Questions

Q1.

The photograph shows a ghost shrimp that lives in fresh water.

© Nicholas Toh/Alamy Stock Photo

The effect of caffeine concentration on the heart rate of ghost shrimps was investigated.

A shrimp was placed in a caffeine solution and observed using a microscope.

The number of heartbeats in one minute was counted and the heart rate was recorded.

This was repeated for other concentrations of caffeine solution.

The investigation was repeated using two more ghost shrimps.

The table shows the results of this investigation.

Concentration of caffeine / mg cm^{-3}	Heart rate / beats min^{-1}		
	Shrimp 1	Shrimp 2	Shrimp 3
3	272	298	304
7	268	284	298
10	260	270	266
13	152	242	292

(i) State and justify a suitable control for this investigation.

(2)

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(ii) Variables relating to the caffeine solution and the ghost shrimps should have been controlled.

State and justify **two** variables that should have been controlled in this investigation.

(4)

Variable relating to the caffeine solution

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Variable relating to the ghost shrimps

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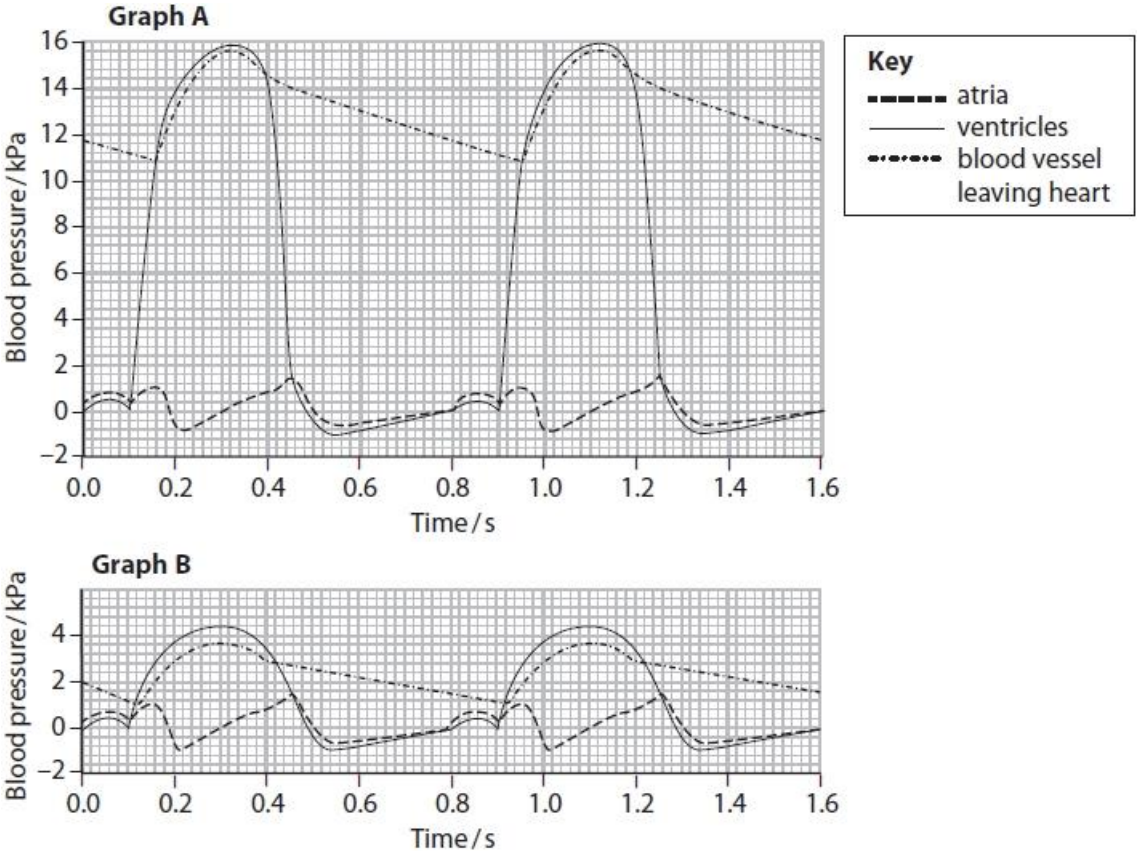
(Total for question = 6 marks)

Q2.

The pressure of the blood passing through the heart can vary.

Graph A shows the changes in blood pressure in one side of the heart. Graph B shows the changes in blood pressure in the other side of the heart over the same time period.



(i) Calculate the heart rate.

(2)

Answer .....

(ii) Increased heart rate is often associated with high blood pressure.

Which of the following will reduce blood pressure?

