

MCAT Chemical and Physical Foundations of Biological Systems

Practice Test 1

MCAT Chemical and Physical Foundations of Biological Systems • Form 1

Directions. This is an original independent practice form designed to mirror the current MCAT section structure. Select the best answer for each question. Do not use the answer fields or explanations until you have completed the form. **Timing.** 95 minutes. The practice form uses the AAMC section timing; it is not an official AAMC form and does not produce an official scaled score. **Blueprint note.** Foundational Concepts 4 and 5; approximate disciplines: general chemistry 30%, biochemistry 25%, physics 25%, organic chemistry 15%, biology 5%; Skills 1-4.

Passage 1: Gas exchange

A research team investigated alveolar diffusion using a controlled comparison. The investigators varied the partial-pressure gradient and kept the other stated conditions as constant as possible. Their working model was that increasing the partial-pressure gradient increases the driving force for diffusion across the membrane. The pilot results were not interpreted from a single observation. Replicate samples were measured, the outcome was recorded before and after the manipulation, and a comparison condition was included. Data summary: At the larger gradient, oxygen-transfer rate was 18 percent higher while membrane thickness and surface area were unchanged. The team concluded that a larger gradient provides a larger driving force for net diffusion. The conclusion is limited to the variables measured; it does not establish that every related system behaves identically.

1. Which observation from the study most directly supports the proposed relationship involving alveolar diffusion?
 - A. Membrane thickness cannot affect the rate of transfer.
 - B. Increasing the partial-pressure gradient increases the driving force for diffusion across the membrane.
 - C. A larger gradient guarantees unlimited transfer regardless of membrane properties.
 - D. The equilibrium constant changes solely because the gradient changes.
2. If the partial-pressure gradient increases while the other stated conditions remain fixed, which result best follows from the passage's model?
 - A. Membrane thickness cannot affect the rate of transfer.
 - B. The rate of oxygen transfer into blood increases.
 - C. A larger gradient guarantees unlimited transfer regardless of membrane properties.
 - D. The equilibrium constant changes solely because the gradient changes.
3. Which comparison would most directly test whether the observed result is caused by the partial-pressure gradient rather than by a competing variable?
 - A. The equilibrium constant changes solely because the gradient changes.
 - B. Measure diffusion with membrane thickness held constant.
 - C. A second sample with the same membrane shows the predicted increase.
 - D. A larger gradient guarantees unlimited transfer regardless of membrane properties.
4. In a related system, the partial-pressure gradient increases while the other stated conditions remain fixed. Which prediction best transfers the mechanism?

- A. A larger gradient guarantees unlimited transfer regardless of membrane properties.
 - B. Measure diffusion with membrane thickness held constant.
 - C. The equilibrium constant changes solely because the gradient changes.
 - D. The rate of oxygen transfer into blood increases.
5. Which additional result would most strengthen the claim about alveolar diffusion?
- A. A larger gradient guarantees unlimited transfer regardless of membrane properties.
 - B. The equilibrium constant changes solely because the gradient changes.
 - C. Membrane thickness cannot affect the rate of transfer.
 - D. A second sample with the same membrane shows the predicted increase.

Passage 2: Buffer chemistry

A research team investigated acid-base buffering using a controlled comparison. The investigators varied the amount of added strong acid and kept the other stated conditions as constant as possible. Their working model was that a buffer resists a large pH change because its conjugate base consumes much of the added hydrogen ion. The pilot results were not interpreted from a single observation. Replicate samples were measured, the outcome was recorded before and after the manipulation, and a comparison condition was included. Data summary: The buffered sample changed by 0.18 pH units after the acid addition, whereas the unbuffered comparison changed by 1.21 units. The team concluded that the conjugate base reacts with added hydrogen ion before free hydrogen ion accumulates. The conclusion is limited to the variables measured; it does not establish that every related system behaves identically.

