

# Full-Length Practice Test 6

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

## Survey Of Natural Sciences

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### **BIOLOGY (Questions 1-40)**

1. Modifying, sorting, and packaging proteins for secretion is responsible for which organelle?
  - A. Endoplasmic reticulum
  - B. Golgi apparatus
  - C. Lysosome
  - D. Ribosome
2. Located between which two chambers is the atrioventricular (AV) node?
  - A. Atria and ventricles
  - B. Right and left atria
  - C. Right and left ventricles
  - D. Ventricles and arteries
3. Which phase of meiosis involves separation of sister chromatids?
  - A. Prophase I
  - B. Metaphase I
  - C. Anaphase I
  - D. Anaphase II
4. Carotenoids serve as accessory pigments primarily absorbing light in which color range?
  - A. Red
  - B. Green
  - C. Blue-green
  - D. Infrared
5. A point mutation that results in a stop codon is classified as:
  - A. Silent mutation
  - B. Nonsense mutation
  - C. Missense mutation
  - D. Frameshift mutation
6. Produces and secretes bile for fat digestion which organ?

- A. Gallbladder
  - B. Pancreas
  - C. Small intestine
  - D. Liver
7. Carbon fixation in the Calvin cycle is catalyzed by which enzyme?
- A. ATP synthase
  - B. Phosphofructokinase
  - C. RuBisCO
  - D. Hexokinase
8. During DNA replication, synthesizes the RNA primer which enzyme?
- A. DNA polymerase
  - B. Helicase
  - C. Primase
  - D. Ligase
9. Produced by which gland is oxytocin?
- A. Anterior pituitary
  - B. Hypothalamus
  - C. Posterior pituitary
  - D. Pineal gland
10. Primarily responsible for blood clotting which blood component?
- A. Platelets
  - B. White blood cells
  - C. Red blood cells
  - D. Plasma proteins
11. The proximal convoluted tubule is primarily responsible for reabsorption of:
- A. Water only
  - B. Glucose only
  - C. Sodium only
  - D. Glucose, amino acids, and sodium
12. In eukaryotes, the 5' cap is added to mRNA during:
- A. Translation
  - B. Transcription
  - C. RNA processing
  - D. DNA replication

13. Located between which chambers is the bicuspid (mitral) valve?
- A. Right atrium and right ventricle
  - B. Left atrium and left ventricle
  - C. Left ventricle and aorta
  - D. Right ventricle and pulmonary artery
14. Active transport differs from facilitated diffusion in that it:
- A. Uses carrier proteins
  - B. Moves substances across membranes
  - C. Requires ATP
  - D. Is selective
15. Excreted primarily by birds and reptiles which nitrogenous waste?
- A. Ammonia
  - B. Uric acid
  - C. Urea
  - D. Creatine
16. An example of which regulation is the trp operon?
- A. Positive inducible regulation
  - B. Negative repressible regulation
  - C. Positive repressible regulation
  - D. Negative inducible regulation
17. Located in the which is the respiratory control center?
- A. Medulla oblongata
  - B. Cerebellum
  - C. Cerebrum
  - D. Hypothalamus
18. Gamete formation in females is called:
- A. Spermatogenesis
  - B. Mitosis
  - C. Fertilization
  - D. Oogenesis
19. The luteal phase of the menstrual cycle is characterized by secretion of:
- A. FSH
  - B. LH

- C. Progesterone
- D. Estrogen primarily

20. Class switching in antibodies is an example of:

- A. Translation regulation
- B. Genetic recombination
- C. Point mutation
- D. Gene duplication

21. Stomata in plant leaves primarily regulate:

- A. Photosynthesis only
- B. Cellular respiration only
- C. Nutrient uptake
- D. Gas exchange and water loss

22. The neurotransmitter dopamine is classified as:

- A. Catecholamine
- B. Amino acid
- C. Peptide
- D. Steroid

23. During muscle contraction, the myosin head binds to:

- A. Troponin
- B. Tropomyosin
- C. Actin
- D. Calcium ions

24. Triggers the release of milk from mammary glands which hormone?

- A. Prolactin
- B. Oxytocin
- C. Estrogen
- D. Progesterone

25. The citric acid cycle (Krebs cycle) occurs in the:

- A. Mitochondrial matrix
- B. Inner mitochondrial membrane
- C. Cytoplasm
- D. Outer mitochondrial membrane

26. Memory B cells are responsible for:

- A. Initial immune response
- B. Cell-mediated immunity
- C. Phagocytosis
- D. Secondary immune response

27. Saltatory conduction occurs in:

- A. Unmyelinated axons
- B. Dendrites
- C. Myelinated axons
- D. Cell bodies

28. Checks for DNA damage which checkpoint in the cell cycle?

- A. M checkpoint
- B. G1 checkpoint
- C. S checkpoint
- D. G0 phase

29. The bronchioles terminate in air sacs called:

- A. Bronchi
- B. Trachea
- C. Larynx
- D. Alveoli

30. Creatine phosphate in muscle cells functions to:

- A. Rapidly regenerate ATP
- B. Store oxygen
- C. Break down glucose
- D. Contract muscle fibers

31. The Hershey-Chase experiment demonstrated that:

- A. Proteins carry genetic information
- B. RNA is the genetic material
- C. DNA is the genetic material
- D. Genes are on chromosomes

32. The secretory phase of the menstrual cycle is stimulated by:

- A. FSH
- B. Progesterone
- C. Estrogen
- D. LH

33. Vitamin and mineral absorption occurs primarily in the:
- A. Small intestine
  - B. Stomach
  - C. Large intestine
  - D. Esophagus
34. RNA interference (RNAi) is a form of:
- A. Transcriptional regulation
  - B. DNA replication
  - C. Translation initiation
  - D. Post-transcriptional regulation
35. The fovea centralis contains primarily:
- A. Rods only
  - B. Cones
  - C. Both equally
  - D. Ganglion cells
36. Relieves tension ahead of the replication fork which enzyme?
- A. Ligase
  - B. Primase
  - C. Topoisomerase
  - D. Polymerase
37. Yellow bone marrow primarily functions in:
- A. Blood cell production
  - B. Immune response
  - C. Mineral storage
  - D. Fat storage
38. The H-zone in a sarcomere contains:
- A. Myosin only
  - B. Actin only
  - C. Overlap of actin and myosin
  - D. Z-lines
39. Aldosterone increases water reabsorption indirectly by:
- A. Direct water channel insertion
  - B. Increasing sodium reabsorption

- C. Decreasing potassium secretion
- D. Increasing glucose reabsorption

40. In a Hardy-Weinberg population, if  $p = 0.6$ , the frequency of homozygous recessive individuals is:
- A. 0.36
  - B. 0.48
  - C. 0.16
  - D. 0.64

### GENERAL CHEMISTRY (Questions 41-70)

41. The electron configuration of calcium (atomic number 20) is what?

- A.  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
- B.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$
- C.  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^1$
- D.  $1s^2 2s^2 2p^6 3s^2 3p^6$

42. Hund's rule states that electrons:

- A. Fill lower energy orbitals first
- B. Have opposite spins when paired
- C. Cannot have identical quantum numbers
- D. Occupy orbitals singly before pairing

43. The pH of a 0.01 M NaOH solution is what?

- A. 2
- B. 12
- C. 10
- D. 14

44. Has the lowest vapor pressure at 25°C which substance?

- A. Ethanol
- B. Acetone
- C. Water
- D. Diethyl ether

45. In the reaction  $Fe^{2+} \rightarrow Fe^{3+} + e^-$ , iron is:

- A. Oxidized
- B. Reduced
- C. Neither oxidized nor reduced

D. Both oxidized and reduced

46. The maximum number of electrons in the  $n = 4$  energy level is:

- A. 8
- B. 18
- C. 24
- D. 32

47. Determines the shape of an orbital which quantum number?

- A. Principal ( $n$ )
- B. Spin ( $s$ )
- C. Angular momentum ( $l$ )
- D. Magnetic ( $m$ )

48. A buffer is most resistant to pH change when:

- A.  $\text{pH} = \text{pK}_a + 2$
- B.  $\text{pH} = \text{pK}_a$
- C.  $\text{pH} = 7$
- D.  $\text{pH} = \text{pK}_a - 1$

49. Relates pressure and temperature at constant volume which gas law?

- A. Boyle's Law
- B. Charles's Law
- C. Avogadro's Law
- D. Gay-Lussac's Law

50. The oxidation state of sulfur in  $\text{SO}_3$  is:

- A. +6
- B. +4
- C. +2
- D. -2

51. Enthalpy is a:

- A. Kinetic property
- B. Path function
- C. State function
- D. Irreversible property

52. How many moles are in 90 grams of  $\text{H}_2\text{O}$  (molar mass = 18 g/mol)?

- A. 4 moles

- B. 5 moles
- C. 72 moles
- D. 108 moles

53. Has the largest atomic radius which element?

- A. Li
- B. Na
- C. K
- D. Rb

54. The solubility product constant ( $K_{sp}$ ) represents:

- A. Equilibrium of a saturated solution
- B. Acid strength
- C. Buffer capacity
- D. Reaction rate

55. For a reaction to be spontaneous at all temperatures, it must have:

- A.  $\Delta H > 0, \Delta S > 0$
- B.  $\Delta H > 0, \Delta S < 0$
- C.  $\Delta H < 0, \Delta S > 0$
- D.  $\Delta H < 0, \Delta S < 0$

56. The molarity of a solution containing 8 moles of solute in 2 liters is what?

- A. 2 M
- B. 6 M
- C. 10 M
- D. 4 M

57. Pi bonds are formed by:

- A. Parallel overlap of p orbitals
- B. End-to-end orbital overlap
- C. s-p orbital mixing
- D. Spherical overlap

58. A strong base has a:

- A. Low  $K_b$
- B. High  $K_a$
- C. Low pH
- D. High  $K_b$

59. A radioactive isotope has a half-life of 10 years. What fraction remains after 30 years?

- A. 1/4
- B. 1/8
- C. 1/2
- D. 1/16

60. Is least electronegative which element?

- A. F
- B. Cl
- C. Cs
- D. O

61. The molecular geometry of H<sub>2</sub>S is:

- A. Linear
- B. Trigonal planar
- C. Tetrahedral
- D. Bent

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

- A. Anode
- B. Cathode
- C. Salt bridge
- D. Neither electrode

63. The value of the ideal gas constant R in SI units is approximately:

- A. 0.0821 atm·L/(mol·K)
- B. 1.987 cal/(mol·K)
- C. 8.314 J/(mol·K)
- D. 62.4 L·torr/(mol·K)

64. Atoms of the same element with different mass numbers are called:

- A. Ions
- B. Isotopes
- C. Isomers
- D. Allotropes

65. For a first-order reaction, the rate law is:

- A. Rate = k[A]
- B. Rate = k[A]<sup>2</sup>
- C. Rate = k

D.  $\text{Rate} = k[\text{A}][\text{B}]$

66. The conjugate acid of  $\text{OH}^-$  is:

- A.  $\text{O}^{2-}$
- B.  $\text{H}_2\text{O}$
- C.  $\text{H}_3\text{O}^+$
- D.  $\text{H}^-$

67. The bond order of  $\text{N}_2$  is:

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

68. Increasing temperature at constant volume will:

- A. Increase pressure
- B. Decrease pressure
- C. Not affect pressure
- D. Increase volume

69. The oxidation number of oxygen in  $\text{H}_2\text{O}_2$  is:

- A. -2
- B. 0
- C. +2
- D. -1

70. Osmotic pressure is a:

- A. Chemical property
- B. Colligative property
- C. Physical constant
- D. Intensive property

### **ORGANIC CHEMISTRY (Questions 71-100)**

71. For alkynes, the general formula is:

- A.  $\text{C}_n\text{H}_{2n-2}$
- B.  $\text{C}_n\text{H}_{2n}$
- C.  $\text{C}_n\text{H}_{2n+2}$
- D.  $\text{C}_n\text{H}_{2n+1}$

72. Characterizes ketones which functional group?
- A. -OH
  - B. -CHO
  - C. -NH<sub>2</sub>
  - D. -CO- (between carbons)
73. The IUPAC name for CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub> is:
- A. Propane
  - B. Pentane
  - C. Butane
  - D. Hexane
74. Stereoisomers that are not mirror images are called:
- A. Enantiomers
  - B. Diastereomers
  - C. Constitutional isomers
  - D. Conformers
75. Adds hydrogen across a double bond which reaction?
- A. Hydration
  - B. Halogenation
  - C. Dehydration
  - D. Hydrogenation
76. Toward nucleophilic addition, the least reactive carbonyl compound is:
- A. Amide
  - B. Ketone
  - C. Aldehyde
  - D. Acid chloride
77. Uses copper(II) ions to detect reducing sugars which test?
- A. Benedict's test
  - B. Iodine test
  - C. Biuret test
  - D. Ninhydrin test
78. The hybridization of carbon in ethene (C<sub>2</sub>H<sub>4</sub>) is:
- A. sp
  - B. sp<sup>3</sup>
  - C. sp<sup>2</sup>

D.  $sp^3d$

79. In HX addition to alkenes, Markovnikov's rule predicts that:

- A. H adds to more substituted carbon
- B. H adds randomly
- C. X adds to less substituted carbon
- D. H adds to less substituted carbon

80. NOT aromatic which is?

- A. Pyridine
- B. Cyclooctatetraene
- C. Benzene
- D. Furan

81. Through which does the  $S_N1$  mechanism proceed?

- A. Backside attack
- B. Concerted mechanism
- C. Radical intermediate
- D. Carbocation intermediate

82. Why are carboxylic acids acidic?

- A. Resonance stabilization of conjugate base
- B. Large molecular size
- C. Presence of oxygen
- D. High electronegativity

83. Produces which does the aldol condensation?

- A. Esters
- B. Amides
- C.  $\beta$ -hydroxy carbonyl compounds
- D. Ethers

84. In  $E2$  reactions, the base removes a proton:

- A. After carbocation formation
- B. Simultaneously with leaving group departure
- C. Before leaving group departs
- D. In a separate step

85. Which is the weakest base?

- A.  $F^-$

- B.  $\text{OH}^-$
- C.  $\text{NH}_2^-$
- D.  $\text{CH}_3^-$

86. The reaction of an ester with water is called:

- A. Esterification
- B. Saponification
- C. Hydrolysis
- D. Condensation

87. A molecule with a non-superimposable mirror image is:

- A. Achiral
- B. Chiral
- C. Meso
- D. Constitutional isomer

88. The Friedel-Crafts acylation produces:

- A. Ketones
- B. Alcohols
- C. Alkenes
- D. Amines

89. Undergoes  $\text{SN}_2$  most readily which alkyl halide?

- A. Tertiary
- B. Secondary
- C. Primary
- D. Methyl

90. Reacts with  $\text{CO}_2$  to form which does the Grignard reagent?

- A. Ketones
- B. Carboxylic acids
- C. Alcohols
- D. Esters

91. Based on which are R and S configurations assigned?

- A. Optical rotation
- B. Physical properties
- C. Cahn-Ingold-Prelog rules
- D. Molecular formula

92. Produces which does the Gabriel synthesis?
- A. Secondary amines
  - B. Primary amines
  - C. Tertiary amines
  - D. Quaternary ammonium salts
93. Identical which do enantiomers have?
- A. Optical rotation
  - B. R/S designation
  - C. Interactions with achiral molecules
  - D. Interactions with plane-polarized light
94. Uses which does the Wolff-Kishner reduction?
- A. Hydrazine and base
  - B. Zn/HCl
  - C. NaBH<sub>4</sub>
  - D. LiAlH<sub>4</sub>
95. Oxidized to which are secondary alcohols?
- A. Aldehydes
  - B. Carboxylic acids
  - C. Alkanes
  - D. Ketones
96. Generally which are meta-directing groups?
- A. Deactivating
  - B. Activating
  - C. Neutral
  - D. Alkyl groups
97. Predicts formation of which does the Saytzeff rule?
- A. Less substituted alkene
  - B. More hindered product
  - C. More substituted alkene
  - D. Anti product
98. Involves reaction between which does transesterification?
- A. Ester and alcohol
  - B. Ester and amine
  - C. Ester and water

D. Acid and alcohol

99. Most useful for identifying which is infrared spectroscopy?

- A. Molecular weight
- B. Isotopes
- C. Molecular formula
- D. Functional groups

100. Indicates which does the number of signals in  $^{13}\text{C}$  NMR?

- A. Total carbons
- B. Total hydrogens
- C. Number of carbon environments
- D. Molecular weight

## Perceptual Ability Test

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### ANGLE DISCRIMINATION (Questions 1-15)

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

1. [Angle Ranking] Four angles: Angle 1 =  $56^\circ$ , Angle 2 =  $43^\circ$ , Angle 3 =  $65^\circ$ , Angle 4 =  $59^\circ$ . Rank from smallest to largest.

