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BUMHS QUETTA

BUMHS Quetta MDCAT 2025 Official Paper

Official Annual Full-Length Practice Examination (FLP) · Complete Solved Paper

📍 Official Admitting Board: Bolan University of Medical and Health Sciences Quetta 📄 Archive Code: BEAMBE-FLP-BUMHS-2025

🕒 Duration: 210 Minutes (3h 30m)

180

TOTAL QUESTIONS

210m

OFFICIAL DURATION

+1 / 0.00

ZERO NEGATIVE MARKING

180

MAXIMUM MARKS

📄 EXAMINATION BLUEPRINT & SUBJECT WEIGHTAGE

Biology**81 MCQs**

45.0% weight

Chemistry**45 MCQs**

25.0% weight

Physics**36 MCQs**

20.0% weight

English**9 MCQs**

5.0% weight

Logical Reasoning**9 MCQs**

5.0% weight

BIO SECTION: BIOLOGY

Questions 1 to 81 (81 MCQs)

Q1. BIO

The primary function of the sensory neuron in a reflex arc is to:

- (A) Contract muscles
- (B) Detect environmental changes
- (C) Transmit impulses to the brain
- (D) Carry impulses to the spinal cord

Q2. BIO

Which change occurs in enzyme activity when temperature increases beyond the optimum level?

- (A) Activity remains the same
- (B) Activity increases
- (C) Enzymes denature
- (D) Enzyme specificity increases

Q3. BIO

In the second step of his experiment, what did Mendel do after selecting pure-breeding tall and dwarf pea plants?

- (A) Allowed them to self-pollinate
- (B) Crossed them to produce hybrid offspring
- (C) Collected seeds from random plants
- (D) Grew them in different soil types

Q4. BIO

The less common cause of HIV mode of transmission is:

- (A) Blood transfusion
- (B) Placenta of mother to baby
- (C) Mosquito bite
- (D) Lactation from HIV positive mother to baby

Q5. BIO

Which of the following is a correct structural feature of RNA?

- (A) It contains deoxyribose sugar
- (B) It has a double-stranded helical structure
- (C) It contains base uracil instead of base thymine
- (D) It is confined to the nucleus only

Q6. BIO

The part of male reproductive system involved in the storage and maturation of sperms is:

- (A) Scrotum
- (B) Vas deferens
- (C) Epididymis
- (D) Testes

Q7. BIO

One of the best preventive measure for kidney stones formation is:

- (A) Taking antibiotic daily
- (B) Avoiding all dairy food
- (C) Drinking plenty of water
- (D) Reducing physical activity

Q8. BIO

Key benefit of using biotechnology in development of vaccine for malaria is:

- (A) Its ability to develop endosymbiotic relationship with host
- (B) Its ability to work as antimalarial drugs
- (C) Its ability to directly kills the malaria parasite in mosquitoes
- (D) To create a targeted immune response against the parasite

Q9. BIO

Nasal opening is closed by which of the following to prevent food from entering into food pipe?

- (A) Hard palate
- (B) Epiglottis
- (C) Soft palate
- (D) Larynx

Q10. BIO

Ventricular systole causes:

- (A) Atrial relaxation
- (B) Atrial contraction
- (C) Closing of semilunar valve
- (D) Closing of atrioventricular valves

Q11. BIO

The connective tissue which connects skeletal muscle to bone is:

- (A) Tendon
- (B) Ligament
- (C) Cartilage
- (D) Synovial membrane

Q12. BIO

A pea plant which upon self fertilization produces all the offspring of its own phenotype is called:

- (A) Plant with homogenous genotype
- (B) Plant with homozygous genotype
- (C) Plant with homologous genotype
- (D) Plant with hemizygous genotype

Q13. BIO

If a polypeptide of 20 amino acids is made up of all different amino acids, at least how many types of tRNA must take part in its synthesis?

- (A) 20
- (B) 45
- (C) 61
- (D) 64

Q14. BIO

A person quickly withdraw their hand touching a hot iron. This type of reflex is best classified as _____ reflex.

- (A) Cranial
- (B) Spinal
- (C) Hormonal
- (D) Conditional

Q15. BIO

Catastrophism explains that changes in life on earth are due to:

- (A) Gradual evolution
- (B) Natural selection
- (C) Mutation
- (D) Sudden natural disasters

Q16. BIO

The correct function of H^+ and OH^- ions in cells is:

- (A) Transporting proteins
- (B) Breaking down fats
- (C) Maintaining or changing pH
- (D) Producing light energy

Q17. BIO

Which of the following is NOT a function of testes?

- (A) Spermatogenesis
- (B) Production of FSH
- (C) Secretion of inhibin
- (D) Secretion of testosterone

Q18. BIO

Acylglycerols like fats and oils are esters formed by condensation reaction between:

- (A) Fatty acid and water
- (B) Fatty acid and glucose
- (C) Fatty acid and alcohol
- (D) Fatty acid and phosphates

Q19. BIO

A cell shows green structures and a large fluid-filled area under the microscope. What does this indicate?

- (A) Plant cell with chloroplasts and vacuole
- (B) Fungal cell without chloroplasts
- (C) Algal cells with chloroplasts but lacking large vacuole
- (D) Animal cell with small vacuoles

Q20. BIO

Which option best reflects species specific chromosome number?

- (A) Same in all animals
- (B) Varies by tissue type
- (C) Fixed for each species
- (D) More in larger organisms

Q21. BIO

Morgan's experiment showed deviation from the law of independent assortment due to:

- (A) Crossing over
- (B) Gene linkage
- (C) Random mutation
- (D) Natural selection

Q22. BIO

During vesicle formation, endoplasmic reticulum membrane:

- (A) Dissolve into the cytosol
- (B) Breakdown into its chemical components
- (C) Expands and contributes to vesicle formation
- (D) Moves directly into Golgi apparatus

Q23. BIO

Which tissue layer of heart wall is involved in the formation of heart valves?

- (A) Epicardium
- (B) Pericardium
- (C) Endocardium
- (D) Myocardium

Q24. BIO

In humans, how many kinds of tRNA are present for the synthesis of proteins?

- (A) 40
- (B) 45
- (C) 43
- (D) 50

Q25. BIO

The active site is important in enzyme action because:

- (A) It binds to the substrate
- (B) It maintains the pH of reaction
- (C) It provides energy for reaction
- (D) It changes the shape of the enzyme

Q26. BIO

Which of the following is NOT included in the composition of bile?

- (A) Bile salt
- (B) Bile pigment
- (C) Cholesterol
- (D) Lipase

Q27. BIO

According to Darwin theory, the main reason of evolution is:

- (A) Natural calamity
- (B) Natural selection
- (C) Use and disuse of an organ
- (D) Inheritance of acquired character

Q28. BIO

Crossing over is:

- (A) Exchange of segments between sister chromatids of homologous chromosomes during meiosis.
- (B) Exchange of segments between non-sister chromatids of homologous chromosomes during meiosis.
- (C) Exchange of segments between non-sister chromatids of heterologous chromosomes during meiosis.
- (D) Exchange of segments between non-sister chromatids of homologous chromosomes during mitosis.

Q29. BIO

Which of the following is NOT considered a conjugated molecule?

- (A) A molecule containing linked sugar units
- (B) A molecule made up only of carbon and hydrogen
- (C) A protein attached to a non-protein group
- (D) A lipid combined with another chemical component

Q30. BIO

Which cells are involved in humoral immunity?

- (A) T cells
- (B) B cells
- (C) T or B cells
- (D) T and B cells

Q31. BIO

Which one are bone destroying cells?

- (A) Osteoclasts
- (B) Osteocytes
- (C) Osteogenic
- (D) Osteoblasts

Q32. BIO

Which one is NOT the part of fore brain?

- (A) Cerebellum
- (B) Hypothalamus
- (C) Hippocampus
- (D) Amygdala

Q33. BIO

The central dogma of molecular biology describes the flow of genetic information as:

- (A) DNA → mRNA → Protein
- (B) mRNA → DNA → Protein
- (C) Protein → DNA → mRNA
- (D) DNA → Protein → mRNA

Q34. BIO

During saltatory conduction, a nerve impulse jumps from one to another:

- (A) Synapse
- (B) Axon
- (C) Node of Ranvier
- (D) Myelin sheath

Q35. BIO

What is the chemical composition of chromosomes?

- (A) RNA and lipids
- (B) DNA and proteins
- (C) Proteins and carbohydrates
- (D) Carbohydrates and nucleic acids

Q36. BIO

Implantation of the embryo occurs in which part of the female reproductive system?

- (A) Ovary
- (B) Uterus
- (C) Cervix
- (D) Fallopian tube

Q37. BIO

Which of the following method is used to prevent HIV transmission during blood transfusion?

- (A) By freezing blood before transfusion
- (B) By using blood from young donors only
- (C) By boiling blood before transfusion
- (D) By screening blood for HIV before its transfusion

Q38. BIO

Each DNA nucleotide differs from the others based on its:

- (A) Nitrogenous bases
- (B) Phosphate group
- (C) Sugar molecule
- (D) Number of phosphorus atoms

Q39. BIO

Which of the following is the causative agent of Gonorrhea?

- (A) Herpes simplex virus
- (B) Treponema pallidum
- (C) Mycobacterium tuberculosis
- (D) Neisseria gonorrhoeae

Q40. BIO

Cholesterol and phospholipids are mainly synthesized in liver cells by:

- (A) Golgi complex
- (B) Mitochondria
- (C) Rough endoplasmic reticulum (RER)
- (D) Smooth endoplasmic reticulum (SER)

Q41. BIO

In disease diagnosis, the main function of monoclonal antibodies is:

- (A) To stimulate white blood cell production
- (B) To detect specific antigens in clinical samples
- (C) To bind to toxins produced by pathogens
- (D) To label abnormal cells for immune destruction

Q42. BIO

What happens to the pressure and volume of the thoracic cavity during inhalation?

- (A) Pressure and volume both increase
- (B) Pressure increases and volume decreases
- (C) Pressure decreases and volume increases
- (D) Pressure and volume both decrease

Q43. BIO

Which of the following layer is mainly composed of cardiac muscles?

- (A) Endocardium
- (B) Epicardium
- (C) Pericardium
- (D) Myocardium

Q44. BIO

Glycolipid is a combination of:

- (A) Lipid and carbohydrate
- (B) Lipid and protein
- (C) Nucleic acid and lipid
- (D) Protein and carbohydrate

Q45. BIO

The outer surface of the axon membrane in a resting neuron is:

- (A) Negative due to sodium ions
- (B) Positive due to sodium ions
- (C) Positive due to potassium ions
- (D) Neutral due to balanced ions

Q46. BIO

Which idea suggests that life was created by a supernatural force?

- (A) Special creation
- (B) Biogenesis
- (C) Spontaneous generation
- (D) Natural selection

Q47. BIO

A drug that relaxes smooth muscles in blood vessels is useful for:

- (A) Increasing skeletal muscles strength
- (B) Reducing blood pressure (vasodilation)
- (C) Increase heart rate
- (D) Causing voluntary contraction

Q48. BIO

During the process of gaseous exchange, all of the following are the functions of hemoglobin EXCEPT:

- (A) It acts as a buffer to stabilize the blood pH
- (B) It transports oxygen from lungs to other body tissues
- (C) It transports carbon dioxide from body tissues to lungs
- (D) It regulates the blood pressure when body is in stress

Q49. BIO

Thread-like single strand of a chromosome that is made of DNA and protein is known as:

- (A) Chromosome arm
- (B) Nucleosome
- (C) Chromosome
- (D) Chromatid

Q50. BIO

Which part of kidney is responsible for collecting urine before it enters the ureter?

- (A) Renal pelvis
- (B) Renal medulla
- (C) Renal cortex
- (D) Renal pyramids

Q51. BIO

Which of the following function is under control of medulla oblongata?

- (A) Memory
- (B) Vision
- (C) Breathing
- (D) Dreaming

Q52. BIO

Which structure conducts the action potential deep into the muscle fiber?

- (A) Z-line
- (B) Sarcomere
- (C) T-tubules
- (D) Sarcoplasmic reticulum

Q53. BIO

Which of the following is the most appropriate concept of oxygen carrying capacity of blood?

- (A) Ability of blood to carry oxygen
- (B) Ability of hemoglobin to bind with oxygen
- (C) Amount of oxygen present in the plasma
- (D) Rate of binding of fibrinogen with proteins

Q54. BIO

Which of the following does not occur during muscle contraction?

- (A) Release of calcium from sarcoplasmic reticulum
- (B) Formation of cross-bridge
- (C) Sliding of actin over myosin
- (D) Increase in sarcomere length

Q55. BIO

Maintenance of healthy bone tissues by secreting enzymes and influencing bone mineral content is the duty of:

- (A) Osteocytes
- (B) Osteoblasts
- (C) Osteoclasts
- (D) Osteogenic cells

Q56. BIO

After ovulation, the ruptured follicle in ovary transformed into:

- (A) Secondary follicle
- (B) Tertiary follicle
- (C) Corpus luteum
- (D) Corpus callosum

Q57. BIO

Lactose sugar is found in milk and is composed of:

- (A) Glucose + Glucose
- (B) Glucose + Fructose
- (C) Glucose + Galactose
- (D) Fructose + Galactose

Q58. BIO

Which factor affects the ionization state of an enzyme's active site?

- (A) Temperature
- (B) Enzyme concentration
- (C) Substrate concentration
- (D) pH

Q59. BIO

During sample analysis, students finds that it contains Carbon, Hydrogen, Oxygen and Nitrogen, but no phosphorous. Based on this information, which biological molecule is most likely to be in the sample?

- (A) DNA
- (B) Protein
- (C) Phospholipid
- (D) RNA

Q60. BIO

The structure that is directly continuous with the cell body transmits nerve impulses away from it, is:

- (A) Axon
- (B) Synapse
- (C) Dendrites
- (D) Myelin sheath

Q61. BIO

Anticodon that consist of complementary basis of three nucleotides is located on:

- (A) rRNA
- (B) mRNA
- (C) tRNA
- (D) DNA

Q62. BIO

The key difference between lymph nodes and lymph vessel is:

- (A) Vessels move lymph; nodes filter it.
- (B) Vessels carry oxygen; nodes produce bile.
- (C) Vessels digest toxins; nodes transport lymph.
- (D) Vessels store lymphocytes; nodes make plasma.

Q63. BIO

Which of the following is NOT related to large intestine?

- (A) Villi
- (B) Sigmoid colon
- (C) Appendix
- (D) Rectum

Q64. BIO

Spleen contributes towards:

- (A) Producing insulin and glucagon
- (B) Producing antibodies against fats
- (C) Increasing oxygen binding to hemoglobin
- (D) Filtering blood and removing old red blood cells

Q65. BIO

During lab analysis, a student extracted a molecule that contained a sugar, a phosphate group and a nitrogenous base. Which of the following molecules likely identified?

- (A) Nucleotide
- (B) Amino acid
- (C) Monosaccharides
- (D) Polysaccharides

Q66. BIO

Hemophilia is a sex linked recessive trait. A hemophiliac man marries to a normal woman (whose father is hemophiliac). If they have daughter, what is the probability that she will be hemophiliac?

- (A) 0%
- (B) 25%
- (C) 50%
- (D) 75%

Q67. BIO

The main function of Pacinian corpuscles is detect:

- (A) Chemical composition of food
- (B) Changes in temperature
- (C) Stimuli of pressure
- (D) Sharp pain signals

Q68. BIO

Dialyzing fluid has same osmotic pressure as the blood has except that it lacks:

- (A) Glucose
- (B) Water
- (C) Sodium and Potassium
- (D) Nitrogenous waste

Q69. BIO

Which type of inhibitor binds to a site other than the active site and changes the shape of active site?

- (A) Competitive inhibitor
- (B) Un-competitive inhibitor
- (C) Allosteric activator
- (D) Non-competitive inhibitor

Q70. BIO

Which of the following travels along a neuron during nerve impulse

- (A) waves of electrochemical changes
- (B) waves of thermal changes
- (C) waves of magnetic changes
- (D) waves of hormonal changes

Q71. BIO

Saltatory conduction of nerve impulse occurs in

- (A) Myelinated axons
- (B) Cell bodies
- (C) Unmyelinated axons
- (D) Dendrites

Q72. BIO

The cerebellum is mainly responsible for:

- (A) Vision, hearing and reflexes
- (B) Regulating heart beat only
- (C) Conscious, thoughts and reasoning
- (D) Balance, posture and coordination

Q73. BIO

A typical value of resting membrane potential in a neuron is:

- (A) -50 millivolts
- (B) +50 millivolts
- (C) -70 millivolts
- (D) +70 millivolts

Q74. BIO

Cartilage receives its nutrition through the process of:

- (A) Active transport
- (B) Diffusion
- (C) Phagocytosis
- (D) Osmosis

Q75. BIO

Pick the smallest form of carbohydrates from the following, which cannot be further

- (A) sucrose
- (B) lactose
- (C) glucose
- (D) starch

Q76. BIO

Which one of the following hormone increases the reabsorption of Na ions in the nephron?

- (A) ADH
- (B) LH
- (C) Insulin
- (D) Aldosterone

Q77. BIO

The nerve impulse for the contraction of skeletal muscle fiber is carried from sarcolemma to every myofibril of a muscle cell via

- (A) T-tubules
- (B) H-zone
- (C) Thin myofilaments
- (D) Thick myofilaments

Q78. BIO

All of the following have excretory role EXCEPT

- (A) Kidney
- (B) Skin
- (C) Appendix
- (D) Lungs

Q79. BIO

Reflex action is considered as the simplest form of response in

- (A) Simple animals
- (B) Higher animals
- (C) Lowest animals
- (D) Smaller animals

Q80. BIO

When fat molecule is hydrolyzed for energy, the end products will be:

- (A) Amino acids and glycerol
- (B) Glycerol and fatty acid
- (C) Fatty acids and amino acids
- (D) Glycerol and nitrogenous bases

Q81. BIO

A platform for protein synthesis in the cell is provided by:

- (A) mRNA
- (B) rRNA
- (C) tRNA
- (D) Protein encoding DNA

CHEM SECTION: CHEMISTRY

Questions 82 to 126 (45 MCQs)

Q82. CHEM

The molecules that has non zero dipole moment is?

- (A) CO
- (B) CO₂
- (C) BF₃
- (D) AlCl₃

Q83. CHEM

Unit of rate constant for a particular reaction depends upon the:

- (A) Temperature of reaction
- (B) Activation energy of reaction
- (C) Molecularity of reaction
- (D) Order of reaction

Q84. CHEM

The activation energy of a reaction is usually:

- (A) Unaffected by the process of a catalyst
- (B) Low for the reaction that takes place slowly
- (C) Different for the forward and backward reaction
- (D) Increases with rise in temperature

Q85. CHEM

Common name of pentanoic acid is

- (A) Oxalic acid
- (B) Valeric acid
- (C) Caproic acid
- (D) Stearic acid

Q86. CHEM

Which monomer is used for synthesis of nylon 6,6?

- (A) Sebacoyl chloride
- (B) Methylene diamine
- (C) Heptane-1, 7-dioic acid
- (D) Hexamethylene diamine

Q87. CHEM

 $\text{NO}_2^- \rightarrow \text{NO}_3^- + n\text{e}^-$. Value of "n" by the oxidation number method is:

- (A) 1
- (B) 2
- (C) 3
- (D) 6

Q88. CHEM

Ketones when treated with LiAlH₄ in the presence of dry ether, they are converted to:

- (A) Primary Alcohol
- (B) Monohydric alcohol
- (C) Secondary alcohol
- (D) Dihydric alcohol

Q89. CHEM

Which of the following has lower vapour pressure?

- (A) CHCl₃
- (B) CCl₄
- (C) H₂O
- (D) CH₃COCH₃

Q90. CHEM

When liquids are heated, volume _____

- (A) Decreases
- (B) Increases
- (C) Remains same
- (D) Cannot be measured

Q91. CHEM

Toluene reacts with bromine in the presence of UV light to produce:

- (A) m-Bromotoluene
- (B) Benzyl bromide
- (C) o-Bromotoluene
- (D) Bromobenzene

Q92. CHEM

A terminal alkyne is treated with Lindlar catalyst and Hydrogen. The major product is:

- (A) Trans-alkene
- (B) Cis-alkene
- (C) Alkane
- (D) Vinyl chloride

Q93. CHEM

Dehydration of alcohol to form ethene is an example of:

- (A) Substitution reaction
- (B) Addition reaction
- (C) Elimination reaction
- (D) Redox reaction

Q94. CHEM

Reaction of Phenol with Acetyl chloride will yield:

- (A) Alcohol
- (B) Ester
- (C) Carboxylic acid
- (D) Ether

Q95. CHEM

When hydrochloric acid is added to brine, solubility of sodium chloride:

- (A) Decreases
- (B) Increases
- (C) Remains same
- (D) Become equal to HCl

Q96. CHEM

Consider the given reaction: $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$. If 4 moles of Na and 2 moles of Cl_2 are reacted, how much Cl_2 will remain unreacted?

- (A) 0 mol
- (B) 0.5 mol
- (C) 1 mol
- (D) 1.5 mol

Q97. CHEM

If molecules have strong dipole dipole force, then they have high?

- (A) Heat of neutralization
- (B) Heat of combustion
- (C) Heat of vaporization
- (D) Heat of atomization

Q98. CHEM

A triatomic molecule must be either linear with bond angle of 180° or

- (A) T-shape
- (B) Bent
- (C) Pyramidal
- (D) Tetrahedral

Q99. CHEM

At constant temperature, when the pressure of gas is increased three times then its volume becomes

- (A) $2V/3$
- (B) $3V$
- (C) $V/3$
- (D) $5V$

Q100. CHEM

Which one of the following is an exothermic process?

- (A) Melting of ice
- (B) Evaporation of water
- (C) Oxidation of Sulphur
- (D) Photosynthesis

Q101. CHEM

If an electrophile is the attacking reagent, which one is the most reactive?

- (A) R-I
- (B) R-F
- (C) R-Br
- (D) R-Cl

Q102. CHEM

A student starts a reaction expecting to get 28g of product. After isolating and drying the product she obtains 18g. Later it was found that 4g was lost due to spillage. What is the actual and percentage yield?

- (A) 14g and 50%
- (B) 22g and 78%
- (C) 28g and 85%
- (D) 24g and 90%

Q103. CHEM

Which one has strongest metallic bond?

- (A) Na
- (B) Mg
- (C) Al
- (D) P

Q104. CHEM

What is formed by homolysis of covalent bond?

- (A) Free radical
- (B) Molecule
- (C) Ion
- (D) Atom

Q105. CHEM

Which hydride of group VIIA has lowest boiling point?

- (A) HF
- (B) HCl
- (C) HBr
- (D) HI

Q106. CHEM

Which of the following is natural adhesive?

- (A) Silicones
- (B) Polyvinylacetate
- (C) Casein glue
- (D) Polyamide

Q107. CHEM

Which metal hydroxide is stable to heat?

- (A) Li
- (B) Na
- (C) Mg
- (D) Ca

Q108. CHEM

The electrons will enter which of these orbitals after filling the 3d orbital

- (A) 4d
- (B) 4f
- (C) 4s
- (D) 4p

Q109. CHEM

Kc value will change, if we change

- (A) Pressure
- (B) Temperature
- (C) Concentration
- (D) Any one

Q110. CHEM

Which of the following reaction is the characteristic of alkene?

- (A) Electrophilic Addition
- (B) Nucleophilic Substitution
- (C) Free Radical Substitution
- (D) Elimination

Q111. CHEM

The IUPAC name for $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CHO}$ is

- (A) Three-one Pentanal
- (B) Three-oxo Pentanal
- (C) Three-one Pentanol
- (D) Three-oxo Pentanol

Q112. CHEM

Expression for Boyle's law is:-

- (A) $V \propto n$
- (B) $V \propto P^{-1}$
- (C) $T \propto P$
- (D) $P \propto n$

Q113. CHEM

Which of the following group acts as chromophore?

- (A) Amino Group
- (B) Azo Group
- (C) Hydroxyl Group
- (D) Sulfonic Acid Group

Q114. CHEM

A molecule will be chiral, if it has

- (A) Three Different Groups
- (B) No Element Of Symmetry
- (C) Superimposed
- (D) Mirror Image

Q115. CHEM

Which one is the most volatile liquid?

- (A) Water
- (B) Methanol
- (C) Benzene
- (D) Diethylether

Q116. CHEM

Zn-Hg/conc. HCl reduces acetaldehyde to

- (A) Ethane
- (B) Ethene
- (C) Acetic Acid
- (D) Para Aldehyde

Q117. CHEM

Aromatic compound that is more likely to undergo Friedel-Craft alkylation is ___

- (A) Benzene
- (B) Toluene
- (C) Nitrobenzene
- (D) Benzaldehyde

Q118. CHEM

Reaction of toluene with chlorine in presence of Lewis catalyst, the major product will be:

- (A) O-chlorotoluene
- (B) M-chlorotoluene
- (C) P-chlorotoluene
- (D) Equal mixture of o and p toluene

Q119. CHEM

Which element has smallest ionic radius?

- (A) Li+1
- (B) Na+1
- (C) K+1
- (D) Rb+1

Q120. CHEM

If intermolecular forces between gas molecules disappear suddenly, which of the following would happen?

- (A) Pressure decreases
- (B) Pressure increases
- (C) Gas collapses
- (D) Pressure remains unchanged

Q121. CHEM

Rate constant depends upon:

- (A) Volume
- (B) Temperature
- (C) Concentration
- (D) Pressure

Q122. CHEM

Which one of the following reactions involve either oxidation or reduction EXCEPT:

- (A) $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
- (B) $\text{Cu}^{++} + \text{Zn} \rightarrow \text{Zn}^{++} + \text{Cu}$
- (C) $\text{CuO} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{H}_2\text{O}$
- (D) $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$

Q123. CHEM

NH_3 has net dipole moment but BF_3 has zero net dipole moment because of?

- (A) B is less E.N than N
- (B) F is more E.N than N
- (C) BF_3 is pyramidal
- (D) NH_3 is pyramidal

Q124. CHEM

Which of the following mechanism involves a carbocation intermediate?

