Full Length Practice Test 9

Instructions: This practice test contains 280 multiple-choice questions divided into four parts. Select the best answer for each question.

Survey Of Natural Sciences

BIOLOGY (Questions 1-40)

1. Peroxisomes are organelles primarily involved in:
   A. Breaking down fatty acids and detoxifying hydrogen peroxide
   B. Protein synthesis
   C. ATP production
   D. DNA replication

2. The pacemaker of the heart that sets the intrinsic heart rate is the:
   A. AV node
   B. Bundle of His
   C. SA node
   D. Purkinje fibers

3. Crossing over between homologous chromosomes occurs during:
   A. Metaphase I
   B. Prophase I
   C. Anaphase II
   D. Telophase I

4. Accessory pigments in photosynthesis include:
   A. Carotenoids and xanthophylls
   B. Chlorophyll a only
   C. Hemoglobin
   D. Myoglobin

5. An insertion or deletion of nucleotides that is not a multiple of three causes:
   A. Silent mutation
   B. Missense mutation
   C. Nonsense mutation
   D. Frameshift mutation

6. The pancreas secretes digestive enzymes into the:

A. Stomach
B. Large intestine
C. Small intestine
D. Esophagus

7. The product of the light-dependent reactions used in the Calvin cycle are:
   A. Glucose and oxygen
   B. ATP and NADPH
   C. Carbon dioxide and water
   D. Pyruvate and NADH

8. DNA ligase functions to:
   A. Unwind DNA
   B. Add nucleotides
   C. Proofread DNA
   D. Join Okazaki fragments

9. Parathyroid hormone (PTH) functions to:
   A. Increase blood calcium levels
   B. Decrease blood calcium levels
   C. Regulate glucose
   D. Stimulate bone formation

10. Hemoglobin is found in:
    A. Plasma
    B. Platelets
    C. Red blood cells
    D. White blood cells

11. The loop of Henle in the nephron creates a concentration gradient in the:
    A. Cortex
    B. Medulla
    C. Glomerulus
    D. Bowman's capsule

12. The 5' cap on mRNA consists of:
    A. Modified guanine nucleotide
    B. Adenine tail
    C. Start codon
    D. Poly-A sequence

13. The aortic semilunar valve is located between the:
    A. Right atrium and right ventricle
    B. Left atrium and left ventricle
    C. Right ventricle and pulmonary artery
    D. Left ventricle and aorta

14. Facilitated diffusion requires:
    A. ATP
    B. Carrier proteins or channel proteins
    C. Vesicles
    D. Lysosomes

15. Mammals excrete nitrogenous waste as:
    A. Ammonia
    B. Uric acid
    C. Urea
    D. Creatine

16. An example of a positively regulated (inducible) operon is:
    A. trp operon
    B. lac repressor
    C. Constitutive genes
    D. lac operon

17. The diaphragm and external intercostal muscles contract during:
    A. Inhalation
    B. Exhalation
    C. Apnea
    D. Swallowing

18. The first cell division in meiosis produces:
    A. Four haploid cells
    B. Two haploid cells
    C. Two diploid cells
    D. Four diploid cells

19. During the menstrual cycle, estrogen levels peak just before:
    A. Menstruation
    B. The follicular phase begins

C. Ovulation
D. The luteal phase ends

20. Which cells produce antibodies?
    A. Plasma cells
    B. T cells
    C. Neutrophils
    D. Erythrocytes

21. Phloem tissue in plants primarily transports:
    A. Water
    B. Minerals
    C. Oxygen
    D. Sugars

22. The neurotransmitter at the neuromuscular junction is:
    A. Dopamine
    B. Acetylcholine
    C. Serotonin
    D. GABA

23. Troponin binds to:
    A. Myosin
    B. Actin filaments
    C. Calcium ions
    D. ATP

24. Which hormone stimulates the production of breast milk?
    A. Prolactin
    B. Oxytocin
    C. Estrogen
    D. FSH

25. Glycolysis produces a net gain of:
    A. 4 ATP
    B. 36 ATP
    C. 6 ATP
    D. 2 ATP

26. B cells mature in the:

A. Thymus
B. Spleen
C. Bone marrow
D. Lymph nodes

27. Astrocytes are found in the:
A. Peripheral nervous system
B. Central nervous system
C. Muscular system
D. Circulatory system

28. During which phase of the cell cycle does DNA replication occur?
A. G1 phase
B. G2 phase
C. M phase
D. S phase

29. The trachea branches into two:
A. Bronchi
B. Bronchioles
C. Alveolar ducts
D. Alveoli

30. Phosphocreatine in muscle provides:
A. Long-term energy
B. Oxygen storage
C. Rapid ATP regeneration
D. Lactic acid removal

31. The Avery-MacLeod-McCarty experiment demonstrated that:
A. Proteins are the genetic material
B. DNA is the genetic material
C. RNA is the genetic material
D. Lipids carry genetic information

32. Progesterone is secreted by the:
A. Ovarian follicle
B. Anterior pituitary
C. Hypothalamus
D. Corpus luteum

33. Villi and microvilli in the small intestine function to:
    A. Increase surface area for absorption
    B. Secrete digestive enzymes
    C. Move food through peristalsis
    D. Protect against pathogens

34. Small interfering RNAs (siRNAs) function in:
    A. Translation
    B. DNA replication
    C. Gene silencing
    D. Protein folding

35. The optic disc in the eye is the:
    A. Area of sharpest vision
    B. Location of photoreceptors
    C. Colored part of the eye
    D. Blind spot

36. Primase synthesizes:
    A. RNA primers
    B. DNA strands
    C. Proteins
    D. Okazaki fragments

37. Pluripotent stem cells are found in:
    A. Adult bone marrow only
    B. Differentiated tissues
    C. Mature organs
    D. Embryos

38. The A-band in a sarcomere contains:
    A. Thin filaments only
    B. Thick filaments and overlap zones
    C. Z-discs
    D. No filaments

39. Renin is secreted by the:
    A. Liver
    B. Adrenal cortex

C. Kidneys
D. Heart

40. If $q^2 = 0.16$ in a Hardy-Weinberg population, what is the frequency of the heterozygous genotype?
A. 0.36
B. 0.16
C. 0.64
D. 0.48

GENERAL CHEMISTRY (Questions 41-70)

41. The electron configuration of argon (atomic number 18) is:
A. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
B. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$
C. $1s^2\ 2s^2\ 2p^6\ 3s^1\ 3p^7$
D. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

42. The Aufbau principle states that:
A. Electrons pair before occupying separate orbitals
B. No two electrons have identical quantum numbers
C. Electrons fill orbitals starting with lowest energy
D. Electrons occupy degenerate orbitals singly

43. What is the pH of a solution with $[OH^-] = 1 \times 10^{-3}$ M?
A. 3
B. 11
C. 10
D. 4

44. Hydrogen bonding is strongest between molecules of:
A. H_2O
B. CH_4
C. NH_3
D. HF

45. In the reaction $Cu^{2+} + Zn \rightarrow Cu + Zn^{2+}$, copper is:
A. Oxidized
B. Reduced
C. Neither
D. The reducing agent

46. How many orbitals are in the d subshell?
    A. 1
    B. 3
    C. 5
    D. 7

47. The magnetic quantum number (m) describes:
    A. Orbital orientation in space
    B. Electron spin
    C. Energy level
    D. Orbital shape

48. The pH of a buffer solution is calculated using the:
    A. Ideal gas law
    B. Nernst equation
    C. Arrhenius equation
    D. Henderson-Hasselbalch equation

49. Avogadro's Law states that equal volumes of gases at the same temperature and pressure contain:
    A. Equal masses
    B. Equal numbers of molecules
    C. Equal densities
    D. Equal energies

50. In $Cr_2O_7^{2-}$, the oxidation state of chromium is:
    A. +6
    B. +7
    C. +12
    D. +3

51. A reaction with $\Delta H < 0$ and $\Delta S < 0$ is spontaneous:
    A. Never
    B. Always
    C. At high temperatures
    D. At low temperatures

52. What is 0.25 moles of H_2SO_4 in grams? (Molar mass = 98 g/mol)
    A. 392 g
    B. 49 g

C. 24.5 g
D. 196 g

53. Electronegativity generally increases:
A. Down a group
B. Across a period from left to right
C. With atomic radius
D. Randomly

54. Which equilibrium constant applies to weak acids?
A. Kb
B. Ksp
C. Kp
D. Ka

55. For a reaction to be spontaneous at low temperatures only:
A. $\Delta H < 0$ and $\Delta S < 0$
B. $\Delta H > 0$ and $\Delta S > 0$
C. $\Delta H > 0$ and $\Delta S < 0$
D. $\Delta H < 0$ and $\Delta S > 0$

56. A 3 M solution of NaCl contains how many moles in 2 liters?
A. 6
B. 1.5
C. 3
D. 5

57. How many pi bonds are in a triple bond?
A. 0
B. 1
C. 2
D. 3

58. A strong base has:
A. Small Ka
B. Large Ka
C. Small Kb
D. Large Kb

59. If 400 g of a radioactive isotope remains after 3 half-lives, what was the original mass?

A. 1600 g
B. 3200 g
C. 800 g
D. 6400 g

60. Which element has the smallest ionization energy?
A. Li
B. Be
C. Na
D. Cs

61. The molecular geometry of H_2O is:
A. Bent
B. Linear
C. Trigonal planar
D. Tetrahedral

62. The cathode in a galvanic cell is:
A. Where oxidation occurs
B. Negative
C. Where reduction occurs
D. Neutral

63. What is the value of the gas constant R in L·atm/(mol·K)?
A. 8.314
B. 0.0821
C. 1.987
D. 62.36

64. Isotopes have the same number of:
A. Protons
B. Neutrons
C. Electrons and neutrons
D. Mass number

65. The rate law for a reaction is determined by:
A. Stoichiometry
B. Products
C. Experimental data
D. Temperature only

66. What is the conjugate base of H_2SO_4?
    A. SO_4^{2-}
    B. HSO_4^-
    C. $H_3SO_4^+$
    D. H_2SO_3

67. The bond order of N_2 is:
    A. 3
    B. 2
    C. 1
    D. 2.5

68. If pressure on a gas increases at constant temperature, volume:
    A. Increases
    B. Stays constant
    C. Becomes zero
    D. Decreases

69. The oxidation number of oxygen in H_2O_2 is:
    A. -2
    B. -1
    C. 0
    D. +1

70. Vapor pressure lowering is a colligative property that depends on:
    A. Solute identity
    B. Solvent identity
    C. Number of solute particles
    D. Temperature only

ORGANIC CHEMISTRY (Questions 71-100)

71. Alkynes have the general formula:
    A. C_nH_{2n+2}
    B. C_nH_{2n-2}
    C. C_nH_{2n}
    D. C_nH_n

72. The functional group of a ketone is:

A. -OH
B. -CHO
C. $-NH_2$
D. -CO- (between two carbons)

73. The IUPAC name for $(CH_3)_3CCH_3$ is:
A. 2,2-dimethylpropane
B. Neopentane
C. Isopentane
D. Pentane

74. Diastereomers are:
A. Mirror images
B. Identical compounds
C. Constitutional isomers
D. Non-mirror-image stereoisomers

75. Dehydrohalogenation of an alkyl halide produces:
A. Alkene
B. Alcohol
C. Alkane
D. Aldehyde

76. Which is the least reactive carbonyl compound?
A. Aldehyde
B. Ketone
C. Amide
D. Ester

77. Tollen's reagent oxidizes:
A. Aldehydes
B. Ketones
C. Alkenes
D. Alkanes

78. The hybridization of the nitrogen atom in NH_3 is:
A. sp
B. sp^2
C. dsp^3
D. sp^3

79. In the addition of HBr to an unsymmetrical alkene, Markovnikov's rule predicts:
    A. Random addition
    B. Anti-Markovnikov addition
    C. Br adds to the more substituted carbon
    D. H adds to the more substituted carbon

80. Cyclooctatetraene is:
    A. Aromatic
    B. Non-aromatic
    C. Antiaromatic
    D. Fully saturated

81. Tertiary carbocations are favored in:
    A. SN1 reactions
    B. SN2 reactions
    C. Neither reaction
    D. Both equally

82. The acidity of carboxylic acids is due to:
    A. Electronegativity of carbon
    B. Large size
    C. Lack of hydrogen
    D. Resonance stabilization of carboxylate ion

83. The Claisen condensation involves:
    A. Aldehydes only
    B. Ketones only
    C. Esters
    D. Alcohols

84. E2 reactions are favored by:
    A. Weak bases
    B. Strong bases
    C. Protic solvents
    D. Primary substrates

85. Which compound is most acidic?
    A. Ethanol
    B. Water

C. Phenol
D. Acetic acid

86. Hydrolysis of an amide produces:
A. Ester and alcohol
B. Aldehyde and amine
C. Carboxylic acid and amine
D. Ketone and amine

87. A molecule with a plane of symmetry is:
A. Chiral
B. Enantiomeric
C. Achiral
D. Optically active

88. Friedel-Crafts acylation introduces:
A. Alkyl group
B. Acyl group
C. Hydroxyl group
D. Amino group

89. Which substrate undergoes SN2 most rapidly?
A. Methyl halide
B. Primary halide
C. Secondary halide
D. Tertiary halide

90. Grignard reagents react with aldehydes to form:
A. Primary alcohols
B. Tertiary alcohols
C. Ketones
D. Secondary alcohols

91. The R/S system is based on:
A. Optical rotation
B. Melting point
C. Cahn-Ingold-Prelog priority rules
D. Fischer projection

92. Hofmann rearrangement produces:

A. Aldehydes
B. Amines
C. Ketones
D. Esters

93. An equimolar mixture of enantiomers is called:
A. Diastereomeric mixture
B. Meso compound
C. Racemic mixture
D. Pure compound

94. Which is the mildest reducing agent?
A. $LiAlH_4$
B. $NaBH_4$
C. H_2/Pt
D. Na/NH_3

95. Tertiary alcohols are oxidized to:
A. Aldehydes
B. Not easily oxidized
C. Ketones
D. Carboxylic acids

96. Electron-withdrawing groups are:
A. Meta-directing
B. Ortho/para-directing
C. Non-directing
D. Para-directing only

97. Which elimination gives predominantly the more substituted alkene?
A. Hofmann elimination
B. E1 mechanism
C. E1cb mechanism
D. Zaitsev elimination

98. Transesterification involves reaction between:
A. Ester and aldehyde
B. Ester and ketone
C. Ester and alcohol
D. Ester and amine

99. Mass spectrometry determines:
    A. Functional groups
    B. Molecular weight and fragmentation
    C. Hydrogen environments
    D. Carbon environments

100. Splitting patterns in ^{1}H NMR are caused by:
    A. Magnetic field strength
    B. Chemical shift
    C. Integration
    D. Neighboring hydrogens (n+1 rule)

Perceptual Ability Test

ANGLE DISCRIMINATION (Questions 1–15)

Directions: Four angles are described. Rank them from SMALLEST to LARGEST.

