 'oxygenated and deoxygenated blood mix' **IGNORE** 'blood between the two ventricles is not separated'

			deoxygenated blood passes into left ventricle (during atrial systole) ✓ less oxygenated blood pumped, around the body / to tissues / to cells ✓ less oxygen available for (aerobic) respiration / ATP production ✓		**ALLOW** 'less oxygen transported to, the body / tissues / cells' **ALLOW** 'less aerobic respiration takes place'
			Total	**6**	
40		i	*assume answer refers to heart **2** unless stated otherwise:* can see / it has, aorta / (pulmonary) artery / (pulmonary) vein / vena cava / <u>blood</u> vessel(s) ✓	1	**DO NOT ALLOW** coronary artery **ALLOW** ORA that aorta / (pulmonary) artery / (pulmonary) vein / vena cava / <u>blood</u> vessel(s), not present on heart **1** **<u>Examiner's Comments</u>** Most candidates referred to the visible blood vessels or a named vessel on heart 2.
		ii	**Z** = <u>left ventricle</u> ✓	1	**IGNORE** cardiac muscle **<u>Examiner's Comments</u>** Most candidates identified the left ventricle. Some wrote cardiac muscle which is a tissue rather than a structure.
			Total	**2**	
41		i	(branches of) coronary artery (1)	1	
		ii	(cardiac / heart) muscle (1)	1	
		iii	<table><tr><th>Feature</th><th>Visible</th></tr><tr><td>AV valve</td><td>✓</td></tr><tr><td>bundle of His</td><td>X</td></tr><tr><td>left ventricular wall</td><td>✓</td></tr><tr><td>Pulmonary vein</td><td>X</td></tr><tr><td>Purkyne fibres</td><td>X</td></tr><tr><td>SA node</td><td>X</td></tr><tr><td>semi-lunar valve</td><td>✓</td></tr><tr><td>septum</td><td>✓</td></tr></table>	3	4 correct ticks = **3 marks** 3 correct ticks (and no more than 1 incorrect) = **2 marks** 2 correct ticks (and no more than 2 incorrect) = **1 mark**
			Total	**5**	

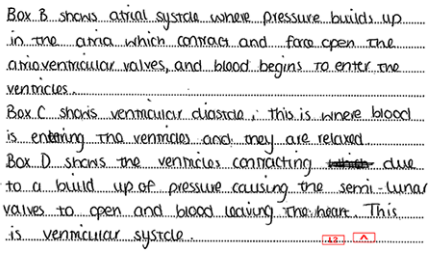
4 2		i	1. similar increase **and** decrease (in pressure), between 0 to 0.15s / to 0.15s / to point X ✓ 2. steeper / faster, rise / fall, in ventricle (pressure) ✓ 3. bigger , increase / decrease, in ventricle (pressure) ✓ 4. *idea that* at approximately 0.15s atrial (pressure) has, (small) rise and fall / AW, but ventricular is increasing ✓ 5. *idea that* from approximately 0.3s ventricular pressure decreases but atrial pressure still increasing ✓ 6. from 0.5s no change in pressure(s) in both ✓ 7. comparative figures with units ✓	4 max(AO1.2) (AO2.5)	**ALLOW** changes in pressure are the same, between 0 to 0.15s / to point X / to 0.15s **ALLOW** ORA for atrium **ALLOW** ORA for atrium **NOTE: MPs 2** and/or **3** may be implied using comparative figures For **MP7** units must be mentioned once Figures must show **change** in pressure in kPa **ALLOW** +/- 0.5 throughout for pressure e.g. at 0.15s ventricle pressure goes from 0.2 kPa to 16kPa but atrial has 'blip' from 0.2 to 0.8 and back down = **MP4** and **MP7** e.g. ventricular pressure has big increase from 0.2kPa to 16kPa but atrial only goes to 0.8kPa = **MP3** and **MP7** **Examiner's Comments** Good responses demonstrated the ability to compare the changes in pressure between the two heart chambers. The increase in pressure being greater in the (left) ventricle than in the atrium was recognised by many candidates, and those who gave figures for the pressure changes often gained two marks. Good responses also used approximate times when comparing increases and decreases of pressure at the different stages shown in Fig.16.Many candidates gave descriptions or explanations of what was happening during the cardiac cycle, detail of blood flow through the heart and valve action. Despite being accurate, these responses

