24. The immortal jellyfish, *Turritopsis dohrnii*, and the sea bass, *Dicentrarchus labrax*, are both found in the Mediterranean Sea.

i. The table below shows some data on these two organisms.

Organism	**Surface area (cm^2)**	**Volume (cm^3)**
Immortal jellyfish	10.5	1.5
Sea bass	270.0	810.0

A student made the following statement:

'The immortal jellyfish does not need a transport system to transport oxygen as it has a very large surface area. The sea bass does need a transport system as it is a larger organism.'

Use the data in the table to evaluate the statement made by the student.

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____ **[3]**

ii. **Fig. 2.1** shows the circulatory system of the sea bass.

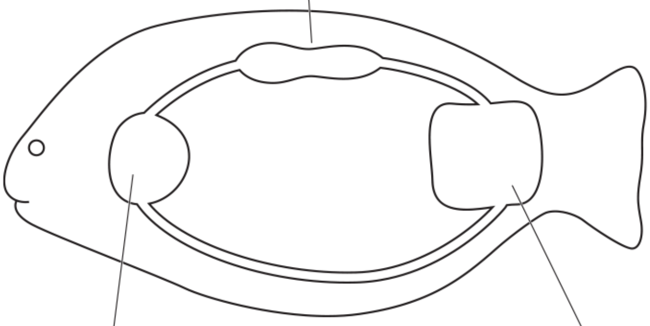

Fig. 2.1

Name the type of circulatory system shown in **Fig. 2.1**.

____ **[1]**

iii. The circulatory systems of the sea bass and mammals are described as closed circulatory systems.

Define the term **closed circulatory system**.

____

____ **[1]**

iv. State **two** differences between the closed circulatory system of the sea bass and the closed circulatory system of a mammal.

1 ____

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2 ____

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[2]

25. Outline the reasons why insects and other animals need well-developed transport systems.

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____ **[3]**

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

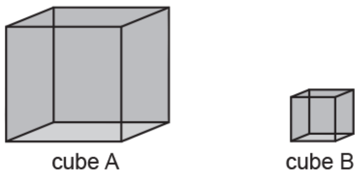

Fig. 21.2

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

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

1 ____

____

2 ____

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[2]

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

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

Cube A ....

Cube B .... **[2]**

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

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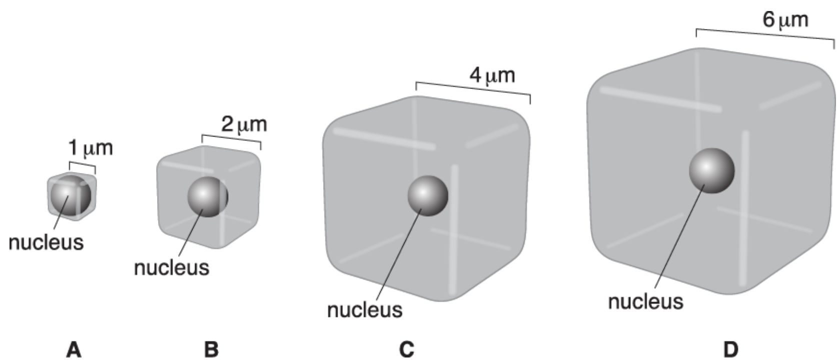
.... **[3]**

27. Which of the cells below, represented by cubes **A** to **D**, has a surface area to volume ratio of 3 : 1?



Your answer [ ]

[1]

28. Mammals and fish both need circulatory systems to transport oxygen to respiring tissues. They have different circulatory systems because they have different oxygen requirements.

* Compare and contrast the circulatory systems of mammals and fish.

[6]

29(a). Fig. 5.1 shows the circulatory systems of three groups of animals.

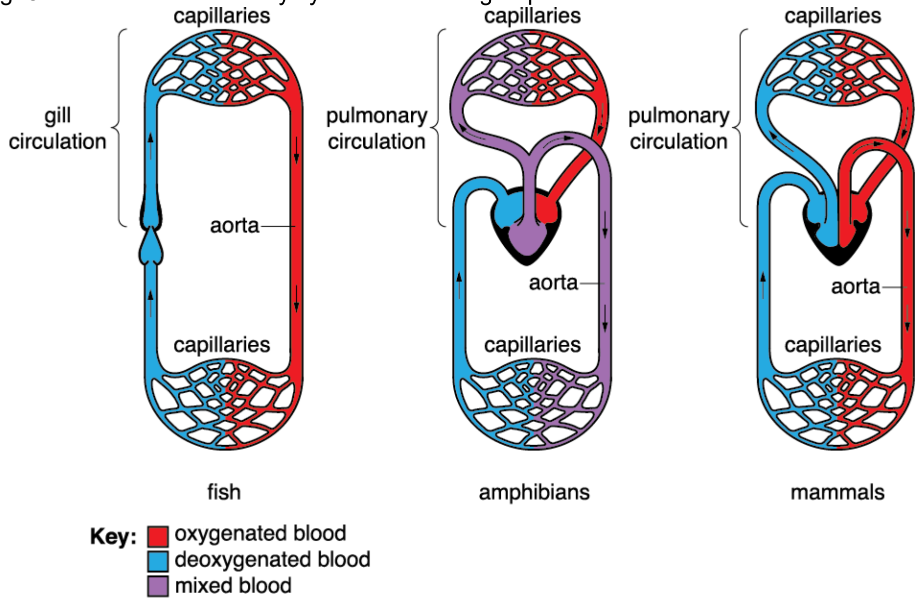


Fig. 5.1

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

____ **[1]**

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

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____ **[1]**

(b). Fig. 5.2 shows the flow of blood through the heart of an amphibian such as a frog.

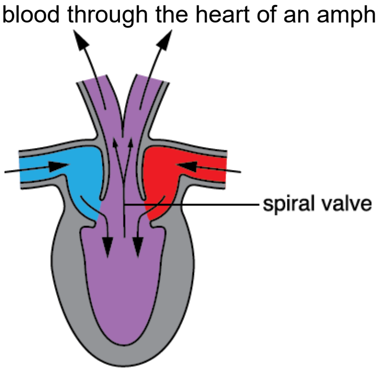

Fig. 5.2

Use the information in Fig. 5.1 **and** Fig. 5.2 to compare the circulations of a frog and a mammal and the relative effectiveness of each type of circulation.