(1)

☒ **A** anticoagulants

☒ **B** antihypertensives

☒ **C** cholesterol

☒ **D** platelet inhibitors

(Total for question = 3 marks)

Q3.

During the development of the mammalian heart, there is a hole between the left ventricle and the right ventricle.

This hole usually becomes sealed before the mammal is born. If it is not sealed, the mammal will become easily tired due to a lack of energy.

Explain why a mammal born with a hole between the two ventricles will have these symptoms.

(3)

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(Total for question = 3 marks)

Q4.

Caffeine is a stimulant found in coffee.

The effect of different types of coffee on blood pressure was investigated.
Decaffeinated coffee has most of the caffeine removed.

Four groups of volunteers had their blood pressure measured before having a drink and again 30 minutes later.

The results of this investigation are shown in the table.

Drink provided to volunteers	Mean systolic blood pressure / mm Hg	
	Before the drink	30 minutes later
Water	115	119
Decaffeinated coffee	120	118
Regular coffee	106	118

(i) Calculate the percentage increase in the mean systolic blood pressure after drinking regular coffee.

(1)

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(ii) *Daphnia* can be used to investigate the effects of caffeine on heart rate.

Devise a procedure to compare the effects of decaffeinated coffee and regular coffee on the heart rate of *Daphnia*.

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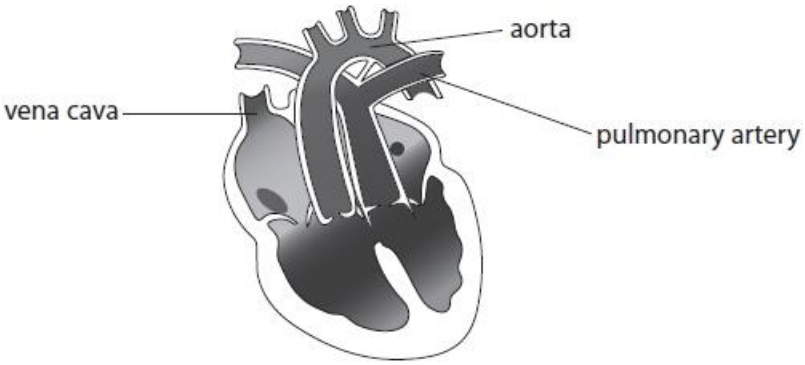
(Total for question = 5 marks)

Q5.

A baby was born with an abnormal heart. The diagram shows the heart of this baby. There is a hole in the septum between the two ventricles.



(i) Identify the problem with the blood vessels of this heart.

(1)

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(ii) The baby survived because of the hole in the septum of the heart.

Explain how the hole in the septum allowed this baby to survive.

(3)

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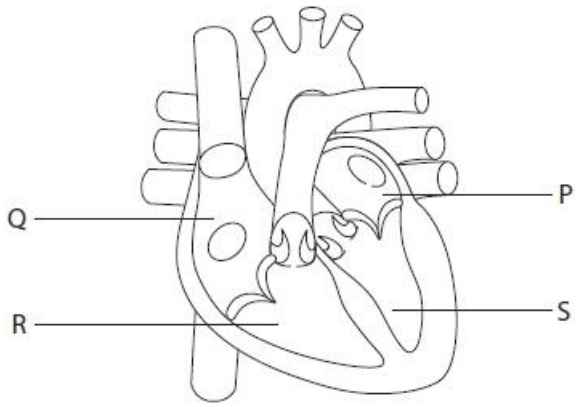
(Total for question = 4 marks)

Q6.

This diagram shows the structure of a normal human heart.



(i) Which chamber of the heart generates the highest blood pressure?

(1)

- ☒ **A** P
- ☒ **B** Q
- ☒ **C** R
- ☒ **D** S

(ii) Which stage of the cardiac cycle is shown in the diagram of the heart?

(1)

- ☒ **A** atrial diastole
- ☒ **B** atrial systole
- ☒ **C** ventricular diastole
- ☒ **D** ventricular systole

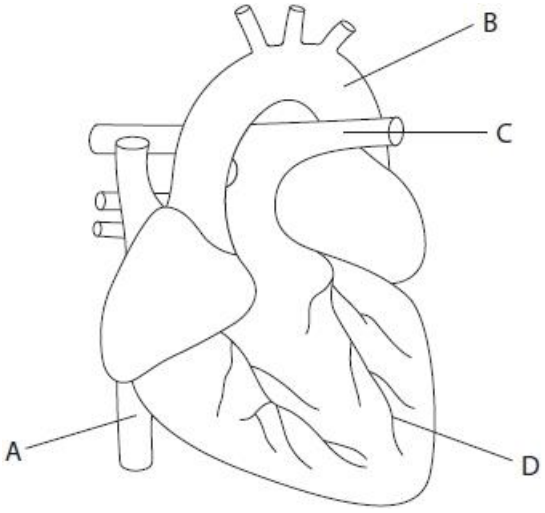
(Total for question = 2 marks)

Q7.