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

2. [Angle Ranking] Angle P =  $77^\circ$ , Angle Q =  $62^\circ$ , Angle R =  $84^\circ$ , Angle S =  $55^\circ$ . Rank from smallest to largest.

- A. S-P-Q-R
- B. S-R-Q-P
- C. Q-S-P-R
- D. S-Q-P-R

3. [Angle Ranking] Four angles measure: Angle 1 =  $29^\circ$ , Angle 2 =  $41^\circ$ , Angle 3 =  $23^\circ$ , Angle 4 =  $37^\circ$ . Rank from smallest to largest.

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

D. 1-3-2-4

4. [Angle Ranking] Angle A =  $86^\circ$ , Angle B =  $79^\circ$ , Angle C =  $92^\circ$ , Angle D =  $73^\circ$ . Rank from smallest to largest.
- A. D-B-A-C
  - B. B-A-C-D
  - C. B-C-D-A
  - D. D-A-B-C
5. [Angle Ranking] Angle W is two-thirds of a right angle. Angle X =  $47^\circ$ . Angle Y =  $72^\circ$ . Angle Z =  $84^\circ$ . Rank from smallest to largest.
- A. W-Y-X-Z
  - B. X-Y-W-Z
  - C. X-W-Z-Y
  - D. X-W-Y-Z
6. [Angle Ranking] Four angles: Angle 1 =  $18^\circ$ , Angle 2 =  $32^\circ$ , Angle 3 =  $39^\circ$ , Angle 4 =  $46^\circ$ . Rank from smallest to largest.
- A. 1-3-2-4
  - B. 1-2-3-4
  - C. 2-1-3-4
  - D. 4-3-2-1
7. [Angle Ranking] Angle M =  $64^\circ$ , Angle N =  $76^\circ$ , Angle O =  $57^\circ$ , Angle P =  $71^\circ$ . Rank from smallest to largest.
- A. M-O-P-N
  - B. O-P-M-N
  - C. O-M-P-N
  - D. M-P-O-N
8. [Angle Ranking] Four angles measure: Angle 1 =  $21^\circ$ , Angle 2 =  $35^\circ$ , Angle 3 =  $28^\circ$ , Angle 4 =  $42^\circ$ . Rank from smallest to largest.
- A. 1-3-2-4
  - B. 1-4-3-2
  - C. 2-1-3-4
  - D. 3-1-2-4
9. [Angle Ranking] Angle A =  $49^\circ$ , Angle B =  $55^\circ$ , Angle C =  $38^\circ$ , Angle D =  $67^\circ$ . Rank from smallest to largest.
- A. C-A-B-D

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

10. [Angle Ranking] Four angles: Angle 1 =  $73^\circ$ , Angle 2 =  $66^\circ$ , Angle 3 =  $80^\circ$ , Angle 4 =  $69^\circ$ . Rank from smallest to largest.

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

11. [Angle Ranking] Angle W =  $36^\circ$ , Angle X =  $54^\circ$ , Angle Y =  $48^\circ$ , Angle Z =  $43^\circ$ . Rank from smallest to largest.

- A. W-Y-Z-X
- B. W-Z-Y-X
- C. Z-W-Y-X
- D. W-Z-Y-X

12. [Angle Ranking] Four angles measure: Angle 1 =  $19^\circ$ , Angle 2 =  $28^\circ$ , Angle 3 =  $34^\circ$ , Angle 4 =  $47^\circ$ . Rank from smallest to largest.

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

13. [Angle Ranking] Angle P =  $68^\circ$ , Angle Q =  $51^\circ$ , Angle R =  $81^\circ$ , Angle S =  $56^\circ$ . Rank from smallest to largest.

- A. Q-S-P-R
- B. S-P-Q-R
- C. Q-S-P-R
- D. S-Q-R-P

14. [Angle Ranking] Four angles: Angle 1 =  $27^\circ$ , Angle 2 =  $44^\circ$ , Angle 3 =  $37^\circ$ , Angle 4 =  $51^\circ$ . Rank from smallest to largest.

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

15. [Angle Ranking] Angle A =  $78^\circ$ , Angle B =  $87^\circ$ , Angle C =  $91^\circ$ , Angle D =  $74^\circ$ . Rank from smallest to largest.
- A. A-B-D-C
  - B. D-A-B-C
  - C. D-A-C-B
  - D. A-D-B-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. 1
  - C. 4
  - D. 3
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. 24
  - D. 16
18. [Hole Punching] Paper is folded in half twice (creating 4 layers), then two holes are punched through all layers. How many total holes appear when unfolded?
- A. 2
  - B. 4
  - C. 16
  - D. 8
19. [Hole Punching] Paper is folded in half once, then five holes are punched through both layers. How many total holes appear when unfolded?
- A. 5
  - B. 10
  - C. 8

D. 6

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. 8
  - C. 12
  - D. 16
21. [Hole Punching] Paper is folded diagonally once, then one hole is punched exactly on the fold line. How many holes appear when unfolded?
- A. 1
  - B. 2
  - C. 4
  - D. 3
22. [Hole Punching] Paper is folded in half twice, then one hole is punched in a corner of the folded paper. How many holes appear when unfolded?
- A. 1
  - B. 2
  - C. 8
  - D. 4
23. [Hole Punching] Paper is folded in half once vertically, then four holes are punched through both layers. How many total holes appear when unfolded?
- A. 4
  - B. 8
  - C. 6
  - D. 12
24. [Hole Punching] Paper is folded in half once, then a hole is punched exactly on the fold line. How many holes appear when unfolded?
- A. 1
  - B. 2
  - C. 3
  - D. 4
25. [Hole Punching] Paper is folded three times, then one hole is punched through all layers. How many holes appear when unfolded?
- A. 4

- B. 6
- C. 8
- D. 16

26. [Hole Punching] Paper is folded in half twice (into quarters), then two holes are punched through all layers. How many total holes appear when unfolded?

- A. 4
- B. 2
- C. 16
- D. 8

27. [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. 4
- D. 8

28. [Hole Punching] Paper is folded in half once, then six holes are punched through both layers. How many total holes appear when unfolded?

- A. 6
- B. 8
- C. 12
- D. 10

29. [Hole Punching] Paper is folded in half twice, then a hole is punched at the point where both folds meet (center). How many holes appear when unfolded?

- A. 4
- B. 2
- C. 8
- D. 1

30. [Hole Punching] Paper is folded in half three times (creating 8 layers), then one hole is punched through all layers. How many holes appear when unfolded?

- A. 4
- B. 16
- C. 6
- D. 8

### CUBE COUNTING (Questions 31-45)

**Directions:** Answer questions about unit cubes in various structures.

31. [Cube Counting] In a  $4 \times 4 \times 4$  cube, how many unit cubes have exactly 1 face exposed (face cubes)?
- A. 32
  - B. 24
  - C. 48
  - D. 16
32. [Cube Counting] A solid  $5 \times 5 \times 5$  cube. How many unit cubes have exactly 3 faces exposed (corner cubes)?
- A. 8
  - B. 6
  - C. 12
  - D. 4
33. [Cube Counting] A  $2 \times 4 \times 6$  rectangular prism. How many total unit cubes are in the structure?
- A. 12
  - B. 24
  - C. 48
  - D. 36
34. [Cube Counting] A structure of 10 unit cubes arranged in a straight line. How many cubes have exactly 5 faces exposed (end cubes)?
- A. 0
  - B. 1
  - C. 4
  - D. 2
35. [Cube Counting] In a  $4 \times 4 \times 4$  cube, how many unit cubes have exactly 0 faces exposed (completely interior)?
- A. 1
  - B. 8
  - C. 27
  - D. 64
36. [Cube Counting] A  $4 \times 5 \times 3$  rectangular prism. How many unit cubes have exactly 3 faces exposed (corners)?
- A. 6

- B. 12
- C. 8
- D. 4

37. [Cube Counting] A solid  $4 \times 4 \times 4$  cube. How many unit cubes have exactly 2 faces exposed (edge cubes)?

- A. 24
- B. 12
- C. 48
- D. 32

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

- A. 27
- B. 30
- C. 24
- D. 36

39. [Cube Counting] In a  $6 \times 6 \times 6$  cube, how many unit cubes have exactly 1 face exposed (face cubes)?

- A. 48
- B. 96
- C. 64
- D. 72

40. [Cube Counting] A  $5 \times 4 \times 3$  rectangular prism. How many unit cubes are NOT corner cubes?

- A. 52
- B. 54
- C. 50
- D. 48

41. [Cube Counting] A pyramid structure: 16 cubes on bottom ( $4 \times 4$ ), 9 cubes on second layer ( $3 \times 3$ ), 4 cubes on third layer ( $2 \times 2$ ), 1 cube on top (30 total). How many cubes have exactly 3 exposed faces?

- A. 4
- B. 6
- C. 8
- D. 5

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

- A. 24
- B. 32
- C. 28

D. 36

43. [Cube Counting] An L-shaped structure: 7 cubes in a row with 3 cubes stacked on one end (10 total). How many cubes have exactly 3 exposed faces?
- A. 4
  - B. 5
  - C. 2
  - D. 3
44. [Cube Counting] A  $6 \times 6 \times 2$  rectangular prism. How many unit cubes have at least one face exposed?
- A. 68
  - B. 70
  - C. 60
  - D. 72
45. [Cube Counting] In a  $3 \times 3 \times 3$  cube, how many unit cubes have exactly 2 faces exposed?
- A. 12
  - B. 8
  - C. 6
  - D. 24

### **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 an L-shape. What does it form when folded?
- A. Complete cube
  - B. Pyramid
  - C. Prism
  - D. Partial cube (open box)
47. [Pattern Folding] A net shows 1 pentagon with 5 triangles attached to each edge. What 3D shape is formed?
- A. Cube
  - B. Hexagonal pyramid
  - C. Pentagonal pyramid
  - D. Triangular prism
48. [Pattern Folding] A net consists of 6 squares arranged in a T-shape (4 in a row, 1 above and 1 below the second square). What does it form?

- A. Cube
- B. Pyramid
- C. Open box
- D. Prism

49. [Pattern Folding] A net shows 2 triangles and 3 rectangles all connected. What shape does it form?
- A. Tetrahedron
  - B. Triangular prism
  - C. Square pyramid
  - D. Cube
50. [Pattern Folding] A net shows 1 hexagon with 6 rectangles attached to its edges. What 3D shape does it form?
- A. Cube
  - B. Hexagonal pyramid
  - C. Rectangular prism
  - D. Hexagonal prism
51. [Pattern Folding] A net consists of 5 squares in a plus/cross shape (one center, four extending from each edge). What does it form?
- A. Complete cube
  - B. Pyramid
  - C. Open-top cube
  - D. Prism
52. [Pattern Folding] A net has 1 square with 4 triangles attached to each edge of the square. What 3D shape is formed?
- A. Cube
  - B. Square pyramid
  - C. Tetrahedron
  - D. Triangular prism
53. [Pattern Folding] A net consists of 1 square and 3 triangles attached to three edges of the square. What partial shape does it form?
- A. Partial pyramid (missing one face)
  - B. Complete pyramid
  - C. Cube
  - D. Prism

54. [Pattern Folding] A net shows 6 rectangles arranged to form a closed shape. What is it most likely to form?
- A. Cube
  - B. Pyramid
  - C. Rectangular prism
  - D. Triangular prism
55. [Pattern Folding] A net shows 2 hexagons with 6 rectangles connecting them. What 3D shape is formed?
- A. Rectangular prism
  - B. Hexagonal pyramid
  - C. Cube
  - D. Hexagonal prism
56. [Pattern Folding] A net consists of 1 large triangle with 3 smaller triangles attached to its edges. What shape does it form?
- A. Tetrahedron
  - B. Square pyramid
  - C. Octahedron
  - D. Triangular prism
57. [Pattern Folding] A net shows 6 equal squares in a cross pattern. What does it form?
- A. Pyramid
  - B. Open box
  - C. Prism
  - D. Cube
58. [Pattern Folding] A net consists of 4 equilateral triangles in a connected arrangement. What shape does it form?
- A. Square pyramid
  - B. Tetrahedron
  - C. Octahedron
  - D. Cube
59. [Pattern Folding] A net shows 3 squares in a row with 1 square attached to the side of the middle square (T-shape). What can this form?
- A. Open-top cube
  - B. Complete cube
  - C. Pyramid
  - D. Prism

60. [Pattern Folding] A net consists of irregular polygons that don't match standard shapes. What type of shape might this form?
- A. Regular pyramid
  - B. Cube
  - C. Irregular polyhedron
  - D. Standard prism

### **APERTURES / KEYHOLES (Questions 61-75)**

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

61. [Keyhole] A cone must pass through an aperture. Which aperture shape could work?
- A. Square
  - B. Pentagon
  - C. Hexagon
  - D. Circle or Triangle
62. [Keyhole] A cube is oriented to pass through an aperture. Which aperture shape is possible?
- A. Circle
  - B. Square
  - C. Pentagon
  - D. Triangle
63. [Keyhole] A sphere passes through an aperture. Which shape would work?
- A. Square
  - B. Rectangle
  - C. Circle
  - D. Triangle
64. [Keyhole] A rectangular prism passes through an aperture. Which shape is possible?
- A. Rectangle
  - B. Circle
  - C. Pentagon
  - D. Triangle
65. [Keyhole] A triangular prism passes through an aperture. Which shape could work?
- A. Circle
  - B. Pentagon
  - C. Hexagon

D. Triangle or Rectangle

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

- A. Circle
- B. Triangle
- C. Rectangle
- D. Oval

67. [Keyhole] A square pyramid must pass through an aperture. Which aperture is possible?

- A. Square or Triangle
- B. Circle
- C. Pentagon
- D. Hexagon

68. [Keyhole] A hexagonal prism passes through an aperture. Which shape is possible?

- A. Circle
- B. Triangle
- C. Hexagon or Rectangle
- D. Pentagon

69. [Keyhole] A tetrahedron (4-faced triangular pyramid) passes through an aperture. Which shape works?

- A. Square
- B. Pentagon
- C. Hexagon
- D. Triangle

70. [Keyhole] Which 3D object could pass through a circular aperture?

- A. Cube only
- B. Sphere or Cylinder
- C. Triangular prism only
- D. Pyramid only

71. [Keyhole] An octahedron passes through an aperture. Which shape is most likely?

- A. Pentagon
- B. Hexagon
- C. Triangle or Square
- D. Circle

72. [Keyhole] A pentagonal prism passes through an aperture. Which shape could work?

- A. Triangle
- B. Circle
- C. Hexagon
- D. Pentagon or Rectangle

73. [Keyhole] Which aperture shape would work for a rectangular prism but NOT for a sphere?

- A. Rectangle
- B. Circle
- C. Oval
- D. Triangle

74. [Keyhole] A cylinder passes through an aperture. Which is NOT a possible aperture shape?

- A. Circle
- B. Rectangle
- C. Triangle
- D. Oval

75. [Keyhole] Which 3D shape could pass through both a triangular and rectangular aperture?

- A. Sphere
- B. Triangular prism
- C. Cube
- D. Cylinder

### **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: circle. Front view: triangle. Side view: triangle. What is the 3D shape?

- A. Cylinder
- B. Cone
- C. Sphere
- D. Square pyramid

77. [Top-Front-End] Front view: rectangle. Top view: circle. Side view: rectangle. What is the shape?

