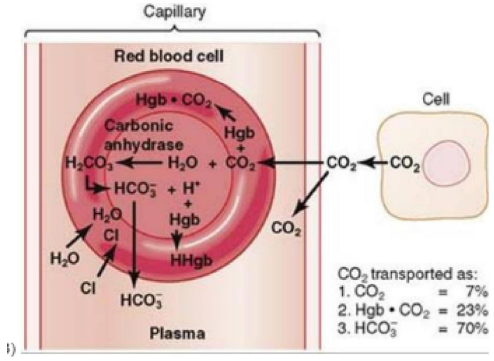
SOLUTIONS

8.1: The circulatory system

1. **C**
   Arteries have a smooth squamous inner layer to reduce friction, a middle layer of collagen, elastic fibers, and smooth muscle for strength and flexibility, and an outer layer of collagen and elastic fibers for support.
2. **D**
   A hole between the atria causes oxygenated and deoxygenated blood to mix, reducing oxygen levels in the body. To compensate, the body increases red blood cell production to enhance oxygen transport.
3. **D**
   Increased carbon dioxide leads to higher H^+ concentration, lowering blood pH. This causes the Bohr effect, where haemoglobin's affinity for oxygen decreases, promoting oxygen release to tissues, shown by option D.
4. **B**
   The image shows a narrow blood vessel with thin walls and a small lumen, characteristic of capillaries, which allow exchange of substances between blood and tissues.
5. **C**
   At the venous end of capillaries, lower blood pressure and higher water potential in tissue fluid cause water to move back into the capillaries by osmosis.
6. **A**
   The labelled tissue "A" represents the cartilage, which prevents the trachea from collapsing by providing structural support.
7. **D**
   Water has a high specific heat capacity, meaning it absorbs and retains heat, causing it to cool down slowly. This property helps regulate temperature in biological systems like blood and tissue fluid.
8. **A**
   The hydrostatic pressure decreases as blood moves from the arteriole to the venule end, facilitating tissue fluid formation at the arteriole end of capillaries.
9. **C**
   The inner layer of veins and capillaries is lined with endothelium, which forms a smooth surface to reduce resistance to blood flow.
10. **A**
    Carbonic anhydrase accelerates the Bohr shift (1 correct), lower pH leads to haemoglobin dissociation (2 correct), and reduced carbon dioxide increases oxygen binding (3 correct).
11. **A**
    Mature red blood cells lack a nucleus and organelles, preventing cell division, protein synthesis, and phagocytosis. However, they can perform active transport to maintain ion balance.
12. **B**
    Cell X is a lymphocyte, identified by its large nucleus. Cell Y is a neutrophil, noted for its multi-lobed nucleus. Cell Z is a monocyte, recognized by its kidney-shaped nucleus.
13. **D**
    The muscular artery is responsible for distributing blood to organs. Damage to a vein prevents blood from returning to the heart, and damage to an elastic artery disrupts blood pressure regulation.
14. **B**
    The two properties of water that are essential for its role in the transport of blood in mammals are:
    High latent heat of vaporization: Water has a high latent heat of vaporization, which means it requires a significant amount of heat energy to change from a liquid to a vapor. This property is essential for maintaining a stable body temperature in mammals because when blood flows through capillaries, it helps dissipate excess heat through sweating or evaporative cooling.
    Solvent for polar substances: Water is an excellent solvent for polar substances, which is crucial for transporting various solutes in the blood, including ions, gases (e.g., oxygen and carbon dioxide), nutrients, and waste products. The polar nature of water allows it to dissolve and transport these substances efficiently within the bloodstream.

15. B



16. A

Carbon dioxide, fatty acids, white blood cells, and proteins are indeed components found in blood, and most of them also diffuse into tissue fluid to various extents. Proteins, however, are typically present in much lower concentrations in tissue fluid compared to blood due to the selective permeability of the blood vessel walls, but they are still present.

17. D

The first reaction listed (CO_2 + haemoglobin $\rightarrow$ carbaminohaemoglobin) is not catalyzed by carbonic anhydrase, so an inhibitor of this enzyme would not affect this process. Reactions 2 and 3, involving the conversion of CO_2 to H_2CO_3 and its subsequent dissociation, are catalyzed by carbonic anhydrase. Therefore, an inhibitor of carbonic anhydrase would slow down these two reactions.

18. A

In human veins, you can find the following components:
Chloride ions: Chloride ions (Cl^-) are present in the blood as a component of the electrolyte balance, helping to maintain the overall balance of ions in the blood.
Carbonic anhydrase: Carbonic anhydrase is an enzyme found in red blood cells that plays a crucial role in the transport of carbon dioxide in the blood by catalyzing the conversion of carbon dioxide and water into bicarbonate ions (HCO_3^-) and hydrogen ions (H^+).
Oxyhemoglobin: Oxyhemoglobin is the form of hemoglobin that is bound to oxygen. Hemoglobin is the protein found in red blood cells that carries oxygen from the lungs to the body's tissues and returns carbon dioxide from the tissues to the lungs for exhalation.
So, all three components, 1, 2, and 3, are present in the blood in human veins. The correct answer is A 1, 2 and 3.

19. C

Identifying different types of white blood cells from a photomicrograph involves the application of knowledge about cell morphology. The ability to distinguish cells based on features like size, nucleus shape, and cytoplasm appearance is a critical skill in cell biology.

20. A

Typically, arteries carry oxygenated blood from the heart to various parts of the body, except for the pulmonary artery which carries deoxygenated blood from the heart to the lungs. Since the question does not specify it is the pulmonary artery, the default assumption is that the artery in question is carrying oxygenated blood. The artery is described as muscular, which refers to the type of artery that has more smooth muscle in its structure and is involved in controlling blood flow by constricting or dilating.

21. C

Vessel P is a vein due to the presence of thin wall. Vessel Q is an artery due to the presence of visibly thick walls. Vein carries blood from venules and Artery carries blood into arterioles

22. B

The movement of tissue fluid would be in a way that it leaves the capillaries at the arteriolar end and is returned back to the capillary at the venule end. Thus, option B would be correct. At the arteriolar end, we would need greater pressure inside the capillary (Z) than outside (W) so that fluid can move out. Whereas, at the venule end we would need greater pressure outside than inside. Generally, the pressure would be higher at the arteriolar end because of the greater fluid in the capillar at that end as well.

23. C
The oxygen dissociation curve for hemoglobin describes how readily hemoglobin acquires and releases oxygen molecules into the tissues. In smaller mammals, the hemoglobin has to release oxygen more readily due to their higher metabolic rates and the need to supply oxygen to their tissues more quickly. This is reflected in a right-shifted oxygen dissociation curve compared to larger mammals, which indicates that at a given partial pressure of oxygen, the hemoglobin of smaller mammals releases oxygen more easily.

24. C
Arteries are characterized by their ability to resist high pressure, the pulse resulting from a surge in blood from heart contractions, and the presence of semilunar valves at the junction with the heart for specific arteries.

25. A
Identifying a monocyte in a blood smear involves recognizing its large size, kidney-shaped nucleus, and the distinct cytoplasmic appearance compared to other blood cells.

26. A
Identifying different blood vessels requires knowledge of their structural features, such as the thickness of the vessel wall and the presence or absence of valves, which are indicative of their function and the type of blood they carry.

27. B
A shortage of protein in the diet leads to a condition where a decrease in plasma protein concentration lowers blood osmotic pressure, reducing reabsorption of tissue fluid into capillaries and increasing fluid in the interstitial spaces.

28. D
Blood vessels that carry blood into the atria include the vena cava and the pulmonary vein, bringing deoxygenated blood from the body and oxygenated blood from the lungs, respectively.

