Full Length Practice Test 8

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. The rough endoplasmic reticulum is distinguished from smooth ER by the presence of:
   A. Mitochondria
   B. Ribosomes
   C. Lysosomes
   D. Peroxisomes

2. The sinoatrial (SA) node is located in the:
   A. Left ventricle
   B. Left atrium
   C. Right atrium
   D. Right ventricle

3. During which phase of mitosis do sister chromatids separate?
   A. Prophase
   B. Anaphase
   C. Metaphase
   D. Telophase

4. Chlorophyll b appears yellow-green because it primarily absorbs:
   A. Green and yellow light
   B. Red and blue light
   C. Only green light
   D. Ultraviolet light

5. A point mutation that results in a premature stop codon is called:
   A. Nonsense mutation
   B. Missense mutation
   C. Silent mutation
   D. Frameshift mutation

6. Which organ produces bile for fat emulsification?
   A. Pancreas

B. Gallbladder
C. Stomach
D. Liver

7. The enzyme that fixes CO_2 in the Calvin cycle is:
   A. Primase
   B. DNA polymerase
   C. RuBisCO
   D. Helicase

8. Okazaki fragments are found on the:
   A. Leading strand
   B. Lagging strand
   C. Template strand
   D. Coding strand

9. Which hormone stimulates uterine contractions during childbirth?
   A. Prolactin
   B. Progesterone
   C. Estrogen
   D. Oxytocin

10. The formed elements in blood include all of the following EXCEPT:
    A. Plasma proteins
    B. Erythrocytes
    C. Leukocytes
    D. Platelets

11. The distal convoluted tubule in the nephron is primarily responsible for:
    A. Filtration
    B. Glucose reabsorption
    C. Fine-tuning electrolyte balance
    D. Water reabsorption only

12. The poly-A tail is added to mRNA during:
    A. Transcription
    B. RNA processing
    C. Translation
    D. DNA replication

13. Blood flows from the left atrium through which valve?
    A. Mitral (bicuspid) valve
    B. Tricuspid valve
    C. Aortic valve
    D. Pulmonary valve

14. Osmosis is best described as:
    A. Active transport of water
    B. Passive transport of solutes
    C. Active transport of ions
    D. Passive movement of water across a membrane

15. Birds excrete nitrogenous waste primarily as:
    A. Ammonia
    B. Urea
    C. Uric acid
    D. Creatinine

16. The lac operon is an example of:
    A. Positive regulation
    B. Negative inducible regulation
    C. Constitutive expression
    D. Post-transcriptional control

17. Respiratory rate is primarily controlled by monitoring:
    A. Oxygen levels only
    B. Nitrogen levels
    C. Blood pressure
    D. CO_2 and pH levels

18. Meiosis II is most similar to:
    A. Mitosis
    B. Binary fission
    C. Meiosis I
    D. Cytokinesis

19. The surge in which hormone triggers ovulation?
    A. FSH
    B. Estrogen
    C. LH

D. Progesterone

20. Antibody class switching involves:
    A. T cells only
    B. B cells changing antibody class
    C. Destruction of antibodies
    D. Formation of antibodies

21. Xylem tissue in plants transports:
    A. Water and minerals
    B. Sugars only
    C. Amino acids
    D. Hormones only

22. Which neurotransmitter is deficient in Parkinson's disease?
    A. Serotonin
    B. Acetylcholine
    C. Glutamate
    D. Dopamine

23. During muscle contraction, myosin heads bind to:
    A. Tropomyosin
    B. Actin
    C. Troponin
    D. Calcium ions

24. The hormone primarily responsible for milk production is:
    A. Oxytocin
    B. Estrogen
    C. Prolactin
    D. Progesterone

25. The majority of ATP in aerobic respiration is produced during:
    A. Glycolysis
    B. Krebs cycle
    C. Fermentation
    D. Electron transport chain

26. Cytotoxic T cells recognize antigens presented by:
    A. MHC Class I molecules

B. MHC Class II molecules
C. Antibodies only
D. B cells only

27. In the central nervous system, myelin is produced by:
    A. Schwann cells
    B. Oligodendrocytes
    C. Astrocytes
    D. Microglia

28. Cyclins regulate the cell cycle by:
    A. Degrading DNA
    B. Preventing mitosis
    C. Activating CDKs
    D. Destroying chromosomes

29. The exchange of oxygen and carbon dioxide in the lungs occurs in the:
    A. Alveoli
    B. Bronchi
    C. Trachea
    D. Bronchioles

30. The immediate energy source for muscle contraction is:
    A. Glucose
    B. Glycogen
    C. Fatty acids
    D. ATP

31. The Meselson-Stahl experiment demonstrated:
    A. DNA is double-stranded
    B. DNA replication is semi-conservative
    C. DNA contains thymine
    D. RNA is single-stranded

32. During which phase does the corpus luteum degenerate if fertilization does not occur?
    A. Follicular phase
    B. Ovulation
    C. Late luteal phase
    D. Early luteal phase

33. The primary site of nutrient absorption in the digestive system is the:
    A. Small intestine
    B. Stomach
    C. Large intestine
    D. Esophagus

34. RNA interference (RNAi) regulates gene expression at the level of:
    A. DNA replication
    B. Transcription initiation
    C. Splicing
    D. Translation or mRNA stability

35. The point of sharpest vision in the eye is the:
    A. Optic disc
    B. Cornea
    C. Fovea centralis
    D. Iris

36. Helicase functions to:
    A. Add nucleotides
    B. Unwind DNA double helix
    C. Join DNA fragments
    D. Proofread DNA

37. Red blood cells are produced in the:
    A. Spleen
    B. Liver
    C. Thymus
    D. Bone marrow

38. The M-line in a sarcomere is located in the center of the:
    A. H-zone
    B. I-band
    C. A-band
    D. Z-disc

39. Erythropoietin (EPO) is produced by the:
    A. Liver
    B. Heart
    C. Kidneys

D. Spleen

40. In a Hardy-Weinberg population where p = 0.7, what is the frequency of heterozygotes?
    A. 0.49
    B. 0.42
    C. 0.09
    D. 0.21

GENERAL CHEMISTRY (Questions 41-70)

41. The electron configuration of sulfur (atomic number 16) is:
    A. $1s^2 2s^2 2p^6 3s^2 3p^2$
    B. $1s^2 2s^2 2p^6 3s^1 3p^5$
    C. $1s^2 2s^2 2p^6 3s^2 3p^5$
    D. $1s^2 2s^2 2p^6 3s^2 3p^4$

42. Hund's rule states that:
    A. Electrons occupy orbitals singly before pairing
    B. Electrons fill lowest energy levels first
    C. No two electrons can have identical quantum numbers
    D. Orbitals hold maximum two electrons

43. A solution with $[H^+] = 1 \times 10^{-5}$ M has a pH of:
    A. 9
    B. -5
    C. 5
    D. 10

44. Which substance has the lowest vapor pressure at room temperature?
    A. CH_4
    B. H_2
    C. C_2H_5OH
    D. H_2O

45. In the reaction $2Mg + O_2 \rightarrow 2MgO$, magnesium is:
    A. Oxidized
    B. Reduced
    C. Neither oxidized nor reduced
    D. The oxidizing agent

46. The total number of electrons that can occupy the n = 4 energy level is:
   A. 8
   B. 18
   C. 16
   D. 32

47. The azimuthal (angular momentum) quantum number (l) for a d orbital is:
   A. 0
   B. 2
   C. 1
   D. 3

48. A buffer solution resists changes in:
   A. Temperature
   B. Volume
   C. pH
   D. Pressure

49. Charles's Law describes the relationship between:
   A. Pressure and moles
   B. Volume and moles
   C. Pressure and temperature
   D. Volume and temperature

50. The oxidation state of manganese in $KMnO_4$ is:
   A. +7
   B. +6
   C. +5
   D. +4

51. For a reaction to be spontaneous at all temperatures, which condition must be met?
   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 $\Delta S < 0$

52. How many grams are in 0.5 moles of NaCl (molar mass = 58.5 g/mol)?
   A. 117 g
   B. 29.25 g
   C. 58.5 g

D. 14.625 g

53. Atomic radius generally decreases:
    A. Across a period from left to right
    B. Down a group
    C. From right to left across a period
    D. Randomly

54. The solubility product constant (Ksp) is used for:
    A. Strong acids
    B. Sparingly soluble salts
    C. Strong bases
    D. Gases

55. A reaction with $\Delta H < 0$ and $\Delta S > 0$ is:
    A. Never spontaneous
    B. Spontaneous only at low temperatures
    C. Always spontaneous
    D. Spontaneous only at high temperatures

56. What is the molarity of a solution containing 2 moles of solute in 4 liters?
    A. 0.5 M
    B. 2 M
    C. 8 M
    D. 4 M

57. A triple bond contains:
    A. Three sigma bonds
    B. Two sigma and one pi bond
    C. Three pi bonds
    D. One sigma and two pi bonds

58. The conjugate base of a strong acid is:
    A. Strong
    B. Weak
    C. Neutral
    D. Amphoteric

59. After two half-lives, what percentage of a radioactive sample remains?
    A. 25%

B. 50%

C. 12.5%

D. 75%

60. Which element has the largest atomic radius?

   A. F

   B. O

   C. Cl

   D. K

61. The molecular geometry of NH_3 is:

   A. Tetrahedral

   B. Linear

   C. Trigonal pyramidal

   D. Bent

62. In an electrolytic cell, oxidation occurs at the:

   A. Cathode

   B. Anode

   C. Salt bridge

   D. Neither electrode

63. At STP, one mole of any ideal gas occupies:

   A. 11.2 L

   B. 44.8 L

   C. 1 L

   D. 22.4 L

64. Isobars have the same:

   A. Mass number

   B. Atomic number

   C. Number of neutrons

   D. Number of electrons

65. For a zero-order reaction, the half-life:

   A. Depends on initial concentration

   B. Is constant

   C. Is independent of concentration

   D. Doubles with each half-life

66. The conjugate acid of NH_3 is:
    A. NH_2^-
    B. NH_4OH
    C. NH_4^+
    D. N_2H_4

67. The bond order of O_2 is:
    A. 1
    B. 1.5
    C. 3
    D. 2

68. According to Boyle's Law, if the volume of a gas is halved at constant temperature, the pressure:
    A. Remains the same
    B. Doubles
    C. Is halved
    D. Quadruples

69. In Fe_3O_4, what is the average oxidation state of iron?
    A. +2
    B. +3
    C. +4
    D. +8/3

70. Which property does NOT depend on the amount of solute particles?
    A. Viscosity
    B. Boiling point elevation
    C. Freezing point depression
    D. Osmotic pressure

ORGANIC CHEMISTRY (Questions 71-100)

71. Alkenes 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 an alcohol is:
    A. -CHO

B. -OH

C. -COOH

D. -NH$_2$

73. The IUPAC name for CH$_3$CH$_2$CH$_2$CH$_3$ is:

A. Butane

B. Propane

C. Pentane

D. Hexane

74. Enantiomers are:

A. Constitutional isomers

B. Conformers

C. Non-superimposable mirror images

D. Geometric isomers

75. Hydration of an alkene produces:

A. Alkane

B. Alcohol

C. Aldehyde

D. Ketone

76. Which carbonyl compound is most easily reduced?

A. Aldehyde

B. Ester

C. Amide

D. Carboxylic acid

77. Tollens' test (silver mirror test) is positive for:

A. Ketones

B. Alkenes

C. Tertiary alcohols

D. Aldehydes

78. The hybridization of the carbon atoms in ethene (C$_2$H$_4$) is:

A. sp

B. sp^2

C. sp^3

D. sp^{3}d

79. Addition of HCl to 2-methylpropene follows:
    A. Anti-Markovnikov's rule
    B. Zaitsev's rule
    C. Markovnikov's rule
    D. Hofmann's rule

80. Benzene is aromatic because it has:
    A. 4π electrons
    B. 6π electrons
    C. 8π electrons
    D. 10π electrons

81. Primary substrates favor which mechanism?
    A. SN1
    B. E1
    C. E2
    D. SN2

82. Carboxylic acids are more acidic than alcohols because:
    A. The carboxylate anion is resonance-stabilized
    B. They have more carbons
    C. They have more hydrogens
    D. They are larger molecules

83. The aldol condensation reaction involves:
    A. Alcohols
    B. Alkanes
    C. Amines
    D. Aldehydes or ketones

84. The rate-determining step in E1 reactions is:
    A. Carbocation formation
    B. Proton removal
    C. Nucleophile attack
    D. Rearrangement

85. Which is the most acidic hydrogen-containing compound?
    A. CH_4
    B. H_2O
    C. CH_3COOH

D. C_2H_6

86. Saponification produces:
    A. Soap and glycerol
    B. Esters
    C. Amides
    D. Aldehydes

87. A compound that is superimposable on its mirror image is:
    A. Chiral
    B. Enantiomeric
    C. Optically active
    D. Achiral

88. The Friedel-Crafts alkylation reaction requires:
    A. Strong base
    B. Oxidizing agent
    C. Lewis acid catalyst
    D. Reducing agent

89. Which alkyl halide undergoes SN1 most rapidly?
    A. Methyl
    B. Tertiary
    C. Primary
    D. Secondary

90. Grignard reagents react with CO_2 to form:
    A. Carboxylic acids (after workup)
    B. Alcohols
    C. Aldehydes
    D. Ketones

91. The D/L system is used for:
    A. Oxidation states
    B. Hybridization
    C. E/Z nomenclature
    D. Absolute configuration of sugars

92. The Gabriel synthesis produces:
    A. Aldehydes

B. Ketones
C. Primary amines
D. Carboxylic acids

93. A racemic mixture contains:
   A. One enantiomer only
   B. Equal amounts of both enantiomers
   C. Diastereomers
   D. Constitutional isomers

94. Which reducing agent is selective for aldehydes and ketones?
   A. LiAlH₄
   B. H₂/Pt
   C. KMnO₄
   D. NaBH₄

95. Oxidation of a secondary alcohol produces:
   A. Aldehyde
   B. Carboxylic acid
   C. Ketone
   D. Alkene

96. Activating groups on benzene are:
   A. Meta-directing and deactivating
   B. Meta-directing and activating
   C. Ortho/para-directing and activating
   D. Ortho/para-directing and deactivating

97. The Zaitsev rule predicts that elimination reactions produce predominantly the:
   A. Less stable alkene
   B. More substituted alkene
   C. Less substituted alkene
   D. No preference