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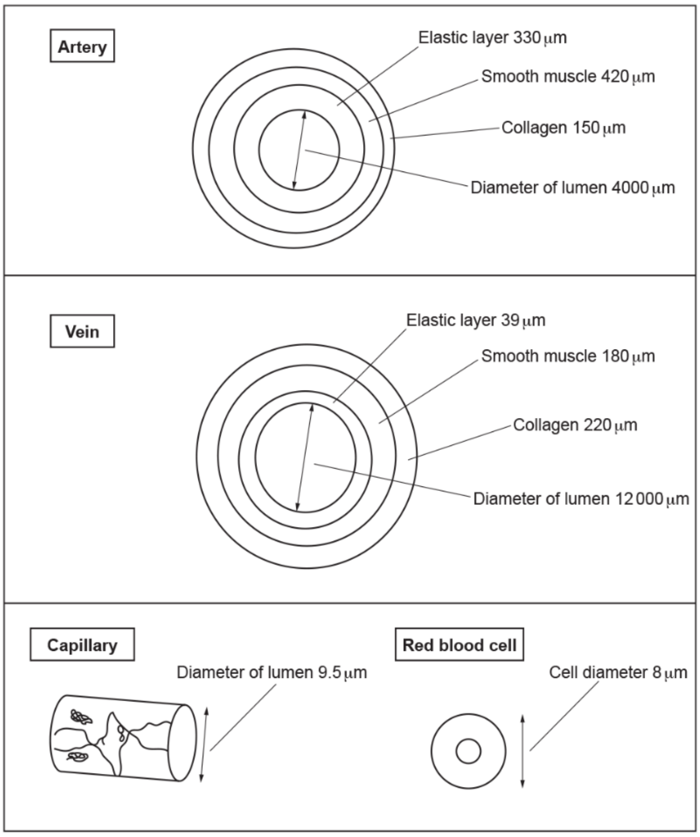
____ **[6]**

30. Three types of blood vessels found in mammals are arteries, veins and capillaries.

Fig. 2.3 shows data on these blood vessels.



Not to scale
Fig. 2.3

With reference to **Fig. 2.3** describe how the structure of each type of blood vessel is adapted to its function.

[6]

31(a). Fig. 21.1 shows the cross sectional structure of a large artery and a large vein.

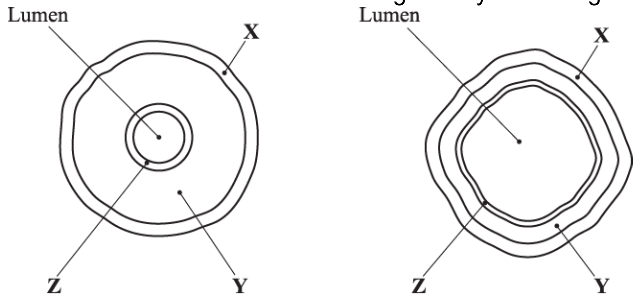


Fig. 21.1

Name the structure labelled **Z.**

____ **[1]**

(b). Use Fig. 21.1 to calculate the cross sectional area of the artery's lumen as a proportion of that of the vein. (Assume that the artery is circular and the vein is a square in cross-section). Show the steps in your calculation.

Answer.. **[3]**

(c). Outline how the difference in **lumen size** between arteries and veins is related to their function.

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____ **[3]**

32(a). The formation of tissue fluid is an example of ultrafiltration. Osmosis plays an important part in ultrafiltration.

The water potential of the blood depends on the concentration of solutes such as glucose, amino acids and mineral ions as well as large plasma proteins.

i. State the effect on the water potential of the blood if the concentration of glucose increases.

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____ **[1]**

ii. Explain why the oncotic pressure of the blood depends **only** on the concentration of large plasma proteins.

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____ **[2]**

(b). The table below compares a capillary with the surrounding tissue fluid.

Property	**Capillary**	**Tissue fluid**
Oncotic pressure	4.2 kPa	0.03 kPa
Hydrostatic pressure	4.5 kPa	0.15 kPa
Concentration of the protein albumin	0.04 g cm^{-3}	0.02 g cm^{-3}

Net movement of fluid between the capillary and tissue fluid depends on the net driving force (J_v):

$J_v = (P_c - P_i) - \sigma (\pi_c - \pi_i)$

Where:

P_c = capillary hydrostatic pressure

P_i = tissue fluid hydrostatic pressure

π_c = capillary oncotic pressure

π_i = tissue fluid oncotic pressure

σ = reflectance factor

The reflectance factor is a measure of how permeable the capillary is to albumin. It varies between 0 (totally permeable) and 1 (totally impermeable).

Inflammation can reduce the value of the reflectance factor.

i. In one type of capillary the reflectance factor was found to be 0.75.

Use this information and the data in the table to calculate a value for the net driving force and predict the direction of movement.

Net driving force, *Jv* = ... kPa

Direction of movement ....

[2]

ii. Nephrotic syndrome is a kidney disease where protein is excreted in the urine.

One group of patients with nephrotic syndrome had a plasma albumin concentration of 0.015 g dm^{-3}.

Explain what effect this would have on the net driving force. (There is no need to perform a further calculation.)

[2]

iii. A medical student concluded that a patient with kidney disease and a plasma albumin concentration of 0.015 g dm^{-3} would show signs of swelling, such as swollen ankles.

Evaluate the student's conclusion.

[4]

(c). The table below contains statements about the composition of lymph and tissue fluid.

Place ticks (✓) in the boxes in the table to indicate whether the statements are true or false.

Statement	**True**	**False**
Lymph is similar in composition to tissue fluid but has more oxygen.		
Tissue fluid does not contain lymphocytes because they are too large to pass through the capillary wall.		
Lymph contains more protein than tissue fluid because of antibody production by plasma cells.		

[2]

33. * A student cut their hand during a field trip. The bleeding stopped within a few minutes and formed a scab over the cut. However, over the next three days they noted that the area around the cut became swollen, red and tender. They also noted a small swelling and discomfort in their armpit.