6. Which observation from the study most directly supports the proposed relationship involving acid-base buffering?
- A. A buffered sample changes pH by exactly the same amount as pure water.
 - B. Conjugate-base concentration has no bearing on the buffer's pH.
 - C. A buffer resists a large pH change because its conjugate base consumes much of the added hydrogen ion.
 - D. The pH becomes exactly 7 after any amount of added acid.
7. If the amount of added strong acid increases while the other stated conditions remain fixed, which result best follows from the passage's model?
- A. A buffered sample changes pH by exactly the same amount as pure water.
 - B. Conjugate-base concentration has no bearing on the buffer's pH.
 - C. The pH decreases only modestly after a small acid addition.
 - D. The pH becomes exactly 7 after any amount of added acid.
8. Which comparison would most directly test whether the observed result is caused by the amount of added strong acid rather than by a competing variable?
- A. A buffered sample changes pH by exactly the same amount as pure water.
 - B. Compare equal-volume buffer samples receiving different known amounts of strong acid while keeping conjugate-base concentration and temperature fixed.
 - C. The unbuffered control shows a much larger pH change.

- D. The pH becomes exactly 7 after any amount of added acid.
9. In a related system, the amount of added strong acid increases while the other stated conditions remain fixed. Which prediction best transfers the mechanism?
- A. A buffered sample changes pH by exactly the same amount as pure water.
 - B. The pH decreases only modestly after a small acid addition.
 - C. Compare equal-volume buffer samples receiving different known amounts of strong acid while keeping conjugate-base concentration and temperature fixed.
 - D. The pH becomes exactly 7 after any amount of added acid.
10. Which additional result would most strengthen the claim about acid-base buffering?
- A. The pH becomes exactly 7 after any amount of added acid.
 - B. A buffered sample changes pH by exactly the same amount as pure water.
 - C. Conjugate-base concentration has no bearing on the buffer's pH.
 - D. The unbuffered control shows a much larger pH change.

Passage 3: Enzyme energetics

A research team investigated activation energy using a controlled comparison. The investigators varied the concentration of catalyst and kept the other stated conditions as constant as possible. Their working model was that a catalyst increases reaction rate by lowering the activation-energy barrier without changing the equilibrium constant. The pilot results were not interpreted from a single observation. Replicate samples were measured, the outcome was recorded before and after the manipulation, and a comparison condition was included. Data summary: The catalyzed reaction reached the same final product ratio sooner than the uncatalyzed reaction at the same temperature. The team concluded that the catalyst changes the pathway and rate but not the energy difference between reactants and products. The conclusion is limited to the variables measured; it does not establish that every related system behaves identically.

11. Which observation from the study most directly supports the proposed relationship involving activation energy?
- A. A catalyst increases reaction rate by lowering the activation-energy barrier without changing the equilibrium constant.
 - B. A catalyst changes the equilibrium constant without changing the reaction conditions.
 - C. Only the reverse reaction's activation barrier can be lowered.
 - D. At equilibrium, the products disappear as quickly as they form.
12. If catalyst concentration increases while the other stated conditions remain fixed, which result best follows from the passage's model?
- A. The system reaches equilibrium sooner while the final equilibrium composition remains the same.
 - B. A catalyst changes the equilibrium constant without changing the reaction conditions.
 - C. Only the reverse reaction's activation barrier can be lowered.
 - D. At equilibrium, the products disappear as quickly as they form.

13. Which comparison would most directly test whether the observed result is caused by the concentration of catalyst rather than by a competing variable?
- A. Both reaction directions speed up by comparable factors.
 - B. A catalyst changes the equilibrium constant without changing the reaction conditions.
 - C. Only the reverse reaction's activation barrier can be lowered.
 - D. Compare catalyzed and uncatalyzed reactions at the same temperature and starting concentrations.
14. In a related system, catalyst concentration is increased while the other stated conditions remain fixed. Which prediction best transfers the mechanism?
- A. A catalyst changes the equilibrium constant without changing the reaction conditions.
 - B. Only the reverse reaction's activation barrier can be lowered.
 - C. The system reaches equilibrium sooner while the final equilibrium composition remains the same.
 - D. Compare catalyzed and uncatalyzed reactions at the same temperature and starting concentrations.
15. Which additional result would most strengthen the claim about activation energy?
- A. A catalyst changes the equilibrium constant without changing the reaction conditions.
 - B. Only the reverse reaction's activation barrier can be lowered.
 - C. At equilibrium, the products disappear as quickly as they form.
 - D. Both reaction directions speed up by comparable factors.

