

MCAT Chemical and Physical Foundations of Biological Systems

Practice Test 2

MCAT Chemical and Physical Foundations of Biological Systems • Form 2

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: Nuclear chemistry

In a follow-up study of radioactive decay, investigators compared two conditions that differed in the elapsed time after a sample is prepared. They preregistered the expected direction and repeated the measurement with an independent batch of samples. The follow-up was designed to separate the proposed mechanism from a tempting alternative explanation. Data summary: Samples of different starting activity lost the same fraction, rather than the same number of nuclei, during one half-life. The researchers also monitored the comparison variable described in the protocol. The result supports the interpretation that each half-life removes half of the nuclei present at its beginning. A replication supports the mechanism only within the tested range and does not remove the need to identify possible confounders.

1. Which new result would most clearly distinguish the proposed explanation of radioactive decay from a competing mechanism?
 - A. Half-life changes when the amount of sample changes.
 - B. Radioactive decay requires a catalyst to proceed.
 - C. Samples with different initial activities show the same fractional decrease.
 - D. The same absolute number of nuclei disappears during every equal time interval.
2. The investigators repeat the study after the focal variable changes in the direction described by the passage. Which immediate outcome should be measured first?
 - A. The same absolute number of nuclei disappears during every equal time interval.
 - B. Half-life changes when the amount of sample changes.
 - C. Radioactive decay requires a catalyst to proceed.
 - D. After one half-life, approximately half of the original radioactive nuclei remain.
3. Which protocol would best isolate the effect of the elapsed time after a sample is prepared on radioactive decay?
 - A. Samples with different initial activities show the same fractional decrease.
 - B. Measure matched samples of the same isotope at several elapsed times while recording starting activity and keeping temperature constant.
 - C. The same absolute number of nuclei disappears during every equal time interval.
 - D. Half-life changes when the amount of sample changes.
4. Which prediction follows when the focal variable moves in the same direction described in the passage and the mechanism operates within the tested range?

- A. The same absolute number of nuclei disappears during every equal time interval.
 - B. Half-life changes when the amount of sample changes.
 - C. After one half-life, approximately half of the original radioactive nuclei remain.
 - D. Measure matched samples of the same isotope at several elapsed times while recording starting activity and keeping temperature constant.
5. Which observation would be most inconsistent with the proposed explanation of radioactive decay?
- A. Samples with different initial activities show the same fractional decrease.
 - B. After one half-life, approximately half of the original radioactive nuclei remain.
 - C. Half-life provides an isotope-specific time scale for comparing fractional activity across matched samples.
 - D. The same absolute number of nuclei disappears during every equal time interval.

Passage 2: Membrane transport

In a follow-up study of electrochemical gradients, investigators compared two conditions that differed in the concentration gradient of an ion. They preregistered the expected direction and repeated the measurement with an independent batch of samples. The follow-up was designed to separate the proposed mechanism from a tempting alternative explanation. Data summary: With voltage fixed, increasing the ion concentration ratio increased the initial current through the open channels. The researchers also monitored the comparison variable described in the protocol. The result supports the interpretation that an ion responds to the combined electrochemical gradient. A replication supports the mechanism only within the tested range and does not remove the need to identify possible confounders.

6. Which new result would most clearly distinguish the proposed explanation of electrochemical gradients from a competing mechanism?
- A. The reversal potential shifts when the concentration ratio changes.
 - B. Passive transport moves solute against its electrochemical gradient without energy input.
 - C. ATP is required for every form of membrane movement.
 - D. Membrane composition cannot affect solute flux.
7. The investigators repeat the study after the focal variable changes in the direction described by the passage. Which immediate outcome should be measured first?
- A. Net ion movement initially increases in the direction favored by the larger concentration gradient.
 - B. Passive transport moves solute against its electrochemical gradient without energy input.
 - C. ATP is required for every form of membrane movement.
 - D. Membrane composition cannot affect solute flux.
8. Which protocol would best isolate the effect of the concentration gradient of an ion on electrochemical gradients?
- A. Keep membrane voltage and channel number fixed while varying the ion concentration ratio.
 - B. Passive transport moves solute against its electrochemical gradient without energy input.
 - C. ATP is required for every form of membrane movement.