Describe the non-specific defences against pathogens that would explain **all** these observations.

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[6]

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

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

[6]

35.

i. Ions have a number of important roles in living organisms.

Complete the table below by identifying the ion that plays each of the roles. Choose from the following list.

NH_4^+ **Cl^-** **H^+** **OH^-** **PO_4^{3-}** **Ca^{2+}**

Important role	Ion
Production of nitrate ions by bacteria	NH_4^+
Loading of phloem	
DNA structure	
Cofactor for amylase	

[2]

ii. Dissolved ions diffuse between blood plasma and tissue fluid.

Pressure differences at the arterial and venous ends of capillaries are responsible for the formation of tissue fluid. The following measurements were made in one capillary:

- Net hydrostatic pressure at the arterial end was 4.6 KPa
- Net oncotic pressure was -3.0 KPa
- Net hydrostatic pressure at the venous end was 2.3 KPa.

Use this information to explain the movement of fluid in and out of a capillary.

-- **[2]**

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

	Blood in aorta	**Tissue fluid**	**Lymph**	**Blood in vena cava**
Pressure				

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

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

Your answer

[1]

37. A group of students were examining a mammalian heart prior to dissection. The atria and ventricles were clearly visible.

i. Name **two** arteries that could be seen by the students.

1 --

2 --

[2]

ii. The students then carried out a dissection of the heart. **Fig. 2.2** is an example of a drawing from one of the students.

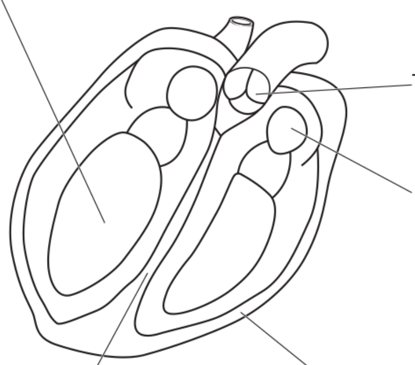

Fig. 2.2

Name the structure labelled **X** on **Fig. 2.2**.

____ **[1]**

iii. Another student pointed out that there were structural and labelling errors in the drawing in **Fig. 2.2**.

In the space below, list **three** of these errors **and** the correction you would make.

Biological drawing errors are not required.

Error and correction 1

____

____

____

Error and correction 2

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Error and correction 3

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____

____ **[3]**

38. Fig. 16.1 shows a drawing of a dissected human heart.

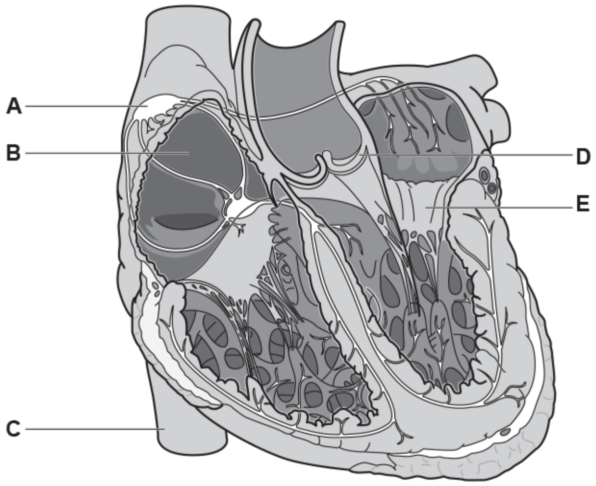


Fig. 16.1

i. Identify the structures labelled **A** to **E** on **Fig. 16.1**.

A ______________________________

B ______________________________

C ______________________________

D ______________________________

E ______________________________

[5]

ii. State which subdivision of the peripheral nervous system supplies structure **A** on **Fig. 16.1**.

______________________________ **[1]**

39(a). Valves control the flow of blood through the heart.

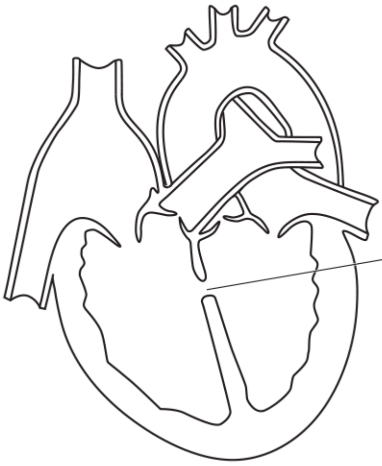
Complete the table below to show the roles of two valves in the heart.

Source of blood	Valve that controls blood flow	Destination of blood
....	right semilunar valve	....
left atrium	....	left ventricle

[2]

(b). A ventricular septal defect (VSD) is a hole in the septum of the heart.

The diagram below shows a heart with VSD.



Describe and explain why people with VSD can easily become tired.

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____ **[4]**

40.

Fig. 2.2, below and on the Insert H020/02, Depth in biology, June 2018, shows photographs of sheep's hearts that were considered for use in a school dissection.

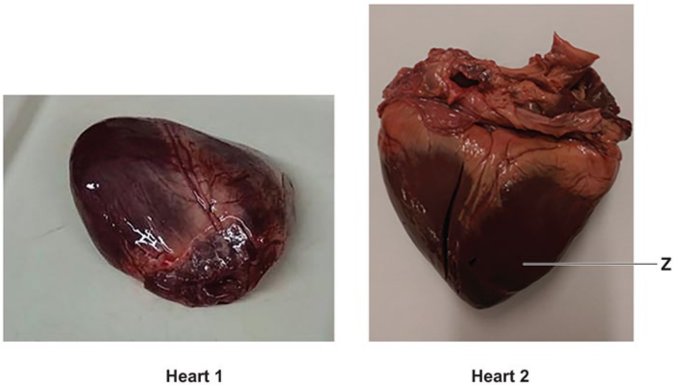

Fig. 2.2

i. Looking at the two hearts in Fig. 2.2, a student decided that **Heart 2** was a better choice for the dissection because it had more structures present.

What evidence from the two hearts in Fig. 2.2 supports the student's decision?

____

____ **[1]**

ii. Name the structure labelled **Z** on Fig. 2.2.