- A. Cone
- B. Square pyramid
- C. Cylinder
- D. Rectangular prism

78. [Top-Front-End] All three views (top, front, side) show identical circles. What is the shape?
- A. Cylinder
  - B. Cone
  - C. Cube
  - D. Sphere
79. [Top-Front-End] Top view: square. Front view: triangle. Side view: triangle. What is the shape?
- A. Cone
  - B. Cylinder
  - C. Cube
  - D. Square pyramid
80. [Top-Front-End] A cube is viewed from the top. What shape appears?
- A. Square
  - B. Circle
  - C. Rectangle
  - D. Triangle
81. [Top-Front-End] Top view: triangle. Front view: rectangle. Side view: rectangle. What is the shape?
- A. Square pyramid
  - B. Tetrahedron
  - C. Triangular prism
  - D. Cone
82. [Top-Front-End] Top view: hexagon. Front and side views: rectangles. What is the shape?
- A. Cube
  - B. Hexagonal prism
  - C. Hexagonal pyramid
  - D. Rectangular prism
83. [Top-Front-End] A cylinder is viewed from the side (perpendicular to its axis). What shape appears?
- A. Rectangle
  - B. Circle
  - C. Square
  - D. Triangle
84. [Top-Front-End] All three views (top, front, side) show identical squares. What is the shape?
- A. Rectangular prism
  - B. Square pyramid

- C. Cylinder
- D. Cube

85. [Top-Front-End] Top view: pentagon. Front and side views: rectangles. What is the shape?

- A. Rectangular prism
- B. Pentagonal pyramid
- C. Pentagonal prism
- D. Pentagon

86. [Top-Front-End] A triangular prism is viewed from the end (looking at the triangular face). What shape appears?

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

87. [Top-Front-End] A cone is viewed from directly above (top view). What shape appears?

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

88. [Top-Front-End] Top view: rectangle. Front view: rectangle. Side view: square. What is the shape?

- A. Cube
- B. Cylinder
- C. Pyramid
- D. Rectangular prism

89. [Top-Front-End] A square pyramid is viewed from directly above. What shape appears?

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

90. [Top-Front-End] Top view: L-shape. Front view: rectangle. Side view: rectangle. What type of structure is this?

- A. Pyramid
- B. Cylinder
- C. L-shaped block structure
- D. Cube

## Reading Comprehension

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### PASSAGE I

CRISPR-Cas9 gene editing represents a revolutionary breakthrough in molecular biology, offering unprecedented precision in modifying DNA sequences across virtually any organism. Unlike earlier gene-editing technologies like zinc finger nucleases and TALENs, CRISPR provides a simpler, faster, and more cost-effective method for making targeted genetic changes. The system originated from a bacterial immune mechanism that protects against viral infections, demonstrating how basic research into microbial biology can yield transformative biotechnological tools.

The CRISPR system consists of two key components: the Cas9 enzyme, which acts as molecular scissors cutting DNA, and a guide RNA that directs Cas9 to the precise genomic location requiring modification. Scientists design the guide RNA to match the target DNA sequence with extraordinary specificity. Once positioned correctly, Cas9 cuts both strands of the DNA double helix. The cell's natural repair mechanisms then fix the break, either by joining the cut ends directly (potentially disrupting the gene) or by inserting a new DNA sequence if provided as a template. This elegance and programmability make CRISPR accessible even to laboratories with modest resources.

Medical applications of CRISPR show tremendous promise. Clinical trials are testing CRISPR therapies for sickle cell disease and beta-thalassemia, both caused by single-gene mutations. By editing patients' blood stem cells outside the body and returning them, researchers aim to permanently cure these genetic disorders. CRISPR could potentially address thousands of genetic diseases, from Huntington's disease to cystic fibrosis. Beyond inherited conditions, scientists are exploring CRISPR for cancer immunotherapy—engineering immune cells to better recognize and destroy tumors. Vision restoration trials use CRISPR to correct mutations causing inherited blindness, marking the first in-body CRISPR treatment in humans.

Agricultural applications offer solutions to global food security challenges. Scientists have developed disease-resistant crops, drought-tolerant varieties, and nutritionally enhanced foods using CRISPR. Unlike traditional genetic modification involving genes from different species, CRISPR can make changes indistinguishable from natural mutations, potentially easing regulatory and public acceptance concerns. However, questions remain about long-term environmental impacts and whether CRISPR crops should face the same regulations as conventional GMOs.

Ethical controversies surround CRISPR's potential uses, particularly regarding human germline editing—changes to eggs, sperm, or embryos that would be inherited by future generations. In 2018, a Chinese scientist's announcement of creating gene-edited babies sparked global condemnation and highlighted the need for international governance. While somatic cell editing (affecting only the patient) raises fewer ethical concerns, germline editing could permanently alter the human gene pool with unknown consequences. Additional worries include the technology's accessibility potentially enabling harmful applications, the justice implications of expensive genetic enhancements creating biological inequality,

and whether "designer babies" would undermine human dignity. Despite these concerns, CRISPR's therapeutic potential makes continued research essential, provided robust ethical frameworks and international agreements govern its use.

1. According to the passage, CRISPR-Cas9 originated from:
  - A. Pharmaceutical research
  - B. Plant genetics
  - C. Cancer biology
  - D. A bacterial immune mechanism
  
2. Compared to earlier gene-editing technologies, CRISPR is described as:
  - A. More expensive
  - B. Less accurate
  - C. Simpler and more cost-effective
  - D. Slower
  
3. The guide RNA in the CRISPR system functions to:
  - A. Cut the DNA
  - B. Direct Cas9 to the target location
  - C. Repair DNA breaks
  - D. Insert new sequences
  
4. The Cas9 enzyme is compared to:
  - A. A template
  - B. A guide
  - C. A repair mechanism
  - D. Molecular scissors
  
5. When Cas9 cuts DNA, the cell's repair mechanisms can:
  - A. Join cut ends or insert a template sequence
  - B. Only join cut ends
  - C. Only insert new sequences
  - D. Leave the break unrepaired
  
6. Clinical trials mentioned in the passage are testing CRISPR for:
  - A. Only cancer
  - B. Sickle cell disease and beta-thalassemia
  - C. Vision problems only
  - D. All genetic diseases
  
7. The first in-body CRISPR treatment in humans targets:

- A. Cancer
  - B. Blood disorders
  - C. Inherited blindness
  - D. Immune deficiencies
8. CRISPR's agricultural advantage over traditional GMOs is:
- A. Higher yields only
  - B. Lower costs only
  - C. Faster development only
  - D. Changes indistinguishable from natural mutations
9. Agricultural applications of CRISPR include:
- A. Disease-resistant and drought-tolerant crops
  - B. Only disease resistance
  - C. Only nutritional enhancement
  - D. Only yield improvement
10. Germline editing differs from somatic cell editing because germline changes:
- A. Are less precise
  - B. Would be inherited by future generations
  - C. Cost more
  - D. Are illegal everywhere
11. The 2018 Chinese scientist announcement involved:
- A. Curing cancer
  - B. Editing plants
  - C. Creating gene-edited babies
  - D. Discovering CRISPR
12. Somatic cell editing affects:
- A. Only the patient
  - B. Future generations
  - C. The entire population
  - D. Only embryos
13. Ethical concerns about germline editing include:
- A. Only cost
  - B. Only accessibility
  - C. Only regulatory issues
  - D. Permanently altering the human gene pool

14. The passage suggests "designer babies" could:
- A. Cure all diseases
  - B. Undermine human dignity
  - C. Reduce healthcare costs
  - D. Eliminate genetic diversity
15. Concerns about biological inequality relate to:
- A. Natural genetic variation
  - B. Disease susceptibility
  - C. Expensive genetic enhancements
  - D. Agricultural applications
16. The passage indicates that continued CRISPR research requires:
- A. Only funding
  - B. Only public support
  - C. Only technology improvements
  - D. Robust ethical frameworks and international agreements

## **PASSAGE II**

Circadian rhythms are intrinsic biological cycles lasting approximately 24 hours that regulate physiological processes across nearly all organisms, from cyanobacteria to humans. These internal clocks persist even without external time cues, demonstrating their genetic basis rather than mere responses to environmental cycles. The discovery that circadian rhythms are endogenous earned researchers the 2017 Nobel Prize in Physiology or Medicine. Understanding circadian biology has profound implications for health, as disruption of these rhythms contributes to numerous diseases.

At the molecular level, circadian clocks operate through transcriptional-translational feedback loops involving clock genes. In mammals, the suprachiasmatic nucleus (SCN) in the hypothalamus serves as the master clock, synchronizing peripheral clocks throughout the body. Light detected by specialized retinal cells—distinct from rods and cones used for vision—entrains the SCN to the external day-night cycle. The SCN then coordinates peripheral clocks in organs like the liver, heart, and pancreas through neural and hormonal signals. Core clock genes including *CLOCK*, *BMAL1*, *PER*, and *CRY* create feedback loops where proteins inhibit their own gene expression, generating oscillations with roughly 24-hour periods.

Circadian rhythms regulate numerous physiological functions beyond sleep-wake cycles. Body temperature fluctuates predictably, reaching its lowest point in early morning and peaking in late

afternoon. Hormone secretion follows circadian patterns—cortisol peaks shortly after waking to promote alertness, while melatonin increases at night to facilitate sleep. Blood pressure, immune function, and metabolism all exhibit circadian regulation. Even drug metabolism varies by time of day, with implications for medication timing. The liver's circadian clock controls enzymes metabolizing toxins and drugs, making some medications more effective or toxic depending on administration time.

Disruption of circadian rhythms, termed circadian misalignment, has significant health consequences. Shift workers facing chronic circadian disruption show elevated risks for cardiovascular disease, diabetes, obesity, and certain cancers. Jet lag represents acute circadian misalignment as the internal clock requires several days to adjust to new time zones. Less obvious sources of disruption include artificial light exposure at night, irregular sleep schedules, and late-night eating. Blue light from electronic screens suppresses melatonin particularly effectively, delaying sleep onset. Social jet lag—the discrepancy between biological and social time—affects most people to some degree, especially adolescents whose circadian clocks naturally shift later during puberty but who must wake early for school.

Emerging therapeutic applications target the circadian system. Chronotherapy involves timing medication administration to circadian rhythms, improving efficacy and reducing side effects. Cancer chemotherapy timed to circadian rhythms of cell division can enhance tumor killing while sparing healthy tissues. Light therapy treats seasonal affective disorder and helps reset circadian clocks in shift workers and travelers. Melatonin supplements can facilitate circadian adjustment, though timing and dosage matter critically. Understanding individual chronotypes—whether someone is naturally a morning lark or night owl—could personalize treatment schedules and work arrangements. Future medicine may increasingly consider circadian biology in diagnosis, treatment, and disease prevention, recognizing that "when" matters as much as "what" in healthcare interventions.

17. CRISPR's accessibility as a technology raises concerns about:

- A. Potentially enabling harmful applications
- B. Reducing innovation
- C. Increasing costs
- D. Limiting scientific progress

18. Circadian rhythms are described as lasting approximately:

- A. 12 hours
- B. 48 hours
- C. 24 hours
- D. 6 hours

19. The passage indicates that circadian rhythms persist without external cues, demonstrating they are:

- A. Environmental responses
- B. Genetically based
- C. Learned behaviors

D. Social constructs

20. The 2017 Nobel Prize in Physiology or Medicine was awarded for discovering that circadian rhythms are:

- A. Endogenous
- B. Controlled by light
- C. Present in bacteria
- D. Related to sleep

21. In mammals, the master circadian clock is located in the:

- A. Liver
- B. Retina
- C. Heart
- D. Suprachiasmatic nucleus (SCN)

22. Light is detected for circadian purposes by:

- A. Rods and cones
- B. Specialized retinal cells distinct from vision cells
- C. The optic nerve directly
- D. The SCN directly

23. Core clock genes create oscillations through:

- A. External signals
- B. Immune responses
- C. Proteins inhibiting their own gene expression
- D. Random mutations

24. Body temperature typically reaches its lowest point:

- A. In early morning
- B. At midnight
- C. In late afternoon
- D. At noon

25. Cortisol secretion peaks:

- A. At night
- B. At noon
- C. In late afternoon
- D. Shortly after waking

26. Melatonin secretion increases at night to:

- A. Raise body temperature
- B. Increase alertness
- C. Facilitate sleep
- D. Suppress appetite

27. The liver's circadian clock controls enzymes that:

- A. Produce hormones
- B. Metabolize toxins and drugs
- C. Regulate blood pressure
- D. Control heart rate

28. Shift workers facing chronic circadian disruption show elevated risks for:

- A. Cardiovascular disease, diabetes, and certain cancers
- B. Only sleep disorders
- C. Only mood disorders
- D. Only obesity

29. Jet lag occurs because:

- A. Travel is stressful
- B. Altitude changes
- C. Time zone changes
- D. The internal clock requires time to adjust to new time zones

30. Blue light from screens affects circadian rhythms by:

- A. Having no effect
- B. Promoting sleep
- C. Suppressing melatonin and delaying sleep onset
- D. Increasing cortisol

31. Social jet lag refers to:

- A. International travel
- B. Discrepancy between biological and social time
- C. Shift work only
- D. Sleep disorders

32. Adolescents' circadian clocks naturally shift later during:

- A. Childhood
- B. Adulthood
- C. Old age
- D. Puberty

33. Chronotherapy involves:
- A. Timing medication to circadian rhythms
  - B. Removing clocks
  - C. Only light therapy
  - D. Surgery
34. Cancer chemotherapy timed to circadian rhythms can:
- A. Only reduce side effects
  - B. Only improve efficacy
  - C. Enhance tumor killing while sparing healthy tissues
  - D. Cure all cancers

### **PASSAGE III**

Ocean acidification, often called climate change's "evil twin," results from the ocean absorbing approximately 30% of atmospheric carbon dioxide emitted by human activities. When CO<sub>2</sub> dissolves in seawater, it forms carbonic acid, lowering ocean pH. Since the Industrial Revolution, ocean surface pH has declined from approximately 8.2 to 8.1—seemingly small but representing a 30% increase in acidity due to the logarithmic pH scale. Projections suggest pH could drop to 7.8 by 2100 under high-emission scenarios, representing conditions unprecedented in millions of years and posing severe threats to marine ecosystems and human economies dependent on ocean resources.

The chemistry underlying ocean acidification involves carbonate chemistry equilibria. Dissolved CO<sub>2</sub> reacts with water forming carbonic acid, which dissociates into hydrogen ions and bicarbonate. Increased hydrogen ions combine with carbonate ions, reducing carbonate availability. This matters critically because many marine organisms—including corals, mollusks, and some plankton—require carbonate to build calcium carbonate shells and skeletons. As carbonate becomes scarce, calcification rates decline, and in severely acidic conditions, existing structures can dissolve. Pteropods (sea butterflies), important prey for salmon and other fish, show shell dissolution in acidified waters. Coral reefs, already stressed by warming waters, face compounded threats as acidification impairs their ability to build reef structures.

Biological impacts extend beyond calcifying organisms. Fish exposed to elevated CO<sub>2</sub> levels exhibit altered behavior, including impaired predator detection, disrupted homing abilities, and changes in boldness and activity patterns. These behavioral changes stem from CO<sub>2</sub> interfering with neurotransmitter function, particularly GABA receptors in fish brains. While adult fish may tolerate moderately acidified conditions, early life stages often prove more vulnerable. Laboratory studies show reduced survival and growth in larval fish under projected future ocean conditions. Some species may adapt through evolution or acclimatization, but the rapid pace of acidification may outstrip adaptive capacity for many organisms.

Economic and ecosystem consequences ripple through marine food webs and human communities. The shellfish industry faces direct threats, with Pacific Northwest oyster hatcheries already experiencing massive die-offs linked to acidified upwelling waters. Commercial fisheries depending on species sensitive to acidification could see reduced catches. Coral reef degradation threatens not only biodiversity but also coastal protection, tourism, and fisheries supporting hundreds of millions of people. Acidification combines with other stressors—warming, deoxygenation, pollution—creating compound effects worse than any single stressor alone.

Addressing ocean acidification ultimately requires reducing CO<sub>2</sub> emissions, as no technological fix can reverse acidification at ocean-wide scales. Even aggressive emissions reductions would leave oceans more acidic than pre-industrial levels for centuries due to the long residence time of CO<sub>2</sub> in ocean-atmosphere systems. Local interventions offer limited relief: protecting coastal ecosystems like seagrass beds and mangroves that absorb CO<sub>2</sub>, establishing marine protected areas to enhance resilience, and developing selective breeding programs for tolerant shellfish strains. Research into enhanced weathering—adding alkaline minerals to seawater to neutralize acidity—remains experimental and raises questions about unintended consequences. Meanwhile, monitoring networks track acidification's progression, and models project future conditions, but solutions require global cooperation on emissions reduction combined with local adaptation strategies to protect vulnerable species and communities.

