TRANSPORT

PART ONE: TRANSPORT IN ANIMALS SUGGESTED RESPONSES

1. With examples, explain the lack of specialised transport system in some organisms. (20 marks)

- Externally**;** these organisms have a large surface area to volume ratio**;** hence diffusion alone is adequate to meet their metabolic demands**;** and exchange of materials occurs over the whole body surface**;** for example
- Unicellular organisms like amoeba**;** are very small**;**
- Flat worms (platyhelminthes)**;** have flattened bodies**;**
- Hydra**;** are hollow**;**
- Bryophytes**;** are small**;** and lack cuticle**;**
- Internally**;** the distance the materials have to travel in such animals are small enough**;** for them to move by diffusion alone**;** or cytoplasmic streaming**;**
- Some organisms are not very active**;** hence their metabolic wastes accumulate slowly**;** and can be removed buy diffusion alone**;**

2. (a) Explain the need of transport system and respiratory pigments in some organisms. (15 marks)

- Some animals are large in size**;** with small surface area to volume ratio**;** hence diffusion alone cannot occur fast enough to meet their metabolic demands**;**
- Internally**;** materials would have to travel longer distances within the body**;**
- Some animals are also highly physically active**;** and need metabolites delivered to**;** and waste materials removed from cells**;** rapidly**;**
- In some animals, the body maybe covered with impervious layers**;** that prevents the exchange of materials directly diffusion**;**
- Respiratory pigments have a higher affinity of respiratory gases**;** and thus larger amounts can be transported**;**

(b) Explain the role of a blood vascular system in animals. (05 marks)

- To provide a rapid**;** mass flow**;** of materials from one part of the body to another**;** over long distances**;** where diffusion would be inadequate**;**

3. (a) Describe the characteristics of the blood vascular system. (08 marks)

- A circulating fluid**;** the blood**;**
- A contractile pumping device**;** which is the heart in some animals**;** or a modified blood vessel**;**
- Vessels through which blood passes**;** which can be tubular blood vessels**;** or sinuses**;**

(b) Name the two types of circulatory systems found in animals. (02 marks)

- Open blood circulatory system**;**
- Closed blood circulatory system**;**

(c) State the distinguishing features of the circulatory systems you have mentioned in (b) above. Give examples in each case. (10 marks)

Open blood circulatory system

- Blood is not contained in blood vessels but also flows in the haemocoel**;**
- Blood gets into direct contact with the body cells**;**
- Blood flows under low pressure**;**
- Blood does not transport respiratory gases**;**
- There is poor control of blood distribution**;**
- Example; insects**;**

Closed blood circulatory system

- Blood is confined to blood vessels**;**
- Blood does not get into direct contact with cells**;**
- Blood flows at a high pressure**;**
- Transports respiratory gases**;**
- Distribution of blood is well controlled according to the demands of the body**;**
- Example; in mammals and birds**;**

4. Explain the;

(a) Advantages of an open circulatory system. (10 marks)

- Animals are less vulnerable to pressure changes**;** which allows some of them like the molluscs to live at great depth**;** since their bodies cannot be compressed**;**
- Gives animals greater control of their body temperature**;** by easily dissipating off heat**;** allowing insects to survive extremely hot conditions**;**
- Blood requires less energy for distribution**;** since it occurs at low pressure**;**
- In insects the blood does not carry respiratory gases**;** hence damage to the system does not disrupt their movement in and out the body**;**

(b) Disadvantages of an open circulatory system. (10 marks)

- It is only suitable for small organisms**;** where blood travels short distances**;** as it is pumped at low pressure**;**
- There is poor control of blood distribution**;** which deprives vital organism of blood**;** during times of urgency**;**
- Suitable for less active organisms**;** where the metabolic requirements are low**;** which results in slow movement**;** and adaptability to new environments**;**

5. Explain the

(a) Advantages of a closed circulatory system. (10 marks)

- Due to high pressure involved; there is more efficient delivery**;** and removal of materials**;** to and from the tissues; since blood travels faster;.
- It also allows organisms to attain larger sizes; since blood can travel longer distances;

- Allows higher metabolic rates; and hence activity in animals due; to its efficiency in terms of delivery of metabolites to and removal of wastes from the tissues
- There is greater control of the blood distribution; hence better body functioning when there is urgent need of materials to specific organs;
- Pulmonary and systematic circulation like in mammals and birds can maintain their separate pressures as required by the body;

(b) Disadvantages of closed circulatory system. (10 marks)

- The system is linked with many other systems**;** such as respiratory and excretory system**;** and damage to it disrupts many other processes**;**
- Blood is transported at high pressure**;** and requires more energy to maintain**;**
- There is need to control the pressure in the system**;** as any deviations from the norm may lead to death of the individual**;**

6. (a) Giving an example, explain what is meant by the term *single circulatory system*. (02 marks)

- Is a system in which blood flows once through the heart for every complete circuit around the body**;** for example in fish**;**

(b) Explain the problems associated with single circulatory system in those animals that possess it. (08 marks)

- Blood passes through two capillary systems**;** that of the gills**;** and the rest of the body**;** before returning to the heart**;** which leads to a decrease in pressure**;** as capillaries offer much more resistance to blood flow**;**
- Consequently, venous blood return is slow**;** and imposes severe limitations on the activities of the fish**;**

(c) Explain how the problems associated with a single circulatory system have been solved in;

(i) Organisms that possess it. (03 marks)

- Veins are replaced with large sinuses**;** that offer less resistance to blood flow**;** hence blood can flow more faster**;**

(ii) Molluscs. (06 marks)

- Molluscs have the main heart**;** that pumps oxygenated blood to all the body organs**;** and a pair branchial hearts**;** that pump deoxygenated blood to the gills**;**
- They have large sinuses instead of veins**;** which offer minimum resistance to blood flowing back to the heart**;**

(iii) Mammals. (06 marks)

- Development of a double circulatory system**;** where deoxygenated blood is pumped to the lungs**;**, oxygenated blood returns to the heart**;** and is then pumped to the rest of the body**;**

- The heart is divided into the right and left sides**;** to prevent mixing of oxygenated and deoxygenated blood**;**

7. (a) Describe the blood circulatory system of an insect. (10 marks)

- The blood circulatory system of an insect comprises of the haemocoel**;** that is divided transversely by the pericardial membrane**;** into the pericardial cavity**;** containing the heart**;** and the perivisceral cavity**;** containing other body organs**;**
- Suspended in the pericardial cavity by the heart ligaments**;** is the heart which is tubular**;** and chambered**;** with a chamber in each segment**;** Each chamber has a pair of ostia**;**
- The pericardial membrane contains the alary muscles**;**

(b) Describe the blood circulation in insects (07 marks)

- During diastole**;** blood is pumped out of the heart by contractions starting from the posterior end to the anterior end**;** through the aorta**;** into the haemocoel**;**
- During systole**;** the alary muscles contract**;** the pericardial membrane is pulled downwards**;** and
  - ✓ Pressure in the perivisceral cavity increases beyond that in the pericardial cavity**;** and blood flows from the perivisceral cavity to the pericardial cavity**;**
  - ✓ Tension in the ligaments increases**;** which expands the heart chambers**;** and blood enters the heart through the ostia**;** which have valves**;** that prevent back flow**;**

(c) How does blood circulation in insects differ from the blood circulation in man? (07 marks)

Blood circulation in insects	Blood circulation in man
Blood flows through the heart once for every complete circuit around the body	Blood flows through the heart twice for every complete circuit around the body
Blood gets into contact with the body cells	Blood does not get into direct contact with body cells
Blood does not carry respiratory gases	Blood carries respiratory gases
Blood does not contain respiratory pigments	Blood contains haemoglobin as a respiratory pigment
Blood flows under low pressure	Blood flows under high pressure
Blood distribution is poorly controlled	Blood distribution in body is well controlled
Blood flows in an open cavity	Blood is confined in blood vessels
Blood is pumped by a tubular heart with many chambers	Blood is pumped by a four chambered heart

8. (a) Distinguish between *plasma* and *serum*. (02 marks)

- Plasma is the liquid part of blood**;**
- Serum is the liquid part of blood without fibrinogen/ clotting factors**;**

(b) Explain why red blood cells have a relatively short lifespan. (02 marks)