Time (s)	LA (kPa)	LV (kPa)
0	0.2	0.2
0.08	1.5	1.0
0.15	0.2	0.2
0.30	0.8	16.0
0.50	0.2	0.2

					did not address what was being asked by the question and could not be credited. Candidates are reminded to use units e.g. (kPa) and (s) in this case, when using figures to support their responses. **Exemplar 1** 16 (a) Fig. 16 shows pressure changes during the cardiac cycle.  Fig. 16 (i) Using Fig. 16, compare the changes in pressure in the left ventricle with the changes in pressure in the left atrium. In the first 0.15 seconds, the left ventricle & left atrium (atrial systole) have a similar pressure, this is atrial systole. From 0.15 seconds to 0.3 (rapidly) seconds, the pressure of the left ventricle increases from 0kPa to 16kPa, this is showing ventricular systole. At the same time, the pressure in the left atrium increases steadily to a pressure of 1.5kPa at ~0.18 seconds. The ventricular pressure decreases rapidly from 16kPa to 0kPa from 0.3s to 0.55, before ventricular and atrial pressure remain roughly the same from 0.5s to 0.7s. [4] This response identifies a high attaining response where the candidate has clearly compared pressure changes and included the use of figures and units from Fig.16.
		ii	86 bpm ✓	1(AO1.2)	**Unit must be given** **ALLOW** beats per minute **Examiner's Comments** The majority of candidates demonstrated that they could use Fig.16 to extract the information and perform a heart rate calculation. Some candidates were not credited for this single mark question because they did not give their answer to two significant figures or did not include units e.g. beats min^{-1} **OCR support** The 'Maths for Biology' website provides support on the correct use of significant figures:

					https:/www.ocr.org.uk/subjects/biology/maths-for-biology/handling-data/
		iii	45 (%) ✓✓	2(AO1.2)	**IGNORE** + or – **ALLOW for 1 max** 44 or 46 If answer incorrect or not given to 2 sig.figs: **ALLOW for 1 max** 5 ÷11 x 100 **OR** 45.45 **OR** 45.5 **Examiner's Comments** The mathematical skill of calculating percentage change is still proving challenging for many candidates. As in Q16(a)(ii) some candidates did not give their answer to two significant figures which was a requirement of the question to achieve both marks. **OCR support** The 'Maths for Biology' website provides support on how to calculate percentage change: https:/www.ocr.org.uk/subjects/biology/maths-for-biology/handling-data/ The mathematical Skills Handbook can also be used to assist candidates with the maths skill 'M0.3': https:/www.ocr.org.uk/Images/294471-biology-mathematical-skills-handbook.pdf
		iv	atrioventricular ✓	1(AO1.2)	**ALLOW** bicuspid / mitral **IGNORE** AV **DO NOT ALLOW** tricuspid **Examiner's Comments** Many candidates gave atrioventricular (valve) as the correct response with a few also gaining credit for bicuspid (valve).
			Total	**8**	
43			For answers marked by levels of response: Read through the whole answer from start to finish, concentrating	6 max	Indicative scientific points may include the following: (answers may start at any point in the cycle. IGNORE box A description)

			on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme. Once the level is located, award the higher or lower mark. **The higher mark** should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met. **The lower mark** should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing. **In summary:** • **The science content determines the level.** • **The communication statement determines the mark within a level.** **Level 3 (5–6 marks)** A detailed description of the cardiac cycle with references to B, C, and D in Fig. 2.3. *There is a well-developed line of*		B • atrial diastole • ventricular diastole • atria relax • ventricles relax • blood flows through, atrioventricular / AV / bicuspid / tricuspid, valve(s) OR ref. to their opening (more) • blood enters atria (passively) • blood enters ventricles (passively) C • atrial systole • atria contract • pressure (on blood) in atria increases • blood flows through, atrioventricular / AV / bicuspid / tricuspid, valve(s) OR ref. to their being open • ventricles fill / more blood enters ventricles • volume (of ventricles) increases • pressure (of blood against ventricles) increases • pressure in arteries is, low / at a minimum D • ventricular systole • ventricles contact • volume (of ventricles) decreases • pressure (on blood in ventricles) increases • atrioventricular / bicuspid / tricuspid, valves close • semi-lunar valves open • blood flows into aorta • blood flows into pulmonary arteries **<u>Examiner's Comments</u>** In order to be successful on this level of response question, candidates had to apply their recalled knowledge of the cardiac cycle to the sequence of stages shown on Fig. 2.3. Most candidates tried to do this and made clear references, as instructed, to stages B, C and D. A correct and clearly communicated account with a reasonable level of detail scored 6 marks, but the next commonest mark was a level 2