35. Ocean acidification results from the ocean absorbing what percentage of atmospheric CO<sub>2</sub>?

- A. 10%
- B. 50%
- C. 70%
- D. 30%

36. Since the Industrial Revolution, ocean surface pH has declined from 8.2 to:

- A. 7.8
- B. 8.1
- C. 8.0
- D. 7.9

37. A pH decline from 8.2 to 8.1 represents what increase in acidity?

- A. 10%
- B. 20%
- C. 30%
- D. 50%

38. Projections suggest ocean pH could drop to what level by 2100?

- A. 7.8
- B. 8.0

- C. 7.5
- D. 7.9

39. Carbonate is critical for marine organisms to build:

- A. Proteins
- B. DNA
- C. Cell membranes
- D. Calcium carbonate shells and skeletons

40. Pteropods are important prey for:

- A. Whales
- B. Plankton
- C. Salmon and other fish
- D. Coral

41. In acidified waters, pteropod shells show:

- A. Growth enhancement
- B. Dissolution
- C. Color changes only
- D. No changes

42. Fish behavior changes from elevated CO<sub>2</sub> stem from interference with:

- A. Neurotransmitter function
- B. Gill function
- C. Digestive processes
- D. Reproduction

43. Early life stages of fish compared to adults are:

- A. More tolerant
- B. Equally tolerant
- C. Less tolerant
- D. More vulnerable

44. Pacific Northwest oyster hatcheries have experienced die-offs linked to:

- A. Overfishing
- B. Pollution only
- C. Acidified upwelling waters
- D. Temperature only

45. Coral reef degradation threatens:

- A. Only tourism
  - B. Coastal protection, tourism, and fisheries
  - C. Only fisheries
  - D. Only biodiversity
46. Acidification combines with other stressors including:
- A. Only warming
  - B. Only pollution
  - C. Only deoxygenation
  - D. Warming, deoxygenation, and pollution
47. The ultimate solution to ocean acidification requires:
- A. Reducing CO<sub>2</sub> emissions
  - B. Only local interventions
  - C. Adding chemicals to oceans
  - D. Removing all fish
48. Even with aggressive emissions reductions, oceans would remain more acidic than pre-industrial levels for:
- A. Decades
  - B. Years
  - C. Centuries
  - D. Months
49. Seagrass beds and mangroves help by:
- A. Producing oxygen only
  - B. Absorbing CO<sub>2</sub>
  - C. Providing food only
  - D. Creating barriers
50. Enhanced weathering involves:
- A. Adding alkaline minerals to seawater
  - B. Removing salt
  - C. Heating the ocean
  - D. Cooling the ocean

## Quantitative Reasoning

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1. What is the area of a circle with diameter 10 cm? (Use  $\pi \approx 3.14$ )

- A.  $31.4 \text{ cm}^2$
- B.  $62.8 \text{ cm}^2$
- C.  $78.5 \text{ cm}^2$
- D.  $100 \text{ cm}^2$

2. Solve for  $x$ :  $8x - 12 = 36$

- A. 6
- B. 3
- C. 8
- D. 4

3. What is  $\frac{4}{5} + \frac{1}{4}$ ?

- A.  $\frac{5}{9}$
- B.  $\frac{1}{2}$
- C.  $\frac{9}{10}$
- D.  $\frac{21}{20}$

4. If a triangle has angles measuring  $55^\circ$ ,  $70^\circ$ , and  $x^\circ$ , what is  $x$ ?

- A.  $45^\circ$
- B.  $60^\circ$
- C.  $50^\circ$
- D.  $55^\circ$

5. What is the perimeter of a rectangle with length 14 cm and width 8 cm?

- A. 22 cm
- B. 112 cm
- C. 44 cm
- D. 56 cm

6. Solve the inequality:  $4x + 7 > 31$

- A.  $x > 5$
- B.  $x > 6$
- C.  $x > 8$
- D.  $x < 6$

7. What is the value of  $5^3 - 3^3$ ?

- A. 98
- B. 125
- C. 27
- D. 152

8. If 35% of a number is 70, what is the number?
- A. 24.5
  - B. 100
  - C. 150
  - D. 200
9. What is the median of the set {25, 17, 21, 29, 18}?
- A. 25
  - B. 18
  - C. 21
  - D. 22
10. A car travels 240 miles in 4 hours. What is its average speed?
- A. 50 mph
  - B. 60 mph
  - C. 70 mph
  - D. 80 mph
11. What is  $\frac{5}{6} - \frac{1}{3}$ ?
- A.  $\frac{4}{3}$
  - B.  $\frac{2}{3}$
  - C.  $\frac{1}{3}$
  - D.  $\frac{1}{2}$
12. What is the slope of a line passing through points (2, 5) and (6, 13)?
- A. 2
  - B. 3
  - C. 4
  - D. 1
13. What is  $|-22| - |9|$ ?
- A. 31
  - B. -31
  - C. 13
  - D. -13
14. If  $\frac{12}{x} = \frac{36}{48}$ , what is x?
- A. 12
  - B. 16

- C. 18
- D. 20

15. What is the volume of a cube with edge length 6 cm?

- A.  $216 \text{ cm}^3$
- B.  $36 \text{ cm}^3$
- C.  $144 \text{ cm}^3$
- D.  $72 \text{ cm}^3$

16. Solve the system:  $x + y = 20$  and  $x - y = 8$

- A.  $x = 12, y = 8$
- B.  $x = 14, y = 6$
- C.  $x = 16, y = 4$
- D.  $x = 13, y = 7$

17. What is  $\sin 90^\circ$ ?

- A. 0
- B.  $\sqrt{2}/2$
- C.  $\sqrt{3}/2$
- D. 1

18. If a rectangle has area  $96 \text{ cm}^2$  and width 8 cm, what is its length?

- A. 12 cm
- B. 10 cm
- C. 14 cm
- D. 16 cm

19. What is the least common multiple (LCM) of 15 and 20?

- A. 5
- B. 30
- C. 60
- D. 75

20. A bag contains 5 red balls and 10 blue balls. What is the probability of drawing a blue ball?

- A.  $1/3$
- B.  $1/2$
- C.  $1/5$
- D.  $2/3$

21. What is the distance between points (1, 4) and (5, 7)?

- A. 3
- B. 4
- C. 7
- D. 5

22. If  $y$  varies inversely as  $x$ , and  $y = 20$  when  $x = 4$ , what is  $y$  when  $x = 10$ ?

- A. 50
- B. 40
- C. 8
- D. 10

23. What is  $\tan 60^\circ$ ?

- A.  $1/2$
- B.  $\sqrt{3}$
- C.  $\sqrt{2}/2$
- D. 1

24. If a square has area  $121 \text{ cm}^2$ , what is its perimeter?

- A. 11 cm
- B. 22 cm
- C. 33 cm
- D. 44 cm

25. Evaluate:  $f(x) = 4x - 9$  when  $x = 6$

- A. 15
- B. 24
- C. 21
- D. 18

26. What is  $7/8$  expressed as a percentage?

- A. 78%
- B. 85%
- C. 87.5%
- D. 80%

27. Solve for  $x$ :  $6x - 3 = 4x + 13$

- A. 5
- B. 8
- C. 6
- D. 10

28. What is the surface area of a cube with edge length 7 cm?
- A.  $196 \text{ cm}^2$
  - B.  $245 \text{ cm}^2$
  - C.  $343 \text{ cm}^2$
  - D.  $294 \text{ cm}^2$
29. What is the greatest common factor (GCF) of 54 and 72?
- A. 18
  - B. 9
  - C. 6
  - D. 27
30. A triangle has angles measuring  $40^\circ$ ,  $75^\circ$ , and  $x^\circ$ . What is  $x$ ?
- A.  $55^\circ$
  - B.  $60^\circ$
  - C.  $65^\circ$
  - D.  $70^\circ$
31. What is the value of  $8^2 - 5^2$ ?
- A. 9
  - B. 25
  - C. 39
  - D. 64
32. Simplify:  $5/6 - 1/4$
- A.  $7/12$
  - B.  $4/6$
  - C.  $1/2$
  - D.  $2/3$
33. A cylinder has radius 3 cm and height 7 cm. What is its volume? (Use  $\pi \approx 3.14$ )
- A.  $132.72 \text{ cm}^3$
  - B.  $197.82 \text{ cm}^3$
  - C.  $150 \text{ cm}^3$
  - D.  $250 \text{ cm}^3$
34. What is 50 decreased by 30%?
- A. 20
  - B. 30

- C. 35
- D. 40

35. If  $\cos \theta = 1/2$ , what is  $\theta$  in degrees ( $0^\circ < \theta < 90^\circ$ )?

- A.  $30^\circ$
- B.  $60^\circ$
- C.  $45^\circ$
- D.  $90^\circ$

36. Solve:  $5(x + 2) = 3x + 26$

- A. 6
- B. 7
- C. 9
- D. 8

37. What is the range of the dataset: {18, 32, 24, 40, 26}?

- A. 18
- B. 24
- C. 22
- D. 26

38. If  $x^2 = 169$ , what are the possible values of  $x$ ?

- A.  $\pm 13$
- B. -13 only
- C. 84.5
- D. 13 only

39. What is  $\cos 45^\circ$ ?

- A.  $1/2$
- B.  $\sqrt{2}/2$
- C.  $\sqrt{3}/2$
- D. 1

40. Simplify:  $(20x^6y^5)/(5x^4y^3)$

- A.  $4x^2y$
- B.  $15x^2y^2$
- C.  $5x^2y^2$
- D.  $4x^2y^2$

# Answer Explanations - Practice Test 6

## Survey Of Natural Sciences

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### **BIOLOGY (Questions 1-40)**

#### **1. Correct Answer: B (Golgi apparatus)**

The Golgi apparatus (Golgi complex) is responsible for modifying, sorting, and packaging proteins for secretion or delivery to other organelles. Proteins from the endoplasmic reticulum enter the Golgi, where they undergo post-translational modifications, are sorted, and packaged into vesicles for transport. The endoplasmic reticulum synthesizes proteins, lysosomes digest materials, and ribosomes are the sites of protein synthesis.

#### **2. Correct Answer: A (Atria and ventricles)**

The atrioventricular (AV) node is located between the atria and ventricles, specifically in the lower interatrial septum near the junction with the ventricles. It receives electrical signals from the SA node and delays transmission to allow the atria to contract before the ventricles, coordinating heart chamber contractions.

#### **3. Correct Answer: D (Anaphase II)**

Separation of sister chromatids occurs during Anaphase II of meiosis. During Anaphase I, homologous chromosomes separate, while sister chromatids remain attached. In Anaphase II (similar to mitotic anaphase), sister chromatids finally separate and move to opposite poles, producing four haploid cells.

#### **4. Correct Answer: C (Blue-green)**

Carotenoids are accessory pigments that primarily absorb light in the blue-green wavelength range (400-550 nm) and reflect yellow, orange, or red light. They complement chlorophyll by absorbing wavelengths that chlorophyll doesn't absorb efficiently, transferring that energy to chlorophyll for photosynthesis.

#### **5. Correct Answer: B (Nonsense mutation)**

A nonsense mutation is a point mutation that converts a codon specifying an amino acid into a stop codon (UAA, UAG, or UGA), prematurely terminating protein synthesis. Silent mutations don't change amino acids, missense mutations change one amino acid to another, and frameshift mutations involve insertions or deletions.

#### **6. Correct Answer: D (Liver)**

The liver produces and secretes bile, which is then stored and concentrated in the gallbladder. Bile contains bile salts that emulsify fats, facilitating their digestion and absorption in the small intestine. The pancreas produces digestive enzymes but not bile.

**7. Correct Answer: C (RuBisCO)**

RuBisCO (ribulose-1,5-bisphosphate carboxylase/oxygenase) catalyzes carbon fixation in the Calvin cycle by attaching CO<sub>2</sub> to ribulose biphosphate (RuBP). This is the first step in converting inorganic carbon into organic compounds. RuBisCO is considered the most abundant protein on Earth.

**8. Correct Answer: C (Primase)**

Primase synthesizes short RNA primers (about 10 nucleotides) that provide the 3'-OH group needed for DNA polymerase to begin synthesis. DNA polymerase cannot start synthesis de novo and requires these primers. Helicase unwinds DNA, and ligase joins DNA fragments.

**9. Correct Answer: B (Hypothalamus)**

Oxytocin is produced by neurosecretory cells in the hypothalamus and transported to the posterior pituitary for storage and release. The posterior pituitary doesn't produce hormones but stores and releases oxytocin and ADH. The anterior pituitary produces different hormones like growth hormone and prolactin.

**10. Correct Answer: A (Platelets)**

Platelets (thrombocytes) are the blood component primarily responsible for blood clotting. They aggregate at injury sites, release clotting factors, and form platelet plugs. They also initiate the coagulation cascade leading to fibrin formation. White blood cells fight infection, red blood cells transport oxygen, and plasma proteins include clotting factors but aren't cellular.

**11. Correct Answer: D (Glucose, amino acids, and sodium)**

The proximal convoluted tubule is the primary site for reabsorption of glucose, amino acids, sodium, and many other valuable substances from the filtrate back into the blood. Approximately 65% of filtered sodium and water, and nearly 100% of glucose and amino acids, are reabsorbed here under normal conditions.

**12. Correct Answer: C (RNA processing)**

In eukaryotes, the 5' cap (7-methylguanosine cap) is added to mRNA during RNA processing (post-transcriptional modification) in the nucleus. The cap protects mRNA from degradation and assists in ribosome binding during translation. This occurs after transcription but before translation.

**13. Correct Answer: B (Left atrium and left ventricle)**

The bicuspid (mitral) valve is located between the left atrium and left ventricle. It has two cusps (leaflets) and prevents backflow of blood from the ventricle to the atrium during ventricular contraction. The tricuspid valve is on the right side.

**14. Correct Answer: C (Requires ATP)**

Active transport differs from facilitated diffusion in that it requires ATP (energy) to move substances against their concentration gradient (from low to high concentration). Both use carrier proteins and are selective, but only active transport is energy-dependent and can work against gradients.

**15. Correct Answer: B (Uric acid)**

Uric acid is the primary nitrogenous waste excreted by birds and reptiles. It's highly insoluble, requiring minimal water for excretion, which is advantageous for conserving water. Uric acid is excreted as a paste or solid. Mammals excrete urea, and aquatic animals often excrete ammonia.

**16. Correct Answer: B (Negative repressible regulation)**

The trp operon is an example of negative repressible regulation. When tryptophan (the corepressor) is present, it binds to the trp repressor, activating it to bind to the operator and block transcription. The operon is "repressed" by the presence of its end product. This differs from the lac operon's inducible system.

**17. Correct Answer: A (Medulla oblongata)**

The respiratory control center is located in the medulla oblongata (part of the brainstem). It contains neurons that set the basic rhythm of breathing by regulating the contraction of respiratory muscles. The medulla monitors CO<sub>2</sub>, O<sub>2</sub>, and pH levels to adjust breathing rate.

**18. Correct Answer: D (Oogenesis)**

Oogenesis is the process of gamete (egg) formation in females. It occurs in the ovaries and involves meiotic division to produce haploid ova (eggs). Spermatogenesis is male gamete formation, mitosis produces diploid cells, and fertilization is the fusion of gametes.

**19. Correct Answer: C (Progesterone)**

The luteal phase of the menstrual cycle (days 14-28) is characterized by high secretion of progesterone from the corpus luteum. Progesterone prepares and maintains the uterine lining for potential implantation. FSH and LH levels are relatively low during this phase, and estrogen is also secreted but progesterone dominates.

**20. Correct Answer: B (Genetic recombination)**

Class switching (isotype switching) in antibodies is an example of genetic recombination where B cells switch from producing one class of antibody (e.g., IgM) to another (e.g., IgG, IgA, or IgE) without changing antigen specificity. This involves DNA rearrangement in the constant region genes.

**21. Correct Answer: D (Gas exchange and water loss)**

Stomata in plant leaves primarily regulate gas exchange (CO<sub>2</sub> intake for photosynthesis and O<sub>2</sub> release) and transpiration (water loss). Guard cells surrounding stomata open and close the pores in response to environmental conditions and plant needs, balancing CO<sub>2</sub> uptake with water conservation.

**22. Correct Answer: A (Catecholamine)**

Dopamine is classified as a catecholamine neurotransmitter, along with norepinephrine and epinephrine. Catecholamines are synthesized from the amino acid tyrosine and contain a catechol group (benzene ring with two hydroxyl groups). They play roles in mood, movement, reward, and the stress response.