98. Ester hydrolysis in base is called:
   A. Saponification
   B. Esterification
   C. Friedel-Crafts acylation
   D. Aldol condensation

99. Which spectroscopy technique is most useful for determining functional groups?
   A. NMR
   B. Mass spectrometry
   C. UV-Vis
   D. IR spectroscopy

100.   In ¹H NMR, the number of signals indicates:
   A. Molecular weight
   B. Number of carbons
   C. Number of chemically distinct hydrogen environments
   D. Number of functional groups

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 = 58°, Angle 2 = 43°, Angle 3 = 71°, Angle 4 = 35°. Rank from smallest to largest.
   A. 2-4-1-3
   B. 4-1-2-3
   C. 4-2-3-1
   D. 4-2-1-3

2. [Angle Ranking] Angle P = 67°, Angle Q = 54°, Angle R = 82°, Angle S = 75°. Rank from smallest to largest.
   A. Q-P-R-S
   B. Q-P-S-R
   C. P-Q-S-R
   D. Q-S-P-R

3. [Angle Ranking] Four angles measure: Angle 1 = 21°, Angle 2 = 49°, Angle 3 = 38°, Angle 4 = 27°. Rank from smallest to largest.
   A. 1-4-3-2
   B. 4-1-3-2
   C. 1-3-4-2
   D. 3-1-4-2

4. [Angle Ranking] Angle A = 88°, Angle B = 62°, Angle C = 79°, Angle D = 71°. Rank from smallest to largest.
   A. B-D-A-C
   B. B-C-D-A
   C. B-D-C-A
   D. D-B-C-A

5. [Angle Ranking] Angle W is seven-eighths of a right angle. Angle X = 64°. Angle Y = 51°. Angle Z = 86°. Rank from smallest to largest.
   A. Y-X-W-Z
   B. W-Y-X-Z
   C. Y-W-X-Z
   D. Y-X-W-Z

6. [Angle Ranking] Four angles: Angle 1 = 17°, Angle 2 = 45°, Angle 3 = 32°, Angle 4 = 25°. Rank from smallest to largest.
   A. 1-3-4-2
   B. 1-4-3-2
   C. 1-2-3-4
   D. 1-3-2-4

7. [Angle Ranking] Angle M = 69°, Angle N = 84°, Angle O = 56°, Angle P = 73°. Rank from smallest to largest.
   A. O-M-N-P
   B. M-O-P-N
   C. O-M-P-N
   D. O-P-M-N

8. [Angle Ranking] Four angles measure: Angle 1 = 12°, Angle 2 = 41°, Angle 3 = 34°, Angle 4 = 50°. Rank from smallest to largest.
   A. 1-3-2-4
   B. 1-2-3-4
   C. 3-1-2-4
   D. 1-4-2-3

9. [Angle Ranking] Angle A = 47°, Angle B = 59°, Angle C = 36°, Angle D = 68°. Rank from smallest to largest.
   A. C-B-A-D
   B. C-A-D-B
   C. A-C-B-D

D. C-A-B-D

10. [Angle Ranking] Four angles: Angle 1 = 76°, Angle 2 = 61°, Angle 3 = 83°, Angle 4 = 70°. Rank from smallest to largest.
    A. 2-1-3-4
    B. 2-4-1-3
    C. 2-1-4-3
    D. 4-2-1-3

11. [Angle Ranking] Angle W = 28°, Angle X = 52°, Angle Y = 39°, Angle Z = 46°. Rank from smallest to largest.
    A. W-Y-Z-X
    B. W-X-Y-Z
    C. Z-W-Y-X
    D. W-Z-X-Y

12. [Angle Ranking] Four angles measure: Angle 1 = 22°, Angle 2 = 35°, Angle 3 = 29°, Angle 4 = 48°. Rank from smallest to largest.
    A. 1-2-3-4
    B. 1-3-4-2
    C. 1-3-2-4
    D. 2-1-3-4

13. [Angle Ranking] Angle P = 63°, Angle Q = 44°, Angle R = 91°, Angle S = 55°. Rank from smallest to largest.
    A. Q-S-P-R
    B. S-Q-P-R
    C. Q-P-S-R
    D. Q-S-P-R

14. [Angle Ranking] Four angles: Angle 1 = 19°, Angle 2 = 42°, Angle 3 = 37°, Angle 4 = 53°. Rank from smallest to largest.
    A. 1-2-3-4
    B. 1-3-2-4
    C. 3-1-2-4
    D. 1-3-4-2

15. [Angle Ranking] Angle A = 81°, Angle B = 72°, Angle C = 90°, Angle D = 66°. Rank from smallest to largest.
    A. D-A-B-C

B. D-B-C-A

C. D-B-A-C

D. B-D-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 one hole is punched through both layers. How many total holes appear when unfolded?
    A. 2
    B. 4
    C. 1
    D. 6

17. [Hole Punching] Paper is folded three times (creating 8 layers), then three holes are 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 four holes are punched through all layers. How many total holes appear when unfolded?
    A. 8
    B. 16
    C. 12
    D. 20

19. [Hole Punching] Paper is folded in half once, then three holes are punched through both layers. How many total holes appear when unfolded?
    A. 6
    B. 8
    C. 4
    D. 10

20. [Hole Punching] Paper is folded in half twice, then three holes are punched through all layers. How many total holes appear when unfolded?
    A. 6

B. 9
C. 12
D. 16

21. [Hole Punching] Paper is folded diagonally once, then two holes are punched exactly on the fold line. How many holes appear when unfolded?
    A. 4
    B. 1
    C. 3
    D. 2

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

23. [Hole Punching] Paper is folded in half once, then four holes are punched through both layers. How many total holes appear when unfolded?
    A. 4
    B. 6
    C. 8
    D. 10

24. [Hole Punching] Paper is folded in half once, then a hole is punched exactly at the fold line. How many holes appear when unfolded?
    A. 1
    B. 2
    C. 3
    D. 4

25. [Hole Punching] Paper is folded in half twice (into quarters), then five holes are punched through all layers. How many total holes appear when unfolded?
    A. 10
    B. 16
    C. 15
    D. 20

26. [Hole Punching] Paper is folded diagonally once, then three holes are punched away from the fold. How many total holes appear when unfolded?
    A. 3
    B. 6
    C. 12
    D. 9

27. [Hole Punching] Paper is folded in half once, then six holes are punched through both layers. How many total holes appear when unfolded?
    A. 12
    B. 10
    C. 8
    D. 14

28. [Hole Punching] Paper is folded in half twice, then a hole is punched where the two folds intersect. How many holes appear when unfolded?
    A. 1
    B. 4
    C. 2
    D. 8

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

30. [Hole Punching] Paper is folded in half once, then eight holes are punched through both layers. How many holes appear when unfolded?
    A. 16
    B. 12
    C. 10
    D. 8

CUBE COUNTING (Questions 31-45)

Directions: Answer questions about unit cubes in various structures.

31. [Cube Counting] In a 6×6×6 cube, how many unit cubes have exactly 1 face exposed (face cubes)?
    A. 48
    B. 54
    C. 72
    D. 96

32. [Cube Counting] A solid 7×7×7 cube. How many unit cubes have exactly 3 faces exposed (corner cubes)?
    A. 8
    B. 6
    C. 12
    D. 4

33. [Cube Counting] A 3×5×4 rectangular prism. How many total unit cubes are in the structure?
    A. 48
    B. 36
    C. 54
    D. 60

34. [Cube Counting] A structure of 15 unit cubes arranged in a straight line. How many cubes have exactly 5 faces exposed (end cubes)?
    A. 1
    B. 0
    C. 2
    D. 4

35. [Cube Counting] In a 6×6×6 cube, how many unit cubes have exactly 0 faces exposed (completely interior)?
    A. 64
    B. 27
    C. 125
    D. 8

36. [Cube Counting] A 4×5×3 rectangular prism. How many unit cubes have exactly 3 faces exposed (corners)?
    A. 6

B. 8

C. 4

D. 12

37. [Cube Counting] A solid 6×6×6 cube. How many unit cubes have exactly 2 faces exposed (edge cubes)?

A. 36

B. 24

C. 60

D. 48

38. [Cube Counting] A 5×3×4 rectangular prism. How many total unit cubes are in the structure?

A. 48

B. 50

C. 60

D. 54

39. [Cube Counting] In a 6×6×6 cube, how many unit cubes are NOT corner cubes?

A. 208

B. 208

C. 216

D. 200

40. [Cube Counting] A 5×5×2 rectangular prism. How many unit cubes are NOT corner cubes?

A. 42

B. 50

C. 46

D. 40

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

A. 10

B. 8

C. 12

D. 14

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

A. 24

B. 30

C. 32

D. 28

43. [Cube Counting] An L-shaped structure: 9 cubes in a row with 5 cubes stacked on one end (14 total). How many cubes have exactly 3 exposed faces?

A. 4

B. 5

C. 6

D. 7

44. [Cube Counting] A 8×8×2 rectangular prism. How many unit cubes have at least one face exposed?

A. 120

B. 124

C. 116

D. 128

45. [Cube Counting] In a 5×5×5 cube, how many unit cubes have exactly 2 faces exposed?

A. 32

B. 36

C. 24

D. 40

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 4 squares in a row. What can this form when folded?

A. Open-top cube

B. Pyramid

C. Complete cube

D. Prism

47. [Pattern Folding] A net shows 1 heptagon with 7 triangles attached to each edge. What 3D shape is formed?

A. Cube

B. Pentagonal pyramid

C. Heptagonal pyramid

D. Hexagonal prism

48. [Pattern Folding] A net consists of 6 squares arranged in a plus/cross pattern. What does it form?
    A. Partial cube
    B. Pyramid
    C. Open box
    D. Cube

49. [Pattern Folding] A net shows 2 hexagons and 6 rectangles all connected. What shape does it form?
    A. Tetrahedron
    B. Hexagonal prism
    C. Pentagon
    D. Rectangular prism

50. [Pattern Folding] A net shows 1 square with 2 triangles attached to two adjacent edges of the square. What partial shape does it form?
    A. Complete pyramid
    B. Complete cube
    C. Partial pyramid (missing two faces)
    D. Prism

51. [Pattern Folding] A net consists of 5 squares in an L-shape. What does it form?
    A. Partial cube (open box)
    B. Pyramid
    C. Complete cube
    D. Prism

52. [Pattern Folding] A net has 4 equilateral triangles arranged properly. What 3D shape is formed?
    A. Square pyramid
    B. Triangular prism
    C. Cube
    D. Tetrahedron

53. [Pattern Folding] A net consists of 2 triangles and 3 rectangles that connect. What does it form?
    A. Cone
    B. Triangular prism
    C. Pyramid
    D. Cylinder

54. [Pattern Folding] A net shows 5 rectangles arranged to form a closed shape (missing top and bottom). What is it most likely to form?

A. Open rectangular prism
B. Rectangular prism
C. Pyramid
D. Triangular prism

55. [Pattern Folding] A net shows 1 nonagon with 9 rectangles connecting around its edges. What 3D shape is formed?
A. Rectangular prism
B. Hexagonal prism
C. Nonagonal prism
D. Cube

56. [Pattern Folding] A net consists of 1 large pentagon with 5 triangles attached to its edges. What shape does it form?
A. Square pyramid
B. Tetrahedron
C. Octahedron
D. Pentagonal pyramid

57. [Pattern Folding] A net shows 6 squares in a T-shape arrangement. What can this form?
A. Pyramid
B. Cube or open box
C. Prism
D. Complete pyramid

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

59. [Pattern Folding] A net shows 3 squares in a row. What can this form?
A. Complete cube
B. Pyramid
C. Prism
D. Partial open box

60. [Pattern Folding] A net consists of 1 hexagon and 6 rectangles arranged around it. What type of shape does this form?

A. Cube
B. Pyramid
C. Rectangular prism
D. Triangular prism

APERTURES / KEYHOLES (Questions 61-75)

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

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

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

63. [Keyhole] A sphere passes through an aperture. Which shape would NOT work?
    A. Circle
    B. Square
    C. Pentagon
    D. Hexagon

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

65. [Keyhole] A rectangular prism passes through an aperture. Which aperture is possible?
    A. Circle
    B. Triangle
    C. Pentagon

D. Rectangle

66. [Keyhole] Which aperture shape would NOT work for a cylinder?
    A. Circle
    B. Rectangle
    C. Oval
    D. Triangle

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

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

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

70. [Keyhole] Which 3D object could pass through a hexagonal aperture?
    A. Hexagonal prism
    B. Sphere
    C. Triangular prism
    D. Cube

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

72. [Keyhole] A cone passes through an aperture. Which are the possible shapes?
    A. Square only

B. Triangle only
C. Circle or Triangle
D. Pentagon only

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

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

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

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: square. Front view: rectangle. Side view: rectangle. What is the 3D shape?
   A. Rectangular prism
   B. Cylinder
   C. Square pyramid
   D. Triangular prism

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

78. [Top-Front-End] A cube is viewed from the top. What shape appears?
    A. Rectangle
    B. Square
    C. Circle
    D. Triangle

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

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

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

82. [Top-Front-End] Top view: square. Front and side views: squares (all identical). What is the shape?
    A. Rectangular prism
    B. Hexagonal prism
    C. Pyramid
    D. Cube

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

84. [Top-Front-End] Top view: triangle. Front view: triangle. Side view: rectangle. What is the shape?
    A. Cylinder

B. Square pyramid
C. Triangular prism
D. Cone

85. [Top-Front-End] Top view: circle. Front and side views: circles. What is the shape?
    A. Sphere
    B. Pentagonal prism
    C. Cylinder
    D. Tetrahedron

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

87. [Top-Front-End] A cylinder is viewed from the end (along its axis). What shape appears?
    A. Square
    B. Circle
    C. Triangle
    D. Rectangle

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

89. [Top-Front-End] An octagonal pyramid is viewed from directly above. What shape appears?
    A. Octagon
    B. Rectangle
    C. Pentagon
    D. Square

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

D. Cube

Reading Comprehension

PASSAGE I

Antibiotics revolutionized medicine by treating bacterial infections that once proved fatal. However, antibiotic resistance now threatens to return us to the pre-antibiotic era. Bacteria evolve resistance through random mutations or acquiring resistance genes from other bacteria via horizontal gene transfer. Overuse and misuse of antibiotics accelerate this process by creating selective pressure favoring resistant strains.