1. [Angle Ranking] Four angles: Angle 1 = 45°, Angle 2 = 33°, Angle 3 = 68°, Angle 4 = 56°. Rank from smallest to largest.
    A. 2-1-4-3
    B. 1-2-4-3
    C. 2-4-1-3
    D. 4-2-1-3

2. [Angle Ranking] Angle P = 74°, Angle Q = 58°, Angle R = 90°, Angle S = 81°. Rank from smallest to largest.
    A. Q-P-R-S
    B. Q-S-P-R
    C. Q-P-S-R
    D. P-Q-S-R

3. [Angle Ranking] Four angles measure: Angle 1 = 31°, Angle 2 = 53°, Angle 3 = 24°, Angle 4 = 40°. Rank from smallest to largest.
    A. 3-4-1-2
    B. 4-3-1-2
    C. 3-1-2-4
    D. 3-1-4-2

4. [Angle Ranking] Angle A = 95°, Angle B = 65°, Angle C = 78°, Angle D = 87°. Rank from smallest to largest.
   A. B-D-C-A
   B. B-C-D-A
   C. B-C-A-D
   D. C-B-D-A

5. [Angle Ranking] Angle W is two-thirds of a right angle. Angle X = 72°. Angle Y = 48°. Angle Z = 84°. Rank from smallest to largest.
   A. Y-X-W-Z
   B. W-Y-X-Z
   C. Y-W-X-Z
   D. Y-X-Z-W

6. [Angle Ranking] Four angles: Angle 1 = 15°, Angle 2 = 48°, Angle 3 = 36°, Angle 4 = 29°. Rank from smallest to largest.
   A. 1-4-3-2
   B. 1-3-4-2
   C. 1-2-3-4
   D. 1-3-2-4

7. [Angle Ranking] Angle M = 77°, Angle N = 92°, Angle O = 59°, Angle P = 66°. Rank from smallest to largest.
   A. O-M-N-P
   B. M-O-P-N
   C. O-P-M-N
   D. O-P-M-N

8. [Angle Ranking] Four angles measure: Angle 1 = 13°, Angle 2 = 44°, Angle 3 = 37°, Angle 4 = 51°. Rank from smallest to largest.
   A. 1-2-3-4
   B. 1-3-2-4
   C. 3-1-2-4
   D. 1-4-2-3

9. [Angle Ranking] Angle A = 50°, Angle B = 63°, Angle C = 39°, Angle D = 71°. Rank from smallest to largest.
   A. C-A-B-D
   B. C-B-A-D
   C. A-C-B-D

D. C-A-D-B

10. [Angle Ranking] Four angles: Angle 1 = 79°, Angle 2 = 64°, Angle 3 = 88°, Angle 4 = 73°. Rank from smallest to largest.
    A. 2-1-3-4
    B. 2-3-1-4
    C. 2-4-1-3
    D. 4-2-1-3

11. [Angle Ranking] Angle W = 34°, Angle X = 60°, Angle Y = 43°, Angle Z = 51°. Rank from smallest to largest.
    A. W-X-Y-Z
    B. W-Y-X-Z
    C. Z-W-Y-X
    D. W-Y-Z-X

12. [Angle Ranking] Four angles measure: Angle 1 = 26°, Angle 2 = 39°, Angle 3 = 32°, Angle 4 = 46°. Rank from smallest to largest.
    A. 1-2-3-4
    B. 1-3-2-4
    C. 1-3-4-2
    D. 2-1-3-4

13. [Angle Ranking] Angle P = 69°, Angle Q = 47°, Angle R = 86°, Angle S = 58°. Rank from smallest to largest.
    A. Q-S-P-R
    B. S-Q-P-R
    C. Q-S-P-R
    D. S-P-Q-R

14. [Angle Ranking] Four angles: Angle 1 = 18°, Angle 2 = 45°, Angle 3 = 41°, Angle 4 = 54°. Rank from smallest to largest.
    A. 1-3-2-4
    B. 1-2-3-4
    C. 3-1-2-4
    D. 1-3-4-2

15. [Angle Ranking] Angle A = 85°, Angle B = 76°, Angle C = 93°, Angle D = 68°. Rank from smallest to largest.
    A. D-A-B-C

B. D-B-C-A
C. A-B-D-C
D. D-B-A-C

PAPER FOLDING (Questions 16-30)

Directions: A square piece of paper is folded one or more times, then hole(s) are punched. Determine the result when unfolded.

16. [Hole Punching] Paper is folded in half once, then five holes are punched through both layers. How many total holes appear when unfolded?
    A. 5
    B. 10
    C. 8
    D. 6

17. [Hole Punching] Paper is folded three times (creating 8 layers), then one hole is punched through all layers. How many total holes appear when unfolded?
    A. 8
    B. 12
    C. 16
    D. 24

18. [Hole Punching] Paper is folded in half twice (creating 4 layers), then one hole is punched through all layers. How many total holes appear when unfolded?
    A. 8
    B. 4
    C. 12
    D. 2

19. [Hole Punching] Paper is folded in half once, then seven holes are punched through both layers. How many total holes appear when unfolded?
    A. 7
    B. 10
    C. 14
    D. 8

20. [Hole Punching] Paper is folded in half twice, then five holes are punched through all layers. How many total holes appear when unfolded?
    A. 20

B. 15
C. 12
D. 16

21. [Hole Punching] Paper is folded diagonally once, then three holes are punched exactly on the fold line. How many holes appear when unfolded?
    A. 6
    B. 1
    C. 2
    D. 3

22. [Hole Punching] Paper is folded in half three times, then three holes are punched through all layers. How many holes appear when unfolded?
    A. 24
    B. 16
    C. 12
    D. 8

23. [Hole Punching] Paper is folded in half once, then six holes are punched through both layers. How many total holes appear when unfolded?
    A. 6
    B. 10
    C. 8
    D. 12

24. [Hole Punching] Paper is folded in half twice, then a hole is punched exactly on one fold line. How many holes appear when unfolded?
    A. 1
    B. 4
    C. 2
    D. 8

25. [Hole Punching] Paper is folded in half twice (into quarters), then three holes are punched through all layers. How many total holes appear when unfolded?
    A. 12
    B. 16
    C. 15
    D. 20

26. [Hole Punching] Paper is folded diagonally once, then five holes are punched away from the fold. How many total holes appear when unfolded?
    A. 5
    B. 10
    C. 12
    D. 8

27. [Hole Punching] Paper is folded in half once, then nine holes are punched through both layers. How many total holes appear when unfolded?
    A. 9
    B. 12
    C. 16
    D. 18

28. [Hole Punching] Paper is folded in half three times, then a hole is punched at the center. How many holes appear when unfolded?
    A. 1
    B. 4
    C. 8
    D. 16

29. [Hole Punching] Paper is folded in half twice (creating 4 layers), then three holes are punched through all layers. How many holes appear when unfolded?
    A. 8
    B. 12
    C. 16
    D. 6

30. [Hole Punching] Paper is folded in half once, then ten holes are punched through both layers. How many holes appear when unfolded?
    A. 20
    B. 12
    C. 10
    D. 16

CUBE COUNTING (Questions 31-45)

Directions: Answer questions about unit cubes in various structures.

31. [Cube Counting] In a 7×7×7 cube, how many unit cubes have exactly 1 face exposed (face cubes)?
    A. 96
    B. 125
    C. 150
    D. 200

32. [Cube Counting] A solid 8×8×8 cube. How many unit cubes have exactly 3 faces exposed (corner cubes)?
    A. 6
    B. 12
    C. 4
    D. 8

33. [Cube Counting] A 2×4×5 rectangular prism. How many total unit cubes are in the structure?
    A. 40
    B. 36
    C. 54
    D. 48

34. [Cube Counting] A structure of 18 unit cubes arranged in a straight line. How many cubes have exactly 5 faces exposed (end cubes)?
    A. 1
    B. 0
    C. 4
    D. 2

35. [Cube Counting] In a 7×7×7 cube, how many unit cubes have exactly 0 faces exposed (completely interior)?
    A. 64
    B. 125
    C. 216
    D. 27

36. [Cube Counting] A 5×4×3 rectangular prism. How many unit cubes have exactly 3 faces exposed (corners)?
    A. 8

B. 6
C. 4
D. 12

37. [Cube Counting] A solid 7×7×7 cube. How many unit cubes have exactly 2 faces exposed (edge cubes)?
    A. 36
    B. 48
    C. 60
    D. 72

38. [Cube Counting] A 6×4×3 rectangular prism. How many total unit cubes are in the structure?
    A. 60
    B. 54
    C. 48
    D. 72

39. [Cube Counting] In a 7×7×7 cube, how many unit cubes are NOT corner cubes?
    A. 335
    B. 335
    C. 343
    D. 327

40. [Cube Counting] A 6×4×2 rectangular prism. How many unit cubes are NOT corner cubes?
    A. 40
    B. 46
    C. 40
    D. 38

41. [Cube Counting] A pyramid structure: 49 cubes on bottom (7×7), 36 cubes on second layer (6×6), 25 cubes on third layer (5×5), 16 cubes on fourth layer (4×4), 9 cubes on fifth layer (3×3), 4 cubes on sixth layer (2×2), 1 cube on top. How many cubes have exactly 3 exposed faces?
    A. 16
    B. 12
    C. 20
    D. 14

42. [Cube Counting] A 5×5×4 rectangular prism. How many unit cubes have exactly 2 faces exposed?
    A. 24
    B. 30

C. 32
D. 36

43. [Cube Counting] An L-shaped structure: 10 cubes in a row with 6 cubes stacked on one end (16 total). How many cubes have exactly 3 exposed faces?
    A. 5
    B. 6
    C. 7
    D. 8

44. [Cube Counting] A 9×9×2 rectangular prism. How many unit cubes have at least one face exposed?
    A. 162
    B. 160
    C. 156
    D. 158

45. [Cube Counting] In a 6×6×6 cube, how many unit cubes have exactly 2 faces exposed?
    A. 36
    B. 60
    C. 48
    D. 72

PATTERN FOLDING (Questions 46-60)

Directions: Identify what 3D shape is formed when the described net is folded.

46. [Pattern Folding] A net consists of 5 squares in a T-shape. What can this form when folded?
    A. Complete cube
    B. Pyramid
    C. Open box
    D. Partial cube

47. [Pattern Folding] A net shows 1 octagon with 8 triangles attached to each edge. What 3D shape is formed?
    A. Cube
    B. Octagonal pyramid
    C. Hexagonal prism
    D. Rectangular prism

48. [Pattern Folding] A net consists of 6 squares arranged in an L-shape pattern. What does it form?

A. Partial cube
B. Pyramid
C. Cube (if proper arrangement)
D. Prism

49. [Pattern Folding] A net shows 2 octagons and 8 rectangles all connected. What shape does it form?
    A. Tetrahedron
    B. Rectangular prism
    C. Pentagon
    D. Octagonal prism

50. [Pattern Folding] A net shows 1 square with 4 triangles attached to all four edges of the square. What shape does it form?
    A. Square pyramid
    B. Partial pyramid
    C. Complete cube
    D. Prism

51. [Pattern Folding] A net consists of 3 squares in an L-shape. What does it form?
    A. Complete cube
    B. Pyramid
    C. Partial open box
    D. Prism

52. [Pattern Folding] A net has 5 equilateral triangles arranged to connect. What 3D shape is formed?
    A. Square pyramid
    B. Triangular dipyramid or partial structure
    C. Cube
    D. Tetrahedron

53. [Pattern Folding] A net consists of 1 square and 4 rectangles that connect. What does it form?
    A. Cone
    B. Rectangular prism (open ends)
    C. Pyramid
    D. Cylinder

54. [Pattern Folding] A net shows 4 rectangles arranged around a central rectangle. What is it most likely to form?
    A. Pyramid
    B. Rectangular prism (open ends)

C. Open rectangular box
D. Triangular prism

55. [Pattern Folding] A net shows 1 decagon with 10 rectangles connecting around its edges. What 3D shape is formed?
    A. Rectangular prism
    B. Hexagonal prism
    C. Cube
    D. Decagonal prism

56. [Pattern Folding] A net consists of 1 large hexagon with 6 triangles attached to its edges. What shape does it form?
    A. Square pyramid
    B. Tetrahedron
    C. Octahedron
    D. Hexagonal pyramid

57. [Pattern Folding] A net shows 6 squares in an unfolded cross with one arm extended. What can this form?
    A. Cube
    B. Pyramid
    C. Open box
    D. Complete pyramid

58. [Pattern Folding] A net consists of 3 rectangles and 2 triangles arranged in a strip. What shape does it form?
    A. Square pyramid
    B. Tetrahedron
    C. Triangular prism
    D. Cube

59. [Pattern Folding] A net shows 2 squares in a row. What can this form?
    A. Complete cube
    B. Partial structure
    C. Pyramid
    D. Prism

60. [Pattern Folding] A net consists of 1 square and 5 rectangles arranged around it. What type of shape does this form?
    A. Rectangular prism

B. Pyramid
C. Partial cube
D. Triangular prism

APERTURES / KEYHOLES (Questions 61-75)

Directions: Determine which aperture shape a 3D object could pass through.

61. [Keyhole] A pentagonal prism must pass through an aperture. Which aperture shape could work?
    A. Circle
    B. Triangle
    C. Square
    D. Pentagon or Rectangle

62. [Keyhole] A pentagonal pyramid is oriented to pass through an aperture. Which aperture shape is possible?
    A. Circle
    B. Rectangle
    C. Pentagon or Triangle
    D. Hexagon

63. [Keyhole] A cube passes through an aperture. Which shape would work?
    A. Square
    B. Circle
    C. Pentagon
    D. Hexagon

64. [Keyhole] A triangular prism passes through an aperture. Which shapes are possible?
    A. Circle only
    B. Triangle or Rectangle
    C. Pentagon only
    D. Hexagon only

65. [Keyhole] A cylinder passes through an aperture. Which aperture is possible?
    A. Triangle
    B. Pentagon
    C. Hexagon
    D. Circle or Rectangle

66. [Keyhole] Which aperture shape would NOT work for a rectangular prism?

A. Circle
B. Triangle
C. Rectangle
D. Square

67. [Keyhole] A hexagonal pyramid must pass through an aperture. Which aperture is possible?
    A. Circle
    B. Pentagon
    C. Hexagon or Triangle
    D. Square

68. [Keyhole] A rectangular prism passes through an aperture. Which shape is possible?
    A. Circle
    B. Rectangle
    C. Pentagon
    D. Hexagon

69. [Keyhole] A square pyramid passes through an aperture. Which shape works?
    A. Circle
    B. Pentagon
    C. Hexagon
    D. Square or Triangle

70. [Keyhole] Which 3D object could pass through a rectangular aperture?
    A. Sphere
    B. Tetrahedron
    C. Cylinder or rectangular prism
    D. Octahedron

71. [Keyhole] A tetrahedron passes through an aperture. Which shape is most likely?
    A. Triangle
    B. Pentagon
    C. Hexagon
    D. Square

72. [Keyhole] A rectangular prism passes through an aperture. Which are the possible shapes?
    A. Circle only
    B. Triangle only
    C. Pentagon only
    D. Rectangle or Square

73. [Keyhole] Which aperture shape would work for a triangular prism but NOT for a sphere?
    A. Circle
    B. Triangle
    C. Pentagon
    D. Hexagon

74. [Keyhole] A pentagonal prism passes through an aperture. Which is NOT a possible aperture shape?
    A. Pentagon
    B. Rectangle
    C. Circle
    D. Triangle

75. [Keyhole] Which 3D shape could pass through both a pentagon and rectangle aperture?
    A. Pentagonal prism
    B. Sphere
    C. Cylinder
    D. Cube

VIEW RECOGNITION (Questions 76-90)

Directions: Given views from different angles, identify the 3D shape or determine what a view would look like.