- D. The reversal potential shifts when the concentration ratio changes.
9. Which prediction follows when the focal variable moves in the same direction described in the passage and the mechanism operates within the tested range?
- A. Passive transport moves solute against its electrochemical gradient without energy input.
 - B. Keep membrane voltage and channel number fixed while varying the ion concentration ratio.
 - C. ATP is required for every form of membrane movement.
 - D. Net ion movement initially increases in the direction favored by the larger concentration gradient.
10. Which observation would be most inconsistent with the proposed explanation of electrochemical gradients?
- A. Net ion movement initially increases in the direction favored by the larger concentration gradient.
 - B. A concentration gradient alone does not fully determine charged-particle movement because membrane voltage also contributes.
 - C. Passive transport moves solute against its electrochemical gradient without energy input.
 - D. The reversal potential shifts when the concentration ratio changes.

Passage 3: Thermodynamics

In a follow-up study of free-energy change, investigators compared two conditions that differed in the temperature of a reaction with a favorable entropy change. They preregistered the expected direction and repeated the measurement with an independent batch of samples. The follow-up was designed to separate the proposed mechanism from a tempting alternative explanation. Data summary: The process became favorable only above the temperature at which the entropy term outweighed the unfavorable enthalpy term. The researchers also monitored the comparison variable described in the protocol. The result supports the interpretation that Gibbs free energy combines enthalpy with the temperature-weighted entropy change. A replication supports the mechanism only within the tested range and does not remove the need to identify possible confounders.

11. Which new result would most clearly distinguish the proposed explanation of free-energy change from a competing mechanism?
- A. Temperature cannot affect the Gibbs free-energy change.
 - B. Enthalpy and entropy are interchangeable measures of energy.
 - C. The reaction becomes favorable only above a temperature threshold.
 - D. A positive entropy change guarantees spontaneity at every temperature.
12. The investigators repeat the study after the focal variable changes in the direction described by the passage. Which immediate outcome should be measured first?
- A. The process becomes more favorable as temperature rises when the entropy change is positive.
 - B. A positive entropy change guarantees spontaneity at every temperature.
 - C. Temperature cannot affect the Gibbs free-energy change.
 - D. Enthalpy and entropy are interchangeable measures of energy.

13. Which protocol would best isolate the effect of the temperature of a reaction with a favorable entropy change on free-energy change?
- A. A positive entropy change guarantees spontaneity at every temperature.
 - B. Temperature cannot affect the Gibbs free-energy change.
 - C. The reaction becomes favorable only above a temperature threshold.
 - D. Compare the same reaction at several temperatures while holding pressure and reactant amounts constant and estimating enthalpy and entropy under each condition.
14. Which prediction follows when the focal variable moves in the same direction described in the passage and the mechanism operates within the tested range?
- A. A positive entropy change guarantees spontaneity at every temperature.
 - B. Compare the same reaction at several temperatures while holding pressure and reactant amounts constant and estimating enthalpy and entropy under each condition.
 - C. The process becomes more favorable as temperature rises when the entropy change is positive.
 - D. Temperature cannot affect the Gibbs free-energy change.
15. Which observation would be most inconsistent with the proposed explanation of free-energy change?
- A. The reaction becomes favorable only above a temperature threshold.
 - B. The process becomes more favorable as temperature rises when the entropy change is positive.
 - C. A temperature change can alter spontaneity when enthalpy and entropy make competing contributions.
 - D. A positive entropy change guarantees spontaneity at every temperature.