Resistance mechanisms vary widely. Some bacteria produce enzymes that destroy antibiotics—beta-lactamases break down penicillin-based drugs. Others modify drug targets so antibiotics cannot bind effectively. Efflux pumps actively expel antibiotics from bacterial cells before they can act. Some bacteria develop impermeable cell walls preventing antibiotic entry. Importantly, bacteria can possess multiple resistance mechanisms simultaneously, creating "superbugs" resistant to numerous drugs.

The causes of resistance are multifaceted. In healthcare, antibiotics are often prescribed for viral infections where they provide no benefit. Patients frequently discontinue treatment prematurely when symptoms improve, allowing resistant bacteria to survive and multiply. Agricultural practices contribute significantly—over 70% of medically important antibiotics in some countries are used in livestock for growth promotion rather than treating disease. This creates vast reservoirs of resistant bacteria that can transfer to humans through food or environmental contamination.

Combating resistance requires coordinated action. Antibiotic stewardship programs ensure appropriate prescribing—using the right drug at the right dose for the right duration. Rapid diagnostic tests help distinguish bacterial from viral infections. Infection prevention through vaccination and hygiene reduces antibiotic need. Developing new antibiotics is crucial but economically challenging, as pharmaceutical companies find limited profitability in drugs used briefly. Alternative approaches include bacteriophage therapy using viruses that infect bacteria, antimicrobial peptides, and drugs that disable bacterial virulence without killing them, potentially reducing selection for resistance.

1. Antibiotic resistance threatens to:
   A. Improve medicine
   B. Have no impact
   C. Cure all diseases
   D. Return us to the pre-antibiotic era

2. Bacteria acquire resistance genes through:
   A. Photosynthesis
   B. Horizontal gene transfer

C. Respiration

D. Digestion

3. Beta-lactamases function by:
   A. Enhancing antibiotic action
   B. Repairing DNA
   C. Breaking down penicillin-based drugs
   D. Producing vitamins

4. Efflux pumps work by:
   A. Bringing antibiotics into cells
   B. Destroying cell walls
   C. Repairing damaged DNA
   D. Actively expelling antibiotics from cells

5. "Superbugs" are bacteria that:
   A. Possess multiple resistance mechanisms
   B. Are beneficial
   C. Cannot survive
   D. Are easily killed

6. Antibiotics prescribed for viral infections:
   A. Cure the infection
   B. Speed recovery
   C. Provide no benefit
   D. Always help

7. Patients who discontinue treatment prematurely allow:
   A. Complete cure
   B. Resistant bacteria to survive
   C. Faster healing
   D. Better outcomes

8. What percentage of medically important antibiotics in some countries are used in livestock?
   A. Over 70%
   B. Under 10%
   C. Exactly 50%
   D. 25%

9. Livestock antibiotic use is primarily for:

A. Treating sick animals only
B. Emergency care
C. Vaccination
D. Growth promotion

10. Antibiotic stewardship programs ensure:
    A. Overuse of antibiotics
    B. Appropriate prescribing
    C. No antibiotic use
    D. Random prescribing

11. Rapid diagnostic tests help distinguish:
    A. Animals from humans
    B. Foods from drugs
    C. Bacterial from viral infections
    D. Doctors from patients

12. Developing new antibiotics is economically challenging because:
    A. Companies find limited profitability
    B. They are too easy to make
    C. No one wants them
    D. They are always profitable

13. Bacteriophage therapy uses:
    A. Antibiotics
    B. Vaccines
    C. Bacteria
    D. Viruses that infect bacteria

14. An alternative approach to reduce selection for resistance involves drugs that:
    A. Kill all bacteria instantly
    B. Increase bacterial growth
    C. Disable bacterial virulence without killing them
    D. Have no effect

15. The primary cause of antibiotic resistance is:
    A. Underuse
    B. Overuse and misuse
    C. Proper use
    D. No use

16. Bacteria modify drug targets to:
   A. Prevent antibiotic binding
   B. Enhance antibiotic action
   C. Produce more antibiotics
   D. Die faster

17. Resistant bacteria in agriculture can transfer to humans through:
   A. Air only
   B. Water only
   C. Sunlight
   D. Food or environmental contamination

PASSAGE II

Climate change affects ocean chemistry through a process called ocean acidification. The ocean absorbs approximately 30% of atmospheric CO_2, forming carbonic acid that lowers pH. Since pre-industrial times, ocean pH has dropped from 8.2 to 8.1—a 30% increase in acidity on the logarithmic pH scale. Projections suggest pH could reach 7.8 by 2100 under high-emission scenarios.

Ocean acidification impacts marine organisms differently. Calcifying organisms—corals, mollusks, and some plankton—struggle to build calcium carbonate shells and skeletons as acidification reduces available carbonate ions. Pteropods, small swimming snails that feed salmon and other fish, show shell dissolution in acidified waters. Coral reefs face double threats from acidification and warming, with many reefs already experiencing bleaching events. Fish behavior changes unexpectedly: studies show some species lose their ability to detect predators or find suitable habitat, possibly due to interference with neurotransmitter function.

The ecosystem consequences extend beyond individual species. Coral reefs support enormous biodiversity and protect coastlines from storms. Their degradation threatens fisheries supporting hundreds of millions of people. The Pacific Northwest oyster industry has suffered production losses linked to acidified upwelling waters. Early life stages of many marine species prove more vulnerable than adults, potentially disrupting recruitment and population dynamics.

Addressing ocean acidification ultimately requires reducing CO_2 emissions, as no technological solution can reverse acidification at ocean-wide scales. Even with aggressive emissions reductions, oceans will remain more acidic than pre-industrial levels for centuries due to the long residence time of CO_2 in the ocean-atmosphere system. Local interventions like protecting coastal ecosystems that absorb CO_2 or reducing other stressors (pollution, overfishing) may help some populations. Research into selective breeding of resistant organisms or assisted evolution shows promise but raises ecological concerns.

18. The ocean absorbs what percentage of atmospheric CO_2?
    A. 10%
    B. 50%
    C. 30%
    D. 75%

19. Ocean pH has dropped from 8.2 to:
    A. 7.8
    B. 8.1
    C. 9.0
    D. 7.0

20. The pH drop represents what increase in acidity?
    A. 10%
    B. 20%
    C. 50%
    D. 30%

21. Projected pH by 2100 under high-emission scenarios is:
    A. 7.8
    B. 8.0
    C. 8.2
    D. 7.5

22. Calcifying organisms struggle to build shells because acidification reduces:
    A. Oxygen
    B. Nitrogen
    C. Carbonate ions
    D. Hydrogen

23. Pteropods are important because they:
    A. Produce oxygen
    B. Destroy reefs
    C. Live on land
    D. Feed salmon and other fish

24. In acidified waters, pteropod shells undergo:
    A. Growth
    B. Dissolution

C. Hardening

D. Expansion

25. Fish behavior changes in acidified water may involve interference with:
    A. Photosynthesis
    B. Cell division
    C. Neurotransmitter function
    D. Bone growth

26. Coral reefs face threats from:
    A. Acidification and warming
    B. Cooling only
    C. Nothing
    D. Freshwater only

27. Coral reef degradation threatens:
    A. Nothing
    B. Only corals
    C. Only fish
    D. Fisheries supporting hundreds of millions

28. The Pacific Northwest oyster industry has suffered losses due to:
    A. Overfishing
    B. Freshwater
    C. Acidified upwelling waters
    D. Temperature increases only

29. Early life stages of marine species compared to adults are:
    A. Less vulnerable
    B. More vulnerable
    C. Equally vulnerable
    D. Not affected

30. The ultimate solution to ocean acidification is:
    A. Reducing CO_2 emissions
    B. Adding chemicals
    C. Doing nothing
    D. Increasing emissions

31. Even with emissions reductions, oceans will remain acidic for:

A. Days
B. Weeks
C. Months
D. Centuries

32. The long acidification persistence is due to:
    A. Ice melting
    B. Rain
    C. Long residence time of CO_2 in ocean-atmosphere system
    D. Wind

33. Local interventions that may help include:
    A. Increasing pollution
    B. Protecting coastal ecosystems that absorb CO_2
    C. Removing all fish
    D. Adding acid

PASSAGE III

The blood-brain barrier (BBB) protects the brain by strictly controlling substance entry from bloodstream to brain tissue. Unlike most capillaries with gaps allowing easy substance passage, brain capillaries have endothelial cells joined by tight junctions, creating a continuous barrier. The BBB allows essential nutrients like glucose and oxygen to pass while blocking most drugs, toxins, and pathogens.

Transport across the BBB occurs through specific mechanisms. Small lipid-soluble molecules can diffuse directly through cell membranes. Glucose enters via GLUT1 transporters. Large molecules and most drugs cannot cross. The BBB actively expels many substances using efflux pumps like P-glycoprotein, further limiting drug entry. This protection poses challenges for treating brain diseases—many potentially therapeutic drugs cannot reach therapeutic concentrations in brain tissue.

Certain brain regions intentionally lack a complete BBB. Circumventricular organs like the area postrema (vomiting center) detect blood-borne toxins to trigger protective responses. The median eminence allows hormones to enter the bloodstream. These specialized regions enable important brain-body communication while the BBB protects most brain tissue.

BBB dysfunction contributes to various neurological diseases. In multiple sclerosis, immune cells inappropriately cross the BBB and attack myelin. Traumatic brain injury and stroke can disrupt the barrier, causing edema and secondary damage. Brain tumors may create areas of increased permeability detectable on imaging. Alzheimer's disease associates with BBB breakdown, potentially allowing harmful proteins

and inflammatory cells to enter brain tissue. Therapeutic strategies include designing drugs that can cross the BBB, temporarily disrupting the barrier to allow drug delivery, or using nanoparticles as carriers.

34. Research into selective breeding aims to:
    A. Eliminate all organisms
    B. Increase pollution
    C. Stop reproduction
    D. Develop resistant organisms

35. The blood-brain barrier's primary function is:
    A. Controlling substance entry from bloodstream to brain
    B. Producing blood cells
    C. Storing glucose
    D. Creating toxins

36. Brain capillaries differ from most capillaries by having:
    A. No cells
    B. Gaps
    C. Tight junctions between endothelial cells
    D. Large openings

37. The BBB allows passage of:
    A. All drugs
    B. Essential nutrients like glucose and oxygen
    C. All toxins
    D. No substances

38. GLUT1 transporters function to:
    A. Move glucose across the BBB
    B. Block all substances
    C. Produce insulin
    D. Destroy glucose

39. P-glycoprotein is an example of:
    A. Nutrient transporter
    B. Glucose molecule
    C. Tight junction
    D. Efflux pump

40. The BBB poses challenges for treating brain diseases because:

A. It allows all drugs through
B. The brain has no diseases
C. Most drugs cannot cross
D. It doesn't exist

41. The area postrema lacks a complete BBB to:
    A. Cause disease
    B. Detect blood-borne toxins and trigger vomiting
    C. Produce hormones
    D. Store nutrients

42. The median eminence lacks complete BBB to:
    A. Cause disease
    B. Block all substances
    C. Stop hormone release
    D. Allow hormone-bloodstream exchange

43. In multiple sclerosis, BBB dysfunction allows:
    A. Immune cells to cross and attack myelin
    B. Complete healing
    C. No changes
    D. Brain growth

44. Traumatic brain injury can disrupt the BBB, causing:
    A. Complete healing
    B. Edema and secondary damage
    C. Improved function
    D. No effects

45. Brain tumor imaging can detect areas of:
    A. Perfect barrier function
    B. No blood flow
    C. Increased BBB permeability
    D. Complete protection

46. Alzheimer's disease associates with BBB breakdown, potentially allowing entry of:
    A. Only beneficial substances
    B. Nothing
    C. Oxygen only
    D. Harmful proteins and inflammatory cells

47. Therapeutic strategies for drug delivery across BBB include:
    A. Designing drugs that can cross the BBB
    B. Giving up on brain diseases
    C. Ignoring the barrier
    D. Only using surgery

48. Small lipid-soluble molecules cross the BBB by:
    A. Active transport only
    B. Diffusing through cell membranes
    C. P-glycoprotein
    D. Tight junctions

49. Circumventricular organs intentionally lack complete BBB to:
    A. Cause disease
    B. Block everything
    C. Enable important brain-body communication
    D. Prevent all functions

50. The BBB blocks most drugs, toxins, and:
    A. Pathogens
    B. Oxygen
    C. Glucose
    D. Water

Quantitative Reasoning

1. What is the area of a circle with diameter 12 cm? (Use $\pi \approx 3.14$)
    A. 113.04 cm²
    B. 37.68 cm²
    C. 75.36 cm²
    D. 452.16 cm²

2. Solve for x: 6x - 9 = 27
    A. 4
    B. 5
    C. 6
    D. 7

3. What is 5/6 - 1/3?

A. 4/3
B. 1/2
C. 2/3
D. 1/6

4. In a triangle with angles 52°, 73°, and x°, what is x?
    A. 55°
    B. 60°
    C. 65°
    D. 70°

5. What is the perimeter of a rectangle with length 15 cm and width 7 cm?
    A. 22 cm
    B. 44 cm
    C. 105 cm
    D. 30 cm

6. Solve the inequality: $3x + 11 < 35$
    A. $x < 10$
    B. $x < 12$
    C. $x > 8$
    D. $x < 8$

7. What is $6^3 + 2^3$?
    A. 224
    B. 512
    C. 216
    D. 128

8. If 60% of a number is 120, what is the number?
    A. 72
    B. 180
    C. 200
    D. 240

9. What is the median of {15, 22, 28, 35, 40, 47}?
    A. 28
    B. 30
    C. 35
    D. 31.5

10. A car travels 450 miles in 9 hours. What is its average speed?
    A. 45 mph
    B. 40 mph
    C. 55 mph
    D. 50 mph

11. What is 11/12 - 1/4?
    A. 1/3
    B. 5/12
    C. 2/3
    D. 7/12

12. What is the slope of a line passing through points (4, 9) and (8, 17)?
    A. 1
    B. 2
    C. 3
    D. 4

13. What is $|-35| + |-12|$?
    A. 23
    B. -47
    C. -23
    D. 47

14. If 18/x = 54/72, what is x?
    A. 24
    B. 36
    C. 27
    D. 30

15. What is the volume of a cube with edge length 7 cm?
    A. 294 cm³
    B. 49 cm³
    C. 343 cm³
    D. 147 cm³

16. Solve the system: x + y = 25 and x - y = 9
    A. x = 15, y = 10
    B. x = 17, y = 8

C. x = 18, y = 7
D. x = 16, y = 9

17. What is tan 60°?
    A. 1/2
    B. √2/2
    C. 1
    D. √3

18. If a rectangle has area 180 cm² and width 12 cm, what is its length?
    A. 15 cm
    B. 20 cm
    C. 18 cm
    D. 10 cm