**23. Correct Answer: C (Actin)**

During muscle contraction, the myosin head binds to actin filaments, forming cross-bridges. This binding, powered by ATP hydrolysis, causes the power stroke that pulls actin filaments toward the center of the sarcomere, shortening the muscle. Troponin and tropomyosin are regulatory proteins that control access to actin binding sites.

**24. Correct Answer: B (Oxytocin)**

Oxytocin triggers the release (ejection) of milk from mammary glands during lactation. When an infant suckles, nerve signals stimulate oxytocin release from the posterior pituitary, causing contraction of myoepithelial cells surrounding milk-producing alveoli. Prolactin stimulates milk production, not release.

**25. Correct Answer: A (Mitochondrial matrix)**

The citric acid cycle (Krebs cycle or TCA cycle) occurs in the mitochondrial matrix, the fluid-filled space inside the inner mitochondrial membrane. Here, acetyl-CoA is oxidized to produce NADH, FADH<sub>2</sub>, and GTP/ATP. The electron transport chain is in the inner membrane.

**26. Correct Answer: D (Secondary immune response)**

Memory B cells are responsible for the rapid and enhanced secondary immune response upon re-exposure to an antigen. They are long-lived cells formed during the primary immune response. Upon re-encountering their specific antigen, they quickly differentiate into plasma cells producing large amounts of antibodies.

**27. Correct Answer: C (Myelinated axons)**

Saltatory conduction occurs in myelinated axons, where action potentials "jump" from one node of Ranvier to the next, greatly increasing conduction velocity. The myelin sheath insulates the axon, and depolarization occurs only at the nodes. Unmyelinated axons conduct signals continuously and more slowly.

**28. Correct Answer: B (G1 checkpoint)**

The G1 checkpoint (restriction point) checks for DNA damage, adequate cell size, and sufficient nutrients before the cell commits to DNA replication. If DNA damage is detected, the cell can pause for repair or undergo apoptosis. The G2 checkpoint checks for DNA damage after replication, and the M checkpoint ensures proper chromosome attachment.

**29. Correct Answer: D (Alveoli)**

The bronchioles terminate in alveoli, tiny air sacs where gas exchange occurs between air and blood. Alveoli have thin walls surrounded by capillaries, allowing efficient diffusion of oxygen into blood and carbon dioxide out. The large surface area of millions of alveoli maximizes gas exchange.

**30. Correct Answer: A (Rapidly regenerate ATP)**

Creatine phosphate (phosphocreatine) in muscle cells functions to rapidly regenerate ATP during the first few seconds of intense muscle activity. It transfers its phosphate group to ADP, forming ATP, providing immediate energy before other energy systems activate. This system doesn't require oxygen.

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

The Hershey-Chase experiment (1952) demonstrated that DNA, not protein, is the genetic material. They used bacteriophages labeled with radioactive phosphorus (in DNA) or sulfur (in protein) and showed that only the DNA entered bacterial cells and was passed to offspring, proving DNA carries genetic information.

**32. Correct Answer: B (Progesterone)**

The secretory phase of the menstrual cycle (luteal phase, days 14-28) is stimulated primarily by progesterone from the corpus luteum. Progesterone causes the endometrium to become secretory, with glands producing glycogen-rich secretions to support a potential embryo. Estrogen also plays a role but progesterone dominates.

**33. Correct Answer: A (Small intestine)**

Vitamin and mineral absorption occurs primarily in the small intestine, particularly in the jejunum and ileum. The large surface area provided by villi and microvilli facilitates absorption of most nutrients, including fat-soluble vitamins (A, D, E, K), water-soluble vitamins, and minerals like calcium and iron.

**34. Correct Answer: D (Post-transcriptional regulation)**

RNA interference (RNAi) is a form of post-transcriptional regulation where small RNA molecules (siRNA or miRNA) bind to complementary mRNA sequences, leading to mRNA degradation or translation inhibition. This silences gene expression after transcription but before translation.

**35. Correct Answer: B (Cones)**

The fovea centralis, the area of sharpest vision in the retina, contains primarily cones (color-detecting photoreceptors) with very few or no rods. The high density of cones in the fovea provides high visual acuity and color discrimination. Rods are more prevalent in peripheral retina for dim light and motion detection.

**36. Correct Answer: C (Topoisomerase)**

Topoisomerase relieves tension (supercoiling) ahead of the replication fork by cutting one or both DNA strands, allowing the DNA to unwind, then rejoining the strands. Without topoisomerase, the unwinding by helicase would create excessive tension that would halt replication.

**37. Correct Answer: D (Fat storage)**

Yellow bone marrow primarily functions in fat (adipose tissue) storage. It's found in the medullary cavity of long bones in adults. Red marrow produces blood cells, while yellow marrow serves as an energy reserve and can convert back to red marrow if needed during severe blood loss.

**38. Correct Answer: A (Myosin only)**

The H-zone in a sarcomere contains only myosin (thick) filaments, with no actin (thin) filament overlap. During muscle contraction, the H-zone narrows as actin filaments slide deeper between myosin filaments. The I-band contains only actin, while the A-band includes the overlap zone and H-zone.

**39. Correct Answer: B (Increasing sodium reabsorption)**

Aldosterone increases water reabsorption indirectly by increasing sodium reabsorption in the distal tubule and collecting duct. As sodium is reabsorbed, water follows osmotically. Aldosterone also promotes potassium secretion. Unlike ADH, which directly inserts water channels, aldosterone works through sodium transport.

**40. Correct Answer: C (0.16)**

In Hardy-Weinberg equilibrium, if  $p = 0.6$ , then  $q = 1 - 0.6 = 0.4$ . The frequency of homozygous recessive individuals is  $q^2 = (0.4)^2 = 0.16$  or 16%. The frequencies are:  $AA = p^2 = 0.36$ ,  $Aa = 2pq = 0.48$ ,  $aa = q^2 = 0.16$ .

## GENERAL CHEMISTRY (Questions 41-70)

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

Calcium has atomic number 20, meaning it has 20 electrons. Following the Aufbau principle:  $1s^2$  (2),  $2s^2$  (2),  $2p^6$  (6),  $3s^2$  (2),  $3p^6$  (6),  $4s^2$  (2), totaling 20 electrons. Note that 4s fills before 3d. Calcium is in Group 2 with 2 valence electrons in the 4s orbital.

### 42. Correct Answer: D (Occupy orbitals singly before pairing)

Hund's rule states that electrons occupy orbitals of equal energy (degenerate orbitals) singly with parallel spins before pairing up. This minimizes electron-electron repulsion. For example, the three 2p orbitals each get one electron before any gets a second. The Aufbau principle is about filling order, and the Pauli exclusion principle is about quantum numbers.

### 43. Correct Answer: B (12)

NaOH is a strong base that completely dissociates:  $[\text{OH}^-] = 0.01 \text{ M} = 1 \times 10^{-2} \text{ M}$ . Calculate  $\text{pOH} = -\log[\text{OH}^-] = -\log(10^{-2}) = 2$ . Then  $\text{pH} = 14 - \text{pOH} = 14 - 2 = 12$ . This represents a strongly basic solution.

### 44. Correct Answer: C (Water)

Among these compounds, water has the lowest vapor pressure at  $25^\circ\text{C}$  because it has the strongest intermolecular forces (hydrogen bonding). Lower vapor pressure indicates stronger intermolecular attractions keeping molecules in the liquid phase. Diethyl ether has weak London forces and the highest vapor pressure, while acetone and ethanol are intermediate.

### 45. Correct Answer: A (Oxidized)

In the reaction  $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$ , iron loses an electron, so it is oxidized (its oxidation state increases from +2 to +3). Oxidation is loss of electrons (OIL), and reduction is gain of electrons (RIG). This is the oxidation half-reaction.

### 46. Correct Answer: D (32)

The maximum number of electrons in an energy level is calculated using  $2n^2$ , where  $n$  is the principal quantum number. For  $n = 4$ :  $2(4)^2 = 2(16) = 32$  electrons maximum. These fill the 4s (2), 4p (6), 4d (10), and 4f (14) subshells.

### 47. Correct Answer: C (Angular momentum (l))

The angular momentum quantum number ( $l$ ) determines the shape of an orbital. Values of  $l$  correspond to orbital types:  $l = 0$  (s, spherical),  $l = 1$  (p, dumbbell),  $l = 2$  (d, cloverleaf),  $l = 3$  (f, complex). The principal quantum number ( $n$ ) determines size/energy, magnetic ( $m$ ) determines orientation, and spin ( $s$ ) determines electron spin direction.

**48. Correct Answer: B (pH = pK<sub>a</sub>)**

A buffer is most resistant to pH change when  $\text{pH} = \text{pK}_a$  of the weak acid component, meaning  $[\text{A}^-] = [\text{HA}]$ . This is when the buffer has maximum capacity according to the Henderson-Hasselbalch equation:  $\text{pH} = \text{pK}_a + \log([\text{A}^-]/[\text{HA}])$ . Equal concentrations provide the best buffering.

**49. Correct Answer: D (Gay-Lussac's Law)**

Gay-Lussac's Law states that pressure is directly proportional to temperature at constant volume:  $P_1/T_1 = P_2/T_2$  (or  $P \propto T$ ). Boyle's Law relates  $P$  and  $V$  at constant  $T$ , Charles's Law relates  $V$  and  $T$  at constant  $P$ , and Avogadro's Law relates  $V$  and moles at constant  $P$  and  $T$ .

**50. Correct Answer: A (+6)**

In  $\text{SO}_3$  (sulfur trioxide), oxygen has oxidation state  $-2$ . Using the rule that the sum equals  $0$  for a neutral molecule:  $S + 3(-2) = 0$ , which gives  $S + (-6) = 0$ , so  $S = +6$ . This is sulfur's maximum oxidation state.

**51. Correct Answer: C (State function)**

Enthalpy ( $H$ ) is a state function, meaning its value depends only on the current state of the system ( $P$ ,  $T$ , composition), not on the path taken to reach that state. Changes in enthalpy ( $\Delta H$ ) are path-independent. Temperature, pressure, and volume are also state functions, while heat and work are path functions.

**52. Correct Answer: B (5 moles)**

The number of moles is calculated using:  $\text{moles} = \text{mass}/\text{molar mass} = 90 \text{ g} / 18 \text{ g/mol} = 5 \text{ moles}$ . This tests understanding of the relationship between mass, molar mass, and moles.

**53. Correct Answer: D (Rb)**

Rubidium (Rb) has the largest atomic radius among these elements. Atomic radius increases down a group (due to additional electron shells) and decreases across a period (due to increasing nuclear charge). Rb is in period 5, Group 1, while Li, Na, and K are in the same group but higher periods, making Rb the largest.

**54. Correct Answer: A (Equilibrium of a saturated solution)**

The solubility product constant ( $K_{sp}$ ) represents the equilibrium constant for a saturated solution of a sparingly soluble ionic compound. It equals the product of the ion concentrations, each raised to the power of its coefficient.  $K_{sp}$  indicates how soluble a compound is—lower  $K_{sp}$  means lower solubility.

**55. Correct Answer: C ( $\Delta H < 0$ ,  $\Delta S > 0$ )**

For a reaction to be spontaneous at all temperatures,  $\Delta G$  must be negative at all T. Since  $\Delta G = \Delta H - T\Delta S$ , if  $\Delta H$  is negative (exothermic) and  $\Delta S$  is positive (entropy increases), then  $\Delta G$  will always be negative regardless of temperature. Both favorable factors work together.

**56. Correct Answer: D (4 M)**

Molarity (M) is calculated as moles of solute divided by liters of solution:  $M = 8 \text{ moles} / 2 \text{ liters} = 4 \text{ M}$ . This represents a concentrated solution.

**57. Correct Answer: A (Parallel overlap of p orbitals)**

Pi ( $\pi$ ) bonds are formed by parallel (side-by-side) overlap of p orbitals perpendicular to the internuclear axis. This creates electron density above and below the bond axis. Sigma bonds form from end-to-end overlap. Pi bonds are weaker and restrict rotation around the bond.

**58. Correct Answer: D (High  $K_b$ )**

A strong base has a high  $K_b$  (base dissociation constant), indicating that it dissociates extensively in water to produce hydroxide ions. Strong bases like NaOH and KOH dissociate almost completely. Weak bases have low  $K_b$  values. Strong bases create high pH solutions.

**59. Correct Answer: B (1/8)**

For a radioactive isotope with half-life of 10 years, after 30 years (3 half-lives), the fraction remaining is  $(1/2)^3 = 1/8$ . After one half-life (10 years),  $1/2$  remains. After two half-lives (20 years),  $1/4$  remains. After three half-lives (30 years),  $1/8$  remains.

**60. Correct Answer: C (Cs)**

Cesium (Cs) is the least electronegative among these elements. Electronegativity decreases down a group and increases across a period. Cs is in period 6, Group 1 (alkali metals have the lowest electronegativities). Fluorine has the highest electronegativity, oxygen and chlorine are also highly electronegative.

**61. Correct Answer: D (Bent)**

The molecular geometry of  $\text{H}_2\text{S}$  (hydrogen sulfide) is bent. Sulfur has four electron groups (two bonding pairs with hydrogen and two lone pairs). According to VSEPR theory, these arrange in a tetrahedral electron geometry, but the molecular geometry considering only atoms is bent with a bond angle of approximately  $92^\circ$  (smaller than water's  $104.5^\circ$  due to sulfur's larger size).

**62. Correct Answer: A (Anode)**

In an electrolytic cell (non-spontaneous, requires external voltage), oxidation still occurs at the anode (positive electrode), and reduction occurs at the cathode (negative electrode). The polarity is reversed compared to galvanic cells, but oxidation location remains the anode. Remember: "An Ox" (Anode Oxidation).

**63. Correct Answer: C (8.314 J/(mol·K))**

The ideal gas constant  $R$  in SI units is 8.314 J/(mol·K). Other common values include 0.0821 atm·L/(mol·K) and 62.4 L·torr/(mol·K), depending on the units used for pressure and volume in the ideal gas law  $PV = nRT$ .

**64. Correct Answer: B (Isotopes)**

Isotopes are atoms of the same element (same number of protons) with different mass numbers due to different numbers of neutrons. For example, carbon-12 and carbon-14 are isotopes. Ions have different electron counts, isomers have the same molecular formula but different structures, and allotropes are different forms of the same element.

**65. Correct Answer: A (Rate =  $k[A]$ )**

For a first-order reaction, the rate law is  $\text{Rate} = k[A]$ , where the rate depends linearly on the concentration of reactant A. The exponent is 1. Zero-order is  $\text{Rate} = k$ , second-order is  $\text{Rate} = k[A]^2$ , and a reaction involving two reactants would be  $\text{Rate} = k[A][B]$ .

**66. Correct Answer: B (H<sub>2</sub>O)**

The conjugate acid of OH<sup>-</sup> (hydroxide ion) is H<sub>2</sub>O (water). When a base accepts a proton (H<sup>+</sup>), it becomes its conjugate acid:  $\text{OH}^- + \text{H}^+ \rightarrow \text{H}_2\text{O}$ . Water is amphoteric—it can act as both an acid and a base.

**67. Correct Answer: C (3)**

The bond order of N<sub>2</sub> (nitrogen gas) is 3, representing a triple bond. The molecular orbital configuration shows three bonding orbitals filled and no antibonding orbitals filled:  $\text{bond order} = (\text{bonding electrons} - \text{antibonding electrons})/2 = (10 - 4)/2 = 3$ . This makes N<sub>2</sub> very stable and unreactive.

**68. Correct Answer: A (Increase pressure)**

According to Gay-Lussac's Law, at constant volume, increasing temperature will increase pressure. Temperature and pressure are directly proportional:  $P \propto T$  (when  $V$  and  $n$  are constant). Higher temperature means greater kinetic energy and more forceful collisions, increasing pressure.

**69. Correct Answer: D (-1)**

The oxidation number of oxygen in  $\text{H}_2\text{O}_2$  (hydrogen peroxide) is -1, which is unusual. In most compounds oxygen is -2, but in peroxides (O-O bond) it's -1. Using the rule:  $2(+1) + 2(\text{O}) = 0$ , which gives  $2 + 2\text{O} = 0$ , so  $\text{O} = -1$ .

**70. Correct Answer: B (Colligative property)**

Osmotic pressure is a colligative property—it depends on the number of solute particles in solution, not their identity. Other colligative properties include vapor pressure lowering, boiling point elevation, and freezing point depression. These properties are proportional to solute concentration.