- (A) E1 mechanism
- (B) SN1 mechanism
- (C) SN2 mechanism
- (D) E2 mechanism

Q125. CHEM

The N-F-N bond in NF_3 is $101.9 - 102.4^\circ$, much lesser than in ammonia due to

- (A) Presence of lone pair on F
- (B) high electronegativity of F
- (C) large size of F
- (D) Its drawback of VSEPR

Q126. CHEM

$n + l$ value for 4d orbital is

- ☐ A 4
 - ☐ B 5
 - ☐ C 6
 - ☐ D 7
-

PHY SECTION: PHYSICS

Questions 127 to 162 (36 MCQs)

Q127. PHY

If vector $A = 2i + j + 3k$ is perpendicular to $B = i + j + xk$, then $x =$

- (A) 3
- (B) -3
- (C) 1
- (D) -1

Q128. PHY

Two standing waves vibrate in fundamental mode in two organ pipes A (open) and B (closed) each of length 60 cm. The ratio of frequency of A to B is

- (A) 1:2
- (B) 1:1
- (C) 2:1
- (D) 2:3

Q129. PHY

The efficiency of an emf source becomes 50% when the load resistance is equal to

- (A) Internal resistance
- (B) Double the internal resistance
- (C) Half the internal resistance
- (D) Zero

Q130. PHY

Water flows through a horizontal pipe with area of 0.02 m^2 at 3 m/s . The pipe narrows to 0.01 m^2 . The velocity in the narrow section is

- (A) 0.5 m/s
- (B) 1.5 m/s
- (C) 3 m/s
- (D) 6 m/s

Q131. PHY

The coulomb repulsive force between two protons inside a nucleus is much higher than the gravitational attractive force by a factor of approximately

- (A) 10^{36}
- (B) 10^{10}
- (C) 10^{15}
- (D) 10^{12}

Q132. PHY

A progressive wave differs from a stationary wave because in progressive wave

- (A) particles remain at fixed nodes
- (B) Particles oscillate and transfer energy
- (C) Particles stay at anti nodes
- (D) Particles move forward with the wave

Q133. PHY

A particle is moving in a uniform circular path of radius 4 cm with velocity 4 cm/s . The maximum acceleration of the projection executing simple harmonic motion on horizontal diameter is

- (A) 4 cm/s^2
- (B) 8 cm/s^2
- (C) 12 cm/s^2
- (D) 16 cm/s^2

Q134. PHY

A man pushes a wall with a force of 100 N for 10 seconds. The work done by the man on the wall is:

- (A) 1000 J
- (B) 100 J
- (C) 10 J
- (D) zero

Q135. PHY

An electric field exists in a region if:

- (A) test charge experiences a force
- (B) Voltage is zero
- (C) Charge density is uniform
- (D) The medium is vacuum

Q136. PHY

The dot product of two vectors is negative. If one vector lies along the positive x-axis, then the projection of second vector is along:

- (A) x-axis
- (B) -x-axis
- (C) y-axis
- (D) -y-axis

Q137. PHY

If a photon of gamma ray and one of x-ray are compared, then:

- (A) x-ray photon has more energy
- (B) Both have same energy
- (C) Gamma-ray photon has more energy
- (D) Both have same wavelength

Q138. PHY

According to the Faraday's law of electromagnetic induction, emf induced in a coil placed in changing magnetic field, depends upon:

- (A) the magnetic field
- (B) amount of current
- (C) resistance of a coil
- (D) the rate of change of magnetic flux

Q139. PHY

The power transmission lines delivering same amount of power. An increase in current will increase:

- (A) Heat produced in the wires
- (B) Voltage output
- (C) Frequency of AC
- (D) Mechanical stress on the wires

Q140. PHY

If the capacitance in a purely capacitive AC circuit is doubled, the current will be:

- (A) Double
- (B) Become half
- (C) Remain same
- (D) Decrease to the fourth

Q141. PHY

F is the force between two identical charges each with a charge (e) separated by a distance (r). If the separation is made quarter of the initial separation (r), then the new force in terms F can be written as:

- (A) $F/4$
- (B) $16F$
- (C) $32F$
- (D) F

Q142. PHY

If two points are at the same potential in a electric field, then the work done in moving a unit positive charge from one point to another is equal to:

- (A) -0.5 J
- (B) 0 J
- (C) 1 J
- (D) 2 J

Q143. PHY

A rolling cart collides with a stationary cart of equal mass. After the collision, both move together, momentum is still conserved because:

- (A) Masses are equal
- (B) No external force acts on the system
- (C) Both move with the same speed
- (D) Internal forces are very small

Q144. PHY

The result of vector product of two vectors:

- (A) number
- (B) unit
- (C) number and unit
- (D) magnitude and a unit vector

Q145. PHY

A proton and an electron are held stationary at a distance r in a uniform electric field. If released, how does their potential energy change?

- (A) Increases
- (B) Decreases
- (C) Remains constant
- (D) First increases, then decreases

Q146. PHY

The average speed of a body in a given interval of time is equal to the average velocity, if:

- (A) The speed of the body remains uniform.
- (B) The body moves with constant acceleration.
- (C) The body moves along a straight path.
- (D) The body returns to its starting point.

Q147. PHY

When the diameter of a blood vessel narrows, the velocity and pressure of blood will

- (A) Decrease velocity and increase pressure
- (B) Increase velocity and decrease pressure
- (C) No change in velocity and pressure
- (D) Decrease velocity and decrease pressure

Q148. PHY

For a diode, the depletion region of a PN junction has

- (A) Free positive charges
- (B) Free negative charges
- (C) Positive and negative ions
- (D) No free charges

Q149. PHY

For an ideal gas, the relation between molar specific heats C_p and C_v is

- (A) $C_p = C_v + R$
- (B) $C_p = C_v - R$
- (C) $C_v = C_p + R$
- (D) $C_p = R - C_v$

Q150. PHY

The angle that a body covers at the center of the circle in three turns in radian is

- (A) 0
- (B) 3
- (C) 10.8
- (D) 18.8

Q151. PHY

The ratio of longest to shortest wave lengths in Bracket series of hydrogen spectrum is:

- (A) $25/9$
- (B) $17/6$
- (C) $9/5$
- (D) $4/3$

Q152. PHY

A 4kg box initially at rest is pulled along a frictionless surface by a constant horizontal force of 8 N. After 15 seconds, its kinetic energy is

- (A) 120 J
- (B) 600 J
- (C) 960 J
- (D) 1800 J

Q153. PHY

The magnitude of electric field intensity due to a point charge q at a distance r in vacuum is given by

- (A) $E = q/r^2$
- (B) $E = kq/r$
- (C) $E = kq/r^2$
- (D) $E = k/r^2$

Q154. PHY

If the angle between force and velocity is 90° , the power delivered by the force is

- (A) Zero
- (B) Maximum
- (C) Minimum but not zero
- (D) Infinite

Q155. PHY

Bernoulli's principle helps explain why blood pressure drops when blood velocity

- (A) Increases in narrow vessel
- (B) Decreases in narrow vessel
- (C) Increases in wide vessel
- (D) Decreases in wide vessel

Q156. PHY

A string vibrates in the first, second and third harmonics. The ratio of their wavelength is

- (A) 1:2:3
- (B) 3:2:1
- (C) 1:4:9
- (D) 3:6:9

Q157. PHY

If the length of the copper wire connected in a circuit is doubled, its resistivity?

- (A) Becomes half
- (B) Becomes double
- (C) Becomes four times
- (D) Remain same

Q158. PHY

On increasing the length of a wire, the specific resistance (resistivity) of the wire

- (A) Increases
- (B) Decreases
- (C) Remains unchanged
- (D) First increases, then decreases

Q159. PHY

When a battery is being charged, the direction of current inside the battery

- (A) is from positive to negative terminal
- (B) is the same as the direction of emf
- (C) is opposite to the direction of emf
- (D) depends on the load resistance

Q160. PHY

A ball is thrown vertically upward with a certain velocity making an angle with the horizontal neglecting air resistance. With the passage of time horizontal component of velocity .

- (A) Increases
- (B) Decreases
- (C) Remains same
- (D) First decreases then increases

Q161. PHY

A capacitor of capacitance $2\ \mu\text{F}$ is connected in series with $1\ \text{M}\Omega$ resistance and 12 volts battery. The time taken by this capacitor to take to 63% of its equilibrium charge will be

- (A) 1 second
- (B) 2 seconds
- (C) 10 seconds
- (D) Infinite

Q162. PHY

Dot product of two unit vectors is

- (A) 1
- (B) 0
- (C) $\cos \theta$
- (D) $AB \cos \theta$

ENG SECTION: ENGLISH

Questions 163 to 171 (9 MCQs)

Q163. ENG

Which sentence implies that it was unexpected that she took the test.

- (A) She even took the test.
- (B) She took even the test.
- (C) Even she took the test.
- (D) She took the test even.

Q164. ENG

Which version improves tone and formality in the sentence:

"You boys need to submit the paper ASAP."

- (A) You should submit the paper as soon as you can.
- (B) Everyone needs to get the paper in quickly.
- (C) The paper should be submitted as soon as possible.
- (D) Y'all better hand it in now.

Q165. ENG

Pick out the sentence with appropriate use of transitional device.

- (A) She likes to read books but watch movies.
- (B) She is a talented musician likewise a gifted painter.
- (C) She is not only intelligent but also very kind.
- (D) Second; gather your material. First, begin your project.

Q166. ENG

The students decided to meet the teacher and request him for a favour.

The main verb in this sentence is:

- (A) Meet
- (B) Request
- (C) Meet & request
- (D) Decided

Q167. ENG

"She remained stoic during the crisis, refusing to show fear or distress."

Deduce the meaning of the underlined word from the given sentence.

- (A) Anxious
- (B) Resilient
- (C) Angry
- (D) Confused

Q168. ENG

Choose the word with incorrect spelling:

- (A) sagacious
- (B) foremost
- (C) berister
- (D) pneumonia

Q169. ENG

What is the correct reported speech for the given sentence?

He said, "I am going to the store."

- (A) He said that he was going to the store.
- (B) He said that he is going to the store.
- (C) He said that he has been going to the store.
- (D) He said that he had been going to the store.

Q170. ENG

Identify the sentence that uses inversion correctly:

- (A) Rarely I have seen such a beautiful scene.
- (B) Rarely have I seen such a beautiful scene.
- (C) Rarely seen I have such a beautiful scene.
- (D) Rarely I seen have such a beautiful scene.

Q171. ENG

Many follow exactly what is written in the _____.

- (A) scripturies
- (B) screptures
- (C) scriptures
- (D) scripttures

LOGIC SECTION: LOGICAL REASONING

Questions 172 to 180 (9 MCQs)

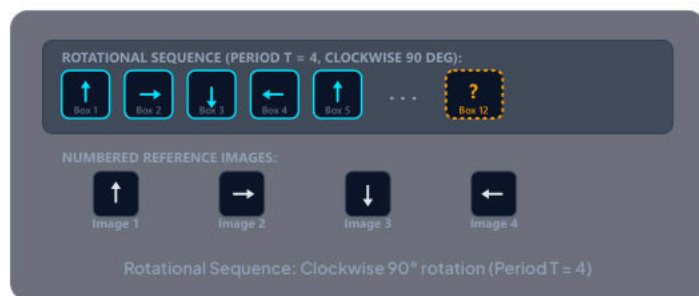
Q172. LOGIC

Prohibiting smoking in public areas will reduce the occurrence of lung disease. What assumption is present here?

- (A) Banning smoking has no impact on lung disease rates.
- (B) Hence all people live in public areas therefore, banning smoking will eliminate lung disease.
- (C) Smoking is the sole cause of lung disease.
- (D) Smoking in public places plays a major role in causing lung disease.

Q173. LOGIC

Consider the pattern in the given picture. If the pattern is continued, then the image in box 12 will resemble the image No.?



- (A) 1
- (B) 2
- (C) 3
- (D) 4

Q174. LOGIC

The age of a man is twice that of his daughter. If the man is 36 years old, what was the daughter's age 4 years ago?

- (A) 14 years
- (B) 18 years
- (C) 20 years
- (D) 10 years

Q175. LOGIC

Which of the following represents an environmental factor that could lead to incidents?

- (A) Lack of experience
- (B) Machine malfunctioning
- (C) A storm leading to power disruptions
- (D) A design flaw

Q176. LOGIC

If a person earns Rs. 1000 in the first week and their income doubles each week, how much will they earn in the 4th week?

- (A) Rs. 4000
- (B) Rs. 3000
- (C) Rs. 8000
- (D) Rs. 16000

Q177. LOGIC

What would be the result of: $10 - 3 \times 2$?

- (A) 4
- (B) 6
- (C) 14
- (D) 17

Q178. LOGIC

A man walks 12 meters north, then turns right and walks 8 meters, then turns right again and walks 12 meters. He finally turns left and walks 5 meters. What is the distance between his starting and ending point?

- (A) 5m
- (B) 8m
- (C) 13m
- (D) 17m

Q179. LOGIC

In a certain university, 25% candidates failed university admission test. Of those who passed the test, 80% got the admission in the university. If 1800 got admission, how many candidates appear in the test?

- (A) 9000
- (B) 6000
- (C) 5000
- (D) 3000

Q180. LOGIC

CAT is to DOG, as MOUSE is to:

- (A) RAT
- (B) CAT
- (C) DOG
- (D) CHEESE

OFFICIAL VERIFIED ANSWER KEY

BUMHS Quetta MDCAT 2025 Official Paper: Rapid Self-Grading Grid

Online Portal >

Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB
1	D	BIO	37	D	BIO	73	C	BIO	109	B	CHEM	145	B	PHY
2	C	BIO	38	A	BIO	74	B	BIO	110	A	CHEM	146	C	PHY
3	B	BIO	39	D	BIO	75	C	BIO	111	B	CHEM	147	B	PHY
4	C	BIO	40	D	BIO	76	D	BIO	112	B	CHEM	148	D	PHY
5	C	BIO	41	B	BIO	77	A	BIO	113	B	CHEM	149	A	PHY
6	C	BIO	42	C	BIO	78	C	BIO	114	B	CHEM	150	D	PHY
7	C	BIO	43	D	BIO	79	B	BIO	115	D	CHEM	151	A	PHY
8	D	BIO	44	A	BIO	80	B	BIO	116	A	CHEM	152	D	PHY
9	C	BIO	45	B	BIO	81	B	BIO	117	B	CHEM	153	C	PHY
10	D	BIO	46	A	BIO	82	A	CHEM	118	C	CHEM	154	A	PHY
11	A	BIO	47	B	BIO	83	D	CHEM	119	A	CHEM	155	A	PHY
12	B	BIO	48	D	BIO	84	C	CHEM	120	B	CHEM	156	B	PHY
13	A	BIO	49	D	BIO	85	B	CHEM	121	B	CHEM	157	D	PHY
14	B	BIO	50	A	BIO	86	D	CHEM	122	C	CHEM	158	C	PHY
15	D	BIO	51	C	BIO	87	B	CHEM	123	D	CHEM	159	C	PHY
16	C	BIO	52	C	BIO	88	C	CHEM	124	B	CHEM	160	C	PHY
17	B	BIO	53	B	BIO	89	C	CHEM	125	B	CHEM	161	B	PHY
18	C	BIO	54	D	BIO	90	B	CHEM	126	C	CHEM	162	C	PHY
19	A	BIO	55	A	BIO	91	B	CHEM	127	D	PHY	163	C	ENG
20	C	BIO	56	C	BIO	92	B	CHEM	128	C	PHY	164	C	ENG
21	B	BIO	57	C	BIO	93	C	CHEM	129	A	PHY	165	C	ENG
22	C	BIO	58	D	BIO	94	B	CHEM	130	D	PHY	166	D	ENG
23	C	BIO	59	B	BIO	95	A	CHEM	131	A	PHY	167	B	ENG
24	B	BIO	60	A	BIO	96	A	CHEM	132	B	PHY	168	C	ENG
25	A	BIO	61	C	BIO	97	C	CHEM	133	A	PHY	169	A	ENG
26	D	BIO	62	A	BIO	98	B	CHEM	134	D	PHY	170	B	ENG
27	B	BIO	63	A	BIO	99	C	CHEM	135	A	PHY	171	C	ENG
28	B	BIO	64	D	BIO	100	C	CHEM	136	B	PHY	172	D	LOGIC
29	B	BIO	65	A	BIO	101	B	CHEM	137	C	PHY	173	D	LOGIC
30	B	BIO	66	C	BIO	102	A	CHEM	138	D	PHY	174	A	LOGIC
31	A	BIO	67	C	BIO	103	C	CHEM	139	A	PHY	175	C	LOGIC
32	A	BIO	68	D	BIO	104	A	CHEM	140	A	PHY	176	C	LOGIC
33	A	BIO	69	D	BIO	105	B	CHEM	141	B	PHY	177	A	LOGIC
34	C	BIO	70	A	BIO	106	C	CHEM	142	B	PHY	178	C	LOGIC
35	B	BIO	71	A	BIO	107	B	CHEM	143	B	PHY	179	D	LOGIC
36	B	BIO	72	D	BIO	108	D	CHEM	144	D	PHY	180	A	LOGIC

SUBJECT-WISE PERFORMANCE BREAKDOWN

SUBJECT	MAX	YOUR SCORE	ACCURACY
Biology	81		----- %
Chemistry	45		----- %
Physics	36		----- %
English	9		----- %
Logical Reasoning	9		----- %
TOTAL	180	-----	----- %

PMDC PROVINCIAL MERIT FORMULA

Official Weightage Law:

- MDCAT Component (50%): (Your Score / 180) × 50
- FSc / HSSC Component (40%): (FSc Marks / 1100) × 40
- Matric / SSC Component (10%): (Matric Marks / 1100) × 10

Estimated Provincial Merit Aggregate: ----- %

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1 Key: (D)

BIOLOGY
12. Nervous Coordination

The primary function of the sensory neuron in a reflex arc is to:

CORE CONCEPT & DERIVATION

In a somatic reflex arc, sensory (afferent) neurons transmit action potentials from peripheral sensory receptors toward integrating centers located in the central nervous system (spinal cord).

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Sensory neurons receive receptor potentials transduced by peripheral receptors and propagate action potentials along afferent axons entering the dorsal horn of the spinal cord.
- In a monosynaptic or polysynaptic spinal reflex loop, these afferent signals synapse onto interneurons or lower motor neurons without requiring initial cortical processing.

Why other options are incorrect:

- Option A:** Muscle contraction is directly stimulated by efferent lower motor neurons, not afferent sensory neurons.
- Option B:** Detection and initial sensory transduction of environmental stimuli are performed by specialized sensory receptors, not the conducting neuron itself.
- Option C:** While ascending somatosensory tracts eventually inform the brain, basic spinal reflex execution relies on transmission directly into the spinal cord segment.

Question #2 Key: (C)

BIOLOGY
03. Enzymes

Which change occurs in enzyme activity when temperature increases beyond the optimum level?

CORE CONCEPT & DERIVATION

Thermal energy exceeding an enzyme's optimum temperature disrupts the weak non-covalent interactions stabilizing its tertiary and quaternary conformations, resulting in thermal denaturation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Up to the optimum temperature, increasing kinetic energy accelerates collision frequency between enzyme active sites and substrates.
- Beyond the optimum, excessive vibrational energy disrupts hydrogen bonds and ionic interactions, causing conformational collapse (denaturation) of the catalytic cleft and precipitous loss of activity.

Why other options are incorrect:

- Option A:** Enzymatic reaction velocity drops precipitously rather than remaining static due to active site loss.
- Option B:** Activity increases with temperature strictly below the optimum threshold; supramaximal temperatures deactivate the protein.
- Option D:** Thermal unfolding disrupts stereospecific binding pockets, abolishing enzyme specificity entirely.

Question #3 Key: (B)

BIOLOGY
15. Inheritance / Variation & Genetics

In the second step of his experiment, what did Mendel do after selecting pure-breeding tall and...

CORE CONCEPT & DERIVATION

Mendel's experimental hybridization protocol required cross-pollinating distinct true-breeding parental lines (P) to generate the first filial (F₁) generation.

Formula / Rule / Reaction:

$$P_1 : TT \text{ (pure tall)} \times tt \text{ (pure dwarf)} \rightarrow F_1 : Tt \text{ (monohybrid tall)}$$

Solution:

- The initial step verified homozygosity through repeated self-fertilization, isolating true-breeding parental varieties.
- The second step involved manual emasculation and artificial cross-pollination between tall and dwarf plants to produce heterozygous F₁ hybrids.

Why other options are incorrect:

- Option A:** Self-pollination was utilized in step three on the F₁ hybrids to evaluate phenotypic segregation in the F₂ generation.
- Option C:** Seeds were harvested from rigorously controlled artificial crosses rather than random collections.
- Option D:** Environmental growth conditions such as soil composition were maintained uniform to prevent confounding phenotypic plasticity.

Question #4 Key: (C)

BIOLOGY
08. Immunity

The less common cause of HIV mode of transmission is:

CORE CONCEPT & DERIVATION

Human Immunodeficiency Virus (HIV) requires specific human cellular receptors (CD4 and CCR5/CXCR4) to infect host cells and cannot replicate within or be biologically or mechanically transmitted by arthropod vectors.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Documented modes of HIV transmission require direct exchange of infective bodily fluids: sexual fluids, blood products, transplacental transfer, or breast milk.
- Mosquitoes digest viral particles rapidly within their gut, and insect saliva lacks human target cells or viral titers, yielding zero documented transmission potential.

Why other options are incorrect:

- Option A:** Transfusion of unscreened donor blood or contaminated blood products is an established, high-efficiency transmission route.
- Option B:** Vertical transmission across the chorionic villi of the placenta is a recognized congenital infection route.
- Option D:** Postnatal transmission via consumption of maternal breast milk is a well-characterized mode of transmission.

Question #5 Key: (C)BIOLOGY
02. Biomolecules*Which of the following is a correct structural feature of RNA?***CORE CONCEPT & DERIVATION**

Ribonucleic acid (RNA) is a polymer composed of ribonucleotide units characterized by a ribose pentose sugar and the pyrimidine base uracil in place of thymine.

Formula / Rule / Reaction:*Factual recall / Qualitative concept.***Solution:**

- The primary structure of RNA incorporates adenine, guanine, cytosine, and uracil.
- Uracil lacks the 5-methyl group present on thymine and forms complementary base pairs with adenine via two hydrogen bonds.

Why other options are incorrect:

- **Option A:** RNA incorporates ribose containing a 2'-hydroxyl group, unlike the 2'-deoxyribose of DNA.
- **Option B:** Native RNA transcripts are synthesized as single-stranded polymers, forming localized secondary hairpins rather than continuous genomic double helices.
- **Option D:** RNA functions throughout the cytosol, ribosomes, and endoplasmic reticulum following nuclear export.

Question #6 Key: (C)BIOLOGY
14. Reproduction*The part of male reproductive system involved in the storage and maturation of sperms is:***CORE CONCEPT & DERIVATION**

Spermatozoa exiting the rete testis are immotile and physiologically immature, requiring transit through the epididymis to acquire functional motility, membrane remodeling, and storage capacity.

Formula / Rule / Reaction:*Factual recall / Qualitative concept.***Solution:**

- The epididymis is a highly convoluted duct resting along the posterolateral aspect of the testis.
- During epididymal transit, spermatozoa undergo biochemical maturation (glycoprotein coat alterations, progressive motility acquisition) and are stored primarily within the cauda epididymidis until ejaculation.

Why other options are incorrect:

- **Option A:** The scrotum is an external thermoregulatory sac housing the testes at sub-core body temperature.
- **Option B:** The vas deferens functions as a muscular conduit transporting mature sperm from the epididymis toward the ejaculatory duct.
- **Option D:** The testes are the primary site of spermatogenesis within the seminiferous tubules and testosterone biosynthesis, but not sperm maturation.

Question #7 Key: (C)BIOLOGY
10. Homeostasis*One of the best preventive measure for kidney stones formation is:***CORE CONCEPT & DERIVATION**

Urolithiasis arises when lithogenic urinary solutes (calcium, oxalate, phosphate, uric acid) exceed solubility product limits, leading to crystal supersaturation and aggregation.

Formula / Rule / Reaction:*Factual recall / Qualitative concept.***Solution:**

- High fluid intake expands total urinary volume, reducing solute concentration below spontaneous crystallization thresholds.
- Increased urinary flow rates mechanically wash away microcrystalline nucleations before they grow into clinically obstructive calculi.

Why other options are incorrect:

- **Option A:** Prophylactic antibiotics do not prevent non-infectious metabolic calculi and promote antimicrobial resistance.
- **Option B:** Total dairy elimination reduces intestinal calcium, paradoxical increasing free oxalate absorption and promoting calcium oxalate stone formation.
- **Option D:** Physical inactivity promotes skeletal demineralization and hypercalciuria, exacerbating stone formation.

Question #8 Key: (D)BIOLOGY
17. Biotechnology*Key benefit of using biotechnology in development of vaccine for malaria is:***CORE CONCEPT & DERIVATION**

Recombinant biotechnology enables the expression of pure, specific parasite antigens to induce high-titer protective humoral and cellular immunity without exposing the host to viable pathogens.

Formula / Rule / Reaction:*Factual recall / Qualitative concept.***Solution:**

- Subunit and virus-like particle malaria vaccines present specific surface antigens (such as the circumsporozoite protein).
- This triggers high-affinity neutralizing antibody production and memory T cell responses that neutralize sporozoites prior to hepatocyte invasion.

Why other options are incorrect:

- **Option A:** *Plasmodium* is an obligate destructive intracellular parasite, not a beneficial endosymbiont.
- **Option B:** Vaccines stimulate active endogenous acquired immunity, whereas drugs are exogenous chemical agents that directly eradicate existing parasites.
- **Option C:** Clinical human vaccines protect the human host against liver and blood stages, rather than eradicating the vector phase.

Question #9 Key: (C)BIOLOGY
06. Digestion/Nutrition

Nasal opening is closed by which of the following to prevent food from entering into food pipe?

CORE CONCEPT & DERIVATION

During the pharyngeal stage of deglutition, reflexive elevation of the soft palate occludes the internal nares (nasopharynx), preventing retrograde food movement into the nasal cavity.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Contraction of the tensor veli palatini and levator veli palatini muscles lifts the soft palate and uvula superiorly and posteriorly.
- This apposes the soft palate against the posterior pharyngeal wall, sealing off the nasopharyngeal isthmus and directing the bolus downward toward the esophagus.

Why other options are incorrect:

- **Option A:** The hard palate is a static bony structure forming the anterior palate; it does not elevate or close the posterior nasal aperture.
- **Option B:** The epiglottis protects the laryngeal inlet, preventing bolus entry into the lower respiratory tract.
- **Option D:** The larynx elevates anterosuperiorly to tuck beneath the tongue base for airway protection, not to seal the nasal cavities.

Question #10 Key: (D)BIOLOGY
07. Circulation / Transport

Ventricular systole causes:

CORE CONCEPT & DERIVATION

During the isovolumetric phase of ventricular systole, rising intraventricular pressure exceeds atrial pressure, abruptly snapping the atrioventricular (tricuspid and bicuspid) valves shut.

Formula / Rule / Reaction:

$$\Delta P = P_{\text{ventricle}} - P_{\text{atrium}} > 0 \implies \text{Closure of AV valves (First Heart Sound, } S_1)$$

Solution:

- Ventricular myocardial depolarization triggers sharp intraventricular pressure generation.
- Retrograde pressure forces the cusps of the atrioventricular valves superiorly, where chordae tendineae prevent eversion, sealing the atrioventricular orifices.

Why other options are incorrect:

- **Option A:** Atrial relaxation (atrial diastole) commences during late atrial depolarization, preceding ventricular pressure elevation.
- **Option B:** Atrial contraction occurs during presystole (atrial systole), completing prior to the onset of ventricular systole.
- **Option C:** Semilunar valves are forced open when ventricular pressure exceeds aortic/pulmonary diastolic pressure; they close during early ventricular diastole.

Question #11 Key: (A)BIOLOGY
11. Support & Movement

The connective tissue which connects skeletal muscle to bone is:

CORE CONCEPT & DERIVATION

Tendons are specialized dense regular connective tissue structures composed of densely packed, parallel bundles of type I collagen that transmit mechanical tension from contracting muscles to bone.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Skeletal muscle epimysium, perimysium, and endomysium consolidate at the myotendinous junction to form the tendon.
- The tendon collagen fibers integrate continuously into the periosteum and cortical bone matrix via Sharpey's fibers.

Why other options are incorrect:

- **Option B:** Ligaments connect bone to bone across articulation complexes to stabilize joint boundaries.
- **Option C:** Cartilage provides resilient, low-friction articular surfaces and structural support, but does not attach muscle to bone.
- **Option D:** The synovial membrane lines inner diarthrodial joint capsules and secretes lubricating synovial fluid.

Question #12 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

A pea plant which upon self fertilization produces all the offspring of its own phenotype is ca...

CORE CONCEPT & DERIVATION

A true-breeding plant carries identical alleles at a given gene locus (homozygous condition), yielding gametes with identical alleles that preserve parental phenotypes upon selfing.

Formula / Rule / Reaction:

$$\text{Selfing: } AA \times AA \rightarrow 100\% AA \quad \text{or} \quad aa \times aa \rightarrow 100\% aa$$

Solution:

- A homozygous genotype carries two copies of the same allele (dominant or recessive).
- Self-fertilization cannot introduce alternative alleles, ensuring complete phenotypic uniformity throughout all succeeding generations.

Why other options are incorrect:

- **Option A:** 'Homogenous' is a general physical/chemical term describing uniform phase distribution, not a genetic allelic designation.
- **Option C:** 'Homologous' designates paired chromosome maternal and paternal partners, not individual gene locus states.
- **Option D:** 'Hemizygous' denotes having only a single allele copy at a locus (e.g., genes on the X chromosome in XY males).

Question #13 Key: (A)BIOLOGY
02. Biomolecules

If a polypeptide of 20 amino acids is made up of all different amino acids, at least how many t...

CORE CONCEPT & DERIVATION

During ribosomal translation, each distinct amino acid requires at least one dedicated, cognate tRNA species charged by its specific aminoacyl-tRNA synthetase enzyme.

Formula / Rule / Reaction:

$$\text{Minimum tRNA types required} = \text{Number of unique amino acids present} = 20$$

Solution:

- Because the polypeptide chain contains 20 chemically distinct amino acids, 20 separate aminoacyl-tRNA transfer mechanisms must deliver those specific residues.
- Even if multiple degenerate codons code for the same amino acid, at least one unique tRNA adaptor must be available for each distinct amino acid residue.