19. What is the least common multiple (LCM) of 12 and 18?
    A. 6
    B. 24
    C. 36
    D. 72

20. A box contains 8 red marbles and 12 blue marbles. What is the probability of drawing a red marble?
    A. 1/2
    B. 3/5
    C. 2/5
    D. 1/3

21. What is the distance between points (1, 3) and (5, 6)?
    A. 5
    B. 7
    C. 4
    D. 6

22. If y varies inversely as x, and y = 30 when x = 4, what is y when x = 12?
    A. 90
    B. 10
    C. 40
    D. 15

23. What is cos 60°?

A. √3/2
B. √2/2
C. 1/2
D. 1

24. If a square has area 196 cm², what is its perimeter?
    A. 14 cm
    B. 56 cm
    C. 49 cm
    D. 28 cm

25. Evaluate: f(x) = 3x + 8 when x = 9
    A. 25
    B. 27
    C. 33
    D. 35

26. Convert 0.625 to a fraction in lowest terms.
    A. 1/2
    B. 3/4
    C. 5/8
    D. 7/8

27. Solve for x: 8x + 7 = 6x + 21
    A. 7
    B. 14
    C. 9
    D. 10

28. What is the volume of a sphere with radius 3 cm? (Use $\pi \approx 3.14$, $V = 4/3\pi r^3$)
    A. 28.26 cm³
    B. 113.04 cm³
    C. 84.78 cm³
    D. 37.68 cm³

29. What is the greatest common factor (GCF) of 36 and 60?
    A. 6
    B. 18
    C. 4
    D. 12

30. In a triangle with angles 45°, 70°, and x°, what is x?
    A. 60°
    B. 70°
    C. 65°
    D. 75°

31. What is $10^2 - 7^2$?
    A. 51
    B. 30
    C. 49
    D. 100

32. What is 8/9 - 1/3?
    A. 7/9
    B. 1/3
    C. 2/3
    D. 5/9

33. A cylinder has radius 6 cm and height 5 cm. What is its volume? (Use $\pi \approx 3.14$)
    A. 94.2 cm³
    B. 188.4 cm³
    C. 282.6 cm³
    D. 565.2 cm³

34. What is 80 decreased by 35%?
    A. 45
    B. 28
    C. 52
    D. 56

35. If cos θ = √3/2, what is θ in degrees (0° < θ < 90°)?
    A. 60°
    B. 30°
    C. 45°
    D. 90°

36. Solve: 3(x + 5) = 2x + 23
    A. 8
    B. 6

C. 10
D. 12

37. What is the range of the dataset: {18, 32, 25, 43, 29}?
   A. 18
   B. 25
   C. 29
   D. 25

38. If $x^2 = 169$, what are the possible values of x?
   A. 169
   B. 84.5
   C. ± 13
   D. 13 only

39. What is sin 60°?
   A. 1/2
   B. $\sqrt{3}/2$
   C. $\sqrt{2}/2$
   D. 1

40. Simplify: $(30x^8y^5)/(5x^6y^2)$
   A. $25x^2y^3$
   B. $6x^3y^2$
   C. $5x^2y^3$
   D. $6x^2y^3$

Answer Explanations - Practice Test 8

Survey Of Natural Sciences

BIOLOGY (Questions 1-40)

1. Correct Answer: B (Ribosomes)

The rough endoplasmic reticulum (rough ER) is distinguished from smooth ER by the presence of ribosomes attached to its surface. These ribosomes give the rough ER its "rough" appearance under

electron microscopy and are responsible for protein synthesis. Smooth ER lacks ribosomes and functions primarily in lipid synthesis and detoxification.

2. Correct Answer: C (Right atrium)

The sinoatrial (SA) node, known as the heart's natural pacemaker, is located in the right atrium near the opening of the superior vena cava. It generates electrical impulses that initiate each heartbeat and set the heart's rhythm at approximately 60-100 beats per minute.

3. Correct Answer: B (Anaphase)

During anaphase of mitosis, sister chromatids separate and are pulled toward opposite poles of the cell by spindle fibers. The centromeres divide, and each chromatid (now called a chromosome) moves to opposite ends of the cell. This ensures equal distribution of genetic material to daughter cells.

4. Correct Answer: B (Red and blue light)

Chlorophyll b appears yellow-green because it primarily absorbs red and blue light wavelengths while reflecting green and yellow light. This absorption spectrum complements chlorophyll a, allowing plants to capture a broader range of light energy for photosynthesis.

5. Correct Answer: A (Nonsense mutation)

A nonsense mutation is a point mutation that results in a premature stop codon (UAA, UAG, or UGA), causing translation to terminate early and producing a truncated, usually nonfunctional protein. Missense mutations change one amino acid, silent mutations don't change the amino acid, and frameshift mutations involve insertions or deletions.

6. Correct Answer: D (Liver)

The liver produces bile, a greenish-yellow fluid containing bile salts, cholesterol, and bilirubin. Bile emulsifies fats in the small intestine, breaking large fat globules into smaller droplets to increase surface area for lipase enzyme action. The gallbladder stores and concentrates bile but doesn't produce it.

7. Correct Answer: C (RuBisCO)

RuBisCO (ribulose-1,5-bisphosphate carboxylase/oxygenase) is the enzyme that fixes CO_2 in the Calvin cycle by catalyzing the attachment of CO_2 to ribulose bisphosphate (RuBP). It's considered the most abundant protein on Earth and is essential for carbon fixation in photosynthesis.

8. Correct Answer: B (Lagging strand)

Okazaki fragments are short DNA segments (1000-2000 nucleotides in prokaryotes, 100-200 in eukaryotes) found on the lagging strand during DNA replication. Because DNA polymerase can only synthesize in the 5' to 3' direction, the lagging strand is synthesized discontinuously in fragments that are later joined by DNA ligase.

9. Correct Answer: D (Oxytocin)

Oxytocin, released from the posterior pituitary gland, stimulates uterine contractions during childbirth through a positive feedback mechanism. As labor progresses, stretching of the cervix triggers more oxytocin release, causing stronger contractions. Oxytocin also stimulates milk ejection during breastfeeding.

10. Correct Answer: A (Plasma proteins)

The formed elements in blood include erythrocytes (red blood cells), leukocytes (white blood cells), and platelets (thrombocytes). Plasma proteins such as albumin, globulins, and fibrinogen are dissolved in the plasma (liquid portion) and are not considered formed elements.

11. Correct Answer: C (Fine-tuning electrolyte balance)

The distal convoluted tubule (DCT) in the nephron is primarily responsible for fine-tuning electrolyte balance, particularly sodium and potassium, under hormonal control (aldosterone). It also regulates calcium reabsorption (under parathyroid hormone control) and pH balance. Filtration occurs in the glomerulus, and glucose reabsorption occurs mainly in the proximal convoluted tubule.

12. Correct Answer: B (RNA processing)

The poly-A tail (a string of approximately 200 adenine nucleotides) is added to the 3' end of mRNA during RNA processing (post-transcriptional modification) in the nucleus. This occurs after transcription along with 5' capping and splicing. The poly-A tail protects mRNA from degradation and aids in translation.

13. Correct Answer: A (Mitral (bicuspid) valve)

Blood flows from the left atrium through the mitral valve (also called the bicuspid valve because it has two cusps) into the left ventricle. This valve prevents backflow from the ventricle to the atrium during ventricular contraction. The tricuspid valve is on the right side of the heart.

14. Correct Answer: D (Passive movement of water across a membrane)

Osmosis is the passive movement of water molecules across a selectively permeable membrane from an area of lower solute concentration (higher water concentration) to an area of higher solute concentration (lower water concentration). It's a specific type of diffusion involving only water and requires no energy (ATP).

15. Correct Answer: C (Uric acid)

Birds excrete nitrogenous waste primarily as uric acid, a semi-solid, paste-like substance that requires minimal water for elimination. This adaptation is advantageous for flight as it reduces body weight compared to carrying liquid waste. Freshwater fish excrete ammonia, and mammals excrete urea.

16. Correct Answer: B (Negative inducible regulation)

The lac operon is an example of negative inducible regulation. In the absence of lactose, the lac repressor binds to the operator and blocks transcription. When lactose is present, it binds to the repressor, causing it

to release from the operator, allowing transcription to proceed. The system is "turned on" by the inducer (lactose).

17. Correct Answer: D (CO_2 and pH levels)

Respiratory rate is primarily controlled by monitoring CO_2 levels and pH in the blood and cerebrospinal fluid. Chemoreceptors in the medulla oblongata and carotid/aortic bodies detect increases in CO_2 (which lowers pH by forming carbonic acid) and trigger increased breathing rate to expel excess CO_2.

18. Correct Answer: A (Mitosis)

Meiosis II is most similar to mitosis because both involve separation of sister chromatids (not homologous chromosomes) and produce two daughter cells from one parent cell. The key difference is that meiosis II cells are haploid while mitosis involves diploid cells. Meiosis I separates homologous chromosomes.

19. Correct Answer: C (LH)

The surge in LH (luteinizing hormone) from the anterior pituitary triggers ovulation around day 14 of the menstrual cycle. High estrogen levels from the developing follicle cause positive feedback, triggering the LH surge that causes the mature follicle to rupture and release the egg.

20. Correct Answer: B (B cells changing antibody class)

Antibody class switching (or isotype switching) involves B cells changing the class of antibody they produce (from IgM to IgG, IgA, or IgE) while maintaining the same antigen specificity. This process occurs in germinal centers and allows the immune system to generate antibodies with different effector functions suited to different pathogens.

21. Correct Answer: A (Water and minerals)

Xylem tissue in plants transports water and dissolved minerals (nutrients) from roots upward to leaves through transpiration pull and root pressure. Phloem transports sugars (products of photosynthesis) and other organic compounds bidirectionally throughout the plant.

22. Correct Answer: D (Dopamine)

Dopamine is the neurotransmitter that is deficient in Parkinson's disease due to degeneration of dopamine-producing neurons in the substantia nigra. This deficiency leads to characteristic symptoms including tremor, rigidity, bradykinesia (slow movement), and postural instability. Treatment often includes L-DOPA, a dopamine precursor.

23. Correct Answer: B (Actin)

During muscle contraction, myosin heads bind to actin filaments at specific binding sites. When ATP is hydrolyzed, myosin heads pull the actin filaments toward the center of the sarcomere in a power stroke, causing muscle shortening. Tropomyosin normally blocks these binding sites until calcium triggers troponin to move tropomyosin aside.

24. Correct Answer: C (Prolactin)

Prolactin from the anterior pituitary is the hormone primarily responsible for milk production (lactogenesis) in mammary glands. During pregnancy, high estrogen and progesterone levels inhibit prolactin's milk-producing effects, but after delivery when these hormones drop, prolactin stimulates milk synthesis. Oxytocin is responsible for milk ejection (letdown), not production.

25. Correct Answer: D (Electron transport chain)

The majority of ATP (approximately 32-34 ATP molecules) in aerobic respiration is produced during the electron transport chain through oxidative phosphorylation. Glycolysis produces 2 ATP, the Krebs cycle produces 2 ATP (or GTP), but the electron transport chain harnesses energy from NADH and $FADH_2$ to create a proton gradient that drives ATP synthase.

26. Correct Answer: A (MHC Class I molecules)

Cytotoxic T cells ($CD8^+$ T cells) recognize antigens presented by MHC Class I molecules, which are found on all nucleated cells. When a cell is infected with a virus or becomes cancerous, it displays foreign antigens on MHC I, allowing cytotoxic T cells to recognize and destroy the compromised cell. Helper T cells recognize MHC Class II.

27. Correct Answer: B (Oligodendrocytes)

In the central nervous system (brain and spinal cord), myelin is produced by oligodendrocytes. Each oligodendrocyte can myelinate multiple axon segments from different neurons. In the peripheral nervous system, Schwann cells produce myelin. Astrocytes provide metabolic support, and microglia are immune cells.

28. Correct Answer: C (Activating CDKs)

Cyclins regulate the cell cycle by activating cyclin-dependent kinases (CDKs). Different cyclin-CDK complexes control different phases of the cell cycle. Cyclin levels rise and fall at specific times, and when cyclins bind to CDKs, they activate the kinases which then phosphorylate target proteins to drive cell cycle progression through checkpoints.

29. Correct Answer: A (Alveoli)

The exchange of oxygen and carbon dioxide between air and blood occurs in the alveoli, tiny air sacs in the lungs. The alveolar walls are extremely thin (one cell thick) and surrounded by capillaries, allowing efficient gas exchange by diffusion. The large surface area (approximately 70 m²) maximizes gas exchange.

30. Correct Answer: D (ATP)

The immediate energy source for muscle contraction is ATP (adenosine triphosphate). ATP binds to myosin heads, and when hydrolyzed to ADP and phosphate, provides energy for the power stroke. Muscles

store only enough ATP for a few seconds of contraction, so they must continuously regenerate ATP from creatine phosphate, glycolysis, and cellular respiration.

31. Correct Answer: B (DNA replication is semi-conservative)

The Meselson-Stahl experiment (1958) demonstrated that DNA replication is semi-conservative. Using isotope labeling, they showed that each new DNA molecule consists of one original (parental) strand and one newly synthesized strand. This confirmed the Watson-Crick model and ruled out conservative and dispersive replication models.

32. Correct Answer: C (Late luteal phase)

During the late luteal phase (days 21-28) of the menstrual cycle, if fertilization does not occur, the corpus luteum degenerates into the corpus albicans. This causes estrogen and progesterone levels to drop, which triggers menstruation as the endometrial lining breaks down and is shed.

33. Correct Answer: A (Small intestine)

The small intestine, particularly the jejunum and ileum, is the primary site of nutrient absorption in the digestive system. Its large surface area (increased by villi and microvilli) and specialized transport mechanisms allow efficient absorption of carbohydrates, proteins, fats, vitamins, and minerals. The stomach primarily digests, and the large intestine absorbs mainly water.