Answer the question with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Cardiovascular disease can occur in blood vessels in organs such as the brain and the heart.

The diagram shows a human heart.



(i) Which is the correct label for a coronary artery?

(1)

- ☐ **A**
- ☐ **B**
- ☐ **C**
- ☐ **D**

(ii) Which is the correct label for the blood vessel carrying deoxygenated blood under the lowest pressure?

(1)

- ☐ **A**
- ☐ **B**
- ☐ **C**
- ☐ **D**

(iii) State the type of blood vessel that has no collagen in its wall.

(1)

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(Total for question = 3 marks)

Q8.

Some chemicals can affect the heart rate of animals.

The effects of dopamine and caffeine on the heart rate of *Daphnia* were investigated.

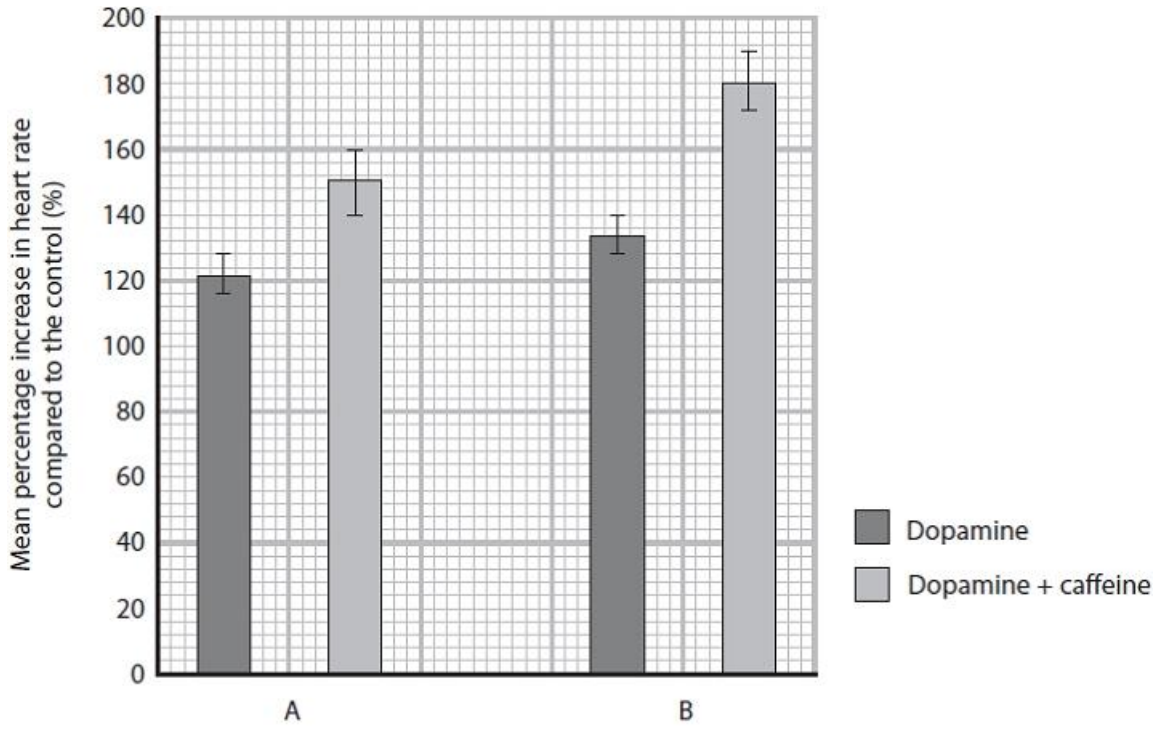
Investigation A used three different solutions:

- a control solution
- a solution containing 0.8 mg cm^{-3} dopamine
- a solution containing 80 µg cm^{-3} caffeine and 0.8 mg cm^{-3} dopamine

Investigation B used three different solutions:

- a control solution
- a solution containing 1.6 mg cm^{-3} dopamine
- a solution containing 80 µg cm^{-3} caffeine and 1.6 mg cm^{-3} dopamine

The graph shows the percentage increase in heart rate compared with the controls, for both investigations.