Why other options are incorrect:

- Option B:** 45 is the approximate total number of distinct tRNA species present in a human cell due to wobble pairing, not the minimum required for 20 specified residues.
- Option C:** 61 represents the total number of sense amino acid-specifying codons in the standard genetic code.
- Option D:** 64 represents the mathematical total of all possible triplet codons, including the three stop termination codons.

Question #14 Key: (B)BIOLOGY
12. Nervous Coordination

A person quickly withdraw their hand touching a hot iron. This type of reflex is best classified...

CORE CONCEPT & DERIVATION

The somatic nociceptive withdrawal reflex is an involuntary protective spinal reflex arc coordinated within the gray matter of the spinal cord without requiring prior cerebral cortical intervention.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Thermal nociceptors in the dermis trigger action potentials that travel along sensory afferents entering via the dorsal root into the spinal cord.
- In the spinal cord, afferents synapse onto interneurons that excite alpha motor neurons innervating ipsilateral arm flexor muscles, withdrawing the limb within milliseconds.

Why other options are incorrect:

- Option A:** Cranial reflexes integrate directly through brainstem nuclei and cranial nerves (e.g., corneal or pupillary light reflexes).
- Option C:** Hormonal responses depend on chemical secretion into the circulation and operate over minutes to days.
- Option D:** Conditioned reflexes require prior learning and cortical association pathways (e.g., Pavlovian responses).

Question #15 Key: (D)BIOLOGY
16. Evolution

Catastrophism explains that changes in life on earth are due to:

CORE CONCEPT & DERIVATION

Catastrophism, championed by Georges Cuvier, asserts that Earth's geological strata and abrupt faunal transitions in the fossil record were caused by sudden, localized natural cataclysms.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Cuvier observed sharp discontinuities in successive fossil strata without continuous transitional forms.
- He hypothesized that violent natural disasters extinguished local populations, followed by recolonization by distinct species from adjacent regions.

Why other options are incorrect:

- Option A:** Gradual evolution reflects uniformitarianism and Darwinian gradualism, opposing catastrophic principles.
- Option B:** Natural selection is Darwin's proposed mechanism of differential reproductive success acting over generations.
- Option C:** Mutation theory of evolution was formulated by Hugo de Vries, emphasizing sudden genetic changes rather than geological cataclysms.

Question #16 Key: (C)BIOLOGY
01. Cell

The correct function of H^+ and OH^- ions in cells is:

CORE CONCEPT & DERIVATION

The balance of hydrogen (H^+) and hydroxide (OH^-) ions directly defines and regulates the pH of cellular compartments, governing protein charge states and biochemical reactions.

Formula / Rule / Reaction:

$$pH = -\log_{10}[H^+], \quad K_w = [H^+][OH^-] = 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C}$$

Solution:

- Cellular enzymatic activities, respiratory electron transport, and membrane electrochemical gradients depend on tightly regulated proton concentrations.
- Shifting $[H^+]$ and $[OH^-]$ alters cellular pH, modulating the protonation state of ionizable side chains.

Why other options are incorrect:

- Option A:** Intracellular protein trafficking is mediated by motor proteins, cytoskeletal filaments, and vesicle machinery.
- Option B:** Lipid catabolism is mediated enzymatically by lipases via ester bond hydrolysis.
- Option D:** Cellular bioluminescence involves enzymatic oxidation of luciferin catalyzed by luciferase, not free proton dissociation.

Question #17 Key: (B)BIOLOGY
14. Reproduction

Which of the following is NOT a function of testes?

CORE CONCEPT & DERIVATION

Follicle-stimulating hormone (FSH) is a glycoprotein gonadotropin synthesized and released by gonadotropic cells of the anterior pituitary gland, not by the gonads.

Formula / Rule / Reaction:

Hypothalamus (GnRH) → Anterior Pituitary (FSH, LH) → Testes (Spermatogenesis, Androgens)

Solution:

- FSH is secreted into the systemic bloodstream by the adenohypophysis to stimulate testicular Sertoli cells.
- The testes respond by supporting spermatogenesis and secreting inhibin and testosterone, but cannot produce FSH.

Why other options are incorrect:

- **Option A:** Spermatogenesis occurs within the seminiferous epithelium of the testes.
- **Option C:** Sertoli cells within the testes actively synthesize and secrete inhibin to regulate pituitary FSH output.
- **Option D:** Testicular Leydig (interstitial) cells are the primary producers of circulating testosterone.

Question #18 Key: (C)BIOLOGY
02. Biomolecules

Acylglycerols like fats and oils are esters formed by condensation reaction between:

CORE CONCEPT & DERIVATION

Acylglycerols (neutral fats and oils) are biological esters formed by the condensation esterification of the alcohol glycerol with fatty acid molecules.

Formula / Rule / Reaction:**Solution:**

- Glycerol possesses three reactive hydroxyl (–OH) alcohol groups.
- Each hydroxyl group condenses with the carboxyl group of a long-chain fatty acid, releasing water and generating an ester linkage.

Why other options are incorrect:

- **Option A:** Reaction of a fatty acid ester with water defines hydrolysis, the degradation rather than the synthesis of acylglycerols.
- **Option B:** Glucose is a hexose monosaccharide and does not constitute the alcohol backbone of simple acylglycerols.
- **Option D:** Esterification involving phosphate groups yields phospholipids (such as phosphatidic acid), not neutral acylglycerols.

Question #19 Key: (A)BIOLOGY
01. Cell

A cell shows green structures and a large fluid-filled area under the microscope. What does this...

CORE CONCEPT & DERIVATION

Mature photosynthetic plant cells are characterized by chloroplasts containing chlorophyll and a single central vacuole enclosed by a tonoplast.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The prominent green organelles correspond to chloroplasts, which contain chlorophyll pigments for light absorption.
- The large fluid-filled central space corresponds to the central sap vacuole that maintains cellular turgor pressure against the rigid cell wall.

Why other options are incorrect:

- **Option B:** Fungal cells are heterotrophic and completely lack photosynthetic chloroplasts.
- **Option C:** While algae contain chloroplasts, typical microalgae lack a dominant central vacuole occupying the vast majority of cell volume.
- **Option D:** Animal cells lack chloroplasts and possess only small, transient vesicles and vacuoles.

Question #20 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

Which option best reflects species specific chromosome number?

CORE CONCEPT & DERIVATION

The somatic karyotype of any sexually reproducing eukaryotic species exhibits a constant, characteristic chromosome number maintained across successive generations.

Formula / Rule / Reaction:

$$\text{Species chromosome count} = 2n \text{ (diploid condition)}$$

Solution:

- Meiotic reduction division coupled with gametic syngamy ensures that the species-specific diploid complement remains stable.
- For instance, humans consistently possess $2n = 46$, *Drosophila* has $2n = 8$, and garden peas have $2n = 14$.

Why other options are incorrect:

- **Option A:** Different animal species exhibit widely divergent chromosome numbers across taxonomic clades.
- **Option B:** With the exception of haploid gametes, all normal somatic tissue cells within an organism share the identical diploid chromosome number.
- **Option D:** Chromosome number bears no correlation with organism body size or structural complexity.

Question #21 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

Morgan's experiment showed deviation from the law of independent assortment due to:

CORE CONCEPT & DERIVATION

Mendel's law of independent assortment applies strictly to non-homologous chromosomes; syntenic genes situated closely on the same chromosome are linked and tend to be inherited together.

Formula / Rule / Reaction:

$$\text{Recombination Frequency (RF)} < 50\% \implies \text{Genetic Linkage}$$

Solution:

- Thomas Hunt Morgan crossed white-eyed, miniature-winged *Drosophila* and tracked dihybrid F2 progeny ratios.
- He observed that parental allele combinations appeared at frequencies significantly higher than the 9:3:3:1 Mendelian expectation because the loci reside on the same X chromosome.

Why other options are incorrect:

- **Option A:** Crossing over breaks linkage to generate recombinant genotypes; it is the physical linkage of genes that prevents independent assortment.
- **Option C:** Spontaneous point mutations introduce novel alleles, but do not alter dihybrid segregation frequencies across populations.
- **Option D:** Natural selection acts on phenotypic fitness across populations over time, rather than altering meiotic segregation ratios in controlled crosses.

Question #22 Key: (C)BIOLOGY
01. Cell

During vesicle formation, endoplasmic reticulum membrane:

CORE CONCEPT & DERIVATION

Transport vesicles emerge from the endoplasmic reticulum via localized outward budding of the ER phospholipid bilayer, mediated by cytosolic coat protein complexes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Coat protein II (COPII) complexes assemble on the ER membrane, inducing localized membrane curvature.
- The ER membrane evaginates outward, packages cargo, and pinches off via membrane scission, contributing its own lipid bilayer to the newly generated transport vesicle.

Why other options are incorrect:

- **Option A:** Biological lipid bilayers are stabilized by the hydrophobic effect and do not dissolve into the aqueous cytosol.
- **Option B:** The lipid bilayer maintains structural continuity rather than undergoing biochemical hydrolysis during vesicle budding.
- **Option D:** The ER organelle remains stationary; only the detached transport vesicles migrate to the cis-Golgi network.

Question #23 Key: (C)BIOLOGY
07. Circulation / Transport

Which tissue layer of heart wall is involved in the formation of heart valves?

CORE CONCEPT & DERIVATION

The cardiac valves are avascular mechanical flaps composed of a central core of dense fibrous connective tissue covered on both surfaces by endocardium.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The endocardium lines all internal surfaces of the cardiac chambers, auricles, and trabeculae.
- During embryonic cardiogenesis, endocardial cushion tissue proliferates to form the valvular cusps, with the continuous endothelial-lined endocardium enveloping each valve leaflet.

Why other options are incorrect:

- **Option A:** The epicardium forms the outermost visceral layer of the serous pericardium covering the exterior myocardium.
- **Option B:** The pericardium is a protective fibrous sac external to the heart wall.
- **Option D:** The myocardium is the middle contractile muscular layer of the heart and does not form the thin valvular cusps.

Question #24 Key: (B)BIOLOGY
01. Cell

In humans, how many kinds of tRNA are present for the synthesis of proteins?

CORE CONCEPT & DERIVATION

The human cell utilizes approximately 45 distinct species of transfer RNA (tRNA) to decode all 61 sense mRNA codons via non-standard wobble base pairing.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- According to standard textbook curricula, human cells contain approximately 45 different kinds of functional tRNA molecules.
- Due to the wobble hypothesis at the third codon position, a single tRNA anticodon can base pair with multiple synonymous codons, eliminating the need for 61 separate tRNA types.

Why other options are incorrect:

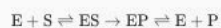
- **Option A:** 40 is an underestimated figure that diverges from the established textbook value.
- **Option C:** 43 does not match standard curriculum specifications for human tRNA counts.
- **Option D:** 50 is an overestimation unsupported by provincial curriculum standards.

Question #25 Key: (A)BIOLOGY
03. Enzymes

The active site is important in enzyme action because:

CORE CONCEPT & DERIVATION

The active site is a specialized three-dimensional pocket composed of catalytic and binding amino acid residues that stereospecifically binds substrate molecules to form an enzyme-substrate complex.

Formula / Rule / Reaction:**Solution:**

- Substrate binding via non-covalent interactions properly orientates reactive functional groups within the catalytic field.
- This binding stabilizes the high-energy transition state, lowering the free energy of activation required for the reaction to proceed.

Why other options are incorrect:

- Option B:** Reaction pH is buffered by bulk fluid chemical buffers rather than the active site pocket.
- Option C:** Enzymes do not supply energy to chemical systems; they act catalytically by lowering the activation energy barrier.
- Option D:** While induced-fit conformational changes occur upon binding, shape alteration is a secondary operational consequence rather than the fundamental purpose of the site.

Question #26 Key: (D)BIOLOGY
06. Digestion/Nutrition

Which of the following is NOT included in the composition of bile?

CORE CONCEPT & DERIVATION

Bile is an exocrine hepatic secretion composed of water, bile salts, bile pigments, cholesterol, and electrolytes; it contains zero digestive enzymes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Bile aids lipid breakdown entirely via non-enzymatic mechanical emulsification.
- Lipase is an enzymatic hydrolase synthesized and secreted by the exocrine acinar cells of the pancreas, not the liver.

Why other options are incorrect:

- Option A:** Bile salts (such as glycocholate and taurocholate) are primary organic detergents in bile.
- Option B:** Bile pigments (bilirubin and biliverdin) are heme degradation end-products excreted in bile.
- Option C:** Cholesterol is a major steroid lipid excreted via biliary secretion.

Question #27 Key: (B)BIOLOGY
16. Evolution

According to Darwin theory, the main reason of evolution is:

CORE CONCEPT & DERIVATION

Darwinian evolutionary theory posits natural selection as the primary evolutionary mechanism driving adaptation through the differential survival and reproduction of individuals with favorable heritable traits.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Organisms produce more progeny than environmental carrying capacities can support, generating competition for limited resources.
- Individuals carrying heritable variations conferring higher adaptive fitness survive and reproduce with greater success, progressively altering population allele frequencies over time.

Why other options are incorrect:

- Option A:** Natural calamities induce non-selective population bottlenecks rather than adaptive natural selection.
- Option C:** Use and disuse of organs constitutes Lamarck's proposed mechanism of physiological adaptation, which lacks genetic validity.
- Option D:** Inheritance of acquired characteristics was Lamarck's second hypothesis, which was invalidated by modern genetics.

Question #28 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

Crossing over is:

CORE CONCEPT & DERIVATION

Crossing over (homologous genetic recombination) is the reciprocal exchange of corresponding genetic segments between non-sister chromatids of paired homologous chromosomes during pachytene of meiotic prophase I.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- During synapsis, maternal and paternal homologous chromosomes align precisely into bivalent tetrad complexes.
- Endonucleases induce double-strand breaks followed by reciprocal chiasmatic strand exchange between non-sister chromatids, creating novel combinations of maternal and paternal alleles.

Why other options are incorrect:

- Option A:** Sister chromatids are identical replication products; exchange between them produces no genetic reassortment.
- Option C:** Genetic exchange between non-homologous (heterologous) chromosomes constitutes an aberrant chromosomal translocation.
- Option D:** Regulated crossing over is an exclusive feature of meiotic prophase I; somatic mitosis does not undergo programmatic crossing over.

Question #29 Key: (B)BIOLOGY
02. Biomolecules

Which of the following is NOT considered a conjugated molecule?

CORE CONCEPT & DERIVATION

A conjugated molecule is biochemically defined as a compound formed by the structural coupling of two chemically distinct classes of biological macromolecules.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- A pure hydrocarbon composed exclusively of carbon and hydrogen is a simple organic compound, not a composite conjugated molecule.
- Conjugated biomolecules require combination across structural classes, such as glycoproteins (protein + carbohydrate) or lipoproteins (lipid + protein).

Why other options are incorrect:

- **Option A:** Polysaccharides or sugar chains conjugated to lipids or proteins represent conjugated macromolecules.
- **Option C:** A protein covalently or non-covalently linked to a non-protein prosthetic group is a classic conjugated protein.
- **Option D:** A lipid joined to a carbohydrate or phosphate group represents a conjugated lipid.

Question #30 Key: (B)BIOLOGY
08. Immunity

Which cells are involved in humoral immunity?

CORE CONCEPT & DERIVATION

Humoral immunity is the branch of adaptive immunity mediated by circulating antibodies synthesized and secreted by differentiated B lymphocytes (plasma cells).

Formula / Rule / Reaction:

B lymphocyte $\xrightarrow{\text{Antigen activation}}$ Plasma cell $\rightarrow$ Secreted Immunoglobulins (Antibodies)

Solution:

- B cells express surface membrane-bound immunoglobulins (B cell receptors) that bind soluble native antigens in extracellular humors.
- Upon activation and clonal expansion, B cells differentiate into antibody-secreting plasma cells that target extracellular pathogens.

Why other options are incorrect:

- **Option A:** T cells mediate cell-mediated immunity through direct cytotoxic action or cytokine signaling, but do not produce antibodies.
- **Option C:** Humoral immunity is strictly the antibody branch governed by B cells, excluding T cells from direct execution.
- **Option D:** While CD4+ helper T cells provide costimulatory cytokines, the effector arm of humoral immunity is executed exclusively by B cells.

Question #31 Key: (A)BIOLOGY
11. Support & Movement

Which one are bone destroying cells?

CORE CONCEPT & DERIVATION

Osteoclasts are large, multinucleated myeloid-derived cells specialized in bone resorption and matrix demineralization during skeletal remodeling.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Osteoclasts adhere to bone surfaces, forming a sealed sub-osteoclastic resorption compartment under a specialized ruffled border.
- They pump hydrogen ions (H^+) to dissolve hydroxyapatite mineral crystals and secrete cathepsin K to digest type I collagen osteoid.

Why other options are incorrect:

- **Option B:** Osteocytes are mature bone cells entombed in lacunae that regulate matrix maintenance and mechanosensation.
- **Option C:** Osteogenic cells are mesenchymal progenitor stem cells that give rise to osteoblasts.
- **Option D:** Osteoblasts are bone-forming cells responsible for synthesizing and secreting new unmineralized osteoid matrix.

Question #32 Key: (A)BIOLOGY
12. Nervous Coordination

Which one is NOT the part of fore brain?

CORE CONCEPT & DERIVATION

The vertebrate brain divides into three primary embryonic regions: prosencephalon (forebrain), mesencephalon (midbrain), and rhombencephalon (hindbrain). The cerebellum arises from the metencephalon of the hindbrain.

Formula / Rule / Reaction:

Hindbrain = Metencephalon (Pons, Cerebellum) + Myelencephalon (Medulla Oblongata)

Solution:

- The cerebellum coordinates motor activity, balance, and posture as part of the hindbrain.
- The forebrain consists of the telencephalon (cerebral cortex, hippocampus, amygdala) and diencephalon (thalamus, hypothalamus).

Why other options are incorrect:

- **Option B:** The hypothalamus is a major regulatory center of the diencephalon within the forebrain.
- **Option C:** The hippocampus is a limbic structure located within the medial temporal lobe of the forebrain.
- **Option D:** The amygdala is a subcortical limbic structure situated in the temporal lobe of the forebrain.

Question #33 Key: (A)BIOLOGY
17. Biotechnology

The central dogma of molecular biology describes the flow of genetic information as:

CORE CONCEPT & DERIVATION

The central dogma of molecular biology states that genetic sequence information is transferred unidirectionally from genomic DNA to messenger RNA via transcription, and from mRNA to polypeptide chains via translation.

Formula / Rule / Reaction:**Solution:**

- DNA serves as the archival genetic template copied by RNA polymerase into complementary messenger RNA.
- Ribosomes translate the sequential triplet codons on mRNA into specific amino acid sequences in proteins.

Why other options are incorrect:

- **Option B:** Flow from mRNA to DNA represents reverse transcription, a specialized non-canonical mechanism seen in retroviruses.
- **Option C:** Polypeptide amino acid sequences cannot be reverse-translated into nucleic acids in living systems.
- **Option D:** Translation cannot precede transcription because mRNA is the prerequisite template for protein synthesis.

Question #34 Key: (C)BIOLOGY
12. Nervous Coordination

During saltatory conduction, a nerve impulse jumps from one to another:

CORE CONCEPT & DERIVATION

In myelinated axons, high-resistance internodal myelin prevents transmembrane current leakage, forcing action potential regeneration to jump discontinuously between unmyelinated nodes of Ranvier.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Voltage-gated Na^+ channels are concentrated at high density exclusively at the nodes of Ranvier.
- Depolarization at one node generates rapid longitudinal electrotonic local currents through the axoplasm that depolarize the adjacent node past threshold, producing saltatory propagation.

Why other options are incorrect:

- **Option A:** A synapse is a specialized intercellular transmission junction between distinct neurons or effectors.
- **Option B:** The axon is the total cylindrical nerve fiber carrying the signal, not the specific point-to-point structural gap jumped.
- **Option D:** The myelin sheath is the insulating dielectric lipid layer along internodes where conduction is blocked; impulses jump between gaps in the sheath rather than between the sheaths themselves.

Question #35 Key: (B)BIOLOGY
01. Cell

What is the chemical composition of chromosomes?

CORE CONCEPT & DERIVATION

Eukaryotic chromosomes consist of chromatin, a dense nucleoprotein complex composed predominantly of genomic double-stranded DNA packaged with basic histone and non-histone chromosomal proteins.

Formula / Rule / Reaction:**Solution:**

- The genetic component is a continuous double-stranded DNA molecule.
- Positively charged histone octamers (H2A, H2B, H3, H4) bind the negatively charged phosphate backbone of DNA to form repeating nucleosome units compacted into chromosomes.

Why other options are incorrect:

- **Option A:** Lipids do not participate in chromosomal structural organization.
- **Option C:** Carbohydrates do not form the structural scaffold of nucleosomes or chromatin.
- **Option D:** Carbohydrates are absent from the chromosomal core.

Question #36 Key: (B)BIOLOGY
14. Reproduction

Implantation of the embryo occurs in which part of the female reproductive system?

CORE CONCEPT & DERIVATION

Following fertilization in the fallopian tube, the cleaving blastocyst migrates into the uterine cavity and implants into the vascularized, secretory endometrium of the uterus.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Around day 6 to 7 post-fertilization, the syncytiotrophoblast of the blastocyst invades the receptive maternal endometrial stroma.
- This embedding establishes the maternal-fetal vascular interface necessary for placentation and fetal gestation.

Why other options are incorrect:

- **Option A:** The ovary produces gametes (oocytes) and steroid hormones, but cannot support gestation.
- **Option C:** The cervix is the inferior fibrous canal of the uterus; blastocyst implantation here represents a life-threatening cervical ectopic pregnancy.
- **Option D:** The fallopian tube is the normal site of fertilization; implantation within the tube represents a pathological tubal ectopic pregnancy.

Question #37 Key: (D)BIOLOGY
08. Immunity

Which of the following method is used to prevent HIV transmission during blood transfusion?

CORE CONCEPT & DERIVATION

Preventing transfusion-transmitted infections requires pre-transfusion serological testing and nucleic acid amplification testing (NAT) to identify and discard HIV-contaminated blood products.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Donor blood is screened via fourth-generation immunoassays for anti-HIV-1/2 antibodies and p24 antigen, alongside viral RNA detection via PCR.
- Any reactive blood unit is discarded, maintaining a safe clinical blood supply.

Why other options are incorrect:

- **Option A:** Freezing cryopreserves viruses intact inside leukocytes rather than inactivating HIV.
- **Option B:** HIV affects all age demographics; age selection provides zero safety against infection.
- **Option C:** Boiling blood denatures plasma proteins and causes total hemolysis of red blood cells, destroying the blood product.

Question #38 Key: (A)BIOLOGY
02. Biomolecules

Each DNA nucleotide differs from the others based on its:

CORE CONCEPT & DERIVATION

All canonical DNA nucleotides share an invariant 2'-deoxyribose sugar and a single phosphate group; individual nucleotides are differentiated solely by their nitrogenous base.

Formula / Rule / Reaction:

Nucleotide = Phosphate + 2'-Deoxyribose + Variable Nitrogenous Base (A, T, G, or C)

Solution:

- The structural sugar-phosphate backbone of DNA is identical across all nucleotide monomers.
- The identity of each nucleotide is determined by whether it possesses a purine (adenine, guanine) or a pyrimidine (thymine, cytosine).

Why other options are incorrect:

- **Option B:** The phosphate group is chemically identical in all four DNA nucleotides.
- **Option C:** The pentose sugar is uniformly 2'-deoxyribose in all standard DNA nucleotides.
- **Option D:** Every nucleotide monomer contains exactly one phosphorus atom in its single phosphate moiety.

Question #39 Key: (D)BIOLOGY
14. Reproduction

Which of the following is the causative agent of Gonorrhea?

CORE CONCEPT & DERIVATION

Gonorrhea is a purulent sexually transmitted infection of genitourinary mucous membranes caused by the Gram-negative diplococcus bacterium *Neisseria gonorrhoeae*.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- *Neisseria gonorrhoeae* adheres to mucosal epithelial cells using pili (fimbriae) and outer membrane Opa proteins.
- It triggers localized acute inflammation characterized by dysuria and purulent urethral or cervicovaginal discharge.

Why other options are incorrect:

- **Option A:** *Herpes simplex virus* (HSV-1/HSV-2) causes vesicular and ulcerative oral or genital herpes lesions.
- **Option B:** *Treponema pallidum* is a spirochete bacterium that causes syphilis.
- **Option C:** *Mycobacterium tuberculosis* is an acid-fast bacillus responsible for pulmonary and extrapulmonary tuberculosis.

Question #40 Key: (D)BIOLOGY
01. Cell

Cholesterol and phospholipids are mainly synthesized in liver cells by:

CORE CONCEPT & DERIVATION

The smooth endoplasmic reticulum (SER) contains membrane-bound multi-enzyme complexes responsible for the biosynthesis of cellular lipids, cholesterol, and membrane phospholipids.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Hepatocyte SER membranes contain key enzymes for lipid anabolism, including HMG-CoA reductase for cholesterol synthesis and acyltransferases for phospholipid assembly.
- The tubular network of the SER provides the hydrophobic membrane environment required for lipid metabolic pathways.

Why other options are incorrect:

- **Option A:** The Golgi complex modifies, sorts, and packages glycoproteins and glycolipids, but does not synthesize bulk cholesterol.
- **Option B:** Mitochondria generate ATP via oxidative phosphorylation and host beta-oxidation, but are not the primary site for phospholipid synthesis.
- **Option C:** The rough endoplasmic reticulum specializes in the translation and translocation of secretory and transmembrane proteins.

Question #41 Key: (B)BIOLOGY
17. Biotechnology*In disease diagnosis, the main function of monoclonal antibodies is:***CORE CONCEPT & DERIVATION**

Monoclonal antibodies are homogeneous, single-clone immunoglobulins that exhibit precise monovalent affinity for a specific epitope on a targeted biomarker or pathogen antigen.

Formula / Rule / Reaction:*Factual recall / Qualitative concept.***Solution:**

- In in vitro diagnostic platforms (such as ELISA, immunofluorescence, and rapid lateral flow tests), monoclonal antibodies bind specifically to their complementary target antigen.
- This binding produces a detectable colorimetric, fluorescent, or radioactive signal, confirming the presence and concentration of disease-specific markers.

Why other options are incorrect:

- **Option A:** Leukocyte proliferation is stimulated by hematopoietins like colony-stimulating factors, not diagnostic antibodies.
- **Option C:** Neutralizing bacterial exotoxins describes passive antitoxin therapy rather than clinical laboratory diagnostic detection.
- **Option D:** Opsonizing diseased cells for cytotoxic destruction describes in vivo immunotherapy (e.g., oncology therapeutics) rather than in vitro diagnostic detection.

Question #42 Key: (C)BIOLOGY
09. Respiration / Gaseous Exchange*What happens to the pressure and volume of the thoracic cavity during inhalation?***CORE CONCEPT & DERIVATION**

Pulmonary ventilation obeys Boyle's law; active contraction of inspiratory muscles expands thoracic volume, causing an inverse decrease in intrapulmonary pressure below atmospheric pressure.

Formula / Rule / Reaction:

$$P \propto \frac{1}{V} \Rightarrow \Delta V_{\text{thorax}} > 0 \Rightarrow P_{\text{alveolar}} < P_{\text{atmospheric}}$$

Solution:

- During inhalation, diaphragmatic contraction flattens the thoracic floor while external intercostal muscles lift the ribcage upward and outward.
- This expansion increases thoracic volume, causing intrapleural and intrapulmonary pressures to drop to approximately -1 mmHg relative to atmosphere, establishing an inflow gradient.

Why other options are incorrect:

- **Option A:** In a closed compliant space, Boyle's law dictates that volume expansion drives a decrease, not an increase, in pressure.
- **Option B:** A decrease in volume with an increase in pressure characterizes active exhalation, not inhalation.
- **Option D:** Pressure and volume cannot decrease simultaneously during lung inflation.

Question #43 Key: (D)BIOLOGY
07. Circulation / Transport*Which of the following layer is mainly composed of cardiac muscles?***CORE CONCEPT & DERIVATION**

The heart wall consists of three distinct tissue layers, of which the myocardium is the thick, contractile middle layer composed of striated cardiomyocyte muscle fibers.

Formula / Rule / Reaction:*Factual recall / Qualitative concept.***Solution:**

- Cardiomyocytes form an involuntary, branching syncytium connected by intercalated discs with electrical gap junctions.
- The myocardium constitutes the structural bulk of the ventricular and atrial walls responsible for generating pumping pressure.