34. Correct Answer: D (Translation or mRNA stability)

RNA interference (RNAi) regulates gene expression at the post-transcriptional level by affecting translation or mRNA stability. Small interfering RNAs (siRNAs) and microRNAs (miRNAs) bind to complementary mRNA sequences, either blocking translation or marking the mRNA for degradation, effectively silencing gene expression without affecting DNA.

35. Correct Answer: C (Fovea centralis)

The fovea centralis, a small depression in the center of the macula of the retina, is the point of sharpest vision. It contains the highest concentration of cone photoreceptors and lacks rod cells and blood vessels, allowing for maximum visual acuity and color discrimination. This is why we direct our gaze to focus objects on the fovea.

36. Correct Answer: B (Unwind DNA double helix)

Helicase is the enzyme that unwinds the DNA double helix during replication by breaking the hydrogen bonds between complementary base pairs. This creates two single-stranded DNA templates that can be copied. DNA polymerase adds nucleotides, ligase joins fragments, and proofreading is done by DNA polymerase's 3' to 5' exonuclease activity.

37. Correct Answer: D (Bone marrow)

Red blood cells (erythrocytes) are produced in red bone marrow through a process called erythropoiesis, stimulated by the hormone erythropoietin (EPO) from the kidneys. Red bone marrow is found in flat bones (skull, ribs, sternum, pelvis) and the ends of long bones. The spleen and liver produce blood cells during fetal development.

38. Correct Answer: A (H-zone)

The M-line in a sarcomere is located in the center of the H-zone, which itself is in the middle of the A-band. The M-line contains proteins that hold the thick (myosin) filaments in place. During contraction, the H-zone (containing only thick filaments) shortens as thin filaments slide inward.

39. Correct Answer: C (Kidneys)

Erythropoietin (EPO) is produced primarily by the kidneys (about 90%) in response to hypoxia (low oxygen levels). EPO stimulates red bone marrow to increase production of red blood cells, thereby increasing oxygen-carrying capacity. A small amount (10%) is produced by the liver. This is why kidney disease often causes anemia.

40. Correct Answer: B (0.42)

In Hardy-Weinberg equilibrium, if $p = 0.7$, then $q = 1 - 0.7 = 0.3$. The frequency of heterozygotes is $2pq = 2(0.7)(0.3) = 0.42$ or 42%. The genotype frequencies are: homozygous dominant (p^2) = 0.49, heterozygous ($2pq$) = 0.42, homozygous recessive (q^2) = 0.09.

GENERAL CHEMISTRY (Questions 41-70)

41. Correct Answer: D ($1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$)

Sulfur has atomic number 16, meaning it has 16 electrons. Following the Aufbau principle: $1s^2$ (2 electrons), $2s^2$ (2), $2p^6$ (6), $3s^2$ (2), $3p^4$ (4), totaling 16 electrons. Sulfur is in Group 16 with 6 valence electrons ($3s^2\ 3p^4$).

42. Correct Answer: A (Electrons occupy orbitals singly before pairing)

Hund's rule states that electrons occupy degenerate (equal-energy) orbitals singly with parallel spins before pairing up. This minimizes electron-electron repulsion and results in maximum spin multiplicity, which is more stable. For example, the three p orbitals each receive one electron before any receives a second.

43. Correct Answer: C (5)

With $[H^+] = 1 \times 10^{-5}$ M, the pH is calculated as: $pH = -\log[H^+] = -\log(10^{-5}) = 5$. This represents a weakly acidic solution (pH < 7).

44. Correct Answer: D (H_2O)

Water (H_2O) has the lowest vapor pressure at room temperature among these substances due to strong hydrogen bonding between molecules. These intermolecular forces hold molecules in the liquid phase,

reducing their tendency to evaporate. CH_4 and H_2 are gases at room temperature with very high vapor pressures, and ethanol has higher vapor pressure than water.

45. Correct Answer: A (Oxidized)

In the reaction $2Mg + O_2 \rightarrow 2MgO$, magnesium loses electrons (goes from 0 to +2 oxidation state), so it is oxidized. Oxygen gains electrons (goes from 0 to -2), so it is reduced. Remember: OIL RIG (Oxidation Is Loss, Reduction Is Gain of electrons).

46. Correct Answer: D (32)

The total number of electrons that can occupy an energy level is $2n^2$. For $n = 4$: $2(4^2) = 2(16) = 32$ electrons maximum. These occupy 1 s orbital ($2e^-$), 3 p orbitals ($6e^-$), 5 d orbitals ($10e^-$), and 7 f orbitals ($14e^-$).

47. Correct Answer: B (2)

The azimuthal (angular momentum) quantum number (l) for a d orbital is 2. The values of l range from 0 to n-1: $l = 0$ (s orbital), $l = 1$ (p orbital), $l = 2$ (d orbital), $l = 3$ (f orbital).

48. Correct Answer: C (pH)

A buffer solution resists changes in pH when small amounts of acid or base are added. Buffers consist of a weak acid and its conjugate base (or a weak base and its conjugate acid), which can neutralize added H^+ or OH^- ions, maintaining relatively stable pH.

49. Correct Answer: D (Volume and temperature)

Charles's Law describes the direct relationship between volume and temperature of a gas at constant pressure: $V_1/T_1 = V_2/T_2$ (with temperature in Kelvin). As temperature increases, volume increases proportionally. Boyle's Law relates pressure and volume, and Gay-Lussac's Law relates pressure and temperature.

50. Correct Answer: A (+7)

In $KMnO_4$ (potassium permanganate), potassium has +1 and oxygen has -2. Using the rule that the sum equals 0: $(+1) + Mn + 4(-2) = 0$, which gives $1 + Mn - 8 = 0$, so $Mn = +7$. This is the maximum oxidation state for manganese.

51. Correct Answer: C ($\Delta H > 0$ and $\Delta S > 0$)

For a reaction to be spontaneous at all temperatures, the Gibbs free energy change must always be negative: $\Delta G = \Delta H - T\Delta S < 0$. This requires $\Delta H < 0$ (exothermic) and $\Delta S > 0$ (entropy increases), so that both terms contribute to negative ΔG regardless of temperature. If $\Delta H > 0$ and $\Delta S > 0$, spontaneity depends on temperature (spontaneous only at high T).

52. Correct Answer: B (29.25 g)

Mass is calculated using: mass = moles × molar mass = 0.5 moles × 58.5 g/mol = 29.25 g. This tests the fundamental relationship between moles, mass, and molar mass.

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

Atomic radius generally decreases across a period from left to right due to increasing nuclear charge (more protons) pulling electrons closer to the nucleus while shielding remains relatively constant. Atomic radius increases down a group as additional electron shells are added.

54. Correct Answer: B (Sparingly soluble salts)

The solubility product constant (Ksp) is used for sparingly soluble salts. It represents the equilibrium constant for the dissolution of an ionic solid in water, equal to the product of the ion concentrations each raised to the power of their stoichiometric coefficients in a saturated solution.

55. Correct Answer: C (Always spontaneous)

A reaction with $\Delta H < 0$ (exothermic) and $\Delta S > 0$ (entropy increases) is always spontaneous at all temperatures. Using $\Delta G = \Delta H - T\Delta S$, both terms contribute to negative ΔG: negative ΔH contributes directly, and positive ΔS means $-T\Delta S$ is negative regardless of temperature.

56. Correct Answer: A (0.5 M)

Molarity is calculated as: M = moles/volume (L) = 2 moles/4 L = 0.5 M. Molarity expresses concentration as moles of solute per liter of solution.

57. Correct Answer: D (One sigma and two pi bonds)

A triple bond contains one sigma (σ) bond formed by end-to-end orbital overlap and two pi (π) bonds formed by parallel (side-by-side) p orbital overlap. The sigma bond is along the internuclear axis, while pi bonds have electron density above and below (and in front and behind) the axis. Example: N≡N in nitrogen gas.

58. Correct Answer: B (Weak)

The conjugate base of a strong acid is weak. Strong acids completely dissociate (Ka >> 1), meaning they have little tendency to accept a proton back, so their conjugate bases are very weak. Conversely, weak acids have strong conjugate bases. For example, HCl (strong acid) has Cl⁻ (very weak base).

59. Correct Answer: A (25%)

After two half-lives, the fraction remaining is $(1/2)^2 = 1/4 = 25\%$. After one half-life, 50% remains; after two half-lives, 25% remains; after three half-lives, 12.5% remains.

60. Correct Answer: D (K)

Potassium (K) has the largest atomic radius among these elements. Atomic radius increases down a group (K is in period 4 while others are in period 2-3) and decreases across a period. K is in Group 1 and has the most electron shells among the options.

61. Correct Answer: C (Trigonal pyramidal)

The molecular geometry of NH_3 (ammonia) is trigonal pyramidal. Nitrogen has 4 electron groups (3 bonding pairs with hydrogen and 1 lone pair), giving a tetrahedral electron geometry. However, the molecular geometry considers only atoms, so with one lone pair, the shape is trigonal pyramidal with bond angles of approximately 107°.

62. Correct Answer: B (Anode)

In an electrolytic cell, oxidation occurs at the anode (positive electrode). Unlike galvanic cells where the anode is negative, in electrolytic cells external voltage forces non-spontaneous reactions, making the anode positive. Reduction occurs at the cathode (negative electrode). Remember: AN OX, RED CAT.

63. Correct Answer: D (22.4 L)

At STP (standard temperature and pressure: 0°C and 1 atm), one mole of any ideal gas occupies 22.4 liters. This is the molar volume and is useful for gas stoichiometry calculations.

64. Correct Answer: A (Mass number)

Isobars are atoms of different elements that have the same mass number (total protons + neutrons) but different atomic numbers (different number of protons). Example: ^{14}C and ^{14}N both have mass number 14. Isotopes have the same atomic number but different mass numbers.

65. Correct Answer: A (Depends on initial concentration)

For a zero-order reaction, the half-life depends on initial concentration and is calculated as: $t_{1/2} = [A]_0/(2k)$. As the reaction proceeds and concentration decreases, the half-life also changes. This differs from first-order reactions where half-life is constant and independent of concentration.

66. Correct Answer: C (NH_4^+)

The conjugate acid of NH_3 (ammonia) is NH_4^+ (ammonium ion). When a base accepts a proton (H^+), it forms its conjugate acid: $NH_3 + H^+ \rightarrow NH_4^+$. NH_4^+ can then donate a proton back to reform NH_3.

67. Correct Answer: D (2)

The bond order of O_2 is 2. Using molecular orbital theory, O_2 has 8 bonding electrons and 4 antibonding electrons: bond order = (bonding - antibonding)/2 = (8-4)/2 = 2. This corresponds to a double bond (O=O), explaining oxygen's reactivity and paramagnetism.

68. Correct Answer: B (Doubles)

According to Boyle's Law ($P_1V_1 = P_2V_2$ at constant temperature), pressure and volume are inversely proportional. If the volume is halved ($V_2 = V_1/2$), the pressure must double ($P_2 = 2P_1$) to maintain the equality.

69. Correct Answer: D (+8/3)

In Fe_3O_4 (magnetite), oxygen has -2 oxidation state. For the compound to be neutral: $3(Fe) + 4(-2) = 0$, so $3Fe - 8 = 0$, giving $3Fe = 8$, and $Fe = +8/3 = +2.67$ on average. Actually, Fe_3O_4 contains both Fe^{2+} and Fe^{3+} ions (one Fe^{2+} and two Fe^{3+}), giving an average of +8/3.

70. Correct Answer: A (Viscosity)

Viscosity is NOT a colligative property. Colligative properties depend only on the number of solute particles, not their identity: boiling point elevation, freezing point depression, vapor pressure lowering, and osmotic pressure. Viscosity depends on the nature and size of molecules, not just their number.

ORGANIC CHEMISTRY (Questions 71-100)

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

Alkenes have the general formula C_nH_{2n}, the same as cycloalkanes. The carbon-carbon double bond "costs" the molecule two hydrogens compared to alkanes (C_nH_{2n+2}). For example, ethene is C_2H_4 and propene is C_3H_6. Alkynes have formula C_nH_{2n-2}.

72. Correct Answer: B (-OH)

The functional group of an alcohol is -OH (hydroxyl group) bonded to a saturated carbon. -CHO is an aldehyde, -COOH is a carboxylic acid, and $-NH_2$ is an amine. Examples of alcohols include methanol (CH_3OH) and ethanol (C_2H_5OH).

73. Correct Answer: A (Butane)

The IUPAC name for $CH_3CH_2CH_2CH_3$ is butane. The molecule has 4 carbon atoms in a continuous chain (but- prefix) with all single bonds (alkane -ane suffix), and no substituents.

74. Correct Answer: C (Non-superimposable mirror images)

Enantiomers are stereoisomers that are non-superimposable mirror images of each other, like left and right hands. They have identical physical properties except for rotating plane-polarized light in opposite directions. Constitutional isomers have different connectivity, conformers are rotational variations, and geometric isomers involve cis/trans configurations.

75. Correct Answer: B (Alcohol)

Hydration of an alkene (addition of water across the double bond) produces an alcohol. The reaction typically requires acid catalyst: $R-CH=CH_2 + H_2O \rightarrow R-CH(OH)-CH_3$. Markovnikov's rule predicts that the -OH group attaches to the more substituted carbon.

76. Correct Answer: A (Aldehyde)

Aldehydes are the most easily reduced carbonyl compounds among the options. They can be reduced to primary alcohols using mild reducing agents like $NaBH_4$ or $LiAlH_4$. Ketones are also easily reduced to secondary alcohols. Esters and amides require stronger reducing agents like $LiAlH_4$. Carboxylic acids are harder to reduce.

77. Correct Answer: D (Aldehydes)

Tollens' test (silver mirror test) is positive for aldehydes (and some reducing sugars). The aldehyde is oxidized to a carboxylic acid while silver ions (Ag^+) in the reagent are reduced to metallic silver (Ag^0), which deposits as a silver mirror on the test tube. Ketones (except α-hydroxy ketones) do not react.

78. Correct Answer: B (sp²)

The hybridization of the carbon atoms in ethene (C_2H_4) is sp^2. Each carbon forms three sigma bonds (two C-H and one C-C) requiring three hybrid orbitals, resulting in sp^2 hybridization. The unhybridized p orbital on each carbon forms the pi bond of the C=C double bond. The molecule is planar with 120° bond angles.

79. Correct Answer: C (Markovnikov's rule)

Addition of HCl to 2-methylpropene follows Markovnikov's rule: the hydrogen adds to the carbon with more hydrogens (less substituted), and the halogen adds to the carbon with fewer hydrogens (more substituted). This occurs because the mechanism proceeds through the more stable carbocation (tertiary > secondary > primary).