- They lack a nucleus**;** to control repair processes that occur during its lifetime**;**

(c) Explain why individuals inhabiting highlands have higher red blood cell count per unit volume of blood than normal average. (06 marks)

- In highlands, the partial pressure of oxygen is lower**;** than on low lands**;** this stimulates the bone marrow**;** to produce more RBCs**;** than those destroyed by the liver**;** in order to take up more oxygen from the environment**;**

(d) Give the different examples of respiratory pigments and the metals in their prosthetic groups. **(08 marks)**

Respiratory pigment	**Metal in the prosthetic group**
Haemoglobin	Iron
Haemocyanin	Copper
Chlorocruorin	Iron
Haemoerythrin	Iron

9. E**xplain the**

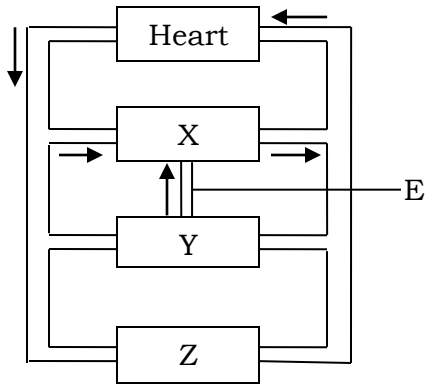
(a) Structural adaptations of red blood cells to their functions (14 marks)

Feature of the red cell	**Suitability**
Biconcave shape**;**	Increases the surface are to volume ratio**;** increasing the rate of diffusion of the gases**;**
Thin membrane**;**	Reduces the diffusion distance**;**
It is very flexible**;**	Bends as it goes through blood capillaries**;** exposing much of its surface for gaseous exchange**;**
Has haemoglobin**;**	Carries oxygen and carbon dioxide**;**
Lacks a nucleus**;**	Increases space for carriage of the gases**;**
Lacks mitochondria**;**	Increases space**;** and oxygen carried is not used**;**

(b) Physiological adaptations of red blood cells to their functions. (06 marks)

Feature of the red blood cell	**Suitability**
Has enzyme carbonic anhydrase**;**	Catalyses reaction between water and carbon dioxide**;**
Haemoglobin binds reversibly with oxygen**;**	Allows loading of oxygen in the lungs**;** and its unloading in the respiring tissues**;**
Respires anaerobically**;**	Oxygen is not used up during its transport**;**
Haemoglobin binds hydrogen ions**;**	Buffers blood to allow transport of much carbon dioxide**;**

10. Below is a part of the basic plan of the human circulatory system. Study it carefully and answer the questions that follow.



(a) Describe the arrangement of the organs

(i) X, Y and Z with respect to the heart (01 mark)

- Organs are arranged in parallel**;**

(ii) X and Y. (01 mark)

- Organs are arranged in series**;**

(b) What is the *general name* given to blood vessel E. Give a reason for your answer? (02 marks)

- A portal blood vessel**;** because it connects two organs neither of which is the heart**;**

(c) Explain the significance of the arrangement of the organs in (a) (i). (05 marks)

- Organs receive blood at the same pressure**;** with the same amount of nutrients/ metabolites**;** and oxygen**;**
- Damage to one vessel linking the organ to the heart**;** does not disrupt the rest of the circulation**;**

(d) Name the organs in human that can be represented by the letters X and Y and the blood vessel that can be represented by the letter E. (03 marks)

- X:- Liver**;**
- Y:- Gut**;**
- E:- Hepatic portal vein

(e) What is the significance of the arrangement of the organs X and Y in man as identified in (d) above? **(03 marks)**

- Blood from the gut has variable composition in terms of the nutrients it contains**;** hence flows to the liver to have adjust to the normal levels**;** before it is distributed to the rest of the body**;**

11. (a) Describe how the following blood vessels are suited for their functions.

(i) Arteries. (10 marks)

Features of arteries	**Suitability**
Thick tunica media**;** with smooth**;** and elastic muscles**;**	Allows them to dilate**;** without rupturing**;** when blood flows into the at high pressure**;**
Elastic recoil**;** and contractions between heart beats**;**	Keeps the blood moving forward during ventricular diastole; Smoothens the flow of blood along the arteries**;**
Narrow lumen**;**	Maintains a high pressure in the arteries**;**

(ii) Veins. (04 marks)

Features of veins	**Suitability**
Wide lumen**;**	Offers less resistance to blood flow back to heart**;**
Have semi lunar valves along their length**;**	To prevent the back flow of blood**;**

(b) How does the functioning of arteries differ from that of the veins? (04 marks)

Functioning of arteries	**Functioning of veins**
Carry oxygenated blood except the pulmonary artery;	Carry deoxygenated blood except pulmonary vein;
Carry blood from the heart to other body organs	Carry blood from other body organs back to the heart
Carry blood at higher pressure	Carry blood at lower pressure
Blood flowing in them has a pulse	Blood flowing in them has no pulse

12. (a) Distinguish between *systemic circulation* and *pulmonary circulation* in humans. (02 marks)

- Systemic circulation is the flow of blood from the heart to the lungs and back**;**
- Pulmonary circulation is the flow of blood from the heart around the body**;**

(b) Explain the significance of the difference in the thickness of the walls of heart ventricles. (08 marks)

- The right ventricle is thicker than the left ventricle**;**
- The right ventricle pumps blood to the lungs**;** which are near the heart**;** thus lower pressure is required**;** to prevent damage of the lung capillaries**;**
- The left ventricle pumps blood to all the parts of the body**;** some of which are far from the heart**;** and a high pressure is required**;** to overcome the peripheral resistance**;**

(c) What advantages are there in supplying the pulmonary circulation with blood at lower pressure than that of the systemic circulation? (08 marks)

- Oxygenated blood of the systemic circulation should reach body capillaries far away from the heart**;** at a much higher pressure**;** which is essential for the formation of tissue fluid**;** and efficient functioning of the organs**;** as oxygen and metabolites are quickly delivered to the tissue cells**;** which permits high metabolic rates**;**

- A lower pressure in the pulmonary circulation prevents rupture of the delicate pulmonary capillaries**;** which are found in the lungs that are near the heart**;**

13. (a) Describe the structure of the cardiac muscle. (09 marks)

- Cardiac muscles fibres contain one or two nuclei**;** and many**;** large mitochondria**;**
- Each muscle fibre is made up of many myofibrils**;** containing actin**;** and myosin**;** giving the muscle a stripped appearance**;**
- Intercalated discs separate individual muscle cells**;**
- Fibres branch and cross-connect with other**;**

(b) Explain the significance of a long absolute refractory period in cardiac muscles (06 marks)

- Allows the muscle to recover fully**;** during rapid contractions**;** without fatigue**;** which prevents tetanus**;** and oxygen debts**;** which would lead to death of an individual**;**

(c) How does the heart regain its original shape after its contraction? (05 marks)

- The cardiac muscles relax**;** increasing the length of the sarcomere**;** hence the whole muscle
- The heart undergoes elastic recoil**;** due to presence of connective tissues**;** which are distorted during contraction**;**

14. (a) What is meant by the term *cardiac cycle?* (01 mark)

- A sequence of events that take place during the completion of a single heart beat**;**

(b) Describe the sequence of events that occur during the cardiac cycle. (19 marks)

Stage	Description
Atrial diastole**;**	• Atria are relaxed**;** pressure is low and the volume is large**;** • Atrio-ventricular valves are closed**;** • Atria fill with blood**;**
Atrial systole**;**	• Atria contract**;** pressure in them increases**;** beyond that in the ventricles**;** while the volume decreases**;** • The atrio-ventricular valves open**;** • Blood flows into the relaxed ventricles**;**
Ventricular systole**;**	• Ventricles contract**;** pressure increases beyond that in the atria**;** pulmonary artery and aorta**;** • Atrio-ventricular valves close (making the first heart sound - ***lub***)**;** to prevent back flow of blood into the atria**;** • Pocket valves open**;** and blood enters in to the pulmonary artery and aorta**;**
Ventricular systole**;**	• Ventricles relax**;** volume in them increases**;** pressure decreases below that of the pulmonary artery and aorta**;** pocket (semi-lunar) valves close (making the second heart sound - ***dub***)**;** to prevent back flow is blood**;**