Passage 4: Fluid resistance

A research team investigated vascular flow using a controlled comparison. The investigators varied the radius of a vessel and kept the other stated conditions as constant as possible. Their working model was that small changes in vessel radius can produce large changes in flow because resistance is strongly radius-dependent. The pilot results were not interpreted from a single observation. Replicate samples were measured, the outcome was recorded before and after the manipulation, and a comparison condition was included. Data summary: Doubling vessel radius increased measured flow by much more than twofold when pressure difference and viscosity were fixed. The team concluded that the radius appears with a high power in the flow relationship. The conclusion is limited to the variables measured; it does not establish that every related system behaves identically.

16. Which observation from the study most directly supports the proposed relationship involving vascular flow?
- A. Flow is independent of vessel radius when pressure is fixed.
 - B. Viscosity cannot affect flow when radius changes.
 - C. Changing radius forces the pressure difference to reverse.
 - D. Small changes in vessel radius can produce large changes in flow because resistance is strongly radius-dependent.
17. If the radius of a vessel increases while the other stated conditions remain fixed, which result best follows from the passage's model?
- A. Changing radius forces the pressure difference to reverse.
 - B. Increasing radius increases flow when the pressure difference and viscosity remain fixed.

- C. Flow is independent of vessel radius when pressure is fixed.
 - D. Viscosity cannot affect flow when radius changes.
18. Which comparison would most directly test whether the observed result is caused by the radius of a vessel rather than by a competing variable?
- A. Viscosity cannot affect flow when radius changes.
 - B. Hold pressure difference, vessel length, and fluid viscosity constant.
 - C. Measured flow rises more than proportionally as radius increases.
 - D. Flow is independent of vessel radius when pressure is fixed.
19. In a related system, the radius of a vessel increases while the other stated conditions remain fixed. Which prediction best transfers the mechanism?
- A. Flow is independent of vessel radius when pressure is fixed.
 - B. Viscosity cannot affect flow when radius changes.
 - C. Increasing radius increases flow when the pressure difference and viscosity remain fixed.
 - D. Hold pressure difference, vessel length, and fluid viscosity constant.
20. Which additional result would most strengthen the claim about vascular flow?
- A. Viscosity cannot affect flow when radius changes.
 - B. Changing radius forces the pressure difference to reverse.
 - C. Measured flow rises more than proportionally as radius increases.
 - D. Flow is independent of vessel radius when pressure is fixed.

Passage 5: Electrochemistry

A research team investigated cell potential using a controlled comparison. The investigators varied the concentration ratio of reaction species and kept the other stated conditions as constant as possible. Their working model was that cell potential depends on the reaction quotient as well as the standard potential. The pilot results were not interpreted from a single observation. Replicate samples were measured, the outcome was recorded before and after the manipulation, and a comparison condition was included. Data summary: Changing the reaction quotient shifted the measured cell potential in the direction predicted by the Nernst relationship. The team concluded that the Nernst relationship includes the logarithm of the reaction quotient. The conclusion is limited to the variables measured; it does not establish that every related system behaves identically.

21. Which observation from the study most directly supports the proposed relationship involving cell potential?
- A. Cell voltage is fixed by electrode labels alone.
 - B. Ion concentration cannot affect cell potential.
 - C. Electron transfer cannot occur through the external circuit.
 - D. Cell potential depends on the reaction quotient as well as the standard potential.
22. If the concentration ratio of reaction species increases while the other stated conditions remain fixed, which result best follows from the passage's model?

- A. Cell voltage is fixed by electrode labels alone.
 - B. Ion concentration cannot affect cell potential.
 - C. Electron transfer cannot occur through the external circuit.
 - D. Changing ion concentrations can change the measured cell voltage.
23. Which comparison would most directly test whether the observed result is caused by the concentration ratio of reaction species rather than by a competing variable?
- A. The voltage shifts predictably when the reaction quotient changes.
 - B. Cell voltage is fixed by electrode labels alone.
 - C. Ion concentration cannot affect cell potential.
 - D. Use identical electrodes and temperature while varying only the solution composition.
24. In a related system, the concentration ratio of reaction species increases while the other stated conditions remain fixed. Which prediction best transfers the mechanism?
- A. Ion concentration cannot affect cell potential.
 - B. Changing ion concentrations can change the measured cell voltage.
 - C. Use identical electrodes and temperature while varying only the solution composition.
 - D. Cell voltage is fixed by electrode labels alone.