80. Correct Answer: B (6 π electrons)

Benzene is aromatic because it has 6 π electrons in a cyclic, planar, fully conjugated system, fitting Hückel's rule ($4n+2$ π electrons, where $n=1$). The six π electrons are delocalized over all six carbon atoms, providing exceptional stability (aromatic stabilization energy of about 36 kcal/mol).

81. Correct Answer: D (SN2)

Primary substrates favor the SN2 mechanism because they have minimal steric hindrance, allowing the nucleophile to approach the backside of the carbon-halogen bond. The reaction occurs in one concerted step with simultaneous bond formation and bond breaking, resulting in inversion of configuration. Tertiary substrates favor SN1.

82. Correct Answer: A (The carboxylate anion is resonance-stabilized)

Carboxylic acids are more acidic than alcohols because the carboxylate anion (conjugate base) is stabilized by resonance delocalization of the negative charge over two oxygen atoms. Alcohols' alkoxide ions have the negative charge localized on one oxygen, providing less stability. More stable conjugate base = stronger acid.

83. Correct Answer: D (Aldehydes or ketones)

The aldol condensation reaction involves aldehydes or ketones with α-hydrogens reacting under base or acid catalysis. An enolate ion from one carbonyl compound attacks another carbonyl compound, forming a β-hydroxy carbonyl compound (aldol product). Subsequent dehydration often produces an α,β-unsaturated carbonyl compound.

84. Correct Answer: A (Carbocation formation)

The rate-determining step in E1 (elimination, unimolecular) reactions is carbocation formation through loss of the leaving group. This is the slow step that determines the overall reaction rate. After carbocation formation, rapid loss of a β-proton occurs to form the alkene. E1 follows first-order kinetics depending only on substrate concentration.

85. Correct Answer: C (CH_3COOH)

Among the options, CH_3COOH (acetic acid) is the most acidic hydrogen-containing compound because it's a carboxylic acid with a resonance-stabilized conjugate base. Carboxylic acids (pKa ≈ 4-5) are much more acidic than water (pKa = 15.7) or hydrocarbons like CH_4 and C_2H_6 (pKa ≈ 50).

86. Correct Answer: A (Soap and glycerol)

Saponification is the base-catalyzed hydrolysis of esters (specifically fats and oils, which are triglycerides) producing soap (fatty acid salts) and glycerol (glycerin). The reaction uses strong base (NaOH or KOH): Fat + 3NaOH → 3Soap + Glycerol. This is how traditional soap is made.

87. Correct Answer: D (Achiral)

A compound that is superimposable on its mirror image is achiral (not chiral). Achiral molecules have a plane of symmetry or other symmetry element that makes them identical to their mirror images. They do not rotate plane-polarized light. Chiral molecules are non-superimposable on their mirror images and are optically active.

88. Correct Answer: C (Lewis acid catalyst)

The Friedel-Crafts alkylation reaction requires a Lewis acid catalyst, typically $AlCl_3$, $FeBr_3$, or BF_3. The Lewis acid coordinates with the alkyl halide, making the carbon more electrophilic for attack by the aromatic ring. The reaction adds an alkyl group to an aromatic ring.

89. Correct Answer: B (Tertiary)

Tertiary alkyl halides undergo SN1 reactions most rapidly because they form the most stable carbocations (tertiary > secondary > primary > methyl). The stability comes from hyperconjugation and inductive effects from the three alkyl groups. Methyl halides can only undergo SN2.

90. Correct Answer: A (Carboxylic acids after workup)

Grignard reagents react with CO_2 to form carboxylic acids after aqueous acid workup. The Grignard (R-MgX) attacks CO_2 forming a carboxylate salt (R-COO$^-$MgX$^+$), which upon acidification produces the carboxylic acid (R-COOH). This is a useful method for adding one carbon to form a carboxylic acid.

91. Correct Answer: D (Absolute configuration of sugars)

The D/L system is used for describing the absolute configuration of sugars (and amino acids). It's based on the configuration of glyceraldehyde: D-sugars have the -OH on the highest-numbered chiral center (farthest from the carbonyl) on the right in Fischer projection, while L-sugars have it on the left. This differs from the R/S system.

92. Correct Answer: C (Primary amines)

The Gabriel synthesis produces primary amines from alkyl halides using phthalimide. The phthalimide nitrogen acts as a nucleophile to displace the halide, and subsequent hydrolysis releases the primary amine. This method avoids the over-alkylation problem of direct alkylation of ammonia.

93. Correct Answer: B (Equal amounts of both enantiomers)

A racemic mixture (or racemate) contains equal amounts (50:50 ratio) of both enantiomers of a chiral compound. Because the enantiomers rotate plane-polarized light in opposite directions by equal amounts, a racemic mixture shows no net optical rotation (optically inactive) despite containing chiral molecules.

94. Correct Answer: D (NaBH₄)

NaBH$_4$ (sodium borohydride) is selective for aldehydes and ketones, reducing them to alcohols without affecting other functional groups like esters, carboxylic acids, or amides. It's a milder reducing agent than LiAlH$_4$, which reduces almost all carbonyl compounds including esters and carboxylic acids. H$_2$/Pt reduces C=C bonds, and KMnO$_4$ is an oxidizing agent.

95. Correct Answer: C (Ketone)

Oxidation of a secondary alcohol produces a ketone. Secondary alcohols have the -OH group on a carbon bonded to two other carbons. Mild oxidizing agents like chromic acid, PCC, or Swern oxidation convert R$_2$CHOH → R$_2$C=O. Primary alcohols oxidize to aldehydes then carboxylic acids, while tertiary alcohols generally resist oxidation.

96. Correct Answer: C (Ortho/para-directing and activating)

Activating groups on benzene (like -OH, -NH$_2$, -OCH$_3$, alkyl groups) are ortho/para-directing and increase the rate of electrophilic aromatic substitution. They donate electron density to the ring through resonance or inductive effects, making positions ortho and para to the substituent more reactive. Deactivating groups are typically meta-directing.

97. Correct Answer: B (More substituted alkene)

The Zaitsev (Saytzeff) rule predicts that elimination reactions produce predominantly the more substituted (more stable) alkene as the major product. More substituted alkenes are thermodynamically more stable due to hyperconjugation. Hofmann elimination is the exception, producing the less substituted alkene.

98. Correct Answer: A (Saponification)

Ester hydrolysis in base is called saponification. The base attacks the carbonyl carbon, and the reaction produces a carboxylate salt and an alcohol: RCOOR' + NaOH → RCOONa + R'OH. This is irreversible because the carboxylate anion doesn't react with alcohols. Acid-catalyzed ester hydrolysis is reversible.

99. Correct Answer: D (IR spectroscopy)

IR (infrared) spectroscopy is most useful for determining functional groups. Different functional groups have characteristic absorption frequencies: O-H stretch (3200-3600 cm^{-1}), C=O stretch (1650-1750 cm^{-1}), C-H stretch (2800-3000 cm^{-1}), etc. NMR determines carbon skeleton and environment, while mass spectrometry determines molecular weight.

100. Correct Answer: C (Number of chemically distinct hydrogen environments)

In ^{1}H NMR spectroscopy, the number of signals (peaks) indicates the number of chemically distinct (non-equivalent) hydrogen environments in the molecule. Hydrogens in the same environment (equivalent by symmetry) produce one signal. Integration tells how many hydrogens are in each environment, and splitting patterns show neighboring hydrogens.

Perceptual Ability Test

ANGLE DISCRIMINATION (Questions 1-15)

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

The angles in order from smallest to largest are: Angle 4 (35°) < Angle 2 (43°) < Angle 1 (58°) < Angle 3 (71°). This gives the sequence 4-2-1-3, correctly ranking all four angles from smallest to largest based on their degree measurements.

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

The angles rank as: Angle Q (54°) < Angle P (67°) < Angle S (75°) < Angle R (82°). The sequence Q-P-S-R correctly orders these angles from smallest to largest.

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

The angles in order are: Angle 1 (21°) < Angle 4 (27°) < Angle 3 (38°) < Angle 2 (49°). This ranking correctly sequences the four angles from smallest to largest.

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

The angles rank as: Angle B (62°) < Angle D (71°) < Angle C (79°) < Angle A (88°). The sequence B-D-C-A correctly orders these angles from smallest to largest.

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

Angle W = 78.75° (seven-eighths of 90°), Angle X = 64°, Angle Y = 51°, Angle Z = 86°. Ordering from smallest to largest: Y (51°) < X (64°) < W (78.75°) < Z (86°). The sequence Y-X-W-Z is the correct ascending order.

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

The angles rank as: Angle 1 (17°) < Angle 4 (25°) < Angle 3 (32°) < Angle 2 (45°). This sequence correctly orders the angles from smallest to largest.

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

The angles in order are: Angle O (56°) < Angle M (69°) < Angle P (73°) < Angle N (84°). The sequence O-M-P-N correctly ranks these angles.

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

The angles rank as: Angle 1 (12°) < Angle 3 (34°) < Angle 2 (41°) < Angle 4 (50°). This sequence correctly orders the angles from smallest to largest.

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

The angles in order are: Angle C (36°) < Angle A (47°) < Angle B (59°) < Angle D (68°). The sequence C-A-B-D correctly ranks these angles.

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

The angles rank as: Angle 2 (61°) < Angle 4 (70°) < Angle 1 (76°) < Angle 3 (83°). This sequence correctly orders the angles from smallest to largest.

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

The angles in order are: Angle W (28°) < Angle Y (39°) < Angle Z (46°) < Angle X (52°). The sequence W-Y-Z-X correctly ranks these angles from smallest to largest.

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

The angles rank as: Angle 1 (22°) < Angle 3 (29°) < Angle 2 (35°) < Angle 4 (48°). This sequence correctly orders all four angles from smallest to largest.

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

The angles in order are: Angle Q (44°) < Angle S (55°) < Angle P (63°) < Angle R (91°). The sequence Q-S-P-R correctly ranks these angles.

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

The angles rank as: Angle 1 (19°) < Angle 3 (37°) < Angle 2 (42°) < Angle 4 (53°). This sequence correctly orders the angles from smallest to largest.

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

The angles in order are: Angle D (66°) < Angle B (72°) < Angle A (81°) < Angle C (90°). The sequence D-B-A-C correctly ranks these angles from smallest to largest.

PAPER FOLDING (Questions 16-30)

16. Correct Answer: A (2)

When paper is folded in half once (creating 2 layers) and one hole is punched through both layers, unfolding reveals 1 × 2 = 2 total holes positioned symmetrically across the fold line.

17. Correct Answer: D (24)

Three folds create 8 layers ($2^3 = 8$). Punching 3 holes through all 8 layers produces 3 × 8 = 24 total holes when unfolded.

18. Correct Answer: B (16)

Two folds create 4 layers ($2^2 = 4$). Punching 4 holes through all 4 layers produces 4 × 4 = 16 total holes when unfolded.

19. Correct Answer: A (6)

One fold creates 2 layers. Punching 3 holes through both layers produces 3 × 2 = 6 total holes when unfolded.

20. Correct Answer: C (12)

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

21. Correct Answer: D (2)

When paper is folded diagonally and two holes are punched exactly on the diagonal fold line, both layers are punched at the same two locations. Unfolding reveals 2 holes on the diagonal.

22. Correct Answer: B (16)

Three folds create 8 layers ($2^3 = 8$). Two punches through all 8 layers produce 2 × 8 = 16 holes when completely unfolded, arranged in a symmetric pattern.

23. Correct Answer: C (8)

One fold creates 2 layers. Punching 4 holes through both layers produces 4 × 2 = 8 total holes when unfolded.

24. Correct Answer: A (1)

When a hole is punched exactly at the fold line of paper folded once, both layers are punched at the same location. When unfolded, this appears as a single hole positioned on what was the fold line.

25. Correct Answer: D (20)

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

26. Correct Answer: B (6)

A diagonal fold creates 2 layers. Punching 3 holes away from the fold produces 3 × 2 = 6 holes when unfolded, positioned symmetrically across the diagonal fold line.

27. Correct Answer: A (12)

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

28. Correct Answer: B (4)

Two folds create 4 layers. Punching at the point where both folds meet (the center of the original paper) produces 4 holes when unfolded, clustered near the center in a symmetric pattern.

29. Correct Answer: C (8)

Two folds create 4 layers. Two punches through all 4 layers produce 2 × 4 = 8 holes when unfolded.

30. Correct Answer: A (16)

One fold creates 2 layers. Punching 8 holes through both layers produces 8 × 2 = 16 total holes when unfolded.

CUBE COUNTING (Questions 31-45)

31. Correct Answer: D (96)

Face cubes (1 face exposed) in a 6×6×6 cube: $2[(a-2)(b-2) + (b-2)(c-2) + (a-2)(c-2)] = 2[(4)(4) + (4)(4) + (4)(4)] = 2[16+16+16] = 2(48) = 96$ face cubes.

32. Correct Answer: A (8)

Any cube or rectangular prism has exactly 8 corners. A 7×7×7 cube has 8 corner cubes where 3 faces meet, giving 8 cubes with exactly 3 faces exposed.

33. Correct Answer: D (60)

A 3×5×4 rectangular prism contains 3×5×4 = 60 total unit cubes.

34. Correct Answer: C (2)

In a straight line of 15 cubes, the 2 end cubes each have 5 faces exposed (all faces except the one touching the adjacent cube). The 13 middle cubes each have 4 faces exposed.

35. Correct Answer: A (64)

Interior cubes (0 faces exposed) formula: (a-2)(b-2)(c-2) = (6-2)(6-2)(6-2) = 4 × 4 × 4 = 64 completely interior cubes in a 6×6×6 cube.

36. Correct Answer: B (8)

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

37. Correct Answer: D (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.

38. Correct Answer: C (60)

A 5×3×4 rectangular prism contains 5×3×4 = 60 total unit cubes.

39. Correct Answer: B (208)

A 6×6×6 cube contains 6×6×6 = 216 total unit cubes. Every cube has exactly 8 corner cubes. Therefore, cubes that are NOT corner cubes = 216 - 8 = 208 cubes.

40. Correct Answer: A (42)

A 5×5×2 rectangular prism contains 5×5×2 = 50 total unit cubes. Every rectangular prism has exactly 8 corner cubes. Therefore, cubes that are NOT corner cubes = 50 - 8 = 42 cubes.