15. (a) Explain the suitability of the cardiac muscle to its function. (13 marks)

Feature of the cardiac muscle	Suitability
Many (large) mitochondria;	To provide energy for contraction of the muscle;
Actin and myosin filaments;	Makes the muscle contract and relax;
Intercalated discs;	Modified to allow rapid diffusion of ions; and hence rapid spread of action potential through the muscle;
Tough junctions between myofibrils of successive cells;	Hold the cells together during contraction;
Branched fibres;	Rapid spread of excitations through the whole muscle;
Longer absolute refractory period;	Allow the muscle to recover fully; during rapid contractions; without fatigue; tetanus;, and oxygen debts;

(b) Describe how the heartbeat is stimulated. (07 marks)

- Electrical stimulations originate from the sino-atrial node (SAN) in the right atria;
- These spread to the through the atria; and then to the atrio-ventricular node (AVN);
- The AVN the transmits the excitations to the ventricles; through the Purkinje tissue; to the base of the ventricles causing them to contract; from the apex upwards;

16. (a) Explain the significance of the following in the functioning of the heart

(i) Delay in the conduction of impulses from the SAN to the AVN. (03 marks)

- Allows the atria to contract completely; before the ventricles begin to do so; which forces blood to move from the atria to the ventricles;

(ii) Arrangement of the Purkinje tissue in the heart chambers. (06 marks)

- Purkinje tissue runs through the septum to the bottom of the heart; and then rises within the walls of the ventricles;
- This arrangement allows the ventricular contractions to start from the bottom of the heart; and move upwards; which squeezes blood out the ventricles; into the pulmonary artery and aorta;

(b) Describe the role of the medulla in the control of heartbeat rate. (11 marks)

- During a vigorous physical activity much blood returning to the heart stretches the vena cava; impulses are conveyed from the vena cava to the cardiac accelerator centre in the medulla; which responds by sending impulses via the sympathetic nerve; to the SAN; and the heartbeat rate is increased;
- The heart responds by contracting more strongly and much blood is forced out of the heart;
- As much blood leaves the heart the aorta and carotid arteries are stretched; which stimulates the stretch receptors that send the impulses to the cardiac inhibitory centre in the medulla; that respond by sending impulses to the SAN; and AVN; via the vagus nerve; to inhibit further contraction; and the heart rate is reduced

17. (a) Describe the

(i) Nervous control of heartbeat rate. (11 marks)

- During a vigorous physical activity much blood returning to the heart stretches the vena cava**;** impulses are conveyed from the vena cava to the cardiac accelerator centre in the medulla**;** which responds by sending impulses via the sympathetic nerve**;** to the SAN**;** and the heartbeat rate is increased**;**
- The heart responds by contracting more strongly and much blood is forced out of the heart**;**
- As much blood leaves the heart the aorta and carotid arteries are stretched**;** which stimulates the stretch receptors that send the impulses to the cardiac inhibitory centre in the medulla**;** that respond by sending impulses to the SAN**;** and AVN**;** via the vagus nerve**;** to inhibit further contraction**;** and the heart rate is reduced

(ii) Hormonal control of the heartbeat rate. (05 marks)

- Adrenaline hormone**;** from adrenal medulla**;** stimulates the heart to beat faster**;**
- Thyroxin**;** from the thyroid gland**;** stimulates the heart to beat faster directly**;**
- Thyroxin raises the basal metabolic rate**;** more carbon dioxide**;** and heat are produced**;** which cause vasodilation**;**, increased blood flow**;** and heart beat rate.

(b) State the other factors that can influence the rate of the heartbeat.(04 marks)

- pH; low pH increased the heartbeat rate while high pH decreases it;
- Temperature; low pH reduces heartbeat rate while high pH increases it;
- High amount mineral ions increase the heartbeat rate
- Age;
- Exercise;
- Level of fitness

18. (a) Outline the main adjustments that occur to the heart rate and circulatory system

(i) Before 100m race. (06 marks)

- Adrenaline is secreted in anticipation for the race**;** which stimulates vasoconstriction throughout the body**;** except in the most vital organs**;** and blood pressure is raised**;** heart rate also raises**;** and extra blood is passed to the general circulation from the spleen**;**

(ii) After 100m race. (06 marks)

- The oxygen debt is paid off**;** and lactic acid is removed from the blood**;** by the liver**;** tissue activity reduces**;** and carbon dioxide levels decrease**;** heartbeat rate and blood pressure decrease**;**

(b) Explain why when an animal is wounded, its overall blood pressure rises but the area in the vicinity of the wound swell. (08 marks)

- Local vasodilation occurs in the vicinity of the wound**;** allowing more blood to reach the site**;** bringing in oxygen**;** and nutrients**;** to speed up the process of repair**;**
- Increased blood pressure around the body occurs as a result of vasoconstriction**;** to allow blood move faster**;** so that the body to respond more efficiently to any other stress**;**

19. (a) Describe the changes that occur to the heart rate and circulatory system during a 100m race. (13 marks)

- The metabolic rate increases especially in the skeletal muscles to provide energy**;**
- Increased carbon dioxide**;** and heat**;** production in these regions promote local vasodilation**;**
- The carbon dioxide in blood is detected by the chemoreceptors in the aorta**;** and carotid bodies**;** which in turn stimulate the vasomotor centre**;** to promote vasoconstriction elsewhere in the body**;** this increases the blood pressure**;** which speeds up blood flow**;**
- The heart rate also increases**;** and more complete emptying of the ventricles occurs**;**
- Towards the end of the race, the muscles respire anaerobically**;** and produce lactic acid**;** strong muscles contractions occurs to squeeze veins and promote faster venous return to the heart**;**

(b) Explain the effect of increased levels of carbon dioxide in blood on blood pressure in man. (07 marks)

- Increased amount of carbon dioxide is detected by the chemoreptors in the carotid and aortic bodies; the send impulses through the afferent neurones to vasomotor centre;
- The vasomotor centre sends impulses to blood vessels (arterioles) via the sympathetic nerves; which causes them to constrict; and blood pressure increases;
- Carbon dioxide also directly stimulates the blood vessels in the area where it produced to dilate; so that more blood flows in this region;
- Increased carbon dioxide levels also stimulates the cardiac accelerator centre that sends impulses to the SAN via the sympathetic nerve to increase the cardiac output; and hence blood pressure increases

20. (a) What is meant by the term *blood pressure?* (01 mark)

- Is the force with which blood pushes against the blood vessels**;**

(b) State four factors that can blood pressure. (04 marks)

- Age**;**
- Sex**;**
- State of health**;**
- Cardiac output**;**
- Stress**;**
- Peripheral resistance**;**

(c) Explain the role of the vasomotor centre in the regulation of blood pressure in man. (15 marks)

- When blood pressure increases**;** the baroreceptors in the aorta**;** and carotid sinuses**;** are stimulated**;** and send impulses to the vasomotor centre in the medulla**;** which respond by sending impulses to the SAN**;** and AVN**;** via the vagus nerve**;** to decrease the heart rate**;** Vasodilation of the peripheral blood vessels occurs throughout the body**;** and the blood pressure decreases

- When blood pressure decreases**;** the stretch receptors will not be stimulated**;** and the vasomotor centre sends impulses via the sympathetic nerves**;** to the SAN of the heart**;** to increase heart rate**;** and the peripheral blood vessels to constrict**;** and blood pressure rises

21. (a) Explain the significance of controlling blood pressure. (05 marks)

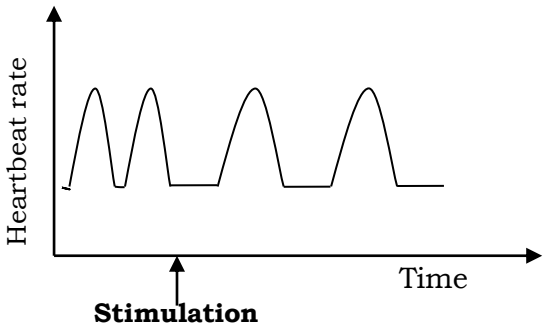
- Adequate blood pressure is required to move blood from the heart through the arteries**;** to the capillaries; and then move it back to the heart in the veins**;**
- Low blood pressure would affect the delivery of materials to the tissues**;** and the speed of blood returning in the veins**;**
- High blood pressure would lead to bursting of delicate capillaries**;** haemorrhages**;** and heart infarction**;** affecting vital body organs which may be fatal**;**

