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Blood Buffer System & Acid–Base Balance

Study Guide — Blood & Hemoglobin

Pre-med/IB-style questions on what buffers are, the bicarbonate buffer system, why CO2 matters, and how lungs and kidneys maintain blood pH. Includes tricky scenarios for respiratory vs metabolic acidosis/alkalosis and compensation.

50 items — Study Guide with Answers

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1 **Which definition BEST describes a chemical buffer?**

- A A substance that makes pH exactly 7 in all solutions
- B A mixture that prevents any chemical reaction from occurring
- C **A solution that resists pH change by containing a weak acid and its conjugate base** ✓
- D A strong acid that neutralizes any base instantly
- E A salt solution that always becomes neutral when diluted

▶ **Explanation:** Buffers resist pH changes because the weak acid can neutralize added base and the conjugate base can neutralize added acid. Strong acids/bases do not buffer well.

2 **The main buffer system in human blood plasma is best represented by which equilibrium?**

- A H2O H^+ + OH–
- B **CO2 + H2O H2CO3 H^+ + HCO3–** ✓
- C NaCl Na^+ + Cl–
- D O2 + Hb HbO2–
- E Glucose lactate

▶ **Explanation:** The bicarbonate buffer system links CO2 (from respiration) with carbonic acid and bicarbonate, allowing tight pH regulation through both lungs and kidneys.

3 **Carbonic anhydrase is important in blood because it:**

- A Breaks down hemoglobin into amino acids

- B **Speeds up the conversion between $CO_2 + H_2O$ and H_2CO_3 ✓**
- C Pumps bicarbonate out of the kidneys using ATP
- D Converts glucose into glycogen
- E Destroys acids by turning them into salts

▶ **Explanation:** Carbonic anhydrase catalyzes $CO_2 + H_2O$ H_2CO_3, making the bicarbonate buffer respond fast enough for real-time CO_2 transport and pH control.

4 Why is the bicarbonate buffer system especially effective in the body, even though the pKa of carbonic acid is far from normal blood pH?

- A Because bicarbonate is a strong acid
- B **Because the system is "open": CO_2 can be removed by the lungs, shifting equilibrium ✓**
- C Because water is the strongest buffer in the body
- D Because hemoglobin destroys all H^+ ions
- E Because bicarbonate can only buffer bases, not acids

▶ **Explanation:** The bicarbonate system is powerful because the lungs can exhale CO_2 (a reactant/product of the buffer equilibrium), effectively extending buffering beyond what a closed system could do.

5 If a strong acid is added to blood, the immediate buffer response in the bicarbonate system is best described by:

- A **H^+ combines with HCO_3^- to form H_2CO_3, which can become $CO_2 + H_2O$ ✓**
- B H^+ combines with CO_2 to form glucose
- C H^+ is pumped directly into red blood cells and disappears
- D H^+ causes bicarbonate to become a stronger base

E H^+ binds to chloride to form hydrochloric acid gas

▶ **Explanation:** Added H^+ is buffered mainly by bicarbonate: $H^+ + HCO_3^- \rightarrow H_2CO_3 \rightarrow CO_2 + H_2O$. CO_2 can then be exhaled, helping remove the acid load.

6 Immediately after adding a strong acid to blood (before the lungs and kidneys compensate), which change is most likely?

- A **HCO_3^- decreases and CO_2 increases ✓**
- B HCO_3^- increases and CO_2 decreases
- C Both HCO_3^- and CO_2 decrease
- D Both HCO_3^- and CO_2 increase
- E Neither changes because buffers prevent all chemical change

▶ **Explanation:** Buffering consumes bicarbonate (so HCO_3^- falls) and forms carbonic acid that converts to CO_2 (so CO_2 rises). Compensation later may lower CO_2 via ventilation.