____ **[1]**

41. A school biology class carried out a dissection of a mammalian heart. A student drew the diagram shown in Fig. 3.1.

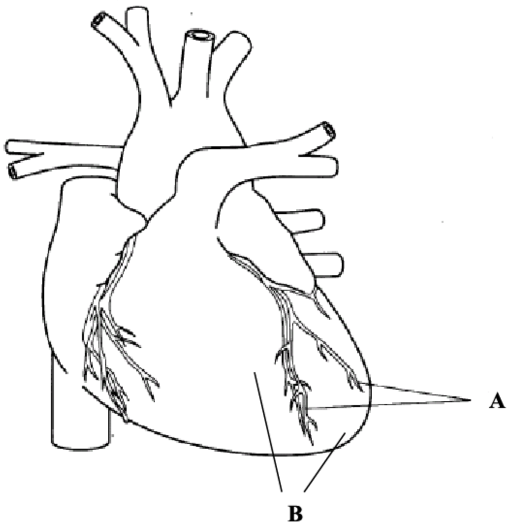

Fig. 3.1

i. Name the structures labelled **A**.

____ **[1]**

ii. Name the tissue labelled **B**.

____ **[1]**

iii. Table 3.1 lists some features of a mammalian heart.

One heart being examined in the lesson had both atria missing. The internal structure of this heart was examined by a pair of students.

Complete Table 3.1 to indicate which features were **visible to the naked eye** on the heart with **no atria**.

Feature	Visible (✓) or Not Visible (X)
AV valve	
bundle of His	
left ventricular wall	
Pulmonary vein	
Purkyne fibres	
SA node	
semi-lunar valve	
septum	

Table 3.1

[3]

42. Fig. 16 shows pressure changes during the cardiac cycle.

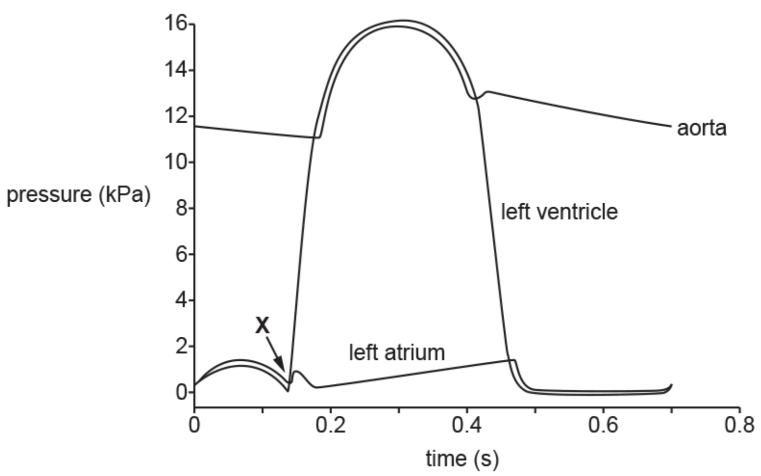

Fig. 16

i. Using Fig. 16, compare the changes in pressure in the left ventricle with the changes in pressure in the left atrium.

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____ **[4]**

ii. Using Fig. 16, calculate the heart rate of this individual.

Give your answer to **2** significant figures.

heart rate = ... **[1]**

iii. Using Fig. 16, calculate the percentage change between minimum and maximum pressure in the aorta.

Give your answer to **2** significant figures.

percentage change = ... **[2]**

iv. Name the valve which closes at point **X** on Fig. 16.

____ **[1]**

43. Fig. 2.3 shows the heart at different stages of the cardiac cycle.

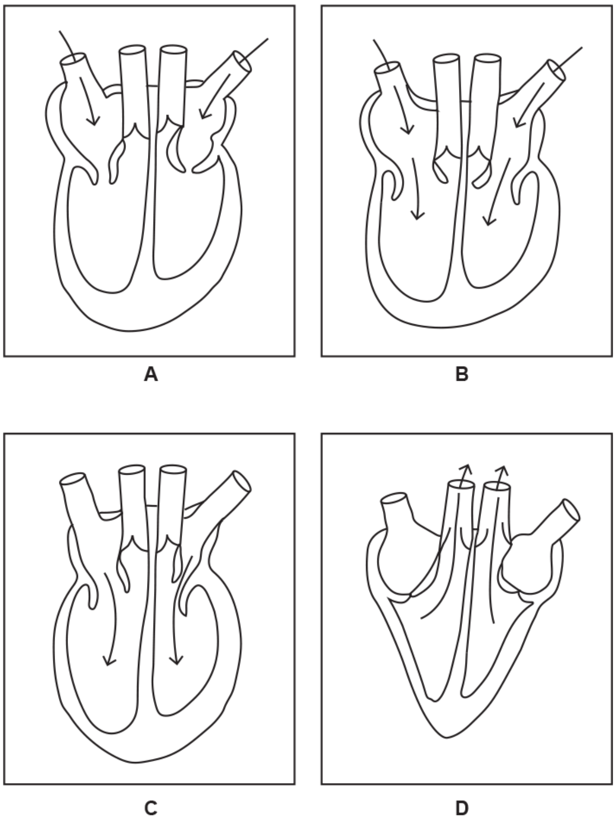

Fig. 2.3

Box A shows atrial diastole. Blood is entering the atria, which are relaxed.

Outline the remaining stages of the cardiac cycle, with reference to boxes B, C and D in Fig. 2.3.

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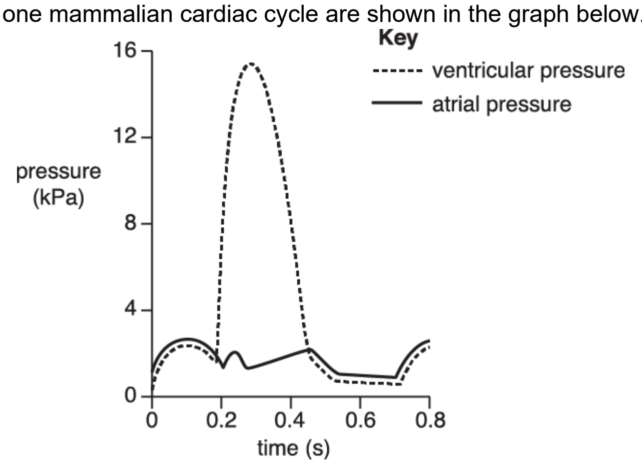
____ **[6]**

44. The pressure changes in one mammalian cardiac cycle are shown in the graph below.



Which of the following time periods, **A** to **D**, shows ventricular systole?

