Chapters 2 & 27: Acid -Base Balance and Buffer Systems

*** Read pages 41 – 43, and 1042, and 1046 - 1051**

TOPIC OUTLINE AND OBJECTIVES NAME _____

A. Acids, bases, pH, and buffers

1. Define pH and explain the role of a buffer system as a homeostatic mechanism that maintains the pH of a body fluid.

B. Acid-base balance and imbalance

2. Compare the roles of buffers, respiration, and kidney excretion in maintaining body pH.
3. Define acid-base imbalances and their effect on the body.
4. Explain the appropriate treatments for acidosis and alkalosis.

C. Clinical Applications

A. Acids, bases, pH, and buffers (pages 41 – 43, and 1042)

A1. Match the description below with the answers in the box.

A. Acid	**B. Base**	**C. Salt**

a. A substance that acts as a good proton acceptor.
Example: NaOH. _____

b. A substance that dissociates into hydrogen ions (H^+); a proton donor.
Example: H_2SO_4 _____

c. A substance that dissolves in water forming cations and anions neither of which is Ca^+ or Cl^-
Example: $CaCl_2$ _____

d. A substance that causes the pH of a solution to decrease. _____

e. A substance that forms important electrolytes required for bodily function. _____

A2. Choose the correct answer regarding pH.

a. Which pH is most acidic?
A. 4 B. 7 C. 10

b. Which pH has the lowest concentration of H^+ ions?
A. 4 B. 7 C. 10

c. Which solution has pH closest to neutral?
A. Gastric juices (from the stomach)
B. Blood
C. Lemon juice
D. Antacid (Pepcid Ac)

d. A solution with pH 8 has 10 times (*more? fewer?*) H^+ ions than a solution with pH 7.

e. A solution with pH 5 has (*10? 20? 100?*) times (*more? fewer?*) H^+ ions than a solution with pH 7.

A3. Contrast between the pairs of terms:

a. Strong acid/Weak acid

b. Strong base/Weak base

A4. Fill in the blanks to complete the statements below.

a. When the body continues to take in or produce excess strong acid, the concentration of the _____ member of the buffer pair will decrease as it is used up in attempt to maintain homeostasis of pH. **Hint:** which member is soaking up?

b. Though buffer systems provide rapid response to acid-base imbalance, they are limited since one member of the buffer pair can be used up. Also, they can convert only strong acids or bases to weak ones; they CAN'T eliminate them! Two systems of the body that can actually eliminate acid or basic substances are _____ and _____ .

B. Acid-base balance and imbalance (pages 1046 – 1051)

B1. Complete this section about acid-base regulation.

a. The pH of blood and other ECF should be maintained between _____ and _____ .

b. Name the three major mechanisms that work together to maintain acid-base balance. Give the approximate time for each method to respond to pH changes.

1. _____

2. _____

3. _____

c. List the three main buffer systems in the body fluids. Also, indicate in which bodily fluid the buffer is found, ie. ICF, ECF or both.

1. _____ 2. _____

3. _____

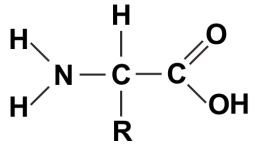
B2. Explain how the hemoglobin buffer system works (using the chemical equation) if:

$$HbH \Leftrightarrow H^+ + Hb^-$$

a. H^+ is added. i.e. Discuss the shifts in the equation.

b. H^+ is removed. i.e. Discuss the shifts in the equation.

B3. Which is the most abundant buffer system in the body? _____ .
a. Circle the part of the amino acid shown below that buffers acid (acts as the proton acceptor).
b. Draw a square around the part of the amino acid that buffers base (acts as the proton donor).



c. Explain why proteins are such excellent buffers?

B4. Match the pH values in Column B with the conditions described in Column A.
NOTE: you may use column B more than once! See page 1049-1051 in your text for help.