(Source from: https://f1000research.com/articles/7-254/v1)

(i) Comment on the effects of dopamine alone and dopamine with caffeine on the heart rate of *Daphnia* in this investigation.

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(ii) State and justify a suitable control for these investigations.

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(iii) Devise a procedure that could have been used to produce the results shown in the graph.

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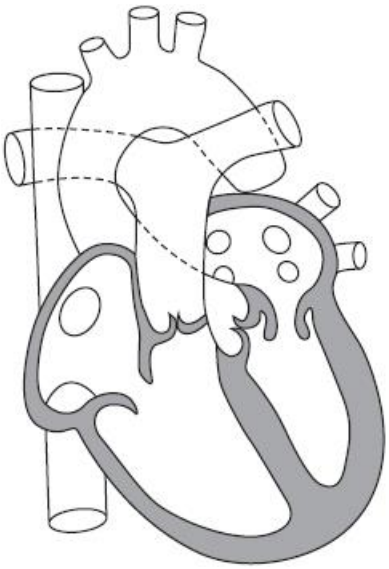
(Total for question = 11 marks)

Q9.

The diagram shows the internal structure of a human heart.



Name the valves in this heart.

(2)

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(Total for question = 2 marks)

Q10.

As levels of activity increase, the heart can respond to the changing demand for oxygen.

During the cardiac cycle there are pressure changes in the chambers of the heart.

Explain how pressure differences in the heart ensure efficient pumping of the blood into the arteries.

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(Total for question = 3 marks)

Q11.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The cardiac cycle is the sequence of events in one heartbeat.
In humans, the cardiac cycle can be divided into three stages.

In the ventricular systole stage of the cardiac cycle, the

(1)

- ☐ **A** ventricles contract, atrioventricular valves close and semilunar valves open
- ☐ **B** ventricles contract, atrioventricular valves open and semilunar valves close
- ☐ **C** ventricles relax, atrioventricular valves close and semilunar valves open
- ☐ **D** ventricles relax, atrioventricular valves open and semilunar valves close

(Total for question = 1 mark)

Q12.

Nicotine is a drug found in the smoke of cigarettes.

The effect of inhaling nicotine on the circulatory system of rats was investigated.

In this investigation, three variables were considered:

- the concentration of nicotine in blood plasma
- the diameter of the lumen of one artery
- blood pressure

Two groups of rats were treated as shown in the table.

Group	Number of rats in group	Nicotine dose / mg
A	6	1.0
B	6	0.1

(i) The concentration of nicotine in the blood plasma of the group A rats was recorded at different times and

the means calculated.
The means are shown in the table along with the range of data for each mean.

Time of sampling / minutes	Mean concentration of nicotine in blood plasma / ng cm^{-3}
0 (immediately after inhalation)	35.0 ± 9.3
30 (after inhalation)	24.1 ± 5.6

Determine the maximum rate of decrease in the concentration of nicotine in the blood plasma per minute after being given the nicotine.

(2)

Answer ..... ng cm^{-3} min^{-1}

(ii) The diameter of the lumen of one artery, in each of the 12 rats, was measured when the rats were resting. The blood pressure of each rat was also measured and the mean blood pressure calculated.
The diameter of the lumen of the artery and the blood pressure of each rat were then recorded at intervals, for a total of 30 minutes. The rats inhaled nicotine for the first minute (0.0 to 1.0).
The table shows the results for the mean diameter of the lumen of the artery.

Time / minutes	Mean diameter of lumen / μm	
	Group A (1.0 mg nicotine)	Group B (0.1 mg nicotine)
0.0	48	48
0.5	44	44
1.0	49	45
2.0	52	48
5.0	57	52
10.0	55	48
15.0	49	48
30.0	49	48

Determine the effect of nicotine concentration on the percentage change in lumen diameter in the first minute.

(2)