Passage 6: Optics and imaging

A research team investigated lens formation using a controlled comparison. The investigators varied the curvature of a converging lens and kept the other stated conditions as constant as possible. Their working model was that changing lens curvature changes focal length and therefore the location of a formed image. The pilot results were not interpreted from a single observation. Replicate samples were measured, the outcome was recorded before and after the manipulation, and a comparison condition was included. Data summary: The lens with greater curvature formed a sharp image at a shorter focal length when object distance was held constant. The team concluded that focal length is determined by optical power, which depends on curvature and refractive index. The conclusion is limited to the variables measured; it does not establish that every related system behaves identically.

25. Which observation from the study most directly supports the proposed relationship involving lens formation?
- A. Image distance is always equal to object distance.
 - B. Changing lens curvature changes focal length and therefore the location of a formed image.
 - C. Focal length is determined only by object brightness.
 - D. A curved interface cannot refract light.
26. If the curvature of a converging lens increases while the other stated conditions remain fixed, which result best follows from the passage's model?
- A. A curved interface cannot refract light.
 - B. Image distance is always equal to object distance.
 - C. A more strongly converging lens has a shorter focal length.

- D. Focal length is determined only by object brightness.
27. Which comparison would most directly test whether the observed result is caused by the curvature of a converging lens rather than by a competing variable?
- A. Focal length is determined only by object brightness.
 - B. A curved interface cannot refract light.
 - C. Keep object distance and refractive index constant.
 - D. Independent focal-length measurements shift in the predicted direction.
28. In a related system, the curvature of a converging lens increases while the other stated conditions remain fixed. Which prediction best transfers the mechanism?
- A. A more strongly converging lens has a shorter focal length.
 - B. Keep object distance and refractive index constant.
 - C. Focal length is determined only by object brightness.
 - D. A curved interface cannot refract light.

Passage 7: Organic functional groups

A research team investigated carbonyl reactivity using a controlled comparison. The investigators varied the electron-withdrawing strength near a carbonyl and kept the other stated conditions as constant as possible. Their working model was that electron-withdrawing groups can increase the electrophilic character of a carbonyl carbon. The pilot results were not interpreted from a single observation. Replicate samples were measured, the outcome was recorded before and after the manipulation, and a comparison condition was included. Data summary: The substrate with the stronger electron-withdrawing group reacted faster with the same nucleophile under matched conditions. The team concluded that electron withdrawal leaves the carbonyl carbon more electron-poor. The conclusion is limited to the variables measured; it does not establish that every related system behaves identically.

29. Which observation from the study most directly supports the proposed relationship involving carbonyl reactivity?
- A. Substituents cannot alter electron density near a carbonyl.
 - B. Electron-withdrawing groups can increase the electrophilic character of a carbonyl carbon.
 - C. The carbonyl carbon acts as a nucleophile in every reaction.
 - D. Related carbonyl compounds must have identical reaction rates.
30. If the electron-withdrawing strength near a carbonyl increases while the other stated conditions remain fixed, which result best follows from the passage's model?
- A. A nucleophile attacks the carbonyl carbon more readily.
 - B. The carbonyl carbon acts as a nucleophile in every reaction.
 - C. Related carbonyl compounds must have identical reaction rates.
 - D. Substituents cannot alter electron density near a carbonyl.
31. Which comparison would most directly test whether the observed result is caused by the electron-withdrawing strength near a carbonyl rather than by a competing variable?