A. 0.0 to 0.1 s
B. 0.2 to 0.3 s
C. 0.4 to 0.5 s
D. 0.6 to 0.8 s

Your answer

[1]

45. Fig. 3.2 shows the changes in pressure inside the heart during one cardiac cycle.

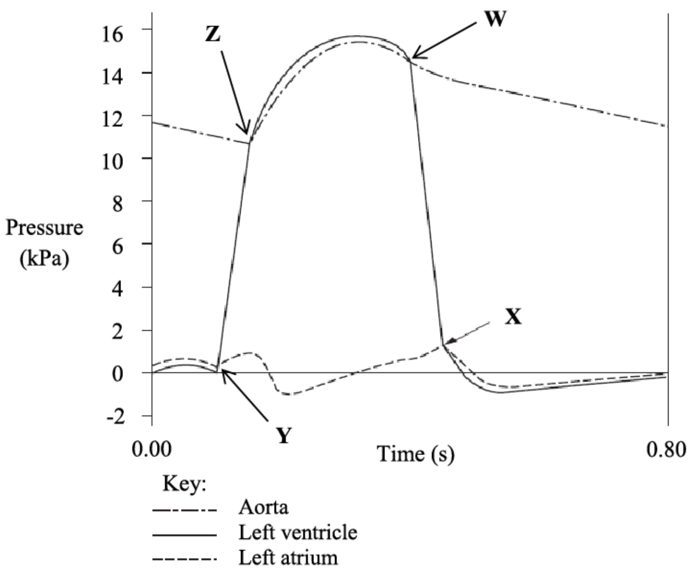


Fig. 3.2

i. Draw a line **on Fig. 3.2** that shows the pressure changes in the **right ventricle**.

[2]

ii. * Describe the events taking place at the points marked **W**, **X**, **Y** and **Z** and explain how these events are related to the changes in pressure shown in the diagram.

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____ **[6]**

46. A patient was admitted to a hospital ward suffering from a heart rhythm abnormality.

Fig. 2.1(a) shows an ECG trace of the patient upon arrival at the hospital.

Fig. 2.1(b) shows an ECG trace of the patient when their heart rhythm had settled down to that of a normally functioning heart.

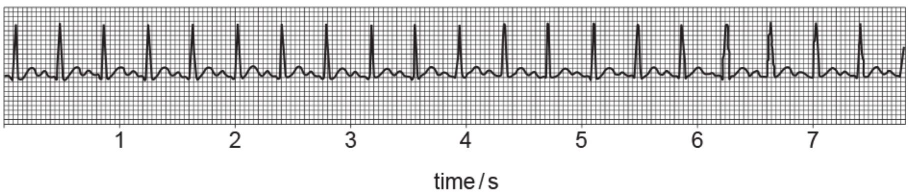

Fig. 2.1(a)

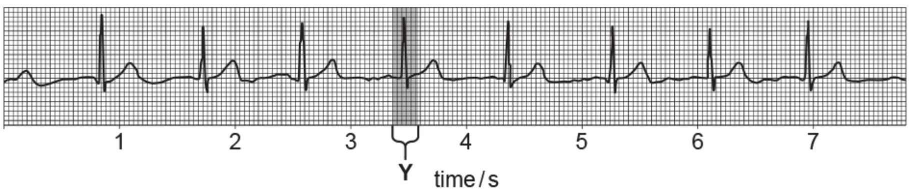

Fig. 2.1(a)

i. Using the traces shown in Fig. 2.1, name the heart rhythm abnormality that the patient is suffering from.

____ **[1]**

ii. The equation for working out cardiac output is:

cardiac output = stroke volume × heart rate

Stroke volume is the volume of blood pumped per heart beat.

The stroke volume of the patient is 80 cm^3.

Calculate the cardiac output of the patient using **Fig. 2.1(b)**. Give your answer in standard form.

Answer .... Units .... **[3]**

iii. Explain how the heart is controlling the electrical activity at Y on Fig. 2.1(b).

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____ **[2]**

47. Fig. 16.4 is an ECG trace of a person with an abnormal heart rhythm.

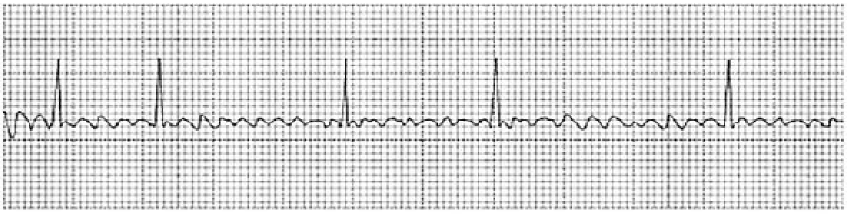

Fig. 16.4

Using the information from **Fig. 16.4**, what conclusions can you draw about the way in which this person's heart is functioning abnormally?

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____ **[3]**

48. Respiration is an important metabolic process that takes place in all living cells.

Fig. 19.2 shows an electrocardiogram trace (ECG) of a patient's heart after a black widow spider bite.

Fig. 19.2

What heart abnormality is suggested by this trace?

____ **[1]**

49(a). The rhythm and rate at which a human's heart beats can be determined by several factors.

Fig. 5.1 shows electrocardiogram traces (ECGs) from two different individuals, **X** and **Y**.