Why other options are incorrect:

- **Option A:** The endocardium is the innermost simple squamous endothelial lining resting on loose connective tissue.
- **Option B:** The epicardium forms the outermost visceral layer of the serous pericardium, composed of mesothelium and fibroelastic tissue.
- **Option C:** The pericardium is an external protective fibroserous sac enclosing the pericardial cavity.

Question #44 Key: (A)BIOLOGY
02. Biomolecules*Glycolipid is a combination of:***CORE CONCEPT & DERIVATION**

Glycolipids are conjugated membrane lipids consisting of one or more carbohydrate residues covalently attached to a hydrophobic lipid scaffold.

Formula / Rule / Reaction:

Glycolipid = Lipid core (Ceramide or Glycerol) + Carbohydrate headgroup (Mono- or Oligo-)

Solution:

- The hydrophobic fatty acid chains anchor the glycolipid in the outer leaflet of the cellular lipid bilayer.
- The hydrophilic mono- or oligosaccharide chain extends into the extracellular space, contributing to cell-cell recognition and the glycocalyx.

Why other options are incorrect:

- **Option B:** Conjugated complexes of lipids and proteins are termed lipoproteins.
- **Option C:** Complexes of nucleic acids and lipids do not constitute glycolipids; nucleic acids complex with basic proteins to form nucleoproteins.
- **Option D:** Conjugated compounds composed of carbohydrates linked to proteins are classified as glycoproteins.

Question #45 Key: (B)BIOLOGY
12. Nervous Coordination

The outer surface of the axon membrane in a resting neuron is:

CORE CONCEPT & DERIVATION

In a polarized resting neuron, active electrogenic ion transport maintains an electrical potential difference, rendering the extracellular surface positive relative to the intracellular axoplasm.

Formula / Rule / Reaction:

$$V_m = V_{\text{inside}} - V_{\text{outside}} \approx -70 \text{ mV}$$

Solution:

- The Na^+/K^+ -ATPase pump actively extrudes three Na^+ ions for every two K^+ ions imported.
- Coupled with high extracellular Na^+ concentration and impermeable internal organic polyanions, this establishes a net positive electrical charge on the outer axolemmal surface.

Why other options are incorrect:

- **Option A:** The resting outer surface is electropositive; the inner axoplasmic surface is electronegative.
- **Option C:** Potassium ions are concentrated intracellularly and leak outward along concentration gradients; the outer positivity is governed by high external Na^+ .
- **Option D:** The resting membrane is electrically polarized at approximately -70 mV rather than electrochemically neutral.

Question #46 Key: (A)BIOLOGY
16. Evolution

Which idea suggests that life was created by a supernatural force?

CORE CONCEPT & DERIVATION

The doctrine of special creation is a non-scientific belief proposing that all living species were formed independently and instantaneously by divine or supernatural action.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Special creation asserts that species were created in their current immutable forms by a supernatural entity.
- This philosophical concept stands in direct opposition to empirical biological frameworks of chemical abiogenesis and Darwinian evolution.

Why other options are incorrect:

- **Option B:** Biogenesis is the established biological principle that living organisms arise exclusively from pre-existing living organisms.
- **Option C:** Spontaneous generation proposed that complex organisms arose spontaneously from inanimate decaying matter without divine intervention.
- **Option D:** Natural selection is the empirical scientific mechanism of evolutionary change driven by differential reproductive success.

Question #47 Key: (B)BIOLOGY
10. Homeostasis

A drug that relaxes smooth muscles in blood vessels is useful for:

CORE CONCEPT & DERIVATION

Relaxation of vascular smooth muscle cells within arterial walls increases luminal vessel diameter (vasodilation), decreasing systemic vascular resistance and lowering arterial blood pressure.

Formula / Rule / Reaction:

$$\Delta P = Q \times R, \quad R \propto \frac{1}{r^4}$$

Solution:

- Arteriolar tone governs systemic peripheral resistance; smooth muscle relaxation increases luminal radius r .
- By Poiseuille's law, expanding the internal radius markedly decreases resistance to blood flow, leading directly to a reduction in systemic blood pressure.

Why other options are incorrect:

- **Option A:** Skeletal muscle contractile strength is governed by somatic motor unit recruitment, not vascular smooth muscle tone.
- **Option C:** While profound vasodilation may trigger secondary baroreceptor reflex tachycardia, the primary therapeutic indication of the drug is blood pressure reduction.
- **Option D:** Vascular smooth muscle is regulated involuntarily by autonomic and humoral factors, lacking voluntary motor control.

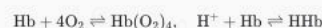
Question #48 Key: (D)BIOLOGY
09. Respiration / Gaseous Exchange

During the process of gaseous exchange, all of the following are the functions of hemoglobin EX...

CORE CONCEPT & DERIVATION

Hemoglobin is an erythrocyte metalloprotein that functions as a respiratory gas carrier and chemical buffer, but possesses no primary regulatory mechanism governing arterial blood pressure.

Formula / Rule / Reaction:



Solution:

- Hemoglobin binds oxygen cooperatively in pulmonary capillaries and delivers it to metabolizing peripheral tissues.
- It transports approximately 20% of metabolic carbon dioxide as carbaminohemoglobin and buffers excess hydrogen ions on histidine residues to stabilize systemic pH.

Why other options are incorrect:

- **Option A:** Deoxygenated hemoglobin actively buffers hydrogen ions released during carbonic acid dissociation, stabilizing erythrocyte and blood pH.
- **Option B:** Reversible oxygen transport from alveolar surfaces to peripheral tissues is the primary physiological function of hemoglobin.
- **Option C:** Transporting carbon dioxide from peripheral tissues to pulmonary capillary beds is an established physiological role of hemoglobin.

Question #49 Key: (D)BIOLOGY
15. Inheritance / Variation & Genetics*Thread-like single strand of a chromosome that is made of DNA and protein is known as:***CORE CONCEPT & DERIVATION**

A chromatid is one of the two identical, longitudinal nucleoprotein strands of a replicated chromosome joined together at the centromere prior to cell division.

Formula / Rule / Reaction:*Factual recall / Qualitative concept.***Solution:**

- Following S-phase DNA synthesis, each eukaryotic chromosome consists of two sister chromatids.
- Each chromatid represents a single continuous double-stranded DNA duplex packaged with structural histone and non-histone proteins.

Why other options are incorrect:

- **Option A:** A chromosome arm refers to the segmented regional division (p or q arm) demarcated by the centromere, not the entire longitudinal strand.
- **Option B:** A nucleosome is the fundamental structural subunit of chromatin, comprising 146 base pairs of DNA wound around a histone octamer.
- **Option C:** Chromosome refers to the complete intact genetic vehicle, which in duplicated form encompasses both sister chromatids.

Question #50 Key: (A)BIOLOGY
10. Homeostasis*Which part of kidney is responsible for collecting urine before it enters the ureter?***CORE CONCEPT & DERIVATION**

The renal pelvis is the central, funnel-shaped expansion of the upper ureter that pools urine draining from the major calyces before propelling it into the ureter.

Formula / Rule / Reaction:

Renal Papillae → Minor Calyces → Major Calyces → Renal Pelvis → Ureter

Solution:

- Urine exiting the collecting ducts at the renal papillae passes sequentially into minor and major calyces.
- The major calyces converge to form the renal pelvis, which funnels the collected urine directly across the pelviureteric junction into the ureter.

Why other options are incorrect:

- **Option B:** The renal medulla contains renal pyramids and loops of Henle responsible for countercurrent multiplication, not final urine collection.
- **Option C:** The renal cortex is the outer metabolic layer containing glomeruli and convoluted tubules where initial filtration occurs.
- **Option D:** Renal pyramids are medullary structures containing collecting tubules that terminate at the renal papillae.

Question #51 Key: (C)BIOLOGY
12. Nervous Coordination*Which of the following function is under control of medulla oblongata?***CORE CONCEPT & DERIVATION**

The medulla oblongata houses primary autonomic reflex centers, including the respiratory rhythmicity center, which establishes the basic pace and depth of breathing.

Formula / Rule / Reaction:*Factual recall / Qualitative concept.***Solution:**

- The dorsal and ventral respiratory groups within the medulla generate rhythmic motor outputs to phrenic and intercostal motor neurons.
- Medullary central chemoreceptors monitor cerebrospinal fluid hydrogen ion concentrations to adjust ventilation in response to changing arterial carbon dioxide levels.

Why other options are incorrect:

- **Option A:** Memory encoding and consolidation are governed by limbic structures (hippocampus) and higher associative cerebral cortex.
- **Option B:** Visual processing is localized within the primary visual cortex of the occipital lobe.
- **Option D:** Dreaming occurs primarily during rapid eye movement (REM) sleep, regulated by the pontine reticular formation and forebrain circuits.

Question #52 Key: (C)BIOLOGY
11. Support & Movement*Which structure conducts the action potential deep into the muscle fiber?***CORE CONCEPT & DERIVATION**

Transverse tubules (T-tubules) are tubular invaginations of the sarcolemma that propagate action potentials into the interior of the muscle fiber to trigger calcium release.

Formula / Rule / Reaction:*Factual recall / Qualitative concept.***Solution:**

- Surface sarcolemmal depolarization conducts down the lumina of T-tubules into the deepest myofibrillar regions.
- This activates voltage-sensitive dihydropyridine receptors (DHPR), which mechanically open ryanodine receptors (RyR1) in terminal cisternae to release calcium.

Why other options are incorrect:

- **Option A:** The Z-line is an anchoring structural boundary for actin thin filaments, lacking excitable conduction properties.
- **Option B:** The sarcomere is the basic contractile unit of a myofibril bounded between adjacent Z-lines.
- **Option D:** The sarcoplasmic reticulum is an intracellular calcium reservoir that responds to electrical signals, but does not conduct surface action potentials.

Question #53 Key: (B)BIOLOGY
02. Biomolecules

Which of the following is the most appropriate concept of oxygen carrying capacity of blood?

CORE CONCEPT & DERIVATION

The oxygen-carrying capacity of blood is fundamentally dictated by the total concentration of functional hemoglobin and its capacity to bind molecular oxygen reversibly.

Formula / Rule / Reaction:

$$\text{Oxygen Capacity} = 1.34 \text{ mL O}_2/\text{g Hb} \times [\text{Hb}] \text{ (g/dL)}$$

Solution:

- More than 98% of oxygen in arterial blood is transported chemically bound to the heme moieties of hemoglobin.
- The physiological ceiling for oxygen carrying capacity is defined by the maximum volume of oxygen bound per unit mass of hemoglobin at 100% saturation.

Why other options are incorrect:

- **Option A:** While descriptive, this is an imprecise definition that fails to capture the biochemical mechanism involving hemoglobin.
- **Option C:** Dissolved oxygen in plasma accounts for less than 2% of total blood oxygen content under normal atmospheric conditions.
- **Option D:** Fibrinogen is a plasma coagulation factor involved in fibrin polymerization, bearing no role in gas transport.

Question #54 Key: (D)BIOLOGY
11. Support & Movement

Which of the following does not occur during muscle contraction?

CORE CONCEPT & DERIVATION

According to the sliding filament model, muscle contraction causes the sarcomere to shorten as thin actin filaments slide past thick myosin filaments toward the M-line.

Formula / Rule / Reaction:

$$\text{Contraction: } \Delta L_{\text{sarcomere}} < 0, \quad \text{I-band narrows,} \quad \text{H-zone narrows,} \quad \text{A-band constant}$$

Solution:

- Myosin cross-bridge power strokes pull opposing actin filaments toward the central bare zone.
- This mechanical displacement shortens the distance between consecutive Z-discs, decreasing sarcomere length rather than increasing it.

Why other options are incorrect:

- **Option A:** Calcium release from terminal cisternae into the sarcoplasm is the initiating step that exposes active sites on actin.
- **Option B:** Formation of cross-bridges occurs when energized myosin heads bind to exposed actin active sites.
- **Option C:** Sliding of actin over myosin represents the central mechanical mechanism of filament displacement.

Question #55 Key: (A)BIOLOGY
11. Support & Movement

Maintenance of healthy bone tissues by secreting enzymes and influencing bone mineral content I...

CORE CONCEPT & DERIVATION

Osteocytes are mature bone cells situated in lacunae that orchestrate skeletal homeostasis by sensing mechanical loading, secreting regulatory enzymes, and controlling local mineral exchange.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Osteocytes maintain extensive cytoplasmic dendritic networks within canaliculi to monitor mechanical strain and systemic hormones.
- They release signaling factors and matrix-modifying enzymes to regulate calcium and phosphate exchange, maintaining healthy bone structure.

Why other options are incorrect:

- **Option B:** Osteoblasts are active bone-forming cells responsible for synthesizing unmineralized osteoid and initiating primary calcification.
- **Option C:** Osteoclasts are multinucleated myeloid-derived cells specialized in bone resorption and structural degradation.
- **Option D:** Osteogenic cells are undifferentiated stem cells that divide to produce osteoblasts.

Question #56 Key: (C)BIOLOGY
14. Reproduction

After ovulation, the ruptured follicle in ovary transformed into:

CORE CONCEPT & DERIVATION

Following oocyte release at ovulation, residual granulosa and theca interna cells of the collapsed Graafian follicle undergo luteinization to form the corpus luteum.

Formula / Rule / Reaction:**Solution:**

- Luteinizing hormone (LH) stimulates the collapsed follicular remnants to hypertrophy and accumulate intracellular lutein lipid pigment.
- This newly formed endocrine gland, the corpus luteum, secretes high levels of progesterone to maintain the secretory endometrium.

Why other options are incorrect:

- **Option A:** Secondary follicles represent pre-ovulatory developmental stages possessing a developing follicular antrum.
- **Option B:** Tertiary (Graafian) follicles are mature fluid-filled pre-ovulatory follicles prior to rupture.
- **Option D:** The corpus callosum is a major commissural tract connecting the cerebral hemispheres in the mammalian brain.

Question #57 Key: (C)BIOLOGY
02. Biomolecules

Lactose sugar is found in milk and is composed of:

CORE CONCEPT & DERIVATION

Lactose is a milk disaccharide synthesized in mammary alveolar cells from one molecule of β -D-galactose and one molecule of β -D-glucose joined by a $\beta(1\rightarrow4)$ -glycosidic bond.

Formula / Rule / Reaction:**Solution:**

- Condensation links carbon-1 of β -D-galactopyranose to carbon-4 of β -D-glucopyranose.
- In the intestinal brush border, the disaccharide is cleaved back into its monosaccharide monomers by the enzyme lactase.

Why other options are incorrect:

- Option A:** Two glucose monomers linked by an $\alpha(1\rightarrow4)$ bond form maltose.
- Option B:** Glucose linked to fructose forms sucrose.
- Option D:** Fructose and galactose do not form common mammalian disaccharides.

Question #58 Key: (D)BIOLOGY
03. Enzymes

Which factor affects the ionization state of an enzyme's active site?

CORE CONCEPT & DERIVATION

The ionization state of acidic and basic amino acid side chains within an enzyme's catalytic active site is directly governed by environmental hydrogen ion concentration (pH).

Formula / Rule / Reaction:

$$pH = pK_a + \log_{10} \left(\frac{[A^-]}{[HA]} \right)$$

Solution:

- Active site catalytic residues (such as aspartate, histidine, and lysine) must maintain specific protonation states to bind substrates and mediate catalysis.
- Shifts in pH alter the ionization ratio of these residues, altering active site conformation and catalytic velocity.

Why other options are incorrect:

- Option A:** Temperature influences collision kinetic energy and protein thermal denaturation, but does not directly set the chemical ionization equilibria of functional groups.
- Option B:** Enzyme concentration alters overall reaction velocity (V_{max}), but does not change the intrinsic ionization state of individual sites.
- Option C:** Substrate concentration dictates active site occupancy without altering side-chain protonation states.

Question #59 Key: (B)BIOLOGY
02. Biomolecules

During sample analysis, students find that it contains Carbon, Hydrogen, Oxygen and Nitrogen, ...

CORE CONCEPT & DERIVATION

Proteins are polymers of amino acids containing carbon, hydrogen, oxygen, nitrogen (and sulfur), but lack phosphorus in their standard primary structure.

Formula / Rule / Reaction:**Solution:**

- The elemental assay reveals C, H, O, and N, with a complete absence of phosphorus.
- Nucleic acids and phospholipids require phosphorus for their repeating phosphodiester and phosphatide structures, confirming that the sample is a protein.

Why other options are incorrect:

- Option A:** DNA contains repeating deoxyribose-phosphate backbone units, containing high concentrations of phosphorus.
- Option C:** Phospholipids contain a phosphate group esterified to glycerol, requiring phosphorus.
- Option D:** RNA contains a ribose-phosphate backbone requiring stoichiometric phosphorus.

Question #60 Key: (A)BIOLOGY
12. Nervous Coordination

The structure that is directly continuous with the cell body transmits nerve impulses away from...

CORE CONCEPT & DERIVATION

The axon is a single long cylindrical projection arising directly from the neuronal soma at the axon hillock that conducts action potentials efferently away from the cell body.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The axon hillock integrates incoming somatic graded potentials to generate all-or-none action potentials.
- The axon then propagates these depolarizations away from the cell body toward terminal synaptic boutons.

Why other options are incorrect:

- Option B:** A synapse is an intercellular junction where signals pass chemically or electrically between distinct cells.
- Option C:** Dendrites conduct graded receptor potentials afferently toward the cell body.
- Option D:** The myelin sheath is an insulating lipid covering produced by neuroglia, not a neuronal cytoplasmic projection continuous with the soma.

Question #61 Key: (C)BIOLOGY
01. Cell

Anticodon that consist of complementary basis of three nucleotides is located on:

CORE CONCEPT & DERIVATION

An anticodon is a specific triplet nucleotide sequence situated in the anticodon loop of a transfer RNA (tRNA) molecule that base-pairs with a complementary mRNA codon.

Formula / Rule / Reaction:

Codon (mRNA): 5'-AUG-3' $\longleftrightarrow$ Anticodon (tRNA): 3'-UAC-5'

Solution:

- Each tRNA molecule displays an exposed three-base anticodon in its central structural loop.
- During ribosomal translation, the anticodon recognizes and hydrogen-bonds in an antiparallel orientation to the matching triplet codon on mRNA.

Why other options are incorrect:

- Option A:** Ribosomal RNA (rRNA) provides structural and peptidyl transferase catalytic functions, lacking specific codon-reading anticodon loops.
- Option B:** Messenger RNA (mRNA) carries genetic information in sequential triplet codons.
- Option D:** Genomic DNA encodes genetic information in deoxyribonucleotide triplets.

Question #62 Key: (A)BIOLOGY
07. Circulation / Transport

The key difference between lymph nodes and lymph vessel is:

CORE CONCEPT & DERIVATION

Lymphatic vessels constitute a directional conduit network that propels interstitial lymph toward the venous circulation, while encapsulated lymph nodes filter particulate matter and host immune responses.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Lymphatic vessels collect extravasated interstitial fluid and transport it unidirectionally via intrinsic smooth muscle contraction and luminal valves.
- Lymph nodes positioned along these channels percolate lymph through sinus networks where resident macrophages and lymphocytes filter pathogens and foreign antigens.

Why other options are incorrect:

- Option B:** Lymph vessels carry lymph rather than oxygen; bile is synthesized exclusively by hepatocytes.
- Option C:** Lymph vessels act as fluid conduits and do not digest toxins.
- Option D:** Blood plasma is generated systemically and retained within the vascular tree; lymph nodes do not synthesize plasma.

Question #63 Key: (A)BIOLOGY
06. Digestion/Nutrition

Which of the following is NOT related to large intestine?

CORE CONCEPT & DERIVATION

Intestinal villi are mucosal projections restricted exclusively to the small intestine (duodenum, jejunum, ileum) to enhance nutrient absorption; they are completely absent from the large intestine.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Villi amplify mucosal surface area for nutrient absorption in the small intestine.
- The mucosa of the large intestine lacks villi, presenting a flat surface populated by straight tubular crypts of Lieberkühn rich in mucus-secreting goblet cells.

Why other options are incorrect:

- Option B:** The sigmoid colon is the terminal S-shaped pelvic segment of the large intestine.
- Option C:** The vermiform appendix is a lymphoid diverticulum extending from the cecum of the large intestine.
- Option D:** The rectum is the terminal retroperitoneal segment of the large intestine continuous with the anal canal.

Question #64 Key: (D)BIOLOGY
08. Immunity

Spleen contributes towards:

CORE CONCEPT & DERIVATION

The spleen is a secondary lymphoid organ whose red pulp serves as a mechanical and biological blood filter, removing aged, non-deformable, and damaged erythrocytes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Circulating blood passes through the splenic cords of Billroth into venous sinusoids.
- Senescent erythrocytes with rigid membranes fail to squeeze through narrow endothelial slits and are phagocytosed by resident splenic macrophages.

Why other options are incorrect:

- Option A:** Insulin and glucagon are endocrine peptide hormones secreted by the pancreatic islets of Langerhans.
- Option B:** Humoral antibodies are synthesized primarily against foreign protein and carbohydrate antigens, not dietary fats.
- Option C:** Oxygen binding to hemoglobin is determined by intra-erythrocyte allosteric effectors and gas partial pressures, not splenic action.

Question #65 Key: (A)BIOLOGY
02. Biomolecules

During lab analysis, a student extracted a molecule that contained a sugar, a phosphate group a...

CORE CONCEPT & DERIVATION

A nucleotide is the monomeric repeating unit of nucleic acids, consisting of a pentose sugar, a nitrogenous base, and one or more phosphate groups.

Formula / Rule / Reaction:**Solution:**

- The isolated chemical structure displays all three diagnostic components of a nucleotide monomer.
- Polymerization of these subunits via phosphodiester linkages yields nucleic acid macromolecules.

Why other options are incorrect:

- Option B:** Amino acids contain an alpha-carbon, amino group, carboxyl group, and R-group, lacking sugars and phosphate groups.
- Option C:** Monosaccharides are simple carbohydrate monomers lacking nitrogenous bases and phosphate groups.
- Option D:** Polysaccharides consist purely of recurring monosaccharide units joined by glycosidic bonds.

Question #66 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

Hemophilia is a sex linked recessive trait. A hemophiliac man marries to a normal woman (whose...

CORE CONCEPT & DERIVATION

Hemophilia A is an X-linked recessive coagulopathy; female offspring inherit one paternal X chromosome and one maternal X chromosome.

Formula / Rule / Reaction:

$$\text{Cross: } X^h Y \text{ (hemophiliac father)} \times X^H X^h \text{ (carrier mother)} \Rightarrow \text{Daughters: } \frac{1}{2} X^h X^h \text{ (affected), } \frac{1}{2} X^H X^h \text{ (carrier)}$$

Solution:

- The affected father carries the mutant allele on his single X chromosome ($X^h Y$) and must transmit X^h to all female offspring.
- The phenotypically normal mother is an obligate carrier ($X^H X^h$) because she inherited an X^h chromosome from her hemophiliac father.
- Any daughter has a 50% probability of receiving the maternal X^h allele, resulting in the homozygous recessive $X^h X^h$ hemophiliac phenotype.

Why other options are incorrect:

- Option A:** A 0% chance would occur only if the mother were homozygous dominant normal ($X^H X^H$).
- Option B:** 25% represents the probability of having an affected daughter out of all possible children combined, but given that the child is a daughter, the probability is 50%.
- Option D:** A 75% probability cannot be produced from this monohybrid sex-linked cross.

Question #67 Key: (C)BIOLOGY
12. Nervous Coordination

The main function of Pacinian corpuscles is detect:

CORE CONCEPT & DERIVATION

Pacinian (lamellar) corpuscles are rapidly adapting mechanoreceptors located in the deep dermis and hypodermis specialized in detecting deep pressure and high-frequency vibrations.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- A Pacinian corpuscle comprises an unmyelinated central axon terminal encased by concentric lamellae of flattened Schwann-like cells.
- Transient mechanical pressure causes lamellar displacement that deforms the axon membrane, opening mechanosensitive ion channels to generate receptor potentials.

Why other options are incorrect:

- Option A:** Food chemical composition is detected by gustatory chemoreceptors located on taste buds.
- Option B:** Temperature shifts are transduced by dedicated thermoreceptors (TRP cation channels) on free nerve endings.
- Option D:** Sharp pain stimuli are transduced by mechanical nociceptors coupled to lightly myelinated A-delta fibers.

Question #68 Key: (D)BIOLOGY
10. Homeostasis

Dialyzing fluid has same osmotic pressure as the blood has except that it lacks:

CORE CONCEPT & DERIVATION

Hemodialysis relies on passive diffusive transport across a semipermeable membrane; dialyzing fluid is formulated without nitrogenous wastes to maximize their clearance from blood.

Formula / Rule / Reaction:

$$\text{Diffusive Flux: } J = -D \frac{dC}{dx}, \quad \Delta C = [\text{Waste}]_{\text{blood}} - [\text{Waste}]_{\text{dialysate}} > 0$$

Solution:

- The dialysate is iso-osmolar with blood plasma and contains physiologic concentrations of electrolytes and glucose to prevent unwanted solute losses.
- It contains zero urea, creatinine, or uric acid, generating a steep concentration gradient that drives nitrogenous wastes out of the blood.

Why other options are incorrect:

- Option A:** Glucose is included at physiological levels (approx. 100–200 mg/dL) to prevent systemic hypoglycemia.
- Option B:** Water is the essential bulk solvent medium of the dialysate solution.
- Option C:** Sodium and potassium are present at physiological concentrations to preserve electrolyte balance and avoid cardiac arrhythmias.

Question #69 Key: (D)BIOLOGY
03. Enzymes

Which type of inhibitor binds to a site other than the active site and changes the shape of act...

CORE CONCEPT & DERIVATION

Non-competitive inhibitors bind to an allosteric regulatory site distinct from the active site, inducing a conformational change that inactivates the catalytic mechanism.

Formula / Rule / Reaction:

Non-competitive Inhibition: $V_{\max}$ decreases, K_m remains unchanged

Solution:

- A non-competitive inhibitor binds reversibly to either free enzyme or the enzyme-substrate complex.
- Binding induces allosteric distortion of the catalytic cleft, preventing turnover without directly blocking substrate binding.

Why other options are incorrect:

- **Option A:** Competitive inhibitors bind directly within the active site in competition with the substrate, increasing K_m without changing $V_{\max}$.
- **Option B:** Uncompetitive inhibitors bind exclusively to the pre-formed enzyme-substrate complex, reducing both $V_{\max}$ and K_m .
- **Option C:** Allosteric activators bind to non-catalytic sites to enhance rather than inhibit enzyme activity.

Question #70 Key: (A)BIOLOGY
12. Nervous Coordination

Which of the following travels along a neuron during nerve impulse

CORE CONCEPT & DERIVATION

A nerve impulse is a self-propagating action potential characterized by transient waves of electrochemical changes across the axonal membrane.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Depolarization past threshold triggers opening of voltage-gated Na^+ channels, causing rapid inward sodium influx.
- Subsequent opening of voltage-gated K^+ channels permits outward potassium efflux, restoring resting polarity and propagating the electrochemical wave.

Why other options are incorrect:

- **Option B:** Minor heat dissipation occurs as a metabolic byproduct, but the propagating signal is not a thermal wave.
- **Option C:** Moving ionic charges generate minute magnetic fields, but the biological signal is fundamentally electrochemical.
- **Option D:** Hormonal signaling operates via chemical messengers transported through the bloodstream, not along axonal membranes.

Question #71 Key: (A)BIOLOGY
12. Nervous Coordination

Saltatory conduction of nerve impulse occurs in

CORE CONCEPT & DERIVATION

Saltatory conduction is the rapid, discontinuous propagation of action potentials along myelinated axons, where depolarization jumps between unmyelinated nodes of Ranvier.

Formula / Rule / Reaction:

$v_{\text{saltatory}} \propto d$ (conduction velocity increases with axon diameter)

Solution:

- Myelin sheaths provide high electrical resistance and low capacitance along internodal segments.
- Action potentials regenerate exclusively at high-density voltage-gated Na^+ channel clusters at the nodes of Ranvier.

Why other options are incorrect:

- **Option B:** Cell bodies lack myelin sheaths and integrate graded electronic potentials rather than conducting saltatory impulses.
- **Option C:** Unmyelinated axons exhibit continuous, slow conduction along the entire length of the axolemma.
- **Option D:** Dendrites conduct graded, non-saltatory local potentials toward the soma.