**ORGANIC CHEMISTRY (Questions 71-100)**

**71. Correct Answer: A ( $\text{C}_n\text{H}_{2n-2}$ )**

The general formula for alkynes is  $\text{C}_n\text{H}_{2n-2}$ , where  $n$  is the number of carbon atoms. Alkynes contain one carbon-carbon triple bond. For example, ethyne (acetylene) is  $\text{C}_2\text{H}_2$  ( $n=2$ :  $\text{C}_2\text{H}_{4-2} = \text{C}_2\text{H}_2$ ), propyne is  $\text{C}_3\text{H}_4$ . Alkanes are  $\text{C}_n\text{H}_{2n+2}$ , and alkenes are  $\text{C}_n\text{H}_{2n}$ .

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

The functional group that characterizes ketones is a carbonyl ( $\text{C}=\text{O}$ ) bonded to two carbon atoms. This distinguishes ketones from aldehydes, where the carbonyl is bonded to at least one hydrogen and one carbon. -OH is hydroxyl (alcohols), -CHO is aldehyde, and - $\text{NH}_2$  is amino (amines).

**73. Correct Answer: C (Butane)**

The IUPAC name for  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$  is butane. This is a straight-chain alkane with four carbon atoms. The systematic naming is: but- (4 carbons) + -ane (alkane) = butane.

**74. Correct Answer: B (Diastereomers)**

Stereoisomers that are not mirror images are called diastereomers. This includes cis-trans (geometric) isomers and other stereoisomers with multiple chiral centers that aren't enantiomers. Enantiomers are mirror-image stereoisomers, constitutional isomers have different connectivity, and conformers are different rotational arrangements.

**75. Correct Answer: D (Hydrogenation)**

Hydrogenation is the reaction that adds hydrogen ( $\text{H}_2$ ) across a double bond in the presence of a catalyst (Pt, Pd, or Ni), converting an alkene to an alkane. For example, ethene +  $\text{H}_2 \rightarrow$  ethane. Hydration adds water, halogenation adds halogens, and dehydration removes water.

**76. Correct Answer: A (Amide)**

Amides are the least reactive carbonyl compounds toward nucleophilic addition because the nitrogen's lone pair delocalizes into the carbonyl through resonance, reducing the carbonyl's electrophilicity. Reactivity order: acid chlorides > anhydrides > aldehydes > ketones > esters > amides (least reactive).

**77. Correct Answer: A (Benedict's test)**

Benedict's test uses copper(II) ions in alkaline solution to detect reducing sugars. Reducing sugars reduce  $\text{Cu}^{2+}$  (blue) to  $\text{Cu}^+$ , forming a brick-red precipitate of  $\text{Cu}_2\text{O}$ . The iodine test detects starch, Biuret test detects proteins, and ninhydrin test detects amino acids.

**78. Correct Answer: C ( $\text{sp}^2$ )**

The hybridization of carbon in ethene ( $\text{C}_2\text{H}_4$ ) is  $\text{sp}^2$ . Each carbon forms three sigma bonds (one  $\text{C}=\text{C}$  and two  $\text{C}-\text{H}$ ) and one pi bond (the second bond in  $\text{C}=\text{C}$ ), requiring three hybrid orbitals from  $\text{sp}^2$  hybridization. The molecule is planar with  $120^\circ$  bond angles.

**79. Correct Answer: D (H adds to less substituted carbon)**

Markovnikov's rule predicts that in the addition of  $\text{HX}$  to an alkene, the hydrogen adds to the carbon with more hydrogens (less substituted carbon), and  $\text{X}$  (the halogen or other group) adds to the more substituted carbon. This occurs because the mechanism proceeds through the more stable carbocation.

**80. Correct Answer: B (Cyclooctatetraene)**

Cyclooctatetraene is NOT aromatic. Although it's cyclic and has 8  $\pi$  electrons, it doesn't meet Hückel's rule ( $4n+2$   $\pi$  electrons, where  $n$  is an integer). It's also not planar—it adopts a tub conformation. Pyridine, benzene, and furan are all aromatic.

**81. Correct Answer: D (Carbocation intermediate)**

The  $\text{S}_\text{N}1$  mechanism proceeds through a carbocation intermediate in a two-step process. First, the leaving group departs, forming a carbocation (rate-determining step). Second, the nucleophile attacks the carbocation.  $\text{S}_\text{N}2$  reactions proceed via backside attack in a concerted mechanism.

**82. Correct Answer: A (Resonance stabilization of conjugate base)**

Carboxylic acids are acidic because the conjugate base (carboxylate anion) is stabilized by resonance. The negative charge is delocalized over two oxygen atoms, making the anion very stable. This stabilization makes carboxylic acids more willing to donate a proton compared to alcohols, where the alkoxide ion has localized charge.

**83. Correct Answer: C ( $\beta$ -hydroxy carbonyl compounds)**

The aldol condensation produces  $\beta$ -hydroxy carbonyl compounds (aldol products). The reaction involves the nucleophilic addition of an enolate ion to a carbonyl group, forming a carbon-carbon bond. If heated, the product can dehydrate to form an  $\alpha,\beta$ -unsaturated carbonyl.

**84. Correct Answer: B (Simultaneously with leaving group departure)**

In E2 reactions (bimolecular elimination), the base removes a proton simultaneously with (concerted with) leaving group departure. This is a one-step mechanism where bond breaking and forming occur at the same time, requiring anti-coplanar geometry. E1 reactions occur in two steps with carbocation formation first.

**85. Correct Answer: A ( $F^-$ )**

Among these options,  $F^-$  (fluoride ion) is the weakest base because it's the conjugate base of HF, a relatively strong acid (for a weak acid). The stronger the acid, the weaker its conjugate base. Base strength order:  $CH_3^- > NH_2^- > OH^- > F^-$ .

**86. Correct Answer: C (Hydrolysis)**

The reaction of an ester with water is called hydrolysis. It can be acid-catalyzed (producing carboxylic acid + alcohol) or base-catalyzed (saponification, producing carboxylate salt + alcohol). Esterification is the reverse—forming an ester from acid and alcohol.

**87. Correct Answer: B (Chiral)**

A molecule with a non-superimposable mirror image is chiral. Chiral molecules lack an internal plane of symmetry and typically have at least one stereocenter (carbon with four different groups). They exist as enantiomers—non-superimposable mirror images. Achiral molecules are superimposable on their mirror images.

**88. Correct Answer: A (Ketones)**

The Friedel-Crafts acylation produces aromatic ketones. An acyl halide ( $RCOCl$ ) reacts with benzene in the presence of a Lewis acid catalyst ( $AlCl_3$ ), replacing a hydrogen on the ring with an acyl group ( $-COR$ ), forming an aromatic ketone. Friedel-Crafts alkylation produces alkylbenzenes.

**89. Correct Answer: D (Methyl)**

Methyl halides ( $CH_3X$ ) undergo  $S_N2$  reactions most readily because they have no steric hindrance—the carbon is completely accessible to nucleophile attack.  $S_N2$  reactivity order: methyl > primary > secondary >> tertiary (which favors  $S_N1$  instead). Steric hindrance dramatically slows  $S_N2$ .

**90. Correct Answer: B (Carboxylic acids)**

The Grignard reagent ( $\text{RMgX}$ ) reacts with  $\text{CO}_2$  to form carboxylic acids after acidic workup. The Grignard acts as a nucleophile, attacking the carbon of  $\text{CO}_2$  to form  $\text{RCO}_2^-\text{MgX}^+$ , which upon protonation yields  $\text{RCOOH}$ . This lengthens the carbon chain by one.

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

R and S configurations are assigned based on Cahn-Ingold-Prelog priority rules. Atoms directly attached to the stereocenter are ranked by atomic number (higher = higher priority). The molecule is oriented with the lowest priority group away, and the remaining groups are traced clockwise (R) or counterclockwise (S).

**92. Correct Answer: B (Primary amines)**

The Gabriel synthesis produces primary amines specifically. It uses phthalimide and involves  $\text{S}_\text{N}2$  displacement with an alkyl halide followed by hydrolysis. This method avoids the over-alkylation problem that occurs in direct alkylation of ammonia, ensuring only primary amines are formed.

**93. Correct Answer: D (Interactions with plane-polarized light)**

Enantiomers have identical interactions with achiral molecules (same melting points, boiling points, solubility in achiral solvents). However, they rotate plane-polarized light in opposite directions (one clockwise +, one counterclockwise -) by the same magnitude. They have opposite R/S designations and opposite optical rotations.

**94. Correct Answer: A (Hydrazine and base)**

The Wolff-Kishner reduction uses hydrazine ( $\text{NH}_2\text{NH}_2$ ) and a strong base (KOH) at high temperature to reduce carbonyl groups (aldehydes or ketones) to alkanes:  $\text{R}_2\text{C}=\text{O} \rightarrow \text{R}_2\text{CH}_2$ . The Clemmensen reduction ( $\text{Zn}/\text{HCl}$ ) accomplishes the same transformation under acidic conditions.

**95. Correct Answer: D (Ketones)**

Secondary alcohols are oxidized to ketones. The oxidation removes the hydrogen from the carbon bearing the hydroxyl group:  $\text{R}_2\text{CHOH} \rightarrow \text{R}_2\text{C}=\text{O}$ . Common oxidizing agents include chromic acid (Jones reagent), PCC, or potassium dichromate. Primary alcohols oxidize to aldehydes then carboxylic acids, while tertiary alcohols don't oxidize easily.

**96. Correct Answer: A (Deactivating)**

Meta-directing groups in electrophilic aromatic substitution are generally deactivating—they withdraw electrons from the benzene ring, making it less reactive than benzene itself. Examples include  $-\text{NO}_2$ ,  $-\text{CN}$ ,  $-\text{COOH}$ ,  $-\text{SO}_3\text{H}$ , and carbonyls. They direct incoming groups to the meta position. Activating groups are typically ortho/para directors.

**97. Correct Answer: C (More substituted alkene)**

The Saytzeff rule (Zaitsev's rule) predicts that elimination reactions produce the more substituted (more stable) alkene as the major product. The base removes the hydrogen from the carbon with fewer hydrogens, creating the double bond with more alkyl substituents. This is opposite to the Hofmann product.

**98. Correct Answer: A (Ester and alcohol)**

Transesterification involves the reaction between an ester and an alcohol, producing a different ester and alcohol. The alkoxy group of the ester is exchanged:  $\text{RCOOR}' + \text{R}''\text{OH} \rightarrow \text{RCOOR}'' + \text{R}'\text{OH}$ . This is catalyzed by acid or base and is used in biodiesel production.

**99. Correct Answer: D (Functional groups)**

Infrared (IR) spectroscopy is most useful for identifying functional groups. Different functional groups absorb IR radiation at characteristic frequencies: O-H (broad,  $3200\text{-}3600\text{ cm}^{-1}$ ), C=O (sharp,  $\sim 1700\text{ cm}^{-1}$ ), C=C ( $\sim 1650\text{ cm}^{-1}$ ), etc. Mass spectrometry determines molecular weight, NMR shows carbon/hydrogen environments.

**100. Correct Answer: C (Number of carbon environments)**

In  $^{13}\text{C}$  NMR spectroscopy, the number of signals indicates the number of different carbon environments in the molecule. Equivalent carbons (chemically identical) produce one signal, while non-equivalent carbons produce separate signals. This helps determine molecular structure and symmetry.

## Perceptual Ability Test

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### ANGLE DISCRIMINATION (Questions 1-15)

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

The angles in order from smallest to largest are: Angle 2 ( $43^\circ$ ) < Angle 1 ( $56^\circ$ ) < Angle 4 ( $59^\circ$ ) < Angle 3 ( $65^\circ$ ). This gives the sequence 2-1-4-3, correctly ranking all four angles from smallest to largest based on their degree measurements.

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

The angles rank as: Angle S ( $55^\circ$ ) < Angle Q ( $62^\circ$ ) < Angle P ( $77^\circ$ ) < Angle R ( $84^\circ$ ). The sequence S-Q-P-R correctly orders these angles from smallest to largest.

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

The angles in order are: Angle 3 ( $23^\circ$ ) < Angle 1 ( $29^\circ$ ) < Angle 4 ( $37^\circ$ ) < Angle 2 ( $41^\circ$ ). This ranking correctly sequences the four angles from smallest to largest.

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

The angles rank as: Angle D ( $73^\circ$ ) < Angle B ( $79^\circ$ ) < Angle A ( $86^\circ$ ) < Angle C ( $92^\circ$ ). The sequence D-B-A-C correctly orders these angles from smallest to largest.

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

Angle W =  $60^\circ$  (two-thirds of  $90^\circ$ ), Angle X =  $47^\circ$ , Angle Y =  $72^\circ$ , Angle Z =  $84^\circ$ . Ordering from smallest to largest: X ( $47^\circ$ ) < W ( $60^\circ$ ) < Y ( $72^\circ$ ) < Z ( $84^\circ$ ). The sequence X-W-Y-Z is the correct ascending order.

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

The angles rank as: Angle 1 ( $18^\circ$ ) < Angle 2 ( $32^\circ$ ) < Angle 3 ( $39^\circ$ ) < Angle 4 ( $46^\circ$ ). This sequence correctly orders the angles from smallest to largest, which are already in numerical order.

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

The angles in order are: Angle O ( $57^\circ$ ) < Angle M ( $64^\circ$ ) < Angle P ( $71^\circ$ ) < Angle N ( $76^\circ$ ). The sequence O-M-P-N correctly ranks these angles.

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

The angles rank as: Angle 1 ( $21^\circ$ ) < Angle 3 ( $28^\circ$ ) < Angle 2 ( $35^\circ$ ) < Angle 4 ( $42^\circ$ ). This sequence correctly orders the angles from smallest to largest.

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

The angles in order are: Angle C ( $38^\circ$ ) < Angle A ( $49^\circ$ ) < Angle B ( $55^\circ$ ) < Angle D ( $67^\circ$ ). The sequence C-A-B-D correctly ranks these angles.

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

The angles rank as: Angle 2 ( $66^\circ$ ) < Angle 4 ( $69^\circ$ ) < Angle 1 ( $73^\circ$ ) < Angle 3 ( $80^\circ$ ). This sequence correctly orders the angles from smallest to largest.

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

The angles in order are: Angle W ( $36^\circ$ ) < Angle Z ( $43^\circ$ ) < Angle Y ( $48^\circ$ ) < Angle X ( $54^\circ$ ). The sequence W-Z-Y-X correctly ranks these angles from smallest to largest.

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

The angles rank as: Angle 1 ( $19^\circ$ ) < Angle 2 ( $28^\circ$ ) < Angle 3 ( $34^\circ$ ) < Angle 4 ( $47^\circ$ ). This sequence correctly orders all four angles from smallest to largest, which are already in numerical order.

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

The angles in order are: Angle Q ( $51^\circ$ ) < Angle S ( $56^\circ$ ) < Angle P ( $68^\circ$ ) < Angle R ( $81^\circ$ ). The sequence Q-S-P-R correctly ranks these angles.

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

The angles rank as: Angle 1 ( $27^\circ$ ) < Angle 3 ( $37^\circ$ ) < Angle 2 ( $44^\circ$ ) < Angle 4 ( $51^\circ$ ). This sequence correctly orders the angles from smallest to largest.

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

The angles in order are: Angle D ( $74^\circ$ ) < Angle A ( $78^\circ$ ) < Angle B ( $87^\circ$ ) < Angle C ( $91^\circ$ ). The sequence D-A-B-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  $1 \times 2 = 2$  total holes positioned symmetrically across the fold line.

**17. Correct Answer: C (24)**

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

**18. Correct Answer: D (8)**

Two folds create 4 layers ( $2^2 = 4$ ). Punching 2 holes through all 4 layers produces  $2 \times 4 = 8$  total holes when unfolded.

**19. Correct Answer: B (10)**

One fold creates 2 layers. Punching 5 holes through both layers produces  $5 \times 2 = 10$  total holes when unfolded.

**20. Correct Answer: C (12)**

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

**21. Correct Answer: A (1)**

When paper is folded diagonally and a hole is punched exactly on the diagonal fold line, both layers are punched at the same location. Unfolding reveals 1 hole on the diagonal.

**22. Correct Answer: D (4)**

Two folds create 4 layers. Punching a corner of the folded paper produces 4 holes when unfolded, positioned near corners or edges of the original square in a symmetric pattern.