(b) Describe the maintenance flow of blood in humans. (15 marks)

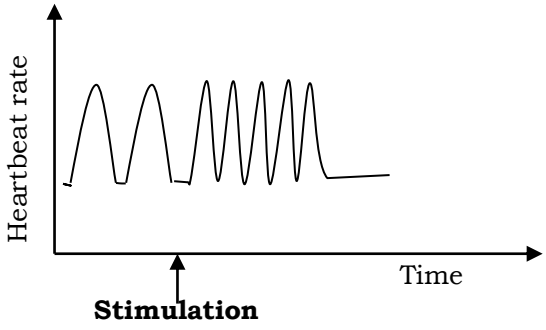
- **Arteries;** receive blood from the heart under high pressure; during ventricular systole;. This pressure moves the blood in the arteries throughout the body;. The movement is pulsative at first; flowing fast at systole and slow at diastole; but further away from the heart, blood flows evenly; due to elastic recoil of the smooth muscles in the arteries;
- **Veins;** blood flow is due to the action of the skeletal muscles squeezing them; and back flow is prevented by the valves present along their walls;
- The large diameter minimises resistance to blood flow;
- The negative pressure developed in the thorax during inspiration draws back blood towards to the hearts**;**

22. The graphs below show the effect of stimulating the heart through two different nerves, Y and Z on the rate of heart beat

Stimulation through nerve **Y**



Stimulation through nerve **Z**



(a) With a reason, identify the

(i) Nerve *Y* **(02 marks)**

- Vagus/ parasympathetic nerve**;** because stimulating it decreases the heart rate**;**

(ii) Nerve *Z* **(02 marks)**

- Sympathetic nerve**;** because stimulating it increases the heart rate**;**

(b) Explain how the heartbeat response is brought about when stimulate through

(i) Nerve *Y*. (05 marks)

- Impulses pass via the vagus nerve reach the SAN**;** and AVN**;** acetylcholine is released**;** and cause a decrease a decrease in the frequency of excitations**;** which slows the heartbeat rate**;**

(ii) Nerve *Z*. (04 marks)

- Impulses pass via the sympathetic nerve reach the SAN**;** noradrenaline is released**;** causing the heart to produce more excitations**;** which increases the heartbeat rate**;**

23. (a) Describe how blood capillaries are suited for their functions. (08 marks)

Features of the capillaries	**Suitability**
Thin endothelium	Allows rapid diffusion of materials
They are numerous	To increase surface area for diffusion
Smooth endothelium	For frictionless flow of blood
Sphincter muscles	Regulate the flow of blood through the capillaries

(b) Explain how the supply of materials to body tissues is regulated. (12 marks)

- Dilation of arterioles**;** increases the blood supply to some parts**;** while constriction of arterioles**;** decreases blood flow through some body parts**;**
- At the arteriole – capillary junctions**;** there are sphincter muscles**;** which contract to decrease**;** or relax to increase the blood flow through the capillaries**;** under the influence of nerve impulse**;** hormones**;** or localised metabolites**;**
- There are shunt vessels that connect arterioles to vennules**;** bypassing the capillaries**;**. These can constrict**;** allowing more blood flow through capillaries hence increasing blood supply to the tissues**;** or dilate**;** decreasing blood flow through the capillaries hence decreasing blood supply to the tissues**;**

24. (a) Explain the significance of the endothelium in blood vessels. (12 marks)

- They are made of flattened cells**;** whose smoothness allows frictionless flow of blood**;** and prevents clotting of blood within the blood vessels**;**
- Cells of endothelium contain pinocytic vacuoles**;** that transport materials across the cells**;**
- Endothelial cells can sense changes in blood pressure**;** and carbon dioxide level**;** produce regulatory substances like
  - ✓ Endothelin**;** that causes vasoconstriction of arterioles**;** increasing the blood pressure**;**
  - ✓ nitric oxide that causes vasodilation**;** prevents formation of blood clots (anticoagulant) by suppressing platelet activation**;**

(b) Describe the structure of a haemoglobin molecule. (08 marks)

- It consists of four polypeptide chains**;** two alpha**;** and two beta**;** held together by hydrophobic interactions**;** hydrogen bonds**;** and ionic bonds**;**
- Each polypeptide has haem group**;** with iron at the centre**;**

25. The oxygen dissociation curve for adult human haemoglobin is sigmoid.

(a) Explain why the curve is sigmoid. (10 marks)

- Without oxygen**;** the haemoglobin molecule is stable**;** due to hydrogen bonds**;** ionic bonds**;** and hydrophobic interactions**;** so the first oxygen molecules attaches with difficulty**;**
- However, when one of the chains accepts an oxygen molecule**;** the structure is altered**;** and the remaining haem groups are exposed**;** so that the other oxygen molecules are taken up more rapidly/ easily**;**

(b) Explain the significance of the sigmoid shape of the curve. (06 marks)

- Haemoglobin easily saturates with oxygen**;** when the oxygen partial pressures are high**;** for example in the lungs**;**
- A small decrease in partial pressure of oxygen**;** causes a rapid release of oxygen from the haemoglobin**;** so that the respiring tissues can use it**;**

26. (a) What is the *Bohr Effect?* (03 marks)

- This is the shifting of the oxygen dissociation curve downwards**;** and to the right**;** as a result of increased partial pressure of carbon dioxide**;**

(b) Explain the basis of the *Bohr Effect.* (09 marks)

- Carbon dioxide reduces the haemoglobin's affinity for oxygen**;**
- Carbon dioxide dissolves in water to form carbonic acid**;** which dissociates in to hydrogen ions**;** and bicarbonate (hydrogencarbonate) ions**;**
- The hydrogen ions combine with haemoglobin**;** to form haemoglobinic acid**;** thus reinforcing the chemical links between the polypeptides**;** thus stabilising the haemoglobin**;** and displacing oxygen in the process**;**

(c) Explain the physiological significance of the *Bohr Effect.* (04 marks)

- Respiring tissues use up oxygen and produce large amounts of carbon dioxide**;**
- In the presence of increased carbon dioxide concentration**;** haemoglobin easily releases oxygen**;** to be used by the respiring tissues**;**

(d) Explain the need to remove carbon dioxide from the body. (05 marks)

- Carbon dioxide is a waste product of metabolism**;** which reacts with water to form carbonic acid**;** which leads to changes in the pH of blood**;** and tissue fluid**;** interfering with the functioning of enzymes**;**

27. Explain why

(a) Compared to humans, the oxygen dissociation curve for small mammals is displaced to the right. (05 marks)

- Smaller mammals have a lager surface area to volume ratio**;** and lose heat faster**;** which is compensated by the high metabolic rate**;**
- Their haemoglobin shows low affinity for oxygen**;** to easily release it to the highly respiring tissues**;**

(b) The oxygen dissociation curve of the foetus is displaced to the left of that the mother. (05 marks)

- Foetal haemoglobin has a much higher affinity for oxygen than that of the mother**;** because the foetal haemoglobin has to obtain oxygen from the maternal haemoglobin**;** via the placenta**;**
- Hence at any given partial pressure of oxygen, the foetal haemoglobin can take up oxygen**;** from the more saturated maternal blood**;**

(c) Mammals living on highlands have their oxygen dissociation curves located on the left of other mammals. (03 marks)

- Highlands have low partial pressures of oxygen**;**
- Haemoglobin of such mammals has a higher affinity for oxygen compared to the other mammals**;** making it able to saturate easily even at low oxygen partial pressures**;**

(d) Muscles of highly active mammals contain large amounts of myoglobin. (04 marks)

- Myoglobin has a high affinity for oxygen compared to haemoglobin**;** and thus can store more oxygen**;** releasing it only when that of haemoglobin is depleted**;** to be used in aerobic respiration for the muscles to produce enough energy**;**

28. (a) Explain the effect of carbon monoxide on the transport of respiratory gases in humans. (05 marks)

- Haemoglobin has a high affinity for carbon monoxide**;** compared to oxygen**;** and combines irreversibly with it**;** forming a stable carboxyhaemoglobin molecule**;** that prevents the carriage of oxygen and carbon dioxide**;**