- A. Compare substrates with the same carbon skeleton and different substituents.
 - B. The more electron-poor substrate reacts faster under matched conditions.
 - C. The carbonyl carbon acts as a nucleophile in every reaction.
 - D. Related carbonyl compounds must have identical reaction rates.
32. In a related system, the electron-withdrawing strength near a carbonyl increases while the other stated conditions remain fixed. Which prediction best transfers the mechanism?
- A. Related carbonyl compounds must have identical reaction rates.
 - B. A nucleophile attacks the carbonyl carbon more readily.
 - C. The carbonyl carbon acts as a nucleophile in every reaction.
 - D. Compare substrates with the same carbon skeleton and different substituents.

Passage 8: Thermodynamics

A research team investigated free-energy change using a controlled comparison. The investigators varied the temperature of a reaction with a favorable entropy change and kept the other stated conditions as constant as possible. Their working model was that at fixed enthalpy, increasing temperature makes the negative entropy term more influential in the gibbs free-energy change. The pilot results were not interpreted from a single observation. Replicate samples were measured, the outcome was recorded before and after the manipulation, and a comparison condition was included. Data summary: The process became favorable only above the temperature at which the entropy term outweighed the unfavorable enthalpy term. The team concluded that Gibbs free energy combines enthalpy with the temperature-weighted entropy change. The conclusion is limited to the variables measured; it does not establish that every related system behaves identically.

33. Which observation from the study most directly supports the proposed relationship involving free-energy change?
- A. Enthalpy and entropy are interchangeable measures of energy.
 - B. At fixed enthalpy, increasing temperature makes the negative entropy term more influential in the Gibbs free-energy change.
 - C. A positive entropy change guarantees spontaneity at every temperature.
 - D. Temperature cannot affect the Gibbs free-energy change.
34. If the temperature of a reaction with a favorable entropy change increases while the other stated conditions remain fixed, which result best follows from the passage's model?
- A. A positive entropy change guarantees spontaneity at every temperature.
 - B. Temperature cannot affect the Gibbs free-energy change.
 - C. Enthalpy and entropy are interchangeable measures of energy.
 - D. The process becomes more favorable as temperature rises when the entropy change is positive.
35. Which comparison would most directly test whether the observed result is caused by the temperature of a reaction with a favorable entropy change rather than by a competing variable?
- A. Compare the same reaction at several temperatures while holding pressure and reactant amounts constant and estimating enthalpy and entropy under each condition.

- B. The reaction becomes favorable only above a temperature threshold.
 - C. A positive entropy change guarantees spontaneity at every temperature.
 - D. Temperature cannot affect the Gibbs free-energy change.
36. In a related system, the temperature of a reaction with a favorable entropy change increases while the other stated conditions remain fixed. Which prediction best transfers the mechanism?
- A. The process becomes more favorable as temperature rises when the entropy change is positive.
 - B. Compare the same reaction at several temperatures while holding pressure and reactant amounts constant and estimating enthalpy and entropy under each condition.
 - C. A positive entropy change guarantees spontaneity at every temperature.
 - D. Temperature cannot affect the Gibbs free-energy change.

Passage 9: Membrane transport

A research team investigated electrochemical gradients using a controlled comparison. The investigators varied the concentration gradient of an ion and kept the other stated conditions as constant as possible. Their working model was that net ion movement reflects both concentration and electrical gradients across the membrane. The pilot results were not interpreted from a single observation. Replicate samples were measured, the outcome was recorded before and after the manipulation, and a comparison condition was included. Data summary: With voltage fixed, increasing the ion concentration ratio increased the initial current through the open channels. The team concluded that an ion responds to the combined electrochemical gradient. The conclusion is limited to the variables measured; it does not establish that every related system behaves identically.

37. Which observation from the study most directly supports the proposed relationship involving electrochemical gradients?
- A. ATP is required for every form of membrane movement.
 - B. Membrane composition cannot affect solute flux.
 - C. Net ion movement reflects both concentration and electrical gradients across the membrane.
 - D. Passive transport moves solute against its electrochemical gradient without energy input.
38. If the concentration gradient of an ion increases while the other stated conditions remain fixed, which result best follows from the passage's model?
- A. Membrane composition cannot affect solute flux.
 - B. Net ion movement initially increases in the direction favored by the larger concentration gradient.
 - C. Passive transport moves solute against its electrochemical gradient without energy input.
 - D. ATP is required for every form of membrane movement.
39. Which comparison would most directly test whether the observed result is caused by the concentration gradient of an ion rather than by a competing variable?
- A. Passive transport moves solute against its electrochemical gradient without energy input.
 - B. ATP is required for every form of membrane movement.
 - C. Keep membrane voltage and channel number fixed while varying the ion concentration ratio.
 - D. The reversal potential shifts when the concentration ratio changes.