29. B
Haemoglobinic acid formation is linked to the action of carbonic anhydrase and helps prevent blood from becoming too acidic by removing excess hydrogen ions.

30. B
The position on the graph where most chloride ions would be found in red blood cells correlates with the affinity of hemoglobin for oxygen under different carbon dioxide pressures.

31. B
Increased tissue fluid around body cells, leading to oedema, can be caused by a lower than normal blood plasma protein concentration, affecting osmotic pressure.

32. D
Option D is the correct answer as veins have a large lumen and a thick outer wall that allows them to transmit the blood at low pressure back to the heart. Options A and B are incorrect due to narrow lumen and option C is incorrect due to the thin outer wall.

33. C
Option C is the correct answer as the tissue fluid bathing the cells has a high water potential as compared to the capillaries and due to the change in potential and the low hydrostatic pressure inside the capillary water moves into the capillary via osmosis.

34. D
Option D is the correct answer as the tunica media of arteries contains elastic fibers, collagen and smooth muscle.

35. B
After the correct arrangement the second structure is the sinoatrial node after which in the right ventricle before the semi-lunar valve blood passes the Purkyne tissue making option B the correct answer.

36. D
Option D is the correct answer as G represents the right ventricle which is has a larger lumen as compared to H which represents the left ventricle due to the high pressure involved in it and the shape of the tricuspid and bicuspid valves.

37. A
Option A is the correct answer as P is an elastic artery that contains a high amount of elastic tissue. Q represents a muscular artery due to the large quantity of muscle tissue and R represents a vein that contain more muscle tissue but almost an equivalent amount of elastic tissue.

38. A

Option A is the correct answer as the tissue fluid contain less proteins as proteins are too large to pass through into the tissue fluid. Similarly, red blood cells are also not present in it. Lymph may contain lipids, carbon dioxide and phagocytes. Tissue fluid contain amino acids, glucose, urea and carbon dioxide as it is the medium for exchange of substances with cells and tissues.

39. C

Option C is the correct answer as X has a lobed nucleus which means that it is a neutrophil which is a phagocyte.

40. D

Option D is the correct answer as X and Z are macrophage and neutrophil respectively while Y is a lymphocyte due to presence of granulated cytoplasm. Neutrophil due to the three lobed nucleus and macrophage due to nucleus occupying majority of the cell.

41. D

Option D is the correct answer as only the endothelial tissue is common among all the blood vessels.

42. B

Option B is the correct answer as lymph and tissue fluid contain all of the following components except red blood cells.

43. A

Option A is the correct answer as the pulmonary artery is relatively thicker and has a high blood pressure as blood needs to be sent with enough pressure to the lungs. It contains deoxygenated blood.

44. B

Option B is the correct answer as collagen provides support, endothelium is prevent in all blood vessels and smooth vessels allows the arteries to maintain shape.

45. A

Option A is the correct answer as carbon dioxide, glucose, white blood cells and antibodies are present in all blood vessels, lymph and tissue fluid.

46. B

Option B is the correct answer as double circulation refers to the fact that the blood flows through the heart twice in one complete circuit of the body.

47. C

Option C is the correct answer as 3 is carbonic anhydrase which catalyzes the conversion of carbon dioxide and water is hydrogen carbonate ions and protons. 9 is oxyhemoglobin that dissociates to release oxygen and 11 is carbaminohemoglobin which is one of the forms that carbon dioxide is transported in blood.

48. A

Option A is the correct answer as the diameter of the vessels, systolic pressure of the heart and the volume of blood returning to the heart each time all affect blood pressure.

49. C

Statement 1 is incorrect as hemoglobin concentration does not affect the affinity for oxygen at different partial pressures. Statement 3 is incorrect as living at higher altitudes would mean that acclimatization would cause species T to have greater percentage saturation at low partial pressures. Statement 2 is correct as species T has a low percentage saturation at similar partial pressures to species S suggesting that the hemoglobin in species T has a lower affinity for oxygen. Hence, option C is the correct answer.

50. B

Option B is the correct answer as carbonic anhydrase does produce carbonic acid in red blood cells as carbon dioxide reacts with water in the red blood cells. Statement 3 is incorrect as carbon dioxide combining with hemoglobin forms carbaminohemoglobin.

51. A

Option A is the correct answer as capillaries contain only the endothelium.

52. A

Option A shows the correct order as the wave of excitation arriving at the sinoatrial node causes the atrial walls to contract. The wave of excitation then enters the atrioventricular node where it is delayed a fraction of a second before travelling down the Purkyne tissues and causing the ventricles to contract.

53. C

Option C is the correct answer as cell X contains granules that makes it a monocyte. Cell Y is a neutrophil since it has a lobed nucleus and cell Z is a lymphocyte due to the nucleus occupying most of the cell space.

54. C
Option C is the correct answer as lowering the partial pressure of carbon dioxide causes hemoglobin to have a greater affinity with oxygen meaning that it takes it up more efficiently but is less efficient at releasing it.

55. D
Option D is the correct answer as veins have endothelium, smooth tissue, elastic tissue and collagen fibers.

56. C
Option A is incorrect as antibodies are also present in the blood. Option B is incorrect as plasma proteins are also present in the lymph. Option D is incorrect as phagocytes are also present in the lymph. Hence, option C is the correct answer as lymphocytes are found in blood, lymph and tissue fluid.

57. C
Option C is the correct answer as lowering the concentration of carbon dioxide causes hemoglobin to have a greater affinity with oxygen meaning that it takes it up more efficiently but is less efficient at releasing it.

58. A
Option A is the correct answer as cell Y contains granules that makes it a monocyte. Cell Z is a neutrophil since it has a lobed nucleus and cell X is a lymphocyte due to the nucleus occupying most of the cell space.

59. C
Option C is the correct answer as curve X shows the cross section area that dramatically increase as blood flows into capillaries. Curve Y shows the speed of blood flow that decreases near capillaries and then increases again in veins. Curve Z shows the pressure of blood that dramatically increases as blood flows further from the heart and reaches lowest in the veins.

60. A
Option A is the correct answer as lymph contains white blood cells, proteins and sodium ions.

61. A
Option B is incorrect as there are less oxygen molecules at high altitude. Option C is incorrect as cytokines do not simulate increased red blood cell production. Option D is incorrect as acclimatization takes weeks not days. Hence, option A is the correct answer as after a few weeks the red blood cells increase in order to compensate for the less oxygen available.

62. D
Option D is the correct answer as cell Z contains granules that makes it a monocyte. Cell X is a neutrophil since it has a lobed nucleus and cell Y is a lymphocyte due to the nucleus occupying most of the cell space.

63. B
Option B is the correct answer as collagen fibers prevent overstretching in arteries and veins and elastic fibers allows arteries to stretch during ventricular systole. Smooth muscles in arteries control the distribution of blood. Statement 4 is incorrect as veins have valves to prevent the backflow of blood.

64. C
Option C is the correct answer as carbon dioxide can either combine with hemoglobin to form carbaminohemoglobin or can combine with water in the presence of carbonic anhydrase to form carbonic acid that dissociates in hydrogen ions and bicarbonate ions.

65. D
Option D is the correct answer as increased number of red blood cells suggests that the person moved to a higher altitude meaning that more exertion is required resulting in more ATP being produced. The high number of lymphocytes might be due to an infectious agent that causes the body temperature to increase.

66. B
Statement 1 is correct as the enzyme causes the product of hydrogen ions which reduce pH. Statements 2 and 3 are incorrect as carbonic anhydrase catalyzes the formation of carbonic acid and does not facilitate Bohr effect or increase the speed of the reaction.