(b) During the treatment of carbon monoxide poisoning, the victim is made to inhale pure oxygen containing a small amount of carbon dioxide. Explain why

(i) Pure oxygen is used. (03 marks)

-

(ii) Carbon dioxide is added to pure oxygen. (03 marks)

- Carbon dioxide stimulates the respiratory centre**;** leading to faster breathing rate**;** that flashes out the carbon monoxide from the lungs**;**

(c) Explain the role of carbon monoxide as a respiratory poison. (07 marks)

- Haemoglobin has a high affinity for carbon monoxide compared to oxygen**;** and combines irreversibly with it**;** forming a stable carboxyhaemoglobin molecule**;** that prevents the carriage of oxygen to the respiring tissues**;**
- Without oxygen, tissues cannot respire**;** and thus lack energy to keep the cells alive**;** leading to death of the victim**;**

29. (a) Describe how carbon dioxide is transported from its site of production to the lung capillaries in man. (14 marks)

- In solution as a gas dissolved in water**;**
- Combined with protein (haemoglobin) amino groups to form carbaminohaemoglobin**;**
- As hydrogen carbonate**;**
  - Carbon dioxide produced from the tissues diffuses into plasma**;** and then into the red blood cells**;** where it combines with water to form carbonic acid**;** a reaction catalysed by carbonic anhydrase enzyme**;**
  - Carbonic acid dissociates into hydrogen ions and hydrogen carbonate ions**;**
  - The hydrogen ions combine with haemoglobin form haemoglobinic acid**;** by displacing oxygen**;**
  - The hydrogen carbonate ions diffuse out of the RBC into plasma**;** since the red blood cell membrane is permeable to negative ions but not positive ions**;** while the chloride ions diffuse into the RBC**;** to restore electroneutrality**;**
  - The hydrogen carbonate is carried in plasma to the lungs where carbon dioxide is regenerated and expelled out of the body**;**

(b) Describe how carbon dioxide in blood is expelled as gaseous carbon dioxide into the lungs. (06 marks)

- Haemoglobinic acid reaches the lungs and takes up oxygen to form oxyhaemoglobin**;** while releasing hydrogen ions**;**
- Hydrogen ions combine with hydrogen carbonate in the RBC to form carbonic acid**;** which dissociates in to carbon dioxide and water**;** catalysed by carbonic anhydrase**;**
- Carbon dioxide diffuses out of the RBCs into the lungs**;**

30. (a) What is meant by the term *chloride shift*? (02 marks)

- Is the diffusion of chloride ions from the plasma into the red blood cell**;** during the transport of carbon dioxide**;**

(b) Explain the significance of the chloride shift. (02 marks)

- To restore electroneutrality in the red blood cell**;** after the outward diffusion of hydrogencarbonate**;**

(c) Explain the following

(i) The significance of the formation of haemoglobinic acid during the transport of carbon dioxide in the body. (03 marks)

- By combining with the hydrogen ions, haemoglobin buffers blood**;** allowing large quantities of carbon dioxide to be transported to the lungs**;** without large changes in the pH**;**

(ii) The Bohr Effect is not shown by the haemoglobin of animals living in environments with low oxygen tensions. (04 marks)

- Such habitats have high levels of carbon dioxide**;** which would reduce the haemoglobin's affinity for oxygen**;** and with little oxygen in the environment, the haemoglobin would not take up enough oxygen**;** and the organism would not survive**;**

31. (a) Explain the how individuals become acclimatised to high altitudes. **(10 marks)**

- At high altitudes the partial pressure of oxygen is low**;** deeper breathing (hyperventilation) takes place**;** to increase the amount of oxygen reaching the lungs**;**
- Deeper breathing removes more carbon dioxide than produced**;** and the blood pH rises**;** more hydrogen carbonate ions are removed by the kidney to restore blood pH to normal**;**
- Improved capillary network in the lungs**;** to absorb more oxygen**;**
- Increased red blood cell count**;** and haemoglobin concentration in the red blood cells**;** to carry more oxygen**;**
- Increased myoglobin levels in the muscles**;** due to its high affinity for oxygen**;** more oxygen can be stored and later exchanged with tissues**;**

(b) Describe the adaptations of the circulatory systems in water diving mammals. **(10 marks)**

- Increased concentration of red blood cell count; and haemoglobin concentration; to take up more oxygen**;**
- During diving, heartbeat slows down; and blood pressure maintained by constriction of arteries;
- Higher concentration of myoglobin in muscles; to store more oxygen;
- Tolerate higher concentration of lactic acid; so that muscles are not affected
- Reduced sensitivity to low pH so that breathing and heartbeat are not stimulated automatically as the concentration of carbon dioxide in the body increases;
- Blood is distributed to vital organs during the dive; to keep the body functioning;
- Blood makes up a greater proportion of the body mass to carry more oxygen;

32. (a) Describe the process leading to the formation of a blood clot following tissue injury. **(07 marks)**

- Damages tissues and platelets**;** release thromboplpastin (thrombokinase)**;** which catalyses the conversion of a plasma protein prothrombin to thrombin**;** in the presence of clotting factors like vitamin K**;** and calcium ions**;**
- Thrombin catalyses the conversion of fibrinogen (a soluble blood protein) to fibrin**;** which forms a meshwork around the damaged tissue**;** this traps red blood cells and clot begins to form**;**

(b) State the importance of blood clotting. **(03 marks)**

- Prevents excessive blood loss;
- Initiates wound healing**;**
- Closes off the wound thus preventing the entry of pathogens**;**

(c) Explain the likely consequences of excessive blood clotting **(06 marks)**

- Excessive bleeding leads to reduction in blood volume**;** and hence lowers blood pressure**;** so the speed with which the nutrients are supplied to**;** and the waste materials removed from the vital organs low**;** hence damaging the body cells**;**
- loss of iron in the red blood cells lead to iron deficiency anaemia**;**

(d) Describe the role of blood clotting in wound healing. (04 marks)

- Blood clotting leads to the formation of network of fibres around the wound**;** into which the blood cells are trapped**;**
- Cells within the clot perform different functions

• White blood cells**;**	• Produce interferon**;** that makes other cells resist viral attack**;** • Engulf any other foreign material**;** • Remove cellular debris**;**
• Fibroblasts**;**	• Secrete collagen**;** that forms the scar tissue around the wound**;**

33. (a) Explain the term *thrombosis*? (04 marks)

- Is the formation of a blood clot within the blood circulation (a blood vessels)**;**
- Due to damage of endothelium of blood vessels**;** so that platelets breakdown**;** and release clotting factors**;**

(b) How is thrombosis in humans prevented? (09 marks)

- The endothelium of blood vessels is smooth**;** thus platelets do not rupture**;**
- Heparin**;**, an anticoagulant is produced by the mast cells**;** and it prevents the conversion of prothrombin to thrombin**;** as well as fibrinogen to fibrin**;**
- Nitric oxide (nitrogen monoxide)**;** is produced by the capillary endothelial cells**;** suppresses the activation of platelets**;**

(c) What is meant by the term *haemophilia*? (04 marks)

- Is a sex-linked recessive disorder**;** characterised by excessive bleeding**;** from any minor cut or tissue injury**;** due to absence of clotting actors VIII**;**

(d) Explain why haemophilia is more common in human males than females. (05 marks)

- In males, the Y – chromosome lacks a homologous portion of the X – chromosome**;** on which the haemophilia causing allele is located**;** hence its presence will always affect the phenotype**;**
- While in females, one of the X – chromosome may carry the dominant allele**;** hence the effects of the recessive allele the other X – chromosome are not manifested in the individual**;** who lives as a carrier**;**

34. (a) What is *phagocytosis*? (01 marks)

- Is the process by which white blood cells in the body engulf (take in solid substances**;**

(b) Name the two main phagocytes cells in the human body. (02 marks)

- Monocytes/ macrophages**;**
- Neutrophils**;**

(c) Outline the role of each cell in the body's immune system. (10 marks)

- **Macrophages** are large white blood cells**;** found in areas liver**/**spleen**/**lymph**;**
  - ✓ They engulf larger particles like RBCs and plasmodium**;**

- ✓ They are antigen presenting cells; which initiates immune responses;
- ✓ They also produce interferon; that makes other cells resist viral attack;