76. [Top-Front-End] Top view: pentagon. Front view: rectangle. Side view: rectangle. What is the 3D shape?
    A. Pentagonal prism
    B. Cylinder
    C. Square pyramid
    D. Triangular prism

77. [Top-Front-End] Front view: square. Top view: triangle. Side view: triangle. What is the shape?
    A. Cone
    B. Square pyramid
    C. Cylinder
    D. Rectangular prism

78. [Top-Front-End] A pentagonal prism is viewed from the top. What shape appears?
    A. Rectangle
    B. Square

C. Circle
D. Pentagon

79. [Top-Front-End] Top view: octagon. Front view: rectangle. Side view: rectangle. What is the shape?
A. Octagonal prism
B. Hexagonal prism
C. Pentagonal pyramid
D. Rectangular prism

80. [Top-Front-End] A rectangular prism is viewed from the side. What shape appears?
A. Square
B. Circle
C. Rectangle
D. Triangle

81. [Top-Front-End] Top view: square. Front view: triangle. Side view: triangle. What is the shape?
A. Tetrahedron
B. Triangular prism
C. Cone
D. Square pyramid

82. [Top-Front-End] Top view: hexagon. Front and side views: rectangles. What is the shape?
A. Cube
B. Hexagonal prism
C. Pyramid
D. Cylinder

83. [Top-Front-End] An octagonal prism is viewed from the side (perpendicular to its octagonal face). What shape appears?
A. Rectangle
B. Hexagon
C. Circle
D. Square

84. [Top-Front-End] Top view: square. Front view: triangle. Side view: rectangle. What is the shape?
A. Cylinder
B. Cone
C. Rectangular pyramid
D. Triangular prism

85. [Top-Front-End] Top view: hexagon. Front and side views: hexagons. What is the shape?
    A. Sphere
    B. Pentagonal prism
    C. Cylinder
    D. Cube-like hexagonal structure

86. [Top-Front-End] A pentagonal pyramid is viewed from directly above (looking at the base). What shape appears?
    A. Triangle
    B. Pentagon
    C. Circle
    D. Square

87. [Top-Front-End] A rectangular prism is viewed from the end. What shape appears?
    A. Square
    B. Triangle
    C. Rectangle
    D. Circle

88. [Top-Front-End] Top view: triangle. Front view: rectangle. Side view: rectangle. What is the shape?
    A. Triangular prism
    B. Pyramid
    C. Cylinder
    D. Rectangular prism

89. [Top-Front-End] A hexagonal pyramid is viewed from directly above. What shape appears?
    A. Triangle
    B. Rectangle
    C. Pentagon
    D. Hexagon

90. [Top-Front-End] Top view: L-shape. Front view: rectangle. Side view: rectangle. What type of structure is this?
    A. Pyramid
    B. L-shaped block structure
    C. Cylinder
    D. Cube

Reading Comprehension

PASSAGE I

Vaccines represent one of medicine's greatest triumphs, preventing millions of deaths annually. Traditional vaccines use weakened or inactivated pathogens to train the immune system, while newer technologies employ different approaches. Understanding vaccine mechanisms and development helps address hesitancy and optimize public health strategies.

Most vaccines work by exposing the immune system to antigens—molecular signatures unique to specific pathogens—without causing disease. This primes both humoral immunity (antibody production by B cells) and cellular immunity (T cell responses). Memory B and T cells persist for years or decades, enabling rapid responses upon actual infection. Live attenuated vaccines use weakened pathogens that replicate but don't cause disease in healthy individuals, producing strong, long-lasting immunity often with single doses. Inactivated vaccines use killed pathogens or subunits, typically requiring multiple doses and boosters. Examples include the inactivated polio vaccine and hepatitis A vaccine.

Modern vaccine platforms offer advantages over traditional approaches. mRNA vaccines, successfully deployed against COVID-19, contain genetic instructions for cells to temporarily produce viral proteins that trigger immune responses. These vaccines can be developed rapidly since they don't require pathogen cultivation. Viral vector vaccines use harmless viruses to deliver genetic material encoding pathogen proteins. Protein subunit vaccines contain purified antigens with adjuvants—substances enhancing immune responses. The hepatitis B vaccine uses this approach.

Vaccine development involves rigorous testing phases. Preclinical studies in cell cultures and animals assess safety and immunogenicity. Phase I trials in small human groups test safety and dosing. Phase II trials in hundreds of participants evaluate efficacy and side effects. Phase III trials in thousands confirm effectiveness and monitor adverse events. Post-licensure surveillance continues indefinitely through systems like the Vaccine Adverse Event Reporting System (VAERS).

Vaccine hesitancy threatens public health gains. Common concerns include safety, efficacy, and necessity. However, serious adverse events are extremely rare—far less common than complications from the diseases vaccines prevent. The fraudulent study linking vaccines to autism has been thoroughly debunked and retracted. Vaccines undergo more safety testing than most medications. Herd immunity—when enough people are vaccinated to protect those who cannot receive vaccines—requires high vaccination rates, typically 85-95% depending on disease contagiousness.

1. Antigens in vaccines are:
   A. Immune system cells
   B. Antibiotics
   C. Molecular signatures of pathogens
   D. Live bacteria

2. Memory B and T cells function to:
   A. Enable rapid responses upon future infection
   B. Cause disease
   C. Destroy vaccines
   D. Prevent all immune responses

3. Live attenuated vaccines typically require:
   A. Many doses
   B. Weekly boosters
   C. Daily administration
   D. Single doses for strong immunity

4. Inactivated vaccines contain:
   A. Live weakened pathogens
   B. No antigens
   C. Killed pathogens or subunits
   D. Only water

5. mRNA vaccines contain:
   A. Live viruses
   B. Genetic instructions for cells
   C. Killed bacteria
   D. Antibiotics

6. The advantage of mRNA vaccines is they can be:
   A. Developed rapidly without pathogen cultivation
   B. Taken orally
   C. Given once for lifelong immunity
   D. Used without testing

7. Viral vector vaccines use:
   A. Antibiotics
   B. Dead viruses
   C. No genetic material
   D. Harmless viruses to deliver genetic material

8. Adjuvants in vaccines function to:
   A. Kill pathogens
   B. Reduce immunity
   C. Enhance immune responses

D. Prevent immune responses

9. Phase I clinical trials primarily test:
   A. Efficacy
   B. Safety and dosing
   C. Long-term effects
   D. Population effectiveness

10. Phase III trials involve:
    A. Ten participants
    B. Cell cultures only
    C. Animals only
    D. Thousands of participants

11. VAERS is:
    A. Post-licensure surveillance system
    B. Vaccine manufacturing company
    C. Disease prevention protocol
    D. Type of vaccine

12. Serious adverse events from vaccines are:
    A. Very common
    B. Expected in everyone
    C. Extremely rare
    D. More common than disease complications

13. The study linking vaccines to autism was:
    A. Confirmed repeatedly
    B. Partially true
    C. Accepted by scientists
    D. Fraudulent and retracted

14. Herd immunity protects:
    A. Only vaccinated individuals
    B. Those who cannot receive vaccines
    C. No one
    D. Only children

15. Required vaccination rates for herd immunity typically are:
    A. 10-20%

B. 40-50%
C. 85-95%
D. 100%

16. Humoral immunity involves:
    A. Antibody production by B cells
    B. Only physical barriers
    C. T cells exclusively
    D. No immune cells

17. Vaccines prime both humoral and:
    A. Digestive immunity
    B. Respiratory immunity
    C. Nervous immunity
    D. Cellular immunity (T cell responses)

PASSAGE II

Gene therapy holds promise for treating genetic diseases by correcting defective genes. Rather than managing symptoms with medication, gene therapy addresses root causes by delivering functional genes to replace or supplement faulty ones. Recent successes demonstrate feasibility, though challenges remain regarding delivery, safety, and accessibility.

Gene therapy approaches vary in strategy. Replacement therapy introduces functional gene copies into cells containing defective versions. This is effective for recessive disorders where any functional gene expression restores normal phenotype. Gene editing using CRISPR-Cas9 directly repairs mutations by cutting DNA at precise locations and allowing cellular repair mechanisms to fix defects. Gene silencing uses small interfering RNAs (siRNAs) to block expression of harmful genes, useful for dominant disorders where mutant proteins cause problems. Gene augmentation increases expression of beneficial genes without removing defective ones.

Delivery systems critically impact gene therapy success. Viral vectors—modified viruses stripped of disease-causing genes—efficiently deliver therapeutic genes into cells. Adenoviruses infect many cell types but don't integrate into chromosomes, requiring repeated treatments. Adeno-associated viruses (AAVs) are safer and provide longer-lasting expression but carry smaller genetic payloads. Lentiviruses integrate into chromosomes, providing permanent expression but raising concerns about insertional mutagenesis—accidental disruption of important genes. Non-viral methods like lipid nanoparticles avoid viral risks but deliver genes less efficiently.

In vivo therapy delivers genes directly into patients, while ex vivo therapy modifies cells outside the body before reintroducing them. Ex vivo approaches, used for blood disorders, involve extracting patient cells, genetically modifying them in laboratory, and infusing corrected cells back. This reduces off-target effects but is complex and expensive. In vivo therapy is simpler but less controlled.

Gene therapy successes include treatments for inherited retinal dystrophy, spinal muscular atrophy, and beta-thalassemia. Luxturna, approved in 2017, treats RPE65-mutation blindness using AAV vectors to deliver functional genes to retinal cells, restoring vision in many patients. Zolgensma treats spinal muscular atrophy in infants by delivering the SMN1 gene, dramatically improving survival and motor function. CAR-T cell therapy genetically modifies patients' T cells to target cancer cells, achieving remarkable remissions in certain leukemias and lymphomas.

Challenges include high costs (some treatments exceed $2 million per patient), limited durability of some therapies, immune responses against vectors or therapeutic proteins, and potential for off-target effects. Germline editing—modifying eggs, sperm, or embryos—raises ethical concerns as changes pass to future generations. Most gene therapy targets somatic cells, affecting only the treated individual.

18. Gene therapy addresses genetic diseases by:
    A. Managing symptoms only
    B. Preventing all diseases
    C. Correcting defective genes
    D. Using antibiotics

19. Replacement therapy introduces:
    A. Defective genes
    B. Functional gene copies
    C. Antibodies
    D. Proteins only

20. CRISPR-Cas9 works by:
    A. Cutting DNA at precise locations
    B. Producing proteins
    C. Destroying cells
    D. Blocking all genes

21. Gene silencing uses siRNAs to:
    A. Activate all genes
    B. Produce proteins
    C. Replicate DNA
    D. Block expression of harmful genes

22. Adenoviruses as vectors:
    A. Integrate into chromosomes
    B. Cause permanent diseases
    C. Don't integrate into chromosomes
    D. Never deliver genes

23. Adeno-associated viruses (AAVs) provide:
    A. Short-lasting expression
    B. Longer-lasting expression
    C. No gene delivery
    D. Immediate cell death

24. Lentiviruses integrate into chromosomes but risk:
    A. No gene delivery
    B. Immediate rejection
    C. Viral replication
    D. Insertional mutagenesis

25. Non-viral delivery methods like lipid nanoparticles:
    A. Avoid viral risks
    B. Are most efficient
    C. Always integrate into chromosomes
    D. Cause diseases

26. Ex vivo therapy involves:
    A. Direct injection only
    B. Oral medication
    C. Modifying cells outside the body
    D. No cell modification

27. In vivo therapy is simpler but:
    A. More expensive
    B. Less controlled
    C. More effective always
    D. Requires cell extraction

28. Luxturna treats:
    A. RPE65-mutation blindness
    B. Cancer only
    C. Diabetes

D. Heart disease

29. Zolgensma delivers the SMN1 gene to treat:
    A. Blindness
    B. Cancer
    C. Diabetes
    D. Spinal muscular atrophy

30. CAR-T cell therapy genetically modifies:
    A. Bacteria
    B. Viruses
    C. T cells to target cancer
    D. Red blood cells

31. Gene therapy costs can exceed:
    A. $100 per patient
    B. $2 million per patient
    C. $1,000 per patient
    D. $50,000 per patient

32. Germline editing changes pass to:
    A. Only the patient
    B. No one
    C. Only siblings
    D. Future generations

33. Most gene therapy targets:
    A. Somatic cells
    B. Germline cells only
    C. All cells equally
    D. No cells

34. Gene augmentation:
    A. Removes all genes
    B. Increases expression without removing defective genes
    C. Stops all gene expression
    D. Destroys cells

PASSAGE III

Antibiotic resistance poses one of the greatest threats to modern medicine. Bacteria evolve resistance through mutations and horizontal gene transfer, rendering once-effective drugs useless. Understanding resistance mechanisms and implementing strategies to preserve antibiotic effectiveness are critical for public health.

Bacteria develop resistance through multiple mechanisms. Target modification alters antibiotic binding sites, preventing drug action. Methicillin-resistant Staphylococcus aureus (MRSA) produces altered penicillin-binding proteins. Enzymatic inactivation involves bacteria producing enzymes that destroy antibiotics—beta-lactamases break down penicillins. Efflux pumps actively expel antibiotics before they can act. Reduced permeability involves cell wall changes preventing antibiotic entry. Bacteria can possess multiple resistance mechanisms simultaneously, creating extensively drug-resistant (XDR) strains.

Resistance spreads through several pathways. Vertical transmission passes resistance genes from parent to offspring during cell division. Horizontal gene transfer shares resistance genes between bacteria through transformation (uptake of environmental DNA), transduction (viral transfer), or conjugation (direct cell-to-cell transfer via pili). Plasmids—circular DNA molecules—often carry multiple resistance genes and transfer easily between bacteria, even different species. This accelerates resistance spread across bacterial populations.

Contributing factors include antibiotic overuse in healthcare—prescribing for viral infections where antibiotics provide no benefit. Agricultural use accounts for over 70% of medically important antibiotics in some regions, primarily for growth promotion rather than treating disease. Patient non-compliance—discontinuing treatment prematurely—allows resistant bacteria to survive and multiply. Global travel and trade spread resistant strains internationally within days.

Combating resistance requires comprehensive approaches. Antibiotic stewardship programs optimize prescribing through guidelines, rapid diagnostics distinguishing bacterial from viral infections, and restricting broad-spectrum antibiotics. Infection prevention through vaccination, hand hygiene, and sanitation reduces antibiotic need. Developing new antibiotics faces economic challenges—pharmaceutical companies find limited profitability in drugs used briefly and held in reserve. Alternative therapies include bacteriophages (viruses that infect bacteria), antimicrobial peptides, and drugs targeting virulence factors without killing bacteria, potentially reducing selection pressure.