7 If a strong base is added to blood, which immediate buffer reaction best describes what happens?

- A **OH^- reacts with H_2CO_3 to form HCO_3^- and water ✓**
- B OH^- reacts with bicarbonate to form carbonic acid and water
- C OH^- is converted into CO_2 by carbonic anhydrase
- D OH^- causes hemoglobin to release oxygen immediately
- E Bases cannot be buffered in blood

▶ **Explanation:** A base (OH^-) is buffered when carbonic acid donates H^+: $OH^- + H_2CO_3 \rightarrow HCO_3^- + H_2O$. This consumes carbonic acid and increases bicarbonate.

8 **Blood pH depends strongly on the ratio of bicarbonate to dissolved CO2. Which statement is correct?**

A If both HCO3— and CO2 double, pH must increase

B **If both HCO3— and CO2 double, pH stays approximately the same because the ratio is unchanged** ✓

C pH depends only on CO2 and not on bicarbonate

D pH depends only on bicarbonate and not on CO2

E pH is independent of all buffers in blood

▶ **Explanation:** A key concept is ratio control: pH is mainly determined by the balance (ratio) of base (HCO3—) to acid (CO2/H2CO3). Changing both proportionally keeps the ratio similar.

9 **Which statement BEST explains why CO2 is sometimes called a "volatile acid" in physiology?**

A CO2 is a strong acid that burns tissues

B **CO2 can be converted to carbonic acid and then eliminated by exhalation** ✓

C CO2 is stored in bones as calcium carbonate

D CO2 is volatile because it evaporates from blood like alcohol

E CO2 is produced only in the lungs

▶ **Explanation:** CO2 is "volatile" because it can leave the body through the lungs. In water, CO2 relates to carbonic acid, so changing ventilation changes the acid component of the buffer system.

10 **Which organ system provides the fastest physiological compensation for a sudden acid load in blood?**

- A Liver (by making glycogen)
- B **Lungs (by changing ventilation and CO2 removal)** ✓
- C Kidneys (by changing transporter gene expression within minutes)
- D Bones (by growing longer)
- E Skin (by sweating out H^+ rapidly)

▶ **Explanation:** Ventilation can change within seconds to minutes, altering CO2 and therefore pH quickly. Kidneys are crucial for long-term acid-base control but act more slowly (hours to days).

11 **Which organ system is most important for long-term regulation of blood pH by managing non-volatile acids and bicarbonate levels?**

- A Lungs
- B **Kidneys** ✓
- C Salivary glands
- D Pancreas (via insulin only)
- E Skeletal muscle

▶ **Explanation:** Kidneys can excrete H^+ (non-volatile acid) and regenerate/adjust plasma bicarbonate, giving the body long-term control of the base component of the bicarbonate buffer system.

12 **Which scenario most directly causes metabolic acidosis at a basic level?**

- A Hyperventilation during a panic attack

- B **Diarrhea causing loss of bicarbonate-rich intestinal fluids ✓**
- C Holding your breath for 2 minutes
- D High altitude exposure for 1 hour
- E Vomiting stomach acid repeatedly

▶ **Explanation:** Metabolic acidosis is often caused by loss of bicarbonate or gain of non-volatile acids. Diarrhea can remove bicarbonate, lowering the base component (HCO3—).

13 Which scenario most directly causes metabolic alkalosis at a basic level?

- A Breathing very fast for several minutes
- B Retaining CO2 due to hypoventilation
- C **Repeated vomiting causing loss of gastric acid (HCl) ✓**
- D Running hard and producing lactic acid
- E Severe diarrhea with bicarbonate loss

▶ **Explanation:** Vomiting removes acid from the body. Losing H^+ shifts blood toward alkalinity (metabolic alkalosis). Diarrhea tends to cause acidosis via bicarbonate loss.

14 Which change is most consistent with respiratory acidosis?

- A Decreased CO2 due to hyperventilation
- B **Increased CO2 due to hypoventilation ✓**
- C Loss of bicarbonate due to diarrhea
- D Loss of stomach acid due to vomiting
- E Increased bicarbonate due to kidney failure

▶ **Explanation:** Respiratory acidosis is caused by a primary rise in CO2 (the acidic component) from inadequate ventilation, which shifts equilibrium toward more H^+ and lower pH.

