CHAPTER 18 READING QUESTIONS

These reading questions are designed to help you focus your reading on the most important points in the chapter. They are arranged using chapter section headers so that the file can be easily edited to reflect the material covered in class.

1. Identify the main components of exchange and transport of O_2 and CO_2. (Fig. 18.1)

2. What three variables of arterial blood composition are monitored and regulated to prevent hypoxia and hypercapnia? (Tbl. 18.2)

18.1 Gas Exchange in the Lungs and Tissues

3. Give the following partial pressures for P_{O2} and P_{CO2} in a normal person at sea level: atmospheric air, alveoli, arterial blood, resting cells, venous blood (Fig. 18.2; Tbl. 18.2)

4. If the alveolar P_{O2} is 98 mm Hg, what will the arterial P_{O2} be? Why?

Lower Alveolar P_{O2} Decreases Oxygen Uptake

Composition of the Inspired Air

5. Explain the relationship between altitude and P_{O2}.

Alveolar Ventilation

6. What are the pathological factors that cause hypoventilation? (Fig. 18.3c)

Diffusion Problems Cause Hypoxia

7. What two cell layers must gases cross to go from the alveoli to the plasma? (Fig. 18.3b)

8. Write the mathematical expression that relates diffusion rate to surface area, concentration gradient, barrier permeability, and diffusion distance.

9. List the pathological changes that adversely affect gas exchange.

Surface Area

10. Explain how emphysema can result in a high-compliance, low-elastance lung with reduced alveolar surface area. (Fig. 18.3c)

Diffusion Barrier Permeability

11. How much of the exchange epithelium must be incapacitated before arterial P_{O2} drops significantly?

Diffusion Distance

12. What causes pulmonary edema and how does it alter gas exchange? (Fig. 18.3b, c)

13. Explain alveolar flooding and adult respiratory distress syndrome (ARDS).

Gas Solubility Affects Diffusion

14. When a gas is placed in contact with a liquid, what three factors determine how much gas will dissolve in the liquid?

15. True or false: If a liquid is exposed to a P_{CO2} of 100 mm Hg and a P_{O2} of 100 mm Hg, equal amounts of oxygen and carbon dioxide will dissolve in the liquid. Defend your answer. (Fig. 18.4)

16. The more soluble a gas is in a particular liquid, the _____ (higher or lower?) the partial pressure required to force the gas into solution.

17. Gases move between liquid and gaseous phases until is reached. (Fig. 18.4)

18. True or false: At equilibrium, the concentration of O_2 in the gaseous phase will be equal to the concentration of O_2 in the liquid phase. Defend your answer. (Fig. 18.4)

18.2 Gas Transport in the Blood

19. Where is most of the arterial O_2 found? (Fig. 18.5)

20. If mass flow = concentration □ volume flow, then show how you would calculate the mass flow of oxygen traveling from the lungs to the cells. (Fig. 18.6)

21. Relate oxygen consumption (Q_{O2}), cardiac output (CO), and blood oxygen content using the Fick equation. (Fig. 18.6)

Hemoglobin Binds to Oxygen

22. Complete the following equation (Fig. 18.5):

Total blood O_2 content = _____ + _____

23. Hemoglobin molecules are composed of (how many?) _____ protein subunits. Each subunit contains a _____ group that can bind weakly to oxygen.

24. Hb bound to O_2 is called _____ , written as HbO_2, or $Hb(O_2)_{1–4}$.

Oxygen Binding Obeys the Law of Mass Action

25. Using $Hb + O_2 \leftrightarrow HbO_2$, show how the equation shifts according to the law of mass action when O_2 concentration increases or decreases.

Hemoglobin Transports Most Oxygen to the Tissues

26. Using a cardiac output of 5 L/min, compare the rate of oxygen delivery to the cells with and without hemoglobin. (Fig. 18.7)

P_{O2} Determines Oxygen-Hb Binding

27. Diagram the factors affecting the amount of oxygen bound to Hb. Start with Figure 18.8 and incorporate additional details from the section.