			reasoning which is clear and logically structured. The information presented is relevant and substantiated. **Level 2 (3–4 marks)** A description of the cardiac cycle with some references to B, C and/or D in Fig. 2.3. *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)** A basic description of the cardiac cycle with limited reference to B, C and/or D in Fig. 2.3. *A basic structure and some relevant information is provided, although a clear line of reasoning may not be present. 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.		mark of 3 for the type of answer shown in the exemplar. A common error for stage C was to say that the atrioventricular valves were being forced closed when the diagram does not show this. Some candidates confused the names of the atrioventricular valves and the semi-lunar valves which muddled the clarity of their communication. Many thought that the AV valves closed automatically to prevent backflow at the beginning of ventricular systole and do not realise that this occurs due to the build-up of pressure in the ventricles created by the contraction of the muscular wall. Exemplar 2  Box B shows atrial systole where pressure builds up in the atria which contract and force open the atrioventricular valves, and blood begins to enter the ventricles. Box C shows ventricular diastole, this is where blood is entering the ventricles and they are relaxed. Box D shows the ventricles contracting ~~ventricular~~ due to a build up of pressure causing the semi-lunar valves to open and blood leaving the heart. This is ventricular systole. This candidate scores 3/6 for an answer that gets one stage completely wrong (B incorrectly described as atrial systole), one stage right with an appropriate level of detail (D described as ventricular systole) and one stage not wrong but lacking the main correct descriptive points (C, should be recognised from the diagram as atrial systole). This exemplifies a common pattern of wrong answer that which may have been due to candidates relying too much on memorised accounts and not enough on studying the diagrams provided.
			Total	**6**	
44			B	1	**Examiner's Comments** This was well understood by many candidates, correctly interpreting the graph to determine the period of ventricular systole and then choosing the correct time period. C and A were common incorrect suggestions.
			Total	**1**	
45		i	line clearly rises and falls at the same time as the left ventricle line	2	

			(1) peak between 2 and 15 kPa (1)		
		ii	For answers marked by levels of response: Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme. Once the level is located, award the higher or lower mark. **The higher mark** should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met. **The lower mark** should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing. **In summary:** • **The science content determines the level.**	•	

		ii	• **The communication statement determines the mark within a level.** **Level 3 (5–6 marks)** Describes fully the behaviour of the chambers **and** valves at **W**, **X**, **Y** and **Z**, **and** relates these behaviours to changes in pressure, at all of points **W**-**Z**. *There is a well-developed connection between the events and causes at all four points, which is clear and logically structured and uses scientific terminology at an appropriate level.* **Level 2 (3–4 marks)** Describes the behaviour of the chambers or valves, **and** relates some of these behaviours to changes in pressure, at all of the points **W**-**Z**. *There is a developed connection between the events and causes discussed, which is clear and logically structured and uses scientific terminology at an appropriate level.* **Level 1 (1–2 marks)** Describes the behaviour of the chambers or valves, **or** describes the pressure changes, at some of points **W**-**Z**. *The description provided is clear and unambiguous and uses scientific terminology at an appropriate level.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include…** *Chambers* • ventricles begin to contract at **Y** • ventricles are relaxing between **W** and **Y** • atria relaxed at **W**, **X**, **Y** and **Z** • atrial contraction completed before **Y**. *Valves* • A-V / bicuspid, valve closes at **Y** and opens at **X** • semilunar / aortic, valve opens at **Z** and closes at **W**. *Pressure* • At **W** ventricular pressure falls below aortic pressure • At **X** ventricular pressure falls below atrial pressure • At **Y** ventricular pressure rises above atrial pressure • At **Z** ventricular pressure rises above aortic pressure.
			Total	**8**	