41. Correct Answer: C (12)

In a pyramid structure with the given configuration (36+25+16+9+4+1 = 91 total), analyzing the exposed faces shows that approximately 12 cubes have exactly 3 faces exposed at various corner and edge positions of the pyramid structure.

42. Correct Answer: D (28)

Edge cubes in a 4×4×5 prism: 4[(a-2) + (b-2) + (c-2)] = 4[(4-2) + (4-2) + (5-2)] = 4[2+2+3] = 4(7) = 28 cubes with exactly 2 faces exposed.

43. Correct Answer: A (4)

In an L-shaped structure with 14 total cubes (9 in a row + 5 stacked on one end), analyzing the configuration shows approximately 4 cubes have exactly 3 exposed faces at corner-like positions of the L-shape.

44. Correct Answer: D (128)

An 8×8×2 rectangular prism contains 8×8×2 = 128 total cubes. Since one dimension is only 2 (meaning 2-2 = 0), there are no completely interior cubes. All 128 cubes have at least one face exposed.

45. Correct Answer: B (36)

Edge cubes (2 faces exposed) in a 5×5×5 cube: 4[(a-2) + (b-2) + (c-2)] = 4[(5-2) + (5-2) + (5-2)] = 4[3+3+3] = 4(9) = 36 edge cubes.

PATTERN FOLDING (Questions 46-60)

46. Correct Answer: A (Open-top cube)

Four squares in a row can form an open-top cube with one square as bottom and three forming three sides, leaving two sides and the top open. A complete cube requires 6 squares.

47. Correct Answer: C (Heptagonal pyramid)

A heptagon base with 7 triangles (one on each edge) folds into a heptagonal pyramid. The triangles meet at an apex above the heptagonal base.

48. Correct Answer: D (Cube)

Six squares in a plus/cross pattern (one center, four around it, one opposite) is a standard net for a complete cube. When folded properly, all six faces close to form a cube.

49. Correct Answer: B (Hexagonal prism)

Two hexagonal faces (the ends) and 6 rectangular faces (wrapping around) form a hexagonal prism when folded. This is the standard net for a prism with hexagonal cross-section.

50. Correct Answer: C (Partial pyramid - missing two faces)

With only 2 triangles attached to a square base, this forms an incomplete pyramid missing two triangular faces. A complete square pyramid requires 4 triangular faces plus the base.

51. Correct Answer: A (Partial cube / open box)

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

52. Correct Answer: D (Tetrahedron)

Four equilateral triangles arranged properly fold into a tetrahedron (triangular pyramid) with 4 triangular faces total, forming a regular polyhedron.

53. Correct Answer: B (Triangular prism)

Two triangular faces (the ends) and 3 rectangular faces (wrapping around) form a triangular prism when folded. This is the standard net for a prism with triangular cross-section.

54. Correct Answer: A (Open rectangular prism)

Five rectangles arranged to form a closed shape (missing top and bottom) create an open rectangular prism when folded, with rectangular sides but no top or bottom faces.

55. Correct Answer: C (Nonagonal prism)

A nonagon (9-sided polygon) with 9 rectangles connecting around its edges forms a nonagonal prism. The rectangles wrap around to form the sides, creating a prism with nonagonal cross-section.

56. Correct Answer: D (Pentagonal pyramid)

A net with 1 pentagon and 5 triangles attached to the pentagon's edges folds into a pentagonal pyramid. The pentagon forms the base, and the five triangles fold upward to meet at a common apex.

57. Correct Answer: B (Cube or open box)

Six squares in a T-shape arrangement can fold into either a cube (if properly arranged) or an open box structure depending on the exact configuration of the T-shape.

58. Correct Answer: C (Rectangular prism)

Two rectangles and 2 squares arranged in a strip can form a rectangular prism when additional faces are included or when the squares and rectangles form the sides of a box-like structure.

59. Correct Answer: D (Partial open box)

Three squares in a row can form a partial open box structure with one square forming the bottom and two forming two adjacent sides, leaving most faces open. A complete cube requires 6 squares.

60. Correct Answer: A (Hexagonal prism)

A hexagon with 6 rectangles arranged around it forms a hexagonal prism. The rectangles wrap around the hexagon to form the sides, with another hexagon completing the other end.

APERTURES / KEYHOLES (Questions 61-75)

61. Correct Answer: C (Square or Rectangle)

A square prism can pass through a square aperture (when oriented to show a square face) or a rectangular aperture (when oriented to show a rectangular side). Both aperture shapes work depending on orientation.

62. Correct Answer: B (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.

63. Correct Answer: B (Square)

A sphere viewed from any angle appears as a circle. Therefore, a square aperture would NOT work for a sphere as the sphere cannot produce a square silhouette from any orientation.

64. Correct Answer: C (Hexagon or Rectangle)

A hexagonal prism shows hexagonal silhouettes from the ends and rectangular silhouettes from the sides. Both aperture shapes are possible.

65. Correct Answer: D (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.

66. Correct Answer: D (Triangle)

A cylinder can show circle (end view) or rectangle (side view) silhouettes, but cannot produce a triangular silhouette regardless of orientation. Triangle would NOT work.

67. Correct Answer: A (Octagon or Triangle)

An octagonal pyramid shows an octagonal silhouette when viewed from the base and triangular silhouettes when viewed from the sides. Both aperture shapes are possible.

68. Correct Answer: C (Pentagon or Rectangle)

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

69. Correct Answer: B (Triangle)

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

70. Correct Answer: A (Hexagonal prism)

A hexagonal prism can pass through a hexagonal aperture when oriented to show its hexagonal end face. The prism's geometry allows this orientation.

71. Correct Answer: D (Triangle or Square)

An octahedron (8 triangular faces) can show triangular silhouettes from most angles and square silhouettes when viewed along certain axes. Both aperture shapes are possible.

72. Correct Answer: C (Circle or Triangle)

A cone shows a circular silhouette when viewed from the base and a triangular silhouette when viewed from the side. Both aperture shapes are possible depending on orientation.

73. Correct Answer: A (Square)

A cube can produce square silhouettes from face-on views, but a sphere can only produce circular silhouettes. A square aperture works for the cube but NOT for the sphere.

74. Correct Answer: B (Circle)

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

75. Correct Answer: D (Triangular prism)

A triangular prism can pass through both a triangle aperture (when oriented to show the triangular 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 (Rectangular prism)

A square top view with rectangular front and side views identifies a rectangular prism where the top is square but the height creates rectangular views from the sides.

77. Correct Answer: C (Cone)

A cone has a triangular front view (showing the slant from base to apex), circular top view (looking down at the circular base), and circular side view. This combination identifies a cone.

78. Correct Answer: B (Square)

Viewing a cube from the top shows a square (one face directly). The top view of a cube is a square matching the face dimensions.

79. Correct Answer: D (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 length.

80. Correct Answer: C (Triangle)

A cone viewed from the side shows a triangular silhouette with the apex at the top and the base forming the bottom of the triangle.

81. Correct Answer: A (Hexagonal pyramid)

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

82. Correct Answer: D (Cube)

All three views (top, front, side) showing identical squares indicates a cube. Only a cube has this property where all faces are identical squares and all three orthogonal views are the same.

83. Correct Answer: B (Rectangle)

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

84. Correct Answer: C (Triangular prism)

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

85. Correct Answer: A (Sphere)

A sphere viewed from any angle (top, front, side) always appears as identical circles because it's perfectly round in all directions. Only a sphere has this property.

86. Correct Answer: A (Square)

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

87. Correct Answer: B (Circle)

A cylinder viewed from the end (along its axis) shows a circular silhouette representing the circular cross-section.

88. Correct Answer: D (Rectangular prism)

A rectangular top view, rectangular front view, and square side view indicate a rectangular prism where two dimensions are equal (making the square side view) and one dimension is different.

89. Correct Answer: A (Octagon)

An octagonal pyramid viewed from directly above shows an octagon (the base). The apex is at the center, but the outline viewed from above is octagonal.

90. Correct Answer: C (T-shaped block structure)

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

Reading Comprehension

PASSAGE I - Antibiotic Resistance (Questions 1-17)

1. Correct Answer: D (Return us to the pre-antibiotic era)

The passage states "antibiotic resistance now threatens to return us to the pre-antibiotic era." This directly indicates that resistance threatens to eliminate the benefits antibiotics have provided, potentially making previously treatable infections fatal again.

2. Correct Answer: B (Horizontal gene transfer)

The passage notes "Bacteria evolve resistance through random mutations or acquiring resistance genes from other bacteria via horizontal gene transfer." Horizontal gene transfer is the specific mechanism by which bacteria share resistance genes with each other.

3. Correct Answer: C (Breaking down penicillin-based drugs)

The passage states "Some bacteria produce enzymes that destroy antibiotics—beta-lactamases break down penicillin-based drugs." This describes the specific function of beta-lactamases.

4. Correct Answer: D (Actively expelling antibiotics from cells)

The passage explains "Efflux pumps actively expel antibiotics from bacterial cells before they can act." This describes how efflux pumps remove antibiotics from inside the bacteria.

5. Correct Answer: A (Possess multiple resistance mechanisms)

The passage notes "bacteria can possess multiple resistance mechanisms simultaneously, creating 'superbugs' resistant to numerous drugs." The key defining characteristic is having multiple resistance mechanisms.

6. Correct Answer: C (Provide no benefit)

The passage states "antibiotics are often prescribed for viral infections where they provide no benefit." Antibiotics only work against bacteria, not viruses.

7. Correct Answer: B (Resistant bacteria to survive)

The passage explains "Patients frequently discontinue treatment prematurely when symptoms improve, allowing resistant bacteria to survive and multiply." Early discontinuation leaves resistant bacteria alive.

8. Correct Answer: A (Over 70%)

The passage specifically states "over 70% of medically important antibiotics in some countries are used in livestock." This statistic highlights the agricultural contribution to resistance.

9. Correct Answer: D (Growth promotion)

The passage notes antibiotics in livestock are used "for growth promotion rather than treating disease." This non-therapeutic use contributes significantly to resistance development.

10. Correct Answer: B (Appropriate prescribing)

The passage states "Antibiotic stewardship programs ensure appropriate prescribing—using the right drug at the right dose for the right duration." This defines the purpose of stewardship.

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

The passage notes "Rapid diagnostic tests help distinguish bacterial from viral infections." This distinction is crucial for appropriate antibiotic use.

12. Correct Answer: A (Companies find limited profitability)

The passage explains "Developing new antibiotics is crucial but economically challenging, as pharmaceutical companies find limited profitability in drugs used briefly." Short treatment courses limit revenue.

13. Correct Answer: D (Viruses that infect bacteria)

The passage states "Alternative approaches include bacteriophage therapy using viruses that infect bacteria." Bacteriophages are viruses that specifically target bacteria.

14. Correct Answer: C (Disable bacterial virulence without killing them)

The passage mentions "drugs that disable bacterial virulence without killing them, potentially reducing selection for resistance." This approach avoids creating selective pressure.

15. Correct Answer: B (Overuse and misuse)

The passage states "Overuse and misuse of antibiotics accelerate this process by creating selective pressure favoring resistant strains." This is identified as the primary cause.

16. Correct Answer: A (Prevent antibiotic binding)

The passage notes "Others modify drug targets so antibiotics cannot bind effectively." Modifying targets prevents antibiotics from attaching and working.

17. Correct Answer: D (Food or environmental contamination)

The passage states resistant bacteria "can transfer to humans through food or environmental contamination." This describes the transmission route from agriculture to humans.

PASSAGE II - Ocean Acidification (Questions 18-34)

18. Correct Answer: C (30%)

The passage states "The ocean absorbs approximately 30% of atmospheric CO_2." This specific percentage is provided in the passage.

19. Correct Answer: B (8.1)

The passage notes "Since pre-industrial times, ocean pH has dropped from approximately 8.2 to 8.1." The current pH level is 8.1.

20. Correct Answer: D (30%)

The passage states the pH drop is "representing a 30% increase in acidity due to the logarithmic pH scale." This specific percentage increase is mentioned.

21. Correct Answer: A (7.8)

The passage notes "Projections suggest pH could reach 7.8 by 2100 under high-emission scenarios." This is the projected future pH level.

22. Correct Answer: C (Carbonate ions)

The passage explains "Calcifying organisms—corals, mollusks, and some plankton—struggle to build calcium carbonate shells and skeletons as acidification reduces available carbonate ions." Carbonate ion reduction is the key problem.

23. Correct Answer: D (Feed salmon and other fish)

The passage states "Pteropods, small swimming snails that feed salmon and other fish." This describes their ecological importance.

24. Correct Answer: B (Dissolution)

The passage notes pteropods "show shell dissolution in acidified waters." Their shells literally dissolve in more acidic conditions.

25. Correct Answer: C (Neurotransmitter function)

The passage states "studies show some species lose their ability to detect predators or find suitable habitat, possibly due to interference with neurotransmitter function." This is the suspected mechanism.

26. Correct Answer: A (Acidification and warming)

The passage notes "Coral reefs face double threats from acidification and warming." Both stressors affect coral reefs simultaneously.

27. Correct Answer: D (Fisheries supporting hundreds of millions)

The passage states "Their degradation threatens fisheries supporting hundreds of millions of people." This describes the human impact of reef loss.

28. Correct Answer: C (Acidified upwelling waters)

The passage notes "The Pacific Northwest oyster industry has suffered production losses linked to acidified upwelling waters." This specific cause is identified.

29. Correct Answer: B (More vulnerable)

The passage states "Early life stages of many marine species prove more vulnerable than adults." Young organisms are more susceptible to acidification.

30. Correct Answer: A (Reducing CO₂ emissions)

The passage states "Addressing ocean acidification ultimately requires reducing CO_2 emissions, as no technological solution can reverse acidification at ocean-wide scales." Emissions reduction is the fundamental solution.

31. Correct Answer: D (Centuries)

The passage notes "Even with aggressive emissions reductions, oceans will remain more acidic than pre-industrial levels for centuries." The long-term persistence is emphasized.

32. Correct Answer: C (Long residence time of CO₂ in ocean-atmosphere system)

The passage explains the centuries-long persistence is "due to the long residence time of CO_2 in the ocean-atmosphere system." This explains why recovery is so slow.

33. Correct Answer: B (Protecting coastal ecosystems that absorb CO₂)

The passage mentions "Local interventions like protecting coastal ecosystems that absorb CO_2" as a helpful measure. These ecosystems can help locally.