Passage 4: Organic functional groups

In a follow-up study of carbonyl reactivity, investigators compared two conditions that differed in the electron-withdrawing strength near a carbonyl. They preregistered the expected direction and repeated the measurement with an independent batch of samples. The follow-up was designed to separate the proposed mechanism from a tempting alternative explanation. Data summary: The substrate with the stronger electron-withdrawing group reacted faster with the same nucleophile under matched conditions. The researchers also monitored the comparison variable described in the protocol. The result supports the interpretation that electron withdrawal leaves the carbonyl carbon more electron-poor. A replication supports the mechanism only within the tested range and does not remove the need to identify possible confounders.

16. Which new result would most clearly distinguish the proposed explanation of carbonyl reactivity from a competing mechanism?
- A. The carbonyl carbon acts as a nucleophile in every reaction.
 - B. Related carbonyl compounds must have identical reaction rates.
 - C. Substituents cannot alter electron density near a carbonyl.
 - D. The more electron-poor substrate reacts faster under matched conditions.
17. The investigators repeat the study after the focal variable changes in the direction described by the passage. Which immediate outcome should be measured first?

- 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.
18. Which protocol would best isolate the effect of the electron-withdrawing strength near a carbonyl on carbonyl reactivity?
- A. The more electron-poor substrate reacts faster under matched conditions.
 - B. Compare substrates with the same carbon skeleton and different substituents.
 - C. The carbonyl carbon acts as a nucleophile in every reaction.
 - D. Related carbonyl compounds must have identical reaction rates.
19. Which prediction follows when the focal variable moves in the same direction described in the passage and the mechanism operates within the tested range?
- A. A nucleophile attacks the carbonyl carbon more readily.
 - B. The carbonyl carbon acts as a nucleophile in every reaction.
 - C. Compare substrates with the same carbon skeleton and different substituents.
 - D. Related carbonyl compounds must have identical reaction rates.
20. Which observation would be most inconsistent with the proposed explanation of carbonyl reactivity?
- A. The more electron-poor substrate reacts faster under matched conditions.
 - B. A nucleophile attacks the carbonyl carbon more readily.
 - C. Electronic effects help explain why related carbonyl compounds have different reactivities.
 - D. The carbonyl carbon acts as a nucleophile in every reaction.

Passage 5: Optics and imaging

In a follow-up study of lens formation, investigators compared two conditions that differed in the curvature of a converging lens. They preregistered the expected direction and repeated the measurement with an independent batch of samples. The follow-up was designed to separate the proposed mechanism from a tempting alternative explanation. Data summary: The lens with greater curvature formed a sharp image at a shorter focal length when object distance was held constant. The researchers also monitored the comparison variable described in the protocol. The result supports the interpretation that focal length is determined by optical power, which depends on curvature and refractive index. A replication supports the mechanism only within the tested range and does not remove the need to identify possible confounders.

21. Which new result would most clearly distinguish the proposed explanation of lens formation from a competing mechanism?
- A. Independent focal-length measurements shift in the predicted direction.
 - B. Focal length is determined only by object brightness.
 - C. A curved interface cannot refract light.
 - D. Image distance is always equal to object distance.

22. The investigators repeat the study after the focal variable changes in the direction described by the passage. Which immediate outcome should be measured first?
- A. A more strongly converging lens has a shorter focal length.
 - B. Focal length is determined only by object brightness.
 - C. A curved interface cannot refract light.
 - D. Image distance is always equal to object distance.
23. Which protocol would best isolate the effect of the curvature of a converging lens on lens formation?
- A. Keep object distance and refractive index constant.
 - B. Focal length is determined only by object brightness.
 - C. A curved interface cannot refract light.
 - D. Independent focal-length measurements shift in the predicted direction.
24. Which prediction follows when the focal variable moves in the same direction described in the passage and the mechanism operates within the tested range?
- A. A more strongly converging lens has a shorter focal length.
 - B. A curved interface cannot refract light.
 - C. Focal length is determined only by object brightness.
 - D. Keep object distance and refractive index constant.