4 6		i	(supraventricular) tachycardia ✓	1	**ALLOW** tachyarrhythmia **ALLOW** spelling variants: tachycardic / tacchycardia / tackycardia (to sound same, not 'tr' at start) **DO NOT ALLOW** trachecardia / tracardia / tracycardia / tracchycardia / trachycardia **Examiner's Comments** Of those who attempted to name the abnormally fast heart rhythm, around half got the correct answer. Most of the rest provided a spelling that was unacceptably far from the correct one, tachycardia, though a few opted for other heart abnormalities like atrial fibrillation or bradycardia.
		ii	*calculated cardiac output (in cm^3):* figure in range from 5333 to 5520 ✓ *presentation in standard form:* figure in range from 5.3(33) x 10^3 to 5.5(20) x 10^3 ✓ *units:* cm^3 min^{-1} **OR** cm^3 / min(ute) OR cm^3 per min(ute) ✓	3	**Correct answer in standard form** gets 2 marks automatically if working not shown for mp 1. **ALLOW** calculated figure within this range **ALLOW** up to 3 extra decimal places within this range **DO NOT ALLOW** rounding error when reducing no. of s.f. **ALLOW** up to 3 extra significant figures e.g. 5.48571 × 10^3 **ALLOW** ECF for any calculated figure outside the allowed range presented in standard form: e.g. 4800 shown as 4.8 × 10^3 gets mp2 **ALLOW** ECF if >3 extra d.p. already penalised for mp 1 **ALLOW** conversion from cm^3 to **dm^3** so for example: 5.333 / 5.434 / 5.463 / 5.485, **× 10^0 dm^3 $minute^{-1}$** and 5.3 / 5.4 / 5.5, **× 10^0 dm^3 min^{-1}** gets 3 marks **DO NOT ALLOW** beats or letter 'b' in unit **Examiner's Comments** This was another problem requiring several steps of mathematical processing to solve. Just under half of candidates gained one or more marks. A stepwise approach to dealing with this question is detailed in the AfL box, and some

					support materials are listed below this. The error carried forward rule meant that candidates who only got part way through the calculation were credited if they gave their calculated figure in standard form. Similarly if a wrong answer was given with a correct unit, a mark was credited. **AfL** 1. Use the ECG in Fig. 2.1 (b) to measure the time in seconds for a set number of heart beats to occur. Ideally a larger number (wider sample) should be chosen, e.g. all nine beats occurring in 8 seconds, though the mark scheme made allowance for a smaller section of the ECG trace being used. 3. Convert the number of heart beats in this number of seconds to a heart rate in beats per minute. E.g. 9/8 > 60 = 67.5 bpm. 4. Substitute into the equation for cardiac output the stroke volume of 80cm3 and the calculated figure for heart rate. E.g. 80 × 67.5 = 5480. 5. Give the answer in standard form. 6. Determine the units as a measure of volume per unit time. **OCR support** Tutorial sheets and quizzes are available to support the teaching of the skills listed in the specification for Maths for Biology. Two in particular cover key skills needed to successfully answer this question: http:/www.ocr.org.uk/qualifications/by-subject/biology-related/maths-for-biology/m2-algebra/ (using algebraic equations) http:/www.ocr.org.uk/qualifications/by-subject/biology-related/maths-for-biology/m0-

					arithmetic-and-numerical-computation/ (using standard form)
		iii	**1** impulse **OR** (wave of) depolarisation **OR** wave of excitation ✓ **2** correct ref. atrioventricular node / AV node / AVN ✓ **3** (through / along) bundle of His / Purkyne fibres, to (cause contraction of) ventricles ✓	2 max	**IGNORE** signals / messages / electrical waves **IGNORE** SAN **Examiner's Comments** This was well answered with most candidates mentioning the atrioventricular node (AVN) and referring correctly to a wave of excitation of electrical impulses (rather than signals or messages).
			Total	**6**	
47			*three from* no distinct, P curve / atrial depolarisation (1) irregular / weak, atrial contraction (1) insufficient blood forced into ventricles (1) although ventricles contract there is less blood forced from the heart (1)	3	
			Total	**3**	
48			(ventricular) tachycardia (1)	1	
			Total	**1**	
49	a	i		4	**IGNORE** references to T waves
			(in X) *idea of* no defined P phase (1)		**ALLOW** Y has a defined P phase
			atrial fibrillation (1)		**ALLOW** Y does not show atrial fibrillation
		i	*idea of* rapid or frequent electrical impulses in atria (1)		**ALLOW** *idea of* regular bursts of electrical impulses through atria in Y
			idea of electrical impulses not only from SAN (1)		**ALLOW** electrical impulses only from SAN in Y
			idea of smaller gaps between QRS phases (1) **ORA** *idea of* heart rate set by SAN is faster (1) **ORA**		