40. In a related system, the concentration gradient of an ion increases while the other stated conditions remain fixed. Which prediction best transfers the mechanism?
- A. Net ion movement initially increases in the direction favored by the larger concentration gradient.
 - B. ATP is required for every form of membrane movement.
 - C. Passive transport moves solute against its electrochemical gradient without energy input.
 - D. Keep membrane voltage and channel number fixed while varying the ion concentration ratio.

Passage 10: Nuclear chemistry

A research team investigated radioactive decay using a controlled comparison. The investigators varied the elapsed time after a sample is prepared and kept the other stated conditions as constant as possible. Their working model was that radioactive decay follows a characteristic half-life that is independent of the initial amount. The pilot results were not interpreted from a single observation. Replicate samples were measured, the outcome was recorded before and after the manipulation, and a comparison condition was included. Data summary: Samples of different starting activity lost the same fraction, rather than the same number of nuclei, during one half-life. The team concluded that each half-life removes half of the nuclei present at its beginning. The conclusion is limited to the variables measured; it does not establish that every related system behaves identically.

41. Which observation from the study most directly supports the proposed relationship involving radioactive decay?
- A. Radioactive decay follows a characteristic half-life that is independent of the initial amount.
 - B. The same absolute number of nuclei disappears during every equal time interval.
 - C. Half-life changes when the amount of sample changes.
 - D. Radioactive decay requires a catalyst to proceed.
42. If the elapsed time after a sample is prepared increases while the other stated conditions remain fixed, which result best follows from the passage's model?
- A. Half-life changes when the amount of sample changes.
 - B. Radioactive decay requires a catalyst to proceed.
 - C. After one half-life, approximately half of the original radioactive nuclei remain.
 - D. The same absolute number of nuclei disappears during every equal time interval.
43. Which comparison would most directly test whether the observed result is caused by the elapsed time after a sample is prepared rather than by a competing variable?
- A. Half-life changes when the amount of sample changes.
 - B. Measure matched samples of the same isotope at several elapsed times while recording starting activity and keeping temperature constant.
 - C. Samples with different initial activities show the same fractional decrease.
 - D. The same absolute number of nuclei disappears during every equal time interval.
44. In a related system, the elapsed time after a sample is prepared increases while the other stated conditions remain fixed. Which prediction best transfers the mechanism?
- A. Half-life changes when the amount of sample changes.

- B. After one half-life, approximately half of the original radioactive nuclei remain.
 - C. Measure matched samples of the same isotope at several elapsed times while recording starting activity and keeping temperature constant.
 - D. The same absolute number of nuclei disappears during every equal time interval.
45. A 0.50 mol sample occupies 2.0 L. Its molarity is:
- A. 1.0 M
 - B. 2.5 M
 - C. 4.0 M
 - D. 0.25 M
46. If a solution has pH 3, its hydrogen-ion concentration is:
- A. 0.333 M
 - B. 0.001 M
 - C. 3 M
 - D. 1000 M
47. A 2 kg object moving at 3 m/s has kinetic energy:
- A. 18 J
 - B. 3 J
 - C. 6 J
 - D. 9 J
48. A 12 V battery is connected to a 4 ohm resistor. The current is:
- A. 3 A
 - B. 8 A
 - C. 48 A
 - D. 0.33 A
49. Which change increases the rate of a reaction without changing the equilibrium constant?
- A. Removing all reactants
 - B. Lowering every collision energy
 - C. Changing the balanced equation
 - D. Adding a catalyst
50. A peptide bond forms between the:
- A. two sugar molecules only

- B. hydrogen atoms of water
- C. amino group of one amino acid and carboxyl group of another
- D. two phosphate groups