Column A	Column B
1. _____Normal pH of arterial blood	A. pH < 7.00
2. _____ Normal pH of intracellular fluid(ICF)	B. pH = 7.00
3. _____Normal pH of venous blood and interstitial fluid	C. pH < 7.35
4. _____Physiological alkalosis (arterial blood)	D. pH = 7.35
5. _____Physiological acidosis (arterial blood)	E. pH = 7.40
6. _____Chemical neutrality; neither acid nor basic	F. pH > 7.45
7. _____Chemical acidity	

B5. Indicate the chief sources of the following acids found in the body. How are they formed?
NOTE: See lecture notes for help.

1. Lactic acid _____

2. Carbonic acid _____

3. Hydrochloric acid _____

4. Fatty acids and ketones _____

5. Phosphoric acid _____

C. Clinical Application (for extra help see Table 27.4. page 1051)

C1. Match the key choices with the acid-base balance abnormalities described below.
(***Note:*** $\mathbf{P_{CO2}}$ = partial pressure of CO_2)

KEY CHOICES

A. Metabolic acidosis **C.** Normal range **E.** Respiratory alkalosis

B. Metabolic alkalosis **D**. Respiratory acidosis

1. _____ Indicated by plasma HCO_3^- levels above the normal range

2. _____P_{CO2} = 35 – 45 mm Hg; pH = 7.35 – 7.45

3. _____A common result of hyperventilation

4. _____Indicated by plasma P_{CO2} levels above normal range

5. _____ A common cause is excess HCO_3^- loss resulting from prolonged diarrhea

6. _____Imbalance where HCO_3^- levels are high; compensated by slow, shallow breathing (therefore, high P_{CO2})

7. _____Prolonged vomiting of stomach contents

8. _____Decreased respiratory rate in a patient taking an overdose of morphine

C2. Please respond in complete sentences and thoughts!
a. It is determined that a patient is in acidosis. What does this mean, and would you treat the condition with a chemical that would *raise* or *lower* the pH?

b. Carbon dioxide concentration influences blood pH in the following manner: High levels of CO_2 increase the rate of formation of carbonic acid. If a patient has difficulty ventilating the lungs (particularly in exhaling, as in emphysema), would you expect the patient to be in *acidosis* or *alkalosis*? Why?

c. Hugo, a patient with kidney disease, is unable to excrete sufficient amounts of hydrogen ions. Would you expect Hugo to *hyperventilate* or *hypoventilate* (with respect to compensation of the elevated H^+)? Explain.

C3. Respond in detail to the following case studies (see Chapter 27 and handout for help).
a. Ed is admitted to the hospital in complete collapse. His blood pH is 6.7, and his $\mathbf{HCO_3^-}$ (bicarbonate) is 20 mEq/L; normal levels would be 24 mEq/L. Also, his $\mathbf{pCO_2}$ is 30 mm Hg. What diagnosis would you give? A medical history reveals that this person is a chronic alcoholic. Be sure to mention if it is metabolic or respiratory imbalance, and if any system is compensating.

b. Helen is a 62 year-old smoker. Her physician has diagnosed her as having emphysema that caused her to breath rapidly in order to compensate for the low blood pH. She is tired and sedentary. Her blood pH is 6.8, and has a $\mathbf{pCO_2}$ of 48 mm Hg. The physician also found her $\mathbf{HCO_3^-}$ to be 27 mEq/L. Besides having difficulty breathing, what other conditions is contributing to her tiredness? Be sure to mention if it is metabolic or respiratory imbalance, and if any system is compensating.

Chapter 27 Essay Questions:

1. What provides the shortest-term mechanism and the longest-term mechanism for preventing acid-base imbalance in the body? Please give time factors, examples of each mechanism and in general, how does each mechanism operate to compensate for acid-base imbalances.

2. What is *respiratory acidosis* and give a possible cause for the condition? Explain how the carbonic acid-bicarbonate buffer system compensates to maintain the optimum pH of bodily fluids? Give a possible compensation by the kidneys for this condition.

3. What is *respiratory alkalosis* and give a possible cause for the condition? Explain how the carbonic acid-bicarbonate buffer system compensates to maintain the optimum pH of bodily fluids? Give a possible compensation by the kidneys for this condition.

4. Be able to analyze data generated from the buffer lab in the form of an essay.