		ii	4570 (1)(1) $cm^3\ min^{-1}$ (1)	3	**Apply ECF** **ALLOW** 4571 to 4572 **ALLOW 1 mark for** heart rate of 57.14 (allow 57.0 to 57.2) bpm (4 full cycles in 4.2 seconds) **if no other mark awarded**
	b		three cardiac cycles drawn (1) second cardiac cycle closer to the first cycle than the third cycle (1) abnormal QRS in second cycle (e.g. extended peak or lack of T phase) (1)	2	e.g. 2 marks for 
			Total	**9**	
5 0		i	*normal rate* 78.9 bpm (1) *rate for tachycardia* 125 bpm (1) *percentage increase* 58 (%) (1)(1)	4	**ALLOW** 1.3 bps. **ALLOW** 2.1 bps. **ALLOW 2 marks** for percentage increase correctly calculated using candidate's figures for rates and answer given to nearest whole number. **ALLOW 1 mark** for correct working [(125 − 78.9) ÷ 78.9 × 100 or correct use of candidate's figures for rates] **or** a correctly calculated but unrounded answer **DO NOT ALLOW** answers that divide by the rate for tachycardia as a percentage **increase** is asked for.
		ii	*two from* lower (Q)R(S) peak (1) P and T equal in height (1) width of T wave greater (1)	2	
			Total	**6**	
5 1		i	Z **THEN** X ✓ Y ✓	2(AO1.2)(AO 2.8)	**Order MUST be Z, X then Y for two marks** **Examiner's Comments** Many candidates ordered the heart rate patterns

					correctly. Some candidates were able to score one mark by having Y in the right place, even though X and Z had been reversed.
		ii	large single peaks present ✓ small wavy line between peaks with at least three waves between any two peaks ✓	2(AO2.6)	**0 marks** if just a wavy line drawn with no peaks **Examiner's Comments** There was a great deal of variation in the traces drawn by candidates. The majority of candidates achieved one mark for drawing taller peaks, but many struggled to produce a reasonable sketch of the trace between the peaks. Some candidates often drew traces in regular rhythm from the previous question and others drew incomplete traces i.e. only showing 1 beat and not using the entirety of the space provided. **Exemplar 5**  This exemplar shows a good response to this part of the question. The candidate has clearly sketched a trace typical of atrial fibrillation.
		ii i	increased stroke volume / AW ✓ increased volume of ventricle (chamber) ✓ increased , thickness / strength , of heart <u>muscle</u> ✓	2(AO2.7)	**ALLOW** myocardium for muscle **Examiner's Comments** Good responses for this part of the question understood that there would be an increased thickness of cardiac muscle and that stroke volume would increase. Few candidates mentioned the increase in ventricular volume. **Misconception** There appeared to be a misconception amongst many candidates that aerobically fit people would not need as much oxygen delivered to

					cells, had more red blood cells or needed less ATP.
			Total	**6**	
52		i	-14 ± 1 % (1) (1) (1)	3	**ALLOW** 3 marks for correct answer Max 2 if no negative sign If answer is incorrect award 1 mark for 64.5 ± 1 (bpm)
		ii	only one (full) cardiac cycle / heartbeat, shown (1) could be anomalous / atypical (1) *idea that* measurement of cycle from different points gives different values (1) mean (of several cycles) would be better (1)	3	
		iii	longer T-wave or broader R wave (1)	1	
			Total	**7**	
53		i	temperature ✓ enzyme concentration ✓ substrate / carbon dioxide, concentration ✓	2 max	
		ii	idea of H^+ reacts with haemoglobin to form haemoglobinic acid, which lowers pH (back to 7.4)✓ idea of H^+ reacts with HCO_3^- to form H_2CO_3, which lowers pH (back to 7.4)✓ *idea of* H_2CO_3 dissociates to form H^+ and HCO_3^-, which raises pH (back to 7.4)✓	3	
			Total	**5**	
54	a		**Level 3 (5–6 marks)** Describes differences and similarities of llama and camel haemoglobin at all four levels of protein structure with correct	6	**Indicative scientific points include:** • difference in primary structure • different amino acid / polypeptide sequence