15 **Which change is most consistent with respiratory alkalosis?**

- A Increased CO2 due to hypoventilation
- B **Decreased CO2 due to hyperventilation** ✓
- C Decreased bicarbonate due to diarrhea
- D Increased non-volatile acids due to kidney failure
- E Loss of bicarbonate due to vomiting

▶ **Explanation:** Respiratory alkalosis results from excessive CO2 removal by hyperventilation, lowering the acid component and raising pH.

16 **A patient has metabolic acidosis. What is the most expected immediate compensatory response?**

- A Hypoventilation to retain CO2 and raise pH
- B **Hyperventilation to lower CO2 and raise pH** ✓
- C Kidneys rapidly increase bicarbonate within seconds
- D The body stops producing CO2 entirely
- E Hemoglobin releases bicarbonate into plasma

▶ **Explanation:** In metabolic acidosis, the body often compensates quickly by increasing ventilation to reduce CO2 (acid), helping raise pH. Renal compensation is slower.

17 **A patient has respiratory acidosis due to chronic hypoventilation. Which long-term compensation is most expected?**

- A **Kidneys increase bicarbonate reabsorption/production and increase H^+ excretion** ✓
- B Kidneys excrete bicarbonate to fix the low pH
- C Lungs begin exhaling oxygen instead of CO2
- D Red blood cells stop producing carbonic anhydrase
- E Hemoglobin is converted into bicarbonate

▶ **Explanation:** With chronically high CO2, kidneys compensate by increasing the base component (HCO3—) and removing more H^+ in urine, helping bring pH closer to normal.

18 **A patient has metabolic alkalosis. Which respiratory compensation trend is most expected (even if limited)?**

- A Hyperventilation to decrease CO2
- B **Hypoventilation to increase CO2** ✓
- C No change in ventilation is possible
- D Ventilation increases until CO2 is zero
- E Ventilation decreases until oxygen becomes zero

▶ **Explanation:** In alkalosis, retaining CO2 (acid) by slightly reducing ventilation can help lower pH toward normal. This compensation is limited because the body must maintain oxygen levels.

19 **Hemoglobin is considered an important buffer in blood mainly because it can:**

- A Convert CO2 into O2

B **Bind H^+ and reduce free hydrogen ion concentration ✓**

C Destroy bicarbonate permanently

D Replace the kidneys in excreting acids

E Prevent CO_2 from entering red blood cells

▶ **Explanation:** Hemoglobin can accept (bind) H^+ ions, especially in tissues where CO_2 is converted to H^+ and HCO_3^-. This reduces changes in free H^+ and helps stabilize pH.

20 Which statement about hemoglobin buffering is most accurate?

A Oxygenated hemoglobin binds H^+ more strongly than deoxygenated hemoglobin

B **Deoxygenated hemoglobin tends to bind H^+ more readily, helping buffer acids in tissues ✓**

C Hemoglobin cannot bind H^+ because it only binds oxygen

D Hemoglobin buffers by converting H^+ into glucose

E Hemoglobin buffering occurs only in plasma, not in red blood cells

▶ **Explanation:** Deoxygenated hemoglobin is a better H^+ buffer. This helps tissues handle CO_2-derived H^+ while promoting oxygen release where it is needed.

21 The "chloride shift" in systemic tissues refers to:

A Cl^- leaving red blood cells when oxygen binds to hemoglobin

B **HCO_3^- leaving red blood cells into plasma while Cl^- enters to maintain electroneutrality ✓**

C Cl^- entering mitochondria to power ATP synthase

D Bicarbonate entering red blood cells only in tissues

E Chloride converting into carbonic acid in plasma

▶ **Explanation:** In tissues, CO_2 becomes HCO_3^- in RBCs. Bicarbonate exits into plasma for transport, and chloride enters RBCs to keep charge balanced (electroneutrality).