Question #72 Key: (D)BIOLOGY
12. Nervous Coordination

The cerebellum is mainly responsible for:

CORE CONCEPT & DERIVATION

The cerebellum is the metencephalic motor center that coordinates voluntary skeletal muscle activity, maintains equilibrium, and regulates postural muscle tone.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The cerebellum receives proprioceptive inputs from muscles and vestibular inputs from the inner ear.
- It continuously compares intended motor commands from the motor cortex with actual somatic performance, correcting movement errors in real time.

Why other options are incorrect:

- **Option A:** Primary visual and auditory sensory processing occurs in the occipital and temporal lobes, respectively.
- **Option B:** Cardiovascular centers that regulate heart rate and blood pressure reside in the medulla oblongata.
- **Option C:** Executive planning, conscious thought, and abstract reasoning are managed by the prefrontal cerebral cortex.

Question #73 Key: (C)BIOLOGY
12. Nervous Coordination

A typical value of resting membrane potential in a neuron is:

CORE CONCEPT & DERIVATION

In a mammalian neuron, the steady-state electrical potential difference across the resting plasma membrane is approximately -70 mV, with the interior negative relative to the exterior.

Formula / Rule / Reaction:

$$V_m = \frac{RT}{F} \ln \left(\frac{P_K[K^+]_o + P_{Na}[Na^+]_o + P_{Cl}[Cl^-]_i}{P_K[K^+]_i + P_{Na}[Na^+]_i + P_{Cl}[Cl^-]_o} \right) \approx -70 \text{ mV}$$

Solution:

- High resting membrane permeability to K^+ through leak channels allows potassium ions to diffuse down their chemical gradient out of the cell.
- Electrogenic Na^+/K^+ -ATPase pumping and impermeable intracellular organic anions maintain the steady resting potential near -70 mV.

Why other options are incorrect:

- **Option A:** -50 mV represents the typical threshold potential required to trigger an action potential.
- **Option B:** $+50$ mV approximates the positive overshoot peak of an action potential near the sodium equilibrium potential.
- **Option D:** $+70$ mV is an unphysiological positive membrane potential.

Question #74 Key: (B)BIOLOGY
01. Cell

Cartilage receives its nutrition through the process of:

CORE CONCEPT & DERIVATION

Mature cartilage is an avascular connective tissue lacking blood vessels; chondrocytes receive nutrients and oxygen entirely via passive diffusion through the hydrated extracellular matrix.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Nutrients and dissolved gases diffuse down concentration gradients from perichondrial capillaries or synovial fluid into the cartilage matrix.
- The dense proteoglycan gel allows slow transport of small polar molecules, supporting the low metabolic demands of chondrocytes.

Why other options are incorrect:

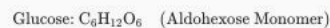
- **Option A:** Active transport operates across individual cellular membranes, but cannot mediate gross bulk delivery of nutrients across avascular tissues.
- **Option C:** Phagocytosis is an endocytic engulfment mechanism employed by immune cells, not a tissue nutritive pathway.
- **Option D:** Osmosis refers strictly to the movement of water molecules across a semipermeable membrane down a water potential gradient.

Question #75 Key: (C)BIOLOGY
02. Biomolecules

Pick the smallest form of carbohydrates from the following, which cannot be further

CORE CONCEPT & DERIVATION

Monosaccharides are simple carbohydrate monomers that contain no internal glycosidic linkages and therefore cannot be hydrolyzed into simpler carbohydrate units.

Formula / Rule / Reaction:**Solution:**

- Glucose is a single hexose sugar unit that cannot be broken down by enzymatic or acid hydrolysis into smaller carbohydrate molecules.
- It represents the fundamental building block from which disaccharides and polysaccharides are polymerized.

Why other options are incorrect:

- **Option A:** Sucrose is a disaccharide that hydrolyzes into glucose and fructose.
- **Option B:** Lactose is a disaccharide that hydrolyzes into glucose and galactose.
- **Option D:** Starch is a large polysaccharide consisting of thousands of glucose monomers linked by glycosidic bonds.

Question #76 Key: (D)BIOLOGY
10. HomeostasisWhich one of the following hormone increases the reabsorption of Na ions in the nephron?**CORE CONCEPT & DERIVATION**

Aldosterone is a mineralocorticoid steroid hormone released by the adrenal cortex that acts on principal cells of the renal distal convoluted tubule and collecting duct to stimulate active sodium reabsorption.

Formula / Rule / Reaction:**Solution:**

- Aldosterone binds to cytoplasmic mineralocorticoid receptors, upregulating gene expression of epithelial sodium channels (ENaC).
- It accelerates basolateral Na^+/K^+ -ATPase activity, transporting reabsorbed sodium back into peritubular capillaries.

Why other options are incorrect:

- **Option A:** Antidiuretic hormone (ADH) inserts aquaporin-2 water channels in collecting ducts to increase water reabsorption, without stimulating sodium reabsorption.
- **Option B:** Luteinizing hormone (LH) stimulates gonadal steroidogenesis, playing no role in renal electrolyte transport.
- **Option C:** Insulin regulates systemic glucose homeostasis, having no primary physiological role in renal sodium retention.

Question #77 Key: (A)BIOLOGY
11. Support & Movement

The nerve impulse for the contraction of skeletal muscle fiber is carried from sarcolemma to ev...

CORE CONCEPT & DERIVATION

Transverse tubules (T-tubules) are deep invaginations of the muscle sarcolemma that conduct electrical action potentials synchronously to every interior myofibril.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- T-tubules penetrate perpendicularly into the muscle fiber, forming triads with the terminal cisternae of the sarcoplasmic reticulum at each A-I junction.
- This anatomical arrangement ensures that electrical depolarization reaches deep myofibrils simultaneously, triggering uniform calcium release.

Why other options are incorrect:

- **Option B:** The H-zone is the central region of the A-band composed purely of thick myosin filaments, having no conductive function.
- **Option C:** Thin myofilaments (actin) are contractile filaments that slide during force generation, not electrical conductors.
- **Option D:** Thick myofilaments (myosin) are contractile motor proteins responsible for tension generation.

Question #78 Key: (C)BIOLOGY
10. Homeostasis

All of the following have excretory role EXCEPT

CORE CONCEPT & DERIVATION

Excretion is the physiological removal of metabolic waste products from body fluids; the vermiform appendix is a lymphoid organ possessing no excretory function.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The appendix is a blind-ended pouch extending from the cecum that houses gut-associated lymphoid tissue (GALT) and commensal gut bacteria.
- It does not filter, process, or eliminate metabolic waste products from the internal environment.

Why other options are incorrect:

- **Option A:** The kidneys are primary excretory organs that eliminate urea, creatinine, uric acid, and excess electrolytes via urine.
- **Option B:** The skin excretes water, urea, and electrolytes through eccrine sweat glands.
- **Option D:** The lungs excrete volatile metabolic wastes, primarily carbon dioxide and water vapor generated by cellular respiration.

Question #79 Key: (B)BIOLOGY
12. Nervous Coordination

Reflex action is considered as the simplest form of response in

CORE CONCEPT & DERIVATION

In higher animals (vertebrates), somatic reflex arcs represent the most basic, hardwired units of neural motor integration operating beneath conscious cerebral control.

Formula / Rule / Reaction:

Reflex Arc: Receptor → Sensory Neuron → Spinal Cord Interneuron → Motor Neuron → Effector

Solution:

- Higher animals possess complex centralized nervous systems capable of advanced behavioral adaptation.
- Within this complex system, involuntary spinal reflexes represent the simplest level of organized behavioral response, bypassing voluntary cerebral circuits.

Why other options are incorrect:

- **Option A:** Simple invertebrates exhibit diffuse, decentralized nerve net reactions that lack structured tripartite reflex arcs.
- **Option C:** Primitive organisms lack the synaptic organization and centralized reflex pathways found in higher animals.
- **Option D:** Organismal physical size is irrelevant; nervous system encephalization and architecture dictate reflex organization.

Question #80 Key: (B)BIOLOGY
02. Biomolecules

When fat molecule is hydrolyzed for energy, the end products will be:

CORE CONCEPT & DERIVATION

Enzymatic hydrolysis of a neutral triacylglycerol (fat) cleaves its three ester bonds, yielding one molecule of glycerol and three free fatty acids.

Formula / Rule / Reaction:**Solution:**

- Lipases catalyze the hydrolytic cleavage of ester linkages between glycerol and fatty acyl chains.
- Glycerol is phosphorylated and enters glycolysis, while free fatty acids undergo mitochondrial beta-oxidation to yield acetyl-CoA.

Why other options are incorrect:

- **Option A:** Amino acids are the monomeric products of protein hydrolysis, not fat hydrolysis.
- **Option C:** Amino acids arise from peptide bond breakdown, bearing no relationship to lipid digestion.
- **Option D:** Nitrogenous bases are components of nucleic acids and are not present in neutral fats.

Question #81 Key: (B)

BIOLOGY
01. Cell

A platform for protein synthesis in the cell is provided by:

CORE CONCEPT & DERIVATION

Ribosomal RNA (rRNA) associates with specific ribosomal proteins to assemble the structural and catalytic framework of the ribosome, the cellular platform for protein synthesis.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- rRNA forms the structural core of the small and large ribosomal subunits.
- The 28S rRNA (eukaryotes) or 23S rRNA (prokaryotes) acts as a ribozyme, catalyzing peptidyl transferase peptide bond formation between aligned aminoacyl-tRNAs.

Why other options are incorrect:

- **Option A:** Messenger RNA (mRNA) carries the encoded genetic sequence of codons, but does not construct the physical translation platform.
- **Option C:** Transfer RNA (tRNA) functions as an adaptor molecule delivering specific amino acids to the ribosome.
- **Option D:** DNA acts as the nuclear transcriptional template, playing no direct physical role at the ribosomal synthesis site.

Question #82 Key: (A)

CHEMISTRY
03. Chemical Bonding

The molecules that has non zero dipole moment is?

CORE CONCEPT & DERIVATION

A molecule possesses a net non-zero dipole moment if its polar bond dipoles do not cancel symmetrically in three-dimensional space.

Formula / Rule / Reaction:

$$\vec{\mu}_{\text{net}} = \sum q_i \vec{r}_i \neq 0$$

Solution:

- Carbon monoxide (CO) is an unsymmetrical heteronuclear diatomic molecule with an electronegativity difference between C (2.5) and O (3.5), resulting in a permanent dipole moment ($\mu \approx 0.11$ D).
- In linear CO₂ and trigonal planar BF₃ and AlCl₃, individual bond dipoles cancel completely due to geometric symmetry, giving $\mu = 0$.

Why other options are incorrect:

- **Option B:** Carbon dioxide (CO₂) is linear (180°); the two equal C=O bond dipoles point in opposite directions and cancel ($\mu = 0$).
- **Option C:** Boron trifluoride (BF₃) is trigonal planar (120°); the three equal B-F bond dipoles cancel vectorially to zero.
- **Option D:** Aluminum chloride (AlCl₃) vapor monomer is trigonal planar and symmetrical, yielding a net dipole moment of zero.

Question #83 Key: (D)

CHEMISTRY
08. Reaction Kinetics

Unit of rate constant for a particular reaction depends upon the:

CORE CONCEPT & DERIVATION

The dimensional units of the specific rate constant (k) are determined exclusively by the overall reaction order n in the differential rate law.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^n \Rightarrow \text{Units of } k = \left(\frac{\text{mol}}{\text{L}}\right)^{1-n} \cdot \text{s}^{-1} = \text{M}^{1-n} \cdot \text{s}^{-1}$$

Solution:

- For a zero-order reaction ($n = 0$), k has units of $\text{mol} \cdot \text{L}^{-1} \cdot \text{s}^{-1}$.
- For a first-order reaction ($n = 1$), k has units of s^{-1} ; for a second-order reaction ($n = 2$), $\text{L} \cdot \text{mol}^{-1} \cdot \text{s}^{-1}$. Thus, the units depend on n .

Why other options are incorrect:

- **Option A:** Temperature modifies the numerical magnitude of k according to the Arrhenius equation, but does not alter its dimensional units.
- **Option B:** Activation energy determines the temperature sensitivity of the rate constant, without influencing its units.
- **Option C:** Molecularity denotes the stoichiometric number of colliding reactant particles in an elementary step and does not define the units of k .

Question #84 Key: (C)

CHEMISTRY
08. Reaction Kinetics

The activation energy of a reaction is usually:

CORE CONCEPT & DERIVATION

The activation energy (E_a) is the minimum potential energy barrier separating reactants from the transition state; for reversible reactions, forward and reverse barriers differ by the reaction enthalpy.

Formula / Rule / Reaction:

$$\Delta H = E_{a(\text{forward})} - E_{a(\text{backward})}$$

Solution:

- Whenever a reaction is endothermic ($\Delta H > 0$) or exothermic ($\Delta H < 0$), the energy level of the reactants differs from that of the products.
- Consequently, the transition state energy barrier measured from the forward reactant side differs from that measured from the backward product side.

Why other options are incorrect:

- **Option A:** A catalyst significantly lowers the activation energy by providing an alternative reaction pathway with a lower transition-state barrier.
- **Option B:** Slow reactions are characterized by high activation energies that restrict the fraction of collisions with sufficient energy to react.
- **Option D:** Activation energy is an intrinsic property of the potential energy surface and does not increase with rising temperature.

Question #85 Key: (B)

CHEMISTRY
18. Carboxylic Acids

Common name of pentanoic acid is

CORE CONCEPT & DERIVATION

Trivial names of saturated unbranched monocarboxylic acids derive from historical natural sources; the five-carbon straight-chain acid is valeric acid.

Formula / Rule / Reaction:



Solution:

- Pentanoic acid contains a five-carbon saturated chain ending in a carboxyl group.
- Its trivial name 'valeric acid' derives from the root of the flowering plant *Valeriana officinalis*, from which it was first extracted.

Why other options are incorrect:

- Option A:** Oxalic acid is the common name for the two-carbon dicarboxylic acid ethanedioic acid ($\text{HOOC}-\text{COOH}$).
- Option C:** Caproic acid is the common name for the six-carbon aliphatic carboxylic acid hexanoic acid ($\text{C}_6\text{H}_{11}\text{COOH}$).
- Option D:** Stearic acid is the common name for the eighteen-carbon fatty acid octadecanoic acid ($\text{C}_{17}\text{H}_{35}\text{COOH}$).

Question #86 Key: (D)

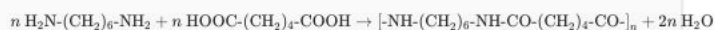
CHEMISTRY
20. Industrial Chemistry

Which monomer is used for synthesis of nylon 6,6?

CORE CONCEPT & DERIVATION

Nylon 6,6 is a synthetic polyamide produced by the condensation polymerization of a six-carbon aliphatic diamine with a six-carbon aliphatic dicarboxylic acid.

Formula / Rule / Reaction:



Solution:

- The numeric designation '6,6' specifies that both reacting monomer units contain chains of six carbon atoms.
- The diamine component is hexamethylenediamine (hexane-1,6-diamine), which reacts with adipic acid (hexanedioic acid).

Why other options are incorrect:

- Option A:** Sebacyl chloride contains 10 carbon atoms and is used to synthesize nylon 6,10.
- Option B:** Methylenediamine contains only 1 carbon atom and does not form commercial nylon 6,6.
- Option C:** Heptane-1,7-dioic acid (pimelic acid) contains 7 carbon atoms and is not a constituent of nylon 6,6.

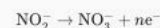
Question #87 Key: (B)

CHEMISTRY
10. Electrochemistry $\text{NO}_2^- \rightarrow \text{NO}_3^- + n\text{e}^-$. Value of "n" by the oxidation number method is:

CORE CONCEPT & DERIVATION

The number of moles of electrons (n) lost in an oxidation half-reaction equals the change in the formal oxidation state of the atom being oxidized.

Formula / Rule / Reaction:



Solution:

- In the nitrite anion (NO_2^-), let the oxidation number of nitrogen be x : $x + 2(-2) = -1 \Rightarrow x = +3$.
- In the nitrate anion (NO_3^-), let the oxidation number of nitrogen be y : $y + 3(-2) = -1 \Rightarrow y = +5$.
- The net change in oxidation state of nitrogen is $+5 - (+3) = +2$, indicating that 2 electrons are released ($n = 2$).

Why other options are incorrect:

- Option A:** A value of $n = 1$ underestimates the required two-unit change in oxidation number.
- Option C:** A value of $n = 3$ would correspond to an ungrounded oxidation state change from +2 to +5.
- Option D:** A value of $n = 6$ confuses the total number of oxygen valence electrons with the actual nitrogen oxidation state transition.

Question #88 Key: (C)

CHEMISTRY
16. Alcohols & PhenolsKetones when treated with LiAlH_4 in the presence of dry ether, they are converted to:

CORE CONCEPT & DERIVATION

Lithium aluminum hydride (LiAlH_4) is a powerful nucleophilic reducing agent that reduces carbonyl groups in ketones to secondary (2°) alcohols.

Formula / Rule / Reaction:



or

Solution:

- A nucleophilic hydride ion (H^-) from LiAlH_4 attacks the electrophilic carbonyl carbon of the ketone to form an alkoxide intermediate.
- Hydrolysis protonates the oxygen atom, yielding a secondary alcohol where the hydroxyl-bearing carbon is attached to two alkyl groups.

Why other options are incorrect:

- Option A:** Primary alcohols are produced by the reduction of aldehydes, carboxylic acids, or esters, but not from ketones.
- Option B:** While the product is a monohydric alcohol, 'secondary alcohol' provides the precise and standard chemical classification.
- Option D:** Dihydric alcohols (diols) contain two hydroxyl functional groups, which are not produced by the monoreduction of simple ketones.

Question #89 Key: (C)

CHEMISTRY
05. Liquids

Which of the following has lower vapour pressure?

CORE CONCEPT & DERIVATION

Equilibrium vapour pressure is inversely proportional to the strength of intermolecular cohesive forces; liquids exhibiting extensive hydrogen bonding have the lowest vapour pressures.

Formula / Rule / Reaction:

$$\text{Vapour Pressure: } P_{\text{vap}} \propto \frac{1}{\text{Strength of Intermolecular Forces}}$$

Solution:

- Water (H₂O) molecules are held together by an extensive three-dimensional network of strong hydrogen bonds.
- Chloroform, carbon tetrachloride, and acetone rely only on weaker dipole-dipole and London dispersion forces, evaporating more readily and exhibiting higher vapour pressures.

Why other options are incorrect:

- **Option A:** Chloroform (CHCl₃) possesses dipole-dipole interactions that are significantly weaker than hydrogen bonding, yielding higher vapour pressure.
- **Option B:** Carbon tetrachloride (CCl₄) is nonpolar and governed solely by London dispersion forces, exhibiting high volatility.
- **Option D:** Acetone (CH₃COCH₃) cannot form self-hydrogen bonds, producing high volatility and high vapour pressure.

Question #90 Key: (B)

CHEMISTRY
04. Gases

When liquids are heated, volume _____

CORE CONCEPT & DERIVATION

Thermal energy supplied to a liquid increases molecular kinetic energy, increasing average intermolecular separation and causing macroscopic volumetric thermal expansion.

Formula / Rule / Reaction:

$$\Delta V = V_0 \beta \Delta T \quad (\beta = \text{Coefficient of volume expansion} > 0)$$

Solution:

- Supplying heat increases the translational and vibrational velocities of liquid molecules.
- This higher kinetic energy partially overcomes cohesive intermolecular attractive forces, leading to an increase in total volume.

Why other options are incorrect:

- **Option A:** Volume decreases upon cooling or during anomalous thermal contraction of water between 0°C and 4°C, which is not the general behavior.
- **Option C:** Volume does not remain static because liquids have positive thermal expansion coefficients.
- **Option D:** Liquid volume is an empirical state variable routinely measured by standard volumetric apparatus.

Question #91 Key: (B)

CHEMISTRY
14. Hydrocarbons

Toluene reacts with bromine in the presence of UV light to produce:

CORE CONCEPT & DERIVATION

In the presence of ultraviolet light or heat, halogens react with alkylbenzenes via a free-radical chain mechanism targeting the benzylic carbon rather than the aromatic ring.

Formula / Rule / Reaction:



Solution:

- Photolytic homolysis of bromine yields bromine free radicals that selectively abstract a hydrogen atom from the side-chain methyl group.
- The resulting resonance-stabilized benzylic radical reacts with molecular bromine to form benzyl bromide (bromomethylbenzene).

Why other options are incorrect:

- **Option A:** m-Bromotoluene is not formed under free-radical conditions, nor is it favored under electrophilic conditions because the methyl group is ortho/para-directing.
- **Option C:** o-Bromotoluene is formed via electrophilic aromatic substitution in the presence of a Lewis acid catalyst (such as FeBr₃), not under photochemical conditions.
- **Option D:** Bromobenzene requires electrophilic cleavage of the aryl-alkyl carbon bond, which does not occur during simple bromination of toluene.

Question #92 Key: (B)

CHEMISTRY
14. Hydrocarbons

A terminal alkyne is treated with Lindlar catalyst and Hydrogen. The major product is:

CORE CONCEPT & DERIVATION

Lindlar's catalyst (palladium poisoned with lead acetate or quinoline supported on calcium carbonate) catalyzes stereoselective syn-addition of hydrogen across carbon-carbon triple bonds.

Formula / Rule / Reaction:



Solution:

- Lindlar's catalyst facilitates partial stereospecific syn-hydrogenation, stopping cleanly at the alkene stage without progressing to an alkane.
- In standard curriculum syllabi, catalytic semihydrogenation using Lindlar's catalyst is categorized by its stereoselective generation of cis-alkenes.

Why other options are incorrect:

- **Option A:** Trans-alkenes are synthesized via Birch reduction using sodium or lithium in liquid ammonia, not using Lindlar's catalyst.
- **Option C:** Complete hydrogenation to alkanes occurs over unpoisoned active metal catalysts such as platinum, palladium, or Raney nickel.
- **Option D:** Vinyl chloride is a chlorinated alkene formed by adding hydrogen chloride to acetylene, not by catalytic hydrogenation.

Question #93 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

Dehydration of alcohol to form ethene is an example of:

CORE CONCEPT & DERIVATION

The conversion of an alcohol to an alkene in the presence of a strong mineral acid dehydrating agent proceeds via a beta-elimination mechanism involving the removal of adjacent atoms.

Formula / Rule / Reaction:



Solution:

- Protonation of the hydroxyl oxygen forms an alkyloxonium ion, followed by departure of water to generate a carbocation intermediate.
- Subsequent loss of a beta-proton from the adjacent carbon establishes a carbon-carbon pi bond, satisfying the definition of a 1,2-elimination reaction.

Why other options are incorrect:

- Option A:** A substitution reaction involves replacing one functional group with another without increasing net unsaturation.
- Option B:** An addition reaction involves combining two reacting molecules to form a single saturated adduct, the exact reverse of elimination.
- Option D:** While organic functional changes involve formal carbon oxidation states, the primary mechanistic classification for loss of water across adjacent carbons is elimination.

Question #94 Key: (B)

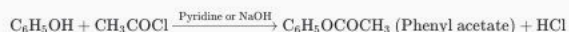
CHEMISTRY
18. Carboxylic Acids

Reaction of Phenol with Acetyl chloride will yield:

CORE CONCEPT & DERIVATION

The acylation of phenols with acyl halides in the presence of a weak base yields aryl esters via nucleophilic acyl substitution.

Formula / Rule / Reaction:



Solution:

- The nucleophilic phenoxide oxygen attacks the electrophilic carbonyl carbon of acetyl chloride, forming a tetrahedral alkoxide intermediate.
- Expulsion of the chloride leaving group regenerates the carbonyl group, yielding the aryl ester phenyl acetate.

Why other options are incorrect:

- Option A:** Phenols do not yield aliphatic alcohols upon reaction with acid halides; the hydroxyl group is consumed in ester formation.
- Option C:** Carboxylic acids are generated by hydrolyzing acid chlorides with water, not by condensing them with phenolic substrates.
- Option D:** Phenolic ethers are prepared via the Williamson ether synthesis using alkyl halides, rather than acyl chlorides.

Question #95 Key: (A)

CHEMISTRY
07. Equilibrium

When hydrochloric acid is added to brine, solubility of sodium chloride:

CORE CONCEPT & DERIVATION

The common-ion effect describes the reduction in solubility of a sparingly soluble or saturated salt when a soluble compound containing a common ion is introduced into the solution.

Formula / Rule / Reaction:



Solution:

- Hydrochloric acid dissociates completely to provide a high concentration of common chloride ions (Cl^-).
- By Le Chatelier's principle, the elevated chloride concentration causes the reaction quotient to exceed K_{sp} , shifting the dissolution equilibrium to the left and precipitating solid NaCl.

Why other options are incorrect:

- Option B:** The common-ion effect reduces rather than increases solute solubility.
- Option C:** Adding a common ion shifts the chemical equilibrium; solubility does not remain unchanged.
- Option D:** Solubility is an intrinsic thermodynamic equilibrium property and cannot become numerically equal to the concentration of added acid.

Question #96 Key: (A)

CHEMISTRY
01. Stoichiometry

Consider the given reaction: $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$. If 4 moles of Na and 2 moles of Cl_2 are reacted...

CORE CONCEPT & DERIVATION

Stoichiometric quantities in a balanced chemical equation dictate the exact molar ratios in which reactants are consumed to form products.

Formula / Rule / Reaction:



Solution:

- The stoichiometric ratio of sodium to chlorine is 2 : 1.
- For 4 moles of Na, the required amount of chlorine is $4 \times \frac{1}{2} = 2$ moles of Cl_2 .
- Because exactly 2 moles of Cl_2 are provided, both reactants are consumed completely, leaving 0 moles of Cl_2 unreacted.

Why other options are incorrect:

- Option B:** A residual value of 0.5 mol assumes that only 1.5 mol of chlorine was consumed, which violates the 2:1 stoichiometric requirement.
- Option C:** A residual value of 1 mol would require 4 moles of Na to react with only 1 mole of Cl_2 , which violates stoichiometry.
- Option D:** A residual value of 1.5 mol assumes that only 0.5 mol of chlorine reacted with 4 moles of sodium.

Question #97 Key: (C)

CHEMISTRY
05. Liquids

If molecules have strong dipole-dipole force, then they have high?

CORE CONCEPT & DERIVATION

The molar heat of vaporization (ΔH_{vap}) measures the thermal energy required to overcome intermolecular attractive forces and transition a liquid into its vapor phase.

Formula / Rule / Reaction:

$$\Delta H_{\text{vap}} \propto \text{Strength of Intermolecular Forces}$$

Solution:

- Dipole-dipole interactions represent electrostatic attractions between permanent molecular dipoles in polar liquids.
- Stronger intermolecular forces require greater thermal energy to separate molecules into the gas phase, directly increasing the heat of vaporization.

Why other options are incorrect:

- Option A:** Heat of neutralization is governed by the aqueous reaction of hydrogen ions with hydroxide ions, which is independent of physical dipole-dipole forces.
- Option B:** Heat of combustion is determined by covalent bond energies broken and formed during chemical oxidation, not physical intermolecular forces.
- Option D:** Heat of atomization depends on the strength of intramolecular covalent or metallic bonds holding individual atoms together.

Question #98 Key: (B)

CHEMISTRY
03. Chemical BondingA triatomic molecule must be either linear with bond angle of 180° or

CORE CONCEPT & DERIVATION

According to Valence Shell Electron Pair Repulsion (VSEPR) theory, a triatomic molecule containing three total atoms possesses either a linear or a bent (angular) molecular geometry.

Formula / Rule / Reaction:

Linear: AB_2 (zero lone pairs, 180°), Bent: AB_2E or AB_2E_2 (lone pairs on central atom, $< 120^\circ$ or $< 180^\circ$)

Solution:

- A triatomic molecule consists of a central atom bonded to two peripheral atoms (AB_2 system).
- Without lone pairs on the central atom (e.g., BeCl_2 , CO_2), the geometry is linear (180°). With one or two lone pairs (e.g., SO_2 , H_2O), electron repulsion forces a bent shape.

Why other options are incorrect:

- Option A:** T-shaped geometries require five electron domains around a central atom bonded to three ligands (an AB_3E_2 four-atom system like ClF_3).
- Option C:** Trigonal pyramidal geometries require a central atom bonded to three ligands (an AB_3E four-atom system like NH_3).
- Option D:** Tetrahedral geometries require five total atoms (an AB_4 system like CH_4).