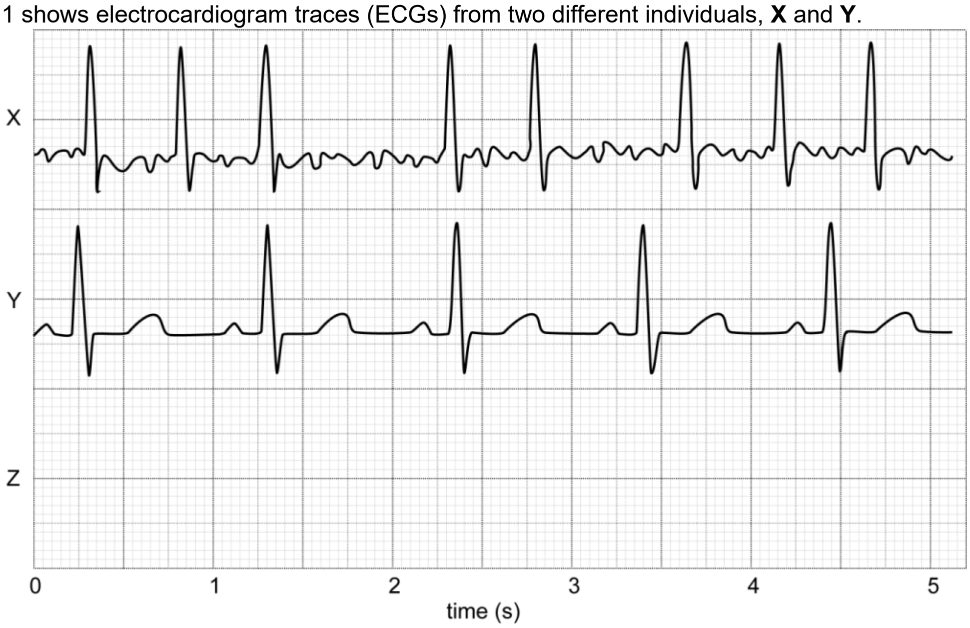

Fig. 5.1

i. Describe and explain the differences between the two ECGs.

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____ **[4]**

ii. An individual's cardiac output is calculated using the following equation:

Cardiac output = stroke volume x heart rate

The individual who produced ECG **Y** on Fig. 5.1 had a stroke volume of 80 cm^3.

Calculate the cardiac output of the individual responsible for ECG **Y**.

Include appropriate units in your answer.

Answer .... **[3]**

(b). Draw an ECG trace **on Fig. 5.1** (next to **Z**) to represent a recording from a patient with an ectopic heartbeat.

Show at least three cardiac cycles.

[2]

50. The electrical activity of the heart can be monitored using an electrocardiogram (ECG) trace.

Fig. 16.1 shows the ECG pattern for a single normal heartbeat.

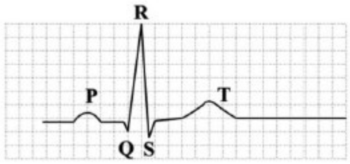

Fig. 16.1

Fig. 16.2 shows an ECG trace for a person with normal heart rhythm and **Fig. 16.3** shows the trace for a person with tachycardia.

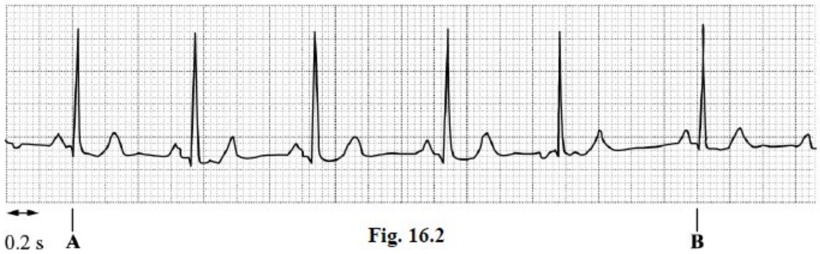

Fig. 16.2

Fig. 16.3

i. Calculate the percentage increase in heart rate for the person with tachycardia compared to the person with normal heart rhythm.

Use the data between points **A** and **B** on **Fig. 16.2** and points **C** and **D** on **Fig. 16.3** for your calculations.
Show your working. Give your answer to the nearest whole number.

Answer………………………………………………… % **[4]**

ii. The most obvious feature of tachycardia is an increased heart rate.

Using the information in **Fig. 16.1**, **Fig. 16.2** and **Fig. 16.3**, what are **other** key features of tachycardia?

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____ **[2]**

51. Phaeochromocytoma is a rare tumour of adrenal gland tissue. It causes increased hormone release from the adrenal glands.

Fig 21.2 shows three ECG traces showing the heart rhythms of three different patients.

- Patient **X** has a normal heart rhythm.
- Patient **Y** has phaeochromocytoma.
- Patient **Z** has bradycardia.

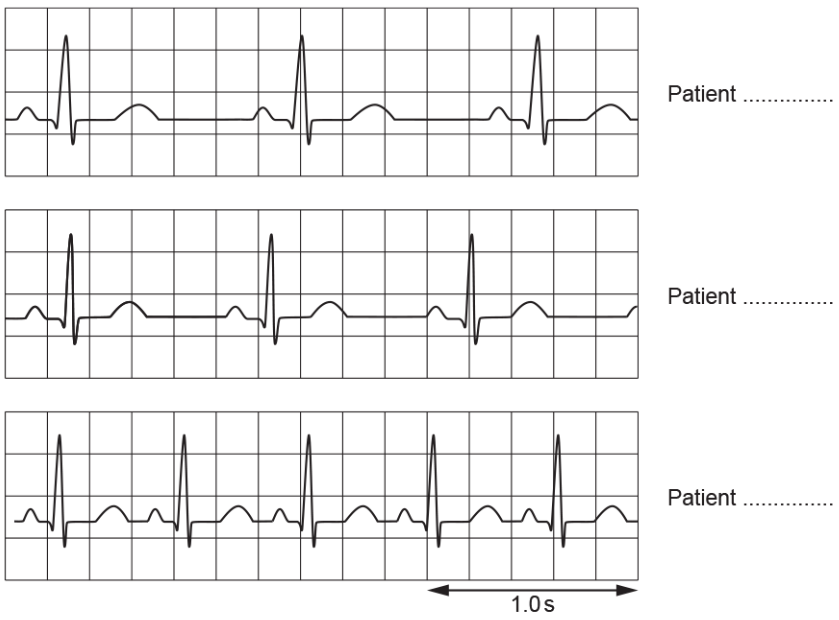
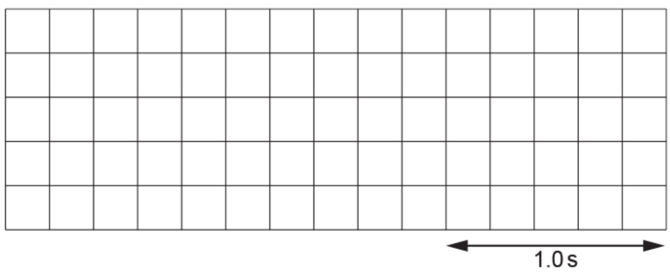


Fig. 21.2

i. Identify patients **X**, **Y** and **Z** by labelling the traces in Fig. 21.2.