22 **In the lungs, which event best supports CO_2 exhalation based on the bicarbonate system?**

- A Bicarbonate exits RBCs so CO_2 stays dissolved in plasma
- B **Bicarbonate enters RBCs, combines with H^+ to form H_2CO_3, which becomes CO_2 to be exhaled** ✓
- C Carbonic anhydrase is turned off so CO_2 cannot form
- D Hemoglobin releases bicarbonate directly as a gas
- E Oxygen is converted into bicarbonate

▶ **Explanation:** In lungs, the process reverses: HCO_3^- re-enters RBCs, recombines with H^+ to form carbonic acid, which converts to $CO_2 + H_2O$, allowing CO_2 to be exhaled.

23 **Which best describes the role of plasma proteins (like albumin) in acid–base balance?**

- A They function only as enzymes and do not affect pH
- B **They act as buffers by accepting or donating H^+ depending on pH** ✓
- C They directly exhale CO_2 through the skin
- D They neutralize acids by becoming glucose
- E They replace bicarbonate entirely in blood

▶ **Explanation:** Proteins contain groups that can bind or release H^+, making them effective buffers. They complement bicarbonate, especially in plasma and inside cells.

24 **Which buffer system is especially important inside cells and in kidney tubules (urine), rather than being the main buffer in plasma?**

- A Bicarbonate buffer
- B **Phosphate buffer (H2PO4—/HPO42—)** ✓
- C Sodium chloride buffer
- D Glucose buffer
- E Oxygen buffer

▶ **Explanation:** Phosphate buffers are more influential in intracellular fluid and the renal tubular system. In plasma, bicarbonate is dominant because it links to CO2 removal by the lungs.

25 **Which statement BEST distinguishes "buffering" from "compensation" in physiology?**

- A Buffering is done by the brain; compensation is done by the heart
- B **Buffering is immediate chemical binding of H^+; compensation is physiological adjustment by organs (lungs/kidneys) over time** ✓
- C Buffering changes pH permanently; compensation never changes pH
- D Compensation occurs first, then buffering occurs later
- E They mean exactly the same thing

▶ **Explanation:** Buffers act immediately by chemical reactions that bind/release H^+. Compensation involves organ-level responses (changing CO2 via breathing; changing H^+ and HCO3— via kidneys).

26 **Which statement correctly uses the terms acidemia and acidosis?**

- A Acidemia is the process; acidosis is the measured low blood pH

- B **Acidosis is the process that tends to lower pH; acidemia means the blood pH is actually low ✓**
- C Acidosis and acidemia both mean the same thing: any increase in CO2
- D Acidemia refers only to kidney problems; acidosis refers only to lung problems
- E Acidemia means high blood sugar; acidosis means low blood sugar

▶ **Explanation:** Acidosis is a cause/process that pushes pH down. Acidemia is the actual state of low blood pH. A person can have an acidosis process with near-normal pH if compensation is strong.

27 A student says: "If someone is in acidosis, their blood pH must always be low." What is the best correction?

- A Correct: compensation is impossible in humans
- B **Incorrect: compensation can bring pH closer to normal even when an acidosis process is present ✓**
- C Correct: acidosis always means pH below 6
- D Incorrect: blood pH never changes in any disease
- E Correct: acidosis refers only to low bicarbonate, not to pH

▶ **Explanation:** Acidosis is a process that pushes pH down; compensation (respiratory or renal) can partially correct pH. Therefore pH can be near normal in compensated states.

28 A person suddenly hyperventilates due to anxiety. Which primary acid–base disturbance is most likely first?

- A Metabolic acidosis
- B Metabolic alkalosis
- C **Respiratory alkalosis ✓**
- D Respiratory acidosis

E No disturbance because breathing cannot affect pH

▶ **Explanation:** Hyperventilation lowers CO2 quickly, reducing the acid component of the bicarbonate system and raising pH (respiratory alkalosis).

29 A person holds their breath for a prolonged time. Which primary acid–base disturbance is most likely first?

- A **Respiratory acidosis ✓**
- B Respiratory alkalosis
- C Metabolic alkalosis
- D Metabolic acidosis
- E No disturbance because CO2 is not related to pH

▶ **Explanation:** Holding your breath retains CO2, increasing the acid component (CO2/H2CO3) and lowering pH: respiratory acidosis.