- **Neutrophils** are smaller white blood cells; that move throughout the body by amoeboid movement;
  - ✓ They engulf smaller particles like bacteria;
  - ✓ They produce cytokines; that amplify inflammatory responses

(d) Briefly outline the events that lead to wound healing after formation of a blood clot (07 marks)

- White blood cells enter the clot; they engulf any other foreign material; and remove cellular debris;
- Fibroblasts enter the clot; and secrete collagen; that forms the scar tissue around the wound;
- Epidermal cells around the wound; divide by mitosis; to replace the damaged cells; and ingest debris; and fibrin of the clot;

35. Describe the role of T – cells in the body's immunity. (20 marks)

- T – cells are produced in the bone marrow; develop from the thymus gland; and are mainly found in the lymph;
- **T4 / CD4 / T – helper cells;** they produce cytokines; that activate
  - ✓ Plasma cells; to produce antibodies against a specific antigen;
  - ✓ Phagocytic cells of the blood stream; to ingest foreign materials;
- **T8 / CD8 cells;** they include cytotoxic; and suppressor cells;
  - ✓ Cytotoxic (killer) cells attack and kill cancer cells;, virus infected body cells; and cells in transplanted organs; by using chemicals;
  - ✓ Suppressor cells produce cytokines; that suppress the activities of plasma cells; and phagocytic cells;

36. (a) Describe the role of each of the following in the body's immune system

(i) B – cells. (10 marks)

- These are produce; and mature in the bone marrow;
- Upon activation by the T4 – lymphocytes; they divide into
  - ✓ plasma cells; that secrete the antibodies; and last for short period of time in the body; which are involved in primary response;
  - ✓ memory cells; which remain in the body for a long time ready to produce antibodies rapidly once the same antigen returns; and are involved in the secondary response;

(ii) Antibodies. (10 marks)

- Antibodies bind specific antigens preventing them from causing harm; by
- Agglutination; where the antigens are clamped together making them vulnerable to attack by phagocytes;
- Precipitation; where soluble antigens are bind into larger units that render them insoluble; so that they can easily be ingested by phagocytes;
- Neutralisation; where toxic molecules are bound so that they cannot cause harm
- Lysis; antibodies catalyse the breakdown of a pathogen carrying a particular antigen;

37. (a) Distinguish between the following pairs of words as used in immunity

(i) Passive immunity and Active immunity. (10 marks)

- ***Passive immunity*** is obtained by passing antibodies into the body of an individual; this can be natural; for example mother to foetus; across the placenta or artificial; for example injecting an individual with antibodies against a specific antigen;
- ***Active immunity*** is obtained when the body of individual synthesises antibodies against the antigens; this can natural; when the individual suffers from a disease; the body makes antibodies to fight it off; or artificial if the individual is injected with antigens; to which they produce the antigen without suffering from the disease;

(ii) Primary response and secondary response. (10 marks)

Primary response	**Secondary response**
• Body immune response upon the first encounter with the antigen	• Body's immune response upon the second encounter with the antigen
• Fewer antibodies are produced since only one type is produced	• More antibodies are produced because two different types of antibodies are produced
• The response is slower because of the longer process involved to bring about antibody production; for example antigen processing; b-cell activation and proliferation	• The response is rapid because of the presence of memory cells; whose start producing antibodies immediately when the antigen returns;

38. (a) Outline the different types of vaccines used in immunisation. (05 marks)

- Toxoids**;** (treated toxins)
- Killed organisms**;**
- Attenuated organisms**;** (living organisms rendered harmless)
- Extracted antigens**;** (part of the pathogen that stimulates antibody production but doesn't cause the disease)
- Artificial antigens**;**

(b) Outline the non-specific ways in which the body defends itself from pathogens. (10 marks)

- Physical skin barrier prevents entry pathogens**;**
- Acid in the stomach kill pathogens**;**
- Enzymes in the stomach can cause of hydrolysis of cell walls of pathogens**;**
- Mucus in trachea and lungs trap pathogens**;**
- Lysozymes in the saliva can cause of hydrolysis of cell walls of pathogens**;**
- Clotting of blood prevents entry of pathogens through a cut**;**
- Commensal microorganisms on skin and in the gut compete with pathogens for the nutrients prevent them of flourishing**;**
- Phagocytes engulf pathogens**;**
- Cytotoxic T – cells kill virus infected cells**;**
- Interferons make cells resistant to viral attack**;**

(c) Explain how passive immunity can be acquired naturally (04 marks)

- Antibodies move from the mother to the unborn child**;** across the placenta**;**
- Antibodies can be transferred from the mother to the baby**;** in the milk during breastfeeding**;**

39. (a) Explain the cause of the haemolytic disease of the newborn. (06 marks)

- HDN arises when a rhesus negative (D-) mother carries a rhesus positive (D+) child**;**
- RBC fragments of the foetus enter into the mother's blood circulation via the placenta**;**
- The mother's body produces anti-rhesus (anti-D) antibodies**;** that cross the placenta in to the foetal blood circulation**;** here the antibodies attack and destroy the RBCs of the foetus**;** rendering the newborn haemolytic**;**

(b) Explain why children of blood groups other than O do not develop haemolytic disease if the mother is blood group O. (08 marks)

- The mother blood contains antibodies **a;** and **b;** so when the foetal RBCs with antigens A**;** or B enter the mother's blood circulation**;** they are destroyed**;** before they can stimulate production of anti-rhesus antibodies**;**
- In case the child has blood group O, the cells would not be destroyed**;** and hence they will stimulate production of anti-rhesus antibodies**;** that will attack the foetal RBCs in return**;**

(c) Describe how haemolytic disease of the newborn can be prevented during pregnancy. (05 marks)

- Anti-rhesus antibodies are injected into the mother**;** within 72 hours of giving birth**;**
- These antibodies will attack and destroy any RBC fragments of the foetus with rhesus antigen**;** before they are recognised by the mother's body**;** this prevents her body from producing the antibodies naturally**;**

40. (a) Describe the different ways in which blood flow through the coronary artery can be interrupted. (08 marks)

- Through coronary thrombosis**;** which blocks the coronary vessel**;**
- Atherosclerosis (narrowing of the lumen of arteries)**;** due to deposition of fats**;** fibrous tissue**;** or salts on the arterial walls**;** narrows the diameter of the coronary artery**;**
- Spasms (repeated contractions of the muscles) in the coronary artery**;** reduce the diameter of the coronary artery**;**

(b) Explain the likely consequence of blockage of the coronary artery. (05 marks)

- The heart muscles are deprived oxygen**;** and metabolites**;** energy production decreases**;** the heart stops pumping**;** leading to death**;**

(c) State the factors that increase the risk of coronary heart disease. (06 marks)

- Smoking**;** which increases the risks of both atherosclerosis and thrombosis
- Increased fat levels in the body**;** lead to atherosclerosis
- High blood pressure**;** leads to damage of the blood vessels
- High levels of salt in diet**;**

- Diabetes**;**
- High levels of unsaturated fat in diet**;** especially from meat and milk;

41. (a) Describe how immunity to a viral infection can be achieved. (09 marks)

- Naturally**;** when an individual suffers and recovers from the viral attack**;** the body produces antibodies against the viral antigens**;**
- Artificially**;** when the individual is injected with the viral antigens**;** that stimulate the production of the antibodies**;**
- In both cases, memory cells are produced**;** so that in case of a subsequent attack**;** the body can rapidly fight off the pathogen;

(b) Explain how the pH of blood and tissue fluid is controlled. (10 marks)

- This is done by controlling the concentration of acid and base in the body**;**
- Lungs expel carbon dioxide**;** which would accumulate and combine with water forming carbonic acid**;**
- The buffering mechanisms of blood suppresses the hydrogen ions concentration**;** for example if the acidity is increased sodium hydrogen carbonate combine with free hydrogen ions**;** and if alkalinity increases it reacts with the free hydroxyl ions**;**
- Kidneys get rid of hydrogen ions and retain hydrogen carbonate ions**;** in the cells of the proximal convoluted tubules**;** carbon dioxide reacts with water to form carbonic acid**;** that dissociates to form hydrogen and hydrogen carbonate ions**;** hydrogen ions are pumped into the lumen of the tubules in exchange for sodium ions**;** the sodium ions combine with hydrogen carbonate ions to form sodium hydrogen carbonate which is reabsorbed into the blood**;**
- Once in the lumen the hydrogen ions are buffered mainly by the phosphate salts**;** and the excess hydrogen ions combine with ammonia**;** in the distal convoluted tubules to form ammonium ions which are excreted**;**
- In blood plasma protein have acidic groups that react with excess hydroxyl ions in case of increased alkalinity**;** and the basic groups combine with hydrogen ions in case of increased acidity**;**