Passage 6: Electrochemistry

In a follow-up study of cell potential, investigators compared two conditions that differed in the concentration ratio of reaction species. They preregistered the expected direction and repeated the measurement with an independent batch of samples. The follow-up was designed to separate the proposed mechanism from a tempting alternative explanation. Data summary: Changing the reaction quotient shifted the measured cell potential in the direction predicted by the Nernst relationship. The researchers also monitored the comparison variable described in the protocol. The result supports the interpretation that the Nernst relationship includes the logarithm of the reaction quotient. A replication supports the mechanism only within the tested range and does not remove the need to identify possible confounders.

25. Which new result would most clearly distinguish the proposed explanation of cell potential from a competing mechanism?
- A. Electron transfer cannot occur through the external circuit.
 - B. The voltage shifts predictably when the reaction quotient changes.
 - C. Cell voltage is fixed by electrode labels alone.
 - D. Ion concentration cannot affect cell potential.
26. The investigators repeat the study after the focal variable changes in the direction described by the passage. Which immediate outcome should be measured first?
- A. Electron transfer cannot occur through the external circuit.
 - B. Changing ion concentrations can change the measured cell voltage.
 - C. Cell voltage is fixed by electrode labels alone.

D. Ion concentration cannot affect cell potential.

27. Which protocol would best isolate the effect of the concentration ratio of reaction species on cell potential?

A. Use identical electrodes and temperature while varying only the solution composition.

B. Cell voltage is fixed by electrode labels alone.

C. Ion concentration cannot affect cell potential.

D. The voltage shifts predictably when the reaction quotient changes.

28. Which prediction follows when the focal variable moves in the same direction described in the passage and the mechanism operates within the tested range?

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 7: Fluid resistance

In a follow-up study of vascular flow, investigators compared two conditions that differed in the radius of a vessel. They preregistered the expected direction and repeated the measurement with an independent batch of samples. The follow-up was designed to separate the proposed mechanism from a tempting alternative explanation. Data summary: Doubling vessel radius increased measured flow by much more than twofold when pressure difference and viscosity were fixed. The researchers also monitored the comparison variable described in the protocol. The result supports the interpretation that the radius appears with a high power in the flow relationship. A replication supports the mechanism only within the tested range and does not remove the need to identify possible confounders.

29. Which new result would most clearly distinguish the proposed explanation of vascular flow from a competing mechanism?

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. Measured flow rises more than proportionally as radius increases.

30. The investigators repeat the study after the focal variable changes in the direction described by the passage. Which immediate outcome should be measured first?

A. Increasing radius increases flow when the pressure difference and viscosity remain fixed.

B. Flow is independent of vessel radius when pressure is fixed.

C. Viscosity cannot affect flow when radius changes.

D. Changing radius forces the pressure difference to reverse.

31. Which protocol would best isolate the effect of the radius of a vessel on vascular flow?

A. Measured flow rises more than proportionally as radius increases.

- B. Hold pressure difference, vessel length, and fluid viscosity constant.
- C. Flow is independent of vessel radius when pressure is fixed.
- D. Viscosity cannot affect flow when radius changes.

32. Which prediction follows when the focal variable moves in the same direction described in the passage and the mechanism operates within the tested range?

- A. Increasing radius increases flow when the pressure difference and viscosity remain fixed.
- B. Hold pressure difference, vessel length, and fluid viscosity constant.
- C. Flow is independent of vessel radius when pressure is fixed.
- D. Viscosity cannot affect flow when radius changes.