51. At constant temperature, doubling the volume of an ideal gas causes pressure to:

- A. remain fixed
- B. become negative
- C. double
- D. halve

52. The net work done by a constant force parallel to displacement is:

- A. F divided by d
- B. F times d
- C. d divided by F
- D. zero in every case

53. A reducing agent is oxidized because it:

- A. gains electrons
- B. loses electrons
- C. gains protons only
- D. loses neutrons

54. A buffer works best when:

- A. all solute has precipitated
- B. weak acid and conjugate base are present in comparable amounts
- C. only strong acid is present
- D. no solvent is present

55. The derivative of position with respect to time represents:

- A. acceleration
- B. force
- C. power
- D. velocity

56. A molecule with a polar covalent bond has:

- A. complete electron transfer only
- B. no electrons

- C. identical charges at every point
 - D. unequal sharing of electrons
57. If a reaction has a positive entropy change and negative enthalpy change, it is:
- A. unrelated to temperature
 - B. thermodynamically favorable at all temperatures
 - C. never favorable
 - D. favorable only at zero temperature
58. The pKa of an acid is the pH at which:
- A. acid and conjugate base concentrations are equal
 - B. all acid is gone
 - C. water is neutral only
 - D. the acid is fully protonated at every concentration
59. A semipermeable membrane allows water to cross but not a solute. Water moves toward:
- A. neither side under any condition
 - B. the side with greater effective solute concentration
 - C. the side with lower solute concentration
 - D. the side with no membrane

Answer Key and Explanations

1. **Answer: B.** The supporting observation must address alveolar diffusion and preserve the controls described in the passage.
2. **Answer: B.** The direction follows from the reported mechanism: a larger gradient provides a larger driving force for net diffusion.
3. **Answer: B.** The comparison changes the proposed variable while controlling the alternatives relevant to alveolar diffusion.
4. **Answer: D.** The transferred prediction follows the same mechanism without adding an unsupported claim: a larger gradient provides a larger driving force for net diffusion.
5. **Answer: D.** The selected measurement directly checks the proposed relationship involving alveolar diffusion rather than recording an unrelated observation.
6. **Answer: C.** The supporting observation must address acid-base buffering and preserve the controls described in the passage.
7. **Answer: C.** The direction follows from the reported mechanism: the conjugate base reacts with added hydrogen ion before free hydrogen ion accumulates.
8. **Answer: B.** The comparison changes the proposed variable while controlling the alternatives relevant to acid-base buffering.
9. **Answer: B.** The transferred prediction follows the same mechanism without adding an unsupported claim: the conjugate base reacts with added hydrogen ion before free hydrogen ion accumulates.
10. **Answer: D.** The selected measurement directly checks the proposed relationship involving acid-base buffering rather than recording an unrelated observation.
11. **Answer: A.** The supporting observation must address activation energy and preserve the controls described in the passage.
12. **Answer: A.** The direction follows from the reported mechanism: the catalyst changes the pathway and rate but not the energy difference between reactants and products.
13. **Answer: D.** The comparison changes the proposed variable while controlling the alternatives relevant to activation energy.
14. **Answer: C.** The transferred prediction follows the same mechanism without adding an unsupported claim: the catalyst changes the pathway and rate but not the energy difference between reactants and products.
15. **Answer: D.** The selected measurement directly checks the proposed relationship involving activation energy rather than recording an unrelated observation.