42. (a) Explain the formation of tissue fluid. (07 marks)

- Tissue fluid is formed in the capillary area; due to the hydrostatic pressure of blood in the arteriole side;
- This pressure force the fluid out of blood into the intercellular space; except the red blood cells; and plasma proteins; since they are large to pass through the capillary pores;
- At the venule side of the capillary bed; the solute potential of blood is more negative; and hydrostatic pressure is lower; thus fluid drains back into the blood vessels;
- The fluid which does not to the blood vessels enters the lymphatic system;

(b) Describe how the flow is lymph is maintained in the human body. (05 marks)

- **By hydrostatic pressure;** the pressure of tissue fluid leaving the arterioles helps push the lymph along the lymph system**;**

- **Muscle contraction;** the contraction of skeletal muscles compresses the lymph vessels**;** exerting a pressure on the lymph in them**;**. The valves in the vessels prevent the back flow**;**
- **Inspiratory movements;** on breathing in**;** pressure in the thorax is decreased**;** this helps to draw lymph towards the vessels in the thorax**;**

(c) What are the differences between the lymphatic system and the blood vascular system? (05 marks)

Lymphatic system	Blood vascular system
• There is no pumping organ	• Has a heart which pumps blood
• Circulating fluid is the lymph	• Circulating fluid is the blood
• Fluid flows in a single direction only from the tissues	• Blood flows in two directions to and from the tissues
• Has one type if vessels	• Has different types of vessels; like arteries; veins; and capillaries;
• Does not contain red blood cells	• Contains red blood cells
• Lower concentration of proteins	• Higher concentration of proteins
• Does not carry respiratory gases	• Carries respiratory gases
• Carries fluid with less nutrients	• Carries fluid with more nutrients
• Transports more fats	• Transports less fats

(d) What are the functions of the lymphatic system in humans? (03 marks)

- It is responsible for the removal of interstitial fluid from tissues**;**
- It absorbs and transports fatty acids from the digestive system**;**
- It transports white blood cells to and from the lymph nodes into the bones**;**
- The lymph transports antigen presenting cells to the lymph nodes where an immune response is stimulated**;**

43. (a) What is *hypertension*? (01 mark)

- A persistently raised blood pressure**;**

(b) Explain the possible causes of hypertension in humans. (06 marks)

- Atherosclerosis**;** which reduced the elasticity of the arterial walls**;** and narrows their lumens**;**
- Kidney disease**;** which can trigger excessive release of aldosterone from adrenal glands**;** causing high retention of salts and water**;**

(c) Explain the dangers associated with hypertension. (07 marks)

- The heart uses more energy in pumping blood**;** leading to chest pains**;** and increased chances of myocardial infarctions (heart attack);
- Arteries in the brain**;** may rupture causing haemorrhage**;**
- In the kidneys**;** the arterioles supplying the kidney tubules thicken**;** and develop a reduced lumen**;** blood supply to the cells of the tubules may be dangerously reduced**;**

(d) Describe the possible management of hypertension. (07 marks)

- Change in diet**;** to reduce weight**;**
- Reduce salt intake in diet**;** to reduce blood volume**;**
- Stop smoking**;** as nicotine is vasoconstriction drug that elevates blood pressure**;**
- Taking drugs that block the adrenaline receptors on the SAN in the heart**;** This prevents adrenaline stimulating increased heart rate and raising blood pressure**;**

44. (a) Describe the adaptations of blood in terrestrial animals living in the following environmental conditions

(i) Extreme oxygen tension. (08 marks)

- In low oxygen tensions**;** the blood of animals has haemoglobin with high affinity of oxygen**;** high number of red blood cells**;** and low dissociation of oxygen**;** this enables the animals to extract more oxygen from its environment**;** releasing it slowly to the tissues**;**
- In high oxygen tensions**;** the haemoglobin has a lower affinity for oxygen**;** and a higher dissociation**;** to deliver oxygen more readily to the animal tissues**;** that is highly active**;**

(ii) High altitudes (04 marks)

- At high altitudes, there is a low partial pressure of oxygen**;**. In order to meet their body requirements**;** animals have blood with more RBCs**;** containing more haemoglobin**;** with higher affinity for oxygen**;** and less oxygen dissociation**;**

(b) Explain how each of the following affects the dissociation of haemoglobin in the mammalian blood suggesting in each case, the physiological advantage of the effect.

(i) Increased body temperature. (04 marks)

- Increased body temperature is as a result of increased metabolic activity**;** provides a reduction in the affinity for oxygen**;** and increase dissociation of oxygen**;** this ensures that more oxygen is released to the actively respiring tissues**;**

(ii) Small body size. (04 marks)

- Small mammals have high metabolic rates than big ones**;** so the haemoglobin of small mammals has less affinity for oxygen**;** and a higher dissociation of oxygen**;** in order to release oxygen more readily**;**

45. (a) Explain why at rest, trained athletes have a higher stroke volume and lower heart rate than untrained athletes. (10 marks)

- Heart stroke volume depends on the strength with which the heart contracts**;** and during training, the heart muscles become thicker**;** and highly vascularised**;** with more mitochondria**;** hence can contract more strongly**;** to increase the volume of blood being pumped out of the heart**;**
- The large volume of blood leaving the heart through the aorta and carotid arteries**;** stretches the sinuses in them**;** and stimulate them to fire impulses to the cardiac

inhibitory centre**;** that responds by passing impulses through the vagus nerve**;** to slow down the heart rate**;**

(b) Why should a person with high stroke volume have a low heart rate? **(07 marks)**

- Strong heart contractions occur at lower rates**;** allowing the cardiac muscles to relax/ recover completely**;** between each contraction**;**
- This prevents tetanus**;** fatigue**;** and oxygen debts**;** which would damage the heart itself**;**

46. (a) Describe how the Stroke volume is increased during an intense physical activity Stroke volume. **(06 marks)**

- This is amount/ volume of blood pumped out of the heart per each heartbeat;
- During an intense physical activity the volume of blood returning to the heart increases**;** this stretches the cardiac muscles fibres**;** as they are about to contract**;** the cardiac muscles respond by contracting more strongly**;** during systole and more blood is pumped out of the heart**;**

(b) How does the human body deal with changes in the blood pH during the acclimatisation to high altitudes? **(08 marks)**

- At high altitudes the partial pressure of oxygen decreases**;** this stimulates an increase in the breathing rate**;** in order to supply more oxygen to the lungs**;**
- Hyperventilation removes from the body more carbon dioxide than produced**;** this lowers the blood pH**;**
- The body responds by excreting more hydrogen carbonates**;** via the kidneys**;** to restore the pH back to normal**;**

(c) Explain the effect of temperature on the haemoglobin dissociation curve and the physiological significance of the effect. **(05 marks)**

- Increase in temperature is due to increase in metabolic rate (or increases metabolic rate)**;** which reduces the affinity for oxygen by haemoglobin**;** and increases the ease with which oxygen is released from haemoglobin**;** the dissociation curve shifts to the right**;**
- This enables the highly respiring tissues to easily obtain oxygen**;**

47. (a) Describe how the structure of the heart is suited for its function. **(10 marks)**

- Valves; to ensure flow of blood in a single direction;
- Elastic to allow expansion to accommodate the large volume of blood;
- Highly muscular for generation of greater contractile force to pump blood at high pressure;
- Supplied with coronary arteries to supply oxygen and nutrients to the cardiac muscle
- Cardiac muscles have long refractory periods to prevent fatigue
- SAN generates electrical excitations leading to contraction and relaxation of cardiac muscles;
- AVN spreads out waves of excitation throughout the heart;
- Purkyne tissue to spread waves of excitation to lower apex/ vertex of the ventricles;

- The lining of inner chambers consist of squamous epithelium to allow smooth flow of blood in the heart;
- Surrounded by pericardium to limit expansion of the heart to maintain the internal pressure
- Septum to separate oxygenated and deoxygenated blood preventing them from mixing;
- Innervated by the vagus nerve and sympathetic nerves to control heart rate.
- Valve tendons attached to atria-ventricular walls to support valve preventing them from turning inside out due to
- changes in heart chambers;

48. (a) Compare the vascular system of flowering plants and mammals. (10 marks)

Similarities

- Both take place via specialised tissues called tubes/ vessels
- Both carry materials in the circulatory fluid
- Both are facilitated by some pumping forces.
- Both are involved in transport of materials e.g food, wastes, carbon dioxide and hormones.
- Both are involved in regulation of body temperatures
- Both systems have high tensile strength so that the tubes do not collapse
- Both systems form a continuous flow and connect or link all body cells.