[2]

ii. Sketch a trace for a patient who has entered atrial fibrillation.



[2]

iii. Suggest why reduced heart rate is sometimes seen in people who are very aerobically fit.

-- **[2]**

52. Fig. 3.3 shows two ECG traces.

- **Trace A** is a normal trace
- **Trace B** is from a patient that has been treated with the drug digoxin.

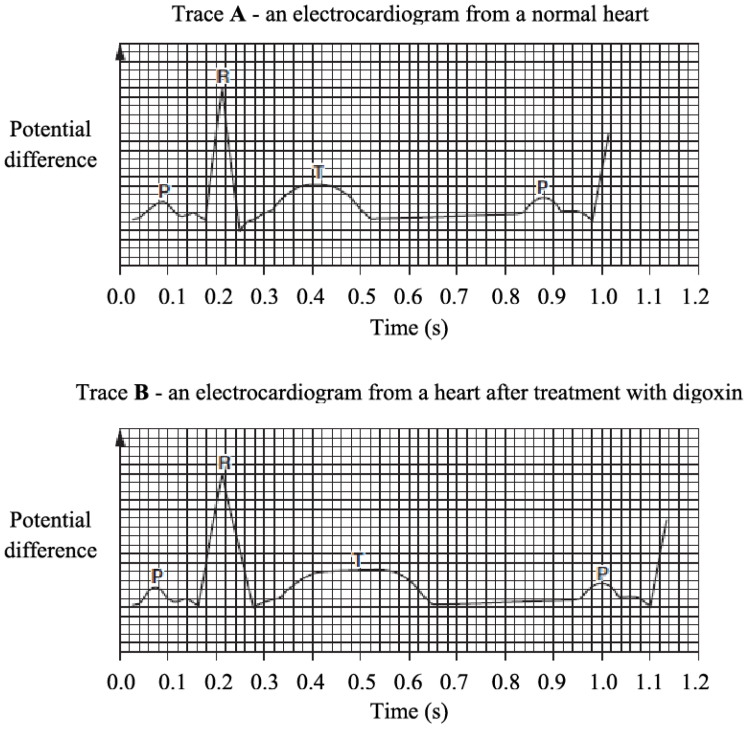


Fig. 3.3

i. Before being given digoxin, the patient's heart rate was 75 beats per minute.

Using **Trace B** in Fig. 3.3, calculate the percentage change in the patient's heart rate after receiving digoxin.

Answer ....% **[3]**

ii. Explain why the answer calculated in part **(i)** may not be an accurate representation of the patient's heart rate **and** suggest how a more accurate answer could be obtained.

--- **[3]**

iii. Digoxin caused the heart rate to change.

Identify **one other** effect of digoxin evident from Fig. 3.3.

--- **[1]**

53. Red blood cells contain high concentrations of the enzyme carbonic anhydrase.

i. A scientist planned to investigate the effect of pH on the activity of carbonic anhydrase.

State **two** factors that the scientist would need to control during this investigation.

1 ---

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2 ---

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[2]

ii. Human blood is maintained at a pH of 7.4 by reactions that occur in red blood cells.

Use your knowledge of these reactions to explain how a pH of 7.4 is maintained.

--- **[3]**

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

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____ **[6]**

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

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

Fig. 4.1

- Llamas live at high altitudes and camels live at low altitudes.
- At high altitudes the partial pressure of oxygen is low.
- Llama and camel haemoglobin consists of 2 α subunits and 2 β subunits.
- Each subunit contains a haem group and is able to bind to one molecule of oxygen.
- In the β subunits, one amino acid present in camel haemoglobin has been replaced by a different amino acid in llama haemoglobin.

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

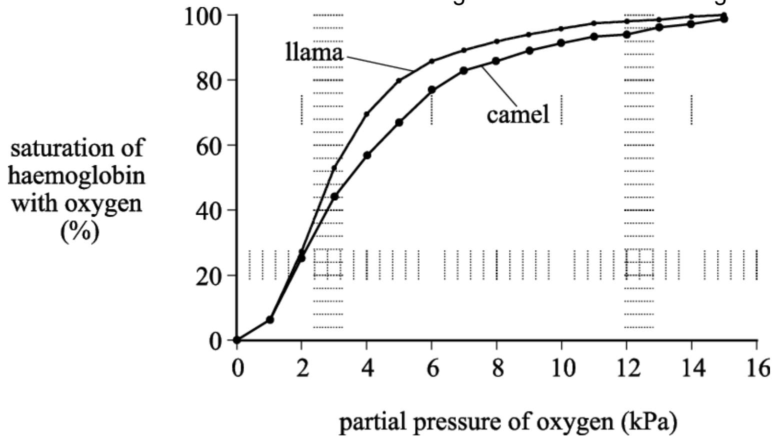

Fig. 4.2

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

Answer.. **[1]**

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

____

____

____ **[2]**

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

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

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

Show your working.

Answer = ... % **[2]**

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

i.

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

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

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

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

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

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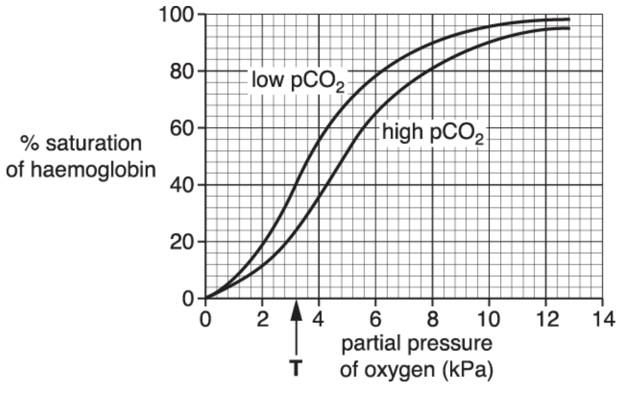
____ **[2]**

(c). The figure shows the oxygen dissociation curves at different carbon dioxide concentrations.