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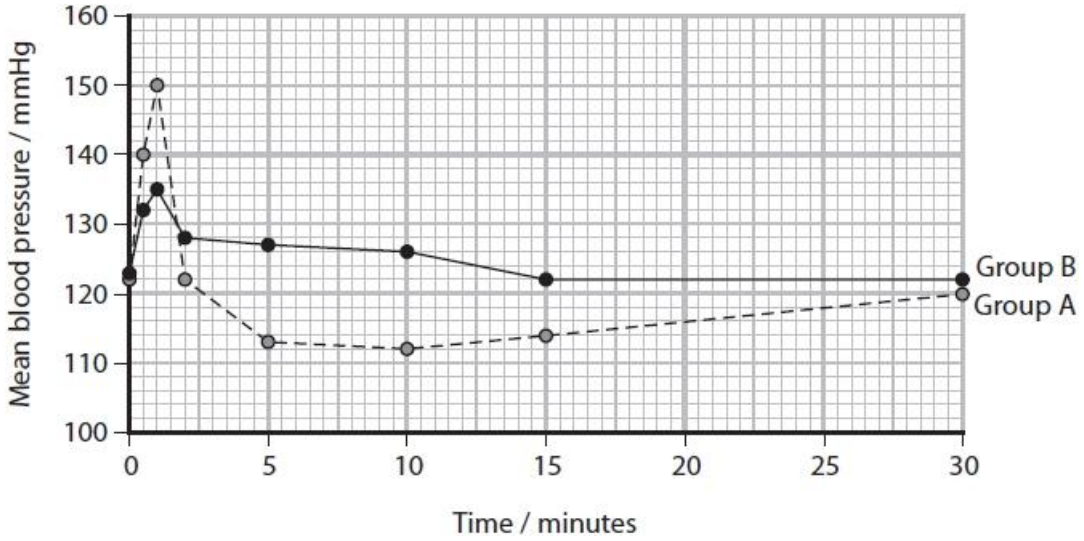
*(iii) The graph shows the results for the mean blood pressure for the two groups of rats. Nicotine was inhaled for the first minute.



It has been stated that:

'Nicotine gained from smoking cigarettes in humans causes an increase in blood pressure and a decrease in the lumen of arteries.'

Analyse all the data from this investigation using rats to evaluate the validity of this statement.

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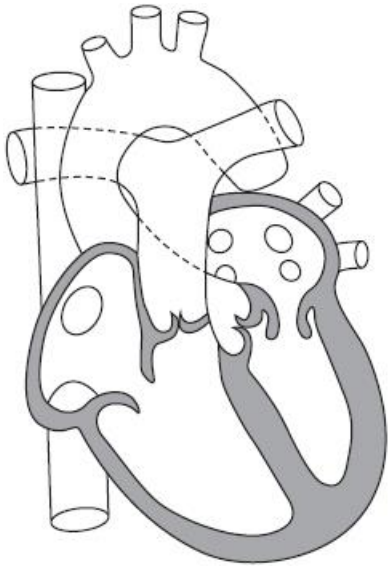
(Total for question = 10 marks)

Q13.

The diagram shows the internal structure of a human heart.



(i) Draw arrows to show the route blood would take as it returns from the body, enters the heart and is then pumped to the lungs.

(2)

(ii) State which stage of the cardiac cycle is shown in the diagram.

(1)

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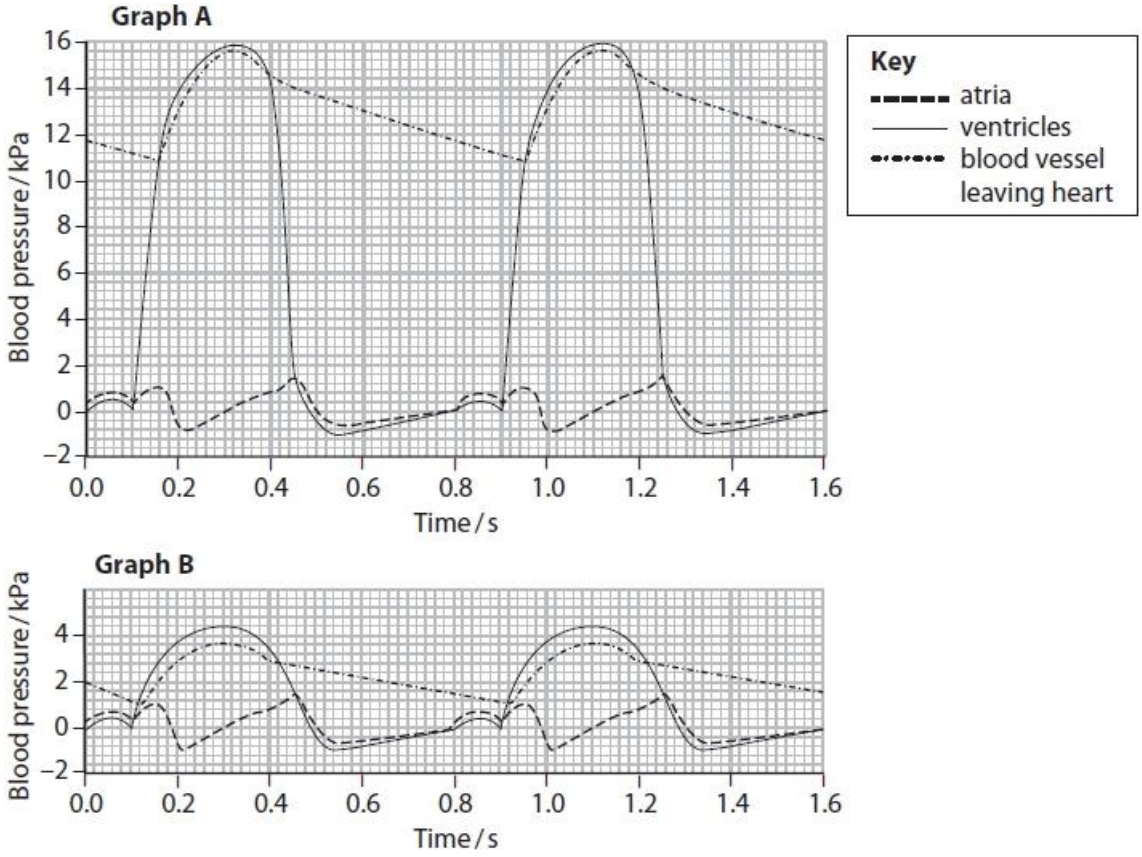
(Total for question = 3 marks)