16. **Answer: D.** The supporting observation must address vascular flow and preserve the controls described in the passage.
17. **Answer: B.** The direction follows from the reported mechanism: the radius appears with a high power in the flow relationship.
18. **Answer: B.** The comparison changes the proposed variable while controlling the alternatives relevant to vascular flow.
19. **Answer: C.** The transferred prediction follows the same mechanism without adding an unsupported claim: the radius appears with a high power in the flow relationship.
20. **Answer: C.** The selected measurement directly checks the proposed relationship involving vascular flow rather than recording an unrelated observation.
21. **Answer: D.** The supporting observation must address cell potential and preserve the controls described in the passage.
22. **Answer: D.** The direction follows from the reported mechanism: the Nernst relationship includes the logarithm of the reaction quotient.
23. **Answer: D.** The comparison changes the proposed variable while controlling the alternatives relevant to cell potential.
24. **Answer: B.** The transferred prediction follows the same mechanism without adding an unsupported claim: the Nernst relationship includes the logarithm of the reaction quotient.
25. **Answer: B.** The supporting observation must address lens formation and preserve the controls described in the passage.
26. **Answer: C.** The direction follows from the reported mechanism: focal length is determined by optical power, which depends on curvature and refractive index.
27. **Answer: C.** The comparison changes the proposed variable while controlling the alternatives relevant to lens formation.
28. **Answer: A.** The transferred prediction follows the same mechanism without adding an unsupported claim: focal length is determined by optical power, which depends on curvature and refractive index.
29. **Answer: B.** The supporting observation must address carbonyl reactivity and preserve the controls described in the passage.
30. **Answer: A.** The direction follows from the reported mechanism: electron withdrawal leaves the carbonyl carbon more electron-poor.
31. **Answer: A.** The comparison changes the proposed variable while controlling the alternatives relevant to carbonyl reactivity.

- 32. Answer: B.** The transferred prediction follows the same mechanism without adding an unsupported claim: electron withdrawal leaves the carbonyl carbon more electron-poor.
- 33. Answer: B.** The supporting observation must address free-energy change and preserve the controls described in the passage.
- 34. Answer: D.** The direction follows from the reported mechanism: Gibbs free energy combines enthalpy with the temperature-weighted entropy change.
- 35. Answer: A.** The comparison changes the proposed variable while controlling the alternatives relevant to free-energy change.
- 36. Answer: A.** The transferred prediction follows the same mechanism without adding an unsupported claim: Gibbs free energy combines enthalpy with the temperature-weighted entropy change.
- 37. Answer: C.** The supporting observation must address electrochemical gradients and preserve the controls described in the passage.
- 38. Answer: B.** The direction follows from the reported mechanism: an ion responds to the combined electrochemical gradient.
- 39. Answer: C.** The comparison changes the proposed variable while controlling the alternatives relevant to electrochemical gradients.
- 40. Answer: A.** The transferred prediction follows the same mechanism without adding an unsupported claim: an ion responds to the combined electrochemical gradient.
- 41. Answer: A.** The supporting observation must address radioactive decay and preserve the controls described in the passage.
- 42. Answer: C.** The direction follows from the reported mechanism: each half-life removes half of the nuclei present at its beginning.
- 43. Answer: B.** The comparison changes the proposed variable while controlling the alternatives relevant to radioactive decay.
- 44. Answer: B.** The transferred prediction follows the same mechanism without adding an unsupported claim: each half-life removes half of the nuclei present at its beginning.
- 45. Answer: D.** Molarity is moles per liter, so 0.50 divided by 2.0 equals 0.25 M.
- 46. Answer: B.** pH equals negative log of hydrogen-ion concentration, so pH 3 corresponds to 0.001 M.
- 47. Answer: D.** Kinetic energy is one-half mv squared: one-half times 2 times 9 equals 9 J.
- 48. Answer: A.** Ohm law gives I equals V divided by R, or 12 divided by 4 equals 3 A.

- 49. Answer: D.** A catalyst lowers activation energy for the forward and reverse pathways but does not change the equilibrium constant.
- 50. Answer: C.** Peptide bonds join the amino group of one amino acid to the carboxyl group of another with water released.
- 51. Answer: D.** Boyle law gives an inverse relationship between pressure and volume at constant temperature.
- 52. Answer: B.** For a parallel force, work equals force times displacement.
- 53. Answer: B.** A reducing agent donates electrons and is therefore oxidized.
- 54. Answer: B.** Comparable weak-acid and conjugate-base amounts allow the pair to consume added base or acid.
- 55. Answer: D.** Velocity is the time derivative of position; acceleration is the derivative of velocity.
- 56. Answer: D.** A polar covalent bond shares electrons unequally because of an electronegativity difference.
- 57. Answer: B.** Negative enthalpy and positive entropy both favor a negative Gibbs free-energy change.
- 58. Answer: A.** The Henderson-Hasselbalch relationship gives pH equal to pKa when the acid and conjugate-base concentrations match.
- 59. Answer: B.** Osmosis moves water toward the side with higher effective solute concentration.