67. B
Option B is the correct answer as cell Z contains granules that makes it a monocyte. Cell Y is a neutrophil since it has a lobed nucleus and cell X is a lymphocyte due to the nucleus occupying most of the cell space.

68. A
Option C is incorrect as lymphocytes are also present in the tissue fluid. Option B is incorrect as plasma proteins are also present in the lymph. Option D is incorrect as phagocytes are also present in the blood. Hence, option A is the correct answer as antibodies are found in blood, lymph and tissue fluid.

69. A
Option A is the correct answer as arteries contain all of the features listed in the table.

70. B
Option B is the correct answer as curve W shows the dissociation curve at a higher concentration of carbon dioxide as the affinity for oxygen decreases. At 7kpa curve X shows higher affinity than curve W due to the greater percentage saturation.

71. D
Option D is the correct answer as phagocytes are found in the blood, lymph and the tissue fluid.

72. D
Option D is the correct answer as oxyhemoglobin dissociates readily due to the Bohr effect which means that hemoglobin needs a higher concentration of oxygen to be fully saturated. Statement 1 is incorrect as carbon dioxide affinity with hemoglobin is not a reason for rapid dissociation of oxyhemoglobin.

73. C
Option C is the correct answer as at 100 partial pressure and the first curve the saturation is 94 percent and at 35 partial pressure and using the second curve the percentage saturation is 40 percent.

74. D
Option A is incorrect as the oxygen combining with hemoglobin changes its shape until the molecule is saturated. Option B is incorrect as 1 oxygen molecule can bind with each haem group. Option C is incorrect as the first molecule does change the shape of hemoglobin. Option D is the correct answer as the second oxygen molecule makes it easier for the third molecule to combine with hemoglobin.

75. A
Option A is the correct answer as the low partial pressure of oxygen at high altitudes leads to hemoglobin not being saturated completely.

76. D
The curve Y is due to a greater concentration of carbon dioxide and a low pH caused y dissociation of carbonic acid. Hence, option D is the correct answer.

77. B
Option B is the correct answer the thick elastic layer keep the pressure in the arteries constant while making sure that it can stretch enough to prevent the arteries from bursting. It does not reduce the friction in the arteries.

78. C
Option C is the correct answer as cell X contains granules that makes it a monocyte. Cell Z is a neutrophil since it has a lobed nucleus and cell Y is a lymphocyte due to the nucleus occupying most of the cell space.

79. C
Option C is the correct answer as the pressure in the right ventricle is lower than the right atrium and the pulmonary artery when the atrioventricular valve is open and the semi-lunar valve is closed.

80. B
Option B is the correct answer as carbonic anhydrase catalyzes the reaction of carbon dioxide and water. This produces carbonic acid which dissociates into hydrogen ions which combine with hemoglobin to form hemoglobinic acid and hydrogen carbonate ions which travel in the plasma.

81. B
Option B is the correct answer as at high altitudes lower partial pressures of oxygen cause increased production of red blood cells and this promotes the red blood cells to take up more oxygen in lower concentrations.

82. B
Option B is the correct answer as when leaving an active muscle, the concentration of carbon dioxide will be much higher than oxygen causing the dissociation curve to shift to the right. The percentage saturation will also be low as carbon dioxide inversely affects the affinity of hemoglobin for oxygen making it easier to give up oxygen and therefore reduces the saturation.

83. C
Option C is the correct answer as the oxygen diffuses through the top and bottom of the alveolar epithelial cell and then the top and bottom of the endothelial cells of the capillaries before finally entering the red blood cell by passing through its membrane. Hence, there are 5 layers.

84. B
Option B is the correct answer as carbaminohemoglobin is formed when carbon dioxide combines with hemoglobin and this causes the dissociation curve to shift to the right.

85. D
Option D is the correct answer as neutrophils can be found in blood, lymph and tissue fluid.

86. B
Option B is the correct answer as the greatest change in percentage saturation can be seen by the point where the gradient is the steepest as shown in option B.

87. A
Options B and D are incorrect as the ability to release oxygen is dependent on the percentage saturation of hemoglobin. Option C is incorrect as the graph does not show any correlation between metabolic activity and the ability of hemoglobin to release oxygen. Hence, option A is the correct answer as the size of animals decreases they requires a greater partial pressure to achieve the same amount of saturation that a larger animal has at lower partial pressure.

88. C
Option C is the correct answer as the layer W contains smooth muscle and elastic fibers.

89. C
Option C is the correct answer as carbon monoxide and oxygen bind to one site whereas carbon dioxide binds to a different site in hemoglobin.

90. A
Option A is the correct answer as mature red blood cells can carry out active transport but not cell division since they do not have a nucleus or phagocytosis since they are not phagocytes or protein synthesis since they do not have a nucleus.

91. A
Option A is the correct answer as lymph contains water, antibodies and lipids.

92. B
Option B is the correct answer as oxyhemoglobin dissociates or is dissociated by the hydrogen ions that form hemoglobinic acid. Carbonic acid is also produced when carbon dioxide and water combine.

93. B
Option B is the correct answer as L represent the saturation at lungs and K represents the saturation at liver since it is an actively respiring tissue with greater carbon dioxide which is why the curve shifts to the right.

94. D
Option D is the correct answer as the person after a few months will have a greater mass of red blood cells due to acclimatization to the high altitude.

95. A
Option A is correct as all the 3 statements are correct. Hemoglobinic acid can form only when oxygen dissociates form hemoglobin. Hemoglobinic acid is produced as a result of the action of carbonic anhydrase which produces hydrogen ions that result in this being produced. Hemoglobinic acid prevents the blood from becoming too acidic as hydrogen ions are taken up by hemoglobin.

96. B
Option B is the correct answer as a reduced concentration of carbonic anhydrase means that carbon dioxide will not be converted into carbonic acid which means that it will lower the affinity of hemoglobin for oxygen resulting in less oxygen being released from oxyhemoglobin.

97. A
Option A is the correct answer as blood plasma contains plasma proteins which are absent in tissue fluid.

98. D
Option D is the correct answer as the curve is shifted to the right due to an increased concentration of carbon dioxide that causes the affinity of hemoglobin for oxygen to decrease. The formation of carbonic acid that dissociates in red blood cells also causes the curve to shift due to the hydrogen ions lowering the pH.

99. C
Option A is incorrect as contraction of heart muscles causes blood to move from one chamber to another as well. Option B is incorrect as there are not just 2 sets of vessels that are connected to the heart. Option D is incorrect as the heart's main purpose is to distribute blood not pump it with enough force. Hence, option C is the correct answer as the heart muscle's contracting and relaxing moves materials from one part of the body to another.

100. B
Option B is the correct answer as the formation of oxyhemoglobin increase the red blood cells capacity to carry oxygen since it has a higher affinity.

101. D
Option D is the correct answer as an increase in the oxygen carrying capacity of the blood will allow for more oxygen to be transported at low partial pressures. An increase in the blood output of the heart would allow faster oxygen transport to cells that require it.

102. A
Option A is the correct answer as in one cycle blood passes from the heart to the lungs and then back to the heart again. Option B is incorrect as lymph is part of the lymphatic system. Option C is incorrect as veins have the lowest blood pressure. Option D is incorrect as pulmonary vein carries oxygenated blood.

103. D
Option D is the correct answer as cell 1 contains granules that makes it a monocyte. Cell 2 is a neutrophil since it has a lobed nucleus and cell 3 is a lymphocyte due to the nucleus occupying most of the cell space.