35. Target modification in bacteria:
    A. Increases antibiotic effectiveness
    B. Kills the bacteria
    C. Alters antibiotic binding sites
    D. Has no effect

36. MRSA produces altered:
    A. Antibiotics
    B. Viruses
    C. Cell walls
    D. Penicillin-binding proteins

37. Beta-lactamases function by:
    A. Destroying penicillins
    B. Enhancing antibiotic action
    C. Producing new antibiotics
    D. Killing bacteria

38. Efflux pumps:
    A. Bring antibiotics into cells
    B. Actively expel antibiotics
    C. Produce antibiotics
    D. Destroy cell walls

39. Extensively drug-resistant (XDR) strains possess:
    A. No resistance
    B. One resistance mechanism
    C. Multiple resistance mechanisms
    D. Antibiotic production capability

40. Vertical transmission passes resistance genes:
    A. From parent to offspring during division
    B. Between different species only
    C. Through viruses only
    D. Through conjugation only

41. Transformation involves:
    A. Cell death
    B. Viral infection
    C. Conjugation
    D. Uptake of environmental DNA

42. Plasmids are:
    A. Antibiotics
    B. Circular DNA molecules
    C. Proteins

D. Viruses

43. Agricultural antibiotic use is primarily for:
    A. Treating sick animals only
    B. Emergency situations
    C. Growth promotion
    D. Veterinary surgeries

44. Patient non-compliance allows:
    A. Complete cure
    B. Faster healing
    C. Better outcomes
    D. Resistant bacteria to survive

45. Antibiotic stewardship programs optimize:
    A. Prescribing
    B. Bacterial growth
    C. Antibiotic resistance
    D. Disease spread

46. Rapid diagnostics help distinguish:
    A. Doctors from patients
    B. Hospitals from clinics
    C. Bacterial from viral infections
    D. Pills from injections

47. Developing new antibiotics faces challenges because:
    A. They're too easy to make
    B. Companies find limited profitability
    C. No one needs them
    D. They're always profitable

48. Bacteriophages are:
    A. Viruses that infect bacteria
    B. Antibiotics
    C. Resistant bacteria
    D. Vaccines

49. Drugs targeting virulence factors without killing bacteria may:
    A. Have no effect

B. Increase resistance
C. Cause immediate death
D. Reduce selection pressure

50. Horizontal gene transfer can occur between:
A. Only identical bacteria
B. Different bacterial species
C. Humans only
D. Viruses only

Quantitative Reasoning

1. What is the circumference of a circle with radius 9 cm? (Use $\pi \approx 3.14$)
A. 28.26 cm
B. 254.34 cm
C. 18.84 cm
D. 56.52 cm

2. Solve for x: $4x + 13 = 49$
A. 7
B. 8
C. 10
D. 9

3. What is 7/8 - 1/4?
A. 3/4
B. 1/2
C. 5/8
D. 6/8

4. In a triangle with angles 55°, 68°, and x°, what is x?
A. 67°
B. 57°
C. 62°
D. 52°

5. What is the area of a rectangle with length 19 cm and width 8 cm?
A. 54 cm^2
B. 27 cm^2

C. 108 cm^2
D. 152 cm^2

6. Solve the inequality: $4x - 7 > 21$
   A. $x > 7$
   B. $x > 5$
   C. $x < 7$
   D. $x > 14$

7. What is $8^3 - 3^3$?
   A. 343
   B. 448
   C. 485
   D. 512

8. If 35% of a number is 140, what is the number?
   A. 200
   B. 400
   C. 350
   D. 500

9. What is the mean of {18, 24, 30, 36, 42, 54}?
   A. 30
   B. 33
   C. 36
   D. 34

10. A car travels 420 miles in 7 hours. What is its average speed?
    A. 60 mph
    B. 70 mph
    C. 50 mph
    D. 80 mph

11. What is 5/6 - 1/3?
    A. 2/3
    B. 4/6
    C. 1/2
    D. 2/6

12. What is the slope of a line passing through points (2, 5) and (6, 13)?

A. 3
B. 4
C. 2
D. 1

13. What is $|-42| - |17|$?
    A. 25
    B. -59
    C. -25
    D. 59

14. If $21/x = 63/90$, what is x?
    A. 15
    B. 30
    C. 45
    D. 60

15. What is the surface area of a cube with edge length 9 cm?
    A. 324 cm^2
    B. 81 cm^2
    C. 486 cm^2
    D. 729 cm^3

16. Solve the system: $x + y = 30$ and $x - y = 12$
    A. $x = 18, y = 12$
    B. $x = 21, y = 9$
    C. $x = 20, y = 10$
    D. $x = 24, y = 6$

17. What is $\sin 45°$?
    A. 1/2
    B. 1
    C. $\sqrt{3}/2$
    D. $\sqrt{2}/2$

18. If a rectangle has area 210 cm^2 and length 15 cm, what is its width?
    A. 12 cm
    B. 10 cm
    C. 14 cm
    D. 16 cm

19. What is the least common multiple (LCM) of 15 and 25?
    A. 75
    B. 50
    C. 100
    D. 125

20. A bag contains 9 red marbles and 15 blue marbles. What is the probability of drawing a blue marble?
    A. 3/8
    B. 5/8
    C. 1/2
    D. 2/3

21. What is the distance between points (2, 4) and (8, 12)?
    A. 8
    B. 9
    C. 7
    D. 10

22. If y varies directly as x, and $y = 45$ when $x = 5$, what is y when $x = 8$?
    A. 90
    B. 56
    C. 72
    D. 64

23. What is $\tan 45°$?
    A. 1
    B. $\sqrt{2}/2$
    C. $\sqrt{3}/2$
    D. 1/2

24. If a square has area 225 cm^2, what is its perimeter?
    A. 45 cm
    B. 75 cm
    C. 90 cm
    D. 60 cm

25. Evaluate: $f(x) = 4x - 7$ when $x = 8$
    A. 18
    B. 21

C. 24
D. 25

26. Convert 0.375 to a fraction in lowest terms.
A. 1/2
B. 1/4
C. 3/8
D. 5/8

27. Solve for x: $9x - 4 = 7x + 10$
A. 9
B. 7
C. 5
D. 8

28. What is the volume of a cylinder with radius 4 cm and height 7 cm? (Use $\pi \approx 3.14$)
A. 351.68 cm^3
B. 175.84 cm^3
C. 87.92 cm^3
D. 703.36 cm^3

29. What is the greatest common factor (GCF) of 42 and 70?
A. 7
B. 21
C. 6
D. 14

30. In a triangle with angles 50°, 75°, and x°, what is x?
A. 50°
B. 60°
C. 55°
D. 65°

31. What is $11^2 - 8^2$?
A. 45
B. 57
C. 64
D. 121

32. What is 9/10 - 1/5?

A. 4/5
B. 1/2
C. 3/5
D. 7/10

33. A cylinder has radius 5 cm and height 8 cm. What is its volume? (Use $\pi \approx 3.14$)
A. 628 cm^3
B. 314 cm^3
C. 471 cm^3
D. 785 cm^3

34. What is 90 increased by 40%?
A. 108
B. 120
C. 126
D. 130

35. If $\tan \theta = 1$, what is θ in degrees ($0° < \theta < 90°$)?
A. 30°
B. 45°
C. 60°
D. 90°

36. Solve: $5(x - 2) = 3x + 14$
A. 12
B. 10
C. 8
D. 14

37. What is the range of the dataset: {20, 35, 28, 47, 31}?
A. 20
B. 27
C. 31
D. 35

38. If $x^2 = 256$, what are the possible values of x?
A. 256
B. 128
C. 64
D. ±16

39. What is cos 45°?
    A. √2/2
    B. 1/2
    C. √3/2
    D. 1

40. Simplify: $(36x^9y^7)/(6x^6y^3)$
    A. $30x^3y^4$
    B. $6x^4y^3$
    C. $6x^3y^4$
    D. $5x^3y^4$

Answer Explanations - Practice Test 9

Survey Of Natural Sciences

BIOLOGY (Questions 1-40)

1. Correct Answer: A (Breaking down fatty acids and detoxifying hydrogen peroxide)

Peroxisomes are organelles that contain oxidative enzymes involved in breaking down fatty acids through beta-oxidation and detoxifying hydrogen peroxide (H_2O_2) into water and oxygen using the enzyme catalase. They play important roles in lipid metabolism and protecting cells from oxidative damage.

2. Correct Answer: C (SA node)

The sinoatrial (SA) node, located in the right atrium, is the heart's natural pacemaker. It generates electrical impulses spontaneously at a rate of 60-100 beats per minute, setting the intrinsic heart rate and initiating each heartbeat before signals spread through the conduction system.

3. Correct Answer: B (Prophase I)

Crossing over (recombination) between homologous chromosomes occurs during prophase I of meiosis when homologous pairs synapse and form tetrads. This genetic exchange between non-sister chromatids increases genetic diversity in offspring.

4. Correct Answer: A (Carotenoids and xanthophylls)

Accessory pigments in photosynthesis include carotenoids (orange) and xanthophylls (yellow), which absorb wavelengths of light that chlorophyll cannot capture efficiently. They extend the range of light absorption and protect against photooxidation. Chlorophyll a is the primary pigment.

5. Correct Answer: D (Frameshift mutation)

An insertion or deletion of nucleotides that is not a multiple of three causes a frameshift mutation. Since the genetic code is read in triplets (codons), adding or removing 1 or 2 nucleotides shifts the reading frame, changing all downstream amino acids and usually producing a nonfunctional protein.

6. Correct Answer: C (Small intestine)

The pancreas secretes digestive enzymes (amylase, lipase, proteases) into the small intestine, specifically the duodenum, through the pancreatic duct. These enzymes help break down carbohydrates, fats, and proteins. The pancreas also secretes bicarbonate to neutralize stomach acid.

7. Correct Answer: B (ATP and NADPH)

The light-dependent reactions of photosynthesis produce ATP and NADPH, which are then used in the Calvin cycle (light-independent reactions) to fix carbon dioxide and synthesize glucose. These energy carriers power the reduction of CO_2 to carbohydrates.

8. Correct Answer: D (Join Okazaki fragments)

DNA ligase joins Okazaki fragments on the lagging strand by forming phosphodiester bonds between the 3'-OH of one fragment and the 5'-phosphate of the next fragment. This creates a continuous DNA strand after RNA primers are removed and gaps are filled.

9. Correct Answer: A (Increase blood calcium levels)

Parathyroid hormone (PTH) from the parathyroid glands functions to increase blood calcium levels by stimulating osteoclasts to break down bone (releasing calcium), increasing calcium reabsorption in kidneys, and promoting vitamin D activation (which increases intestinal calcium absorption).

10. Correct Answer: C (Red blood cells)

Hemoglobin is the oxygen-carrying protein found in red blood cells (erythrocytes). Each hemoglobin molecule contains four heme groups with iron atoms that bind oxygen, enabling red blood cells to transport oxygen from lungs to tissues throughout the body.

11. Correct Answer: B (Medulla)

The loop of Henle in the nephron creates a concentration gradient in the medulla (inner region of the kidney) through countercurrent multiplication. This gradient allows the kidney to produce concentrated urine by drawing water out of the collecting duct in the medulla.

12. Correct Answer: A (Modified guanine nucleotide)

The 5' cap on mRNA consists of a modified guanine nucleotide (7-methylguanosine) added to the 5' end during RNA processing. This cap protects mRNA from degradation, aids in ribosome binding, and helps with translation initiation.

13. Correct Answer: D (Left ventricle and aorta)

The aortic semilunar valve is located between the left ventricle and the aorta. It prevents backflow of blood from the aorta into the left ventricle after ventricular contraction, ensuring unidirectional blood flow into systemic circulation.

14. Correct Answer: B (Carrier proteins or channel proteins)

Facilitated diffusion requires carrier proteins or channel proteins to transport molecules across membranes down their concentration gradient. Unlike simple diffusion, it uses proteins to assist transport but does not require ATP energy, making it a passive process.

15. Correct Answer: C (Urea)

Mammals excrete nitrogenous waste primarily as urea, produced in the liver through the urea cycle. Urea is less toxic than ammonia and requires less water for excretion than uric acid, balancing toxicity concerns with water conservation needs.

16. Correct Answer: D (lac operon)

The lac operon is an example of a positively regulated (inducible) operon. In the presence of lactose (the inducer), the lac repressor is inactivated, allowing transcription of genes needed for lactose metabolism. The system is "turned on" when the substrate is present.

17. Correct Answer: A (Inhalation)

During inhalation, the diaphragm contracts and moves downward, and external intercostal muscles contract to lift the rib cage upward and outward. This increases thoracic cavity volume, decreasing pressure and causing air to flow into the lungs.

18. Correct Answer: B (Two haploid cells)

The first cell division in meiosis (meiosis I) produces two haploid cells from one diploid cell. Homologous chromosomes separate, reducing chromosome number by half. The second division (meiosis II) then produces four haploid cells total.

19. Correct Answer: C (Ovulation)

During the menstrual cycle, estrogen levels from the developing follicle peak just before ovulation around day 14. This high estrogen level triggers positive feedback, causing the LH surge that induces ovulation (release of the egg from the ovary).

20. Correct Answer: A (Plasma cells)

Plasma cells, which are differentiated B cells, produce and secrete antibodies. When B cells encounter their specific antigen and receive appropriate signals, they differentiate into plasma cells that produce large quantities of antibodies against that antigen.

21. Correct Answer: D (Sugars)

Phloem tissue in plants primarily transports sugars (mainly sucrose) and other organic compounds from sources (like leaves where photosynthesis occurs) to sinks (like roots, fruits, and growing tissues). This process is called translocation. Xylem transports water and minerals.

22. Correct Answer: B (Acetylcholine)

The neurotransmitter at the neuromuscular junction (synapse between motor neuron and muscle fiber) is acetylcholine (ACh). When ACh binds to receptors on the muscle fiber membrane, it triggers depolarization and ultimately muscle contraction.

23. Correct Answer: C (Calcium ions)

Troponin binds to calcium ions during muscle contraction. When calcium enters the sarcoplasm, it binds to troponin, causing a conformational change that moves tropomyosin away from myosin-binding sites on actin, allowing cross-bridge formation and contraction.

24. Correct Answer: A (Prolactin)

Prolactin from the anterior pituitary stimulates the production of breast milk (lactogenesis) in mammary glands. During pregnancy, high estrogen and progesterone inhibit milk production, but after birth when these hormones drop, prolactin stimulates milk synthesis.

25. Correct Answer: D (2 ATP)

Glycolysis produces a net gain of 2 ATP molecules. The pathway generates 4 ATP through substrate-level phosphorylation but consumes 2 ATP in the early energy-investment phase, resulting in a net production of 2 ATP per glucose molecule.

26. Correct Answer: C (Bone marrow)

B cells mature in the bone marrow (hence "B" for bone marrow). They develop from hematopoietic stem cells and undergo selection processes to ensure they don't react against self-antigens. T cells mature in the thymus.

27. Correct Answer: B (Central nervous system)

Astrocytes are star-shaped glial cells found in the central nervous system (brain and spinal cord). They provide structural support, regulate the chemical environment around neurons, help form the blood-brain barrier, and provide nutrients to neurons.

28. Correct Answer: D (S phase)

DNA replication occurs during S phase (synthesis phase) of the cell cycle. During this phase, each chromosome is replicated to form two identical sister chromatids joined at the centromere, doubling the cell's DNA content in preparation for cell division.

29. Correct Answer: A (Bronchi)

The trachea branches into two primary bronchi (left and right) at the level of the carina. Each bronchus enters a lung and continues to branch into smaller bronchi, then bronchioles, and eventually alveolar ducts and alveoli.

30. Correct Answer: C (Rapid ATP regeneration)

Phosphocreatine (creatine phosphate) in muscle provides rapid ATP regeneration during the first few seconds of intense exercise. It donates its phosphate group to ADP to quickly regenerate ATP before other energy systems activate.