Passage 8: Enzyme energetics

In a follow-up study of activation energy, investigators compared two conditions that differed in the concentration of catalyst. They preregistered the expected direction and repeated the measurement with an independent batch of samples. The follow-up was designed to separate the proposed mechanism from a tempting alternative explanation. Data summary: The catalyzed reaction reached the same final product ratio sooner than the uncatalyzed reaction at the same temperature. The researchers also monitored the comparison variable described in the protocol. The result supports the interpretation that the catalyst changes the pathway and rate but not the energy difference between reactants and products. A replication supports the mechanism only within the tested range and does not remove the need to identify possible confounders.

33. Which new result would most clearly distinguish the proposed explanation of activation energy from a competing 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. At equilibrium, the products disappear as quickly as they form.
- D. Both reaction directions speed up by comparable factors.

34. The investigators repeat the study after the focal variable changes in the direction described by the passage. Which immediate outcome should be measured first?

- 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. The system reaches equilibrium sooner while the final equilibrium composition remains the same.

35. Which protocol would best isolate the effect of the concentration of catalyst on activation energy?

- A. Compare catalyzed and uncatalyzed reactions at the same temperature and starting concentrations.
- B. A catalyst changes the equilibrium constant without changing the reaction conditions.
- C. Only the reverse reaction's activation barrier can be lowered.
- D. Both reaction directions speed up by comparable factors.

36. Which prediction follows when the focal variable moves in the same direction described in the passage and the mechanism operates within the tested range?
- 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. Compare catalyzed and uncatalyzed reactions at the same temperature and starting concentrations.
 - D. Only the reverse reaction's activation barrier can be lowered.

Passage 9: Buffer chemistry

In a follow-up study of acid-base buffering, investigators compared two conditions that differed in the amount of added strong acid. They preregistered the expected direction and repeated the measurement with an independent batch of samples. The follow-up was designed to separate the proposed mechanism from a tempting alternative explanation. 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 researchers also monitored the comparison variable described in the protocol. The result supports the interpretation that the conjugate base reacts with added hydrogen ion before free hydrogen ion accumulates. A replication supports the mechanism only within the tested range and does not remove the need to identify possible confounders.

37. Which new result would most clearly distinguish the proposed explanation of acid-base buffering from a competing mechanism?
- A. The unbuffered control shows a much larger pH change.
 - B. The pH becomes exactly 7 after any amount of added acid.
 - C. A buffered sample changes pH by exactly the same amount as pure water.
 - D. Conjugate-base concentration has no bearing on the buffer's pH.
38. The investigators repeat the study after the focal variable changes in the direction described by the passage. Which immediate outcome should be measured first?
- 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.
39. Which protocol would best isolate the effect of the amount of added strong acid on acid-base buffering?
- A. The unbuffered control shows a much larger pH change.
 - B. Compare equal-volume buffer samples receiving different known amounts of strong acid while keeping conjugate-base concentration and temperature fixed.
 - C. The pH becomes exactly 7 after any amount of added acid.
 - D. A buffered sample changes pH by exactly the same amount as pure water.
40. Which prediction follows when the focal variable moves in the same direction described in the passage and the mechanism operates within the tested range?
- 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. The pH decreases only modestly after a small acid addition.
- D. Compare equal-volume buffer samples receiving different known amounts of strong acid while keeping conjugate-base concentration and temperature fixed.

Passage 10: Gas exchange

In a follow-up study of alveolar diffusion, investigators compared two conditions that differed in the partial-pressure gradient. They preregistered the expected direction and repeated the measurement with an independent batch of samples. The follow-up was designed to separate the proposed mechanism from a tempting alternative explanation. Data summary: At the larger gradient, oxygen-transfer rate was 18 percent higher while membrane thickness and surface area were unchanged. The researchers also monitored the comparison variable described in the protocol. The result supports the interpretation that a larger gradient provides a larger driving force for net diffusion. A replication supports the mechanism only within the tested range and does not remove the need to identify possible confounders.