104. D
Option D is the correct answer as oxygen and carbon monoxide share a binding site and compete for it.

105. D
Option D is the correct answer as oxygen can be displaced by carbon monoxide which has a higher affinity with hemoglobin and hydrogen ions can displace it as well to form hemoglobinic acid.

106. B
Option B is the correct answer as blood entering the pulmonary artery will be deoxygenated meaning that it will have a low percentage saturation in the second curve.

107. C
Option C is the correct answer as 1 is a neutrophil due to the three lobed nucleus. 2 is a monocyte and 3 is a lymphocyte as lymphocytes are smaller than monocytes and there are granule visible in the monocyte.

108. C
Option C is the correct answer as carbon dioxide reacting with water to form carbonic acid and the dissociation of the carbonic acid causes hydrogen ions to combine with hemoglobin to form hemoglobinic acid shifts the curve to the right. Statement 1 is incorrect as carbon dioxide does not compete with the same site as oxygen so it cannot effect it like this.

109. D
Option D is the correct answer as the count of red blood cells increases to transport more oxygen since oxygen is scarce at high altitudes. Statements 1 and 2 are incorrect as increasing the effect of the Bohr effect or increasing the gradient do not explain why the red blood cell count increases.

110. B
Option B is the correct answer as statements 1 and 2 are correct but statement 3 is incorrect as macrophages can enter the tissue fluid.

111. A
Option A is the correct answer as the tunica externa contain collagen for structural support. Tunica media contains elastic muscles for recoil and maintaining shape and tunica interna contains the endothelium.

112. A
Option A is the correct answer as the pulmonary artery carries blood from the heart to the lungs and it needs to pump it at high pressure meaning that it has thick muscles and a narrow lumen.

113. C
Option C is the correct answer as the blood in arteries is at high pressure and they have a thicker middle layer than veins which would make it difficult to penetrate with a needle. Veins on the other hand carry blood at the lowest pressure and have a wide lumen allowing easier collection of blood.

114. A
Option A is the correct answer as an increase in the carbon dioxide concentration causes a decrease in the pH as hydrogen ions displace oxygen to form hemoglobinic acid to shift the curve to the right.

115. A
Option A is the correct answer as blood moves form arteries towards veins the pressure gradually decreases and is lowest in the veins.

116. C
Option C is the correct answer as most carbon dioxide in the blood is transported in the form of hydrogen carbonate ions.

117. C
Option C is the correct answer as 3 is carbonic anhydrase that catalyzes the reaction between carbon dioxide and water. 9 is oxyhemoglobin that dissociates into oxygen molecules and 11 is carbaminohemoglobin that forms when carbon dioxide combines with hemoglobin.

118. D
Option D is the correct answer as the arteries have the thickest walls followed by arterioles and then it decreases to the least in capillaries after in starts to increase in venule and veins but not as much as arteriole or arteries.

119. A
Option A is the correct answer as carbon dioxide combines with hemoglobin to form carbaminohemoglobin.

120. D
Option D is the correct answer as increased carbon dioxide concentration causes the curve to shift to the right and this means that the affinity of hemoglobin for oxygen has decreases which allow it to offload more oxygen in respiring tissues.

121. D
Option A is incorrect as carbon dioxide decrease affinity for oxygen. Option B is incorrect as affinity with oxygen is not dependent on altitude. Option C is incorrect as carbon monoxide binds irreversibly with hemoglobin. Hence, option D is the correct answer as carbon dioxide can bind with hemoglobin to form carbaminohemoglobin.

122. D
Option D is the correct answer as the lowest blood pressure is at 4 just before blood returns to the heart and the lowest speed is at 1 where the blood is in the capillaries.

123. A
Option A is the correct answer as the increase in red blood cells compensates for the lower percentage saturation of hemoglobin by ensuring that more cells carry the same amount and deliver it to the respiring tissues.

124. D
Option D is the correct answer as oxygen binds to hemoglobin one molecule after another the shape of the molecule change which affects its ability to leave the oxygen or hold on to it.

125. B
Option B is the correct answer as the hydrogen ions dissociate form hemoglobin to allow oxygen to bind to it and hydrogen carbonate ions combine with hydrogen ions to form carbon dioxide and water in the presence of carbonic anhydrase and then this carbon dioxide diffuses into the alveolus.

126. C
Option C is the correct answer as both arteries and veins contains all of the listed structural components.

127. D
Option A is incorrect as smaller mammals carry less oxygen at high partial pressures. Option B is incorrect as to release oxygen more easily at low partial pressures. Option C is incorrect as it saturates with oxygen less easily. Hence, option D is the correct answer as smaller mammals can unload oxygen more easily.

128. A
Option A is the correct answer as the lowest pressure will be in the right atrium since it sends blood into the right ventricle only. The highest pressure will be in the artery in the arm and then the second highest will be in the capillary in the arm and then the third highest will be in the vein in the arm but not as low as the pressure in the right atrium.

129. C
Option C is the correct answer as carbonic anhydrase catalyzes the production of carbonic acid which dissociates to produce hydrogen ions that increase in concentration. These hydrogen ions combine with hemoglobin to produce hemoglobinic acid that lowers the affinity of hemoglobin for oxygen. Statement 2 is incorrect as carboxyhemoglobin is formed when carbon monoxide reacts with hemoglobin.

130. D
Option D is the correct answer as the endothelial muscle is present in all blood vessels.

131. C
Option C is the correct answer as at lower partial pressures of oxygen the animal muscles release oxygen more easily as compared to human muscles.

132. A
Option A is the correct answer as tissue fluid contains phagocytes, proteins and sodium ions as well.

133. A
Option A is the correct answer as all the 3 statements are correct. Hemoglobinic acid cannot form unless oxygen is displaced from hemoglobin. It helps to keep the pH of blood down and depends on the release of hydrogen ions by the action of carbonic anhydrase.

134. D
Option D is the correct answer as hydrogen ions are released from hemoglobinic acid but they are converted into carbon dioxide and water in the red blood cell not outside it.

135. A
Option A is the correct answer as from the graph it is seen that the percentage saturation is greater at higher altitudes at the same partial pressures for the lower altitudes as well suggesting that hemoglobin has an increased affinity for oxygen.

136. A
Option A is the correct answer as 1 is carbaminohemoglobin that forms when carbon dioxide combines with hemoglobin. 2 is carbonic anhydrase that catalyzes the reaction between carbon dioxide and water. 3 is hydrogen carbonate ions.

137. D
Option D is the correct answer as reactions 1, 2 and 3 are all occurring at a higher rate in active muscles. Only 4 occurs at a faster rate in the alveolus.

138. B
Option B is the correct answer as gradually increasing the partial pressure of carbon dioxide makes hemoglobin less efficient at taking up oxygen but more efficient at releasing it.

139. C
Option C is the correct answer as in active tissue capillaries carbonic acid forms and carbaminohemoglobin forms as different forms to carry carbon dioxide to the lungs.

140. A
Option A is the correct answer as tissue fluid contains glucose, proteins and white blood cells.

141. B
Option B is the correct answer as carbaminohemoglobin, hemoglobinic acid and carbonic acid are all mediums for the transport of carbon dioxide from actively respiring tissues.

142. B
Option B is the correct answer as the pulmonary artery contains blood at a high pressure. Option A is incorrect as there is a single valve in the artery not a series. Option C is incorrect as it contains blood moving towards the lungs. Option D is incorrect as it contains deoxygenated blood.

143. B
Option B is the correct answer as oxyhemoglobin greatly increases the oxygen carrying capacity of red blood cells as it can carry up to 4 oxygen molecules.