30 Which statement about where carbonic anhydrase is especially abundant is most accurate?

- A It is found only in the lungs, not in blood
- B **It is abundant in red blood cells and also important in kidney tubule cells ✓**
- C It is found only in bone marrow to make platelets
- D It is found only in mitochondria to run the electron transport chain
- E It is found only in the brain for neurotransmitters

▶ **Explanation:** Carbonic anhydrase is crucial in RBCs for fast CO2 transport and in kidneys for acid secretion and bicarbonate handling. It is not restricted to the lungs.

31 **Why is pure water a poor buffer at physiological pH?**

A Because water is not polar

B Because water contains no H^+ ions at all

C **Because effective buffers require a weak acid/conjugate base pair at useful concentrations; water's autoionization is minimal at pH ~7** ✓

D Because water is a strong base

E Because water reacts only with salts, not with acids

▶ **Explanation:** Water does self-ionize, but the concentrations of H^+ and OH— are very small at neutral pH. Buffers work because they contain a weak acid/base pair in significant amounts.

32 **In the bicarbonate buffer system, bicarbonate (HCO3—) is best described as the:**

A Strong acid component

B **Conjugate base that can accept H^+** ✓

C Enzyme that catalyzes CO2 breakdown

D Gas that is exhaled by the lungs

E Protein buffer found in hemoglobin

▶ **Explanation:** HCO3— is the base form that binds H^+ to form carbonic acid. CO2 is the gas that links this buffer to breathing.

33 **Which statement best describes why exhaling CO2 can raise blood pH?**

A Exhaling CO_2 removes oxygen, which directly increases pH

B **Removing CO_2 shifts the equilibrium away from H^+ production (Le Chatelier's principle), lowering $[H^+]$** ✓

C CO_2 is a base, so exhaling it removes base and raises pH

D Exhaling CO_2 converts acids into salts in the lungs

E Exhaling CO_2 increases bicarbonate instantly without any equilibrium

▶ **Explanation:** CO_2 is tied to H^+ through the bicarbonate equilibrium. Removing CO_2 pulls the reaction toward CO_2 formation, consuming H^+ and thereby increasing pH.

34 **Which blood pH range is considered normal in most physiology references?**

A 6.0–6.5

B 6.8–7.0

C **7.35–7.45** ✓

D 7.8–8.2

E 9.0–10.0

▶ **Explanation:** Normal arterial blood pH is tightly regulated around ~7.4, commonly given as 7.35–7.45. Values outside this range can disrupt protein and enzyme function.

35 **A student says: "If CO_2 increases, pH should increase too because CO_2 is neutral." Which is the best correction?**

A Correct: CO_2 cannot affect pH in water

B **Incorrect: CO_2 reacts with water to form carbonic acid, increasing H^+ and lowering pH** ✓

C Incorrect: CO_2 directly turns into NaOH, raising pH

D Correct: only kidneys control pH, never lungs

E Incorrect: CO_2 is a strong base, so it lowers pH

▶ **Explanation:** CO_2 is linked to carbonic acid formation: $CO_2 + H_2O$ H_2CO_3 $H^+ + HCO_3-$. More CO_2 drives the reaction toward more H^+, lowering pH.

36 Which statement correctly matches a primary disturbance with the first variable that changes?

A Respiratory acidosis: primary fall in bicarbonate

B **Metabolic alkalosis: primary rise in bicarbonate (or loss of H^+)** ✓

C Respiratory alkalosis: primary rise in bicarbonate

D Metabolic acidosis: primary rise in CO_2

E Metabolic acidosis: primary rise in pH

▶ **Explanation:** Respiratory disorders primarily change CO_2 (ventilation). Metabolic disorders primarily change bicarbonate (base) or non-volatile acid levels. Metabolic alkalosis often shows increased bicarbonate or effective H^+ loss.