34. Correct Answer: D (Develop resistant organisms)

The passage states "Research into selective breeding of resistant organisms or assisted evolution shows promise." The goal is to create more resistant species.

PASSAGE III - Blood-Brain Barrier (Questions 35-50)

35. Correct Answer: A (Controlling substance entry from bloodstream to brain)

The passage states "The blood-brain barrier (BBB) protects the brain by strictly controlling substance entry from bloodstream to brain tissue." This is the BBB's primary function.

36. Correct Answer: C (Tight junctions between endothelial cells)

The passage notes "brain capillaries have endothelial cells joined by tight junctions, creating a continuous barrier." Tight junctions are the key structural difference.

37. Correct Answer: B (Essential nutrients like glucose and oxygen)

The passage states "The BBB allows essential nutrients like glucose and oxygen to pass while blocking most drugs, toxins, and pathogens." Nutrients can cross but most other substances cannot.

38. Correct Answer: A (Move glucose across the BBB)

The passage notes "Glucose enters via GLUT1 transporters." GLUT1 specifically transports glucose across the barrier.

39. Correct Answer: D (Efflux pump)

The passage states "The BBB actively expels many substances using efflux pumps like P-glycoprotein." P-glycoprotein is an example of an efflux pump.

40. Correct Answer: C (Most drugs cannot cross)

The passage explains "This protection poses challenges for treating brain diseases—many potentially therapeutic drugs cannot reach therapeutic concentrations in brain tissue." The barrier blocks drug entry.

41. Correct Answer: B (Detect blood-borne toxins and trigger vomiting)

The passage notes "Circumventricular organs like the area postrema (vomiting center) detect blood-borne toxins to trigger protective responses." This explains why this region lacks complete BBB.

42. Correct Answer: D (Allow hormone-bloodstream exchange)

The passage states "The median eminence allows hormones to enter the bloodstream." This brain-body communication requires lack of complete BBB.

43. Correct Answer: A (Immune cells to cross and attack myelin)

The passage notes "In multiple sclerosis, immune cells inappropriately cross the BBB and attack myelin." BBB breakdown allows harmful immune attack.

44. Correct Answer: B (Edema and secondary damage)

The passage states "Traumatic brain injury and stroke can disrupt the barrier, causing edema and secondary damage." BBB disruption leads to these complications.

45. Correct Answer: C (Increased BBB permeability)

The passage notes "Brain tumors may create areas of increased permeability detectable on imaging." Tumors disrupt normal BBB function.

46. Correct Answer: D (Harmful proteins and inflammatory cells)

The passage states "Alzheimer's disease associates with BBB breakdown, potentially allowing harmful proteins and inflammatory cells to enter brain tissue." BBB failure allows damaging substances entry.

47. Correct Answer: A (Designing drugs that can cross the BBB)

The passage notes "Therapeutic strategies include designing drugs that can cross the BBB, temporarily disrupting the barrier to allow drug delivery, or using nanoparticles as carriers." Multiple strategies are mentioned, with drug design being the first.

48. Correct Answer: B (Diffusing through cell membranes)

The passage states "Small lipid-soluble molecules can diffuse directly through cell membranes." This describes passive diffusion for small lipophilic molecules.

49. Correct Answer: C (Enable important brain-body communication)

The passage explains "These specialized regions enable important brain-body communication while the BBB protects most brain tissue." The lack of complete BBB serves a functional purpose.

50. Correct Answer: A (Pathogens)

The passage states "The BBB allows essential nutrients like glucose and oxygen to pass while blocking most drugs, toxins, and pathogens." All three categories (drugs, toxins, pathogens) are blocked.

Quantitative Reasoning

1. Correct Answer: A (113.04 cm²)

The area of a circle is $A = \pi r^2$. With diameter = 12 cm, the radius = 6 cm. Using $\pi \approx 3.14$: $A = 3.14 \times 6^2 = 3.14 \times 36 = 113.04$ cm². This formula calculates the space enclosed by the circle.

2. Correct Answer: C (6)

Solve the equation 6x - 9 = 27 by first adding 9 to both sides: 6x = 27 + 9 = 36. Divide both sides by 6: x = 36/6 = 6. Verify: 6(6) - 9 = 36 - 9 = 27 ✓.

3. Correct Answer: B (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.

4. Correct Answer: A (55°)

In any triangle, the three angles sum to 180°. With angles 52°, 73°, and x°: 52 + 73 + x = 180, so 125 + x = 180, giving x = 55°. This tests the fundamental triangle angle sum property.

5. Correct Answer: B (44 cm)

The perimeter of a rectangle is P = 2(length + width). With length = 15 cm and width = 7 cm: P = 2(15 + 7) = 2(22) = 44 cm. This is a direct application of the rectangle perimeter formula.

6. Correct Answer: D (x < 8)

Solve the inequality 3x + 11 < 35 by subtracting 11 from both sides: 3x < 24. Divide both sides by 3: x < 8. The inequality direction remains the same because we divided by a positive number.

7. Correct Answer: A (224)

Calculate $6^3 + 2^3$: First, $6^3 = 6 \times 6 \times 6 = 216$. Then, $2^3 = 2 \times 2 \times 2 = 8$. Finally, $216 + 8 = 224$. This tests exponent evaluation and addition.

8. Correct Answer: C (200)

If 60% of a number equals 120, set up the equation: $0.60 \times N = 120$. Divide both sides by 0.60: N = 120/0.60 = 200. Alternatively, recognize that if 60% = 120, then 100% = 120 × (100/60) = 200.

9. Correct Answer: D (31.5)

To find the median of an even number of values {15, 22, 28, 35, 40, 47}, take the average of the two middle values (3rd and 4th): (28 + 35)/2 = 63/2 = 31.5. The median divides the dataset in half.

10. Correct Answer: D (50 mph)

Average speed = distance ÷ time = 450 miles ÷ 9 hours = 50 miles per hour. This straightforward calculation tests understanding of the distance-rate-time relationship.

11. Correct Answer: C (2/3)

To subtract fractions with different denominators, find a common denominator. The LCD of 12 and 4 is 12: 1/4 = 3/12. Then 11/12 - 3/12 = 8/12 = 2/3. This tests fraction subtraction with unlike denominators.

12. Correct Answer: B (2)

The slope formula is $m = (y_2 - y_1)/(x_2 - x_1)$. With points (4, 9) and (8, 17): m = (17 - 9)/(8 - 4) = 8/4 = 2. A slope of 2 means the line rises 2 units vertically for every 1 unit horizontally.

13. Correct Answer: D (47)

The absolute value of -35 is 35, and the absolute value of -12 is 12. Therefore, $|-35| + |-12| = 35 + 12 = 47$. Absolute value represents distance from zero, always positive or zero.

14. Correct Answer: A (24)

Solve 18/x = 54/72 by first simplifying the right side: 54/72 = 3/4. So 18/x = 3/4. Cross-multiply: 18 × 4 = 3 × x, giving 72 = 3x, so x = 24. Verify: 18/24 = 3/4 ✓.

15. Correct Answer: C (343 cm³)

The volume of a cube is $V = s^3$ where s is the edge length. With s = 7 cm: $V = 7^3 = 7 \times 7 \times 7 = 343$ cm³. This tests the cube volume formula.

16. Correct Answer: B (x = 17, y = 8)

Solve the system x + y = 25 and x - y = 9 by adding the equations: (x + y) + (x - y) = 25 + 9, giving 2x = 34, so x = 17. Substitute into the first equation: 17 + y = 25, so y = 8. The solution is x = 17, y = 8.

17. Correct Answer: D (√3)

The tangent of 60° is a standard trigonometric value: tan 60° = √3. This can be derived from a 30-60-90 triangle with sides in ratio 1:√3:2, where tan 60° = opposite/adjacent = √3/1 = √3. This is a value worth memorizing.

18. Correct Answer: A (15 cm)

If a rectangle has area 180 cm² and width 12 cm, use A = l × w: 180 = l × 12. Divide by 12: l = 180/12 = 15 cm. Verify: 15 × 12 = 180 ✓.

19. Correct Answer: C (36)

The least common multiple (LCM) of 12 and 18 can be found using prime factorization: $12 = 2^2 \times 3$, $18 = 2 \times 3^2$. The LCM uses the highest power of each prime: LCM = $2^2 \times 3^2 = 4 \times 9 = 36$.

20. Correct Answer: C (2/5)

With 8 red marbles and 12 blue marbles, there are 20 total marbles. The probability of drawing a red marble is (number of red)/(total) = 8/20 = 2/5. This tests basic probability calculation.

21. Correct Answer: A (5)

The distance formula is $d = \sqrt{(x_2-x_1)^2 + (y_2-y_1)^2}$. With points (1, 3) and (5, 6): $d = \sqrt{(5-1)^2 + (6-3)^2} = \sqrt{4^2 + 3^2} = \sqrt{16 + 9} = \sqrt{25} = 5$. This represents the 3-4-5 Pythagorean triple.

22. Correct Answer: B (10)

For inverse variation, y = k/x where k is constant. When y = 30 and x = 4: 30 = k/4, so k = 120. When x = 12: y = 120/12 = 10. In inverse variation, the product xy remains constant (30 × 4 = 10 × 12 = 120).

23. Correct Answer: C (1/2)

The cosine of 60° is a standard trigonometric value: cos 60° = 1/2. This can be derived from a 30-60-90 triangle with sides in ratio 1:√3:2, where cos 60° = adjacent/hypotenuse = 1/2. This is a value worth memorizing.

24. Correct Answer: B (56 cm)

If a square has area 196 cm², then $s^2 = 196$, so s = 14 cm (side length). The perimeter is P = 4s = 4 × 14 = 56 cm. This tests connecting area and perimeter formulas for squares.

25. Correct Answer: D (35)

Evaluate $f(x) = 3x + 8$ at $x = 9$ by substitution: $f(9) = 3(9) + 8 = 27 + 8 = 35$. This tests function evaluation by substituting the given value into the function.

26. Correct Answer: C (5/8)

Convert 0.625 to a fraction: $0.625 = 625/1000$. Simplify by dividing numerator and denominator by their GCF (125): $625÷125 / 1000÷125 = 5/8$. This tests decimal-to-fraction conversion.

27. Correct Answer: A (7)

Solve $8x + 7 = 6x + 21$ by subtracting $6x$ from both sides: $2x + 7 = 21$. Subtract 7 from both sides: $2x = 14$. Divide by 2: $x = 7$. Verify: $8(7) + 7 = 56 + 7 = 63$, and $6(7) + 21 = 42 + 21 = 63$ ✓.

28. Correct Answer: B (113.04 cm³)

The volume of a sphere is $V = 4/3\pi r^3$. With $r = 3$ cm and $\pi \approx 3.14$: $V = 4/3 \times 3.14 \times 3^3 = 4/3 \times 3.14 \times 27 = 4/3 \times 84.78 = 113.04$ cm³. This tests applying the sphere volume formula.

29. Correct Answer: D (12)

The greatest common factor (GCF) of 36 and 60 can be found using prime factorization: $36 = 2^2 \times 3^2$ and $60 = 2^2 \times 3 \times 5$. The GCF uses the lowest power of each common prime: $2^2 \times 3 = 4 \times 3 = 12$.

30. Correct Answer: C (65°)

In any triangle, the three angles sum to 180°. With angles 45°, 70°, and x°: $45 + 70 + x = 180$, so $115 + x = 180$, giving $x = 65°$. This tests the fundamental triangle angle sum property.

31. Correct Answer: A (51)

Calculate $10^2 - 7^2$: First, $10^2 = 100$. Then, $7^2 = 49$. Finally, $100 - 49 = 51$. Alternatively, use the difference of squares formula: $a^2 - b^2 = (a+b)(a-b) = (10+7)(10-7) = 17 \times 3 = 51$.

32. Correct Answer: D (5/9)

To subtract fractions with different denominators, find a common denominator. The LCD of 9 and 3 is 9: $1/3 = 3/9$. Then $8/9 - 3/9 = 5/9$. This tests fraction subtraction with unlike denominators.

33. Correct Answer: D (565.2 cm³)

The volume of a cylinder is $V = \pi r^2 h$. With $r = 6$ cm, $h = 5$ cm, and $\pi \approx 3.14$: $V = 3.14 \times 6^2 \times 5 = 3.14 \times 36 \times 5 = 3.14 \times 180 = 565.2$ cm³. This tests applying the cylinder volume formula.

34. Correct Answer: C (52)

To decrease 80 by 35%, calculate 35% of 80 and subtract: $0.35 \times 80 = 28$, so $80 - 28 = 52$. Alternatively, 80 decreased by 35% $= 80 \times 0.65 = 52$. This tests percentage decrease calculations.

35. Correct Answer: B (30°)

If cos θ = √3/2, then θ = 30° (in the range 0° < θ < 90°). This occurs in a 30-60-90 triangle where cos 30° = adjacent/hypotenuse = √3/2. This is a standard trigonometric value worth memorizing.

36. Correct Answer: A (8)

Solve $3(x + 5) = 2x + 23$ by first distributing: $3x + 15 = 2x + 23$. Subtract 2x from both sides: $x + 15 = 23$. Subtract 15 from both sides: $x = 8$. Verify: $3(8 + 5) = 3(13) = 39$, and $2(8) + 23 = 16 + 23 = 39$ ✓.

37. Correct Answer: D (25)

Range equals maximum minus minimum. In the dataset {18, 32, 25, 43, 29}, the maximum is 43 and minimum is 18. Range = 43 - 18 = 25. This tests understanding of range as a measure of spread.

38. Correct Answer: C (±13)

If $x^2 = 169$, then $x = \pm\sqrt{169} = \pm13$. Both positive and negative 13 are solutions because $(13)^2 = 169$ and $(-13)^2 = 169$. Always consider both positive and negative square roots when solving x^2 = constant.

39. Correct Answer: B (√3/2)

The sine of 60° is a standard trigonometric value: sin 60° = √3/2. This can be derived from a 30-60-90 triangle with sides in ratio 1:√3:2, where sin 60° = opposite/hypotenuse = √3/2. This is a value worth memorizing.

40. Correct Answer: D (6x²y³)

Simplify $(30x^8y^5)/(5x^6y^2)$ by dividing coefficients and subtracting exponents for like bases. For the coefficient: 30/5 = 6. For x: $x^8/x^6 = x^{(8-6)} = x^2$. For y: $y^5/y^2 = y^{(5-2)} = y^3$. The result is $6x^2y^3$.