144. A
Option A is the correct answer as after carbonic anhydrase catalyzes the reaction oxyhemoglobin dissociates to form oxygen and hemoglobin so that hydrogen ions can form hemoglobinic acid.

145. B
Option B is the correct answer as the x-axis should have the label partial pressure of oxygen and the y-axis should have the label percentage saturation of hemoglobin with oxygen.

146. D
Option D is the correct answer as the pulmonary vein carries oxygenated blood, has thin muscles and a large lumen.

147. C
Option C is the correct answer as in the Bohr effect at low partial pressures of oxygen, high partial pressures of carbon dioxide causes the affinity of hemoglobin for oxygen to decrease.

148. C
Option C is the correct answer as the carbonic acid produced in the reaction dissociates into hydrogen ions and hydrogen carbonate ions.

149. D
Option D is the correct answer as the resting muscle would have a lower partial pressure of carbon dioxide as compared to an active muscle meaning that the percentage saturation will be higher since resting muscles also require oxygen regardless of their activity levels.

150. C
Option C is the correct answer as the tissue fluid contains phagocytes but no platelets and has a lower concentration of proteins as compared to blood plasma.

8.2: The heart

1. **A**
When pressure in the left ventricle exceeds that in the left atrium, the left atrioventricular valve closes to prevent backflow of blood.
2. **C**
Label C correctly identifies the right atrium, which receives deoxygenated blood from the vena cava before passing it to the right ventricle.
3. **C**
Point C represents the start of atrial systole, where the atria contract, increasing ventricular volume as blood is forced into the ventricles.
4. **A**
The AVN and Purkyne tissue transmit electrical impulses to the ventricles. A malfunction slows ventricular contraction, causing heart block, while the SAN remains functional.
5. **D**
At the venule end of the capillary, hydrostatic pressure drops, while plasma proteins create a higher osmotic pressure. This causes water to move back into the capillary by osmosis, returning tissue fluid to the blood.
6. **B**
During ventricular diastole, the ventricles relax, pressure falls below atrial pressure, causing the atrioventricular valves to open and allowing blood to flow into the ventricles.
7. **B**
The atrioventricular node (AV node) is located at the base of the right atrium, near the septum, which is correctly marked by letter B in the diagram.
8. **A**
Blood pressure is influenced by the diameter of blood vessels (1), the systolic pressure exerted by the ventricles (2), and the volume of blood returning to the heart (3). All three factors directly affect pressure regulation.
9. **C**
The pulmonary artery carries deoxygenated blood to the lungs (label 1), semilunar valves prevent backflow into ventricles (label 2), atrioventricular valves stop backflow into the atria (label 3), and the vena cava returns deoxygenated blood to the heart (label 4).
10. **B**
A small decrease in oxygen partial pressure from 7 kPa to 4 kPa causes a large decrease in oxygen saturation due to the steep region of the oxygen dissociation curve, leading to more oxygen molecules dissociating from haemoglobin.
11. **A**
Sulthiame inhibits carbonic anhydrase, reducing the formation of carbonic acid in red blood cells. This leads to a decrease in the production of haemoglobinic acid, slowing its formation.
12. **A**
Diagram 1 shows that atrioventricular wolves are open but semilunar valves are closed. This represents diastole. The ventricles are relaxed and pressure of blood in aorta is more than that is ventricles. So, to prevent backflow of blood the valves close. The atria are also in diastole but the AV valves are open to allow for the filling of blood into the ventricles. The atria only contract at the very end to push the remaining blood in the ventricles. Hence, at this stage all chambers of the heart are undergoing diastole
Diagram 2 represents ventricular systole. This is because the AV valves are closed to prevent the backflow of blood into the atria and Semilunar valves are pushed open by the force of blood.
13. **B**
The correct sequence follows atrial contraction (1), signal passing through the AV node (4), then conduction via Purkyne tissue (3), and finally ventricular contraction (2).
14. **C**
The sequence of events in the cardiac cycle involves understanding the timing and coordination of electrical impulses and muscle contractions in the heart. Recognizing the pathway of cardiac excitation from the sinoatrial node through to ventricular contraction requires knowledge of the heart's electrical conduction system.

15. B

Recognizing and differentiating between the structural characteristics of blood vessels in plan diagrams requires knowledge of blood vessel anatomy. Understanding features such as wall thickness, the presence of elastic fibers, and the type of tissue lining the lumen is essential.

16. D

Interpreting a graph showing blood pressure changes in the heart during the cardiac cycle demands a comprehensive understanding of the cardiac cycle phases and valve functions. Matching pressure changes with valve activity requires the ability to correlate physiological data with cardiac function.

17. A

During ventricular systole in a mammalian heart, the following events occur:
A) Aortic pressure increases.
Here's an explanation:
Ventricular systole is the phase of the cardiac cycle where the ventricles contract to pump blood into the pulmonary artery and aorta.
When the ventricles contract, they generate pressure that forces the semilunar valves (aortic and pulmonic valves) to open. This allows blood to be ejected from the ventricles into the aorta and pulmonary artery.
As a result of this ventricular contraction and ejection of blood into the aorta, the pressure in the aorta increases.
So, option A correctly describes what happens during ventricular systole in a mammalian heart.

18. B

The Purkinje fibers are part of the cardiac conduction system responsible for triggering the contraction of the ventricles. They are located in the ventricular walls of the heart and help ensure that the ventricles contract in a coordinated manner. If there is a decrease in the transmission of impulses in the Purkinje tissue, especially on the right side, it could cause the muscle of the right ventricle to contract more slowly compared to the left ventricle. This delay could lead to desynchronization of ventricular contractions.

19. B

An increased concentration of carbon dioxide in the blood leads to the formation of carbonic acid (H_2CO_3) when CO_2 reacts with water in the presence of the enzyme carbonic anhydrase. This reaction is part of the body's buffering system, which maintains the pH of the blood. The carbonic acid can then dissociate into bicarbonate (HCO_3^-) and hydrogen ions (H^+), leading to an increase in hydrogen ions which, in turn, causes a decrease in pH and results in a condition known as respiratory acidosis if not compensated by the body.

20. C

In the circulatory system, arteries carry blood away from the heart, and this blood is typically under higher pressure due to the pumping action of the heart. Veins carry blood back to the heart, and the blood pressure in veins is generally lower than in arteries. Therefore, the blood pressure at X (artery) would be higher than at Y (vein).
The water potential of blood is influenced by solute concentration and pressure. At the arterial end of capillaries (X), the water potential of blood is higher, as the blood pressure is higher and filtration occurs out of the capillaries. At the venous end (Y), the water potential is lower as solutes and wastes accumulate, and water has left the bloodstream.

21. D

In ventricular septal defect (VSD), the hole in the septum alters the normal flow of blood between the ventricles. This can lead to an increased volume of blood passing through the lungs and reduced oxygen delivery to body tissues.

22. A

The correct statement about the heart's structure relates to the functioning of the semilunar valves. These valves close when the pressure in the ventricles falls lower than the pressure in the arteries, which occurs during the relaxation phase of the cardiac cycle. This mechanism prevents the backflow of blood from the arteries (aorta and pulmonary artery) into the ventricles, ensuring unidirectional blood flow and efficient circulation. The other options either describe incorrect anatomical features or functions related to heart structure.

23. B

23-Bisphosphoglycerate (23-BPG) affects hemoglobin's oxygen-binding affinity, causing the oxygen dissociation curve to shift to the right, indicating a lower affinity of hemoglobin for oxygen, facilitating oxygen release to tissues.

24. D

During ventricular systole, the pressure in the ventricles rises, and the atrioventricular valves close to prevent backflow into the atria, while the semilunar valves open to allow blood ejection into the arteries.