37 A patient's blood shows low pH and high CO_2. The primary disturbance is most likely:

A **Respiratory acidosis** ✓

B Respiratory alkalosis

C Metabolic alkalosis

D Metabolic acidosis with full respiratory compensation

E No disturbance; this is normal

▶ **Explanation:** High CO_2 pushes pH down. That combination points to respiratory acidosis as the primary problem (CO_2 retention).

38 **A patient's blood shows low pH and low bicarbonate. The primary disturbance is most likely:**

- A **Metabolic acidosis ✓**
- B Metabolic alkalosis
- C Respiratory alkalosis
- D Respiratory acidosis
- E Normal physiology

▶ **Explanation:** A drop in bicarbonate (base) is the hallmark of metabolic acidosis. CO_2 may also drop later if the lungs compensate, but the primary change is low HCO_3^-.

39 **A patient has low pH, low bicarbonate, and low CO_2. Which interpretation is best?**

- A Primary respiratory alkalosis with renal compensation
- B **Primary metabolic acidosis with respiratory compensation ✓**
- C Primary respiratory acidosis with metabolic compensation
- D Primary metabolic alkalosis with respiratory compensation
- E No acid-base disturbance because two variables are low

▶ **Explanation:** Low pH indicates acidemia. Low bicarbonate suggests a metabolic acidosis primary problem. Low CO_2 fits compensation: the lungs hyperventilate to lower CO_2 (acid) and raise pH toward normal.

40 **A patient has high pH, low CO2, and low bicarbonate. Which interpretation is best?**

- A **Primary respiratory alkalosis with renal compensation** ✓
- B Primary metabolic alkalosis with respiratory compensation
- C Primary metabolic acidosis with respiratory compensation
- D Primary respiratory acidosis with renal compensation
- E No disturbance because bicarbonate is low

▶ **Explanation:** High pH indicates alkalemia. Low CO2 points to respiratory alkalosis as the primary change. The low bicarbonate is consistent with kidney compensation (excreting bicarbonate) over time.

41 **Which change would most directly increase blood pH (all else equal)?**

- A Increase CO2 while keeping bicarbonate constant
- B **Decrease CO2 while keeping bicarbonate constant** ✓
- C Decrease bicarbonate while keeping CO2 constant
- D Increase H^+ while keeping CO2 constant
- E Increase lactic acid production while keeping ventilation constant

▶ **Explanation:** Lower CO2 reduces the acid component of the bicarbonate system, lowering H^+ and raising pH. Decreasing bicarbonate or increasing acids lowers pH.

42 **Which change would most directly decrease blood pH (all else equal)?**

- A Increase bicarbonate while CO2 stays constant
- B Decrease CO2 while bicarbonate stays constant

C **Increase CO_2 while bicarbonate stays constant ✓**

D Decrease H^+ concentration

E Increase ventilation

▶ **Explanation:** More CO_2 shifts the equilibrium toward more H^+ production, lowering pH. Increasing ventilation would tend to lower CO_2 and raise pH.

43 Which statement about compensation is correct?

A Compensation always returns pH exactly to 7.40 in all cases

B **Compensation can reduce the pH change, but it may not fully normalize pH if the primary problem is severe ✓**

C Compensation always changes the same variable that caused the problem

D Only the kidneys can compensate for any acid-base disturbance

E Only the lungs can compensate for any acid-base disturbance

▶ **Explanation:** Compensation aims to move pH toward normal, not necessarily to perfectly normalize it. It often involves a different system than the one causing the disturbance (lungs compensate metabolic problems; kidneys compensate respiratory problems).

44 During intense exercise, lactic acid production increases. Which immediate blood buffer system helps resist the drop in pH?

A **Bicarbonate buffer (and hemoglobin/protein buffers) binding added H^+ ✓**

B Peptidoglycan buffer in plasma

C Cell wall buffer in red blood cells

D DNA buffer inside the nucleus

E ATP synthase removing H^+ by making ATP in plasma

▶ **Explanation:** Added H^+ from acids is buffered quickly by chemical buffers, especially bicarbonate in plasma and proteins/hemoglobin in blood cells. Ventilation can also increase as a compensatory response.