Q14.

The pressure of the blood passing through the heart can vary.

Graph A shows the changes in blood pressure in one side of the heart. Graph B shows the changes in blood pressure in the other side of the heart over the same time period.



(i) Explain which side of the human heart is represented by graph B.

(2)

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(ii) In graph A, which blood vessel carries the blood leaving the heart?

(1)

☒ **A** aorta

☒ **B** pulmonary artery

☒ **C** pulmonary vein

☒ **D** vena cava

(iii) In graph A, the blood pressure inside the ventricle changes between 0.0 and 0.45 seconds.

Explain how these changes in blood pressure occur in this part of the cardiac cycle.

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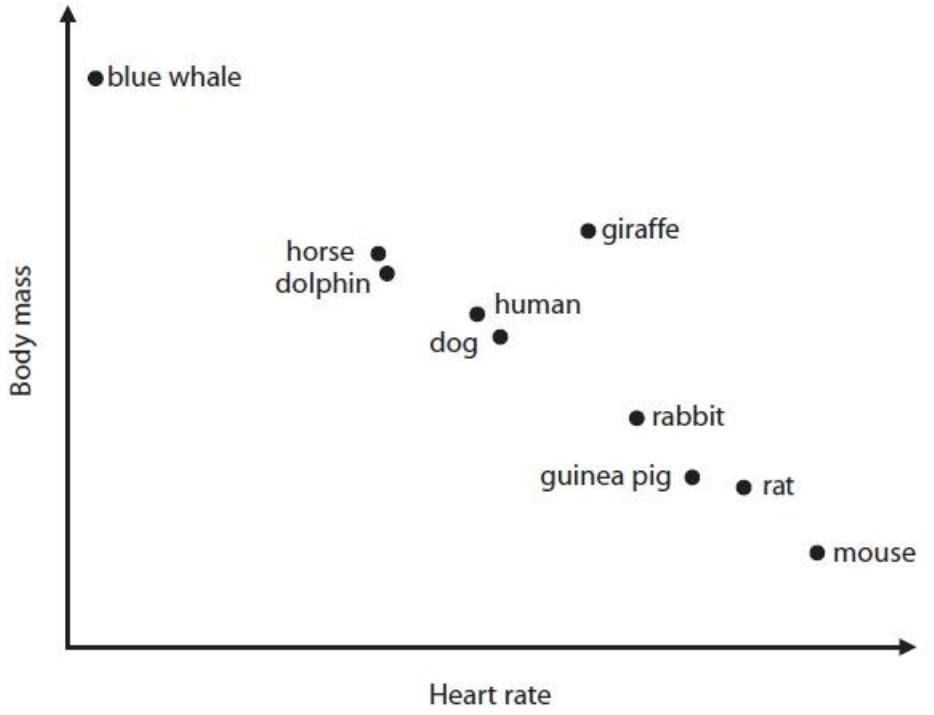
(Total for question = 7 marks)

Q15.

The heart rate of an animal often depends on its body mass.

The graph shows the mean heart rate of some animals and their mean body mass.



(Adapted from: http://www.cardio-research.com/quick-facts/animals)

State the relationship between the average heart rate and the average body mass of these animals.