41. Which new result would most clearly distinguish the proposed explanation of alveolar diffusion from a competing mechanism?
- A. Membrane thickness cannot affect the rate of transfer.
 - B. A second sample with the same membrane shows the predicted increase.
 - C. A larger gradient guarantees unlimited transfer regardless of membrane properties.
 - D. The equilibrium constant changes solely because the gradient changes.
42. The investigators repeat the study after the focal variable changes in the direction described by the passage. Which immediate outcome should be measured first?
- 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. The rate of oxygen transfer into blood increases.
43. Which protocol would best isolate the effect of the partial-pressure gradient on alveolar diffusion?
- A. Measure diffusion with membrane thickness held constant.
 - B. A larger gradient guarantees unlimited transfer regardless of membrane properties.
 - C. The equilibrium constant changes solely because the gradient changes.
 - D. A second sample with the same membrane shows the predicted increase.
44. Which prediction follows when the focal variable moves in the same direction described in the passage and the mechanism operates within the tested range?
- A. The equilibrium constant changes solely because the gradient changes.
 - B. The rate of oxygen transfer into blood increases.
 - C. A larger gradient guarantees unlimited transfer regardless of membrane properties.
 - D. Measure diffusion with membrane thickness held constant.
45. A solution contains 0.75 mol of solute in 3.0 L. Its molarity is:
- A. 0.40 M

- B. 2.25 M
- C. 4.0 M
- D. 0.25 M

46. A solution with pH 5 has approximately which hydrogen-ion concentration?

- A. 0.00001 M
- B. 5 M
- C. 100000 M
- D. 0.20 M

47. A 4.0 kg object moves at 2.0 m/s. Its kinetic energy is:

- A. 16 J
- B. 32 J
- C. 4 J
- D. 8 J

48. A 6.0 V source is connected to a 2.0 ohm resistor. The current is:

- A. 12 A
- B. 0.33 A
- C. 3.0 A
- D. 8.0 A

49. A catalyst is added to a system that has not yet reached equilibrium. Which statement is correct?

- A. The catalyst permanently removes reactants.
- B. Only products form faster.
- C. Both directions can speed up, but K remains unchanged.
- D. K changes because activation energy changes.

50. Hydrolysis of a peptide bond directly adds water across a bond between:

- A. Two nucleobases only
- B. An amino group and a carboxyl group
- C. Two phosphate groups
- D. Two hydrocarbon tails

51. If an ideal gas is compressed to one-half its original volume at constant temperature, its pressure will:

- A. Remain unchanged
- B. Become zero

- C. Be halved
 - D. Double
52. A 30 N force acts parallel to a displacement of 0.50 m. The work is:
- A. 15 J
 - B. 30 J
 - C. 60 J
 - D. 0 J
53. An oxidizing agent is reduced because it:
- A. Loses protons only
 - B. Gains electrons
 - C. Loses electrons
 - D. Gains neutrons
54. For a buffer containing comparable amounts of a weak acid and conjugate base, the pH is approximately:
- A. The pKa
 - B. Always 7
 - C. The pH of pure water
 - D. The concentration in molarity
55. The derivative of velocity with respect to time represents:
- A. Work
 - B. Power
 - C. Acceleration
 - D. Position
56. A molecule with polar bonds can be nonpolar overall when:
- A. Its atoms have identical masses
 - B. Its bond dipoles cancel because of molecular geometry
 - C. It contains no electrons
 - D. All bonds are ionic
57. A process with positive enthalpy change and negative entropy change is:
- A. Favorable only at high temperature
 - B. Unrelated to free energy
 - C. Unfavorable at every temperature