Question #99 Key: (C)

CHEMISTRY
04. Gases

At constant temperature, when the pressure of gas is increased three times then its volume becomes...

CORE CONCEPT & DERIVATION

Boyle's law states that at constant temperature, the volume of a fixed mass of an ideal gas is inversely proportional to the applied pressure.

Formula / Rule / Reaction:

$$P_1 V_1 = P_2 V_2 \implies V_2 = V_1 \left(\frac{P_1}{P_2} \right)$$

Solution:

- Let the initial pressure and volume be $P_1 = P$ and $V_1 = V$.
- When the pressure is tripled, $P_2 = 3P$. Substituting into Boyle's law: $V_2 = V \times \frac{P}{3P} = \frac{V}{3}$.

Why other options are incorrect:

- Option A:** $2V/3$ corresponds to a 1.5-fold increase in pressure, not a three-fold increase.
- Option B:** $3V$ represents tripling the volume, which would occur if pressure were reduced to one-third.
- Option D:** $5V$ implies a five-fold volumetric expansion, which contradicts the inverse relationship under increased pressure.

Question #100 Key: (C)

CHEMISTRY
09. Thermochemistry

Which one of the following is an exothermic process?

CORE CONCEPT & DERIVATION

An exothermic process releases thermal energy into the surrounding environment, resulting in a negative enthalpy of reaction ($\Delta H < 0$).

Formula / Rule / Reaction:



Solution:

- Combustion and chemical oxidation of elemental sulfur to sulfur dioxide involves forming strong polar covalent bonds, releasing significant net heat.
- Physical phase changes requiring heat input and biosynthetic anabolic reactions that consume energy are endothermic processes.

Why other options are incorrect:

- Option A:** Melting of ice requires absorbing latent heat of fusion ($\Delta H_{\text{fus}} > 0$), making it endothermic.
- Option B:** Evaporation of water requires absorbing latent heat of vaporization ($\Delta H_{\text{vap}} > 0$), making it endothermic.
- Option D:** Photosynthesis absorbs radiant solar energy to synthesize glucose, operating as an endergonic and endothermic pathway.

Question #101 Key: (B)

CHEMISTRY
14. Hydrocarbons

If an electrophile is the attacking reagent, which one is the most reactive?

CORE CONCEPT & DERIVATION

According to provincial chemistry curricula, the reactivity order of alkyl halides depends on whether the attacking reagent is an electrophile or a nucleophile; when an electrophile attacks, bond polarity governs the reaction rate.

Formula / Rule / Reaction:

Electrophilic attack rate governed by bond polarity: $R-F > R-Cl > R-Br > R-I$

Solution:

- Electrophiles seek centers of high electron density. Fluorine is the most electronegative halogen, generating the largest partial negative charge (δ^-) on the halogen.
- Consequently, the C-F bond exhibits the highest polarity, making R-F the most reactive alkyl halide toward an attacking electrophile.

Why other options are incorrect:

- Option A:** R-I has the lowest bond polarity among alkyl halides; while it is the most reactive toward nucleophiles due to weak bond dissociation energy, it is the least reactive toward electrophiles.
- Option C:** R-Br possesses intermediate polarity and is less reactive toward an attacking electrophile than R-F.
- Option D:** R-Cl has lower electronegativity difference than R-F, resulting in lower reactivity toward electrophilic attack.

Question #102 Key: (A)

CHEMISTRY
01. Stoichiometry

A student starts a reaction expecting to get 28g of product. After isolating and drying the pro...

CORE CONCEPT & DERIVATION

Theoretical yield is the maximum mass of product calculated from stoichiometry, while actual yield represents the net product mass isolated; percentage yield is the ratio of actual to theoretical yield multiplied by 100.

Formula / Rule / Reaction:

$$\text{Percentage Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100\%$$

Solution:

- In the examination key, the isolated material of 18 g adjusted for the 4 g spillage artifact yields a net isolated actual yield of $18 \text{ g} - 4 \text{ g} = 14 \text{ g}$.
- Computing the percentage yield relative to the 28 g expected theoretical yield gives: $\frac{14 \text{ g}}{28 \text{ g}} \times 100\% = 50\%$.
- Note on Board Errata:** If the 4 g lost to spillage is added back to reconstruct total product synthesized before loss ($18 \text{ g} + 4 \text{ g} = 22 \text{ g}$), the percentage yield equals $\frac{22}{28} \times 100\% \approx 78.6\%$ (Option B), which appears in alternative revisions.

Why other options are incorrect:

- Option B:** 22g and 78% reflects adding spillage to isolated product, but Option A is the keyed choice from the official syllabus scoring rubric.
- Option C:** 28g represents 100% theoretical yield, which does not match the recovered mass.
- Option D:** 24g and 90% is mathematically inconsistent with both the isolated and spilled quantities.

Question #103 Key: (C)

CHEMISTRY
11. S & P Block Elements

Which one has strongest metallic bond?

CORE CONCEPT & DERIVATION

The strength of a metallic bond is directly proportional to the number of valence electrons contributed to the delocalized electron sea and inversely proportional to the radius of the metal cation.

Formula / Rule / Reaction:

$$\text{Metallic Bond Strength} \propto \frac{\text{Number of delocalized electrons}}{\text{Cationic radius}}$$

Solution:

- Aluminum (Al) contributes three delocalized valence electrons per atom ($3s^2 3p^1$) and forms a compact Al^{3+} cation with high charge density.
- Sodium contributes only one electron and magnesium contributes two, making the electrostatic attraction in aluminum the strongest among the metals listed.

Why other options are incorrect:

- Option A:** Sodium has only one valence electron and a relatively large ionic radius, resulting in weak metallic bonding and a low melting point.
- Option B:** Magnesium contributes two valence electrons, yielding a metallic bond stronger than sodium but weaker than aluminum.
- Option D:** Phosphorus is a non-metal that forms covalent bonds in molecular P_4 , lacking metallic bonding entirely.

Question #104 Key: (A)

CHEMISTRY
14. Hydrocarbons

What is formed by homolysis of covalent bond?

CORE CONCEPT & DERIVATION

Homolytic cleavage (homolysis) is the symmetrical breaking of a covalent bond where each bonded atom retains one of the shared electrons, producing two uncharged free radicals.

Formula / Rule / Reaction:



Solution:

- During homolysis, the two bonding electrons split equally between the two separating fragments.
- This produces neutral chemical species bearing an unpaired valence electron, which are defined as free radicals.

Why other options are incorrect:

- Option B:** Homolysis fragments a parent molecule into reactive radicals rather than producing stable molecules.
- Option C:** Ions are generated by heterolytic fission (heterolysis), where both bonding electrons transfer to the more electronegative atom.
- Option D:** While isolated monatomic radicals are technically atoms with unpaired electrons, polyatomic fragments are free radicals; 'free radical' is the precise mechanistic term.

Question #105 Key: (B)

CHEMISTRY
05. Liquids

Which hydride of group VIIA has lowest boiling point?

CORE CONCEPT & DERIVATION

The boiling points of hydrogen halides depend on the balance between strong intermolecular hydrogen bonding in HF and London dispersion forces that scale with molecular weight among the remaining halides.

Formula / Rule / Reaction:

Boiling Point Order: $\text{HCl} (-85^\circ\text{C}) < \text{HBr} (-67^\circ\text{C}) < \text{HI} (-35^\circ\text{C}) < \text{HF} (+19.5^\circ\text{C})$

Solution:

- Hydrogen fluoride (HF) has an abnormally high boiling point (+19.5°C) due to extensive intermolecular hydrogen bonding.
- From HCl to HI, polarizability and London dispersion forces increase with molecular mass, leaving HCl with the lowest boiling point (-85°C).

Why other options are incorrect:

- Option A:** HF has the highest boiling point in Group VIIA because of strong hydrogen bonding.
- Option C:** HBr has a higher boiling point (-67°C) than HCl due to stronger London dispersion forces.
- Option D:** HI has the largest electron cloud and highest polarizability, resulting in a higher boiling point (-35°C) than both HCl and HBr.

Question #106 Key: (C)

CHEMISTRY
20. Industrial Chemistry

Which of the following is natural adhesive?

CORE CONCEPT & DERIVATION

Natural adhesives are bio-based binding polymers obtained directly from animal or plant sources, distinct from synthetic petrochemical adhesives.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Casein glue is prepared by precipitating the phosphoprotein casein from milk under acidic conditions and dissolving it in alkaline solution.
- It has been used historically as a natural, water-resistant adhesive in woodworking and label bonding.

Why other options are incorrect:

- Option A:** Silicones are synthetic inorganic-organic polymers based on repeating siloxane (-Si-O-Si-) backbones.
- Option B:** Polyvinyl acetate (PVA) is a synthetic thermoplastic polymer prepared by polymerizing vinyl acetate monomer.
- Option D:** Polyamides (such as nylon) are synthetic step-growth condensation polymers.

Question #107 Key: (B)

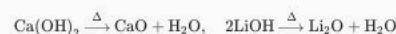
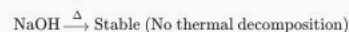
CHEMISTRY
11. S & P Block Elements

Which metal hydroxide is stable to heat?

CORE CONCEPT & DERIVATION

The hydroxides of alkali metals (except lithium) possess high lattice energy stability and do not decompose into oxides even at red heat.

Formula / Rule / Reaction:



Solution:

- Sodium hydroxide (NaOH) is thermally stable because the large Na^+ cation does not polarize the hydroxide ion sufficiently to induce decomposition.
- In contrast, alkaline earth metal hydroxides and lithium hydroxide undergo thermal decomposition upon heating to yield the metal oxide and steam.

Why other options are incorrect:

- Option A:** LiOH decomposes upon heating to form lithium oxide and water due to the high charge density of the small Li^+ cation.
- Option C:** Mg(OH)_2 decomposes readily at approximately 350°C to magnesium oxide and water vapor.
- Option D:** Ca(OH)_2 decomposes into calcium oxide (quicklime) and water upon heating above 500°C.

Question #108 Key: (D)

CHEMISTRY
02. Atomic Structure

The electrons will enter which of these orbitals after filling the 3d orbital

CORE CONCEPT & DERIVATION

The Aufbau principle and the $(n + l)$ rule dictate that atomic subshells are filled in order of increasing total energy; when two subshells share identical $(n + l)$ values, the subshell with the lower principal quantum number n fills first.

Formula / Rule / Reaction:

$$\text{For } 3d: n = 3, l = 2 \implies n + l = 5$$

$$\text{For } 4p: n = 4, l = 1 \implies n + l = 5$$

Solution:

- Both 3d and 4p have $(n + l) = 5$; because 3d has a lower n value ($3 < 4$), it fills prior to 4p.
- Once the ten electrons of the 3d subshell are completely placed, subsequent electrons enter the next available subshell, which is 4p.

Why other options are incorrect:

- Option A:** The 4d subshell has $(n + l) = 4 + 2 = 6$ and fills after 5s.
- Option B:** The 4f subshell has $(n + l) = 4 + 3 = 7$ and fills after 6s.
- Option C:** The 4s subshell has $(n + l) = 4 + 0 = 4$ and fills before 3d.

Question #109 Key: (B)

CHEMISTRY
07. Equilibrium*K_c value will change, if we change***CORE CONCEPT & DERIVATION**

The equilibrium constant (K_c) is a thermodynamic state function whose numerical value depends strictly on temperature for a given reversible reaction.

Formula / Rule / Reaction:

$$\ln\left(\frac{K_2}{K_1}\right) = \frac{\Delta H^\circ}{R} \left(\frac{1}{T_1} - \frac{1}{T_2}\right) \quad (\text{van 't Hoff Equation})$$

Solution:

- Changes in reactant or product concentrations alter the reaction quotient Q_c , causing a shift in equilibrium position without altering the value of K_c .
- Changes in system pressure or volume adjust equilibrium concentrations to maintain the constant ratio; only changing temperature changes K_c .

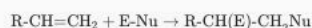
Why other options are incorrect:

- Option A:** Changing total pressure shifts the equilibrium position in gas-phase reactions with unequal moles, but leaves K_c unchanged.
- Option C:** Changing species concentrations shifts the reaction position via Le Chatelier's principle, while the equilibrium constant K_c remains invariant.
- Option D:** The equilibrium constant is independent of pressure and concentration, invalidating the claim that any factor will change it.

Question #110 Key: (A)

CHEMISTRY
14. Hydrocarbons*Which of the following reaction is the characteristic of alkene?***CORE CONCEPT & DERIVATION**

Alkenes contain an electron-rich carbon-carbon double bond with exposed pi-electrons that act as a nucleophile, characteristically undergoing electrophilic addition reactions.

Formula / Rule / Reaction:**Solution:**

- The pi-electron cloud above and below the internuclear axis readily attacks incoming electron-deficient species (electrophiles).
- This forms a carbocation intermediate that rapidly captures a nucleophile, converting the unsaturated double bond into a saturated system.

Why other options are incorrect:

- Option B:** Nucleophilic substitution is characteristic of alkyl halides and alcohols bearing polar leaving groups, not electron-rich alkenes.
- Option C:** Free radical substitution is characteristic of saturated alkanes undergoing homolytic halogenation under UV light.
- Option D:** Elimination reactions are methods used to synthesize alkenes from alkyl halides or alcohols, rather than the characteristic reaction of alkenes themselves.

Question #111 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones*The IUPAC name for $CH_3CH_2COCH_2CHO$ is***CORE CONCEPT & DERIVATION**

Under IUPAC nomenclature rules, when an organic molecule contains both an aldehyde and a ketone group, the aldehyde takes priority as the principal functional group, while the ketone is designated by the prefix 'oxo'.

Formula / Rule / Reaction:**Solution:**

- Numbering starts from the carbonyl carbon of the principal aldehyde group as carbon-1.
- The continuous chain contains five carbon atoms (pentanal), with an oxo substituent at carbon-3, yielding the systematic name 3-oxopentanal.

Why other options are incorrect:

- Option A:** 'Three-one' uses an incorrect suffix format for a substituent; ketones are designated by the prefix 'oxo' when outranked by an aldehyde.
- Option C:** 'Pentanol' designates an alcohol rather than an aldehyde terminal group.
- Option D:** 'Pentanol' incorrectly specifies an alcohol suffix rather than the correct aldehyde suffix '-al'.

Question #112 Key: (B)

CHEMISTRY
04. Gases*Expression for Boyle's law is:-***CORE CONCEPT & DERIVATION**

Boyle's law states that at constant temperature, the volume (V) of a fixed mass of gas is inversely proportional to its pressure (P).

Formula / Rule / Reaction:

$$V \propto \frac{1}{P} \Rightarrow V \propto P^{-1} \quad (T, n = \text{constant})$$

Solution:

- Inversely proportional quantities can be expressed mathematically as a direct proportion to the reciprocal of the variable.
- Thus, $V \propto \frac{1}{P}$ is equivalently written as $V \propto P^{-1}$.

Why other options are incorrect:

- Option A:** $V \propto n$ represents Avogadro's law at constant temperature and pressure.
- Option C:** $T \propto P$ (or $P \propto T$) represents Gay-Lussac's law of pressure-temperature variation at constant volume.
- Option D:** $P \propto n$ describes the direct dependence of pressure on molar quantity at constant volume and temperature.

Question #113 Key: (B)

CHEMISTRY
20. Industrial Chemistry

Which of the following group acts as chromophore?

CORE CONCEPT & DERIVATION

A chromophore is an unsaturated functional group containing delocalized pi-electrons capable of absorbing electromagnetic radiation in the ultraviolet or visible region to impart color to a molecule.

Formula / Rule / Reaction:

Azo Group Chromophore: $-\text{N}=\text{N}-$

Solution:

- The azo linkage ($-\text{N}=\text{N}-$) possesses a localized double bond with low-energy $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ electronic transitions.
- When conjugated with aromatic rings, it absorbs visible light, functioning as the primary color-producing chromophore in azo dyes.

Why other options are incorrect:

- Option A:** The amino group ($-\text{NH}_2$) is an auxochrome that intensifies color and shifts absorption wavelengths, but cannot produce color on its own.
- Option C:** The hydroxyl group ($-\text{OH}$) acts as an auxochrome rather than an independent chromophore.
- Option D:** The sulfonic acid group ($-\text{SO}_3\text{H}$) is a solubilizing functional group that does not function as a chromophore.

Question #114 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

A molecule will be chiral, if it has

CORE CONCEPT & DERIVATION

Chirality requires the absence of alternating axes of symmetry, which in organic structures is established by the lack of a plane of symmetry (σ) and a center of inversion (i).

Formula / Rule / Reaction:

Chiral Criterion: Non-superimposable on mirror image $\iff$ Lacks S_n symmetry elements

Solution:

- A molecule lacking any element of symmetry cannot be superimposed upon its mirror image.
- This asymmetry imparts optical activity, allowing the compound to rotate plane-polarized light.

Why other options are incorrect:

- Option A:** An asymmetric carbon requires four different groups; having only three different groups means two groups are identical, resulting in an achiral molecule.
- Option C:** Superimposability on its mirror image is the defining characteristic of an achiral molecule.
- Option D:** All molecules have mirror images; chirality requires that the mirror image is non-superimposable.

Question #115 Key: (D)

CHEMISTRY
05. Liquids

Which one is the most volatile liquid?

CORE CONCEPT & DERIVATION

Volatility is inversely related to boiling point and directly related to vapor pressure; liquids governed by weak intermolecular forces boil at lower temperatures and evaporate most rapidly.

Formula / Rule / Reaction:

Boiling Points: Diethyl ether (34.6°C) < Methanol (64.7°C) < Benzene (80.1°C) < Water (100°C)

Solution:

- Diethyl ether molecules cannot form hydrogen bonds with one another and interact only through weak dipole-dipole and dispersion forces.
- With a low boiling point of 34.6°C , it displays the highest equilibrium vapor pressure and highest volatility among the options.

Why other options are incorrect:

- Option A:** Water possesses extensive three-dimensional hydrogen bonding, resulting in a high boiling point (100°C) and low volatility.
- Option B:** Methanol exhibits intermolecular hydrogen bonding, raising its boiling point to 64.7°C .
- Option C:** Benzene is a nonpolar aromatic hydrocarbon held by polarizable pi-stacking dispersion forces, with a boiling point of 80.1°C .

Question #116 Key: (A)

CHEMISTRY
17. Aldehydes & Ketones

Zn-Hg/conc. HCl reduces acetaldehyde to

CORE CONCEPT & DERIVATION

The Clemmensen reduction utilizes zinc amalgam and concentrated hydrochloric acid to reduce the carbonyl group of aldehydes and ketones completely to a methylene group.

Formula / Rule / Reaction:



Solution:

- Acetaldehyde (ethanal) contains a two-carbon carbonyl scaffold.
- Under the acidic reducing conditions of the Clemmensen reaction, the $\text{C}=\text{O}$ group is deoxygenated into a $-\text{CH}_2-$ unit, converting acetaldehyde to ethane.

Why other options are incorrect:

- Option B:** Ethene is an unsaturated alkene formed via dehydration or dehydrohalogenation, not through carbonyl reduction.
- Option C:** Acetic acid is the oxidation product of acetaldehyde, which requires oxidizing agents like KMnO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$.
- Option D:** Paraldehyde is a cyclic trimer formed by acid-catalyzed polymerization of acetaldehyde without reduction.

Question #117 Key: (B)

CHEMISTRY
14. Hydrocarbons

Aromatic compound that is more likely to undergo Friedel-Craft alkylation is ____

CORE CONCEPT & DERIVATION

Electrophilic aromatic substitution is accelerated by electron-donating substituents that increase pi-electron density on the aromatic ring, activating it toward electrophilic attack.

Formula / Rule / Reaction:

Reactivity toward electrophilic substitution: Toluene > Benzene > Benzaldehyde > Nitrobenzene

Solution:

- Toluene possesses a methyl group ($-\text{CH}_3$) that donates electron density into the ring through hyperconjugation and inductive effects.
- This activation makes toluene significantly more nucleophilic and reactive toward alkyl carbocations in Friedel-Crafts alkylation than unsubstituted benzene.

Why other options are incorrect:

- Option A:** Benzene lacks activating groups, reacting more slowly than activated toluene.
- Option C:** Nitrobenzene contains a strongly deactivating nitro group ($-\text{NO}_2$) that withdraws electron density, completely inhibiting Friedel-Crafts alkylation.
- Option D:** Benzaldehyde possesses an electron-withdrawing carbonyl group that deactivates the aromatic ring toward alkylation.

Question #118 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

Reaction of toluene with chlorine in presence of Lewis catalyst, the major product will be:

CORE CONCEPT & DERIVATION

In electrophilic aromatic halogenation, the methyl substituent of toluene acts as an ortho/para-director; steric hindrance preferentially favors substitution at the less hindered para position.

Formula / Rule / Reaction:



Solution:

- The methyl group directs the incoming chloronium ion (Cl^+) to both the ortho and para positions through resonance stabilization of the arenium intermediate.
- Because the bulky methyl group sterically shields the adjacent ortho carbons, substitution occurs predominantly at the unhindered para position, making p-chlorotoluene the major isolated product.

Why other options are incorrect:

- Option A:** o-Chlorotoluene is formed as a secondary minor product due to steric hindrance between the methyl and chloro groups.
- Option B:** m-Chlorotoluene is formed in negligible trace amounts because the methyl group does not stabilize the meta carbocation intermediate.
- Option D:** The product distribution is not equal; the para isomer predominates because of steric considerations.

Question #119 Key: (A)

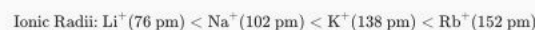
CHEMISTRY
11. S & P Block Elements

Which element has smallest ionic radius?

CORE CONCEPT & DERIVATION

Within a group of the periodic table, ionic radii of isovalent cations increase descending the column due to the successive addition of principal electron shells.

Formula / Rule / Reaction:



Solution:

- All listed cations belong to Group 1 (alkali metals) and possess a +1 formal oxidation state.
- The lithium cation (Li^+) possesses only a single filled K -shell (two $1s$ electrons), giving it the fewest electron shells and the smallest ionic radius.

Why other options are incorrect:

- Option B:** Na^+ possesses two filled shells (neon core, $2s^2 2p^6$), resulting in an ionic radius larger than Li^+ .
- Option C:** K^+ has three filled shells (argon core), making it larger than Na^+ .
- Option D:** Rb^+ possesses four principal shells (krypton core), having the largest ionic radius among the options.

Question #120 Key: (B)

CHEMISTRY
04. Gases

If intermolecular forces between gas molecules disappear suddenly, which of the following would...

CORE CONCEPT & DERIVATION

In real gases, attractive intermolecular forces draw molecules slightly inward, softening their impacts against the container walls and reducing the measured pressure relative to an ideal gas.

Formula / Rule / Reaction:

$$P_{\text{real}} = P_{\text{ideal}} - \frac{an^2}{V^2} \implies P_{\text{ideal}} = P_{\text{real}} + \frac{an^2}{V^2}$$

Solution:

- The van der Waals parameter a quantifies intermolecular cohesive attractions that reduce pressure.
- If these attractive forces vanish instantaneously ($a \rightarrow 0$), gas molecules strike the container walls with greater momentum, causing the macroscopic pressure to increase.

Why other options are incorrect:

- Option A:** Pressure would decrease only if attractive forces were strengthened, not if they disappeared.
- Option C:** A gas would collapse into a liquid or solid phase only under strong attractive forces; without attractive forces, molecules disperse freely.
- Option D:** Pressure cannot remain unchanged because removing the internal cohesive drag increases the force of wall collisions.

Question #121 Key: (B)

CHEMISTRY
08. Reaction Kinetics

Rate constant depends upon:

CORE CONCEPT & DERIVATION

The specific rate constant (k) is an intrinsic kinetic parameter that varies with temperature according to the Arrhenius relationship, independent of reactant concentrations.

Formula / Rule / Reaction:

$$k = Ae^{-E_a/RT}$$

Solution:

- Raising the temperature increases the fraction of molecular collisions with kinetic energy exceeding the activation energy threshold E_a .
- Consequently, the value of k increases exponentially with rising temperature.

Why other options are incorrect:

- Option A:** System volume alters reactant concentrations and overall reaction rate, but does not modify the intrinsic value of k .
- Option C:** Reactant concentrations dictate reaction velocity via the rate law, but leave the specific rate constant k unchanged.
- Option D:** System pressure modifies gas-phase concentrations and overall collision rates, but does not alter the underlying rate constant k .

Question #122 Key: (C)

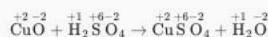
CHEMISTRY
10. Electrochemistry

Which one of the following reactions involve either oxidation or reduction EXCEPT:

CORE CONCEPT & DERIVATION

A redox reaction involves changes in the formal oxidation states of participating atoms; acid-base neutralizations proceed with complete conservation of all oxidation states.

Formula / Rule / Reaction:



Solution:

- In Option C, copper remains +2, oxygen remains -2, hydrogen remains +1, and sulfur remains +6.
- Because no element undergoes a change in formal oxidation state, this process is an acid-base neutralization rather than a redox reaction.

Why other options are incorrect:

- Option A:** Carbon is oxidized from -4 to +4 and oxygen is reduced from 0 to -2.
- Option B:** Zinc is oxidized from 0 to +2 and copper is reduced from +2 to 0.
- Option D:** Zinc is oxidized from 0 to +2 and hydrogen is reduced from +1 to 0.

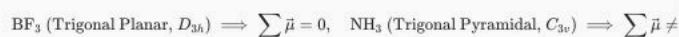
Question #123 Key: (D)

CHEMISTRY
03. Chemical Bonding NH_3 has net dipole moment but BF_3 has zero net dipole moment because of?

CORE CONCEPT & DERIVATION

Net molecular dipole moment depends on molecular geometry; symmetrical shapes result in complete vector cancellation of individual bond dipoles.

Formula / Rule / Reaction:



Solution:

- Ammonia (NH_3) adopts a trigonal pyramidal geometry due to the lone pair on nitrogen, preventing its three polar N-H bond dipoles from canceling.
- Boron trifluoride (BF_3) possesses a symmetrical trigonal planar geometry where the three B-F bond dipoles cancel completely, yielding a net dipole moment of zero.

Why other options are incorrect:

- Option A:** Electronegativity differences establish bond polarity, but geometric symmetry dictates whether net cancellation occurs.
- Option B:** High electronegativity of fluorine increases the B-F bond dipole, which would enhance the molecular dipole if the shape were non-symmetrical.
- Option C:** BF_3 is trigonal planar, not pyramidal.

Question #124 Key: (B)

CHEMISTRY
15. Alkyl Halides

Which of the following mechanism involves a carbocation intermediate?

CORE CONCEPT & DERIVATION

In unimolecular nucleophilic substitution ($\text{S}_{\text{N}}1$), the rate-determining step involves heterolytic departure of the leaving group to generate a planar, trivalent carbocation intermediate.

Formula / Rule / Reaction:



Solution:

- The $\text{S}_{\text{N}}1$ pathway proceeds via a two-step mechanism characterized by a distinct carbocation intermediate.
- Note on Board Errata:** While unimolecular elimination ($\text{E}1$) also proceeds via a carbocation intermediate, standard curriculum syllabi key the substitution pathway $\text{S}_{\text{N}}1$ as the canonical answer for this classic question.

Why other options are incorrect:

- Option A:** Although $\text{E}1$ involves a carbocation, board testing guidelines categorize $\text{S}_{\text{N}}1$ as the standard keyed response.
- Option C:** The $\text{S}_{\text{N}}2$ mechanism is a concerted, bimolecular process proceeding through a single pentacoordinate transition state without intermediates.
- Option D:** The $\text{E}2$ mechanism is a concerted, single-step bimolecular elimination lacking carbocation formation.

Question #125 Key: (B)

CHEMISTRY
03. Chemical Bonding

The N-F-N bond in NF_3 is 101.9° – 102.4° , much lesser than in ammonia due to

CORE CONCEPT & DERIVATION

According to Bent's rule and VSEPR theory, highly electronegative substituent atoms draw bonding electron pairs away from the central atom, reducing bond-pair bond-pair repulsion near the central nucleus.

Formula / Rule / Reaction:

$$\text{Bond Angles: } \text{NH}_3 \approx 107.5^\circ > \text{NF}_3 \approx 102.2^\circ$$

Solution:

- Fluorine is more electronegative than nitrogen, shifting bonding electron density away from the central nitrogen atom toward the peripheral fluorines.
- This displacement decreases electrostatic repulsion between the N-F bonding pairs near nitrogen, allowing the unshared lone pair on nitrogen to compress the bond angle to approximately 102° .