45 Which statement about kidney action in acid–base balance is MOST accurate at a basic level?

- A Kidneys can eliminate CO2 directly by filtration
- B **Kidneys primarily control blood pH by adjusting H^+ excretion and bicarbonate handling over time** ✓
- C Kidneys control pH mainly by changing hemoglobin levels
- D Kidneys compensate within seconds by changing breathing rate
- E Kidneys do not influence blood pH

▶ **Explanation:** Kidneys manage non-volatile acid and the bicarbonate "base reserve." They can excrete H^+ and conserve or generate bicarbonate, but these effects take hours to days.

46 A student claims: "Bicarbonate is the acid in the buffer system." What is the best correction?

- A Correct: bicarbonate is a strong acid that donates H^+ readily
- B **Incorrect: bicarbonate is the conjugate base; the acid form is carbonic acid (closely linked to CO2 in blood)** ✓
- C Incorrect: bicarbonate is neither acid nor base and does not affect pH
- D Correct: bicarbonate is the enzyme that makes CO2
- E Correct: bicarbonate is oxygen dissolved in blood

▶ **Explanation:** In the bicarbonate buffer, HCO3– is the conjugate base that accepts H^+. The acid side is carbonic acid (H2CO3), which is in equilibrium with CO2 + H2O.

47 **A patient has metabolic acidosis. Their breathing becomes deep and rapid. Which statement best explains the benefit of this breathing pattern?**

- A It increases CO2 to neutralize acid
- B **It lowers CO2, pulling the buffer reaction to consume H^+ and raise pH** ✓
- C It prevents kidneys from excreting acid
- D It increases bicarbonate instantly by secretion from the lungs
- E It converts lactic acid into glucose in the alveoli

▶ **Explanation:** Deep/rapid breathing increases CO2 elimination. Lower CO2 shifts the bicarbonate equilibrium toward less H^+, helping oppose metabolic acidosis (classic respiratory compensation).

48 **High altitude often causes hyperventilation. What primary acid–base effect does this tend to cause initially?**

- A Respiratory acidosis because oxygen is low
- B **Respiratory alkalosis because CO2 is blown off** ✓
- C Metabolic acidosis because bicarbonate rises
- D Metabolic alkalosis because lactic acid rises
- E No effect on pH because altitude affects only oxygen, not CO2

▶ **Explanation:** Hyperventilation lowers CO2, increasing pH (respiratory alkalosis). Over time, kidneys can compensate by excreting bicarbonate to bring pH closer to normal.

49 Which statement best links blood buffering to oxygen delivery in tissues (concept level)?

A When H^+ rises, hemoglobin binds oxygen more tightly, so tissues receive more oxygen

B When H^+ rises (more acidic), hemoglobin tends to release oxygen more easily, supporting oxygen delivery where metabolism is high ✓

C Oxygen delivery is unrelated to CO2 and H^+ in any situation

D Bicarbonate binds oxygen directly, carrying it to tissues

E Only phosphate buffer affects oxygen delivery

▶ **Explanation:** Higher CO2 and H^+ in active tissues shifts hemoglobin toward releasing O2 more readily (Bohr effect concept). This links metabolism, buffering chemistry, and oxygen delivery.

50 Which statement best describes what happens in the lungs that helps remove CO2 from the blood (hard concept, simplified)?

A Oxygen binding to hemoglobin can promote release of H^+, which helps convert bicarbonate back into CO2 for exhalation ✓

B Oxygen binding to hemoglobin permanently destroys bicarbonate

C CO2 is exhaled because it is filtered by the kidney first

D CO2 is removed mainly by platelets carrying it to the alveoli

E CO2 leaves blood only when blood becomes alkaline, never otherwise

▶ **Explanation:** In the lungs, oxygenation of hemoglobin favors releasing H^+. Those H^+ can combine with bicarbonate to form carbonic acid, which becomes CO2 + H2O, supporting CO2 exhalation (a key idea behind efficient CO2 unloading).