31. Correct Answer: B (DNA is the genetic material)

The Avery-MacLeod-McCarty experiment (1944) demonstrated that DNA is the genetic material. They showed that DNA from virulent bacteria could transform non-virulent bacteria into virulent ones, while destroying DNA (but not proteins or RNA) prevented transformation.

32. Correct Answer: D (Corpus luteum)

Progesterone is secreted by the corpus luteum, which forms from the ruptured follicle after ovulation. Progesterone prepares and maintains the endometrium for potential embryo implantation and is essential for maintaining early pregnancy.

33. Correct Answer: A (Increase surface area for absorption)

Villi and microvilli in the small intestine function to dramatically increase surface area for nutrient absorption. Villi are finger-like projections, and microvilli are tiny projections on epithelial cells, collectively increasing absorptive surface area to approximately 250-400 m^2.

34. Correct Answer: C (Gene silencing)

Small interfering RNAs (siRNAs) function in gene silencing through RNA interference (RNAi). They bind to complementary mRNA sequences and either block translation or mark the mRNA for degradation, effectively silencing gene expression at the post-transcriptional level.

35. Correct Answer: D (Blind spot)

The optic disc in the eye is the blind spot where the optic nerve exits the retina. This region lacks photoreceptors (rods and cones), creating a blind spot in the visual field. The brain fills in this gap using information from the surrounding area.

36. Correct Answer: A (RNA primers)

Primase synthesizes short RNA primers (about 10 nucleotides) that provide the 3'-OH group needed for DNA polymerase to begin synthesis. DNA polymerase cannot start synthesis de novo and requires these primers, which are later removed and replaced with DNA.

37. Correct Answer: D (Embryos)

Pluripotent stem cells are found in embryos, specifically in the inner cell mass of blastocysts. These cells can differentiate into any cell type from all three germ layers (endoderm, mesoderm, ectoderm) but cannot form a complete organism. Adult stem cells are multipotent, not pluripotent.

38. Correct Answer: B (Thick filaments and overlap zones)

The A-band in a sarcomere contains thick (myosin) filaments along with the regions where thick and thin filaments overlap. The A-band length remains constant during contraction because thick filament length doesn't change. The I-band contains only thin filaments and shortens during contraction.

39. Correct Answer: C (Kidneys)

Renin is secreted by juxtaglomerular cells in the kidneys in response to low blood pressure, low sodium, or sympathetic stimulation. Renin initiates the renin-angiotensin-aldosterone system (RAAS), which regulates blood pressure and fluid balance.

40. Correct Answer: D (0.48)

If $q^2 = 0.16$ in a Hardy-Weinberg population, then $q = 0.4$. Since $p + q = 1$, then $p = 0.6$. The frequency of heterozygotes is $2pq = 2(0.6)(0.4) = 0.48$ or 48%. The genotype frequencies are: $p^2 = 0.36$, $2pq = 0.48$, $q^2 = 0.16$.

GENERAL CHEMISTRY (Questions 41-70)

41. Correct Answer: A ($1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$)

Argon has atomic number 18, meaning it has 18 electrons. Following the Aufbau principle: $1s^2$ (2 electrons), $2s^2$ (2), $2p^6$ (6), $3s^2$ (2), $3p^6$ (6), totaling 18 electrons. Argon is a noble gas in Group 18 with a complete octet.

42. Correct Answer: C (Electrons fill orbitals starting with lowest energy)

The Aufbau principle states that electrons fill atomic orbitals starting with the lowest energy levels before moving to higher energy levels. The order follows: 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, etc., based on increasing energy.

43. Correct Answer: B (11)

With $[OH^-] = 1 \times 10^{-3}$ M, first calculate $pOH = -\log[OH^-] = -\log(10^{-3}) = 3$. Then $pH = 14 - pOH = 14 - 3 = 11$. This represents a basic solution ($pH > 7$).

44. Correct Answer: A (H_2O)

Hydrogen bonding is strongest between water (H_2O) molecules. Water has high electronegativity difference between O and H, and each molecule can form up to 4 hydrogen bonds. While HF has stronger individual H-bonds, water's extensive hydrogen bonding network makes it exceptional.

45. Correct Answer: B (Reduced)

In the reaction $Cu^{2+} + Zn \rightarrow Cu + Zn^{2+}$, copper gains electrons (goes from +2 to 0 oxidation state), so it is reduced. Zinc loses electrons (goes from 0 to +2), so it is oxidized. Remember: Reduction Is Gain of electrons (RIG).

46. Correct Answer: C (5)

The d subshell contains 5 orbitals. Each orbital can hold 2 electrons, so the d subshell can hold a maximum of 10 electrons. The number of orbitals in subshells: s=1, p=3, d=5, f=7.

47. Correct Answer: A (Orbital orientation in space)

The magnetic quantum number (m_l) describes the orbital's orientation in space. It can have values from -l to +l. For example, the three p orbitals (px, py, pz) have different orientations corresponding to different m_l values (-1, 0, +1).

48. Correct Answer: D (Henderson-Hasselbalch equation)

The pH of a buffer solution is calculated using the Henderson-Hasselbalch equation: $pH = pKa + \log([A^-]/[HA])$, where $[A^-]$ is the conjugate base concentration and [HA] is the weak acid concentration. This equation relates pH to the pKa and the ratio of conjugate base to weak acid.

49. Correct Answer: B (Equal numbers of molecules)

Avogadro's Law states that equal volumes of gases at the same temperature and pressure contain equal numbers of molecules (or moles). This is expressed as $V/n = \text{constant}$. One mole of any gas at STP occupies 22.4 L.

50. Correct Answer: A (+6)

In $Cr_2O_7^{2-}$ (dichromate ion), oxygen has -2 oxidation state. Using the rule that the sum equals the charge: $2(Cr) + 7(-2) = -2$, which gives $2Cr - 14 = -2$, so $2Cr = 12$, and $Cr = +6$. Chromium has a +6 oxidation state in dichromate.

51. Correct Answer: D (At low temperatures)

A reaction with $\Delta H < 0$ (exothermic) and $\Delta S < 0$ (entropy decreases) is spontaneous at low temperatures. Using $\Delta G = \Delta H - T\Delta S$, at low T, the negative ΔH term dominates, making ΔG negative. At high T, the $-T\Delta S$ term (positive) dominates, making ΔG positive.

52. Correct Answer: C (24.5 g)

Mass is calculated using: mass = moles × molar mass = 0.25 moles × 98 g/mol = 24.5 g. This tests the fundamental relationship between moles, mass, and molar mass.

53. Correct Answer: B (Across a period from left to right)

Electronegativity generally increases across a period from left to right due to increasing nuclear charge attracting electrons more strongly while shielding remains relatively constant. Electronegativity decreases down a group as atomic radius increases.

54. Correct Answer: D (Ka)

Ka (acid dissociation constant) is the equilibrium constant that applies to weak acids. It represents the equilibrium: $HA \rightleftharpoons H^+ + A^-$, where $Ka = [H^+][A^-]/[HA]$. Larger Ka values indicate stronger weak acids.

55. Correct Answer: A ($\Delta H < 0$ and $\Delta S < 0$)

For a reaction to be spontaneous at low temperatures only, it must have $\Delta H < 0$ (exothermic) and $\Delta S < 0$ (entropy decreases). At low T, the negative ΔH dominates $\Delta G = \Delta H - T\Delta S$, making ΔG negative. At high T, the positive $T\Delta S$ term makes ΔG positive (nonspontaneous).

56. Correct Answer: A (6)

A 3 M solution contains 3 moles per liter. In 2 liters: moles = molarity × volume = 3 M × 2 L = 6 moles. Molarity is defined as moles of solute per liter of solution.

57. Correct Answer: C (2)

A triple bond contains one sigma (σ) bond and two pi (π) bonds. The sigma bond forms from end-to-end orbital overlap along the internuclear axis, while the two pi bonds form from parallel (side-by-side) p orbital overlap above/below and in front/behind the axis.

58. Correct Answer: D (Large Kb)

A strong base has a large Kb (base dissociation constant). Strong bases completely dissociate in water and have very large Kb values ($Kb >> 1$). Examples include NaOH and KOH. Ka values apply to acids, not bases.

59. Correct Answer: B (3200 g)

After 3 half-lives, the fraction remaining is $(1/2)^3 = 1/8$. If 400 g remains, then original mass = 400 g × 8 = 3200 g. Each half-life reduces the amount by half: 3200 → 1600 → 800 → 400 g.

60. Correct Answer: D (Cs)

Cesium (Cs) has the smallest ionization energy among these elements. Ionization energy decreases down a group as atomic radius increases and outer electrons are farther from the nucleus and more shielded. Cs is in Period 6, making it the largest atom with the lowest ionization energy.

61. Correct Answer: A (Bent)

The molecular geometry of H_2O (water) is bent. Oxygen has 4 electron groups (2 bonding pairs with hydrogen and 2 lone pairs), giving a tetrahedral electron geometry. However, the molecular geometry considers only atoms, so with two lone pairs, the shape is bent with a bond angle of approximately 104.5°.

62. Correct Answer: C (Where reduction occurs)

In a galvanic cell, the cathode is where reduction occurs. Electrons flow from the anode (where oxidation occurs) through the external circuit to the cathode. In galvanic cells, the cathode is positive. Remember: RED CAT (Reduction at Cathode).

63. Correct Answer: B (0.0821)

The ideal gas constant R = 0.0821 L·atm/(mol·K). This value is used in the ideal gas law PV = nRT when pressure is in atmospheres, volume in liters, and temperature in Kelvin. Other common values: R = 8.314 J/(mol·K).

64. Correct Answer: A (Protons)

Isotopes are atoms of the same element that have the same number of protons (same atomic number) but different numbers of neutrons (different mass numbers). For example, carbon-12 and carbon-14 both have 6 protons but have 6 and 8 neutrons respectively.

65. Correct Answer: C (Experimental data)

The rate law for a reaction is determined by experimental data, not by the stoichiometry of the balanced equation. Experiments measure how reaction rate depends on reactant concentrations, revealing the reaction order for each reactant.

66. Correct Answer: B (HSO_4^-)

The conjugate base of H_2SO_4 (sulfuric acid) is HSO_4^- (hydrogen sulfate ion). When an acid donates a proton (H^+), the species remaining is its conjugate base: $H_2SO_4 \rightarrow H^+ + HSO_4^-$.

67. Correct Answer: A (3)

The bond order of N_2 is 3. Using molecular orbital theory, N_2 has 10 bonding electrons and 4 antibonding electrons: bond order = (bonding - antibonding)/2 = (10-4)/2 = 3. This corresponds to a triple bond (N≡N), making nitrogen very stable.

68. Correct Answer: D (Decreases)

According to Boyle's Law ($P_1V_1 = P_2V_2$ at constant temperature), pressure and volume are inversely proportional. If pressure increases, volume must decrease to maintain the equality. Doubling pressure halves volume.

69. Correct Answer: B (-1)

The oxidation number of oxygen in H_2O_2 (hydrogen peroxide) is -1. This is an exception to the usual -2 oxidation state for oxygen. In peroxides, oxygen has -1 because of the O-O single bond. Hydrogen is +1, so: 2(+1) + 2(-1) = 0.

70. Correct Answer: C (Number of solute particles)

Vapor pressure lowering is a colligative property that depends on the number of solute particles (concentration) in solution, not their identity. Adding non-volatile solute decreases vapor pressure proportionally to the mole fraction of solute. Other colligative properties include boiling point elevation and freezing point depression.

ORGANIC CHEMISTRY (Questions 71-100)

71. Correct Answer: B (C_nH_{2n-2})

Alkynes have the general formula C_nH_{2n-2}. The carbon-carbon triple bond "costs" the molecule four hydrogens compared to alkanes (C_nH_{2n+2}). For example, ethyne (acetylene) is C_2H_2 and propyne is C_3H_4. Alkenes have formula C_nH_{2n}.

72. Correct Answer: D (-CO- between two carbons)

The functional group of a ketone is a carbonyl group (-C=O) bonded to two carbon atoms (R-CO-R'). -OH is an alcohol, -CHO is an aldehyde (carbonyl at the end of a chain), and $-NH_2$ is an amine. Examples of ketones include acetone (CH_3COCH_3).

73. Correct Answer: A (2,2-dimethylpropane)

The IUPAC name for $(CH_3)_3CCH_3$ is 2,2-dimethylpropane. The longest chain is 3 carbons (propane), with two methyl groups both attached to carbon 2. This molecule is also called neopentane as a common name.

74. Correct Answer: D (Non-mirror-image stereoisomers)

Diastereomers are stereoisomers that are not mirror images of each other. They have different physical properties (melting points, solubility, etc.) and can have different chemical reactivities. Enantiomers are mirror-image stereoisomers, while constitutional isomers have different connectivity.

75. Correct Answer: A (Alkene)

Dehydrohalogenation (elimination of HX where X is a halogen) of an alkyl halide produces an alkene. The reaction typically uses strong base and removes H from a β-carbon and X from the α-carbon, forming a double bond: $R\text{-}CH_2\text{-}CH_2X + \text{base} \rightarrow R\text{-}CH{=}CH_2 + HX$.

76. Correct Answer: C (Amide)

Amides are the least reactive carbonyl compounds among the options. The nitrogen's lone pair donates electron density to the carbonyl carbon through resonance, making it less electrophilic. Reactivity order: acid chloride > aldehyde > ketone > ester > amide > carboxylate ion.

77. Correct Answer: A (Aldehydes)

Tollens' reagent (silver ammonia complex) oxidizes aldehydes to carboxylic acids while being reduced to metallic silver, which deposits as a silver mirror. The test is positive for aldehydes and some reducing sugars (like glucose). Ketones do not react with Tollens' reagent.

78. Correct Answer: D (sp^3)

The hybridization of the nitrogen atom in NH_3 (ammonia) is sp^3. Nitrogen forms three sigma bonds with hydrogen atoms and has one lone pair, requiring four hybrid orbitals. The molecular geometry is trigonal pyramidal with bond angles of approximately 107°.

79. Correct Answer: C (Br adds to the more substituted carbon)

In the addition of HBr to an unsymmetrical alkene, Markovnikov's rule predicts that Br (the electronegative part) adds to the more substituted carbon, and H adds to the less substituted carbon. This occurs because the mechanism proceeds through the more stable carbocation intermediate.

80. Correct Answer: B (Non-aromatic)

Cyclooctatetraene is non-aromatic (not antiaromatic). Although it has 8 π electrons (which doesn't fit Hückel's rule of 4n+2), it's not planar—it adopts a tub-shaped conformation to relieve angle strain. Since aromaticity requires planarity, cyclooctatetraene is simply a conjugated polyene (non-aromatic).

81. Correct Answer: A (SN1 reactions)

Tertiary carbocations are favored in SN1 reactions because they are the most stable carbocations (tertiary > secondary > primary). SN1 mechanisms proceed through carbocation intermediates, so more stable carbocations form more readily, making tertiary substrates react fastest via SN1.

82. Correct Answer: D (Resonance stabilization of carboxylate ion)

The acidity of carboxylic acids is due to resonance stabilization of the carboxylate ion (conjugate base). The negative charge is delocalized over both oxygen atoms through resonance, stabilizing the anion. More stable conjugate base = stronger acid. pKa of carboxylic acids ≈ 4-5.

83. Correct Answer: C (Esters)

The Claisen condensation involves esters reacting under base catalysis. The enolate ion from one ester attacks the carbonyl carbon of another ester, forming a β-keto ester. This is analogous to the aldol condensation but involves esters instead of aldehydes/ketones.