**23. Correct Answer: B (8)**

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

**24. Correct Answer: A (1)**

When a hole is punched exactly on 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: C (8)**

Three folds create 8 layers ( $2^3 = 8$ ). One punch through all 8 layers produces 8 holes when completely unfolded, arranged in a symmetric pattern.

**26. Correct Answer: D (8)**

Two folds create 4 layers. Punching 2 holes through all 4 layers produces  $2 \times 4 = 8$  total holes when unfolded.

**27. Correct Answer: B (6)**

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

**28. Correct Answer: C (12)**

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

**29. Correct Answer: A (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.

**30. Correct Answer: D (8)**

Three folds create 8 layers ( $2^3 = 8$ ). One punch through all 8 layers produces 8 holes when unfolded.

**CUBE COUNTING (Questions 31-45)**

**31. Correct Answer: B (24)**

Face cubes (1 face exposed) in a  $4 \times 4 \times 4$  cube:  $2[(a-2)(b-2) + (b-2)(c-2) + (a-2)(c-2)] = 2[(2)(2) + (2)(2) + (2)(2)] = 2[4+4+4] = 2(12) = 24$  face cubes.

**32. Correct Answer: A (8)**

Any cube or rectangular prism has exactly 8 corners. A  $5 \times 5 \times 5$  cube has 8 corner cubes where 3 faces meet, giving 8 cubes with exactly 3 faces exposed.

**33. Correct Answer: C (48)**

A  $2 \times 4 \times 6$  rectangular prism contains  $2 \times 4 \times 6 = 48$  total unit cubes.

**34. Correct Answer: D (2)**

In a straight line of 10 cubes, the 2 end cubes each have 5 faces exposed (all faces except the one touching the adjacent cube). The 8 middle cubes each have 4 faces exposed.

**35. Correct Answer: B (8)**

Interior cubes (0 faces exposed) formula:  $(a-2)(b-2)(c-2) = (4-2)(4-2)(4-2) = 2 \times 2 \times 2 = 8$  completely interior cubes in a  $4 \times 4 \times 4$  cube.

**36. Correct Answer: C (8)**

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

**37. Correct Answer: A (24)**

Edge cubes (2 faces exposed) in a  $4 \times 4 \times 4$  cube:  $4[(a-2) + (b-2) + (c-2)] = 4[(4-2) + (4-2) + (4-2)] = 4[2+2+2] = 4(6) = 24$  edge cubes.

**38. Correct Answer: D (36)**

A  $3 \times 3 \times 4$  rectangular prism contains  $3 \times 3 \times 4 = 36$  total unit cubes.

**39. Correct Answer: B (96)**

Face cubes (1 face exposed) in a  $6 \times 6 \times 6$  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.

**40. Correct Answer: A (52)**

A  $5 \times 4 \times 3$  rectangular prism contains  $5 \times 4 \times 3 = 60$  total unit cubes. Every rectangular prism has exactly 8 corner cubes. Therefore, cubes that are NOT corner cubes =  $60 - 8 = 52$  cubes.

**41. Correct Answer: B (6)**

In a pyramid structure with specific configuration (16 bottom, 9 second, 4 third, 1 top), analyzing the exposed faces shows that approximately 6 cubes have exactly 3 faces exposed at various corner positions of the pyramid structure.

**42. Correct Answer: C (28)**

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

**43. Correct Answer: A (4)**

In an L-shaped structure with 10 total cubes (7 in a row + 3 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 (72)**

A  $6 \times 6 \times 2$  rectangular prism contains  $6 \times 6 \times 2 = 72$  total cubes. Since one dimension is only 2 (meaning  $2-2 = 0$ ), there are no completely interior cubes. All 72 cubes have at least one face exposed.

**45. Correct Answer: A (12)**

Edge cubes (2 faces exposed) in a  $3 \times 3 \times 3$  cube:  $4[(a-2) + (b-2) + (c-2)] = 4[(3-2) + (3-2) + (3-2)] = 4[1+1+1] = 4(3) = 12$  edge cubes.

**PATTERN FOLDING (Questions 46-60)**

**46. Correct Answer: D (Partial cube / open box)**

Four 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.

**47. Correct Answer: C (Pentagonal pyramid)**

A pentagon base with 5 triangles (one on each edge) folds into a pentagonal pyramid. The triangles meet at an apex above the pentagonal base.

**48. Correct Answer: A (Cube)**

Six squares in a T-shape (4 in a row, 1 above and 1 below the second square) is one of the standard nets for a complete cube. When folded properly, all six faces close to form a cube.

**49. 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.

**50. Correct Answer: D (Hexagonal prism)**

A hexagon with 6 rectangles attached to its edges forms a hexagonal prism. The rectangles wrap around to form the sides, creating a prism with hexagonal cross-section.

**51. Correct Answer: C (Open-top cube)**

Five squares in a plus/cross shape (one center, four extending from each edge) form an open-top cube when folded. One square is the bottom, four form the sides, but there's no sixth square for the top, creating a 5-sided box.

**52. Correct Answer: B (Square pyramid)**

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

**53. Correct Answer: A (Partial pyramid / missing one face)**

With only 3 triangles attached to a square base, this forms an incomplete pyramid missing one triangular face. A complete square pyramid requires 4 triangular faces plus the base.

**54. Correct Answer: C (Rectangular prism)**

Six rectangles arranged appropriately fold into a rectangular prism (box shape). The rectangles form the top, bottom, and four sides.

**55. Correct Answer: D (Hexagonal prism)**

Two hexagonal ends connected by 6 rectangles form a complete hexagonal prism. This creates a prism with hexagonal cross-section.

**56. Correct Answer: A (Tetrahedron)**

One large triangle with 3 smaller triangles attached to its edges folds into a tetrahedron (triangular pyramid) with 4 triangular faces total.

**57. Correct Answer: D (Cube)**

Six equal squares in a cross pattern is a standard cube net. When folded, it forms a complete cube with all six faces.

**58. Correct Answer: B (Tetrahedron)**

Four equilateral triangles in a connected arrangement can fold into a tetrahedron (triangular pyramid) where all four faces are triangles, forming a 4-faced polyhedron.

**59. Correct Answer: A (Open-top cube)**

Three squares in a row with 1 square attached to the side of the middle square (T-shape) provides only 4 squares. This can form an open-top cube with one square as bottom and three forming three sides, leaving two sides and the top open.

**60. Correct Answer: C (Irregular polyhedron)**

Irregular polygons that don't match standard shapes form an irregular 3D shape when folded that doesn't fit standard categories like cubes, pyramids, or regular prisms.

**APERTURES / KEYHOLES (Questions 61-75)**

**61. Correct Answer: D (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.

**62. Correct Answer: B (Square)**

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

**63. Correct Answer: C (Circle)**

A sphere viewed from any angle appears as a circle. Therefore, a circular aperture is the shape a sphere could pass through (assuming the aperture matches the sphere's diameter).

**64. Correct Answer: A (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 to show a rectangular face.

**65. Correct Answer: D (Triangle or Rectangle)**

A triangular prism shows a triangular silhouette when viewed from the end (showing the triangular face) and a rectangular silhouette when viewed from the side. Both aperture shapes work.

**66. Correct Answer: B (Triangle)**

A cylinder can show circle (end view), rectangle (side view), or oval (angled view) silhouettes, but never a triangular silhouette regardless of orientation. Triangle would NOT work.

**67. Correct Answer: A (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.

**68. 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.

**69. Correct Answer: D (Triangle)**

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

**70. Correct Answer: B (Sphere or Cylinder)**

Among the 3D objects listed, both sphere and cylinder can pass through a circular aperture. A sphere shows circles from all angles, and a cylinder shows a circle when viewed along its axis.

**71. Correct Answer: C (Triangle or Square)**

An octahedron has triangular faces and when viewed from certain angles can show either triangular or square silhouettes depending on orientation. Both are possible apertures.

**72. Correct Answer: D (Pentagon or Rectangle)**

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

**73. Correct Answer: A (Rectangle)**

A rectangular prism can produce rectangular silhouettes from certain angles, but a sphere can only produce circular silhouettes. A rectangle aperture works for the prism but NOT for the sphere.

**74. Correct Answer: C (Triangle)**

A cylinder positioned appropriately can show circle (end view), rectangle (side view), or oval (angled) silhouettes, but cannot produce a triangular silhouette. Triangle is NOT a possible aperture shape.

**75. Correct Answer: B (Triangular prism)**

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

**VIEW RECOGNITION (Questions 76-90)**

**76. Correct Answer: B (Cone)**

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

**77. Correct Answer: C (Cylinder)**

A cylinder has a circular top view (looking down the axis), rectangular front view (showing the length and diameter), and rectangular side view. This combination uniquely identifies a cylinder.

**78. Correct Answer: D (Sphere)**

A sphere shows identical circular views from all three orthogonal directions (top, front, side) because it's perfectly round in all directions. Only a sphere has this property among the options.

**79. Correct Answer: D (Square pyramid)**

A square pyramid has a square top view (the base), triangular front view (showing the slant from base to apex), and triangular side view. This combination uniquely identifies a square pyramid.

**80. Correct Answer: A (Square)**

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

**81. Correct Answer: C (Triangular prism)**

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

**82. Correct Answer: B (Hexagonal prism)**

A hexagonal top view with rectangular front and side views identifies a hexagonal prism. The prism has a hexagonal cross-section with length extending perpendicular to it.

**83. Correct Answer: A (Rectangle)**

Viewing a cylinder from the side (perpendicular to its axis) shows a rectangular silhouette with the length being the cylinder height and width being the diameter.

**84. 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.

**85. Correct Answer: C (Pentagonal prism)**

A pentagonal top view with rectangular front and side views identifies a pentagonal prism. The prism has a pentagon cross-section with length extending perpendicular to it.

**86. Correct Answer: A (Triangle)**

Viewing a triangular prism from the end (looking directly at the triangular face) shows a triangle. This is the cross-sectional shape of the prism.

**87. Correct Answer: B (Circle)**

Viewing a cone from directly above (top view) shows a circle representing the circular base. The apex is at the center of this circle.

**88. Correct Answer: D (Rectangular prism)**

Different rectangular views (rectangle top, rectangle front, square side) indicate a rectangular prism with different length, width, and height dimensions. The square side view means two dimensions are equal.

**89. 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.

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

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

## Reading Comprehension

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### PASSAGE I - CRISPR-Cas9 Gene Editing (Questions 1-17)

**1. Correct Answer: D (A bacterial immune mechanism)**

The passage explicitly states "The system originated from a bacterial immune mechanism that protects against viral infections." CRISPR was discovered as part of how bacteria defend themselves against viruses.

**2. Correct Answer: C (Simpler and more cost-effective)**

The passage notes "Unlike earlier gene-editing technologies like zinc finger nucleases and TALENs, CRISPR provides a simpler, faster, and more cost-effective method for making targeted genetic changes." This comparison highlights CRISPR's advantages.

**3. Correct Answer: B (Direct Cas9 to the target location)**

The passage explains "a guide RNA that directs Cas9 to the precise genomic location requiring modification. Scientists design the guide RNA to match the target DNA sequence with extraordinary specificity." The guide RNA's function is to direct Cas9.

**4. Correct Answer: D (Molecular scissors)**

The passage describes "the Cas9 enzyme, which acts as molecular scissors cutting DNA." This metaphor illustrates Cas9's function of cutting DNA strands.

**5. Correct Answer: A (Join cut ends or insert a template sequence)**

The passage states "The cell's natural repair mechanisms then fix the break, either by joining the cut ends directly (potentially disrupting the gene) or by inserting a new DNA sequence if provided as a template." Both repair options are mentioned.

**6. Correct Answer: B (Sickle cell disease and beta-thalassemia)**

The passage notes "Clinical trials are testing CRISPR therapies for sickle cell disease and beta-thalassemia, both caused by single-gene mutations." These are the specific conditions mentioned in clinical trials.

**7. Correct Answer: C (Inherited blindness)**

The passage states "Vision restoration trials use CRISPR to correct mutations causing inherited blindness, marking the first in-body CRISPR treatment in humans." This identifies inherited blindness as the target.

**8. Correct Answer: D (Changes indistinguishable from natural mutations)**

The passage explains "Unlike traditional genetic modification involving genes from different species, CRISPR can make changes indistinguishable from natural mutations, potentially easing regulatory and public acceptance concerns." This is CRISPR's agricultural advantage.

**9. Correct Answer: A (Disease-resistant and drought-tolerant crops)**

The passage states "Scientists have developed disease-resistant crops, drought-tolerant varieties, and nutritionally enhanced foods using CRISPR." Multiple applications are mentioned, including disease resistance and drought tolerance.

**10. Correct Answer: B (Would be inherited by future generations)**

The passage defines germline editing as "changes to eggs, sperm, or embryos that would be inherited by future generations." This inheritance distinguishes germline from somatic editing.

**11. Correct Answer: C (Creating gene-edited babies)**

The passage notes "In 2018, a Chinese scientist's announcement of creating gene-edited babies sparked global condemnation." This specific event is described.

**12. Correct Answer: A (Only the patient)**

The passage explains "somatic cell editing (affecting only the patient)" in contrast to germline editing that affects future generations. Somatic changes are limited to the individual.

**13. Correct Answer: D (Permanently altering the human gene pool)**

The passage states concerns about "germline editing could permanently alter the human gene pool with unknown consequences." This represents a major ethical concern.

**14. Correct Answer: B (Undermine human dignity)**

The passage mentions concerns about "whether 'designer babies' would undermine human dignity" as one of the ethical worries about genetic enhancement.

**15. Correct Answer: C (Expensive genetic enhancements)**

The passage notes "the justice implications of expensive genetic enhancements creating biological inequality" as a concern about access and fairness.

**16. Correct Answer: D (Robust ethical frameworks and international agreements)**

The passage concludes "CRISPR's therapeutic potential makes continued research essential, provided robust ethical frameworks and international agreements govern its use." Both governance structures are mentioned.

**17. Correct Answer: A (Potentially enabling harmful applications)**

The passage states "Additional worries include the technology's accessibility potentially enabling harmful applications." Accessibility raises concerns about misuse.

**PASSAGE II - Circadian Rhythms (Questions 18-34)**

**18. Correct Answer: C (24 hours)**

The passage defines "Circadian rhythms are intrinsic biological cycles lasting approximately 24 hours." This is the fundamental characteristic of circadian rhythms.

**19. Correct Answer: B (Genetically based)**

The passage states "These internal clocks persist even without external time cues, demonstrating their genetic basis rather than mere responses to environmental cycles." The persistence proves genetic basis.

**20. Correct Answer: A (Endogenous)**

The passage notes "The discovery that circadian rhythms are endogenous earned researchers the 2017 Nobel Prize." Endogenous means originating internally, not from external factors.

**21. Correct Answer: D (Suprachiasmatic nucleus (SCN))**

The passage states "the suprachiasmatic nucleus (SCN) in the hypothalamus serves as the master clock, synchronizing peripheral clocks throughout the body." The SCN is explicitly identified.

**22. Correct Answer: B (Specialized retinal cells distinct from vision cells)**

The passage explains "Light detected by specialized retinal cells—distinct from rods and cones used for vision—entrains the SCN to the external day-night cycle." These are separate from vision cells.

**23. Correct Answer: C (Proteins inhibiting their own gene expression)**

The passage describes "Core clock genes including CLOCK, BMAL1, PER, and CRY create feedback loops where proteins inhibit their own gene expression, generating oscillations with roughly 24-hour periods." This negative feedback creates rhythms.

**24. Correct Answer: A (In early morning)**

The passage states "Body temperature fluctuates predictably, reaching its lowest point in early morning and peaking in late afternoon." Early morning is when temperature is lowest.

**25. Correct Answer: D (Shortly after waking)**

The passage notes "cortisol peaks shortly after waking to promote alertness." This timing supports the body's transition to wakefulness.

**26. Correct Answer: C (Facilitate sleep)**

The passage states "melatonin increases at night to facilitate sleep." This is melatonin's primary circadian function.

**27. Correct Answer: B (Metabolize toxins and drugs)**

The passage explains "The liver's circadian clock controls enzymes metabolizing toxins and drugs, making some medications more effective or toxic depending on administration time." This describes the liver clock's function.

**28. Correct Answer: A (Cardiovascular disease, diabetes, and certain cancers)**

The passage states "Shift workers facing chronic circadian disruption show elevated risks for cardiovascular disease, diabetes, obesity, and certain cancers." Multiple health risks are listed.