			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.		• 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**	
5 5	a		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.
	b	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.
		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)	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**

			or short diffusion distance for capillary ✓		**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.
	c	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	**9**	
5 6		i	1. cluster / iron / molybdenum / sulfur , are, cofactors / prosthetic groups ✓ 2. H_2 is a, competitive inhibitor / end product inhibitor ✓ 3. CO is a <u>non-competitive</u> inhibitor ✓ 4. (CO binds to allosteric site and) causes change in shape of active site ✓ 5. energy required (from ATP) ✓ 6. acidic conditions, are tolerated / increase reaction rate ✓	**4 max**	**DO NOT ACCEPT** coenzyme 2. **ACCEPT** H_2, competes / AW, with N_2 for the active site **OR** 'increase in H_2 will reduce the activity of the enzyme' 3. **ACCEPT** CO acts as a cofactor (as candidates may be unfamiliar with CO) 5. **ACCEPT** ATP required as process is active **Examiner's Comments** It was pleasing to see that the majority of candidates were awarded two or three marks for this question accessing marking points 2, 3 and 4, for identifying H_2 as a competitive inhibitor and CO as a non-competitive inhibitor (and then going on to add how this affects the shape of the enzyme's active site). The other two marking points for this question were rarely mentioned, but sometimes the marks for these were missed when candidates did not expressly say that as ATP is needed, the process is active/energy requiring or for saying that acidic conditions are tolerated or increase reaction rate. In addition, some marks were lost for marking points 3 and 4 as students mistake CO for CO_2.
		ii	transport of oxygen, for respiration / to generate ATP (in *Rhizobium*)✓ removes(excess) oxygen so less inhibition (of enzyme / reaction)✓ removes CO to prevent inhibition (of nitrogenase) ✓	**2**	**ACCEPT** removes oxygen / creates anaerobic conditions, for nitrogen fixation **IGNORE** removes H_2 so more N_2 can bind (to active site) **Examiner's Comments** Few candidates obtained full marks on this

					question. Those that did talked about the removal of oxygen and CO and therefore removal of inhibition of the enzyme. Some common errors/omissions on this question included: • Candidates mentioned the removal/ binding of CO/oxygen by leghaemoglobin but did not then mention how this affects the enzyme. • Candidates talked about how leghaemoglobin provides the Iron (from the haem group) for the enzyme's prosthetic group or protons/electrons for the reaction.
			Total	**6**	
5 7			carbon dioxide / CO_2 , forms , carbonic acid / H_2CO_3 **OR** carbonic acid / H_2CO_3 , dissociates into H^+ (and HCO_3^-) ✓ haemocyanin , acts as a buffer / associates with (excess) H^+ ✓ H^+ / low pH , causes change in (tertiary) structure of haemocyanin ✓	2 max (AO2.5)	**ALLOW** hydrogen ions / H ions throughout for H^+ **IGNORE** cannot bind to oxygen / reduced affinity for oxygen **IGNORE** Bohr effect **If 2 MPs awarded give max 1** if haemoglobin instead of haemocyanin written **ALLOW** equation e.g. CO_2 (+ H_2O) → H_2CO_3 **OR** e.g. H_2CO_3 → H^+ (+ HCO^{3-}) **DO NOT ALLOW** hydrogen / H atoms / molecules **Examiner's Comments** There were some excellent responses that included information about carbonic acid formation and how this was linked to a change in the tertiary structure of haemocyanin. There were some good step by step descriptions of the production of hydrogen ions (H^+) and their subsequent binding to the protein. Many candidates thought that carbon dioxide would bind to the haemocyanin directly, displacing or blocking the oxygen which did not gain credit. It was also common to see the Bohr shift being described as the mechanism for reducing affinity for oxygen without further detail but this didn't score any marks

			Total	**2**	
58	a		*idea of* habitat is low(er) in oxygen ✓	1 (AO3.1)	
	b	i	low pO_2 in the placenta ✓ *idea of* O_2 transferred from adult to fetal haemoglobin (in the placenta) ✓ fetus receives (sufficient) oxygen for respiration ✓ maintains O_2 concentration gradient ✓	2 max (AO1.1)	**ALLOW** 'low oxygen concentration in placenta' e.g. 'adult haemoglobin releases oxygen at low pO_2, but fetal haemoglobin will pick up oxygen at the same pO_2'.
		ii	initial straight line towards 80% and 10 mmHg (from the origin) ✓ curved line to 52 mmHg at 100% ✓	2 (AO2.2)	**ALLOW** straight line that stops short of 80% saturation as long as it passes through the 80% and 10 mmHg point if extrapolated **or** straight line that goes beyond this point
			Total	**5**	