(1)

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(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer which makes reference to the following: • (pond /plain) water / solvent used for caffeine solution (1) • to compare with the caffeine solutions / to show {normal/ resting / starting} heart rate (1)	ALLOW solution with no caffeine	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer which makes reference to the following: • {temperature / aeration} of solution / acclimatisation time (1) • correct justification relating to effect on heart rate (1) • same {sex / size / age} of ghost shrimp (1) • so caffeine would affect the ghost shrimp equally / to produce more valid results (1)	e.g. a cold temperature would decrease the heart rate ignore species ignore accuracy	(4)

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	• correct figures from graph • correct answer with unit	Example of calculation e.g. 120 and 1.6 or 60 and 0.8 120 ÷ 1.6 / 60 ÷ 0.8 75 bpm	(2)

Question Number	Answer	Mark
(ii)	***The only correct answer is B as antihypertensives lower blood pressure*** ***A*** *is not correct because anticoagulants do not reduce blood pressure* ***C*** *is not correct because cholesterol does not reduce blood pressure* ***D*** *is not correct because platelet inhibitors do not reduce blood pressure*	(1)

Q3.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: • less oxygen available for aerobic respiration (1) • deoxygenated blood mixes with oxygenated blood (1) • therefore reducing the concentration of oxygen in the bloodcirculating in the body (1) • because some deoxygenated blood {does not leave right ventricle / is transferred to the left ventricle / does not go to thelungs / goes to the respiring tissues} (1)	ALLOW lack of oxygen leads to (some) anaerobic respiration ALLOW some oxygenated blood {does not leave left ventricle / is transferred to the right ventricle / does not go to the respiring tissues / goes to the lungs}	**(3)**

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	• correct value for percentage increase	11.3 / 11.32 (%)	**(1)**

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to four of the following • details of the procedure (1) • record heartbeat before and after placing in regular ordecaffeinated coffee (1) • controlled variable for the coffee (1) • reference to controlled variables (1) • use of a suitable statistical test to compare the results (1)	e.g. use of a microscope / method ofcounting / allowing acclimatisation ALLOW ref to heartbeat for *Daphnia* inwater and coffee e.g. concentration or volume e.g. temperature / length of time tocount heartbeat / same species	(4)

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	The aorta and pulmonary artery are { attached to the wrong ventricles / the wrong way around }	Allow aorta leaves the right ventricle and the pulmonary artery leaves the left ventricle	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • the hole allows oxygenated and deoxygenated blood to mix (between the two ventricles) (1) • oxygenated blood { travels to the body / enters aorta } / deoxygenated blood { travels to the lungs / enters pulmonary artery } (1) • providing some oxygen for respiration (1)	Allow converse	(3)

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	D - S		(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	D - ventricular systole		(1)

Q7.

Question Number	Answer	Mark
(i)	**The only correct answer is D** ***A*** *is incorrect because it labels the vena cava* ***B*** *is incorrect because it labels the aorta* ***C*** *is incorrect because it labels a pulmonary artery*	(1)

Question Number	Answer	Mark
(ii)	**The only correct answer is A** ***B*** *is incorrect because* the aorta carries blood under highest pressure ***C*** *is incorrect because* arteries carry blood under higher pressure than a vein ***D*** *is incorrect because* arteries carry blood under higher pressure than a vein	(1)

Question Number	Answer	Mark
(iii)	• capillary	(1)

Q8.

Question Number	Answer	Additional guidance	Mark
(i)	An answer which makes reference to the following: • adding caffeine (to dopamine) increases heart rate (1) • {adding / increasing the concentration of} dopamine increases heart rate (1) • larger increase when both are used together at higher concentration (1) • no overlap between error bars indicates significant difference between dopamine and dopamine with caffeine / overlap between error bars indicates no significant difference between dopamine concentrations (1)	ALLOW dopamine with caffeine increases HR more than just dopamine – not to go in final MS ALLOW comparative data	(4)

Question	Answer	Additional guidance	Mark
(ii)	An answer which makes reference to the following: • {distilled / pond} water / the solvent used to make the {dopamine / dopamine and caffeine solutions} (1) • to show the solvent did not have an effect / to see the heart rate in the absence of added chemicals (1)	ALLOW inactive molecule of same size and concentration as dopamine	

Question Number	Answer	Additional guidance	Mark
(iii)	An answer which makes reference to the following: • Daphnia (immobilised) on (cavity) slide (1) • acclimatisation time in {control / dopamine / dopamine and caffeine} solution (1) • use of concentrations from graph (1) • suitable method for counting and recording heart rate (1) • use Daphnia of same {species / age / sex / size} (1) • repeats and calculation of {mean / SD} (1)		(5)

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Q9.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: • {atrioventricular / AV} (valve) (1) • semilunar (valve) (1)	ALLOW tricuspid / bicuspid / mitral (valve) ALLOW pulmonary / aortic (valve)	**(2)**

Q10.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following points: • pressure increases in the ventricles (1) • greater pressure (in the ventricles) than in the { atria / arteries } (1) • causing atrioventricular valves to close (1) • causing the semilunar valves to open / forcing blood into the arteries (1)	IGNORE reference to events during atrial systole	(3)

Q11.