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

____ **[1]**

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

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

____

____

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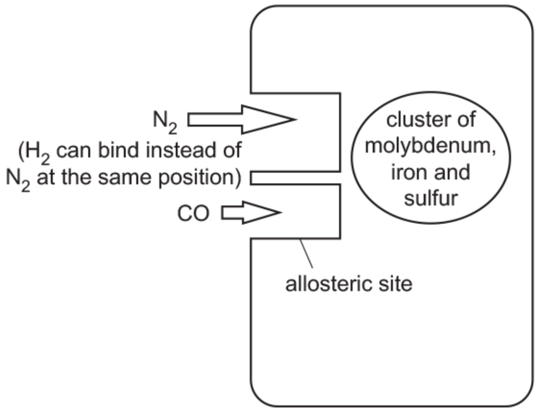
____ **[2]**

56. Nitrogen fixation is an important part of the nitrogen cycle.

The rate of nitrogen fixation is reduced by the presence of oxygen.

Rhizobium uses the enzyme nitrogenase to fix atmospheric nitrogen.

Fig. 4 shows a simplified representation of the structure of nitrogenase and the reaction that it catalyses.



Overall reaction: $N_2 + 8H^+ + 8e^- + 16ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16P_i$

Fig. 4

i. What can you conclude from Fig. 4 about the molecules or ions that affect the functioning of the nitrogenase enzyme?

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____ [4]

ii. Leghaemoglobin is a molecule that improves the performance of nitrogenase. It has very similar properties to mammalian haemoglobin.

Suggest **two** ways in which leghaemoglobin improves the performance of the nitrogenase enzyme.

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____

____

____ [2]

57. Squid blood contains a blue oxygen-carrying protein called haemocyanin.

High partial pressures of carbon dioxide reduce the affinity for oxygen of haemocyanin.

Suggest a mechanism by which carbon dioxide could reduce the affinity for oxygen of haemocyanin.

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____ [2]

58(a). Haemocyanin is an oxygen-binding pigment that is found in many invertebrate animals, including lobsters.

Fig. 6.2 shows the oxygen dissociation curves for haemoglobin and haemocyanin.

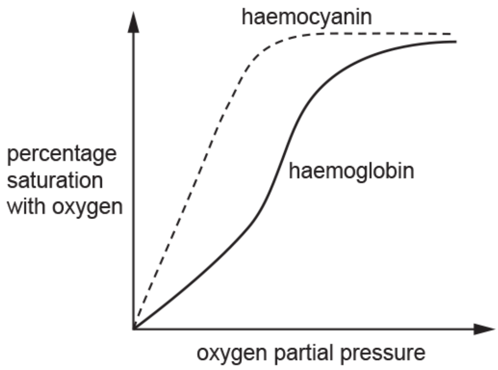

Fig. 6.2

What can you conclude about the habitat of a lobster?

____

____ **[1]**

(b). The oxygen dissociation curves for adult haemoglobin and fetal haemoglobin are shown in Fig. 6.1.

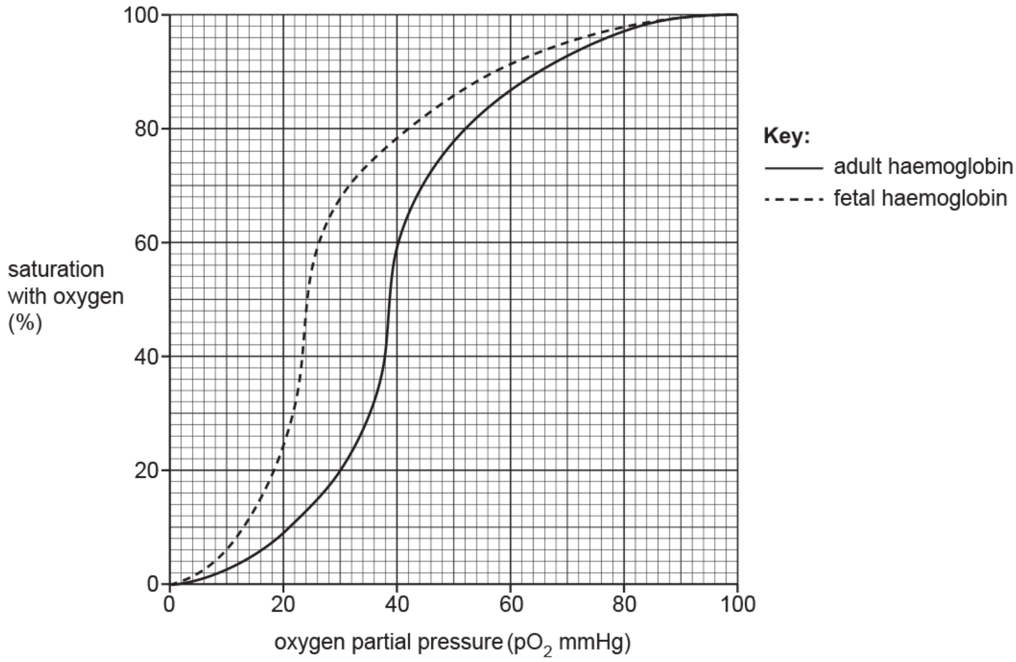

Fig. 6.1

i. Outline why it is important that fetal haemoglobin has a higher oxygen affinity than adult haemoglobin.

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____ **[2]**

ii. Myoglobin is a protein found in muscles. Oxygen binds to myoglobin.

A student described the oxygen dissociation curve for myoglobin as follows:

- When oxygen first becomes available, myoglobin saturation increases at a constant rate of 8% per mmHg of oxygen.
- When there is a slightly higher partial pressure of oxygen, the rate of oxygen binding slows gradually until the myoglobin is 100% saturated.
- The partial pressure at which myoglobin reaches 100% saturation is the partial pressure at which adult haemoglobin is 80% saturated.

Sketch an oxygen dissociation curve for myoglobin **on Fig. 6.1** based on the description provided above.

Answer **on Fig. 6.1**

________________________ ________________________ **[2]**