25. B
The chloride shift is a process that occurs in red blood cells where chloride ions (Cl^-) move into the cell as bicarbonate ions (HCO_3^-) move out, to maintain electrochemical neutrality. The exchange is necessary because the negatively charged bicarbonate ions leave the red blood cells, and without an influx of other negatively charged ions, like chloride, this would disrupt the ionic balance across the cell membrane. The shift helps maintain the balance of charge between the interior of the cell and the plasma, which is critical for proper cell function and the continued exchange of gases and ions.

26. C
The cardiac cycle involves the simultaneous contraction of both ventricles and the transmission of electrical impulses along Purkyne tissue, coordinating heartbeats.

27. C
In the cardiac cycle, when the pressure in the right ventricle is lower than in the right atrium and the pulmonary artery, it indicates the phase of ventricular filling.

28. D
Option D is the correct answer as carbonic anhydrase is an enzyme so its concentration remains the same only its activity changes. The concentration of hydrogen carbonate ions increases due to the action of carbonic anhydrase and this also causes an increase in the hydrogen ions due to dissociation of hydrogen carbonate ions.

29. B
Option B is the correct answer as the dissociation of hemoglobinic acid and the formation of carbonic acid from hydrogen carbonate ions and hydrogen ions takes place in the capillaries surrounding the alveolus.

30. B
Option B is the correct answer as the removal of hydrogen carbonate ions from the red blood cells results in a net positive charge that is counteracted by the movement of negative chloride ions into the red blood cells.

31. A
Option A is the correct answer as hemoglobinic acid cannot form unless oxygen dissociates from hemoglobin as both molecules occupy the same sites on hemoglobin. Hemoglobinic acid removes excess hydrogen ions from the blood prevent respiratory acidosis. It is linked to the action of carbonic anhydrase since carbonic anhydrase forms carbonic acid which dissociates to form hydrogen carbonate ions and hydrogen ions.

32. C
Option C is the correct answer as carbonic anhydrase catalyzes the conversion of carbon dioxide and water into carbonic acid inside the red blood cell.

33. C
Option C is the correct answer as carbon dioxide is transported either in the form of carbaminohemoglobin or hydrogen carbonate ions as carboxyhemoglobin is the complex formed with carbon monoxide.

34. B
Increasing the concentration or the partial pressure of carbon dioxide cause hemoglobin to be less efficient at taking up oxygen but more efficient at releasing it. Hence, option B is the correct answer.

35. A
Option A is the correct answer as the curve shifted to the left at high altitude indicates that hemoglobin has a higher affinity for oxygen. Option B is incorrect as higher affinity means that hemoglobin does not release oxygen readily. Options C and D are incorrect as at high altitudes the concentration of carbon dioxide remains the same.

36. C
Option C is the correct answer as since hemoglobin acid competes with the oxygen carrying capacity of hemoglobin, its concentration would be lowest at the lowest partial pressure of carbon dioxide where the percentage saturation of hemoglobin is the highest.

37. C
Option C is the correct answer as at W the atrioventricular valves close. At X the semi-lunar valves open followed by the semi-lunar valves closing at Y. Finally at Z the atrioventricular valves open again.

38. B
Option B is the correct answer as oxygen and carbon monoxide compete with each other in binding to the haem group. Carbon dioxide binds to the globular part of hemoglobin.

39. D
Option D is the correct answer as most of carbon dioxide is carried by red blood cells in the form of hydrogen carbonate ions that are formed as a result of the action of carbonic anhydrase.

40. C
Option C is the correct answer as acclimatization to high altitudes involves an increase in the number of red blood cells in order to carry more oxygen per unit.

41. B
Option B is the correct answer as carbon dioxide reduces the affinity of hemoglobin for oxygen while carbon monoxide and hydrogen ions both occupy the oxygen binding sites on hemoglobin.

42. C
Option C is the correct answer as 1 represents the movement of oxygen from the red blood cells into the tissues. 2 represents the movement of water and small solutes into the tissue fluid. 3 represents the diffusion of carbon dioxide form the tissues into the blood plasma. 4 represents the movement of tissue fluid via the lymphatic system.

43. A
Option A is the correct answer as P shows the dissociation curve when in the lungs as there the percentage saturation is close to maximum. The active muscles are represented by R since there is less oxygen available there resulting in low saturation and more carbon dioxide that causes the curve to shift slightly to the right.

44. D
Using the formula for percentage increase that is (final value – initial value)/(initial value) × 100. Putting the values from 3 and 5 kpa into the formula we find the answer to be 65.5% making option D the correct answer.

45. C
Option C is the correct answer as the purkyne tissues links the 2 sides of the heart such that the wave of excitation causes them to contract simultaneously.

46. C
Option D is the correct answer as first the contraction of the sinoatrial node occurs which results in a wave of excitation spreading across the atria. This causes the atria to contract which is the third step in the cycle.

47. C
Option C is the correct answer as the semi-lunar valves are open during a systole when blood is being pumped out of the ventricles and is at a high pressure. This is in the region C and during this time the atrioventricular valves are shut.

48. B
Option B is the correct answer as the semi-lunar valves are open when the pressure in the aorta is at a maximum which is seen at 0.3s.

49. A
Option A is the correct answer as X represents the pulmonary artery where the pressure spikes when the right ventricle contracts.

50. D
Option D is the correct answer as the narrow opening would cause the heart to continuously exert itself to pump blood into the aorta. This will result in the wall of the left ventricle thickening to generate high pressures. This will cause the heart to be abnormally large and not being filled completely during a diastole.

51. B
Option B is the correct answer as the atrioventricular node transmits a signal to the apex of the heart that causes the ventricles to contract. This results in the semi-lunar valves opening and atrioventricular valves closing.

52. D
Option D is the correct answer as the left and the right sides of the heart beat simultaneously meaning that the left and right atrioventricular valves open at the same time and the pulmonary semi-lunar valve and the aortic valve also open at the same time after the atrioventricular valves.

53. D
Option D is the correct answer as W is the right ventricle and X is the left ventricle which is larger and more muscular since it has to pump blood throughout the body.

54. C
Option C is the correct answer as first the sinoatrial nodes contract and this causes the wave of excitation to sweep across the atria.

55. B
Option B is the correct answer as P and Q are the left atrium and the left ventricle. R is the coronary artery on the heart muscle externally and S is the vena cava that brings blood into the right atrium.

56. B
Option A is incorrect as the atrioventricular node causes the ventricles to contract from the apex downwards. Options C and D are incorrect as the same wave from the sinoatrial node is used and the purkyne tissue provides a non-conducting barrier not the atrioventricular node. Hence, option B is the correct answer as the atrioventricular node delays the transmission of the impulse form the sinoatrial node.

57. B
Option B is the correct answer as this indicates the ventricular systole as the pressure spikes to the maximum in a short period of time.

58. B
Option B is the correct answer as the blood flows in the left side from 2 to 1 and then in the right side from 3 to 4.

59. B
Option B is the correct answer as the wave of excitation has to pass through a small area of conducting fibers called the Purkyne tissue in order for the ventricles to contract.

60. D
Option D is the correct answer as if the valves remain open the pressure in the left atrium increases due to backflow and less blood enters the aorta. Option A is incorrect as even if blood is less it should carry oxygen as the normal amount not less. Option B is incorrect as the left ventricle sends blood into the aorta not the pulmonary artery. Option C is incorrect as the systolic pressure in the left atrium would increase due to backflow.

61. A
Option A is the correct answer as it represents the aorta which has the thickest walls.

62. B
Option B is the correct answer as each time there is a peak in the graph that is one beat. In option B over 4 seconds there are 5 beats meaning that it 60 seconds there will be 75 beats. $(5 \times 60)/(4)$.