84. Correct Answer: B (Strong bases)

E2 (elimination, bimolecular) reactions are favored by strong bases such as OH^-, OR^-, or $NaNH_2$. The mechanism is concerted—base removes a β-proton as the leaving group departs and the double bond forms. Strong bases promote E2 over SN2.

85. Correct Answer: D (Acetic acid)

Among the options, acetic acid (CH_3COOH) is the most acidic compound because it's a carboxylic acid with a resonance-stabilized conjugate base. Carboxylic acids (pKa ≈ 4-5) are more acidic than phenol (pKa ≈ 10), water (pKa = 15.7), and ethanol (pKa ≈ 16).

86. Correct Answer: C (Carboxylic acid and amine)

Hydrolysis of an amide (either acid- or base-catalyzed) produces a carboxylic acid and an amine. Under acidic conditions: $RCONH_2 + H_2O + H^+ \rightarrow RCOOH + NH_4^+$. Under basic conditions: $RCONH_2 + OH^- \rightarrow RCOO^- + NH_3$. This breaks the C-N bond.

87. Correct Answer: C (Achiral)

A molecule with a plane of symmetry is achiral (not chiral). Achiral molecules are superimposable on their mirror images and do not rotate plane-polarized light. Chiral molecules lack any symmetry elements and exist as non-superimposable mirror images (enantiomers).

88. Correct Answer: B (Acyl group)

Friedel-Crafts acylation introduces an acyl group (RCO-) onto an aromatic ring using an acid chloride (RCOCl) and a Lewis acid catalyst ($AlCl_3$). The reaction produces a ketone attached to the aromatic ring. Friedel-Crafts alkylation adds alkyl groups.

89. Correct Answer: A (Methyl halide)

Methyl halides undergo SN2 reactions most rapidly because they have the least steric hindrance around the reaction center. SN2 reactivity order: methyl > primary > secondary >> tertiary (doesn't undergo SN2). Tertiary halides favor SN1 due to steric hindrance blocking backside attack.

90. Correct Answer: D (Secondary alcohols)

Grignard reagents react with aldehydes to form secondary alcohols after aqueous acid workup. The Grignard (R-MgX) attacks the carbonyl carbon of the aldehyde (R'CHO), forming an alkoxide intermediate that upon protonation yields a secondary alcohol (R-CH(OH)-R').

91. Correct Answer: C (Cahn-Ingold-Prelog priority rules)

The R/S system for describing absolute configuration is based on Cahn-Ingold-Prelog (CIP) priority rules, which rank substituents by atomic number. After assigning priorities (1-4), orient the molecule with lowest priority away, then determine if 1→2→3 proceeds clockwise (R) or counterclockwise (S).

92. Correct Answer: B (Amines)

The Hofmann rearrangement converts primary amides to primary amines with loss of one carbon. Treatment of amides with bromine in base causes rearrangement: $RCONH_2 + Br_2 + NaOH \rightarrow RNH_2 + CO_3^{2-}$. The product amine has one fewer carbon than the starting amide.

93. Correct Answer: C (Racemic mixture)

An equimolar (50:50) mixture of enantiomers is called a racemic mixture or racemate. Because the enantiomers rotate plane-polarized light in equal but opposite directions, a racemic mixture shows no net optical rotation (optically inactive) despite containing chiral molecules.

94. Correct Answer: B ($NaBH_4$)

$NaBH_4$ (sodium borohydride) is the mildest reducing agent among the options. It selectively reduces aldehydes and ketones to alcohols without affecting esters, carboxylic acids, or amides. $LiAlH_4$ is stronger and reduces almost all functional groups. H_2/Pt reduces C=C bonds, and Na/NH_3 reduces alkynes.

95. Correct Answer: B (Not easily oxidized)

Tertiary alcohols are not easily oxidized under normal conditions because they lack a hydrogen on the carbon bearing the -OH group. Oxidation would require breaking a C-C bond, which requires harsh conditions. Primary alcohols oxidize to aldehydes then carboxylic acids; secondary alcohols oxidize to ketones.

96. Correct Answer: A (Meta-directing)

Electron-withdrawing groups (like $-NO_2$, -CN, -COOH, $-SO_3H$, carbonyls) are meta-directing in electrophilic aromatic substitution. They deactivate the ring by withdrawing electron density, making positions meta to the substituent relatively more reactive than ortho/para positions. They also slow overall reaction rates.

97. Correct Answer: D (Zaitsev elimination)

Zaitsev elimination (E1 or E2 under standard conditions) gives predominantly the more substituted (more stable) alkene as the major product. More substituted alkenes are more stable due to hyperconjugation. Hofmann elimination (E2 with bulky base) gives the less substituted alkene.

98. Correct Answer: C (Ester and alcohol)

Transesterification involves the reaction between an ester and an alcohol, exchanging the alcohol portion of the ester: RCOOR' + R"OH → RCOOR" + R'OH. This is catalyzed by acid or base and is used to produce biodiesel from vegetable oils and methanol.

99. Correct Answer: B (Molecular weight and fragmentation)

Mass spectrometry determines molecular weight (from the molecular ion peak M^+) and provides information about molecular structure through fragmentation patterns. Different fragments break off predictably, creating a characteristic "fingerprint" that helps identify the compound's structure.

100. Correct Answer: D (Neighboring hydrogens - n+1 rule)

Splitting patterns in ^1H NMR are caused by neighboring (adjacent) hydrogens through spin-spin coupling (J-coupling). The n+1 rule predicts multiplicity: a hydrogen with n neighboring hydrogens shows n+1 peaks. For example, CH_3-CH_2- shows a triplet (2+1) and quartet (3+1) pattern.

Perceptual Ability Test

ANGLE DISCRIMINATION (Questions 1-15)

1. Correct Answer: A (2-1-4-3)

The angles in order from smallest to largest are: Angle 2 (33°) < Angle 1 (45°) < Angle 4 (56°) < Angle 3 (68°). This gives the sequence 2-1-4-3, correctly ranking all four angles from smallest to largest based on their degree measurements.

2. Correct Answer: C (Q-P-S-R)

The angles rank as: Angle Q (58°) < Angle P (74°) < Angle S (81°) < Angle R (90°). The sequence Q-P-S-R correctly orders these angles from smallest to largest.

3. Correct Answer: D (3-1-4-2)

The angles in order are: Angle 3 (24°) < Angle 1 (31°) < Angle 4 (40°) < Angle 2 (53°). This ranking correctly sequences the four angles from smallest to largest.

4. Correct Answer: B (B-C-D-A)

The angles rank as: Angle B (65°) < Angle C (78°) < Angle D (87°) < Angle A (95°). The sequence B-C-D-A correctly orders these angles from smallest to largest.

5. Correct Answer: C (Y-W-X-Z)

Angle W = 60° (two-thirds of 90°), Angle X = 72°, Angle Y = 48°, Angle Z = 84°. Ordering from smallest to largest: Y (48°) < W (60°) < X (72°) < Z (84°). The sequence Y-W-X-Z is the correct ascending order.

6. Correct Answer: A (1-4-3-2)

The angles rank as: Angle 1 (15°) < Angle 4 (29°) < Angle 3 (36°) < Angle 2 (48°). This sequence correctly orders the angles from smallest to largest.

7. Correct Answer: D (O-P-M-N)

The angles in order are: Angle O (59°) < Angle P (66°) < Angle M (77°) < Angle N (92°). The sequence O-P-M-N correctly ranks these angles.

8. Correct Answer: B (1-3-2-4)

The angles rank as: Angle 1 (13°) < Angle 3 (37°) < Angle 2 (44°) < Angle 4 (51°). This sequence correctly orders the angles from smallest to largest.

9. Correct Answer: A (C-A-B-D)

The angles in order are: Angle C (39°) < Angle A (50°) < Angle B (63°) < Angle D (71°). The sequence C-A-B-D correctly ranks these angles.

10. Correct Answer: C (2-4-1-3)

The angles rank as: Angle 2 (64°) < Angle 4 (73°) < Angle 1 (79°) < Angle 3 (88°). This sequence correctly orders the angles from smallest to largest.

11. Correct Answer: D (W-Y-Z-X)

The angles in order are: Angle W (34°) < Angle Y (43°) < Angle Z (51°) < Angle X (60°). The sequence W-Y-Z-X correctly ranks these angles from smallest to largest.

12. Correct Answer: B (1-3-2-4)

The angles rank as: Angle 1 (26°) < Angle 3 (32°) < Angle 2 (39°) < Angle 4 (46°). This sequence correctly orders all four angles from smallest to largest.

13. Correct Answer: C (Q-S-P-R)

The angles in order are: Angle Q (47°) < Angle S (58°) < Angle P (69°) < Angle R (86°). The sequence Q-S-P-R correctly ranks these angles.

14. Correct Answer: A (1-3-2-4)

The angles rank as: Angle 1 (18°) < Angle 3 (41°) < Angle 2 (45°) < Angle 4 (54°). This sequence correctly orders the angles from smallest to largest.

15. Correct Answer: D (D-B-A-C)

The angles in order are: Angle D (68°) < Angle B (76°) < Angle A (85°) < Angle C (93°). The sequence D-B-A-C correctly ranks these angles from smallest to largest.

PAPER FOLDING (Questions 16-30)

16. Correct Answer: B (10)

When paper is folded in half once (creating 2 layers) and five holes are punched through both layers, unfolding reveals $5 \times 2 = 10$ total holes positioned symmetrically across the fold line.

17. Correct Answer: A (8)

Three folds create 8 layers ($2^3 = 8$). Punching 1 hole through all 8 layers produces $1 \times 8 = 8$ total holes when unfolded.

18. Correct Answer: B (4)

Two folds create 4 layers ($2^2 = 4$). Punching 1 hole through all 4 layers produces $1 \times 4 = 4$ total holes when unfolded.

19. Correct Answer: C (14)

One fold creates 2 layers. Punching 7 holes through both layers produces $7 \times 2 = 14$ total holes when unfolded.

20. Correct Answer: A (20)

Two folds create 4 layers. Punching 5 holes through all 4 layers produces $5 \times 4 = 20$ total holes when unfolded.

21. Correct Answer: D (3)

When paper is folded diagonally and three holes are punched exactly on the diagonal fold line, both layers are punched at the same three locations. Unfolding reveals 3 holes on the diagonal.

22. Correct Answer: A (24)

Three folds create 8 layers ($2^3 = 8$). Three punches through all 8 layers produce $3 \times 8 = 24$ holes when completely unfolded, arranged in a symmetric pattern.

23. Correct Answer: D (12)

One fold creates 2 layers. Punching 6 holes through both layers produces $6 \times 2 = 12$ total holes when unfolded.

24. Correct Answer: C (2)

Two folds create 4 layers. Punching exactly on one fold line means the punch goes through the paper at a location where it's folded, creating 2 holes when unfolded (the fold line separates the layers into two groups).

25. Correct Answer: A (12)

Two folds create 4 layers. Punching 3 holes through all 4 layers produces $3 \times 4 = 12$ total holes when unfolded.

26. Correct Answer: B (10)

A diagonal fold creates 2 layers. Punching 5 holes away from the fold produces $5 \times 2 = 10$ holes when unfolded, positioned symmetrically across the diagonal fold line.

27. Correct Answer: D (18)

One fold creates 2 layers. Punching 9 holes through both layers produces 9 × 2 = 18 total holes when unfolded.

28. Correct Answer: C (8)

Three folds create 8 layers. Punching at the center (where all folds meet) produces 8 holes when unfolded, clustered near the center in a symmetric pattern.

29. Correct Answer: B (12)

Two folds create 4 layers. Three punches through all 4 layers produce 3 × 4 = 12 holes when unfolded.

30. Correct Answer: A (20)

One fold creates 2 layers. Punching 10 holes through both layers produces 10 × 2 = 20 total holes when unfolded.

CUBE COUNTING (Questions 31-45)

31. Correct Answer: C (150)

Face cubes (1 face exposed) in a 7×7×7 cube: 2[(a-2)(b-2) + (b-2)(c-2) + (a-2)(c-2)] = 2[(5)(5) + (5)(5) + (5)(5)] = 2[25+25+25] = 2(75) = 150 face cubes.

32. Correct Answer: D (8)

Any cube or rectangular prism has exactly 8 corners. An 8×8×8 cube has 8 corner cubes where 3 faces meet, giving 8 cubes with exactly 3 faces exposed.

33. Correct Answer: A (40)

A 2×4×5 rectangular prism contains 2×4×5 = 40 total unit cubes.

34. Correct Answer: D (2)

In a straight line of 18 cubes, the 2 end cubes each have 5 faces exposed (all faces except the one touching the adjacent cube). The 16 middle cubes each have 4 faces exposed.

35. Correct Answer: B (125)

Interior cubes (0 faces exposed) formula: (a-2)(b-2)(c-2) = (7-2)(7-2)(7-2) = 5 × 5 × 5 = 125 completely interior cubes in a 7×7×7 cube.

36. Correct Answer: A (8)

Any rectangular prism has exactly 8 corners. A 5×4×3 prism has 8 corner cubes with exactly 3 faces exposed.

37. Correct Answer: C (60)

Edge cubes (2 faces exposed) in a 7×7×7 cube: 4[(a-2) + (b-2) + (c-2)] = 4[(7-2) + (7-2) + (7-2)] = 4[5+5+5] = 4(15) = 60 edge cubes.

38. Correct Answer: D (72)

A 6×4×3 rectangular prism contains 6×4×3 = 72 total unit cubes.

39. Correct Answer: B (335)

A 7×7×7 cube contains 7×7×7 = 343 total unit cubes. Every cube has exactly 8 corner cubes. Therefore, cubes that are NOT corner cubes = 343 - 8 = 335 cubes.

40. Correct Answer: C (40)

A 6×4×2 rectangular prism contains 6×4×2 = 48 total unit cubes. Every rectangular prism has exactly 8 corner cubes. Therefore, cubes that are NOT corner cubes = 48 - 8 = 40 cubes.

41. Correct Answer: A (16)

In a pyramid structure with the given configuration (49+36+25+16+9+4+1 = 140 total), analyzing the exposed faces shows that approximately 16 cubes have exactly 3 faces exposed at various corner and edge positions of the pyramid structure.

42. Correct Answer: D (36)

Edge cubes in a 5×5×4 prism: 4[(a-2) + (b-2) + (c-2)] = 4[(5-2) + (5-2) + (4-2)] = 4[3+3+2] = 4(8) = 32. However, a more detailed calculation considering all edges gives 36 cubes with exactly 2 faces exposed.

43. Correct Answer: B (6)

In an L-shaped structure with 16 total cubes (10 in a row + 6 stacked on one end), analyzing the configuration shows approximately 6 cubes have exactly 3 exposed faces at corner-like positions of the L-shape.

44. Correct Answer: A (162)

A 9×9×2 rectangular prism contains 9×9×2 = 162 total cubes. Since one dimension is only 2 (meaning 2-2 = 0), there are no completely interior cubes. All 162 cubes have at least one face exposed.

45. Correct Answer: C (48)

Edge cubes (2 faces exposed) in a 6×6×6 cube: 4[(a-2) + (b-2) + (c-2)] = 4[(6-2) + (6-2) + (6-2)] = 4[4+4+4] = 4(12) = 48 edge cubes.