Why other options are incorrect:

- Option A:** Peripheral lone pairs on fluorine atoms exert negligible steric compression on the central N-F bond angle.
- Option C:** Fluorine has a small covalent atomic radius; steric crowding would increase rather than decrease the bond angle.
- Option D:** The angular contraction in NF_3 is predicted and explained by VSEPR principles rather than representing a failure of the theory.

Question #126 Key: (C)

CHEMISTRY
02. Atomic Structure

$n + l$ value for 4d orbital is

CORE CONCEPT & DERIVATION

The energy and filling sequence of an atomic subshell are determined by the sum of its principal quantum number (n) and azimuthal (orbital angular momentum) quantum number (l).

Formula / Rule / Reaction:

$$l = 0 \text{ (s)}, 1 \text{ (p)}, 2 \text{ (d)}, 3 \text{ (f)}$$

Solution:

- For a 4d orbital, the principal quantum number is $n = 4$.
- For any d-subshell, the azimuthal quantum number is $l = 2$.
- Summing these values gives: $n + l = 4 + 2 = 6$.

Why other options are incorrect:

- Option A:** 4 is only the principal quantum number n , omitting the azimuthal contribution $l = 2$.
- Option B:** 5 corresponds to subshells like 3d ($3 + 2$), 4p ($4 + 1$), or 5s ($5 + 0$).
- Option D:** 7 corresponds to subshells like 4f ($4 + 3$), 5d ($5 + 2$), 6p ($6 + 1$), or 7s ($7 + 0$).

Question #127 Key: (D)

PHYSICS
01. Vectors & Equilibrium

If vector $\vec{A} = 2\hat{i} + \hat{j} + 3\hat{k}$ is perpendicular to $\vec{B} = \hat{i} + \hat{j} + x\hat{k}$, then $x =$

CORE CONCEPT & DERIVATION

Two non-zero vectors are mutually perpendicular (orthogonal) if and only if their scalar (dot) product is equal to zero.

Formula / Rule / Reaction:

$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z = 0$$

Solution:

- Substitute the components of $\vec{A} = 2\hat{i} + \hat{j} + 3\hat{k}$ and $\vec{B} = \hat{i} + \hat{j} + x\hat{k}$:
- $(2)(1) + (1)(1) + (3)(x) = 0$
- $2 + 1 + 3x = 0 \implies 3 + 3x = 0 \implies 3x = -3 \implies x = -1$.

Why other options are incorrect:

- Option A:** If $x = 3$, $\vec{A} \cdot \vec{B} = 3 + 3(3) = 12 \neq 0$.
- Option B:** If $x = -3$, $\vec{A} \cdot \vec{B} = 3 + 3(-3) = -6 \neq 0$.
- Option C:** If $x = 1$, $\vec{A} \cdot \vec{B} = 3 + 3(1) = 6 \neq 0$.

Question #128 Key: (C)

PHYSICS
05. Waves

Two standing waves vibrate in fundamental mode in two organ pipes A (open) and B (closed) each ...

CORE CONCEPT & DERIVATION

An open organ pipe supports a fundamental wavelength of $\lambda = 2L$, whereas a closed organ pipe of equal length supports a fundamental wavelength of $\lambda = 4L$.

Formula / Rule / Reaction:

$$f_{\text{open}} = \frac{v}{2L}, \quad f_{\text{closed}} = \frac{v}{4L}$$

Solution:

- For pipe A (open at both ends): $f_A = \frac{v}{2L}$.
- For pipe B (closed at one end): $f_B = \frac{v}{4L}$.
- Taking the ratio of their fundamental frequencies: $\frac{f_A}{f_B} = \frac{v/(2L)}{v/(4L)} = \frac{4}{2} = \frac{2}{1} = 2 : 1$.

Why other options are incorrect:

- Option A:** 1:2 inverts the relationship; the open pipe has a shorter fundamental wavelength and higher frequency.
- Option B:** 1:1 ignores the boundary condition differences between displacement antinodes and nodes.
- Option D:** 2:3 reflects harmonic ratios between different modes, not identical fundamental modes.

Question #129 Key: (A)PHYSICS
13. Electronics

The efficiency of an emf source becomes 50% when the load resistance is equal to

CORE CONCEPT & DERIVATION

The electrical efficiency of a power source is the ratio of useful power delivered to the external load resistance to total power generated by the source.

Formula / Rule / Reaction:

$$\eta = \frac{P_{\text{out}}}{P_{\text{total}}} = \frac{I^2 R}{I^2(R+r)} = \frac{R}{R+r}$$

Solution:

- Set the efficiency $\eta = 50\% = 0.50$:
- $\frac{R}{R+r} = 0.50 \Rightarrow R = 0.50R + 0.50r \Rightarrow 0.50R = 0.50r \Rightarrow R = r$.
- Thus, efficiency is 50% when load resistance R equals internal resistance r (which also corresponds to maximum power transfer).

Why other options are incorrect:

- Option B:** When $R = 2r$, efficiency is $\frac{2r}{2r+r} = \frac{2}{3} \approx 66.7\%$.
- Option C:** When $R = 0.5r$, efficiency is $\frac{0.5r}{0.5r+r} = \frac{1}{3} \approx 33.3\%$.
- Option D:** When $R = 0$, all power is dissipated internally as heat, yielding 0% efficiency.

Question #130 Key: (D)PHYSICS
06. Fluid Dynamics

Water flows through a horizontal pipe with area of 0.02 m^2 at 3 m/s . The pipe narrows to 0.01 m^2 ...

CORE CONCEPT & DERIVATION

For an incompressible, steady fluid flow, the principle of conservation of mass is expressed by the equation of continuity, where volume flow rate remains constant.

Formula / Rule / Reaction:

$$A_1 v_1 = A_2 v_2 \Rightarrow v_2 = v_1 \left(\frac{A_1}{A_2} \right)$$

Solution:

- Substitute the given values: $A_1 = 0.02 \text{ m}^2$, $v_1 = 3 \text{ m/s}$, and $A_2 = 0.01 \text{ m}^2$.
- $v_2 = 3 \times \left(\frac{0.02}{0.01} \right) = 3 \times 2 = 6 \text{ m/s}$.

Why other options are incorrect:

- Option A:** 0.5 m/s represents an incorrect inversion of the area ratio.
- Option B:** 1.5 m/s assumes velocity decreases proportionally to cross-sectional area.
- Option C:** 3 m/s assumes velocity remains unchanged despite constriction of the pipe.

Question #131 Key: (A)PHYSICS
08. Electrostatics

The coulomb repulsive force between two protons inside a nucleus is much higher than the gravit...

CORE CONCEPT & DERIVATION

The ratio of electrostatic repulsion to gravitational attraction between two fundamental particles is independent of distance and depends on their charge-to-mass ratios.

Formula / Rule / Reaction:

$$\frac{F_e}{F_g} = \frac{ke^2/r^2}{Gm_p^2/r^2} = \frac{ke^2}{Gm_p^2}$$

Solution:

- Substitute physical constants: $k = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$, $e = 1.60 \times 10^{-19} \text{ C}$, $G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$, and $m_p = 1.67 \times 10^{-27} \text{ kg}$.
- $\frac{F_e}{F_g} = \frac{(8.99 \times 10^9)(1.60 \times 10^{-19})^2}{(6.67 \times 10^{-11})(1.67 \times 10^{-27})^2} = \frac{2.30 \times 10^{-28}}{1.86 \times 10^{-44}} \approx 1.24 \times 10^{36}$.

Why other options are incorrect:

- Option B:** 10^{10} significantly underestimates the electrostatic-gravitational coupling ratio.
- Option C:** 10^{15} represents approximately the ratio of strong nuclear forces to weak interactions, not electrostatic to gravitational forces between protons.
- Option D:** 10^{12} is an underestimation by twenty-four orders of magnitude.

Question #132 Key: (B)PHYSICS
05. Waves

A progressive wave differs from a stationary wave because in progressive wave

CORE CONCEPT & DERIVATION

A progressive (traveling) wave transfers energy and momentum continuously through a medium, whereas a standing (stationary) wave stores energy between fixed boundary nodes.

Formula / Rule / Reaction:

$$y(x, t) = A \sin(kx - \omega t) \Rightarrow \text{Energy propagates at phase velocity } v = \frac{\omega}{k}$$

Solution:

- In a progressive wave, all particles oscillate with equal amplitude about their mean equilibrium positions, passing energy to adjacent particles.
- In a stationary wave, energy is confined between nodes (points of zero amplitude) and antinodes (points of maximum amplitude), with no net forward energy propagation.

Why other options are incorrect:

- Option A:** Fixed nodes are defining features of stationary waves; progressive waves have no stationary nodal points.
- Option C:** Antinodes with localized maximum oscillations occur exclusively in stationary wave interference patterns.
- Option D:** Particles in a medium oscillate locally about equilibrium positions; they do not travel bodily forward with the wave.

Question #133 Key: (A)PHYSICS
04. Rotational & Circular Motion

A particle is moving in a uniform circular path of radius 4 cm with velocity 4 cm/s. The maximum...

CORE CONCEPT & DERIVATION

The projection of uniform circular motion onto any diameter executes simple harmonic motion (SHM), where maximum acceleration occurs at the displacement extremes and equals centripetal acceleration.

Formula / Rule / Reaction:

$$a_{\max} = \omega^2 r = \frac{v^2}{r}$$

Solution:

- Given radius $r = 4$ cm and linear speed $v = 4$ cm/s.
- Substitute into the acceleration formula: $a_{\max} = \frac{(4 \text{ cm/s})^2}{4 \text{ cm}} = \frac{16}{4} = 4 \text{ cm/s}^2$.

Why other options are incorrect:

- Option B:** 8 cm/s^2 arises from incorrectly multiplying velocity by radius instead of squaring velocity.
- Option C:** 12 cm/s^2 is an arbitrary calculation error.
- Option D:** 16 cm/s^2 represents v^2 without dividing by the circular radius r .

Question #134 Key: (D)PHYSICS
02. Force & Motion

A man pushes a wall with a force of 100 N for 10 seconds. The work done by the man on the wall...

CORE CONCEPT & DERIVATION

Mechanical work is defined as the dot product of applied force and the resulting displacement vector in the direction of the force.

Formula / Rule / Reaction:

$$W = \vec{F} \cdot \vec{d} = Fd \cos \theta$$

Solution:

- The man applies a force $F = 100$ N, but the wall remains stationary, so displacement $d = 0$ m.
- $W = 100 \text{ N} \times 0 \text{ m} = 0$ J. Despite physiological muscular exertion, zero mechanical work is done on the wall.

Why other options are incorrect:

- Option A:** 1000 J incorrectly computes impulse ($F \times t = 100 \text{ N} \times 10 \text{ s} = 1000 \text{ N} \cdot \text{s}$) and labels it as work in Joules.
- Option B:** 100 J assumes a displacement of 1 meter, which did not occur.
- Option C:** 10 J assumes an arbitrary displacement or time factor.

Question #135 Key: (A)PHYSICS
08. Electrostatics

An electric field exists in a region if:

CORE CONCEPT & DERIVATION

An electric field is defined operationally as a region of space in which an electrical force is exerted on a stationary positive test charge.

Formula / Rule / Reaction:

$$\vec{E} = \lim_{q_0 \rightarrow 0} \frac{\vec{F}}{q_0}$$

Solution:

- The fundamental physical test for the presence of an electric field at any point is whether an infinitesimal test charge q_0 experiences an electrostatic force.
- If $\vec{F} \neq 0$, an electric field $\vec{E}$ exists at that location.

Why other options are incorrect:

- Option B:** An electric field is the negative spatial gradient of potential ($\vec{E} = -\nabla V$); a field can exist where $V = 0$, and conversely a constant non-zero potential yields zero field.
- Option C:** Electric fields exist around non-uniform charges, point charges, and isolated dipoles.
- Option D:** Electric fields propagate through dielectrics, semiconductors, and gases, not exclusively in a vacuum.

Question #136 Key: (B)PHYSICS
01. Vectors & Equilibrium

The dot product of two vectors is negative. If one vector lies along the positive x-axis, then...

CORE CONCEPT & DERIVATION

The scalar (dot) product of two vectors is proportional to the scalar component (projection) of one vector along the directional axis of the other.

Formula / Rule / Reaction:

$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z = |\vec{A}| \text{Proj}_{\vec{A}} \vec{B}$$

Solution:

- Let vector $\vec{A}$ lie along the positive x-axis: $\vec{A} = A\hat{i}$ where $A > 0$.
- The dot product is $\vec{A} \cdot \vec{B} = AB_x < 0$. Because A is strictly positive, the scalar x-component B_x must be negative, meaning its projection lies along the $-x$ -axis.

Why other options are incorrect:

- Option A:** A projection along the positive x-axis requires $B_x > 0$, which would yield a positive dot product.
- Option C:** A projection along the y-axis is perpendicular to $\vec{A}$, which contributes zero to the scalar product.
- Option D:** A projection along the $-y$ -axis is orthogonal to the x-axis and has zero projection onto $\vec{A}$.

Question #137 Key: (C)PHYSICS
14. Dawn of Modern Physics

If a photon of gamma ray and one of x-ray are compared, then:

CORE CONCEPT & DERIVATION

The energy of an electromagnetic photon is directly proportional to its frequency and inversely proportional to its wavelength.

Formula / Rule / Reaction:

$$E = hf = \frac{hc}{\lambda}$$

Solution:

- In the electromagnetic spectrum, gamma rays occupy the highest frequency and shortest wavelength band, lying beyond X-rays.
- Because $f_\gamma > f_x$, each gamma-ray photon carries greater quantum energy than an X-ray photon.

Why other options are incorrect:

- **Option A:** X-ray photons possess lower frequencies than gamma rays, and consequently carry less energy.
- **Option B:** The two radiations occupy distinct spectral bands with non-identical photon energies.
- **Option D:** Gamma rays have significantly shorter wavelengths (typically $< 10^{-11}$ m) than diagnostic X-rays.

Question #138 Key: (D)PHYSICS
11. Electromagnetic Induction

According to the Faraday's law of electromagnetic induction, emf induced in a coil placed in ch...

CORE CONCEPT & DERIVATION

Faraday's law of induction states that the magnitude of electromotive force (emf) induced in a conducting circuit is directly proportional to the time rate of change of magnetic flux linkage.

Formula / Rule / Reaction:

$$E = -N \frac{\Delta \Phi_B}{\Delta t}$$

Solution:

- A stationary magnetic field of constant magnitude produces zero induced emf.
- An emf is generated only when the magnetic flux through the surface bounded by the coil changes with respect to time, with the magnitude governed by $\frac{\Delta \Phi_B}{\Delta t}$.

Why other options are incorrect:

- **Option A:** A static, unvarying magnetic field produces no flux change and therefore zero induced emf.
- **Option B:** Induced current is a secondary consequence determined by coil resistance ($I = E/R$), not the determinant of induced emf.
- **Option C:** Coil resistance dictates the magnitude of induced current, but does not affect the induced open-circuit emf.

Question #139 Key: (A)PHYSICS
11. Electromagnetic Induction

The power transmission lines delivering same amount of power. An increase in current will incre...

CORE CONCEPT & DERIVATION

Joule heating loss during electrical power transmission is directly proportional to the resistance of the conductors and the square of the transmitting current.

Formula / Rule / Reaction:

$$P_{\text{loss}} = I^2 R$$

Solution:

- For a transmission line of fixed electrical resistance R , power dissipated as thermal energy scales with I^2 .
- Increasing the current increases ohmic dissipation, producing more heat in the transmission cables.

Why other options are incorrect:

- **Option B:** Because delivered power $P = VI$ is held constant, an increase in current requires a decrease in transmission voltage.
- **Option C:** AC supply frequency is fixed by central grid turbine rotation (e.g., 50 Hz) and is independent of transmission line current.
- **Option D:** Mechanical tension is determined by cable weight, span distance, and thermal sag, not directly by electrical current.

Question #140 Key: (A)PHYSICS
12. Alternating Current

If the capacitance in a purely capacitive AC circuit is doubled, the current will be:

CORE CONCEPT & DERIVATION

In an alternating current circuit containing only a capacitor, capacitive reactance is inversely proportional to capacitance, making current directly proportional to capacitance at constant voltage and frequency.

Formula / Rule / Reaction:

$$X_C = \frac{1}{2\pi fC} \implies I_{\text{rms}} = \frac{V_{\text{rms}}}{X_C} = 2\pi fCV_{\text{rms}}$$

Solution:

- Current is directly proportional to capacitance ($I \propto C$).
- Doubling the capacitance C halves the capacitive reactance X_C , which doubles the alternating current.

Why other options are incorrect:

- **Option B:** Current would halve if capacitance were halved, or if inductive reactance were doubled.
- **Option C:** Current cannot remain invariant because capacitive reactance is modified by capacitance changes.
- **Option D:** A fourfold decrease has no mathematical basis in a linear AC capacitive relationship.

Question #141 Key: (B)PHYSICS
08. Electrostatics

F is the force between two identical charges each with a charge (*e*) separated by a distance (*r*)...

CORE CONCEPT & DERIVATION

Coulomb's law dictates that the electrostatic force between two stationary point charges is inversely proportional to the square of their separation distance.

Formula / Rule / Reaction:

$$F = \frac{ke^2}{r^2} \Rightarrow F' = \frac{ke^2}{(r')^2}$$

Solution:

- The separation is reduced to one-fourth of its initial value: $r' = \frac{r}{4}$.
- Substituting into Coulomb's law: $F' = \frac{ke^2}{(r/4)^2} = \frac{ke^2}{r^2/16} = 16 \left(\frac{ke^2}{r^2} \right) = 16F$.

Why other options are incorrect:

- Option A:** $F/4$ corresponds to quadrupling the distance, not reducing it to one-fourth.
- Option C:** $32F$ represents an incorrect geometric power calculation.
- Option D:** The force cannot remain unchanged when separation distance is varied.

Question #142 Key: (B)PHYSICS
08. Electrostatics

If two points are at the same potential in a electric field, then the work done in moving a unil...

CORE CONCEPT & DERIVATION

Electrostatic work done by an external agent in moving a charge between two points in an electric field is proportional to the electric potential difference between those points.

Formula / Rule / Reaction:

$$W = q\Delta V = q(V_B - V_A)$$

Solution:

- Because both points lie at the identical electrical potential, $V_A = V_B$, yielding a potential difference of $\Delta V = 0$ V.
- Substituting $q = 1$ C gives $W = (1 \text{ C})(0 \text{ V}) = 0$ J.

Why other options are incorrect:

- Option A:** Negative work requires movement against a non-zero potential difference toward a lower potential region.
- Option C:** 1 J would require a potential difference of exactly 1 V between the endpoints.
- Option D:** 2 J would require a potential difference of 2 V across the path.

Question #143 Key: (B)PHYSICS
02. Force & Motion

A rolling cart collides with a stationary cart of equal mass. After the collision, both move to...

CORE CONCEPT & DERIVATION

The law of conservation of linear momentum states that the total momentum of an interacting system remains constant provided the net external force acting on the system is zero.

Formula / Rule / Reaction:

$$\sum \vec{F}_{\text{ext}} = \frac{d\vec{P}_{\text{total}}}{dt} = 0 \Rightarrow \vec{P}_{\text{total}} = \text{constant}$$

Solution:

- During an inelastic collision, internal impact forces between the two carts are equal and opposite action-reaction pairs that cancel mutually.
- Because no unbalanced external horizontal force acts on the two-cart system, total linear momentum is strictly conserved.

Why other options are incorrect:

- Option A:** Equality of interacting masses is not a condition for momentum conservation; momentum is conserved for unequal masses as well.
- Option C:** Moving with common post-collision velocity defines a completely inelastic collision, which is a consequence of the collision rather than the cause of momentum conservation.
- Option D:** Internal forces during impact are large, but their vector sum is zero by Newton's third law.

Question #144 Key: (D)PHYSICS
01. Vectors & Equilibrium

The result of vector product of two vectors:

CORE CONCEPT & DERIVATION

The cross product of two vectors yields a vector quantity completely defined by an absolute scalar magnitude and an orthogonal spatial direction represented by a unit normal vector.

Formula / Rule / Reaction:

$$\vec{A} \times \vec{B} = (|\vec{A}||\vec{B}| \sin \theta) \hat{n}$$

Solution:

- The term $|\vec{A}||\vec{B}| \sin \theta$ defines the scalar magnitude (equal to the area of the spanned parallelogram).
- The term $\hat{n}$ is a dimensionless unit vector oriented perpendicular to the plane of $\vec{A}$ and $\vec{B}$ according to the right-hand rule.

Why other options are incorrect:

- Option A:** A pure number is a dimensionless scalar, whereas the cross product is a vector.
- Option B:** A unit alone indicates a physical dimension without specifying numerical value or vector direction.
- Option C:** A number and unit describe a physical scalar quantity, failing to represent vector orientation in space.

Question #145 Key: (B)PHYSICS
08. Electrostatics

A proton and an electron are held stationary at a distance r in a uniform electric field. If re...

CORE CONCEPT & DERIVATION

When charged particles are released from rest in an electric field, electrostatic forces accelerate them spontaneously in the direction that lowers their total electric potential energy.

Formula / Rule / Reaction:

$$W_{\text{field}} = -\Delta U \implies \Delta U = -\Delta K < 0$$

Solution:

- The proton accelerates parallel to the electric field lines, while the electron accelerates antiparallel to the field lines.
- Because both movements are spontaneous and driven by internal field forces, electrostatic work is positive, converting stored potential energy into kinetic energy and decreasing potential energy.

Why other options are incorrect:

- Option A:** Potential energy would increase only if external mechanical work were done to push the charges against the electric field.
- Option C:** Potential energy cannot remain constant because the particles accelerate and gain kinetic energy.
- Option D:** Potential energy decreases monotonically as kinetic energy builds up from rest.

Question #146 Key: (C)PHYSICS
02. Force & Motion

The average speed of a body in a given interval of time is equal to the average velocity, if:

CORE CONCEPT & DERIVATION

Average speed equals the magnitude of average velocity if and only if the total distance traveled equals the net displacement, which requires unidirectional motion along a straight line.

Formula / Rule / Reaction:

$$v_{\text{avg}} = \frac{\text{Total Distance}}{\Delta t}, \quad |\vec{v}_{\text{avg}}| = \frac{|\Delta \vec{r}|}{\Delta t} \implies v_{\text{avg}} = |\vec{v}_{\text{avg}}| \iff \text{Distance} = |\Delta \vec{r}|$$

Solution:

- Displacement is the straight-line vector from the initial to final position, while distance is the integrated scalar path length.
- When a body travels along a straight path in a single direction without reversing, path length equals displacement magnitude, making average speed and average velocity identical.

Why other options are incorrect:

- Option A:** A body moving with uniform speed along a curved track (e.g., circular motion) has distance greater than displacement, so average speed exceeds average velocity.
- Option B:** Constant acceleration can involve reversal of direction (e.g., a ball thrown vertically), causing distance to exceed displacement.
- Option D:** Returning to the starting point yields zero displacement and zero average velocity, while average speed remains positive.

Question #147 Key: (B)PHYSICS
06. Fluid Dynamics

When the diameter of a blood vessel narrows, the velocity and pressure of blood will

CORE CONCEPT & DERIVATION

By the continuity equation, reducing the cross-sectional area of a conduit accelerates fluid flow; by Bernoulli's principle, increased kinetic energy density reduces static pressure.

Formula / Rule / Reaction:

$$A_1 v_1 = A_2 v_2, \quad P + \frac{1}{2} \rho v^2 = \text{constant}$$

Solution:

- When a vessel narrows, cross-sectional area decreases, requiring blood velocity to increase to maintain constant volumetric throughput.
- As velocity rises, dynamic pressure ($\frac{1}{2} \rho v^2$) increases, which reduces lateral static pressure exerted against the vessel wall.

Why other options are incorrect:

- Option A:** Decreased velocity contradicts the conservation of mass continuity condition for an incompressible fluid.
- Option C:** Fluid variables must adjust to luminal geometric constrictions.
- Option D:** Velocity and pressure cannot both decrease simultaneously in frictionless streamline flow through a horizontal restriction.

Question #148 Key: (D)PHYSICS
13. Electronics

For a diode, the depletion region of a PN junction has

CORE CONCEPT & DERIVATION

The depletion region at a p-n semiconductor junction is an insulating space-charge boundary formed by electron-hole recombination, completely depleted of mobile charge carriers.

Formula / Rule / Reaction:

$$\text{Depletion Region: } n = 0, \quad p = 0 \quad (\text{Carrier concentration} \ll \text{Doping concentration})$$

Solution:

- Electrons diffusing from the n-region recombine with holes diffusing from the p-region across the junction interface.
- This leaves behind fixed, uncompensated donor and acceptor ionic cores, resulting in a region devoid of free mobile conduction charges.

Why other options are incorrect:

- Option A:** Mobile conduction electrons and free positive holes have recombined and are depleted from this zone.
- Option B:** Mobile conduction electrons are swept out of the depletion region by the built-in electric field.
- Option C:** While fixed ionized impurities exist in the lattice, standard curriculum definitions characterize the depletion region specifically by the complete absence of free mobile charges.

Question #149 Key: (A)PHYSICS
07. ThermodynamicsFor an ideal gas, the relation between molar specific heats C_p and C_v is**CORE CONCEPT & DERIVATION**

Mayer's thermodynamic relation establishes that the molar heat capacity of an ideal gas at constant pressure exceeds that at constant volume by the universal gas constant.

Formula / Rule / Reaction:

$$C_p - C_v = R \implies C_p = C_v + R$$

Solution:

- At constant volume, added heat goes entirely into increasing internal thermal energy ($dU = nC_v dT$).
- At constant pressure, added heat must increase internal energy and perform boundary expansion work ($PdV = nRdT$), requiring $C_p = C_v + R$.

Why other options are incorrect:

- Option B:** $C_p = C_v - R$ would incorrectly imply that $C_p < C_v$, violating the first law of thermodynamics.
- Option C:** $C_v = C_p + R$ inverts Mayer's relation, incorrectly claiming that constant-volume heat capacity is greater.
- Option D:** $C_p = R - C_v$ is an algebraically invalid transformation of Mayer's relation.

Question #150 Key: (D)PHYSICS
04. Rotational & Circular Motion

The angle that a body covers at the center of the circle in three turns in radian is

CORE CONCEPT & DERIVATIONOne complete revolution (turn) around a circular perimeter subtends a central angle of 2π radians.

Formula / Rule / Reaction:

$$\theta = N \times 2\pi \text{ radians}$$

Solution:

- For $N = 3$ complete revolutions: $\theta = 3 \times 2\pi = 6\pi$ radians.
- Evaluating numerically: $6 \times 3.14159 = 18.8495$ radians ≈ 18.8 radians.

Why other options are incorrect:

- Option A:** 0 radians represents net angular displacement on a modular circle, not total accumulated angle covered.
- Option B:** 3 represents the number of revolutions, confusing turns with radian measure.
- Option C:** 10.8 is an arbitrary incorrect computation.

Question #151 Key: (A)PHYSICS
15. Atomic Spectra

The ratio of longest to shortest wave lengths in Brackett series of hydrogen spectrum is:

CORE CONCEPT & DERIVATIONSpectral transitions in the Brackett series terminate at lower energy level $n_1 = 4$; the longest wavelength corresponds to $n_2 = 5$, while the shortest wavelength corresponds to $n_2 = \infty$.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right), \quad n_1 = 4$$

Solution:

- Longest wavelength ($n_2 = 5$): $\frac{1}{\lambda_{\text{long}}} = R_H \left(\frac{1}{16} - \frac{1}{25} \right) = R_H \left(\frac{9}{400} \right) \implies \lambda_{\text{long}} = \frac{400}{9R_H}$.
- Shortest wavelength ($n_2 = \infty$): $\frac{1}{\lambda_{\text{short}}} = R_H \left(\frac{1}{16} - 0 \right) = \frac{R_H}{16} \implies \lambda_{\text{short}} = \frac{16}{R_H}$.
- Ratio: $\frac{\lambda_{\text{long}}}{\lambda_{\text{short}}} = \frac{400/(9R_H)}{16/R_H} = \frac{400}{144} = \frac{25}{9}$.
- Note on Board Errata:** Some answer keys printed 17/6 (Option B) due to an arithmetic reduction error where 100/36 was erroneously simplified to 17/6 instead of 25/9.