Question Number	Answer	Mark
	The only correct answer is A - the ventricles contract, atrioventricular valves close and semilunarvalves open *B is incorrect because the AV valves do not open* *C is incorrect because the ventricles do not relax* *D is incorrect because the semilunar valves do not close*	**(1)**

Q12.

Question Number	Answer	Additional Guidance	Mark
(i)	• calculation of { largest difference in concentration / largest value at 0 minutes and smallest value at 30 minutes } (1) • calculation of rate of decrease in nicotine concentration per minute (1)	Example of calculation (35.0 + 9.3) / 44.3 and (24.1 – 5.6) / 18.5 25.8 ÷ 30 = 0.86 Correct answer without working gains full marks	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to two of the following: • percentage change greater for {the lower concentration of / 0.1 mg } nicotine (1) • a higher concentration causes a positive (percentage) change whilst the lower concentration leads to a negative (percentage) change (1) • correct calculation of percentage change for both rat groups (1)	2.08% for { 1.0 mg nicotine / group A } and 6.25% for { 0.1mg nicotine / group B }	(2)

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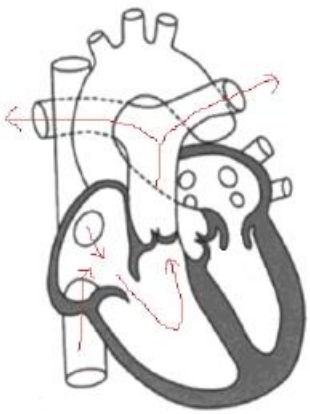
Question Number	Indicative content
*(iii)	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant. Give examples of relevant biological knowledge and understanding: <u>Validating the statement</u> • Investigation involved rats inhaling nicotine which humans do during smoking • Rats are mammals so can extrapolate to humans <u>Not validating the statement</u> • Nicotine inhaled (for both nicotine concentrations) leads to vasoconstriction and then vasodilation and then returns to original diameter • Blood pressure for 1mg nicotine concentration increases and decreases but drops below original value • Presence of nicotine leads to noradrenaline release which increases heart rate • Blood pressure (for both nicotine concentrations) increases and decreases • No reference to rats inhaling smoke, only nicotine • Rats are not the same as humans • Sample size too small to make a valid statement <u>Comment</u> • whether agree or disagree with statement

			Additional guidance
Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	An answer that refers to just one piece of evidence – either lumen size or blood pressure Simple conclusion drawn from the evidence
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	An answer that refers to evidence concerning both lumen size and blood pressure Links made between lumen size, vasoconstriction and blood pressure
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	An answer that refers to data about vasoconstriction and vasodilation and links it to effect of nicotine on the release of noradrenaline and therefore on blood pressure Conclusion made considering validity of data collected from rats and how it can be applied to humans

Q13.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following: • arrows on right hand side of heart only (1) • arrows enter heart through vena cava and leaves heart through pulmonary artery (1)		(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: • atrial systole		(1)

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: • right (1) • because the pressure is lower (in blood transported from heart to the lungs) (1)		(2)

Question Number	Answer	Mark
(ii)	***The only correct answer is A because it carries blood under high pressure away from the heart*** ***B*** *is not correct because this is shown in graph B* ***C*** *is not correct because pulmonary veins do not leave the heart* ***D*** *is not correct because the vena cava does not leave the heart*	(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation which makes reference to the following: • from 0 s (to 0.05 s) pressure increases due to atrial systole (1) • ventricle fills with blood { from the atrium / due to atrial systole } (1) • after atrial systole finishes (from 0.05s to 0.1s) there is a fall in ventricular pressure (1) • from 0.1s (to 0.32 s) increase in pressure due to ventricular systole (1) • (from 0.32 s) ventricular pressure decreases due to (ventricular) diastole (1)	ALLOW contraction of (muscular)walls of atria ALLOW contraction of (muscular walls of) ventricle ALLOW relaxation of (muscular walls of) ventricle	(4)

Q15.

Question	Answer	Additional guidance	Mark
	An answer which makes reference to the following: • negative correlation between heart rate and body mass (1)	ALLOW animals with a {lower body mass have a higher heart rate / higher body mass have a lower heart rate}	(1)