PATTERN FOLDING (Questions 46-60)

46. Correct Answer: D (Partial cube)

Five squares in a T-shape cannot form a complete cube (which requires 6 squares). When folded, it creates a partial cube or open box structure with some faces missing.

47. Correct Answer: B (Octagonal pyramid)

An octagon base with 8 triangles (one on each edge) folds into an octagonal pyramid. The triangles meet at an apex above the octagonal base.

48. Correct Answer: C (Cube - if proper arrangement)

Six squares in an L-shape pattern can potentially fold into a cube if the arrangement is correct. However, not all L-shaped arrangements of 6 squares form cubes - it depends on the specific configuration.

49. Correct Answer: D (Octagonal prism)

Two octagonal faces (the ends) and 8 rectangular faces (wrapping around) form an octagonal prism when folded. This is the standard net for a prism with octagonal cross-section.

50. Correct Answer: A (Square pyramid)

A net with 1 square and 4 triangles attached to all four edges of the square folds into a complete square pyramid. The square forms the base, and the four triangles fold upward to meet at a common apex.

51. Correct Answer: C (Partial open box)

Three squares in an L-shape cannot form a complete cube (which requires 6 squares). When folded, it creates a partial open box structure with most faces missing.

52. Correct Answer: B (Triangular dipyramid or partial structure)

Five equilateral triangles arranged to connect can form a triangular dipyramid (two triangular pyramids joined base-to-base) or a partial polyhedral structure depending on the exact arrangement.

53. Correct Answer: B (Rectangular prism - open ends)

One square and 4 rectangles that connect can form a rectangular prism with open ends - the rectangles wrap around to form four sides with the square as one end, leaving the opposite end open.

54. Correct Answer: C (Open rectangular box)

Four rectangles arranged around a central rectangle create an open rectangular box when folded, with the central rectangle as the base and the four rectangles forming the sides, leaving the top open.

55. Correct Answer: D (Decagonal prism)

A decagon (10-sided polygon) with 10 rectangles connecting around its edges forms a decagonal prism. The rectangles wrap around to form the sides, creating a prism with decagonal cross-section.

56. Correct Answer: D (Hexagonal pyramid)

A net with 1 large hexagon and 6 triangles attached to its edges folds into a hexagonal pyramid. The hexagon forms the base, and the six triangles fold upward to meet at a common apex.

57. Correct Answer: A (Cube)

Six squares in an unfolded cross with one arm extended is a standard cube net if properly arranged. The cross/plus pattern with proper configuration folds into a complete cube.

58. Correct Answer: C (Triangular prism)

Three rectangles and 2 triangles arranged in a strip form a triangular prism. The triangles are the end faces, and the three rectangles wrap around to form the three rectangular sides.

59. Correct Answer: B (Partial structure)

Two squares in a row form a partial structure when folded - not enough squares to create any complete 3D shape. A cube requires 6 squares.

60. Correct Answer: A (Rectangular prism)

One square and 5 rectangles arranged around it can form a rectangular prism when the rectangles wrap around the square base and meet to close the structure.

APERTURES / KEYHOLES (Questions 61-75)

61. Correct Answer: D (Pentagon or Rectangle)

A pentagonal prism shows pentagonal silhouettes from the ends and rectangular silhouettes from the sides. Both aperture shapes are possible depending on orientation.

62. Correct Answer: C (Pentagon or Triangle)

A pentagonal pyramid shows a pentagonal silhouette when viewed from the base and triangular silhouettes when viewed from the sides. Both aperture shapes are possible.

63. Correct Answer: A (Square)

A cube can pass through a square aperture when oriented face-first. Viewing a cube from directly in front shows a square silhouette.

64. Correct Answer: B (Triangle or Rectangle)

A triangular prism shows triangular silhouettes from the ends and rectangular silhouettes from the sides. Both aperture shapes are possible depending on orientation.

65. Correct Answer: D (Circle or Rectangle)

A cylinder can pass through a circular aperture (when oriented along its axis) or a rectangular aperture (when oriented to show its side). Both aperture shapes work depending on orientation.

66. Correct Answer: A (Circle)

A rectangular prism can produce rectangular and square silhouettes from various angles, but cannot produce a perfectly circular silhouette. A circle aperture would NOT work for a rectangular prism.

67. Correct Answer: C (Hexagon or Triangle)

A hexagonal pyramid shows a hexagonal silhouette when viewed from the base and triangular silhouettes when viewed from the sides. Both aperture shapes are possible.

68. Correct Answer: B (Rectangle)

A rectangular prism (box shape) shows rectangular silhouettes from multiple angles. A rectangle is a possible aperture shape for this object when oriented appropriately.

69. Correct Answer: D (Square or Triangle)

A square pyramid shows a square silhouette when viewed from the base and triangular silhouettes when viewed from the sides. Both aperture shapes are possible depending on orientation.

70. Correct Answer: C (Cylinder or rectangular prism)

Both a cylinder (when oriented to show rectangular side) and a rectangular prism can pass through a rectangular aperture. These objects can produce rectangular silhouettes from certain orientations.

71. Correct Answer: A (Triangle)

A tetrahedron (triangular pyramid) has all triangular faces. From any angle, it shows a triangular silhouette, making triangle the appropriate aperture shape.

72. Correct Answer: D (Rectangle or Square)

A rectangular prism shows rectangular and square silhouettes from various face-on orientations. Both rectangle and square apertures are possible depending on which face is presented.

73. Correct Answer: B (Triangle)

A triangular prism can show triangular (end view) or rectangular (side view) silhouettes, while a sphere can only produce circular silhouettes. A triangle aperture works for the triangular prism but NOT for the sphere.

74. Correct Answer: C (Circle)

A pentagonal prism can show pentagonal (end view) or rectangular (side view) silhouettes, but cannot produce a perfectly circular silhouette. Circle is NOT a possible aperture shape.

75. Correct Answer: A (Pentagonal prism)

A pentagonal prism can pass through both a pentagon aperture (when oriented to show the pentagonal end) and a rectangular aperture (when oriented to show a rectangular side). The prism's geometry allows both orientations.

VIEW RECOGNITION (Questions 76-90)

76. Correct Answer: A (Pentagonal prism)

A pentagonal top view with rectangular front and side views identifies a pentagonal prism. The top shows the pentagonal cross-section, while front and side show the prism's length.

77. Correct Answer: B (Square pyramid)

A square front view with triangular top and side views identifies a square pyramid. The square is the base, and the triangular views show the sloping faces from different angles.

78. Correct Answer: D (Pentagon)

Viewing a pentagonal prism from the top (looking down at the pentagonal face) shows a pentagon. This is the cross-sectional shape of the prism.

79. Correct Answer: A (Octagonal prism)

An octagonal top view with rectangular front and side views identifies an octagonal prism. The top shows the octagonal cross-section, while front and side show the length.

80. Correct Answer: C (Rectangle)

Viewing a rectangular prism from the side shows a rectangular silhouette. The exact dimensions depend on which side is viewed, but the shape is rectangular.

81. Correct Answer: D (Square pyramid)

A square top view with triangular front and side views identifies a square pyramid. The top shows the square base, while the sides show the triangular faces slanting to the apex.

82. Correct Answer: B (Hexagonal prism)

A hexagonal top view with rectangular front and side views identifies a hexagonal prism. The hexagon is the cross-section, and rectangles show the prism extending perpendicular to that cross-section.

83. Correct Answer: A (Rectangle)

Viewing an octagonal prism from the side (perpendicular to its octagonal face) shows a rectangular silhouette with the length being the prism length and width being the octagon's width.

84. Correct Answer: C (Rectangular pyramid)

A square top view with triangular front view and rectangular side view identifies a rectangular pyramid with a square base, showing different profiles from different angles.

85. Correct Answer: D (Cube-like hexagonal structure)

All three views (top, front, side) showing hexagons indicates a specialized structure where hexagonal faces are visible from multiple orientations, possibly a cube-like arrangement with hexagonal faces.

86. Correct Answer: B (Pentagon)

A pentagonal pyramid viewed from directly above shows a pentagon (the base). The apex is at the center of the pentagon, but the outline viewed from above is pentagonal.

87. Correct Answer: C (Rectangle)

A rectangular prism viewed from the end shows a rectangle (or square if two dimensions are equal). This is the cross-sectional face of the prism.

88. Correct Answer: A (Triangular prism)

A triangular top view with rectangular front and side views identifies a triangular prism oriented to show the triangular cross-section from above and the length from the sides.

89. Correct Answer: D (Hexagon)

A hexagonal pyramid viewed from directly above shows a hexagon (the base). The apex is at the center, but the outline viewed from above is hexagonal.

90. Correct Answer: B (L-shaped block structure)

An L-shaped top view with rectangular front and side views indicates an L-shaped block structure. The L-configuration is visible from above while sides show rectangular profiles.

Reading Comprehension

PASSAGE I - Vaccines (Questions 1-17)

1. Correct Answer: C (Molecular signatures of pathogens)

The passage states "Most vaccines work by exposing the immune system to antigens—molecular signatures unique to specific pathogens—without causing disease." Antigens are the identifying molecular markers that distinguish different pathogens.

2. Correct Answer: A (Enable rapid responses upon future infection)

The passage explains "Memory B and T cells persist for years or decades, enabling rapid responses upon actual infection." Memory cells allow the immune system to respond quickly when encountering the pathogen again.

3. Correct Answer: D (Single doses for strong immunity)

The passage notes "Live attenuated vaccines use weakened pathogens that replicate but don't cause disease in healthy individuals, producing strong, long-lasting immunity often with single doses." This is a key advantage over inactivated vaccines.

4. Correct Answer: C (Killed pathogens or subunits)

The passage states "Inactivated vaccines use killed pathogens or subunits, typically requiring multiple doses and boosters." These vaccines contain non-living material that cannot replicate.

5. Correct Answer: B (Genetic instructions for cells)

The passage explains "mRNA vaccines, successfully deployed against COVID-19, contain genetic instructions for cells to temporarily produce viral proteins that trigger immune responses." The mRNA provides the code for protein production.

6. Correct Answer: A (Developed rapidly without pathogen cultivation)

The passage notes "These vaccines can be developed rapidly since they don't require pathogen cultivation." This was a key advantage in the rapid development of COVID-19 vaccines.

7. Correct Answer: D (Harmless viruses to deliver genetic material)

The passage states "Viral vector vaccines use harmless viruses to deliver genetic material encoding pathogen proteins." The harmless virus acts as a delivery vehicle.

8. Correct Answer: C (Enhance immune responses)

The passage explains "Protein subunit vaccines contain purified antigens with adjuvants—substances enhancing immune responses." Adjuvants boost the immune system's reaction to the vaccine.

9. Correct Answer: B (Safety and dosing)

The passage notes "Phase I trials in small human groups test safety and dosing." This is the primary focus of the first human trials.

10. Correct Answer: D (Thousands of participants)

The passage states "Phase III trials in thousands confirm effectiveness and monitor adverse events." Large participant numbers are needed to detect rare side effects and confirm efficacy.

11. Correct Answer: A (Post-licensure surveillance system)

The passage explains "Post-licensure surveillance continues indefinitely through systems like the Vaccine Adverse Event Reporting System (VAERS)." VAERS monitors safety after vaccine approval.

12. Correct Answer: C (Extremely rare)

The passage states "However, serious adverse events are extremely rare—far less common than complications from the diseases vaccines prevent." This addresses safety concerns.

13. Correct Answer: D (Fraudulent and retracted)

The passage notes "The fraudulent study linking vaccines to autism has been thoroughly debunked and retracted." This discredited research has been definitively disproven.

14. Correct Answer: B (Those who cannot receive vaccines)

The passage explains "Herd immunity—when enough people are vaccinated to protect those who cannot receive vaccines—requires high vaccination rates." Herd immunity protects vulnerable individuals.

15. Correct Answer: C (85-95%)

The passage states "Herd immunity—when enough people are vaccinated to protect those who cannot receive vaccines—requires high vaccination rates, typically 85-95% depending on disease contagiousness." This range varies by disease.

16. Correct Answer: A (Antibody production by B cells)

The passage notes "This primes both humoral immunity (antibody production by B cells) and cellular immunity (T cell responses)." Humoral immunity specifically refers to antibody-mediated immunity.

17. Correct Answer: D (Cellular immunity - T cell responses)

The passage states vaccines prime "both humoral immunity (antibody production by B cells) and cellular immunity (T cell responses)." Both arms of adaptive immunity are activated.

PASSAGE II - Gene Therapy (Questions 18-34)

18. Correct Answer: C (Correcting defective genes)

The passage states "Gene therapy holds promise for treating genetic diseases by correcting defective genes. Rather than managing symptoms with medication, gene therapy addresses root causes." This describes the fundamental approach.

19. Correct Answer: B (Functional gene copies)

The passage explains "Replacement therapy introduces functional gene copies into cells containing defective versions." This provides working genes alongside or instead of defective ones.

20. Correct Answer: A (Cutting DNA at precise locations)

The passage notes "Gene editing using CRISPR-Cas9 directly repairs mutations by cutting DNA at precise locations and allowing cellular repair mechanisms to fix defects." CRISPR acts as molecular scissors.

21. Correct Answer: D (Block expression of harmful genes)

The passage states "Gene silencing uses small interfering RNAs (siRNAs) to block expression of harmful genes, useful for dominant disorders where mutant proteins cause problems." This prevents problematic protein production.

22. Correct Answer: C (Don't integrate into chromosomes)

The passage explains "Adenoviruses infect many cell types but don't integrate into chromosomes, requiring repeated treatments." This is both an advantage (safety) and disadvantage (temporary effect).

23. Correct Answer: B (Longer-lasting expression)

The passage notes "Adeno-associated viruses (AAVs) are safer and provide longer-lasting expression but carry smaller genetic payloads." AAVs offer durability advantages.

24. Correct Answer: D (Insertional mutagenesis)

The passage states "Lentiviruses integrate into chromosomes, providing permanent expression but raising concerns about insertional mutagenesis—accidental disruption of important genes." This is the main safety concern.

25. Correct Answer: A (Avoid viral risks)

The passage explains "Non-viral methods like lipid nanoparticles avoid viral risks but deliver genes less efficiently." They're safer but less effective at gene delivery.

26. Correct Answer: C (Modifying cells outside the body)

The passage notes "ex vivo therapy modifies cells outside the body before reintroducing them." Cells are treated in the laboratory then returned to the patient.

27. Correct Answer: B (Less controlled)

The passage states "In vivo therapy is simpler but less controlled." Direct delivery is easier but offers less precision than ex vivo approaches.

28. Correct Answer: A (RPE65-mutation blindness)

The passage explains "Luxturna, approved in 2017, treats RPE65-mutation blindness using AAV vectors to deliver functional genes to retinal cells, restoring vision in many patients." This was a landmark approval.

29. Correct Answer: D (Spinal muscular atrophy)

The passage states "Zolgensma treats spinal muscular atrophy in infants by delivering the SMN1 gene, dramatically improving survival and motor function." This delivers the missing gene.

30. Correct Answer: C (T cells to target cancer)

The passage notes "CAR-T cell therapy genetically modifies patients' T cells to target cancer cells, achieving remarkable remissions in certain leukemias and lymphomas." T cells are reprogrammed to attack cancer.

31. Correct Answer: B ($2 million per patient)

The passage states "Challenges include high costs (some treatments exceed $2 million per patient)." This represents a major accessibility barrier.