Oxygen Binding Is Expressed as a Percentage

28. Define percent saturation of hemoglobin, and write the formula for how it is calculated.

29. At 100% saturation, all possible binding sites are _____ (bound or free?).

30. What is the physiological significance of the shape of the oxyhemoglobin saturation curve at P_{O2} values between 40 and 100 mm Hg? (Fig. 18.9)

31. Below P_{O2} of 40 mm Hg, where the curve is steeper, small changes in P_{O2} cause relatively _____ (small or large?) releases of O_2 from hemoglobin. (Fig. 18.9)

Several Factors Affect O_2-Hb Binding

32. An increase in pH _____ (increases or decreases?) Hb's affinity for oxygen. What is the Bohr effect? (Fig. 18.9c)

33. An increase in temperature _____ (increases or decreases?) Hb's affinity for oxygen. (Fig. 18.9d)

34. An increase in P_{CO2} _____ (increases or decreases?) Hb's affinity for oxygen. (Fig. 18.9e)

35. The metabolite 2,3-BPG _____ (increases or decreases?) Hb's affinity for oxygen. What triggers an increase in 2,3-BPG production? (Fig. 18.9f)

36. Fetal Hb has a/an _____ (increased or decreased?) affinity for oxygen relative to the maternal hemoglobin. (Fig. 18.9b)

37. A left shift in the curve indicates _____ (increased or decreased?) binding affinity.

38. A right shift in the curve indicates _____ (increased or decreased?) binding affinity.

Carbon Dioxide Is Transported in Three Ways

39. Why is it important that CO_2 be removed from the body?

40. List the three ways CO_2 is transported in the blood. (Fig. 18.11)

CO_2 and Bicarbonate Ions

41. What two purposes does the conversion of CO_2 to HCO_3^- serve?

42. Write the equation in which CO_2 is converted into bicarbonate ion (HCO_3^-) and H^+. What enzyme catalyzes this reaction, and where in the blood is it found?

43. Why must H^+ and HCO_3^- be removed from RBC cytoplasm?

44. What is the chloride shift and what does it accomplish?

Hemoglobin and H^+

45. What is respiratory acidosis?

46. How does Hb help prevent this condition?

Hemoglobin and CO_2

47. What facilitates the formation of carbaminohemoglobin? How? (Fig. 18.9)

CO_2 Removal at the Lungs

48. Diagram CO_2 removal at the lungs and how this removal influences other CO_2 transport mechanisms to effectively remove CO_2 from the body. (Fig. 18.11, bottom)

18.3 Regulation of Ventilation

49. Contrast the rhythmicity and control of breathing to that of the heartbeat.

50. What is a central pattern generator?

51. Based on the contemporary model, describe what we currently know about neural control of breathing. (Fig. 18.13)

Neurons in the Medulla Control Breathing

52. Diagram the complex interactions of medullary neurons that exert influence on respiration. Your diagram should include the following terms: nucleus tractus solitarius,

dorsal respiratory group (DRG), phrenic nerves, intercostal nerves, intercostal muscles, vagus and glossopharyngeal nerves, pontine respiratory groups, ventral respiratory group (VRG), pre-Bötzinger complex, quiet breathing, forced breathing. (Figs. 18.13, 18.14, 18.15)

53. In the context of respiratory neurophysiology, what is ramping? (Fig. 18.15)

CO_2, Oxygen, and pH Influence Ventilation

54. What is the primary chemical stimulus for changes in ventilation?

55. Explain the strategic significance of the location of the peripheral chemoreceptors. (Fig. 18.13)

Peripheral Chemoreceptors

56. What chemical signals activate the carotid and aortic bodies?

57. Diagram the basic mechanism by which the carotid and aortic bodies respond to stimuli. (Fig. 18.16) What area of the brain integrates this sensory information? What is the homeostatic response that is initiated?

Central Chemoreceptors

58. Diagram how the central chemoreceptors respond to elevated blood P_{CO2}. (Fig. 18.17)

59. If a person has chronic hypercapnia and hypoxia, is CO_2 the primary chemical drive for ventilation? Why? What will happen to ventilation if this person with chronic hypercapnia and hypoxia is given pure O_2 to breathe? Explain.

Protective Reflexes Guard the Lungs

60. Describe the reflex response to an inhaled irritant.

61. Describe the Hering-Breuer inflation reflex.

Higher Brain Centers Affect Patterns of Ventilation

62. Give two examples of how higher brain centers can influence ventilation.