D. Favorable at every temperature

58. At pH equal to pKa, the ratio of conjugate base to weak acid is:

A. Dependent only on volume

B. 1

C. 10

D. 0.1

59. A cell is placed in a hypotonic solution containing a nonpenetrating solute. Water tends to:

A. Enter the cell

B. Leave the cell

C. Stop moving permanently

D. Move only into the nucleus

Answer Key and Explanations

1. **Answer: C.** The distinguishing result should change in the direction predicted by the mechanism while addressing the alternative: each half-life removes half of the nuclei present at its beginning.
2. **Answer: D.** The immediate outcome should match the stated prediction and mechanism: each half-life removes half of the nuclei present at its beginning.
3. **Answer: B.** A valid protocol holds the relevant competing variables steady while measuring radioactive decay.
4. **Answer: C.** The prediction is limited to the tested range and follows because each half-life removes half of the nuclei present at its beginning.
5. **Answer: D.** The observation is inconsistent because it conflicts with the mechanism used to explain radioactive decay: each half-life removes half of the nuclei present at its beginning.
6. **Answer: A.** The distinguishing result should change in the direction predicted by the mechanism while addressing the alternative: an ion responds to the combined electrochemical gradient.
7. **Answer: A.** The immediate outcome should match the stated prediction and mechanism: an ion responds to the combined electrochemical gradient.
8. **Answer: A.** A valid protocol holds the relevant competing variables steady while measuring electrochemical gradients.
9. **Answer: D.** The prediction is limited to the tested range and follows because an ion responds to the combined electrochemical gradient.
10. **Answer: C.** The observation is inconsistent because it conflicts with the mechanism used to explain electrochemical gradients: an ion responds to the combined electrochemical gradient.
11. **Answer: C.** The distinguishing result should change in the direction predicted by the mechanism while addressing the alternative: Gibbs free energy combines enthalpy with the temperature-weighted entropy change.
12. **Answer: A.** The immediate outcome should match the stated prediction and mechanism: Gibbs free energy combines enthalpy with the temperature-weighted entropy change.
13. **Answer: D.** A valid protocol holds the relevant competing variables steady while measuring free-energy change.
14. **Answer: C.** The prediction is limited to the tested range and follows because Gibbs free energy combines enthalpy with the temperature-weighted entropy change.
15. **Answer: D.** The observation is inconsistent because it conflicts with the mechanism used to explain free-energy change: Gibbs free energy combines enthalpy with the temperature-weighted entropy change.

16. **Answer: D.** The distinguishing result should change in the direction predicted by the mechanism while addressing the alternative: electron withdrawal leaves the carbonyl carbon more electron-poor.
17. **Answer: A.** The immediate outcome should match the stated prediction and mechanism: electron withdrawal leaves the carbonyl carbon more electron-poor.
18. **Answer: B.** A valid protocol holds the relevant competing variables steady while measuring carbonyl reactivity.
19. **Answer: A.** The prediction is limited to the tested range and follows because electron withdrawal leaves the carbonyl carbon more electron-poor.
20. **Answer: D.** The observation is inconsistent because it conflicts with the mechanism used to explain carbonyl reactivity: electron withdrawal leaves the carbonyl carbon more electron-poor.
21. **Answer: A.** The distinguishing result should change in the direction predicted by the mechanism while addressing the alternative: focal length is determined by optical power, which depends on curvature and refractive index.
22. **Answer: A.** The immediate outcome should match the stated prediction and mechanism: focal length is determined by optical power, which depends on curvature and refractive index.
23. **Answer: A.** A valid protocol holds the relevant competing variables steady while measuring lens formation.
24. **Answer: A.** The prediction is limited to the tested range and follows because focal length is determined by optical power, which depends on curvature and refractive index.
25. **Answer: B.** The distinguishing result should change in the direction predicted by the mechanism while addressing the alternative: the Nernst relationship includes the logarithm of the reaction quotient.
26. **Answer: B.** The immediate outcome should match the stated prediction and mechanism: the Nernst relationship includes the logarithm of the reaction quotient.
27. **Answer: A.** A valid protocol holds the relevant competing variables steady while measuring cell potential.
28. **Answer: B.** The prediction is limited to the tested range and follows because the Nernst relationship includes the logarithm of the reaction quotient.
29. **Answer: D.** The distinguishing result should change in the direction predicted by the mechanism while addressing the alternative: the radius appears with a high power in the flow relationship.
30. **Answer: A.** The immediate outcome should match the stated prediction and mechanism: the radius appears with a high power in the flow relationship.
31. **Answer: B.** A valid protocol holds the relevant competing variables steady while measuring vascular flow.