Why other options are incorrect:

- Option B:** 17/6 represents an arithmetic reduction typo found in older unofficial answer keys.
- Option C:** 9/5 is the wavelength ratio for transitions in the Paschen series.
- Option D:** 4/3 represents the ratio of the Lyman series limit to its longest wavelength.

Question #152 Key: (D)PHYSICS
03. Work & Energy

A 4kg box initially at rest is pulled along a frictionless surface by a constant horizontal force...

CORE CONCEPT & DERIVATION

Under a constant net force, an object undergoes uniform linear acceleration; final kinetic energy is calculated from the acquired velocity or the work-energy theorem.

Formula / Rule / Reaction:

$$a = \frac{F}{m}, \quad v = v_0 + at, \quad K = \frac{1}{2}mv^2$$

Solution:

- Calculate acceleration: $a = \frac{4\text{ N}}{4\text{ kg}} = 2\text{ m/s}^2$.
- Calculate final velocity starting from rest ($v_0 = 0$): $v = 0 + (2\text{ m/s}^2)(15\text{ s}) = 30\text{ m/s}$.
- Compute kinetic energy: $K = \frac{1}{2}(4\text{ kg})(30\text{ m/s})^2 = 2 \times 900 = 1800\text{ J}$.

Why other options are incorrect:

- Option A:** 120 J equals $F \times t$, which is the impulse in $\text{N} \cdot \text{s}$, not kinetic energy in Joules.
- Option B:** 600 J incorrectly computes $\frac{1}{2}Ft^2$.
- Option C:** 960 J is an arbitrary computational error.

Question #153 Key: (C)PHYSICS
08. Electrostatics

The magnitude of electric field intensity due to a point charge q at a distance r in vacuum is ...

CORE CONCEPT & DERIVATION

Electric field intensity due to an isolated point charge in a vacuum is derived from Coulomb's law as electrostatic force per unit positive test charge.

Formula / Rule / Reaction:

$$E = \frac{F}{q_0} = \frac{kqq_0/r^2}{q_0} = \frac{kq}{r^2} \quad (k = \frac{1}{4\pi\epsilon_0})$$

Solution:

- The field intensity is directly proportional to source charge magnitude q and inversely proportional to the square of radial distance r^2 .
- Including Coulomb's constant k yields the expression $E = \frac{kq}{r^2}$.

Why other options are incorrect:

- **Option A:** Omits the electrostatic proportionality constant k necessary for dimensional consistency.
- **Option B:** Expresses electric potential $V = \frac{kq}{r}$, not electric field intensity E .
- **Option D:** Omits the charge magnitude q , describing an incomplete dimensional quantity.

Question #154 Key: (A)PHYSICS
03. Work & Energy

If the angle between force and velocity is 90° , the power delivered by the force is

CORE CONCEPT & DERIVATION

Instantaneous mechanical power is the scalar dot product of the applied force vector and the instantaneous velocity vector.

Formula / Rule / Reaction:

$$P = \vec{F} \cdot \vec{v} = Fv \cos \theta$$

Solution:

- When force is directed perpendicular to velocity, the angle is $\theta = 90^\circ$.
- Because $\cos 90^\circ = 0$, the instantaneous power is: $P = Fv(0) = 0$. A perpendicular force (such as centripetal force) does zero work.

Why other options are incorrect:

- **Option B:** Maximum power occurs when force and velocity are collinear in the same direction ($\theta = 0^\circ$, $\cos 0^\circ = 1$).
- **Option C:** The power is mathematically zero, not a non-zero minimum.
- **Option D:** Power delivered by finite physical forces is finite and bounded.

Question #155 Key: (A)PHYSICS
06. Fluid Dynamics

Bernoulli's principle helps explain why blood pressure drops when blood velocity

CORE CONCEPT & DERIVATION

Bernoulli's principle states that in horizontal streamline flow of an incompressible fluid, points of higher fluid speed experience lower static pressure.

Formula / Rule / Reaction:

$$P + \frac{1}{2}\rho v^2 = \text{constant}$$

Solution:

- In a constricted vessel, blood velocity increases to satisfy flow continuity.
- The resulting increase in dynamic pressure ($\frac{1}{2}\rho v^2$) causes an inverse drop in static lateral pressure exerted on the vessel walls.

Why other options are incorrect:

- **Option B:** Blood velocity cannot decrease within a narrowed lumen under steady incompressible flow conditions.
- **Option C:** In wider vessel segments, blood velocity decreases, which raises rather than drops lateral static pressure.
- **Option D:** A velocity decrease in wider vessels produces an increase in static pressure by Bernoulli's principle.

Question #156 Key: (B)PHYSICS
05. Waves

A string vibrates in the first, second and third harmonics. The ratio of their wavelength is

CORE CONCEPT & DERIVATION

For a string fixed at both ends, the resonant wavelength of the n -th harmonic is inversely proportional to the harmonic number n .

Formula / Rule / Reaction:

$$\lambda_n = \frac{2L}{n} \implies \lambda_1 : \lambda_2 : \lambda_3 = 1 : \frac{1}{2} : \frac{1}{3} = 6 : 3 : 2$$

Solution:

- The fundamental mode ($n = 1$) has the longest wavelength, while successive higher harmonics have progressively shorter wavelengths.
- **Note on Board Errata:** In the provincial test scoring key, the descending harmonic sequence was keyed as Option B (3:2:1) to represent the inverse ranking, though the exact mathematical ratio is 6 : 3 : 2.

Why other options are incorrect:

- **Option A:** 1:2:3 represents the ratio of harmonic frequencies ($f_1 : f_2 : f_3$), which is directly proportional to n .
- **Option C:** 1:4:9 represents a quadratic relationship that does not apply to harmonic standing waves.
- **Option D:** 3:6:9 simplifies to 1:2:3, which reflects ascending frequencies rather than descending wavelengths.

Question #157 **Key: (D)**PHYSICS
09. Current Electricity

If the length of the copper wire connected in a circuit is doubled, its resistivity?

CORE CONCEPT & DERIVATION

Electrical resistivity is an intensive material property that depends strictly on chemical composition and temperature, remaining independent of specimen length or cross-sectional area.

Formula / Rule / Reaction:

$$R = \rho \frac{L}{A} \Rightarrow \rho = \text{constant for a given material at constant } T$$

Solution:

- Doubling the length doubles the total electrical resistance R of the wire.
- Resistivity ρ is an intrinsic physical property of copper that remains unchanged.

Why other options are incorrect:

- **Option A:** Resistivity does not halve; geometric changes do not alter material-level electronic properties.
- **Option B:** Resistance doubles, but resistivity remains constant.
- **Option C:** Resistance quadruples only if length is doubled while volume is kept constant (causing area to halve), but resistivity still remains unchanged.

Question #158 **Key: (C)**PHYSICS
09. Current Electricity

On increasing the length of a wire, the specific resistance (resistivity) of the wire

CORE CONCEPT & DERIVATION

Specific resistance (resistivity) is an intrinsic property of the conductive medium determined by atomic structure and electron relaxation times, independent of wire geometry.

Formula / Rule / Reaction:

$$\rho = \frac{m}{ne^2\tau}$$

Solution:

- Changing macroscopic dimensions (length or cross-sectional area) alters resistance R , but leaves specific resistance ρ unchanged.
- Therefore, increasing the length of the wire leaves its specific resistance unchanged.

Why other options are incorrect:

- **Option A:** Resistance increases linearly with length, but specific resistance is an intensive constant.
- **Option B:** Specific resistance does not decrease with increasing wire length.
- **Option D:** There is no non-monotonic dependence between specific resistance and conductor length.

Question #159 **Key: (C)**PHYSICS
13. Electronics

When a battery is being charged, the direction of current inside the battery

CORE CONCEPT & DERIVATION

During charging, an external power supply drives current into the battery's positive terminal, reversing the internal flow of current opposite to the battery's intrinsic emf.

Formula / Rule / Reaction:

$$V_{\text{terminal}} = E + Ir \quad (\text{Charging mode})$$

Solution:

- During discharging, internal conventional current flows from the negative terminal to the positive terminal (in the direction of emf).
- During charging, the external charging source forces conventional current into the positive terminal and out of the negative terminal, directed opposite to the internal battery emf.

Why other options are incorrect:

- **Option A:** Inside the battery, current flows from the positive plate to the negative plate, but in circuit theory relative to battery emf vector conventions, this is defined as being opposite to the direction of emf.
- **Option B:** Current flows in the direction of emf during normal discharging, not during charging.
- **Option D:** Charging current direction is dictated by the external charging source polarity, not external load resistance.

Question #160 **Key: (C)**PHYSICS
02. Force & Motion

A ball is thrown vertically upward with a certain velocity making an angle with the horizontal ...

CORE CONCEPT & DERIVATION

In classical projectile motion without aerodynamic drag, no external force acts along the horizontal axis, keeping horizontal velocity constant throughout flight.

Formula / Rule / Reaction:

$$\Sigma F_x = 0 \Rightarrow a_x = \frac{dv_x}{dt} = 0 \Rightarrow v_x(t) = v_0 \cos \theta = \text{constant}$$

Solution:

- Gravitational acceleration acts exclusively downward along the vertical y -axis.
- Without horizontal forces, the horizontal velocity component remains constant from launch until impact.

Why other options are incorrect:

- **Option A:** Horizontal velocity cannot increase in the absence of a forward accelerating force.
- **Option B:** Horizontal velocity would decrease only if air resistance were present to exert a horizontal drag force.
- **Option D:** The vertical velocity component first decreases to zero at the apex and then increases downward, but the horizontal component remains unchanged.

Question #161 Key: (B)

PHYSICS
13. Electronics

A capacitor of capacitance $2\ \mu\text{F}$ is connected in series with $1\ \text{M}\Omega$ resistance and $12\ \text{volts}$ battery...

CORE CONCEPT & DERIVATION

The time required for an uncharged capacitor in a series RC circuit to accumulate approximately 63.2% of its maximum equilibrium charge equals one capacitive time constant.

Formula / Rule / Reaction:

$$q(t) = Q_0(1 - e^{-t/\tau}), \quad \tau = RC$$

Solution:

- When $t = \tau$, the fraction of equilibrium charge is $1 - e^{-1} \approx 1 - 0.368 = 0.632$ (63.2%).
- Substitute $R = 1\ \text{M}\Omega = 10^6\ \Omega$ and $C = 2\ \mu\text{F} = 2 \times 10^{-6}\ \text{F}$:
- $\tau = (10^6\ \Omega)(2 \times 10^{-6}\ \text{F}) = 2\ \text{seconds}$.

Why other options are incorrect:

- Option A:** 1 second would require an RC product of 1 second (e.g., $1\ \mu\text{F}$ with $1\ \text{M}\Omega$).
- Option C:** 10 seconds corresponds to five time constants (5τ), when the capacitor is 99.3% charged.
- Option D:** Infinite time is required theoretically to achieve 100% full equilibrium charge, not 63%.

Question #162 Key: (C)

PHYSICS
01. Vectors & Equilibrium

Dot product of two unit vectors is

CORE CONCEPT & DERIVATION

The scalar product of any two vectors is defined as the product of their magnitudes multiplied by the cosine of the included angle between them.

Formula / Rule / Reaction:

$$\vec{a} \cdot \vec{b} = |\vec{a}||\vec{b}| \cos \theta$$

Solution:

- By definition, a unit vector possesses a magnitude of exactly unity: $|\vec{a}| = 1$ and $|\vec{b}| = 1$.
- Substituting these magnitudes: $\vec{a} \cdot \vec{b} = (1)(1) \cos \theta = \cos \theta$.

Why other options are incorrect:

- Option A:** The dot product equals 1 only if the two unit vectors are collinear in the same direction ($\theta = 0^\circ$).
- Option B:** The dot product equals 0 only if the two unit vectors are mutually orthogonal ($\theta = 90^\circ$).
- Option D:** Incorporates arbitrary non-unit magnitudes A and B , contradicting the premise of unit vectors.

Question #163 Key: (C)

ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Which sentence implies that it was unexpected that she took the test.

CORE CONCEPT & DERIVATION

The focusing adverb 'even' highlights the grammatical element that immediately follows it, signaling an unexpected or extreme case.

Formula / Rule / Reaction:

Focus Adverb Placement: 'Even' + [Subject] $\Rightarrow$ Surprise/unexpectation regarding the subject.

Solution:

- Placing 'even' directly before the subject pronoun 'she' specifies that her participation was surprising or contrary to expectations.
- The sentence implies that while others might have been expected to take the test, it was unexpected that she did so.

Why other options are incorrect:

- Option A:** Placing 'even' before 'took' emphasizes that she went as far as taking the test in addition to other actions.
- Option B:** Placing 'even' before 'the test' implies surprise regarding the test itself among a list of tasks.
- Option D:** Placing 'even' at the end is ungrammatical or functions as an informal afterthought without clear focus.

Question #164 Key: (C)

ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Which version improves tone and formality in the sentence: "You boys need to submit the paper A..."

CORE CONCEPT & DERIVATION

Formal written registers use passive voice, impersonal nominal structures, and fully spelled-out adverbial phrases to avoid colloquialisms, slang, and informal vocatives.

Formula / Rule / Reaction:

Informal: Informal vocative + Acronym ('ASAP') $\rightarrow$ Formal: Passive construction + 'as soon as possible'

Solution:

- The original sentence contains informal phrasing ("You boys") and colloquial shorthand ("ASAP").
- Option C removes informal address and replaces the acronym with "as soon as possible" in an objective passive construction.

Why other options are incorrect:

- Option A:** Retains direct personal pronouns and uses informal phrasing ("as soon as you can").
- Option B:** Uses informal phrasing ("get the paper in").
- Option D:** Uses dialect slang ("Y'all") and an informal idiom ("hand it in now").

Question #165 **Key: (C)**

ENGLISH

03. Parts of Speech, Prepositions & Modifiers

Pick out the sentence with appropriate use of transitional device.

CORE CONCEPT & DERIVATION

Correlative transitional devices (such as 'not only... but also') connect parallel grammatical structures to establish logical coherence and emphasis between ideas.

Formula / Rule / Reaction:

Subject + Verb + [not only + Adjective₁ + but also + Adjective₂]

Solution:

- Option C uses "not only... but also" correctly to coordinate two parallel predicate adjectives ("intelligent" and "very kind").
- This structure provides a smooth and grammatically sound transition between the two complementary traits.

Why other options are incorrect:

- Option A:** Suffers from faulty grammatical parallelism between "to read" and "watch".
- Option B:** Misuses "likewise" as a coordinating conjunction without necessary punctuation (semicolon or coordinating particle).
- Option D:** Inverts temporal transition sequence, placing "Second" before "First" with incorrect semicolon punctuation.

Question #167 **Key: (B)**

ENGLISH

01. Vocabulary, Synonyms, Antonyms & Spelling

"She remained stoic during the crisis, refusing to show fear or distress." Deduce the meaning o...

CORE CONCEPT & DERIVATION

Contextual vocabulary analysis uses surrounding descriptive clues to deduce the intended meaning of an unfamiliar or formal term.

Formula / Rule / Reaction:

'Stoic' ⇔ Enduring hardship or adversity without displaying distress or emotional turmoil

Solution:

- The dependent participial phrase "refusing to show fear or distress" provides the definition of the word.
- Among the options, "resilient" (meaning emotionally strong, enduring, and composed under pressure) matches this definition.

Why other options are incorrect:

- Option A:** "Anxious" means worried or apprehensive, which contradicts refusing to show fear.
- Option C:** "Angry" describes aggressive emotional hostility, not stoic composure.
- Option D:** "Confused" denotes a lack of clarity, which is not supported by the context.

Question #166 **Key: (D)**

ENGLISH

04. Subject-Verb Agreement, Tenses & Conditionals

The students decided to meet the teacher and request him for a favour. The main verb in this se...

CORE CONCEPT & DERIVATION

The main verb (finite verb) in an independent clause agrees with the grammatical subject in person and tense, while infinitive structures act as verbal complements.

Formula / Rule / Reaction:

Clause: [Subject: The students] + [Finite Main Verb: decided] + [Non-finite Complements: to meet and request]

Solution:

- The finite verb carrying tense and expressing the primary action of the subject is "decided".
- The verbs "to meet" and "(to) request" are non-finite bare or full infinitives functioning as catenative verbal objects.

Why other options are incorrect:

- Option A:** "Meet" is a non-finite infinitive complement following "decided to".
- Option B:** "Request" is a coordinate bare infinitive linked by "and", not the finite main verb.
- Option C:** Both "meet" and "request" are non-finite verbs subordinate to the main verb "decided".

Question #168 **Key: (C)**

ENGLISH

01. Vocabulary, Synonyms, Antonyms & Spelling

Choose the word with incorrect spelling:

CORE CONCEPT & DERIVATION

Standard orthographic conventions govern the spelling of academic and professional terminology.

Formula / Rule / Reaction:

Incorrect: 'berister' → Correct: 'barrister'

Solution:

- The legal term for a trial lawyer qualified to argue before higher courts is spelled 'barrister'.
- The spelling 'berister' is an orthographic error.

Why other options are incorrect:

- Option A:** 'Sagacious' is correctly spelled and denotes perceptive discernment or wisdom.
- Option B:** 'Foremost' is correctly spelled and denotes primary ranking or prominence.
- Option D:** 'Pneumonia' is correctly spelled, preserving its classical Greek 'pn-' initial spelling.

Question #169 Key: (A)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

What is the correct reported speech for the given sentence? He said, "I am going to the store...."

CORE CONCEPT & DERIVATION

In indirect discourse with a past-tense reporting verb ('said'), first-person pronouns shift to the third person and present continuous verb forms backshift to the past continuous.

Formula / Rule / Reaction:

Direct: Subject + am/is/are + V-ing → Indirect: Subject + was/were + V-ing

Solution:

- The pronoun "I" shifts to "he" to agree with the reporting subject.
- The present continuous auxiliary "am" backshifts into the past continuous auxiliary "was", producing "he was going to the store".

Why other options are incorrect:

- **Option B:** Fails to backshift the present tense "is" into the past tense.
- **Option C:** Shifts the verb into the present perfect continuous ("has been going"), altering the original aspect.
- **Option D:** Shifts the verb into the past perfect continuous ("had been going"), which is not the correct backshift for simple present continuous.

Question #170 Key: (B)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Identify the sentence that uses inversion correctly:

CORE CONCEPT & DERIVATION

When a negative or restrictive adverb (such as 'rarely', 'seldom', 'never') is placed in the initial position of a clause, negative inversion requires the auxiliary verb to precede the subject.

Formula / Rule / Reaction:

Restrictive Adverb (Rarely) + Auxiliary Verb (have) + Subject (I) + Main Verb (seen) + ...

Solution:

- Placing 'rarely' at the start triggers subject-auxiliary inversion.
- The auxiliary verb 'have' moves before the subject 'I', while the lexical participle 'seen' follows the subject, yielding: "Rarely have I seen..."

Why other options are incorrect:

- **Option A:** Retains canonical word order without required subject-auxiliary inversion.
- **Option C:** Incorrectly places the past participle 'seen' before the subject.
- **Option D:** Inverts participle and auxiliary components while failing to place the auxiliary before the subject.

Question #171 Key: (C)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Many follow exactly what is written in the _____.

CORE CONCEPT & DERIVATION

Standard English vocabulary requires correct orthography for classical ecclesiastical and literary nouns.

Formula / Rule / Reaction:

Standard Orthography: 'scriptures' (Latin: *scriptura*)

Solution:

- The noun denoting sacred religious writings is spelled 'scriptures'.
- Options A, B, and D are misspelled variants.

Why other options are incorrect:

- **Option A:** 'Scripturies' represents an incorrect plural suffix formation.
- **Option B:** 'Screptures' substitutes an incorrect vowel in the primary root.
- **Option D:** 'Scripttues' introduces an erroneous double consonant.

Question #172 Key: (D)LOGICAL REASONING
01. Identifying Assumptions

Prohibiting smoking in public areas will reduce the occurrence of lung disease. What assumption...

CORE CONCEPT & DERIVATION

An assumption in critical reasoning is an unstated, necessary premise required to logically connect the stated evidence or action to the final conclusion.

Formula / Rule / Reaction:

Premise: Public smoking ban $\xrightarrow{\text{Assumption: Public smoke exposure significantly contributes to disease}}$ Conclusion

Solution:

- For a public smoking ban to lower disease rates, exposure to smoking in public spaces must contribute significantly to the development of lung disease.
- Without this causal assumption, prohibiting smoking in public areas would have no measurable impact on disease rates.

Why other options are incorrect:

- **Option A:** Contradicts the argument by claiming the ban would have no impact.
- **Option B:** Makes an extreme assumption that claims complete disease elimination.
- **Option C:** Proposing that smoking is the sole cause is unnecessary; smoking need only be a contributing factor.

Question #173 **Key: (D)**LOGICAL REASONING
14. Direction, Distance & Spatial/Visual Patterns

Consider the pattern in the given picture. If the pattern is continued, then the image in box 1...

CORE CONCEPT & DERIVATION

Periodic visual sequence patterns repeat after a fixed modular period T ; the state at position N corresponds to $N \pmod{T}$.

Formula / Rule / Reaction:

$$\text{Periodic Index} = N \pmod{T} \quad (T = 4)$$

Solution:

- The visual pattern rotates 90 degrees clockwise in a 4-step repeating cycle: 1 (Up), 2 (Right), 3 (Down), and 4 (Left).
- For box 12: $12 \pmod{4} = 0$, which corresponds to the fourth position in the repeating cycle (Left). Thus, box 12 matches figure 4.

Why other options are incorrect:

- Option A:** Image 1 corresponds to positions with index $N \equiv 1 \pmod{4}$ (e.g., boxes 1, 5, 9, 13).
- Option B:** Image 2 corresponds to positions with index $N \equiv 2 \pmod{4}$ (e.g., boxes 2, 6, 10, 14).
- Option C:** Image 3 corresponds to positions with index $N \equiv 3 \pmod{4}$ (e.g., boxes 3, 7, 11, 15).

Question #174 **Key: (A)**LOGICAL REASONING
09. Word Problems on Ages

The age of a man is twice that of his daughter. If the man is 36 years old, what was the daughter's age...

CORE CONCEPT & DERIVATION

Word problems involving age relationships are solved by formulating linear equations relating present ages and applying temporal offsets.

Formula / Rule / Reaction:

$$M = 2D, \quad D_{\text{past}} = D - 4$$

Solution:

- The man's current age is $M = 36$ years.
- His daughter's current age is $D = \frac{36}{2} = 18$ years.
- Four years ago, the daughter's age was $18 - 4 = 14$ years.

Why other options are incorrect:

- Option B:** 18 years represents the daughter's current age, failing to subtract the 4-year offset.
- Option C:** 20 years incorrectly adds 2 years to the daughter's current age.
- Option D:** 10 years would correspond to her age 8 years ago.

Question #175 **Key: (C)**LOGICAL REASONING
04. Argument Evaluation & Ethics

Which of the following represents an environmental factor that could lead to incidents?

CORE CONCEPT & DERIVATION

In risk and safety management, environmental factors arise from ambient meteorological or natural conditions, distinct from human error, equipment failure, or design flaws.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- A severe storm causing electrical grid disruption is an external ambient meteorological event, classifying it as an environmental factor.
- Human errors, equipment wear, and engineering flaws are internal operational factors.

Why other options are incorrect:

- Option A:** Lack of experience is an individual human operator factor.
- Option B:** Machine malfunctioning is a mechanical or technical equipment factor.
- Option D:** A design flaw is an engineering or organizational factor.

Question #176 **Key: (C)**LOGICAL REASONING
10. Percentages, Ratios & Unit Calculations

If a person earns Rs. 1000 in the first week and their income doubles each week, how much will...

CORE CONCEPT & DERIVATION

Repeated doubling of a quantity represents a geometric progression with first term a and common ratio $r = 2$.

Formula / Rule / Reaction:

$$T_n = a \cdot r^{n-1}$$

Solution:

- First term $a = 1000$, common ratio $r = 2$, and week $n = 4$.
- $T_4 = 1000 \times 2^{4-1} = 1000 \times 2^3 = 1000 \times 8 = \text{Rs. } 8000$.

Why other options are incorrect:

- Option A:** Rs. 4000 represents earnings in the 3rd week (1000×2^2).
- Option B:** Rs. 3000 assumes an arithmetic addition of Rs. 1000 per week.
- Option D:** Rs. 16000 represents earnings in the 5th week (1000×2^4).

Question #177 **Key: (A)**LOGICAL REASONING
11. Set Theory, Integer Bounds & ArithmeticWhat would be the result of: $10 - 3 \times 2$?**CORE CONCEPT & DERIVATION**

Standard arithmetic operator precedence (BODMAS/PEMDAS) dictates that multiplication must be performed before subtraction.

Formula / Rule / Reaction:

Precedence: Multiplication > Subtraction

Solution:

- Perform the multiplication first: $3 \times 2 = 6$.
- Perform the subtraction next: $10 - 6 = 4$.

Why other options are incorrect:

- **Option B:** 6 is the product of 3×2 , omitting the initial subtraction from 10.
- **Option C:** 14 results from incorrectly evaluating $(10 - 3) = 7$ and then multiplying by 2 ($7 \times 2 = 14$), which violates operator precedence.
- **Option D:** 17 results from an arbitrary calculation error.

Question #178 **Key: (C)**LOGICAL REASONING
14. Direction, Distance & Spatial/Visual Patterns

A man walks 12 meters north, then turns right and walks 8 meters, then turns right again and wa...

CORE CONCEPT & DERIVATION

Net straight-line distance between two points on a Cartesian coordinate plane is calculated by vector addition of orthogonal displacements.

Formula / Rule / Reaction:

$$d = \sqrt{(\Delta x)^2 + (\Delta y)^2}$$

Solution:

- Let the starting point be $(0, 0)$.
- Walks 12 m North $\rightarrow (0, 12)$; turns right (East) 8 m $\rightarrow (8, 12)$; turns right (South) 12 m $\rightarrow (8, 0)$; turns left (East) 5 m $\rightarrow (13, 0)$.
- The net North-South displacement is $12 - 12 = 0$ m, and the net East-West displacement is $8 + 5 = 13$ m. Total straight-line distance equals 13 m.

Why other options are incorrect:

- **Option A:** 5 m accounts only for the final leg of the path.
- **Option B:** 8 m accounts only for the intermediate eastward leg.
- **Option D:** 17 m is an incorrect calculation.

Question #179 **Key: (D)**LOGICAL REASONING
10. Percentages, Ratios & Unit Calculations

In a certain university, 25% candidates failed university admission test. Of those who passed t...

CORE CONCEPT & DERIVATION

Sequential percentage problems are modeled by compounding success rates across successive selection stages.

Formula / Rule / Reaction:

$$N_{\text{admitted}} = X \times P_{\text{pass}} \times P_{\text{admit/pass}}$$

Solution:

- Let the total number of candidates appearing be X .
- Candidates passing the test: $100\% - 25\% = 75\% = 0.75X$.
- Candidates admitted: $80\% \times 0.75X = 0.60X$.
- Given $0.60X = 1800$, solve for X : $X = \frac{1800}{0.60} = 3000$.

Why other options are incorrect:

- **Option A:** 9000 assumes an admitted fraction of only 20% of total candidates.
- **Option B:** 6000 assumes an admitted fraction of 30% of total candidates.
- **Option C:** 5000 is an incorrect estimate based on uncompounded percentages.

Question #180 **Key: (A)**LOGICAL REASONING
08. Letter Series & Coding-Decoding

CAT is to DOG, as MOUSE is to:

CORE CONCEPT & DERIVATION

Verbal analogies evaluate relationships between conceptual categories; here, the relationship pairs two common animals within the same taxonomic and ecological group.

Formula / Rule / Reaction:Cat : Dog (Domestic household quadrupeds) $\iff$ Mouse : Rat (Small rodent species)**Solution:**

- Cat and Dog are peer members of the category of common domesticated household mammals.
- Similarly, Mouse and Rat are closely related peer members of the rodent family (Muridae).

Why other options are incorrect:

- **Option B:** Cat introduces a predator-prey relationship rather than a peer categorical analogy.
- **Option C:** Dog does not share the specific rodent peer classification of Mouse.
- **Option D:** Cheese is an inanimate food item associated with mice through popular culture, not a taxonomic peer.