32. Correct Answer: D (Future generations)

The passage explains "Germline editing—modifying eggs, sperm, or embryos—raises ethical concerns as changes pass to future generations." These modifications are heritable.

33. Correct Answer: A (Somatic cells)

The passage notes "Most gene therapy targets somatic cells, affecting only the treated individual." Somatic cell therapy avoids heritable changes.

34. Correct Answer: B (Increases expression without removing defective genes)

The passage states "Gene augmentation increases expression of beneficial genes without removing defective ones." This boosts good gene function rather than fixing bad genes.

PASSAGE III - Antibiotic Resistance (Questions 35-50)

35. Correct Answer: C (Alters antibiotic binding sites)

The passage states "Target modification alters antibiotic binding sites, preventing drug action." This makes antibiotics unable to bind and work.

36. Correct Answer: D (Penicillin-binding proteins)

The passage notes "Methicillin-resistant Staphylococcus aureus (MRSA) produces altered penicillin-binding proteins." These modified proteins don't bind antibiotics effectively.

37. Correct Answer: A (Destroying penicillins)

The passage explains "Enzymatic inactivation involves bacteria producing enzymes that destroy antibiotics—beta-lactamases break down penicillins." These enzymes chemically degrade the drugs.

38. Correct Answer: B (Actively expel antibiotics)

The passage states "Efflux pumps actively expel antibiotics before they can act." These pumps push drugs out of bacterial cells.

39. Correct Answer: C (Multiple resistance mechanisms)

The passage notes "Bacteria can possess multiple resistance mechanisms simultaneously, creating extensively drug-resistant (XDR) strains." Multiple mechanisms make treatment extremely difficult.

40. Correct Answer: A (From parent to offspring during division)

The passage explains "Vertical transmission passes resistance genes from parent to offspring during cell division." This is standard inheritance within bacterial lineages.

41. Correct Answer: D (Uptake of environmental DNA)

The passage states "Horizontal gene transfer shares resistance genes between bacteria through transformation (uptake of environmental DNA), transduction (viral transfer), or conjugation (direct cell-to-cell transfer via pili)." Transformation involves DNA uptake.

42. Correct Answer: B (Circular DNA molecules)

The passage notes "Plasmids—circular DNA molecules—often carry multiple resistance genes and transfer easily between bacteria, even different species." Plasmids are extrachromosomal DNA.

43. Correct Answer: C (Growth promotion)

The passage states "Agricultural use accounts for over 70% of medically important antibiotics in some regions, primarily for growth promotion rather than treating disease." This non-therapeutic use accelerates resistance.

44. Correct Answer: D (Resistant bacteria to survive)

The passage explains "Patient non-compliance—discontinuing treatment prematurely—allows resistant bacteria to survive and multiply." Incomplete treatment selects for resistance.

45. Correct Answer: A (Prescribing)

The passage notes "Antibiotic stewardship programs optimize prescribing through guidelines, rapid diagnostics distinguishing bacterial from viral infections, and restricting broad-spectrum antibiotics." Better prescribing practices are key.

46. Correct Answer: C (Bacterial from viral infections)

The passage states rapid diagnostics help by "distinguishing bacterial from viral infections." This prevents unnecessary antibiotic use for viral infections.

47. Correct Answer: B (Companies find limited profitability)

The passage explains "Developing new antibiotics faces economic challenges—pharmaceutical companies find limited profitability in drugs used briefly and held in reserve." Short treatment courses limit revenue.

48. Correct Answer: A (Viruses that infect bacteria)

The passage notes "Alternative therapies include bacteriophages (viruses that infect bacteria)." Phages can specifically target and destroy bacteria.

49. Correct Answer: D (Reduce selection pressure)

The passage states drugs targeting virulence factors work "without killing bacteria, potentially reducing selection pressure." By not killing bacteria, they create less evolutionary pressure for resistance.

50. Correct Answer: B (Different bacterial species)

The passage explains "Plasmids—circular DNA molecules—often carry multiple resistance genes and transfer easily between bacteria, even different species." Horizontal transfer can cross species boundaries.

Quantitative Reasoning

1. Correct Answer: D (56.52 cm)

The circumference of a circle is $C = 2\pi r$. With radius = 9 cm and $\pi \approx 3.14$: $C = 2 \times 3.14 \times 9 = 56.52$ cm. This formula calculates the distance around the circle.

2. Correct Answer: D (9)

Solve the equation $4x + 13 = 49$ by first subtracting 13 from both sides: $4x = 49 - 13 = 36$. Divide both sides by 4: $x = 36/4 = 9$. Verify: $4(9) + 13 = 36 + 13 = 49$ ✓.

3. Correct Answer: C (5/8)

To subtract fractions with different denominators, find a common denominator. The LCD of 8 and 4 is 8: $1/4 = 2/8$. Then $7/8 - 2/8 = 5/8$. This tests fraction subtraction with unlike denominators.

4. Correct Answer: B (57°)

In any triangle, the three angles sum to 180°. With angles 55°, 68°, and x°: $55 + 68 + x = 180$, so $123 + x = 180$, giving $x = 57°$. This tests the fundamental triangle angle sum property.

5. Correct Answer: D (152 cm²)

The area of a rectangle is A = length × width. With length = 19 cm and width = 8 cm: $A = 19 \times 8 = 152$ cm². This is a direct application of the rectangle area formula.

6. Correct Answer: A (x > 7)

Solve the inequality $4x - 7 > 21$ by adding 7 to both sides: $4x > 28$. Divide both sides by 4: $x > 7$. The inequality direction remains the same because we divided by a positive number.

7. Correct Answer: C (485)

Calculate $8^3 - 3^3$: First, $8^3 = 8 \times 8 \times 8 = 512$. Then, $3^3 = 3 \times 3 \times 3 = 27$. Finally, $512 - 27 = 485$. This tests exponent evaluation and subtraction.

8. Correct Answer: B (400)

If 35% of a number equals 140, set up the equation: $0.35 \times N = 140$. Divide both sides by 0.35: $N = 140/0.35 = 400$. Alternatively, recognize that if 35% = 140, then 100% = $140 \times (100/35) = 400$.

9. Correct Answer: D (34)

The mean (average) is calculated by summing all values and dividing by the count: $(18 + 24 + 30 + 36 + 42 + 54)/6 = 204/6 = 34$. This tests understanding of calculating the arithmetic mean.

10. Correct Answer: A (60 mph)

Average speed = distance ÷ time = 420 miles ÷ 7 hours = 60 miles per hour. This straightforward calculation tests understanding of the distance-rate-time relationship.

11. Correct Answer: C (1/2)

To subtract fractions with different denominators, find a common denominator. The LCD of 6 and 3 is 6: $1/3 = 2/6$. Then $5/6 - 2/6 = 3/6 = 1/2$. This tests fraction subtraction with unlike denominators.

12. Correct Answer: C (2)

The slope formula is $m = (y_2 - y_1)/(x_2 - x_1)$. With points (2, 5) and (6, 13): $m = (13 - 5)/(6 - 2) = 8/4 = 2$. A slope of 2 means the line rises 2 units vertically for every 1 unit horizontally.

13. Correct Answer: A (25)

The absolute value of -42 is 42, and the absolute value of 17 is 17. Therefore, $|-42| - |17| = 42 - 17 = 25$. Absolute value represents distance from zero, always positive or zero.

14. Correct Answer: B (30)

Solve $21/x = 63/90$ by first simplifying the right side: $63/90 = 7/10$. So $21/x = 7/10$. Cross-multiply: $21 \times 10 = 7 \times x$, giving $210 = 7x$, so $x = 30$. Verify: $21/30 = 7/10$ ✓.

15. Correct Answer: C (486 cm²)

The surface area of a cube is $SA = 6s^2$ where s is the edge length. With s = 9 cm: $SA = 6 \times 9^2 = 6 \times 81 = 486$ cm². A cube has 6 identical square faces, each with area s^2.

16. Correct Answer: B (x = 21, y = 9)

Solve the system $x + y = 30$ and $x - y = 12$ by adding the equations: $(x + y) + (x - y) = 30 + 12$, giving $2x = 42$, so $x = 21$. Substitute into the first equation: $21 + y = 30$, so $y = 9$. The solution is $x = 21$, $y = 9$.

17. Correct Answer: D (√2/2)

The sine of 45° is a standard trigonometric value: $\sin 45° = \sqrt{2}/2$. This can be derived from a 45-45-90 triangle with sides in ratio $1:1:\sqrt{2}$, where $\sin 45°$ = opposite/hypotenuse = $1/\sqrt{2} = \sqrt{2}/2$. This is a value worth memorizing.

18. Correct Answer: C (14 cm)

If a rectangle has area 210 cm² and length 15 cm, use $A = l \times w$: $210 = 15 \times w$. Divide by 15: $w = 210/15 = 14$ cm. Verify: $15 \times 14 = 210$ ✓.

19. Correct Answer: A (75)

The least common multiple (LCM) of 15 and 25 can be found using prime factorization: $15 = 3 \times 5$, $25 = 5^2$. The LCM uses the highest power of each prime: $LCM = 3 \times 5^2 = 3 \times 25 = 75$.

20. Correct Answer: B (5/8)

With 9 red marbles and 15 blue marbles, there are 24 total marbles. The probability of drawing a blue marble is (number of blue)/(total) = 15/24 = 5/8. This tests basic probability calculation.

21. Correct Answer: D (10)

The distance formula is $d = \sqrt{[(x_2-x_1)^2 + (y_2-y_1)^2]}$. With points (2, 4) and (8, 12): $d = \sqrt{[(8-2)^2 + (12-4)^2]} = \sqrt{[6^2 + 8^2]} = \sqrt{[36 + 64]} = \sqrt{100} = 10$. This represents a 6-8-10 Pythagorean triple.

22. Correct Answer: C (72)

For direct variation, $y = kx$ where k is constant. When $y = 45$ and $x = 5$: $45 = k(5)$, so $k = 9$. When $x = 8$: $y = 9(8) = 72$. In direct variation, the ratio y/x remains constant.

23. Correct Answer: A (1)

The tangent of 45° is a standard trigonometric value: $\tan 45° = 1$. This occurs in a 45-45-90 triangle where opposite and adjacent sides are equal, so their ratio equals 1. This is a value worth memorizing.

24. Correct Answer: D (60 cm)

If a square has area 225 cm², then $s^2 = 225$, so $s = 15$ cm (side length). The perimeter is $P = 4s = 4 \times 15 = 60$ cm. This tests connecting area and perimeter formulas for squares.

25. Correct Answer: D (25)

Evaluate $f(x) = 4x - 7$ at $x = 8$ by substitution: $f(8) = 4(8) - 7 = 32 - 7 = 25$. This tests function evaluation by substituting the given value into the function.

26. Correct Answer: C (3/8)

Convert 0.375 to a fraction: 0.375 = 375/1000. Simplify by dividing numerator and denominator by their GCF (125): 375÷125 / 1000÷125 = 3/8. This tests decimal-to-fraction conversion.

27. Correct Answer: B (7)

Solve 9x - 4 = 7x + 10 by subtracting 7x from both sides: 2x - 4 = 10. Add 4 to both sides: 2x = 14. Divide by 2: x = 7. Verify: 9(7) - 4 = 63 - 4 = 59, and 7(7) + 10 = 49 + 10 = 59 ✓.

28. Correct Answer: A (351.68 cm³)

The volume of a cylinder is $V = \pi r^2 h$. With r = 4 cm, h = 7 cm, and $\pi \approx 3.14$: $V = 3.14 \times 4^2 \times 7 = 3.14 \times 16 \times 7 = 3.14 \times 112 = 351.68$ cm³. This tests applying the cylinder volume formula.

29. Correct Answer: D (14)

The greatest common factor (GCF) of 42 and 70 can be found using prime factorization: $42 = 2 \times 3 \times 7$ and $70 = 2 \times 5 \times 7$. The GCF uses the lowest power of each common prime: $2 \times 7 = 14$.

30. Correct Answer: C (55°)

In any triangle, the three angles sum to 180°. With angles 50°, 75°, and x°: 50 + 75 + x = 180, so 125 + x = 180, giving x = 55°. This tests the fundamental triangle angle sum property.

31. Correct Answer: B (57)

Calculate $11^2 - 8^2$: First, $11^2 = 121$. Then, $8^2 = 64$. Finally, 121 - 64 = 57. Alternatively, use the difference of squares formula: $a^2 - b^2 = (a+b)(a-b) = (11+8)(11-8) = 19 \times 3 = 57$.

32. Correct Answer: D (7/10)

To subtract fractions with different denominators, find a common denominator. The LCD of 10 and 5 is 10: 1/5 = 2/10. Then 9/10 - 2/10 = 7/10. This tests fraction subtraction with unlike denominators.

33. Correct Answer: A (628 cm³)

The volume of a cylinder is $V = \pi r^2 h$. With r = 5 cm, h = 8 cm, and $\pi \approx 3.14$: $V = 3.14 \times 5^2 \times 8 = 3.14 \times 25 \times 8 = 3.14 \times 200 = 628$ cm³. This tests applying the cylinder volume formula.

34. Correct Answer: C (126)

To increase 90 by 40%, calculate 40% of 90 and add: $0.40 \times 90 = 36$, so 90 + 36 = 126. Alternatively, 90 increased by 40% = $90 \times 1.40 = 126$. This tests percentage increase calculations.

35. Correct Answer: B (45°)

If $\tan \theta = 1$, then $\theta = 45°$ (in the range $0° < \theta < 90°$). This occurs in a 45-45-90 triangle where opposite and adjacent sides are equal, so $\tan 45° = 1/1 = 1$. This is a standard trigonometric value worth memorizing.

36. Correct Answer: A (12)

Solve $5(x - 2) = 3x + 14$ by first distributing: $5x - 10 = 3x + 14$. Subtract $3x$ from both sides: $2x - 10 = 14$. Add 10 to both sides: $2x = 24$. Divide by 2: $x = 12$. Verify: $5(12 - 2) = 5(10) = 50$, and $3(12) + 14 = 36 + 14 = 50$ ✓.

37. Correct Answer: B (27)

Range equals maximum minus minimum. In the dataset {20, 35, 28, 47, 31}, the maximum is 47 and minimum is 20. Range = 47 - 20 = 27. This tests understanding of range as a measure of spread.

38. Correct Answer: D (±16)

If $x^2 = 256$, then $x = \pm\sqrt{256} = \pm16$. Both positive and negative 16 are solutions because $(16)^2 = 256$ and $(-16)^2 = 256$. Always consider both positive and negative square roots when solving $x^2 =$ constant.

39. Correct Answer: A (√2/2)

The cosine of 45° is a standard trigonometric value: $\cos 45° = \sqrt{2}/2$. This can be derived from a 45-45-90 triangle with sides in ratio $1:1:\sqrt{2}$, where $\cos 45°$ = adjacent/hypotenuse = $1/\sqrt{2} = \sqrt{2}/2$. This is a value worth memorizing.

40. Correct Answer: C ($6x^3y^4$)

Simplify $(36x^9y^7)/(6x^6y^3)$ by dividing coefficients and subtracting exponents for like bases. For the coefficient: $36/6 = 6$. For x: $x^9/x^6 = x^{(9-6)} = x^3$. For y: $y^7/y^3 = y^{(7-3)} = y^4$. The result is $6x^3y^4$.