Differences

Transport system in plants	**Transport system in mammals**
• Lack contractile tissues such as muscles	• Powered by contractile tissues like muscles
• Movement is mainly by passive means	• Movement is mainly by active means
• Transport may occur in dead vessels.	• Transport restricted to living tissues only
• Transport systems lack valves	• Possess valves that prevents back flow
• Lack a pumping organ	• Possess a pumping device
• Lack pigments for carriage of respiratory gases	• Have pigments for transportation of gases
• Single circulation eg transport of water from roots to leaves and out	• They have double circulation

(b) Explain the properties of water that enables it serve as a good transport medium. (10 marks)

- It is neutral; thus does not affect the nature of the substances transported;
- Dissolves a wide range of substances; like ionic compounds; and molecular compounds with polar groups; making their transport in solution easier;
- Low viscosity; allows rapid movement of water and the material being transported;
- Has high thermo-conductivity; allows for transfer of heat where it is required;

49. (a) Outline the features that ensure efficient flow of blood within the mammalian body (10 marks)

- Pumping action of the heart; generates a strong propulsive force that pumps blood.
- Smooth muscles in arteries; generate wave like contraction and recoils; keep blood flow in the arteries.
- Muscular contraction; squeeze thin walled veins; increase pressure within them; facilitate venous return.
- Inspiratory movements; reduce intrathoracic pressure; aid venous return of blood to the heart.
- Gravity; aids venous return from areas of the body above the heart
- Residual heart pressure usually -10mmHg or less allows venous return.
- Pocket valves; Prevent retrograde blood flow/ back flow; augments unidirectional blood flow.
- Narrow lumen of the arteries; maintains high pressure of forward flow of blood.
- Wider lumen of veins; reduce resistance to blood flow such that unidirectional flow is maintained.
- Effect of hydrostatic pressure generated at the arterial end of the capillary bed.

(b) Discuss the factors that alter the rate of heart beat in mammals. ***(10 marks)***

- **Environmental temperature;** increases metabolic rate; heart beat is faster when the external temperature is high.
- **Level of activity/ exercise;** increased muscular activities result in increased carbon dioxide in the body which result in a higher heart rate.
- **Effect of hormones;** hormones like adrenaline increases heart rate to prepare for escape.
- **Effect of neurotransmitters;** acetylcholine inhibits heart beat while noradrenaline increases heartbeat.
- **Effect of drugs/ poisons;** some drugs inhibit while others accelerate heart rate
- **State of health;** heart rate is faster in diseased organisms due to increased carbon dioxide & temperature.
- **Body size;** Small organisms have a higher heart rate than larger ones due to their higher metabolic rate**;**
- **Age;** Young organisms have higher metabolic rate due to rapid growth and hence higher heart rate**;**
- **Environmental temperature;** Increase in temperature increases metabolic/respiratory rate leading increase in heart rate to eliminate excess carbon dioxide and to supply metabolites**;**
- **State of emotion;** increase heart beat causing supply of more nutrients to tissues**;**
- **Sex;** heart rate is higher in males than females since males are poorly insulated leading to higher metabolic rate**;**

50. (a) Although the heart is myogenic, it is innervated. Explain the significance of the innervation of the heart. (07 marks)

- Maintains a constant heartbeat rate under normal circumstances**;**
- The AVN delays he ventricular systole until the atria contract**;** which allows time for ventricles to fill with blood before they can contract**;**

- Ensures that atrial systole occurs before ventricular systole**;** to pump blood from atria to ventricles**;**
- Ensures that atrial systole begins from the top of the heart proceeding downwards**;** so that blood is squeezed into the ventricles**;**
- Through the bundle of His, it ensures that the main contraction of the ventricles starts at the bottom of the heart and spreads upwards**;** squeezing blood out on the ventricles**;**

(b) Outline the cardinal signs of inflammation. (05 marks)

- Heat
- Swelling
- Redness
- Loss of function
- Pain

(c) Explain the importance of inflammation. (08 marks)

- There is release of chemical like histamine from the damaged tissues**;** which cause local vasodilation of capillaries**;** increasing the amount of blood flowing in the area**;** and rises the temperature locally**;**
- Permeability of the capillaries also increases**;** permitting the escape of plasma**;** containing chemical like interferon**;** which make body cells resistant to infection by viruses**;** and fibrinogen**;** to bring about blood clotting**;**
- Allows white blood cells into the surrounding tissues**;** which combats the spread of the infection**;**
- Excess tissue fluid dilutes**;** and reduces the effect of potential toxic substances in the area of the wound**;**

51. (a) Explain how phagocytes are able to reach areas where tissue damage has occurred. (03 marks)

- Phagocytes move to injured site by amoeboid movement**;** by chemotaxis**;** due to chemicals released by damaged tissue cells**;**

(b) State the roles of complement proteins in the body defence against infections. (07 marks)

- Some attract phagocytes**;** by chemotaxis**;**
- Some coat bacteria**;** that allow phagocytes to recognise**;** bind**;** and therefore engulf the bacteria**;**
- Some punch holes in the cell surface membranes of bacteria**;** causing the cells to swell and burst**;**
- Some promote inflammation around a wounded tissues**;**

(c) Explain the role of blood in defence against diseases. (10 marks)

- Blood contains platelets**;** and clotting factors like fibrinogen**;** which bring about blood clotting**;** to prevent excessive blood**;** entry of pathogens**;** and initiate wound healing**;**
- Blood contains phagocytes**;** like neutrophils and monocytes**;** that engulf**;** and digest bacteria**;**

- Neutrophils also secrete interferon**;** that render tissue cells resistant to viral attacks**;**
- Lymphocytes like cytotoxic (T- killers) cells**;** attack and destroy infected body cells**;**
- B – cells**;** produce antibodies**;** that neutralise specific antigens**;**, coat bacteria**;** making it easy for the phagocytes to engulf them**;**

52. (a) Briefly explain the features of HIV that makes it a successful pathogen.
(10 marks)

- Antigenic variations/ change of antigens**;** due to mutations**;** so that it can no longer be identified by the white blood cells**;** hence it escapes being removed from the body**;**
- Long latency periods within the infected cells**;** allows the spread of the viral DNA**;** without triggering an immune response**;** and also protects the virus from antiviral agents**;**
- Attack on the CD4 cells**;** leads to improper meditation of immune responses**;** weakening the whole system making it unable to fight the virus**;**
- It does not kill its host quickly**;** this provides more time for its spread**;**

(b) Explain what would happen if an individual of blood group A is transfused with blood of

(i) blood group B. (06 marks)

- Agglutination of the donor red blood cells occurs**;** because the donor red blood cells have antigen B**;** while the recipient blood has antibodies b due to presence of the antigen A**;**
- Upon receiving the blood, the antibodies in the recipient interact with the antigens on the red blood cells of the donor making them to clamp together**;**
- The clamped up cells can cause blockage of narrow blood vessels**;** leading to death of the recipient**;**
- The antibodies a present in the donor blood do not have serious impacts**;** because they are in very few amounts thus easily diluted by the recipients blood**;**

(ii) blood group O (04 marks)

- When transfused into an individual of blood group B no agglutination occurs**;** because blood of blood group O contains no antigens**;**
- The antibodies a and b**;** present in the donor blood do not have serious impacts**;** because they are in very few amounts thus easily diluted by the recipients blood**;**

THE END; FOR NOW