- 32. Answer: A.** The prediction is limited to the tested range and follows because the radius appears with a high power in the flow relationship.
- 33. Answer: D.** The distinguishing result should change in the direction predicted by the mechanism while addressing the alternative: the catalyst changes the pathway and rate but not the energy difference between reactants and products.
- 34. Answer: D.** The immediate outcome should match the stated prediction and mechanism: the catalyst changes the pathway and rate but not the energy difference between reactants and products.
- 35. Answer: A.** A valid protocol holds the relevant competing variables steady while measuring activation energy.
- 36. Answer: A.** The prediction is limited to the tested range and follows because the catalyst changes the pathway and rate but not the energy difference between reactants and products.
- 37. Answer: A.** The distinguishing result should change in the direction predicted by the mechanism while addressing the alternative: the conjugate base reacts with added hydrogen ion before free hydrogen ion accumulates.
- 38. Answer: C.** The immediate outcome should match the stated prediction and mechanism: the conjugate base reacts with added hydrogen ion before free hydrogen ion accumulates.
- 39. Answer: B.** A valid protocol holds the relevant competing variables steady while measuring acid-base buffering.
- 40. Answer: C.** The prediction is limited to the tested range and follows because the conjugate base reacts with added hydrogen ion before free hydrogen ion accumulates.
- 41. Answer: B.** The distinguishing result should change in the direction predicted by the mechanism while addressing the alternative: a larger gradient provides a larger driving force for net diffusion.
- 42. Answer: D.** The immediate outcome should match the stated prediction and mechanism: a larger gradient provides a larger driving force for net diffusion.
- 43. Answer: A.** A valid protocol holds the relevant competing variables steady while measuring alveolar diffusion.
- 44. Answer: B.** The prediction is limited to the tested range and follows because a larger gradient provides a larger driving force for net diffusion.
- 45. Answer: D.** Molarity is moles divided by liters: $0.75/3.0 = 0.25 \text{ M}$.
- 46. Answer: A.** pH equals negative log of hydrogen-ion concentration, so pH 5 corresponds to 0.00001 M .
- 47. Answer: D.** Kinetic energy is one-half mv squared: $0.5 \times 4.0 \times 2.0 \text{ squared} = 8 \text{ J}$.
- 48. Answer: C.** Ohm's law gives $I = V/R = 6.0/2.0 = 3.0 \text{ A}$.

- 49. Answer: C.** A catalyst lowers the activation barrier for both directions and does not change the equilibrium constant.
- 50. Answer: B.** Peptide-bond hydrolysis reverses condensation between an amino group and a carboxyl group.
- 51. Answer: D.** At constant temperature and amount, pressure is inversely proportional to volume.
- 52. Answer: A.** For a parallel force, work equals force times displacement: $30 \times 0.50 = 15 \text{ J}$.
- 53. Answer: B.** The oxidizing agent accepts electrons and is therefore reduced.
- 54. Answer: A.** The Henderson-Hasselbalch relationship gives $\text{pH} = \text{pK}_a$ when the acid and conjugate-base concentrations are equal.
- 55. Answer: C.** Acceleration is the time derivative of velocity.
- 56. Answer: B.** Overall molecular polarity depends on the vector sum of bond dipoles, not on one bond alone.
- 57. Answer: C.** Both terms make Gibbs free energy positive: positive enthalpy and subtracting a negative entropy term.
- 58. Answer: B.** The Henderson-Hasselbalch relationship gives equal concentrations when pH equals pK_a .
- 59. Answer: A.** Water moves toward the side with greater effective concentration of nonpenetrating solute.