**29. Correct Answer: D (The internal clock requires time to adjust to new time zones)**

The passage explains "Jet lag represents acute circadian misalignment as the internal clock requires several days to adjust to new time zones." The adjustment lag causes jet lag.

**30. Correct Answer: C (Suppressing melatonin and delaying sleep onset)**

The passage notes "Blue light from electronic screens suppresses melatonin particularly effectively, delaying sleep onset." This describes blue light's mechanism.

**31. Correct Answer: B (Discrepancy between biological and social time)**

The passage defines "Social jet lag—the discrepancy between biological and social time—affects most people to some degree." This describes the mismatch between internal and social schedules.

**32. Correct Answer: D (Puberty)**

The passage states "especially adolescents whose circadian clocks naturally shift later during puberty but who must wake early for school." Puberty is when this shift occurs.

**33. Correct Answer: A (Timing medication to circadian rhythms)**

The passage defines "Chronotherapy involves timing medication administration to circadian rhythms, improving efficacy and reducing side effects." This is the definition of chronotherapy.

**34. Correct Answer: C (Enhance tumor killing while sparing healthy tissues)**

The passage states "Cancer chemotherapy timed to circadian rhythms of cell division can enhance tumor killing while sparing healthy tissues." Both benefits are mentioned together.

**PASSAGE III - Ocean Acidification (Questions 35-50)**

**35. Correct Answer: D (30%)**

The passage states "the ocean absorbing approximately 30% of atmospheric carbon dioxide emitted by human activities." This specific percentage is provided.

**36. Correct Answer: B (8.1)**

The passage notes "Since the Industrial Revolution, ocean surface pH has declined from approximately 8.2 to 8.1." The current pH is 8.1.

**37. Correct Answer: C (30%)**

The passage states the pH decline "representing a 30% increase in acidity due to the logarithmic pH scale." This is explicitly stated.

**38. Correct Answer: A (7.8)**

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

**39. Correct Answer: D (Calcium carbonate shells and skeletons)**

The passage explains "many marine organisms—including corals, mollusks, and some plankton—require carbonate to build calcium carbonate shells and skeletons." This is what carbonate is used for.

**40. Correct Answer: C (Salmon and other fish)**

The passage states "Pteropods (sea butterflies), important prey for salmon and other fish." Salmon are specifically mentioned as predators.

**41. Correct Answer: B (Dissolution)**

The passage notes "Pteropods (sea butterflies), important prey for salmon and other fish, show shell dissolution in acidified waters." Their shells dissolve.

**42. Correct Answer: A (Neurotransmitter function)**

The passage explains "These behavioral changes stem from CO<sub>2</sub> interfering with neurotransmitter function, particularly GABA receptors in fish brains." Neurotransmitter interference is the mechanism.

**43. Correct Answer: D (More vulnerable)**

The passage states "While adult fish may tolerate moderately acidified conditions, early life stages often prove more vulnerable." Early stages are more vulnerable than adults.

**44. Correct Answer: C (Acidified upwelling waters)**

The passage notes "Pacific Northwest oyster hatcheries already experiencing massive die-offs linked to acidified upwelling waters." Acidified upwelling is specifically identified.

**45. Correct Answer: B (Coastal protection, tourism, and fisheries)**

The passage states "Coral reef degradation threatens not only biodiversity but also coastal protection, tourism, and fisheries supporting hundreds of millions of people." Multiple threats are listed.

**46. Correct Answer: D (Warming, deoxygenation, and pollution)**

The passage notes "Acidification combines with other stressors—warming, deoxygenation, pollution—creating compound effects." All three stressors are mentioned.

**47. Correct Answer: A (Reducing CO<sub>2</sub> emissions)**

The passage states "Addressing ocean acidification ultimately requires reducing CO<sub>2</sub> emissions, as no technological fix can reverse acidification at ocean-wide scales." Emissions reduction is the ultimate solution.

**48. Correct Answer: C (Centuries)**

The passage notes "Even aggressive emissions reductions would leave oceans more acidic than pre-industrial levels for centuries due to the long residence time of CO<sub>2</sub> in ocean-atmosphere systems." The persistence is measured in centuries.

**49. Correct Answer: B (Absorbing CO<sub>2</sub>)**

The passage mentions "protecting coastal ecosystems like seagrass beds and mangroves that absorb CO<sub>2</sub>" as a local intervention. CO<sub>2</sub> absorption is their function.

**50. Correct Answer: A (Adding alkaline minerals to seawater)**

The passage describes "Research into enhanced weathering—adding alkaline minerals to seawater to neutralize acidity—remains experimental." This defines enhanced weathering.

## Quantitative Reasoning

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**1. Correct Answer: C (78.5 cm<sup>2</sup>)**

The area of a circle is  $A = \pi r^2$ . With diameter = 10 cm, the radius = 5 cm. Using  $\pi \approx 3.14$ :  $A = 3.14 \times 5^2 = 3.14 \times 25 = 78.5 \text{ cm}^2$ . This tests understanding of the relationship between diameter and radius.

**2. Correct Answer: A (6)**

Solve the equation  $8x - 12 = 36$  by first adding 12 to both sides:  $8x = 36 + 12 = 48$ . Divide both sides by 8:  $x = 48/8 = 6$ . Verify:  $8(6) - 12 = 48 - 12 = 36 \checkmark$ .

**3. Correct Answer: D (21/20)**

To add fractions with different denominators, find a common denominator. The LCD of 5 and 4 is 20:  $4/5 = 16/20$  and  $1/4 = 5/20$ . Then  $16/20 + 5/20 = 21/20 = 1 \frac{1}{20}$ . This tests fraction addition with unlike denominators.

**4. Correct Answer: D (55°)**

In any triangle, the three angles sum to  $180^\circ$ . With angles  $55^\circ$ ,  $70^\circ$ , and  $x^\circ$ :  $55 + 70 + x = 180$ , so  $125 + x = 180$ , giving  $x = 55^\circ$ . This tests the fundamental triangle angle sum property.

**5. Correct Answer: C (44 cm)**

The perimeter of a rectangle is  $P = 2(\text{length} + \text{width})$ . With length = 14 cm and width = 8 cm:  $P = 2(14 + 8) = 2(22) = 44$  cm. This is a direct application of the rectangle perimeter formula.

**6. Correct Answer: B ( $x > 6$ )**

Solve the inequality  $4x + 7 > 31$  by subtracting 7 from both sides:  $4x > 24$ . Divide both sides by 4:  $x > 6$ . The inequality direction remains the same because we divided by a positive number.

**7. Correct Answer: A (98)**

Calculate  $5^3 - 3^3$ : First,  $5^3 = 5 \times 5 \times 5 = 125$ . Then,  $3^3 = 3 \times 3 \times 3 = 27$ . Finally,  $125 - 27 = 98$ . This tests exponent evaluation and subtraction.

**8. Correct Answer: D (200)**

If 35% of a number equals 70, set up the equation:  $0.35 \times N = 70$ . Divide both sides by 0.35:  $N = 70/0.35 = 200$ . Alternatively, recognize that  $35\% = 7/20$ , so if  $7/20$  of  $N = 70$ , then  $N = 70 \times (20/7) = 200$ .

**9. Correct Answer: C (21)**

To find the median, first arrange the numbers in order:  $\{17, 18, 21, 25, 29\}$ . The median is the middle value in an ordered set. With 5 values, the third value is the median: 21.

**10. Correct Answer: B (60 mph)**

Average speed = distance  $\div$  time = 240 miles  $\div$  4 hours = 60 miles per hour. This straightforward calculation tests understanding of the distance-rate-time relationship.

**11. Correct Answer: D (1/2)**

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

**12. Correct Answer: A (2)**

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

**13. Correct Answer: C (13)**

The absolute value of -22 is 22, and the absolute value of 9 is 9. Therefore,  $|-22| - |9| = 22 - 9 = 13$ . Absolute value represents distance from zero, always positive or zero.

**14. Correct Answer: B (16)**

Solve  $12/x = 36/48$  by first simplifying the right side:  $36/48 = 3/4$ . So  $12/x = 3/4$ . Cross-multiply:  $12 \times 4 = 3 \times x$ , giving  $48 = 3x$ , so  $x = 16$ . Verify:  $12/16 = 3/4 \checkmark$ .

**15. Correct Answer: A (216 cm<sup>3</sup>)**

The volume of a cube is  $V = s^3$  where  $s$  is the edge length. With  $s = 6$  cm:  $V = 6^3 = 6 \times 6 \times 6 = 216$  cm<sup>3</sup>. This tests the cube volume formula.

**16. Correct Answer: B (x = 14, y = 6)**

Solve the system  $x + y = 20$  and  $x - y = 8$  by adding the equations:  $(x + y) + (x - y) = 20 + 8$ , giving  $2x = 28$ , so  $x = 14$ . Substitute into the first equation:  $14 + y = 20$ , so  $y = 6$ . The solution is  $x = 14, y = 6$ .

**17. Correct Answer: D (1)**

The sine of  $90^\circ$  is a standard trigonometric value:  $\sin 90^\circ = 1$ . This represents the maximum value of the sine function. This is a value worth memorizing for the unit circle.

**18. Correct Answer: A (12 cm)**

If a rectangle has area  $96$  cm<sup>2</sup> and width  $8$  cm, use  $A = l \times w$ :  $96 = l \times 8$ . Divide by  $8$ :  $l = 96/8 = 12$  cm. Verify:  $12 \times 8 = 96 \checkmark$ .

**19. Correct Answer: C (60)**

The least common multiple (LCM) of  $15$  and  $20$  can be found using prime factorization:  $15 = 3 \times 5$ ,  $20 = 2^2 \times 5$ . The LCM uses the highest power of each prime:  $\text{LCM} = 2^2 \times 3 \times 5 = 4 \times 3 \times 5 = 60$ .

**20. Correct Answer: D (2/3)**

With  $5$  red balls and  $10$  blue balls, there are  $15$  total balls. The probability of drawing a blue ball is (number of blue)/(total) =  $10/15 = 2/3$ . This tests basic probability calculation.

**21. Correct Answer: D (5)**

The distance formula is  $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ . With points  $(1, 4)$  and  $(5, 7)$ :  $d = \sqrt{[(5-1)^2 + (7-4)^2]} = \sqrt{[4^2 + 3^2]} = \sqrt{[16 + 9]} = \sqrt{25} = 5$ . This represents the 3-4-5 Pythagorean triple.

**22. Correct Answer: C (8)**

For inverse variation,  $y = k/x$  where  $k$  is constant. When  $y = 20$  and  $x = 4$ :  $20 = k/4$ , so  $k = 80$ . When  $x = 10$ :  $y = 80/10 = 8$ . In inverse variation, the product  $xy$  remains constant.

**23. Correct Answer: B ( $\sqrt{3}$ )**

The tangent of  $60^\circ$  is a standard trigonometric value:  $\tan 60^\circ = \sqrt{3}$ . This can be derived from a 30-60-90 triangle with sides in ratio  $1:\sqrt{3}:2$ , where  $\tan 60^\circ = \text{opposite/adjacent} = \sqrt{3}/1 = \sqrt{3}$ . This is a value worth memorizing.

**24. Correct Answer: D (44 cm)**

If a square has area  $121 \text{ cm}^2$ , then  $s^2 = 121$ , so  $s = 11 \text{ cm}$  (side length). The perimeter is  $P = 4s = 4 \times 11 = 44 \text{ cm}$ . This tests connecting area and perimeter formulas for squares.

**25. Correct Answer: A (15)**

Evaluate  $f(x) = 4x - 9$  at  $x = 6$  by substitution:  $f(6) = 4(6) - 9 = 24 - 9 = 15$ . This tests function evaluation by substituting the given value into the function.

**26. Correct Answer: C (87.5%)**

Convert  $7/8$  to decimal first:  $7 \div 8 = 0.875$ . Then multiply by 100 to get percentage:  $0.875 \times 100 = 87.5\%$ . Alternatively,  $7/8 = 875/1000 = 87.5\%$ .

**27. Correct Answer: B (8)**

Solve  $6x - 3 = 4x + 13$  by subtracting  $4x$  from both sides:  $2x - 3 = 13$ . Add 3 to both sides:  $2x = 16$ . Divide by 2:  $x = 8$ . Verify:  $6(8) - 3 = 48 - 3 = 45$ , and  $4(8) + 13 = 32 + 13 = 45 \checkmark$ .

**28. Correct Answer: D (294  $\text{cm}^2$ )**

The surface area of a cube is  $SA = 6s^2$  where  $s$  is the edge length. With  $s = 7 \text{ cm}$ :  $SA = 6 \times 7^2 = 6 \times 49 = 294 \text{ cm}^2$ . A cube has 6 identical square faces, each with area  $s^2$ .

**29. Correct Answer: A (18)**

The greatest common factor (GCF) of 54 and 72 can be found using prime factorization:  $54 = 2 \times 3^3$  and  $72 = 2^3 \times 3^2$ . The GCF uses the lowest power of each common prime:  $2 \times 3^2 = 2 \times 9 = 18$ .

**30. Correct Answer: C ( $65^\circ$ )**

In any triangle, the three angles sum to  $180^\circ$ . With angles  $40^\circ$ ,  $75^\circ$ , and  $x^\circ$ :  $40 + 75 + x = 180$ , so  $115 + x = 180$ , giving  $x = 65^\circ$ . This tests the fundamental triangle angle sum property.

**31. Correct Answer: C (39)**

Calculate  $8^2 - 5^2$ : First,  $8^2 = 64$ . Then,  $5^2 = 25$ . Finally,  $64 - 25 = 39$ . Alternatively, use the difference of squares formula:  $a^2 - b^2 = (a+b)(a-b) = (8+5)(8-5) = 13 \times 3 = 39$ .

**32. Correct Answer: A (7/12)**

To subtract fractions with different denominators, find a common denominator. The LCD of 6 and 4 is 12:  $5/6 = 10/12$  and  $1/4 = 3/12$ . Then  $10/12 - 3/12 = 7/12$ . This tests fraction subtraction with unlike denominators.

**33. Correct Answer: B (197.82 cm<sup>3</sup>)**

The volume of a cylinder is  $V = \pi r^2 h$ . With  $r = 3$  cm,  $h = 7$  cm, and  $\pi \approx 3.14$ :  $V = 3.14 \times 3^2 \times 7 = 3.14 \times 9 \times 7 = 3.14 \times 63 = 197.82$  cm<sup>3</sup>. This tests applying the cylinder volume formula.

**34. Correct Answer: C (35)**

To decrease 50 by 30%, calculate 30% of 50 and subtract:  $0.30 \times 50 = 15$ , so  $50 - 15 = 35$ . Alternatively, 50 decreased by 30% =  $50 \times 0.70 = 35$ .

**35. Correct Answer: B (60°)**

If  $\cos \theta = 1/2$ , then  $\theta = 60^\circ$  (in the range  $0^\circ < \theta < 90^\circ$ ). This occurs in a 30-60-90 triangle where  $\cos 60^\circ = \text{adjacent/hypotenuse} = 1/2$ . This is a standard trigonometric value worth memorizing.

**36. Correct Answer: D (8)**

Solve  $5(x + 2) = 3x + 26$  by first distributing:  $5x + 10 = 3x + 26$ . Subtract  $3x$  from both sides:  $2x + 10 = 26$ . Subtract 10 from both sides:  $2x = 16$ . Divide by 2:  $x = 8$ . Verify:  $5(8 + 2) = 5(10) = 50$ , and  $3(8) + 26 = 24 + 26 = 50 \checkmark$ .

**37. Correct Answer: C (22)**

Range equals maximum minus minimum. In the dataset  $\{18, 32, 24, 40, 26\}$ , the maximum is 40 and minimum is 18. Range =  $40 - 18 = 22$ . This tests understanding of range as a measure of spread.

**38. Correct Answer: A ( $\pm 13$ )**

If  $x^2 = 169$ , then  $x = \pm\sqrt{169} = \pm 13$ . 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  $x^2 = \text{constant}$ .

**39. Correct Answer: B ( $\sqrt{2}/2$ )**

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

**40. Correct Answer: D ( $4x^2y^2$ )**

Simplify  $(20x^6y^5)/(5x^4y^3)$  by dividing coefficients and subtracting exponents for like bases. For the coefficient:  $20/5 = 4$ . For x:  $x^6/x^4 = x^{(6-4)} = x^2$ . For y:  $y^5/y^3 = y^{(5-3)} = y^2$ . The result is  $4x^2y^2$ .