63. C
Option A is incorrect as blood moves into the aorta as a result of the contraction of the left ventricle. Option B is incorrect as blood flows into the left atrium from the pulmonary vein. Option D is incorrect as blood flows into the right ventricle through the atrioventricular valve not a semi-lunar valve. Hence, option C is the correct answer as blood flows into the right atrium through the vena cava when it relaxes.

64. D
Option D is the correct answer as the wave of excitation causes the ventricle to contract causing the pressure in the ventricle to go higher than that of the aorta resulting in the semi-lunar valve opening.

65. B
Option B shows the correct sequence as the impulse generated form the sinoatrial node travels across both the right and the left atria and then it goes to the atrioventricular node from where it travels across the Purkyne tissue and causes the ventricles to contract.

66. A
Option A is the correct as at point P the ventricle has already been filled with blood so the atrioventricular valve closes and at R the systole has taken place so the semi-lunar valve closes to prevent backflow.

67. A
Option A is the correct answer as the collagen fibers provide structural support and the elastin fibers allow the blood vessels to contract in order to prevent them from bursting and to maintain the pressure.

68. C
Option C is the correct answer as the impulses form the sinoatrial node travel to the atrioventricular node form where they travel down the Purkyne tissue.

69. A
Option A is the correct answer as the impulses travel across the right and left atria after which they go to the atrioventricular node. From there the wave of excitation travels across the Purkyne tissue towards the ventricle walls which contract.

70. C
Option C is the correct answer as the vena cava carries blood into the right atrium and the pulmonary vein carries blood into the left atrium.

71. B
Option B is the correct answer as at X there is a ventricular systole meaning that the semi-lunar valves open and this means that at W the atrioventricular valves close due to the semi-lunar valves opening. Once the systole is over at Y the semi-lunar valves close and then at Z the atrioventricular valves open.

72. C
Option C is the correct answer as it shows the only correct label. A is aorta, B is left atrium and D is pulmonary artery.

73. C
Option C is the correct answer as in the graph at 0.2 seconds we can see that the pressure spikes in the left ventricle which is responding to the wave of excitation from the atrioventricular node.

74. B
Option B is the correct answer as when an atrial systole occurs there is a small spike in pressure as blood is just moving from one chamber to another. This is shown in option B.

75. C
Option C is the correct answer as during a ventricular systole the atrioventricular valves close and the semilunar valves open. The ventricles wall muscles are contracting not relaxing.

76. D
Option D is the correct answer as at point X the aortic semi-lunar valve is opening since there is a spike in pressure and at the same time the right atrium is filling with blood for the next cycle.

77. B
Option A is incorrect as the time delay is not for the atria to fill up with blood but rather so that all the blood from the atria can move into the ventricles. Option C is incorrect as the wave of excitation passes to the atrioventricular node and then to the Purkyne fibers. Option D is incorrect as the sinoatrial node is in the right atrium. Hence, option B is the correct answer as the contraction of the ventricles following atrial systole allows the blood pressure to rise causing the atrioventricular valves to shut.

78. C
Option C is the correct answer as the impulses travel from the sinoatrial node to the walls of the atria after which the wave of excitation travels to the atrioventricular node and then down to the Purkyne tissue.

79. B
Option B is the correct answer as there are more fibers in the walls of the left ventricle compared to the right since greater fibers means that the walls contract with more force which is necessary since the blood has to be sent to all parts of the body.

80. C
Option C is the correct answer as at this point the atrial systole starts that forces the blood out of the atria and into the ventricles.

81. A
Option A is the correct answer as since one cycle takes 0.8 seconds, dividing this by 60 gives 75 beats per minute.

82. A
Option A is the correct answer as during an atrial systole the atrioventricular valves open to allow blood to flow into the ventricles and the semilunar valves remain closed. In a ventricular systole the semilunar valves open and the atrioventricular valves close to prevent the backflow of blood.

83. C
Option C is the correct answer as at O the impulse leaves the sinoatrial node and at P the atria contract resulting in a small spike in electrical activity. QRS is where the ventricles contract due to the large spike in electrical activity and at T the ventricles relax.

84. A
Option A is the correct answer as that is the aorta. B is the pulmonary vein, C is the vena cava and D is the pulmonary artery.

85. D
Option D is the correct answer as an increase in pressure in the right atrium will cause the blood pressure in the pulmonary artery to increase as well and since there is less blood on the left side the pressure in the aorta will decrease. Since blood moves from the left side into the right the pulmonary artery will have blood with increased percentage of oxygenation.

86. D
Option D is the correct answer as the SAN produced the wave of excitation for atria to contract and the wave of excitation produced by the AVN passes through the Purkyne tissue for the ventricles to contract.

87. C
Option C is the correct answer as on the graph the pressure in the ventricle drops significantly in this region indicating that all the blood has been sent out from it.

88. A
Option A is the correct answer as there is a delay before the wave of excitation passes down the Purkyne tissue to the ventricles form the atrioventricular node. Option B is incorrect as the atrioventricular valves close when the ventricles contract. Option C is incorrect as the wave of excitation passes to the atrioventricular node before the Purkyne tissue. Option D is incorrect as the sinoatrial node is in the right atrium.

8.3: Multiple topics

1. B
Point B lies on the curve with high carbon dioxide and low oxygen saturation, indicating maximum oxygen release and thus highest haemoglobinic acid concentration.

2. A
Carbonic anhydrase forms carbonic acid (1), which dissociates into H^+ and HCO_3^- (2); some CO_2 binds to haemoglobin to form carbaminohaemoglobin (3). Haemoglobin does not bind directly to hydrogen carbonate ions, so statements 1, 2 and are correct.

3. B
Carbonic anhydrase is an enzyme that catalyzes the reaction between CO_2 and H_2O, forming carbonic acid, which dissociates into bicarbonate and hydrogen ions.

4. D
Option D is the correct answer as the blood moves from the left to the right atria meaning that less oxygenated blood is pumped via the aorta resulting in a shortage of oxygen that causes the number of red blood cells to increase.

5. B
Increasing CO_2 from 1.0 kPa to 1.5 kPa shifts the oxygen dissociation curve right (Bohr effect), reducing haemoglobin's oxygen saturation at 6 kPa O_2 from about 78% to 58%, a 20% decrease.

6. A
Tissue fluid contains phagocytes, some proteins, and sodium ions, which diffuse from the blood plasma into the tissue spaces. Large proteins like albumin and fibrinogen generally remain in the blood.

7. A
At point X, the pressure in the left ventricle starts to rise as it contracts, causing the atrioventricular valves to close to prevent backflow into the atrium.

8. C
The electrical impulse in the cardiac cycle starts at the sinoatrial node (4), then travels to the muscle wall of the atria (2), to the atrioventricular node (1), and finally through the Purkyne tissue (3).

9. A
At P during ventricular systole, the atrioventricular valve closes to prevent backflow into the atria, and the semilunar valve closes during diastole at R to prevent backflow into the ventricles.

10. C
At low partial pressures of oxygen, the graph shows that oxygen is released more easily from cat hemoglobin than from human hemoglobin, as indicated by the steeper curve for cats.

11. B
Each hemoglobin molecule has four heme groups, and each heme group can bind to one oxygen molecule, allowing one oxygen molecule to combine with each heme group.

12. B
Atrial systole occurs when atrial pressure rises slightly as the atria contract, pushing blood into the ventricles. Arrow B corresponds to the pressure increase in the atria, indicating atrial systole.

13. D
The sinoatrial node (SAN) is the pacemaker of the heart that generates electrical impulses to initiate atrial contraction. Damage to the SAN results in an irregular heartbeat due to improper stimulation of the atria.

14. B

Higher levels of carbon dioxide cause the oxygen dissociation curve to shift right, known as the Bohr effect. This reduces hemoglobin's affinity for oxygen, making it less efficient at oxygen uptake but more efficient at releasing oxygen.

15. B

In the capillary next to an alveolus, oxygen binds to hemoglobin to form oxyhemoglobin (reaction 1). Carbonic acid is not formed at this point since CO_2 is being released into the alveolus, so only reaction 1 is correct.

16. D

Atrial septal defect (ASD) causes increased blood flow to the lungs, raising pulmonary artery pressure and oxygenation. It also reduces aortic blood pressure due to shunting of blood from the left to the right atrium.

17. B

Carbaminohaemoglobin and haemoglobinic acid concentrations decrease in the lungs as carbon dioxide is released. Oxyhaemoglobin increases due to oxygen binding, while carbonic anhydrase remains unchanged. Two substances decrease in concentration.

18. B

An increase in blood pressure forces more fluid out of capillaries into surrounding tissues, potentially leading to excess tissue fluid accumulation.

19. C

The net pressure causing tissue fluid to flow out at the arteriole end is the difference between blood pressure (+4.3 kPa) and water potential (–3.1 kPa), resulting in a net pressure of +1.2 kPa.

20. D

In respiring muscles, carbon dioxide binds to haemoglobin to form carbaminohaemoglobin, increasing its concentration.

21. A

Systole in the right atrium starts at T and ends at V, while systole in the right ventricle starts at V and ends at X, corresponding to the changes in blood pressure during the cardiac cycle.

22. D

When CO_2 enters red blood cells, it is converted to hydrogencarbonate ions, which diffuse into the plasma. To maintain charge balance, chloride ions move into the red blood cells, a process known as the chloride shift.

23. B

Option B is the correct answer as during a ventricular systole the pressure in the ventricle increase and when it exceeds the pressure of the aorta the aortic semi-lunar valve open and this results in an increase in the aortic pressure as well.

24. C

Option C is the correct answer as systolic blood pressure is the maximum blood pressure of the arteries since systole refers to the contraction of the arteries.

25. A

The ventricles are full of blood when their pressure starts to increase up to the point where it is less than the aortic pressure after which blood flows into the aorta. Hence, option A is the correct answer as it shows the ventricular systole being initiated at which point ventricle is full of blood.

26. C

Option C is the correct answer as at 0.07 seconds both the valves are closed since the systole does not take place yet.

27. C

The right ventricle would have the second highest pressure since the left ventricle would have the highest. Hence, option C is the correct answer.

28. A

Option A is the correct answer as T represents the pulmonary artery where the pressure remains high and does not drop below a certain amount.

29. D

Option D is the correct answer as when the pressure in the right ventricles increases than the pressure in the right atrium the right atrioventricular valve closes and the semi-lunar valve in the pulmonary artery opens.

30. B
Option B is the correct answer as at W the atrioventricular valves close due to the spike in pressure of the ventricle. Once the pressure in the ventricle exceeds that of the aorta at X, the semi-lunar valve opens. This valve closes when the pressure in the ventricle drops below that of the aorta at Y. At Z the atrioventricular valves open.

31. D
Option D is the correct answer as in the atrial contraction the SAN node produces the wave of excitation that causes contraction. For ventricular contraction the wave of excitation is produced by the AVN and this wave is carried by the purkyne tissue.

32. D
Option D is the correct answer as the lowest pressure is in the vena cava when the blood is returning to the heart. The lowest speed however is in region 1 where the arterioles are. This is to allow that there is enough time for exchange of substances between the cells and the blood.

33. D
Option D is the correct answer as the correct order is as follows 4 to 2 to 7 to 1 to 3 to 5 to 6. Hence, step 5 is the sixth step.

34. B
Option B is the correct answer as the left and right atria contract at first followed by the left and the right ventricles contracting.

35. B
Option B is the correct answer as first the contraction of the sinoatrial node occurs which results in a wave of excitation spreading across the atria. This causes the atria to contract which is the third step in the cycle and this is followed by the AVN delaying the impulse for a fraction of a second.

36. A
Option A is the correct answer as the lowest pressure will be in the right atrium since it sends blood into the right ventricle only. The highest pressure will be in the artery in the arm and then the second highest will be in the capillary in the arm and then the third highest will be in the vein in the arm but not as low as the pressure in the right atrium.

37. B
Option B is the correct answer as blood flows into the right side from the vena cava and after passing through the atrium and ventricle goes to the lungs. From there it enters the left side via the pulmonary vein and then goes through the right atrium and ventricle into the aorta.

38. D
Option D is the correct answer as during an atrial systole the walls of the ventricle as relaxed but the spike in pressure causes the atrioventricular valves to open and the semi-lunar valves to close.

39. A
Option A is the correct answer as all of the listed structures carry substances via mass flow.

40. B
Option B is the correct answer as the increased red blood cell count allows more oxygen to be taken up by the hemoglobin as the partial pressure of oxygen is low.

41. A
Option A is the correct answer as the development of leukemia can cause the number of white blood cells to decrease and variola can cause the number to decreases as well since it is a virus and uses cells to reproduce. Living for 6 months at a high altitude will also change the ratio as the number of red blood cells increase.

42. B
Option B is the correct answer as P and R are the aorta and the pulmonary vein respectively and each one of them carries oxygenated blood. Option A is incorrect as Q contain deoxygenated blood. Options C and D are incorrect as S and Q carry blood with a low oxygen concentration and more hemoglobin that oxyhemoglobin.

43. B
Option B is the correct answer as the binding of 2,3BPG causes the curve to shift to the right meaning that it decreases the affinity of hemoglobin for oxygen. It does not reduce the Bohr effect and when it is absent oxyhemoglobin is still likely to unload oxygen.

44. A
Option A is the correct answer as active transport can take place in mature red blood cells but not division, translation or transcription as red blood cells have no nucleus.

45. D
Option D is the correct answer as the binding of 2,3BPG causes the curve to shift to the right meaning that it decreases the affinity of hemoglobin for oxygen. It does not reduce the Bohr effect and when it is absent oxyhemoglobin is still likely to unload oxygen.

46. A
Option A is the correct answer as all of the statements above are correct.

47. D
Option D is the correct answer as carbonic anhydrase is found in the red blood cells in the blood and small amounts of oxyhemoglobin are also present. Collagen is not found in veins.

48. C
The curve with points P and S is with a lower concentration of carbon dioxide that the curve with points Q and R. This means that the difference between P and S represents the amount of oxygen delivered to resting muscles since active muscles would have the second curve due to higher concentration of carbon dioxide.

49. C
Option C is the correct answer as the binding of 2,3BPG causes the curve to shift to the right meaning that it decreases the affinity of hemoglobin for oxygen.

50. B
Option B is the correct answer as the humans with have curve Y between X and Z. The fish will have curve X since the graph shows high percentage saturation at low partial pressures and that means that Z is for the very active mammal which would have a high percentage of carbon dioxide that would shift the dissociation curve to the right.

51. C
Option C is the correct answer as 3 and 4 represent the right atrium and the pulmonary artery both of which transport deoxygenated blood.

52. D
Option D is the correct answer as the muscles in the arterioles allow for the adjustment of the diameter of the vessels that allows for an increase or decrease in flow of blood.

53. C
Option C is the correct answer as the sound that comes after an atrial systole is the sound of the atrioventricular valves closing.